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F. B. MUMFORD, *Director*

# GROWTH AND DEVELOPMENT

*With Special Reference to Domestic Animals*

## XXXIX. Relation Between Monetary Profit and Energetic Efficiency of Milk Production with Special Reference to the Influence of Live Weight Thereon.

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## FOREWORD

The special investigation on growth and development is a cooperative enterprise in which the departments of Animal Husbandry, Dairy Husbandry, Agricultural Chemistry, and Poultry Husbandry have each contributed a substantial part. The parts for the investigation in the beginning were inaugurated by a committee including A. C. Ragsdale, E. A. Trowbridge, H. L. Kempster, A. G. Hogan, F. B. Mumford, Samuel Brody served as Chairman of this committee and has been chiefly responsible for the execution of the plans, interpretation of results and the preparation of the publications resulting from this enterprise.

The investigation has been made possible through a grant by the Herman Frasch Foundation, now represented by Dr. F. J. Sievers.

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## ABSTRACT

Gross energetic efficiency is not dependent physiologically on body weight of cow; but monetary profit is. Monetary profit per cow, increases with increasing body weight; monetary profit per unit body weight decreases with increasing body weight; monetary profit per unit milk (FCM) production or per unit feed consumption tends to be independent of body weight and is almost directly proportional to energetic efficiency. While profit for the entire dairy enterprise (not necessarily per cow or per unit live weight) is an index of the commercial value of a cow under given conditions, energetic efficiency is an index of physiological value. Milk production by itself is a poor index of either commercial or physiological value and should be replaced by gross energetic efficiency in the estimate of which body weight as well as milk production enter as factors. The above statements are analyzed and illustrated graphically in detail. Alignment charts (nomographs) are presented for quick estimation of energetic efficiency and various kinds of profit (per cow, per unit body weight, per unit milk).

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### I. INTRODUCTION

The preceding bulletins (Missouri Research Bulletins 222 and 238) were concerned with energetic *efficiency* of milk production; that is, with the *ratio* of energy output as milk to energy expended as digestible feed. The present bulletin is concerned with monetary *profit* of milk production; that is, with the *difference* between money realized for milk produced and money expended for feed consumed.

Profits from milk production are dependent not only on energetic efficiency of milk production but also on other factors such as milk and feed prices and costs of: labor, management, housing, taxes, etc. The differential between milk price and feed cost is obviously the most important factor. No matter how efficient a cow may be energetically, no matter how much milk she may produce, she will not yield a profit if price of milk is below cost of feed required to produce milk. Indeed, if price of milk is below cost of feed then the more milk produced the greater the loss. Monetary profit is therefore by no means identical with energetic efficiency, and the dairyman naturally wishes to be informed concerning the relation between monetary profit and energetic efficiency. The purpose of this bulletin is to supply some of this desired information with special reference to rapid methods for computing monetary profit and to the influence of live weight and of energetic efficiency of animal on the monetary profit of milk production.

### II. DEFINITIONS OF PROFIT FROM MILK PRODUCTION AND THE INFLUENCE OF LIVE WEIGHT AND ENERGETIC EFFICIENCY ON PROFIT.

The first question needing clarification is: what does one mean by profit from milk production?

1. Is it profit per cow?
2. Is it profit per unit live weight of cow?
3. Is it profit per unit milk produced?
4. Is it profit per unit feed consumed?

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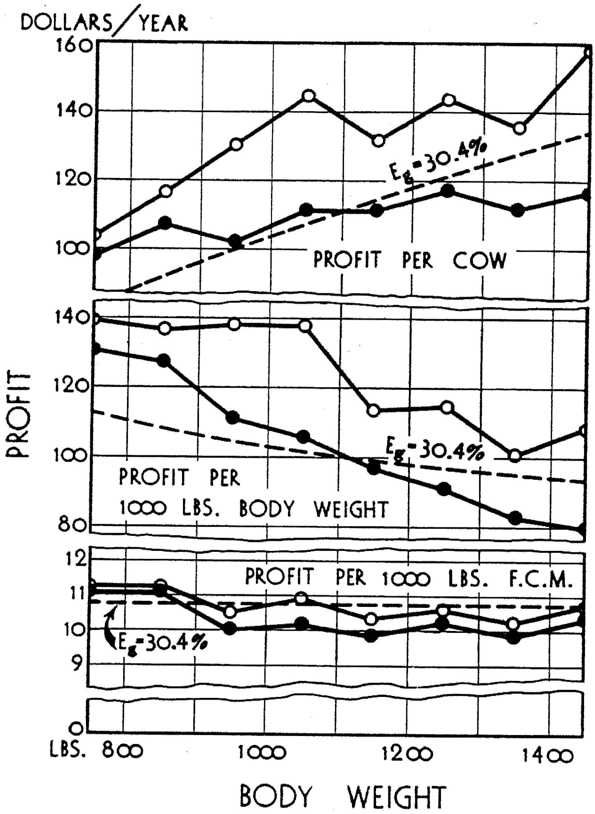



Fig. 1.—Influence of live weight on profit per cow (top segment), per 1000 pounds body weight (middle segment), and per 1000 pounds milk (FCM) production (bottom segment). The light broken curves indicate the effect when gross energetic efficiency is assumed to be the same, namely, 30.4% for all live weights. The continuous curves represent the observed data listed in the appendix. Profit is defined by the difference between monetary return for milk at $2.00 per 100 pounds FCM and monetary cost of feed at $1.50 per 100 pounds TDN, ignoring all other expenses.

Figure 1 illustrates the influence of live weight of cows on: profit per cow (top segment); profit per 1000 pounds live weight (middle segment); profit per 1000 pounds FCM production (bottom segment). The broken curves indicate the effects of live weight on the assumption that gross energetic efficiency is the same (30.4%) for small and large cows. The curves connecting the data points, represent data listed in the appendix of this bulletin.

It is instructive to discuss the answers to each of these three questions in some detail. To simplify the discussion, we shall leave out from computations the overhead cost of management, housing, labor, etc., and define "profit" by the difference between monetary return for milk produced and monetary cost of feed consumed. In constructing Fig. 1 we assumed that the price of milk is $2.00 per 100 pounds FCM*, and of feed $1.50 per 100 pounds TDN.

**1. Profit Per Cow, or "Productive Capacity":** (See top segment in Fig. 1.) It is well known that other conditions being the same (especially fatness), large animals produce more milk than small. Under farm conditions, as illustrated by dairy cattle herd improvement association records, there is a difference of about 250 pounds of FCM per year for every 100 pounds live weight. Under official-test conditions, there is a difference of about 500 pounds FCM per year for every 100 pounds live-weight. Since a large cow tends to produce more milk than a small, then if gross energetic efficiency and profit per pound of milk is the same, the large cow producing more milk than the small, will also bring in the greater total monetary return per cow. If, therefore, the aim is to secure the largest production *per cow,* and if other conditions are the same, then large cows should generally be chosen.

**2. Profit per Unit Live Weight, or "Productive Intensity":** (See middle segment in Fig. 1) While a large cows tends to produce more milk than a small, a small cow tends to produce more *in proportion to her body weight* than a large. If, therefore, the aim is to secure the largest production and largest profit per unit weight of cow, small animals should be generally chosen. This statement does not imply that smaller animals are more efficient energetically than large; because, as indicated in the preceding bulletin (Res. Bull. 238), maintenance feed needs per unit live weight of animal increase with decreasing size of animal in such manner that energetic efficiency (i. e., ratio of energy in milk to energy in feed) tends to be independent of live weight. True that the small cow produces more FCM per unit of body weight than the large, but she also consumes more feed per unit of body weight; with the net result that energetic efficiency remains the same.

**3. Profit per Unit Milk Produced, or "Productive Effciency":** (See bottom segment in Fig. 1.) If overhead costs of management, housing, labor, etc. are left out of consideration, and profit is defined by the difference between monetary return for milk produced and monetary costs of feed consumed, then profit per unit milk produced tends to be the same for large and small cows for the same reason that energetic efficiency tends to be the same. This is illustrated in the lower segment of Fig. 1 and in Fig. 3.

*FCM represents milk corrected to 4% fat according to the methods of Gaines. TDN represents total digestible nutrients.

**4. Profit per Unit Feed Consumed:** As indicated in section 6f, profit per unit feed consumed, like profit per unit milk produced, tends to be independent of body weight and almost proportional to energetic efficiency.

**5. Influence of Gross Energetic Efficiency on Profit:** Figure 2 shows that profit per cow and profit per 1000-pounds live weight of cow increase more rapidly than gross energetic efficiency. The greater the efficiency level, the greater the profit per efficiency increment. Profit approaches infinity as energetic efficiency approaches 100%. (It will be noted later that a 50% gross energetic efficiency with respect to TDN consumed is perhaps near the biologic maximum. The most TDN that can be recovered in milk is about 50%.)

It is interesting to note from Fig. 2 that for the assumed milk and feed prices, gross energetic efficiency must exceed 14% in order to make any profit at all; also that *per cow,* large cows bring in a larger profit than small; but per unit *live weight* small cows bring in a larger profit than large cows. This is evident from the fact, previously explained, that at a given energetic efficiency, a large cow produces more milk than a small and therefore more profit; but per unit body weight, a small cow tends to produce more milk than a large even if the energetic efficiency is the same in both.

Figure 2 shows that unlike per cow or per unit body weight, profit per unit milk (FCM) is represented by a single curve, i. e., it is a function of efficiency alone, and tends to be independent of live weight for the same reason that efficiency tends to be independent of live weight. The ratio of profit per unit milk to energetic efficiency, is then, nearly the same for all live weights.* The independence of profit per unit FCM and body weight is shown in a direct manner in Fig. 3, and in the bottom segment of Fig. 1.

*Ratios of profit to energetic efficiency of cows represented in Table 2, Research Bulletin 222 is practically independent of live weight as shown below:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Body Weight, lbs. | 700 — | 800 — | 900 — | 1000 — | 1100 — | 1200 — | 1300 — | 1400 — |
| Ratio profit per unit FCM to energetic efficiency | 0.344 | 0.341 | 0.328 | 0.347 | 0.338 | 0.349 | 0.332 | 0.351 |

In the above example FCM is in terms of 1000 pounds per year.

The ratio of profit per unit milk, $\frac{P}{FCM}$, to energetic efficiency, $E_g$, is obtained from equation (4) in the Appendix. Dividing (4) by $E_g$ gives,

$$\frac{P/FCM}{E_g} = \frac{c_1}{E_g} - \frac{c_2 k}{E^2_g}$$

Assuming a milk price of $2.00 per 100 pounds FCM and a feed cost of $1.50 per 100 pounds TDN eliminates variations due to market conditions. The equation is multiplied by 365 and $\frac{1000}{365}$ converting to profit units of dollars per year per 1000 pounds FCM per year. The resulting equation is

$$\frac{P/FCM}{E_g} = \frac{20}{E_g} - \frac{281}{E^2_g}.$$

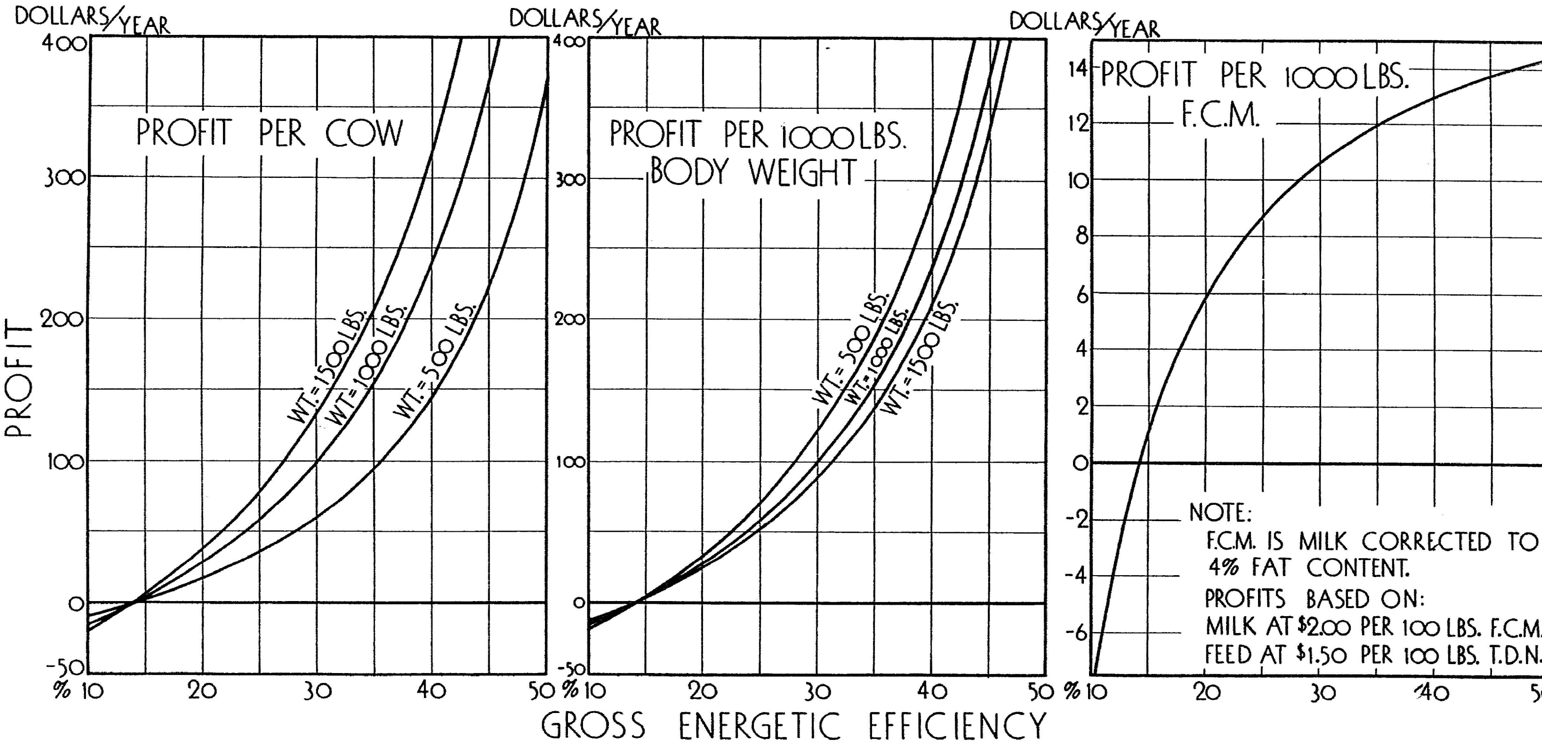



Fig. 2.—Influence of gross energetic efficiency on profit per cow, per unit live weight, and per unit milk production. These curves were computed from equations (13), (15), and (17) of the Appendix.

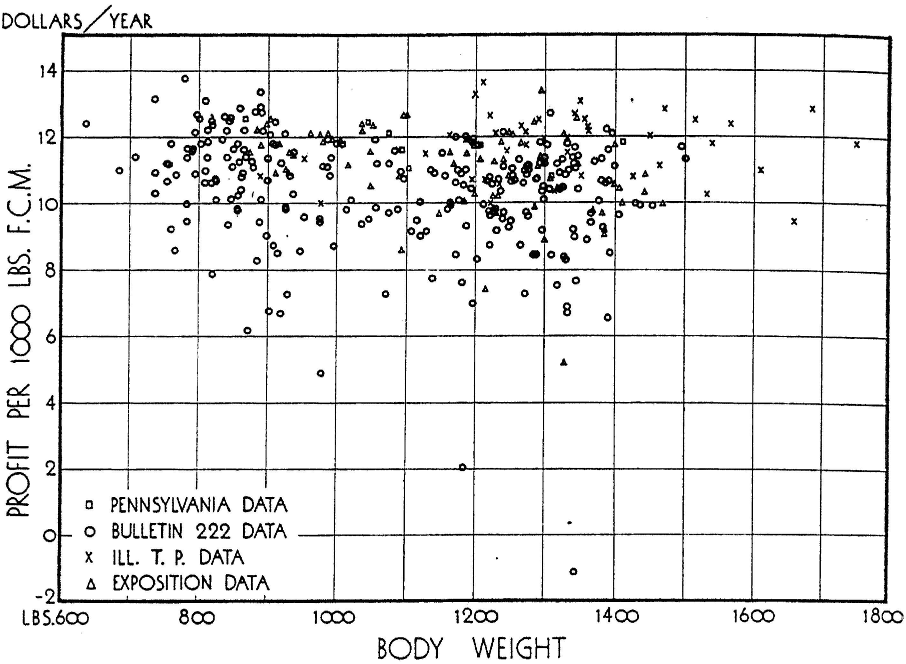



Fig. 3.—Profit per unit milk (1000 pounds FCM) is nearly the same for large and small cows; plotted from data listed in the appendix. It is assumed that milk sells at $2.00 per 100 pounds FCM and feed costs $1.50 per 100 pounds TDN.

**6. Influence of Live Weight of Cow on Profit:** The preceding discussion made it clear that if other conditions remain the same, profit per cow increases with increasing size; profit per 1000 pounds live weight of cow decreases with increasing size; profit per 1000 pounds milk (FCM) production is practically independent of size.

In the above discussion "profit" was defined by the difference between money received for milk and money expended for feed. Expenses other than cost of feed were ignored. This section lists some of the other expenses in relation to the influence of size of cow on profit.

a. *Cost of milking*: Cost of milking per cow is nearly the same for small and large as shown in Fig. 4; since a large cow produces, on the average, more milk than a small, the cost of milking, *per unit milk,* is less for a large than small.

b. *Cost of managing and housing*: Housing and managing costs per cow are nearly the same for large and small; since a large cow produces, on the average, more milk than a small, the housing and managing cost *per unit milk* produced is less for a large than small.

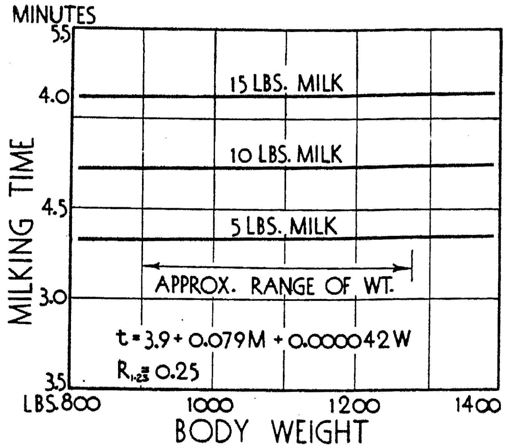



Fig. 4.—Time required to milk cows of different body weights at 5, 10, and 15-pound milking levels. The equation constants on the chart (t, time taken to milk; M, production per milking; W, body weight) indicate that the time required to milk a cow is practically independent of live weight. This chart represents 1289 timed milkings done by milking machine. (From unpublished data by A. C. Ragsdale).

c. *Taxes*: Taxes are paid on a per cow and not size basis; since a large cow produces, on the average, more milk than a small, the tax *per unit milk* is less for a large than small.

d. *Investment*: The market price per cow is in some cases nearly the same for a large and small; when such is the case, then since a large cow produces, on the average, more milk than a small, the investment cost *per unit milk* is less for a large than small. This is not an important item. More important is the investment on buildings and equipment which is roughly the same for large and small cows on a *per cow* basis, and therefore greater for a small cow on a per unit milk basis.

e. *Market demands*: Where milk is sold by volume regardless of fat percentage, as is the case of many market milks, then, if the energetic efficiencies are the same, the profit per unit milk will be greatest when the milk has least fat. Since large cows tend to produce a greater volume of milk of lower fat content than small, the milk profits *per cow* and *per unit milk* are likely to be larger for large cows.

When milk is sold for its solids-not-fat (as for fat-poor cheese), cows producing relatively large quantities of relatively fat-poor milk (usually large cows) may be more profitable *per unit milk and per cow* than cows producing relatively small quantities of relatively fat-rich milk (usually small cows). The opposite may be true when milk is sold for its fat (as for butter making). It is generally known that while milk from large Holsteins tends to be more economical for cheese making, milk from small Jerseys tends to be more economical for butter making. One reason for the more economic production of butter from small cow's milk, was pointed out by Whetham and Hammond. Milk from small cows has larger fat globules, which therefore separate out more easily from the milk; with the result that: (1) milk from smaller cows has a better cream line in market milk; (2) fat churns more completely, so that under home churning conditions a pound of milk fat from small cows yields more butter than from large cows.

"It requires, at one extreme with Friesian milk, 1.160 lbs of fat to make 1 pound of butter, and at the other extreme with Jersey milk only 1.011 pounds of fat to make 1 pound of butter."* Does this mean that the utilization of the butter fat for butter making is about 25% greater for Jersey than Friesian milk? (1.260 — 1.011 = .249 or about 25%).

f. *Limitation of market for milk or supply of feed*: If the dairyman has to produce a *given, constant, amount of milk,* should he produce it from large or small cows? Would large or small cows producing the given amount of milk bring the larger profit? If the gross energetic efficiency of milk production is the same, and if overhead expenses (labor, management, housing, taxes, environment) are left out of consideration, then the profit for the given amount of milk will be the same when the milk is produced by large or small cows as indicated by the bottom segment in Fig. 1†, and also by Figs. 2 and 3.

If the dairyman has a *given limited amount of feed* for milk production, should he use it for feeding large or small cows? Would

*J. Dairy Res. *6*, 320, 1935. Incidentally, the following figures cited from Whetham and Hammond on the amount of fat required to make a pound of butter from different cows will appear incredible to American dairymen who usually make one pound of butter from 0.80 pounds of butterfat.

| Breed | Friesian (Holstein) | Red Poll | Shorthorn | Blue Albion | South Devon | Ayrshire | Devon | Guernsey | Kerry | Dexter | Jersey |
|---|---|---|---|---|---|---|---|---|---|---|---|
| "Weight of fat in the milk required to make 1 lb. of butter" | 1.260 | 1.213 | 1.213 | 1.209 | 1.167 | 1.148 | 1.124 | 1.102 | 1.090 | 1.061 | 1.011 |

†The profit in this case is simply the difference between FCM produced times price, $C_1$, per pound FCM, and TDN consumed times price, $C_2$, per pound TDN; or in equation form

$$\text{Profit} = C_1\text{FCM} - C_2\text{TDN}$$

The *dollar* efficiency may be expressed:

$$\text{Dollar efficiency} = \frac{C_1\text{FCM}}{C_2\text{TDN}} = C\frac{k_1\text{FCM}}{k_2\text{TDN}} = C \times \text{energetic efficiency},$$ where $C_1$ and $C_2$ are the factors for converting FCM and TDN to dollar units and $k_1$ and $k_2$ are the factors for converting FCM and TDN to energy units. In accordance with the assumptions of this case TDN is the only *variable* in the formulas for dollar efficiency and profit. Then the smaller the TDN, and hence the greater the efficiency, the greater is the profit. In this case the most efficient is the most profitable, regardless of size or number of cows.

large or small cows produce more milk from the given amount of feed? The answer to this question is identical with that to the preceding question where milk production was the constant factor. If the gross energetic efficiency of milk production is the small in large and small cows, and if overhead expenses (labor, management, housing, taxes, etc.) are left out of consideration, then the return for the given feed will be the same when fed to large or to small cows, as indicated by the bottom segment in Fig. 1, and also by Figs. 2 and 3.

If, however, overhead expenses (labor, management, housing, taxes, investment, etc.) are deducted from the milk return, and if the gross energetic efficiency of milk production is the same in large and small cows, then profit per unit milk (FCM) from large cows is likely to be greater than from small; because, as previously pointed out, costs of labor, management, bookkeeping, housing, investment, taxes, etc. are likely to be less *per unit milk* produced by large than by small cows. This is illustrated by the following example:

Each of two herds is producing 1000 pounds of milk per day. One herd consists of 900-pound cows the other of 1400-pound cows. The energetic efficiency of milk production is the same in both cases, namely, 30%.

| | 900 lb. Cows | 1400 lb. Cows |
|---|---|---|
| No. of cows required to produce 1000 lbs. FCM per day at an energetic efficiency of 30% | 42 | 30 |
| TDN required | 625 lbs./day | 625 lbs./day |
| Approximate time for milking | 13.6 hrs. | 10.0 hrs. |
| Housing, records, taxes, etc. | $42 x | $30 x |

(x = 10c per cow per day)

| Cost for 900 lb. Herd = | | Cost for 1400 lb. Herd = | |
|---|---|---|---|
| feed | $9.37 | feed | $9.37 |
| labor | 2.72 | labor | $2.00 |
| rcds. etc. | 4.20 | rcds. | 3.00 |
| | 16.29 | | 14.37 |

Return from milk = $20 per day.

Profit on the small cows = $3.71 per day; on the large cows = $5.63 per day. It cost 13% more to produce the 1000 pounds FCM by the small than large cows. The profit was computed on the assumption that milk sells for $2.00 per 100 pounds FCM; feed costs $1.50 per 100 pounds TDN; labor, 20c per hour; housing, records, taxes, etc. 10c per day.

g. *Tendency for selective breeding for small cows of high efficiency and large cows of low efficiency*: The above discussion indicates that if large and small cows produce milk with the same energetic efficiency, and if allowance is made for overhead expenses, large cows return the larger net profit per unit milk and consequently larger profit on the enterprise than small, because cost—energy expenditure—of labor, housing, managing, recording, taxes, etc. is less per unit of milk from large cows than small. This conclusion is true but is complicated by present dairy practice described below.

It was explained in Research Bulletins 222 and 238 that there is no mechanical relation between body size and energetic efficiency; however, larger cows tend to be less efficient energetically than small as inferred from the following situation: Dairymen judge cows by their milk production level and not energetic efficiency. Thus 900 and 1100 pound cows are judged to be equally good if they produce the same amounts of milk (FCM), in spite of the fact that the 900-pound cow is more efficient if she produces as much milk as the 1100-pound cow. The smaller the cow the greater is her struggle for survival in the herd; the smaller the cow the more she must compensate for her small size by high energetic efficiency. In other words, our present system of judging cows by milk production level regardless of size tends to associate in selection high energetic efficiency with small size. It is entirely possible that the relatively superior overhead economies of large cows are on the average compensated by the tendency (for the reason just explained) of small cows to produce milk with higher energetic efficiency; so that *on the average* large and small cows may be equally profitable. This discussion leads to the conclusion that if energetic efficiency and other conditions are the same for small and large cows, large cows produce greater profit per unit FCM than small because the overhead expense (cost of milking, housing, taxes, etc.) per unit milk will be less for large cows. However, energetic efficiency and other conditions are not the same for large and small cows. Large cows tend to produce milk at lower efficiencies on account of selective breeding and for other reasons explained in Research Bulletins 222 and 238. Market and technical conditions are likewise influential. Thus as previously noted butter is produced more economically from small cows and milk from small cows gives a better cream line for market milk. For these and other reasons, applications of the generalization that large cows tend to return a larger net profit per unit milk than small, must be qualified by special considerations.

## III. METHODS FOR ESTIMATING ENERGETIC EFFICIENCY AND MONETARY PROFIT

This section presents a series of alignment or nomograph charts for estimating energetic efficiency and monetary profit on milk production.

The first four charts have similar designs, and may for convenience be described together. The known variables are live weight and milk (FCM) production; the desired unknown variables are respectively: (1) gross energetic efficiency of milk production; (2) profit per cow;

(3) profit per 1000 pounds live weight; (4) profit per 1000 pounds milk (FCM) production. The charts are composed of three axes so spaced and graduated that a straight line drawn through the points representing live weight and FCM production on the live weight and FCM axes, intersects the third, energetic efficiency or profit axes.

It is only necessary to describe the technique of using one of these charts, such as the gross energetic efficiency chart; the use of the other charts will then be clear without further explanation.

1. **Gross Energetic Efficiency:** Gross energetic efficiency is the ratio of milk energy produced to digestible feed energy consumed

TABLE 1.—TO EQUALIZE ENERGY IN MILK, CONVERT MILK TO GIVEN FAT PERCENTAGE TO "4 PER CENT MILK" BY MEANS OF TABLE 1.*

| A<br>Per Cent Fat in Milk | B<br>Factor for Converting to 4% Milk | A<br>Per Cent Fat in Milk | B<br>Factor for Converting to 4% Milk |
|---|---|---|---|
| 2.5 | 0.775 | 5.0 | 1.150 |
| 2.6 | 0.790 | 5.1 | 1.165 |
| 2.7 | 0.805 | 5.2 | 1.180 |
| 2.8 | 0.820 | 5.3 | 1.195 |
| 2.9 | 0.835 | 5.4 | 1.210 |
| 3.0 | 0.850 | 5.5 | 1.225 |
| 3.1 | 0.865 | 5.6 | 1.240 |
| 3.2 | 0.880 | 5.7 | 1.255 |
| 3.3 | 0.895 | 5.8 | 1.270 |
| 3.4 | 0.910 | 5.9 | 1.285 |
| 3.5 | 0.925 | 6.0 | 1.300 |
| 3.6 | 0.940 | 6.1 | 1.315 |
| 3.7 | 0.955 | 6.2 | 1.330 |
| 3.8 | 0.970 | 6.3 | 1.345 |
| 3.9 | 0.985 | 6.4 | 1.360 |
| 4.0 | 1.000 | 6.5 | 1.375 |
| 4.1 | 1.015 | 6.6 | 1.390 |
| 4.2 | 1.030 | 6.7 | 1.405 |
| 4.3 | 1.045 | 6.8 | 1.420 |
| 4.4 | 1.060 | 6.9 | 1.435 |
| 4.5 | 1.075 | 7.0 | 1.450 |
| 4.6 | 1.090 | 7.1 | 1.465 |
| 4.7 | 1.105 | 7.2 | 1.480 |
| 4.8 | 1.120 | 7.3 | 1.495 |
| 4.9 | 1.135 | 7.4 | 1.510 |

Column A gives fat percentages, column B corresponding conversion factors, which when multiplied by pounds of milk produced, will convert the given milk to 4% milk. Thus if a cow produced 10,000 pounds of 3% milk multiply 10,000 by 0.850 and get the answer 8500 pounds of 4% milk. In other words 10,000 pounds of 3% milk contains the same amount of energy as 8500 pounds of 4% milk.

during production. Details of the method for measuring gross energetic efficiency are described in Missouri Station Bulletin 351. To determine the energetic efficiency of a cow, the first step is to convert the milk of the given fat per cent to 4% milk (FCM) by the method indicated in Table 1* or Fig. 5*. The exact procedure of using Table 1 and Fig. 5 are described in the respective legends.

*Table 1 and Fig. 6 with the accompanying discussions, are taken from Missouri *Station* Bulletin 351. Fig. 5 is taken from Missouri *Research* Bulletin 222.

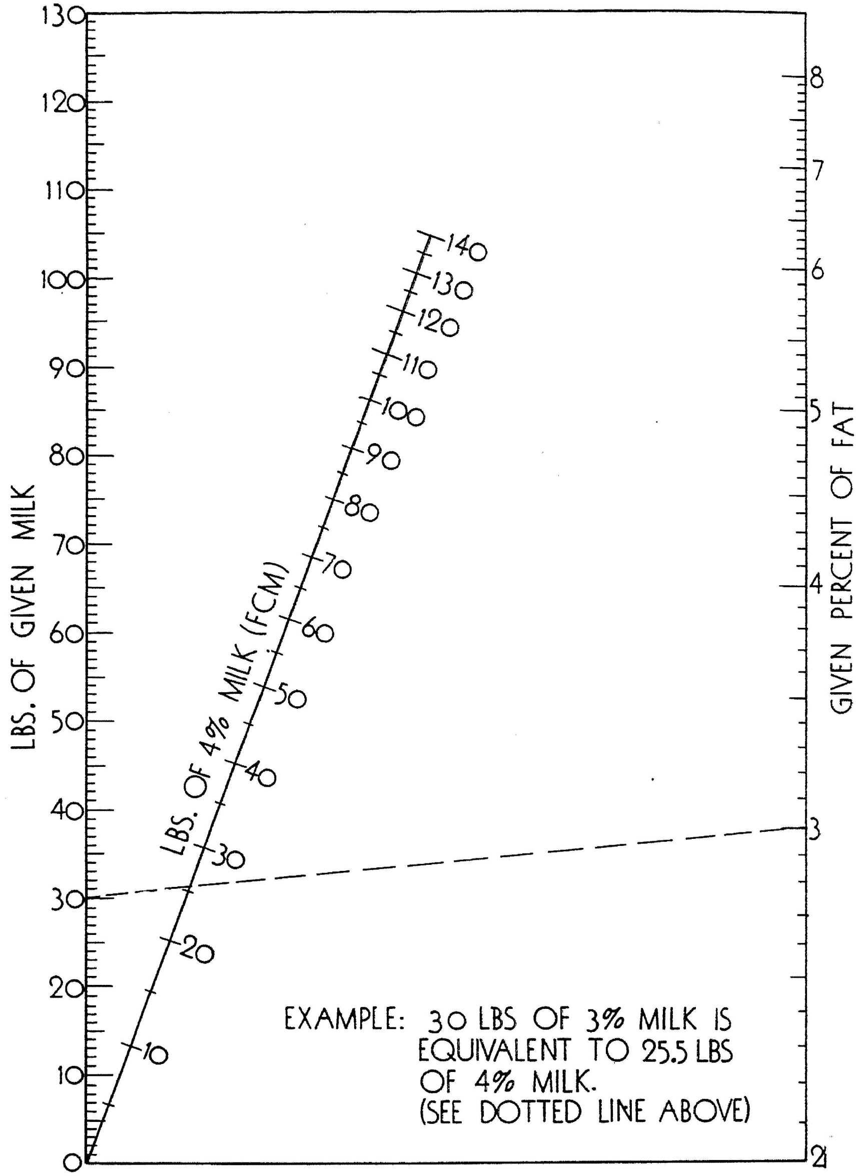



Fig. 5.—Nomograph for converting pounds of milk containing any per cent of fat to milk containing 4 per cent of fat. Thus to convert 30 pounds 3% milk to pounds 4% milk, stretch a string between 30 on the left scale and 3 on the right scale and read the answer (25.5 pounds 4% milk) on the middle scale. This nomograph was constructed from Gaines' well known formula, as was also the conversion table in Missouri Station Bulletin 351.

Knowing live weight and the amount of 4% milk produced, the energetic efficiency of milk production is then estimated from Fig. 6.

Figure 6 has three scales. The left scale shows production in pounds of 4% milk per year and per day; the right scale shows live-weight; and the center scale gives percentage efficiency. To find the efficiency of the 700-pound cow producing (in terms of 4% milk) 8500 pounds per year (an average of 23.3 pounds per day) place a straight edge (or stretch a string) across the chart between points 8500 (or 23.3) on the left (milk) scale and 700 on the right (body weight) scale, as shown by line (1). Line (1) cuts the center (efficiency) scale at 32½, which is the percentage efficiency with which the 700 pound cow produced milk. To find the efficiency of the 1550-pound cow producing 9300 pounds per year (an average of 25.5 pounds per day), place the straight edge across points 9300 (or 25.5) on the left scale and 1550 on the right scale as shown by line (2). The center scale shows that the efficiency is 25 per cent.

It will be observed that the percentage scale in Fig. 6 is divided into three zones: 15 to 25 per cent zone, containing inferior producers; 25 to 35 per cent zone, containing good producers; 35 to 40 per cent zone, containing superior producers. The energetic efficiency of milk production is on the average about 30 per cent for good producing cows, the exact value varying with the milk yield.

It is instructive to recall in this connection the following conclusions listed in the preceding bulletins (Research Bulletins 222 and 238) that: energetic efficiency of milk production is independent of body weight (if other conditions are the same); energetic efficiency (with respect to TDN consumed) of good experiment station cows is of the order of 30%; the energetic efficiencies of cows exhibited at the St. Louis "World's Fair" were 34.3% for Holsteins, 33.6% for Jerseys, 29.6% for Shorthorns, 28% for Brown-Swiss; a group of superior Holstein cows at the Dixon, Illinois, Testing Plant produced milk at an efficiency of 34.3%; the highest gross energetic efficiency encountered in our studies (estimated with the nomograph, Fig. 6) was 47.5% for the 700-pound Jersey champion Stonehurst Patrician's Lily who produced 25,946 pounds FCM for the year.

While the 1700-pound 1936 Holstein champion, Carnation Ormsby Butter King "Daisy," produced 36,476 pounds FCM, that is, 40.6% $(= \frac{36{,}476-25{,}946}{25{,}946} \times 100)$ more FCM than the 700-pound Jersey champion, yet the gross energetic efficiency of the Holstein was estimated to be only 43.5% because the Holstein weighed 143% $(= \frac{1700-700}{700} \times 100)$ more than the Jersey, so that the Holstein expended

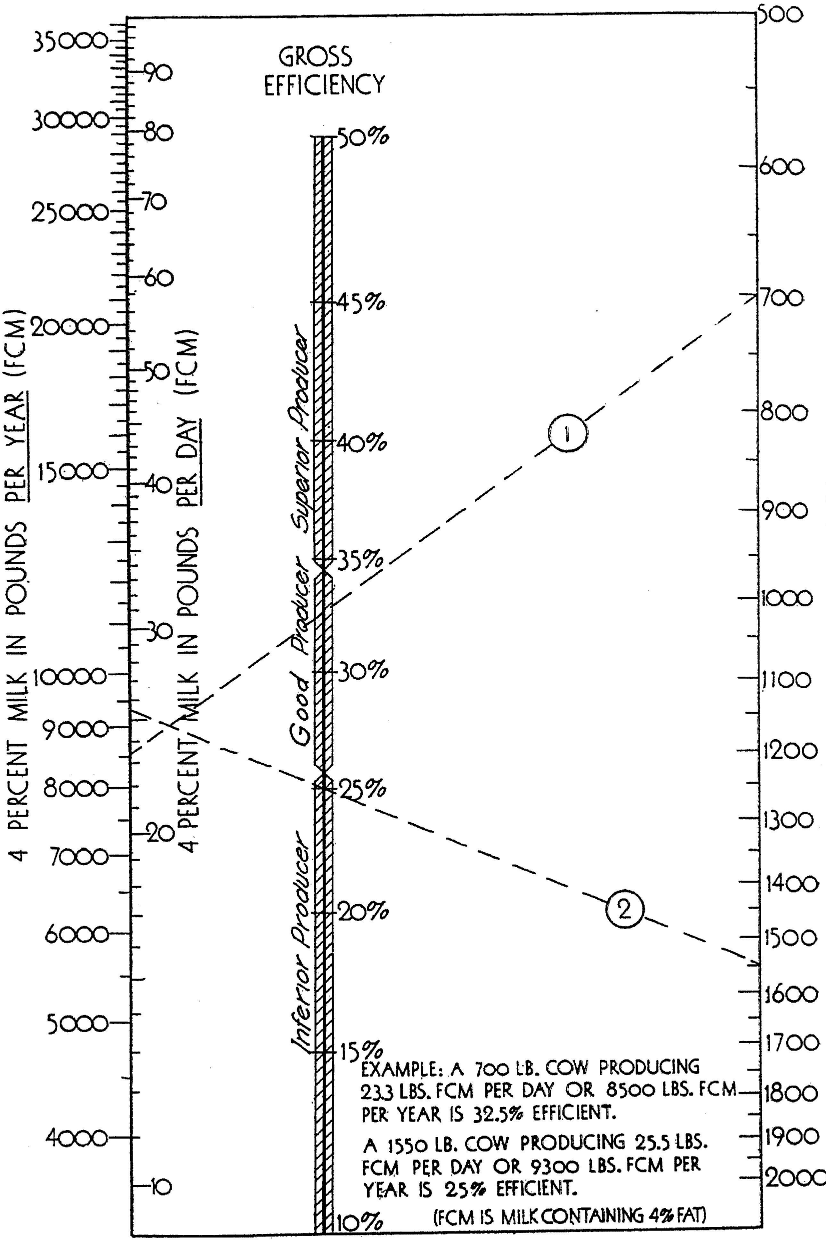



Fig. 6.—Nomograph for estimating gross energetic efficiency with which cows produce milk. First, the pounds of the given milk must be converted to pounds "FCM" (Gaines) that is, to milk containing 4% fat. The efficiency of milk production is then read from this chart. Thus if it is desired to find the efficiency of a 700-pound cow producing 8500 pounds yearly or on the average 23.3 pounds daily from FCM (4% milk), place a straight edge between 23.3 on the left (or milk) scale, and 700 on the right (or body-weight) scale, and read the answer 32.5 on the center (or efficiency) scale.

perhaps 90% more energy for maintenance than the smaller Jersey. The contrast between estimated production and efficiencies of the very small Jersey and the very large Holstein illustrates the fact that milk production level is by itself not a good measure of dairy value; that live-weight must be related with milk production in such manner as to give energetic efficiency in order to have a good estimate of a cow's dairy value. Fig. 6 makes it simple to estimate energetic efficiency, and progressive breeders of dairy cattle should select breeding animals primarily on the basis of the efficiency of individual cows by the aid of Fig. 6 rather than by milk production level. (See Missouri Station Bulletin 351.)

**2. Profit per Cow at a Given Milk and Feed Price:** As in the case of energetic efficiency, the first step is to convert milk of the given fat percentage to FCM by the method indicated in Table 1 or Fig. 5. Profit per cow is then estimated from Fig. 7 in exactly the same manner as was energetic efficiency from Fig. 6. Fig. 7 was prepared on the basis of the partition equation $TDN=0.305\ FCM+0.053\ M^{0.73}+2.1\Delta M$ described in Missouri Research Bulletins 222 and 238, and on the assumption that the price of FCM is $2.00 per 100 pounds and of TDN is $.150 per 100 pounds.

It is again instructive to compare the 1700-pound Holstein champion Daisy with the 700-pound Jersey champion Lily. From Fig. 7 the line for Daisy connecting 1700 on the live weight scale, and 36,500, on the milk scale passes through 500 on the profit scale; that is, if Daisy's milk sold at $2.00 per 100 pounds FCM, and if feed cost $1.50 per 100 pounds TDN, the milk return above feed cost would be $500 for the year. The line for Lily connecting 700 on the live-weight scale and 25,946 on the milk scale, gives for Lily a return of $367 for the year above the assumed feed cost.

The fact that 1700-pound Daisy made a larger monetary return for the year than 700-pound Lily does not, as previously explained, mean that Daisy produced milk with a higher energetic efficiency than Lily. In fact the reverse is true: the energetic efficiency of Daisy is only 43.5%, as compared to that of Lily which is 47.5%. While the profit per cow was less for Lily than for Daisy, the energetic efficiency was less for Daisy than Lily. Since the profit *per pound* of milk is nearly the same in large and small cows therefore the cow which produces more milk pounds naturally makes the greater profit. This conclusion is obvious, and serves as another illustration of the fact that energetic efficiency and profitableness *per cow* may differ depending on live weight, as illustrated in Figs. 1 and 2.

**3. Profit per Unit Live Weight of Cow at Given Milk and Feed Prices:** The procedure for estimating profit per unit live

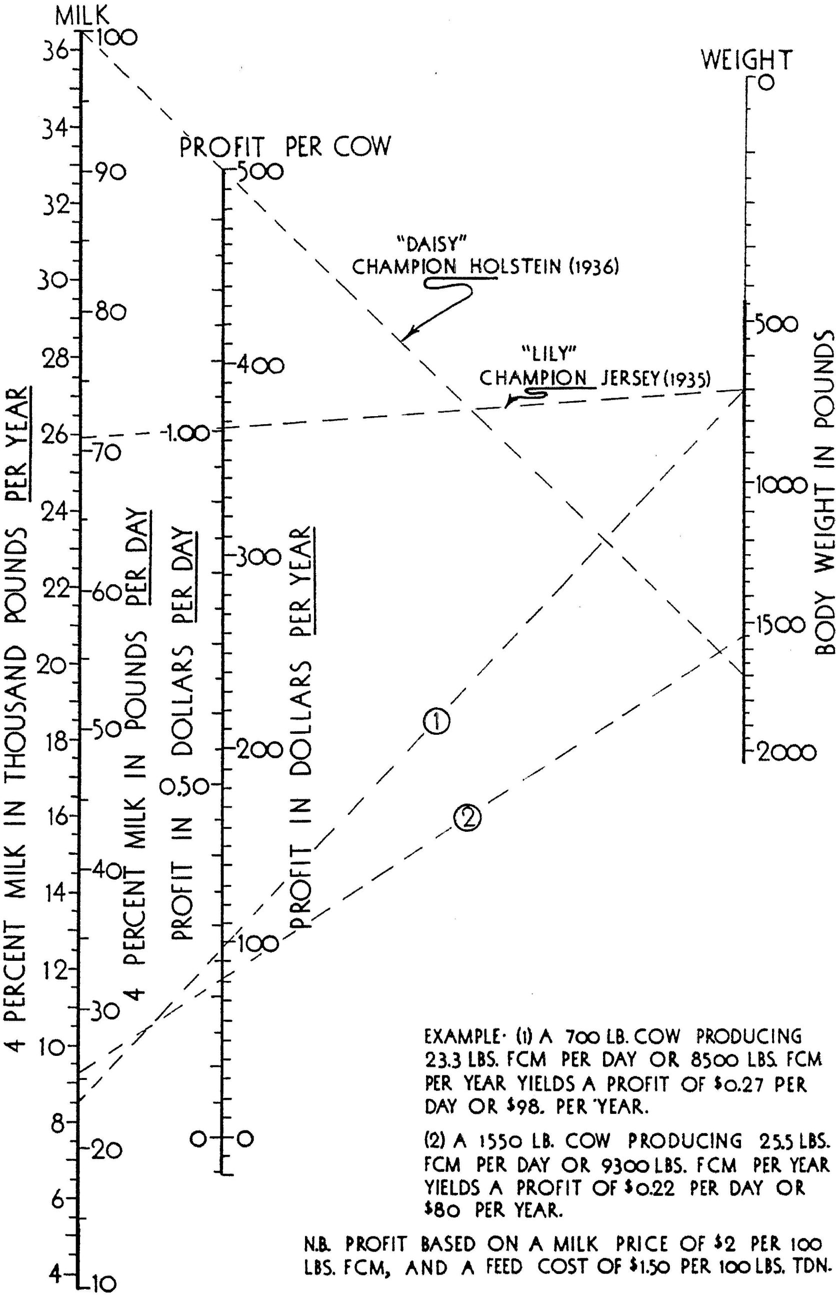



Fig. 7.—Nomograph for estimating *profit per cow* from body weight and milk production (FCM) assuming that price of milk is $2.00 per 100 pounds FCM and of feed $1.50 per 100 pounds TDN. Broken lines (1) and (2) indicate the solutions of examples (1) and (2) on the chart. The profits for Daisy and Lily, discussed in the text, are also indicated by broken lines, as labelled. This nomograph is derived from equation (13) of the Appendix.

weight from Fig. 8 is exactly the same as for estimating profit per cow from Fig. 7.

The profit line for the 1700-pound Holstein champion, Daisy, and for the 700-pound champion, Lily, are also shown in Fig. 8. From Fig. 7, the profit *per cow* is $500 per year for Daisy, and $367 for Lily; but from Fig. 8, the profit *per 1000 pounds live weight* is only $292 for Daisy and $522 for Lily. The profit *per cow* is $\frac{500-367}{367} \times 100 = 36\%$ greater for Daisy than for Lily, but profit *per 1000 pounds live weight* is $\frac{522-292}{292} \times 100 = 79\%$ greater for Lily than for Daisy. Which of the two ways of estimating profit is the better for indicating dairy qualities of a cow, profit per cow, or profit per unit live weight? Is Lily or Daisy the better dairy animal? We believe that neither profit per cow nor profit per unit live weight is a good measure of dairy quality, but energetic efficiency as estimated from Fig. 6; or profit per unit milk production which tends to be proportional to energetic efficiency.

**4. Profit per Unit Milk (FCM) Production at Given Milk and Feed Prices:** Figure 9 presents a nomograph for estimating profit per 1000 pounds FCM. Here again we compare the relative performances of 1700-pound Daisy with 700-pound Lily. It is estimated on a *per cow* basis that Daisy returned 36% greater profit than Lily; on a *per 1000-pound body weight* basis, Lily returned 79% greater profit than Daisy; on a *per 1000-pound milk (FCM)* basis, Lily returned $\frac{1415-1365}{1365} \times 100 = 4\%$ greater profit than Daisy. Lily's gross energetic efficiency is $\frac{47.5-43.5}{43.5} \times 100 = 9\%$ higher than Daisy's. It is therefore obvious that profit per unit milk production is a better index of a cow's gross energetic efficiency than either profit per cow or profit per 1000 pounds live weight. To summarize: on a *per cow* basis Daisy brought in a 36% greater profit than Lily; on a *per 1000-pound live weight* basis, Lily brought a 79% greater profit than Daisy; on a *per 1000-pound milk (FCM)* basis, Lily brought in a 4% greater profit than Daisy; the gross energetic efficiency of Lily is 9% greater than Daisy's. All figures are estimates made on the basis of the nomograph presented in Figs. 6 to 9. Is large Daisy or small Lily the better *dairy* cow? Is large Daisy or small Lily the better *commercial* cow? Under what conditions is one *commercially* superior to the other? Under what conditions is one *genetically* or *biologically* superior to the other?

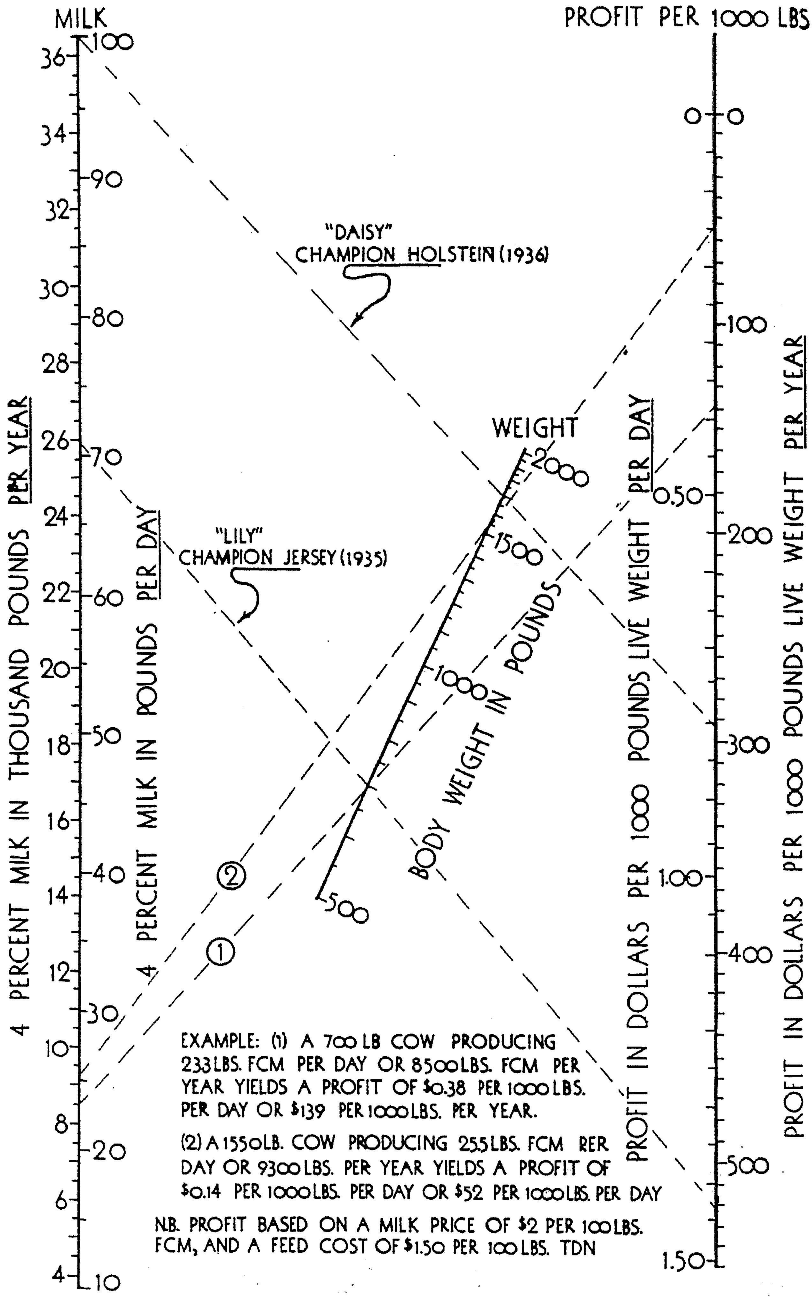



Fig. 8.—Nomograph for estimating *profit per 1000-pounds live weight.* See text and legend for Fig. 7 for method of reading chart. This chart is derived from equation (15) of the Appendix.

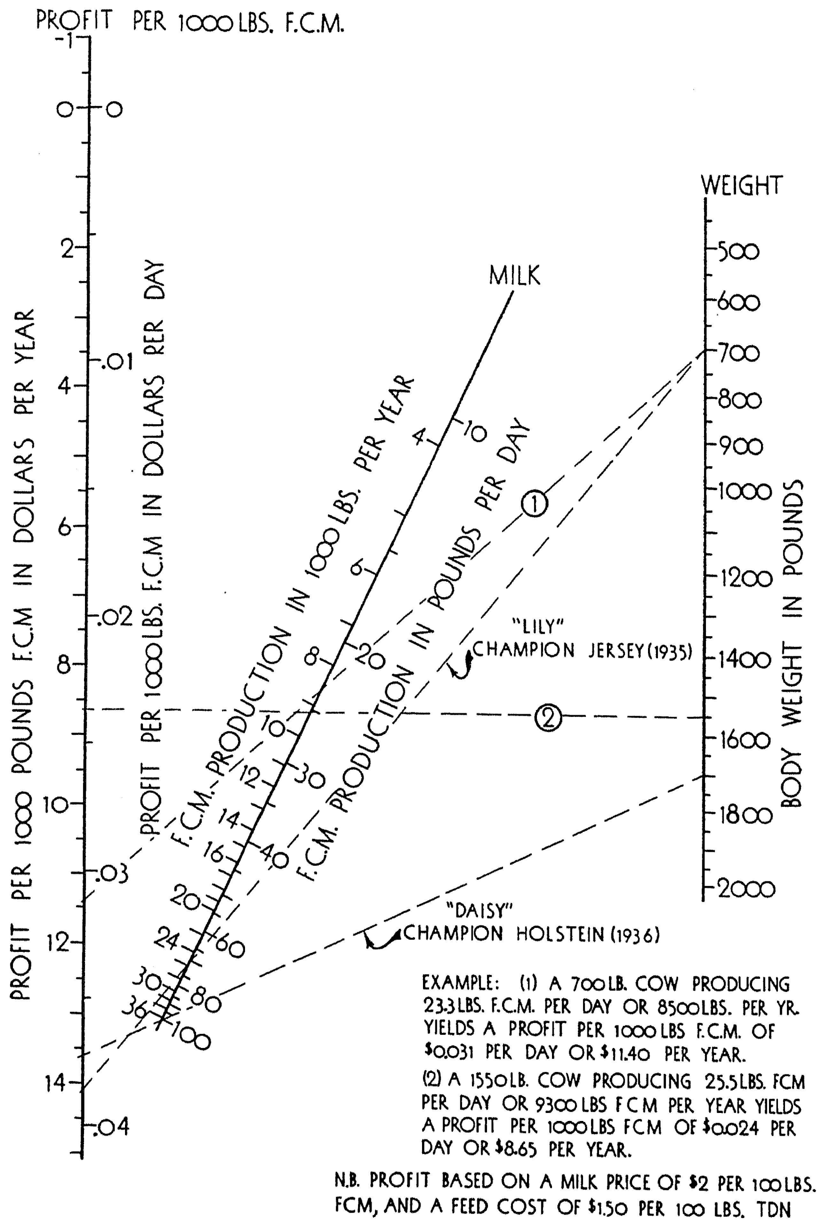
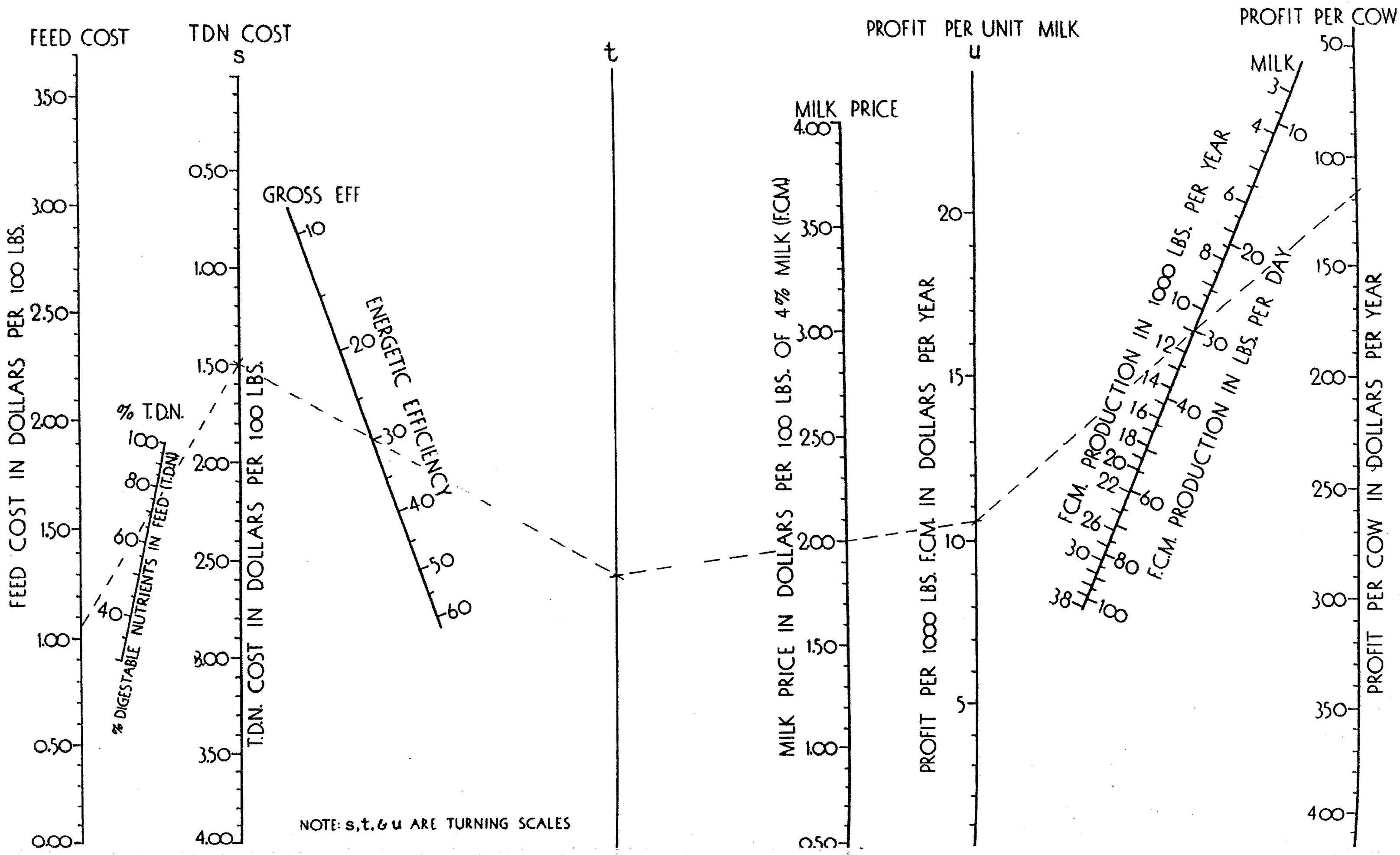


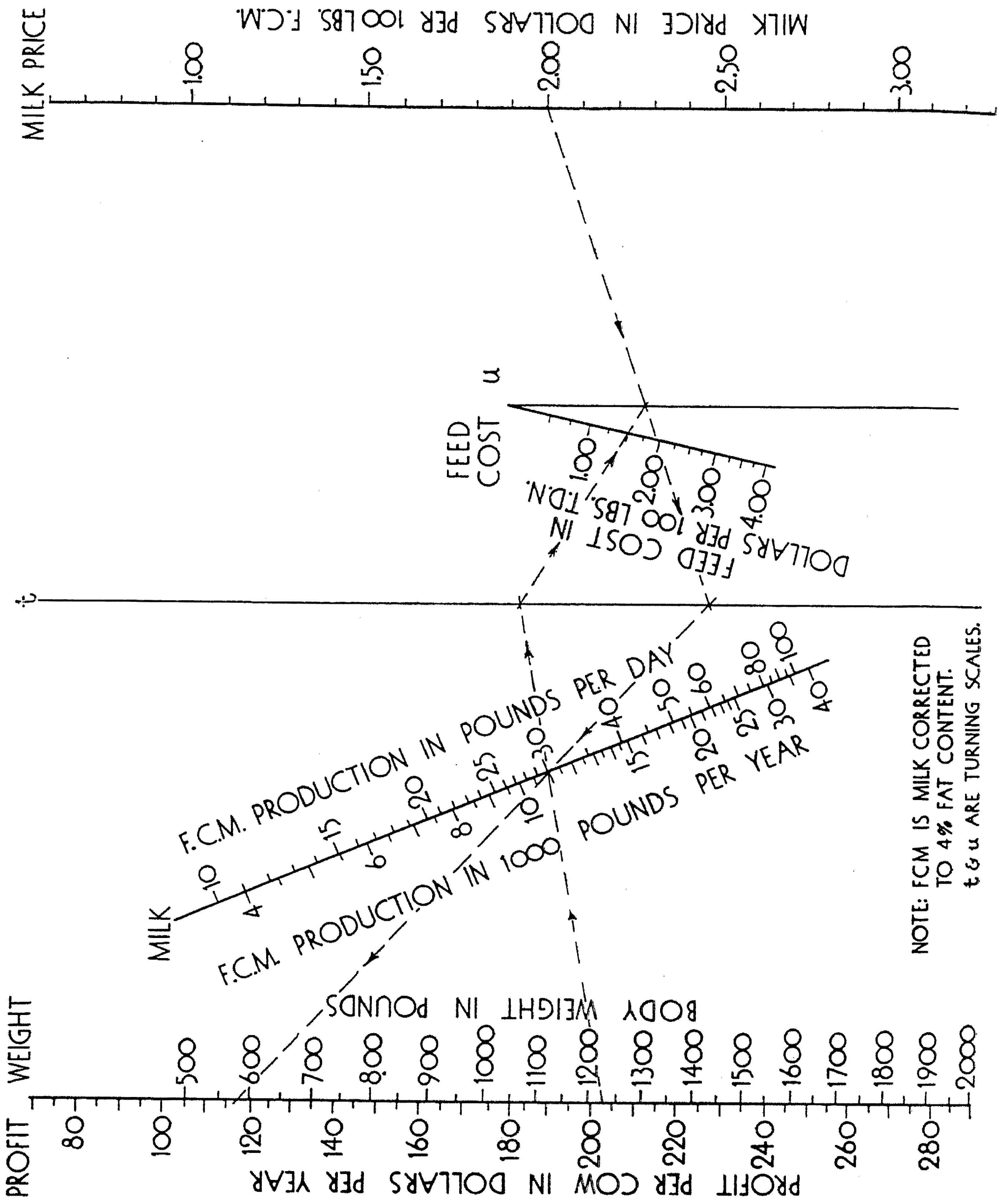

Fig. 9.—Nomograph for estimating *profit per 1000-pound milk (FCM)*. As in Figs. 7 and 8, solutions of two examples are indicated, and a comparison is shown between the profits of the Holstein and Jersey champions. This nomograph is derived from equation (17) of the Appendix.



FEED COST
FEED COST IN DOLLARS PER 100 LBS.
% T.D.N.
% DIGESTABLE NUTRIENTS IN FEED (T.D.N)
TDN COST
s
T.D.N. COST IN DOLLARS PER 100 LBS.
GROSS EFF
ENERGETIC EFFICIENCY
t
NOTE: s, t, & u ARE TURNING SCALES
MILK PRICE
MILK PRICE IN DOLLARS PER 100 LBS. OF 4% MILK (F.C.M.)
PROFIT PER UNIT MILK
u
PROFIT PER 1000 LBS. F.C.M. IN DOLLARS PER YEAR
MILK
F.C.M. PRODUCTION IN 1000 LBS. PER YEAR
F.C.M. PRODUCTION IN LBS. PER DAY
PROFIT PER COW
PROFIT PER COW IN DOLLARS PER YEAR

EXAMPLE: Feeding a ration, costing $1.05 per 100 lbs. and yielding 70% T. D. N., to a cow producing 30 lbs. F. C. M. per day at a gross ficiency of 30% and selling her milk at $2.00 per 100 lbs. F. C. M., returns a profit of $117 per year or $10.50 per 1000 lbs. F. C. M.

Fig. 10.—Nomograph for estimating profit per 1000 pounds FCM and per cow from milk (FCM) and feed prices, and from energetic efficiency. The oken line indicates the solution of the example on the chart. Begin on the left side with feed cost ($1.05 per 100 pounds feed); connect with percentage DN in feed (70% TDN); extrapolate to the TDN cost axis which gives cost per unit TDN ($1.50 per 100 pounds TDN). Connect $1.50 on the TDN cost cis with gross energetic efficiency (30%); extrapolate to line t, connect thepoint on line t with milk price (assumed to be $2.00 per 100 pounds FCM) and trapolate to the u line whwich gives profit per unit milk ($10.50 profit per 1000 pounds FCM). Connect point on u line with milk (FCM) line (cow assumed produce 30 pounds FCM per day) and extrapolate to profit line, indicating a profit of $117 per year, the answer. The derivation of this nomograph is given the Appendix, equations 4 - 7.


MILK PRICE
MILK PRICE IN DOLLARS PER 100 LBS. F.C.M.
FEED COST
u
FEED COST IN DOLLARS PER 100 LBS. T.D.N.
t
MILK
F.C.M. PRODUCTION IN POUNDS PER DAY
F.C.M. PRODUCTION IN 1000 POUNDS PER YEAR
PROFIT WEIGHT
BODY WEIGHT IN POUNDS
PROFIT PER COW IN DOLLARS PER YEAR
NOTE: FCM IS MILK CORRECTED TO 4% FAT CONTENT.
t & u ARE TURNING SCALES.

**EXAMPLE: A 1225 lb. cow producing 30 lbs. FCM per day is fed a ration costing $1.50 per 100 lbs. TDN. selling her milk at $2.00 per 100 lbs. F.C.M., returns a profit of $117 per year.**

Fig. 11.—Another method for estimating profit per cow. The solution of the example on the chart is indicated by the directed broken lines. See text for details. See Appendix equations 11 and 18-21 for the derivation of the chart.

**5. Profits per Cow at Variable Milk and Feed Prices:** Figures 7 to 9 were prepared on the assumption that the price of milk was $2.00 per 100 pounds FCM, and of feed, $1.50 per 100 pounds TDN. Fig. 10 on the other hand indicates profit per cow and profit per 1000 pounds milk (FCM) for any price of feed and milk. The broken line in Fig. 10 indicates the solution of the example given at the bottom of the chart. The example gives cost of feed ($1.05 per 100 pounds); percentage TDN in feed (70%); energetic efficiency of the cow (30%); price of milk ($2.00 per 100 pounds FCM); milk production (30 pounds FCM per day). What is the profit per year (profit in the sense of difference between income for milk and expense for feed)? The broken line in Fig. 10 indicates the method of solving this problem. Connect $1.05 (price of feed) on feed-cost axis with 70 (% TDN in feed) on % TDN axis and extrapolate to the TDN cost axis. Connect $1.50 on the TDN-cost axis with 30%, on the energetic efficiency axis and extrapolate to line t; connect the point on t with $2.00, on the milk-price axis and extrapolate to line u where it intersects $10.50, which is profit per 1000 pounds FCM. Connect point $10.50 with 30 on the milk production axis, and extrapolate to the profit per cow axis where it intersects at $117, which is the profit per cow per year.

Figure 11 presents another method of estimating profit per cow per year. The directed broken curves in Fig. 11 indicate the method of solving the example given on the chart. Connect 1225 (weight of cow) on the body weight axis with 30 (FCM yield) on the the FCM-yield axis and extrapolate to line t. Connect this point with 1.50 (cost per 100 pounds TDN) on the feed cost axis and extrapolate to line u. Connect 2.00 (price per 100 pounds FCM) on the milk-price axis with the point on line u intersected by the line extrapolated from the feed cost axis, and continue to line t. Connect this point on line t with 30 (FCM production of cow) on the FCM production line, and extrapolate to the profit axis, where it cuts point 117, profit in dollars per year, which is the answer to the problem given on the chart.

## IV. SUMMARY AND CONCLUSIONS

Two preceding bulletins (Missouri Research Bulletins 222 and 238) analyzed milk production data from the standpoint of energetic efficiency with special reference to the influence of live weight thereon; the present bulletin is an extension of the analysis to include monetary profit.

The present bulletin on monetary profit analyzes the following questions; Should profit be computed per cow, per unit live weight (such as per 1000-pounds live weight), per unit milk produced (such as per 1000 pounds FCM), or per unit feed consumed? What is the influence of live weight on each of these varieties of profit? What is the influence of gross energetic efficiency on each of these varieties of profit? What is the influence of overhead expenses and related factors on each of these varieties of profit (such factors as: cost of milking, housing, managing, taxes, investment, market demands, limitation of market for milk, limitation of supply of feed, tendency for selective breeding for small cows of high efficiency and large cows of low efficiency)?

The analysis led to the following conclusions: 1. Profit on a per cow basis increases with increasing size of cow. 2. Profit on a per body weight basis (as per 1000 pounds live weight) decreases with increasing size. 3. Profit on a per unit milk basis (as per 1000 pounds FCM) tends to be independent of size and almost directly proportional to gross energetic efficiency of milk production. 4. Profit on a per unit feed consumption basis tends to be independent of size and almost directly proportional to gross energetic efficiency.

If gross energetic efficiency is the same, large cows are more profitable than small because large cows produce more milk, and because there is less expense in producing a unit milk from a large than a small cow. (Milking, housing, taxes, etc. are nearly the same for a large as for a small cow, and therefore less per unit milk for the large cow than the small.) But as matter of fact gross energetic efficiency under present dairy practice tends to be higher in small cows than in large not for physiological reasons, but because of a tendency for selective breeding of small cows of high energetic efficiency and large cows of small efficiency as previously explained.

Gross energetic efficiency of milk production, that is ratio of energy in milk produced to energy in digestible nutrients consumed, is unquestionably the only proper index of physiologic dairy value. Using this index it was shown that the production of 25,946 pounds FCM by the 700-pound Jersey champion Lily is a considerably superior performance to the production of 36,476 pounds FCM by the 1700-pound Holstein champion Daisy.

Alignment charts (nomographs) are presented for estimating gross energetic efficiency and each of the several kinds of profit (per cow, per unit body weight, per unit milk production). However, "profit" was defined as return for milk above cost of feed. The costs of milking, housing, taxes, etc. were not considered in the preparation of the nomographs.

The important lesson of this bulletin is that milk production by itself is a poor index of either commercial or physiologic value of a cow. Gross energetic efficiency, which takes account of both milk production and live weight, is the best measure of physiological dairy value; profit for the entire dairy enterprise (not necessarily per cow or per unit body weight, or per unit milk) is the best measure of commercial value.

# V. APPENDIX

## 1. Algebraic Solution of the Profit Equations and Their Application to Alignment Charts

The following list of symbols will be used throughout:

- P = profit per cow in dollars per day
- FCM = milk corrected to 4% fat content in pounds per day
- TDN = total digestible nutrient of feed in pounds per day
- M = body weight of cow in pounds
- $E_g$ = gross energetic efficiency in per cent
- $E_m$ = monetary efficiency in per cent
- k = proportionality constant (ratio of energy in 1 pound of FCM to energy in 1 pound of TDN)
- $c_1$ = milk price per pound FCM ($N_1 = 100\ c_1$)
- $c_2$ = feed cost per pound TDN ($N_2 = 100\ c_2$)

In this treatment only milk and feed are considered. The simplest statement of profit is:

$$P = c_1\,(FCM) - c_2\,(TDN). \qquad (1)$$

by definition

$$E_g = k\,\frac{FCM}{TDN}\,\%, \qquad (2a)$$

or

$$TDN = k\,\frac{FCM}{E_g}\,. \qquad (2b)$$

Substituting (2b) in (1) we get

$$P = c_1\,(FCM) - c_2k\,\frac{FCM}{E_g}, \qquad (3a)$$

or

$$P = FCM\left\{c_1 - \frac{c_2k}{E_g}\right\}. \qquad (3b)$$

Dividing both sides of (3a) or (3b) by FCM gives the profit per unit milk, which may be written

$$\frac{P}{FCM} = c_1 - \frac{c_2k}{E_g}. \qquad (4)$$

Letting $\frac{P}{FCM} = Y$, $c_1 = Z$, and $\frac{c_2k}{E_g} = X$, equation (4) may be written

$$Y = Z - X \qquad \text{or} \qquad X + Y = Z \qquad (5)$$

which is the general equation for the parallel line alignment chart. (see Appendix 2, section A)

In the above relation X and Y are complex functions which may be solved by alignment charts by making further substitutions. Letting

P = A and FCM = B, the relation is

$$Y = \frac{P}{FCM} = \frac{A}{B}, \qquad \text{or} \qquad B \cdot Y = A \cdot \qquad (6)$$

Equation (6) is the general equation of a "Z" chart which may be laid out with Y on one of the parallel axes. (see Appendix 2, section B)

By substituting $c_2k$ = D and $E_g$ = E, X becomes:

$$X = \frac{c_2k}{E_g} = \frac{D}{E} \qquad \text{or} \qquad E \cdot X = D \cdot \qquad (7)$$

Equation (7) is also the general form of a "Z" chart in which X is on one of the parallel axes.

Equations (5), (6), and (7), representing three alignment charts, are combined into a single diagram (Fig. 10) as indicated in Fig. 12.

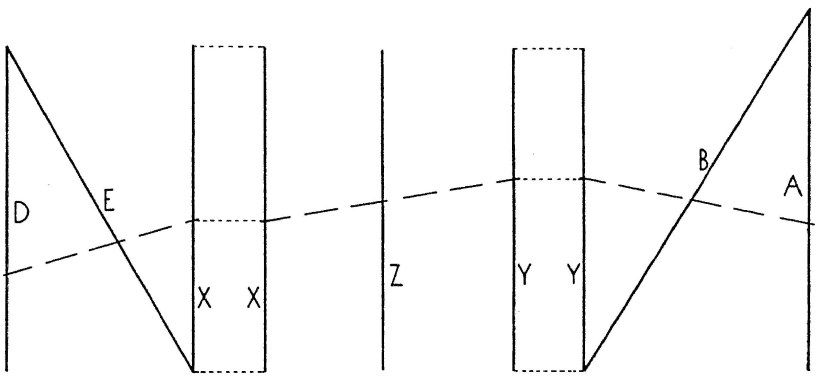



Fig. 12.—Schematic diagram indicating the component nomograms of Fig. 10. Axes connected by dotted lines are identical in the complete chart.

The scales are so arranged that axes connected by dotted lines are identical and coincident in the final chart.

In case the feed cost is in terms of pounds of *feed* then the cost of TDN will be $c_2 = \frac{\text{cost of feed}}{\%\ \text{TDN in feed}} \times 100$. For convenience in computing this cost another "Z" chart is included in Fig. 10 such that the axis D (= $c_2k$) is computed from cost of feed and % TDN.

Summarizing, equation (4) is stated in terms of general functions to illustrate how the general equations of the alignment charts (given in the following section) are applied to a specific problem in the form of Fig. 10.

To study the effect of body weight on the profit it is necessary to refer to the partition equation discussed previously (Bulletins 222 and 238),

$$TDN = .305\ FCM + .053\ M^{0.73}.$$

Substituting this equation in (1):

$$P = c_1\ FCM - c_2\ (.305\ (FCM) + .053\ M^{0.73}), \qquad (8)$$

collecting terms

$$P = (c_1 - .305\ c_2)\ FCM - .053\ c_2\ M^{0.73}. \qquad (9)$$

By dividing both sides of equation (9) by the body weight the relation is the profit per unit weight:

$$\frac{P}{M} = (c_1 - .305\ c_2)\ \frac{FCM}{M} = .053\ c_2\ \frac{M^{0.73}}{M}. \qquad (10)$$

To find the profit per unit milk, divide both sides of equation (9) by FCM giving

$$\frac{P}{FCM} = (c_1 - .305\ c_2) - \frac{.053\ c_2\ M^{0.73}}{FCM}. \qquad (11)$$

To show the effect of weight on profit, other things remaining the same, assume the prices fixed at $1.50 per 100 pounds TDN and $2.00 per 100 pounds FCM. Substituting these prices in equation (9) the profit per day becomes

$$P = (.0200 - .305 \times .0150)\ FCM - .053 \times .0150\ M^{0.73}. \qquad (12)$$

Multiplying by 365 gives the profit in dollars per year:

$$P_y = 5.63\ FCM - 0.290\ M^{0.73}. \qquad (13)$$

Similarly equation (10) becomes,

$$\frac{P_y}{M} = 5.63\ \frac{FCM}{M} - 0.290\ M^{-.27}. \qquad (14)$$

Multiplying by 1000 gives the profit per 1000 pounds live weight in dollars per year,

$$\text{Profit per 1000 pounds wt.} = P_m = 5630\ \frac{FCM}{M} - 290\ M^{-.27}. \qquad (15)$$

Also, equation (11) becomes,

$$\frac{P_y}{FCM} = 5.63 - 0.290\ \frac{M^{0.73}}{FCM}. \qquad (16)$$

Multiplying by $\frac{1000}{365} = 2.74$ gives the profit per 1000 pounds annual milk production in dollars per year,

$$\text{Profit per 1000 pounds FCM} = P_F = 15.42 - .795\ \frac{M^{0.73}}{FCM}. \qquad (17)$$

The conversion of equations (13), (15), and (17) into forms corresponding to general equations of alignment charts may be accomplished in single steps. In the case of (13), let $P_y = X$, $5.63\ FCM = Z$, and $.290\ M^{0.73} = Y$, then equation (13) becomes,

$$X = Z - Y \qquad \text{or} \qquad X + Y = Z$$

which is the equation for a parallel line chart. In equation (15) let $- P_m = X$, $5630\ FCM = Y$, $\frac{1}{M} = Z_1$ and $290\ M^{-.27} = Z_2$. Equation (15) becomes,

$$- X = Y \cdot Z_1 - Z_2$$

or by rearranging terms and changing signs

$$X + Y \cdot Z_1 = Z_2$$

which is the general equation of the straight and curved line chart. (see Appendix 2, section C.)

Equation (17) may be rearranged to read,

$$-(P_F - 15.42) = -.795 \frac{M^{0.73}}{FCM}$$

Letting $-(P_F - 15.42) = Y$, $FCM = X$, and $.795\ M^{0.73} = Z$, equation (17) becomes,

$$-Y = -\frac{Z}{X} \qquad \text{or} \qquad X \cdot Y = Z$$

which is the equation for a "Z" type chart.

Thus, by referring to the partition equation and assuming prices fixed, it is possible to devise simple, three axis charts which show the relative profitableness of different weights and productions. Although it is realized that the actual values may vary widely, due to market conditions, nevertheless, the most profitable cow under one set of prices will be the most profitable under any other, where the milk prices are based on FCM equivalents.

To devise a chart to estimate the profitableness of a cow which will include prices as variables as well as body weight and milk production, it is necessary to refer back to equation (11). Letting $P = X$, $FCM = Y$, and $[c_1 - .305\ c_2 - .053 c_2 \frac{M^{0.73}}{FCM}] = Z$ equation (11) becomes,

$$\frac{X}{Y} = Z \qquad \text{or} \qquad X = Y\,Z \tag{18}$$

which may be solved by a "Z" type chart. It is obvious, though, that the function, Z, is very complex, requiring several steps to complete. The value of Z may be rearranged, becoming,

$$Z = c_1 - c_2\,(.305 + .053 \frac{M^{0.73}}{FCM}). \tag{19}$$

$$\text{or } Z = c_1 - c_2 D.$$

Letting $.053\ M^{0.73} = A$ and $FCM = B$ the terms inside the parenthesis, denoted by D, may be solved by a "Z" type chart. The relation now reduces to

$$Z = c_1 - c_2 D \qquad \text{or} \qquad Z = c_1 - E \tag{20}$$

where E may also be solved by a "Z" type chart, since $E = c_2 D$.

Equation (20) is recognized as the general form of the parallel line chart when it is rearranged to read

$$Z + E = c_1. \tag{21}$$

Having thus determined the value of Z by a series of three "Z" type charts and one parallel line chart, the ultimate solution follows from equation (18). The combination of these charts into a single diagram (Fig. 11), although straightforward in principle, is rather complex. The diagram below indicates this combination.

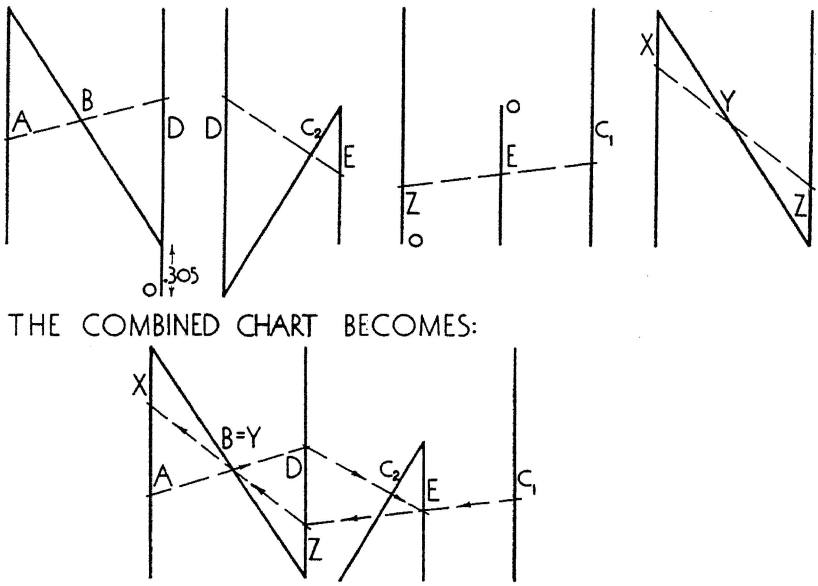



Fig. 13.—Schematic diagram indicating the component nomograms of Fig. 11. The bottom half shows the combination as used for Fig. 11.

The letters refer to the functions as assumed in the discussion above. Since the values of D, E, and Z are of no importance to the reader the axes upon which they appear become turning lines and no scale is plotted.

## 2. Geometric Proof of Alignment Chart Equations

To justify the use of the various types of alignment charts it is necessary to prove, by the methods of plane geometry, that these charts give the solutions to general equations. The proofs are included here merely for the convenience of the reader in checking the work or in preparing similar charts.

### A. *Parallel Line Chart*

Figure 14 illustrates the general case of the parallel line chart consisting of three parallel axes (AX, BY, and CZ) cut by a transversal (UV). The variables x, y, and z are measured, as indicated, from A, B, and C. Drawing DV and EW parallel to AB forms two similar triangles giving the following relation:

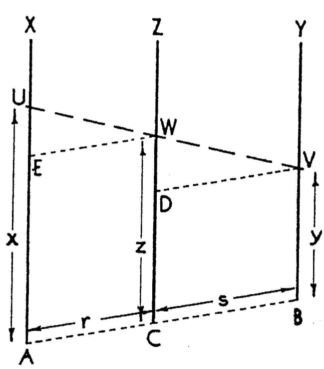



Fig. 14.

$$UE : WD = EW : DV \qquad (22)$$

let EW = r and DV = s
then substituting equivalents

$$(x - z) : (z - y) = r : s \qquad (23)$$

or by solving the proportion and separating variables

$$xs + yr = z\,(r + s). \qquad (24)$$

Dividing by r · s,

$$\frac{x}{r} + \frac{y}{s} = z\,\frac{r + s}{rs}. \qquad (25)$$

If X, Y, and Z represent functions of three variables and these functions are plotted on the axes such that

$$X = \frac{x}{r}; \qquad Y = \frac{y}{s}; \qquad \text{and } Z = z\,\frac{r + s}{rs},$$

then $X + Y = Z$ is solved by this chart. (26)

B. *"N" or "Z" Type Chart*

Figure 15 shows the "N" or "Z" type chart in which the axes AX and BY are parallel with the third axis AZ at any angle. These three axes are cut by a transversal at U, V, and W. The variables x, y, and z are measured from the intersections of the axes (A and B), as indicated. By similar triangles:

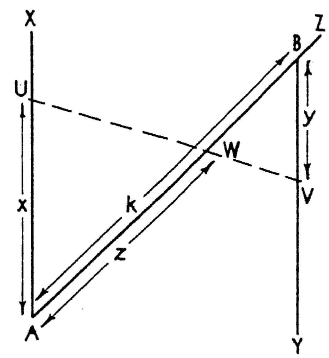



Fig. 15.

$$AU : BV = AW : BW. \qquad (27)$$

Let AB = k, then by substituting identities:

$$x : y = z : (k - z) \qquad (28)$$

solving

$$x\,(k - z) = yz \qquad (29)$$

or

$$x = y \cdot \frac{z}{k - z}. \qquad (30)$$

If X, Y, and Z represent functions of three variables and these functions are plotted on the axes such that

$$x = \theta_1 X \text{ and } y = \theta_2 Y$$

where $\theta_1$ and $\theta_2$ are proportionality constants, which add to the convenience in plotting X and Y (i. e., they may be plotted to any scale).

By substitution

$$\theta_1 X = \theta_2 Y \frac{z}{k - z} \tag{31}$$

or

$$X = Y \frac{\theta_2 z}{\theta_1 (k - z)}.$$

Letting

$$Z = \frac{\theta_2 z}{\theta_1 (k - z)} \quad \text{or} \quad z = \frac{k \theta_1 Z}{\theta_1 Z + \theta_2} \tag{32}$$

then

$$X = Y \cdot Z. \tag{33}$$

This, then, is the simplified general equation of the "Z" type chart.

C. *Straight and Curved Line Chart*

Figure 16 illustrates the straight and curved line chart in which axes AX and BY are parallel straight lines and CZ is any curved intermediate axis. These axes are cut by the transversal UV. Referring to the figure: DW is parallel to AX and BY. EW and FV are parallel to AB. Let AU = x, BV = y, AB = k, EW = AD = s, and DW = r. By similar triangles

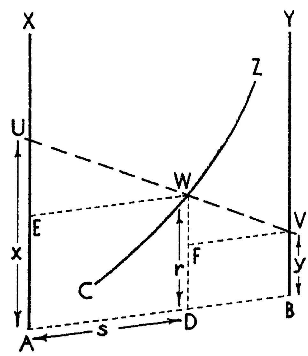



Fig. 16.

$$UE : WF = EW : FV. \tag{34}$$

or by substituting the identities above,

$$(x - r) : (r - y) = s : (k - s). \tag{35}$$

Solving,

$$(k - s)(x - r) = s (r - y) \tag{36}$$

or

$$x (k - s) + ys = rs + r (k - s) \tag{37}$$

and

$$x (k - s) + ys = kr. \tag{38}$$

Dividing by $(k - s)$,

$$x + y \frac{s}{k - s} = \frac{kr}{k - s}. \tag{39}$$

Then if $x = \theta_1 X$, $y = \theta_2 Y$, $\frac{s}{k - s} = \frac{\theta_1}{\theta_2} Z$, and $\frac{kr}{k - s} = \theta_1 Z_2$

($\theta_1$ and $\theta_2$ are proportionality constants depending upon the scales used) and substituting identities,

$$\theta_1 X + \theta_2 Y \frac{\theta_1}{\theta_2} Z_1 = \theta_1 Z_2 \tag{40}$$

$$\text{or} \quad X + YZ_1 = Z_2. \tag{41}$$

Thus, this type chart solves an equation involving functions of X and Y and two functions of Z ($Z_1$ and $Z_2$).

These three proofs then lead to the solutions of any equation involving three variables where the functions of these three variables may be written in the forms:

$$(1)\quad X + Y = Z$$
$$(2)\quad X = YZ$$
$$(3)\quad X + YZ_1 = Z_2.$$

### 3. Slide-Rule for Estimating Efficiency and Profitableness of Milk Production

Instead of using page nomographs for estimating efficiency and profit of milk production, it is possible to make such estimates from a more compact slide rule as illustrated in Fig. 17a.

A brief outline will serve to illustrate the method of designing the slide-rule scales. The equation giving energetic efficiency of milk production is:

$$E = \frac{18.74}{0.305 + \dfrac{0.0535M^{0.73}}{FCM}}.$$

(see page 22 Res. Bul. 222)

Taking the reciprocal

$$\frac{1}{E} = \frac{.305}{18.74} + \frac{0.0535M^{0.73}}{18.74\ FCM}$$

or

$$\left(\frac{1}{E} - \frac{.305}{18.74}\right) = \frac{0.0535M^{0.73}}{18.74\ FCM}.$$

By taking logarithms of both sides the linear relation is obtained,

$$\log\left(\frac{1}{E} - .01628\right) = \log 0.0535M^{0.73} - \log 18.74\ FCM.$$

This may be written

$$\Theta_3 = \Theta_1 - \Theta_2$$

by substituting term for term as indicated. In this form the equation yields to solution by the circular rule.

Values of $\Theta_1$ were computed for each value of M desired on the nomogram; similarly $\Theta_2$ and $\Theta_3$ values were computed for FCM and E respectively. In the particular lay-out shown, a unit of logarithm equals 259°. For convenience in plotting the scales the initial value of $\Theta$ was taken as zero by subtracting it from succeeding values. The scales were plotted with arbitrary origins for weight and FCM. However, the efficiency scale must be placed so that the value of 10% is displaced 97° clockwise from the value of 4000 pounds FCM per year. With the efficiency scale in such a position the index pointer on the top card (see efficiency slide of Fig. 17a) will be diametrically opposite 1000 pounds body weight.

Table 2 gives the angular displacement in degrees for scale values as plotted in Fig. 17.

Knowing the energetic efficiency of milk production, and feed and milk prices, the profit per unit milk may be gotten indirectly by a second circular slide rule, which may be printed on the reverse side of the first one. This slide rule is shown in Fig. 17b, and was prepared as follows:

$$\text{Energetic Efficiency} = E = 18.74 \frac{FCM}{TDN}.$$

$$\text{Cost of feed} = c_2\, TDN$$

$$\text{Return on milk} = c_1\, FCM.$$

If the milk return equals the feed cost then

$$c_2\, TDN = c_1\, FCM,$$

or

$$\frac{c_2}{c_1} = \frac{FCM}{TDN}.$$

But

$$\frac{FCM}{TDN} = \frac{E}{18.74},$$

therefore,

$$\frac{c_2}{c_1} = \frac{E}{18.74}.$$

Taking logarithms of both sides,

$$\log c_2 - \log c_1 = \log \frac{E}{18.74}.$$

Let

$$\theta_1 - \theta_2 = \theta_3$$

be the corresponding slide-rule equation and proceed as before.

Suppose the question to be, "If I feed a cow a ration costing $N_2$ dollars per 100 pounds of TDN and she produces milk with an energetic efficiency of E%, what price must I get per 100 pounds FCM for her milk to pay for the feed?" The equation and the slide-rule answer this question. Thus, the difference between the price you are getting for milk and the price indicated by the slide-rule is the profit per 100 pounds FCM (from the standpoint of feed and milk only).

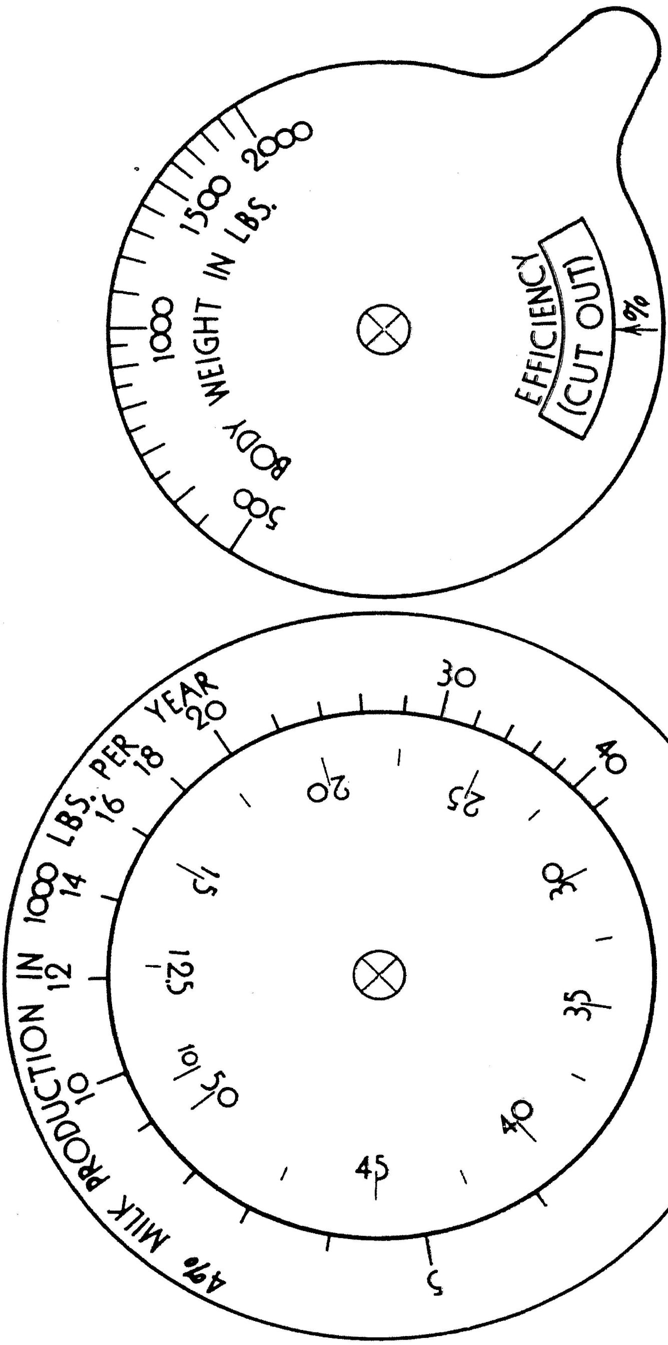
Table 3 gives the angular displacement in degrees for scale values as plotted in Fig. 17b.

TABLE 2.—ANGULAR DISPLACEMENTS IN DEGREES FOR SCALE VALUES

| Body Weight in Pounds M | Angle in degrees $\Theta_1$ | 4% Milk production in 1000 lbs./year FCM | Angle in degrees $\Theta_2$ | Gross efficiency E % | Angle in degrees $\Theta_3$ |
|---|---|---|---|---|---|
| 500 | 0 | 4 | 0 | 10 | 0 |
| 550 | 9 | 5 | 25 | 12.5 | 31 |
| 600 | 16 | 6 | 45 | 15 | 57 |
| 650 | 22 | 7 | 63 | 17.5 | 81 |
| 700 | 28 | 8 | 78 | 20 | 103 |
| 750 | 34 | 9 | 91 | 22.5 | 122 |
| 800 | 39 | 10 | 103 | 25 | 142 |
| 850 | 44 | 12 | 124 | 27.5 | 160 |
| 900 | 48 | 14 | 141 | 30 | 179 |
| 950 | 53 | 16 | 156 | 32.5 | 197 |
| 1000 | 57 | 18 | 169 | 35 | 216 |
| 1100 | 65 | 20 | 181 | 37.5 | 235 |
| 1200 | 73 | 22 | 192 | 40 | 255 |
| 1300 | 79 | 24 | 202 | 42.5 | 275 |
| 1400 | 85 | 26 | 210 | 45 | 298 |
| 1500 | 91 | 28 | 219 | 47.5 | 322 |
| 1600 | 96 | 30 | 227 | 50 | 351 |
| 1700 | 100 | 32 | 234 | | |
| 1800 | 105 | 34 | 241 | | |
| 1900 | 110 | 36 | 247 | | |
| 2000 | 114 | 38 | 253 | | |
| | | 40 | 259 | | |
| | | 42 | 265 | | |

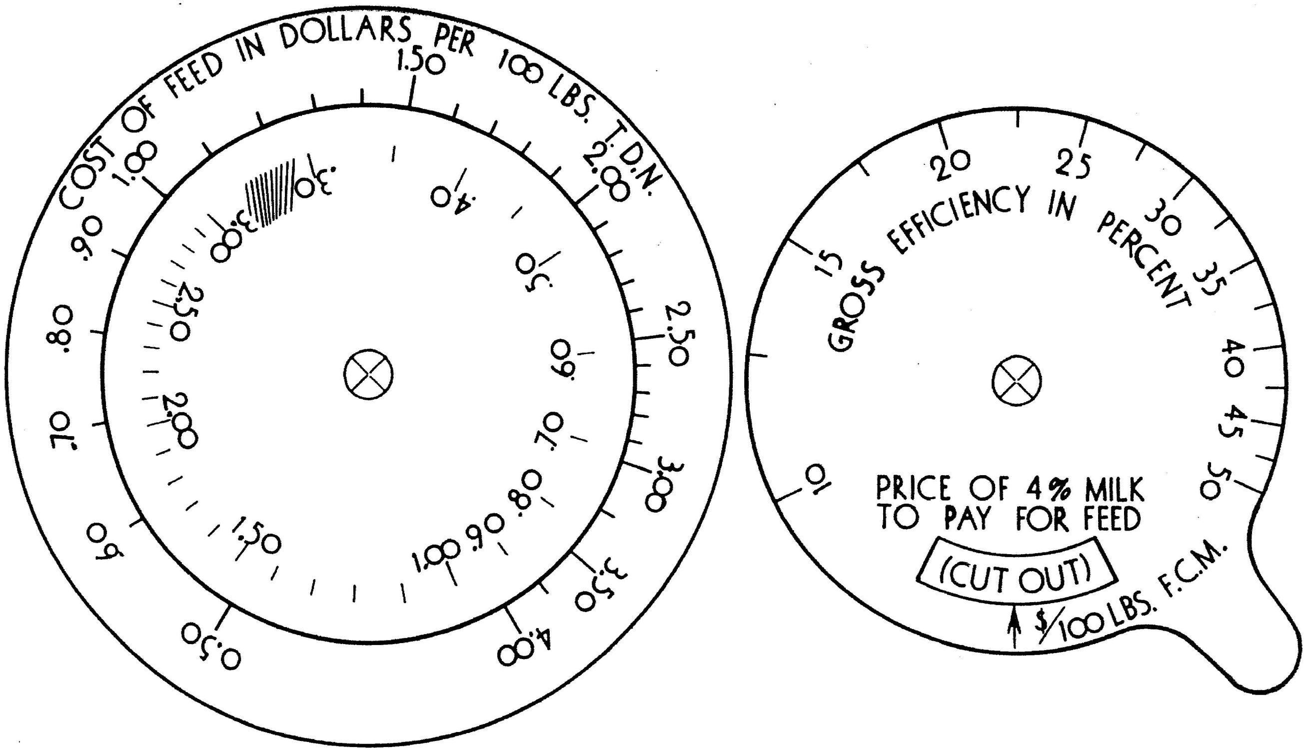
TABLE 3.—ANGULAR DISPLACEMENT IN DEGREES FOR SCALE VALUES

| Prices in dollars per 100 lbs. $N_1$ or $N_2$ | Angle in degrees $\Theta$) | Gross efficiency % | Angle in degrees $\Theta_3$ |
|---|---|---|---|
| 0.30 | −73 | 10 | 0 |
| 0.35 | −51 | 12.5 | 32 |
| 0.40 | −32 | 15 | 58 |
| 0.45 | −15 | 17.5 | 80 |
| 0.50 | 0 | 20 | 99 |
| 0.60 | 26 | 22.5 | 116 |
| 0.70 | 48 | 25 | 131 |
| 0.80 | 68 | 27.5 | 145 |
| 0.90 | 84 | 30 | 157 |
| 1.00 | 99 | 32.5 | 169 |
| 1.10 | 113 | 35 | 180 |
| 1.20 | 126 | 37.5 | 189 |
| 1.30 | 137 | 40 | 198 |
| 1.40 | 148 | 42.5 | 207 |
| 1.50 | 158 | 45 | 215 |
| 1.60 | 167 | 47.5 | 223 |
| 1.70 | 176 | 50 | 231 |
| 1.80 | 184 | | |
| 1.90 | 191 | | |
| 2.00 | 199 | | |
| 2.10 | 206 | | |
| 2.20 | 212 | | |
| 2.30 | 219 | | |
| 2.40 | 225 | | |
| 2.50 | 231 | | |
| 2.60 | 236 | | |
| 2.70 | 242 | | |
| 2.80 | 247 | | |
| 2.90 | 252 | | |
| 3.00 | 257 | | |
| 3.25 | 268 | | |
| 3.50 | 279 | | |
| 3.75 | 289 | | |
| 4.00 | 298 | | |




A — SLIDE RULE FOR ESTIMATING EFFICIENCY OF MILK PRODUCTION

Fig. 17A.




B— SLIDE RULE FOR ESTIMATING MINIMUM MILK PRICE

Fig. 17B.

## 4. Individual Records on Which this Bulletin and Missouri Research Bulletin 238 Are Based

### I. LOUISIANA PURCHASE "WORLD'S FAIR" DATA

| Average Live wt. lbs. | Feed TDN lbs./day | Milk FCM lbs./day | Live wt. gain lbs./day | Gross Energetic Effic. | | Profit per year, dollars* | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Not corrected for wt. gain | Corrected for wt. gain | per cow | per 1000 lbs. live wt. | per 1000 lbs. FCM |
| **Brown Swiss, 5 cows** | | | | | | | | |
| 1181 | 23.97 | 36.14 | .550 | 28.3 | 29.0 | 132 | 112 | 10.05 |
| 1248 | 28.31 | 46.46 | .617 | 30.8 | 31.6 | 184 | 147 | 10.85 |
| 1367 | 29.16 | 42.58 | .417 | 27.4 | 27.8 | 151 | 110 | 9.73 |
| 1384 | 27.23 | 37.34 | 1.225 | 25.7 | 27.1 | 124 | 90 | 9.07 |
| 1467 | 30.24 | 44.93 | .567 | 27.8 | 28.5 | 162 | 110 | 9.92 |
| **Holsteins, 15 cows** | | | | | | | | |
| 1167 | 25.76 | 43.72 | .967 | 31.7 | 33.3 | 178 | 153 | 11.15 |
| 1225 | 25.51 | 43.54 | .700 | 32.0 | 33.1 | 178 | 145 | 11.20 |
| 1236 | 26.53 | 48.82 | 1.392 | 34.5 | 36.8 | 211 | 171 | 11.84 |
| 1239 | 26.54 | 45.85 | .750 | 32.4 | 33.5 | 189 | 153 | 11.32 |
| 1247 | 27.51 | 52.36 | .567 | 35.7 | 36.6 | 232 | 186 | 12.38 |
| 1252 | 26.59 | 50.11 | .842 | 35.3 | 36.7 | 220 | 176 | 12.03 |
| 1264 | 27.01 | 49.46 | .725 | 34.3 | 35.4 | 213 | 169 | 11.81 |
| 1283 | 26.19 | 51.78 | .717 | 37.1 | 38.3 | 235 | 183 | 12.41 |
| 1286 | 26.04 | 45.50 | .975 | 32.8 | 34.3 | 190 | 148 | 11.42 |
| 1292 | 27.55 | 62.45 | .450 | 42.5 | 43.3 | 305 | 236 | 13.37 |
| 1327 | 26.77 | 48.65 | .967 | 34.1 | 35.6 | 208 | 157 | 11.75 |
| 1343 | 27.14 | 55.15 | .767 | 38.1 | 39.4 | 254 | 189 | 12.63 |
| 1344 | 26.99 | 45.73 | .308 | 31.8 | 32.2 | 186 | 138 | 11.15 |
| 1398 | 26.24 | 47.59 | .992 | 34.0 | 35.6 | 204 | 146 | 11.73 |
| 1438 | 27.08 | 41.50 | 1.225 | 28.7 | 30.4 | 155 | 108 | 10.22 |
| **Jerseys, 25 cows** | | | | | | | | |
| 782 | 23.82 | 41.98 | .458 | 33.0 | 33.8 | 176 | 225 | 11.48 |
| 786 | 22.58 | 42.80 | .758 | 31.4 | 37.0 | 189 | 240 | 12.08 |
| 868 | 23.92 | 42.26 | .842 | 33.1 | 34.6 | 178 | 205 | 11.51 |
| 883 | 25.14 | 47.72 | .633 | 34.2 | 36.7 | 211 | 239 | 12.11 |
| 884 | 24.06 | 43.28 | .358 | 33.7 | 34.3 | 184 | 217 | 11.67 |
| 899 | 26.09 | 50.77 | .683 | 36.5 | 37.6 | 228 | 254 | 12.30 |
| 902 | 25.46 | 50.46 | .425 | 37.2 | 37.9 | 229 | 254 | 12.44 |
| 914 | 25.66 | 42.30 | .733 | 30.9 | 32.0 | 168 | 184 | 10.90 |
| 914 | 26.04 | 47.48 | .292 | 34.2 | 34.6 | 204 | 223 | 11.78 |
| 927 | 22.98 | 38.35 | .483 | 31.3 | 32.1 | 154 | 166 | 11.01 |
| 928 | 24.29 | 39.88 | .658 | 30.8 | 31.8 | 158 | 170 | 10.88 |
| 930 | 23.30 | 41.34 | .425 | 33.2 | 34.0 | 174 | 187 | 11.53 |
| 936 | 23.32 | 41.07 | .558 | 33.0 | 34.0 | 172 | 184 | 11.48 |
| 961 | 24.63 | 46.61 | .742 | 35.5 | 36.8 | 205 | 213 | 12.08 |
| 974 | 24.49 | 46.18 | .542 | 35.3 | 36.3 | 203 | 208 | 12.05 |
| 976 | 26.46 | 48.62 | .525 | 34.4 | 35.3 | 210 | 215 | 11.84 |
| 984 | 25.35 | 47.79 | .617 | 35.3 | 36.4 | 210 | 213 | 12.05 |
| 990 | 25.56 | 47.35 | .675 | 34.7 | 35.8 | 206 | 208 | 11.89 |
| 1002 | 25.80 | 47.56 | .608 | 34.6 | 35.5 | 206 | 206 | 11.86 |
| 1036 | 26.54 | 50.61 | .583 | 35.7 | 36.7 | 224 | 216 | 12.14 |
| 1036 | 27.47 | 54.16 | .642 | 37.0 | 38.0 | 245 | 236 | 12.38 |
| 1046 | 25.28 | 39.94 | .708 | 29.6 | 30.6 | 153 | 146 | 10.49 |
| 1047 | 25.86 | 45.78 | .533 | 33.2 | 34.0 | 193 | 184 | 11.53 |
| 1050 | 25.95 | 50.57 | .642 | 36.5 | 37.6 | 227 | 216 | 12.30 |
| 1090 | 27.27 | 44.85 | .850 | 30.8 | 32.0 | 178 | 163 | 10.88 |
| **Shorthorns, 28 cows** | | | | | | | | |
| 1014 | 19.90 | 33.62 | .775 | 31.7 | 33.2 | 136 | 134 | 11.12 |
| 1093 | 16.10 | 21.07 | 1.167 | 24.5 | 26.8 | 66 | 60 | 8.55 |
| 1094 | 18.86 | 38.53 | .625 | 38.4 | 39.8 | 178 | 163 | 12.66 |
| 1100 | 21.28 | 43.40 | 1.158 | 38.2 | 40.9 | 200 | 182 | 12.66 |
| 1146 | 22.46 | 32.38 | 1.067 | 27.0 | 28.6 | 113 | 99 | 9.59 |
| 1172 | 19.57 | 34.79 | 1.092 | 33.3 | 35.7 | 147 | 125 | 11.56 |
| 1184 | 20.17 | 37.53 | .725 | 34.9 | 36.4 | 164 | 139 | 11.94 |
| 1186 | 20.06 | 35.36 | .942 | 33.0 | 35.0 | 148 | 125 | 11.48 |
| 1196 | 21.67 | 33.46 | 1.050 | 28.9 | 30.7 | 126 | 105 | 10.27 |
| 1206 | 19.15 | 32.98 | 1.067 | 32.3 | 34.6 | 136 | 113 | 11.29 |
| 1214 | 20.14 | 24.05 | 1.525 | 22.4 | 24.6 | 65 | 54 | 7.42 |
| 1214 | 20.63 | 31.36 | .992 | 28.5 | 30.2 | 116 | 96 | 10.14 |
| 1223 | 17.64 | 26.94 | .100 | 28.6 | 28.8 | 100 | 82 | 10.16 |
| 1226 | 22.16 | 32.49 | 1.058 | 27.5 | 29.1 | 116 | 95 | 9.78 |
| 1230 | 21.45 | 32.58 | .950 | 28.5 | 30.0 | 120 | 98 | 10.14 |

*Assuming that price of feed is $1.50 per 100 lbs. TDN; price of milk is $2.00 per 100 lbs. FCM.

| Average Live wt. lbs. | Feed TDN lbs./day | Milk FCM lbs./day | Livewt. gain lbs./day | Gross Energetic Effic. Not corrected for wt. gain | Gross Energetic Effic. Corrected for wt. gain | Profit per year, dollars per cow | Profit per year, dollars per 1000 lbs. live wt. | Profit per year, dollars pers 1000 lbs. FCM |
|---|---|---|---|---|---|---|---|---|
| 1286 | 18.81 | 27.92 | .667 | 27.8 | 29.0 | 101 | 79 | 9.89 |
| 1289 | 19.86 | 33.71 | .383 | 31.8 | 32.6 | 137 | 106 | 11.15 |
| 1297 | 23.44 | 31.55 | .917 | 25.2 | 26.5 | 102 | 79 | 8.85 |
| 1306 | 20.48 | 33.05 | 1.058 | 30.2 | 32.2 | 129 | 99 | 10.71 |
| 1314 | 20.89 | 32.76 | .817 | 29.4 | 30.8 | 125 | 95 | 10.44 |
| 1326 | 18.70 | 35.40 | .342 | 35.5 | 36.3 | 156 | 118 | 12.08 |
| 1329 | 20.86 | 21.11 | 1.950 | 19.0 | 21.4 | 40 | 30 | 5.18 |
| 1380 | 23.91 | 34.72 | 1.192 | 27.2 | 28.9 | 122 | 88 | 9.67 |
| 1386 | 20.85 | 28.97 | .825 | 26.0 | 27.3 | 97 | 70 | 9.20 |
| 1398 | 25.62 | 40.60 | .642 | 29.7 | 30.6 | 156 | 112 | 10.55 |
| 1405 | 22.85 | 35.88 | .850 | 29.4 | 30.8 | 137 | 98 | 10.44 |
| 1408 | 20.58 | 30.69 | .667 | 27.9 | 29.1 | 111 | 79 | 9.94 |
| 1442 | 21.28 | 34.79 | 1.158 | 30.6 | 32.8 | 137 | 95 | 10.82 |
| **II. PENNSYLVANIA (FORBES) HOLSTEINS, 10 cows** | | | | | | | | |
| 867 | 16.02 | 32.53 | −.056 | 38.0 | 37.8 | 149 | 172 | 12.55 |
| 1008 | 16.55 | 30.56 | .036 | 34.7 | 34.7 | 132 | 131 | 11.84 |
| 1042 | 19.99 | 39.71 | .259 | 37.3 | 38.0 | 181 | 174 | 12.49 |
| 1073 | 18.87 | 36.08 | .205 | 35.8 | 36.4 | 160 | 149 | 12.14 |
| 1092 | 19.76 | 35.51 | −.056 | 33.7 | 33.5 | 151 | 138 | 11.64 |
| 1102 | 20.61 | 34.59 | .652 | 31.5 | 33.0 | 140 | 127 | 11.10 |
| 1198 | 21.55 | 39.35 | .580 | 34.3 | 35.7 | 169 | 141 | 11.75 |
| 1207 | 19.14 | 34.94 | .154 | 34.3 | 34.6 | 150 | 124 | 11.75 |
| 1308 | 20.66 | 33.62 | .542 | 30.5 | 31.7 | 132 | 101 | 10.77 |
| 1408 | 24.39 | 45.13 | −.165 | 34.7 | 34.3 | 195 | 138 | 11.83 |
| **III. DIXON, LLINOIS, TESTING PLANT HOLSTEINS, 42 COWS** | | | | | | | | |
| 889 | 26.60 | 43.55 | .370 | 30.7 | 30.8 | 172 | 194 | 10.82 |
| 952 | 25.12 | 43.68 | .192 | 32.6 | 32.7 | 181 | 190 | 11.34 |
| 976 | 25.86 | 38.68 | −.110 | 28.0 | 28.0 | 141 | 144 | 10.00 |
| 1086 | 23.15 | 41.31 | .520 | 33.4 | 33.7 | 175 | 161 | 11.62 |
| 1126 | 26.44 | 47.02 | .358 | 33.3 | 33.5 | 198 | 176 | 11.53 |
| 1161 | 27.71 | 52.47 | .233 | 35.5 | 35.6 | 231 | 199 | 12.05 |
| 1194 | 26.41 | 42.69 | −.356 | 30.3 | 30.2 | 167 | 140 | 10.71 |
| 1198 | 29.92 | 67.22 | .096 | 42.1 | 42.2 | 327 | 273 | 13.32 |
| 1210 | 28.65 | 67.82 | .110 | 44.4 | 44.4 | 338 | 279 | 13.64 |
| 1211 | 26.61 | 43.01 | .000 | 30.3 | 30.3 | 168 | 139 | 10.71 |
| 1220 | 29.99 | 61.43 | .000 | 38.4 | 38.4 | 284 | 233 | 12.66 |
| 1221 | 27.32 | 41.02 | .559 | 28.1 | 28.3 | 150 | 123 | 10.03 |
| 1229 | 27.98 | 53.54 | −.301 | 35.9 | 35.7 | 237 | 193 | 12.14 |
| 1233 | 29.44 | 47.02 | −.301 | 33.2 | 33.3 | 182 | 148 | 10.60 |
| 1245 | 28.13 | 50.16 | −.068 | 33.4 | 33.4 | 212 | 170 | 11.59 |
| 1247 | 27.08 | 44.70 | .206 | 30.9 | 31.0 | 178 | 143 | 10.90 |
| 1265 | 28.31 | 55.31 | .274 | 36.6 | 36.7 | 249 | 197 | 12.33 |
| 1271 | 28.95 | 55.59 | .247 | 36.0 | 36.1 | 247 | 194 | 12.16 |
| 1272 | 28.75 | 52.51 | −.333 | 34.2 | 34.1 | 226 | 178 | 11.78 |
| 1291 | 26.94 | 53.84 | −.329 | 37.5 | 37.3 | 246 | 191 | 12.52 |
| 1297 | 27.26 | 50.86 | .301 | 35.0 | 35.1 | 222 | 171 | 11.95 |
| 1312 | 28.18 | 43.90 | −.274 | 29.2 | 29.1 | 166 | 127 | 10.36 |
| 1330 | 28.46 | 53.25 | .000 | 35.1 | 35.1 | 233 | 175 | 12.00 |
| 1331 | 25.85 | 45.64 | .315 | 33.1 | 33.2 | 192 | 144 | 11.53 |
| 1340 | 26.10 | 53.39 | −1.041 | 38.4 | 37.8 | 247 | 184 | 12.68 |
| 1347 | 27.76 | 59.93 | .109 | 40.5 | 40.5 | 286 | 212 | 13.07 |
| 1350 | 25.48 | 41.87 | .247 | 30.8 | 30.9 | 166 | 123 | 10.85 |
| 1354 | 27.11 | 54.25 | .055 | 37.5 | 37.5 | 248 | 183 | 12.52 |
| 1358 | 29.22 | 56.81 | −.192 | 36.4 | 36.4 | 255 | 188 | 12.30 |
| 1360 | 29.50 | 56.85 | .041 | 36.1 | 36.1 | 253 | 186 | 12.19 |
| 1425 | 26.19 | 42.64 | .137 | 30.5 | 30.6 | 168 | 118 | 10.79 |
| 1448 | 30.17 | 56.66 | −.269 | 35.2 | 35.1 | 248 | 171 | 12.00 |
| 1464 | 27.65 | 46.91 | .167 | 31.8 | 31.9 | 191 | 130 | 11.15 |
| 1469 | 30.78 | 64.59 | −.110 | 39.3 | 39.3 | 303 | 206 | 12.85 |
| 1514 | 28.62 | 57.28 | −.055 | 37.5 | 37.5 | 261 | 172 | 12.49 |
| 1531 | 23.78 | 36.42 | .548 | 28.7 | 28.9 | 136 | 89 | 10.22 |
| 1538 | 28.97 | 53.02 | .055 | 34.3 | 34.3 | 228 | 148 | 11.78 |
| 1566 | 28.73 | 56.29 | 205 | 36.7 | 36.8 | 254 | 162 | 12.36 |
| 1609 | 30.34 | 50.28 | .208 | 31.1 | 31.1 | 201 | 125 | 10.96 |
| 1660 | 27.99 | 39.95 | .192 | 26.8 | 26.8 | 138 | 83 | 9.45 |
| 1683 | 29.41 | 61.35 | .137 | 39.1 | 39.2 | 287 | 171 | 12.82 |
| 1748 | 31.94 | 58.39 | .274 | 34.3 | 34.4 | 251 | 144 | 11.78 |

## IV. EXPERIMENT STATION DATA

| Average Live wt. lbs. | Feed TDN lbs./day | Milk FCM lbs./day | Live wt. gain lbs./day | Gross Energetic Effic. Not corrected for wt. gain | Gross Energetic Effic. Corrected for wt. gain | Profit per year, dollars per cow | Profit per year, dollars per 1000 lbs. live wt. | Profit per year, dollars per 1000 lbs. FCM |
|---|---|---|---|---|---|---|---|---|
| **Haecker's Guernseys, 16** | | | | | | | | |
| 765 | 12.62 | 16.55 | .196 | 24.6 | 25.4 | 52 | 68 | 8.60 |
| 766 | 13.85 | 22.66 | .050 | 30.7 | 30.9 | 90 | 117 | 10.88 |
| 782 | 12.50 | 21.86 | .102 | 32.8 | 33.4 | 91 | 116 | 11.40 |
| 790 | 13.81 | 24.73 | .008 | 27.6 | 27.6 | 84 | 98 | 9.84 |
| 801 | 12.39 | 22.67 | −.133 | 34.3 | 33.5 | 98 | 122 | 11.84 |
| 840 | 17.19 | 29.83 | .029 | 32.5 | 33.7 | 124 | 148 | 11.40 |
| 843 | 13.51 | 26.95 | −.240 | 37.4 | 36.0 | 123 | 146 | 12.49 |
| 855 | 15.94 | 23.43 | .008 | 27.6 | 27.6 | 84 | 98 | 9.84 |
| 864 | 16.95 | 30.38 | −.109 | 33.6 | 33.1 | 129 | 149 | 11.64 |
| 887 | 13.98 | 29.68 | −.488 | 39.8 | 37.0 | 140 | 158 | 12.93 |
| 909 | 17.97 | 32.79 | −.082 | 34.2 | 33.9 | 141 | 155 | 11.78 |
| 925 | 15.08 | 22.27 | −.060 | 27.7 | 27.4 | 80 | 86 | 9.84 |
| 947 | 15.29 | 20.13 | −.095 | 24.7 | 24.4 | 63 | 67 | 8.58 |
| 996 | 15.78 | 21.07 | .103 | 25.0 | 25.4 | 67 | 67 | 8.71 |
| 998 | 20.53 | 37.62 | −.191 | 34.3 | 33.7 | 162 | 162 | 11.81 |
| 1019 | 17.37 | 26.28 | .143 | 28.4 | 28.9 | 97 | 95 | 10.11 |
| **Haecker's Holsteins, 27** | | | | | | | | |
| 781 | 15.08 | 22.49 | .077 | 27.9 | 28.2 | 82 | 105 | 10.00 |
| 817 | 14.14 | 22.69 | .095 | 30.1 | 30.5 | 88 | 108 | 10.63 |
| 844 | 14.60 | 29.64 | −.429 | 38.0 | 35.8 | 136 | 161 | 12.58 |
| 872 | 15.97 | 17.27 | .165 | 20.3 | 20.7 | 39 | 45 | 6.19 |
| 877 | 17.35 | 29.35 | −.089 | 31.7 | 31.4 | 119 | 136 | 11.10 |
| 880 | 16.86 | 35.17 | .050 | 39.1 | 39.4 | 164 | 186 | 12.77 |
| 887 | 13.42 | 30.15 | .278 | 42.1 | 40.3 | 147 | 166 | 13.37 |
| 888 | 14.80 | 28.55 | −.230 | 36.1 | 35.0 | 127 | 143 | 12.19 |
| 890 | 18.34 | 37.83 | −.319 | 38.7 | 37.3 | 176 | 198 | 12.74 |
| 906 | 17.54 | 32.25 | −.071 | 35.5 | 35.2 | 139 | 153 | 11.81 |
| 919 | 16.22 | 27.79 | −.214 | 32.1 | 31.2 | 114 | 124 | 11.23 |
| 923 | 16.47 | 31.43 | −.286 | 35.8 | 34.5 | 139 | 151 | 12.11 |
| 975 | 16.37 | 23.51 | .191 | 26.9 | 27.6 | 82 | 84 | 9.56 |
| 976 | 18.81 | 26.65 | .223 | 26.6 | 27.2 | 92 | 94 | 9.45 |
| 978 | 19.15 | 32.29 | −.196 | 31.6 | 30.9 | 131 | 134 | 11.12 |
| 985 | 19.88 | 36.99 | −.120 | 34.9 | 34.4 | 161 | 163 | 11.92 |
| 1086 | 18.75 | 27.69 | .143 | 27.7 | 28.1 | 99 | 91 | 9.81 |
| 1095 | 18.44 | 29.83 | −.042 | 30.2 | 30.2 | 117 | 107 | 10.74 |
| 1106 | 15.13 | 20.88 | .226 | 25.9 | 26.7 | 70 | 63 | 9.18 |
| 1114 | 19.74 | 28.25 | .161 | 26.8 | 27.3 | 98 | 88 | 9.51 |
| 1117 | 18.65 | 28.30 | .113 | 28.4 | 28.8 | 104 | 93 | 10.05 |
| 1128 | 18.40 | 25.41 | .238 | 25.9 | 26.6 | 85 | 75 | 9.18 |
| 1137 | 20.23 | 24.71 | .226 | 22.9 | 23.4 | 70 | 62 | 7.75 |
| 1273 | 18.18 | 30.57 | −.137 | 31.5 | 31.0 | 124 | 97 | 11.12 |
| 1292 | 19.66 | 36.09 | .117 | 34.4 | 34.8 | 156 | 121 | 11.84 |
| 1298 | 20.07 | 30.41 | .192 | 28.4 | 29.0 | 112 | 86 | 10.80 |
| 1315 | 18.64 | 31.84 | .321 | 32.0 | 33.2 | 130 | 99 | 11.18 |
| **Haecker's Jerseys, 55** | | | | | | | | |
| 634 | 14.45 | 28.47 | −.137 | 36.9 | 36.2 | 129 | 203 | 12.41 |
| 683 | 11.10 | 18.65 | −.053 | 31.5 | 31.2 | 75 | 110 | 11.01 |
| 706 | 14.66 | 25.48 | −.286 | 32.6 | 31.3 | 106 | 150 | 11.40 |
| 734 | 12.51 | 27.48 | −.010 | 41.2 | 41.4 | 132 | 180 | 13.15 |
| 735 | 12.57 | 20.79 | −.034 | 31.0 | 31.2 | 83 | 113 | 10.93 |
| 735 | 14.64 | 22.60 | .238 | 28.9 | 30.0 | 85 | 116 | 10.30 |
| 752 | 12.84 | 21.78 | −.060 | 31.8 | 31.5 | 89 | 118 | 11.21 |
| 752 | 14.21 | 22.85 | .006 | 30.1 | 30.1 | 89 | 118 | 10.66 |
| 754 | 13.78 | 23.49 | −.027 | 31.9 | 31.8 | 96 | 127 | 11.21 |
| 758 | 15.14 | 27.59 | −.114 | 34.1 | 33.6 | 119 | 158 | 11.81 |
| 760 | 11.79 | 16.34 | .008 | 26.0 | 26.0 | 55 | 72 | 9.23 |
| 778 | 13.09 | 31.60 | −.893 | 45.2 | 39.5 | 159 | 204 | 13.78 |
| 782 | 15.93 | 28.85 | .137 | 33.9 | 34.6 | 123 | 157 | 11.67 |
| 783 | 12.49 | 19.35 | −.080 | 29.0 | 28.6 | 67 | 86 | 9.48 |
| 789 | 13.45 | 24.09 | .202 | 33.6 | 34.7 | 102 | 129 | 11.59 |
| 792 | 14.50 | 27.77 | −.398 | 35.9 | 33.9 | 123 | 155 | 12.14 |
| 793 | 14.27 | 23.63 | .115 | 31.0 | 31.6 | 94 | 119 | 10.90 |
| 796 | 12.54 | 25.51 | −.092 | 38.1 | 37.5 | 118 | 148 | 12.68 |
| 800 | 14.10 | 28.56 | −.095 | 38.0 | 37.4 | 131 | 164 | 12.58 |
| 809 | 14.17 | 30.90 | −.414 | 40.9 | 38.5 | 148 | 183 | 13.12 |
| 809 | 15.31 | 25.41 | .048 | 31.1 | 31.3 | 102 | 129 | 11.59 |
| 811 | 13.75 | 24.06 | −.333 | 32.8 | 31.2 | 100 | 123 | 11.40 |
| 811 | 15.29 | 29.39 | −.184 | 36.0 | 35.1 | 131 | 162 | 12.22 |

| Average Live wt. lbs. | Feed TDN lbs./day | Milk FCM lbs./day | Live wt. gain lbs./day | Gross Energetic Effic. Not corrected for wt. gain | Gross Energetic Effic. Corrected for wt. gain | Profit per year, Dollars per cow | Profit per year, Dollars per 1000 lbs. live wt. | Profit per year, Dollars per 1000 lbs. FCM |
|---|---|---|---|---|---|---|---|---|
| 817 | 12.74 | 25.65 | −.364 | 37.7 | 35.6 | 117 | 143 | 12.49 |
| 817 | 13.73 | 27.02 | −.060 | 36.9 | 36.5 | 122 | 149 | 12.38 |
| 820 | 13.96 | 22.53 | .113 | 30.3 | 30.8 | 88 | 107 | 10.71 |
| 820 | 15.08 | 18.47 | .196 | 23.0 | 23.6 | 52 | 63 | 7.84 |
| 824 | 16.60 | 26.67 | −.036 | 30.1 | 30.0 | 104 | 126 | 10.68 |
| 833 | 16.21 | 30.04 | −.161 | 34.7 | 34.0 | 131 | 157 | 11.95 |
| 836 | 13.96 | 28.39 | −.143 | 38.1 | 37.3 | 131 | 157 | 12.63 |
| 838 | 13.56 | 26.21 | −.097 | 36.2 | 35.7 | 117 | 140 | 12.22 |
| 843 | 14.94 | 21.07 | .143 | 26.4 | 27.0 | 72 | 85 | 9.37 |
| 845 | 13.61 | 23.15 | −.010 | 31.9 | 31.8 | 94 | 111 | 11.12 |
| 849 | 16.85 | 30.14 | −.225 | 33.5 | 32.6 | 128 | 151 | 11.64 |
| 854 | 14.50 | 21.09 | .017 | 27.3 | 27.3 | 75 | 88 | 9.75 |
| 855 | 16.01 | 29.25 | −.025 | 34.2 | 34.1 | 126 | 147 | 11.81 |
| 856 | 15.27 | 23.50 | −.080 | 28.8 | 28.5 | 88 | 103 | 10.25 |
| 858 | 13.40 | 23.12 | −.500 | 32.3 | 30.0 | 95 | 111 | 11.26 |
| 859 | 12.28 | 25.95 | −.311 | 39.6 | 37.6 | 122 | 142 | 12.88 |
| 861 | 14.85 | 24.34 | .101 | 30.7 | 31.2 | 96 | 111 | 10.79 |
| 863 | 14.96 | 24.65 | .018 | 30.9 | 30.8 | 98 | 114 | 10.90 |
| 867 | 14.68 | 25.64 | −.214 | 32.7 | 31.8 | 107 | 123 | 11.42 |
| 876 | 13.85 | 24.01 | −.082 | 32.5 | 32.1 | 99 | 113 | 11.29 |
| 887 | 15.44 | 22.05 | −.103 | 26.8 | 26.4 | 76 | 86 | 9.45 |
| 890 | 15.16 | 23.04 | .071 | 28.5 | 28.8 | 85 | 96 | 10.11 |
| 898 | 14.78 | 23.77 | −.131 | 30.1 | 29.6 | 93 | 104 | 10.71 |
| 902 | 16.24 | 30.87 | −.036 | 35.6 | 35.5 | 136 | 151 | 12.08 |
| 910 | 18.65 | 36.95 | .024 | 37.1 | 37.2 | 168 | 185 | 12.47 |
| 915 | 13.70 | 17.99 | .036 | 24.6 | 24.7 | 56 | 61 | 8.52 |
| 935 | 17.63 | 31.33 | −.074 | 33.3 | 33.0 | 132 | 141 | 11.53 |
| 936 | 18.62 | 28.77 | −.113 | 28.9 | 28.6 | 108 | 115 | 10.27 |
| 989 | 15.91 | 26.06 | .250 | 30.7 | 31.8 | 103 | 104 | 10.82 |
| 1013 | 15.81 | 23.18 | −.009 | 27.5 | 27.4 | 83 | 82 | 9.81 |
| 1046 | 14.28 | 20.43 | .148 | 26.8 | 27.4 | 71 | 68 | 9.53 |
| 1071 | 13.05 | 15.41 | .077 | 22.1 | 22.4 | 41 | 38 | 7.29 |
| | | | **Eckles' Holsteins, 2** | | | | | |
| 1056 | 20.03 | 34.26 | .000 | 32.1 | 32.1 | 140 | 133 | 11.21 |
| 1319 | 18.13 | 29.89 | .019 | 30.9 | 29.9 | 119 | 90 | 10.90 |
| | | | **Eckles' Jerseys, 5** | | | | | |
| 807 | 15.47 | 24.75 | .041 | 30.0 | 30.1 | 96 | 119 | 10.63 |
| 824 | 14.91 | 22.75 | .137 | 28.6 | 29.2 | 84 | 102 | 10.11 |
| 899 | 16.42 | 28.65 | .044 | 32.7 | 32.9 | 119 | 132 | 11.37 |
| 902 | 9.22 | 10.46 | .049 | 21.3 | 21.5 | 26 | 29 | 6.77 |
| 952 | 15.03 | 21.73 | .000 | 27.1 | 27.1 | 76 | 80 | 9.59 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **Savage's Guernseys, 2** | | | | | |
| 846 | 16.05 | 24.42 | .200 | 28.5 | 29.3 | 90 | 106 | 10.14 |
| 1072 | 19.27 | 32.74 | .514 | 31.8 | 33.8 | 134 | 125 | 11.21 |
| | | | **Savage's Holsteins, 14** | | | | | |
| 985 | 21.20 | 35.81 | .695 | 31.7 | 34.0 | 145 | 147 | 11.10 |
| 990 | 21.21 | 36.87 | .086 | 32.6 | 32.9 | 153 | 155 | 11.37 |
| 1035 | 20.94 | 29.71 | .838 | 26.6 | 29.1 | 102 | 99 | 9.40 |
| 1053 | 22.86 | 42.53 | .295 | 34.9 | 35.9 | 185 | 176 | 11.92 |
| 1054 | 20.15 | 29.90 | .029 | 27.8 | 27.9 | 108 | 102 | 9.89 |
| 1073 | 20.84 | 30.39 | .162 | 27.3 | 27.8 | 108 | 101 | 9.73 |
| 1090 | 22.71 | 37.69 | .657 | 31.1 | 33.2 | 151 | 139 | 10.96 |
| 1150 | 21.69 | 38.51 | .638 | 33.3 | 35.5 | 162 | 141 | 11.53 |
| 1175 | 21.38 | 32.36 | .581 | 28.4 | 30.1 | 119 | 101 | 10.08 |
| 1179 | 22.70 | 37.48 | .019 | 30.9 | 31.0 | 149 | 126 | 10.90 |
| 1184 | 24.36 | 40.55 | .209 | 31.2 | 31.8 | 163 | 138 | 11.01 |
| 1239 | 23.83 | 40.15 | .419 | 31.6 | 32.8 | 163 | 132 | 11.12 |
| 1253 | 23.36 | 38.24 | .752 | 30.7 | 29.4 | 151 | 121 | 10.82 |
| 1341 | 22.13 | 30.12 | .438 | 25.5 | 26.6 | 99 | 74 | 8.99 |
| | | | **Savage's Jerseys, 6** | | | | | |
| 812 | 18.81 | 34.67 | .009 | 34.5 | 34.6 | 150 | 185 | 11.86 |
| 860 | 17.05 | 26.59 | .095 | 29.2 | 29.6 | 101 | 117 | 10.41 |
| 865 | 17.86 | 34.44 | .248 | 36.1 | 35.1 | 154 | 178 | 12.25 |
| 909 | 17.57 | 23.42 | .505 | 25.0 | 26.6 | 75 | 83 | 8.74 |
| 925 | 16.64 | 24.71 | .571 | 27.8 | 30.0 | 89 | 96 | 9.89 |
| 931 | 19.73 | 32.31 | .752 | 30.7 | 33.4 | 128 | 137 | 10.85 |

| Average Live wt. lbs. | Feed TDN lbs./day | Milk FCM lbs./day | Live wt. gain lbs./day | Gross Energetic Effic. Not corrected for wt. gain | Gross Energetic Effic. Corrected for wt. gain | Profit per year, dollars per cow | Profit per year, dollars per 1000 lbs. live wt. | Profit per year, dollars per 1000 lbs. FCM |
|---|---|---|---|---|---|---|---|---|
| **Hill's Holsteins, 4** | | | | | | | | |
| 1184 | 11.25 | 9.40 | .487 | 15.7 | 17.3 | 7 | 6 | 2.05 |
| 1317 | 17.20 | 20.70 | .752 | 22.5 | 23.4 | 57 | 43 | 7.53 |
| 1341 | 16.20 | 11.41 | .893 | 13.2 | 14.9 | −5 | −4 | −1.29 |
| 1390 | 18.40 | 20.49 | .307 | 20.9 | 21.6 | 49 | 35 | 6.55 |
| **Hill's Jerseys, 5** | | | | | | | | |
| 885 | 13.95 | 17.89 | .627 | 24.0 | 26.6 | 54 | 61 | 8.30 |
| 899 | 14.20 | 19.43 | .548 | 25.6 | 27.9 | 64 | 71 | 9.04 |
| 920 | 15.20 | 17.16 | .613 | 21.1 | 22.8 | 42 | 46 | 6.71 |
| 929 | 16.55 | 19.45 | .410 | 22.0 | 23.2 | 51 | 55 | 7.26 |
| 978 | 13.70 | 13.60 | .458 | 18.6 | 20.0 | 24 | 25 | 4.88 |
| **Perkin's Holsteins, 4** | | | | | | | | |
| 1288 | 21.96 | 28.58 | .336 | 24.4 | 25.2 | 88 | 68 | 8.47 |
| 1330 | 22.03 | 28.23 | .781 | 24.0 | 26.0 | 85 | 64 | 8.30 |
| 1360 | 18.33 | 24.76 | .432 | 25.3 | 26.7 | 80 | 59 | 8.90 |
| 1393 | 21.36 | 27.83 | .371 | 24.4 | 25.4 | 86 | 62 | 8.49 |
| **Harrison and Savage's Holsteins, 103** | | | | | | | | |
| 1081 | 19.38 | 34.49 | .155 | 33.4 | 33.9 | 146 | 135 | 11.59 |
| 1120 | 16.25 | 22.23 | .192 | 25.6 | 26.3 | 73 | 65 | 9.04 |
| 1134 | 19.59 | 32.82 | .075 | 31.4 | 31.7 | 132 | 116 | 11.01 |
| 1138 | 18.86 | 31.31 | .367 | 31.1 | 32.5 | 125 | 110 | 10.93 |
| 1154 | 19.95 | 32.81 | −.150 | 30.8 | 30.3 | 130 | 113 | 10.85 |
| 1159 | 16.50 | 24.36 | .425 | 27.7 | 29.3 | 87 | 75 | 9.84 |
| 1162 | 18.88 | 28.45 | −.376 | 28.2 | 27.1 | 104 | 90 | 10.03 |
| 1163 | 18.94 | 28.13 | .214 | 27.8 | 28.5 | 102 | 88 | 9.95 |
| 1170 | 19.19 | 30.70 | .711 | 28.9 | 31.3 | 119 | 102 | 10.63 |
| 1170 | 23.07 | 43.19 | .169 | 35.1 | 35.6 | 189 | 162 | 12.00 |
| 1172 | 17.45 | 22.70 | .432 | 24.4 | 25.7 | 70 | 60 | 8.47 |
| 1173 | 20.49 | 34.30 | −.316 | 31.4 | 30.4 | 138 | 118 | 11.01 |
| 1181 | 16.60 | 20.14 | .335 | 22.7 | 23.7 | 56 | 47 | 7.62 |
| 1182 | 18.80 | 29.60 | −.078 | 29.7 | 29.4 | 115 | 97 | 10.58 |
| 1184 | 22.20 | 41.90 | .171 | 35.4 | 36.0 | 184 | 155 | 12.03 |
| 1187 | 18.41 | 25.93 | .244 | 26.4 | 27.2 | 88 | 74 | 9.34 |
| 1192 | 18.60 | 29.31 | .004 | 29.5 | 29.6 | 112 | 94 | 10.47 |
| 1195 | 21.96 | 41.04 | .120 | 35.0 | 35.4 | 179 | 150 | 11.95 |
| 1195 | 22.28 | 41.01 | −.026 | 34.5 | 34.4 | 177 | 148 | 11.84 |
| 1196 | 16.57 | 19.09 | .120 | 21.6 | 21.9 | 49 | 41 | 6.99 |
| 1203 | 21.72 | 39.39 | −.030 | 34.0 | 23.9 | 169 | 140 | 11.75 |
| 1203 | 18.14 | 23.31 | .530 | 24.1 | 25.7 | 71 | 59 | 8.33 |
| 1210 | 18.18 | 27.19 | .150 | 28.0 | 28.5 | 99 | 82 | 9.97 |
| 1215 | 19.64 | 31.55 | .398 | 30.1 | 31.5 | 123 | 101 | 10.68 |
| 1217 | 19.30 | 28.38 | .384 | 27.6 | 28.8 | 101 | 83 | 9.75 |
| 1219 | 20.92 | 34.04 | −.184 | 30.5 | 29.9 | 134 | 110 | 10.79 |
| 1220 | 16.91 | 22.57 | .756 | 25.0 | 27.6 | 72 | 59 | 8.77 |
| 1220 | 16.14 | 23.41 | .004 | 27.2 | 27.2 | 82 | 67 | 9.64 |
| 1223 | 16.76 | 26.85 | .188 | 30.0 | 30.8 | 139 | 104 | 11.37 |
| 1224 | 19.11 | 28.00 | 1.053 | 27.5 | 31.1 | 100 | 82 | 9.75 |
| 1227 | 17.88 | 26.39 | −.489 | 27.7 | 26.1 | 95 | 77 | 9.84 |
| 1230 | 16.81 | 23.36 | .249 | 26.1 | 26.9 | 78 | 63 | 9.21 |
| 1232 | 20.42 | 33.19 | .087 | 30.5 | 30.7 | 130 | 106 | 10.74 |
| 1234 | 16.16 | 25.11 | −.200 | 29.1 | 28.4 | 95 | 77 | 10.36 |
| 1238 | 18.28 | 26.35 | −.278 | 27.0 | 26.2 | 92 | 74 | 9.56 |
| 1239 | 20.05 | 38.16 | .074 | 35.7 | 36.0 | 169 | 136 | 12.14 |
| 1239 | 19.65 | 28.71 | .192 | 27.4 | 28.0 | 102 | 82 | 9.73 |
| 1248 | 18.86 | 26.46 | .466 | 26.3 | 27.8 | 90 | 72 | 9.32 |
| 1250 | 19.67 | 31.60 | .188 | 30.1 | 30.7 | 123 | 98 | 10.66 |
| 1251 | 19.39 | 32.29 | −.278 | 31.2 | 30.3 | 130 | 104 | 11.04 |
| 1251 | 19.03 | 27.10 | .015 | 26.7 | 26.7 | 94 | 75 | 9.51 |
| 1254 | 19.53 | 31.55 | −.188 | 30.3 | 29.7 | 123 | 98 | 10.68 |
| 1255 | 18.24 | 29.59 | −.049 | 30.4 | 30.2 | 116 | 92 | 10.74 |
| 1261 | 20.86 | 36.03 | .155 | 32.4 | 32.9 | 149 | 118 | 11.34 |
| 1266 | 17.74 | 23.72 | .282 | 25.1 | 25.9 | 76 | 60 | 8.77 |
| 1267 | 19.55 | 31.23 | .455 | 29.9 | 31.5 | 121 | 96 | 10.60 |
| 1270 | 20.42 | 33.75 | −.116 | 31.0 | 30.6 | 134 | 106 | 10.96 |
| 1271 | 18.67 | 27.25 | .587 | 27.4 | 29.3 | 97 | 76 | 9.73 |
| 1272 | 17.39 | 20.55 | .327 | 22.2 | 23.1 | 55 | 43 | 7.31 |
| 1272 | 18.57 | 30.46 | .098 | 30.7 | 31.1 | 121 | 95 | 10.88 |
| 1272 | 20.83 | 34.91 | .216 | 31.4 | 32.1 | 141 | 111 | 11.07 |
| 1275 | 20.13 | 29.22 | .470 | 27.2 | 28.6 | 103 | 102 | 9.64 |

| Average Live wt. lbs. | Feed TDN lbs./day | Milk FCM lbs./day | Live wt. gain lbs./day | Gross Energetic Effic.: Not corrected for wt. gain | Gross Energetic Effic.: Corrected for wt. gain | Profit per year, dollars: per cow | Profit per year, dollars: per 1000 lbs. live wt. | Profit per year, dollars: per 1000 lbs. FCM |
|---|---|---|---|---|---|---|---|---|
| 1275 | 20.71 | 34.56 | .443 | 31.3 | 32.8 | 139 | 109 | 11.01 |
| 1283 | 17.51 | 22.75 | .244 | 24.3 | 25.1 | 70 | 55 | 8.47 |
| 1285 | 20.45 | 32.83 | .229 | 30.1 | 30.8 | 128 | 100 | 10.68 |
| 2186 | 17.87 | 23.19 | .105 | 24.3 | 24.6 | 71 | 55 | 8.44 |
| 1287 | 19.70 | 31.87 | .169 | 30.3 | 30.9 | 125 | 97 | 10.74 |
| 1292 | 20.68 | 35.09 | .045 | 31.8 | 32.0 | 143 | 111 | 11.18 |
| 1295 | 19.54 | 30.40 | .263 | 29.2 | 30.0 | 115 | 89 | 10.36 |
| 1296 | 19.08 | 26.50 | .131 | 26.0 | 26.4 | 89 | 69 | 9.21 |
| 1297 | 20.73 | 32.63 | .470 | 29.5 | 31.0 | 125 | 96 | 10.49 |
| 1298 | 20.40 | 34.94 | .613 | 32.1 | 34.3 | 143 | 110 | 11.21 |
| 1298 | 20.98 | 36.36 | .065 | 32.5 | 32.7 | 150 | 116 | 11.37 |
| 1301 | 21.53 | 39.18 | .090 | 34.1 | 34.4 | 168 | 129 | 11.75 |
| 1305 | 20.76 | 32.38 | .384 | 29.2 | 30.4 | 123 | 94 | 10.41 |
| 1306 | 18.50 | 27.76 | .511 | 28.1 | 29.9 | 101 | 77 | 12.71 |
| 1308 | 17.53 | 22.74 | .756 | 24.3 | 26.8 | 70 | 54 | 9.44 |
| 1320 | 19.65 | 30.79 | .131 | 29.4 | 29.8 | 117 | 89 | 10.41 |
| 1323 | 19.70 | 33.91 | .176 | 32.3 | 32.9 | 140 | 106 | 11.32 |
| 1323 | 20.65 | 32.29 | .214 | 29.3 | 30.0 | 123 | 93 | 10.44 |
| 1327 | 20.78 | 34.06 | .128 | 30.7 | 31.1 | 135 | 102 | 10.85 |
| 1327 | 17.63 | 22.85 | .150 | 24.3 | 24.7 | 70 | 53 | 8.41 |
| 1331 | 21.71 | 39.74 | −.237 | 34.3 | 33.5 | 171 | 128 | 11.78 |
| 1332 | 17.34 | 19.84 | −.011 | 21.4 | 21.4 | 50 | 38 | 6.90 |
| 1332 | 17.94 | 20.25 | .688 | 21.2 | 23.1 | 50 | 38 | 6.71 |
| 1333 | 21.48 | 35.65 | .261 | 31.1 | 31.9 | 143 | 107 | 10.99 |
| 1337 | 19.35 | 33.53 | .351 | 32.5 | 33.8 | 139 | 104 | 11.37 |
| 1338 | 20.80 | 35.29 | .004 | 31.8 | 31.8 | 144 | 108 | 11.18 |
| 1340 | 18.72 | 26.11 | −.045 | 26.1 | 26.0 | 88 | 66 | 9.23 |
| 1340 | 18.02 | 32.76 | .327 | 34.1 | 35.4 | 140 | 104 | 11.70 |
| 1341 | 20.00 | 33.45 | .192 | 31.4 | 32.0 | 135 | 101 | 11.07 |
| 1344 | 18.09 | 21.97 | .853 | 22.8 | 25.3 | 61 | 45 | 7.64 |
| 1344 | 18.77 | 32.87 | −.331 | 32.8 | 31.6 | 137 | 102 | 11.42 |
| 1346 | 21.00 | 32.88 | .343 | 29.4 | 30.4 | 125 | 93 | 10.41 |
| 1364 | 18.40 | 26.62 | .421 | 27.1 | 28.5 | 94 | 69 | 9.67 |
| 1366 | 19.49 | 27.62 | .518 | 26.6 | 28.2 | 95 | 70 | 9.42 |
| 1368 | 18.89 | 32.59 | .053 | 32.3 | 32.5 | 134 | 98 | 10.26 |
| 1375 | 19.26 | 29.17 | .004 | 28.4 | 28.4 | 107 | 78 | 10.05 |
| 1379 | 19.08 | 30.56 | .147 | 30.0 | 29.5 | 119 | 86 | 10.66 |
| 1379 | 19.61 | 33.87 | −.131 | 32.4 | 31.9 | 140 | 102 | 11.32 |
| 1382 | 18.63 | 22.85 | .150 | 24.3 | 24.7 | 70 | 53 | 8.41 |
| 1384 | 20.91 | 33.34 | .286 | 29.9 | 30.8 | 129 | 93 | 10.60 |
| 1386 | 21.31 | 41.03 | .016 | 36.1 | 36.1 | 183 | 132 | 12.22 |
| 1388 | 21.82 | 38.77 | .265 | 33.3 | 34.2 | 164 | 118 | 11.59 |
| 1389 | 19.86 | 31.70 | .447 | 29.9 | 31.4 | 123 | 89 | 10.63 |
| 1394 | 21.31 | 40.14 | −.690 | 35.3 | 33.0 | 176 | 126 | 12.08 |
| 1398 | 20.89 | 35.07 | .271 | 31.5 | 32.4 | 142 | 102 | 11.10 |
| 1404 | 15.83 | 22.86 | .637 | 27.1 | 29.6 | 80 | 57 | 9.62 |
| 1428 | 19.18 | 28.58 | −.387 | 27.9 | 26.8 | 104 | 73 | 9.97 |
| 1436 | 19.22 | 28.55 | .082 | 27.8 | 28.1 | 103 | 72 | 9.92 |
| 1453 | 18.45 | 27.41 | .494 | 27.9 | 29.5 | 99 | 68 | 9.89 |
| 1494 | 21.47 | 38.71 | −.327 | 33.8 | 32.7 | 165 | 110 | 11.67 |
| 1500 | 21.11 | 36.35 | −.019 | 32.3 | 32.2 | 150 | 100 | 11.32 |