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The Minimum Protein Requirement for Growing Dairy Heifers

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The Minimum Protein Requirement for Growing Dairy Heifers

W. W. SWETT, C. H. ECKLES and A. C. RAGSDALE*

Abstract.—Thirty-four purebred Holstein and Jersey heifers were kept on carefully controlled rations for an average of 14.9 or a total of 508.8 thirty-day periods, extending over approximately seven and one-half years. The rations were calculated to furnish energy equal to or slightly in excess of that recommended by the correct feeding standards, and an adequacy of mineral salts and vitamines, while the proportions of protein were varied from very low to very high planes. The development and behavior rather than the nitrogen balance of the animals was adopted as a basis for interpreting results. The normal growth values of Eckles were used as a standard for comparison. On the average an increase in the protein plan was rather consistently accompanied by a steady increase in percentage of normal growth in weight and by a significant but less regular and less extensive increase in percentage of normal skeletal development, which is normally influenced to a much smaller degree by the manipulation of the ration than a variation in other conditions. The Holsteins made normal development on a lower protein plane than did the Jerseys. This breed difference was particularly noticeable on the intermediate and high planes. An excess of energy apparently increased rather consistently the efficiency of a given protein plane. There was a tendency for the intermediate planes to become more efficient as the age of the animals advanced. The Wolff-Lehmann and Armsby protein standards appear to be from 20 to 25 per cent and from 50 to 60 per cent higher, respectively, than is necessary for the promotion of normal growth in weight. The annual feed cost of raising to producing age a number of heifers sufficient to maintain the present dairy cow population in the United States is approximately $400,000,000. Protein is generally the most expensive constituent in the dairy ration. The possibilty of a tremendous saving is indicated.

THE PROTEIN MINIMUM

Much has been done in an attempt to determine the minimum amount of protein necessary for production in its different forms. The term production is herein used in a broad sense and is understood to include the production of meat, milk, eggs, and the production or promotion of growth. There is very little uniformity in the recommendations of the several feeding standards regarding the amount of protein

*The project was outlined and commenced by C. H. Eckles in 1913. From April 1, 1919, the work was under the general supervision of A. C. Ragsdale. W. W. Swett, who began work on the project on July 1, 1916, is largely responsible for developing the plans as the work progressed, for the compilation and interpretation of the data, and for the preparation of the material for publication.

necessary to be fed to growing cattle and in the interpretation of the term "protein minimum". A productive ration must contain digestible protein at least equal to the maintenance requirement plus the amount of protein contained in the product. Some investigators have shown that moderate production can be secured on a quantity of protein only very slightly in excess of this theoretical minimum and that a greater quantity is useless. Others have shown the need of quantities of protein greatly in excess of this amount.

Many factors have been suggested as affecting the efficiency of the proteins fed and therefore affecting the minimum protein requirements. Hindehede[1] concludes that the need for protein increases almost directly with the energy consumption. Armsby[2] in discussing the protein minimum for maintenance states that on a diet containing an abundance of carbohydrates, a supply equivalent to the fasting katabolism is sufficient to meet the needs of the organism and that possibly less than that will suffice. He also shows that on a high protein plane it seems that the protein can serve as energy to some extent, but that on the whole a considerable surplus of protein has not proved of any material advantage. This is in accord with observations by Schreuer[3] that large quantities of protein do not permanently increase the protein content of the body. Contrary to the views of Kellner and Strusiewicz[4] and of Hart, Humphrey and Morrison[5], Armsby[6] concludes that the non-protein or amid nitrogen has no material value for production purposes and for that reason uses the "digestible true protein" in all his recommendations for such purposes. Since about one-third the total nitrogen of alfalfa hay is in amid form a question of considerable import arises in any experimental feeding work with dairy cattle. Thomas[7], Fingerling[8], and Flint[9] agree in general with Armsby that an abundance of energy in the ration lowers the protein requirements. Contrary to this view, Gigon[10] and Osterberg and Wolf[11] found no such advantage in an excess of carbohydrates. The wide difference in results reported, is undoubtedly due in part to the fact that many different species and types have been used, and to a great degree to the fact that nearly all the early work was performed without reference to the quality of the proteins. Our present knowledge of the importance of the amino acids of proteins in nutrition even calls for a new definition of protein minimum, and our present knowledge of vitamines further complicates matters.

NEED FOR FURTHER INVESTIGATION

Armsby[12] states that, "the tendency of recent investigators . . . is to show that in all branches of feeding, the minimum protein require-

ment has been considerably exaggerated. This has been shown to be true of the maintenance requirement and the requirement for milk production, while our results suggest that it is also true of growth. At any rate this branch of the subject seems worthy of further investigation."

The annual national feed bill for raising to producing age enough dairy heifers to maintain our present cow population, is approximately $400,000,000. Nitrogenous feeds are expensive, especially in the corn belt. These heifers must be raised if the dairy business is to continue. Protein substances are absolutely essential constituents of all living cells. Without them neither animal nor vegetable life is possible. They cannot be satisfactorily replaced by any other dietary constituent, either organic or inorganic. The fact that protein cannot be synthesized from non-protein material and that it is absolutely essential for life makes the problem of the protein supply in the ration a vital one. It is believed that the present standards are higher than necessary. Any fundamental knowledge which will materially reduce this tremendous feed bill for growing and unproductive heifers will be of great economic value to the dairy industry. With this in view an experiment was outlined and started at the Missouri Agricultural Experiment Station in 1913.

PLAN OF THE EXPERIMENT

The experiment was planned for the purpose of securing data that would lead to a determination of the minimum amount of protein that would promote normal growth of dairy heifers from the age of six months to the time of first calving.

There are two methods of conducting such an experiment. One is to determine the nitrogen balance of the animal, but since this requires a collection of all the urine and feces and a determination of their nitrogen content it involves a great deal of labor and expense. The other method is to control carefully the condition of the animal with special attention to avoid the laying on of fat, and to draw conclusions from the behavior, the body weight and such skeletal measurements as may be considered representative of the development of the animal. As many animals as possible should be used if this latter method is employed so that the fluctuations in live weight may be overcome to as great an extent as possible. There may be controversy over the relative value of the two methods. Undoubtedly the first is the more accurate of the two for some purposes, and undoubtedly a combination of the two would be better than either one. However, the first method prolonged over the period of time required for the second would make the cost prohibitive. On the other hand the second method permits a study of the growth and general development of the animal on known amounts of protein intake

and therefore shows many things that the first method does not. In addition the second method is undoubtedly of more practical value. The second method is the one employed in all our work.

The original plan was to control and standardize all factors except the amount of protein in the ration. In all except the very earliest work it was attempted to avoid amino acid deficiency by selecting feeds from a variety of sources. In only two or three instances has any attempt been made to consider the adequacy of different proteins, but it has been the aim to supply adequate proteins through the variety of feeds selected The amount of energy in the ration was calculated to just meet the requirements of the growing animal. Sufficient mineral was to be furnished by selecting feeds containing an adequate supply or by adding it directly in the form of different mineral salts or animal bone products. It has been pointed out by Rose and Berg[13] that the protein requirement of an animal is less if the ration furnishes an excess of bases. It is believed that all our animals consistently received a slight excess of bases in the common dairy feeds used. Very little was known of the vitamine content of feeds at the time the experiment was started but this was given consideration in the later years of the experiment. While it was originally intended to feed different heifers different quantities or planes of protein and to keep all the other constituents as nearly as possible to the required amount, the energy factor proved to be of importance and was given separate consideration in connection with the protein intake.

Selection of Animals.—Only purebred Jersey and Holstein heifers were used. Most of them were put on experiment at approximately six months of age. A few were put on at five months while several were not started until they were considerably older. Previous to going on experiment they were raised under as nearly normal conditions as possible, having the same care as the other calves in the herd. Most of them were not selected until a few days before going on experiment. They were fed whole milk up to about three weeks, after which the whole milk was gradually replaced by skimmilk which was supplemented by a grain mixture and alfalfa hay in liberal quantities. In the early part of the work not enough attention was paid to the selection of normal animals. In some cases the animals were placed on experiment when they were subnormal in both weight and height and as a result were handicapped at the start. This handicap, followed by a period of adjustment to new conditions, new quarters, and in a few cases a decided change in ration, in some cases resulted in unsatisfactory gains and it is not possible to determine to what extent the protein plane is the responsible factor. In the later years of the experiment more attention was paid to the selection of normal animals. A few animals were just slightly

above the normal in both weight and skeletal size but the majority were almost exactly normal. The animals were selected without reference to their breeding except that the most valuable animals were put on planes of protein and on rations of such character that they would not be likely to be seriously stunted. Animals were selected from as many varieties of breeding as possible, and a great many combinations of blood have been represented in each breed.

Analysis of Feed.—Each lot of feed purchased for use in this experiment was carefully sampled to insure a representative composite. If several sacks of corn, oats or bran were set away for use, a sample was made by taking small quantities from each of a considerable number of the sacks. If a carload of hay or any portion of a carload was set aside for use, several representative bales were cut in a small power cutter and a sample taken from the cut feed. These samples were analyzed by the Department of Agricultural Chemistry for water, ash, nitrogen, fat and crude fiber. From these the nitrogen-free extract was determined, and the protein calculated by multiplying the nitrogen value by 6.25, except in the case of skimmilk powder when the factor 6.38 was used. The total digestible protein was calculated by multiplying the total protein by Henry's[14] average digestion coefficients for protein in the different feeds: timothy hay 48%, alfalfa hay 72%, skimmilk powder 95%, corn 76%, cottonseed meal 83%, bran 77%, oats 77%, and corn silage 53%. The value for bone meal was assumed to be 100%. Protein values thus derived were expressed as pounds digestible crude protein.

The energy values were determined for each feed by using the tables by Putney and Armsby[15]. These values are as follows: alfalfa hay 0.3423, bran 0.5300, corn 0.8916, cottonseed meal 0.9346, oats 0.6756, oilmeal 0.8891, silage 0.1590, skimmilk powder 1.0391, and timothy hay 0.4302 therms per pound of feed. The value used for starch or for starch and sugar was 0.818; a figure for starch given by Armsby.

Since 100 grams fat has the energy equivalent of 232 grams of starch[16] the energy value of 35% cream is determined by multiplying the energy value of starch, which is 0.818 therms per pound, by 2.32 and multiplying the result by 0.35. The energy value thus determined is 0.664 therms per pound of 35% cream.

Method of Handling Heifers.—During the entire experiment the heifers were fed twice a day—once in the morning and once late in the afternoon. All feed was recorded every day. The general plan was to weigh at one time the entire amount of hay and grain to be fed for the day. Approximately half the hay and half the grain was fed at each feeding. This procedure cut in half the labor of weighing feed. Any refused feed was weighed back each day and the amount deducted from

the total amount fed in determining the amount consumed. This was rather difficult at times because in a few cases the feed was given wet. In other cases the refused hay and grain became mixed in the manger so that it was difficult to determine the proportions of each. If the refused part was largely of hay the amount deducted was distributed proportionately between the hays fed. The same method was employed for the refused concentrates.

Only clean, bright, unmixed hay was fed. Except at the very beginning all hay was run through a small size cutter and cut into lengths of approximately two inches. The reason was partly to permit easier weighing and to insure a larger proportion being eaten, but chiefly to make it possible to mix the different kinds of hay together so that the heifers could not readily pick out the more palatable roughage and leave the other. It was also of decided help in feeding wet hay mixed with starch and sugar, a method that will be explained. In a few cases the cutting of the hay proved detrimental because of the fact that baling wire was accidentally run through the cutter and pieces from two to four inches long and very sharp at the ends were swallowed by the heifers. Death resulted in several instances from this cause.

During the early part of the experiment (from 1913 until the fall of 1914) the heifers were kept in box stalls with board floors. Shavings were used for bedding. The heifers were permitted to go out in a dry lot in pleasant weather. In the early part of the experiment the heifers were muzzled when outside in order to prevent their getting any additional feed and to prevent their eating dirt. In November 1914 an experimental barn was completed. It consists of a feed room in one corner, a narrow alley through the center and small individual box stalls on each side. Each stall is equipped with a manger divided so that hay and grain can be kept separate, and has a cinder floor on which shavings were used for bedding. During the daytime the heifers were permitted to run out in a dry lot where they had access to a tank of fresh water and a box of salt. In the fall of 1917 an additional experimental barn was built and was subsequently occupied by the animals on this experiment. Instead of having box stalls this barn is equipped with stanchions of graduated size. The gutter and a part of the floor is of concrete. The mangers are of wood and do not permit keeping the hay and grain separate. The remainder is of clay. Shavings were used for bedding wherever possible. At other times a small quantity of wheat straw was used and so handled that the heifers could not reach it. The heifers were still allowed to go out in a dry lot in the daytime and at night except in the winter months. Fresh water and salt were at all times available in the dry lot.

Weights and Measurements.—At the start the animals were weighed every week. In December, 1914, the plan was changed and subsequently the weights were taken every 10 days, and once every 30 days the weights for three consecutive days were averaged. This plan was followed until the fall of 1915 when the plan was adopted of weighing only on three consecutive days at the beginning of each 30-day period, and everything was put on the basis of the 30-day period. The value derived by averaging the three consecutive weights was used to represent the value for the end of one period and the beginning of the next. In addition to the systematic taking of weights, once each 30 days, at approximately the same time as the three-day weight period, a set of measurements was taken. The measurements at first were twenty-one in number. Later a twenty-second was added. The list of measurements follows:

1. Height at withers (average of three measurements).
2. Height at a point between the hip points.
3. Height at hip points.
4. Depth of chest just behind "elbow" joint.
5. Width of chest just behind "elbow" joint.
6. Width of hips (hip points)
7. Width of loin (center).
8. Length from poll to point of muzzle.
9. Width of forehead.
10. Circumference of muzzle at opening mouth.
11. Length from base of horn to withers.
12. From highest point of withers to a line between hips.
13. From a line between hips to tail.
14. From point of shoulder to point of hips.
15. From point of shoulder to ischium.
16. From point of hip to ischium.
17. From point of hips directly forward to last rib.
18. Heart girth just behind elbow joint.
19. Girth of paunch at end of last rib.
20. Smallest circumference of shin bone of foreleg.
21. Smallest circumference of shin bone of hind leg.
22. Width at thurls.

It was found by Regan[17] that after an animal stood for a short time its muscles relaxed so that it actually measured less than when it first came to a standstill. For this reason the animal was moved about between each measurement for height at withers and the average of three measurements was used to show the height at withers. Numbers 1, 2 and 3 were taken with measuring standards. Numbers 4, 5, 6, 7, and 22

were taken with wooden calipers while the others were all taken with a tape graduated in centimeters. All measurements of skeletal development were recorded in centimeters. Some of the measurements secured have not been used in this connection. It has already been shown[18] that while the body does not grow symmetrically, still the height at withers is at least as accurate as any other measurement, and possibly as satisfactory as all others combined, in showing skeletal growth. In this work the height at withers is the only measurement considered, although the other 21 are available and may be made use of in other studies.

What is Normal Size or Normal Growth?—Reference has been made to normal growth, to an animal being normal in weight and to one normal in size as indicated by skeletal measurements. Tables of normal growth have been prepared at the Missouri Agricultural Experiment Station as a result of nearly ten years work[19]. This is the only extensive study of the normal rate of growth of dairy cattle of which the writers are aware. The table of normal growth of both Holstein and Jersey heifers for weight in pounds and height in centimeters is here given. This table has been used as a basis for comparison in the case of each animal.

TABLE 1.—NORMAL WEIGHT AND HEIGHT AT WITHERS OF JERSEY AND HOLSTEIN HEIFERS.

Age	Holsteins		Jerseys	
	Normal Weight	Normal height at withers	Normal Weight	Normal height at withers
Months	Pounds	Centimeters	Pounds	Centimeters
Birth	90	71.8	55	66.1
1	121	76.8	76	70.3
2	157	82.0	105	74.7
3	200	86.8	140	79.3
4	249	92.0	174	83.9
5	302	96.5	222	89.3
6	349	100.9	260	93.7
7	389	104.0	302	96.8
8	425	107.1	340	99.8
9	466	109.1	376	102.8
10	501	111.2	407	105.0
11	529	112.6	432	106.5
12	558	114.0	456	108.3
13	574	115.7	480	110.1
14	596	117.4	503	111.4
15	612	118.8	520	112.7
16	643	120.3	533	113.4
17	660	121.3	553	114.6
18	686	121.8	572	115.6
19	715	122.7	598	116.8
20	746	123.8	621	117.5
21	774	124.3	649	118.1
22	796	123.8	668	118.9
23	824	125.7	689	119.8
24	841	126.5	716	120.4
25	869	127.6	737	.....
26	893	128.2	758	.....
27	925	129.3	770	121.9
28	966	129.8	784	.....
29	994	130.4	804	.....
30	1021	130.7	...	122.6
33	...	132.0	...	123.2
36	...	132.8	...	124.2
42	...	133.7	...	124.5
48	...	134.9	...	125.6
54	...	135.5	...	125.2
60	...	136.2	...	.....
72	...	137.2	...	.....

THE EXPERIMENT

The experiment was started August 11, 1913 with two purebred Jersey heifers which will be referred to as No. 91 and No. 94. These heifers were half-sisters by the same sire. The mother of No. 91 was a smooth, compactly built cow carrying considerable flesh. The mother of No. 94 was a cow of medium flesh, conformation and general type. The general plan was to feed No. 91 a high protein plane while No. 94 was to receive a very low one. The amount of energy was to be kept approximately the same for each heifer and was intended to be sufficient to insure an adequate supply. No attempt was made to calculate the ration to meet any set standard for protein.

No. 91.—Jersey heifer No. 91 was 6 months, 15 days of age, was in splendid condition and weighed 216 pounds. This is 63 pounds below or 77.4% of the normal in weight and she was at the same time 3.1 cm. below or 96.7% of the normal in height. She was put on a ration of alfalfa hay, and a grain mixture of corn, bran and cottonseed meal. The bran and cottonseed meal were left out of the ration during the latter part of the experiment. She almost invariably took her feed regularly and seemed to relish it. When turned out in the lot she was active and seemed to be in good health and spirits. Cold weather did not affect her abnormally. She did, however, show a tendency to eat straw and lick dirt in the lot. Her gains were almost normal. Her condition of flesh was at all times good and her general health excellent. During the entire twenty-four 28-day periods she was on an arbitrarily calculated high protein plane and received an energy supply which was intended to be above the requirements. Final figures show, however, that according to the Wolff-Lehmann digestible crude protein standard she received 100.6% of the requirements, but that she received only 77.4% and 78.5% respectively of the requirements of digestible true protein according to Armsby's standard by age and by weight. In energy she actually received 95.3% and 97.1% respectively of the requirements according to Armsby by age and by weight. She was taken off experiment June 14, 1915 at the age of 28 months, 17 days. At this time she was reported as being "normal in every respect". In fact she was 75 pounds below or only 90.6% of the normal weight and 0.5 cm. below or 99.6% of the normal height and had made during the entire twenty-four periods 97.7% and 109.6% respectively of the normal gain in weight and in height. She was in splendid condition when taken off experiment.

No. 94—Jersey heifer No. 94 was 6 months, 4 days of age, was in good condition and weighed 235 pounds. This is 31 pounds below or 83.3% of the normal weight. She is at the same time 2.9 cm. above or 103.1% of the normal in height. Her ration at first consisted of timothy

hay and corn, with bone meal and calcium carbonate for the mineral.

During the first few months she became thin and peaked, inactive and unsteady and her eyes were dull. She showed a craving, ate bedding in preference to hay, licked dirt and ate gravel. After receiving calcium carbonate she seemed brighter and more active. She became lank and undeveloped but made satisfactory skeletal development. After the addition of bone meal to the ration her general condition showed slight improvement. Her eyes watered and in April she became totally blind. Following her blindness she became less active and commenced to walk in a circle almost continually and always in the same direction. She ate regularly and her digestion seemed normal. Her pelvic region became very pinched, she continued to lose in weight or to make very poor gains and to make almost normal skeletal gains giving her a tall, narrow and peculiar appearance. She came in heat for the first time on May 5, 1914 and was bred Sept. 24. During the following winter she showed the effects of the cold and stood curled up. She became more narrow, developed a low tail head and sloping rump and showed a spasmodic contraction of the tail muscles and a tendency to lick the boards of her stall. On January 20, 1915 her ration was changed to timothy, alfalfa and starch and sugar, without changing the amount of digestible protein. Later her energy was reduced to equal that of No. 91. Her condition greatly improved. She calved July 4, 1915. Her bull calf weighed 45 pounds, was weak, unable to stand, had no eyeballs but tufts of hair growing from the sockets, partially closed nasal passages and large teeth that were loose in the jaw. The calf died in a few hours. It had been carried 283 days. The cow weighed 535 pounds immediately after calving

During the entire twenty-four 28-day periods she was kept on an arbitrarily calculated low plane, and received only 49.0% of the digestible crude protein requirements recommended by the Wolff-Lehmann standard, and only 37.6% and 39.7% respectively of the digestible true protein requirements by age and by weight according to Armsby. For the entire time she consumed 99.4% and 111.0% respectively of the Armsby net energy requirements by age and by weight. The development of this heifer was very unsatisfactory. At the end of the experimental period she was not only decidedly abnormal in conformation and habits but she was decidedly undersized. Final figures show that she was 169 pounds below or only 78.6% of the normal in weight and 2.7 cm. below or only 97.8% of the normal in height. During the entire time she made only 73.6% and 80.1% respectively of the normal gain in weight and in height.

The work with No. 91 and No. 94 must be considered as preliminary to a great extent. Much of our present knowledge of nutrition

was not at that time available and conditions were not well controlled. The character of the protein may have been a limiting factor. It would seem that the mineral supply was sufficient. It is quite probable that the vitamine supply was inadequate. Lack of energy could not have been a limiting factor in the development of this heifer.

Immediately after calving she was put on a good ration intended to furnish only the required amount for maintenance and milk production. She produced 2430 pounds of milk and 97 pounds of fat in 275 days. She did not increase appreciably either in weight or in skeletal size. She freshened again July 2, 1916, dropping a calf that was blind in both eyes. The eyes seemed to be covered with a film and burst before the death of the calf which occurred within a day or two. For a time she was treated as during the previous period but was later given a liberal ration which resulted in a decided improvement. In the period from July 1916 to June 1917 she gained 222 pounds and 1.3 cm. and showed a great increase in vigor and general condition. Her production was 4368 pounds of milk and 191 pounds of fat in 357 days. A third calf was dropped in August 1917 which was carried 282 days and which seemed normal. It never received colostrum and died at the age of four days. She was fed liberally, produced 4402 pounds of milk and 208 pounds of fat and developed an excellent condition of flesh. She never increased to any appreciable extent over her skeletal measurement of June, 1915. Her fourth calf was dropped in July 1918 after being carried 279 days. The calf was normal in every respect. She was a remarkably regular breeder through her entire life. The results outlined were very interesting at the time they were secured because of the things they suggested. They do not require discussion at this time.

Additional Animals Started on Experiment.—Because of the shortcomings in the control of conditions with No. 91 and No. 94 it was thought advisable to continue the experiment with more animals in an attempt to more nearly eliminate all factors except the amount of protein, and to secure data on a number of heifers on different planes of protein intake.

Holstein heifer, No. 250, was started on experiment December 22, 1914 and Jersey heifer No. 103 on January 21, 1915. No. 250 was 6 months and 25 days old, and No. 103 was 6 months and 28 days of age. Both were in first-class condition but No. 250 weighed only 344 pounds which was 38 pounds below or only 90.1% of the normal, while No. 103 at 281 pounds was 18 pounds below or 94.0% of the normal in weight. In height No. 250 was 3.5 cm. below or only 96.6% of the normal while No. 103 was 1.6 cm. above or 101.7% of the normal. The plan was to give No. 250 the same amount of protein as was fed No. 94 when of the

same body weight, the amount to be regulated according to the weight rather than to the age of the animal. The ration was composed of timothy hay for roughage, skimmilk powder as the chief source of protein and a mixture of starch and sugar in the proportion of 11 to 3 to furnish energy. The skimmilk powder was to furnish casein and albumin, two proteins known to be adequate for maintenance and growth. The quality of protein could hardly be a limiting factor in this ration. The energy furnished was in excess of the requirement calculated by Armsby by age or by weight. The mineral content was in all probability complete and adequate, as calcium carbonate and bone meal were fed liberally from the start. After about 3 months, a daily allowance of magnesium and potassium citrates was added and the calcium carbonate was later omitted. The amount of mineral matter was at least equal to that furnished No. 91 which was considered entirely adequate. As far as the vitamine content is concerned it must now be admitted that there is a possibility of its having been a limiting factor. At that time it was thought that all factors were controlled and adequate with the exception of the amount of protein, which was the factor under consideration. Jersey heifer No. 103 was put on a medium protein plane. It was planned to furnish her an amount of protein about half way between the amounts received by No. 91 and No. 94 in the original experiment. The feeds used at the start were the same as fed No. 250 so that any limiting factor in her ration would be the same as for No. 250. The method of taking weights on these heifers was different than for No. 91 and No. 94. They were weighed every 10 days and an average of weighings on three consecutive days was made once every 30 days and was used as the weight for the end of one and the beginning of the next 30-day period. The 21 body measurements already referred to were taken once each month.

No. 250 did not eat the skimmilk powder readily at the start and scoured considerably. She was inactive and seemed to mind the cold weather abnormally. By the middle of January she seemed entirely normal except for size and was taking her ration readily. The feeding of magnesium and potassium citrates was commenced on April 6, 1915. In early June she began to refuse some feed but was in good condition of flesh and thrift. No. 103 was treated exactly the same as No. 250 except for the amount of protein given. She started off much better than did No. 250, did not scour, and seemed in normal spirits but stood humped up in cold days and occasionally refused some of her feed, especially the hay. On April 6, the citrates of magnesium and potassium were added as in the case of No. 250. In May and June she was reported as fat and sleek, in good spirits, very active and in even better condition than before going on experiment.

Holstein heifer No. 253 was placed on experiment April 21, 1915 at the age of 6 months, 9 days and was commenced on a ration of alfalfa hay to furnish protein and mineral matter, with the starch and sugar mixture to furnish the additional energy required according to standards; or in other words to practically duplicate the energy in the rations of the other heifers. The ration was arbitrarily calculated to furnish a medium amount of protein approximating that of No. 103. At the time of going on experiment this heifer weighed 375 pounds which was 14 pounds above 103.9% of the normal in weight. She was at the same time 2.5 cm. above or 102.5% of the normal in height. Up to June 1915 she took her feed regularly and appeared in normal health but failed to make normal gains.

More Definite Plan of Experiment.—Up to June 1915 an arbitrary method of calculating the protein plane had been used. The aim had been to feed an amount of protein sufficient to furnish what was considered a very low medium, or a very high quantity of protein, but to furnish approximately the same relative amount of energy, in each case approximating the standards, and to make the quality of protein the mineral supply and all other factors adequate. It was considered desirable to use a definite basis for calculating the requirements for the different animals so that the arbitrary method might be abandoned for one more nearly accurate. The difficulty of determining such a method was great. If weight alone was used, the age factor as it applied to the rate of gain was ignored. On the other hand, if age was considered regardless of weight, the error was still greater. The reasons are obvious. It was evident that both weight and age must be used in order to insure any reasonably accurate method. At best there is certain to be a considerable chance for error, because in case an animal is undersized at any time, the fact that weight is used, will limit the amount of nutrients fed the animal and consequently will prevent recuperation or recovery, because the requirements are calculated on the current weight basis and the animal is underfed according to her age requirements.

In June, 1915 L. S. Riford, a graduate student who had conducted much of the work on No. 91 and No. 94 and who had started No. 250, No. 103 and No. 253 on experiment, devised a fairly satisfactory plan for calculating the requirements of a growing heifer on the basis of both weight and age. In the first place it was necessary to have figures of the normal daily gain at the different ages of the growing period for the different breeds. It was also necessary to have values showing the amount of net energy required daily above maintenance to promote normal growth in the different dairy breeds. A table showing the normal daily gain and energy requirements for growth for Jerseys and Holsteins

from six to thirty months follows. This table was compiled from a large amount of experimental data available at the Missouri Agricultural Experiment Station in 1915. Data somewhat more complete for normal growth are available at the present time, but since these have been used throughout the entire experiment since June 1915, in calculating the requirements for the different animals, the original table is given.

TABLE 2.—NORMAL DAILY GAIN AND ENERGY REQUIREMENTS ABOVE MAINTENANCE OR FOR GROWTH.

Age	Jerseys		Holsteins	
	Normal daily gain	Energy required above maintenance daily	Normal daily gain	Energy required above maintenance daily
months	pounds	therms	pounds	therms
6 to 7	1.24	2.69	1.50	3.26
7 to 8	1.18	2.71	1.38	3.17
8 to 9	1.12	2.74	1.28	3.14
9 to 10	1.06	2.75	1.18	3.06
10 to 11	1.00	2.72	1.10	2.99
11 to 12	.95	2.71	1.04	2.97
12 to 13	.90	2.70	1.00	3.00
13 to 14	.86	2.69	.98	3.07
14 to 15	.83	2.71	.97	3.17
15 to 16	.79	2.70	.96	3.28
16 to 17	.76	2.71	.95	3.38
17 to 18	.72	2.66	.94	3.47
18 to 19	.68	2.60	.93	3.56
19 to 20	.64	2.54	.92	3.65
20 to 21	.60	2.50	.91	3.79
21 to 22	.57	2.50	.89	3.90
22 to 23	.53	2.42	.87	3.97
23 to 24	.50	2.39	.80	3.82
24 to 25	.47	2.34	.72	3.59
25 to 26	.44	2.28	.63	3.26
26 to 27	.41	2.21	.53	2.86
27 to 28	.38	2.12	.45	2.52
28 to 29	.35	2.03	.43	2.49
29 to 30	.33	1.98	.40	2.40

Plan for Calculating Requirements for Dairy Heifers.—Following are a few general principles to be considered in calculating the requirements for a growing heifer:

To determine the maintenance energy requirements for any given time, multiply the weight of the animal by 0.006. This gives the therms energy, using Armsby's value of 6.0 therms per 1000 pounds live weight or 0.006 therms per pound[20].

The total energy required is equal to the requirement for maintenance plus the requirement for growth at any given time.

To determine the total energy required for a 30-day period:

Determine the probable average weight for the following thirty days by adding to the weight at the time of calculation fifteen times the normal gain for the age of the animal according to Table 2.

Let W = Weight for any period.

Let T = Therms required daily above maintenance or for growth at the given age (see Table 2).

Then (0.006)W = Energy Maintenance requirement and (0.006)W + T = Total energy requirement.

It is assumed that the therm value of the protein required for main-

tenance should equal 8.5% of the energy value required for maintenance. This value is derived from the net energy value of digestible protein which according to Kellner[21] is 1.016 therms per pound. Since the 1000-pound animal according to Armsby[22] requires 0.5 pounds of digestible protein and 6.00 therms net energy daily, the energy value of the protein is considered to be 0.51 therms which is 8.5% of the total net energy for maintenance.

0.085 (0.006)W is then the energy value in therms necessary for maintenance, to be derived from protein.

The amount of protein above maintenance is the varying factor. For different animals different proportions of the energy available for growth is to be derived from protein.

Let P= per cent energy required for growth which is to be derived from protein.

P(T) is the energy value in therms necessary for growth to be derived from protein.

Then 0.085 (0.006)W+P(T) = the energy value in therms for maintenance and growth to be derived from protein and since each pound of protein supplies 1.016 therms of energy[23], $\frac{0.00051\ W + P(T)}{1.016}$ is the number of pounds of digestible protein which must be supplied for all purposes.

In the early part of the experiment a value of 8% for protein was considered a very low plane, a value of 15% to 20% for protein was considered a medium plane, and a value of 25% for protein was considered a high plane.

The basis of conducting the experiment was changed slightly at this time. The 10-day weights were no longer taken, but all animals were weighed on the last three successive days of each 30-day period and the average of the three weighings was used to represent the end of that period and the beginning of the next. When animals were first started on experiment they were weighed on three successive days before any rations were calculated for them. In addition to the weights the twenty-one measurements already referred to were taken every 30 days. For a time an attempt was made to take these skeletal measurements once each calendar month, but later the measurements were made on one of the three weighing dates whenever possible. As soon as the average weight was determined for the last three days of the period, calculations were made for the following 30 days. Except in case of sickness of the animal or in case of unavoidable circumstances, rations were not changed except at the beginning of a 30-day period.

The calculations for energy and protein were made on the following plan. A preliminary calculation sheet was prepared with fourteen

columns with headings as indicated. An explanation of the derivation of values for these fourteen columns follows:

1. *Date:* The date is the day previous to the beginning of a period, or the day on which the previous period ends.

2. *Herd number of animal:* Refers to the herd number of each animal on experiment. All numbers from 1 to 199 refer to Jerseys. All numbers from 200 to 299 and all numbers from 500 upward refer to Holsteins.

3. *Weight of animal:* The weight is the three-day average referred to.

4. *Age of animal:* Age is given in calendar months and days. An animal born on December 10, 1914 is 12 months and 13 days of age of December 23, 1915.

5. *Normal daily gain for age (pounds):* The normal daily gain is obtained from Table 2. At first there was no definite system of determining whether a heifer 18 months, 27 days of age, for example, should be given the value of 18 or 19 months. Later a rule was established that any heifer 20 or more days over a given month should be considered an additional month of age for all preliminary calculations.

6. *Average weight (calculated) for the ensuing 30-day period (pounds);* If an animal made a normal gain it would have an average weight for the ensuing period of its present three-day average weight plus fifteen times the normal daily gain given in column 5. Fifteen times the value in column 5 was then added to column 3.

7. *Total energy for maintenance (therms):* As an animal requires 6 therms per 1000 pounds live weight it requires 0.006 therms per pound. Column 7 is the result of multiplying column 6 by 0.006.

8. *Energy from protein for maintenance (therms):* It has been calculated as already described that 8.5 per cent of the total energy for maintenance should come from protein. Column 7 is then multiplied by 0.085 to determine the energy required for maintenance which is to be derived from protein.

9. *Energy for growth (therms):* The energy for growth is taken directly from Table 2 and on the same general plan with reference to age as already described in connection with the value for normal daily gain given in column 5.

10. *Per cent of energy for growth to be derived from protein:* The plan used is that followed by Osborne and Mendel[24] in expressing the protein in terms of per cent of net energy for growth in the form of protein. This is the basis for calculating all our experimental work. Reference is made to an animal on an 8% plane or on a 15, 20, 25 and 35% plane. The value in this column is arbitrarily selected, depending upon

the condition of the animal, the type of experiment planned and the results desired. The so-called plane of protein which will be mentioned repeatedly refers to the value chosen for column 10.

11. *Energy from protein for growth (therms):* By multiplying the value in column 9 by the value in column 10 we derive the amount of energy on which that particular plane should come from protein for the purpose of promoting growth.

12. *Total energy required for maintenance plus growth (therms):* The value for the total energy required for maintenance plus growth is secured by adding the values in columns 7 and 9.

13. *Total energy from protein (therms):* The value for the total net energy which is to be furnished by the protein is determined by adding the values in columns 8 and 11.

14. *Total digestible protein (pounds):* The energy value of protein is considered according to Kellner[25] to be 1.016 therms per pound of protein. The total pounds of protein can then be determined by dividing the value for total energy from protein in column 13 by the factor 1.016.

To further illustrate the method employed the table giving the exact figures used for heifers 250, 103 and 253 for the first period for which this method was used (June, 1915) will follow.

TABLE 3.—THE PRELIMINARY CALCULATION SHEET

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Date (1915)	Herd number of heifer	Wt of animal	Age of heifer	Normal daily gain for age	Average weight for ensuing 30-day period	Total energy for maintenance	Energy from protein for maintenance	Energy for growth	Per cent of energy for growth to be derived from protein	Energy from protein for growth	Total energy required for maintenance plus growth	Total energy from protein	Total Digestible protein
		lbs.	mo-da	lbs.	lbs.	therms	therms		Per cent	therms	therms	therms	pounds
6–19	250	420	12–22	.98	435	2.61	.222	3.07	8	.246	5.68	.468	.461
6–19	103	390	11–26	.90	404	2.42	.206	2.70	15	.405	5.12	.611	.601
6–19	253	393	8–7	1.28	412	2.47	.210	3.14	15	.471	5.61	.681	.670

It is evident that the values in columns 12 and 14 are the ones sought. They represent the calculated requirements for the desired plane in both therms net energy and pounds digestible crude protein per day. From these two values for each heifer suitable rations were calculated to meet, as nearly as possible, these requirements.

In the early part of the experiment the amount of digestible protein furnished by the different feeds was determined by using the most recent available analysis as determined and reported by the Department of Agricultural Chemistry, and multiplying the amount of feed by the per cent of protein thus determined to secure the total crude protein for that particular feed, and then multiplying the value thus derived by

the coefficient of digestibility for that particular feed as given in Henry's table[26]. The analyses were found to vary considerably and the average digestible crude protein values for the different feeds as given by Putney and Armsby[27] were subsequently used in calculating the rations for all experimental animals. In determining the actual amounts ingested, however, actual analyses were used. Average figures for protein were used in the preliminary work only.

In determining the energy value of the different feeds in the preliminary work the average net energy value given in the same table[28] were used. These same values were used in determining the amounts of energy actually consumed by the experimental animals, as no attempt was made in this work to determine experimentally the energy values of the different feeds or rations. There is one exception. Starch and sugar are not listed in the table just referred to. At the time the experiment was started a value was determined for the mixture of 11 pounds of corn starch and 3 pounds sugar from data then available from the early works by Kellner[29]. The net energy values for starch were given as 1.071 therms per pound and for sugar 0.812 therms per pound. By using these values in the proportion of 11 to 3 the value derived was 1.016 therms per pound of the mixture. Later work by Armsby shows that the net metabolizable energy of starch is 81.79 therms while for sugar it is 81.20 therms per hundred pounds. This will give values per pound of 0.8179 and 0.8120 therms. All preliminary calculations made to determine the rations to be fed, were based upon the value of 1.016 for sugar and starch or for starch alone. This will mean that, in some cases where the animals were depending to a great extent upon starch and sugar to furnish their energy, there was slightly less energy furnished than was calculated. The experiment had been under way so long, however, before this discrepancy was appreciated that the value 1.016 was used in all preliminary work throughout the entire experiment. In calculating the actual energy furnished, however, the corrected value 0.818 therms per pound was used. The values for starch and for sugar are so nearly identical that the starch value was used in all final determinations and was applied to the mixture or to the starch alone.

Another point should be mentioned regarding a correction in energy value. The original net energy value for corn is given by Putney and Armsby[30] as 0.8916 therms per pound. In a later article[31] this value is corrected to 0.8550 therms per pound. The change was comparatively slight and within the limits of probable error, and as summaries were already started and in many cases nearly completed for some of the animals it was considered desirable to secure consistent results by con-

tinuing the use of the value 0.8916 therms per pound, both in the preliminary work and in the determination of the actual energy derived from corn.

Method of Describing Plane Basis.—The method of calculating the protein and energy requirements of the different animals on the different planes has already been described. An 8% plane has been understood as one furnishing exactly the requirements in energy with 8% of the energy for growth coming from the protein. It seems probable that with an excess of energy in the ration an animal can grow normally on a smaller quantity of protein than it can when a more scanty energy supply is furnished[32]. While it has been considered from the start that all experimental heifers received at all times a sufficient energy supply, it was recognized as possible that a shortage in energy may have been responsible for some of the unsatisfactory gains secured on low and medium planes. Consequently it was thought advisable to increase the quantities of energy supplied in the rations of some of the heifers to see if improved gains would result. The quantities of increase in energy furnished were calculated on a percentage basis. The method of determining the amount of energy theoretically required has been described. When an additional quantity of energy was fed it was calculated as 25, 40 or 50% excess. In other words, if the calculated energy requirement for a heifer was 5.62 therms for a given period and it was desired to give her a 50% excess she would be given 8.43 therms. If a 40% excess were desired it would require 7.87 therms. Any reference to such a plane has been made by first stating the protein plane, followed by a plus sign and the percentage of energy excess or increase desired. Thus if an animal were on a 15% protein plane with a 40% excess of energy her plane would be referred to as a 15+40 plane. In case there were no excess of energy it would be referred to as a 15+0 plane. This method was employed in a great many cases during the latter part of the experiment and in order to avoid confusion, reference to planes hereafter will be made to include not only the protein percentage, but the percentage of energy above or below the calculated requirements. For example 15+0, 15+50, 20+0, 20+25 etc.

The Individuals on Experiment.—Since the experiment covers a long period of time and includes a large number of animals of different breeds and ages, and since some of the animals were on several different planes and types of rations a careful study of the individuals as well as the groups is essential. A table has been prepared for each heifer included in the experiment which shows her exact performance during the entire experimental period.

The Individual Summary Tables.—A brief explanation of the points considered in the summary table for each experimental heifer and the derivations of the values given deserve attention at this point.

Column 1 gives the number of the 30-day period.

Column 2 gives the age of the animal in calendar months and days at the beginning of each period. The age is determined in each case by direct subtraction. One exception to this rule is No. 277 born on January 31.

Column 3 gives the calculated plane for the animal for the period.

Column 4 gives the plane which the animal actually received. The first value is derived by multiplying the pounds digestible protein actually received by 1.016 to give the therms total energy from protein. From this is subtracted the therms energy from protein for maintenance to derive the therms energy to be secured from the protein for growth. This derived value is then divided by the total therms energy for growth and multiplied by 100 to get the per cent of energy for growth to be derived from protein. In other words, referring to the preliminary calculation sheet (Table 3) it is derived by multiplying the pounds digestible protein actually consumed, as derived by analysis, by 1.016 to determine the true value for column 13 and then using the following formula:

$$\frac{\text{Column 13-Column 8}}{\text{Column 9}} \times 100 = \text{Column 10}$$

The second number in column 4 of the individual summary table is the per cent energy above or below the amount calculated and is derived by dividing the difference between the energy actually received and the calculated energy, by the calculated energy value, and multiplying the quotient by 100. If the animal received more than the calculated requirement the result of this calculation is separated from the first number in column 4 by a plus sign. If the quantity of energy consumed was less than the calculated requirement, the result derived is separated by a minus sign. Column 4 then represents the actual plane received by the animal. For example, one animal (Table 12) was put on an 8% plane without any excess of energy allowed. In column 3 the value 8+0 appears. In Column 4 the value 8.6–7.7 is found, indicating that she received almost exactly the protein plane desired but was deficient in energy requirements to the extent of 7.7%.

Column 5 gives the pounds of digestible crude protein which the animal was supposed to require daily. This value is taken directly from Column 14 of the preliminary calculation sheet (Table 3).

Column 6 gives the average number of pounds of digestible crude protein which the animal actually received daily as determined by

analysis of feeds and by applying the average coefficient of digestibility already explained. The total protein received for the period was divided by the number of days in the period to derive the average daily value.

Column 7 gives the pounds of digestible true protein actually consumed daily by the animal. Since, according to Armsby and Fries[33] the digestible crude protein of corn is 7.5% while the digestible true protein is 7.0%, the crude true protein ratio for corn is $\frac{7.0}{7.5}$ or 93.3%. In other words 93.3% of the crude protein of corn is, on the average, digestible true protein. By applying the same principle to the other feeds we secure the following values: alfalfa hay, 67.0%; bran, 86.4%; corn, 93.3%; corn silage, 54.5%; cottonseed meal, 95.7%; oats, 89.7%; skimmilk powder, 100.0%; timothy hay, 73.3%. A value of 100.0% was assumed for bone meal. The value in column 7 was derived by multiplying the digestible crude protein consumed in each feed by its respective coefficient, adding the results to secure the total digestible true protein for the period, and dividing by the number of days in the period to secure the daily average. This value is based entirely on Armsby's average figures and is used only as a comparison for Armsby's standards.

Column 8 gives the pounds digestible true protein required daily for an animal of the *age* of this particular heifer according to Armsby's table[34]. The table from which these values were derived was elaborated by plotting graphically on a large scale the values given by Armsby and connecting the points thus plotted with straight lines. The values for intermediate points were then taken directly from the plot. Undoubtedly it would have been slightly more nearly accurate to connect these points with properly curved instead of straight lines, but such procedure was considered unnecessary for an approximation of this sort. When this plot had been completed a table was developed from it with values given for each half month, from 6 months to 30 months of age. Since the original table was continued only until 30 months and since a few of our heifers were kept on experiment until a more advanced age than that, the value of 1,200 pounds digestible true protein per day was used for all ages above 30 months. No attempt was made to determine values nearer than to the half month. Since the animals on experiment were of variable ages, all animals were given an even month value if less than 8 days or more than 22 days more than an even month in age. If the odd days fell between 8 days and 22 days the heifer was given the half-month value.

Column 9 gives the pounds digestible true protein required daily for an animal of the *weight* of the particular heifer under consideration

according to Armsby[35]. These values were derived in exactly the same manner as the values according to age. The values in Armsby's table were plotted to a large scale and the points were connected with straight lines. The table was then elaborated to give values for each ten pounds increment from 200 pounds to 800 pounds. Some of our experimental heifers weighed even more than 1,000 pounds before they were taken off experiment, but since the increase from 700 to 800 pounds in weight was not attended by any increase in protein requirement, the value of 1.200 pounds protein daily was used for all animals weighing above 800 pounds.

Column 10. Since the values given by Armsby are all based on the *true* protein standard it seems advisable to compare our calculated and actual daily digestible *crude* protein intake with a standard for digestible *crude* protein. The Wolff-Lehmann standard for growing dairy cattle[36] is used for this purpose. The elaboration of the Wolff-Lehmann table was performed in exactly the same manner as described in connection with the Armsby tables. Definite values are given for definite weights making it very simple to elaborate the table according to weight. However, since the corresponding values for ages are applicable to ages ranging between 3 and 6 month limits, the table for age would at best be very indefinite and its elaboration was not attempted. The highest value given for weight was for a 900-pound animal. Some of our heifers went above this weight. The value 1.350 pounds digestible crude protein daily was used in all such instances.

Column 11 gives the number of pounds digestible crude protein actually consumed for every pound of gain made in live weight. This value is derived by multiplying value in column 6 by 30 and dividing the result by the number of pounds gain in weight for the 30-day period. In several cases an actual loss in weight occurred for one or more periods. In such cases, the value was derived by grouping two or more periods together until a gain was actually secured and the total for the two or more periods for column 6 was multiplied by 30 and the result divided by the gain in pounds made during the corresponding two or more periods. This value was then entered for each period used in the calculation. Exceptions occur in the case of No. 91 and No. 94 which were on a 28-day period basis. In these cases the value 28 instead of 30 was used.

Column 12 gives the total therms net energy required daily according to column 12 of the preliminary calculation sheet (see Table 3). This value was taken directly from the preliminary calculation sheet.

Column 13 gives the total therms net energy actually furnished daily. This value was derived as already explained by applying the net energy values given by Armsby and Fries[37] to each of the feeds actually

consumed during the 30-day period, totaling the results, and dividing by 30 to reduce it to a daily average. Exceptions occur in the case of No. 91 and No. 94.

Column 14 gives the daily net energy requirements for growing dairy animals of the same *age* according to Armsby[38]. As described in connection with column 8, Armsby's table already referred to was elaborated to give a value for net energy for each half month from 6 to 30 months. For animals over 30 months of age the energy requirement was increased 0.10 therm per month or 0.05 therm for each halfmonth.

Column 15 gives the corresponding value for daily net energy requirements except that it is calculated on the basis of *weight* instead of age. The table was prepared in exactly the same manner. Since the weights in the table do not continue above 800 pounds, provision was necessary for animals heavier than that. The surface of similarly shaped bodies are proportional to the two-thirds powers of their volumes. The specific gravity of animals varies only slightly and it may be assumed that the body surfaces of animals of the same general shape are in proportion to the two-thirds powers of their weights. Since the energy requirement is almost proportional to the body surface, the values for 1,000 and 1,200 pounds were worked out on the basis of the 800-pound value by using the formula[39]: $S = K W^{2/3}$ in which S = Surface, K = Constant for all similarly shaped animals, and W = Weight of animal.

Since the value given for 800 pounds is 8.2 therms daily, the values derived for 1,000 and 1,200 pounds respectively were 9.515 and 10.74 therms daily. These values were used in the elaboration of the original table.

Column 16 gives the number of therms net energy actually ingested for each pound of gain made in the weight of the animal. It is derived by multiplying the value in column 13 by 30 and dividing the result by the number of pounds live weight gained during the 30-day period. Exceptions occur in the case of No. 91 and No. 94 which were on a 28-day basis. The explanation made in discussing the method of derivation of column 11, relative to the determination of the value when a loss in weight occurred, will apply to this column.

Column 17 gives the normal weight for an animal of the age and breed of the heifer under consideration. Values for this column were secured from the normal weight tables prepared by Eckles[40]. The values in the tables referred to are given for each month of the age of a heifer from birth to thirty months. Animals whose ages fell between the even months were assigned proportionate normal values.

Column 18 gives the actual weight value derived by averaging the three weights secured at the beginning of the experiment and on the

last three days of the preceding period. This average weight has been used each time as a basis for calculating the requirements for the heifer for the following period.

Column 19 gives the number of pounds above or below normal weight. The value for this column is the difference between the values in columns 17 and 18. A plus or a minus sign indicates whether the animal was above or below the normal weight.

Column 20 gives the per cent of normal weight of the animal at the beginning of each period and at the end of the experiment.

Column 21 gives the per cent of normal gain in weight which the animal made while on any one calculated plane. The table is divided according to the calculated plane on which the animal was placed. This value is derived by dividing the actual pounds gain made on any one such plane by the normal gain for the same 30-day periods. In some cases this figure represents only one, and in some cases as many as twenty-five periods. In every case it represents the entire time on any one plane.

TABLE 4.—SUMMARY TABLE FOR JERSEY HEIFER No. 91.

1	2	3	4	5	6	7	8	9	10	11	12	13
28-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.-da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	6 14		21.4–15.4	.....	.686	.425	.859	.741	.730	.800	4.10	3.47
2	7 11		24.5– 7.0	.....	.784	.647	.876	.786	.780	.523	4.26	3.96
3	8 9		30.9–10.4	.....	.989	.817	.892	.856	.860	1.065	4.53	5.00
4	9 6		36.1–23.2	.....	1.143	.944	.900	.885	.905	.914	4.69	5.78
5	10 4		35.9–18.7	.....	1.143	.944	.934	.920	.920	1.104	4.87	5.78
6	11 2		35.5–14.9	.....	1.143	.944	.967	.960	.935	1.185	5.03	5.78
7	11 29		35.2–11.6	.....	1.143	.944	1.000	1.000	.950	1.778	5.18	5.78
8	12 26		37.8–17.1	.....	1.219	1.008	1.016	1.013	.960	1.796	5.27	6.17
9	13 26		31.2– 0.7	.....	1.059	.875	1.033	1.026	.970	.899	5.40	5.36
10	14 23		33.9– 3.4	.....	1.143	.944	1.050	1.046	.985	1.391	5.59	5.78
11	15 21		26.7– 2.8	.....	.967	.778	1.058	1.060	.995	1.231	5.73	5.89
12	16 18		21.3– 1.7	.....	.832	.651	1.075	1.074	1.012	.728	5.86	5.96
13	17 16		21.2– 0.5	.....	.836	.653	1.092	1.100	1.065	1.463	6.00	5.97
14	18 13		20.1– 3.3	.....	.802	.630	1.108	1.106	1.077	1.727	6.03	5.83
15	19 10		21.7– 1.3	.....	.836	.653	1.124	1.116	1.097	1.561	6.05	5.97
16	20 8		24.6– 2.0	.....	.906	.716	1.141	1.126	1.117	1.103	6.09	5.97
17	21 5		31.0– 5.8	.....	1.075	.831	1.150	1.140	1.145	7.525	6.23	6.59
18	22 3		40.9–16.9	.....	1.290	.978	1.166	1.146	1.155	.785	6.17	7.21
19	23 1		40.4–12.3	.....	1.290	.978	1.183	1.173	1.207	2.580	6.42	7.21
20	23 28		41.1–12.0	.....	1.290	.978	1.200	1.188	1.235	1.806	6.44	7.21
21	24 25		38.0– 3.8	.....	1.207	.900	1.200	1.200	1.260	*5.786	6.50	6.26
22	25 25		36.9–12.0	.....	1.168	.863	1.200	1.200	1.269	*5.786	6.58	5.75
23	26 22		38.3–10.6	.....	1.169	.863	1.200	1.200	1.269	*5.786	6.48	5.79
24	27 20		42.0– 9.4	.....	1.209	.863	1.200	1.200	1.269	*5.786	6.39	5.79
	28 17		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Av.	17 15	Arbitrary high plane	31.9– 3.5	.....	1.055	.826	1.068	1.053	1.049	2.296	5.66	5.85

*Because of a loss in weight the average of four periods taken

Column 22 gives in centimeters, the normal height at withers, for animals of the same age and breed. These values are taken from the tables prepared by Eckles[41] and interpolated in the same manner as the normal weight values in column 17.

Column 23. The actual height at withers was determined every 30 days by taking at least three measurements with measuring standards and averaging the three values. These measurements correspond to the actual weights given in column 18.

Column 24 gives the number of centimeters above or below the normal for the particular age of the heifer.

Column 25 gives, in per cent of normal height at withers, the size of the animal at the beginning of each period and at the end of the experiment.

Column 26 shows the per cent of normal gain in height at withers made on the calculated plane. Derivation is the same as for Column 21.

In the summary tables each calculated plane is handled as a unit except in a very few cases where the change in plane has been too

BORN JANUARY 27, 1913. ON EXPERIMENT AUGUST 11, 1913

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.16	3.82	4.05	279	216	−63	77.4		95.1	92.0	−3.1	96.7	
4.24	3.93	2.64	316	240	−76	75.9		97.9	94.0	−3.9	96.0	
4.34	4.12	5.38	351	282	−69	80.3		100.7	97.5	−3.2	96.8	
4.40	4.31	4.62	382	308	−74	80.6		103.2	99.5	−3.7	96.4	
4.62	4.54	5.58	410	343	−67	83.7		105.2	101.3	−3.9	96.3	
4.86	4.82	5.99	434	372	−62	85.7		106.6	103.2	−3.4	96.8	
5.10	5.10	8.99	455	399	−56	87.7		108.2	105.0	−3.2	97.0	
5.32	5.28	9.09	477	417	−60	87.4		109.9	106.5	−3.4	96.9	
5.53	5.44	4.55	500	436	−64	87.2		111.2	108.0	−3.2	97.1	
5.76	5.70	7.04	516	469	−47	90.9		112.4	108.8	−3.6	96.8	
5.86	5.88	7.50	529	492	−37	93.0		113.1	109.0	−4.1	96.4	
6.07	6.04	5.22	545	514	−31	94.3		114.1	111.0	−3.1	97.3	
6.28	6.40	10.45	563	546	−17	97.0		115.1	113.3	−1.8	98.4	
6.50	6.48	12.56	583	562	−21	96.4		116.1	115.0	−1.1	99.1	
6.70	6.60	11.14	606	575	−31	94.9		117.0	115.8	−1.2	99.0	
6.90	6.72	7.27	628	590	−38	93.9		117.7	117.5	−0.2	99.8	
7.00	6.88	46.13	652	613	−39	94.0		118.2	117.5	−0.7	99.4	
7.20	6.96	4.39	670	617	−53	92.1		119.0	117.5	−1.5	98.7	
7.40	7.28	14.42	690	663	−27	96.1		119.8	118.5	−1.3	98.9	
7.60	7.44	10.09	714	677	−37	94.8		120.4	119.8	−0.6	99.5	
7.70	7.60	*28.75	734	697	−37	95.0		120.8	119.8	−1.0	99.2	
7.80	7.72	*28.75	755	722	−33	95.6		121.3	120.8	−0.5	99.6	
7.90	7.72	*28.75	767	720	−47	94.5		121.8	120.9	−0.9	99.3	
7.95	7.72	*28.75	719	721	−58	92.6		122.0	121.5	−0.5	99.6	
.....	.....	.....	795	720	−75	90.6	97.7	122.3	121.8	−0.5	99.6	109.6
6.13	**6.03**	**12.59**	**565**	**516**	**−49**	**90.1**		**113.2**	**111.0**	**−2.1**	**98.0**	

slight to be of consequence. Since each plane is considered as a unit it must contain the initial and the final weights and measurements. Columns 2, 17, 18, 19, 20, 22, 23, 24 and 25 extend down one line below the others. These extended values represent the end of the last period included in that particular plane and except at the end of the experiment are the same as the initial values for the following group of periods of subsequent plane. They are therefore included twice, once with each plane. The average value is given at the end of each group of periods which constitute a plane, with the exception of column 1 which shows

TABLE 5.—SUMMARY TABLE FOR JERSEY HEIFER No. 94

1	2	3	4	5	6	7	8	9	10	11	12	13
28-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.-da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	6 4		6.9+ 8.8	.....	.311	.210	.850	.772	.770	.207	4.21	4.58
2	7 1		7.7+16.1	.....	.354	.318	.868	.856	.860	.367	4.48	5.20
3	7 29		9.5+32.3	.....	.417	.375	.884	.875	.900	.687	4.64	6.14
4	8 26		8.2+21.0	.....	.393	.354	.900	.896	.910	1.223	4.77	5.77
5	9 24		7.5+15.1	.....	.378	.341	.934	.907	.915	1.764	4.83	5.56
6	10 22		8.1+17.8	.....	.393	.354	.950	.920	.920	.579	4.83	5.69
7	11 19		7.4+13.0	.....	.383	.345	.984	.939	.927	.511	4.92	5.56
8	12 16		9.5+30.0	.....	.450	.406	1.008	.973	.940	.840	5.04	6.55
9	13 16		9.9+24.3	.....	.437	.393	1.026	.986	.945	.350	5.11	6.35
10	14 13		9.2+27.2	.....	.467	.420	1.043	1.020	.965	.934	5.34	6.79
11	15 11		8.3+23.8	.....	.448	.403	1.058	1.026	.970	*12.138	5.41	6.70
12	16 8		7.4+12.4	.....	.419	.379	1.075	1.020	.965	*12.138	5.34	6.00
13	17 6		7.1+ 7.1	.....	.413	.376	1.084	1.026	.970	.890	5.38	5.76
14	18 3		7.9+15.4	.....	.436	.395	1.100	1.040	.980	.872	5.39	6.22
15	19 0		7.9+16.1	.....	.442	.399	1.116	1.046	.985	1.125	5.47	6.35
16	19 28		9.4+15.9	.....	.482	.432	1.132	1.053	.990	2.249	5.48	6.35
17	20 25		11.4+28.2	.....	.529	.478	1.150	1.060	.995	1.058	5.47	7.01
18	21 23		13.0+38.2	.....	.576	.520	1.166	1.066	1.000	1.344	5.55	7.67
19	22 21		13.2+38.4	.....	.576	.520	1.174	1.074	1.012	.576	5.54	7.67
20	23 18		19.9+ 3.3	.....	.745	.521	1.191	1.094	1.051	.596	5.68	5.87
21	24 15		20.6— 6.0	.....	.767	.515	1.200	1.116	1.097	.671	5.83	5.48
22	25 15		11.4—13.3	.....	.565	.381	1.200	1.140	1.145	*3.651	5.96	5.17
23	26 12		11.2—14.4	.....	.565	.381	1.200	1.153	1.170	*3.651	6.04	5.17
24	27 10		12.6— 9.8	.....	.565	.381	1.200	1.132	1.130	*3.651	5.73	5.17
	28 7			.....	.....	.....	.....	.....	.....	.....	.....	.....
Av.	17 5	Arbitrary low plane	10.2+15.0	.....	.480	.400	1.062	1.008	.980	2.142	5.27	6.03

*Because of a loss in weight, the average of two or more periods taken

the number of the period, and columns 21 and 26 which include only the values which represent the entire plane. In case one plane was used throughout four 30-day periods, the averages in columns 2, 17, 18, 19, 20, 22, 23, 24 and 25 were derived by adding the entire five values and dividing by five while all other column averages were derived by adding the four values for the plane and dividing by four.

A Discussion of Individual Development.—No. 91 and No. 94 had already completed their experimental period before the definite plan of procedure was put into operation. For the sake of comparison

and because of the fact that they represent long periods of time on one plane, summary tables have been prepared for them. No. 250, No. 103, and No. 253 were commenced on experiment while the arbitrary plan was still being used, but since the arbitrary calculations represent only a comparatively small portion of the period of experiment for these three animals they are, as far as possible, summarized and discussed on the same basis as the others. A discussion of results with No. 91 and No. 94 has already been given. A discussion of the results with each of the other heifers on experiment will follow. (See Tables 4 and 5.)

BORN FEBRUARY 7, 1913. ON EXPERIMENT AUGUST 11, 1916

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.10	3.90	3.05	266	235	−31	88.3		94.1	97.0	+2.9	103.1	
4.20	4.12	5.39	303	277	−26	91.4		96.9	98.5	+1.6	101.6	
4.30	4.24	10.11	339	304	−35	89.7		99.7	99.5	−0.2	99.8	
4.40	4.37	17.95	371	321	−50	86.5		102.4	101.0	−1.4	98.6	
4.62	4.44	25.95	401	330	−71	82.3		104.6	103.8	−0.8	99.2	
4.74	4.54	8.39	425	336	−89	79.1		106.1	104.6	−1.5	98.6	
4.98	4.68	7.41	447	355	−92	79.4		107.6	105.5	−2.1	98.0	
5.19	4.91	12.23	469	376	−93	80.2		109.3	106.0	−3.3	97.0	
5.42	5.00	5.08	492	391	−101	79.5		110.8	107.3	−3.5	96.8	
5.64	5.36	13.58	510	426	−84	83.5		112.0	109.8	−2.2	98.7	
5.86	5.44	*177.80	525	440	−85	83.8		113.0	109.0	−4.0	96.5	
6.07	5.36	*177.80	538	428	−110	79.6		113.7	110.5	−3.2	97.2	
6.19	5.44	12.41	557	442	−115	79.4		114.8	112.0	−2.8	97.6	
6.40	5.62	12.44	575	455	−120	79.1		115.7	113.0	−2.7	97.7	
6.60	5.70	16.16	598	469	−129	78.4		116.8	114.3	−2.5	97.9	
6.80	5.79	29.63	619	480	−139	77.5		117.5	115.5	−2.0	98.3	
7.00	5.88	14.02	644	486	−158	75.5		118.9	115.6	−2.4	98.0	
7.20	5.96	17.90	664	500	−164	75.3		118.7	115.8	−2.9	97.6	
7.30	6.04	7.67	683	512	−171	75.0		119.5	116.0	−3.5	97.1	
7.50	6.30	4.69	705	540	−165	76.6		120.2	117.5	−2.7	97.8	
7.65	6.60	4.80	727	575	−152	79.1		120.7	119.4	−1.3	98.9	
7.75	6.88	*33.41	748	607	−141	81.1		121.2	119.4	−1.8	98.5	
7.85	7.04	*33.41	763	633	−130	83.0		121.6	119.9	−1.7	98.6	
7.95	6.80	*33.41	775	595	−180	76.8		122.0	119.5	−2.5	98.0	
.....	.....	.....	789	620	−169	78.6	73.6	122.2	119.5	−2.7	97.8	80.1
6.07	5.43	28.53	557	445	−112	81.1		112.8	110.8	−2.0	98.4	

No. 250. (*See Table* 6.) At the time the new system of calculating went into effect in June, 1915, Holstein heifer No. 250 was only 73.7% of the normal in weight but was 97.1% of the normal in height. She had made in the first six 30-day periods only 40.4% of the normal gain in weight but had made 100.8% of the normal gain in height. This was in spite of the fact that she was reported as being in normal condition. Following the introduction of the new system of calculation, at which time this heifer was taken from an arbitrarily calculated plane and commenced on an 8+0 plane, she continued to make very poor gains in weight but made almost exactly normal gains in height. In

the early part of the winter of 1915 she was thin and rough but apparently in good physical health. In December the manner of feeding was changed. Up to this time considerable quantities of the starch and sugar had been wasted. From this time the hay was cut and moistened with water. The starch and sugar mixture was then added to the moistened hay until it was thoroughly mixed with it and sticking to it. It was thought probable that it would be somewhat more readily digestible when fed in this manner. In January and February, 1916 she showed some improvement in physical condition and resistance to cold but in February was 205 pounds below the normal weight. All through the summer and fall of 1916 she continued to get farther and farther from the normal weight until in September she was 275 pounds below normal. At this time she was only 70.9% of the normal in weight but was 98.0% of the normal in height. Her condition was considered serious. She ate well, seemed in good health, and to possess good vigor and was reason-

TABLE 6.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 250.

1	2		3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period		Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
								By age	By weight				
	mo.–da.				lbs.	lbs.	lbs.	lbs.	lbs	lbs	lbs	therms	therms
1	6	25	Arbitrary low plane	6.9+ 0.5	.....	.409	.393	.868	.920	.920	.423	5.46	5.43
2	7	24		8.1+ 1.4	.....	.450	.434	.884	.960	.935	1.038	5.53	5.61
3	8	23		9.1+ 3.4	.....	.486	.468	.900	.986	.945	.858	5.57	5.76
4	9	25		9.2+ 2.1	.....	.489	.472	.934	1.000	.950	4.890	5.59	5.71
5	10	24		7.7+ 0.9	.....	.441	.425	.967	1.006	.955	1.470	5.53	5.58
6	11	24		8.2+ 1.6	.....	.457	.439	1.000	1.013	.960	2.742	5.55	5.64
7	12	23	8+0	8.8+ 3.0	.461	.485	.467	1.016	1.013	.960	*1.464	5.68	5.85
8	13	23	8+0	8.7+ 4.5	.470	.491	.464	1.033	1.013	.960	*1.464	5.80	6.06
9	14	22	8+0	8.2+ 6.0	.470	.475	.447	1.043	1.026	.970	2.375	5.81	6.16
10	15	21	8+0	8.9+ 5.8	.492	.521	.486	1.058	1.033	.975	.782	6.07	6.42
11	16	21	8+0	9.3+ 4.5	.508	.550	.512	1.075	1.046	.985	*.928	6.27	6.55
12	17	20	8+0	8.7+ 6.7	.508	.533	.490	1.092	1.040	.980	*.928	6.27	6.69
13	18	20	8+0	8.5+ 6.3	.529	.558	.513	1.108	1.066	1.000	.598	6.65	7.07
14	19	19	8+0	9.0+ 5.4	.558	.593	.549	1.124	1.087	1.040	.613	6.89	7.26
15	20	18	8+0	8.8+ 4.2	.585	.616	.572	1.141	1.106	1.077	.840	7.22	7.52
16	21	19	8+0	9.0+ 4.4	.605	.643	.598	1.158	1.120	1.105	.965	7.46	7.79
17	22	18	8+0	8.8+ 4.1	.621	.654	.608	1.174	1.132	1.130	.727	7.65	7.96
18	23	18	8+0	8.8+ 4.1	.622	.651	.603	1.191	1.153	1.170	9.765	7.65	7.96
19	24	17	8+0	8.2+ 1.1	.607	.615	.570	1.200	1.153	1.170	*1.047	7.47	7.55
20	25	17	8+0	9.9+ 4.2	.607	.676	.629	1.200	1.146	1.155	*1.047	8.16	7.82
21	26	16	8+0	10.4+ 5.2	.564	.631	.584	1.200	1.180	1.220	3.786	6.91	7.27
22	27	15	8+20	10.0+33.4	.539	.589	.545	1.200	1.180	1.220	.384	6.59	8.79
23	28	15	8+20	10.0+26.5	.560	.609	.566	1.200	1.200	1.269	*7.660	6.83	8.64
	29	14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Av	18	5	8+2	8.8+5.6	.405	.549	.515	1.077	1.069	1.045	2.035	6.46	6.83
24	29	14	Arbitrary high plane	24.2+29.3	.539	.923	.772	1.200	1.194	1.247	*7.660	6.59	8.52
25	30	14		23.3+25.7	.554	.916	.767	1.200	1.200	1.269	.528	6.77	8.51
26	31	13		21.1+20.2	.576	.890	.749	1.200	1.200	1.295	.524	7.08	8.51
27	32	12		18.0+15.2	.676	.912	.762	1.200	1.200	1.318	.684	7.39	8.51
28	33	14		22.2+11.5	.627	.962	.804	1.200	1.200	1.336	.627	7.63	8.51
	34	13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Av.	31	28		21.8+20.3	.594	.921	.771	1.200	1.199	1.293	2.005	7.09	8.51

*Because of a loss in weight, the average of two periods taken

ably active, but seemed much younger than she really was, and the fact that she was only approximately two-thirds of normal in weight seemed serious. Since all other factors except quantity of protein and energy were thought to be satisfied, the energy supply of this heifer was arbitrarily increased about 15 or 20 per cent. It was planned to keep her on this increased energy for a few months and in case she did not respond, to increase her protein. The increase in energy was furnished largely by an increase in starch and sugar. The first month after the increase she made a decidedly improved gain of 46 pounds. However, the following month she actually lost 25 pounds. Evidently the increase of the first month was not caused by the increase of energy in the ration. In commenting upon this change at the present writing, it would seem that a period of 60 days is hardly sufficient on which to draw conclusions. However, in order to carry out the plans made in September, 1916, her ration was changed in November, 1916 so that it furnished approxi-

BORN MAY 27, 1914. ON EXPERIMENT DECEMBER 22, 1914

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.20	4.54	5.62	382	344	−38	90.1		103.3	99.8	−3.5	96.6	
4.30	4.82	12.95	418	373	−45	89.2		106.5	102.3	−4.2	96.1	
4.40	5.00	10.16	456	386	−70	84.6		108.7	105.0	−3.7	96.6	
4.62	5.10	57.10	495	403	−92	81.4		110.9	107.8	−3.1	97.2	
4.86	5.18	18.60	523	406	−117	77.6		112.3	108.4	−3.9	96.5	
5.10	5.28	33.84	552	415	−137	75.2		113.7	110.5	−3.2	97.2	
5.32	5.28	*17.87	570	420	−150	73.7		115.4	112.0	−3.4	97.1	
5.53	5.28	*17.87	591	420	−171	71.1		117.1	112.3	−4.8	95.9	
5.64	5.44	30.80	608	440	−168	72.4		118.5	113.4	−5.1	95.7	
5.86	5.52	9.63	634	446	−188	70.3		119.9	114.8	−5.1	95.7	
6.07	5.70	*11.35	655	466	−189	71.1		120.9	115.8	−5.1	95.8	
6.28	5.62	*11.35	677	458	−219	67.7		121.4	115.8	−5.6	95.4	
6.50	5.96	7.58	705	501	−204	71.1		122.1	116.5	−5.6	95.4	
6.70	6.22	7.51	735	529	−206	72.0		123.4	117.8	−5.6	95.5	
6.90	6.48	10.25	763	558	−205	73.1		124.1	120.5	−3.6	97.1	
7.10	6.64	11.69	788	580	−208	73.6		124.7	121.5	−3.2	97.4	
7.30	6.80	8.84	813	600	−213	73.8		125.4	122.7	−2.7	97.8	
7.50	7.04	119.40	834	627	−207	75.2		126.0	124.3	−1.7	98.7	
7.65	7.04	*12.46	857	629	−228	73.4		127.2	124.7	−2.5	98.0	
7.75	6.96	*12.46	883	624	−259	70.7		128.0	124.5	−3.5	97.3	
7.85	7.36	43.62	910	666	−244	73.2		128.8	125.7	−3.1	97.6	
7.95	7.36	5.73	946	671	−275	70.9		129.6	127.0	−2.6	98.0	
8.05	7.72	*85.80	980	717	−263	73.2		130.1	127.0	−3.1	97.6	
.....	.....	.....	1007	692	−315	68.7	55.7	130.5	126.7	−3.8	97.1	98.9
6.24	6.01	24.46	699	515	−184	74.7		120.4	116.5	−3.8	96.8	
8.15	7.52	*85.80	1007	692	−315	68.7		130.5	126.7	−3.8	97.1	
8.25	7.72	4.91	‡1037	723	−314	69.7		131.0	128.1	−2.9	97.8	
8.35	8.08	5.01	‡1067	775	−292	72.6		131.4	128.3	−3.1	97.6	
8.45	8.40	6.38	‡1097	826	−271	75.3		131.7	130.5	−1.2	99.1	
8.55	8.66	5.55	‡1127	866	−261	76.8		132.1	130.6	−1.5	98.9	
.....	.....	.....	‡1157	912	−245	78.8	146.7	132.4	130.8	−1.6	98.8	215.8
8.35	8.08	21.53	1082	799	−283	73.7		131.5	129.2	−2.4	98.2	

‡Because of lack of normals, average of four previous periods taken, and 30 pounds per month used

mately 50% more digestible crude protein than she had received previously. She had been receiving about 0.6 pounds of digestible protein daily but the amount was raised to approximately 0.9 pound. The increased amount of energy which had been fed in September and October was continued with the increased protein.

From the beginning of the experiment up to the time the protein was raised, this heifer continued to make unsatisfactory gains and at that time was 315 pounds below or only 68.7% of the normal in weight and was 3.8 centimeters below or 97.1% of the normal in height. During these twenty-three 30-day periods she made 55.7% and 98.9% respectively of the normal gain in weight and height. During this entire time she received an average of 52.5% of the digestible crude protein specified by the Wolff-Lehmann standard and 47.8% and 48.1% according to age and weight respectively of the digestible true protein recommended by Armsby, and the net energy received was 109.5% and 113.6% respectively of that recommended by Armsby according to age and weight. She remained for five periods on the increased protein plane. From the time the protein was increased the heifer made steady and greatly increased gains. At the termination of the five periods on the high plane she was 245 pounds below or 78.8% of the normal in weight and 1.6 centimeters below or 98.8% of the normal in height. She made in the five periods 146.7% and 215.8% respectively of the normal gain in weight and height. The digestible crude protein received was 71.2% of that recommended by the Wolff-Lehmann Standard while the digestible true protein for the five periods was 64.2% and 64.3% respectively of the amount recommended by Armsby by age and by weight. The net energy was 101.9% and 105.4% respectively of that recommended by Armsby by age and by weight.

Since our normal values for weight do not go beyond 30 months the normal had to be extended. It is found that the normal weight of Holsteins increases approximately 30 pounds a month from the ages of 26 to 30 months. The value of one pound per day was used to represent the normal growth of Holsteins above 30 months. It is believed that this is greater than the actual normal gain. This being the case the percentage of normal gain in weight given for the last five periods is too low. These are the most satisfactory gains the heifer made at any time.

At the time of taking her off experiment on April 9, 1917 she was heavy with calf. This will partly account for her good gains during the last five periods but can account for only a small part of it. It seems probable that the increased protein was largely responsible for the splendid gains obtained. At the time of removal from experiment she

weighed 912 pounds, and was in splendid condition of health. In order that she might become adjusted to her ration and conditions she was taken off experiment at the age of 34 months and previous to calving. On April 26, 1917 she gave birth to a bull calf. The calf was carried 277 days, weighed 87 pounds at birth and was normal. The cow was immediately placed on official test and finished the year with a two-year-old record of 15,614 pounds of milk and 425 pounds of fat. She was always somewhat undersized.

No. 103. (*See Table* 7).—At the beginning of the experiment Jersey heifer No. 103 weighed 281 pounds which was 18 pounds below or 94.0% of the normal in weight. She was also 101.7% of the normal in height. As already stated she was put on a plane of protein planned to be about midway between the high plane of No. 91 and the low plane of No. 94. The character of the ration was to be the same as for No. 250. At the time the new system of calculating was introduced she was 64 pounds below or only 85.9% of the normal in weight but was 1.4 centimeters above or 101.3% of the normal in height. This means that on the arbitrarily calculated medium plane, the heifer had in six 30-day periods made only 70.3% of the normal gain in weight but had made 98.2% of the normal gain in height. Following the introduction of the new method of calculation the animal received almost exactly the same amounts of digestible protein and energy as previously. In July and August she was reported as a little thin in flesh but eating well and in good health. In November and December it was observed that she was making somewhat better gains but that she was getting farther from the normal weight curve. Beginning in January, 1916, the hay was cut and moistened and the starch and sugar mixed with it, as was done for No. 250. In May she was reported as very active, sleek and in splendid condition and as being close to the normal in height but somewhat below the normal in weight.

She was taken off experiment July 13, 1916. At that time she was 84 pounds below or 88.5% of the normal in weight and 0.7 centimeter above or 100.6% of the normal in height. During the entire eighteen 30-day periods on a medium plane she made 84.7% and 96.3% respectively of the normal gain in weight and height. She received an average of 66.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and 61.2% and 62.6% respectively of the digestible true protein according to Armsby by age and by weight. The net energy received was 104.5% and 109.6% respectively of the amount called for by Armsby by age and by weight. She calved on July 14, 1916. The calf was a heifer, weighed 42 pounds at birth and had been carried 275 days. It was apparently normal at birth but died of scours within a

TABLE 7.—SUMMARY TABLE FOR JERSEY HEIFER NO. 103.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo –da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	6 28	Arbitrary medium plane	13.7+ 3.1	.....	.512	.508	.868	.856	.860	1.030	4.49	4.63
2	7 27		22.2+25.1	.....	.752	.739	.884	.860	.865	.550	4.59	5.74
3	8 29		25.6+29.2	.....	.868	.854	.900	.913	.918	1.302	4.86	6.28
4	9 28		14.2+ 7.8	.....	.572	.557	.934	.939	.928	.636	4.99	5.38
5	10 28		16.2+15.5	.....	.636	.617	.967	.976	.942	3.180	5.11	5.90
6	11 27	15+0	16.5+10.2	.601	.643	.622	1.000	.986	.945	1.754	5.12	5.64
7	12 27	15+0	15.9+ 8.6	.610	.635	.612	1.016	1.000	.950	.953	5.23	5.68
8	13 26	15+0	15.3+ 9.0	.617	.624	.601	1.033	1.013	.960	1.872	5.31	5.79
9	14 25	15+0	16.1+ 8.6	.629	.658	.631	1.050	1.020	.965	1.097	5.44	5.91
10	15 25	15+0	16.4+ 8.0	.630	.668	.638	1.066	1.033	.976	1.253	5.47	5.91
11	16 24	15+0	15.3+ 8.6	.639	.648	.616	1.084	1.043	.982	.670	5.56	6.04
12	17 24	15+0	15.7+10.8	.642	.662	.624	1.100	1.060	.998	.685	5.65	6.26
13	18 23	15+0	15.9+ 9.7	.651	.675	.637	1.116	1.080	1.025	.810	5.80	6.36
14	19 22	15+0	16.5+13.9	.654	.693	.649	1.132	1.100	1.065	.693	5.88	6.70
15	20 23	15+0	16.4+13.1	.663	.698	.657	1.150	1.120	1.105	.722	6.02	6.81
16	21 22	15+0	13.4+11.9	.679	.641	.664	1.166	1.138	1.140	1.068	6.20	6.94
17	22 22	15+0	15.9+12.7	.675	.699	.655	1.183	1.150	1.162	1.498	6.22	7.01
18	23 21	15+0	16.0+12.0	.678	.702	.658	1.200	1.160	1.182	2.633	6.27	7.02
	24 21	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Av.	15 25	15+0	16.5+12.1	.465	.666	.641	1.047	1.025	.998	1.245	5.46	6.11

TABLE 8.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 253.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo –da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	6 9	Arbitrary medium plane	6.3–25.7	.....	.341	.228	.859	.973	.940	.930	5.65	4.20
2	7 9		4.1–16.4	.....	.331	.244	.876	.986	.945	1.419	5.61	4.69
3	8 8	15+0	6.7–15.5	.670	.415	.282	.892	.986	.945	.655	5.61	4.74
4	9 8	15+0	7.0–11.5	.666	.426	.291	.917	1.006	.955	.556	5.63	4.98
5	10 7	15+0	6.8–14.4	.668	.426	.293	.934	1.026	.970	.983	5.70	4.88
6	11 6	15+0	11.3–11.2	.674	.566	.385	.967	1.033	.975	.404	5.78	5.13
7	12 6	15+0	14.9–10.9	.696	.694	.471	1.000	1.060	.995	10.410	6.03	5.37
8	13 5	15+0	10.9–26.4	.696	.578	.392	1.016	1.060	.995	17.340	6.03	4.44
9	14 5	15+0	13.6–19.9	.738	.685	.468	1.033	1.060	.995	.604	6.27	5.02
10	15 4	15+0	15.3–11.7	.759	.764	.523	1.050	1.087	1.040	.764	6.52	5.76
11	16 3	15+0	15.1–10.7	.785	.788	.535	1.066	1.106	1.077	.695	6.81	6.08
12	17 4	15+0	14.9– 9.7	.817	.816	.553	1.084	1.126	1.117	.408	7.11	6.42
13	18 3	15+0	10.3–24.9	.860	.695	.471	1.100	1.166	1.195	*1.723	7.56	5.68
14	19 3	15+0	14.9–10.2	.860	.856	.580	1.116	1.166	1.195	*1.723	7.56	6.79
15	20 2	15+0	15.1– 9.7	.907	.909	.616	1.132	1.188	1.235	1.435	7.94	7.17
16	21 2	15+0	15.1– 9.9	.932	.936	.634	1.150	1.200	1.260	.669	8.16	7.35
17	22 1	15+0	14.9–10.0	.964	.962	.651	1.166	1.200	1.277	.995	8.48	7.63
18	23 0	15+0	14.9–10.6	.956	.956	.648	1.183	1.200	1.281	.700	8.50	7.60
19	24 0	15+0	14.4–15.6	.942	.919	.623	1.200	1.200	1.310	*2.997	8.51	7.18
20	24 29	15+0	17.7– 7.1	.891	.979	.663	1.200	1.200	1.310	*2.997	8.15	7.57
21	25 29	15+0	16.2–18.2	.842	.878	.595	1.200	1.200	1.318	1.013	8.56	7.00
22	26 28	15+0	17.7– 9.2	.803	.868	.589	1.200	1.200	1.327	1.002	7.68	6.97
23	27 27	15+0	16.7–10.6	.817	.859	.583	1.200	1.200	1.340	1.171	7.84	7.01
24	28 29	15+0	17.4–10.7	.810	.868	.591	1.200	1.200	1.350	*3.478	7.85	7.01
25	29 28	15+0	17.3–10.7	.818	.871	.595	1.200	1.200	1.350	*3.478	7.94	7.09
	30 28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Av.	18 18	15+0	13.2 –13.7	.743	.735	.500	1.078	1.121	1.148	2.342	7.10	6.15

*Because of a loss in weight, the average of two periods taken.

BORN JUNE 23, 1914. ON EXPERIMENT JANUARY 1, 1915

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.20	4.12	9.26	299	281	−18	94.0		96.7	98.3	+1.6	101.7	
4.30	4.15	4.20	336	296	−40	88.1		99.6	100.9	+1.3	101.3	
4.40	4.49	9.42	375	337	−38	89.9		102.5	103.4	+0.9	100.9	
4.62	4.68	5.98	405	357	−48	88.1		104.6	105.5	+0.9	100.9	
4.86	4.95	29.50	430	384	−46	89.3		106.2	108.0	+1.7	101.6	
5.10	5.00	15.38	454	390	−64	85.9		107.9	109.3	+1.4	101.3	
5.32	5.10	8.52	478	401	−77	83.9		109.8	109.5	−0.3	99.7	
5.53	5.28	17.37	500	421	−79	84.2		111.1	110.2	−0.9	99.2	
5.76	5.36	9.85	517	431	−86	83.4		112.4	112.5	+0.1	100.1	
5.96	5.52	11.08	531	449	−82	84.6		113.2	112.8	−0.4	99.6	
6.19	5.66	6.25	549	465	−84	84.7		114.3	114.3	±0.0	110.0	
6.40	5.90	6.48	568	494	−74	87.0		115.3	115.0	−0.3	99.7	
6.60	6.13	7.63	592	523	−69	88.3		116.4	117.2	+0.8	100.7	
6.80	6.40	6.70	615	548	−67	89.1		117.2	117.5	+0.3	100.3	
7.00	6.64	7.04	642	578	−64	90.0		117.9	118.3	+0.4	100.3	
7.20	6.86	11.57	663	607	−56	91.6		118.7	118.8	+0.1	100.1	
7.40	7.01	15.02	683	625	−58	91.5		119.5	120.5	+1.0	100.8	
7.60	7.12	26.33	708	639	−69	90.3		120.2	120.5	+0.3	100.2	
.....	.....	.....	731	647	−84	88.5	84.7	120.8	121.5	+0.7	100.6	96.3
5.86	5.58	1.153	530	467	−63	88.0		111.8	112.3	+0.3	100.5	

BORN OCTOBER 12, 1914. ON EXPERIMENT APRIL 21, 1915

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.16	4.91	11.45	361	375	+14	103.9		101.8	104.3	+2.5	102.5	
4.24	5.00	20.10	400	386	−14	96.5		104.9	107.3	+2.4	102.3	
4.34	5.00	7.48	436	393	−43	90.1		107.6	109.0	+1.4	101.3	
4.50	5.18	6.50	475	412	−63	86.7		109.7	110.5	+0.8	100.7	
4.62	5.44	11.26	508	435	−73	85.6		111.5	111.6	+0.1	100.1	
4.86	5.52	3.66	535	448	−87	83.7		112.9	113.0	+0.1	100.1	
5.10	5.88	80.55	561	490	−71	87.3		114.3	115.5	+1.2	101.0	
5.32	5.88	133.20	578	492	−86	85.1		116.0	116.5	+0.5	100.4	
5.53	5.88	4.43	599	493	−106	82.3		117.6	117.5	−0.1	99.9	
5.76	6.22	5.77	616	527	−89	85.6		119.0	118.2	−0.8	99.3	
5.96	6.48	5.36	645	557	−88	86.4		120.4	119.8	−0.6	99.5	
6.19	6.72	3.21	663	591	−72	89.1		121.4	120.5	−0.9	99.3	
6.40	7.20	*13.86	689	651	−38	94.5		121.9	121.3	−0.6	99.5	
6.60	7.20	*13.86	718	647	−71	90.1		122.8	122.7	−0.1	99.9	
6.80	7.44	11.32	748	678	−70	90.6		123.8	123.5	−0.3	99.8	
7.00	7.60	5.25	775	697	−78	89.9		124.3	123.8	−0.5	99.6	
7.20	7.84	7.89	797	739	−58	92.7		124.9	125.2	+0.3	100.2	
7.40	8.02	5.56	824	768	−56	93.2		125.7	126.5	+0.8	100.6	
7.60	8.28	*23.29	841	809	−32	96.2		126.5	127.2	+0.7	100.6	
7.70	8.28	*23.29	868	806	−62	92.9		127.6	127.7	+0.1	100.1	
7.80	8.40	8.08	892	828	−64	92.8		128.2	128.5	+0.3	100.2	
7.90	8.53	8.04	923	854	−69	92.5		129.2	129.2	0.0	100.0	
8.00	8.72	9.56	962	880	−82	91.5		129.8	130.5	+0.7	100.5	
8.10	8.86	*28.20	993	902	−91	90.8		130.4	131.0	+0.6	100.5	
8.20	8.99	*28.20	1019	917	−102	90.0	78.8	130.7	131.5	+0.8	100.6	92.8
.....	.....	.....	1049	917	−132	87.4		131.1	131.5	+0.4	100.3	
6.29	6.94	19.17	711	642	−69	90.3		120.5	120.9	+0.4	100.3	

few days. The production of the cow was puzzling. She never produced more than five or six pounds a day. The test varied from 1.5% to over 7%. She was very uneasy, walked around the pen like a caged animal and kicked badly when being milked.

No. 253 (*See Table* 8.)—As already stated Holstein heifer No. 253 was placed on experiment at the age of 6 months, 9 days, and was fed a ration of alfalfa hay to furnish protein and mineral matter with starch and sugar to furnish the balance of energy. She was placed on what was considered a medium protein plane with the idea of approximating that of No. 103. At the beginning she weighed 375 pounds and measured 104.3 cm. This was 14 pounds above or 103.9% of the normal in weight and 2.5 centimeters above or 102.5% of the normal in height. At the time of the introduction of the new method of calculating she was reported in apparently normal condition. In reality she was 90.1% of the normal in weight and 101.3% of the normal in height. Late in June she showed stiffness and swelling of the joints and a general inactivity. The symptoms were similar to those produced by mineral deficiency. Sixty grams of bone meal were added to the daily ration to take care of this possible deficiency. By the latter part of July the stiffness and swelling had disappeared but she was in a thin condition of flesh. September observations show that she was still in thin flesh and that she was less active than normal heifers. In December she was far below the normal weight and seemed to be getting steadily farther away. In skeletal measurement she was almost exactly normal. At that time she was 106 pounds below the normal in weight and 0.1 centimeter below the normal in height.

Because of her poor gains in weight it was thought advisable to make a slight change by adding 0.5 pound of 35% cream to the daily ration. The cream was added with the idea that the poor growth of the heifer might be due to lack of the fat soluble vitamine. At this time the vitamine theory was comparatively new and not very firmly established. Her poor gains were also attributed partly to the fact that the ration was fed in a dry condition. The manner of feeding was changed by cuting the hay and moistening with cream and water and then thoroughly mixing the starch and sugar and bone meal with it. She readily became adjusted to her new manner of feeding and in a comparatively few days was taking the entire ration. February observations show that she was making greatly improved gains in weight. It was considered useless to continue feeding cream as it was not possible to determine whether the improved gains were to be attributed to the vitamines in the cream or to the difference in the method of feeding the ration. Since heifers No. 250 and No. 103 did not receive cream, but did undergo a

similar change in methods of feeding and made correspondingly better gains after the change in methods, it was considered probable that the improvement was due more to the change in methods than to the added cream in the ration. April observations and data show that she was only 38 pounds below normal weight and only 0.6 centimeter below normal height. This was 94.5% of normal in weight, the nearest she had been to normal weight since May, 1915. She was reported as in the very best of condition. Apparently the removal of the cream the ration had no detrimental effect. During the latter part of April she was off feed and showed a loss of 4 pounds during that 30-day period. She was rough, lost flesh, stood humped up in the lot and was stiff in the joints. All through the remainder of the year 1916 she continued to make about normal gains but was still 30 to 80 pounds below normal and averaged somewhat above 90% of normal in weight. From January to April, 1917 she failed to make normal gains in spite of the fact that she was getting heavy with calf. She seemed to be developing scale but not putting on flesh. During the last 30-day period she did not gain or lose.

She was taken off experiment on May 9, 1917 at the age of 30 months and 28 days. She was heavy with calf but seemed at a standstill as regards growth in weight and height. She was in poor flesh and her coat was rough. She was 132 pounds below or 87.4% of the normal in weight and 0.4 centimeters above or 100.3% of the normal in height. During the twenty-five 30-day periods on practically the same medium plane of protein and the same character of ration, she made 78.8% of the normal gain in weight and 92.8% of the normal gain in height. During this entire time she received an average of 64.1% of the digestible crude protein recommended by the Wolff-Lehmann standard and 46.4% and 44.6% respectively of the digestible true protein recommended by Armsby by age and by weight. Her net energy for the same time was 97.8% and 88.6% respectively of the amount recommended by Armsby according to age and weight. On May 20, 1917 she dropped a normal bull calf which weighed 75 pounds and which had been carried 279 days. She proved to be a fair producer but was sold before her first lactation period was completed.

No. 107. (*See Table* 9.)—Jersey heifer No. 107 was placed on experiment July 19, 1915 at the age of 6 months, 2 days, and was started on a ration of timothy, skimmilk powder, starch and sugar, and a supply of bone meal, magnesium citrate and potassium citrate to furnish mineral matter. The ration was calculated to furnish a medium or 15+0, to a 20+0 plane. At the beginning of the experiment she weighed 282 pounds which was 19 pounds above, or 107.2% of the normal in weight.

Due to an error she was not measured before going on experiment but at the beginning of the second 30-day period she was 1.1 cm. above or 101.1% of the normal in height. She remained on her original plane and ration for 30 days. At that time she was raised very slightly for the reason that one of the other heifers died and this one was used to fill her place. In September she was not doing well and was falling behind the normal. She was off feed on September 18 and continued to refuse feed for several days although her appearance was good. On September 22 she still refused her feed, walked in a circle in her pen and seemed to be in great pain. She was on this date treated by a veterinarian. Her ration was supplemented with a supply of green feed and her regular ration was cut exactly in half for five days when the full ration was resumed, except for the skimmilk powder, which on the new calculation was somewhat below that fed earlier in the month. During the first three 30-day periods she was on a plane which fluctuated from 18+0 to 25+0. Beginning with the fourth period she was put permanently on a 20+0 plane of the same character of ration given at the start. She did not make gains anywhere near normal either in weight or height. Her appearance became less and less desirable, her coat was rough and she was inactive. Beginning in December, 0.5 pound of 35% cream was added to her daily ration, and the manner of feeding was changed in exactly the same manner as described in the case of No. 253. It seemed in January and February that she was improved in general health, appearance and condition although the data do not so indicate. Apparently the cream in the ration did not have any decided beneficial results and there is no distinct evidence that the change in methods of feeding was beneficial. She was off feed again in March and making very unsatisfactory gains in both weight and height. She was taken off experiment April 13, 1916, at the age of 14 months, 27 days, because of her poor gains and because she had given so much trouble by going off feed frequently. Her ration had remained practically unchanged during the last 180 days on experiment.

She was on experiment during nine 30-day periods and at the end was 92 pounds below or only 82.2% of the normal in weight and was 3.3 centimeters below or 97.1% of the normal in height. During the entire time she made only 56.5% and 72.0% respectively of the normal gain in weight and height. While these gains were being made the animal received 79.1% of the digestible crude protein recommended by the Wolff-Lehmann standard and 74.6% and 76.6% respectively of the of the digestible true protein and 111.0% and 114.1% respectively of the net energy recommended by Armsby by age and by weight. On February 27, 1917 she dropped a normal heifer calf which had been carried

281 days and which weighed 52 pounds at birth. The heifer calf was later used in this experiment and will be referred to as No. 129. No. 107 proved to be a superior producer, completing her first year in milk as a two-year-old with an official record of 7,866 pounds of milk and 408 pounds of fat in 365 days.

No. 114. (*See Table* 10.)—On August 2, 1916 Jersey heifer No. 114 was started on a preliminary ration of timothy, alfalfa and corn which was calculated to furnish a medium or 15+0 plane. At the time of starting on the preliminary ration she weighed 300 pounds. The heifer became readily adjusted to her conditions and was placed on experiment August 13, 1916. At that time she weighed 287 pounds which was 39 pounds below the normal, and measured 96.3 centimeters in height. This is 88.0% of normal in weight and 97.5% of normal in height. She failed to make normal gains through the first few months, frequently refused a part of her feed though she was not being fed an excessive quantity, and made somewhat less than normal skeletal gains. In February, 1917, after she had been on experiment six 30-day periods, she was 150 pounds below or only 69.5% of the normal in weight and 95.5% of the normal in height. From February to June her gains were approximately normal and in June she was 146 pounds below normal or 74.1% of the normal in weight and 4.6 centimeters below or 96.0% of the normal in height. At the time she was in moderate condition of flesh, was long and rangy but decidely lacking in width and depth of body. During the entire ten 30-day periods on experiment on a 15+0 plane, she had made only 54.9% of the normal gain in weight and 87.1% of the normal gain in height. During these ten 30-day periods on a 15+0 plane she received almost exactly the amount of protein intended for her. The amount of digestible crude protein was 63.2% of the Wolff-Lehmann requirement while the amount of digestible true protein was 46.3% and 49.5% respectively of that recommended by Armsby according to age and weight. This net energy furnished was 95.1% and 106.3% respectively of Armsby's recommendations by age and by weight.

It was noticeable from the start that she was unusually particular and irregular about taking her feed. In order to determine whether her poor gains could be attributed to lack of protein or to an abnormality in the animal herself it seemed advisable at this time to raise her protein plane from 15+0 to 25+0 without altering the character of the ration except the relative amounts of timothy and alfalfa hay. During the first period she made a splendid gain. Her body seemed to fill out and her condition of flesh apparently was improved. During the second period her gain was fairly good but in September she failed to make desirable gains. In October, 1917 it was noticed that all the heifers

showed an unusual appetite. It seemed possible that the proportion of roughage to concentrates was too low so the ration was changed to remedy the condition without changing the amounts of nutrients fed. She was beginning to show a general improvement as a result of her in-

TABLE 9.—SUMMARY TABLE FOR JERSEY HEIFER NO 107.

1	2		3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period		Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
								By age	By weight				
	mo	da.			lbs.	lbs.	bs.	lbs	lbs.	lbs.	lbs.	therms	therms
1	6	2	18+0	17.0 -17.8	.628	.602	.592	.850	.856	.860	.785	4.50	3.70
2	7	1	25+0	22.7+ 6.0	.829	.769	.755	.868	.885	.905	*1.696	4.65	4.93
3	8	0	20+0	20.0+ 6.4	.745	.701	.680	.884	.885	.905	*1.696	4.66	4.96
4	9	0	20+0	21.3+11.6	.716	.753	.728	.900	.907	.915	5.648	4.84	5.40
5	9	29	20+0	20.1+11.6	.716	.718	.694	.934	.920	.920	1.346	4.84	5.40
6	10	29	20+0	20.2+ 9.0	.716	.721	.693	.967	.932	.925	1.030	4.90	5.34
7	11	28	20+0	20.6+12.6	.723	.740	.710	1.000	.960	.935	.965	5.01	5.64
8	12	27	20+0	21.0+14.2	.736	.761	.725	1.016	1.000	.950	*1.477	5.14	5.87
9	13	28	20+0	21.5+14.2	.736	.765	.729	1.033	.986	.945	*1.477	5.14	5.87
	14	27											
Av.	10	14	20.5+0	20.5+ 7.5	.727	.726	.701	.939	.926	.918	1.791	4.85	5.23

*Because of a loss in weight, the average of two periods taken.

TABLE 10.—SUMMARY TABLE FOR JERSEY HEIFER NO. 114.

1	2		3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period		Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
								By age	By weight				
	mo	da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	7	19	15+0	14.6+ 2.6	.554	.544	.434	.876	.865	.880	1.360	4.54	4.66
2	8	18	15+0	13.6 - 1.3	.564	.526	.411	.892	.875	.900	.986	4.64	4.58
3	9	18	15+0	14.4 - 3.2	.573	.556	.437	.917	.890	.907	8.340	4.74	4.59
4	10	17	15+0	15.4+ 3.6	.568	.579	.458	.950	.896	.910	1.336	4.71	4.88
5	11	17	15+0	13.8 - 6.7	.573	.538	.417	.984	.907	.915	.702	4.77	4.45
6	12	16	15+0	13.1 - 8.6	.583	.535	.420	1.008	.932	.925	*1.617	4.90	4.48
7	13	15	15+0	15.8+ 4.4	.576	.597	.467	1.026	.920	.920	*1.617	4.82	5.03
8	14	17	15+0	15.4+ 3.2	.594	.605	.477	1.042	.960	.935	2.593	5.03	5.19
9	15	16	15+0	14.6 - 2.6	.596	.587	.466	1.058	.973	.940	1.258	5.06	4.93
10	16	16	15+0	19.7+ 8.5	.607	.730	.567	1.075	.988	.947	.995	5.15	5.59
	17	15											
Av.	12	17	15+0	15.0+ 0.0	.579	.580	.455	.983	.921	.918	2.080	4.84	4.84
11	17	15	25+0	26.3 - 5.0	.869	.903	.679	1.092	1.013	.960	.774	5.23	4.97
12	18	15	25+0	18.3+ 3.7	.871	.700	.539	1.108	1.003	.975	.840	5.37	5.57
13	19	14	25+0	18.3+ 3.8	.869	.701	.540	1.124	1.053	.990	1.052	5.46	5.67
14	20	13	25+0	18.7+ 2.3	.871	.714	.548	1.141	1.063	.997	1.530	5.54	5.67
15	21	13	25+0	20.2+15.5	.876	.759	.565	1.158	1.074	1.012	.465	5.62	6.49
16	22	12	25+0	20.4+ 9.4	.881	.773	.570	1.174	1.106	1.077	.892	5.83	6.38
	23	12											
Av.	20	13	25+0	20.4+ 5.0	.873	.758	.574	1.133	1.052	1.002	.926	5.51	5.79
17	23	12	25+0	26.3+33.4	.887	.917	.671	1.191	1.123	1.111	.491	5.95	7.94
18	24	11	25+0	24.7+33.4	.901	.895	.664	1.200	1.160	1.182	.655	6.23	8.31
19	25	10	25+0	24.7+32.9	.898	.893	.663	1.200	1.188	1.235	2.061	6.32	8.40
	26	12											
Av.	24	26	25+0	25.2+33.2	.895	.902	.666	1.197	1.157	1.176	1.069	6.17	8.22

*Because of a loss in weight, the average of two periods taken.

creased protein plane. Her gains were about normal but she was still decidedly undersized. In December, after she had been on the 25+0 plane for six 30-day periods it was found that she was 114 pounds below or 83.7% of the normal in weight and 5.6 centimeters below or 95.3%

BORN JANUARY 17, 1915. ON EXPERIMENT JULY 19, 1915

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
								.....	.....	.....	†	
4.10	4.12	4.83	263	282	+19	107.2		96.9	98.0	+1.1	101.1	
4.20	4.31	*11.41	303	305	+2	100.7		99.8	101.5	+1.7	101.7	
4.30	4.31	*11.41	340	305	-35	89.7		102.8	103.5	+0.7	100.7	
4.40	4.44	40.50	376	331	-45	88.0		104.9	104.0	-0.9	99.1	
4.64	4.54	10.13	406	335	-71	82.5		106.5	104.5	-2.0	98.1	
4.86	4.64	7.63	431	351	-80	81.4		108.2	106.5	-1.7	98.4	
5.10	4.82	7.36	454	372	-82	81.9		110.9	107.8	-3.1	97.2	
5.32	5.10	*11.36	478	395	-83	82.6		111.3	109.2	-2.1	98.1	
5.53	5.00	*11.36	501	390	-111	77.8		112.6	109.3	-3.3	97.1	72.0
.....	.....	.....	518	426	-92	82.2	56.5	**106.0**	**104.9**	**-1.1**	**99.1**	
4.72	**4.59**	**12.89**	**407**	**349**	**-58**	**87.4**						

†Measurement for beginning of experiment not available.

BORN DECEMBER 24, 1915. ON EXPERIMENT AUGUST 13, 1916

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.24	4.18	11.65	326	287	-39	88.0		98.8	96.3	-2.5	97.5	
4.34	4.24	8.59	362	299	-63	82.6		101.7	100.1	-1.6	98.4	
4.50	4.34	68.85	395	315	-80	79.7		104.1	100.3	-3.8	96.3	
4.74	4.37	11.26	421	317	-104	75.3		105.9	101.0	-4.9	95.4	
4.98	4.44	5.80	446	330	-116	74.0		107.5	102.0	-5.5	94.9	
5.10	4.64	*13.59	469	353	-116	75.3		109.3	103.7	-5.6	94.9	
5.42	4.54	*13.59	492	342	-150	69.5		110.8	105.8	-5.0	95.5	
5.64	4.82	22.24	513	374	-139	72.9		112.1	106.8	-5.3	95.3	
5.86	4.91	10.56	527	381	-146	72.3		113.0	108.3	-4.7	95.8	
6.07	5.05	7.62	544	395	-149	72.6		114.0	109.3	-4.7	95.9	
.....	.....	.....	563	417	-146	74.1	54.9	115.1	110.5	-4.6	96.0	87.1
5.09	**4.55**	**17.38**	**460**	**346**	**-113**	**76.0**		**108.4**	**104.0**	**-4.4**	**96.0**	
6.28	5.28	4.26	563	417	-146	74.1		115.1	110.5	-4.6	96.0	
6.50	5.52	6.68	585	452	-133	77.3		116.2	110.8	-5.4	95.4	
6.70	5.79	8.51	609	477	-132	78.3		117.2	113.5	-3.7	96.8	
6.90	5.92	12.15	633	497	-136	78.5		117.8	113.0	-4.8	95.9	
7.10	6.04	3.97	657	511	-146	77.8		118.5	114.5	-4.0	96.6	
7.30	6.48	7.36	676	560	-116	82.8		119.3	114.5	-4.8	96.0	
.....	.....	.....	700	586	-114	83.7	123.4	120.1	114.5	-5.6	95.3	80.0
6.80	**5.84**	**7.16**	**632**	**500**	**-132**	**78.9**		**117.7**	**113.0**	**-4.7**	**96.0**	
7.50	6.68	4.25	700	586	-114	83.7		120.1	114.5	-5.6	95.3	
7.65	7.12	6.08	724	642	-82	88.7		120.6	116.0	-4.6	96.2	
7.75	7.44	19.38	744	683	-61	91.8		121.1	116.3	-4.8	96.0	
.....	.....	.....	763	696	-67	91.2	174.6	121.3	116.8	-4.5	96.3	191.7
7.63	**7.08**	**9.90**	**733**	**652**	**-81**	**88.9**		**120.8**	**115.9**	**-4.9**	**96.0**	

of the normal in height, and that her gain in weight had been 123.4% of the normal while her gain in height had been only 80.0% of the normal. These gains had been accomplished on 75.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 50.6% and 54.5% respectively of the digestible crude protein and 85.2% and 99.2% respectively of the net energy recommended by Armsby by age and by weight.

Since she was still 114 pounds below the normal in weight for her age and since her gains had been only approximately normal it seemed desirable to increase her entire ration without changing the proportion of protein and energy. To accomplish this result each constituent in the ration was increased one-fourth. She remained on this increased ration through three 30-day periods during which time she gained 110 pounds or 174.6% of the normal in weight and 191.7% of the normal in height. These gains had been accomplished on 76.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 55.6% and 57.6% respectively of the digestible true protein and 107.6% and 116.1% respectively of the net energy recommended by Armsby by age and by weight. At the end of these three periods on March 5, 1918, she was taken off experiment at the age of 26 months, 2 days, being 67 pounds below or 91.2% of the normal in weight and 96.3% of the normal in height. On March 18, she gave birth to a bull calf weighing 45 pounds and which had been carried 282 days. The calf was apparently normal except that hair was growing from the inside of the eyelid and from the eyeball. This hair was removed but the sight of the eye was destroyed. Later the other eye became partially affected but the bull matured and was used as a herd sire by a breeder in a neighboring state. The cow was a fairly good milker, producing 5,568 pounds of milk and 324 pounds of fat in one year in her first lactation period as a two-year-old.

No. 115. (*See Table* 11.)—Jersey heifer No. 115 was placed on a preliminary ration October 1, 1916. On October 12 she was placed on experiment at the age of eight months, seven days on a ration of timothy hay, corn, oats and starch and sugar. There is some question regarding the completeness of this ration which was calculated to furnish an 8+0 plane. At the time of starting on experiment she weighed 316 pounds which was 32 pounds below or only 90.8% of the normal in weight while in height she was 2.2 centimeters above or 102.2% of the normal. On March 11, 1917 her condition was so poor that magnesium and potassium citrates and bone meal were added in order that she might have an abundance of mineral matter. The quantities given daily were 60, 30 and 60 grams respectively. During the first seven

30-day periods she gained only 79 pounds. She continued to get steadily farther below the normal in weight but remained practically normal in height. She was very shallow and narrow but reasonably long, was rough and thin in flesh and was developing very poorly. At the end of the first seven 30-day periods on the 8+0 plane she was 127 pounds below or only 75.7% of the normal in weight but was 0.7 centimeter above or 100.6% of the normal in height. Her gains on this plane were 45.4% and 87.8% respectively of the normal for weight and height and had been accomplished on 46.1% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 38.6% and 39.9% respectively of the digestible true protein and 106.0% and 111.7% respectively of the net energy recommended by Armsby by age and by weight.

Her ration was changed on May 10, 1917, by the addition of cotton-seed meal, from 8+0 to 15+0 or from a very low to a medium plane. Observations for October, 1917 show that she had made approximately normal gains in height since her ration was increased but that instead of being 27 pounds below normal weight she was 140 pounds below or 77.5% of the normal in weight. She, like the other heifers, manifested an unusual hunger and the proportion of roughage was increased without changing the amount of nutrients furnished. She showed a stiffness which could not be accounted for. Like all other heifers she consumed enormous quantities of salt. During the fall and winter months she made very irregular gains. In March she showed a slight improvement in general condition, being smoother and showing considerable development of barrel, which no doubt was due to the fact that she was heavy with calf.

When taken off experiment on May 4, 1918 she was in rather poor condition of flesh and weighed 632 pounds which was 138 below or only 82.1% of the normal in weight. She was 99.1% of the normal in height. During the twelve 30-day periods since she had been placed on a 15+0 plane she made 95.6% of the normal gain in weight and 80.2% of the normal gain in height, while receiving 69.4% of the digestible crude protein recommended by the Wolff-Lehmann standard and 56.0% and 59.3% respectively of the digestible true protein and 94.3% and 107.1% respectively of the net energy recommended by Armsby by age and by weight. On June 7, she dropped a bull calf that had been carried 276 days. The calf weighed 56 pounds at birth and was apparently normal. The cow proved to be a good producer. She calved at the age of 2 years, 4 months, 2 days and produced in one year as a two-year-old, 7,880 pounds of milk containing 396 pounds of fat.

TABLE 11.—SUMMARY TABLE FOR JERSEY HEIFER NO. 115.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo -da			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	8 7	8+0	9.0+ 7.4	.383	.424	.372	.884	.890	.907	.530	4.74	5.09
2	9 6	8+0	9.1+ 5.9	.396	.424	.372	.900	.920	.920	3.180	4.89	5.18
3	10 6	8+0	6.9+ 1.8	.395	.366	.349	.934	.926	.922	10.980	4.87	4.96
4	11 5	8+0	8.7+ 4.7	.393	.415	.364	.967	.926	.922	.778	4.86	5.09
5	12 4	8+0	9.0+ 4.0	.400	.430	.376	1.000	.946	.930	1.290	4.95	5.15
6	13 6	8+0	10.1+ 7.2	.404	.459	.384	1.016	.960	.935	*1.151	4.99	5.35
7	14 5	8+0	10.2+ 7.6	.402	.462	.385	1.033	.953	.932	*1.151	4.97	5.35
	15 5											
Av.	11 21	8+0	9.0+ 5.5	.399	.426	.372	.962	.932	.924	2.723	4.90	5.17
8	15 5	15+0	17.9+ 8.2	.602	.682	.619	1.050	.992	.947	1.461	5.14	5.56
9	16 4	15+0	17.8+ 7.6	.611	.686	.622	1.066	1.006	.955	.735	5.23	5.63
10	17 4	15+0	17.9+11.6	.618	.695	.621	1.084	1.026	.970	1.043	5.35	5.97
11	18 3	15+0	18.0+12.4	.618	.696	.622	1.100	1.036	.977	10.440	5.40	6.07
12	19 2	15+0	18.4+13.5	.610	.694	.621	1.116	1.040	.980	.868	5.35	6.07
13	20 2	15+0	18.6+17.1	.616	.707	.621	1.132	1.053	.990	.424	5.45	6.38
14	21 1	15+0	19.0+18.3	.641	.740	.645	1.150	1.087	1.040	2.775	5.75	6.80
15	22 1	15+0	20.0+19.1	.633	.753	.657	1.166	1.094	1.051	.525	5.71	6.80
16	23 0	15+0	17.9+16.0	.650	.720	.633	1.183	1.123	1.111	1.800	5.94	6.89
17	23 29	15+0	17.5+15.6	.648	.707	.623	1.200	1.129	1.123	.922	5.96	6.89
18	25 1	15+0	18.5+19.7	.660	.742	.650	1.200	1.146	1.155	11.130	6.10	7.30
19	26 0	15+0	22.5+21.2	.651	.819	.704	1.200	1.146	1.155	2.234	6.04	7.32
	27 0											
Av.	21 2	15+0	18.7+15.0	.630	.720	.637	1.137	1.073	1.038	2.863	5.62	6.47

*Because of a loss in weight, the average of two periods taken.

TABLE 12—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 266.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo -da			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	7 22	8+0	8.6 - 7.7	.454	.473	.321	.876	.980	.942	7.095	5.61	5.18
2	8 21	8+0	8.8 - 7.2	.451	.478	.324	.892	.986	.945	1.793	5.58	5.18
3	9 21	8+0	8.6 - 8.7	.449	.467	.317	.917	.993	.952	1.001	5.54	5.06
4	10 20	8+0	8.4 -14.8	.449	.458	.311	.950	1.006	.955	1.527	5.55	4.73
5	11 19	8+0	8.0 -18.8	.452	.453	.307	.984	1.013	.960	1.510	5.58	4.53
6	12 21	8+0	9.1 - 8.5	.459	.490	.334	1.008	1.020	.965	1.470	5.66	5.18
7	13 20	8+0	9.3 -18.8	.469	.509	.347	1.026	1.026	.970	15.270	5.79	4.70
	14 20											
Av.	11 6	8+0	8.9 -14.1	.455	.475	.323	.950	1.003	.956	4.238	5.62	4.94
8	14 20	15+0	16.4 - 5.8	.696	.740	.562	1.042	1.026	.970	.584	5.89	5.55
9	15 19	15+0	16.5 - 7.2	.731	.781	.601	1.058	1.050	.988	1.116	6.23	5.78
10	16 19	15+0	11.1 - 5.3	.756	.626	.471	1.075	1.066	1.000	.648	6.45	6.11
11	17 18	15+0	11.6 - 5.1	.784	.666	.508	1.092	1.084	1.032	.571	6.72	6.38
12	18 17	15+0	12.0 - 5.8	.815	.711	.547	1.108	1.106	1.077	1.255	7.02	6.61
13	19 17	15+0	13.0 - 1.8	.837	.766	.577	1.124	1.120	1.105	.389	7.21	7.08
14	20 16	15+0	13.9 - 0.4	.887	.844	.645	1.141	1.160	1.182	.974	7.70	7.67
15	21 16	15+0	13.0 - 0.1	.916	.841	.652	1.158	1.176	1.213	.701	7.97	7.96
16	22 15	15+0	11.6 - 0.6	.945	.810	.623	1.174	1.200	1.260	1.519	8.25	8.20
17	23 14	15+0	11.2 - 0.7	.931	.789	.606	1.191	1.200	1.267	.382	8.21	8.15
18	24 16	15+0	11.8+ 0.0	.926	.813	.615	1.200	1.200	1.295	.717	8.32	8.32
19	25 15	15+0	16.7+ 1.2	.892	.948	.706	1.200	1.200	1.310	.547	8.17	8.27
20	26 15	15+0	16.3 - 3.3	.860	.898	.657	1.200	1.200	1.332	1.171	8.09	7.82
	27 14											
Av.	21 2	15+0	13.5 - 2.7	.844	.787	.598	1.136	1.138	1.156	.813	7.40	7.22

BORN FEBRUARY 5, 1916. ON EXPERIMENT OCTOBER 12, 1916

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.30	4.34	6.36	348	316	−32	90.8		100.5	102.7	+2.2	102.2	
4.40	4.54	38.85	382	340	−42	89.0		103.2	103.5	+0.3	100.3	
4.62	4.59	148.80	412	344	−68	83.5		105.3	106.2	+0.9	100.9	
4.86	4.59	9.54	436	345	−91	79.1		106.8	107.0	+0.2	100.2	
5.10	4.72	15.45	459	361	−98	78.6		108.6	109.0	+0.4	100.4	
5.32	4.82	*13.38	485	371	−114	76.5		110.4	111.3	+0.9	100.8	
5.53	4.77	*13.38	506	365	−141	72.1		111.6	112.2	+0.6	100.5	
			522	395	−127	75.7	45.4	112.8	113.5	+0.7	100.6	87.8
4.88	4.62	35.11	444	355	−89	80.7		107.4	108.2	+0.8	100.7	
5.76	5.05	11.91	522	395	−127	75.7		112.8	113.5	+0.7	100.6	
5.96	5.18	6.03	536	409	−127	76.3		113.6	115.0	+1.4	101.2	
6.19	5.44	8.96	556	437	−119	78.6		114.7	115.8	+1.1	101.0	
6.40	5.57	91.05	575	457	−118	79.5		115.7	116.3	+0.6	100.5	
6.60	5.62	7.59	600	459	−141	76.5		116.8	116.8	+0.0	100.0	
6.80	5.79	3.83	623	483	−140	77.5		117.5	118.0	+0.5	100.4	
7.00	6.22	25.50	650	533	−117	82.0		118.1	119.0	+0.9	100.8	
7.20	6.30	4.74	669	541	−128	80.9		118.9	118.2	−0.7	99.4	
7.40	6.68	17.25	689	584	−105	84.8		119.8	119.3	−0.5	99.6	
7.60	6.77	8.99	715	596	−119	83.4		120.4	120.2	−0.2	99.8	
7.70	6.96	109.50	738	619	−119	83.9		120.9	120.5	−0.4	99.7	
7.80	6.96	19.96	758	621	−137	81.9		121.4	120.2	−1.2	99.0	
			770	632	−138	82.1	95.6	121.9	120.8	−1.1	99.1	80.2
6.87	6.05	26.28	646	520	−126	80.2		117.9	118.0	+0.1	100.1	

BORN FEBRUARY 20, 1916. ON EXPERIMENT OCTOBER 12, 1916

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.24	4.95	77.70	415	386	−29	93.0		106.3	102.1	−4.2	96.0	
4.34	5.00	19.43	454	388	−66	85.5		108.5	103.4	−5.1	95.3	
4.50	5.05	10.84	491	396	−95	80.7		110.6	105.8	−4.8	95.7	
4.74	5.18	15.77	520	410	−110	78.8		112.1	107.8	−4.3	96.2	
4.98	5.28	15.10	547	419	−128	76.6		113.5	109.2	−4.3	96.2	
5.19	5.36	15.54	569	428	−141	75.2		115.2	110.3	−4.9	95.7	
5.42	5.44	141.00	589	438	−151	74.4		116.8	112.3	−4.5	96.1	
			607	439	−168	72.3	27.6	118.3	112.8	−5.5	95.4	89.2
4.77	5.18	42.20	524	413	−111	79.6		112.7	108.0	−4.7	95.8	
5.64	5.44	4.38	607	439	−168	72.3		118.3	112.8	−5.5	95.4	
5.86	5.75	8.26	632	477	−155	75.5		119.8	114.3	−5.5	95.4	
6.07	5.96	6.32	654	498	−156	76.1		120.9	114.5	−6.4	94.7	
6.28	6.18	5.47	676	527	−149	78.0		121.6	116.7	−4.9	96.0	
6.50	6.48	11.66	702	562	−140	80.1		122.3	117.5	−4.8	96.1	
6.70	6.64	3.60	733	579	−154	79.0		123.3	117.7	−5.6	95.5	
6.90	7.12	8.85	761	638	−123	83.8		124.1	119.8	−4.3	96.5	
7.10	7.32	6.63	786	664	−122	84.5		124.6	119.7	−4.9	96.1	
7.30	7.60	15.38	810	700	−110	86.4		125.3	120.5	−4.8	96.2	
7.50	7.69	3.94	832	716	−116	86.1		126.1	122.0	−4.1	96.7	
7.65	8.08	7.34	856	778	−78	90.9		127.1	122.7	−4.4	96.5	
7.75	8.28	4.77	881	812	−69	92.2		127.9	123.5	−4.4	96.6	
7.85	8.60	10.20	909	864	−45	95.0		128.8	124.0	−4.8	96.3	
			944	887	−57	94.0	132.9	129.5	124.3	−5.2	96.0	102.7
6.85	7.01	7.45	770	653	−117	83.9		124.3	119.3	−5.0	96.0	

No. 266. (*See Table* 12.)—Holstein heifer No. 266 was commenced on a preliminary ration on October 1, 1916. On October 12, she was placed on experiment at the age of 7 months, 22 days, and continued on a ration of timothy, alfalfa, starch and sugar, calculated to furnish a low plane of 8+0. At the time of starting she weighed 386 pounds which was 29 pounds below or 93.0% of the normal in weight and was 96.0% of the normal in height. She was a beautiful heifer and in good condition. During the first seven 30-day periods she made very unsatisfactory gains, averaging only 7.6 pounds per 30-day period or about one-fourth pound daily. She became long, narrow and shallow and in very poor flesh and general condition. In a good many instances she refused a part of her feed. The refusal may have been due to the fact that the starch and sugar mixture was the only concentrate fed and that this alone was not palatable. There may be some question regarding the mineral matter supplied in this ration, although it would seem adequate. During the 210 days she received an average of only 0.475 pounds digestible crude protein daily. The amount of the protein was low and probably a limiting factor in her development. She was in very poor general condition and was 168 pounds below or only 72.3% of the normal in weight but was 95.4% of the normal in height. During the seven 30-day periods she had made only 27.6% of the normal gain in weight but had made 89.2% of the normal gain in height, while receiving 49.8% of the digestible crude protein recommended by the Wolff-Lehmann standard and 34.0% and 32.2% respectively of the digestible true protein and 103.4% and 95.3% respectively of the net energy recommended by Armsby by age and by weight.

On May 10, 1917 her ration was changed to furnish a 15+0 instead of a 8+0 plane. This change was accomplished by raising the quantity of alfalfa, cutting the timothy, and adding small quantities of cottonseed meal and bran. The quantity of digestible protein was increased approximately 50 per cent. Shortly after the change she began to show general improvement. She took her ration readily and all through the summer and fall made splendid gains. She was in about the poorest condition of any of the heifers at the time of the change in ration but her subsequent improvement was remarkable. In October her roughage was increased without changing the nutrients received. In March, 1918 she was reported as in the best condition she had ever shown, having a good barrel, smooth coat, excellent flesh and first class handling quality. She was taken off experiment June 3, 1918 when still showing all these qualities. She was heavy with calf at the time which may partly account for the unusually large gains made in the last five or six 30-day periods. At the completion of the experiment she was only 57 pounds below or

was 94.0% of the normal in weight and was 96.0% of the normal in height. During the thirteen 30-day periods since the change in plane she gained 132.9% of the normal in weight and 102.7% of the normal in height. She made the most remarkable response to an increase in protein of any heifer on experiment up to that time, and these splendid gains were accomplished on 68.1% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 52.6% and 52.5% respectively of the digestible true protein and 105.4% and 103.0% respectively of the net energy recommended by Armsby by age and by weight. On July 27, 1918 she dropped a heifer calf weighing 88 pounds which had been carried 276 days. She proved to be an exceptionally good milker and completed the year on test with a two-year-old record of 13,542 pounds of milk and 406 pounds of fat. She has since milked as high as 92 pounds in one day and as a four-year-old produced 20,510 pounds of milk and 702 pounds of fat in one year.

No. 267. (*See Table* 13.)—On October 1, 1916, Holstein heifer No. 267 was placed on a preliminary ration calculated to furnish a high or 25+0 plane of protein. On October 12, she was placed on experiment at the age of 7 months, 17 days and continued on a ration composed of timothy, alfalfa, skimmilk powder, and starch and sugar. Such a ration should furnish a moderate amount of mineral matter in the alfalfa hay, the right kind of character of protein because they were derived largely from alfalfa hay and skimmilk powder, a sufficiency of the so-called vitamines, and a liberal quantity of protein. Normal growth was expected from this ration. At the time she was placed on experiment she was in good physical condition and good flesh. She became adjusted very readily to her experimental conditions. Her weight at the beginning was 363 pounds. This is 46 pounds below and represents 88.8% of the normal in weight. At the same time she was 96.1% of the normal in height. From October, 1916 to March, 1917 her condition was excellent and her gains very satisfactory. During the summer months of 1917, however, she seemed to be in poorer general condition but continued to make satisfactory gains. Observations for August, 1917 show that she had made almost exactly normal gains since the beginning of the experiment. At that time she was 48 pounds below the normal while at the start she was 46 pounds below the normal. On July 28, the supply of skimmilk powder was exhausted and the ration was changed by adding corn, bran and cottonseed meal in place of the skimmilk powder. It was planned to make this change without altering the quantity of digestible crude protein or of energy in the ration. She took this new ration readily from the start and continued to make almost exactly normal gains in both weight and height. In October the proportion

of roughage to concentrates was increased as in the case of all other heifers. For a brief period during the summer months she appeared rough and in poor general condition. In December, 1917 she was reported as being in excellent condition and improving. The splendid condition continued to the end of the experiment. She was taken off

TABLE 13.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 267.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo -da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	7 17	25+0	25.2 -18.8	.973	.980	.824	.876	.946	.930	1.729	5.47	4.44
2	8 16	25+0	25.9+ 3.8	.972	1.000	.839	.892	.973	.940	1.111	5.53	5.74
3	9 16	25+0	26.1+ 3.7	.966	1.000	.839	.917	1.006	.955	.968	5.61	5.82
4	10 15	25+0	26.2+ 3.5	.964	1.000	.839	.950	1.026	.970	.938	5.71	5.91
5	11 14	25+0	27.2+ 1.0	.975	1.041	.875	.984	1.046	.985	.868	5.89	5.95
6	12 16	25+0	27.7+ 2.3	1.000	1.080	.909	1.008	1.074	1.012	1.543	6.13	6.27
7	13 15	25+0	25.7+ 1.3	1.018	1.039	.869	1.026	1.087	1.040	.917	6.32	6.40
8	14 15	25+0	25.7+ 1.5	1.070	1.091	.921	1.042	1.106	1.077	1.259	6.63	6.73
9	15 14	25+0	25.8+ 1.7	1.109	1.135	.950	1.058	1.126	1.117	2.838	6.89	7.01
10	16 14	25+0	19.1+ 0.1	1.139	.945	.765	1.075	1.132	1.130	1.181	7.06	7.07
11	17 13	25+0	19.5+ 1.8	1.174	.985	.780	1.092	1.146	1.155	1.019	7.29	7.42
12	18 12	25+0	19.9+ 1.5	1.210	1.035	.820	1.108	1.166	1.195	1.294	7.56	7.67
13	19 12	25+0	21.3+ 6.4	1.245	1.113	.881	1.124	1.184	1.227	.681	7.79	8.29
14	20 11	25+0	22.2+ 7.4	1.304	1.199	.954	1.141	1.200	1.261	.856	8.22	8.83
15	21 11	25+0	19.3+ 3.8	1.352	1.137	.916	1.158	1.200	1.291	.696	8.59	8.26
16	22 10	25+0	20.4+ 3.4	1.392	1.209	.979	1.174	1.200	1.315	1.099	8.94	9.24
17	23 9	25+0	20.6+ 4.9	1.372	1.205	.978	1.191	1.200	1.327	.841	8.99	9.43
18	24 11	25+0	21.9+ 5.8	1.337	1.229	.985	1.200	1.200	1.345	2.048	9.01	9.53
	25 10											
Av.	16 13	25+0	23.3+ 1.5	1.143	1.079	.885	1.056	1.112	1.126	1.216	7.09	7.22

TABLE 14.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 269.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actua net energy received daily
							By age	By weight				
	mo.-da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	6 17	25+0	22.4+ 1.0	.964	.881	.678	.859	.875	.900	.826	5.20	5.25
2	7 17	25+0	24.8+ 2.6	.957	.953	.728	.876	.907	.915	.841	5.29	5.43
3	8 16	25+0	24.6+ 0.5	.966	.953	.726	.892	.960	.935	.773	5.46	5.43
4	9 15	25+0	24.7+ 3.0	.964	.957	.729	.917	1.000	.950	.736	5.59	5.76
5	10 17	25+0	24.8+ 2.8	.967	.962	.732	.950	1.026	.970	1.031	5.75	5.91
6	11 16	25+0	24.5+ 2.0	.975	.963	.733	.984	1.046	.985	1.070	5.89	6.01
7	12 16	25+0	25.7+ 1.0	.996	1.016	.769	1.008	1.066	1.000	1.270	6.08	6.14
8	13 15	25+0	25.7+ 2.1	1.024	1.046	.797	1.026	1.080	1.025	.805	6.29	6.42
9	14 15	25+0	18.7+ 4.5	1.069	.873	.684	1.042	1.106	1.077	1.007	6.62	6.92
10	15 14	25+0	20.0+ 4.9	1.109	.948	.747	1.058	1.126	1.117	.917	6.89	7.23
11	16 13	25+0	19.7+ 3.8	1.148	.974	.768	1.075	1.146	1.155	.835	7.17	7.44
12	17 13	25+0	20.6+ 7.4	1.189	1.041	.806	1.092	1.166	1.195	.578	7.47	8.02
	18 12											
Av.	12 15	25+0	23.1+ 2.9	1.027	.965	.741	.982	1.042	1.019	.891	6.14	6.33

experiment on April 4, 1918. At this time she weighed 910 pounds which was 33 pounds above or 103.8% of the normal in weight. She was, however, 1.5 centimeters below or 98.8% of the normal in height.

She was on experiment eighteen 30-day periods and received a ration calculated to furnish a 25+0 plane. During the entire time she gained

BORN FEBRUARY 25, 1916. ON EXPERIMENT OCTOBER 12, 1916

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.24	4.72	7.84	409	363	−46	88.8		105.7	101.6	−4.1	96.1	
4.34	4.91	6.38	447	380	−67	85.0		108.1	103.8	−4.3	96.0	
4.50	5.18	5.63	485	407	−78	83.9		110.2	106.7	−3.5	96.8	
4.74	5.44	5.54	515	438	−77	85.0		111.9	110.2	−1.7	98.5	
4.98	5.70	4.96	543	470	−73	86.6		113.3	112.8	−0.5	99.6	
5.19	6.04	8.96	567	506	−61	89.2		114.9	113.4	−1.5	98.7	
5.42	6.22	5.65	585	527	−58	90.1		116.5	116.0	−0.5	99.6	
5.64	6.48	7.77	604	561	−43	92.9		118.1	117.0	−1.1	99.1	
5.86	6.72	17.53	626	587	−39	93.8		119.5	119.2	−0.3	99.7	
6.07	6.80	8.84	651	599	−52	92.0		120.8	120.2	−0.6	99.5	
6.28	6.96	7.68	671	623	−48	92.8		121.5	120.0	−1.5	98.8	
6.50	7.20	9.59	698	652	−46	93.4		122.2	121.5	−0.7	99.4	
6.70	7.40	5.08	727	676	−51	93.0		123.1	122.3	−0.8	99.4	
6.90	7.75	6.31	756	725	−31	95.9		124.0	123.0	−1.0	99.2	
7.10	8.02	5.06	782	767	−15	98.1		124.5	124.3	−0.2	99.8	
7.30	8.34	8.40	805	816	+11	101.4		125.2	124.5	−0.7	99.4	
7.50	8.53	6.58	829	849	+20	102.4		125.9	124.3	−1.6	98.7	
7.65	8.80	15.88	851	892	+41	104.8		126.8	125.5	−1.3	99.0	
.....	.....	.....	877	910	+33	103.8	116.9	127.8	126.3	−1.5	98.8	111.8
5.94	6.73	7.98	654	618	−36	93.3		118.9	117.5	−1.4	98.7	

BORN APRIL 24, 1916. ON EXPERIMENT NOVEMBER 11, 1916

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.16	4.24	4.92	372	301	−71	80.9		102.8	98.5	−4.3	95.8	
4.24	4.44	4.79	409	333	−76	81.4		105.9	101.5	−4.4	95.8	
4.34	4.82	4.40	447	367	−80	82.1		108.2	105.3	−2.9	97.3	
4.50	5.10	4.43	484	404	−80	83.5		110.2	107.8	−2.4	97.8	
4.74	5.44	6.33	517	443	−74	85.7		122.0	109.5	−2.5	97.8	
4.98	5.70	6.68	544	471	−73	86.6		113.4	112.3	−1.1	99.0	
5.19	5.96	7.67	567	498	−69	87.8		115.0	114.5	−0.5	99.6	
5.42	6.13	4.94	585	522	−63	89.2		116.6	116.5	−0.1	99.9	
5.64	6.48	7.98	604	561	−43	92.9		118.1	117.7	−0.4	99.7	
5.86	6.72	7.00	626	587	−39	93.8		119.6	118.2	−1.4	98.8	
6.07	6.96	6.38	650	618	−32	95.1		120.8	120.2	−0.6	99.5	
6.28	7.20	4.46	671	653	−18	97.3		121.5	120.0	−1.5	98.8	
.....	.....	.....	698	707	+9	101.3	124.5	122.2	123.2	+1.0	100.8	127.3
5.12	5.78	5.83	552	497	−55	89.0		114.3	112.7	−1.6	98.5	

547 pounds or approximately one pound daily. This represents 116.9% of the normal gain in weight. In height she increased 24.7 centimeters which is 111.8% of the normal gain in height. These gains were accomplished on 95.8% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 83.7% and 79.5% respectively of the digestible true protein and 121.6% and 107.3% respectively of the net energy recommended by Armsby by age and by weight. On April 22, 1918, she dropped a heifer calf which weighed 70 pounds at birth and which had been carried 271 days. As a milk cow she proved to be good. She calved at the age of 2 years, 1 month 27 days and produced in one year as a two-year-old 9,165 pounds of milk containing 271 pounds of fat.

No. 269. (*See Table* 14.)—Holstein heifer No. 269 was started on a preliminary ration October 25, 1916. On November 11, she was placed on experiment at the age of 6 months, 17 days and was continued on a ration of timothy, alfalfa, corn and bran calculated to furnish a 25+0 plane. A normal development was anticipated. At the time of starting on experiment she weighed 301 pounds which was 71 pounds below and represented 80.9% of the normal in weight. In height she was 4.3 centimeters below or 95.8% of the normal. She was on experiment through twelve 30-day periods. During the entire time she made the most uniform and the best gains of any of the animals on the experiment at the time. She did not suffer a single "set back" and was fat and sleek with a fine soft hide and a splendid barrel development. She took her ration without refusal. Two changes were made in the character of the ration. A very small quantity of starch and sugar was added in February and continued through October 16, 1917 and the proportion of roughage to concentrates was increased as with the other heifers. On November 13, 1917 this heifer was off feed. She did not eat anything of consequence for more than two weeks. She was treated for indigestion, impaction and other digestive disorders but without success. She soon showed difficulty with her respiration and her heart action was bad. She lost flesh rapidly, was reduced almost to a skeleton and became very weak. At this time she began to show dropsical symptoms around the throat and on December 3, an abdominal incision was made into the stomach. A piece of wire about 4 inches long had penetrated the heart cavity and was responsible for the trouble. This wire was removed and the walls of the stomach sewed to the body wall leaving an opening directly into the stomach. Following this operation the heifer was able to take fairly liberal quantities of skimmilk. She was in such a weakened condition before the operation was performed, however, that she died December 6, 1917. A post-mortem examination showed that she had two or three

gallons of fluid in the body cavity and that the surface of the heart was almost decomposed. Because of this sickness which resulted in her death, data were stopped with the twelfth 30-day period which ended November 5, 1917—about seven days before any abnormal symptoms were noticed. At that time she was in first class condition in every respect and weighed 707 pounds which was 9 pounds above the normal making her 101.3% of the normal in weight. At the same time she was 100.8% of the normal in height. During the twelve 30-day periods she made 124.5% of the normal in gain in weight and 127.3% of the normal gain in height, while receiving 94.8% of the digestible crude protein recommended by the Wolff-Lehmann standard and 75.5% and 71.2% respectively of the digestible true protein, and 123.7% and 109.8% respectively of the net energy recommended by Armsby by age and by weight.

No. 129. (*See Table* 15.)—Jersey heifer No. 129 was started on a preliminary ration November 25, 1917. On December 6, she was placed on an experiment in which it was planned to duplicate as nearly as possible the conditions which applied to No. 114. It will be remembered that No. 114 was considered abnormal in the way she took her ration. No. 129 was therefore placed on a ration of timothy, alfalfa, corn and starch and sugar calculated to furnish a medium or a 15+0 plane. At the beginning of the experiment she was 9 months, 9 days old. Her weight was 331 pounds which was 54 pounds below or 86.0% of the normal. She was also 2.7 centimeters below or 97.4% of the normal in height. She remained on the 15+0 plane for four 30-day periods. During this time she continued to become thinner in flesh and long, narrow and shallow of body. Her gain in weight for the four periods was only 59.4% while her gain in height was 97.1% of the normal. She had received 55.0% of the digestible crude protein recommended by the Wolff-Lehmann standard and 43.5% and 43.3% respectively of the digestible true protein, and 108.5% and 107.9% respectively of the net energy recommended by Armsby by age and by weight. It was apparent that she was not making satisfactory growth. It seemed advisable to change her from a 15+0 plane to a 25+0 plane without changing the character of the ration more than was necessary. The change was accomplished by reducing the corn and adding cottonseed meal. It was later found that she actually consumed only approximately 86.0% of the digestible protein intended. This is accounted for largely in the variation in the composition of the feeds given. When she was increased to a 25+0 plane, the actual digestible protein received was increased from an average of 0.515 pounds to an average of 0.83 pounds daily, an increase of 61.7%. This increased protein was continued for three 30-day periods. In July

the heifer was in practically the same condition as in April, although in the meantime she had made better gains than in the first four periods. These gains were 84.6% of the normal in weight and 121.2% of the normal in height. During these three 30-day periods she received an average of 87.3% of the digestible crude protein recommended by the Wolff-Lehmann standard and 67.3% and 69.7% respectively of the digestible true protein and 96.1% and 104.2% respectively of the net energy recommended by Armsby by age and by weight. At this time she was 80.9% of the normal in weight and 98.1% of the normal in height. The increased plane during three periods seemed to increase the rate of growth somewhat but did not promote satisfactory development.

On July 4, 1918 the alfalfa and cottonseed meal were increased, raising the plane from 25+0 to 35+0. This increase was sufficient to raise the actual digestible protein consumed to the extent of 39%. On the 35+0 plane she made nearly normal gains but failed to make up for being considerably undersized. On September 3, her ration was again changed so that the proportion of roughage and particularly the quantity of alfalfa hay would be greater. At this time she was placed on a ration of 8 pounds alfalfa, 2 pounds timothy, and 2 pounds corn. Weighings were made every ten days in order to determine whether any increased gains made were due to accumulation in the body of the added amount of roughage or whether they were distributed evenly through the 30-day period which would indicate true gains in weight. The increase for the first 30-day period was more than twice the amount made in previous periods and the increases were made evenly throughout the entire period. Subsequent to December, 1918, all preliminary calculations for rations for all heifers were based on average analyses for the different feeds. This undoubtedly stabilized conditions greatly. She was kept on the 35+0 plane for ten 30-day periods. During this time her gains were very irregular but averaged slightly above the normal. At the beginning of the eighth 30-day period when placed on a 35+0 plane she was 103 pounds below the normal. At the end of the experiment on April 29, 1919 she was 84 pounds below the normal indicating that she had made 19 pounds more than a normal gain in ten periods. Her general condition improved decidedly on the 35+0 plane. When started on it she was in poor flesh and lacked body. At the termination of the experiment she was reported as in excellent condition, fat and smooth and in the best condition she had ever shown.

During the last ten 30-day periods she made 108.6% of the normal gain in weight and 105.1% of the normal gain in height. At the end of the experiment she was only 88.9% of the normal in weight but was 98.5% of the normal in height. She did not make gains that even approxi-

mated what was expected on the rations and planes which she received During the ten 30-day periods on a 35+0 plane she received 117.3% of digestible crude protein recommended by Wolff-Lehmann standard and 79.1% and 83.1% respectively of the digestible true protein and 82.9% and 92.2% respectively of the net energy recommended by Armsby by age and by weight. She calved June 15, 1919 at the age of 2 years, 4 months, dropping a normal bull calf weighing 60 pounds which had been carried 285 days. The cow proved to be a good milker and completed a two-year-old record for 365 days amounting to 6,252 pounds of milk and 370 pounds of fat. She later produced 8,697 pounds of milk and 512 pounds of fat as a three-year-old.

No. 132. (*See Table* 16.)—Jersey heifer No. 132 was placed on a preliminary ration November 25, 1917. On December 6 at the age of 6 months, 28 days, she was started on a ration calculated to furnish a 20+0 plane. The ration was composed of timothy, alfalfa, corn, and bran. When started on experiment the heifer was considerably undersized. weighing 231 pounds which was 68 pounds below or only 77.3% of the normal in weight, and being 2.7 centimeters below or 97.2% of the normal in height. She was a bright, healthy individual and apparently normal except for being undersized. In March, 1918 she went off feed for a very short time. Previous to this she had made poor gains and was continually getting farther from the normal. She became short-bodied, "pot-bellied", and unthrifty. In April she was reported as rough, in poor condition and making very poor gains. It was deemed advisable, therefore, to change the character of the ration without changing the plane of protein of the quantity of energy. The timothy was greatly reduced, the alfalfa doubled, and the corn and bran were greatly reduced and starch and sugar were added. This change in ration apparently did not make any improvement whatever for during the five 30-day periods after the change she gained only 81 pounds in weight, continued in poor flesh, rough and small, and showed a long, narrow, shallow barrel. In September, after being on the 20+0 plane for nine 30-day periods, she was 148 pounds and 3.2 centimeters below normal, or was only 72.1% of the normal in weight and 97.2% of the normal in height. During the nine periods on this plane she had made only 65.4% of the normal gain in weight but had made 97.0% of the normal gain in height. She had received 70.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and 48.5% and 53.5% respectively of the digestible true protein and 93.0% and 106.7% respectively of the net energy recommended by Armsby by age and by weight.

Something was apparently wrong with the ration or with the heifer. She had consistently been making subnormal gains. A possible shortage

TABLE 15.—SUMMARY TABLE FOR JERSEY HEIFER NO. 129.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	9 9	15+0	13.0+ 4.3	.581	.528	.427	.913	.907	.915	.396	4.83	5.04
2	10 8	15+0	11.5+ 3.0	.595	.503	.407	.942	.960	.935	.755	5.04	5.19
3	11 7	15+0	11.2+ 2.5	.604	.504	.409	.975	.986	.945	1.890	5.14	5.27
4	12 9	15+0	11.9+ 3.9	.606	.525	.425	1.006	1.000	.950	*4.170	5.18	5.38
	13 8											
Av.	11 8	15+0	11.9+ 3.4	.597	.515	.417	.959	.963	.936	1.803	5.05	5.22
5	13 8	25+0	25.0+ 8.0	.867	.865	.734	1.023	.986	.945	*4.170	5.11	5.52
6	14 8	25+0	25.6+ 6.7	.879	.896	.758	1.040	1.006	.955	1.680	5.24	5.59
7	15 7	25+0	19.5 – 5.3	.884	.738	.606	1.054	1.017	.962	2.214	5.32	5.04
	16 7											
Av.	14 23	25+0	23.4+ 3.1	.877	.833	.699	1.039	1.003	.954	2.688	5.22	5.38
8	16 7	35+0	33.7+ 2.0	1.162	1.128	.922	1.070	1.023	.967	2.603	5.38	5.49
9	17 6	35+0	35.4+ 1.7	1.146	1.158	.944	1.088	1.033	.975	2.481	5.41	5.50
10	18 5	35+0	40.0 – 0.9	1.133	1.262	.930	1.103	1.040	.980	1.221	5.43	5.38
11	19 5	35+0	36.4 – 3.2	1.128	1.167	.821	1.119	1.060	.995	2.059	5.56	5.38
12	20 4	35+0	38.3 – 1.3	1.121	1.203	.847	1.135	1.074	1.012	.950	5.61	5.54
13	21 4	35+0	38.3 – 1.0	1.140	1.226	.863	1.153	1.100	1.065	6.130	5.84	5.78
14	22 4	35+0	41.5+ 3.8	1.115	1.271	.903	1.168	1.103	1.070	1.121	5.79	6.01
15	23 3	35+0	41.8+ 1.2	1.123	1.287	.915	1.185	1.126	1.115	1.287	5.97	6.04
16	24 4	35+0	42.5 – 0.8	1.120	1.293	.922	1.200	1.146	1.155	1.251	6.09	6.04
17	25 4	35+0	45.1 – 0.3	1.115	1.354	.962	1.200	1.166	1.195	1.562	6.22	6.20
	26 3											
Av.	21 4	35+0	39.3+ 0.1	1.130	1.235	.903	1.142	1.087	1.053	2.067	5.73	5.74

*Because of a loss in weight, the average of two periods taken

TABLE 16.—SUMMARY TABLE FOR JERSEY HEIFER NO. 132.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	6 28	20+0	17.4+ 5.5	.655	.587	.476	.868	.768	.760	.550	4.19	4.42
2	7 27	20+0	17.1+ 5.6	.675	.599	.486	.884	.822	.820	1.797	4.40	4.64
3	8 26	20+0	16.4+ 5.4	.685	.589	.444	.900	.840	.840	.884	4.48	4.72
4	9 28	20+0	15.6+ 5.7	.696	.578	.466	.934	.865	.880	2.168	4.60	4.86
5	10 27	20+0	16.8 – 7.6	.695	.608	.438	.967	.875	.900	6.080	4.62	4.27
6	11 27	20+0	17.9 – 2.4	.693	.637	.459	1.000	.880	.902	.869	4.62	4.51
7	12 26	20+0	17.9 – 7.2	.702	.646	.467	1.016	.907	.915	.923	4.74	4.40
8	13 26	20+0	18.0+ 5.4	.710	.659	.478	1.033	.932	.925	1.521	4.85	4.59
9	14 25	20+0	17.8 – 6.9	.720	.662	.479	1.050	.946	.930	.903	4.95	4.61
	15 24											
Av.	11 11	20+0	17.2 – 0.8	.692	.618	.466	.961	.871	.875	1.744	4.61	4.56
10	15 24	20+50	19.3+39.9	.729	.713	.521	1.066	.973	.940	.522	5.06	7.08
11	16 24	20+50	19.6+37.9	.751	.742	.540	1.084	1.013	.960	.968	5.31	7.32
12	17 23	20+50	21.5+38.4	.754	.787	.573	1.100	1.033	.975	.492	5.41	7 49
13	18 23	20+50	19.1+26.9	.765	.742	.540	1.116	1.060	.995	1.237	5.62	7.13
14	19 22	20+50	21.9+ 3.0	.762	.811	.587	1.132	1.074	1.012	1.217	5.67	5.84
15	20 21	20+50	22.6+32.3	.764	.829	.613	1.141	1.087	1.040	1.130	5.75	7.61
16	21 23	20+50	22.9+35.0	.758	.831	.617	1.166	1.100	1.065	.656	5.68	7.67
17	22 22	20+50	25.0+40.4	.777	.897	.664	1.183	1.126	1.117	1.281	6.02	8.45
	23 22											
Av.	19 23	20+50	21.5+31.7	.758	.794	.582	1.124	1.058	1.013	.938	5.57	7.32

BORN FEBRUARY 27, 1917. ON EXPERIMENT DECEMBER 6, 1917

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs	lbs	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.46	4.44	3.78	385	331	−54	86.0		103.5	100.8	−2.7	97.4	
4.70	4.82	7.79	414	371	−43	89.6		105.4	102.6	−2.8	97.3	
4.92	5.00	19.76	438	391	−47	89.3		106.9	104.5	−2.4	97.8	
5.16	5.10	*32.70	463	399	−64	86.2		108.8	107.5	−1.3	98.8	
.....	.....	.....	486	391	−95	80.5	59.4	110.4	107.5	−2.9	97.4	97.1
4.81	**4.84**	**16.01**	**437**	**377**	**−61**	**86.3**		**107.0**	**104.6**	**−2.4**	**97.7**	
5.39	5.00	*32.70	486	391	−95	80.5		110.4	107.5	−2.9	97.4	
5.61	5.18	10.48	508	409	−99	80.5		111.7	109.8	−1.9	98.3	
5.81	5.32	15.12	523	425	−98	81.3		112.9	111.8	−1.1	99.0	
.....	.....	.....	538	435	−103	80.9	84.6	113.7	111.5	−2.2	98.1	121.2
5.60	**5.17**	**19.43**	**514**	**415**	**−99**	**80.8**		**112.2**	**110.2**	**−2.0**	**98.2**	
6.01	5.40	12.67	538	435	−103	80.9		113.7	111.5	−2.2	98.1	
6.23	5.52	11.79	557	448	−109	80.4		114.8	113.2	−1.6	98.6	
6.44	5.62	5.21	576	462	−114	80.2		115.8	115.2	−0.6	99.5	
6.64	5.88	9.49	602	493	−109	81.9		116.9	115.0	−1.9	98.4	
6.83	6.04	4.37	625	510	−115	81.6		117.6	115.0	−2.6	97.8	
7.03	6.40	28.90	652	548	−104	84.0		118.2	117.3	−0.9	99.2	
7.22	6.44	5.30	671	554	−117	82.6		119.0	116.7	−2.3	98.1	
7.42	6.72	6.04	692	588	−104	85.0		119.8	118.2	−1.6	98.7	
7.62	6.96	5.85	719	618	−101	86.0		120.5	119.6	−0.9	99.3	
7.72	7.20	7.15	740	649	−91	87.7		121.0	118.2	−2.8	97.7	
.....	.....	.....	759	675	−84	88.9	108.6	121.5	119.7	−1.8	98.5	105.1
6.92	**6.22**	**9.68**	**648**	**544**	**−105**	**83.6**		**118.1**	**116.3**	**−1.7**	**98.5**	

BORN MARCH 8, 1917. ON EXPERIMENT DECEMBER 6, 1917.

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.20	3.88	4.14	299	231	−68	77.3		96.5	93.8	−2.7	97.2	
4.30	4.02	13.92	336	263	−73	78.3		99.5	95.5	−4.0	96.0	
4.40	4.06	7.08	371	273	−98	73.6		102.6	97.0	−5.6	94.5	
4.62	4.18	18.23	405	293	−112	72.3		104.8	99.5	−5.3	94.9	
4.87	4.24	42.70	430	301	−129	70.0		106.3	101.2	−5.1	95.2	
5.10	4.27	6.15	454	304	−150	67.0		108.0	102.7	−5.3	95.1	
5.32	4.44	6.29	477	326	−151	68.3		109.8	104.3	−5.5	95.0	
5.53	4.64	10.59	500	347	−153	69.4		111.2	104.3	−6.9	93.8	
5.76	4.72	6.29	517	360	−157	69.6		112.4	108.2	−4.2	96.3	
.....	.....	.....	530	382	−148	72.1	65.4	113.2	110.0	−3.2	97.2	97.0
4.90	**4.27**	**12.82**	**432**	**308**	**−124**	**71.8**		**106.4**	**101.7**	**−4.8**	**95.5**	
5.96	4.91	5.18	530	382	−148	72.1		113.2	110.0	−3.2	97.2	
6.19	5.28	9.55	549	423	−126	77.0		114.3	111.2	−3.1	97.3	
6.40	5.52	4.68	568	446	−122	78.5		115.4	111.8	−3.6	96.9	
6.60	5.88	11.88	592	494	−98	83.4		116.5	114.2	−2.3	98.0	
6.80	6.04	8.76	615	512	−103	83.3		117.3	114.7	−2.6	97.8	
6.90	6.22	10.38	641	532	−109	83.0		117.9	116.0	−1.9	98.4	
7.20	6.40	6.06	664	554	−110	83.4		118.7	116.3	−2.4	98.0	
7.40	6.72	12.07	683	592	−91	86.7		119.5	117.7	−1.8	98.5	
.....	.....	.....	709	613	−96	86.5	129.1	120.2	118.5	−1.7	98.6	121.4
6.68	**5.87**	**8.57**	**617**	**505**	**−111**	**81.5**		**117.0**	**114.5**	**−2.5**	**97.9**	

in the energy of the ration was suggested and her ration was changed so that it furnished as nearly as possible the same amount or plane of protein, while the amount of energy was increased fifty per cent. The ration on which this heifer was placed September 2, 1918 was the same in character except that the very small amount of bran was eliminated. The proportion of the different feeds was changed somewhat but the animal was continued on timothy, alfalfa, corn and starch and sugar. Our data show that while it was attempted to keep the quantity the same the actual protein received was slightly increased. This was due to the fact that the animal had previously been consuming slightly less than was calculated for her. The energy however, was increased almost exactly 50% as calculated. In December, 1918, she refused considerable quantities of starch and sugar. To remedy this condition her ration was slightly changed leaving the protein and energy the same but making the ration more palatable. On April 29, 1919 she was not fat but was in a splendid thrifty condition and making on the average better than normal gains. She was still 96 pounds below or 86.5% of the normal on this date when she was taken off experiment, and was at the same time 98.6% of the normal in height. During the eight 30-day periods on the 20+50 plane she made 129.1% of the normal gain in weight and 121.4% of the normal gain in height. These gains had been accomplished on 78.4% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 51.8% and 55.0% respectively of the digestible true protein and 109.6% and 124.7% respectively of the net energy recommended by Armsby by age and by weight. It would seem that the added energy was of considerable importance because of the improvement on this heifer commenced almost immediately with the increase in energy. On August 7, 1919, she dropped a bull calf that was aborted at 263 days. No weight is available for the calf. During the summer of 1919 a peculiar type of abortion, followed by a severe uterine infection, was prevalent in the University herd. The cause of the trouble has never been explained. This heifer showed the typical symptoms, aborted only approximately three weeks before due, dropped a dead calf and was subsequently very seriously infected. She was isolated, and did not milk heavily. She developed the habit of self sucking. Because of the infection of the uterus she failed to breed and was slaughtered.

No. 273 (*See Table* 17.)—Holstein heifer No. 273 was placed on a preliminary ration November 25, 1917. On December 6 she was commenced on an experiment calculated to furnish a 20+0 or a medium plane, to some extent duplicating that of No. 132. The ration was made up of timothy, alfalfa, corn and bran. She was considerably older than

any of the other heifers, being 12 months 28 days of age at the outset. She weighed 516 pounds which was 57 pounds below or 90.1% of the normal in weight and was 1.7 centimeters below or 98.5% of the normal in height. She took her ration readily from the start but failed to show the condition that might be expected. She was rough and showed a decided lack of depth and width of barrel. Her average gains, however, were somewhat better than normal. After she had been on the 20+0 plane for six 30-day periods it was thought advisable to see if still better growth and development could be obtained on a higher plane. At this time she was 35 pounds below or 95.1% of the normal in weight and 1.4 centimeters below or 98.9% of the normal in height. During the six periods on the 20+0 plane she made 115.9% of the normal gain in weight and 104.3% of the normal gain in height, while receiving 78.5% of the digestible crude protein recommended by the Wolff-Lehmann standard and 64.8% and 61.6% respectively of the digestible true protein and 119.3% and 106.7% respectively of the net energy recommended by Armsby by age and by weight.

Her ration was changed on June 4, 1918 so that, without upsetting the character of the ration more than was necessary, the plane could be raised to a very high or 35+0 value. This was accomplished chiefly by increasing the quantity of alfalfa and adding cottonseed meal. She was on the 35+0 plane for five 30-day periods and her gains were remarkable. At the end of the experiment she weighed 888 pounds which was 51 pounds above or 106.1% of the normal in weight. At the same time she was 0.1 centimeters below or 99.9% of normal in height. This represents 168.3% of the normal gain in weight and 135.1% of the normal gain in height for the five 30-day periods. While these gains were being made the animal received an average of 130.1% of the digestible crude protein recommended by Wolff-Lehmann standard and 118.6% and 113.9% respectively of digestible true protein and 121.0% and 107.1% respectively of net energy recommended by Armsby by age and by weight. These are among the best gains secured on experimental animals on any plane to date. Not only did she make unusual gains in weight but her condition improved greatly. Her condition of hair, hide and flesh became excellent and her barrel showed splendid development. She seemed normal in every respect and was considerably above normal in weight when taken off experiment at the age of 23 months, 23 days on October 31, 1918. She was becoming heavy with calf and on December 27, 1918 gave birth to twin heifers weighing 53 pounds each at birth, which had been carried 273 days, and which were normal, except for size. Following calving the cow developed a severe uterine infection, became emaciated, and nearly died. She was dried up at once and fed

TABLE 17.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 273.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	12 28	20+0	17.8+ 4.5	.857	.795	.638	1.016	1.080	1.025	1.325	6.19	6.47
2	13 27	20+0	15.0+ 3.5	.880	.729	.586	1.033	1.087	1.040	.951	6.36	6.58
3	14 26	20+0	15.2+ 3.5	.911	.764	.616	1.050	1.106	1.077	1.042	6.60	6.83
4	15 28	20+0	16.5+ 4.5	.944	.831	.668	1.066	1.120	1.105	.997	6.84	7.15
5	16 27	20+0	21.8+ 4.1	.975	1.036	.828	1.084	1.132	1.130	1.243	7.09	7.38
6	17 27	20+0	19.3+ 2.7	1.006	.986	.779	1.100	1.153	1.170	.629	7.33	7.53
	18 26											
Av.	15 27	20+0	17.6+ 3.8	.929	.857	.686	1.058	1.113	1.091	1.031	6.74	6.99
7	18 26	35+0	34.9+ 2.9	1.572	1.571	1.286	1.116	1.188	1.235	1.813	7.70	7.92
8	19 26	35+0	34.4 – 0.1	1.616	1.595	1.303	1.132	1.200	1.260	1.544	7.95	7.94
9	20 25	35+0	33.4+ 1.2	1.681	1.625	1.325	1.150	1.200	1.274	.728	8.27	8.37
10	21 24	35+0	34.1+ 2.1	1.752	1.719	1.409	1.166	1.200	1.305	1.097	8.78	8.96
11	22 24	35+0	37.9+ 0.3	1.800	1.818	1.495	1.183	1.200	1.327	1.330	9.13	9.16
	23 23											
Av.	21 10	35+0	34.9+ 1.3	1.684	1.666	1.363	1.149	1.198	1.280	1.302	8.37	8.47

TABLE 18.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 277.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	10 6	35+0	27.5+ 6.1	1.262	1.042	.799	.934	1.033	.975	.727	5.77	6.12
2	11 5	35+0	25.2+ 4.1	1.280	.994	.770	.967	1.066	1.000	1.065	6.04	6.29
3	12 4	35+0	24.6+ 2.6	1.304	1.026	.798	1.000	1.080	1.025	.879	6.23	6.39
4	13 6	35+0	28.3+ 4.6	1.345	1.086	.840	1.016	1.106	1.077	1.358	6.51	6.81
	14 5											
Av.	12 5	35+0	26.4+ 4.4	1.298	1.037	.802	.979	1.071	1.019	1.007	6.14	6.40
5	14 5	20+0	18.4 –25.9	.944	.876	.620	1.033	1.120	1.105	*2.373	6.76	5.01
6	15 5	20+0	17.6 –26.5	.943	.864	.609	1.050	1.120	1.105	*2.373	6.83	5.02
7	16 4	20+0	18.4 – 7.8	.975	.921	.651	1.066	1.136	1.137	1.201	7.09	6.54
8	17 4	20+0	20.7 – 4.8	1.002	1.027	.722	1.084	1.153	1.170	1.541	7.29	6.94
9	18 3	20+0	21.4+ 4.1	1.032	1.080	.768	1.100	1.166	1.195	.926	7.53	7.84
	19 2											
Av.	15 19	20+0	19.3 –12.2	.979	.954	.674	1.067	1.139	1.142	1.683	7.10	6.27
10	19 2	15+0	14.6+ 0.1	.889	.872	.624	1.116	1.188	1.235	2.616	7.83	7.84
11	20 2	15+0	15.9 – 4.3	.916	.952	.683	1.132	1.200	1.260	1.298	8.05	7.70
	21 1											
Av.	20 2	15+0	15.3 – 2.1	.903	.912	.654	1.124	1.194	1.248	1.957	7.94	7.77
12	21 1	15+50	17.4+35.4	.941	1.034	.773	1.150	1.200	1.265	.585	8.27	11.20
13	22 1	15+50	18.2+40.0	.979	1.104	.832	1.166	1.200	1.291	.662	8.66	12.12
14	23 0	15+50	16.6+30.7	.980	1.041	.788	1.183	1.200	1.315	1.041	8.80	11.50
15	23 29	15+50	17.8+37.2	.961	1.063	.804	1.200	1.200	1.327	.709	8.74	11.99
16	25 1	15+50	18.9+38.5	.934	1.062	.810	1.200	1.200	1.345	1.028	8.67	12.01
17	26 0	15+50	19.6+35.0	.899	1.031	.786	1.200	1.200	1.350	*1.656	8.56	11.56
18	26 30	15+50	19.9+39.1	.868	.991	.757	1.200	1.200	1.350	*1.656	8.45	11.75
19	27 29	15+50	16.2+29.7	.875	.904	.695	1.200	1.200	1.350	*1.656	8.55	11.09
	28 29											
Av.	24 30	15+50	18.1+35.7	.930	1.029	.781	1.187	1.200	1.322	1.124	8.59	11.65

*Because of a loss in weight, average of two or more periods taken.

BORN NOVEMBER 8, 1916. ON EXPERIMENT DECEMBER 6, 1917

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
5.32	6.13	10.78	573	516	−57	90.1		115.7	114.0	−1.7	98.5	
5.53	6.32	8.58	594	534	−60	89.9		117.3	115.3	−2.0	98.3	
5.76	6.48	9.31	610	557	−53	91.3		118.7	115.7	−3.0	97.5	
5.96	6.64	8.58	641	579	−62	90.3		120.2	118.2	−2.0	98.3	
6.19	6.80	8.86	658	604	−54	91.8		121.2	118.8	−2.4	98.0	
6.40	7.04	4.81	683	629	−54	92.1		121.7	120.8	−0.9	99.3	
.....	.....	.....	711	676	−35	95.1	115.9	122.6	121.2	−1.4	98.9	104.3
5.86	**6.65**	**8.49**	**638**	**585**	**−54**	**91.5**		**119.6**	**117.7**	**−1.9**	**98.4**	
6.60	7.44	9.14	711	676	−35	95.1		122.6	121.2	−1.4	98.9	
6.80	7.60	7.68	742	702	−40	94.6		123.7	122.3	−1.4	98.9	
7.00	7.78	3.75	769	733	−36	95.3		124.2	123.8	−0.4	99.7	
7.20	8.20	5.72	792	800	+8	101.0		124.8	125.3	+0.5	100.4	
7.40	8.53	6.70	818	847	+29	103.5		125.6	125.8	+0.2	100.2	
.....	.....	.....	837	888	+51	106.1	168.3	126.3	126.2	−0.1	99.9	135.1
7.00	**7.91**	**6.60**	**778**	**774**	**−4**	**99.3**		**124.5**	**124.1**	**−0.4**	**99.7**	

BORN JANUARY 31, 1917. ON EXPERIMENT DECEMBER 6, 1917

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.62	5.52	4.27	507	453	−54	89.3		111.5	108.7	−2.8	97.5	
4.86	5.96	6.74	534	496	−38	92.9		112.8	110.3	−2.5	97.8	
5.10	6.13	5.48	560	524	−36	93.6		114.2	112.7	−1.5	98.7	
5.32	6.48	8.51	578	559	−19	96.7		116.0	115.0	−1.0	99.1	
.....	.....	.....	599	583	−16	97.3	141.3	117.6	117.3	−0.3	99.7	141.0
4.98	**6.02**	**6.25**	**556**	**523**	**−33**	**94.0**		**114.4**	**112.8**	**−1.6**	**98.6**	
5.53	6.64	*13.68	599	583	−16	97.3		117.6	117.3	−0.3	99.7	
5.76	6.64	*13.68	617	578	−39	93.7		119.0	117.8	−1.2	99.0	
5.96	6.84	8.53	645	605	−40	93.8		120.4	119.0	−1.4	98.8	
6.19	7.04	10.41	663	628	−35	94.7		121.4	118.3	−3.1	97.4	
6.40	7.20	6.72	689	648	−41	94.0		121.9	119.8	−2.1	98.3	
.....	.....	.....	717	683	−34	95.3	84.7	122.8	122.7	−0.1	99.9	103.8
5.97	**6.87**	**10.60**	**655**	**621**	**−34**	**94.8**		**120.5**	**119.2**	**−1.4**	**98.8**	
6.60	7.44	23.52	717	683	−34	95.3		122.8	122.7	−0.1	99.9	
6.80	7.60	10.50	748	693	−55	92.6		123.8	123.2	−0.6	99.5	
.....	.....	.....	775	715	−60	92.3	55.2	124.3	124.8	+0.5	100.4	140.0
6.70	**7.52**	**17.01**	**747**	**697**	**−50**	**93.4**		**123.6**	**123.6**	**−0.1**	**99.9**	
7.00	7.66	6.34	775	715	−60	92.3		124.2	124.8	+0.5	100.4	
7.20	8.02	7.27	797	768	−29	96.4		124.9	124.7	−0.2	99.8	
7.40	8.34	11.50	824	818	−6	99.3		125.7	125.5	−0.2	99.8	
7.60	8.53	7.99	841	848	+7	100.8		126.4	125.8	−0.6	99.5	
7.70	8.80	11.62	870	893	+23	102.6		127.6	126.8	−0.8	99.4	
7.80	9.12	*19.47	893	924	+31	103.5		128.2	127.3	−0.9	99.3	
7.90	9.38	*19.47	925	982	+57	106.2		129.2	128.2	−1.0	99.2	
8.00	9.50	*19.47	966	1003	+37	103.8	120.2	129.7	128.5	−1.2	99.1	60.7
.....	.....	.....	993	977	−16	98.4		130.4	128.5	−1.9	98.5	
7.58	**8.67**	**12.89**	**876**	**881**	**+5**	**100.4**		**127.4**	**126.7**	**−0.7**	**99.4**	

liberally as soon as her condition would permit. She grew out into a very large splendid cow, came in heat regularly, and was bred at nearly every oestral period from May, 1919 to December, 1920. In all she was bred sixteen times. It was finally found that her uterus was infected and she was slaughtered. The results with this heifer were at least suggestive. In the first place they confirmed our observations that a Jersey could not make as good gains and development as a Holstein on the same plane and character of ration. In the second place the results suggested that an animal at an advanced age could make better gains than a younger animal on the same plane. A "sliding scale" of planes for animals at different ages, or for the same animal as it grows older, was suggested as a problem for further study.

No. 277. (*See Table* 18.)—Holstein heifer No. 277 was placed on a preliminary ration November 25, 1917. On December 6, at the age of 10 months, 6 days, she was commenced on experiment on a ration composed of timothy, alfalfa, corn and bran calculated to furnish a ration a 35+0 or a very high plane. An attempt has been made since early in the experiment to standardize conditions by limiting the feeds as far as possible to a ration of timothy, alfalfa and corn, with bran and cottonseed meal to supply additional protein and starch and sugar to furnish additional energy. She was in fairly good condition at the beginning except for being somewhat deficient in paunch development. She weighed 453 pounds which was 54 pounds below or 89.3% of the normal weight and was 2.8 centimeters below or 97.5% of the normal in height. The 35+0 plane was continued without material change for four 30-day periods. At the end of the fourth period she was 16 pounds below or 97.3% of the normal in weight and 99.7% of the normal in height. She made 141.3% of the normal gain in weight and 141.0% of the normal gain in height while on the 35+0 plane, while receiving 101.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and 81.9% and 74.8% respectively of the digestible true protein and 128.7% and 106.3% respectively of the net energy recommended by Armsby by age and by weight. At the end of the four periods on a 35+0 plane she was in a good thrifty condition but her barrel was undeveloped.

Since her gains had been so far above normal her plane was lowered on April 5, 1918 from 35+0 to 20+0 by reducing the corn and bran and adding starch and sugar. The quantity of protein furnished both before and after the change was considerably less than calculated and the reduction was not as great as was intended and amounted to approximately 0.2 pound daily or about 20%. After being on the reduced plane for more than 30 days it was discovered that an error had been made in

calculating the average value of the corn in April at the time the reduction and that instead of reducing the protein and leaving the energy constant, the energy also had been reduced approximately 25%. The heifer was continued on this erroneous ration during the remainder of that 30-day period or a total of sixty days. During that time she gained only 22 pounds in weight, developed a thick heavy hide and rough coat and became decidedly lacking in barrel development and very poor in flesh. Owing to the error noted this change in condition cannot be definitely attributed to any one cause. In June the error was corrected and she was placed on the 20+0 plane. She was continued on this corrected ration for three 30-day periods. During this time she made approximately normal gains and improved in general physical condition. Apparently she was making practically normal gains on a 20+0 plane, for considering the fact that she was receiving much less than calculated during two of the five 30-day periods she made 84.7% of the normal gain in weight and 103.8% of the normal gain in height during the five periods while receiving only 83.5% of the digestible crude protein recommended by the Wolff-Lehmann standard and 63.2% and 59.2% respectively of the digestible true protein and 105.1% and 91.2% respectively of the net energy recommended by Armsby by age and by weight.

It was thought advisable to reduce her still further in September, 1918 and place her on a 15+0 plane. This was accomplished almost entirely by increasing the timothy and reducing the alfalfa hay an equal amount. She remained on the 15+0 plane for two 30-day periods and made only 55.2% of the normal gain in weight, but made 140.0% of the normal gain in height. During these 60 days she received 73.1% of the digestible crude protein recommended by the Wolff-Lehmann standard and 58.1% and 54.7% respectively of the digestible true protein and 116.0% and 103.3% respectively of the net energy recommended by Armsby by age and by weight. The physical condition of the heifer was medium at the end of the second period on the 15+0 plane.

The weight and general condition of this heifer followed very closely the plane of protein feeding. It was planned as a check on some results already discussed to increase the energy 50% or to place her on a 15+50 plane to see whether or not and to what extent beneficial results would follow. This animal offered unusual opportunities for this consideration, since her gains from the beginning had so closely followed the manipulation of her ration. The character of the ration was left unchanged as far as possible, the increase in energy being accomplished by an increase in timothy, a reduction in alfalfa and an increase in corn and starch and sugar. The total bulk and weight of the ration was somewhat increased. A change of lots of timothy at the time, increased the amount of protein

in the new ration, making it approximately 10% more in actual quantity than was calculated. This is unfortunate as it makes conclusions difficult, but from the time of this change in ration she continued to make exceptionally good gains in weight. After being on the 15+50 plane for five periods, she was reported as being very fat and making enormous gains in weight and showing decided improvement in general condition. For the purpose of determining the effect of fattening a heifer or cow on starch and sugar, on the test of milk produced, it was desired to continue her on the same ration up until, and probably for some time after, calving. On June 27, 1919 she dropped a heifer calf weighing 80 pounds at birth that had been carried 274 days. The calf was apparently normal. Calving took place on the second day of the weighing period after the weight had been taken, consequently only two weights are available for the end of the experiment which came on June 28, 1919. She was on the 15+50 plane for eight 30-day periods. During this time she became "rolling fat" and in first class condition in every respect and at the end of the experiment weighed only 16 pounds below normal. She was 98.4% of the normal in weight and 98.5% of the normal in height and had made during the eight periods 120.2% of the normal gain in weight and 60.7% of the normal gain in height. These gains on the 15+50 plane had been accomplished on 77.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 65.7% and 65.1% respectively of the digestible true protein and 153.8% and 134.4% respectively of the net energy recommended by Armsby by age and by weight.

Since the experiment was continued up to and even beyond the date of calving and since she actually lost 26 pounds during the last 30-day period as indicated by the two weights at the end of the experiment it would seem fair if the last period were not included in the calculations. This would alter the results considerably. At the end of the previous period she weighed 1,003 pounds which was 37 pounds above normal. She was at that time 103.8% of the normal in weight and 99.1% of the normal in height. During the seven 30-day periods she made 150.8% of the normal gain in weight and 68.5% of the normal gain in height, and these gains were accomplished on 79.3% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 66.9% and 66.1% respectively of the digestible true protein and 156.1% and 137.2% respectively of the net energy recommended by Armsby by age and by weight. In all the summaries made, however, the entire nineteen periods were included in the data for this heifer so that results reported are believed entirely conservative. Throughout the entire experiment from the age of 10 to 28 months she followed the manipula-

tions of the ration more closely than any other heifer. The fact that she was fattened on a high energy ration made up largely of starch and sugar seemed to have no noticeable effect on the test of the milk during the seven-day test which followed. The cow was a splendid producer. She calved at the age of 2 years, 4 months, 26 days, and made an official record during this first lactation period as a two-year-old amounting to 11,022 pounds of milk and 378 pounds of fat.

No. 120 (*See Table* 19.)--Jersey heifer No. 120 was commenced December 8, 1917 on a preliminary ration of timothy, corn and bran calculated to furnish a very low, or an 8+0 plane. She took her ration readily and gained 13 pounds on the 28 days of preliminary feeding. She was placed on experiment January 5, 1918 on the same ration. At this time she was 18 months and 15 days of age. The reason for placing her on this low plane at this advanced age was to determine whether or not a heifer can make normal gains at an advanced age on a plane which is sufficient at an earlier age. On the 8+0 plane she grew steadily worse in general condition and even lost weight during some of the 30-day periods. The completeness of her ration is questionable.

On April 6, after being on the 8+0 plane for three 30-day periods, her ration was changed to timothy, alfalfa, corn, silage and starch and sugar to completely change the character of the ration without altering the plane. The protein was in reality increased to such an extent through change in feeds that the plane was raised to approximately 15+0. From this date her gains were practically normal and her condition was somewhat improved. This ration was continued through the fourth and for 26 days of the fifth 30-day period or through May 30, 1918. It was necessary to change the ration on May 31, because the supply of silage became exhausted on that date. Since it was desirable to see what she would do on a high plane she was changed four days before the end of the fifth period to a 25+0 plane made up of a ration similar to the one which she had been receiving except that bran was again substituted for the corn silage. From the appearance of the animal it seemed evident that the change in character of ration made April 6, was beneficial. She showed considerable improvement and made practically normal gains following the change. It is impossible to conclude whether the difference was due to the character of the ration or to the increase in the quantity of protein brought about by giving feeds of an analysis somewhat higher than was anticipated.

At the beginning of the experiment this heifer weighed 588 pounds which was 3 pounds above or 100.5% of the normal in weight, and was 3.2 centimeters below or 97.2% of the normal in height. At the end of the first five periods she was 64 pounds below or 90.9% of the normal in

TABLE 19.—SUMMARY TABLE FOR JERSEY HEIFER NO. 120.

1	2		3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period		Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protei required daily		Wolff Lenmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
								By age	By weight				
	mo.–da.				lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	18	15	8+0	9.4+18.6	.505	.541	.454	1.108	1.126	1.117	*2.650	6.19	7.34
2	19	14	8+0	8.9+20.1	.494	.519	.416	1.124	1.120	1.105	*2.650	6.07	7.29
3	20	16	8+0	9.1+16.7	.502	.531	.445	1.141	1.132	1.130	*2.863	6.15	7.18
4	21	15	8+0	13.0 - 7.0	.494	.614	.423	1.158	1.126	1.117	*2.863	6.04	5.62
5	22	15	8+0	13.9 - 7.4	.556	.644	.451	1.174	1.140	1.145	.743	6.18	5.72
	23	14											
Av.	**21**	**0**	**8+0**	**10.9+ 8.2**	**.510**	**.570**	**.438**	**1.141**	**1.129**	**1.123**	**2.354**	**6.13**	**6.63**
6	23	14	25+0	22.8 - 8.6	.913	.862	.649	1.191	1.160	1.182	1.175	6.27	5.73
	24	14											
Av.	**23**	**29**	**25+0**	**22.8 - 8.6**	**.913**	**.862**	**.649**	**1.191**	**1.160**	**1.182**	**1.175**	**6.27**	**5.73**

*Because of a loss in weight, the average of two periods taken.

TABLE 20.—SUMMARY TABLE FOR JERSEY HEIFER NO. 140.

1	2		3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period		Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
								By age	By weight				
	mo.–da.				lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	5	25	20+50	16.3+16.6	.673	.577	.450	.850	.840	.840	.524	4.41	5.14
2	6	24	20+50	20.0+32.8	.690	.691	.538	.868	.875	.900	.592	4.61	6.12
3	7	26	20+50	22.2+42.4	.710	.771	.600	.884	.920	.920	.609	4.83	6.88
4	8	25	20+50	23.4+42.6	.736	.829	.636	.900	.946	.930	.995	5.09	7.26
5	9	24	20+50	22.0+36.3	.750	.806	.620	.934	1.000	.950	.780	5.24	7.14
6	10	24	20+50	23.1+40.8	.759	.843	.646	.967	1.020	.965	.816	5.39	7.59
	11	23											
Av.	**8**	**24**	**20+50**	**21.2+35.3**	**.730**	**.753**	**.582**	**.901**	**.934**	**.918**	**.719**	**4.93**	**6.69**
7	11	23	20+25	23.3+22.1	.771	.860	.661	1.000	1.040	.980	.832	5.56	6.79
8	12	23	20+25	20.9+22.8	.785	.811	.631	1.016	1.060	.995	.901	5.74	7.05
9	13	22	20+25	20.7+24.5	.791	.817	.639	1.033	1.080	1.025	.743	5.88	7.32
	14	21											
Av.	**13**	**7**	**20+25**	**21.6+23.1**	**.782**	**.829**	**.644**	**1.016**	**1.060**	**1.000**	**.825**	**5.73**	**7.05**
10	14	21	20+0	19.9 - 0.5	.816	.815	.623	1.042	1.100	1.065	1.164	6.09	6.06
11	15	21	20+0	20.0 - 0.8	.825	.826	.631	1.058	1.113	1.090	2.478	6.21	6.16
12	16	20	20+0	20.2 - 1.0	.831	.838	.638	1.075	1.120	1.105	1.257	6.27	6.21
13	17	20	20+0	20.2 - 0.8	.831	.838	.638	1.092	1.132	1.130	1.479	6.34	6.29
14	18	19	20+0	20.0 - 0.5	.830	.831	.632	1.108	1.146	1.155	1.247	6.40	6.37
15	19	18	20+0	19.6 - 1.9	.827	.819	.624	1.124	1.160	1.182	.910	6.44	6.32
	20	19											
Av	**17**	**20**	**20+0**	**20.0 - 0.9**	**.827**	**.828**	**.631**	**1.083**	**1.129**	**1.121**	**1.423**	**6.29**	**6.24**
16	20	19	15+0	15.5 - 2.3	.708	.721	.562	1.141	1.180	1.220	10.815	6.56	6.41
17	21	18	15+0	14.5 - 2.4	.709	.697	.546	1.158	1.180	1.220	.597	6.57	6.41
18	22	18	15+0	14.2+ 3.1	.714	.695	.544	1.174	1.200	1.260	1.738	6.69	6.90
19	23	17	15+0	14.0+ 2.5	.716	.693	.543	1.191	1.200	1.269	2.079	6.73	6.90
	24	17											
Av.	**22**	**18**	**15+0**	**14.6+0.2**	**.712**	**.702**	**.549**	**1.168**	**1.190**	**1.242**	**3.807**	**6.64**	**6.66**

BORN JUNE 20, 1916. ON EXPERIMENT JANUARY 5, 1918.

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
6.50	6.72	*36.58	585	588	+3	100.5		116.2	113.0	-3.2	97.2	
6.70	6.64	*36.58	609	579	-30	95.1		117.2	116.0	-1.2	99.0	
6.90	6.80	*32.00	636	600	-36	94.3		117.8	115.8	-2.0	98.3	
7.10	6.72	*32.00	659	594	-65	90.1		118.5	119.3	+0.8	100.7	
7.30	6.88	6.60	679	612	-67	90.1		119.4	119.0	-0.4	99.7	
.....	.....	.....	702	638	-64	90.9	42.7	120.1	119.5	-0.6	99.5	166.7
6.90	**6.75**	**28.75**	**645**	**602**	**-43**	**93.5**		**118.2**	**117.1**	**-1.1**	**99.1**	
7.50	7.12	7.81	702	638	-64	90.9		120.1	119.5	-0.6	99.5	
.....	.....	.....	726	660	-66	90.9	91.7	120.7	120.7	±0.0	100.0	200.0
7.50	**7.12**	**7.81**	**714**	**649**	**-65**	**90.9**		**120.4**	**120.1**	**-0.3**	**99.8**	

BORN JULY 6, 1918. ON EXPERIMENT DECEMBER 31, 1918

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.10	4.06	4.67	254	268	+14	105.5		92.8	95.2	+2.4	102.6	
4.20	4.24	5.26	294	301	+7	102.4		96.1	96.8	+0.7	100.7	
4.30	4.54	5.43	335	336	+1	100.3		99.1	100.0	+0.9	100.9	
4.40	4.72	8.71	370	374	+4	101.1		102.3	102.8	+0.5	100.5	
4.62	5.10	6.91	401	399	-2	99.5		104.5	103.7	-0.8	99.2	
4.86	5.36	7.35	427	430	+3	100.7		106.2	105.5	-0.7	99.3	
.....	.....	.....	450	461	+11	102.4	98.5	107.8	107.6	-0.2	99.8	82.7
4.41	**4.67**	**6.39**	**362**	**367**	**+5**	**101.7**		**101.3**	**101.7**	**+0.4**	**100.4**	
5.10	5.62	6.57	450	461	+11	102.4		107.8	107.6	-0.2	99.8	
5.32	5.88	7.83	474	492	+18	103.8		109.6	109.5	-0.1	99.9	
5.53	6.13	6.65	497	519	+22	104.4		111.0	111.3	+0.3	100.3	
.....	.....	.....	515	552	+37	107.2	140.0	112.2	112.0	-0.2	99.8	100.0
5.32	**5.88**	**7.02**	**484**	**506**	**+22**	**104.5**		**110.2**	**110.1**	**-0.1**	**100.0**	
5.64	6.40	8.66	515	552	+37	107.2		112.2	112.0	-0.2	99.8	
5.86	6.56	18.48	529	573	+44	108.3		113.1	113.2	+0.1	100.1	
6.07	6.64	9.32	546	583	+37	106.8		114.2	112.3	-1.9	98.3	
6.28	6.80	11.10	566	603	+37	106.5		115.2	114.8	-0.4	99.7	
6.50	6.96	9.56	588	620	+32	105.4		116.4	114.2	-2.2	98.1	
6.70	7.12	7.02	612	640	+28	104.6		117.2	116.2	-1.0	99.1	
.....	.....	.....	639	667	+28	104.4	92.7	117.9	116.8	-1.1	99.1	84.2
6.18	**6.75**	**10.69**	**571**	**605**	**+35**	**106.2**		**115.2**	**114.2**	**-1.0**	**99.2**	
6.90	7.36	96.15	639	667	+28	104.4		117.9	116.8	-1.1	99.1	
7.10	7.36	5.49	660	669	+9	101.4		118.6	118.2	-0.4	99.7	
7.30	7.60	17.25	681	704	+23	103.4		119.5	118.8	-0.7	99.4	
7.50	7.72	20.70	704	716	+12	101.7		120.0	119.5	-0.5	99.6	
.....	.....	.....	728	726	-2	99.7	66.3	120.7	119.2	-1.5	98.8	85.7
7.20	**7.51**	**34.90**	**682**	**696**	**+14**	**102.1**		**119.3**	**118.5**	**-0.8**	**99.3**	

weight and was 0.6 centimeters below or 99.5% of the normal in height. During the 150 days she made 42.7% and 166.7% respectively of the normal gain in weight and height, on 50.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 38.4% and 38.8% respectively of the digestible true protein and 96.1% and 98.2% respectively of the net energy recommended by Armsby by age and by weight. She remained on the 25+0 plane only one full period. During that period she made 91.7% and 200.0% respectively of the normal gain in weight and in height on 72.9% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 54.5% and 55.9% respectively of the digestible true protein and 76.4% and 80.5% respectively of the net energy recommended by Armsby by age and by weight. At this advanced age the weight increases are normally so small that this value of 200% for one period is not significant. She was 90.9% of the normal in weight, and exactly normal in height at the end of the experiment. Since she was heavy with calf she was taken off experiment July 3, 1918. On August 24, 1918 she gave birth to a bull calf weighing 45 pounds, which had been carried 274 days and which was normal. The cow proved to be a superior producer. She calved at the age of 26 months, 4 days and in her first lactation period as a two-year-old produced 7,932 pounds of milk and 465 pounds of fat. Since her first period she has been a remarkable and persistent producer. She has, however, always been somewhat lacking in chest and barrel development although there is no reason to suppose that this can be attributed to her experimental feeding. As a four-year-old she produced on official test 11,154 pounds of milk and 623 pounds of fat.

No. 140. (*See Table* 20.)—Jersey heifer No. 140 was placed on experiment December 31, 1918 at the age of 5 months, 25 days and was given a ration calculated to furnish a 20+50 plane. Since the age of about 3 months she had been on an experiment to determine the earliest age at which weaning can successfully be accomplished. She had been on a ration of alfalfa hay and a grain mixture made up of corn, bran and linseed meal. The ration on which she was placed was composed of timothy, alfalfa, corn and starch and sugar. The reason for placing her on a 20+50 plane was to determine if possible why the Jerseys on experiment had not made as satisfactory gains as Holsteins on the same plane and the same character of ration. She weighed 268 pounds which was 14 pounds above or 105.5% of the normal in weight, and was 2.4 centimeters above or 102.6% of the normal in height. Not only was she somewhat above normal in size but she was in excellent condition, general appearance, flesh and thrift. She started at the beginning to

make gains in weight that were almost normal. She did, however, refuse a part of her ration at frequent intervals. She remained on the 20+50 plane through six 30-day periods, at the end of which she was reported as in excellent condition. During the six periods she gained 193 pounds or an average daily gain of 1.07 pounds. At the end of the sixth period she was 11 pounds above or 102.4% of the normal in weight and 99.8% of the normal in height. During the six periods she made 98.5% of the normal gain in weight and 82.7% of the normal in height while receiving 82.1% of the digestible crude protein recommended by the Wolff-Lehmann standard and 64.6% and 62.3% respectively of the digestible true protein and 151.5% and 143.2% respectively of the net energy recommended by Armsby by age and by weight.

She was changed in June, 1919 from a plane of 20+50 to one of 20+25. This change left the protein almost exactly the same but reduced the energy about 10%, a change so slight in quantity and proportion that it is hardly worth considering in the calculations. She remained on the 20+25 plane for three 30-day periods, continued in excellent condition and made 140.0% of the normal gain in weight and exactly a normal gain in height. If the nine 30-day periods, during which time she was on a 20+50 and a 20+25 plane, be considered as a unit, she made 108.8% of the normal gain in weight and 86.6% of the normal gain in height, and maintained her excellent condition while receiving 82.4% of the digestible crude protein recommended by the Wolff-Lehmann standard and 64.1% and 61.7% respectively of the digestible true protein and 144.4% and 134.3% respectively of the net energy recommended by Armsby by age and by weight. It should be noted that this heifer was on experiment from the age of about three months and that she was placed on this experiment when much younger than many of the other experimental heifers. She had made about the best development of any Jersey to date on any plane.

In September, 1919 she was placed on a 20+0 plane and given a ration made up of timothy, alfalfa and corn with a very small quantity of starch and sugar. This is the same character of ration she received previously except that the proportions were slightly changed and the starch and sugar almost entirely eliminated. At this time she was 37 pounds above normal, while she was only 14 pounds above normal at the outset. She was dehorned in November and was in heat so her gains for the month were not as good as they had been previously. After being on the 20+0 plane for six 30-day periods, she was in excellent condition, showed a large barrel and was broad and deep. She was considered in normal condition being 104.4% of the normal in weight and 99.1% of the normal in height. During the six periods on a 20+0 plane she made

92.7% of the normal gain in weight and 84.2% of the normal gain in height while receiving 73.8% of the digestible crude protein recommended by the Wolff-Lehmann standard and 58.3% and 55.9% respectively of the digestible true protein and 101.0% and 92.4% respectively of the net energy recommended by Armsby by age and by weight.

It seemed advisable in March, 1920 to further reduce her plane from 20+0 to 15+0 without changing the character of the ration to see if she would continue to make normal development. The gains from this time were much smaller than previously. She was continued on the 15+0 plane through four 30-day periods, at the end of which time she was 2 pounds below or 99.7% of the normal in weight and 98.8% of the normal in height. She was still in splendid condition in general, but had, in the four periods on the 15+0 plane, made only 66.3% of the normal gain in weight and 85.7% of the normal gain in height. While making these gains she received only 56.5% of the digestible crude protein recommended by the Wolff-Lehmann standard and 47.1% and 46.1% respectively of the digestible true protein and 92.4% and 88.6% respectively of the net energy recommended by Armsby by age and by weight. She was taken off experiment July 22, 1920, and calved September 27, 1920 at the age of 2 years, 2 months, 21 days, dropping a bull calf which weighed 50 pounds at birth and which had been carried 294 days. The calf seemed normal at birth but died of indigestion. The cow proved a satisfactory producer, completing her record for one year as a two-year-old with 5,732 pounds of milk and 337 pounds of fat.

No. 143. (*See Table* 21.)—Jersey heifer No. 143 was placed on a preliminary ration February 22, 1919 and was started on experiment March 1, 1919 at the age of 5 months, 27 days, and given a ration composed of alfalfa, corn, ground oats, and bran, and cottonseed meal in very small quantities, calculated to furnish a very high or a 35+0 plane. Such a ration would appear to be entirely adequate. This heifer was in excellent condition. She weighed 299 pounds which was 43 pounds above or 116.8% of the normal in weight, and 5.4 centimeters above or 105.8% of the normal in height. She remained on the same plane and almost the same ration for five 30-day periods. Her gains were good but slightly less than normal and she remained in excellent condition. At the end of this time she was 30 pounds above or 107.0% of the normal in weight and 5.0 centimeters above or 104.7% of the normal in height. During the 150 days she made 92.4% of the normal gain in weight and 96.9% of the normal gain in height. while receiving 132.3% of the digestible crude protein recommended by the Wolff-Lehmann standard and 109.0% and 101.4% respectively of digestible true protein and 117.9% and 106.3% respectively of the net energy recommended by Armsby by age and

by weight. The energy was considered adequate and the ration was considered complete, while the protein was plainly liberal, yet the animal made gains which were slightly below normal.

Since she had made gains slightly below the normal during 150 days on a 35+0 plane, it was considered desirable in July, 1919 to make a complete change in her plane. Apparently she had not been benefited by the high plane of protein and she was changed to a 15+50 plane which placed her on a comparatively low protein plane but with an excess of energy. The ration was necessarily changed considerably in character to accomplish this result. The ration given was changed from one of 5.5 pounds of alfalfa, 1.7 pounds of corn, 1.5 pounds of oats, 0.5 pounds of bran and 0.7 pounds of cottonseed meal to one made up of 3.0 pounds of timothy, 2.5 pounds of alfalfa, 3.0 pounds of corn, 0.5 pounds of bran and 3.2 pounds of starch and sugar. It would appear that such a ration would be less rather than more desirable from the standpoint of character of ration, because of the decreased quantity of alfalfa hay and the introduction of starch and sugar. This ration was continued for 90 days with only such changes as were made necessary by the increased requirements of the animal by growth and increase in age. The change in ration reduced the actual daily consumption of digestible protein 47.3%, while the amount of energy was increased 44.4%. This is one of the most complete and sudden changes to which any heifer had thus far been subjected. During the 90 days on a 15+50 plane she made splendid gains and maintained her excellent condition. At the end she was 48 pounds above or 109.6% of the normal in weight and 5.7 centimeters above or 105.1% of the normal in height. During the 90 days she made 125.7% of the normal gains in weight and 114.6% of the normal gain in height. This is much more satisfactory than that secured on the 35+0 plane and was accomplished on 66.4% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 52.8% and 49.4% respectively of the digestible true protein and 156.6% and 134.6% respectively of the net energy recommended by Armsby by age and by weight.

On October 27, 1919 the ration was again changed so that it furnished a 15+25 plane. At this time she was in excellent condition. The reduction in actual quantity of energy was too small to be of great significance. It may be said in this connection that in view of our present experience reductions or increases of 15 or 25% excess in energy are so slight in actual quantity, that they are of much less value than they were considered to be at the time they were planned. She remained on the 15+25 plane for five 30-day periods. During the entire time she took her ration regularly, made splendid gains, and continued in her

splendid state of health and condition. At the end of this time she was 88 pounds above or 114.9% of the normal in weight and 5.6 centimeters above or 104.8% of the normal in height. During this time she gained 143.5% of the normal in weight and 98.1% of normal in height. These gains were made on 63.1%of the digestible crude protein recommended by the Wolff-Lehmann standard and on 52.8% and 49.5% respectively of the digestible true protein and 128.3% and 111.1% respectively of the net energy recommended by Armsby by age and by weight. If the eight 30-day periods during which the planes were 15+50 and 15+25 be considered as a unit the animal made 135.8% of the normal gain in weight and 105.9% of the normal gain in height.

On March 25, 1920 she was further reduced to a 15+0 plane which was continued through four 30-day periods. During this time she failed to make as good gains as formerly and failed to maintain her splendid condition. At the end she was 42 pounds above normal or 106.2% of the

TABLE 21.—SUMMARY TABLE FOR JERSEY HEIFER NO. 143.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.-da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	5 27	35+0	35.3+ 3.5	1.086	1.096	.874	.850	.875	.900	.865	4.60	4.76
2	6 27	35+0	39.3+ 3.1	1.106	1.221	.958	.868	.920	.920	1.182	4.83	4.98
3	7 26	35+0	40.3+ 1.4	1.127	1.270	.989	.884	.960	.935	1.058	5.03	5.10
4	8 26	35+0	40.5+ 1.1	1.155	1.304	1.016	.900	1.000	.950	1.863	5.27	5.33
5	9 25	35+0	39.1 - 1.3	1.169	1.280	1.000	.934	1.013	.960	1.164	5.40	5.33
	10 25											
Av	8 11	35+0	38.9+ 1.6	1.129	1.234	.967	.887	.954	.933	1.226	5.03	5.10
6	10 25	15+50	16.3+38.7	.638	.674	.527	.967	1.040	.980	.632	5.55	7.70
7	11 24	15+50	14.9+37.9	.653	.652	.516	1.000	1.060	.995	.699	5.73	7.90
8	12 23	15+50	15.0+38.0	.665	.666	.527	1.008	1.080	1.025	.714	5.89	8.13
	13 23											
Av	12 9	15+50	15.4+38.2	.652	.664	.523	.992	1.060	1.000	.682	5.72	7.91
9	13 23	15+25	15.3+17.9	.678	.682	.540	1.026	1.100	1.065	.706	6.04	7.12
10	14 22	15+25	15.3+18.3	.693	.704	.555	1.042	1.116	1.907	.681	6.22	7.36
11	15 22	15+25	15.1+17.8	.710	.715	.562	1.058	1.132	1.130	*.935	6.41	7.55
12	16 21	15+25	15.2+19.6	.712	.718	.564	1.075	1.132	1.130	*.935	6.49	7.76
13	17 20	15+25	15.0+17.0	.725	.726	.572	1.092	1.166	1.195	.838	6.64	7.77
	18 21											
Av	16 7	15+25	15.2+18.1	.704	.709	.559	1.059	1.129	1.123	.819	6.36	7.51
14	18 21	15+0	15.2- 3.0	.720	.727	.567	1.108	1.188	1.235	*2.844	6.67	6.47
15	19 20	15+0	14.1- 2.4	.717	.695	.544	1.124	1.180	1.220	*2.844	6.63	6.47
16	20 20	15+0	13.8- 2.4	.721	.693	.542	1.141	1.194	1.247	1.733	6.71	6.55
17	21 19	15+0	13.5- 3.4	.727	.691	.541	1.158	1.200	1.260	1.152	6.78	6.55
	22 19											
Av	20 20	15- 0	14.2- 2.8	.721	.702	.549	1.133	1.191	1.241	2.143	6.70	6.51
18	22 19	10+0	8.7-10.4	.605	.576	.449	1.174	1.200	1.269	*2.918	6.81	6.10
19	23 18	10+0	9.6- 3.4	.599	.591	.468	1.191	1.200	1.269	*2.918	6.74	6.51
20	24 17	10+0	8.9- 4.1	.602	.577	.455	1.200	1.200	1.277	8.655	6.79	6.51
21	25 17	10+0	10.6- 3.4	.597	.610	.485	1.200	1.200	1.277	1.525	6.74	6.51
22	26 16	10+0	11.4- 3.4	.596	.628	.496	1.200	1.200	1.282	1.178	6.74	6.51
	27 16											
Av	25 2	10+0	9.8- 4.9	.600	.596	.471	1.193	1.200	1.275	3.439	6.76	6.43

*Because of a loss in weight, the average of two periods takem.

normal in weight and was 5.8 centimeters above or 104.9% of the normal in height. During the 120 days she made only 49.5% of the normal gain in weight, but made 106.5% of the normal gain in height, while receiving 56.5% of the digestible crude protein recommended by the Wolff-Lehmann standard and 48.4% and 46.1% respectively of the digestible true protein and 95.7% and 87.0% respectively of the net energy recommended by Armsby by age and by weight.

On July 23, 1920 she was further reduced to a 10+0 plane. The character of the ration was not changed except that the bran was removed. At first she made very poor gains and actually lost weight. Her general condition remained fairly good but not as good as formerly. She was on the 10+0 plane for 150 days, at the end of which she was 12 pounds below or 98.5% of the normal in weight and 5.0 centimeters above or 104.1% of the normal in height. During the 150 days she made 43.8% of the normal gain in weight and 68.0% of the normal gain in

BORN SEPTEMBER 4, 1918. ON EXPERIMENT MARCH 1, 1919

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent or normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.10	4.24	3.76	256	299	+43	116.8		93.3	98.7	+5.4	105.8	
4.20	4.54	4.82	298	337	+39	113.1		96.5	103.7	+7.2	107.5	
4.30	4.82	4.25	335	368	+33	109.9		99.4	106.2	+6.8	106.8	
4.40	5.10	7.61	371	404	+33	108.9		102.4	108.0	+5.6	105.5	
4.62	5.28	4.85	402	425	+23	105.7		104.6	109.5	+4.9	104.7	
.....	.....	.....	428	458	+30	107.0	92.4	106.3	111.3	+5.0	104.7	96.9
4.32	**4.80**	**5.06**	**348**	**382**	**+34**	**110.2**		**100.4**	**106.2**	**+5.8**	**105.8**	
4.86	5.62	7.22	428	458	+30	107.0		106.3	111.3	+5.0	104.7	
5.10	5.88	8.46	451	490	+39	108.6		107.9	114.3	+6.4	105.9	
5.19	6.13	8.71	474	518	+44	109.3		109.6	115.3	+5.7	105.2	
.....	.....	.....	498	546	+48	109.6	125.7	111.1	116.8	+5.7	105.1	114.6
5.05	**5.88**	**8.13**	**463**	**503**	**+40**	**108.6**		**108.7**	**114.4**	**+5.7**	**105.2**	
5.42	6.40	7.37	498	546	+48	109.6		111.1	116.8	+5.7	105.1	
5.64	6.60	7.12	515	575	+60	111.7		112.4	117.8	+5.4	104.8	
5.86	6.80	*9.98	530	606	+76	114.3		113.2	119.5	+6.3	105.6	
6.07	6.80	*9.98	547	605	+58	110.6		114.2	120.0	+5.8	105.1	
6.28	7.20	8.97	566	652	+86	115.2		115.3	120.5	+5.2	104.5	
.....	.....	.....	590	678	+88	114.9	143.5	116.4	122.0	+5.6	104.8	98.1
5.85	**6.76**	**8.68**	**541**	**610**	**+69**	**112.7**		**113.8**	**119.4**	**+5.7**	**105.0**	
6.50	7.44	*25.88	590	678	+88	114.9		116.4	122.0	+5.6	104.8	
6.70	7.36	*25.88	613	672	+59	109.6		117.3	122.3	+5.0	104.3	
6.90	7.52	16.38	640	693	+53	108.3		117.9	123.7	+5.8	104.9	
7.10	7.60	10.92	661	705	+44	106.7		118.6	124.3	+5.7	104.8	
.....	.....	.....	681	723	+42	106.2	49.5	119.5	125.3	+5.8	104.9	106.5
6.80	**7.48**	**19.77**	**637**	**694**	**+57**	**109.1**		**117.9**	**123.5**	**+5.6**	**104.7**	
7.30	7.72	*31.53	681	723	+42	106.2		119.5	125.3	+5.8	104.9	
7.50	7.72	*31.53	705	717	+12	101.7		120.2	125.3	+5.1	104.2	
7.65	7.84	97.65	728	735	+7	101.0		120.7	126.2	+5.5	104.6	
7.75	7.84	16.28	749	737	-12	98.4		121.2	127.3	+6.1	105.0	
7.85	7.90	12.21	764	749	-15	98.0		121.7	126.8	+5.1	104.2	
.....	.....	.....	777	765	-12	98.5	43.8	122.0	127.0	+5.0	104.1	68.0
7.61	**7.80**	**37.84**	**734**	**738**	**+4**	**100.6**		**120.9**	**126.3**	**+5.4**	**104.5**	

height, while receiving 46.8% of the digestible crude protein recommended by the Wolff-Lehmann standard and 39.4% and 39.2% respectively of the digestible true protein and 84.5% and 82.4% respectively of the net energy recommended by Armsby by age and by weight. In spite of the poor gains in the last nine 30-day periods she completed the twenty-two periods in practically a normal condition, being 5.0 centimeters taller but 12 pounds lighter than normal. She was taken off experiment on December 19, 1920. On February 3, 1921 she dropped a bull calf that weighed 48 pounds at birth, that had been carried 280 days, and that was normal except for a tuft of hair growing from the inner side of the lower eyelid. The calf later showed defective eyes which appeared white on some occasions although the calf's eyesight was apparently normal. As a producer the cow was medium. She produced in one year as a two-year-old 5,539 pounds of milk and 325 pounds of fat.

No. 293. (*See Table* 22.)—Holstein heifer No. 293 was placed March 21, 1919 on a preliminary ration calculated to furnish a 15+50 plane. She was placed on experiment on the same plane on March 31, at the age of 6 months, 2 days. The ration consisted of timothy, alfalfa, corn, bran and starch and sugar. She weighed 371 pounds which is 19 pounds above or 105.4% of the normal in weight, but was 1.3 centimeters below or 98.7% of the normal in height. She did not thrive well at the start, refused part of her feed the greater part of the time and made gains in weight which were far below normal. After being on experiment 150 days she was 41 pounds below or only 92.2% of the normal in weight and 98.0% of the normal in height. She made only 65.9% of the normal gain in weight and 91.4% of the normal gain in height, while receiving 68.1% of the digestible crude protein recommended by the Wolff-Lehmann standard and 57.3% and 50.8% respectively of the digestible true protein and 167.3% and 139.8% respectively of the net energy recommended by Armsby by age and by weight.

She was making such poor gains on a 15+50 plane that she was changed on August 28, 1919 to a 20+0 plane. The character of the ration was changed only by the removal of starch and sugar. She was kept on the 20+0 plane for 60 days and in that time gained only 25 pounds. She was in thin flesh but was taking her feed well and was in thrifty condition at the end of the 60 days. It is unfortunate that she was not continued longer on this plane as 60 days is hardly a sufficient period to be of significance. At the end of the 60 days she was 61 pounds below or 89.4% of the normal in weight and 97.4% of the normal in height, while the percentage of normal gains in weight and height were 55.6% and 77.4% respectively, while receiving a ration furnishing 85.8% of the digestible crude protein recommended by the Wolff-Lehmann

standard and 67.5% and 62.6% respectively of the digestible true protein and 121.3% and 102.7% respectively of the net energy recommended by Armsby by age and by weight.

The condition and development were so poor that she was again changed on October 27, to a 20+25 plane in an attempt to secure a normal development. This plane was continued for five 30-day periods. Either from the effects of the change in plane or for some other reason which cannot be explained, this heifer immediately commenced to make splendid gains and a great improvement in general condition. During the first period on the 20+25 plane she gained 44 pounds and in the first two periods the gain was 80 pounds. At the end of the five 30-day periods she was 29 pounds above or 104.2% of the normal in weight and 99.3% of the normal in height, and during the 150 days while receiving only 86.0% of the digestible crude protein recommended by the Wolff-Lehmann standard and 70.4% and 65.6% respectively of the digestible true protein and 140.8% and 120.6% respectively of the net energy recommended by Armsby by age and by weight, she had made 181.8% of the normal gain in weight and 135.0% of the normal gain in height. She was reported as being large, long and growthy, but lacking depth. These exceptional gains can hardly be attributed to the 25% increase in energy.

On March 25, 1920 she was changed to a 20+0 plane since her gains on 20+25 had been so abnormally high. She remained on the 20+0 plane for six 30-day periods. At the beginning of the 20+0 plane she was 29 pounds above the normal in weight and 0.9 centimeters below the normal in height. At the end of the six periods she was 16 pounds below the normal in weight but was 0.2 centimeters above the normal in height. This is 98.1% of the normal in weight and 100.2% of the normal in height and represents only 70.6% of normal gain in weight but 123.9% of the normal gain in height for the 180 days, while she received during the time 82.1% of the digestible crude protein recommended by the Wolff-Lehmann standard and 71.0% and 67.5% respectively of the digestible true protein and 119.2% and 104.7% respectively of the net energy recommended by Armsby by age and by weight. She not only made a poor gain but was in very poor flesh, rough, and lacked decidedly in depth and barrel capacity throughout the greater part of the 180 days.

In September, 1920 she was further reduced to a 10+0 plane in accordance with a general plan which has already been mentioned. This plane was continued for four 30-day periods. Her gains were not satisfactory and were inconsistent. On the whole she was getting farther from the normal every period. At the end of the fourth period on 10+0

plane she was 64 pounds and 2.0 centimeters below the normal or was 93.3% and 98.5% respectively of the normal in weight and in height. Her gains for the 120 days had been only 58.6% of the normal in weight and 35.3% of the normal in height on an ingestion of 55.5% of the digestible crude protein recommended by the Wolff-Lehmann standard and 48.6% and 48.6% respectively of the digestible true protein and 102.2% and 93.7% respectively of the net energy recommended by Armsby by age and by weight. When taken off experiment on January 18, 1921, she was in fair condition of flesh. Her appearance had made some improvement even on the 10+0 plane. This may be partly due to the advanced stage of pregnancy at the time. On January 30, 1921 she dropped a normal bull calf weighing 75 pounds that had been carried 269 days. The cow failed to give milk from two quarters and was therefore of little value as a milker. A possible explanation for the "blind" quarters is the fact that bedding in the experimental barn was hard to keep in place and the udder may have been chilled on the concrete floor. Another possi-

TABLE 22.—SUMMARY TABLE FOR HOLSTEIN HEIFER No. 293.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	6 2	15+50	11.3+16.4	.679	.560	.447	.850	.960	.935	1.527	5.62	6.54
2	7 1	15+50	14.4+27.0	.671	.652	.506	.868	.973	.940	.674	5.59	7.10
3	8 1	15+50	16.8+33.4	.679	.736	.569	.884	1.006	.955	.818	5.72	7.63
4	9 0	15+50	14.4+26.6	.681	.663	.516	.900	1.026	.970	1.658	5.80	7.34
5	10 0	15+50	13.8+30.4	.676	.643	.503	.934	1.033	.975	.521	5.79	7.55
	10 29											
Av	**8 16**	**15+50**	**14.1+26.8**	**.677**	**.651**	**.508**	**.887**	**1.000**	**.955**	**1.040**	**5.90**	**7.23**
6	10 29	20+0	20.5+1.3	.828	.853	.664	.967	1.060	.995	4.265	5.94	6.02
7	11 28	20+0	20.2+0.2	.845	.854	.663	1.000	1.060	.995	1.348	6.05	6.06
	12 28											
Av	**11 28**	**20+0**	**20.4+ 0.8**	**.837**	**.854**	**.664**	**.984**	**1.060**	**.995**	**2.807**	**6.00**	**6.04**
8	12 28	20+25	20.2+19.4	.869	.876	.678	1.016	1.074	1.012	.597	6.23	7.44
9	13 27	20+25	21.6+19.7	.911	.920	.708	1.033	1.106	1.077	.767	6.60	7.90
10	14 27	20+25	21.7+18.5	.950	.965	.738	1.050	1.126	1.117	.804	6.92	8.20
11	15 26	20+25	21.6+11.6	.987	1.005	.773	1.066	1.153	1.170	.942	7.23	8.07
12	16 25	20+25	21.4+18.2	1.020	1.035	.800	1.084	1.173	1.207	.597	7.51	8.88
	17 26											
Av	**15 12**	**20+25**	**21.3+17.5**	**.947**	**.960**	**.739**	**1.050**	**1.126**	**1.117**	**.741**	**6.90**	**8.10**
13	17 26	20+0	19.8– 1.8	1.066	1.060	.792	1.100	1.200	1.265	*3.102	7.92	7.78
14	18 25	20+0	17.9– 1.6	1.078	1.008	.777	1.116	1.200	1.262	*3.102	7.96	7.83
15	19 25	20+0	17.7– 2.4	1.121	1.038	.804	1.132	1.200	1.274	1.153	8.27	8.07
16	20 24	20+0	17.7+0.8	1.155	1.070	.883	1.152	1.200	1.287	*1.944	8.53	8.60
17	21 24	20+0	17.4±0.0	1.169	1.068	.831	1.166	1.200	1.287	*1.944	8.60	8.60
18	22 23	20+0	17.3– 1.9	1.145	1.057	.823	1.183	1.200	1.300	1.133	8.64	8.48
	23 22											
Av	**20 24**	**20+0**	**18.0– 1.2**	**1.122**	**1.050**	**.810**	**1.142**	**1.200**	**1.279**	**2.063**	**8.32**	**8.23**
19	23 22	10+0	9.2– 2.8	.770	.742	.588	1.200	1.200	1.315	*2.645	8.58	8.34
20	24 22	10+0	10.6– 3.0	.736	.757	.601	1.200	1.200	1.315	*2.645	8.23	7.98
21	25 21	10+0	11.4– 2.6	.706	.747	.593	1.200	1.200	1.322	.640	7.93	7.72
22	26 21	10+0	9.9– 1.9	.689	.687	.551	1.200	1.200	1.336	1.288	7.79	7.64
	27 20											
Av	**25 21**	**10+0**	**10.3– 2.6**	**.725**	**.733**	**.583**	**1.200**	**1.200**	**1.322**	**1.805**	**8.13**	**7.92**

*Because of a loss in weight, average of two periods taken.

bility is that the heifer was nursed by some of the other heifers early in her gestation period. This was known to occur with a few of the Jerseys but was never noticed with Holsteins.

No. 294. (*See Table* 23.)—Holstein heifer No. 294 was placed on a preliminary ration April 22, 1919, which was calculated to furnish a 15+40 plane. At that time it was thought desirable to place heifers on a comparatively low protein plane with varying excesses of energy. It was later appreciated, however, that a difference of 10 or 15% excess energy makes only a very slight difference in the quantity of energy actually received. On April 30, at the age of 6 months, 25 days, she was placed on experiment on a continuation of the preliminary ration which was composed of timothy, alfalfa, corn, bran and starch and sugar. While on preliminary feed she was weaned and adjusted to a hay and grain ration and lost 11 pounds in weight. At the beginning of the experiment she weighed 376 pounds which was 6 pounds below or 98.4% of the normal in weight. In height she was 2.6 centimeters below or 97.5% of the normal. She was

BORN SEPTEMBER 29, 1918. ON EXPERIMENT MARCH 31, 1919

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.10	4.82	17.84	352	371	+19	105.4		101.0	99.7	−1.3	98.7	
4.20	4.91	7.34	390	382	−8	97.9		104.0	101.8	−2.2	97.9	
4.30	5.18	8.48	426	411	−15	96.5		107.1	104.1	−3.0	97.2	
4.40	5.44	18.35	466	438	−28	94.0		109.1	106.3	−2.8	97.4	
4.62	5.52	6.12	501	450	−51	89.8		111.2	107.3	−3.9	96.5	
.....	.....	.....	528	487	−41	92.2	65.9	112.6	110.3	−2.3	98.0	91.4
4.32	**5.17**	**11.63**	**444**	**423**	**−21**	**96.0**		**107.5**	**104.9**	**−2.6**	**97.6**	
4.86	5.88	30.10	528	487	−41	92.2		112.6	110.3	−2.3	98.0	
5.10	5.88	9.57	556	493	−63	88.7		114.0	112.7	−1.3	98.9	
.....	.....	.....	573	512	−61	89.4	55.6	115.7	112.7	−3.0	97.4	77.4
4.98	**5.88**	**19.84**	**552**	**497**	**−55**	**90.1**		**114.1**	**111.9**	**−2.2**	**98.1**	
5.32	6.04	5.07	573	512	−61	89.4		115.7	112.7	−3.0	97.4	
5.52	6.48	6.58	594	556	−38	93.6		117.3	114.8	−2.5	97.9	
5.76	6.72	6.83	610	592	−18	97.0		118.7	115.8	−2.9	97.6	
5.96	7.04	7.57	639	628	−11	98.3		120.2	117.7	−2.5	97.9	
6.19	7.28	5.12	657	660	+3	100.5		121.2	119.3	−1.9	98.4	
.....	.....	.....	683	712	+29	104.2	181.8	121.7	120.8	−0.9	99.3	135.0
5.75	**6.71**	**6.23**	**626**	**610**	**−16**	**97.2**		**119.1**	**116.9**	**−2.3**	**98.1**	
6.40	7.66	*23.42	683	712	+29	104.2		121.7	120.8	−0.9	99.3	
6.60	7.63	*23.42	710	705	−5	99.3		122.6	122.8	+0.2	100.2	
6.80	7.78	8.97	741	732	−9	98.8		123.7	123.7	±0.0	100.0	
7.00	7.96	*15.64	768	759	−9	98.8		124.3	124.2	−0.1	99.9	
7.20	7.96	*15.64	792	759	−33	95.8		124.8	124.8	±0.0	100.0	
7.40	8.15	9.09	817	792	−25	96.9		125.6	126.0	0.4	100.3	
.....	.....	.....	836	820	−16	98.1	70.6	126.3	126.5	0.2	100.2	123.9
6.90	**7.86**	**16.03**	**764**	**754**	**−10**	**98.8**		**124.1**	**124.1**	**0.0**	**100.0**	
7.60	8.34	*28.80	836	820	−16	98.1		126.3	126.5	+0.2	100.2	
7.70	8.34	*28.80	862	819	−43	95.0		127.3	126.8	−0.5	99.6	
7.80	8.46	6.62	886	837	−49	94.5		128.0	126.8	−1.2	99.1	
7.90	8.66	14.33	915	872	−43	95.3		129.0	126.5	−2.5	98.1	
.....	.....	.....	952	888	−64	93.3	58.6	129.7	127.7	−2.0	98.5	35.3
7.75	**8.45**	**19.64**	**890**	**847**	**−43**	**95.2**		**128.1**	**126.9**	**−1.2**	**99.1**	

in good, growthy condition, long-bodied, and in medium flesh, and practically normal. She was slow in getting adjusted to her ration and refused a considerable portion of her feed. She remained on the 15+40 plane for four 30-day periods, at the end of which she was 45 pounds and 2.5 centimeters below the normal or was 91.4% and 97.8% respectively of the normal in weight and height. During the 120 days on this plane her growth was 72.1% of the normal in weight and 101.1% of the normal in height, while she was receiving an average of 66.5% of the digestible crude protein recommended by the Wolff-Lehmann standard and 55.6% and 50.1% respectively of the digestible true protein and 156.1% and 133.3% respectively of the net energy recommended by Armsby by age and by weight.

On August 28, 1919 she was in poor flesh but was long and growthy. She was 45 pounds under weight and making unsatisfactory gains. She was changed at this time from a 15+40 plane to a 20+0 plane. The change was accomplished without altering the character of the ration except by the removal for a short time of starch and sugar. She remained on the 20+0 plane during thirteen 30-day periods and made gains which were better than normal, but lacked decidedly in barrel development.

TABLE 23.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 294.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	6 25	15+40	11.6+14.0	.681	.573	.457	.868	.973	.940	.661	5.65	6.44
2	7 25	15+40	14.9+20.8	.681	.676	.527	.884	1.000	.950	2.897	5.71	6.90
3	8 24	15+40	14.8+22.8	.687	.673	.525	.900	1.006	.955	.505	5.71	7.01
4	9 24	15+40	12.7+19.5	.686	.618	.485	.934	1.003	.975	.662	5.86	7.00
	10 23											
Av.	8 24	15+40	13.5+19.3	.683	.635	.498	.897	.996	.955	1.181	5.73	6.84
5	10 23	20+0	20.6+ 1.3	.836	.856	.666	.967	1.053	.990	1.284	5.95	6.03
6	11 22	20+0	20.4+ 0.2	.842	.854	.663	1.000	1.066	1.000	1.025	6.05	6.06
7	12 22	20+0	20.1 – 1.4	.860	.865	.672	1.016	1.080	1.025	.811	6.22	6.13
8	13 21	20+0	20.3+ 0.8	.909	.919	.713	1.026	1.100	1.065	.707	6.58	6.63
9	14 21	20+0	20.2 – 0.4	.950	.957	.733	1.042	1.126	1.117	.870	6.92	6.89
10	15 20	20+0	20.0 – 1.3	.966	.968	.743	1.058	1.153	1.170	1.117	7.12	7.03
11	16 19	20+0	20.1 – 2.0	1.000	1.004	.774	1.075	1.166	1.195	.772	7.38	7.23
12	17 20	20+0	19.7 – 2.1	1.037	1.026	.783	1.092	1.194	1.247	3.848	7.70	7.54
13	18 19	20+0	17.9 – 1.4	1.059	.988	.759	1.108	1.200	1.260	.689	7.84	7.73
14	19 19	20+0	17.7 – 1.2	1.098	1.018	.788	1.124	1.200	1.277	1.018	8.19	8.09
15	20 18	20+0	17.9 – 2.0	1.140	1.066	.820	1.141	1.200	1.291	6.396	8.51	8.34
16	21 18	20+0	17.9 – 2.2	1.164	1.086	.837	1.158	1.200	1.295	.724	8.64	8.45
17	22 17	20+0	17.5 – 3.0	1.201	1.105	.853	1.174	1.200	1.315	.921	8.99	8.72
	23 16											
Av.	17 5	20+0	19.3 – 1.1	1.005	.978	.754	1.075	1.149	1.173	1.552	7.39	7.30
18	23 16	10+0	9.3 – 4.1	.813	.788	.615	1.191	1.200	1.332	1.182	9.04	8.67
19	24 16	10+0	10.4 – 3.9	.799	.814	.641	1.200	1.200	1.340	.555	8.92	8.57
20	25 15	10+0	11.4 – 4.2	.788	.835	.686	1.200	1.200	1.350	.626	8.85	8.48
21	26 15	10+0	10.2 – 3.2	.769	.775	.610	1.200	1.200	1.350	.684	8.68	8.40
	27 14											
Av.	25 15	10+0	10.3 – 3.8	.792	.803	.638	1.198	1.200	1.343	.762	8.87	8.53

She improved considerably in condition of flesh and at the end of the thirteen periods was in a greatly improved condition, but was still lacking in body. At that time she was 25 pounds above the normal in weight and 0.1 centimeters above the normal in height. This was 103.0% and 100.1% respectively of the normal in weight and in height. During the thirteen periods she had made 122.5% and 118.8% respectively of the normal growth in weight and height, while receiving 83.4% of the digestible crude protein recommended by the Wolff-Lehmann standard and 70.1% and 65.6% respectively of the digestible true protein and 120.0% and 102.4% respectively of the net energy recommended by Armsby by age and by weight, and was above the normal in size.

She was reduced on September 21, 1920 from a 20+0 plane to a 10+0 plane. The character of the ration was practically the same as previously except that the bran was eliminated. She continued to gain rapidly on this greatly reduced ration, to make remarkable improvement in general condition, and to mature rapidly. She remained on the 10+0 plane for four 30-day periods, at the end of which she was 52 pounds above the normal weight but 1.0 centimeter below the normal n height. This made her 105.5% and 99.2% respectively of the normal

BORN OCTOBER 5, 1918. ON EXPERIMENT APRIL 30, 1919

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on tnis plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal heignt at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.20	4.71	7.43	382	376	−6	98.4		103.4	100.8	−2.6	97.5	
4.30	5.10	29.57	419	402	−17	95.9		106.5	102.1	−4.4	95.9	
4.40	5.18	5.26	458	409	−49	89.3		108.7	106.8	−1.9	98.3	
4.62	5.52	7.50	494	449	−45	90.9		110.7	107.5	−3.2	97.1	
.....	.....	.....	522	477	−45	91.4	72.1	112.3	109.8	−2.5	97.8	101.1
4.38	**5.13**	**12.44**	**455**	**423**	**−32**	**93.2**		**108.3**	**105.4**	**−2.9**	**97.3**	
4.86	5.79	9.05	522	477	−45	91.4		112.3	109.8	−2.5	97.8	
5.10	5.96	7.27	550	497	−53	90.4		113.5	111.5	−2.0	98.2	
5.32	6.13	5.75	570	522	−48	91.6		115.2	112.8	−2.4	97.9	
5.42	6.40	5.10	589	554	−35	94.1		116.9	114.0	−2.9	97.5	
5.64	6.72	6.26	607	593	−14	97.7		118.4	116.2	−2.2	98.1	
5.86	7.04	8.11	633	626	−7	98.9		119.8	117.3	−2.5	97.9	
6.07	7.20	5.56	654	652	−2	99.7		120.9	120.0	−0.9	99.3	
6.28	7.52	28.28	677	691	+14	102.1		121.5	122.0	+0.5	100.4	
6.50	7.60	5.39	704	699	−5	99.3		122.4	123.3	+0.9	100.7	
6.70	7.84	8.09	735	742	+7	101.0		123.4	125.0	+1.6	101.3	
6.90	8.01	50.04	762	772	+10	101.3		124.0	125.5	+1.5	101.2	
7.10	8.08	5.63	787	777	−10	98.7		124.7	126.2	+1.5	101.2	
7.30	8.34	7.27	812	822	+10	101.2		125.3	126.2	+0.9	100.7	
.....	.....	.....	833	858	+25	103.0	122.5	126.1	126.2	+0.1	100.1	118.8
6.08	**7.13**	**11.68**	**674**	**663**	**−11**	**97.9**		**120.3**	**119.7**	**−0.6**	**99.5**	
7.50	8.60	13.01	833	858	+25	103.0		126.1	126.2	+0.1	100.1	
7.65	8.72	5.84	856	878	+22	102.6		127.0	128.1	+1.1	100.9	
7.75	8.99	6.36	881	922	+41	104.7		127.9	129.0	+1.1	100.9	
7.85	9.24	7.41	909	962	+53	105.8		128.7	127.7	−1.0	99.2	
.....	.....	.....	944	996	+52	105.5	124.3	129.5	128.5	−1.0	99.2	67.6
7.69	**8.89**	**8.16**	**885**	**923**	**+39**	**104.3**		**127.8**	**127.9**	**+0.1**	**100.1**	

in weight and in height. During the 120 days she made 124.3% and 67.6% respectively of the normal gain in weight and height, on a ration which furnished only 59.8% of the digestible crude protein recommended by the Wolff-Lehmann standard and 53.3% and 53.2% respectively of the digestible true protein and 111.0% and 96.0% respectively of the net energy recommended by Armsby by age and by weight. She was taken off experiment January 18, 1921, in excellent and better condition than ever before. She was heavy with calf and on February 10, 1921 dropped a normal bull calf weighing 95 pounds at birth, that had been carried 276 days. The cow, a daughter of the champion Holstein butter cow for the state of Missouri proved to be a medium producer. She had a bad infection in one quarter immediately after calving, which prevented normal secretion from that quarter. Explanation for this condition is not attempted unless it is the same as suggested in the case of No. 293. Her production for one year as a two-year-old on three quarters amounted to 6,646 pounds of milk and 249 pounds of fat.

No. 145.—Jersey heifer No. 145 was placed on a preliminary ration April 22, 1919, calculated to furnish a 15+40 plane similar to that of No. 294. She did not become readily adjusted to her new ration and lost 19 pounds in eight days. On April 30 she was placed on experiment and the same ration continued which was composed of timothy, alfalfa, corn and starch and sugar. She remained on experiment slightly more than one period during which time she made a very unsatisfactory gain and refused much of her feed. She became very sick on June 8, refused her feed entirely, stood in the lot with her head against the barn and acted strangely. She was given Epsom salts and a veterinarian suggested a milk diet which she refused. She died June 9, and post mortem indicated that death was caused by pneumonia. Data for this heifer have not been included since the period of time covered is of such short dura tion.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.-da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	6 6	15+40	15.2+50.5	.667	.675	.522	.850	.932	.925	.779	5.48	8.25
2	7 6	15+40	16.8+52.3	.666	.667	.517	.868	.960	.925	.770	5.53	8.42
3	8 5	15+40	15.8+55.7	.663	.690	.533	.884	1.000	.950	.668	5.53	8.61
	9 4											
Av.	7 20	15+40	15.9+52.8	.665	.677	.524	.867	.964	.937	.739	5.51	8.43

TABLE 24.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 295.

No. 295. (*See Table* 24.)—Holstein heifer No. 295 was placed on a preliminary ration of timothy, alfalfa, corn, bran and starch and sugar on June 19, 1919. This ration was calculated to furnish a 15+40 plane. In the ten days of preliminary feeding she lost 13 pounds. She was in a medium condition when placed on experiment on the same ration June 29, 1919 at the age of 6 months, 6 days. In appearance she was short and dumpy and less growthy than she should have been. She was in a medium condition of flesh and was 10 pounds below or 97.2% of the normal in weight and 0.5 centimeters above or 100.5% of the normal in height. At the end of the third period she was 41 pounds below the normal in weight and 1.1 centimeters below the normal height. This was 91.3% of the normal in weight and 99.0% of the normal in height and her gain represents 72.8% and 79.7% respectively of the normal in weight and height on a ration which furnished 72.3% of the digestible crude protein recommended by the Wolff-Lehmann standard and 60.4% and 54.4% respectively of the digestible true protein and 200.6% and 173.6% respectively of the net energy recommended by Armsby by age and by weight. She suddenly became sick on October 11, 1919. Her symptoms were somewhat like pneumonia. She died on October 12, and a post mortem indicated lead poisoning. As the lot fences had recently been painted it is probable that this was the cause of her death. Data were not included after the third 30-day period.

No. 144. (*See Table* 25.)—Jersey heifer No. 144 was placed on a preliminary ration of timothy, alfalfa, corn and starch and sugar on June 19, 1919. This ration was calculated to furnish a 15+50 plane. In the ten days of preliminary feeding she lost 9 pounds but was still in excellent condition and 21 pounds above the normal in weight when she was placed on experiment on the same ration June 29, 1919 at the age of 8 months, 17 days. She remained on this ration for more than three 30-day periods, during which time she made practically normal

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.10	4.64	9.52	357	347	−10	97.2		101.5	102.0	+0.5	100.5	
4.20	4.82	9.72	396	373	−23	94.2		104.6	105.8	+1.2	101.1	
4.30	5.10	8.33	432	399	−33	92.4		107.4	107.6	+0.2	100.2	
.....	.....	.....	471	430	−41	91.3	72.8	109.4	108.3	−1.1	99.0	79.7
4.20	4.85	9.19	414	387	−27	93.8		105.7	105.9	+0.2	100.2	

BORN DECEMBER 23, 1918. ON EXPERIMENT JUNE 29, 1919

gains. At the end of the third period she was 13 pounds above the normal in weight and 0.3 centimeters above the normal in height. This was 102.9% of the normal in weight and 100.3% of the normal in height, and represents 90.5% and 116.9% respectively of the normal gain in weight and height on a ration which furnished 64.6% of the digestible crude protein recommended by the Wolff-Lehmann standard and 51.1% and 47.0% respectively of the digestible true protein and 155.7% and

TABLE 25.—SUMMARY TABLE FOR JERSEY HEIFER No. 144.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs	therms	therms
1	8 17	15+50	16.6+36.1	.604	.647	.491	.892	.973	.940	.747	5.13	6.92
2	9 17	15+50	14.3+34.6	.619	.600	.460	.917	1.006	.955	.857	5.29	7.18
3	10 16	15+50	14.4+33.1	.615	.601	.459	.950	1.020	.965	.622	5.29	7.04
	11 15											
Av.	10 1	15+50	15.1+34.6	.613	.616	.470	.920	1.000	.953	.742	5.24	7.05

TABLE 26.—SUMMARY TABLE FOR HOLSTEIN HEIFER No. 500.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	6 13	35+0	30.7 – 1.6	1.314	1.176	.968	.859	.946	.930	1.038	5.54	5.45
2	7 13	35+0	31.7 – 9.4	1.209	1.197	.976	.876	.986	.945	1.283	5.64	5.11
3	8 12	35+0	29.2 – 8.8	1.202	1.125	.905	.892	1.013	.960	1.089	5.77	5.26
4	9 11											
Av.	7 27	35+0	30.5 – 6.6	1.272	1.166	.950	.876	.982	.945	1.137	5.65	5.27
4	9 11	25+0	24.0 – 2.9	.988	.967	.748	.917	1.033	.975	.907	5.87	5.70
5	10 12	25+0	24.5 – 0.2	.986	.972	.755	.950	1.053	.990	1.389	5.98	5.97
6	11 11	25+0	21.7+ 0.8	.991	.896	.698	.984	1.066	1.000	.815	6.08	6.13
	12 11											
Av.	10 26	25+0	23.4 – 0.8	.988	.945	.734	.950	1.051	.988	1.037	5.98	5.93
7	12 11	20+0	17.4 – 2.2	.867	.791	.607	1.008	1.094	1.051	.641	6.31	6.17
8	13 10	20+0	17.2 – 2.1	.898	.816	.630	1.026	1.113	1.090	.942	6.59	6.45
9	14 10	20+0	17.2 – 2.0	.932	.845	.650	1.042	1.132	1.130	.576	6.85	6.71
	15 9											
Av.	13 25	20+0	17.3 – 2.1	.899	.817	.629	1.025	1.113	1.090	.720	6.58	6.44
10	15 9	15+0	12.7 – 9.6	.814	.741	.575	1.058	1.160	1.182	1.308	7.22	6.53
11	16 8	15+0	12.1 – 4.7	.836	.742	.577	1.075	1.173	1.207	.718	7.42	7.07
12	17 8	15+0	13.6 – 6.1	.867	.819	.639	1.092	1.194	1.247	2.730	7.70	7.23
	18 7											
Av.	16 23	15+0	12.8 – 6.8	.839	.767	.597	1.075	1.176	1.212	1.585	7.45	6.94
13	18 7	10+0	10.7 – 4.2	.708	.733	.591	1.100	1.200	1.260	.687	7.84	7.51
14	19 7	10+0	10.0 – 4.8	.734	.736	.589	1.116	1.200	1.274	1.299	8.13	7.74
15	20 6	10+0	10.0 – 3.7	.757	.758	.609	1.132	1.200	1.282	2.527	8.38	8.07
16	21 5	10+0	6.5 –18.2	.771	.639	.516	1.150	1.200	1.287	*2.818	8.53	6.98
17	22 7	10+0	9.9 – 3.5	.772	.770	.619	1.166	1.200	1.282	*2.818	8.54	8.24
18	23 6	10+0	10.0 – 3.4	.770	.770	.619	1.183	1.200	1.291	.924	8.53	8.24
	24 6											
Av.	21 6	10+0	9.5 – 6.3	.752	.734	.591	1.141	1.200	1.279	1.846	8.33	7.80

*Because of a loss in weight, the average of two periods taken.

136.8% respectively of the net energy recommended by Armsby by age and by weight. It was planned to reduce her plane in October after she had been on experiment for four 30-day periods, but she was suddenly taken sick on October 11, 1919. Her symptoms were like those of No. 295, and she died on October 12. Post mortem showed, as in the case of 295, that death was caused by lead poisoning. Data are included only for the first three 30-day periods.

BORN OCTOBER 12, 1918. ON EXPERIMENT JUNE 29, 1919

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.34	4.91	8.05	360	381	+21	105.8		101.5	102.3	+0.8	100.8	
4.50	5.18	10.17	394	407	+13	103.3		104.0	105.8	+1.8	101.7	
4.74	5.36	7.28	420	428	+8	101.9		105.8	106.0	-0.2	100.2	
.....	.....	.....	444	457	+13	102.9	90.5	107.4	107.7	+0.3	100.3	116.9
4.53	**5.15**	**8.50**	**405**	**418**	**+14**	**103.5**		**104.7**	**105.5**	**+0.8**	**100.8**	

BORN MAY 13, 1919. ON EXPERIMENT NOVEMBER 26, 1919

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.16	4.72	4.81	366	357	-9	97.5		102.2	102.2	±0.0	100.0	
4.24	5.00	5.48	405	391	-14	96.5		105.3	104.2	-1.1	99.0	
4.34	5.28	5.09	441	419	-22	95.0		107.9	106.3	-1.6	98.5	
.....	.....	.....	479	450	-29	93.9	82.3	110.0	108.3	-1.7	98.5	78.2
4.25	**5.00**	**5.13**	**423**	**404**	**-19**	**95.7**		**106.4**	**105.3**	**-1.1**	**99.0**	
4.50	5.52	5.34	479	450	-29	93.9		110.0	108.3	-1.7	98.5	
4.74	5.79	8.53	512	482	-30	94.1		111.8	111.3	-0.5	99.6	
4.98	5.96	5.57	540	503	-37	93.1		113.2	113.3	+0.1	100.1	
.....	.....	.....	564	536	-28	95.0	101.2	114.6	115.8	+1.2	101.0	163.0
4.74	**5.76**	**6.48**	**524**	**493**	**-31**	**94.0**		**112.4**	**112.2**	**-0.2**	**99.8**	
5.19	6.30	5.00	564	536	-28	95.0		114.6	115.8	+1.2	101.0	
5.42	6.56	7.44	581	573	-8	98.6		116.2	118.5	+2.3	102.0	
5.64	6.80	4.58	601	599	-2	99.7		117.9	119.5	+1.6	101.4	
.....	.....	.....	621	643	+22	103.5	187.7	119.3	120.7	+1.4	101.2	104.3
5.42	**6.55**	**5.67**	**592**	**588**	**-4**	**99.2**		**117.0**	**118.6**	**+1.6**	**101.4**	
5.86	7.12	11.52	621	643	+22	103.5		119.3	120.7	+1.4	101.2	
6.07	7.28	6.84	648	660	+12	101.9		120.6	122.8	+2.2	101.8	
6.28	7.52	24.10	667	691	+24	103.6		121.4	123.3	+1.9	101.6	
.....	.....	.....	693	700	+7	101.0	79.2	122.0	122.8	+0.8	100.7	77.8
6.07	**7.31**	**14.15**	**657**	**674**	**+16**	**102.5**		**120.8**	**122.4**	**+1.6**	**101.3**	
6.40	7.60	7.04	693	700	+7	101.0		122.0	122.8	+0.8	100.7	
6.60	7.78	13.66	722	732	+10	101.4		122.9	124.7	+1.8	101.5	
6.80	7.90	26.90	752	749	-3	99.6		123.9	126.5	+2.6	102.1	
7.00	7.96	*30.44	778	758	-20	97.4		124.4	127.2	+2.8	102.3	
7.20	7.90	*30.44	803	749	-54	93.3		125.0	127.5	+2.5	102.0	
7.40	8.02	9.89	827	773	-54	93.5		125.9	128.7	+2.8	102.2	
.....	.....	.....	847	798	-49	94.2	63.6	126.7	130.2	+3.5	102.8	157.4
6.90	**7.86**	**19.73**	**775**	**751**	**-23**	**97.2**		**124.4**	**126.8**	**+2.4**	**101.9**	

No. 500. (*See Table* 26.)—Holstein heifer No. 500 was started November 16, 1919 on a preliminary ration of alfalfa, corn, oats, bran and cottonseed meal, calculated to furnish a 35+0 plane. Starch was later added in small quantities. It has been suggested that a "sliding scale" of planes might be suitable for an animal as it grows older as it was thought possible that an animal could make normal gains at an advanced age on a plane which would be entirely inadequate for a younger animal. The plan was to start this heifer on a 35+0 plane and to follow out the original plan of reduction, namely; 6 to 9 months, 35+0; 9 to 12 months, 25+0; 12 to 15 months, 20+0; 15 to 18 months, 15+0; above 18 months, 10+0. She remained on the preliminary ration for ten days. Some trouble was experienced in getting her to take enough feed. During the ten days she lost 13 pounds, but was still in excellent condition. She was commenced on experiment November 26, 1919 at the age of 6 months, 13 days. At the time she weighed 357 pounds which was 9 pounds below or 97.5% of the normal in weight. She was exactly normal in height. She remained on the 35+0 plane and practically the same ration through three 30-day periods. She consistently refused a part of her feed and at the end of the 90 days was 29 pounds below or 93.9% of the normal in weight and 1.7 centimeters below or 98.5% of the normal in height. During the 90 days she made 82.3% and 78.2% respectively of the normal gain in weight and in height, on a ration which furnished 123.4% of the digestible crude protein recommended by the Wolff-Lehmann standard and 108.5% and 96.7% respectively of the digestible true protein and 124.2% and 105.5% respectively of the net energy recommended by Armsby by age and by weight.

On February 24, 1920 she was changed to the 25+0 plane as planned. This was accomplished through a considerable change in the character of the ration which made it more readily taken. The new ration was composed of alfalfa, corn and bran. Starch was later added in small quantities. She remained on this ration and plane during three 30-day periods, took her feed regularly, and maintained a good average condition. At the end of this time she was 28 lbs. below or 95.0% of the normal in weight and was 101.0% of the normal in height. During the 90 days she made 101.2% and 163.0% respectively of the normal gain in weight and in height, while receiving 95.6% of the digestible crude protein recommended by the Wolff-Lehmann standard and 77.2% and 69.8% respectively of the digestible true protein and 125.2% and 103.1% respectively of the net energy recommended by Armsby by age and by weight.

On May 24, 1920 she was changed to a 20+0 plane without altering the character of the ration. She continued to take her feed regularly

and remained in a good general condition although somewhat rough. Her gains were unusually good, and at the end of the 90 days on the 20+0 plane she was 22 pounds above or 103.5% of the normal in weight and 101.2% of the normal in height. Her gains in weight and height were 187.7% and 104.3% respectively of the normal and were made on a ration furnishing 75.0% of the digestible crude protein recommended by the Wolff-Lehmann standard and 61.3% and 56.5% respectively of the digestible true protein and 119.0% and 98.3% respectively of the net energy recommended by Armsby by age and by weight.

On August 22, 1920 she was further reduced to a 15+0 plane according to the original plan. The change was accomplished by eliminating the bran which left her on a ration of alfalfa, corn and starch. During the first two 30-day periods she made normal gains, but during the third she gained only nine pounds in weight. She maintained a medium condition and took her feed regularly. At the end of the 90 days she was 7 pounds above or 101.0% of the normal in weight and 100.7% of the normal in height. During the 90 days she made 79.2% of the normal gain in weight and 77.8% of the normal gain in height on 63.3% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 55.5% and 50.8% respectively of the digestible true protein and 114.4% and 95.0% respectively of the net energy recommended by Armsby by age and by weight.

She was further reduced on November 20, 1920 to a 10+0 plane. This change necessitated the reduction of the alfalfa and the addition of timothy in order to maintain a sufficient quantity of roughage. She took her ration regularly, made satisfactory gains and maintained a splendid condition of flesh on the 10+0 plane. She was very sick in March, 1921 for a week or ten days and failed to eat for several days. The result was a loss of 9 pounds in 30 days. She very quickly became adjusted, however, and in April was again reported as in good condition. She remained on the 10+0 plane for six 30-day periods and was taken off experiment May 18, 1921. At this time she weighed 798 pounds which was 49 pounds below or 94.2% of the normal in weight and was 3.5 centimeters above or 102.8% of the normal in height. During these 180 days she made 63.6% and 157.4% respectively of the normal gain in weight and height while receiving 57.4% of the digestible crude protein recommended by the Wolff-Lehmann standard and 51.7% and 49.2% respectively of the digestible true protein and 113.0% and 99.2% respectively of the net energy recommended by Armsby by age and by weight. When taken off experiment she was in splendid condition, well proportioned, growthy and in good flesh. Her gains in weight had, however, been unsatisfactory on the 10+0 plane. She was not pregnant at the termination of the experiment.

No. 501. (*See Table* 27.)—Holstein heifer No. 501 was commenced November 16, 1919 on a preliminary ration composed of timothy, alfalfa, corn and starch and sugar, calculated to furnish a 15+50 plane. She gained 3 pounds on her ten day preliminary period and was placed on experiment November 26, 1919 at the age of 5 months, 28 days. When started on experiment she was in first class condition but was 28 pounds below or 91.9% of the normal in weight and was 98.4% of the normal in height. She continually refused a part of her feed. She remained on the 15+50 plane for eight 30-day periods. During this time she made irregular and not entirely satisfactory gains. In March, 1920 she was reported as in excellent physical condition, growthy and having good barrel capacity. Since an error was made in calculating her ration she did not receive as much as was intended during the fourth 30-day period. She also had received considerable less protein and energy than was intended for the first few periods because of refusal of part of her ration. In the sixth period she was very sick and for five days refused all her feed, but recovered in a comparatively short time. All through the 240 days she received only about 80% of the nutrients intended. This discrepancy is due largely to refusal of part of her ration, partly to her severe sickness and partly to the low analysis of some of the feeds used at that time. After being on a 15+50 plane for 240 days she was reported as rough and in poor flesh. At that time she was 98 pounds below or only 83.4% of the normal in weight and 98.7% of the normal in height. She made 71.5% and 100.6% respectively of the normal gain in weight and height, while receiving only 55.8% of the digestible crude protein recommended by the Wolff-Lehmann standard and 46.9% and 43.9% respectively of the digestible true protein but 148.6% and 133.0% respectively of the net energy recommended by Armsby by age and by weight.

On July 23, 1920 she was changed to a 20+0 plane. As before, the quantity of protein was lower than intended, but was much increased by the change in ration which involved the elimination of the timothy and a corresponding increase in the alfalfa. The actual protein increase was approximately 20%. After the change the energy received was almost exactly as calculated. She remained on the 20+0 plane through ten 30-day periods. Her gains were very poor and she continued in poor flesh, rough, shallow, narrow and decidedly lacking in barrel development. She was taken off experiment May 18, 1921, when she was 184 pounds below or 78.0% of the normal in weight but was 99.7% of the normal in height. During the 300 days on the 20+0 plane she made 64.8% and 112.0% respectively of the normal gain in weight and in height, while receiving 86.6% of the digestible crude protein recommended by the Wolff-Lehmann standard and 63.0% and 62.4% respectively

of the digestible true protein and 109.7% and 107.5% respectively of the net energy recommended by Armsby by age and by weight. She was still decidedly lacking in barrel development and in thin flesh, narrow and shallow, but long and growthy. She showed a slight improvement during the last few periods. She had been bred several times but was not pregnant when taken off experiment.

No. 146. (*See Table* 28.)—Jersey heifer No. 146 was started November 16, 1919 on a preliminary ration of timothy, alfalfa, corn and starch and sugar calculated to furnish a 15+25 plane. She took her feed unusually well and gained 13 pounds during her ten-day preliminary period. She was placed on experiment November 26, 1919 at the age of 7 months, 18 days and was continued on the same ration. She was in good flesh and showed a heavy paunch, and weighed 388 pounds, which was 63 pounds above or 119.4% of the normal in weight and 6.4 centimeters above or 106.5% of the normal in height. She did not make satisfactory gains and in January, 1920 after being on experiment for 60 days was changed from a 15+25 to a 15+50 plane. This change made it necessary to increase the starch and to such an extent that before the period was over she was thrown off her feed and had to be put back on her former ration and plane. She was, therefore, on the 15+25 plane during nearly all of the 90 days, at the end of which time she was in splendid condition though her gains had been below normal, and was 33 pounds above or 107.9% of the normal in weight and 4.1 centimeters above or 103.8% of the normal in height. During the 90 days she made 68.4% and 68.1% respectively of the normal gain in weight and height on 63.1% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 51.6% and 45.9% respectively of the digestible true protein and 147.5% and 123.5% respectively of the net energy recommended by Armsby by age and by weight.

On February 24, 1920 she was changed to a 20+0 plane but the character of her ration was practically unchanged except for a reduction in the starch and sugar. She steadily fell farther behind the normal weight and became narrow, rough and in thin flesh, and was off feed on one or two occasions and was slow in making a recovery. In February and March, 1921 she began to show a general improvement in appearance, condition of flesh, spring of rib, and length and depth of barrel. Her gains at this time were practically normal. She remained on the 20+0 plane through fifteen 30-day periods, and was taken off experiment May 18, 1921. She was 48 pounds below or 93.6% of the normal in weight but was 3.1 centimeters above or 102.6% of the normal in height. She made 75.1% and 93.5% respectively of the normal gain in weight and height for the entire 450 days while receiving 72.4% of the digesti-

TABLE 27.—SUMMARY TABLE FOR HOLSTEIN HEIFER No. 501.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	5 28	15+50	9.2+21.7	.652	.467	.389	.850	.896	.910	.483	5.31	6.46
2	6 28	15+50	6.0+ 2.2	.653	.375	.321	.868	.932	.925	.417	5.38	5.50
3	7 27	15+50	9.6+12.5	.661	.495	.414	.884	.960	.935	.825	5.50	6.19
4	8 26	15+50	9.8+20.8	.657	.502	.419	.900	.986	.945	.377	5.52	6.67
5	9 27	15+50	14.2+38.0	.667	.642	.515	.934	1.020	.965	.664	5.68	7.84
6	10 26	15+50	7.7 - 2.9	.678	.464	.370	.967	1.040	.980	*2.079	5.83	5.66
7	11 26	15+50	13.7+39.4	.682	.645	.520	1.000	1.040	.980	*2.079	5.86	8.17
8	12 25	15+50	13.8+38.5	.701	.664	.528	1.016	1.053	.990	1.172	6.02	8.34
	13 25											
Av.	9 26	15+50	10.5+21.3	.669	.532	.435	.927	.991	.954	1.012	5.64	6.85
9	13 25	20+0	17.5 - 0.8	.879	.801	.616	1.033	1.060	.995	1.092	6.22	6.17
10	14 24	20+0	17.5+ 2.5	.911	.832	.634	1.050	1.080	1.025	2.269	6.46	6.62
11	15 23	20+0	17.1 - 1.7	.937	.843	.646	1.066	1.087	1.040	2.299	6.63	6.52
12	16 23	20+0	17.0 - 0.7	.959	.858	.659	1.084	1.094	1.051	1.030	6.78	6.73
13	17 22	20+0	18.8 - 0.6	.990	.949	.728	1.100	1.106	1.077	1.294	7.02	6.98
14	18 22	20+0	18.8 - 1.1	1.018	.977	.692	1.116	1.126	1.117	2.094	7.24	7.16
15	19 21	20+0	20.8 - 0.4	1.054	1.089	.776	1.124	1.132	1.130	1.815	7.47	7.44
16	20 20	20+0	18.8 - 0.7	1.083	1.042	.798	1.141	1.146	1.155	1.737	7.68	7.63
17	21 22	20+0	18.8 - 0.6	1.107	1.063	.617	1.166	1.160	1.182	1.993	7.86	7.81
18	22 21	20+0	18.8 - 1.2	1.085	1.042	.798	1.174	1.166	1.195	31.260	7.80	7.71
	23 21											
Av.	18 22	20+0	18.4 - 0.5	1.002	.950	.696	1.105	1.116	1.097	4.688	7.12	7.08

*Because of a loss in weight, the average of two periods taken

TABLE 28.—SUMMARY TABLE FOR JERSEY HEIFER No. 146.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	7 18	15+25	14.9+17.9	.604	.602	.459	.876	.986	.945	.821	5.15	6.07
2	8 18	15+25	14.9+18.5	.619	.619	.473	.892	1.006	.955	.619	5.30	6.28
3	9 17	15+50	13.4+26.9	.643	.591	.454	.917	1.026	.970	1.364	5.47	6.94
	10 16											
Av.	9 2	15+33	14.4+21.1	.622	.604	.462	.895	1.006	.957	.935	5.31	6.43
4	10 16	20+0	19.8 - 2.0	.770	.767	.579	.950	1.033	.975	.885	5.53	5.42
5	11 17	20+0	19.6 - 0.7	.781	.771	.582	.984	1.053	.990	*5.528	5.67	5.63
6	12 16	20+0	17.2 - 2.7	.776	.703	.516	1.008	1.046	.985	*5.528	5.63	5.48
7	13 16	20+0	18.1 - 1.1	.780	.730	.554	1.026	1.060	.995	.876	5.69	5.63
8	14 15	20+0	17.9 - 0.7	.796	.742	.566	1.042	1.074	1.012	2.783	5.85	5.81
9	15 15	20+0	17.8 - 1.4	.798	.742	.566	1.058	1.080	1.025	.890	5.89	5.81
10	16 14	20+0	18.7 - 2.0	.813	.779	.598	1.075	1.100	1.065	2.921	6.05	5.93
11	17 13	20+0	20.1 - 1.8	.806	.809	.625	1.092	1.100	1.065	2.023	6.04	5.93
12	18 13	20+0	18.8 - 1.2	.800	.770	.591	1.108	1.113	1.090	2.310	6.05	5.98
13	19 12	20+0	21.0 - 1.2	.793	.820	.624	1.124	1.120	1.105	1.447	6.05	5.98
14	20 12	20+0	20.6 - 2.1	.794	.810	.617	1.141	1.126	1.117	1.869	6.11	5.98
15	21 11	20+0	20.4 - 1.9	.800	.810	.617	1.158	1.140	1.145	1.620	6.18	6.06
16	22 10	20+0	20.7 - 2.1	.791	.810	.617	1.174	1.146	1.155	.759	6.19	6.06
17	23 12	20+0	20.3 - 2.0	.802	.810	.617	1.191	1.166	1.195	1.350	6.35	6.22
18	24 11	20+0	20.4 - 2.8	.800	.810	.617	1.200	1.180	1.220	.900	6.40	6.22
	25 11											
Av.	17 28	20+0	19.4 - 1.7	.793	.779	.592	1.089	1.102	1.076	2.113	5.98	5.88

*Because of a loss in weight, the average of two periods taken.

BORN MAY 28, 1919. ON EXPERIMENT NOVEMBER 26, 1919

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.10	4.37	6.68	346	318	−28	91.9		100.8	99.2	−1.6	98.4	
4.20	4.64	6.11	386	347	−39	89.9		103.9	102.2	−1.7	98.4	
4.30	4.82	10.32	421	374	−47	88.8		106.9	106.2	−0.7	99.3	
4.40	5.00	5.00	461	392	−69	85.0		108.9	106.7	−2.2	98.0	
4.62	5.36	8.11	498	432	−66	86.7		111.1	110.2	−0.9	99.2	
4.86	5.62	*25.93	525	461	−64	87.8		112.5	112.2	−0.3	99.7	
5.10	5.62	*25.93	554	461	−93	83.2		113.9	113.5	−0.4	99.6	
5.32	5.79	14.72	571	477	−94	83.5		115.5	114.7	−0.8	99.3	
			592	494	−98	83.4	71.5	117.2	115.7	−1.5	98.7	100.6
4.61	**5.15**	**12.85**	**484**	**417**	**−66**	**86.7**		**110.1**	**109.0**	**−1.1**	**99.0**	
5.53	5.88	8.41	592	494	−98	83.4		117.2	115.7	−1.5	98.7	
5.76	6.13	18.05	609	516	−93	84.7		118.6	115.8	−2.8	97.6	
5.96	6.22	17.78	636	527	−109	82.9		120.0	117.3	−2.7	97.8	
6.19	6.30	8.08	656	538	−118	82.0		121.1	118.8	−2.3	98.1	
6.40	6.48	9.52	679	563	−116	82.9		121.7	118.8	−2.9	97.6	
6.60	6.72	15.34	707	585	−122	82.7		122.5	120.5	−2.0	98.4	
6.70	6.80	12.40	737	599	−138	81.3		123.5	122.8	−0.7	99.4	
6.90	6.96	12.72	765	617	−148	80.7		124.2	122.8	−1.4	98.9	
7.20	7.12	14.64	790	635	−155	80.4		124.8	122.5	−2.3	98.2	
7.30	7.20	231.30	816	651	−165	79.8		125.6	125.2	−0.4	99.7	
			836	652	−184	78.0	64.8	126.4	126.0	−0.4	99.7	112.0
6.45	**6.58**	**34.82**	**711**	**580**	**−131**	**81.7**		**122.3**	**120.6**	**−1.8**	**98.6**	

BORN APRIL 8, 1919. ON EXPERIMENT NOVEMBER 26, 1919

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.24	5.00	8.28	325	388	+63	119.4		98.5	104.9	+6.4	106.5	
4.34	5.18	6.28	362	410	+48	113.3		101.5	106.0	+4.5	104.4	
4.50	5.44	16.02	394	440	+46	111.7		103.9	106.2	+2.3	102.2	
			420	453	+33	107.9	68.4	105.7	109.8	+4.1	103.8	68.1
4.36	**5.21**	**10.19**	**375**	**423**	**+48**	**113.1**		**102.4**	**106.7**	**+4.3**	**104.2**	
4.74	5.52	6.25	420	453	+33	107.9		105.7	109.8	+4.1	103.8	
4.98	5.79	*41.66	446	479	+33	107.4		107.4	111.7	+4.3	104.0	
5.19	5.70	*41.66	469	474	+5	101.1		109.2	113.3	+4.1	103.8	
5.42	5.88	6.76	492	487	−5	99.0		110.8	115.2	+4.4	104.0	
5.64	6.04	21.79	512	512	±0	100.0		112.0	116.7	+4.7	104.2	
5.86	6.13	6.97	527	520	−7	98.7		113.0	117.8	+4.8	104.2	
6.07	6.40	22.24	542	545	+3	100.6		114.0	119.5	+5.5	104.8	
6.28	6.40	14.83	561	553	−8	98.6		115.0	118.8	+3.8	103.3	
6.50	6.56	17.94	583	565	−18	96.9		116.1	119.4	+3.3	102.8	
6.70	6.64	10.55	607	575	−32	94.7		117.1	119.1	+2.0	101.7	
6.90	6.72	13.80	632	592	−40	93.7		117.7	119.9	+2.2	101.9	
7.10	6.88	12.12	656	605	−51	92.2		118.4	121.0	+2.6	102.2	
7.30	6.96	5.68	675	620	−55	91.9		119.2	121.3	+2.1	101.8	
7.50	7.20	10.37	700	652	−48	93.1		120.0	123.0	+3.0	102.5	
7.65	7.36	6.91	724	670	−54	92.5		120.6	123.0	+2.4	102.0	
			745	697	−48	93.6	75.1	121.1	124.2	+3.1	102.6	93.5
6.26	**6.41**	**15.97**	**581**	**562**	**−18**	**97.6**		**114.8**	**118.4**	**+3.5**	**103.1**	

ble crude protein recommended by the Wolff-Lehmann standard and 54.4% and 53.7% respectively of the digestible true protein and 93.9% and 91.6% respectively of the net energy recommended by Armsby by age and by weight. When taken off experiment she was in excellent general condition, showing a splendid barrel, good size and general development and a good condition of flesh. She apparently had not suffered severely from her experimental conditions. On July 12, she dropped a heifer calf weighing 50 pounds that had been carried 279 days and that was apparently normal. She proved to be an inferior producer.

No. 285. (*See Table* 29.)—On November 16, 1919 Holstein heifer No. 285 was placed on a preliminary ration calculated to furnish a 10+0 plane. On November 26 at the age of 19 months, 4 days, she was started on experiment and was continued on a ration composed of timothy, alfalfa, corn and starch and sugar. She was reported as being a beautiful, large heifer in most excellent condition. She gained 13 pounds during her 10-day preliminary period, readily became adjusted and took her

TABLE 29.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 285.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.-da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	19 4	10+0	9.6 - 4.6	.739	.733	.570	1.116	1.200	1.277	.478	8.19	7.81
2	20 4	10+0	9.8 - 4.9	.776	.770	.594	1.132	1.200	1.300	.563	8.61	8.19
3	21 3	10+0	9.7 - 4.9	.807	.796	.618	1.150	1.200	1.318	.702	8.96	8.52
4	22 2	10+0	9.4 - 4.6	.830	.807	.628	1.166	1.200	1.332	.637	9.23	8.81
	23 3											
Av.	21 3	10+0	9.6 - 4.8	.788	.777	.603	1.141	1.200	1.307	.595	8.75	8.33

TABLE 30.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO, 288.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.-da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs	lbs.	therms	therms
1	16 12	15+0	15.0 - 4.0	.851	.854	.663	1.075	1.194	1.247	1.708	7.59	7.29
2	17 12	15+0	15.3 - 4.2	.873	.883	.685	1.092	1.200	1.260	1.060	7.77	7.44
	18 11											
Av.	17 12	15+0	15.2 - 4.1	.862	.869	.674	1.084	1.197	1.254	1.384	7.68	7.37
3	18 11	15+15	15.4+ 5.7	.897	.911	.709	1.108	1.200	1.274	1.188	8.01	8.47
4	19 10	15+25	14.5+24.1	.922	.906	.711	1.124	1.200	1.282	.971	8.23	10.21
5	20 11	15+25	14.5+17.2	.957	.940	.735	1.141	1.200	1.295	1.880	8.54	10.01
6	21 10	15+25	13.5+17.2	.980	.922	.723	1.158	1.200	1.300	.748	8.74	10.24
7	22 10	15+25	13.4+17.3	1.010	.948	.740	1.174	1.200	1.318	.390	9.03	10.59
	23 9											
Av.	20 25	15+23	14.3+16.3	.953	.925	.724	1.141	1.200	1.294	1.035	8.51	9.90

feed well. At the time she weighed 743 pounds which was 24 pounds above or 103.3% of the normal in weight, and was 3.4 centimeters below or 97.2% of the normal in height. This is the oldest heifer started on experiment to date. The purpose of starting an animal at such an advanced age was to determine the practicability of the "sliding scale" of planes outlined in connection with No. 500. She remained on the 10+0 plane through four 30-day periods. At the outset it was thought probable that she would make poor gains and would have to be removed, or that her plane would have to be raised in a short time. On the contrary she made steady and much better than normal gains from the start, and developed a long deep body and an excellent condition of flesh. At the end of the experiment she was 76 pounds above or 109.2% of the normal in weight but was 2.8 centimeters below or 97.8% of the normal in height. During the four 30-day periods she made 148.6% of the normal gain in weight and 120.0% of the normal gain in height. These splendid gains were accomplished on 59.4% of the digestible crude protein recommended by

BORN APRIL 22, 1918. ON EXPERIMENT NOVEMBER 26, 1919

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
6.60	7.84	5.09	719	743	+24	103.3		122.8	119.4	-3.4	97.2	
6.80	8.15	5.99	750	789	+39	105.2		123.9	121.0	-2.9	97.7	
7.00	8.40	7.52	776	830	+54	107.0		124.4	122.0	-2.4	98.1	
7.20	8.60	6.96	798	864	+66	108.3		125.0	122.2	-2.8	97.8	
.....	.....	.....	826	902	+76	109.2	148.6	125.8	123.0	-2.8	97.8	120.0
6.90	**8.25**	**6.39**	**774**	**826**	**+52**	**106.6**		**124.4**	**121.5**	**-2.9**	**97.7**	

BORN JULY 14, 1918. ON EXPERIMENT NOVEMBER 26, 1919

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Norma gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
6.07	7.52	14.58	650	687	+37	105.7		120.7	119.3	-1.4	98.8	
6.28	7.60	8.93	670	702	+32	104.8		121.5	118.0	-3.5	97.1	
.....	.....	.....	697	727	+30	104.3	85.1	122.1	119.7	-2.4	98.0	28.6
6.18	**7.56**	**11.76**	**672**	**705**	**+33**	**105.0**		**121.4**	**119.0**	**-2.4**	**98.0**	
6.50	7.78	11.05	697	727	+30	104.3		122.1	119.7	-2.4	98.0	
6.70	7.90	10.94	725	750	+25	103.4		123.1	121.2	-1.9	98.5	
6.90	8.08	20.02	756	778	+22	102.9		124.1	122.5	-1.6	98.7	
7.10	8.15	8.30	781	793	+12	101.5		124.5	122.7	-1.8	98.6	
7.30	8.40	4.35	805	830	+25	103.1	133.3	125.2	124.7	-0.5	99.6	126.3
.....	.....	.....	829	903	+74	108.9		125.9	124.5	-1.4	98.9	
6.90	**8.06**	**10.93**	**766**	**797**	**+31**	**104.0**		**124.2**	**122.6**	**-1.6**	**98.7**	

the Wolff-Lehmann standard and on 52.8% and 50.2% respectively of the digestible true protein and 120.8% and 101.0% respectively of the net energy recommended by Armsby by age and by weight. She was taken off experiment March 24, 1920 at the age of 23 months and 3 days and was heavy with calf. The fact that she was pregnant was undoubtedly partially responsible for her splendid gains although it could not have accounted for them to a very great extent. On April 5, 1920 she dropped a normal heifer calf which weighed 80 pounds at the age of five days. She proved to be a splendid milk cow, calving at the age of 1 year, 11 months, 14 days, and producing 11,009 pounds of milk and 367 pounds of fat in her first lactation period. She was a daughter of No. 267, one of the earlier experimental heifers.

No. 288. (*See Table* 30.)—On November 16, 1919 Holstein heifer No. 288 was placed on a preliminary ration of timothy, alfalfa, corn, bran and starch and sugar calculated to furnish a 15+0 plane. During the ten days of preliminary feeding she lost 3 pounds in weight. On November 26, at the age of 16 months, 12 days, she was in good physical condition was taking her feed well, and readily becoming adjusted to experimental conditions. She weighed 687 pounds which was 37 pounds above or 105.7% of the normal in weight and was 98.8% of the normal in height. She was continued on the 15+0 plane for only two 30-day periods. During this time she made slightly less than normal gains and at the end of the 60 days was 30 pounds above or 104.3% of the normal weight and 98.0% of the normal in height and had made 85.1% and 28.6% respectively of the normal gain in weight and height while receiving 69.3% of the digestible crude protein recommended by the Wolff-Lehmann standard and 62.2% and 56.3% respectively of the digestible true protein and 119.3% and 97.4% respectively of the net energy recommended by Armsby by age and by weight. The low percentage gain in height is undoubtedly due to an error in taking the first height measurement since the first mesaurement is 1.3 centimeters greater than the second average.

It was considered in January, 1920 that the gains made by this heifer had been low enough to warrant an increase in plane, and it was planned to increase her to a 15+25 plane. The 1920 influenza epidemic was then prevalent and calculation for all the experimental heifers was made by a student, with the result that this heifer was placed on a 15+15 plane. This was corrected the following month to a 15+25 plane, and the 15+15 plane will not receive separate consideration. On the 15+25 plane she made satisfactory gains, although not noticeably better at first than on a 15+0 plane. On May 24, 1920 she was reported as being in excellent condition, long, wide, and fairly deep, in good flesh and

making normal gains. On June 22 she had been on this plane for five 30-day periods and was 74 pounds above or 108.9% of the normal in weight and 1.4 centimeters below or 98.9% of the normal in height. During the 150 days she made 133.3% and 126.3% respectively of the normal gain in weight and in height while receiving only 71.5% of the digestible crude protein recommended by the Wolff-Lehmann standard and 63.4% and 60.3% respectively of the digestible true protein and 143.5% and 122.8% respectively of the net energy recommended by Armsby by age and by weight. She had shown an increase of 73 pounds in weight in 30 days and was reduced on June 23 to a 15+0 plane but on this date she aborted a fetus that had been carried only 142 days, and was immediately taken off experiment. Her production following this abnormal parturition at the age of 1 year, 11 months, 9 days amounted to 4,994 pounds milk and 166 pounds fat in 274 days. She calved again on May 22, 1921 at the age of 2 years, 10 months, dropping a normal bull calf which weighed 102 pounds and which had been carried 278 days. In this second lactation period as a two-year-old she produced 12,752 pounds of milk and 367 pounds of fat in 365 days.

No. 290. (*See Table* 31.)—On November 16, 1919 Holstein heifer No. 290 was placed on a preliminary ration of timothy, alfalfa, corn bran and starch and sugar calculated to furnish a 15+0 plane. During the ten days of preliminary feeding she lost 14 pounds. On November 26, 1919, at the age of 15 months, 29 days, she weighed 686 pounds which was 44 pounds above or 106.9% of the normal in weight and was 100.3% of the normal in height. She was in poor flesh and lacking in paunch development, but was large and growthy. She remained on the 15+0 plane only two 30-day periods, at the end of which she was 41 pounds above or 106.0% of the normal in weight and 99.9% of the normal in height. She made 92.9% and 66.7% respectively of the normal gain in weight and in height on a ration which furnished 68.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and 62.3% and 56.0% respectively of the digestible true protein and 120.7% and 97.0% respectively of the net energy recommended by Armsby by age and by weight.

She was of almost the same age and general condition as No. 288, she was treated in exactly the same manner. She was on the 15+15 and 15+25 planes for five 30-day periods, at the end of which she was 111.8% and 101.8% respectively of the normal in weight and height and had made 141.2% and 160.5% respectively of the normal gain in weight and in height on a ration furnishing 71.5% of the digestible crude protein recommended by the Wolff-Lehmann standard and 64.1% and 60.5% respectively of the digestible true protein, and 145.3% and 121.6% respectively of the net energy recommended by Armsby by age

TABLE 31.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 290.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.-da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	15 29	15+0	15.3 - 3.8	.850	.861	.670	1.066	1.194	1.247	1.614	7.58	7.29
2	16 29	15+0	14.6 - 5.0	.873	.861	.670	1.084	1.200	1.260	1.123	7.77	7.38
	17 28											
Av.	16 29	15+0	15.0 - 4.4	.862	.861	.670	1.075	1.197	1.254	1.369	7.68	7.34
3	17 28	15+15	15.2+ 6.8	.887	.896	.697	1.100	1.200	1.274	1.120	7.99	8.53
4	18 27	15+25	14.5+17.4	.922	.906	.711	1.116	1.200	1.282	.618	8.23	9.66
5	19 28	15+25	14.5+18.0	.964	.947	.742	1.132	1.200	1.300	1.671	8.63	10.18
6	20 27	15+25	13.7+17.2	.989	.939	.736	1.150	1.200	1.310	.704	8.84	10.36
7	21 27	15+25	13.3+16.7	1.019	.954	.746	1.166	1.200	1.327	.427	9.15	10.68
	22 26											
Av.	20 12	15+23	14.2+15.2	.956	.928	.726	1.133	1.200	1.299	.908	8.57	9.88
8	22 26	15+0	13.2 - 3.3	1.029	.963	.751	1.183	1.200	1.350	1.256	9.39	8.99
	23 26											
Av.	23 11	15+0	13.2 - 3.3	1.029	.963	.751	1.183	1.200	1.350	1.256	9.39	9.08
9	23 26	10+0	9.4 - 3.3	.830	.809	.658	1.200	1.200	1.350	.539	9.30	8.99
10	24 25	10+0	10.3 - 2.9	.820	.830	.680	1.200	1.200	1.350	1.660	9.22	8.95
11	25 24	10+0	8.3 - 3.6	.787	.742	.598	1.200	1.200	1.350	1.712	8.91	8.59
	26 23											
Av.	25 10	10+0	9.3 - 3.3	.812	.794	.645	1.200	1.200	1.350	1.304	9.14	8.84

TABLE 32.—SUMMARY TABLE FOR JERSEY HEIFER NO. 148.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.-da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	11 7	25+0	21.8+ 1.6	.909	.824	.645	.967	1.046	.985	24.720	5.60	5.69
	12 6											
Av.	11 22	25+0	21.8+ 1.6	.909	.824	.645	.967	1.046	.985	24.720	5.60	5.69
2	12 6	20+0	17.7 - 2.1	.774	.714	.570	1.000	1.046	.985	.857	5.60	5.48
3	13 6	20+0	17.8+ 2.6	.783	.725	.578	1.016	1.060	.995	1.208	5.73	5.88
4	14 5	20+0	17.7+ 0.3	.796	.737	.585	1.033	1.074	1.012	2.211	5.85	5.87
	15 4											
Av.	13 20	20+0	17.7+ 0.3	.784	.725	.578	1.016	1.060	.997	1.425	5.73	5.74
5	15 4	15+0	13.2 - 2.2	.666	.619	.485	1.050	1.080	*1.025	*6.283	5.90	5.77
6	16 4	15+0	13.4 - 1.7	.665	.623	.487	1.066	1.080	*1.025	*6.283	5.87	5.77
7	17 3	15+0	14.4 - 2.6	.657	.643	.497	1.084	1.080	*1.025	*6.283	5.83	5.68
	18 3											
Av.	16 19	15+0	13.7 - 2.2	.663	.628	.490	1.067	1.080	1.025	6.283	5.87	5.74
8	18 3	10+0	9.0 - 2.2	.527	.503	.403	1.100	1.087	*1.040	*18.173	5.85	5.72
9	19 2	10+0	8.8 - 1.6	.521	.492	.396	1.116	1.087	*1.040	*18.173	5.77	5.68
10	20 1	10+0	9.7 - 3.3	.520	.514	.416	1.132	1.094	1.051	*18.173	5.77	5.58
	21 3											
Av.	19 17	10+0	9.2 - 2.4	.523	.503	.405	1.116	1.089	1.044	18.173	5.80	5.66
11	21 3	10+50	8.6+39.4	.517	.482	.389	1.150	1.087	1.040	*18.173	5.73	7.99
12	22 2	10+50	6.3+12.8	.520	.432	.350	1.166	1.100	1.065	*18.173	5.78	6.52
	23 2											
Av.	22 2	10+50	7.5+26.1	.519	.457	.370	1.158	1.094	1.053	18.173	5.76	7.26

*Because of a loss in weight, the average of two or more periods taken

BORN JULY 27, 1918. ON EXPERIMENT NOVEMBER 26, 1919.

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
5.96	7.52	13.67	642	686	+44	106.9		120.3	120.7	+0.4	100.3	
6.19	7.60	9.63	659	702	+43	106.5		121.3	121.8	+0.5	100.4	
			684	725	+41	106.0	92.9	121.8	121.7	−0.1	99.9	66.7
6.08	**7.56**	**11.65**	**662**	**704**	**+43**	**106.5**		**121.1**	**121.4**	**+0.3**	**100.2**	
6.40	7.78	10.66	684	725	+41	106.0		121.8	121.7	−0.1	99.9	
6.60	7.90	6.59	712	749	+37	105.2		122.6	123.3	+0.7	100.6	
6.80	8.15	17.96	744	793	+49	106.6		123.9	125.7	+1.8	101.5	
7.00	8.28	7.77	771	810	+39	105.1		124.3	126.8	+2.5	102.0	
7.20	8.53	4.78	794	850	+56	107.1		124.9	128.0	+3.1	102.5	
			820	917	+97	111.8	141.2	125.6	127.8	+2.2	101.8	160.5
6.80	**8.13**	**9.55**	**754**	**807**	**+53**	**107.0**		**123.9**	**125.6**	**+1.7**	**101.4**	
7.40	8.99	11.84	820	917	+97	111.8		125.6	127.8	+2.2	101.8	
			839	940	+101	112.0	121.1	126.4	129.5	+3.1	102.5	212.5
7.40	**8.99**	**11.84**	**830**	**929**	**+99**	**111.9**		**126.0**	**128.7**	**+2.7**	**102.2**	
7.60	9.12	5.99	839	940	+101	112.0		126.4	129.5	+3.1	102.5	
7.70	9.44	17.90	864	985	+121	114.0		127.5	129.0	+1.5	101.2	
7.80	9.50	19.82	888	1000	+112	112.6		128.1	129.7	+1.6	101.2	
			918	1013	+95	110.3	92.4	129.1	130.2	+1.1	100.9	25.9
7.70	**9.35**	**14.57**	**877**	**985**	**+107**	**112.2**		**127.8**	**129.6**	**+1.8**	**101.5**	

BORN JUNE 17, 1919. ON EXPERIMENT MAY 24, 1920

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.86	5.70	170.70	438	468	+30	106.8		107.1	104.3	−2.8	97.4	
			461	469	+8	101.7	4.3	108.8	107.5	−1.3	98.8	188.2
4.86	**5.70**	**170.70**	**450**	**469**	**+19**	**104.3**		**108.0**	**105.9**	**−2.1**	**98.1**	
5.10	5.70	6.58	461	469	+8	101.7		108.8	107.5	−1.3	98.8	
5.32	5.88	9.80	485	494	+9	101.9		110.4	108.7	−1.7	98.5	
5.33	6.04	17.61	506	512	+6	101.2		111.6	109.2	−2.4	97.8	
			522	522	±0	100.0	86.9	112.8	111.7	−1.1	99.0	105.0
5.32	**5.87**	**11.33**	**494**	**499**	**+6**	**101.2**		**110.9**	**109.3**	**−1.6**	**98.5**	
5.76	6.13	*57.40	522	522	±0	100.0		112.8	111.7	−1.1	99.0	
5.96	6.13	*57.40	536	516	−20	96.3		113.6	112.7	−0.9	99.2	
6.19	6.13	*57.40	555	518	−37	93.3		114.7	113.2	−1.5	98.7	
			575	531	−44	92.7	17.0	115.8	112.6	−3.2	97.2	30.0
5.97	**6.13**	**57.40**	**547**	**522**	**−25**	**95.6**		**114.2**	**112.6**	**−1.7**	**98.5**	
6.40	6.22	*236.18	575	531	−44	92.7		115.8	112.6	−3.2	97.2	
6.60	6.22	*236.18	600	529	−71	88.2		116.8	113.5	−3.3	97.2	
6.80	6.30	*236.18	622	536	−86	86.2		117.5	114.7	−2.8	97.6	
			651	529	−122	81.3	−2.6	118.1	115.2	−2.9	97.5	113.0
6.60	**6.25**	**236.18**	**612**	**531**	**−81**	**87.1**		**117.1**	**114.0**	**−3.1**	**97.4**	
7.00	6.22	*236.18	651	529	−122	81.3		118.1	115.2	−2.9	97.5	
7.20	6.40	*236.18	669	552	−117	82.5		118.9	114.5	−4.4	96.3	
			691	535	−156	77.4	15.0	119.8	117.5	−2.3	98.1	135.3
7.10	**6.31**	**236.18**	**670**	**539**	**−132**	**80.4**		**118.9**	**115.7**	**−3.2**	**97.3**	

and by weight. Not only did she make excellent gains, but her condition steadily and rapidly improved and at the end of the 150 days she was in excellent condition. She was reduced on June 23, 1920 to a 15+0 plane with the idea that if she made a normal gain or better on the 15+0 plane for one period she should be further reduced to a 10+0 plane. During this one period on a 15+0 plane she made 23 pounds or 121.1% of the normal gain in weight, made 212.5% of the normal gain in height, and retained her splendid condition. She was then 101 pounds above or 112.0% of the normal in weight and 102.5% of the normal in height. A 30-day period is entirely too short to be of significance. According to the plan, however, she was reduced on July 23, 1920 to a 10+0 plane and a ration of timothy, alfalfa, corn and starch and sugar. She remained on the 10+0 plane for three 30-day periods until October 20, 1920. At that time she was in excellent condition and was taken off experiment. She was 95 pounds and 1.1 centimeters above or was 110.3% and 100.9% respectively of the normal in weight and in height, and had made during the 90 days 92.4% and 25.9% respectively of the normal gain in weight and in height on a ration which supplied 58.8% of the digestible crude protein recommended by the Wolff-Lehmann standard and 53.8% and 53.8% respectively of the digestible true protein and 114.8% and 94.5% respectively of the net energy recommended by Armsby by age and by weight. She was considered entirely normal at the time she was taken off experiment. On December 12, 1920 she dropped a normal living bull calf that weighed 95 pounds at birth, that had been carried 282 days. The cow completed her record as a two-year-old with 9,691 pounds of milk and 316 pounds of fat.

Five Heifers on Sliding Scale.—Five heifers were started on experiment May 24, 1920. It had been customary to put all heifers on a preliminary ration for a week or ten days before putting them on the experiment. As the proposed ration was very similar to the one these heifers had been taking this preliminary period was omitted. The animals selected were No. 148, 149, 150, 504, and 505. They had been on pasture for a week or ten days and during that time had either lost slightly or just maintained their weight. It was thought advisable to put these five animals on experiment and adjust their planes to the sliding scale plan to further test its practicability.

No. 148. (*See Table* 32.)—Jersey heifer No. 148 was started on experiment May 24, 1920 at 11 months, 7 days of age, and was placed on a 25+0 plane. The ration was composed of alfalfa, corn and bran. She was large and growthy and in excellent condition and weighed 468 pounds which was 30 pounds above or 106.8% of the normal in weight, and was 2.8 centimeters below or 97.4% of the normal in height. During the first 30-day period she gained 1 pound in weight making her only

8 pounds above or 101.7% of the normal in weight. During the first period she made 4.3% and 188.2% respectively of the normal gain in weight and height while the ration furnished 83.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and 66.7% and 61.7% respectively of the digestible true protein and 117.1% and 99.8% respectively of the net energy recommended by Armsby by age and by weight. According to schedule she was reduced in June to a 20+0 plane made up of timothy, alfalfa, corn and bran. She remained on the 20+0 plane for three 30-day periods. Her gains were not satisfactory, she was in only fair condition, and was rough and narrow but fairly deep. She was exactly normal in weight and 99.0% of the normal in height at the end of the 90 days. She made 86.9% and 105.0% respectively of the normal gain in weight and height on a ration furnishing 72.7% of the digestible crude protein recommended by the Wolff-Lehmann Standard and 56.8% and 54.5% respectively of the digestible true protein and 108.0% and 97.8% respectively of the net energy recommended by Armsby by age and by weight.

On September 21, her plane was reduced as planned to 15+0, by removing the bran and adding starch. She remained for 90 days on this 15+0 plane, during which time she gained only 9 pounds and at the end was 44 pounds below or 92.7% of the normal in weight and 3.2 centimeters below or 97.2% of the normal in height. During the 90 days she made only 17.0% and 30.0% respectively of the normal gain in weight and height on a ration which furnished 61.3% of the digestible crude protein recommended by the Wolff-Lehmann standard and 45.9% and 45.3% respectively of the digestible true protein and 96.1% and 93.6% respectively of the net energy recommended by Armsby by age and by weight.

According to plan she was reduced further in December from a 15+0 to a 10+0 plane. At this time she was in a medium condition of flesh but was narrow and shallow. The character of the ration was not changed. She remained on the 10+0 plane for 90 days, at the end of which she was in poor condition, but was long and carried a fair barrel except that it was shallow in the rear. At the end of the three periods she was 122 pounds below or only 81.3% of the normal in weight and 2.9 centimeters below or 97.5% of the normal in height. She actually lost 2 pounds or made a gain of −2.6% or a loss of 2.6% in weight, but made a gain of 113.0% in height. During this time she received 48.2% of the digestible crude protein recommended by the Wolff-Lehmann standard and 36.3% and 37.2% respectively of the digestible true protein and 85.8% and 90.6% respectively of the net energy recommended by Armsby by age and by weight.

She had been making such extremely poor gains that she was raised March 30, 1921 to a 10+50 plane. It was planned to allow her to continue on the 10+50 for at least three and possibly four 30-day periods. After she had been on the 10+50 plane for 60 days, she was deep, long and well proportioned except for lacking slightly in barrel, was in medium flesh and apparently in a smoother and better general condition than on the previous month, although the apparent improvement was probably largely due to shedding off her rough winter coat in the meantime. She had been off feed for several days and was partially off feed at the time of the May weighing and on the evening after the second weigh day (May 17) she lost her eyesight and went completely off feed. Since she had actually lost 17 pounds in the last 30 days and since she had gained only 4 pounds in 150 days she was taken off experiment. During the 60 days on the 10+50 plane she made only 15.0% of the normal gain in weight but gained 135.3% of the normal in height on 43.4% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 31.9% and 33.8% respectively of the digestible true protein and 102.2% and 115.0% respectively of the net energy recommended by Armsby by age and by weight. When taken off experiment she was 156 pounds below or 77.4% of the normal in weight and 2.3 centimeters below or 98.1% af the normal in height, whereas at the beginning she was 30 pounds above the normal in weight and 2.8 centimeters below the normal in height. She was bred for the first time on May 15, 1921. The delayed breeding of this heifer was not due to any abnormality on her part but on account of the lack of a suitable Jersey herd sire.

No. 149. (*See Table* 33.)—Jersey heifer No. 149 was started on experiment in exactly the same manner as No. 148. As she was within two days of the same age and weighed within four pounds of the same amount they were placed on the same type of ration and treated in almost identically the same manner throughout the entire experiment. For the most of the time they were on exactly the same rations and changes were made on the same dates. She weighed 472 pounds which was 36 pounds above or 108.3% of the normal in weight and was 1.0 centimeter above or 100.9% of the normal in height and was in excellent condition. During the first 30-day period on the 25+0 plane she made 78.3% and 50.0% respectively of the normal gain in weight and in height while receiving 83.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and 66.7% and 61.7% respectively of the digestible true protein and 120.6% and 99.6% respectively of the net energy recommended by Armsby by age and by weight.

She was reduced on June 23, 1920 to a 20+0 plane on which she remained for 90 days. Her gains were unsatisfactory. She made only 56.5% and 82.9% respectively of the normal gain in weight and in

height, while receiving 72.5% of the digestible crude protein recommended by the Wolff-Lehmann standard and 57.5% and 54.5% respectively of the digestible true protein and 111.0% and 98.1% respectively of the net energy recommended by Armsby by age and by weight. At the end of this period she was 4 pounds above or 100.8% of the normal in weight and 0.6 centimeters below or 99.5% of the normal in height but was in good general condition.

The plan called for a reduction on September 21, 1921 from 20+0 to 15+0. This reduction was made regardless of her poor gains. She remained on a 15+0 plane for 90 days. It was found later that the actual protein consumed by this heifer while on the 25+0 plane, and the 20+0 plane, and to some extent on the 15+0 plane, was considerably below that intended, while the energy was almost exactly as intended. Results on the 15+0 plane were even more unsatisfactory. She made only 44.2% and 31.0% respectively of the normal gain in weight and height while receiving 63.0% of the digestible crude protein recommended by the Wolff-Lehmann standard and 48.4% and 47.4% respectively of the digestible true protein and 98.0% and 93.7% respectively of the net energy recommended by Armsby by age and by weight. She was at this time 25 pounds below or 95.6% of the normal in weight and 97.8% of the normal in height. Observations, however, show that she was deep-bodied, with good barrel development and in good condition of flesh.

The reduction from 15+0 to 10+0 came on December 20, 1920 as planned. She remained on this plane for 90 days and the amounts of protein and energy actually received were almost exactly as calculated. Gains in weight were still more unsatisfactory. She gained only 3 pounds which was only 3.9% of the normal in weight while her gain in height was exactly normal. Her ration furnished 49.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and 38.3% and 38.9% respectively of the digestible true protein and 86.7% and 89.8% respectively of the net energy recommended by Armsby by age and by weight. She was then 99 pounds below or 84.8% of the normal in weight and 97.8% of the normal in height. She was reported as narrow, rough, shallow, lacking in body and in thin flesh.

Since she was in such poor condition and making extremely poor gains she was raised on March 20, 1921 from a 10+0 to a 10+50 plane as in the case of No. 148. It was planned to allow her to continue on the 10+50 plane for at least three 30-day periods. At the time of the May observations after being on the 10+50 plane for 60 days she was in the same general condition as No. 148. She had been badly off feed and had nearly recovered, but refused part of her feed occasionally. Probably the reason for the refusal of feed and the fact that she and No. 148

TABLE 33.—SUMMARY TABLE FOR JERSEY HEIFER NO. 149.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.-da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	11 5	25+0	21.7+ 0.9	.911	.824	.645	.967	1.046	.985	1.373	5.63	5.68
	12 4											
Av.	**11 20**	**25+0**	**21.7+ 0.9**	**.911**	**.824**	**.645**	**.967**	**1.046**	**.985**	**1.373**	**5.63**	**5.68**
2	12 4	20+0	17.7+ 2.8	.784	.725	.578	1.000	1.060	.995	1.279	5.72	5.88
3	13 4	20+0	17.9+ 2.1	.790	.735	.587	1.016	1.074	1.012	2.005	5.81	5.93
4	14 3	20+0	17.7+ 0.2	.799	.738	.587	1.033	1.080	1.025	3.163	5.89	5.90
	15 2											
Av.	**13 18**	**20+0**	**17.8+ 1.7**	**.791**	**.733**	**.584**	**1.016**	**1.071**	**1.011**	**2.149**	**5.81**	**5.90**
5	15 2	15+0	13.4 - 1.0	.668	.626	.491	1.050	1.087	1.040	3.756	5.92	5.86
6	16 2	15+0	14.4 - 1.8	.672	.657	.518	1.066	1.087	1.040	1.643	5.96	5.85
7	17 1	15+0	15.7 - 2.2	.670	.688	.540	1.084	1.094	1.051	*15.195	5.98	5.85
	18 1											
Av.	**16 17**	**15+0**	**14.5 - 1.7**	**.670**	**.657**	**.516**	**1.067**	**1.089**	**1.044**	**6.865**	**5.95**	**5.85**
8	18 1	10+0	9.9 - 2.5	.536	.534	.432	1.100	1.100	1.065	*15.195	5.95	5.80
9	19 0	10+0	9.8 - 2.9	.526	.523	.425	1.116	1.094	1.051	*15.195	5.85	5.68
10	19 29	10+0	10.0 - 2.4	.523	.523	.425	1.132	1.100	1.065	*15.195	5.82	5.68
	21 1											
Av.	**19 15**	**10+0**	**9.9 - 2.6**	**.528**	**.527**	**.427**	**1.116**	**1.098**	**1.060**	**15.195**	**5.87**	**5.72**
11	21 1	10+50	2.1 -12.5	.527	.333	.272	1.150	1.100	1.065	*15.195	5.86	5.13
12	22 0	10+50	6.8+20.9	.513	.438	.338	1.166	1.094	1.051	*15.195	5.70	6.89
	23 0											
Av.	**22 0**	**10+50**	**4.5+ 4.2**	**.520**	**.386**	**.305**	**1.158**	**1.097**	**1.058**	**15.195**	**5.78**	**6.01**

*Because of a loss in weight, the average of six periods taken.

TABLE 34.—SUMMARY TABLE FOR JERSEY HEIFER NO. 150.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.-da			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	10 16	25+0	20.1 - 3.5	.875	.746	.581	.950	1.000	.950	2.487	5.18	5.00
2	11 15	25+0	21.7+ 0.4	.877	.789	.612	.984	1.000	.950	1.246	5.22	5.24
	12 15											
Av.	**11 15**	**25+0**	**20.9 - 1.6**	**.876**	**.768**	**.597**	**.967**	**1.000**	**.950**	**1.867**	**5.20**	**5.12**
3	12 15	20+0	17.6+ 2.6	.751	.688	.547	1.008	1.013	.960	1.032	5.32	5.46
4	13 14	20+0	17.9+ 0.7	.759	.705	.559	1.026	1.026	.970	3.021	5.43	5.47
5	14 13	20+0	17.3 - 0.2	.765	.692	.547	1.042	1.033	.975	4.152	5.48	5.47
	15 13											
Av.	**13 29**	**20+0**	**17.6+ 1.0**	**.758**	**.695**	**.551**	**1.025**	**1.024**	**.968**	**2.735**	**5.41**	**5.47**
6	15 13	15+0	15.1± 0.0	.633	.635	.507	1.058	1.040	.980	3.810	5.50	5.50
7	16 12	15+0	15.8 - 0.7	.638	.660	.523	1.075	1.040	.980	1.100	5.54	5.50
8	17 12	15+0	15.1 - 1.6	.638	.641	.510	1.092	1.053	.990	*2.824	5.59	5.50
	18 11											
Av.	**16 27**	**15+0**	**15.3 - 0.8**	**.636**	**.645**	**.513**	**1.075**	**1.044**	**.983**	**2.578**	**5.54**	**5.50**
9	18 11	20+0	20.5+ 0.5	.757	.771	.593	1.108	1.053	.990	*2.824	5.53	5.56
10	19 10	20+0	20.2 - 0.5	.753	.759	.586	1.124	1.060	.995	11.385	5.56	5.53
11	20 12	20+0	20.5+ 0.2	.745	.759	.586	1.141	1.066	1.000	1.339	5.52	5.53
12	21 11	20+0	20.2 - 0.4	.754	.759	.701	1.158	1.074	1.012	22.770	5.63	5.61
	22 11											
Av.	**20 11**	**20+0**	**20.4 - 0.1**	**.752**	**.762**	**.617**	**1.133**	**1.063**	**.999**	**9.580**	**5.56**	**5.56**

*Because of a loss in weight, the average of two periods taken.

BORN JUNE 19, 1919. ON EXPERIMENT MAY 24, 1920

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.86	5.70	9.47	436	472	+36	108.3		106.8	107.8	+1.0	100.9	
			459	490	+31	106.8	78.3	108.6	108.7	+0.1	100.1	50.0
4.86	**5.70**	**9.47**	**448**	**481**	**+34**	**107.6**		**107.7**	**108.3**	**+0.6**	**100.5**	
5.10	5.88	10.38	459	490	+31	106.8		108.6	108.7	+0.1	100.1	
5.32	6.04	16.17	483	507	+24	105.0		110.3	108.5	-1.8	98.4	
5.53	6.13	25.29	505	518	+13	102.6		111.5	109.5	-2.0	98.2	
			521	525	+4	100.8	56.5	112.7	112.1	-0.6	99.5	82.9
5.32	**6.02**	**17.28**	**492**	**510**	**+18**	**103.8**		**110.8**	**109.7**	**-1.1**	**99.1**	
5.76	6.22	35.16	521	525	+4	100.8		112.7	112.1	-0.6	99.5	
5.96	6.22	14.63	534	530	-4	99.3		113.5	112.7	-0.8	99.3	
6.19	6.30	*175.15	554	542	-12	97.8		114.6	112.8	-1.8	98.4	
			573	548	-25	95.6	44.2	115.6	113.0	-2.6	97.8	31.0
5.97	**6.25**	**74.98**	**546**	**536**	**-9**	**98.4**		**114.1**	**112.7**	**-1.5**	**98.8**	
6.40	6.40	*175.15	573	548	-25	95.6		115.6	113.0	-2.6	97.8	
6.60	6.30	*175.15	598	541	-57	90.5		116.8	114.3	-2.5	97.9	
6.80	6.40	*175.15	620	545	-75	87.9		117.5	115.2	-2.3	98.0	
			650	551	-99	84.8	3.9	118.1	115.5	-2.6	97.8	100.0
6.60	**6.37**	**175.15**	**610**	**546**	**-64**	**89.7**		**117.0**	**114.5**	**-2.5**	**97.9**	
7.00	6.40	175.15	650	551	-99	84.8		118.1	115.5	-2.6	97.8	
7.20	6.30	175.15	668	538	-130	80.5		118.9	115.2	-3.7	96.9	
			689	548	-141	79.5	-7.7	119.8	116.0	-3.8	96.8	29.4
7.10	**6.35**	**175.15**	**669**	**546**	**-123**	**81.6**		**118.9**	**115.6**	**-3.4**	**97.2**	

BORN JULY 8, 1919. ON EXPERIMENT MAY 24, 1920

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.74	5.10	16.67	420	395	-25	94.0		105.8	102.0	-3.8	96.4	
4.98	5.10	8.27	444	404	-40	91.0		107.2	104.3	-2.9	97.3	
			468	423	-45	90.4	58.3	109.2	104.0	-5.2	95.2	58.8
4.96	**5.10**	**12.47**	**444**	**407**	**-37**	**91.8**		**107.4**	**103.4**	**-4.0**	**96.3**	
5.19	5.28	8.19	468	423	-45	90.4		109.2	104.0	-5.2	95.2	
5.42	5.44	23.44	491	443	-48	90.2		110.8	105.7	-5.1	95.4	
5.64	5.52	32.82	510	450	-60	88.2		112.0	106.8	-5.2	95.4	
			526	455	-71	86.5	55.2	113.0	107.5	-5.5	95.1	92.1
5.42	**5.41**	**21.48**	**499**	**443**	**-56**	**88.8**		**111.3**	**106.0**	**-5.3**	**95.3**	
5.86	5.62	33.00	526	455	-71	86.5		113.0	107.5	-5.5	95.1	
6.07	5.62	9.17	541	460	-81	85.0		113.8	107.5	-6.3	94.5	
6.28	5.79	*22.12	561	478	-83	85.2		115.0	108.8	-6.2	94.6	
			582	478	-104	82.1	41.1	116.0	109.3	-6.7	94.2	60.0
6.07	**5.68**	**21.43**	**553**	**468**	**-85**	**84.7**		**114.5**	**108.3**	**-6.2**	**94.6**	
6.50	5.79	*22.12	582	478	-104	82.1		116.0	109.3	-6.7	94.2	
6.70	5.88	82.95	606	493	-113	81.4		117.1	110.2	-6.9	94.1	
6.90	5.96	9.76	632	495	-137	78.3		117.7	110.7	-7.0	94.1	
7.10	6.04	168.30	656	512	-144	78.0		118.4	111.5	-6.9	94.2	
			676	513	-163	75.9	37.2	119.2	112.2	-7.0	94.1	90.6
6.80	**5.92**	**70.78**	**630**	**498**	**-132**	**79.1**		**117.7**	**110.8**	**-6.9**	**94.1**	

had been entirely off feed was the fact that large quantities of timothy hay and starch were fed to animals already in a poor physical condition. The experiment was terminated on this date. She was well proportioned except for lacking in barrel development but in a medium condition of flesh, and was 141 pounds below or only 79.5% of the normal in weight and 3.8 centimeters below or 96.8% of the normal in height. During the 60 days on the 10+50 plane she gained −7.7% or actually lost 7.7% of the normal gain in weight and made only 29.4% of the normal gain in height, while receiving only 36.4% of the digestible crude protein recommended by the Wolff-Lehmann standard and 26.3% and 27.8% respectively of the digestible true protein and 84.6% and 94.6% respectively of the net energy recommended by Armsby by age and by weight. In 360 days her total gain had been only 76 pounds. At the end of the experiment she, like No. 148, had not been bred.

No. 150. (*See Table* 34.)—Jersey heifer No. 150 was started on experiment May 24, 1920 without being placed on a preliminary ration. She was 10 months, 16 days of age, and was placed on a 25+0 plane, and a ration of alfalfa, corn and bran. She was in excellent condition but slightly undersized, and weighed 395 pounds which was 25 pounds below or 94.0% of the normal in weight and was 3.8 centimeters below or 96.4% of the normal in height. She did not readily become adjusted to experimental conditions. She remained on the 25+0 plane for 60 days at the end of which she was 45 pounds below or 90.4% of the normal in weight and 5.2 centimeters below or 95.2% of the normal in height. She made only 58.3% and 58.8% respectively of the normal gain in weight and in height while receiving 80.8% of the digestible crude protein recommended by the Wolff-Lehmann standard and 61.7% and 59.7% respectively of the digestible true protein and 105.3% and 100.4% respectively of the net energy recommended by Armsby by age and by weight.

On July 23, she was changed from a 25+0 to a 20+0 plane on which she was continued for 90 days. Final figures show that the actual digestible protein received on the 25+0 and 20+0 planes was slightly below the amount intended. At the end of the 90 days she was 71 pounds below or 86.5% of the normal in weight and 5.5 centimeters below or 95.1% of the normal in height. She made only 55.2% of the normal gain in weight and 92.1% of the normal gain in height on a ration which furnished 71.8% of the digestible crude protein recommended by the Wolff-Lehmann standard and 53.7% and 53.8% respectively of the digestible true protein and 100.9% and 101.0% respectively of the net energy recommended by Armsby by age and by weight.

On October 21, 1920 she was reduced further to a 15+0 plane. At this time she showed good body but was in only medium flesh. She

remained on this plane for 90 days and the amount of digestible crude protein actually consumed was almost exactly as calculated. While on this plane she became poorer in flesh, down in the back and "pot bellied" and was reported as in poor condition and making very poor gains. She was at that time 104 pounds below or only 82.1% of the normal in weight and 6.7 centimeters below or 94.2% of the normal in height. Her gains in weight and height were 41.1% and 60.0% respectively of the normal, and were made on 65.6% of the digestible crude protein recommended by the Wolff-Lehmann standard and on 47.8% and 49.2% respectively of the digestible true protein and 90.6% and 96.9% respectively of the net energy recommended by Armsby by age and by weight.

The original plan was to reduce her on January 19, 1921 to a 10+0 plane, but since her condition and gains were so unsatisfactory she was raised to a 20+0 plane and continued on the 20+0 plane for four 30-day periods. A part of the time she showed average condition and finish and fair flesh, but at the end of the experiment on May 18, 1921 she was in very poor condition, showed very little barrel, and was rough, down in the back, and only in medium flesh. Her gain for the last 30-day period was 1 pound and for the last nine 30-day periods was only 70 pounds. At the end of the experiment she was 163 pounds below or only 75.9% of the normal in weight and 7.0 centimeters below or 94.1% of the normal in height. On the 20+0 plane she made 37.2% of the normal gain in weight and 90.6% of the normal gain in height on a ration which furnished 76.3% of the digestible crude protein recommended by the Wolff-Lehmann standard and 54.4% and 58.0% respectively of the digestible true protein and 81.7% and 93.9% respectively of the net energy recommended by Armsby by age and by weight. She was bred for the first time on May 15, 1921.

In considering the observations on the three Jerseys Nos. 148, 149, and 150 it seems apparent that the Jerseys did not withstand the low planes as well as did the Holsteins. Nearly all the Jerseys did very poorly on the "reduction plan" or "sliding scale", in some cases even before the 15+0 plane was reached. Possibly a Jersey should be started on a higher plane or reduced more slowly than a Holstein. This would not seem probable, however, since the Jersey matures at an earlier age than the Holstein. It would not seem probable, either that a higher starting plane would be beneficial since poor gains have usually resulted on the 35+0 planes.

No. 504. (*See Table* 35.)—Holstein heifer No. 504 was started on experiment May 24, 1920 at the age of 8 months, 29 days, and was put on a ration of alfalfa, corn, bran, cottonseed meal, and starch, calculated to furnish a 25+0 plane. She was born 6 weeks prematurely and weighed

only 32 pounds at birth. At the time of going on experiment she was in good condition and before going on pasture was nearly normal in size, but lost considerably during the first few days on pasture. At the beginning of the experiment she weighed 420 pounds which was 45 pounds below or 90.3% of the normal in weight, and was 99.5% of the normal in height. She remained on the 25+0 plane for three 30-day periods,

TABLE 35.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 504.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	8 29	25+0	21.2 – 1.9	.973	.882	.692	.900	1.013	.960	1.556	5.69	5.58
2	9 28	25+0	22.4 – 0.4	.963	.886	.694	.934	1.026	.970	1.329	5.71	5.69
3	10 28	25+0	22.2 – 4.0	.968	.886	.694	.967	1.040	.980	1.063	5.81	5.58
	11 27											
Av.	**10 13**	**25+0**	**21.9 – 2.1**	**.968**	**.885**	**.693**	**.934**	**1.026**	**.970**	**1.316**	**5.74**	**5.62**
4	11 27	20+0	17.2 – 4.0	.839	.756	.584	1.000	1.053	.990	.648	5.98	5.74
5	12 26	20+0	16.7 – 2.6	.871	.774	.601	1.016	1.080	1.025	5.805	6.26	6.10
6	13 26	20+0	17.5 – 2.3	.893	.818	.633	1.033	1.080	1.025	1.115	6.39	6.24
	14 25											
Av.	**13 11**	**20+0**	**17.1 – 3.0**	**.868**	**.783**	**.606**	**1.016**	**1.071**	**1.013**	**2.523**	**6.21**	**6.03**
7	14 25	15+0	13.9 – 1.5	.764	.729	.590	1.050	1.094	1.051	1.151	6.62	6.52
8	15 25	15+0	13.3 – 1.3	.788	.731	.590	1.066	1.106	1.077	1.462	6.84	6.75
9	16 24	15+0	14.8 – 2.4	.810	.803	.606	1.084	1.120	1.105	1.268	7.02	6.85
	17 23											
Av.	**16 9**	**15+0**	**14.0 – 1.7**	**.787**	**.754**	**.595**	**1.067**	**1.107**	**1.078**	**1.294**	**6.83**	**6.71**
10	17 23	10+0	10.0 – 3.9	.656	.657	.521	1.100	1.132	1.130	1.643	7.22	6.94
11	18 25	10+0	10.2 – 4.3	.671	.678	.536	1.116	1.140	1.145	6.780	7.38	7.06
12	19 24	10+0	10.1 – 5.2	.687	.690	.544	1.132	1.140	1.145	1.089	7.54	7.15
	20 24											
Av.	**19 9**	**10+0**	**10.1 – 4.5**	**.671**	**.675**	**.534**	**1.116**	**1.137**	**1.140**	**3.171**	**7.38**	**7.05**

TABLE 36.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 503.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	14 13	20+0	17.7 – 3.7	.962	.893	.646	1.042	1.173	1.207	1.218	7.22	6.95
	15 13											
Av.	**14 28**	**20+0**	**17.7 – 3.7**	**.962**	**.893**	**.646**	**1.042**	**1.173**	**1.207**	**1.218**	**7.22**	**6.95**
2	15 13	15+0	14.4 – 1.3	.833	.817	.657	1.058	1.188	1.235	1.885	7.46	7.36
3	16 12	15+0	15.7 – 0.9	.854	.879	.699	1.075	1.200	1.260	*2.092	7.63	7.56
4	17 12	15+0	14.9+ 2.7	.868	.864	.688	1.092	1.200	1.260	*2.092	7.72	7.93
	18 11											
Av.	**16 27**	**15+0**	**15.0+ 0.2**	**.852**	**.853**	**.681**	**1.075**	**1.196**	**1.252**	**2.023**	**7.60**	**7.62**
5	18 11	10+0	9.8 – 2.1	.718	.714	.582	1.108	1.200	1.269	*1.168	7.96	7.79
6	19 10	10+0	9.9 – 1.7	.727	.726	.590	1.124	1.200	1.269	*1.168	8.05	7.91
7	20 12	10+0	9.3 – 2.1	.761	.736	.597	1.141	1.200	1.287	2.760	8.19	8.02
8	21 11	10+0	9.3 – 5.0	.774	.748	.605	1.158	1.200	1.291	.801	8.57	8.14
	22 11											
Av.	**20 11**	**10+0**	**9.6 – 2.7**	**.745**	**.731**	**.594**	**1.133**	**1.200**	**1.279**	**1.474**	**8.19**	**7.97**

Because of a loss in weight, the average of two periods taken. ‡Measurements for beginning of experiment not available

during which her appearance was poor and her gains unsatisfactory. She was then 73 pounds below or 86.8% of the normal in weight and 99.4% of the normal in height. She made 68.9% and 98.0% respectively of the normal gain in weight and in height on a ration furnishing 91.2% of the digestible crude protein recommended by the Wolff-Lehmann standard and 74.3% and 67.6% respectively of the digestible true pro-

BORN AUGUST 25, 1919. ON EXPERIMENT MAY 24, 1920

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
4.40	5.28	9.85	465	420	−45	90.3		109.1	108.5	−0.6	99.5	
4.62	5.44	8.54	499	437	−62	87.6		111.2	109.5	−1.7	98.5	
4.86	5.62	6.70	527	457	−70	86.7		112.6	112.5	−0.1	99.9	
.....	.....	.....	555	482	−73	86.8	68.9	114.0	113.3	−0.7	99.4	98.0
4.63	**5.45**	**8.36**	**512**	**449**	**−63**	**87.8**		**111.7**	**111.0**	**−0.8**	**99.3**	
5.10	5.79	4.92	555	482	−73	86.8		114.0	113.3	−0.7	99.4	
5.32	6.13	45.75	572	517	−55	90.4		115.6	115.7	+0.1	100.1	
5.53	6.13	8.51	593	521	−72	87.9		117.1	116.5	−0.6	99.5	
.....	.....	.....	609	543	−66	89.2	113.0	118.6	117.2	−1.4	98.8	84.8
5.32	**6.02**	**19.73**	**582**	**516**	**−67**	**88.6**		**116.3**	**115.7**	**−0.7**	**99.5**	
5.76	6.30	10.29	609	543	−66	89.2		118.6	117.2	−1.4	98.8	
5.96	6.48	13.50	638	562	−76	88.1		120.1	118.2	−1.9	98.4	
6.19	6.64	10.82	657	577	−80	87.8		121.1	119.3	−1.8	98.5	
.....	.....	.....	680	596	−84	87.6	74.6	121.7	121.0	−0.7	99.4	122.6
5.97	**6.47**	**11.54**	**646**	**570**	**−77**	**88.2**		**120.4**	**118.9**	**−1.5**	**98.8**	
6.40	6.80	17.35	680	596	−84	87.6		121.7	121.0	−0.7	99.4	
6.60	6.88	70.60	710	608	−102	85.6		122.5	121.5	−1.0	99.2	
6.80	6.88	11.29	740	611	−129	82.6		123.6	123.8	+0.2	100.2	
.....	.....	.....	768	630	−138	82.0	38.6	124.1	124.8	+0.7	100.6	158.3
6.60	**6.85**	**33.08**	**725**	**611**	**−113**	**84.5**		**123.0**	**122.8**	**−0.2**	**99.9**	

BORN JULY 8, 1919. ON EXPERIMENT SEPTEMBER 21, 1920

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
5.64	7.28	9.48	603	660	+57	109.5		‡	.....	.....	.....	.....
.....	.....	.....	625	682	+57	109.1	100.0	.....	.....	.....	.....	.....
5.64	**7.28**	**9.48**	**614**	**671**	**+57**	**109.3**		.....	.....	.....	.....	.....
5.86	7.44	16.98	625	682	+57	109.1		119.5	120.8	+1.3	101.1	
6.07	7.60	*18.59	650	695	+45	106.9		120.7	122.9	+2.2	101.8	
6.28	7.60	*18.59	670	695	+25	103.7		121.5	122.5	+1.0	100.8	
.....	.....	.....	697	720	+23	103.3	52.8	122.1	124.9	+2.8	102.3	157.7
6.07	**7.55**	**10.83**	**661**	**698**	**+38**	**105.8**		**121.0**	**122.8**	**+1.8**	**101.5**	
6.50	7.72	*12.73	697	720	+23	103.3		122.1	124.9	+2.8	102.3	
6.70	7.72	*12.73	725	720	−5	99.3		123.1	126.5	+3.4	102.8	
6.90	7.96	30.08	757	757	±0	100.0		124.1	127.7	+3.6	102.9	
7.10	8.02	8.72	782	765	−17	97.8		124.5	128.3	+3.8	103.1	
.....	.....	.....	806	793	−13	98.4	67.0	125.2	131.0	+5.8	104.6	196.8
7.80	**7.86**	**16.07**	**753**	**751**	**−2**	**99.8**		**123.8**	**127.7**	**+3.9**	**103.1**	

tein and 121.4% and 103.1% respectively of the net energy recommended by Armsby by age and by weight.

Reduction to a 20+0 plane occurred on August 22, 1920 as planned. At this time she was in good flesh condition except for being undersized. She remained on the 20+0 plane for three 30-day periods at the end of which she was 66 pounds below or 89.2% of the normal in weight and 98.8% of the normal in height. She made 113.0% and 84.8% respectively of the normal gain in weight and height on a ration which furnished 77.2% of the digestible crude protein recommended by the Wolff-Lehmann standard and 59.6% and 56.6% respectively of the digestible true protein and 113.4% and 100.2% respectively of the net energy recommended by Armsby by age and by weight.

On November 20, 1920 she was reduced to a 15+0 plane on which she remained for three 30-day periods. Data show that during the first nine 30-day periods she received slightly less digestible protein than was intended. At the end of the 90 days on a 15+0 plane she was in a smooth well finished condition and handled well, was in medium flesh but was 84 pounds below or 87.6% of the normal in weight and 99.4% of the normal in height. She made 74.6% and 122.6% respectively of the normal gain in weight and in height while receiving 70.0% of the digestible crude protein recommemded by the Wolff-Lehmann standard and 55.8% and 53.8% respectively of the digestible true protein and 112.3% and 103.6% respectively of the net energy recommended by Armsby by age and by weight.

The change to a 10+0 plane was made February 18, 1921 as scheduled. She remained on this plane through three 30-day periods. At the end of the experiment on May 18, 1921 she was in poor flesh and lacked barrel and was 138 pounds below or only 82.0% of the normal in weight but 100.6% of the normal in height. She made 38.6% and 158.3% respectively of the normal gain in weight and in height on a ration furnishing 59.2% of the digestible crude protein recommended by the Wolff-Lehmann standard and 47.8% and 46.9% respectively of the digestible true protein and 106.8% and 102.9% respectively of the net energy recommended by Armsby by age and by weight. She was first bred on March 12, 1921. On December 17, 1921 she dropped a normal bull calf which weighed 65 pounds and which had been carried 280 days.

No. 505.—Holstein heifer No. 505 was placed on experiment May 24, 1920. She was 8 months, 22 days of age and was 20 pounds above the normal when placed on a 25+0 plane, and a ration of alfalfa, corn, bran, cottonseed meal and starch. She made a very satisfactory development until on the night of June 19th when she suffered a broken leg and was immediately taken off experiment.

No. 503. (*See Table* 36.)—Holstein heifer No. 503 was started on experiment September 21, 1920. Her ration was composed of alfalfa, corn, bran, and starch and since she was 14 months, 13 days of age, it was calculated to furnish a 20+0 plane. She was to be carried on the plan of No. 505. She weighed 660 pounds which was 57 pounds above or 109.5% of the normal. She was not measured before being placed on experiment. She showed unusually good body and development and was in excellent condition. She remained on the 20+0 plane only one 30-day period and in that period made a very satisfactory gain considering the fact that she was suddenly taken off pasture and put on dry feed. At the end of the 30 days she was 57 pounds above or 109.1% of the normal in weight and 1.3 centimeters above or 101.1% of the normal in height. She made exactly a normal gain in weight while receiving 74.0% of the digestible crude protein recommended by the Wolff-Lehmann standard and 62.0% and 55.1% respectively of the digestible true protein and 123.2% and 95.5% respectively of the net energy recommended by Armsby by age and by weight.

The plan called for a change on October 21, 1920 to a 15+0 plane. This was accomplished largely by adding timothy hay and reducing the alfalfa and starch. She remained on the 15+0 plane for three 30-day periods. Her general condition became much poorer and her gains were not satisfactory She was now 23 pounds above or 103.3% of the normal in weight and 2.8 centimeters above or 102.3% of the normal in height. While on the 15+0 plane she made only 52.8% of the normal gain in weight but made 157.7% of the normal gain in height, while receiving 68.2% of the digestible crude protein recommended by the Wolff-Lehmann standard and 63.4% and 57.0% respectively of the digestible true protein and 125.5% and 100.9% respectively of the net energy recommended by Armsby by age and by weight.

On January 19, 1921 she was further reduced to a 10+0 plane and given a ration of timothy, alfalfa, corn and starch. She remained on the 10+0 plane for four 30-day periods, during the early part of which she was growthy and long but lacked barrel development and was shallow and narrow and in only medium flesh. At the termination of the experiment on May 18, 1921, she was in splendid condition and growthy, showing an excellent barrel development and a well portioned body, was 13 pounds below or 98.4% of the normal in weight but was 5.8 centimeters above or 104.6% of the normal in height. At the outset she was 57 pounds above normal weight. During the 120 days on the 10+0 plane she made 67.0% of the normal gain in weight and 196.8% of the normal gain in height at withers on a ration furnishing only 57.2% of the digestible crude protein recommended by the Wolff-Lehmann

standard and 52.4% and 49.5% respectively of the digestible true protein and 117.1% and 101.4% respectively of the net energy recommended by Armsby by age and by weight. She was bred March 11, 1921 for the second time. Apparently she conceived from this second breeding and had been pregnant slightly more than two months at the end of the experiment. On December 16, 1921 she dropped a normal heifer calf which weighed 90 pounds and which had been carried 280 days. She proved to be an exceptional milker.

No. 291. (*See Table* 37.)—Holstein heifer No. 291 was placed on experiment September 21, 1920. Her ration was composed of timothy alfalfa, corn and starch and was calculated to furnish a 10+0 plane. She was 25 months, 4 days of age, and was in a good growthy condition but in thin flesh, weighing 817 pounds, and being 55 pounds below or 93.7% of the normal in weight. On account of the suddenness with which she was put on experiment measurements were not taken on this heifer prior to going on experiment. She was, however, somewhat below the normal and after 30 days on experiment was 5.2 centimeters below

TABLE 37.—SUMMARY TABLE FOR HOLSTEIN HEIFER NO. 291.

1	2	3	4	5	6	7	8	9	10	11	12	13
30-day period	Age at beginning of period	Calculated plane	Actual plane	Calculated digestible crude protein requirement daily	Actual digestible crude protein received daily	Actual digestible true protein received daily	Armsby digestible true protein required daily		Wolff Lehmann digestible crude protein required daily by weight	Digestible crude protein received per pound gain	Calculated net energy required daily	Actual net energy received daily
							By age	By weight				
	mo.–da.			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	therms	therms
1	25 4	10+0	8.7 – 2.3	.736	.696	.565	1.200	1.200	1.315	1.305	8.22	8.03
2	26 4	10+0	10.4 – 1.8	.704	.716	.591	1.200	1.200	1.318	.597	7.91	7.77
3	27 3	10+0	11.2 – 1.7	.688	.719	.593	1.200	1.200	1.336	.654	7.78	7.65
4	28 3	10+0	9.9 – 2.1	.701	.700	.578	1.200	1.200	1.350	.724	7.94	7.77
	29 2											
Av.	27 3	10+0	10.1 – 2.0	.707	.708	.582	1.200	1.200	1.330	.820	7.96	7.81

‡Measurement for beginning of experiment not available.

or 96.0% of the normal in height. The purpose of placing an animal on a low plane at this advanced age is obvious. She remained on experiment during four 30-day periods. At the termination of the experiment she was 65 pounds below or 93.5% of the normal in weight and 4.3 centimeters below or 96.7% of the normal in height. During the 120 days she made 92.7% of the normal gain in weight and during the 90 days for which height values are available she made 145.0% of the normal gain in height. During the entire 120 days she received only 53.2% of the digestible crude protein recommended by the Wolff-Lehmann standard and 48.5% and 48.5% respectively of the digestible true protein and 99.4% and 91.1% respectively of the net energy recommended by Armsby by age and by weight. She remained in a medium condition of flesh and at the end was large-boned and growthy. She was taken off experiment January 18, 1921, and on February 22 gave birth to a normal heifer calf that weighed 90 pounds at birth and that had been carried 278 days. Her production for one year as a two-year-old amounted to 6,747 pounds of milk and 232 pounds of fat from three quarters.

BORN AUGUST 17, 1918. ON EXPERIMENT SEPTEMBER 21, 1920

14	15	16	17	18	19	20	21	22	23	24	25	26
Armsby net energy required daily		Net energy received per pound gain	Normal weight for beginning of period	Actual weight for beginning of period	Above or below normal	Per cent of normal weight	Normal gain in weight on this plane	Normal height at withers for beginning of period	Actual height at withers for beginning of period	Above or below normal	Per cent of normal height at withers	Normal gain in height at withers on this plane
By age	By weight											
therms	therms	therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
7.70	8.34	15.06	872	817	−55	93.7						
7.80	8.40	6.48	897	833	−64	92.9		128.4	123.2	−5.2	96.0	
7.90	8.66	6.95	929	869	−60	93.5		129.4	125.0	−4.4	96.6	
8.00	8.86	8.04	969	902	−67	93.1		129.9	126.0	−3.9	97.0	
			996	931	−65	93.5	92.7	130.4	126.1	−4.3	96.7	145.0
7.85	8.57	9.13	933	870	−62	93.3		129.5	125.1	−4.5	96.6	

DISCUSSION OF RESULTS

The summaries of the individual heifers as given in Tables 4 to 37 inclusive, are of considerable value and significance, yet so much individual variation occurred that group summaries are essential. The entire experiment covered a total of 508.8 30-day periods of which 261 were conducted on Holsteins and 247.8 were conducted on Jerseys. The reason for the portion of a period lies in the fact that two of the heifers were for a long time conducted on an experiment in which the unit of time was the 28-day instead of the 30-day period. In giving proper weight to the results obtained the values for these heifers were converted by multiplying by twenty-eight-thirtieths or 0.933.

Since a considerable number of different planes had been used and since some of the heifers had been on several different planes, the first attempt to study the experiment as a whole was to group together and study as separate units all the 30-day periods of all heifers on each calculated plane such as 8+0, 15+0, 15+50, 20+25, 25+0, etc. The breeds were kept separate for obvious reasons. The values included in this first classification were the totals from which were derived the average values as shown for each corresponding plane in these individual tables. Exceptions to this are found in columns 2, 17, 18, 19, 20, 22, 23, 24, and 25 where the same value is given twice, once to represent the termination of one plane and once to represent the beginning of the next. In these cases the average values for a plane were originally determined by dividing the totals for each plane by a number one greater than the number of periods during which the heifer was on that particular plane. In grouping the planes together for a summary these values could not be used as for the other columns, but the proper total value was derived by multiplying the average by the number of 30-day periods represented. Again in columns 21 and 26 the total to be used in grouping was determined by multiplying the value derived for the plane by the number of 30-day periods represented.

Heifers No. 91 and No. 94 were conducted on the basis of the 28-day instead of the 30-day period. Since the true averages given for all animals were determined on the basis of totals for the actual number of 30-day periods on a given plane, it was necessary to express the total values for these two heifers on the same basis. This necessitated multiplying the averages in columns 2, 17, 18, 19, 20, 22, 23, 24 and 25, and the values in columns 21 to 26, by 22.4 which is twenty-eight-thirtieths of the twenty-four 28-day periods for each of these two animals. The true totals to be subsequently used for these two heifers for columns 4 to 16 inclusive for determining the summaries of plane averages, were

derived by multiplying the totals in the individual tables by 0.933, the decimal equivalent to twenty-eight-thirtieths.

As soon as the planes had been grouped together in this manner an average for each plane from 8+0 to 35+0 was determined by totaling the plane totals for each individual and dividing the grand total by the number of 30-day periods represented for all heifers on the plane. Column 1 does not give an average value. In column 3 the value given is not an average but represents the calculated or arbitrary plane which is a basis for this grouping. The average results obtained for each calculated plane constitute summary B sheets and will be referred to as such.

From the start it was considered that an 8% or 10% plane was very low, that anything above a 25% plane was high and that a plane from 15% to 20% was medium. At least twelve different combinations of planes were used and it was not considered desirable to give each plane separate consideration. Four main groups were considered sufficient, and summary C sheets were developed from summary B sheets on this basis. The low group was made to include all combinations of 8% and 10% planes, the next higher group included all combinations of 15% planes and was considered a low-medium, the third group included all combinations of 20% planes and was considered a high-medium, while the high group included all combinations of 25% and 35% planes. These four distinct groups and the summary C sheets were made for both the Holstein and Jersey breeds.

The next step was to combine, in summary D sheet, the results of both breeds as developed in summary C sheets for the sake of a breed comparison and for the sake of determining the average results for the two breeds on the different plane groups already outlined. In grouping the different animals together for the purpose of determining true average values for a plane or group of planes, a careful consideration of and relative importance of the exact number of periods during which an animal was on a given plane was essential, because the number of periods an animal remained on any one plane varied from one to twenty-five. For this reason, instead of averaging individual averages, all plane or group averages were derived by dividing the plane or group-totals by the total number of 30-day periods represented. The same method was used in deriving all summaries except as already noted.

The sheets referred to as summary B and summary C sheets are preliminary and are not presented. The summary D sheet which gives the combined summary for the breeds is presented as Table 38. The values given in columns 22 and 26 inclusive are in some cases marked with asterisks which indicate that at least one value is lacking and that the averages were derived on the basis of the number of 30-day periods

TABLE 38.—THE COMBINED RESULTS FOR THE TWO BREEDS

Breed	1 30-day periods	2 Age at beginning of period	3 Calculated plane	4 Actual plane	5 Calculated digestible crude protein requirement daily	6 Actual digestible crude protein received daily	6/10 Per cent of Wolff-Lehmann digestible crude protein requirements actually received	7 Actual digestible true protein received daily	7/8 Per cent of Armsby true protein requirements actually received by age
		mo. da.			lbs.	lbs.	per cent	lbs.	per cent
H	62.0	19 28	Low	9.3-1.3	.651	.641	54.2	.535	48.0
J	49.4	18 8	Low	9.6+8.9	.502	.492	47.8	.404	37.3
Av.	***111.4**	**19 6**		**9.5+3.2**	**.603**	**.575**	**51.4**	**.477**	**43.2**
H	92.0	17 14	15+	13.9+6.1	.819	.778	67.1	.584	54.6
J	75.0	16 3	15+	15.7+10.1	.642	.655	64.1	.553	52.7
Av	***167.0**	**16 26**		**14.7+7.9**	**.741**	**.722**	**65.8**	**.570**	**53.7**
H	54.0	16 26	20+	18.7+0.1	.981	.937	82.7	.713	66.4
J	69.0	14 27	20+	19.6+8.3	.760	.748	75.4	.592	57.8
Av.	***123.0**	**15 23**		**19.2+4.7**	**.857**	**.831**	**78.6**	**.645**	**61.6**
H	53.0	16 0	High	24.8+3.0	1.171	1.077	98.2	.865	83.7
J	54.4	17 18	High	30.9+4.0	1.000	1.010	99.9	.791	74.5
Av.	***107.4**	**16 24**		**27.9+3.5**	**1.102**	**1.052**	**99.1**	**.827**	**79.0**

*Total

Table 38—Continued

7/9 Per cent of Armsby true protein requirements actually received by weight	8 Armsby's Digestible true protein required daily by age	9 Armsby's Digestible true protein required daily by weight	10 Wolff-Lehmann digestible crude protein required daily by weight	11 Digestible crude protein received per pound gain	12 Calculated net energy required daily	13 Actual net energy received daily	13/14 Per cent of Armsby net energy requirements actually received by age	13/15 Per cent of Armsby net energy requirements actually received by weight	14 Armsby net energy required daily by age	15 Armsby net energy required daily by wt
per cent	lbs.	lbs.	lbs.	lbs.	therms	therms	per cent	per cent	therms	therms
47.2	1.108	1.126	1.165	1.980	7.34	7.23	109.5	103.2	6.60	7.07
38.7	1.084	1.046	1.031	5.321	5.56	6.02	96.4	103.9	6.29	5.87
43.4	**1.097**	**1.091**	**1.105**	**3.462**	**6.55**	**6.69**	**103.7**	**103.5**	**6.46**	**6.54**
51.9	1.065	1.120	1.150	1.451	7.20	7.62	125.4	111.6	6.13	6.91
53.0	1.049	1.045	1.024	2.226	5.60	6.17	107.0	107.3	5.85	5.79
52.4	**1.058**	**1.086**	**1.093**	**1.799**	**6.48**	**6.97**	**117.1**	**109.6**	**6.00**	**6.41**
62.9	1.073	1.132	1.134	2.117	7.13	7.13	118.2	104.3	6.05	6.84
58.3	1.030	1.021	.993	2.081	5.46	5.90	106.1	107.2	5.63	5.57
60.3	**1.049**	**1.070**	**1.055**	**2.097**	**6.20**	**6.44**	**111.4**	**105.9**	**5.81**	**6.13**
78.8	1.033	1.094	1.097	1.200	6.70	6.92	121.0	107.0	5.77	6.47
75.4	1.072	1.053	1.032	2.317	5.60	5.82	95.6	98.6	6.17	5.91
77.1	**1.053**	**1.073**	**1.064**	**1.766**	**6.14**	**6.37**	**108.1**	**102.8**	**5.97**	**6.19**

Table 38—Continued

16 Net energy received per pound gain	17 Normal weight for beginning of period	18 Actual weight for beginning of period	19 Above or below normal	20 Per cent of normal weight	21 Normal gain in weight on this plane	22 Normal height at withers for beginning of period	23 Actual height at withers for beginning of period	24 Above or below normal	25 Per cent of normal height at withers	26 Normal gain in height at withers on this plane
therms	lbs.	lbs.	lbs.	per cent	per cent	cm.	cm.	cm.	per cent	per cent
21.88	744	660	-84	87.8	67.9	122.3	120.4	-1.9	98.4	106.7
66.28	583	497	-86	85.1	48.9	114.4	113.4	-1.0	99.2	92.1
41.57	**673**	**588**	**-85**	**86.6**	**59.5**	**117.7**	**116.2**	**-1.5**	**97.9**	**100.2**
13.52	679	640	-39	94.0	94.0	119.6	118.6	-1.0	99.2	100.4
20.86	537	491	-46	91.6	77.3	112.4	112.6	+0.1	100.1	85.3
16.82	**615**	**573**	**-42**	**92.9**	**86.5**	**116.4**	**115.9**	**-0.5**	**99.6**	**93.6**
15.86	665	622	-44	93.4	107.5	120.3	119.2	-1.1	99.1	112.3
15.89	511	465	-45	91.4	80.7	111.2	110.2	-1.1	99.0	93.0
15.88	**579**	**534**	**-44**	**92.3**	**92.5**	**115.2**	**114.1**	**-1.1**	**99.1**	**101.5**
8.29	647	586	-61	91.0	122.6	117.8	116.4	-1.3	98.8	129.7
13.75	568	506	-62	89.6	101.9	113.5	111.7	-1.7	98.5	109.7
11.05	**607**	**546**	**-62**	**90.3**	**112.1**	**115.6**	**114.0**	**-1.5**	**98.7**	**119.6**

represented in the height measurements. Again in Column 5 the values are in some cases marked with asterisks which indicate that the requirements and rations for one or more periods, on one or more animals within the group, were arbitrarily calculated. The average was determined as in the case of height values by using as a basis a number equal to the number of periods for which the requirements and rations were regularly calculated.

Table 38, which gives the combined results for the two breeds on the basis of the low, the low-medium, the high-medium and the high planes, shows that six new columns have been added to those used in the individual tables. These additional columns are considered of importance. The table is printed herewith in three sections. The column at the extreme left (first section) indicates the breed of animal studies and is headed with the word "Breed". Immediately following column 6 is a column labeled "$^{6}/_{10}$, Per cent of Wolff-Lehmann digestible crude protein requirements actually received." This is derived by dividing the actual plane totals in column 6 by the corresponding values in column 10 of the individual summary tables, combining the percentages thus derived in the same manner as for columns 21 to 26 in preparing summary B, C, and D sheets, and dividing the grand totals by the number of 30-day periods represented as in the case of all other columns. Two new columns follow column 7. These are labeled "$^{7}/_{8}$, Per cent of Armsby true protein requirements actually received—by age" and "$^{7}/_{9}$, Percent of Armsby true protein requirements actually received —by weight". The values in these two columns were derived from columns 7 and 8, and 7 and 9 of the individual summary tables in a manner just described. Following column 13 are two new columns. The first is headed "$^{13}/_{14}$ Per cent of Armsby net energy requirement actually received—by age". and the second "$^{13}/_{15}$, Percent of Armsby net energy requirements actually received—by weight." These values were derived from columns 13 and 14, and 13 and 15 of the individual summary tables. The method of derivation just described again applies.

It should be pointed out that the basis of classification for Table 38 is the calculated plane. While the weaknesses of the calculated plane are fully appreciated it is believed that it serves as a reasonably accurate guide in estimating the requirements of an animal on varying planes. The defects lie not so much in the system as in the fact that individual differences further complicate matters. Refusal of a portion of the ration for only a short time is sufficient to seriously upset the results as outlined. A variation in the composition of the different lots of feed used from time to time, furnished another source of difficulty.

A Classification on the Basis of the Calculated Plane.—In discussing the results of the experiment as shown in Table 38, a few facts stand out clearly. For convenience, an abbreviated form giving only the values of the most important columns is presented as Table 39 (see Fig. 1). In the first place ,while the number of 30-day periods represented in each plane group for each breed varies, there is a sufficient number in each to make the results comparable. The average age of animals varies only slightly between plane groups and between breeds. It is particularly gratifying also that the actual average planes for both breeds very closely approximate the calculated plane values. The method of determining the actual plane has already been discussed in connection with column 4 of the individual tables. The values showing the per cent of digestible crude protein and the per cent of digestible true protein recommended respectively by the Wolff-Lehmann and Armsby standards which were actually received by the animals, are remarkably uniform and consistent. Not only are they very nearly the same for each breed within a given plane group, but there is a very steady increase in the values for each plane group over the preceding one as was intended. A slight excess of energy was furnished in almost every case according to the actual plane calculations and the energy recommended by Armsby.

TABLE 39.—INFLUENCE OF THE AMOUNT OF PROTEIN SUPPLIED ON GROWTH IN WEIGHT AND HEIGHT.
(Classification by Calculated Plane)

Group†	Breed of animals	Number of periods on plane	Average age mo.-da.	Actual plane	Per cent Wolff-Lehmann protein standard	Per cent Armsby protein standard (Age and weight)	Per cent Armsby Energy standard (Age and weight)	Per cent normal growth in weight	Per cent normal growth in height
I	H	62.0	19–28	9.3 – 1.3	54.2	47.6	106.3	67.9	106.7
	J	49.4	18– 8	9.6+ 8.9	47.8	38.0	100.1	48.9	92.1
	Av.	*111.4	19– 6	9.5+ 3.2	51.4	43.3	103.6	59.5	100.2
II	H	92.0	17–14	13.9+ 6.1	67.1	53.2	118.5	94.0	100.4
	J	75.0	16– 3	15.7+10.1	64.1	52.8	107.2	77.3	85.3
	Av.	*167.0	16–26	14.7+ 7.9	65.8	53.1	113.4	86.5	93.6
III	H	54.0	16–26	18.7+ 0.1	82.7	64.6	111.2	107.5	112.3
	J	69.0	14–27	19.6+ 8.3	75.4	58.0	106.7	80.7	93.0
	Av.	*123.0	15–23	19.2+ 4.7	78.6	60.9	108.7	92.5	101.5
IV	H	53.0	16– 0	24.8+ 3.0	98.2	81.2	114.0	122.6	129.7
	J	54.4	17–18	30.9+ 4.0	99.9	75.0	97.1	101.9	109.7
	Av.	*107.4	16–24	27.9+ 3.5	99.1	78.1	105.5	112.1	119.6

*Totals.
†Group I.—All combinations of 8 and 10 per cent calculated plane. Group II.—All combinations of 15 per cent calculated plane. Group III.—All combinations of 20 per cent calculated plane. Group IV.—All combinations of 25 and 35 per cent calculated plane.

It is evident that with both the Holstein and Jersey breeds a steady increase in the calculated and actual planes results in a corresponding steady increase in the per cent of normal growth in weight. The Holsteins made 67.9% and 94.0%, 107.5% and 122.6% respectively while the Jerseys made 48.9%, 77.3%, 80.7% and 101.9% respectively on the

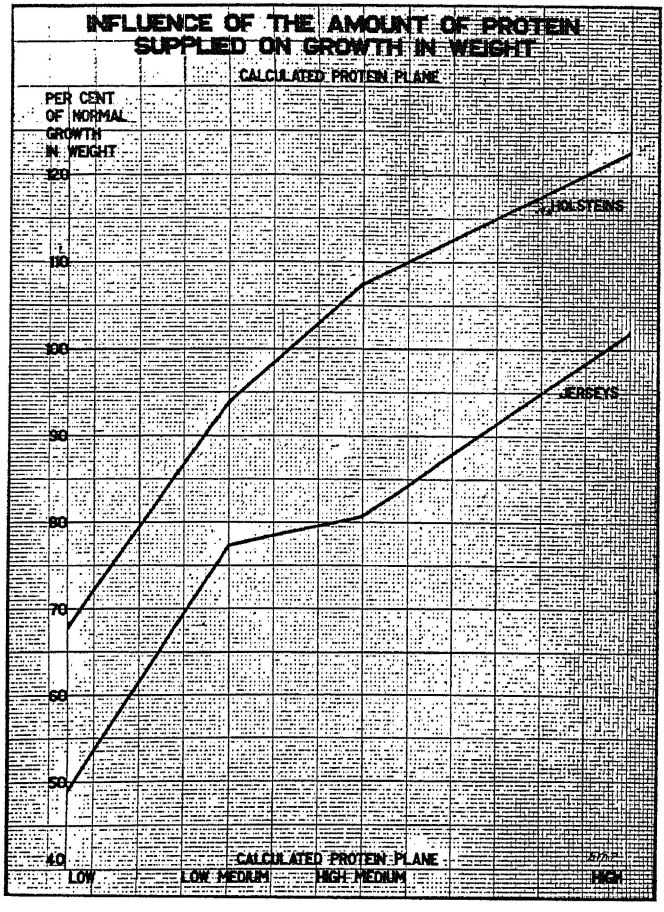

Fig. 1.—This figure represents graphically the values in Table 39 and shows that the Holsteins were capable of making normal growth on a much lower plane of protein than were the Jerseys, and that they were capable of making distinctly excessive gains in weight on the higher planes. Normal growth in weight with Holsteins occurred on a plane intermediate between the low-medium and the high-medium, while with Jerseys it was accomplished only on the high plane. Apparently normal growth was accomplished by Holsteins on an actual plane of 16.0% while the Jerseys required an actual plane of 29.9% for similar results.

low, the low-medium, the high-medium and the high planes. The percentage normal growth in height was not as consistent, but on the whole was satisfactory. In the four groups the percentages of normal growth in height for Holstein were 106.7%, 100.4%, 112.3%, and 129.7% respectively while for Jerseys they were 92.1%, 85.3%, 93.0% and 109.7% respectively. From the low to the low-medium plane group the percentage normal growth in height decreased in both breeds. Such a decrease occurring with both breeds is difficult to explain, particularly since it does not occur in the weight values. A possible explanation is the fact that, as the table will show, a relatively large percentage of the low planes were conducted on somewhat more mature animals; and since the skeletal growth rate at an advanced age is considerably decreased, the percentage of possible error is relatively greater. This is simply offered as a suggestion and is not by any means conclusive.

The combined averages for the two breeds show an unusually satisfactory uniformity, not only for age, actual plane, per cent of Wolff-Lehmann and per cent of Armsby protein and for the per cent of energy according to Armsby, but an increase in the plane as shown in the four plane groups is in each case accompanied by an increase in the per cent of normal growth in weight. The values showing per cent of normal growth in height show the per cent normal growth for the low-medium plane group as lower than the corresponding growth for the low plane group. The same circumstance has been discussed in connection with each of the breeds.

A striking thing about this table based on the calculated plane classification is the fact that there seems to be a decided difference between the planes required by the Holstein and Jersey breeds for making normal growth, particularly in weight. It was observed early in the experiment, and has been already noted that apparently the Jersey required a higher plane than a Holstein in order to make a normal development. The figures in Table 39 show that the Holsteins made a normal increase in weight almost exactly midway between the low-medium and the high-medium calculated planes or showed themselves apparently capable of making normal growth while receiving an actual protein plane of 16.0% and approximately 74.0% of the digestible crude protein recommended by the Wolff-Lehmann standard and 58.3% of the digestible true protein recommended by Armsby. The Jerseys on the other hand seemed to require an actual protein plane of 29.9% and 97.7% of the digestible crude protein recommended by the Wolff-Lehmann standard and 73.4% of the digestible true protein recommended by Armsby in order to make a normal growth. Approximately 100% or a slight excess of energy was furnished in every case as intended.

Again referring to the combined averages for the two breeds it would appear that all animals on experiment averaged 100% or made a normal gain in weight on a plane of protein intermediate between the high-medium and the high plane or while receiving an actual protein plane of 22.5%, and approximately 86.4% and 67.5% respectively of the protein prescribed by the Wolff-Lehmann and Armsby standards.

The results with the skeletal growth are similar but not as extreme. In this connection it should be explained that with any classification or grouping much less significance is attached to the skeletal growth than to growth in weight. There are several reasons for this fact. An animal seems to be capable of making a normal growth in height when receiving a ration which is so unsatisfactory as to even cause the animal to lose weight. It was observed by Waters[42] that an animal kept under extremely adverse circumstances would grow tall and narrow, or that the skeletal growth impulse is much stronger than the impulse to increase in weight. A word of explanation should also be included in connection with the lack of variation in the values in column 25 as compared with column 20 in the individual summaries. From birth to maturity a dairy animal increases only ninety per cent in height at withers[43] while in the same period of time it increases more than 1400 percent in weight[44]. This readily explains the fact that an animal may be only 60 or 70% of the normal in weight but that at the same time is seldom below 95% of the normal in height. For these reasons comparatively less significance is attached to the results obtained on growth in height at withers, yet the data are presented in each case for consideration.

A Classification on the Basis of the Actual Protein Plane.—The defects of the calculated plane have already been pointed out. A realization of these shortcomings was the reason for developing the values in column 4 of the individual tables referred to as the "actual plane" which was derived as already outlined, from the values showing nutrient actually furnished. The actual plane still has the weakness of any arbitrarily calculated plane, but it does eliminate any discrepancy due to refusal of a portion of the ration or to a variation in the composition of the feed, and is consequently somewhat more nearly accurate than the calculated plane. For this reason a reclassification of data was made on the basis of the actual rather than the calculated plane. At this point, in order to avoid recopying all the basic data, summary B sheets were cut into horizontal strips. It will be remembered that these sheets were made to include totals and averages for each of the 31 columns for each calculated plane combination, which means that each horizontal strip included as a unit all the values needed for any one plane on any animal. By cutting these strips apart it became easily possible to rearrange them on the basis of any value, and the value chosen for the next con-

sideration was the actual plane as given in column 4. Before attempting a classification on this basis it was necessary to determine the number of groups to be considered and to establish the limits for each group. It seemed logical to use four groups and to have them cover approximately the same limits as in the classification on the basis of the calculated plane. The breeds were kept separate as in the other considerations. The actual planes up to 12.4% were to be placed in the low plane group, all those from 12.5 to 17.4% were to go in the low-medium group corresponding to the 15% plane, all those from 17.5 to 22.4% were to be classed in the high-medium group corresponding to the 20% plane and those from 22.5% upward were to be included in the high group or plane. All values are inclusive. The strips mentioned were arranged from the lowest to the highest in the order of their actual planes without reference to the excess or deficiency of energy indicated by the plus or minus sign. As soon as these strips as arranged were divided into the four plane groups, the totals on them were added and averaged for each plane group and summary E sheet was prepared. An abbreviated form is presented in Table 40 (see Fig. 2).

TABLE 40.—INFLUENCE OF THE AMOUNT OF PROTEIN SUPPLIED ON GROWTH IN WEIGHT AND HEIGHT.
(Classification by Actual Protein Plane)

Group†	Breed of animals	Number of periods on plane	Average age mo.-da.	Actual plane	Per cent Wolff-Lehmann protein standard	Per cent Armsby protein standard (Age and weight)	Per cent Armsby Energy standard (Age and weight)	Per cent normal growth in weight	Per cent normal growth in height
I	H	70.0	18-23	9.5+1.3	54.4	47.4	110.3	68.3	106.0
	J	53.4	17-22	9.8+8.4	48.3	38.4	100.7	49.7	92.5
	Av.	*123.4	18-10	9.6+4.4	51.8	43.5	106.2	60.3	100.1
II	H	82.0	17-6	14.1+1.0	67.8	53.2	113.0	97.8	103.8
	J	68.0	14-26	15.6+8.2	64.5	52.3	107.3	73.6	87.1
	Av.	*150.0	16-4	14.7+4.3	66.4	52.8	110.4	86.8	96.2
III	H	64.0	19-2	19.2+6.3	82.2	65.6	115.1	106.3	114.9
	J	82.0	16-13	19.9+9.6	75.4	58.6	105.5	86.2	89.5
	Av.	*146.0	17-18	19.6+8.2	78.4	61.6	109.7	95.0	99.9
IV	H	45.0	14-18	25.3+1.4	101.6	83.8	115.3	123.5	122.3
	J	44.4	17-22	33.2+4.2	104.8	79.1	97.0	103.7	115.5
	Av.	*89.4	16-5	29.2+2.8	103.2	81.5	106.2	113.7	118.9

*Totals.
†Group I.—All actual planes up to 12.4%. Group II.—All actual planes from 12.5% to 17.4%. Group III.—All actual planes from 17.5% to 22.4%. Group IV.—All actual planes above 22.5%.

This table shows results very similar to those in Table 39. The number of 30-day periods represented for each of the four plane groups was reasonably uniform for both breeds. The average age was also fairly uniform throughout, the actual planes averaged very close to 10%, 15%, 20% and 30% and there were energy excesses which were comparatively small as desired. The values showing the per cent of Wolff-Lehmann's protein standard actually received were uniform and satisfactory. They were very nearly the same for each breed within

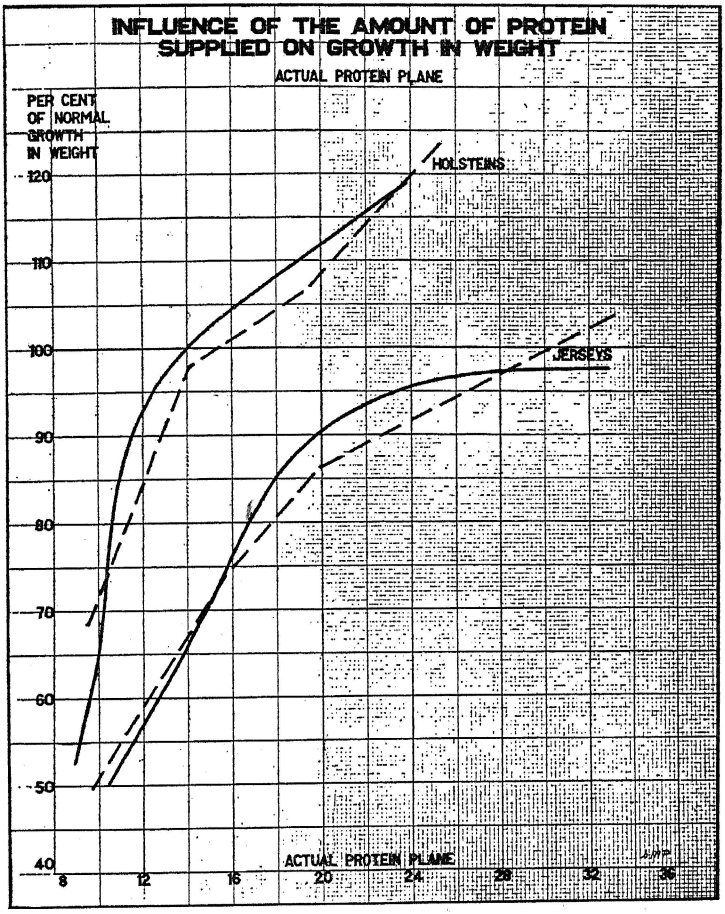

Fig. 2.—This figure represents graphically the actual plane values derived by the four classifications of all available data. The solid lines are prepared by plotting against per cent of normal growth, all of the nineteen actual plane values for each breed appearing in Tables 39, 40, 41, and 42, giving proper relative weight to the points plotted, averaging the values represented by the points within each group and drawing curved lines through the points so determined. Such a procedure is permissible since all four tables are prepared from different classifications of the same original data, and has the advantage of a large number of points as a basis for each curve. The broken lines are made by connecting with straight lines, only the actual plane values appearing in Table 40. The plate shows a decided difference between the relative growth of breeds on any protein plane and indicates that the Holsteins were able to make a normal growth in weight on an actual plane of 15.4%, while the Jerseys required an actual plane of 30.4% for similar development. Both solid and broken lines indicate that an increase in actual plane above 20% is accompanied by relatively higher increase in efficiency with Holsteins than with Jerseys.

each plane group and a steady increase in values is shown with each breed, for each plane group over the preceding one. The same is true for the per cent of Armsby's protein standard actually received. There was a slight excess of energy furnished in every plane group for Holsteins and in all except one for Jerseys. Here again with both breeds a steady increase in the actual plane is associated in every plane group with a steady increase in the per cent of normal growth in weight and a reasonably steady increase in the per cent of normal growth in height The percentages of normal growth in weight for the four plane groups were 68.3%, 97.8%, 106.3%, and 123.5% respectively for Holsteins and 49.7%, 73.6%, 86.2%, and 103.7% respectively for Jerseys. The corresponding percentages for height were 106.0%, 103.8%, 114.9% and 122.3% for Holsteins and 92.5%, 87.1%, 89.5% and 115.5% for Jerseys. The same decrease in percentages of normal height values from the low to the low-medium plane and the similar lack of spread in percentage of normal height growth occurred with both breeds as in the case of the calculated plane classification. The same suggestions for an explanation apply. The combined averages for the two breeds show an even greater uniformity throughout than for the separate breeds. These combined values give the percentages of normal growth in weight for the four plane groups as 60.3%, 86.8%, 95.0% and 113.7% respectively. The combined breed values showing per cent of normal growth in height are very similar to those in Table 39. They are 100.1%, 96.2%. 99.9% and 118.9% respectively for the four plane groups. The decrease in value from the low to the low-medium plane group is again evident.

Table 40 again shows that the Holsteins were able to make a normal gain in weight on a plane considerably lower than that required for normal growth in Jerseys, and that in each plane group the Holsteins made a decidedly greater percentage of normal gain in weight than did the Jerseys. Normal weight development with Holsteins were apparently made on an actual protein plane of 15.4% and on 71.5% of the digestible crude protein recommended by the Wolff-Lehmann standard and 56.4% of the digestible true protein recommended by Armsby. On the other hand, it apparently required an actual protein plane of 30.4%, and 98.6% of the digestible crude protein recommended by the Wolff-Lehmann standard and 74.8% of the digestible true protein recommended by Armsby, to promote normal growth in weight with Jerseys. These figures are comparable with those derived from the calculated plane classification. The energy values for Holsteins and Jerseys are slightly in excess of the requirements according to Armsby. The Holsteins reached a normal gain in weight somewhere between the low-medium and the high-medium planes. The Jerseys did not reach a normal gain in weight except on the so-called high plane. Apparently

there is a difference between the breeds with reference to the plane required for normal development. Normal growth with Holsteins seems to have been made on a protein intake much less than that recommended by the Wolff-Lehmann standard and normal growth with both breeds is possible on far less than the protein standard recommended by Armsby. Again referring to the combined averages for the breeds it is evident that a normal gain in weight was accomplished somewhere between the high-medium and the high plane groups or on an actual protein plane of 22.2% and on 85.0% of the protein prescribed by the Wolff-Lehmann standard and 66.9% of the protein requirements according to Armsby.

A Classification on the Basis of the Per Cent of the Wolff-Lehmann Standard Supplied.—Since the Wolff-Lehmann standard has been one of the two main bases of comparison for our experimental results, it would be decidedly incomplete to neglect a classification on this basis. The horizontal strips cut from summary B sheets were this time regrouped on the basis of the "Per cent of Wolff-Lehmann digestible crude protein requirements actually received" as given in the column immediately following column 6 of the strips. The breeds were first separated and the strips were then arranged for each breed from the lowest to the highest in order of the values appearing in this column. It then became necessary to establish a method of grouping. The old basis of a low, a low-medium, a high-medium and a high plane could no longer be used since the basic value in this case was entirely different than in the two previous classifications. It was considered desirable to select not less than four and not more than six groups which would of necessity be arbitrary, and to have a reasonably uniform distribution of 30-day periods represented in each of the groups selected for each breed. All the values divided themselves nicely into five groups, namely: Those values up to 54.9%, those from 55.0 to 64.9%, those from 65.0 to 74.9%, those from 75.0 to 84.9% and those from 85.0% upward, all inclusive. This grouping was selected also to give approximate averages for the five groups, of 50%, 60%, 70%, 80% and 100% respectively of the digestible crude protein furnished on the basis of the Wolff-Lehmann standard.

This classification resulted in the formation of summary F sheets the results of which are given in abbreviated form in Table 41. (see Fig. 3). The table shows more variation in the number of 30-day periods for each group than desired, although it is reasonably satisfactory. There is comparatively little variation in the average age of animals for each group. There is, as would be expected, a comparatively wide variation in the actual plane on this basis since no attempt was made to make these actual plane values correspond. The average values for each plane group approximate very closely the intended 50%, 60%, 70%, 80% and 100%

value for each breed. Another consistency which should deserve attention is the uniformity within each plane group, of the per cent of Armsby digestible true protein requirements actually received, for each breed. Except for the first group the Holstein and Jersey values within a plane group are very close, and there is a steady increase in the value of each plane group over that for the preceding one. Again, as in the case of the two classifications already discussed, it is apparent that the animals received on the average either approximately the required amount or a slight excess of the energy requirements according to Armsby. An adequate supply of energy seems to have been furnished both breeds.

TABLE 41.—INFLUENCE OF THE AMOUNT OF PROTEIN SUPPLIED ON GROWTH IN WEIGHT AND HEIGHT.
(Classification by Per Cent of Wolff-Lehmann's Protein Standard)

Group†	Breed of animals	Number of periods on plane	Average age mo.-da.	Actual plane	Per cent Wolff-Lehmann protein standard	Per cent Armsby protein standard (Age and weight)	Per cent Armsby Energy standard (Age and weight)	Per cent normal growth in weight	Per cent normal growth in height
I	H	37.0	18–12	9.0+ 0.7	51.7	45.7	106.9	57.3	94.8
	J	49.4	18– 8	9.6+ 8.9	47.8	38.0	100.1	48.9	92.1
	Av.	*86.4	18–10	9.4+ 5.4	49.5	41.3	103.0	52.5	93.2
II	H	62.0	18–28	11.5 - 4.9	60.4	48.1	105.2	80.5	107.6
	J	39.0	14–28	14.4+6.4	60.9	47.7	107.3	67.4	81.6
	Av.	*101.0	17–11	12.6 - 0.5	60.6	48.0	106.0	75.4	97.5
III	H	53.0	18– 6	15.0+10.6	69.6	57.2	122.5	106.0	120.4
	J	76.0	16–14	17.9+ 6.2	70.0	56.2	101.7	80.7	92.6
	Av.	*129.0	17– 5	16.7+ 8.0	69.8	56.6	110.2	91.1	103.9
IV	H	44.0	18–11	18.4+ 4.8	80.5	64.9	115.6	113.6	101.9
	J	43.0	15–17	21.2+17.0	79.0	61.2	113.4	96.8	98.0
	Av.	*87.0	17– 0	19.8+10.8	79.8	63.1	114.5	105.3	100.0
V	H	65.0	15– 1	23.6+ 2.2	97.2	78.2	115.2	114.3	119.2
	J	40.4	17– 2	34.0+ 2.4	107.7	81.4	96.3	98.8	107.8
	Av.	*105.4	15–24	27.6+ 2.3	101.2	79.4	108.0	108.4	114.8

*Total.
†Group I.—All percentages of Wolff-Lehmann up to 54.9%. Group II.—All percentages of Wolff-Lehmann from 55.0% to 64.9%. Group III.—All percentages of Wolff-Lehmann from 65.0% to 74.9%. Group IV.—All percentages of Wolff-Lehmann from 75% to 84.9%. Group V.—All percentages of Wolff-Lehmann above 85.0%.

The most important consideration in this classification shows that the consistent increase in the percentage of Wolff-Lehmann digestible crude protein actually received is accompanied by an almost equally consistent increase in the per cent of normal growth in weight, but a somewhat similar but less consistent increase in the per cent of normal growth in height. The law of diminishing returns seems to apply to Holsteins after 70% and to Jerseys after 80% of the Wolff-Lehmann requirements are reached, which suggests the limit beyond which an added supply of protein is not as economically fed to growing animals. Furthermore, the Holsteins were apparently able to make a normal growth in weight on an actual protein plane of 14.2% and on 67.4% of the Wolff-Lehmann digestible crude protein standard, while the Jerseys failed to make an entirely normal growth in weight on an actual protein plane of 34.0% and on 107.7% of the Wolff-Lehmann standard for

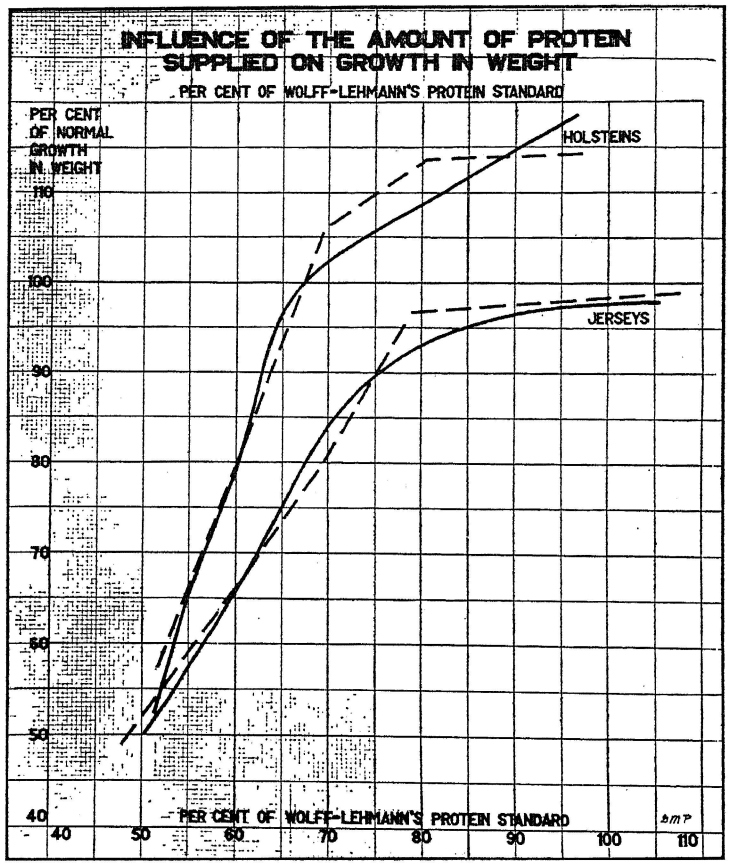

Fig. 3.—This figure represents graphically the percentages of the Wolff-Lehmann protein standard which the animals actually received as indicated by the four classifications of all available data. The solid lines are prepared by plotting against percentage of normal growth all of the nineteen values for each breed indicating percentage of Wolff-Lehmann protein standard actually received, which appear in Tables 39, 40, 41, and 42, and drawing the curved lines as explained in connection with Fig. 2. The broken lines are derived from the percentage of Wolff-Lehmann's Standard values appearing only in Table 41, in the same manner as the broken lines in Fig. 2. Here again the relatively greater and constantly increasing efficiency with increasing protein planes, for Holsteins than for Jerseys, is plainly shown. The Holsteins were able to make a normal gain in weight while receiving 67.4%, while the Jerseys approximated but failed to make an entirely normal growth in weight even when receiving 107.7% of the Wolff-Lehmann protein standard. The dotted lines show that practically as good a gain is made by both breeds on 80% as on 100% of the Wolff-Lehmann protein standard. The solid average lines, however, show that increasing the protein to percentages greater than 80% of the Wolff-Lehmann protein standard resulted in continued efficiency with Holsteins but a greatly reduced efficiency with Jerseys.

digestible crude protein. It is also found that the Holsteins were able to make a normal gain on 55.1% while the Jerseys failed to make an entirely normal gain in weight on 81.4% of Armsby's standard. These values check very closely with the corresponding values derived by the two methods of classification previously discusssed.

The combined averages for the two breeds show a satisfactory distribution of 30-day periods within the groups. The average ages are very uniform and the actual plane and the Wolff-Lehmann and the Armsby values are regular and consistent. Furthermore, the energy furnished was slightly in excess of Armsby's standard in every instance. The averages show that the Wolff-Lehmann values are 49.5%, 60.6%, 69.8%, 79.8% and 101.2% respectively which are almost exactly as intended and that the corresponding percentage of normal growth in weight values were 52.5%, 75.4%, 91.1%, 105.3% and 108.4% respectively. Normal growth in weight was, therefore, apparently made on an actual protein plane of 21.1% and on 76.1% of the digestible crude protein recommended by the Wolff-Lehmann standard and 56.6% of the digestible true protein according to the Armsby standard. The average percentages of normal growth in height for the five plane groups were 93.2%, 97.5%, 103.9%, 100.0% and 114.8% respectively. Since the values for percentage of normal growth in height have such a slight spread and are irregular they will not be given serious consideration. It is apparent from all the groupings considered that the manipulation of the ration or the plane has far less effect on the skeletal growth than on growth in weight.

A Classification on the Basis of the Per Cent of the Armsby Protein Standard Supplied.—The Armsby standard has been used throughout the entire experiment as an important basis for comparison. It would therefore be decidedly incomplete to omit a classification on this basis similar to the one just discussed based on the Wolff-Lehmann standard. The horizontal strips already referred to as cut from summary B sheets were again rearranged; this time on the basis of the average of the two columns immediately following column 7 in the strips and as illustrated in Table 38. The breeds were first separated and the strips arranged for each breed from the lowest to the highest on the basis of the average of the values given in the two columns showing the percentage of Armsby true protein standard actually received, by age and by weight. When this arrangement was completed it again became necessary to establish a method of grouping. It was considered desirable to select not less than four and not more than six arbitrary groups and to have a fairly uniform number of 30-day periods represented in each group for each breed. The values divided themselves fairly definitely into six groups, namely: all values up to 44.9%, those from 45.0% to 49.9%,

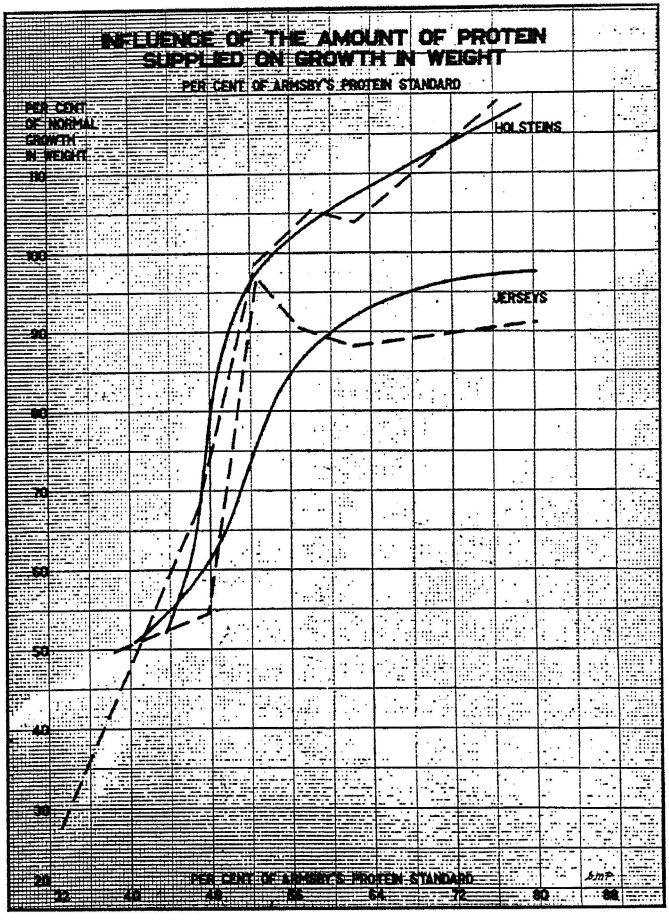

Fig. 4.—This figure shows results similar to those in Figs. 2 and 3 except that the basis of classification and comparison is the per cent of Armsby's protein standard. The solid lines are prepared as in Fig. 2 by plotting against per cent of normal growth all of the nineteen values for each breed showing the per cent of Armsby's protein standard as given in Tables 39, 40, 41, and 42, and drawing similar curved lines as explained in connection with Fig. 2. The broken lines are made in the same manner as the broken lines in Figs. 2 and 3 by connecting with straight lines the points representing the values for per cent of Armsby's protein standard in Table 42 only. The greater efficiency of the plane with Holsteins than with Jerseys is again indicated. The Holsteins made normal growth in weight while receiving an average of 53.9% while the Jerseys approximated but failed to make a normal growth in weight on the highest plane which averaged 80.3% of the Armsby protein standard. The broken line indicates that a better gain in weight was made by Jerseys on 52.7% than on any higher percentage of the Armsby protein standard. The broken lines for both breeds show a decreased growth efficiency on proportions greater than about 52% of the Armsby protein standard.

those from 50.0% to 54.9%, those from 55.0% to 59.9%, those from 60.0% to 64.9% and those from 65.0% upward, of the per cent of digestible true protein according to Armsby's standard which was actually furnished. All values showing group limits are inclusive.

The results of the classification make up summary G sheets, the most important values of which are given in abbreviated form in Table 42 (see Fig. 4). This table shows that the distribution of the 30-day periods is not as even as was intended. This is particularly true for the very high or very low groups or planes. There is a greater variation in the average age of animals for each group and between groups than in any of the other classifications. Again in this grouping the actual plane values varied considerably as was expected, since no consideration whatever was given these values in grouping the data. A considerable although not serious variation is also found for the same reason in the per cent of Wolff-Lehmann values. The Armsby percentage values are very close approximations of the values desired. It is again apparent that the animals received on the average an amount of energy equal to or slightly in excess of the amount recommended by the Armsby energy standard. The average energy excesses were not far different for the two breeds and it is apparent that an adequate supply of energy was furnished both breeds in all the groups.

TABLE 42.—INFLUENCE OF THE AMOUNT OF PROTEIN SUPPLIED ON GROWTH IN WEIGHT AND HEIGHT.
(Classification by Per cent of Armsby's Protein Standard)

Group†	Breed of animals	Number of periods on plane	Average age mo.-da.	Actual plane	Per cent Wolff-Lehmann protein standard	Per cent Armsby protein standard (Age and weight)	Per cent Armsby Energy standard (Age and weight)	Per cent normal growth in weight	Per cent normal growth in height
I	H	7.0	11–6	8.9– 12.1	49.8	33.1	99.4	27.6	89.2
	J	53.4	17–22	9.8+ 8.4	48.3	38.4	100.7	49.7	92.5
	Av.	*60.4	16–29	9.7+ 6.1	48.5	37.8	100.6	47.2	92.1
II	H	67.0	18–11	10.9 – 1.1	57.7	46.8	106.1	67.8	97.7
	J	33.0	15–10	14.7+ 4.3	61.7	47.7	104.0	54.4	75.2
	Av.	*100.0	17–11	12.1+ 0.7	59.1	47.1	105.4	63.4	90.2
III	H	49.0	18–24	11.9+ 1.2	63.0	52.6	114.0	98.4	109.3
	J	49.0	16–17	18.7+ 9.3	72.1	52.7	104.5	96.9	98.7
	Av.	*98.0	17–21	15.3+ 5.3	67.5	52.6	109.2	97.7	103.0
IV	H	16.0	14– 8	16.2+ 7.4	73.1	58.2	120.0	105.4	85.1
	J	32.0	19–12	19.7+ 8.5	72.5	56.8	99.3	90.6	99.0
	Av.	*48.0	17–21	18.5+ 8.1	72.7	57.3	106.2	95.5	94.6
V	H	40.0	20– 4	17.4+ 5.3	77.1	62.4	126.4	103.8	136.6
	J	31.0	13–20	18.5+16.1	73.3	62.3	116.6	88.2	93.1
	Av.	*71.0	17–10	17.9+10.0	75.4	62.4	115.1	97.0	117.6
VI	H	82.0	16– 9	22.6+ 5.0	93.3	76.5	118.0	119.0	114.6
	J	49.4	15–26	31.5+ 3.3	102.5	80.3	99.3	91.1	101.9
	Av.	*131.4	16– 4	26.0+ 4.4	96.7	77.9	110.9	108.5	109.9

*Total

†Group I.—All percentages of Armsby up to 43.9%. Group II.—All percentages of Armsby from 45.0% to 49.9% Group III.—All percentages of Armsby from 50.0% to 54.9%. Group IV.—All percentages of Armsby from 55.0% to 59.9% Group V.—All percentages of Armsby from 60.0% to 64.9%. Group VI.—All percentages of Armsby above 65.0%.

The steady increase in the percentage of Armsby digestible true protein actually received is accompanied in both breeds by a fairly regular increase in the per cent of normal growth in weight and height. There was, however, a much greater lack of consistency than in the classifications previously discussed. The Holsteins appeared to be able to make a normal growth in weight on an actual protein plane of 12.9% and on 65.3% and 53.9% respectively of the Wolff-Lehmann and Armsby protein standards. The Jerseys failed to make an entirely normal growth in weight in the highest group which was equivalent to an actual protein plane of 31.5% and to 102.5% and 80.3% respectively of the Wolff-Lehmann and Armsby protein standards. For some reason which is not explained, the highest percentage gain in weight was made by Jerseys in the third group where the per cent of Armsby's standard was approximately 52.7%. The Holsteins made their lowest or only 27.6% of the normal gain in the first, but made their highest or 119.0% in the sixth group. The Jerseys made their lowest percentage gain in weight amounting to only 49.7% in the first group. In the sixth group the corresponding percentage was 91.1% while in the third group it was 96.9%. The total range of percentages of normal gain in weight from the first to the sixth groups was 91.4% for Holsteins but only 41.4 for Jerseys. In every group except the first the per cent of normal growth in weight was lower for the Jerseys than for the Holstein and the condition in the first group can readily be understood when it is considered that the number of 30-day periods for Holsteins in that group is extremely small. In height at withers there is less consistency than with the weight growth values. The Holsteins made their greatest percentage gain in the fifth and their smallest in the fourth group. The Jerseys made their greatest percentage gain in the sixth and their lowest in the second group. The greatest range for Holsteins was 51.5% while for Jerseys it was only 26.7%. The reason for this slight variation has already been explained on the basis of the relatively small percentage gain in height as compared to weight from birth to maturity, and also on the fact that gain in weight seems to be much more readily influenced than gain in height, by differences in treatment, or that the stimulus which causes skeletal growth appears to be stronger than that which causes growth in weight. Comparatively little importance is attached to the values showing the per cent of normal growth in height.

The combined averages for the two breeds are very regular for age. There is some variation in the actual plane values. The Wolff-Lehmann values are very regular and the Armsby values almost exactly as intended. The values showing the energy supply as compared with Armsby's standard are consistent showing on the average slight excesses

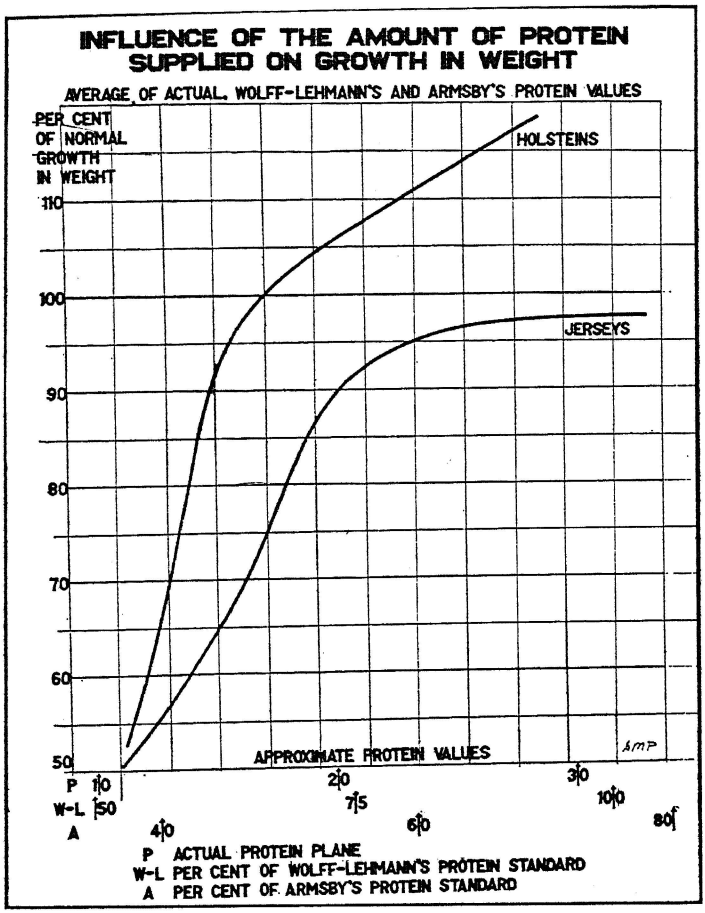

Fig. 5.—This figure is the resultant or average of Figs. 2, 3, and 4. The three plane scales used in these plates are shown at the bottom. The maximum range of protein values for these plates varies slightly but is made identical for Fig. 5. The curved lines are drawn through points determined by the same method as that used in developing the solid lines in Figs. 2, 3, and 4. Fig. 5. shows clearly that the higher planes are much more efficient in promoting growth in weight with Holsteins than with Jerseys. The Holsteins made approximately 118% of the normal growth in weight on a protein plane far below that on which Jerseys made a gain in weight of only approximately 98%.

for every plane group. The percentage normal growth in weight values are not as uniform since the average value for the third plane group is slightly higher than for the fourth and fifth plane groups. Average values indicate that apparently all animals were able to make normal growth in weight on actual protein plane of 20.0% and on 81.0% and 66.4% respectively of the Wolff-Lehmann and Armsby protein standards. This is in accord with the latest work of Armsby[45] which is a preliminary report on the cooperative experiment conducted by the National Research Council to determine the protein minimum for cattle. He states that, "It appears reasonably clear that current feeding standards for growth call for a much greater supply of protein than is necessary to secure satisfactory results." Dr. Armsby, therefore, appreciated before his death that his and other feeding standards were higher than necessary. The values for percentage of normal growth in height are the most irregular of all, yet they show slightly better results on the higher than on the lower plane groups. The classifications on this basis show, as in all other cases, that the Wolff-Lehmann and Armsby standards are higher than necessary and that the Holsteins are capable of making a normal gain on a lower plane or on a smaller proportion of the different standards than are the Jerseys

A Classification on the Basis of the Actual Protein Plane To Determine the Benefits of Excessive Energy With Any Plane. (*Sub-Grouping Based on Excess or Deficiency of Energy As Shown by Actual Plane.*)—In the course of the experiment a considerable amount of attention was devoted to a study of the results produced when varying excesses of energy were furnished with any protein plane. An excess of energy may act as a "protein sparer". Our observations on many of the animals were that an excess of energy seemed beneficial in securing better growth than the same protein plane with only the normal or standard amount of energy would permit. The results, however, were not entirely consistent.

The horizontal strips which were cut from the summary B sheets were again arranged as in the second grouping, on the basis of the actual protein plane. All actual protein values as appearing in column 4 were grouped into the four groups for each breed as already discussed: those up to 12.4%, those from 12.5 to 17.4%, those from 17.5 to 22.4% and those from 22.5% upward—all inclusive. The strips in each of the four groups were then subdivided into two groups on the basis of the second value in column 4 which shows the excess or deficiency in the energy furnished, on the basis used in calculating the protein plane. All the actual planes showing a minus sign or a deficiency of energy and all those showing a plus sign or an excess up to 2.5% were placed in the "normal energy" sub-group. Everything which showed an excess

above 2.5% was placed in the "excessive energy" sub-group. The value of 2.5 excess was arbitrarily chosen in an attempt to make one group average approximately zero or normal, and to make the other group distinctively excessive. In a few cases the lower sub-groups averaged slightly below normal but distinct excesses were obtained in all the higher sub-groups. The results of this classification make up summary H sheets and are shown in abbreviated form in Table 43 (see Fig. 6).

As in all other groupings an attempt was made to secure a reasonably uniform distribution of 30-day periods in each sub-group. This was accomplished to a fairly satisfactory degree. The average age for each sub-group is reasonably uniform. The actual plane values are remarkably uniform except in the high group where there is considerable variation due to a smaller number of 30-day periods. Also, the "excessive energy" sub-group of the high plane actually shows a much smaller excess than was intended while all the other excessive sub-groups show a satisfactory excess. The Wolff-Lehmann digestible crude protein values are remarkably uniform for the sub-groups of each plane group except the last, and the same can be said for the Armsby digestible

TABLE 43.—INFLUENCE OF EXCESSIVE ENERGY ON EFFICIENCY OF THE PROTEIN SUPPLIED.
(Classification by Actual Protein Plane; Subdivision by Actual Energy Plane)

Group†	Breed of animals	Number of periods on plane	Average age mo.-da.	Actual plane	Per cent Wolff-Lehmann protein standard	Per cent Armsby protein standard (Age and weight)	Per cent Armsby Energy standard (Age and weight)	Per cent normal growth in weight	Per cent normal growth in height
I N	H	39.0	21- 0	9.6 - 5.4	55.2	47.4	103.3	75.1	111.5
	J	11.0	22- 1	9.7 - 3.6	48.0	38.4	86.1	20.3	89.0
	Av.	*50.0	21- 7	9.6 - 5.0	53.6	45.4	99.5	63.0	106.4
I E	H	31.0	16- 1	9.3+ 9.7	53.4	47.3	119.1	59.8	99.3
	J	42.4	16-19	9.8+11.6	48.4	38.4	104.6	57.4	93.4
	Av.	*73.4	16-11	9.6+10.8	50.5	42.1	110.7	58.4	95.9
II N	H	60.0	18-16	14.0 - 7.4	67.1	51.5	100.4	96.8	99.7
	J	36.0	15- 9	15.3 - 0.9	63.6	48.3	96.8	53.0	79.9
	Av.	*96.0	17- 7	14.5 - 4.9	65.8	50.3	99.1	80.4	92.2
II E	H	22.0	13-29	14.3+24.0	69.9	57.9	147.3	100.4	115.2
	J	32.0	14-12	15.9+18.4	65.6	56.8	119.0	96.7	95.2
	Av.	*54.0	14- 6	15.2+20.7	67.3	57.2	130.5	98.2	103.4
III N	H	40.0	17- 6	19.1 - 2.4	84.5	65.8	109.1	87.6	112.2
	J	38.0	16-15	19.4 - 0.6	74.1	55.9	96.6	69.1	91.2
	Av.	*78.0	16-26	19.2 - 1.5	79.4	61.0	103.0	78.6	101.8
III E	H	24.0	22-5	19.4+20.7	78.3	65.2	125.1	137.5	119.4
	J	44.0	16-11	20.3+18.5	76.5	60.8	113.1	100.9	88.0
	Av.	*68.0	18-12	20.0+19.3	77.1	62.4	117.3	113.8	99.3
IV N	H	29.0	15-26	26.1+ 0.4	104.5	88.9	114.4	120.6	117.6
	J	16.0	17-10	38.1+ 0.0	119.2	87.0	94.7	102.5	108.5
	Av.	*45.0	16-11	30.4+ 0.3	109.8	88.2	107.4	114.1	114.4
IV E	H	16.0	12-13	23.9+ 3.3	96.4	74.6	116.9	131.0	130.7
	J	28.4	18- 0	30.3+ 6.6	96.7	74.7	98.3	104.4	119.5
	Av.	*44.4	15-29	28.0+ 5.4	96.6	74.7	105.0	113.2	123.5

*Total

†Group I.—All actual planes up to 12.4%. Group II.—All actual planes from 12.5% to 17.4%. Group III.—All actual planes from 17.5% to 22.4%. Group IV.—All actual planes above 22.5%. N.—Normal Energy. E.—Excessive Energy.

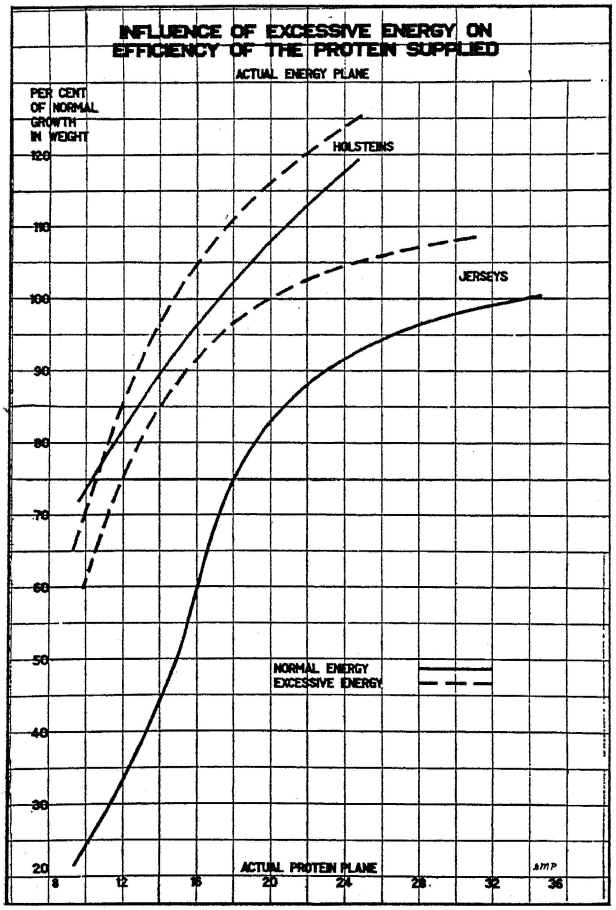

Fig. 6.—This figure is made by plotting against per cent of normal growth all the actual protein plane values in Tables 43 and 44, averaging the values for groups of points so plotted and drawing curved lines through the points determined. The solid line in each case represents the growth values which were accompanied on a given actual protein plane with a normal energy supply. The broken lines represent growth values on an almost identical actual protein plane accompanied by a distinct excess in energy supply. The excessive energy supply is accompanied with both breeds by an increased growth. With Jerseys the advantage of the excessive energy is remarkable. With Holsteins it is somewhat less marked but is distinct.

true protein values. Naturally the values for percentage of energy according to Armsby would fail to be uniform for the sub-groups of each plane group since the classification was based entirely on the more or less arbitrarily developed actual plane. Theoretically they should show approximately 100% for the lower sub-group in each case with a decided excess for the corresponding higher sub-group. In a general way such is the case except that in the high plane group there is less difference between the high and the low sub-groups for each breed than was intended. The reasons for this abnormality have been partially explained on the basis of the uneven number of 30-day periods represented. In general, however, all of the lower sub-groups show on this basis an amount approximately equal to, while the higher sub-groups show an amount decidedly in excess of, the energy requirements according to Armsby. Apparently there was not a deficiency in the energy supply.

It is particularly interesting to note the correlation between the excessive energy as shown in the column headed "Actual plane" and the percentage of normal growth in weight. In each group except the first the Holsteins show a higher percentage of normal growth in weight for the sub-group, having an excess of energy, than for the sub-group showing approximately normal energy. The Jerseys show the same thing without an exception. The greatest difference comes with Holsteins in the high-medium plane where a 19.1–2.4 plane gave 87.6% of normal gain in weight while a 19.4+20.7 plane resulted in 137.5% of the normal gain in weight. With Jerseys the greatest difference comes in the low-medium plane where a 14.3-0.9 plane resulted in 53.0% of the normal gain in weight while a 15.9+18.4 plane produced a gain in weight which was 96.7% of the normal. The Holsteins made almost exactly a normal gain in weight on the low-medium plane with a 24.0% excess of energy. The Jerseys made almost exactly the same percentage of normal gain on a high-medium plane with an excess in energy amounting to 18.5%. These protein planes are lower for each breed than was found adequate for normal growth in height on the original classification, where it was found that it required a plane intermediate between the low-medium and the high-medium to promote normal development in Holsteins, and that it required the high plane to promote normal growth in weight with Jerseys. As in the case of all other classifications the values showing percentage of normal skeletal growth are less consistent and at the same time much less variable than the values for weight growth. The reasons have already been discussed. There is comparatively little significance attached to the skeletal growth values.

The combined averages for both breeds for the sub-groups on each of the low, the low-medium, the high-medium and the high plane groups

are considerably more uniform than the separate breed averages for the sub-groups. These combined values for sub-groups show very definitely that in the low-medium and in the high-medium plane groups the excess of energy amounting to approximately 20% in each case is accompanied by a much greater percentage of normal gain in weight, amounting to a difference of 17.8% and 35.2% respectively in the sub-groups of the two medium plane groups. In the very low and the very high plane group no advantage is shown and the percentage normal gain is approximately the same for the two sub-groups within the plane group. This is not surprising in the high plane group because of the abundance of protein. but an explanation of the lack of difference in the low plane group can only be attempted on the basis that such conditions necessitate the use of large proportions of starch or starch and sugar which is not as palatable as other feeds. As might be expected very little difference is found in the per cent of normal gain in height in any of the groups. Two groups show a slight difference in one direction and the other two groups a difference in the other direction. The combined breed averages show that normal growth in weight was apparently made on an actual protein plane of 15.8% and on 68.4% and 57.8% respectively of the Wolff-Lehmann and Armsby protein standards when an excessive energy supply was furnished, but that normal growth on a normal energy supply apparently required an actual protein plane of 26.0%, and on 97.7% and 77.4% respectively of the Wolff-Lehmann and Armsby protein standards. On the average an animal is apparently able to make a normal growth in weight on a lower plane of protein when an excess of energy is furnished than it can make on the same protein plane when only a normal amount of energy is supplied.

A Classification on the Basis of the Actual Protein Plane To Determine the Benefits of Excessive Energy With Any Plane. (*Sub-Grouping Based on Excess of Deficiency of Energy According to Armsby's Energy Standard*).—The lack of uniformity between the excesses in the actual plane and the corresponding excesses shown by the percentage of energy according to Armsby's standard has been mentioned. For this reason a reclassification of the sub-groups on the basis of values according to Armsby was made. The horizontal strips were again arranged in order in low, low-medium, high-medium and high plane groups. The sub-grouping, however, was this time made on the basis of the percentage energy values according to Armsby. This time the line for subdivision of plane groups was arbitrarily set at 105%. All percentage values below 105% were placed in the normal energy sub-group while all those of 105% and above were placed in the excessive energy sub-group. It was this time attempted to make the normal sub-group average approximately 100% instead of zero as in the classification just discussed, and to

make the other sub-group within each plane group average considerably above 100%. A fairly even distribution of 30-day periods in the different sub-groups was desired but not entirely accomplished. The classification resulted in the formation of summary I sheets, the most important values of which are shown in abbreviated form in Table 44 (see Fig. 7). The average age of animals in the sub-groups varies more than in some of the other classifications, probably due to the lack of even distribution of 30-day periods. The actual plane values for protein are remarkably uniform but since the sub-grouping was made on an entirely different basis a considerable variation in the excess or deficiency of energy shown in the actual plane column would be expected. The values showing the per cent of protein according to the Wolff-Lehmann and Armsby standards are satisfactorily uniform. None of the Holsteins on the high plane fall in the normal energy group, however, but all are distinctly excessive in energy supply.

In the low and low-medium plane groups for Holsteins an excess of energy resulted in a very slightly greater per cent of normal growth in weight. In the high-medium plane group, however, a lower percentage

TABLE 44.—INFLUENCE OF EXCESSIVE ENERGY ON EFFICIENCY OF THE PROTEIN SUPPLIED.
(Classification by Actual Protein Plane; Subdivision by Per cent of Armsby's Energy Standard)

Group†	Breed of animals	Number of periods on plane	Average age mo.-da.	Actual plane	Per cent Wolff-Lehmann protein standard	Per cent Armsby protein standard (Age and weight)	Per cent Armsby Energy standard (Age and weight)	Per cent normal growth in weight	Per cent normal growth in height
I N	H	25.0	21- 1	9.7 - 5.7	53.7	45.5	100.4	67.4	84.3
	J	18.0	21-23	9.4+ 0.5	47.4	37.2	89.5	23.4	104.0
	Av.	*43.0	21-10	9.6 - 3.1	51.1	42.0	95.9	49.0	92.7
I E	H	45.0	17-17	9.4+ 5.2	54.8	48.4	115.8	68.8	117.6
	J	35.4	15-21	10.0+12.5	48.8	39.0	106.5	63.1	86.7
	Av.	*80.4	16-22	9.6+ 8.4	52.1	44.3	111.7	66.3	104.0
II N	H	41.0	19- 7	13.2 - 9.7	65.3	48.3	97.5	96.0	94.8
	J	36.0	15- 9	15.3 - 0.9	63.6	48.3	96.8	53.0	79.9
	Av.	*77.0	17-12	14.2 - 5.6	64.5	48.3	97.2	75.9	87.8
II E	H	41.0	15- 4	14.9+11.8	70.4	58.1	128.4	99.5	112.8
	J	32.0	14-12	15.9+18.4	65.6	56.8	119.0	96.7	95.2
	Av.	*73.0	14-24	15.3+14.7	68.3	57.5	124.3	98.3	105.1
III N M	H	10.0	24- 9	20.5+ 4.1	77.4	62.7	100.9	115.7	159.8
	J	54.0	18- 4	19.3+ 3.4	72.8	55.6	96.6	82.1	86.5
	Av.	*64.0	19- 3	19.5+ 3.5	73.5	56.7	97.3	87.3	97.9
III E	H	54.0	18- 3	18.9+ 6.7	83.0	66.1	117.7	104.6	106.5
	J	28.0	13- 5	21.1+21.6	80.3	64.2	122.6	94.1	95.6
	Av.	*82.0	16-12	19.7+11.8	82.1	65.5	119.4	101.0	102.8
IV N	H	0.0	.....	.....	.....	.....	.....	.....	.....
	J	36.4	18-14	33.0+ 2.2	103.3	77.4	93.7	99.5	111.8
	Av.	*36.4	18-14	33.0+ 2.2	103.3	77.4	93.7	99.5	111.8
IV E	H	45.0	14-18	25.3+ 1.4	101.6	83.8	115.3	123.5	122.3
	J	8.0	14-17	33.8+13.4	111.5	87.0	112.0	123.2	132.5
	Av.	*53.0	14-18	26.6+ 3.2	103.1	84.3	114.8	123.4	123.8

*Total

†Group I.—All actual planes up to 12.4%. Group II.—All actual planes from 12.5% to 17.4%. Group III.—All actual planes from 17.5% to 22.4%. Group IV.—All actual planes above 22.5%. N.—Normal Energy. E.—Excessive Energy.

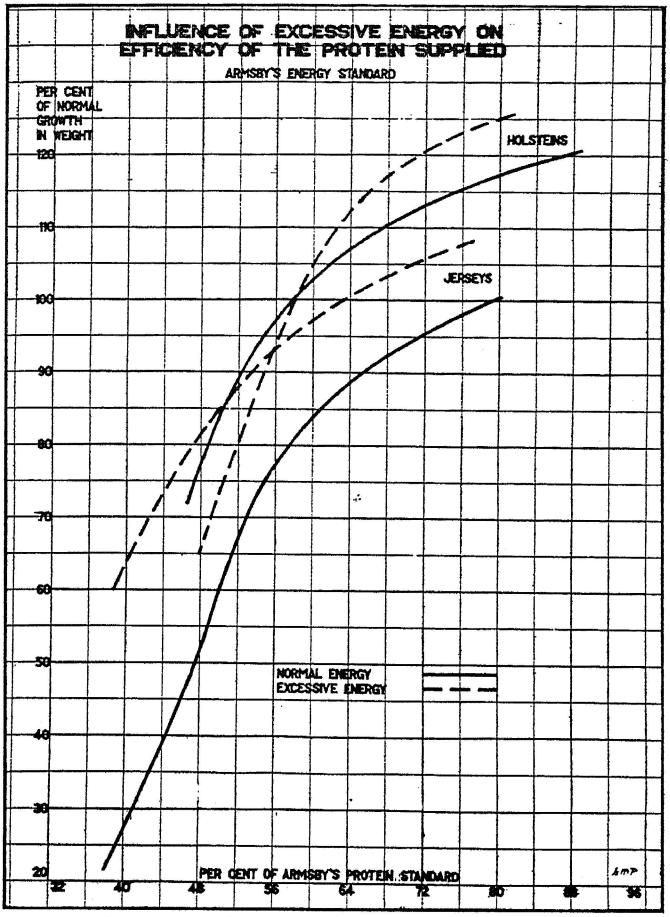

Fig. 7.—This figure is made in exactly the same manner as Fig. 6 except that the per cent of normal growth in weight values are plotted against per cent of Armsby's protein standard values as given in Tables 43 and 44. Here again the Jerseys show that an amount of energy higher than that prescribed by Armsby was decidedly beneficial in promoting growth on all percentages of Armsby's Protein Standard. With Holsteins the excessive energy was accompanied by gains in weight even lower than those made on a normal energy supply on low protein planes, while on the higher protein planes the excessive energy was distinctly beneficial.

gain was made with the excessive than with the normal energy. This can be explained on the strength of the fact that in the lower sub-group only ten 30-day periods are represented as compared to fifty-four 30-day periods in the higher sub-group for the high-medium plane group. In the high plane group none of the Holsteins fall in the lower or normal energy sub-group. The results with Holsteins are therefore not entirely satisfactory or significant. The Jerseys show a somewhat more uniform distribution of 30-day periods and are represented in each sub-group. With them the sub-group showing an excessive energy supply, in every case shows a decidedly greater percentage of normal gain in weight than the lower or normal energy sub-group. The greatest effect is shown in the low-medium plane where the normal energy sub-group produced 53.0% while the excessive energy sub-group produced 96.7% of the normal gain in weight. The number of 30-day periods in each sub-group of this plane group is approximately the same. The Holsteins made 99.5% of the normal gain in weight on the low-medium plane when an excess of energy was furnished. The Jerseys on the contrary did not make a normal gain except on the high plane. In the lower or normal energy sub-group of the high plane they made 99.5% while in the excessive energy sub-group of the high plane they made 123.2% of the normal gain in weight.

While the results for Holsteins on this basis of classification are not entirely satisfactory, the Jerseys show unusually consistent results. The best results, however, are shown when the Holstein and Jersey values are combined. These combined values give a satisfactory distribution of 30-day periods in the different sub-groups. The combined breed averages show that normal growth in weight was apparently accomplished on an actual protein plane of 18.1%, and on 77.0% and 62.5% respectively of the Wolff-Lehmann and Armsby protein standards when an excessive energy supply was furnished. When only the standard energy supply was furnished the corresponding values were 33.0% 103.3% and 77.4% respectively. In every one of the four plane groups, the excessive energy sub-group gives a decidedly greater percentage of normal growth in weight than does the corresponding normal energy sub-group. In the low plane group an average of 95.9% energy produced 49.0% of the normal growth in weight while 111.7% energy produced 66.3% of the normal growth in weight. In the low-medium plane group a 97.2% energy value produced 75.9% while 124.3% energy produced 98.3% of the normal growth in weight. Again, in the high-medium plane group a 97.3% energy value produced 87.3% while 119.4% energy produced 101.0% of the normal growth in weight, and in the high plane group an energy value of 93.7% produced 99.5% while 114.8% energy produced 123.4% of the normal growth in weight. In the case of the low-medium as compared with the high-medium and again in the case of

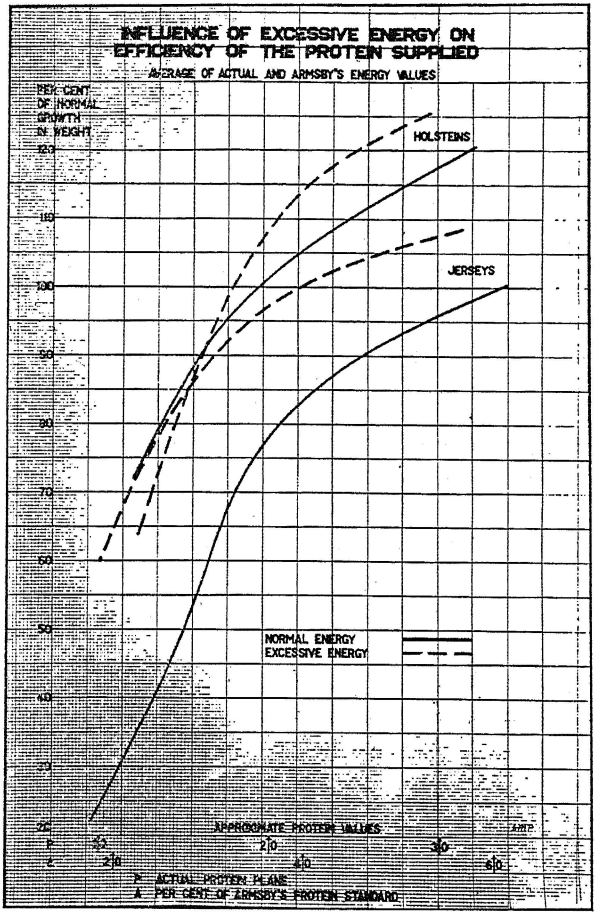

Fig. 8.—This figure is the average or resultant of Figs. 6 and 7 and is prepared in much the same manner as Fig. 5. It shows a decided advantage in favor of excessive energy for Jerseys on all planes and for Holsteins except on the very low planes.

the high-medium as compared with the high plane groups, a higher percentage of normal growth in weight was obtained in the lower protein plane group having the excessive energy, than in the next higher protein plane group having a normal or approximately a normal energy supply. While an attempt was made to have the values in the lower sub-group of each plane group approximately 100%, they were in every case very slightly below 100% although it is thought that the variation below 100% is hardly great enough to be of significance. Combined average values for the breeds show that even the values for per cent normal growth in height show definite results in this case. The sub-groups showing excessive energy, without exception show a decidedly greater per cent of normal growth in height than the corresponding normal energy sub-groups. This consistency in height values has not heretofore been shown. Also in every plane group except the high one, the per cent of normal growth in height is greater on the excessive energy sub-group of one plane group than in the normal energy sub-group of the next higher plane group. It is apparent from Table 44 that on the average, animals are able to make normal growth in both weight and height on a lower plane of protein when an excess of energy is supplied.

The Influence of Age on the Efficiency of the Protein Plane Supplied.—In all work to this point an attempt has been made to compensate for all variables. The age factor has been a difficult one to treat since all planes have been applied to all ages. Also, age was one of the two fundamental factors used as a basis for calculating the rations for the experimental animals. The suggestion that different results may be accomplished on the same protein plane at different ages has already been mentioned as the basis for putting the so-called sliding scale of planes into effect. The results of this systematic reduction of planes with advancing age has already been discussed in connection with the individual animals, but while it has seemed in general that an older animal can make a normal gain on a lower protein plane than can a younger one, the results have been somewhat inconsistent.

In an attempt to determine to what extent age is a factor in determing the efficiency of the protein plane, the original data of the individual summaries were reclassified so that the values for each animal were derived for all the different ages at which the animal was on experiment. The ideal manner of making such a study would be to determine the values for each month of age. However, because of limited data it was considered impracticable to go into such detail and the following seven age groups or units were selected: 6 to 9 months, 9 to 12 months, 12 to 15 months, 15 to 18 months, 18 to 21 months, 21 to 24 months and those above 24 months of age. Each of these seven age groups was treated as

a unit. This was accomplished by determining the values for each animal for the period from 6 to 9 months of age, from 9 to 12 months, etc. The breeds were kept separate. As soon as this was accomplished all Holstein values for the age 6 to 9 months, were grouped together, and all values from 9 to 12 months, etc., were grouped together. The Jersey values were treated in the same manner. Some animals were represented in only one of these age units while others were represented in all seven of them. Instead of making the interval between changes of plane the unit for determining results by this method, the three-month interval became the unit. This change in grouping the data accomplished two things. It first of all made the time unit of consideration practically uniform whereas it had previously varied from one to twenty-five 30-day periods. In the second place it made possible the study of the effect of the same plane on animals of different ages.

Division by Actual Protein Plane.—Now that the values for all animals had been recalculated on the basis of the seven three-month age units it was easily possible to sub-divide the values for each age unit on the plane group basis. The first step in this direction was to consider the actual protein plane values and the four actual protein plane groups were again made use of. All values up to 12.4% were included in the low plane group, those from 12.5 to 17.4% were placed in the low-medium plane group, those from 17.5 to 22.4% constituted the high-medium plane group while all values of 22.5% and above were considered in the high plane group. This classification on the basis of the actual protein plane was applied to each of the seven age groups, meaning that the data for each breed were divided into seven groups according to age, and again into four plane groups, making a total of twenty-eight groups. All data on Holsteins or Jerseys covering ages from 6 to 9 months were first grouped together as an age unit and then subdivided according to the actual plane value into the proper plane group. Data for each breed covering ages from 9 to 12 months and all other age units were handled in the same manner. Since there was a total of only 261 thirty-day experimental periods conducted on Holsteins and 247.8 on Jerseys it is evident that the average for each of the twenty-eight groups is only nine and three-tenths 30-day periods for Holsteins and eight and eight-tenths 30-day periods for Jerseys. Furthermore the number of 30-day periods represented in each of the twenty-eight groups was not uniform, and it seemed necessary to combine the values for the two breeds on this basis which would give an average of eighteen and one-tenth 30-day periods for the twenty-eight groups or units. Not only did combining the breeds increase the number of 30-day periods per group but it gave a more even distribution of them and added considerably

to the value of the results. The breeds therefore, are not considered separately from this standpoint.

The results of combining the values for the breeds produced summary J sheets the essential values of which are shown in Table 45. The values showing the percentage of normal growth in height are so irregular and inconsistent that they are not included. The number of 30-day periods represented in each of the twenty-eight groups is considered of considerable importance in interpreting results and is indicated in each case in the table. As would be expected there is a general tendency for a higher per cent of normal gain in weight to be secured with the higher plane groups for any age, but there is no outstanding tendency in any direction within any plane group on the basis of advance

TABLE 45.—INFLUENCE OF AGE ON EFFICIENCY OF THE PROTEIN SUPPLIED
(Division by Actual Plane; Combined Holstein and Jersey Values)

Division according to age in months	Low Plane*		Low-medium plane*		High-medium plane*		High plane*	
	30-day periods represented	Per cent normal growth in weight	30-day periods represented	Per cent normal growth in weight	30-day periods represented	Per cent normal growth in weight	30-day periods represented	Per cent normal growth in weight
6–9	12.8	55.4	12.0	56.6	8.0	69.0	13.8	84.2
9–12	17.8	50.1	21.0	70.1	13.0	58.8	19.8	114.7
12–15	12.7	63.0	23.0	61.6	26.0	101.5	17.8	104.1
15–18	5.8	28.0	40.0	86.4	30.0	122.3	5.8	115.2
18–21	28.8	58.3	18.0	79.4	34.7	85.1	6.0	117.1
21–24	16.0	62.2	28.8	142.7	19.0	100.6	11.8	139.3
24 up	19.0	86.5	28.7	86.0	10.0	82.2	8.7	93.4

*Explanation of planes.—Low plane.—All actual planes up to 12.4%. Low-medium plane.—All actual planes from 12.5% to 17.4%. High-medium plane.—All actual planes from 17.5% to 22.4%. High plane.—All actual planes above 22.5%.

in age except that it is apparent that animals do not make as nearly a normal growth from 6 to 9 months of age as they do later. This is probably due largely to the fact that at this age the animals undergo an adjustment and are subjected to a more or less severe change in ration and conditions. The maximum percentage of normal growth in the low plane group occurs in the 24+ age group; in the low-medium plane group it comes at 21 to 24 months; on the high-medium plane group it comes at 15 to 18 months and on the high plane group it comes at 21 to 24 months. However, on the low plane a normal growth in weight was never reached, even at the most advanced age. On the low-medium plane normal growth was reached at 21 to 24 months. On the high-medium plane itwas reached at 12 to 15 months and on the high plane it was attained at 9 to 12 months. This would in general indicate a slight increase in efficiency of protein plane with advancing age. The irregularities in this table are numerous and striking and the table does not indicate anything conclusive. When the values in each plane group were plotted graphically they indicate nothing. However, by applying the formula $\frac{b=a+2b+c}{4}$ to these values Fig. 9 was developed.

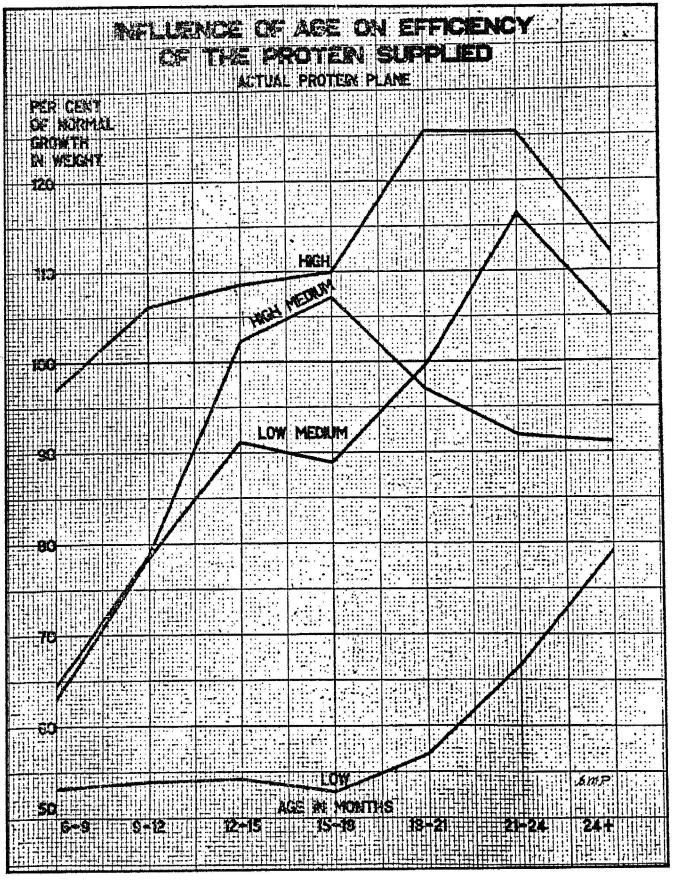

Fig. 9.—This figure is developed by plotting against age, the per cent of normal growth values determined on the basis of a classification according to the actual protein plane as shown in Table 45, after they had been smoothed for each of the four plane groups according to a formula already given. The low plane results are fairly uniform but show a slight increase in efficiency with ages more advanced than 15-18 months. The high plane gives approximately a normal growth from the start but becomes somewhat more efficient with advancing age up to 18-21 months after which a decreasing efficiency with advancing age is shown. For both the low-medium and high-medium planes a decided increase in efficiency for growth is shown up to the age of 12-15 months after which gains are irregular, but fluctuate around 100% or normal. The greatest tendency for an increase in the efficiency for growth with advancing age is shown with the low-medium plane. In general a tendency is shown for a given plane of protein to become more efficient with advancing age, for promoting normal growth in weight.

Division by Per Cent of Wolff-Lehmann's Protein Standard.—The next step was to take the same data which had already been classified on the basis of the seven age units, and subdivide them on the basis of the percentage of the Wolff-Lehmann protein standard. The five divisions selected for other Wolff-Lehmann considerations were again used. This was applied, as in case of the actual plane classification, to each of the seven age groups or units. In this case there are five groups according to the per cent of the Wolff-Lehmann standard, and seven age groups, making a total of thirty-five instead of twenty-eight sub-groups as before. The necessity of combining the values for the two breeds is here emphasized to an even greater extent. The combined breed values on this classification constitute summary K sheets, the essential values of which are shown in Table 46. Here again for the same reasons the values

TABLE 46.—INFLUENCE OF AGE ON EFFICIENCY OF THE PROTEIN SUPPLIED.
(Division by Per cent of Wolff-Lehmann's Protein Standard; Combined Holstein and Jersey Values)

Division according to age in months	Group I		Group II		Group III		Group IV		Group V	
	30-day periods represented	Per cent normal growth in weight	30-day periods represented	Per cent normal growth in weight	30-day periods represented	Per cent normal growth in weigt	30-day periods represented	Per cent normal growth in weight	30-day periods represented	Per cent normal growth in weight
6–9	12.8	55.4	2.0	46.4	10.0	61.7	8.0	65.1	13.8	84.2
9–12	17.8	52.3	9.0	67.2	15.0	68.7	7.0	51.0	22.8	108.7
12–15	12.7	63.0	6.0	99.3	28.0	74.4	15.0	113.7	17.8	141.8
15–18	5.8	28.0	12.0	72.9	34.0	102.4	15.0	100.6	14.8	130.6
18–21	11.8	13.0	17.0	76.4	24.0	89.7	22.7	81.7	12.0	108.5
21–24	7.0	17.9	19.8	90.9	17.0	144.0	16.0	136.9	15.8	132.6
24 up	12.0	79.4	24.7	88.4	17.0	92.9	5.0	84.9	7.7	78.5

Note.—Group I.—All percentages of Wolff-Lehmann up to 54.9%. Group II.-All percentages of Wolff-Lehmann from 55.0% to 64.9%. Group III.—All percentages of Wolff-Lehmann from 65.0% to 74.9%. Group IV.—All percentages of Wolff-Lehmann from 75.0% to 84.9%. Group V.—All percentages of Wolff-Lehmann above 85.0%.

for per cent of normal growth in height are omitted. Table 46 is similar to Table 45 and includes corresponding values except that the grouping is based entirely on the per cent of digestible crude protein actually furnished on the basis of the Wolff-Lehmann standard.

Table 46 shows that there is a correspondingly smaller average number of 30-day periods represented in each of the thirty-five groups than in the twenty-eight in Table 45 and that there is even more variation in the number of 30-day periods in the different sub-groups. Here again there is a general tendency for a higher percentage of normal growth on the higher planes or on the higher percentages of the Wolff-Lehmann protein standard. However, there is no appreciable correlation between age and per cent of normal growth, the maxima for the five plane groups coming in the seventh, third, sixth, sixth and third age groups respectively. The corresponding minima occur in the fifth, first, first, second and seventh age groups respectively. Here again the table indicates that age does not have any definite effect upon the efficiency of a protein plane. Normal growth was never reached on the

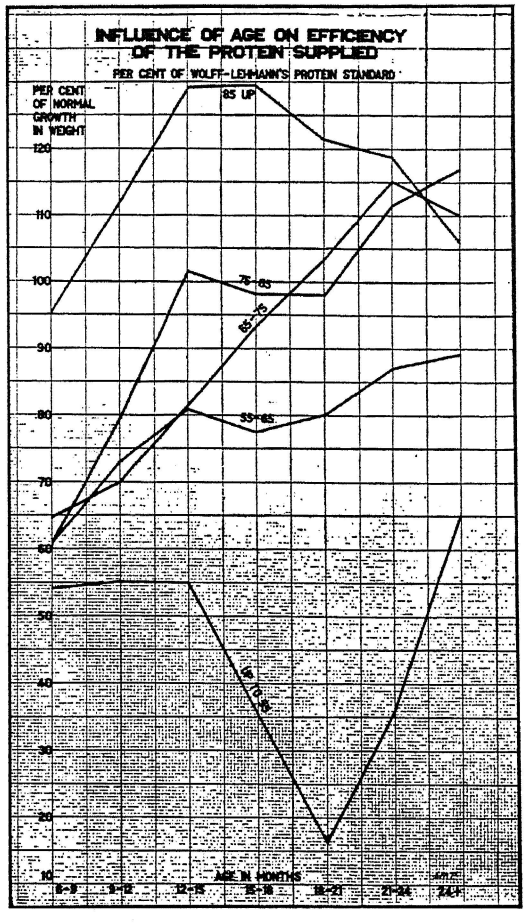

Fig. 10.—This figure is developed by plotting against age the per cent of normal growth values determined on the basis of a classification according to the Wolff-Lehmann Protein Standard, and shown in Table 46, after they had been smoothed for each of the five plane groups according to formula. This figure shows that on the low plane group the results are very irregular and show a decreasing efficiency for growth from 12-15 months to 18-21 months of age after which a rapid increase in efficiency follows. On the highest plane group a fairly rapid increase in efficiency up to 15-18 months is followed by an almost equally rapid decrease in efficiency after that age. The three intermediate plane groups show a fairly uniform increase in efficiency for growth with advancing age, the greatest increase in efficiency accompanying the plane groups representing 65% to 75% and 75% to 85% of the Wolff-Lehmann protein standard.

lowest plane group at any age. In the second group it was practically accomplished at 12 to 15 months but was never entirely accomplished at any age. In the third group it was attained at 15 to 18 months. In the fourth group it came at 12 to 15 months and in the fifth or high plane group it was accomplished at 9 to 12 months af age. A graphical representation of the values in the table shows so much variation that it is practically meaningless. However, when the formula $\frac{b=a+2b+c}{4}$ is applied as in the previous case, Fig. 10 was developed.

Division by Per Cent of Armsby's Protein Standard.—In a previous consideration the data were divided into four groups on the basis of the percentage of the digestible true protein actually furnished on the basis of Armsby's standard. The data which had been divided into the seven age groups were now sub-divided on the basis of these four plane groups. The result was twenty-eight divisions as in the case of division according to the actual plane. The breed values were combined as in the other considerations and constitute summary L sheet, the essential values of which are shown in Table 47. The values for per cent of normal growth

TABLE 47.—INFLUENCE OF AGE ON EFFICIENCY OF THE PROTEIN SUPPLIED
(Division by Per Cent of Armsby's Protein Standard; Combined Holstein and Jersey Values)

Division according to age in months	Group I		Group II		Group III		Group IV	
	30-day periods represented	Per cent normal growth in weight	30-day periods represented	Per cent normal growth in weight	30-day periods represented	Per cent normal growth in weight	30-day periods represented	Per cent normal growth in weight
6–9	10.8	55.1	6.0	49.2	11.0	70.1	18.8	76.6
9–12	17.8	59.7	15.0	55.4	10.0	67.0	28.8	98.5
12–15	12.7	68.4	22.0	75.6	24.0	100.0	20.8	133.6
15–18	2.8	30.0	33.0	89.6	28.0	91.6	17.8	132.1
18–21	11.8	13.0	36.0	80.8	21.7	89.8	18.0	97.4
21–24	10.0	42.1	26.8	114.0	18.0	117.2	20.8	147.7
24 up	8.7	82.0	28.0	90.0	22.0	86.7	7.7	78.5

Note.—Group I.—All percentages of Armsby up to 44.9%. Group II.—All percentages of Armsby from 45.0% to 54.9%. Group III.—All percentages of Armsby from 55.0% to 64.9%. Group IV.—All percentages of Armsby above 65.0%.

n height are omitted as before and for the same reasons. Table 47 is very similar to Table 45 and 46 and includes corresponding values.

Table 47 shows that in the different age groups there is a fairly constant increase in the per cent of normal growth in weight, as the plane or proportion of the Armsby standard is increased. This is true except for the first and the last age groups where there is considerable variation. A consideration of each plane group according to age, shows nothing entirely regular or constant. The maxima for the four plane groups appear in the seventh, the sixth, the sixth and the sixth age groups respectively. The corresponding minima appear in the fifth, the first, the second and the first age groups respectively. In the first plane group, normal growth was not attained at any age. In the second group it was accomplished at 21 to 24 months while in the third and

fourth groups it was reached at 12 to 15 months of age. This would indicate in a very general way that with increasing ages the protein plane becomes more efficient, although the values are extremely irregular. Again, a graphical representation of the values in this table shows so much variation that it is useless. However, by applying the formula $\frac{b=a+2b+c}{4}$ to these values as before, the irregularities are to some extent eliminated. The derived values are plotted as illustrated in Fig. 11

The results of considering the effect of age on the efficiency of different planes or different proportions of protein for promoting growth, have been less significant than the considerations previously discussed. The tables are not particularly significant. The graphical representations show tendencies indicating that especially the intermediate planes promote a percentage of normal growth which is relatively higher as age advances. The results with the low planes are much less regular, probably largely because insufficient data are available for certain ages. On high planes there is less variation than on the low but more irregularity than with the intermediate planes. This can for the most part be attributed to the same factor. It is believed that pregnancy has little, if any, effect upon the increased growth at more advanced age since the tendency on medium planes is shown almost from the start since in most cases the last age group shows a decrease in efficiency.

Effect on Growth in Weight and in Height of Reducing the Protein Plane With Advancing Age.—Reference has been made to the plan of systematically reducing the protein plane on some of the experimental animals as they advanced in age. The plan has been referred to as the "sliding scale" of plane reductions. According to the plan an animal was kept on a 35+0 plane between the ages of 6 to 9 months, on a 25+0 plane between 9 and 12 months, and on a 20+0 plane between 12 to 15 months, on a 15+0 plane from 15 to 18 months and on a 10+0 plane after the age of 18 months was reached. A total of eight animals was included in this study. Only one of these was started at 6 months of age or at an age that would require the 35+0 plane; four were started at ages between 9 and 12 months and on a 25+0 plane, one at 14 months of age on a 20+0 plane and two were commenced at an age advanced enough so that they were immediately placed on the 10+0 plane. Only one animal in the group, No. 500, was carried through all five planes, but each animal was reduced according to schedule as a definite age was reached, except in two or three cases of such poor condition that it became necessary to change the plan to save the life of the animal. Data for this consideration are included only as far as they follow the schedule. The strips already used in preparing previous summaries

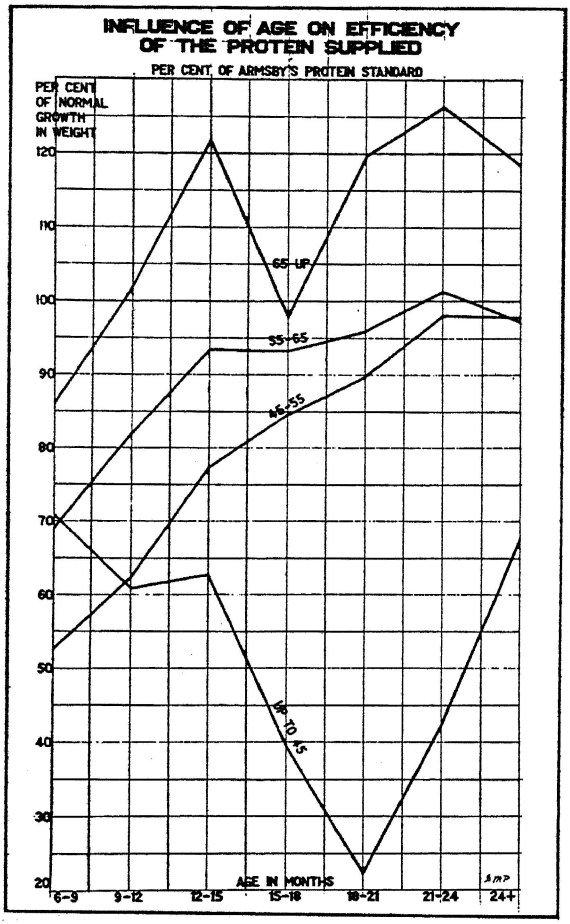

Fig. 11.—This figure is developed by plotting against age, the per cent of normal growth values determined on the basis of a classification according to the Armsby protein standard, and shown in Table 47, after they had been smoothed for each of the four plane groups according to formula. This figure shows for the low plane group an almost continuous decrease in efficiency with advancing age until 18-21 months after which there is a steady and rapid increase. On the high plane group the results are extremely irregular but show slight tendency toward a greater efficiency with advanced age. With both intermediate plane groups, which represent 45% to 55% and 55% to 65% of the Armsby Protein Standard, there is a rapid and fairly uniform increase in efficiency with advancing age except for ages above 21-24 months when a very slight decrease in efficiency occurs.

were again put to use. All the 35+0 plane values on all the heifers in this particular consideration for ages between 6 to 9 months were considered as a unit. All the 25+0 plane values on this group of heifers for ages from 9 to 12 months were considered as another unit, and so on for the five groups for these eight animals. Since the data were limited the values for the two breeds were combined and are presented in Table 48.

As the table indicates, the bases for the division of data is the arbitrary or calculated plane. The number of 30-day periods in each of the five groups is not constant but is sufficient to be satisfactory in each group except the first, where only three-30-day periods are represented. The average age for each group increases by approximately three-month increments as intended. The actual plane values are remarkably regular, although falling slightly below that intended in each group. The actual planes for the five groups are 30.5–6.6, 22.1–0.9, 17.5–0.6, 14.2–2.1, and 9.7-3.8 while they were intended to be 35+0, 25+0, 20+0, 15+0 and 10+0 respectively. Values showing the percentage of Wolff-Lehmann's digestible crude protein standard actually supplied are very regular, steadily decreasing with each successive plane or age group from a maximum of 123.4% for the first, to a minimum of 55.4% for the last group. A very similar regularity and decrease is shown in the successive groups for values indicating the percentage of Armsby's digestible true protein which was actually supplied; the first group showing the maximum value of 102.6% and the last group the minimum value of 47.2%. It was intended that there should be a uniformly slight excess of energy in each group. However, according to the values showing the per cent of energy which according to Armsby's standard was actually supplied there was a slight but steady decrease with each successive group from a maximum of 114.9% for the first group to a minimum of 101.6% for the last group. At any rate, the aim of furnishing a supply of energy which was equal to or slightly in excess of that recommended by the Armsby standard was accomplished. The reason for this variation can largely be explained on the basis of the fact that it is difficult to keep down the energy content of a high protein ration and that, on the other hand, it is equally difficult to make an animal take enough timothy hay and starch to furnish an excessive amount of energy when a very low protein plane is furnished.

It was thought probable when this part of the experiment was planned, that a normal gain would be secured for each plane or age group. The results as shown in Table 48, however, do not so indicate. The values for per cent of normal gain in weight show no regularity; the successive values for the five groups being 82.3%, 71.0%, 99.9%,

51.5% and 64.2% respectively. The data do not support the observations with some individuals indicating that good gains were made with low planes on the more mature animals. It is true that animals placed on experiment for the first time at an advanced age made creditable gains in weight on the low planes; but this was probably due to a reserve supply of material stored in their bodies which those that had been reduced steadily in plane did not possess. Even at the more advanced

TABLE 48.—EFFECT OF REDUCING THE PROTEIN PLANE WITH ADVANCING AGE ON GROWTH IN WEIGHT AND HEIGHT.
(Combined Holstein and Jersey Values)

Calculated plane	Number periods on plane	Average age mo.-da.	Actual plane	Per cent Wolff-Lehmann protein standard	Per cent Armsby protein standard (Age and weight)	Per cent Armsby energy standard (Age and weight)	Per cent normal growth in weight	Per cent normal growth in height
35+0	3	7-27	30.5-6.6	123.4	102.6	114.9	82.3	78.2
25+0	10	11- 1	22.1-0.9	88.9	68.3	110.3	71.0	113.9
20+0	16	13-23	17.5-0.6	73.7	56.6	105.1	99.9	93.8
15+0	18	16-20	14.2-2.1	65.2	51.7	101.7	51.5	79.8
10+0	27	18-29	9.7-3.8	55.4	47.2	101.6	64.2	144.6

ages, the animals were unable to make even an approximately normal gain in weight on a low or low-medium plane. A consideration of the values showing per cent of normal growth in height shows a similar range of values but one in which the lowest value accompanies the highest plane and the highest value accompanies the lowest plane. Again it is evident that the height growth is irregular and that it is affected only slightly and very inconsistently by a variation in the protein plane supplied.

Influence on Growth in Weight of the Per Cent of Total Net Energy Derived from Protein.—A term used by some investigators in describing the protein plane is "Per cent of energy derived from protein" or "Per cent protein calories" and includes the total net energy for maintenance plus growth. *This term should not be confused with the basis used in this experiment in determining the calculated or actual planes which was the "Per cent of energy for growth derived from protein."* For the sake of comparison the values showing "Per cent of total net energy derived from protein" were derived from summary sheets D, E, F and G by multiplying the actual digestible crude protein received as given in column 6 by 1.016, and dividing the resulting value by the actual net energy received as shown in column 13. The values are shown in Table 49. A steady increase in this value is in general accompanied by a fairly steady and uniform increase in per cent normal growth in weight with both breeds and on the average. The per cent normal growth values are the same in this table as in tables 39, 40, 41 and 42. Normal growth was apparently made by Holsteins on 11.0% while the Jerseys required at

TABLE 49.—INFLUENCE OF THE PER CENT OF TOTAL NET ENERGY DERIVED FROM PROTEIN ON GROWTH IN WEIGHT

Breed of animals	Classification by calculated plane		Classification by actual protein plane		Classification by per cent Wolff-Lehmann's protein standard		Classification by per cent Armsby's protein standard	
	Per cent energy from protein	Per cent normal growth in weight	Per cent energy from protein	Per cent normal growth in weight	Per cent energy from protein	Per cent normal growth in weight	Per cent energy from protein	Per cent normal growth in weight
H	9.0	67.9	8.9	68.3	8.6	57.3	9.8	27.6
J	8.3	48.9	8.4	49.7	8.3	48.9	8.4	49.7
Av.	8.7	59.5	8.7	60.3	8.5	52.5	8.6	47.2
H	10.4	94.0	11.0	97.8	10.3	80.5	9.7	67.8
J	10.8	77.3	11.0	73.6	10.6	67.4	11.0	54.4
Av.	10.5	86.5	11.0	86.8	10.4	75.0	10.1	63.4
H	13.4	107.5	12.4	106.3	10.4	106.0	10.0	98.4
J	12.9	80.7	12.7	86.2	12.2	80.7	12.1	96.9
Av.	13.1	92.5	12.6	95.0	11.3	91.1	11.0	97.7
H	15.8	122.6	16.5	123.5	12.2	113.6	11.5	105.4
J	18.0	101.9	18.8	103.7	12.5	96.8	12.3	90.6
Av.	16.8	112.1	17.5	113.7	12.4	105.3	12.0	95.5
H	.....	.....	.....	.....	15.5	114.3	11.8	103.8
J	.....	.....	.....	.....	19.7	98.8	11.7	88.2
Av.	.....	.....	.....	.....	17.0	108.4	11.7	97.0
H	.....	.....	.....	.....	.....	.....	14.3	119.0
J	.....	.....	.....	.....	.....	.....	18.8	91.1
Av.	.....	.....	.....	.....	.....	.....	17.6	108.5

least 18.4% of the total net energy in protein and did not then make an entirely normal growth in weight. The average for the two breeds shows that normal growth was accomplished when 13.4% of the total net energy of the ration was derived from protein.

Obviously, if an excess of energy were supplied with the same quantity of protein the per cent of total net energy in the form of protein would be diminished. This is what occurs when similar values are derived from summary H and I sheets which are represented in

TABLE 50.—INFLUENCE OF THE PER CENT OF TOTAL NET ENERGY DERIVED FROM PROTEIN ON GROWTH IN WEIGHT

(Classification by Actual Protein Plane)

Breed of animals	Subdivision by Actual Energy Plane				Subdivision by Per cent of Armsby's Energy Standard			
	Normal	Energy	Excessive	Energy	Normal	Energy	Excessive	Energy
	Per cent energy from protein	Per cent normal growth in weight	Per cent energy from protein	Per cent normal growth in weight	Per cent energy from protein	Per cent normal growth in weight	Per cent energy from protein	Per cent normal growth in weight
H	9.5	75.1	8.1	59.8	9.5	67.4	8.6	68.8
J	9.3	20.3	8.2	57.4	8.8	23.4	8.2	63.1
Av.	9.4	63.0	8.2	58.4	9.2	49.0	8.4	66.3
H	11.8	96.8	9.3	100.4	11.7	96.0	10.4	99.5
J	12.0	53.0	10.2	96.7	12.0	53.0	10.2	96.7
Av.	11.9	80.4	9.7	98.2	11.8	75.9	10.3	98.3
H	13.9	87.6	10.6	137.5	12.9	115.7	12.4	104.6
J	13.5	69.1	12.0	100.9	12.9	82.1	12.3	94.1
Av.	13.7	78.6	11.4	113.8	12.9	87.3	12.3	101.0
H	16.8	120.6	15.7	131.0	....	....	16.5	123.5
J	22.2	102.5	17.1	104.4	19.0	99.5	18.0	123.2
Av.	18.4	114.1	16.6	113.2	19.0	99.5	16.7	123.4

abbreviated form in Tables 43 and 44. Table 50 was prepared from these summaries and shows a general correlation between the percentage of total net energy supplied by protein, and percentage normal growth in weight. However, the values showing percentage of total net energy supplied by protein are consistently lower and the values showing per cent of normal growth in weight are consistently higher when an excessive rather than a normal energy supply is furnished. The average percentages on which normal growth was made are 17.8% with a normal energy supply and 10.8% with an excessive energy supply.

A Comparison of the Grand Average Values for the Holstein and Jersey Breeds.—It was stated at the beginning of the discussion of results that there was a total of 261 30-day experimental periods conducted on Holsteins and a total of 247.8 30-day experimental periods conducted on Jerseys. This number for each breed includes all planes of protein, all ages, and all the different energy values from a slight deficiency to a decided excess. Since the total number of 30-day experimental periods was nearly the same for each breed, since the ages of animals in each breed ranged within approximately the same limits, and since approximately the same scale of planes was applied to each breed, a true grand average of all values for each breed may be of some value. The averages of the more important values are shown for each breed in Table 51.

TABLE 51.—A COMPARISON OF THE GRAND AVERAGE VALUES FOR THE HOLSTEIN AND JERSEY BREEDS.

Breed of animals	Number periods on experiment	Average age mo. -da.	Actual plane	Per cent Wolff-Lehmann protein standard	Per cent Armsby protein standard (Age and weight)	Per cent Armsby energy standard (Age and weight)	Per cent normal growth in weight	Per cent normal growth in height
H	261.0	17-19	16.0+2.5	73.6	59.7	113.2	96.4	110.3
J	247.8	16-16	18.9+8.0	71.8	56.2	103.4	78.0	94.2

A consideration of this table shows not only approximately the same number of 30-day experimental periods for each breed but the average age of Holsteins was 17 months, 19 days while for Jerseys it was 16 months, 16 days. This difference of approximately one month would, according to data already presented, hardly be considered of importance. The actual protein plane is 16.0+2.5 for Holsteins and 18.9+8.0 for Jerseys which, according to our method of calculating the so-called plane, indicates that the Jerseys were somewhat more liberally fed than the Holsteins, although both values would fall between the so-called low-medium and high-medium planes. In contrast to the fact that the Jerseys received a slightly higher actual plane than the Holsteins, the Holsteins received 73.6% while the Jerseys received 71.8% of the digestible crude protein recommended by the Wolff-Lehmann standard. These

values are almost identical but show a slightly higher value for the Holsteins. Again the Holsteins received 59.7% while the Jerseys received 56.2% of the digestible true protein recommended by the Armsby standard which shows almost an equally small advantage in favor of the Holsteins. The actual plane values indicate a slightly greater excess of energy for Jerseys than for Holsteins but on the contrary the Holsteins received a slightly greater excess than did the Jerseys according to the values showing the per cent which was actually furnished of energy recommended by the Armsby standard.

On the whole the averages for all these values are close for the two breeds. There is, however, a rather important difference in the per cent of normal growth values for the two breeds. The Holsteins made 96.4% of the normal growth in weight while that made by Jerseys under almost exactly the same conditions was only 78.0%. Again, the Holsteins made 110.3% of a normal growth in height while the corresponding growth for Jerseys under almost identical conditions was only 94.2%. The difference in development of the two breeds under the same conditions or on the same plane, has been referred to repeatedly and is again noticeable in the true grand averages of all values for the two breeds covering the entire experiment.

SUMMARY AND CONCLUSIONS

The entire experiment covers a period of more than eight years. Data are included for a total of thirty-four heifers, of which eighteen are Holsteins covering 261 experimental 30-day periods and sixteen are Jerseys covering 247.8 experimental 30-day periods. The total number of experimental 30-day periods covered is 508.8.

On the whole, the actual ingestion of protein and energy was almost exactly as intended.

Throughout the entire experiment the energy supply for both breeds was, on the average, equal to or slightly in excess of the energy standard prescribed by Armsby.

While results with individual heifers varied widely, the group values especially with Holsteins, show that an increase in the protein plane is accomplished almost without exception by a decided and steady although not always proportionate increase in percentage of normal growth in weight. This result was surprising to the writers as it was fully anticipated that the highest planes would be more than sufficient to produce a maximum rate of growth.

In general the group values show that the higher protein planes are accompanied by a higher per cent of normal growth in height. The increase, however, is not as steady and not nearly as great in per cent as is the increase in weight. This smaller range of per cent in height values

is due largely to the fact that from birth to maturity the height of a dairy female increases only 90% while the weight increases more than 1400%.

The manipulation of the ration or the plane has far less effect on the skeletal development than on the growth in weight. This confirms the idea already expressed that the skeletal development is fundamental or inherent, that it is little affected by circumstances, and that the stimulus to grow in dimensions is stronger than the stimulus to increase in weight.

The Holsteins were consistently able to make normal growth in weight on a lower plane than were the Jerseys. Normal growth with Holsteins was apparently accomplished on an average actual protein plane of 14.6%, and an average of 69.6% of the Wolff-Lehmann and 55.9% of the Armsby protein standards. The Jerseys apparently required an average actual protein plane of at least 31.5% and at least 101.6% and 77.5% respectively of the Wolff-Lehmann and Armsby protein standards for the promotion of normal growth in weight.

The low planes were almost equally efficient for both breeds in promoting growth in weight. On the intermediate planes the Holsteins made much higher percentages of normal growth in weight than did the Jerseys. The very highest protein planes used with Holsteins seem to have been accompanied by an almost proportionate per cent of normal growth in weight which reached an average maximum of approximately 120%. With Jerseys, the highest planes seem to have been only very slightly more efficient than the high-medium ones and they were not accompanied by an average maximum per cent of normal growth in weight above 100%.

A given protein plane with an excess of energy seems to promote better gains in weight than the same protein plane with only a normal or standard energy supply. This is true with Jerseys on all planes and with Holsteins except on the very low planes. All animals receiving an excessive quantity of energy apparently made normal growth in weight on an actual protein plane of 17.0%, and on 72.7% and 60.2% respectively of the Wolff-Lehmann and Armsby protein standards. Those receiving a normal or standard energy supply seemed to require an actual protein plane of 29.5%, and 100.5% and 77.4% respectively of the Wolff-Lehmann and Armsby standards, in order to make normal growth in weight.

All animals of both breeds were apparently able on the average to make normal growth in weight and when receiving an actual protein plane of 21.5%, and 82.1% and 64.4% respectively of the Wolff-Lehmann and Armsby protein standards. The Wolff-Lehmann and Armsby standards appear to be from 20 to 25% and from 50 to 60% respectively,

higher than is necessary for the promotion of normal growth in weight. This is in accord with the latest work of Armsby (see reference 45).

The actual values for protein are very slightly higher in the Wolff-Lehmann than in the Armsby standard. In reality the Armsby protein standard is actually much higher than the Wolff-Lehmann standard because the Armsby values are expressed as digestible true protein while the Wolff-Lehmann values are expressed as digestible crude protein. This accounts for the fact that normal growth with both breeds was made on a lower percentage of the Armsby than of the Wolff-Lehmann standard.

The intermediate or medium protein planes show a tendency to become more efficient as the age of the animal advances. This is not consistently true with either the high or the low protein planes. It is apparent that pregnancy is not responsible for this tendency.

Both the Wolff-Lehmann and Armsby protein standards seem to fail to make sufficient allowance for advance in age. They seem to be either too low for the earlier ages or too high for the more advanced ages, or both.

Consistent results were not obtained experimentally by systematically reducing the protein plane with advance in age. It is possible that the scale of reduction used was too rapid. The Jerseys did not withstand the low planes as well as did the Holsteins on the "reduction plan".

Normal growth in weight was apparently made by Holsteins when 11.0%, by Jerseys when 18.4% and by all animals when 13.4% of the total net energy for maintenance plus growth was furnished by the protein in the ration. The animals receiving an excess of energy made a normal growth in weight when 10.8%, while those receiving only a normal energy supply seemed to require that 17.8% of the total net energy for maintenance plus growth be furnished by the protein in the ration. This term or value should not be confused with our so-called calculated or actual planes which show the per cent of energy for *growth* which was furnished by the protein.

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