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A THESIS

THE EFFECT OF DIFFERENT NUTRITIVE PLANES
UPON THE ECONOMY OF GAIN AND THE RATE OF
GROWTH OF YOUNG CATTLE.

By

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THE EFFECT OF DIFFERENT NUTRITIVE PLANES UPON THE ECONOMY
OF GAIN AND THE RATE OF GROWTH OF YOUNG CATTLE.

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OBJECTS OF THE INVESTIGATION.

This Investigation was undertaken in order that something might be learned concerning:

- (a) The Cost of Maintenance of Live Weight in Ungrown Cattle.
- (b) The Effect of a Maintenance Ration upon the Condition of Ungrown Cattle.
- (c) The Effect of Widely Different Nutritive Planes upon the Economy of Gain.
- (d) The Relation between:
  - I. Total Feed Eaten and Total Gain;
  - II. Total Productive Feed Eaten and Total Gain.
- (e) The Energy Value of Normal Growth.
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- (h) The Relative Rate of Growth in Young Cattle as Influenced by the Amount of Feed Eaten.
- (i) The Effect of the Quantity of the Feed Eaten upon the Relative Growth of Different Parts of the Young Animal.

PLAN OF THE EXPERIMENT.

GENERAL PLAN: The Experiment is divided into four periods as follows:

I. Sub Maintenance of thirty (30) days in which the animals lose in live weight. Note here that one steer, 595, is used as a check animal and is kept at a constant live weight throughout the period, or in other words on Maintenance. Period length:- February 26th, 1908 to March 27th, 1908.

II. Maintenance Proper of sixty (60) days in which the animals neither lose nor gain in live weight. March 28th, 1908 to May 25th, 1908.

III. Feeding Period of one hundred and twenty seven (127) days in which varying degrees of feeding are followed thus:

596 --- Full Fed.

598 --- One Half Full Fed, or made to gain about one-half ($1/2$) as much as the full fed steer, 596.

590 --- One Quarter Full Fed, or made to gain about one-fourth ($1/4$) as much as the full fed steer, 596. May 30- October 3, 1908.

IV. Maintenance Proper. Same as Period II only the animals are heavier than in the first period and differ in previous treatment, whereas in preliminary feeding previous to the first Period the steers were all full fed and, of course, would not show any different effects of previous treatment. Oct 4, 1908.

DETAILS OF THE EXPERIMENT:

Ration: The ration consists of Grain ($8/9$ Corn Chop,

and 1/9 Linseed Oil Meal. O. P.) and Alfalfa hay. The grain and hay are fed in the proportion of 1 part Grain to .4 parts hay by weight. In all cases this proportion is preserved so as to make the rations of each steer comparable not only one with the other, but also to insure that the different periods of each steer be comparable one with the other. Based on Average Digestible Nutrients*, the Nutritive ratio of this ration is 1 : 6.29. This insures an abundance of digestible protein for maintenance as well as fattening. The steers are all fed out of the same lots of feed.

System of Feeding: Each steer is fed carefully weighed grain and hay in individual stanchions, and all refuse is gathered up daily and recorded. The Morning feed is given between 6 A. M. and 7 A. M., while the Night feed is between 4 P. M. and 5 P. M. Grain is fed both morning and night. Hay is fed only at night. Daily weighings are made right after the Morning meal is eaten, and before the animals are turned to the troughs. Usually the weighing hour is from 7 to 8 A. M., after which the animals are turned out into the open lot where they remain until turned into the Night Feed. The steers, therefore, have ready access to water from about 8 A. M. until 4 P. M. They are weighed, therefore, about fourteen (14) hours off water.

Feeding Record, How Kept: A specimen heading of the feeding record page is given so as to make clear the system of recording:

*Farmers' Bulletin 22, Revised Edition, Compilation of Dr. E. A. Allen.

PHOTOS BY THE AUTHOR

FEBRUARY 8 1908

CATTLE FEEDING BARN FACING SOUTH
EACH STEER FED IN A STANCHION STALL

THIS METHOD OF FEEDING INSURES THAT EACH ANIMAL GETS ONLY HIS OWN FEED
AND THAT WITHOUT ANY WASTE
WATERING TROUGH ON LEFT SALT BOX ON RIGHT

PHOTOS BY THE AUTHOR

FEBRUARY 8 1908
OPEN LOT LOOKING SOUTH
ALL OF THE STEERS IN THIS EXPERIMENT
HAD THE RUN OF THIS INCLOSURE BETWEEN FEEDING TIMES

Steer Number 595.

Date	Grain Fed		Total	Grain	Grain	Alfalfa	Hay	Alfalfa.
1908	Morning	Night		Refused	Consumed	Fed	Refused	Consumed.
Feb.	(Pounds)!			(Pounds)		(Pounds)		
26	3.25	3.00	6.25		6.25	2.50		2.50
27	3.25	3.00	6.25		6.25	2.50		2.50
28	3.25	3.00	6.25		6.25	2.50		2.50
Jan.								
27	4.50	4.50	9.00	2.00	7.00	3.50	.50	3.00

Pictures: Comparable Photographs were taken of the steers at the beginning of the experiment, and when changes were made in their Nutritive planes. These photographs are taken in a definite system, constant in all cases, in which the steer photographed is always the same distance from the same camera, i. e., the object is always equidistant from the ground glass upon which the focus is made. The side, rear, and front views are all taken on the same scale. This enables one to compare the animals on the same scale, and in a general way note the relative growth of bone, hair, the relative condition, the relations of things pertaining to the animal in general. This is a valuable aid in interpreting experimental results on animals. See pictures pages 71 - 91.

Measurements: Careful Measurements according to the following descriptions* were taken every thirty days beginning with the Sub Maintenance period, and continuing throughout the experiment. Care was taken to measure the steers on exact day in which change of Nutritive plane was begun.

*For List of the Measurements Taken, and their description see Part II.

General Notes: Whenever it was deemed necessary notes were taken on the animals. When change was made in nutritive plane, and at other times, careful notes were made on the relative condition, thrift, growth, quality, coat, etc., etc., of the animals in question.

Analyses of Feed: Analyses were made of all the feeds used in this experiment, but the data are not available for use in this thesis. It may be well to add that the hay throughout the experiment was fed from the same sample, and that the linseed oil meal was not changed until after the animals were on their Second Maintenance Period. some six months, while the corn fed was very uniform in quality and grading. All and all I think we would be quite safe in saying, judging from what analyses are available, that the analyses of the feed will show it all to be remarkable uniform in feeding value.

DESCRIPTION OF THE STEERS USED.

Four steers were used in this experiment, two of them 596 and 598 being half brothers, having the same sire. These two calves at the time of purchase were of about the same size and very remarkably uniform. 590 and 595 are from the same character of stock but somewhat older than the two calves 596 and 598. 590 is a An April 15th calf while 595 was born on May 15th. 596 came on May 19th, 1907 while 598 was calved June 10th, 1907. The range in age is therefore fifty-six days.

These steers were purchased in October, 1907. They all followed their dams on fairly good blue grass pasture from the time dropped until the time brought to the station for this exper-

PHOTOS BY THE AUTHOR

OCTOBER 19 1907
REAR VIEW

PHOTOS BY THE AUTHOR

OCTOBER 19 1907
FRONT VIEW

EXPERIMENTAL BUNCH OF CALVES FROM WHICH 590-595-596 AND 598 WERE SELECTED
SEE REAR VIEW ABOVE

iment. The description of each calf is given separately as well as in a summarized table which table shows at a glance the relative history and breeding of the steers used.

The Check Maintenance steer, 595, is not directly a part of this thesis but was bought and measured and fed along with 590, 596, and 598 by the writer. Through the courtesy of Director H. J. Waters of the Missouri Experiment Station the data of 595 are made available for use in this investigation. 595 is measured on different dates from the other steers, nevertheless, the data secured is of great value as it shows the behavior of a check animal on maintenance throughout the period of transition undergone by the three steers, 590, 596, and 598.

Description of Steer 590:

Calved: April 15, 1907.

Castrated at Birth.

Delivery weight at Station, October 10th, 1907 ----- 419 pounds.

Breeding: 7/8 Hereford-1/8 Shorthorn.

Sire: Purebred Hereford capable of registry. Ridgeway's Bull.

The same as sire of 595.

Weights in good breeding condition about 1750#.

Age (Fall 1907) three years.

Pictures of Sire on page 16.

Dam: 3/4 Hereford and 1/4 Shorthorn.

Weights in good breeding condition about 1200#.

Age (Fall 1907) seven years.

Picture of Dam on page 16

Early Treatment:- Ran with his "mammy" on fair blue grass pasture

PHOTOS BY THE AUTHOR

DAM OF 590
 OCTOBER 9 1907
 BREEDING:- $\frac{3}{4}$ HEREFORD, $\frac{1}{4}$ SHORT HORN
 AGE:- 7 YEARS
 APPROXIMATE BREEDING WEIGHT:- 1200 POUNDS

PHOTOS BY THE AUTHOR

SIRE OF 590 AND 595
 OCTOBER 9 1907
 BREEDING:- FINE BRED HEREFORD
 AGE:- 3 YEARS
 APPROXIMATE BREEDING WEIGHT:- 1750 POUNDS

almost up until the time of purchase, October 4th, 1907. He got no grain.

Description of Steer 596.

Calved: May 19, 1907.

Castrated: August 15th, 1907 at the age of 88 days.

Delivery weight at Station, October 10th, 1907 . . . 290#.

Breeding: Sired by Pure Bred Hereford, Tom Boy 173790, Volume 26 Hereford Registry.

Tom Boy weighs in good breeding condition about 1850#.

Age (Fall 1907) 3 years.

Picture of Sire shown on page 18 Note that he is in crippled condition as a result of getting into the barb wire. This gives him a poor appearance due to "run down" condition as a result of this injury. He is however a very good sire.

Dam:- Pure Bred Hereford, capable of registry.

Weights in good breeding condition about 1000#.

Age (Fall 1907) 4 years.

Unfortunately no pictures of this cow were gotten because she was sent to the butcher a few days before the calf 596 was purchased.

Early Treatment:- Ran with his "mammy" on fair blue grass pasture almost up until time of his purchase. He was given practically no grain.

Description of Steer 598.

Calved: June 10th, 1907.

Castrated: January 18th, 1908 at the age of 223 days.

PHOTOS BY THE AUTHOR

DAM OF 598
 OCTOBER 11 1907
 BREEDING:- $\frac{3}{4}$ HEREFORD, $\frac{1}{4}$ SHORT HORN
 AGE:- ABOUT 5 YEARS
 APPROXIMATE BREEDING WEIGHT:- 1200 POUNDS

PHOTOS BY THE AUTHOR

SIRE OF 596 AND 598
 OCTOBER 11 1907
 BREEDING:- PURE BRED HEREFORD
 AGE:- 3 YEARS
 APPROXIMATE BREEDING WEIGHT:- 1850 POUNDS

Delivery weight at Station, October 12th, 1907 ... 248#.

Breeding: $7/8$ Hereford- $1/8$ Shorthorn.

Sire: Pure Bred Hereford, Tom Boy, Number 173790, the same as sire of 596, which see for description.

Picture of sire shown on page 18

Dam: $3/4$ Hereford- $1/4$ Shorthorn.

Weights in good breeding condition about 1200#.

Age (Fall 1907) about 5 years.

Picture of Dam shown on page 18.

Early Treatment:— Ran with his "mammy" on fair blue grass pasture up until time of delivery to Station. He was given practically no grain.

Description of Steer 595.

Calved: May 15th, 1907.

Castrated: October 9th, 1907 at the age of 147 days.

Delivery Weight at Station, October 10th, 1907 ... 365#.

Breeding: $15/16$ Hereford- $1/16$ Mixed Stock.

Sire: Pure Bred Hereford capable of registry. Ridgeway's bull. The same as the sire of 590.

Picture of Sire shown on page 16.

Dam: $7/8$ Hereford- $1/8$ Mixed Stock.

Weights in good breeding condition 1150#.

Age (Fall 1907) about 4 or 5 years.

Picture of Dam shown on page 20.

Early Treatment: Ran with "mammy" on fair blue grass pasture almost up until time of purchase, October 4th, 1907. He was handled exactly the same as 590, and on the same farm. He got no grain.

PHOTOS BY THE AUTHOR

DAM OF 595

OCTOBER 9 1907

BREEDING:- $\frac{7}{8}$ HEREFORD, $\frac{1}{8}$ MIXED STOCK

AGE:- 4 OR 5 YEARS

APPROXIMATE BREEDING WEIGHT:- 1150 POUNDS

FOR PHOTOGRAPH _____

OF SIRE OF 595

_____ SEE SIRE OF 590

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Summarized Records of the Four Steers, In Table Form.

Steer Numbers: 595, 590, 598, and 596.

Steer No.	Date of delivery to Station.	Delivery Weight (Pounds)	Date of Birth	Breed- ing	Castra- tion Date.	Sire Breed- ing	Dam [*] Wt. Breed- ing	[*] Wt. Lbs.
595 (check)	Oct. 10 1907	365	May 15, 1907	Pure ^{**} Bred Here- ford	Oct. 10, 1907.	Pure Bred Here- ford.	7/8 Here- ford, 1/8 Mixed Stock	1150
598	Oct. 12 1907	248	June 10 1907	7/8 Here- ford, 1/8 Short- horn.	Jan. 18 1908	Pure Bred Here- ford.	3/4 Here- ford, 1/4 Short- horn	1200
590	Oct 10 1907	419	Apr 15, 1907	7/8 Here- ford 1/8 Short- horn.	Apr 15, 1907	Pure Bred Here- ford.	3/4 Here- ford, 1/4 Short- horn.	1200.
596	Oct 10, 1907	290	May 19 1907	Pure Bred Here- ford	Aug 15 1907	Pure Bred Here- ford	Pure Bred Here- ford.	1000.

*Approximate weight in good breeding condition.

**Practically a pure bred Hereford but actually 15/16 Hereford and 1/16 Mixed Stock.

Steers 596 and 598 are half brothers, same sire, .

Approximate weight in good breeding condition is estimated as the animals are seen on foot.

Note that these steers are fairly uniform in breeding, and have sires and dams of about the same weight.

Note also that steers 590 and 595 are half brothers, same sire.

EARLY STATION TREATMENT OF THE STEERS.

These four steers after delivery to the Station were put on feed having with six other mates (See pictures of the ten steers on page 14) the run of an open lot with a south exposure shed for shelter. The feed was gradually increased on these steers until they were nicely on full feed which was about the middle of November 1907. No record was kept of the amount of roughness fed, ad libitum, but the grain was weighed and recorded. The summarized record of these steers during the period of 137 days feeding, ¹²or from October 1907 until February 25, 1908, follows:

Steer Number	Initial Wt. Oct. 12, '07. (Pounds)	Final Wt. Feb. 25, '08. (Pounds)	Total Gain (Pounds)	Average Daily Gain (Pounds)
595	375	609.0	244.0	1.780
590	425	652.7	227.7	1.661
598	248	486.1	238.1	1.738
596	294	512.8	218.8	1.597

As no record was kept of the roughness consumed, ad libitum, it would be useless to figure the grain required per pound gain. The roughness fed consisted of Sorghum (October 12 - November 1, 1907); Corn Fodder (October 12 - November 15, 1907); Cow Pea Hay (October 21 - November 15, 1907); Timothy Hay (October 12 - October 21, 1907); and Alfalfa Hay (November 15, 1907 - February 25, 1908).

In this period, October 12, 1907 to February 25, 1908 1179.7# of grain consisting of 768.3# bran, 737.3# of ground oats, 1092.5# linseed oil meal O. P., and 9195.6# corn chop were consumed by the ten steers. This means an average consumption of

1197.3# per steer for the entire period or an average daily consumption of 8.61#. The ten steers averaged about 500# in weight during this period. The average daily grain consumption per 1000# live weight is something like 17# to 18#. The steers all gained well during this preliminary period of full feeding. They were in all good thrifty condition when the experiment began.

The grain ration of 8/9 corn chop and 1/9 Linseed oil O. P. together with Alfalfa hay was fed from December 26, 1907 on, but the proportion of 1 part grain to .4 parts hay were not preserved until from January 26, 1908 on. The Standard Experimental Ration was fed beginning January 26, ^{1908.} At this time these steers were all put in stanchions and fed separately.

EXPERIMENT PROPER.

PART I - PERIODS OF FEEDING.

The Experiment proper begins with the following thirty day feeding in which the animals lose from 1/2 to 1 1/3 pounds daily. This period is called the Sub-Maintenance Period.

SUB-MAINTENANCE PERIOD RECORD.

In this period began February 26, 1908 and ending March 26, 1908 the steers behaved as follows:-

	Steer 590 (All Quantities in Pounds)	Steer 598	Steer. 596
Number of Days in Period	30	30	30
Initial Weight (Average Ten Weights)	651.8	486.3	512.5
Final Weight (Average Ten Weights)	609.7	466.1	471.3
Total loss or gain in Live Weight	-42.1	-20.2	-41.2
Percent of Initial Weight lost- %	6.46%	4.16%	8.04%
Average of all daily Weights in Period	626.6	476.2	493.0
Total grain consumed in period	141.25	104.0	104.0
Total hay consumed in period	56.5	42.25	42.25
Daily grain eaten	4.71	3.47	3.47
Daily hay eaten	1.88	1.41	1.41

Daily grain eaten per 1000# Live Weight			
Calculated directly/as the live weight	7.51	7.28	7.03
Daily Hay Eaten Per 1000# Live Weight	3.01	2.96	2.86
Maintenance Value of Grain Eaten Daily			
per 1000# Live Weight (1003 Cal. per			
pound grain).	7335.50	7302.80	7053.10
Maintenance Value of Hay eaten Daily			
per 1000# live weight (585 Cals. per			
pound roughness)	1757.93	1729.90	1670.80
Total Maintenance Value of Grain and			
Hay eaten Daily per 1000# Live Wt.	9293.4	9032.70	8723.90

In this period it will be noted that the steers lost quite heavily in live weight, from 4 to 6 percent or from $1\frac{1}{2}$ to $1\frac{1}{3}$ pounds daily.

The effect of this marked loss in live weight is seen in the changes undergone by the animals as discussed under Part II of this thesis.

It is well to add here that these steers lost weight on an amount of food which was afterwards sufficient to maintain them, that is to say, in the Maintenance period immediately following two of these steers maintained their live weight on a less number of Maintenance calories than they got in this period of sub-maintenance, or 590 for 9258 Cals., which is 35.4 less ; 598 for 8350.16 Cals., which is 682.5 Cals less; and 596 for 9363.5 Cals. which is 639.6 Cals. more. As 596 was the heaviest loser in live weight we would naturally expect him to show what he does. Later we shall discuss the effect of previous treatment on the cost of maintenance. These figures show that the animals have readjusted themselves to their low ration, which readjustment ends in a more economical use of the feed eaten.

1908 - 22 days - Feb 29 - 23 days - Mar 2, 10 - 53 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - ~~Sept 22~~ ^{11 days} - Oct 2 - 29 days - Oct 22 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - Jan 2, 2 - 29 days - Feb 1, 9 - 29 days - Mar 2, 10 - 31 days - Apr 2, 10

PROPORTION OF GRAIN TO HAY CONSTANT.
5:2 (by weight)

Scale Horizontal - 1mm = 1 day
Vertical - 1mm = 5 pounds.

CHART 2

1908 22 days - Feb 29 - 28 days - Mch 28 - 58 days - May 5 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - Oct 5 - 19 days - Oct 22 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - Jan 22 - 29 days - Feb 19 - 29 days - Mch 20 - 31 days - Apr 210

ACTUAL DAILY GRAIN EATEN
PER THOUSAND POUNDS LIVE WEIGHT
COMPUTED ON TEN DAY AVERAGES

PROPORTION OF GRAIN TO LAY CONSTANT
5:2 (By Weight)

590
598
596
595
Horizontal - 1mm = 1 lb
Scale Vertical - 1cm = 1 pound

590 One Quarter Full Fed
598 One Half Full Fed
596 Full Fed
595 Maintenance Feb 26 '08 to Feb 19 '09

Slaughtered Feb 22 '09

Preliminary Maintenance Sub Maintenance First Maintenance Proper Feeding Period Second Maintenance Proper Period

CHART 3

1908 - 28 days - Feb 29 - 28 days - Mar 28 - 50 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 32 days - Oct 22 - 29 days - Nov 23 - 29 days - Dec 22 - 31 days - Jan 22 - 29 days - Feb 19 - 29 days - Mar 20 - 31 days - Apr 20

DAILY LIVE WEIGHT

COMPUTED ON TEN DAY AVERAGES

Scale Horizontal ~ 1mm = 1 day
Vertical ~ 1mm = 2 pounds

590
598
596
595

Note: Steers weighed after morning feed and before watering

THE FIRST MAINTENANCE PERIOD RECORD.

In this period begun March 27th, 1908 and extending into the latter part of May and June of the same year the steers have the following record:

	Steer 590 Mar. 27th- May 21st, (1908)	Steer 598 Mar. 27th- May 16th, (1908)	Steer 596 Mar. 27th- June 4th, (1908)
Number of Days in Period	56	51	70
Initial Weight (Av. Ten Wts.)	609.7	466.1	471.30
Final Weight (Av. Ten Wts.)	609.0	466.2	470.00
Total loss or gain in Live Weight	-.7	+.1	-1.30
Average of all daily Wts. in Period	608.29	460.96	463.83
Total Grain Consumed in Period	255.25	157.25	245.75
Total Hay Consumed in Period	101.50	66.00	98.25
Daily Grain eaten	4.558	3.083	3.511
Daily Hay eaten	1.812	1.294	1.404
Daily Grain eaten per 1000# Live Wt.	7.493	6.688	7.570
Daily Hay eaten per 1000# Live Wt.	2.979	2.807	3.027
Maintenance Value of Grain eaten Daily per 1000# live weight (1003 Cals. per pound grain)	7515.48	6708.06	7592.71
Maintenance Value of Hay eaten Daily per 1000# live weight. (585 Cals. per pound roughness).	1742.72	1642.10	1770.79
Total Maintenance Value of Grain and Hay eaten Daily per 1000# live wt.	9285.20	8350.16	9363.50
Fuel Value of Grain eaten Daily per 1000# Live weight (1321 Cals. per pound Grain).	9898.25	8834.84	9999.97
Fuel Value of Hay eaten Daily per 1000# live weight. (807 Cals. per pound roughness)	2404.05	2265.25	2442.79
Total Fuel Value of Grain and Hay eaten Daily per 1000# live weight	12302.31	11100.09	12442.76
Total Fuel Value of Grain and Hay eaten Daily per 500 Kilos. Live Weight.	13560.60	12235.64	13715.65

The period lengths vary somewhat because it was impossible to make all the steers meet their initial weight on any given day. This plan of ending the period on a certain definite day was tried but did not seem so successful as the plan adopted above, the plan

of making the steers meet their initial weights somewhere about the same time. As above figured the steers, practically speaking, did not lose or gain any in live weight. The greatest difference 1.3# sinks into insignificance when we recall that the same steer may vary in weight one day with another as much sometimes as 60# under exactly the same conditions of weighing. The ten day average weights of a number of days on the above maintenance steers shows a daily average range of approximately two pounds. Thus it can be seen that quite a bit of faith can be put on the ten day average although, strictly speaking, it is found wanting for extreme exactness. However, it is the best we can do without resorting to the costly and intricate respiration calorimeter for a solution of these live weight problems.

The calculations per 1000# live weight are all based on the Average of all the daily weights within the period. This reduces the error incurred when it is taken for granted that the average of the initial and final weights of a period represents the average weight of the animal for the entire period, a manifestly absurd supposition.

The Energy Values of Foodstuffs are based upon values set by Dr. H. P. Armsby^{*} of The Institute of Animal Nutrition, State College, Pennsylvania. These Values are as follows:

Energy Values of Foodstuffs per Pound, Calories.

Food	Total Energy	Fuel Value (Available Energy)	Maintenance Values	Production Value
Corn Meal	1708	1308	1016	888
Lin. Oil	1966	1424 ^{**}	903	789
Meal O.P.				
Alfalfa	1732	807	585	348
Hay				

^{*} See top of page 29 for reference and notes).

Alfalfa is approximated the same as if it were clover hay.
No determinations of Energy Values have been made on this roughness.

THE FIRST MAINTENANCE PERIOD, DISCUSSION OF RESULTS.

There seems to be a marked difference in the Maintenance Requirement of Steers, or in the parlance of the feeder, a difference in individuality. Steer 598 maintained on 6.6888/pounds of grain daily per 1000# live weight while steer 596 required 7.570# daily, or .882# daily more, or an increase of 13.2 per cent over 598's requirement. These steers weighed practically the same during the Maintenance period, 596 weighing 462.83 pounds while 598 weighed 460.96 pounds, (Average of all the weights within the period). But their periods are not in the same season. Granted. Take the same period of sixty days on each, from March 27th to May 25th, 1908, and we have this exhibit:

	Steer 598	Steer 596
Initial Weight (Average ten weights).	466.1	471.3
Final Weight (Average ten weights).	469.0	465.7
Gain or loss in Live Weight	+2.9	-5.6
Average of all daily weights within the period	462.23	462.8
Average Daily Grain eaten	3.167	3.254
Average Daily Grain eaten per 1000# Live Wt.	6.851	7.036
Total Maintenance Value of Grain and Hay eaten.		
Daily per 1000# live weight	8520.8	8706.2

In spite of the fact that 596 has the better of the bargain by 8.5# live weight (+2.90 plus -5.6) he still required more feed by 2.7 per cent than did 598, and they weighed within half a pound of each other. (Based on the average of all daily weights within the period, or 462.8 pounds - 462.23 pounds equals .47 pounds.)

The Animal Husbandry men about the farm when asked concerning these two steers as to which would maintain the cheaper without exception said that steer 596 would undoubtedly maintain the

cheaper. ^{It} So~~It~~ was not in this case a question of outstanding quality.

596 graded in condition on March 27th, 1908 as Good to Medium, plus.

598 graded in condition on March 27th, 1908 as Common, or a grade and a half lower in condition.

According to this 596 is the fatter animal. O. Kellner (Landw. Vers. Station., 50, 245; 53, 14) in computing the Maintenance requirement of fattened and unfattened animals found that the Maintenance requirements of fattened animals are greater per unit of surface than those of unfattened ones. These results are based on the averages of seven unfattened animals and three fattened ones, all different animals with one exception. This one animal, we find, showed practically the same requirement per unit live weight unfattened as fattened. It is by no means proven that fattened animals require more for Maintenance per unit live weight than do unfattened ones. Comparative experiments made on identical animals in different stages of fattening in the comparable seasons, and over a sufficient period of time, to insure safe results, will help to solve the problem rightly. On pages 66-70 of this thesis is discussed the effect of previous treatment on the Maintenance cost, a factor which is all important in the comparison of thin and fat animals on Maintenance.

A part of the first plan in this thesis investigation was to work out the "Influence of Condition upon the Cost of Maintenance". The carrying on of these three animals. 590, 598, and 596 in successive Maintenance trials, each time at an increased live weight, and in varying degrees of condition will give us valuable data upon this problem. The work will be written up in a later work, fol-

lowing upon this preliminary report and investigation.

*Bulletin Numbers 71 and 84, Pennsylvania State College Agricultural Experiment Station. Also see Twenty-third Annual Report, Bureau of Animal Industry, 1906, pages 263-285 inclusive, "Investigations in Animal Nutrition", Henry Prentiss Armsby, Ph. D.

** Approximated.

Declining Condition of the Steers on Maintenance:

An ungrown animal put on maintenance grows thinner as the Maintenance period progresses. The animal persists in growing, as the charts in Part II of this thesis show, and manifestly a growing animal which is producing no increase in live weight will grow thin. The fat is resorbed somehow, and with this reserve energy at command the animal is enabled to grow his frame, get taller, longer in leg, deeper in chest, longer and wider in head. Director H. J. Waters of the Missouri Station* has very forcibly demonstrated that ungrown animals kept at stationary live weight undergo profound changes in form, structure, and chemical composition. Really then a Maintenance of live weight in an ungrown animal is not Maintenance at all, unless it so happens that the animal is so thin and changed, after long continued maintenance that he has struck a balance or has come into harmony with his ration. This is perhaps possible after extreme emaciation, caused by long continued maintenance, after the animal has used up all available stores of

* Report 1908, H. J. Waters, "The Capacity of Animals to grow under adverse Conditions", - Society for the Promotion of Agricultural Science. Still Unpublished, May 1909.

energy in the growing process, reaching a point where all reserve is gone and a further call would put his life in jeopardy because it would be a call upon vital tissue. All of the animals in this experiment materially declined in condition on Maintenance.

At the beginning and ^{at the} end of the Maintenance period the animals ranked in condition as follows:

Steer Number	At the Beginning of Maintenance, March 27th, 1908.	At the End of Maintenance, May 25th, 1908.
590	Common-Minus	Inferior-plus
598	Common	Common-minus
596	Good to Medium-plus	Medium-minus.

The terms used in describing condition are Prime, Choice, Good, Medium, Common, Inferior, and Thin in order of decline in condition. These are Standard Grades of Condition with the exception of "Thin" which is added for convenience.

The decline in condition is marked on all the steers, perhaps more so on the fattest one or 596 than on the others.

TRUE MAINTENANCE, therefore, is in ungrown animals, not a Maintenance of Live Weight but a Maintenance of Normal growth, condition, and chemical composition. This necessitates an increase in live weight approximating in the vicinity of half to a pound gain for calves, 3/4 pound for yearlings, and 1/2 to 1/4 pound for twos and threes depending upon the breeding and general maturity tendencies of the animal.

Under practical conditions the Stockman is more interested in TRUE MAINTENANCE than he is in Maintenance of live weight. True maintenance is probably, under general conditions, more desirable than the mere Maintenance of live weight, which maintenance is ac-

companied with a marked decline in condition, a resorption of
 that expensively built material fat. This fat, as ^{the}steer is fit-
 ted for the market, has to be rebuilt, thus necessitating a double
 cost of conversion, which requires energy. A comparison of the
 Maintenance and Production values of food stuffs* will make this
 "Cost of Conversion" clear. On page 26 will be found the Energy
 values of the feed stuffs of the ration used in this experiment.
 Note the difference between mere maintenance and Production values.
 This represents the cost of producing such a material as fat.

Available Energy required for Maintenance of Live Weight.

The available energy required for maintenance of live
 weight has been worked out by such investigators as Kuhn, Armsby,
 and others. Available energy is the same as fuel energy, or that
 portion of the feed stuff available to the animal after the energy
 of the undigested residues is subtracted from the total energy of
 the food fed. In computing this requirement the fuel value is used.

Dr. Armsby** struck an average of all the data pertaining to
 the available energy required to maintain a 500 Kilogram steer and
 found that about 13000 calories daily was a fair figure. Figured
 on a basis of requirement in Calories per 500 Kg. daily the three
 steers of this experiment ran as follows:

Steer No.	Calories Required per 1000# Live Weight Daily.	Cals. Required per 500 Kg. Daily.
590	12302.31	13560.8
598	11100.09	12235.64
596	<u>12442.76</u>	<u>13715.65</u>
Average of the THREE STEERS-	11948.39	13170.69

(All computations made directly as the Live Weight for a want of a

*Report 1906, B. A. I., U. S. Department of Agriculture, pp. 263-285, "Investigations in Animal Nutrition", Dr. H. P. Armsby.

**Sup. to the Report of the Penn. State College, 1897.

more accurate method).

It seems like more luck than sense that these three steers should average within 170.69 Cals. of the average estimated by Dr. Armsby. The range of these three steers is 1480.01 Cals. 598 required 5.9 per cent less than the Standard Armsby Average while 596 required 5.5 more. Taking into account the difference in condition, age, weight, and individuality of cattle as well as the difference in treatment, season, altitude, feed, shelter, and other variable factors that effect the maintenance requirement, it is altogether remarkable that the results should compare so closely.

The attention of Dr. H. P. Armsby was called by the Author to the close agreement between his results and the ones reported herewith, and in his letter of April 16th, 1909 he may be quoted as follows: "The Agreement between your results upon maintenance and our old ones is certainly of much interest. With your figures, ours and Kuhns, it seems to me that the fuel requirement for maintenance is pretty well worked out. Of course, variations must be expected in individual cases. I shall look forward with much interest to seeing your results in print".

MAINTENANCE RECORD OF CHECK STEER 595 THROUGHOUT THE EXPERIMENT.

Steer 595, the check animal of this experiment, was put on Maintenance February 26th, 1908 and kept from gaining or losing live weight until February 21st, 1909, at which time, February 22nd, 1909, he was slaughtered for another experiment. This is a period of 362 days of Maintenance. The plotted charts- No. 1, "Actual

Daily Grain Consumed", No. 2, "Actual Daily Grain eaten per 1000 pounds Live weight", and No. 3, "Daily Live Weight ", will show fluctuations in feed and weight by ten day periods.

Maintenance Record of 595, Check Animal.

Period	No.	Initial Weight.	Final Wt.	Av. of all Daily weights in Per.	Daily Gain or Loss in Live Wt.	Daily Grain Eaten	Daily Hay Eaten	Daily Grain Eaten Per 1000# Live Weight.
1908								
Feb 26- Mar 26.	30	609.8	594.8	603.46	-.50	5.29	2.12	8.76
Mar.27- Apr 25.	30	594.8	604.8	601.13	.33	5.00	2.00	8.32
Apr 26- May 25	30	604.8	613.8	608.03	.30	5.00	2.00	8.22
May 26- Jun 24.	30	613.8	619.7	614.80	.19	5.00	2.00	8.13
Jun 25- Jul 24.	30	619.7	610.3	611.40	-.31	5.00	2.00	8.18
Jul 25- Aug 23.	30	610.3	620.6	618.53	.34	4.93	1.79	7.97
Aug 24- Sep 22.	30	620.6	619.2	624.80	-.05	3.93	1.57	6.29
Sep 23- Oct 22.	30	619.2	619.9	618.60	.02	4.33	1.73	7.00
Oct 23- Nov 21.	30	619.9	602.6	600.00	-.58	4.18	1.66	6.97
Nov 22- Dec 21	30	602.6	611.1	601.10	.28	4.53	1.81	7.55
1909								
Dec 22- Jan 20.	30	611.1	604.6	603.37	-.22	4.65	1.83	7.71
Jan 21- Feb 21.	32	<u>604.6</u>	<u>601.2</u>	<u>600.33</u>	<u>-.11</u>	<u>4.79</u>	<u>1.90</u>	<u>7.97</u>
1908								
Feb 26- Feb 21.	362	609.8	601.2	608.75	-.02	4.72	1.88	7.75
1909								

On Chart 2 is plotted the grain eaten per 1000 pounds live weight by this steer for ten day periods throughout the entire maintenance period. A careful study of this chart in connection with the Live Weight Chart 3 shows that from March to August the allowance of five pounds grain and two pounds hay was sufficient to maintain the animal. Beginning in August a reduction of feed was necessary in order to keep this steer from gaining in Live Weight. The most economical maintenance months seemed to be August, September, and October. November, December, January, and February called for an increase over these three economical months. There seems to be an increase in the cost of maintenance due to the cold weather, while in the autumn months when the temperature is moderate, invigorating, and the climate conducive to general good tone the cost of maintenance decreases. We should expect economy of maintenance also in March, April, and May, and a very slight rise in the maintenance cost in June and July. This slight summer rise over the spring cost corresponds to the winter rise over the fall cost. The summer rise is due to the excessively hot weather, but this rise is probably very slight. In theory real hot weather and real cold weather are both departures from the normal, departures calling for more food to meet the conditions which are unfavorable to economical maintenance. My belief in the matter is that the winter months of December, January, and February are much the higher costing maintenance months, especially so with thin cattle. June and July will probably cost ^{slightly} more than the spring months but not nearly so much as the winter months. All in all it can be safely said that the season of the year affects most profoundly the maintenance cost on cattle.

In practical feeding operations the fall months are considered ideal months for gains. Spring is also conducive to cheap fattening. Summer months are lazy months, the grazing months, the months which for all cattle pasture is the ideal feed. During the summer the dry lot system of feeding is avoided generally. The winter months are the months of dry lot feeding for fattening cattle, but the same months are hard ones on thin cattle wintering through in the open. In working out the factors which affect the gains of cattle during these various feeding seasons the varying seasonal maintenance cost plays a prominent part.

Condition of 595 Check Steer During Maintenance Period.

		Condition.
1908		
February	26	Medium.
March	27	Medium minus
April	26	Medium to Common
May	26	Medium to Common
May	30	Common
June	25	Common
August	24	Common to Inferior
September	23	Inferior plus
October	3	Inferior
October	23	Inferior
November	22	Inferior to thin
December	22	Thin plus
1909		
January	21	Thin minus
February	21	Very thin plus

During the Maintenance period this steer declined markedly in condition. This is the repeated story* of ungrown steers kept on maintenance.

* Report 1908, Society for the Promotion of Agricultural Science.

"The Capacity of Animals to grow under adverse Conditions", By H. J. Waters.

FEEDING PERIOD AND OBJECTS.

Following Maintenance the three steers were placed on varying degrees of feeding as outlined in the Plan of the Experiment. Practically speaking the steers are designated as follows:

596: Full Fed.

598: One Half Full Fed.

590: One Quarter Full Fed.

595: Check on Maintenance.

The feeding period is 127 days in length extending from May 30, 1908 to October 3, 1908, inclusive.

This feeding period was introduced in order that something might be learned concerning the following points:

- (1) Relative Gain or Loss in Condition of the Animals during the Feeding Period.
- (2) Relation between the Productive Grain fed and the total gain. Is the gain proportional to the productive feed eaten ?
- (3) Relation between the total and productive feed eaten per pound gain.
- (4) Correlation between low maintenance cost and ability to use Productive Feed Economically.
- (5) The Significance of the Maintenance Cost.
- (6) Some factors affecting the Appetite of an Animal. Does the appetite keep pace with the increase in live weight ? At what time after being put on full feed does a steer eat his maximum of productive feed ?
- (7) Cost of each pound of gain as the feeding period progresses, and effect of condition upon the cost of this

gain.

- (8) Calorific cost of each pound of increase on steers of different fatness.
- (9) Effect of widely different Nutritive planes upon the subsequent Maintenance cost of animals.
- (10) Effect of widely varying Nutritive planes upon the Rate of growth and form of ungrown steers. For which see Part II of this thesis.

FEEDING PERIOD, RECORD.

May 30, 1908 to October 3, 1908 (inclusive), 127 Days.

	Steer Number 590 (Quarter Full Fed).	Steer Number 598 (Half Full Fed).	Steer Number 596 (Full Fed).
	Pounds unless otherwise indicated.		
Initial Weight (Average Ten Weights)	618.1	470.7	466.2
Final Weight (Average Ten Weights).	705.1	663.5	858.7
Total Gain in Live Weight in period	87.0	192.8	392.5
Average of all Daily Weights in Period	676.04	584.63	682.67
Daily Gain in Live Weight	.685	1.52	3.09
Daily Gain in Live Weight per 1000#	1.013	2.60	4.526
Total Grain Consumed in Period	849.34	938.91	1734.14
Total Hay Consumed in Period	339.86	375.92	686.02
Average Grain Eaten Daily	6.69	7.40	13.65
Average Hay Eaten Daily	2.67	2.96	5.40
Average Grain Eaten Daily per 1000#	9.89	12.67	19.995
Average Hay Eaten Daily per 1000#	3.95	5.06	7.91
Maintenance Requirement in Grain Daily per 1000# -- Based on First Maintenance Period.	7.493	6.688	7.570
Maintenance Requirement in Hay Daily per 1000# -- Based on First Maintenance Period.	2.979	2.807	3.027
Productive Grain Eaten Daily per 1000#	2.397	5.982	12.425
Productive Hay Eaten Daily per 1000#	.971	2.253	4.883
Maintenance Requirement in Grain for period.	643.327	496.570	656.312
Maintenance Requirement in Hay for period.	255.769	208.412	262.431

FEEDING PERIOD, RECORD (continued).	(590)	(598)	(596)
Maintenance Requirement in Grain Daily	5.065	3.910	5.167
Maintenance Requirement in Hay Daily	2.013	1.641	2.066
Total Productive Grain Eaten in period	206.002	442.342	1077.845
Total Productive Hay Eaten in Period	84.09	167.506	423.589
Productive Grain Eaten Daily	1.622	3.483	8.4869
Productive Hay Eaten Daily	.6621	1.3189	3.3353
Ratio of Total Grain Consumed in Period taking 596 as 100. (1734.14 equals 100).	48.97	54.14	100.00
Ratio of Total Productive Grain Eaten in period taking 596 as 100. (1077.845 equals 100).	19.11	41.04	100.00
Ratio of Total Gain in live weight in period taking 596 as 100. (392.5 equals 100).	22.17	49.12	100.00
Ratio of Productive Grain Eaten Daily per 1000# live weight taking 596 as 100. (12.425 equals 100).	19.29	48.14	100.00
Ratio of Daily Gain in Live Weight per 1000# taking 596 as 100. (4.526 equals 100).	22.41	57.52	100.00
Actual Total Grain Consumed per pound gain.	9.76	4.87	4.42
Actual Total Hay Consumed per pound gain	3.90	1.95	1.75
Productive grain eaten per pound Gain	2.366	2.300	2.745
Productive Hay eaten per pound Gain	.958	.866	1.08
Percentage of Food Consumed which is productive. Total food of each steer taken as a 100%.	24.25	47.11	62.15
Ratio of Productive Grain Eaten taking the Total Grain Consumed of 596 as 100. 1734.14 equals 100. (See ratio of Total Grain Consumed in period above).	11.88	25.50	62.15
Productive Calories Required per pound gain. This is in reality the Calorific value of the gain made.	2412.95	2314.45	2783.89
Fuel Value of Grain Eaten per 1000# Live Weight Daily. (1321 Cals.per pound) (Calories)	13064.69	16737.07	26413.39
Fuel Value of Hay Eaten per 1000# Live Weight Daily. (807 Cals.per pound) (Calories)	3187.65	4083.42	6383.37
Fuel Value of Grain and Hay Eaten per 1000# Live Weight Daily (Calories)	16252.34	20820.49	32796.765
Fuel Value of Maintenance Grain and Hay Eaten per 1000# Live Weight Daily See First Maintenance Period Record. This is the Fuel Value of Maintenance Requirement (Calories)	12302.306	11100.097	12442.759
Fuel Value of Productive Grain and Hay Eaten per 1000# Live Weight Daily. (Calories)	3950.034	9720.393	20354.006
Fuel Value Requirement in Grain and Hay per pound Gain on Steers. (Calories)	3899.34	3738.61	4497.13

FEEDING PERIOD, RECORD. (Continued).

Number of Fuel Value Maintenance Cal- ories Burned in the Animal Body for each pound of Gain produced. This represents in a general way the mere cost of running the animal machine for each unit of production. It is the running expense, an expense which goes on independent of pro- duction. (Calories).	(590)	(598)	(596)
	12144.43	4269.27	2749.17

Condition of the Animals During the Feeding Period:

The Condition of the steers during the feeding period was as follows:

	Steer 590 Quarter Full Fed.	Steer 598 Half Full Fed.	Steer 596 Full Fed.
May 30, 1908	Inferior plus	Common minus	Medium minus
June 24, 1908	Inferior plus	Common	Medium
July 24, 1908	Inferior plus	Common plus	Medium plus
August 22, 1908	Inferior plus	Common plus	Med. to Good plus
September 22, 1908	Common minus	Com. to Med.	Good plus
October 3, 1908	Common minus	Com. to Med.	Good to Choice

As one would naturally expect the greatest increase in condition occurs in the full fed steer, while the steer least affected is the quarter fed one. Steer 596 increased his condition a grade and four fifths or practically two grades, steer 598 but four fifths of a grade, and 590 only one fifth of a grade. Practically speaking then 590 rather put all of his increase into normal growth rather than into fat. His excess for fat production was very slight. On the other hand 596 not only had sufficient food to grow nicely on but had a considerable excess for the production of that reserve material fat. 598 (Half Full Fed)

ranks in between the two extremes. It may be well to add here that 595 (Maintenance) was much thinner on October 3 than he was on May 30, 1908. His condition on May 30, 1908 was Common while on October 3, 1908 he ranked Inferior, a loss of a whole grade. This may approximately represent the "Loss in Condition" cost of growth. The Gain or loss of each steer in condition is as follows:

	Gain (+) or loss (-) in Condition Expressed in fifth grades.
595 Maintenance	- 5
590 Quarter full fed	+ 1
598 Half full fed	+ 4
596 Full fed	+ 9

At best this is an approximation but it comparably represents very clearly the change in the condition of these animals.

Relation between the Productive Grain Fed and the Total Gain.

In theory we may expect that an animal will gain somewhat in proportion to the amount of feed supplied over and above Maintenance. In other words the animal uses his food for three purposes, namely: Maintenance, Growth, and Fattening. It has always been assumed by the leading animal husbandmen of this country and abroad that the first draft of an animal upon his feed is to supply Maintenance. Once Maintenance is supplied then the animal will have a reserve for growth and for fat production. The younger the animal the stronger his tendency to grow and the less to fatten. But we find that animals will grow even though they are not maintained in live weight.*

*S. Pl. A. S. Report 1908.

This experiment shows steers to grow in frame while on Maintenance, and to grow, at least for a considerable time, as well on maintenance as on feed. Taking as a basis of our calculation the Maintenance requirement as worked out in the First Maintenance period, preceding this Feeding Period, and the feed eaten in excess of this requirement during the Feeding Period we have this array:

Table showing Relation between Productive Grain eaten and
Total Gain.

	Steer Number 590 Quarter Full Fed. (Figured on Actual Basis, and not per unit weight).	Steer Number 598 Half Full Fed.	Steer Number 596 Full. Fed.
Total Grain Consumed in Period	849.34	938.91	1734.14
Maintenance Requirement in Grain for Period.	643.327	496.57	656.312
Total Productive Grain Eaten in Period	206.002	442.342	1077.845
Ratio of Total Grain Consumed in Period taking 596 as 100.	48.97	54.14	100.00
Ratio of Total Productive Grain Eaten in Period, taking 596 as 100.	19.11	41.04	100.00
Ratio of Total Gain in Live Weight taking 596 as 100.	22.17	49.12	100.00

Or figured on a 1000# unit weight basis we have the following results which are relatively and practically the same as the above.

Ratio of Productive Grain Eaten Daily per 1000# Live Weight taking 596 as 100.	19.29	48.14	100.00
Ratio of Daily gain in Live Weight per 1000# taking 596 as 100.	22.41	57.52	100.00

In this table we see that the total gain of the animals coincides very closely indeed with the total productive grain eaten. For a 100 units productive grain eaten by 596-Full Fed- we get 100 units of gain. This is the basis of the calculated comparison. The half fed steer 598 gained 49.12 units for 41.04 productive grain units. On the other hand the quarter fed steer gained 22.17 units for 19.11 units productive grain eaten. According to this the full fed steer is the most expensive gainer from the standpoint of productive grain. 598 is the most economical gainer, while 590 ranks third. We would naturally expect the full fed and fattening steer to make less units of gain per unit of productive feed than the quarter or half fed steers because:

1. More fat is produced. This steer being fattest it is reasonable to suppose that this is true. Fat is an expensive material to produce, much more so than is mere growth in the form of muscular tissue, bone, tendon, connective tissue, etc., etc. Fat when burned in the calorimeter produces 4220 Cals. per pound* while protein yields about 1860 Cals. per pound. Muscle is for the greater part water while fat tissue has very little water in it. Disregarding the water content we have a difference of 2360 Cals per pound.
2. There is more dry matter in a pound of gain on a fat animal than on a thin one because under ordinary circumstances adipose tissue contains much less water than do other tissues of the body such as muscle, connective, nervous and epithelial. The fatter the animal

*Principles of Animal Nutrition, p 244, Dr. H. P. Armsby.

the less the percentage of water. For example a well fed steer and a fat steer, Lawe's and Gilbert's results compare as follows:

Composition* of steers (Percent).

	Water	Ash	Protein	Fat
Ox Well Fed	66.2	5.9	19.2	8.7
Ox Fat	49.5	4.4	15.6	30.5

Missouri Experiment Station Results, gotten under direction of H. J. Waters, Director and P. F. Trowbridge, Chemist, confirm this change in water content of steers. Results yet unpublished.

3. While little is definitely known in regard to digestibility it stands to reason that the full fed, "stomach crowded", "running at full capacity" steer can not handle his feed as well as the lighter fed one. It would almost be a physical impossibility to expect him to be able to do so.

Relation between the Total and the Productive Grain eaten per pound Gain.

The total grain consumed in Period bears little relation to the ^{Total} gain. The common method of reporting feeding results is to give the number of pounds feed required to make a pound of gain, and to the uninitiated this is perfectly satisfactory. Let us compare the total grain consumed per pound of gain to the productive grain required per pound gain in this experiment.

*See Jordan's Feeds and Feeding page 95.

Steer 590	Steer 598	Steer 596
One Quarter	One Half Full	Full
Full Fed	Fed	Fed.

(All figures in pounds)

Total grain consumed per pound gain.	9.76	4.87	4.42
Productive grain eaten per pound gain.	<u>2.366</u>	<u>2.30</u>	<u>2.745</u>
Difference, or the Maintenance Cost per Pound gain. The Cost of Running the Machinery.	7.394	2.57	1.675

Throughout this feeding period 590 and 596 averaged within 7 pounds of each other, but note how much higher the cost of Maintenance runs on each pound of gain on the light fed one as compared to the heavy fed one. In other words when running a machine there is always a running expense, which is about the same whether the machine is running at full capacity or only half capacity. It will be cheaper then per unit of product to run to the limit of the capacity, if that can be done without undue waste, or without taxing the machine too heavily.

Correlation between Low Maintenance Cost and Ability to use Productive Feed economically.

It is to be especially noted in this experiment that 598 is the most economical steer, both in regards Maintenance cost per 1000# live weight and ability to produce maximum gain per unit of productive grain fed. The question here arises, "Is low Maintenance cost associated with economy of production?" I dare not attempt to answer this question. I merely call attention to the correlation between the maintenance record of this steer 598 and his

economical feeding record. In spite of the fact that throughout all these computations he is charged with a low maintenance cost, thus making available a large amount of productive feed he uses this comparatively large amount of productive feed to even better advantage than does the thinner steer 590 which economical use is certainly unexpected. More animals and more feeding trials must be resorted to in order to get a line on this nutritional problem.

The Significance of the Maintenance Cost.

The amount of feed necessary to keep the animal ^{on} Maintenance of live weight has a greater significance in the feeding operation than we ordinarily think. The truth of the matter is that few think about it at all, and many when their attention is called to its great importance as a factor in the cost of producing a pound of gain fail utterly to comprehend its significance.

Roughly speaking a mature steer in moderate condition weighing a 1000 pounds will maintain its live weight on about 7 pounds of Shelled Corn and 3 pounds of Clover or Alfalfa hay daily. This same steer if put on a six months full feed will eat, at the most, not more than 21 pounds of Shelled Corn and 9 pounds of clover or Alfalfa hay per 1000# live weight throughout the period. But for arguments sake, allowing that he will consume this much feed we have one third of the ration, or 33 and 1/3 per cent, devoted to the running of the machinery. This means that one pound of every three pounds of feed ^{fed} to this steer goes for the running of the machine, and is one pound not productive in the strict sense.

In the making of baby beef the steers are full fed almost

from birth until some 12 to 16 months of age. These steers reach their maximum of appetite or capacity per 1000 pounds live weight when they become about 12 to 14 months of age, choice to prime in condition, and weight about 900 to 1100 pounds. From this time on the capacity of the animals actually increases very little, and they gradually eat less per unit weight as the period of full feeding progresses. Gradually the maintenance cost mounts higher and higher, and the amount of productive grain becomes correspondingly less. The gain too becomes more costly as it decreases. In theory the full fed steer will reach a time when his capacity and appetite will but suffice to meet the maintenance cost, and there being no productive feed eaten, all going to maintenance, the animal will remain at a stationary live weight.

It is a commonly observed and reported fact that hogs make a much more economical gain per unit of feed eaten than do cattle. A hundred pound pig will eat on the average about 40 pounds of grain per 1000# live weight, and oftentimes we know that they exceed this average considerably. It is not at all uncommon to have a thin, fairly well grown, good framed, 100 pound pig eat as high as 60 pounds per 1000 pounds live weight, and even approach closely on to 70 pounds. Compare this with the steer which eats less by far of feed than this, and contrast the productive grain of the two animals. The pig has by far the largest amount of productive grain available after Maintenance is satisfied than has the steer. Will not this factor of "Running Cost" or less Maintenance cost in hogs in proportion to the total amount of feed eaten explain, in part, the great differences in cost of producing a pound of gain

on the two animals, the hog and the steer.

It is the common notion, in fact the prevailing opinion, that the age affects above all things else the ability or power of the animal, as it were, to put on cheap gains. The younger the animal is then the cheaper will be the gain. Nearly all that has been written on this subject attributes this cheapness of gain while young to the greater cell activity of the young organism. It remained for the Missouri Station in a number of practically conducted feeding trials to call animal husbandry men's attention to the fact that the condition of the animal at the beginning of the feeding period affects most profoundly the rate and the cost of the gain. Relative age, therefore, is not so important a factor as is relative condition. Thin cattle with large enough frames, say 800 to 1000 pound three year olds, are able to eat and store away large quantities of feed, thus having a very large proportion devoted to production over and above maintenance, and as a result they gain rapidly, and economically. As the feeding period progresses the cost of each pound of gain increases because of two reasons, First, Less Productive Grain is eaten as the period continues because the Maintenance cost increases faster than does the capacity or appetite of the animal. And, Secondly, because as the feeding, fattening period progresses a more expensive, less watery material is being made this requiring more productive feed (and there is actually less) to make each pound of gain. Is it not then the Maintenance cost a significant factor in this all important array of factors which affect the cost of gain ?

Some Factors affecting the Appetite of an Animal.

The full fed steer 596 reached his Maximum of Consumption

CHART 4

1908
 22 days - Feb 28 - 28 days - Mch 28 - 58 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 11 days - Oct 2 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - 1909
 Jan 22 - 29 days - Feb 19 - 29 days - Mch 20 - 31 days - Apr 20

ACTUAL GRAIN EATEN
PER THOUSAND POUNDS LIVE WEIGHT
 COMPUTED ON TEN DAY AVERAGES
AND AVERAGE MAINTENANCE COST PER THOUSAND POUNDS LIVE WEIGHT
 PROPORTION OF GRAIN TO HAY CONSTANT
 5:2 (By Weight)

Scale Horizontal ~ 1 mm = 1 day
 Vertical ~ 1 cm = 1 pound
 596 — Actual Grain Eaten Per Thousand Pounds Live Weight.
 — Average Maintenance Cost Per Thousand Pounds Live Weight.

per 1000 pounds live weight about 20 days after being put on feed. He maintained this high consumption of approximately 23 pounds per 1000 pounds live weight for only about 20 days when his live weight increased out of all proportion to his capacity as judged by his feed consumption. This steer's record of Daily Feed Consumption per 1000 Pounds Live Weight is plotted on Chart 4 following page 48. The following table sets forth the Feed eaten by 596 during the Feeding period, May 30th to October 3rd, 1908, inclusive dates.

Period.	Average Actual Grain Eaten Daily.	Average Grain Eaten per 1000# Live Wt. Daily.	Average Daily Live Weight	Average Gain in Live Wt. for each Period.
1908.	(Computed on 10 day Averages).			
May 26- June 4.	5.05	10.74	470.00	—
June 5- June 14,	9.65	18.89	510.70	40.70
June 15- June 24,	13.00	23.13	562.9	52.20
June 25- July 4,	13.28	22.62	587.10	24.20
July 5- July 14,	14.58	23.14	630.10	43.00
July 15- July 24,	14.84	22.40	663.00	32.90
July 25- August 3,	14.90	21.62	689.00	20.00
Aug 4- Aug 13,	13.10	18.25	714.00	25.00
Aug 14- Aug 23,	14.80	20.08	737.00	23.00
Aug 24- Sept 2,	14.75	19.39	760.40	23.40
Sept 3- Sept 12,	15.38	19.45	790.90	30.50
Sept 13- Sept 22,	14.90	18.32	812.60	21.70
Sept 23,- Oct 2,	<u>15.30</u>	<u>18.16</u>	<u>842.30</u>	<u>29.70</u>
Average Entire Period 127 Days, May 30- October 3, 1908.	13.65	19.995	682.67	30.90

The actual daily grain consumed (10 day average) is plotted on Chart 1, following page 24 . The Daily Live Weight (10 day averages) is plotted on Chart 3, following page 24.

It will be noted that this full fed steer gradually ate less per 1000 pounds live weight after ^{the} end of the first 40 days of full feeding. The daily grain consumption per 1000 pounds live weight decreased from the maximum of 23.14 pounds to 18.16 in 80 days, a more or less gradual decrease. Assuming that the Maintenance Cost per 1000 pounds live weight remains constant during the entire period one readily sees that the productive grain eaten reaches its maximum amount shortly after full feeding begins, or at about the time the steer begins to refuse feed providing he is put on feed in from 30 to 45 days. It is unfortunate this feeding period could not be continued without doing an injustice to the originally planned experiment. However the general tendency to a gradually decreasing consumption per unit weight and a correspondingly less amount of productive grain eaten daily seems unmistakable. The Live Weight increases out of all proportion to the increase in capacity. The capacity of this growing steer seems to increase but slowly. The question here arises as to whether or not a mature, fully grown steer would increase his capacity very much during a full feeding period, starting him out in thin condition. The gradual decrease in the rate of gain of animals on feed can be partly attributed to the gradually lessening amount of productive grain available, after maintenance is satisfied, out of the total feed eaten.

Indications seem to point toward this: that Maintenance is not directly proportional to the live weight. Some investigators

figure that the maintenance cost is proportional to the two thirds power of the live weights, or as to the exposed surfaces of the animals. No really satisfactory work, however, has been done on this all important problem. The plotted green line representing the grain eaten per 1000 pounds live weight on chart Number 4, following page 47, seems to indicate that the Maintenance cost on steer 596 at a season, April and May, corresponding to the First Maintenance period, will be less per 1000 pounds live weight than during the first period. As it takes some time for a full fed steer to reach a normal and economical plane of Maintenance, (See page 66.) little can be said at this time. However, the indications seem to point toward a decreased Maintenance cost per 1000 #pounds live weight on this animal because of the additional approximate 400 pounds added to his First Period Maintenance weight of 462.8 pounds. The continuance of this experiment will throw some light on this subject and give us a fair basis whereby we may work out the Maintenance Cost at different increasing weights, and thus enable us to estimate a proportion by which we may approximate the maintenance cost at increasing live weights.

Cost of Each Pound of Gain increases as the Feeding Period
Progresses.

There can be no question^{but} that the cost of each pound of gain increases as the feeding period progresses, and this increased cost is especially marked if the animals are on full feed and fattening very considerably. The question here arises: Is this due wholly to an increased Maintenance cost, or does the animal actually require more productive feed per pound of gain, or perhaps better

still, is it due to a combination of the two ? Some data is available on this subject from the results of this experimental feeding trial, and they are given in the table which follows.

Table Showing cost per pound gain as the feeding period progresses.

Period.	Days	Av. in Per.	Daily Gain	Total Grain Con- sumed per Pound Gain.	Main- Grain Eaten per Pound Gain.	Produc- tive Grain Eaten per Pound Gain.	Fuel Val. of Total Feed per Pound Gain.	Fuel Val. of Main- tenance Feed per Pound Gain.	Fuel Val. of produc- tive Feed Eaten per Pound Gain.
1908.									
Steer Number 590 ----- Quarter Full Fed.									
May 30-									
Jun 24	26	1.25	5.12	3.78	1.34	8427.09	6222.71	2204.38'	
Jun 25-									
Jul 24	30	.94	7.63	5.32	2.31	12503.27	8694.21	3809.06	
Jul 25-									
Aug 23	30	.84	9.39	6.10	3.29	15392.18	9969.45	5422.73	
Aug 24-*									
Oct 3	41	.02	31.15	216.827	14.323	386236.77	361832.53	24404.24	
May 30-									
Oct 3,	127	.69	9.76	7.39	2.37	16043.77	12144.43	3899.34	
Steer Number 598 ----- Half Full Fed.									
May 30-									
Jun 24	26	1.86	3.67	1.78	1.89	6113.41	2961.61	3151.80	
Jun 25-									
Jul 24	30	2.14	4.09	1.73	2.36	6721.48	2871.21	3850.27	
Jul 25-									
Aug 23	30	1.83	4.63	2.223	2.407	7617.615	3695.11	3922.51	
Aug 24-*									
Oct 3	41	.62	9.62	6.938	2.682	15824.50	11556.58	4267.92	
May 30-									
Oct 3	127	1.52	4.87	2.570	2.30	8007.88	4269.27	3738.61	

*See next page, following this table.

Steer Number 596- Full Fed Steer.

May 30-									
Jun 24	26	4.25	2.36	.93	1.43	3832.36	1529.16	2303.20	
Jun 25-									
Jul 24	30	3.47	4.12	1.39	2.73	6738.54	2247.20	4491.34	
Jul 25-									
Aug 23	30	2.18	6.53	2.47	4.06	10743.05	4070.25	6672.80	
Aug 24-									
Oct 3	<u>41</u>	<u>2.75</u>	<u>5.48</u>	<u>2.20</u>	<u>3.28</u>	<u>9019.32</u>	<u>3633.98</u>	<u>5385.34</u>	
May 30-									
Oct 3,	127	3.08	4.42	1.67	2.75	7246.30	2749.17	4497.13	

Explanatory notes concerning the above table.

*In studying these tables we note that 590 and 598 behave somewhat abnormally in the period from August 24th to October 3rd, 1908. During this time these steers did not make as large gains as in the previous periods because their feed was reduced somewhat in order to keep them from gaining more than their schedule allowed them. This would effect the Total grain required per pound of gain, making it greater, and would also materially affect the Maintenance feed per pound gain, which on lessened units of productive material or flesh, makes running expense per unit product higher. The high values of 590 in this period are due to the very small gain in live weight, .02 pounds. This steer also had a slight siege with the pink eye during this time, but it is rather to be doubted that this would affect the results to any appreciable extent. For plotted values of the Actual Daily Grain Consumed and Daily Live weight see Chart 1, following page ²⁴ and Chart 3, following page 24.

With the exception of but one period we note that the cost of gain expressed in Total Grain Consumed Per Pound of Gain becomes greater as the feeding period progresses. The data on the

full fed steer is perhaps the more reliable. On this steer we note that the period of cheap gains was in the first 26 days which is accounted for by the rapid rate of gain made possible most likely because of fill. But even in disregarding the first 26 days we have a very marked increase in the cost of gain thereafter. This is due to the increased Maintenance cost and to the more expensive gain made. The fact then that the cost of gain increases as the feeding period progresses is well founded in these results.

Does the Maintenance Grain Eaten per Pound of Gain increase with the feeding period ? These results show that it does. However, to be perfectly fair in this it would be necessary to have the animals on full feed gain approximately the same every period, but at that it is obvious that the Maintenance cost will mount higher and higher as the live weight of the animal increases. As the Full Fed Steer actually gains less in practice the longer the feeding period progresses it is also perfectly obvious that the Maintenance Feed eaten per pound gain will mount even faster than with the lighter fed animals because of two reasons: (1) Live weight increases faster (2) gain actually becomes less. One of the factors therefore entering into the increased Total Cost per pound of Gain as the feeding period progresses is the increasing Maintenance Cost Factor.

Does it require more productive feed to make a pound of gain in the latter part of the feeding period than at the beginning, or in other words, is the cost of gain, reckoned from the standpoint of productive grain eaten, greater as the feeding period goes on ? This is uniformly shown to be the case in the table above. We should expect the full fed steer to show the greatest

range in cost between the first and the last period. If we discard the last period of 590, which period is abnormal for reasons stated, we find this supposition to be true. The more expensive the product becomes the greater is the cost in making it. The increase put on by the growing steer in stationary condition is probably fairly constant as regards energy value, at least we are safe in saying that he is undoubtedly more constant than the full fed, growing, fattening, and finishing steer of the same age. In the latter case the product becomes very valuable as measured in energy values because of the high calorific value of the added fat and higher relative amount of dry matter which this increase contains. The results tabulated above show plainly enough the marked tendency for the cost of each pound of gain, reckoned on productive feed required, to increase as the period progresses, and as the fattening animals take on a higher finish.

Computing rations by means of energy (fuel) values.

It seems altogether probable that rations might well be computed on an energy basis with a fair degree of accuracy. The Fuel Value Requirement for Maintenance per 1000 pounds live weight seems to be pretty well worked out at about 12000 calories daily, which if supplied in the feed will maintain the animal in so far as energy is concerned. In addition to total fuel value energy however we must have our minimum of protein(digestible) present in the food offered, and which minimum ranges between .5 and .7 pounds daily per 1000 pounds live weight. To compute a ration for mere maintenance then we must needs know these things:

1. Feeds available.
2. Fuel values of the different feeds..

Digestible

3. Minimum of protein necessary or .5 to .7

pounds per 1000 pound live weight daily.

4. That about 12000 Calories Fuel Value Energy is necessary for Maintenance per 1000 pound live weight daily.

Knowing these things it is comparatively simple matter to work out the necessary ration.

In dealing with production of flesh, where the animals gain in live weight, to calculate the necessary ration we must needs know these things:

1. Feeds available.
2. Fuel Values of the different feeds.
3. Nutritive Ratio best suited to the production, whether it be production of growth or production of both growth and fat. In other words use the Nutritive ratio of the Feeding Standards.*
4. That about 12000 Cals. Fuel Value Energy are necessary for Maintenance, without production, per 1000 pounds live weight daily.
5. Fuel Value Energy required in the feed to produce a pound of increase after maintenance is satisfied. This will vary with the sort of production, whether it be production of mere growth, or of growth and fat, or of mostly fat plus some protein** as in the case of so called mature animals.

We have found in this experiment that in the case of the growing steer 590, with practically no

*Henry's "Feeds and Feeding", page 637.

**Missouri Experiment Station, Unpublished Results.

increase in fatness that at the age of 13 to 17 months, he required 3899 Calories Fuel Value of productive feed per pound gain, 598 required 3738 Calories, while 596, ^{at the same time} the fattening steer/needed 4497 Calories. If more data is made available on this subject we can with a fair degree of accuracy estimate the Fuel Energy required per pound of gain at different ages, and in different degrees of fatness. Dr. Armsby has recently published in Farmers' Bulletin 346, "The Computation of Rations for Farm Animals by the Use of Energy Values". In this bulletin he has estimated the energy values of the increase put on by animals of different ages, which estimates compare almost identically to those worked out in this single experiment.

6. The Bulk necessary and the proportion of roughness to concentrates will work themselves out in practice. Feeding standards may be a help but cannot replace experience in these matters.

In practice the working out of a ration by means of energy values may not prove a great success, but in theory the possibility of such a method of procedure looks not only plausible but actually possible. And even though this method of computation is not put into practice by feeders generally it is well for the investigator in Animal Nutrition that he know the possibilities and limits of the method.

Calorific Cost of each Pound of Increase on Steers of Different Degrees of Fatness.

If we should be able to burn in a calorimeter the increase

put on by a steer which is gaining in live weight it would be a simple matter to determine the calorific value of each pound of increase. As this is not possible we have to resort to other methods of procedure: (a) Knowing the productive energy value of the productive feed eaten by an animal and the gain made from this feed we can very easily figure the Calorific Value of each pound of gain by dividing the total "Productive Value" energy of the Productive feed by the total gain. (b) Or we can take a uniform bunch of animals, slaughter a few as checks and determine the number of calories per pound. Feed the others to varying degrees of fatness and slaughter them from time to time, determining the calorific value of the carcasses, and by a differential mathematical process figure out the energy value of each pound increase; (c) Dr. Armsby* figured out some of Lawe's and Gilbert's results with pigs and found that 3052 calories were represented in each pound of increase. In some calorimeter work with cattle** he computed that each pound of increase or decrease represented 406 Calories with a Timothy fed steer, 750 Calories when Clover hay was the ration, and 1757 Calories on a Clover hay and Corn Meal feed. The above figures are derived from published data.*** These perhaps represent the truth of these experiments. At best however there is no one value which will suffice for all conditions because of the great variance with

*Letter of July 1st, 1907 to Director H. J. Waters, Missouri Experiment Station.

**Letter of December 10th, 1907 to Director H. J. Waters, Missouri Experiment Station

***See Bulletins 51, 74, and 101. Bureau of Animal Industry, Washington, D. C., By Henry P. Armsby and J. August Fries.

which such factors as condition, age, and so forth affect the composition and the quality of the increase.

Figured under method (a) the three steers in this experiment show the value of the gain put on ^{by} them in the 127 days Feeding Period to run as follows:

Calorific Cost of Each pound of Increase on Steers of different Degrees of Fatness.

Steer 590, Quarter Full Fed, Uniform Growth, ^{very} little fat, 2412.95 Cals
 Steer 598, Half Full Fed, Uniform Growth, Some fat, 2314.45 "
 Steer 596, Full Fed, Uniform Growth, Maximum fat for age, 2783.89 "

That the value of the increase is affected very materially by the degree of fatness is well evidenced by studying the record of the full fed, maximum, fattening steer, 596, and half fed, medium, fattening steer 598. The Calorific value of Each pound of Increase by periods follows:

Calorific Value of Each Pound of Increase as affected by Relative Condition.

Periods 1908.	Length	Steer 596 (Full Fed)	Steer 598 (Half Full Fed)
May 30 to June 24	26 Days	1431.89 Calories.	1914.67 Calories
June 25 to July 24	30 "	2786.05 "	2388.72 "
July 25 to August 23	30 "	4124.51 "	2430.10 "
August 24 to Oct 3	41 "	<u>3328.43</u> "	<u>2638.80</u> "

Average for entire

Period- May 30- 127 Days 2783.89 Calories 2314.45 Calories.
 Oct 3, 1908.

In Steer 596, Full Fed

Condition increased from Medium minus to Good to Choice in this period, or nine fifths grades.

In Steer 598, Half Full Fed,

Condition increased from Common minus to Common to Medium in this period, or four fifths of a grade.

ENERGY VALUE OF NORMAL GROWTH. ESTIMATES OF DR. ARMSBY COMPARED TO ACTUAL EXPERIMENTAL RESULTS.

Dr. Armsby^{*} estimates the energy value of one pound of gain in live weight, that is for normal growth with no considerable fattening, in growing cattle to be as follows:

Age	Energy Value.
Months	Therms.**
3.	1.50
6.	1.75
12.	2.00
18.	2.50
24.	2.75
30.	3.00

*Farmer's Bulletin Number 346, page 17.

**One therm is equivalent to 1000 Calories.

Steer 590 would come under this estimate at from 14 to 18 months of age or an average age of 16 months, the age during the feeding period. According to these estimates he would require about 2330 Calories per pound gain. Really he requires 2413 "Productive Value" Calories or 83 more than the estimate. This is easily within the limits of experimental error, in fact it is remarkable that the estimate and the experimental results should check so closely. The average of the three steers for each pound of gain, energy value, is 2503.76 Calories. However, it is hardly fair to add in 596 because he is fattening considerably. The average of 590 and 598 is 2363.7 Calories, but they will likewise average only 14 1/2 months of age throughout the feeding time. According to Dr. Armsby's figures about 2200 Calories would be the energy value of this

gain. It must be remembered however that the energy value of 598's gain is above that of normal growth as he fattened considerably..

The estimates and the actual experimental results check remarkably close. Dr. H. P. Armsby in commenting upon the close agreement between these figures and the estimates made ~~by~~ him said, *
"The agreement between your figures for growth requirement and those which I estimated in Farmers' Bulletin Number 346 is almost startling. I presume that the close agreement is more or less accidental, but I am very glad to have my estimates confirmed in this way. . . . Of course, the Calories required for each pound of gain are bound to increase, both with advance in age and an increase in fatness on account of the greater energy content of the gain. Your figures are an interesting contribution to this phase of the question also".

THE SECOND MAINTENANCE PERIOD. Following Feeding Period, and beginning October 4, 1908 to (Not Yet completed, May 1909).

This Second Maintenance Period began immediately after The Feeding Period ended, in fact it directly followed it. The hope was to introduce this Second Maintenance Period in order to get a line on the increased cost of Maintenance due to the putting on of varying amounts of gain, 87 pounds for 590, 192 pounds for 598, and 392 pounds for 596. The condition of the animals had changed also from the condition at the end of the First Maintenance Period, and it was hoped that some data on the Influence of Condition upon the Cost of Maintenance might be secured. However, after getting into the problem we find that the Second Maintenance Cost is complicated by the great influencing factor of "Effect of Previous Treatment".

* Letter of April 16th, 1909 written to the author.

Hence the data which we hoped to get is not available at the date this thesis is written, May 1, 1909.

In order to determine the cost of Maintenance due to change in Condition or increase in live weight it would be best to compare Maintenance periods run in the same season of the year, in this manner doing away, as much as possible, with the exerting influence of the Season... Hence in order to compare the Second Maintenance Period with the First it would be better to compare the Maintenance of April and May, 1909 with the corresponding period of April and May 1908. A factor is now being determined on the three steers for this period, but it is not available for this thesis. The Effect of Previous treatment upon the Cost of Maintenance has practically worn off, and the animals are now all on a Normal Nutritive Maintenance plane, which will insure the results of the First and the Second Maintenance period being comparable.

The records of the steers 590, 598, and 596 in the Second Maintenance Period, to date, follow:

SECOND MAINTENANCE PERIOD RECORD TO DATE. INCOMPLETE.

Steer Number 590, Following Quarter Full Feeding Period of
127 Days (May 30- October 3, 1908 inclusive).

Period Date, 1908	Oct 4- Oct 22.	Oct 23- Nov 21.	Nov 22- Dec 21.	Dec 22- Jan 20.	1909 Jan 21- Feb 19.	Feb 20- Mar 21.	Mar 22- Apr 20
Period Length Days. . .	19	30	30	30	30	30	30
Initial Weight	705.1	714.3	704.2	713.1	710.8	699.8	711.7
Final Weight	714.3	704.2	713.1	710.8	699.8	711.7	710.9
Average of all Daily Weights in the Period...	712.5	706.27	698.47	706.53	708.20	710.60	713.4
Total Gain or Loss in Live Weight...	9.20	-10.10	8.90	-2.30	-11.00	11.9	- .8
Daily Gain or Loss in Live Weight...	.48	-.34	.30	-.08	-.37	.397	-.02 ¹
Total Grain Con- sumed in period...	101.62	153.58	159.00	155.68	153.06	147.31	134.38
Total Hay Con- sumed in period...	40.69	61.87	64.00	62.56	60.75	58.82	53.63
Average Daily Grain Eaten in Period...	5.35	5.12	5.30	5.19	5.10	4.91	4.48
Average Daily Hay Eaten in Period...	2.14	2.06	2.13	2.09	2.03	1.96	1.79
Average Daily Grain Eaten per 1000 pounds Live Weight...	7.51	7.25	7.59	7.35	7.20	6.91	6.28
Average Daily Hay Eaten per 1000 pound Live Weight...	3.00	2.91	3.05	2.96	2.86	2.48	2.51

SECOND MAINTENANCE PERIOD RECORD TO DATE. INCOMPLETE.

Steer Number 598, Following Half Full Feeding Period of 127

Days (May 30- October 3, 1908 inclusive).

Period Date, 1908	1909					
	Oct 4- Oct 22.	Oct 23- Nov 21.	Nov 22- Dec 21.	Dec 22- Jan 20.	Jan 21- Feb 19.	Feb 20 Mar 21. Apr 20
Period Length	19	30	30	30	30	30
Initial Weight	663.5	660.7	657.9	682.3	668.7	659.9 672.2
Final Weight	660.7	657.9	682.3	668.7	659.9	672.2 658.6
Average of all Daily Weights in the Period...	664.8	655.6	667.97	669.8	666.13	678.83 669.6
Total Gain or Loss in Live Weight	-2.80	-2.80	24.40	-13.60	-8.80	12.30 -13.6
Daily Gain or Loss in Live Weight	-.15	-.09	.81	-.45	-.29	.41 - .45
Total Grain Con- sumed in Period	101.04	158.00	160.75	150.37	147.93	135.13 120.39
Total Hay Con- sumed in period	40.48	63.89	63.75	60.00	58.88	53.76 48.57
Average Daily Grain Eaten in Period.	5.32	5.27	5.36	5.01	4.93	4.50 4.01
Average Daily Hay Eaten in Period...	2.13	2.13	2.13	2.00	1.96	1.79 1.62
Average Daily Grain Eaten Per 1000 pounds Live Weight	8.00	8.04	8.02	7.48	7.40	6.63 5.99
Average Daily Hay Eaten Per 1000 Pounds Live Weight	3.20	3.25	3.18	2.98	2.94	2.64 2.42

SECOND MAINTENANCE PERIOD RECORD TO DATE. INCOMPLETE

Steer Number 596, Following Full Feeding Period of 127

Days (May 30- October 3, 1908 inclusive).

Period Date, 1908	Oct 4- Oct 22	Oct 23- Nov 21.	Nov 22- Dec 21.	1909 Dec 22- Jan 20.	Jan 21- Feb 19.	Feb 20- Mar 21.	Mar 22 Apr 20
Period Length Days...	19	30	30	30	30	30	30
Initial Weight	858.70	837.60	859.60	886.20	878.70	860.10	868.80
Final Weight	837.6	859.60	886.20	878.70	860.10	868.80	854.2
Average of all Daily Weights in the Period.	854.50	852.77	866.73	883.06	874.47	867.43	855.7
Total Gain or Loss in Live Weight..	21.10	22.00	26.60	-7.50	-18.60	8.70	-14.6
Daily Gain or Loss in Live Weight	-1.11	.73	.89	-.25	-.62	.29	- .48
Total Grain Con- sumed in Period...	169.89	249.88	234.13	203.14	182.88	152.75	159.44
Total Hay Con- sumed in Period	67.56	99.60	93.25	80.57	73.44	60.70	63.62
Average Daily Grain Eaten In Period	8.94	8.33	7.80	6.77	6.10	5.09	5.31
Average Daily Hay Eaten in Period...	3.56	3.32	3.11	2.69	2.45	2.02	2.12
Average Daily Grain Eaten Per 1000 pound Live Weight	10.46	9.77	9.00	7.67	6.97	5.87	6.21
Average Daily Hay Eaten Per 1000 Pound Live Weight	4.16	3.89	3.59	3.05	2.80	2.33	2.48

Preliminary Second Maintenance Record.

Period 1908-09	Steer 590 Oct 4, '08- Jan. 31, '09 Following Quar- ter Full Feed- ing Period of 127 Days	Steer 598 Oct 4, '08- Jan 30, '09 Following Half Feeding Period of 127 Days.	Steer 596 Oct 4, '08- Jan. 30, '09 Following Full Feeding Period of 127 Days.
Previous Treat ment...			
Period Length	120	119	119
Initial Weight	705.10	663.50	858.70
Final Weight	704.90	660.10	860.10
Average of All Daily Weights in Period...	706.06	665.41	866.59
Total Gain or Loss in Live Weight	-.20	-3.40	1.40
Daily Gain or Loss in Live Weight	-.0016	-.029	.012
Total Grain Consumed in Period	626.76	620.09	931.79
Total Hay Consumed in Period...	251.87	248.00	366.73
Daily Grain Eaten in Period...	5.22	5.21	7.83
Daily Hay Eaten in Period...	2.10	2.08	3.08
Average Daily Grain Eaten per 1000 pound Live Weight	7.39	7.83	9.03
Average Daily Hay Eaten per 1000 pound Live Weight	2.97	3.13	3.55

Is the Cost of Maintenance Influenced by the Plane of Nutrition upon which the Animal has been previously kept ?

Does the manner in which cattle are handled previously to being put on Maintenance effect to any appreciable degree the Maintenance Cost ? Those who have had experience in bringing cattle on to a maintenance plane know that some cattle are much more easily brought to a constant live weight and kept there than others. Practical cattle feeders know that cattle full fed in the winter time on grain and hay graze poorly and sometime even lose considerable in weight for two or three months after turning to pasture, but that thin cattle, scantily wintered, graze well, and gain abundantly. Here the effects of previous treatment is plainly evident.

The effect of varying degrees of feeding: quarter full feeding, half full feeding, and full feeding, upon the subsequent Maintenance cost is plainly demonstrated in this investigation. In the transition from the feeding period to Maintenance we find that the greater is the transition in the plane of nourishment the greater is the cost of the transition. The Transition from different degrees of Feeding to Maintenance is shown as per the following table:

Transition from a Higher to a Lower Plane of Nutrition.

Steer 590	Steer 598	Steer 596
One Quarter Full Fed	One Half Full Fed	Full Fed.

(All Data in Pounds- Grain).

Grain Required per 1000 pounds live weight. First Maintenance Period, April and May, 1908. Maintenance Cost..

7.49	6.68	7.53

Grain Eaten per 1000 pounds Live Weight during the Feeding Period, May 30 to October 3, 1908.

9.89	12.67	19.99

Total Gain made in Feeding Period from May 30, 1908, to October 3, 1908...

87.00	192.00	392.00

Grain Required per 1000 pounds Live Weight. Preliminary Second Maintenance Period. October 1908 to February 1909. Maintenance Cost.

7.39	7.83	9.03

Difference in the Maintenance Cost per 1000 pounds Live Weight Daily between the First Maintenance and the Preliminary Second Maintenance Periods, or the cost of Transition from the Feeding to the Maintenance period.

-.10	1.15	1.50

Proportion of Grain to Hay Constant 5 : 2 by Weight.

Discussion of Results. Transition Cost.

It took 1.50 pounds more of grain with the corresponding amount of hay to maintain the full fed steer during the Preliminary Second Maintenance Period than during the First Maintenance trial. The Half full fed steer required more for the Second Maintenance Period than for the First, or 1.15 pounds in excess of the first in order to keep the live weight constant. This is not as much in excess by .55 pounds as the full fed steer required over the First Maintenance trial. The steer not so heavily pushed as full feeding but only half full fed maintains cheaper by .35 pounds (1.50 - 1.15) daily per 1000 pounds live weight. The cost of the Transition is .35 pounds less per 1000 pounds live weight daily. The Quarter full fed steer Maintains for practically the same during the Second as the First Maintenance Period, or to be exact .10 pounds less per 1000 pounds live weight daily. According to these figures the Quarter fed steer makes the transition not only more economically by

1.25 (.10 plus 1.15) pounds per 1000 pounds live weight daily than the half fed steer, but with marked economy over the full fed steer or with a saving of 1.60 pounds (.10 plus 1.50) per 1000 pounds live weight.. For graphic illustration by ten day averages of the gradual readjustment of these three steers to the Maintenance ration see Chart 2, Following page 24, of Grain Eaten Daily per 1000 Pounds Live weight and Chart 3, following page²⁴₆ of Average Daily Live Weight, by 10 day periods. Note how the full fed steer 596 slowly readjusts himself to his new plane of Nutrition, the maintenance plane, gradually requiring less and less feed to maintain his live weight constant.

An animal put on Maintenance from full feed requires much more food per unit weight than one put on maintenance from a condition of less than full feeding. In other words, according to this, a starving animal could be brought on to a Maintenance ration much more economically than a full fed one. The Cost of Transition is greater the more marked the decline between the previous and subsequent planes of nutrition.

These facts have a somewhat practical bearing in the turning of full fed cattle to grass, indicating that a loss will follow a severe change, but that thin and scantily fed hay cattle will graze well from the start. Full fed, fat, cattle when first turned to grass have a high maintenance cost, and cannot eat enough of the succulent, bulky, grass to maintain themselves, ^{at} times losing considerably in live weight for the first two or three months after being turned to grass. Their capacity is perhaps not readily increased because of the fatness, and it is even possible that the capacity

is actually smaller in the concentrate fed as compared with the hay fed cattle. On the other hand the thin, scantily fed, hay cattle are maintaining as cheaply on grass as in the stall, and the change of ration, and difference in the plane of nutrition not being so great, all this combined with a fair capacity there is not a loss but a marked gain in live weight after turning to grass. They have ample capacity and keen enough appetite to eat sufficient grass not only to satisfy the Maintenance Cost Requirement but also to leave a sufficient balance of productive grass to insure rapid gains.

Just why a steer on full feed should require a longer and more expensive transition period when brought on to the maintenance plane than does the less fed steer is hard to satisfactorily explain. However, the following suggestions are offered for what they are worth:

1. The full fed steer has more or less fill, which fill on a Maintenance ration gradually becomes less and less, which means that the animal is slowly losing fill and it is obvious that in order to keep his live weight constant this fill must be replaced by tissue. This tissue is somewhat expensive to make, and necessitates food over and above true Maintenance. The plotted measurements of paunch as seen in charts 24(Depth), 25 (Width), and 26 (Girth), Part II of this thesis, show that the Girth and Width of Paunch decreases markedly on Maintenance, which means perhaps a loss of fill.

2. The Full fed animal becomes accustomed, under high pressure, to the wasting of food. He probably does not digest as thoroughly as do the lighter fed steers. The habit of wasting food becomes more or less fixed with him, and as a result, for a long time after being put on maintenance this wasting of feed continues. Eventually, however, the animal readjusts himself to a more economical plane, more in keeping with the necessities of the maintenance ration.
3. Digestion is perhaps better with a very light than with either a medium or heavy fed animal.

Pictures of the Steers Throughout the Experiment, with Accompanying Notes.

The comparable* photographs which follow show very clearly the change undergone by the Steers during this experiment. The scale upon which these pictures are made is shown on pages 77, 79, 83, 89, and 91 by the upright Measuring Standard Graduated in feet and tenths of feet. By the use of this scale one can approximate surprisingly close some of the measurements taken. These pictures are arranged chronologically by Steers.

*For Description of the System used in securing these comparable photographs See page 12.

PHOTOS BY THE AUTHOR

STEER 595

FEBRUARY 15 1908

BEGINNING OF A MAINTENANCE PERIOD OF 362 DAYS

FEBRUARY 26 1908 TO FEBRUARY 21 1909

AVERAGE WEIGHT:-595.6 POUNDS

HEIGHT AT WITHERS:-110 CM

CONDITION:-MEDIUM

PHOTOS BY THE ARMOR

STEER 595
 AUGUST 30 1908
 AFTER 6 MONTHS OF MAINTENANCE
 AVERAGE WEIGHT:- 6209 POUNDS.
 HEIGHT AT WITHERS:- 117.5 CM.
 CONDITION:- INFERIOR PLUS.

FRONT VIEW
NEGATIVE
ACCIDENTALLY
DESTROYED

PHOTOS BY THE AUTHOR

STEER 595
FEBRUARY 20 1909
AFTER 12 MONTHS OF MAINTENANCE
AVERAGE WEIGHT: 598.9 POUNDS.
HEIGHT AT WITHERS: 120 CM.
CONDITION: VERY THIN PLUS.

PHOTOS BY THE AUTHOR

STEER 590
 FEBRUARY 29 1908
 END OF PRELIMINARY FEEDING PERIOD
 AND
 BEGINNING OF SUB-MAINTENANCE PERIOD
 AVERAGE WEIGHT: 646.9 POUNDS
 HEIGHT AT WITHERS: 113 CM

PHOTOS BY THE AUTHOR

STEER 590

MARCH 28 1908

END OF SUB-MAINTENANCE PERIOD
AND

BEGINNING OF FIRST MAINTENANCE PERIOD
AVERAGE WEIGHT :- 608.5 POUNDS
HEIGHT AT WITHERS :- 118.5 CM
CONDITION :- COMMON MINUS

STEER 590

MAY 25 1908

END OF FIRST MAINTENANCE PERIOD

AND

BEGINNING OF QUARTER FULL FEEDING PERIOD

AVERAGE HEIGHT: 61.6.9 POUNDS

PHOTOS BY THE AUTHOR

Page 71
77
w/ Bunting
Sinter

PHOTOS BY THE AUTHOR

STEER 590

OCTOBER 3 1908

END OF QUARTER FULL FEEDING PERIOD
AND

BEGINNING OF SECOND MAINTENANCE PERIOD

AVERAGE WEIGHT: 705.1 POUNDS

HEIGHT AT WITHERS: 127 CM

CONDITION: COMMON MINUS

FRONT VIEW NOT TAKEN

PHOTOS BY THE AUTHOR

STEER 590

FEBRUARY 20 1909

AFTER 140 DAYS OF MAINTENANCE SECOND MAINTENANCE PERIOD

AVERAGE WEIGHT 699.8 POUNDS

HEIGHT AT WITHERS 130.5 CM

CONDITION INFERIOR

PHOTO BY THE AUTHOR

STEER 590

APRIL 24 1909

AFTER 203 DAYS OF MAINTENANCE - SECOND MAINTENANCE PERIOD
 AVERAGE WEIGHT:- 709.7 POUNDS
 HEIGHT AT WITHERS:- 131 CM
 CONDITION THIN

PHOTOS BY THE AUTHOR

STEER 598

FEBRUARY 29 1908

END OF PRELIMINARY FEEDING PERIOD
AND

BEGINNING OF SUB-MAINTENANCE PERIOD

AVERAGE WEIGHT: 489 POUNDS

HEIGHT AT WITHERS: 106 CM

CONDITION: COMMON PLUS

PHOTOS BY THE AUTHOR

STEER 598

MARCH 28 1908

END OF SUB-MAINTENANCE PERIOD

AND

BEGINNING OF FIRST MAINTENANCE PERIOD

AVERAGE WEIGHT:- 464.7 POUNDS

HEIGHT AT WITHERS:- 107.0 CM.

CONDITION:- COMMON

PHOTOS BY THE AUTHOR

STEER 598

MAY 25 1908

END OF FIRST MAINTENANCE PERIOD

AND

BEGINNING OF HALF FULL FEEDING PERIOD

AVERAGE WEIGHT: 469.1 POUNDS

HEIGHT AT WITHERS: 108.5 CM.

CONDITION: - COMMON MINUS

PHOTOS BY THE AUTHOR

STEER 598
 OCTOBER 3 1908
 END OF HALF FULL FEEDING PERIOD
 AND
 BEGINNING OF SECOND MAINTENANCE PERIOD
 AVERAGE WEIGHT: 663.5 POUNDS
 HEIGHT AT WITHERS: 118 CM
 CONDITION: COMMON TO MEDIUM

PHOTOS BY THE AUTHOR

STEER 598

FEBRUARY 20 1909

AFTER 140 DAYS OF MAINTENANCE - SECOND MAINTENANCE PERIOD

AVERAGE WEIGHT: 659.9 POUNDS

HEIGHT AT WITHERS: 122 CM

CONDITION: COMMON

PHOTOS BY THE AUTHOR

STEER 598

APRIL 24 1909

AFTER 203 DAYS OF MAINTENANCE - SECOND MAINTENANCE PERIOD
 AVERAGE WEIGHT:- 659.9 POUNDS
 HEIGHT AT WITHERS:- 122.5 C.M.
 CONDITION:- COMMON MINUS.

PHOTOS BY THE AUTHOR

STEER 596

FEBRUARY 29 1908

END OF PRELIMINARY FEEDING PERIOD
AND

BEGINNING OF SUB-MAINTENANCE PERIOD
AVERAGE WEIGHT:- 509.6 POUNDS
HEIGHT AT WITHERS:- 105.5 CM
CONDITION:- GOOD MINUS

PHOTOS BY THE AUTHOR

STEER 596

MARCH 28 1908

END OF SUB-MAINTENANCE PERIOD
AND
BEGINNING OF FIRST MAINTENANCE PERIOD
AVERAGE WEIGHT: 469.2 POUNDS
HEIGHT AT WITHERS: 106.5 CM
CONDITION GOOD TO MEDIUM PLUS

PHOTOS BY THE AUTHOR

STEER 596

MAY 25 1908

END OF FIRST MAINTENANCE PERIOD
AND

BEGINNING OF FULL FEEDING PERIOD

AVERAGE HEIGHT: 465.7 POUNDS

HEIGHT AT WITHERS: 109 CM

CONDITION: MEDIUM MINUS

PHOTOS BY THE AUTHOR

STEER 596
OCTOBER 3 1908
END OF FULL FEEDING PERIOD
AND
BEGINNING OF SECOND MAINTENANCE PERIOD
AVERAGE WEIGHT:- 858.7 POUNDS
HEIGHT AT WITHERS:- 119.5 CM
CONDITION:- GOOD TO CHOICE

PHOTOS BY THE AUTHOR

STEER 596

FEBRUARY 20 1909

AFTER 140 DAYS OF MAINTENANCE-SECOND MAINTENANCE PERIOD

AVERAGE WEIGHT:-858.7 POUNDS

HEIGHT AT WITHERS:- 121.75 CM

CONDITION:- GOOD PLUS

PHOTOS BY THE AUTHOR

STEER 596

APRIL 24 1909

AFTER 203 DAYS OF MAINTENANCE - SECOND MAINTENANCE PERIOD

AVERAGE WEIGHT :- 858.8 POUNDS

HEIGHT AT WITHERS :- 123 CM

CONDITION :- GOOD

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PART II.

THE GROWTH OF YOUNG CATTLE AS AFFECTED BY THE PLANE OF NUTRITION.

GENERAL COMMENTS ON WORK DONE BY OTHER INVESTIGATORS.

In looking up the literature* on the growth of cattle one is impressed with the meagerness of the work done. The growth of identical animals under definitely known treatment has been little studied. In but two instances** has the writer been able to find any work reported showing the growth of identical animals under different systems of treatment. The Germans have done considerable work on measuring cattle but the animals measured have been miscellaneously selected generally, and the same animal is usually measured but once. If animals were measured successively it was the result of a "happen so" or accident. The show type of animal has been studied for the major part. In nearly all of this measuring work reported to date but a vague general idea is given of the previous treatment accorded the animals. In so far as the growth of individual cattle is concerned but little has been done, and what has been reported covers but a small part of the animal's life cycle. The deductions are mostly drawn the development, not of individuals, but of the race. But very little of the reported work on growth bears directly upon the problems of this investigation.

*See Bibliography of Measurements pages 133-135.

** "Capacity of Animals to Grow Under Adverse Conditions", By Director H. J. Waters, of the Missouri Experiment Station. S. P. A. S. Report, 1908.

** "The Development of Grade and Cross Bred Beef Cattle", By John R. Fain, and Milton P. Jarnagin, Bulletin 171, Virginia Agricultural Experiment Station. 1907.

SYSTEM OF MEASUREMENTS IN THIS INVESTIGATION.

Monthly measurements were taken of the animals whose complete feeding records are discussed in PART I of this thesis. The principal object of the measurements was to determine the influence of the quantity of the ration fed upon the relative rate of growth and change of form in cattle.

The measurements reveal many interesting studies. In order that they may be easily understood they are all plotted on Cross Section Millimeter paper to an actual scale. The Measurements are, in the order of their arrangement, presented in Chart form as follows:

Description of the Measurement taken and plotted.

Chart Number	The Measurement.
5	Live Weight on Measurement Days.
6	Height at Withers.
7	Height at Point Midway between Hips.
8	Length of Foreleg- Elbow to Ground.
9	Length from Point of Shoulder to Ground.
10	Length from Point of Hock to Ground.
11	Length from Poll to Point of Muzzle.
12	Length of Face- Line between Eyes to Muzzle Point.
13	Width of Jaws. (From Outside).
14	Width of Forehead.
15	Width of Hips.
16	From Top Point of Hip to End of Ischium.
17	Width of Loin.
18	Circumference of Right Thigh.

Description of the Measurement taken and plotted (continued).

19	Height of Hind Flank.
20	Girth of Throat Latch just Back of Jaws.
21	Depth of Chest Just Behind Elbow Joint.
22	Width of Chest just Behind Elbow Joint.
23	Heart Girth (Chest) just Behind Elbow Joint.
24	Depth of Paunch at End of Last Rib.
25	Width of Paunch at End of Last Rib.
26	Girth of Paunch at End of Last Rib.
27	Girth of Hind Flank.
28	Circumference of Right Horn at Base.
29	Length of Right Horn from Base.

The Measurement Points are Graphically Illustrated on pages 99, 100, and 101. A careful study of these pictures will show just exactly where each measurement is made.

MEASURING A STEER WITH TAPE LINE AND STANDARDS

PHOTOS BY THE AUTHOR

STEER IS KEPT IN POSITION BY THE MAN AT ITS HEAD
 HEIGHT AT WITHERS IS BEING TAKEN WITH THE UPRIGHT STANDARD BY THE MAN ON THE LEFT
 GIRTH OF PAUNCH AT END OF LAST RIB IS BEING DETERMINED BY THE MAN WITH THE TAPE
 WIDTH OF HIPS IS MEASURED WITH THE SMALL STANDARD MANIPULATED BY THE MAN TO THE REAR OF THE STEER
 THE LEVEL PLATFORM UPON WHICH THE STEER STANDS IS AN ESSENTIAL AND NECESSARY PART
 OF THE MEASURING APPARATUS.

NOTE:- The large figured standard on right is a photographic standard of measurement; the wheel with projecting pins; seen on left, is used in determining cross section forms of animals at heart, paunch and flank girths.

MEASUREMENT POINTS GRAPHICALLY ILLUSTRATED

STEER 596 (SIDE VIEW) SHOWING MEASUREMENT POINTS:-

1. LENGTH FROM POINT OF HOCK TO GROUND.
2. CIRCUMFERENCE OF RIGHT THIGH.
3. FROM TOP POINT OF HIP TO END OF ISCHIUM.
4. HEIGHT OF HIND FLANK.
5. GIRTH OF HIND FLANK.
6. HEIGHT AT POINT MIDWAY BETWEEN TOP HIP POINTS.
7. WIDTH OF LOIN - JUST IN FRONT OF HIP POINTS.
8. GIRTH, WIDTH, AND DEPTH OF PAUNCH AT END OF LAST RIB.
9. GIRTH, WIDTH AND DEPTH OF PAUNCH (AT HEART) JUST BEHIND ELBOW JOINT.
10. HEIGHT AT WITHERS.
11. GIRTH OF THROAT LATCH JUST BACK OF JAWS
12. WIDTH OF JAWS (FROM OUTSIDE) (Dotted green line shows position of measuring standard on right side of jaws.)
13. LENGTH FROM POLE TO POINT OF MUZZLE

N.B.:- Note that this steer is standing on the ground — all measurements however were made with the steer standing on a level wooden platform

MEASUREMENT POINTS GRAPHICALLY ILLUSTRATED

SKELETON OF HEREFORD BULL CORRECTOR (REAR VIEW)
SHOWING MEASUREMENT POINTS:-

- (1) WIDTH OF HIPS
- (2) LENGTH FROM POINT OF HOCK TO GROUND

HEAD OF 596 (FRONT VIEW)
SHOWING MEASUREMENT POINTS:-

- (1) LENGTH OF HORN FROM BASE
- (2) CIRCUMFERENCE OF HORN AT BASE
- (3) WIDTH OF FOREHEAD
- (4) LENGTH OF FACE - LINE BETWEEN EYES TO MUZZLE POINT

MEASUREMENT POINTS GRAPHICALLY ILLUSTRATED

SKELETON OF HEREFORD BULL CORRECTOR (SIDE VIEW) SHOWING
MEASUREMENT POINTS:-

1. LENGTH FROM POINT OF HOCK TO GROUND
2. FROM TOP POINT OF HIP TO END OF ISCHIUM
3. LENGTH OF FORELEG - ELBOW TO GROUND
4. HEIGHT AT WITHERS
5. LENGTH FROM POINT OF SHOULDER TO GROUND

A STUDY OF THIS SKELETON IN CONNECTION WITH THE MEASUREMENT
CHARTS WILL PROVE HELPFUL

Classification of the Measurements Taken.

All of these Plotted Measurements can be fairly well divided into groups or classes as follows:

(a) Skeletal Measurements which are not complicated with an appreciable amount of flesh. They show skeletal growth. In this class would fall:

Length of foreleg- Elbow to Ground. (Chart 8).

Length from Poll to Point of Muzzle (Chart 11).

Length of Face- Line between Eyes to Muzzle Point.

(Chart 12).

Width of Hips. (Chart 15).

Circumference of Horn at Base. (Chart 28).

Length of Horn from Base. (Chart 29).

(b) Skeletal and Flesh measurements, or those skeletal Measurements affected materially by flesh or fat. We have in this class:

Height at Withers*. (Chart 6).

Height at Point Midway between Hips* (Chart 7).

Length from Point of Hock to Ground. (Chart 10).

Width of Jaws. (From Outside). (Chart 13).

Width of Forehead*. (Chart 14).

From top point of Hip to end of Ischium*. (Chart 16).

Depth of Chest. Just behind Elbow Joint. (Chart 21).

Width of Chest- Just Behind Elbow Joint. (Chart 22).

Heart (Chest) Girth- Just behind Elbow Joint. (Chart 23).

(c) Flesh Measurements Purely. Indicate relative condition somewhat. Here we place:

Width of Loin. (Chart 17).

* Affected materially only in very fat animals.

Circumference of Right Thigh. (Chart 18).

Height of Hind Flank. (Chart 19).

Girth of Throat Latch- Just back of Jaws. (Chart 20).

(d) General or Miscellaneous Measurements. Not falling into any of the above three classes. These are:

Length from Point of Shoulder to Ground.* (Chart 9).

Depth of Paunch at End of Last Rib. (Chart 24).

Width of Paunch at End of Last Rib. (Chart 25).

Girth of Paunch at End of Last Rib. (Chart 26)

Girth of Hind Flank. (Chart 27).

*Not complicated by flesh. See discussion of this Measurement pages 112 - 114.

Some Problems dealing with the Growth and Measurement of Animals.

Some of the questions which arise as one studies the growth of animals are as follows:

1. Does the mere quantity of the ration affect the growth materially ?

2. Do animals develop relatively different in their various parts merely because of a difference in the quantity of the feed supplied ?

3. What Measurements indicate relative fattening ?

4. What measurements are a true measure of bone growth ?

5. Can we widen the animal, relatively speaking, by liberal feeding ?

6. What conditions hasten growth ?

7. What effect does the severe cutting down in the quantity of the ration have upon the form of the animal ?

8. Is there a residual effect upon growth following full feeding as compared to a less degree of feeding ?

A study of these plotted measurement Charts will throw some light on these questions.

WHAT THE MEASUREMENTS SHOW.

DISCUSSION OF RESULTS.

Relation between the Withers Height Growth and Foreleg Length Growth as affected by Relative Nutrition.

In the first 90 days of the Experiment the animals on the Experiment all practically grew the same in Height at Withers. (Chart 6). After this time marked differences in the rate of growth are noticeable. The Maintenance check animal falls behind gradually, but, nevertheless, persists in growing some, especially in leg. There is little, if any, difference between the withers growth of the full fed and the half fed animals. The quarter fed steer falls but a couple centimeters below the full fed one, which slight falling off in growth is not what one would ordinarily expect. During the feeding period about half of the increase at withers is due to the increase in the foreleg. The following table shows the relative growth in length of foreleg as compared to total growth at withers:

TABLE A.

Influence of Plane of Nutrition upon the Relation between Foreleg Length Growth and Withers Height Growth.

Steer Number.	Increase at Withers During the Feeding Period (June 30- October 3, 1908) 127 Days.	Increase in Length of Foreleg during the same Period, (June 30- Oct 3, 1908) 127 Days.	Foreleg Growth is what percent of the Total Height Growth at Withers.
595, Maintenance	3.0 Cm.	3 Cm	100.00%
590, Quarter Full Fed	7.5 "	4 "	53.33%
598, Half Full Fed	9.5 "	5 "	52.62%
596, Full Fed	10.5 "	5 "	47.62%

These figures indicate that animals fed on a high plane of nourishment tend to grow more, proportionally speaking, in body

height than in leg. The Maintenance steer made ^{all} of his growth in foreleg during this period, which growth is perhaps more essential to the preservation of the race than the higher growth of body. In practice we speak of the poorly fed, thin, steer as leggy, and in proportion to the body, this is perhaps the truth of the matter.

In the Second Maintenance Period following the Feeding period we have a comparison between the Growth in Height at Withers and the length of Foreleg as follows:

TABLE B.

Influence of Plane of Nutrition upon the Relation between Foreleg Length Growth and Withers height Growth.

Steer Number.	Increase at Withers During the Second Maintenance Period (Oct 4, '08- Apr 20, '09) 199 Days.	Increase in Foreleg During the same Period, (Oct 4, '08- Apr 20, '09) 199 Days.	Foreleg Growth is what percent of the Total Height Growth.
	Centimeters	Centimeters	Centimeters
595, Continued Maintenance	1	2	200.00%*
590, Maintenance Following Quarter Full Feeding Period.	4	3	75.00%
598, Maintenance Following Half Full Feeding Period.	4.5	2.5	55.55%
596, Maintenance Following Full Feeding Period.	3.5	2.5	71.43%

* A Period of 139 Days.

** It is unfortunate that we do not have the measurement "From the Base of Chest, just behind foreleg, to the Ground". We could, with this measurement, check up the apparent discrepancy noted in these figures. During this period the chest grew 1 Cm. deeper. It does not seem reasonable that a cen-

timeter's depth of flesh should have been resorbed from the top of the withers. It may be within the limits of error, that these figures range, but this is doubtful. The Length from the point of shoulder to ground in this period remained practically stationary, this seemingly indicating a mechanical compensating adjustment of these parts. In other words is it possible that there is an actual lowering of the Chest wall due to the leverage between the Elbow Joint and Shoulder Joint. A study of the Corrector skeleton page 101 will make this clear.

It certainly is entirely possible and altogether probable that with varying size and degrees of fatness of an animal that there is a readjustment* of the skeletal form, especially in the angles between bones making a moveable joint as at ^{the} elbow and shoulder joints.

Our observation of aged people as compared to younger ones, as well as our observations on all sorts of animals in various states of growth, age, and condition, impresses us with the evident changes and readjustment in form.

*See discussion on "Length from Point of Shoulder to the Ground", pages 112 - 114.

Table B plainly shows that the Foreleg Growth is much larger in proportion to the Height at Withers in the Second Maintenance Period than in the Feeding Period. Without exception every steer shows this increased relative foreleg growth, due to a lower plane of nutrition. Summarizing we have this table:

Relation between Withers Height Growth and Foreleg length
Growth in the Feeding and Maintenance Periods.

Foreleg Growth is What PER CENT of the
TOTAL Height Growth at Withers during these
Periods.

Steer Number.	Feeding Period (127- Days), June 30- Oct 3, 1909.	Second Maintenance Period (199 Days), Oct 4, '08- April 20, 1909.
595, Check Maintenance	100.00% (Maintenance)	200.00%* (Maintenance)
590,	53.33% (Quarter Full Fed)	75.00% (Maintenance)
598,	52.62% (Half Full Fed)	55.55% (Maintenance)
596,	47.62% (Full Fed)	71.43% (Maintenance)

* 137 Days.

As the plane of nutrition is lowered there is apparently a well marked tendency for the growth in foreleg as compared to total growth in height to become proportionately greater. In other words the animal persists in growing in foreleg more or less independent of the nutritive plane upon which kept.

These results have practical significance in the fitting of cattle for the show ring. The cattle which win are the low/set short legged, blocky, symmetrical sort. In order to avoid legginess it seems that the thing to do is to feed to the limit from birth. This showmen do for the most part. In this wise they secure a better show ring development, less leg in proportion to body, and a better proportioned animal from the show ring standpoint. The

apparent contradiction to this theory that the system of feeding will help materially to make the animal of show ring type is found in those cattle which have been picked up out of the stalk fields, and successfully fitted for show. Many of our prize winning show steers have been made in this way, if we can believe the men that fitted them. However, this question is still unanswered: What would these same steers have developed into had they been pushed from birth ? All intelligent showmen and fitting herdsmen will tell you that they would have done much better, and most all are of this opinion, that the best show stuff is made by liberal feeding from the start. Of course those animals which are to be shown as calves will be pushed harder than those which are to be shown as yearlings or twos.

CHART 5

1908
Feb 29 - 22 days - Mar 28 ~ 58 days ~
May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 19 days - Oct 22 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - 1909
Jan 22 - 29 days - Feb 19 - 29 days - Mar 20 - 31 days - Apr 20

THE LIVE WEIGHT ON MEASUREMENT DAYS

Scale Horizontal 1mm = 1 day.
Vertical 1mm = 2 lbs.
Ave. of Ten Days. Actual on date.
590
598
596
595

Note: Steers weighed after morning feed and before watering.

590 One Quarter Full Fed
598 One Half Full Fed
596 Full Fed
595 Maintenance Feb 26 '08 to Feb 19 '09

Second Maintenance Proper Period

CHART 6

1908 days Feb 29 - 28 days Mar 28 ~ 58 days ~ May 25 - 30 days June 24 - 30 days July 24 - 29 days Aug 22 - 31 days Sep 22 Oct 13 days Oct 22 - 32 days Nov 23 - 29 days Dec 22 1908 Jan 22 - 29 days Feb 9 - 29 days Mar 20 - 31 days Apr 20

HEIGHT AT WITHERS

Scale Horizontal - 1mm = 1 day
Vertical - Actual.

- 590
- 598
- 596
- 595

590 One Quarter Full Fed
598 One Half Full Fed
596 Full Fed
595 Maintenance Feb 26 '08 to Feb 19 '09

Second Maintenance Proper Period

CHART 7

1908 Feb 9 - 23 days - Feb 28 - 28 days - Mar 28 - 58 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 11 days - Oct 22 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - 1909 Jan 22 - 29 days - Feb 19 - 29 days - Mar 20 - 31 days - Apr 20

HEIGHT AT POINT MIDWAY BETWEEN HIPS

Scale Horizontal - 1 mm = 1 day
Vertical - Actual

590
598
596
595

Correlation between Loss in Body Weight and Increased Bone Growth.

The Stimulation to foreleg Growth, due to a cutting in the feed, so that the animals lose considerably in live weight, is especially well marked. (See Chart 8, Length of Foreleg, Elbow to Ground). The three steers 590, 598, and 596 which lost quite heavily in live weight or from $1\frac{1}{2}$ to $1\frac{1}{3}$ pounds daily during this sub maintenance period show the most marked increase in length of foreleg. Steer 595 did not lose in live weight although he was cut to a Maintenance ration from full feed. He also shows somewhat the effect of the stimulation. It is to be noted that the measurements of February 8, and 29, 1908 are somewhat at variance. More faith is to be placed on the February 29th measurements than on the ones of the 8th of February as the steers were at the latter date measured on ^a somewhat uneven floor, and too the animals were somewhat nervous and excitable because this was the first time they had been measured. The measurements of the 29th were carefully checked, re-measured, and verified at the time of measurement because of their disagreement with the previous readings. There seems but little reason to doubt that there is at least a slight stimulation here due to the excessive cutting in feed with accompanying loss in live weight.

The Height at Withers measurement does not check up this increase in foreleg, but it is barely possible that there could be some increase in foreleg which would not show at withers especially so when flesh is being taken from the top of the withers at the same time that the foreleg increases in length. The Measurement, "Length from Point of Shoulder to the Ground," Chart 9, does check

up this increase in foreleg however.

Is this stimulative effect ^{to} growth caused by the marked decrease in feed, accompanied by loss in weight, noted in other parts of the animal ? A study of Chart 11, Length from Pole to Point of Muzzle, and of Chart 16, From Top Point of Hip to End of Eschium shows this effect of stimulation fairly well.

It is a commonly observed fact* that the periods of maximal growth in the human family are associated with periods of minimal increase in weight, and oftentimes with an actual loss in weight. To quote a passage from the reference**, "Approximately, it is to be observed that the period of Maximal growth in weight, the autumn, is the period of Minimal growth in height; and in spring and summer while the body is growing most rapidly in height, it is actually losing in weight".

I called Professor E. B. Forbes, Head of the Department of Nutrition, Ohio Agricultural Experiment Station, attention to this apparent stimulation to growth, and under date of April 20, 1909 he wrote me, "I find in Medical Literature*** instances of children suffering from acidosis caused by digestive difficulty, and involving a constant loss of alkali from the body in excess of the intake of the same, accompanied by loss in weight, and marked growth in height, the latter apparently due to a redistribution of the body constituents. It may be that the principle active in this cases is the one which explains your observation on cattle".

* American Journal of Psychology, April, 1898, "Growth of Children in Height and Weight", Frederic Burk.

** Manual for Physical Measurements, Boys and Girls, page 5, by William H. Hastings.

*** See next page.

It would seem according to these citations that loss in live weight and increased growth of the body are somewhat correlated.

***See Von Norden, "Metabolism and Practical Medicine", Vol. III, pp. 886-887.

Relative Position of Shoulder and Elbow Points as Influenced by the Relative Condition of the Animals.

Does the condition of the animal affect the relative position of the shoulder and elbow points ? A study of the skeleton of Corrector page 101 shows the skeletal relation between these two points. The measurements "Length of Foreleg, Elbow to Ground", chart and Length from point of Shoulder to the Ground, Chart 9, 8, are the ones used in working out the relative position of these two points. As one studies the skeletal representation of these two measurements he is impressed with the stableness of the foreleg measurement, and the possible variableness of the Shoulder Measurement. The Humerus bone which connects the shoulder blade to the forearm of the foreleg is certainly very movable. The shoulder joint is of the ball and socket type, while the elbow joint is of a somewhat modified hinged type, which all means that there is great possibility for movement and of relative change in position of these parts. The Elbow point is a fairly stable measurement point but the shoulder point is more variable. One can readily perceive how a change in the condition of fatness of the animal might so change the muscular stresses, fat pads, and general tension in the vicinity of these two points, elbow and shoulder, that their relative position would be altered and the shoulder slope changed accordingly. The influence of condition upon the relative position

of the Elbow and shoulder points is shown in the following table:

Table showing the Relative Height of the Elbow and Shoulder Points from the ground under varying condition of the Animal.

	Feeding Period-127 Days-			Maintenance Period-199 Days		
	(Increase in Height from the Ground Cm.)					
	Elbow Point	Shoulder Point	Differ- ence**	Elbow Point	Shoulder Point	Differ- ence.
595 Check Main- tenance through- out both the Feeding and Main- tenance Periods.	3.00	1.00	-2.00	2.00*	.25*	-1.75*
	Steady decline in con- dition. Common to In- ferior.			Continued Steady De- cline in Condition mark- ed. Inferior to very thin plus.		
590 Quarter Full Fed- Maintenance	4.00	4.00	±00.00	3.00	1.00	-2.00
	Growth, practically no fattening. Inferior to Common minus.			Steady Decline in Condi- tion- Marked. Common minus to Thin.		
598 Half Full Fed Maintenance	5.00	5.5	+ .50	2.75	2.25	-.50
	Half Fattening. Common minus to Common to Med- ium.			Steady Decline. Common to Medium to Common min- us.		
596 Full Fed- Maintenance	5.00	6.5	+1.50	2.50	1.00	-1.50
	Maximum Fattening. Med- ium minus to "Good to Choice"			Steady Decline. "Good to Choice" to Good.		

* A Period of 139 Days.

** In favor of the increase of the shoulder point over elbow point.

This table seems to indicate that the thinner the animal the lower the shoulder point end of the humerus in relation to the elbow point end while the fatter the animal the higher the shoulder point in comparison to the elbow point. To put it differently, as the animal grows gradually thinner his shoulder point tends to become more on the level with his elbow point but with the fattening animal just the opposite is true, the distance between the two levels established at the shoulder and elbow points respectively becomes

greater. This all means that in the thin animal the shoulder becomes more sloping while in the fattening one the opposite is true.

Is this letting down of the shoulder points, coupled perhaps with the lowering of the shoulder blades and entire chest wall, a compensating factor in explaining why an animal may grow in foreleg but not show the same increase at the withers ? The taking off of flesh from the top of the withers is to be classed as a compensating factor in this explanation. Further measurements should check this up.

In practice we notice that thin animals have a more marked slope to their shoulders than do fat ones. This slope of the shoulder, especially marked in thin animals, gradually lessens as the animal fattens. Dairy cattle Judges emphasize the slope of the shoulder in the show ring. This slope of shoulder is to be expected according to our theory as the dairy cow is naturally a fairly thin animal. The relative change in position of the shoulder and elbow points as influenced by change in condition is apparently a possible explanation of these practical observations.

CHART 8

1908 Feb 22 ~22 days ~ Feb 29 ~28 days ~ Mar 28 ~58 days ~ May 25 ~30 days ~ June 24 ~30 days ~ July 24 ~29 days ~ Aug 22 ~31 days ~ Sept 22 ~31 days ~ Oct 13 ~19 days ~ Oct 22 ~32 days ~ Nov 23 ~29 days ~ Dec 22 ~31 days ~ 1909 Jan 22 ~28 days ~ Feb 19 ~29 days ~ Mar 20 ~31 days ~ Apr 20

LENGTH OF FORELEG- ELBOW TO GROUND

Scale { Horizontal, 1mm = 1 day.
Vertical, Actual.

590
598
596
595

CHART 9

1908 Feb 2, 8 days - Mar 28 - 55 days - May 25 - 30 days - June 2, 4 - 30 days - July 2, 4 - 29 days - Aug 2, 2 - 31 days - Sep 2, 2 - 11 days - Oct 2, 2 - 32 days - Nov 2, 3 - 29 days - Dec 2, 2 - 31 days - 1909 Jan 2, 2 - 29 days - Feb 19 - 29 days - Mar 2, 0 - 31 days - Apr 20

LENGTH FROM POINT OF SHOULDER TO GROUND

Scale Horizontal - 1 mm = 1 day.
Vertical - Actual.

590
598
596
595

1908
 Feb 29 - 28 days - Mar 28 - 58 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 31 days - Oct 22 - 31 days - Nov 23 - 29 days - Dec 22 - 31 days - Jan 22 - 29 days - Feb 19 - 29 days - Mar 20 - 31 days - Apr 20

STANDARD CROSS SECTION CO., N. Y.
 KEUFFEL & ESSER CO., N. Y.

LENGTH FROM POINT OF HOCK TO GROUND

Scale Horizontal - 1mm = 1 day
 Vertical - Actual

590
 598
 596
 595

590 One Quarter Full Fed
 598 One Half Full Fed
 596 Full Fed
 595 Maintenance Feb 26 '08 to Feb 19 '09

Second Maintenance Proper Period

STANDARD CROSS SECTION MILWAUKEE
KEUFFEL & ESSER CO. N. Y.

1908 Feb 29 ~ 28 days ~ May 28 ~ 58 days ~ May 25 ~ 30 days ~ June 24 ~ 30 days ~ July 24 ~ 29 days ~ Aug 22 ~ 31 days ~ Sept 22 ~ 31 days ~ Oct 22 ~ 32 days ~ Nov 23 ~ 29 days ~ Dec 22 ~ 31 days ~ 1909 Jan 22 ~ 28 days ~ Feb 19 ~ 29 days ~ May 20 ~ 31 days ~ Apr 20

LENGTH FROM POLL TO POINT OF MUZZLE

scale { Horizontal, 1mm = 1 day.
Vertical, Actual.

590
598
596
595

1908 Feb 29 - 28 days - Mar 28 - 58 days - May 25 - 30 days - June 2, 4 - 30 days - July 2, 4 - 29 days - Aug 2, 2 - 31 days - Sep 2, 2 - 31 days - Oct 2, 2 - 32 days - Nov 2, 3 - 29 days - Dec 2, 2 - 31 days - Jan 2, 2 - 29 days - Feb 19 - 29 days - Mar 2, 10 - 31 days - Apr 2, 9

LENGTH OF FACE - LINE BETWEEN EYES TO MUZZLE POINT

Scale Horizontal Vertical
1mm = 1 day.
Actual.

590
598
596
595

35
inches

4

3

2

1

30

9

8

7

6

25

4

3

2

1

0

0

0

0

0

0

0

0

0

590 One Quarter Full Fed
598 One Half Full Fed
596 Full Fed
595 Maintenance Feb 26 '08 to Feb 19 '09.

Slaughtered Feb 22 '09

Preliminary Maintenance Sub Maintenance Proper Period Feeding Period Second Maintenance Proper Period

CHART 13

908 1908 Jan 2, 9 - 28 days - Mar 2, 8 - 58 days - May 2, 5 - 30 days - June 2, 4 - 30 days - July 2, 4 - 29 days - Aug 2, 2 - 31 days - Sep 2, 2 - 19 days - Oct 2, 2 - 32 days - Nov 2, 3 - 29 days - Dec 2, 2 - 31 days - 1909 Jan 2, 2 - 29 days - Feb 1, 9 - 29 days - Mch 2, 0 - 31 days - Apr 2, 0

WIDTH OF JAWS
(FROM OUTSIDE)

Horizontal - 1 mm = 1 day.
Scale Vertical - Actual.

590
598
596
595

25
24
23
22
21
20
19
18
17
16
15

WIDTH OF FOREHEAD

Scale Horizontal ~ 1 mm = 1 day.
Vertical ~ Actual.

590
598
596
595

25
inches

24
23
22
21
20
19
18
17
16
15
14
13
12
11
10

Preliminary
Maintenance

Sub
Maintenance
First
Maintenance Proper
Period

590 One Quarter Full Fed
598 One Half Full Fed
596 Full Fed
595 Maintenance Feb 26 '08 to Feb 19 '09
Feeding Period

Second
Maintenance Proper
Period

28 days - Feb 29 - 28 days - Mar 29 - 58 days - May 25 - 50 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 11 days - Oct 2 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - Jan 22 - 29 days - Feb 19 - 29 days - Mar 20 - 31 days - Apr 20

Effect of the Quantity of Food Eaten upon the Actual Growth
in Width of Hips.

Does the mere quantity of feed influence the Width of Hips ? Is it possible to widen an animal at the hips simply by practicing full feeding ? Will full fed animals grow wider in the hips in proportion to their height than half full fed, quarter full fed, or maintenance fed ones.

A glance at Chart 15, "Width of Hips" shows that the quantity of the feed evidently does effect the width of hips considerably. The measurements of the increased growth in width of the hips are arranged in table form as follows:

Increase in the Width of the Hips during
the following periods.

Sub Maintenance 30 Days.	First Main- tenance 60 Days.	Feeding 127 Days	Second Main- tenance, 199 Days.

All Measurements in Centimeters.

595 Check Maintenance Throughout all of the Periods.	1.00	1.00	1.00 (Maintenance)	.50*
590	.75	0.00	2.50 (Quarter Full Fed)	2.00
598	.50	.50	3.50 (Half Full Fed)	2.50
596	0.00	1.00	7.50 (Full Fed)	2.50

*A period of 139 Days.

Without exception the quarter, half, and full fed steers show a marked increase in the width of hips during the feeding period, the greater the degree of feeding the more marked the increase. The check maintenance steer grew but 3 1/2 centimeters in width of hips in practically a year (Feb 26, 1908- Feb 19, 1909), the full fed steer grew 3 1/2 centimeters in hips in practically 60 days. The

half full fed steer grew not quite half as much as the full fed steer during the feeding period, or 3.5 cm., the quarter fed steer grew but a third as much or 2.5 cm., while the Continued Maintenance Steer grew less than a seventh as much or 1 cm. This shows clearly the effect of the quantity of the feed fed upon the actual growth in the width of hips

Does the flesh put on over the hips influence this measurement appreciably ? This question arises at once when we study the tables showing the growth in width of hips. This measurement is classed in Class B, "Skeletal Measurements which are not affected by an appreciable amount of flesh". In taking this width with the Standards great care is taken to make the Standard as tight as possible that it may pass over both hips simultaneously. The small amount of flesh added here then does not interfere with the accuracy of the bone measurement determination, thus obviating the flesh factor here.

Effect of the Quantity of Feed eaten upon the Relative Height of Body and Width of Hips Growth.

Granted that the quantity of the feed fed actually increases the width of hips this question still arises: Is this increase in the hips out of proportion to the height growth, in other words is the animal which is full fed growing wider in proportion to his height ? The best way I know of to figure this is to find out how much each animal grew—in width—at hips for each centimeter's growth in height. The actual growth in height at withers and hips, and in width of hips is presented in the following table:

Table showing (a) actual growth of Animals in Height at Withers
and Hips and in (b) Width of Hips.

	First Maintenance Per- iod. Increase in 60 Days.			The Feeding Period 129 Days. Increase in			Second Mainten- ance Period. 199 Days. Increase		
	Height at the Withers--Hips	Width of Hips	Hips	Height at the Withers--Hips	Width of Hips	Hips	Height at Withers	Hips	Width Hips
All Measurements in Centimeters.									
595 Check Mainten- ance Thr- ough the Experiment.	2.00*	2.00*	1.00	3.00	4.00	1.00	1.00**	2.00**	.50**
(Continued Mainten- ance)									
590	3.00	2.00*	0.00	5.50	6.00	2.50	4.00	3.00	2.00
(Quarter Full Fed).									
598	1.50	3.00	.50	9.50	6.50	3.50	4.50	3.50	2.50
(Half Full Fed).									
596	2.50	3.00	1.00	10.50	8.00	7.50	3.50	3.50	2.50
(Full Fed).									

*Approximated Closely ^{from} Plotted Charts.

**A Period of 139 Days.

This table plainly shows that the animals grew very marked-
ly while on feed not only in width of hips but in height. The
growth is somewhat proportional to the amount of productive feed
fed.

The relative growth in height of the animal as compared to
the growth in width of hips is shown in this table:

Table showing (a) the growth relation between the height at Withers- hips and (b) Width of Hips.

For each centimeter which the animals grew in height at the Withers and at the hips we have growth in the width of hips as per the following table.

All Measurements in Centimeters.

	First Maintenance Period 60 Days		Feeding Period 127 Days		Second Maintenance Period 199 Days	
	At Withers	At Hips	At Withers-Hips	At Withers	At Hips	At Hips
595 Check Maintenance Throughout the Experi- ment		.500	.500	.333	.250	.500* .250*
590	No growth at Hips		.455	.417	.500	.667
598		.333	.166	.368	.539	.556 .714
596		.400	.333	.714	.938	.714 .714

* A period of 139 Days.

This table is figured from the data given in the Table showing actual growth of Animals in (a) Height at Hips and Withers, and in (b) width of hips. See this table page 117.

The Full fed animal grew more proportionally in width of hips than did any of the others. The maintenance check steer ^{grew} least in hips width. Note that while on the First Maintenance Period the average growth at hips of the three steers 590, 598, and 596 for each centimeter's growth in height at withers is but .244 cm., whereas in the Feeding Period following they average .512 cm., or a difference of .268 cm. as a direct result of the stimulation of the feeding. In other words the animals when fed above maintenance grew twice as fast proportionately to the height growth in the width

of hips as when on First Maintenance. This stimulative effect of the feed on the width of hips growth is plainly seen not only in the Feeding period but also as a residual effect in the Second Maintenance period which follows ^{this} period of feeding. This residual effect is most marked on the full fed animal, much more so than on the half, or quarter fed ones. The Check Maintenance Steer shows no increase over the first Maintenance period. There is no residual effect in case of this steer. There seems to be a gradual lessening of the relative growth of hips in the Maintenance Check animal however.

More Data on the Relative Growth of Height of Body and Width
of Hips.

That the accuracy of these ^{data} might be further checked on other animals, the results of a year's measurements on three representative animals from each of three groups of steers fed under the direction of Director H. J. Waters of the Missouri Experiment Station and measured by the author are figured in this connection. These three groups of steers were fed as follows:

Group I, Full Fed, Gained approximately 2 pounds daily and ate about 15 to 16 pounds grain per 1000 pounds live weight.

Group II, Fed for Maximum Growth without any considerable fattening. Gained approximately 1.25 pounds daily, and ate about 10- 12 pounds ^{grain} per 1000 pounds live weight daily.

Group III, Slow Growth. Gained approximately 1/2 pound daily, and ate about 9- 10 pounds ^{grain} per 1000 pounds live weight daily.

The data on these steers are arranged in table form as follows:

Table showing the effect of the Degree of Feeding upon the
Relative Growth of Animals in Height at Withers and Width of
Hips.

Steer	Calved	Initial	Final	Total	Condition	at the	Increase	at the
No.	When	Weight	Weight	Gain	Beginning	-- End	Hips	Withers
							(Width)	(Height)

Approximate Period- February 1908 to February 1909, practically one year.

Group I Full Fed

501	3/28/07	433	1318	885	Good to choice	Prime Minus	16.75	17.50
515	3/15/07	519	1261	742	Common	Choice plus	16.75	20.50
527	10/8/07	346	1091	<u>745</u>	Medium	Choice	<u>17.65</u>	<u>29.50</u>
AVERAGE				790			17.05	22.50

Ratio of the Height increase at withers to Width increase at hips:

1 : .76

Group II. Maximum Growth without Fat.

507	3/18/07	587	891	304	Medium	Medium plus	9.50	17.50
512	3/7/07	587	925	338	Common plus	Medium	9.25	17.25
526	9/24/07	229	581	<u>352</u>	Thin to Fair	Fair plus	<u>14.25</u>	<u>25.50</u>
AVERAGE				331			11.00	20.08

Ratio of Height Increase at Withers to Width increase at hips.

1 : .55

Group III. Slow Growth.

500	3/2/07	497	714	217	Thin	Fair minus	9.25	16.25
509	3/20/07	492	723	231	Fair	Fair	7.00	16.00
525	9/31/07	329	533	<u>204</u>	Thin	Fair minus	<u>8.25</u>	<u>20.75</u>
AVERAGE				217			8.17	17.67

Ratio of Height increase at Withers to Width Increase at Hips:

1 : .46

In order to check up the above ratios in a general way the relation between the increase in the Foreleg and the increase at the hips was worked out with the following results:

		Ratio of the Length Increase of the Foreleg to Width Increase at the Hips.	Ratio of the Height increase at the Withers to the Width increase at the Hips.
Group	I	1 : 1.37	1 : .76
Group	II	1 : .84	1 : .55
Group	III	1 : .89	1 : .46

These ratios do certainly indicate that the full fed animals grow wider proportionately in the width of hips than do the lighter, fed ones. For every centimeter increase in height of withers we have in the Full Fed Group I a corresponding increase of .76 centimeters, in the maximum growth Group II, approximately half full fed, but .55 centimeters increase, or .21 centimeter less, while in the Slow Growth Group III, practically a quarter Full Fed, an even less increase in hips or .46. This is .09 centimeters less than the Maximum Growth Group and .30 centimeters below the full fed ones. The relative Width growth of the hips as compared to the Height growth at the Withers is greater according to these figures in animals which are quantitatively fed the most.

Is there a reason for this relatively large growth of hips in full fed steers ? An animal which is full fed on grain and hay as these animals have been fed the paunch is always well filled, and distended, and undoubtedly there is a greater mechanical push outward on the hips in the full fed steers than in the lighter fed ones. The Maintenance Animal does not eat enough to distend his

paunch and which, instead of being full and distended just in front of the hips points is empty and "gant". There is practically, in this ^{case,} ~~no~~ mechanical pressure exerted outwardly on the hips. Contrast the pictures of 596 on May 25, 1908 (End of 60 days Maintenance) page 88 and of the same animal on October 3, 1908, (End of 127 days of Full Feeding). Note the contracted, gaunted, appearance of body on maintenance feed as contrasted to the distended, full, appearance of the same steer full fed. It is reasonable to suppose that this mechanical effect of pressure exerted outwardly stimulates the hips to grow somewhat in proportion to the pressure exerted by the feed, which pressure is of course greater the heavier the feeding, and the bulkier the ration. On the same line of reasoning we would probably expect that measurement of the width of hips in young heifers carrying their first calf would show a fairly well marked increase as the foetus developed. This is merely theory, however, and would have to be carefully determined. On the whole it is not unreasonable to suppose that the mechanical effect of pressure induced by the presence of food bulk would tend to change the form of the organism, and alter somewhat materially the relative growth of parts affected.

In the fitting of beef animals for show we want to know how to widen them out, how to make them blocky. It seems that the practice of the showmen wherein he "stuffs" his show animals from birth is well founded in that it induces relative blockiness of the animal. Bulky foods are well adapted to breeding animals and no intelligent breeder would think for a minute of doing away with them in the rearing and raising of breeding stock. These bulky foods such as alfalfa meal or hay, clover, middlings, bran, etc., tend to round out the animal form, and stimulate development without any

considerable fattening. If we tried to feed concentrates such as corn, linseed meal, etc., to breeding animals we could not secure necessary bulk without supplying too much digestible material, and thus induce unnecessary and "unwanted" fattening. Bulkiness has been found to be essential to the development of breeding animals. Why is bulkiness essential to correct development ? Ordinarily we attribute its good effects to its promoting digestive activity, and rendering lighter the materials for digestion. May we not as reasonably suppose that the mechanical outward pressure induced by the bulky food in the paunch of the animal does tend in no small way, to alter the form of the animal, enlarge the capacity, and help to make for those things which we so highly prize in breeding animals.

CHART 15

8-22-06 - Feb 29 - 28 days - Mch 28 - 50 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 31 days - Oct 22 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - 1908 - Jan 22 - 28 days - 1909 - Feb 19 - 29 days - Mch 20 - 31 days - Apr 20

WIDTH OF HIPS

Scale
Horizontal - 1 mm = 1 day
Vertical - Actual.

590
598
596
595

FROM POINT OF HIP
TO END OF ISCHIUM

Horizontal - 1mm = 1 day
Scale Vertical - Actual

590
598
596
595

1908 1909
Feb 29 - 28 days - Mar 28 - 30 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 10 days - Oct 22 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - Jan 22 - 29 days - Feb 19 - 29 days - Mar 20 - 31 days - Apr 20

Some Measurements which Indicate Relative Condition.

Some of the measurements which we have taken are affected very materially by the amount of flesh carried by the animal. Those measurements which give us somewhat of an idea concerning the condition of the animal are:

Width of Loin, Chart 17.

Circumference of Right Thigh, Chart 18.

Height of Hind Flank, Chart 19.

Girth of Throat Latch, Chart 20.

A careful study of the above self-explanatory charts will give a better idea of what these measurements show than will a lengthy discourse on them. Attention is especially called to the effect of the varying degrees of feeding upon the curves of growth.

The student of Stock Judging will be especially interested in tracing the curves on the Height of Hind Flank, Chart 19, and on the Girth of Throat Latch Chart 20.

How Relative Feeding (Condition) affects the Position of the Hind Flank.

Does the degree of fatness affect the position of the hind flank ? In practice we note that the hind flank lowers in a so called mature four year old thin steer when he fattens. In a growing, fattening, animal however we have two compensating factors in the case; namely an increase in height and a letting down of the flank. By the arithmetical process of subtraction we can very easily figure out, however, whether or not an animal "Lets down" or "Tucks up" in hind flank on fattening. This method is employed in working out the following data:

Table showing the Effect of Feeding (Condition) upon the "Letting down", or "Tucking up" of the Hind Flank.

	Feeding Period of 127 Days (Jun 30, 08 to Oct 3, 1908)			Second Maintenance Period of 199 Days (Oct 4, 08- Apr 20, 09)		
	Increase in the height of Hind Flank from the Ground.	Increase in the Height at Hips.	Difference represent- ing (+) "Letting down" or (-) "Tuck- ing up" of the Hind Flank.	Increase in the Height of the Hind Flank from the Ground.	Increase in the Height at Hips.	Difference represent- ing (+) "Let- ting down" or (-) "Tucking up" of the Hind Flank.
	(Centimeters)			(Centimeters)		
595 Check Maintenance throughout Feeding and Maintenance Periods..	3	4	+1	3.5 *	2.0 *	-1.5 *
	Steady decline in condition. Common to Inferior.			Continued Steady Decline in Condition marked. In- ferior to very thin plus.		
590 Quarter Full Fed.- Maintenance	4	6	+2	3.25	3	-.25
	Growth, practically no fat- tening. Inferior to Com- mon minus.			Steady Decline in Condition Marked. Common minus to Thin.		
598 Half Full Fed-Mainten- ance.	3	6.5	+3.5	5.20	3.5	-1.90
	Half Fattening. Common minus to Common to Medium.			Steady Decline. "Common to Medium" to Common minus.		
596 Full Fed- Maintenance	1.5	8.	+6.5	3.25	3.5	+.25
*139 Days.	Maximum Fattening Med- ium minus to "Good to Choice".			Steady Decline. "Good to Choice" to Good.		

This table shows that the greater the degree of feeding the more the flank was "Let down" in comparison to the barrel of the animal, and as a result the less it increased in height from the ground. In other words, the depth of the hind flank actually in-

creased 1 centimeter on the Maintenance steer in the feeding period, 2 centimeters on the quarter full fed steer, 3.5 centimeters on the one half full fed, and 6.5 centimeters on the full fed one. In the Second Maintenance Period however we have a different story. Here the flank actually "Tucked up" in three of the steers, and remained practically the same in the fourth.

chart 19 shows how a fattening and growing animal may lower his flank in relation to his body barrel, and maintain his flank at about the same level from the ground throughout the fattening period although gaining considerably (8 cm.) in height at hips during the same time. In other words the "Letting down" of the flank compensated for the increased growth in height, and maintained the flank at a fairly uniform level from the ground.

Feb 29 - 28 days - Mar 28 - 30 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sept 22 - 31 days - Oct 22 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - Jan 22 - 31 days - Feb 19 - 29 days - Mar 20 - 31 days - Apr 20

WIDTH OF LOIN
 Scale Horizontal - 1mm = 1 day.
 Vertical - Actual.

590
 598
 596
 595

590 One Quarter Full Fed
 598 One Half Full Fed
 596 Full Fed
 595 Maintenance Feb 26 '08 to Feb 19 '09

Sub Maintenance   First Maintenance   Feeding   Maintenance   Second Period   Proper

CHART 18

1908 Feb 29 ~ 28 days ~ Mar 28 ~ 58 days ~ May 25 ~ 30 days ~ June 24 ~ 30 days ~ July 24 ~ 29 days ~ Aug 22 ~ 31 days ~ Sep 22 ~ 31 days ~ Oct 22 ~ 32 days ~ Nov 23 ~ 29 days ~ Dec 22 ~ 31 days ~ 1909 Jan 22 ~ 28 days ~ Feb 19 ~ 29 days ~ Mar 20 ~ 31 days ~ Apr 20

Feb 29 - 28 days - Mar 28 - 30 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sept 22 - 31 days - Oct 22 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - Jan 22 - 28 days - Feb 19 - 29 days - Mch 20 - 31 days - Apr 20

HEIGHT OF HIND FLANK
Horizontal - 1 mm = 1 day
Vertical - Actual

590
598
596
595

590 One Quarter Full Fed
598 One Half Full Fed
596 Full Fed
595 Maintenance Feb 26 '08 to Feb 19 '09

Second Maintenance Proper Period

08
5-32 days - Feb 29 - 28 days - Mar 28 - 58 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 19 days - Oct 10 - 32 days - Nov 13 - 29 days - Dec 22 - 31 days - Jan 22 - 29 days - Feb 19 - 29 days - Mar 20 - 31 days - Apr 20

1908 1909

GIRTH OF THROAT LATCH

JUST BACK OF JAWS

Scale Horizontal - 1mm = 1 day
Vertical - actual

- 590
- 598
- 596
- 595

changes in Depth, Width, and Girth of Chest as affected by Nutrition.

We have exhibited in charts 21, 22, and 23, Depth, Width, and Girth of Chest, Just Behind Elbow Joint, profound changes in the chest of animals brought about by different systems of feeding. A study of these charts will show the following changes, in part, to have taken place:

Maintenance growing animals uniformly increase in Depth of Chest, long continued maintenance, however, putting a check to this increase. During the same maintenance period that we get an increase in depth of the chest we also get a decrease in the width, which decrease is probably due to the resorption of the fore rib fat. The animals on maintenance tend to get narrower, and deeper. Here is a reversion to the range type of steer. The Heart Girth remains fairly constant. The increase in depth and the decrease in the width compensate each other.

During the Feeding Period the Girth, Depth, and Width of Chest all increase just in about the proportion to the amount of Productive feed eaten by the steers.

DEPTH OF CHEST
JUST BEHIND ELBOW JOINT

Scale Horizontal - 1 mm = 1 day
Vertical Actual

- 590
- 598
- 596
- 595

590 One Quarter Full Fed
598 One Half Full Fed
596 Full Fed
595 Maintenance Feb 26 '08 to Feb 19 '09

Slaughtered Feb 22 '09

WIDTH OF CHEST JUST BEHIND ELBOW JOINT

Scale Horizontal - 1mm = 1 day
Vertical - Actual

590
598
596
595

50
45
40
35
30
25
20
15
10
5
0

50
45
40
35
30
25
20
15
10
5
0

1908 - 22 days - Feb 29 - 28 days - Mar 28 - 58 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sept 22 - 19 days - Oct 11 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - 1909 - Jan 22 - 28 days - Feb 19 - 29 days - Mch 20 - 31 days - Apr 20

1908 Feb 29 - 28 days - Mar 28 - 58 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 11 days - Oct 19 - 27 days - Oct 22 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - Jan 21 - 29 days - Feb 19 - 29 days - May 20 - 31 days - Apr 20

HEART GIRTH JUST BEHIND ELBOW JOINT

Scale Horizontal - 1mm = 1 day.
Vertical - Actual.

590
598
596
595

Modification of the Depth, Width, and Girth of Paunch by differences in Quantitative Feeding.

The Charts 24, 25, and 26, "Depth, Width, and Girth of Paunch at end of Last Rib", illustrate very forcibly the response of the paunch to varying amounts of food. The size of the paunch is affected very materially by the amount of feed fed, the larger the quantity fed, ^{and} the heavier, bulkier the ration, the greater the paunch development. In connection with the study of the paunch charts the curves showing the Actual Grain Consumed, Chart 1 and Grain Eaten per 1000 Pounds Live Weight, ^{will prove interesting.} Chart 2. As the ration is lessened in amount the paunch becomes contracted gradually to meet the new conditions. In all of these interesting changes the width of the paunch seems to be the most easily influenced, and most readily responsive to slight changes.

On the sub Maintenance ration following full feeding the paunch contracts generally in spite of the fact that the animal is otherwise growing in stature. The paunch becomes somewhat shallower, very much more narrow, and markedly less in girth.

On Maintenance following sub maintenance of 30 days we have just about the same changes as on sub maintenance but the relative changes are not quite so marked.

During the feeding period ^{the} productively fed animals respond with an increase in depth, width, and girth of the paunch, which increase is somewhat proportional to the amount of productive food eaten.

In the Second Maintenance period we get about the same changes in paunch form as in the First Maintenance period, especially so in the decrease of width and girth of paunch. The decrease in

depth is not quite so marked.

The Check Maintenance Animal Shows a continued Steady decrease in both Depth and Girth of Paunch. The Width of Paunch remains practically constant.

CHART 24

22 days Feb 29 - 28 days Mar 28 - 58 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 17 days - Oct 12 - 32 days - Nov 23 - 29 days - 1908 Dec 22 - 31 days - 1909 Jan 22 - 28 days - Feb 19 - 29 days - Mar 20 - 31 days - Apr 20

DEPTH OF PAUNCH AT END OF LAST RIB

Scale Horizontal - 1mm = 1 day
 Vertical - Actual

590
 598
 596
 595

CHART 25

Feb 29 - 28 days - Mch 28 - 58 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 51 days - Sept 22 - 39 days - Oct 22 - 32 days - Nov 23 - 29 days - 1908 Dec 22 - 31 days - 1909 Jan 22 - 29 days - Feb 19 - 29 days - Mch 20 - 31 days - Apr 20

WIDTH OF PAUNCH AT END OF LAST RIB
 Scale Horizontal - 1 in. = 1 day.
 Vertical - Actual

590
 598
 596
 595

CHART 26

GIRTH OF FAUNCH
AT END OF LAST RIB

Horizontal - 1 day
Vertical - Actual

590
598
596
595

590 One Quarter Full Fed
598 One Half Full Fed
596 Full Fed
595 Maintenance Feb 26 '08 to Feb 19 '09

Second Maintenance Proper Period

1908 22 days Feb 29 - 28 days Mar 28 - 50 days - May 25 - 30 days June 24 - 30 days July 24 - 29 days Aug 22 - 31 days Sep 22 Oct 21 - 32 days Nov 23 - 29 days Dec 22 - 31 days Jan 21 - 29 days Feb 19 - 29 days Mar 20 - 31 days Apr 20

GIRTH OF HIND FLANK

Scale Horizontal - 1 mm = 1 day
 Scale Vertical - Actual

590
 598
 596
 595

590 One Quarter Full Fed
 598 One Half Full Fed
 596 Full Fed
 595 Maintenance Feb 26-'08 to Feb 19-'09

First
 Maintenance Proper
 Period

Second
 Maintenance Proper
 Period

1908 Feb 2, 9 - 28 days - Mar 2, 8 - 58 days - May 2, 5 - 30 days - June 2, 4 - 30 days - July 2, 4 - 29 days - Aug 2, 2 - 31 days - Sep 2, 2 - 11 days - Oct 3, 19 days - Oct 2, 2 - 32 days - Nov 2, 3 - 29 days - Dec 2, 2 - 31 days - 1909 Jan 2, 2 - 29 days - Feb 1, 9 - 29 days - Mch 2, 10 - 31 days - Apr 2, 10

CIRCUMFERENCE OF RIGHT HORN

AT BASE
Scale Horizontal — 1 mm = 1 day
Vertical — Actual

590
598
596

1908 Feb. 8 - 28 days - Feb. 29 - 58 days - May 25 - 30 days - June 24 - 30 days - July 24 - 29 days - Aug 22 - 31 days - Sep 22 - 31 days - Oct 22 - 32 days - Nov 23 - 29 days - Dec 22 - 31 days - 1908 Jan 22 - 29 days - Feb 19 - 29 days - Mar 20 - 31 days - Apr 20

LENGTH OF RIGHT HORN

FROM BASE
Scale Horizontal - 1 mm = 1 day
Vertical - Actual

590
598
596

centimeters

50
49
48
47
46
45
44
43
42
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5

590 One Quarter Full Fed
598 One Half Full Fed
596 Full Fed

Preliminary Maintenance Sub Maintenance Proper Feeding Period Second Maintenance Proper

SOME SUGGESTIONS FROM THE STUDY OF THE MEASUREMENTS.

Marked Changes in form occur in Response to Treatment.

In all this growth and change in form work profound and marked changes occurs regularly in response to the treatment given the steers. The Charts graphically represent changes which we do not ordinarily think of, and some which we have seldom, if ever, thought of.

Quantity, not quality, of feed is the variable factor in this Experiment.

Relative changes in the quantity of the feed with the quality constant has been the basis of this experiment. This must not be over looked in studying the results. A change in quality of the feed fed may, especially if the change is in the mineral elements supplied, bring about very different results. Much needs to be known about the effect of the quality of the feed upon the growth of animals, but this is without the range of this work.

Animals have strong Tendency toward a Normal Rate of Growth.

An animal does not seem to grow regularly but rather by small "spurts and jerks", on the whole however there is a tendency toward a normal rate of growth, which rate, even adverse conditions do not seriously interfere with, unless carried to extremes.

Is Maximum ~~Height~~ Growth induced by Maximum Quantitative Full Feeding ?

The mere quantity of food provided over and above a reasonable amount does not affect appreciable the rate of growth. In other words the quarter, half, and full fed animals, practically speaking, grew about the same in height and length of body throughout

the experiment. The half and full fed ones remain practically together, this showing that over and above half full feeding the food supplied did not hasten the growth in height and length of body. Below a quarter full feeding however approaching Maintenance we have adverse conditions carried to the extreme, and as a result the Maintenance animal gradually falls behind in height and length growth. Maximum height growth according to this experiment then is probably not induced ^{only} by maximum quantitative full feeding.

The Mechanical effect of Food upon the Relative Development of Body Parts.

The Mechanical effect of the food upon the relative development of body parts is especially emphasized by the results of this experiment. It seems reasonable to suppose that the body cavity and frame can be, at least temporarily if not permanently, modified materially by the bulkiness of the food in the paunch. Continued pressure on a growing bone must certainly change its form, and depending upon its application, alter or stimulate growth in many ways. Whether or not you can develop maximum capacity in a steer by the feeding of nutritious bulky foods during the plastic growing age is a very vital practical problem, the solving of which is complicated. However by the continual accumulation of data bearing upon the development of animals we may some day hope for its solution.

Effect of Food upon Animal Type.

Domesticated, ^{im}proved cattle present a very different appearance than their naturally wild brothers. The wild type of cattle are characterized by their long legs; deep, narrow, long bodies; narrow hips; long slim necks; and long narrow heads. Contrast with this type of cattle the modern improved domesticated

animal with short, blocky legs; deep, wide bodies; wide hips; short, well set necks; and short, wide heads. The former range type is a result of the natural environment characterized by scant food, lack of shelter, and a "survival of the fittest", a type fitted for Nature fighting. The latter blocky type is also the result of environment but an environment wholly different. Here, we have the influence of abundant food, artificial selection, good shelter, when needed, and ample protection. Fighting for survival is unnecessary. Just how much, and in what ways, the modern domestic factors enter into this change of type is hard to say. In this report of measurements of cattle we note that the absence of food seems to accentuate those changes which indicate a reversion to the old type while on the other hand an abundance of food ~~tends~~ toward the production of the modern corn belt type. We have shown how the relative width of the animals in hips was increased by abundant food. We have also shown how the chest deepens but becomes narrow, how the flank cuts up, and the legs become longer, in comparison to total height growth, on scant feed. All in all the food seemingly affects in a profound way the type of the growing animal.

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