FACTORS INFLUENCING THE NORMAL RATE OF GROWTH IN DOMESTIC ANIMALS AND THE PERMANENCY OF THE EFFECT OF ARRESTED DEVELOPMENT

by

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Original Plan of the Investigation

As the title indicates, the investigation has for its object the determining of the factors influencing the normal rate of growth of domestic animals and the permanency of arrested development. While all these factors can not be determined immediately or in a few years, it is hoped eventually to determine these factors and to definitely show the results of retarded growth.

The animals used in the investigation are steer calves of the beef type. The calves selected for the experiment are as near the same age as it is possible to obtain, and as near the same breeding as possible.

The calves upon entrance into the experiment are divided into three groups. Group I animals are fed a ration which will allow them to maintain approximately a maximum growth without the laying on of an appreciable amount of fat. Previous experience has taught that the gain of about one pound a day is the growth which brings about this condition.

Group II animals are put on a limited ration, such that their growth is about one-half pound a day or about fifteen pounds a month.

Group III animals are retarded to a marked degree. The ration of this group is such that the gain of the animals is not over ten pounds for a thirty-day period.

The calves at first are fed whole milk, but as they grow older this ration is gradually changed until before weaning the milk is entirely skim milk. In addition to the milk as a ration the calves are given a grain feed of corn chop, bran, and linseed meal, and finely cut timothy hay. It is intended that by the time the calves are weaned from the milk ration they will have learned to eat the hay and grain ration. The timothy hay is gradually changed to a mixture of alfalfa hay and oats straw, so that after a period of sixty days the timothy is entirely replaced by the alfalfa and oats straw. The animals have free access to water at all times. Salt is kept in the stall of each individual and at feeding time each animal can get all that he cares for.

The animals are grown on their plane of nutrition for a period of time and are then fattened and slaughtered. To make the data of the greatest value, the investigation must run for a number of years and a large number of animals must be slaughtered and analyzed. As the number of animals in the investigation is diminished by slaughtering, calves are added to each group. The calves, as before, are selected for uniformity in age and breeding.

After the period of retardation the animals are fattened by increasing the feed and also the relative amount of concentrates in their ration. The bulk or fill of the ration is kept more or less constant. The steers are fed to a good prime condition, their condition being judged by the animal husbandry experts of the University.

When the steers have been fattened to a prime condition they are slaughtered and the carcasses and parts are made ready for analysis. In slaughtering, conditions are held the same for each animal in so far as it is possible; that is, they are killed at the same time of day by the same persons. The animals are watered but not fed on the morning of slaughtering. After slaughtering, the carcasses are chilled and then cut into the wholesale market cuts, which are separated into the lean, fat, and bone. These are finely ground and samples are taken for analysis. The internal organs are held separately for analysis, as are the hair, hide, hoofs, and dew claws. The samples are analyzed for nitrogen, moisture, fat, phosphorus, and ash.

During the entire investigation, records are carefully and accurately kept. Records are kept of the amount of feed at each feeding time. The animal is weighed every morning at about the same time and the weights are kept on permanent files. Every thirty days, certain measurements of the animal are made. Such meas-

urements include data which indicate skeletal growth, others, the filling out of the animals, as chest, paunch, and flank girths. Every ninety days photographs of the animals are taken that the visible changes and growths may be seen and kept permanently.

All the new quantities of feed as they are used in the rations of the animals are sampled for analysis. The milk as it is fed is composited and held for ten days and then analyzed for protein, fat, ash, and sugar. New quantities of hay, straw, corn chop, bran, and linseed meal are sampled as they are used and are analyzed for moisture, protein, fat, ash and crude fiber, the carbohydrates being obtained by difference. New lots of feed are started at the beginning of ten day periods in order to simplify calculations.

The Working of the Plan:

In the spring of 1914 twelve calves were started in the investigation. These calves were about a month or so old and were well bred Shorthorns and Herefords or crosses of the two. The twelve were divided into three groups, Groups I, II, and III. The subsequent discussion in this thesis has only three animals to deal with--No. 520, Group I; No. 587, Group II; and No. 583, Group III.

The three calves under discussion, Nos. 520, 587, and 583, were started June 11, May 30, and May 22, 1917, respec-

tively. The feed, at first, was whole milk and finely cut timothy hay. The whole milk was changed during the progress of the milk ration so that in a few weeks they were receiving skim milk entirely. Timothy hay was used at the outset because experience in calf feeding has shown that alfalfa hay has a tendency to cause scouring. However, by the beginning of the ninth ten-day period the ration had been so modified that the calves were getting practically no timothy hay, but were being fed a mixture of six parts alfalfa hay to four parts of oats straw. This latter mixture soon entirely replaced the timothy hay in the ration. The milk ration was discontinued at the end of one hundred eighty days. As the timothy hay was gradually being replaced, the grain ration of six parts corn chop, three parts bran, and one part linseed meal was being slowly increased. By the time the calves were weaned they had learned to eat the hay and grain ration.

A survey of tables 1, 2, and 3, of the weights and gains will show that there was more or less fluctuation in the gains of the calves. The gains of the three rose fairly rapidly for three or four periods, and then the fluctuations began to be more noticeable. After these first three or four periods the feed ration remained comparatively constant for a considerable length of time.

Whether or not the effects of ratardation were to

Table No. 1

Feeds and Weights of No. 520

Periods	Weight of Animal at Beginning of Period Pounds	Gain in Weight Pounds	Grain Pounds	Hay and Straw Pounds	Milk Pounds
1914					
June 11-June 21	157.0	13.6	----	*3.5	129.6
June 21-July 21	170.6	16.0	11.5	*11.0	462.0
July 21-Aug. 20	186.6	50.6	47.5	+49.5	582.0
Aug. 20-Sept. 19	237.2	49.6	81.0	69.8	600.0
Sept. 19-Oct. 19	286.8	53.0	110.5	101.5	600.0
Oct. 19-Nov. 18	339.8	64.0	140.0	120.0	620.0
Nov. 18-Dec. 18	403.8	12.6	150.0	120.0	°210.0
1915					
Dec. 18-Jan. 17	416.4	24.6	150.0	120.0	
Jan. 17-Feb. 16	441.0	16.2	150.0	120.0	
Feb. 16-Mar. 18	457.2	7.0	150.0	120.0	
Mar. 18-Apr. 17	462.2	13.6	150.0	120.0	
Apr. 17-May 17	477.8	20.4	150.0	120.0	
May 17-June 16	498.2	9.0	150.0	120.0	
June 16-July 16	507.2	14.8	147.5	125.0	
July 16-Aug. 15	522.0	8.0	150.0	150.0	
Aug. 15-Sept. 14	530.0	15.8	167.5	150.0	
Sept. 14-Oct. 14	545.8	39.0	180.0	150.0	
Oct. 14-Nov. 13	584.8	19.2	180.0	150.0	
Nov. 13-Dec. 13	604.0	19.2	180.0	158.0	
1916					
Dec. 13-Jan. 12	623.2	29.4	180.0	185.0	
Jan. 12-Feb. 11	652.6	13.4	180.0	210.0	
Feb. 11-Mar. 12	666.0	20.8	180.0	210.0	
Mar. 12-Apr. 11	686.8	24.8	180.0	210.0	
Apr. 11-May 11	705.6	31.8	185.5	210.0	
May 11-June 10	737.4	37.0	222.0	210.0	
June 10-July 10	774.4	45.2	240.0	210.0	
July 10-Aug. 9	819.6	30.8	240.0	204.0	
Aug. 9-Sept. 8	850.4	73.2	348.0	167.5	
Sept. 8-Oct. 8	923.6	116.0	516.5	214.0	
Oct. 8-Nov. 7	1039.6	81.2	579.5	211.0	
Nov. 7-Dec. 7	1120.8	56.0	571.5	182.0	
1917					
Dec. 7-Jan. 6	1176.8	32.6	570.0	165.0	
Jan. 6-Feb. 5	1209.4	52.4	570.0	166.0	
Feb. 5-Mar. 7	1216.8	79.4	593.0	180.0	
Mar. 7-Apr. 6	1341.2	20.2	541.0	186.0	
Apr. 6-May 6	1361.4	47.4	386.0	200.0	
May 6-June 5	1408.8	27.8	458.0	189.0	
June 5-June 15	1434.6	8.4	160.0	61.0	
June 15	1443.0				

*Timothy hay. +Includes last of timothy hay (5 lbs.), beginning of alfalfa and oats straw.
°Milk for last ten day period.

Table No. 2

Feeds and Weights of No. 587

Periods	Weight of Animal at Beginning of Period Pounds	Gain in Weight Pounds	Grain Pounds	Hay And Straw Pounds	Milk Pounds
1914					
May 30-June 21	121.0	-----	---	*2.65	171.3
June 21-July 21	121.0	9.2	6.75	*14.0	336.5
July 21-Aug. 20	130.2	11.4	35.5	+40.5	354.3
Aug. 20-Sept. 19	141.6	35.4	61.0	59.5	274.4
Sept. 19-Oct. 19	177.0	38.8	74.0	71.0	385.7
Oct. 19-Nov. 18	215.8	37.0	88.5	90.0	392.0
Nov. 18-Dec. 18	252.8	22.2	90.0	103.0	°122.7
1915					
Dec. 18-Jan. 17	275.0	28.0	90.0	120.0	
Jan. 17-Feb.16	303.0	14.0	90.0	120.0	
Feb. 16-Mar. 18	317.0	6.0	90.0	103.0	
Mar. 18-Apr. 17	323.0	18.6	86.0	90.0	
April 17-May 17	341.4	15.8	75.0	90.0	
May 17-June 16	357.2	7.4	75.0	90.0	
June 16-July 16	364.6	0.8°°	72.5	88.0	
July 16-Aug. 15	363.8	11.0	75.0	112.0	
Aug. 15-Sept. 14	374.8	5.6	73.75	155.0	
Sept. 14-Oct. 14	380.4	21.8	83.25	173.5	
Oct. 14-Nov. 13	402.2	5.4	82.5	165.0	
Nov. 13-Dec. 13	407.2	6.8	84.5	170.5	
1916					
Dec. 13-Jan. 12	414.4	6.8	88.5	166.5	
Jan. 12-Feb. 11	421.2	8.0	90.0	165.5	
Feb. 11-Mar. 12	429.2	19.4	90.0	165.0	
Mar. 12-April 11	448.6	25.8	90.0	191.0	
April 11-May 11	474.4	32.8	97.0	195.0	
May 11-June 10	507.2	27.6	132.5	180.0	
June 10-July 10	534.8	40.4	132.0	180.0	
July 10-Aug. 9	575.2	34.4	150.0	180.0	
Aug. 9-Sept. 8	609.6	74.8	256.8	180.0	
Sept. 8-Oct. 8	684.4	111.8	414.0	202.5	
Oct. 8-Nov. 7	796.2	83.4	457.0	200.0	
Nov. 7-Dec. 7	879.6	49.6	479.5	130.0	
1917					
Dec. 7-Jan. 6	929.2	32.8	430.5	129.0	
Jan. 6-Feb. 5	962.0	63.6	396.0	188.5	
Feb. 5-Mar. 7	1025.6	32.4	312.5	186.0	
Mar. 7-April 6	1058.0	54.0	353.5	197.5	
April 6-May 6	1112.0	46.0	329.0	197.5	
May 6-June 5	1158.0	63.4	385.5	180.0	
June 5-June 25	1221.4	6.6	226.6	126.0	
June 25	1228.0				

*Timothy hay only. *Includes last of timothy hay (5 lbs.), beginning of alfalfa and oats straw. °Milk for last ten day period. °°Loss in weight.

Table No. 3.

Feeds and Weights of No. 583

Periods	Weight of Animal at Beginning of Period Pounds	Gain in Weight Pounds	Grain Pounds	Hay and Straw Pounds	Milk Pounds
1914					
May 22-June 21	117.0	1.2 °°	---	*4.75	259.6
June 21-July 21	115.8	7.3 °°	---	*13.5	287.6
July 21-Aug. 20	108.5	14.5	5.0	+48.0	297.0
Aug. 20-Sept. 19	123.0	14.6	15.0	60.0	289.6
Sept. 19-Oct. 19	137.6	17.2	18.5	90.0	291.3
Oct. 19-Nov. 18	154.8	14.0	22.5	90.0	241.3
Nov. 18-Dec. 18	168.8	4.8	22.5	110.0	°99.0
1915					
Dec. 18-Jan. 17	173.6	14.8	22.5	120.0	
Jan. 17-Feb. 16	188.4	4.0	22.5	120.0	
Feb. 16-Mar. 18	192.4	2.0 °°	22.5	120.0	
Mar. 18-Apr. 17	190.4	23.4	22.5	120.0	
Apr. 17-May 17	213.8	1.6	22.0	120.0	
May 17-June 16	215.4	12.2	22.5	120.0	
June 16-July 16	227.6	8.8	19.5	127.0	
July 16-Aug. 15	236.4	7.4	18.5	150.0	
Aug. 15-Sept. 14	243.8	13.0	29.0	150.0	
Sept. 14-Oct. 14	256.8	15.8	25.5	169.0	
Oct. 14-Nov. 13	272.6	2.6	15.0	180.0	
Nov. 13-Dec. 13	275.2	12.8	27.0	180.0	
1916					
Dec. 13-Jan. 12	288.0	15.4	45.0	180.0	
Jan. 12-Feb. 11	303.4	16.4	45.0	180.0	
Feb. 11-Mar. 12	319.8	17.0	45.0	180.0	
Mar. 12-Apr. 11	336.8	13.2	34.5	180.0	
April 11-May 11	350.0	15.4	37.0	180.0	
May 11-June 10	365.4	15.2	67.4	173.0	
June 10-July 10	380.6	40.2	130.9	180.5	
July 10-Aug. 9	420.8	64.0	165.0	180.0	
Aug. 9-Sept. 8	484.8	84.4	263.0	180.0	
Sept. 8-Oct. 8	569.2	73.4	246.5	286.5	
Oct. 8-Nov. 7	642.6	22.2	210.5	321.5	
Nov. 7-Dec. 7	664.8	46.4	164.5	274.0	
1917					
Dec. 7-Jan. 6	711.2	33.2	190.5	270.0	
Jan. 6-Feb. 5	744.4	50.4	246.5	270.5	
Feb. 5-Mar. 7	794.8	51.6	255.0	285.0	
Mar. 7-April 6	846.4	50.0	262.0	285.0	
April 6-May 6	896.4	55.2	288.5	288.5	
May 6-June 5	951.6	21.2 °°	92.5	234.0	
June 5-July 5	930.4	14.6 °°	139.5	247.5	
July 5-Aug. 4	915.8	67.2	279.0	243.5	
Aug. 4-Sept. 3	983.0	61.5	331.0	265.5	
Sept. 3-Oct. 3	1044.5	58.7	411.5	270.0	
Oct. 3-Nov. 2	1103.2	60.8	408.0	270.0	
Nov. 2-Dec. 2	1164.0	23.6	394.0	269.5	
1918					
Dec. 2-Jan 1	1187.6	8.0	291.0	278.0	
Jan. 1-Feb. 1	1195.6	2.2	289.5	285.0	
Feb. 1-Mar. 2	1197.8	29.6	206.5	284.5	
Mar. 2-Mar. 26	1227.4	25.6	206.5	218.5	
Mar. 26	1253.0				

*Timothy hay only.
+Includes last of timothy hay (5 lbs.), beginning of alfalfa and oat straw.
°Milk for last ten day period.
°°Loss in weight.

show up early in the investigation, the present data does not justify any conclusions. At the same time, it can be said that the animals in the groups with the lower planes of nutrition seemed to suffer most. They were frequently sick and were more susceptible to pink eye than No. 520, the Group I animal. The vitality of the animals on the lower planes of nutrition was low and it was necessary at times to increase their feed somewhat to keep them alive. Two animals on these lower planes died early in the investigation. During the time when milk was part of the ration Nos. 587 and 583 frequently left part of their milk. While No. 520 did the same, it was not as often as in the case of the Group II and III animals. The refusing of milk occurred only in the first five ten-day periods of the investigation to any marked degree. After that time the calves consumed the milk pretty regularly. With the hay there was some refusal of feed, but it seems to have been the case of the individuals getting used to a new part of the ration. This refusal does not justify the drawing of any conclusions that the retarding of growth was responsible, for the same condition was found in Group I.

The animals continued on their respective planes of nutrition for twenty-four periods. A study of tables 1, 2 and 3, showing the feed consumed, indicates a slow increase of the amount of feed for the first four or five

periods. After that time, there is a long period just before fattening was begun when the amount of feed used is fairly constant. The weights of the animals show a gradual increase, with some fluctuations.

The entire gains and average thirty-day gains of each animal during the first twenty-four periods are shown in the following table:

Table No. 4.

	No. 520 Pounds	No. 587 Pounds	No. 583 Pounds
Initial weight	157.0	121.0	117.0
Weight at end of twenty-fourth period	737.4	507.2	365.4
Gain in weight	580.4	386.2	248.4
Average thirty-day gain	24.19	16.09	10.35

At the end of twenty-four months it was decided to fatten the steers, attempting to feed them to a prime finished condition. The ration used to fatten the steers was not changed in the constituents used, but rather in their relative amounts. The corn chop, bran, and linseed meal were gradually increased in amount until the animals were on full feed. During the time that the steers were being brought up to a fattening ration there was not much change in the roughage part of the feed. The increase of the concentrates was depended upon to put the steers into the desired condition.

The following tables show the weights of the steers from the beginning of the fattening periods until after they were on full feed, and their feed during the same periods.

Table No. 5

Weights of Steers, Pounds

Periods	Steer 520	Steer 587	Steer 583
25	737.4	507.2	365.4
26	774.4	534.8	380.6
27	819.6	575.2	420.8
28	850.4	609.6	484.8
29	923.6	684.8	569.2
30	1039.6	796.2	642.6
31	1120.8	879.6	664.8
32	1176.8	929.2	711.2
33	1209.4	962.0	744.4
34	1261.8	1025.8	794.8

Table No. 6

Grain Consumed by Steers, Pounds

Periods	Steer 520	Steer 587	Steer 583
25	222.0	132.5	67.4
26	240.0	132.0	130.9
27	240.0	150.0	165.0
28	348.0	256.8	263.0
29	516.5	414.0	246.5
30	579.0	457.0	210.5
31	571.5	479.0	164.5
32	570.0	430.5	190.5
33	570.0	396.0	246.5
34	593.0	312.5	255.0

Roughage Consumed by Steers, Pounds

25	210.0	180.0	173.0
26	210.0	180.0	180.5
27	204.0	180.0	180.0
28	167.5	180.0	180.0
29	214.0	202.5	286.5
30	211.0	200.0	321.5
31	182.0	130.0	274.0
32	165.0	129.0	270.0
33	166.0	188.5	270.5
34	180.0	186.0	285.0

From Table 1 it will be seen that No. 520 of Group I when on full feed gained immediately and continued to gain until he was slaughtered on June 15, 1917. At this time he was thought to be a prime finished animal by the men of the Animal Husbandry Department. Table No. 4 shows his total gain up to the time of fattening to be 580.4 pounds, or an average thirty-day gain of 24.19 pounds. After being put on a fattening ration, the following table (No. 7) shows him to have more than doubled his thirty-day gain up to that time, making 50.4 pounds, or a total gain of 705.6 pounds.

From table No. 1 it will be seen that in the winter of 1916 and 1917 No. 520 made smaller gains, altho his feed remained constant. This would seem to indicate that the loss was from seasonal causes and not from any sickness of the animal, for in the two winters preceding the same thing happened.

When Steer 587 of Group II was put on a fattening ration he showed no ill effects of his period or retardation. From the beginning of the investigation to the beginning of the fattening period he made a total gain of 386.2 pounds, or an average thirty-day gain of 16.09 pounds. From the beginning of the fattening period to the time of slaughter he made a gain of 720.8 pounds, an average thirty-day gain of 51.5 pounds. The total and average gains during the fattening period will be seen from the following table, No. 7, to be greater in No. 587

than in No. 520, altho the former was slightly retarded for two years.

Table No. 7.

	Group I Steer 520 Pounds	II Steer 587 Pounds	III Steer 583 Pounds	*Steer 583 Pounds
Wt. at beginning of fattening period	737.4	507.2	365.4	365.4
Wt. morning of slaughter	1443.0	1228.0	1240.0	931.0
Total gain	705.6	720.8	874.6	565.6
Average gain	50.4	51.5	38.6	40.4

*Data of No. 583 to the day of slaughtering of No. 520.

No. 587, it will be noticed in table No. 7, was making practically the same gains on a fattening ration as No. 520. The average gains of the two were very close.

Table No. 2 shows that No. 587, having reached what might be called a full feed, made smaller gains in the winter of 1916 and 1917, as did No. 520. This, as in the case of No. 520, seems to have been due to seasonal causes, altho in one instance there was a refusal of feed. However, in a short time No. 587 gained again, making these gains on less feed, showing an adaptability in gaining on less feed.

At the time of slaughter, No. 520 was thought to be a prime animal. At this time No. 587, in the opinion of the animal husbandry men, needed about ten days to fin-

ish out. The same men, with one exception, thought that while No. 520 was a smoother finished steer No. 587 was the fatter of the two. No. 587 was slaughtered June 25, 1917, ten days after No. 520.

The Group III animal, No. 583, at this time was thought to need sixty to ninety days in which to come to a finished condition. Up to the fattening period, No. 583 behaved much the same as the other two, taking into consideration his plane of nutrition. It took about four months to get him to a maximum ration that he could handle. After this, he maintained gains in weight shown in Table 3. During the first twenty-four periods his gain was 248.4 pounds, an average thirty-day gain of 10.35 pounds. During this period both No. 587 and No. 583 were more susceptible to pink eye and disturbances than No. 520. Whether this was due to the retardation and a resulting lowered vitality is not to be decided from the investigation at this time, for there have not been enough animals slaughtered to get the data.

No. 583 was put on a fattening ration at the same time as No. 520 and No. 587. From tables Nos. 1, 2, and 3, it will be seen that all began this ration in the twenty-fourth period. Nos. 520 and 587 reached what might be called a full ration in the twenty-ninth period. It was seen at this time that No. 583 did not seem to be able to get to the same plane of nutrition. During the thirtieth period

No. 583 dropped considerably in the amount of his gain, and from the table it will be seen that the feed was greatly reduced. This would seem to indicate a refusal of feed and a condition not found in Nos. 520 and 587, for it will be remembered that altho the two made smaller gains at about this time there was no decrease in the feed of No. 520 and No. 587. During the twenty-eighth period No. 583 made a gain of 84.4 pounds, which might be accounted for by the fact that the steer was well filled by this time. However, the ration was always so planned that the animals had a fill all the time. In the next two periods No. 583 dropped off 62.2 pounds in his gains. Table 3 shows the gains of No. 583 during the fattening period, his grain ration and the roughage. His gains up to the time of his apparent going off feed were large and comparable with those of the Group I and Group II animals. From Tables 5 and 6 it is seen that he made this gain on an equal amount of roughage and less grain than No. 520 or No. 587. After the set-back of No. 583 at this time, he was brought up again to a full feed. He got on full feed again in the thirty-second or thirty-third period (January and February, 1917). While he was on full feed as to the amounts of feed consumed, his gains were less by twenty pounds than they were before. He was not making his gains so economically as before, for his feed consumption was the same and his gains were less. Until the first of May, No. 583 held his gains after his recovery fairly well.

The following table (No. 8) shows the feeds, gains, and weights of the three steers from April, 1917, until July, 1917.

Table No. 8

Weights and Gains of Steers, Pounds.

Period	Steer 520 Weight	Steer 520 Gain	Steer 587 Weight	Steer 587 Gain	Steer 583 Weight	Steer 583 Gain
Mar. 7-April 6	1341.2	20.2	1058.0	54.0	846.4	50.0
April 6-May 6	1361.4	47.4	1112.0	46.0	896.4	55.2
May 6-June 5	1408.8	27.8	1158.0	63.4	951.6	-21.2
June 5-July 5	1434.6	8.0	1221.0	6.6	930.4	-14.6
July 5-Aug. 4	*1443.0		*1228.0		915.8	67.2
Aug.4-Sept.					983.0	

Weights are those at beginning of periods.
*Weight at morning of slaughtering.

Feed Consumed by Steers, Pounds

Grain

	Steer 520	Steer 587	Steer 583
Mar. 7-April 6	541.0	353.5	262.0
Apr. 6-May 6	386.0	329.0	288.5
May 6-June 5	458.0	385.5	92.5
June 5-July 5	*160.0	*226.0	139.5
July 5-Aug. 5			279.0

Roughage

	Steer 520	Steer 587	Steer 583
Mar. 7-April 6	186	197.5	285.0
April 6-May 6	200	197.5	288.5
May 6-June 5	189	180.0	234.0
June 5-July 5	*61	*126.0	247.5
July 5-Aug. 4			243.5

*Weight of feed for only that part of the period before slaughtering.

It will be seen that in May, 1917, No. 583 went off feed again. During the next two thirty-day periods, No. 583 lost over thirty-five pounds in weight. During

this time he refused feed a number of times and did not appear well.

Here the question might arise: has retarding the growth affected the ability of No. 583 to handle a full fattening ration. The weights shown in the last two sets of charts seem to indicate that such has been the case. It will be noticed in both cases of the falling off of No. 583 that this drop occurred when on practically a full feed. During his retardation something seems to have taken place so that when he was on full feed he could not handle it. Whether or not retardation was the cause of such a drop is not to be definitely decided from our limited data, but that is one of the points that the entire investigation hopes to decide definitely.

No. 587, in contrast to No. 583, altho retarded slightly seemed to show no effects of the retardation in so far as finishing is concerned, but gained in weight with no real set-backs. No. 583 after his set-back in May and June, 1917, gradually worked back up to full feed. This, it will be remembered, is about the time when the Group I and Group II animals were killed. Here it is necessary to recall that, in the judgment of the animal husbandry men, No. 583 would need sixty to ninety days to finish to the condition of No. 587 which was ten days behind No. 520 at the time of slaughtering No. 520. With the thought in mind that he would finish out in sixty to ninety days, No. 583 was fed along. But instead of using

his food for finishing he used it to maintain a steady growth. A study of the curves, which are shown with the discussion of the feeds, will show that the growth of No. 583 was fairly continuous tho slow. Nor would he eat a sufficient additional amount of food to enable him to put on a smooth finish. This slow growth continued until March 26, 1918, nine months after the slaughtering of No. 587, when No. 583 was slaughtered. At the time of killing No. 583 was not as smooth finished an animal as No. 587, altho he was in fairly good shape and about the same weight as No. 587 at the time of killing.

The striking thing is that it took No. 583, after severe retarding, just nine months to get to the condition of No. 587, which had no set-backs after its limited retardation.

From the beginning of the investigation records were kept of the growth of the animals. They were weighed every morning immediately after feeding. Records were made of all feeds used. Any feed refused was mixed with the next feed, except in a very few instances, for the purpose of avoiding the analysis of refused feed.

Every thirty days measurements were taken to show the growth of the animals. Every ninety days photographs were taken of the front, rear, and side view. Just before slaughtering front, rear, and side views were also taken.

The total feeds of the three animals are seen in Tables 1, 2, and 3. With these tables can be seen the weights of the animals along with their gains for each thirty-day period.

In the case of each animal there was a time of about six thirty-day periods during which the animals were worked up to a fairly constant ration. It will be noticed that just about the time the animals got on to a fairly constant grain ration the milk part of the ration was dropped. This is partly the cause for the big drop in the curve plotting the total nutrients for each animal for each thirty day period. Having reached this fairly constant ration, the animals were held on this plane of nutrition until it was decided to finish them out, at which time the ration was increased.

The ration used for fattening was not changed in constituents but rather in the amount of the concentrates used. The grain was increased until the animals got on what might be termed a full feed, which was in about the thirtieth period. The roughage of No. 520 and No. 587 was not increased in any large amount, altho there was some increase at the beginning of the fattening period. At no time did either of the two get much over two hundred pounds of roughage in a thirty-day period.
No. 583, in contrast to the other two, after he got up to

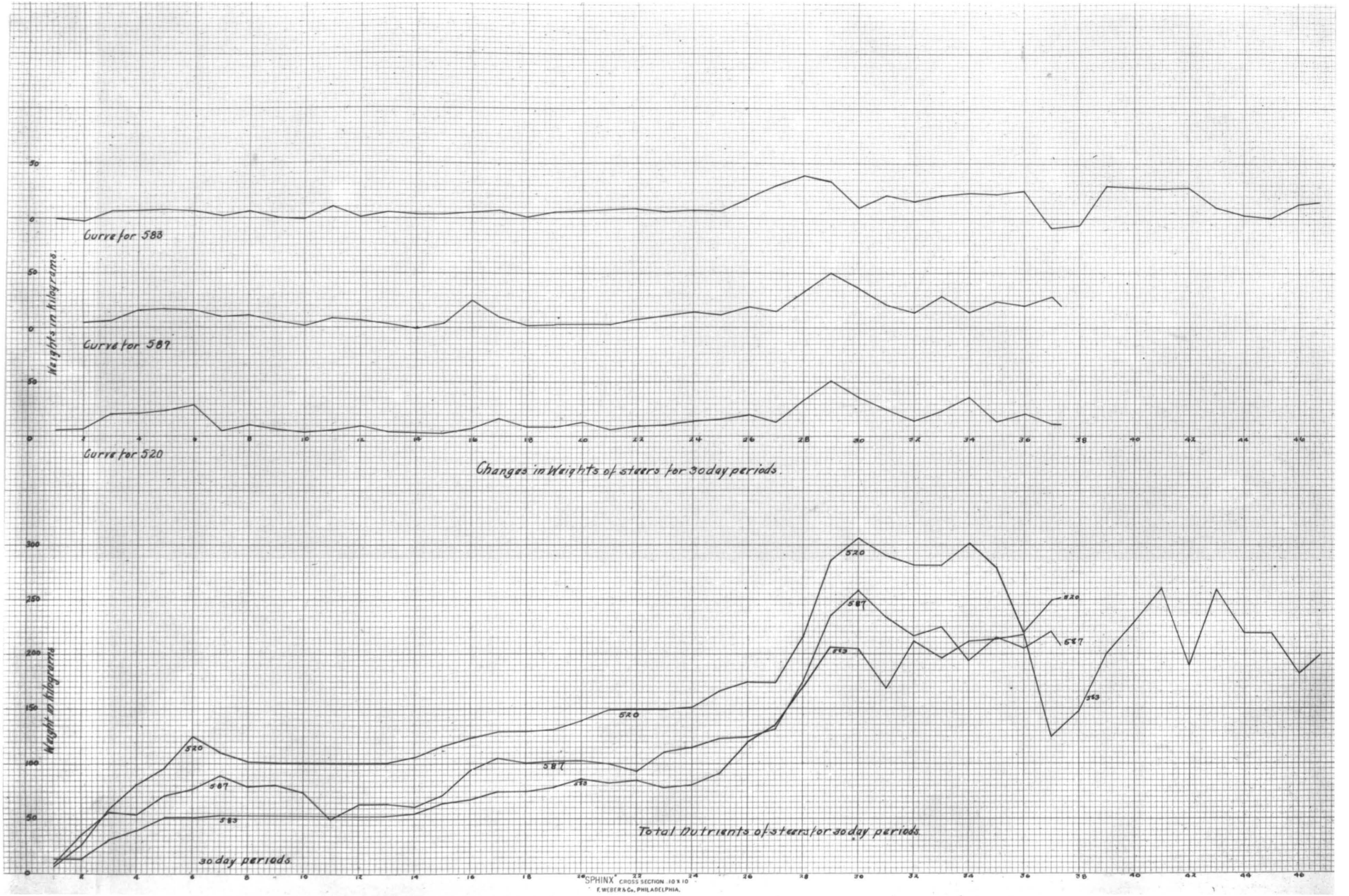
a higher plane of nutrition had his roughage very materially increased, and at this time his grain ration dropped down very noticeably. This was at the time of his first set-back and the hay may have been increased because of a refusal of grain. At this time there is seen to be a loss in the amount of the gain in Nos. 520 and 587, altho the feed has remained constant. It has been suggested that this is due to the season of the year rather than to any abnormal condition of the animal. The figures of the feed of No. 583 show a decrease at this time, indicating a refusal of feed and so an abnormal condition. As this is not shown in the feed records of Nos. 520 and 587 it seems that there is no abnormal condition.

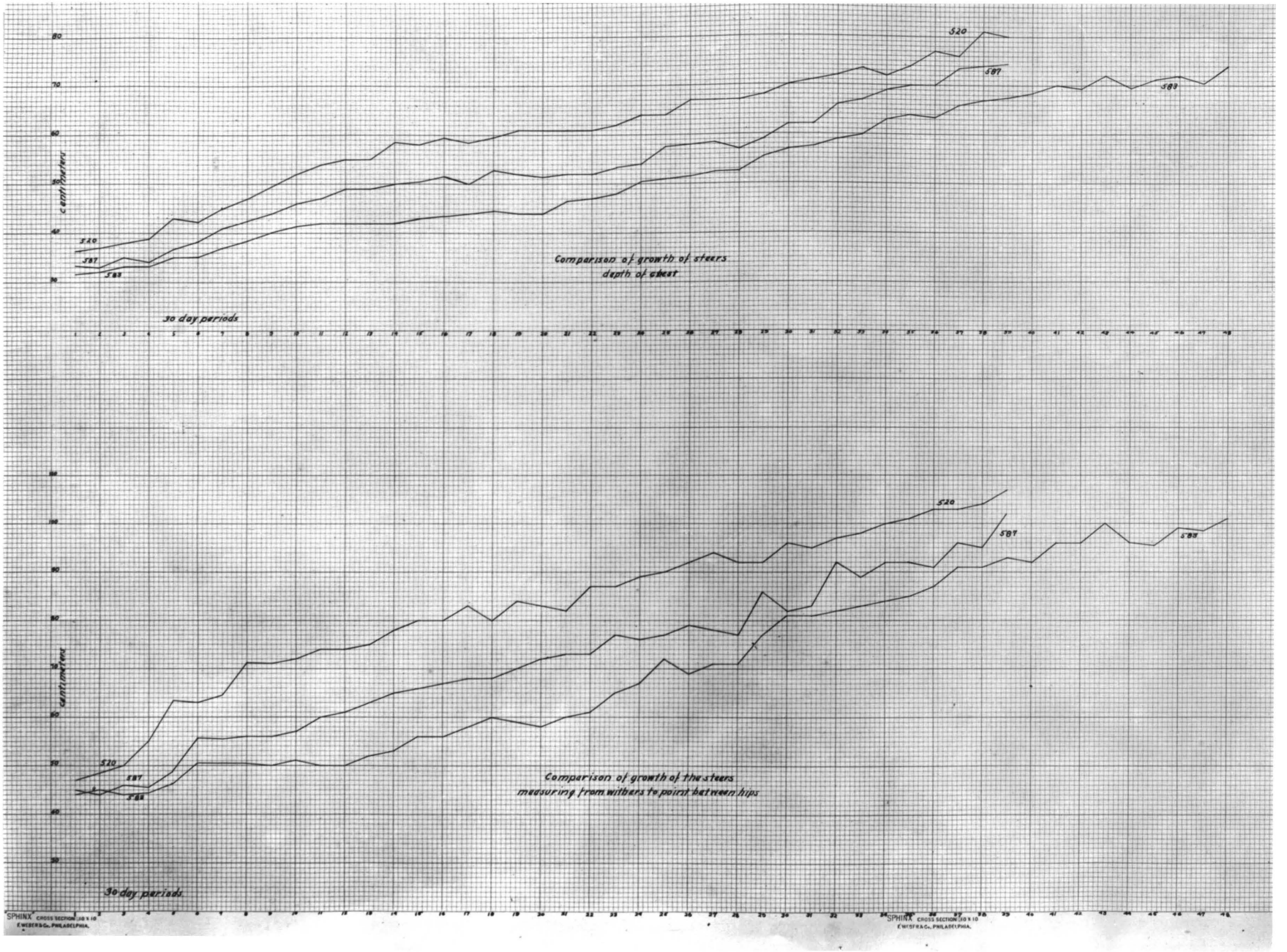
After this set-back of No. 583 he was worked back gradually to the maximum feed that he could handle. After he got on to this his gains were fairly large and about the same as those of No. 520 and No. 587. Just about the time No. 587 and No. 520 were slaughtered No. 583 went off feed again. His grain ration was lowered from nearly three hundred pounds to less than one hundred pounds, altho the amount of his roughage was lowered only about fifty pounds. This big drop is shown in the curve plotting the total nutrients of the animals during the thirty-seventh and thirty-eighth periods. The recovery of No. 583 after this set-back is not so rapid, for it was three thirty-day periods before he got back up to his former feed and gains. During this set-back he actually

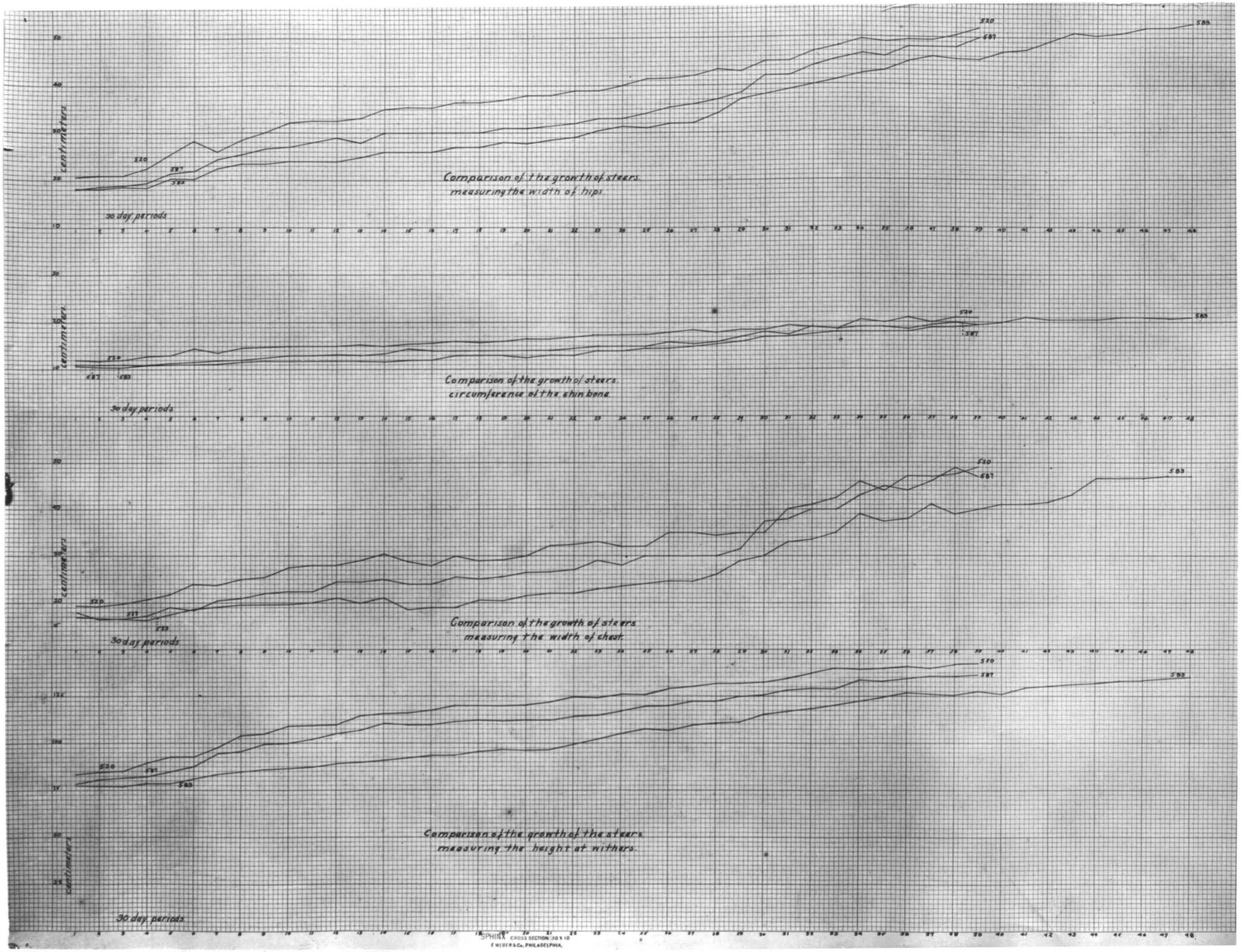
lost in weight, as is seen where the curves run below the zero line. Following this falling off in weight, No. 583 got back up to his former gains, and kept so for about six thirty-day periods. During December, 1917, and January, 1918, his gains dropped down to eight pounds, altho his grain feeds at this time were decreased only by a little over a hundred pounds, the roughage remaining fairly constant, tho there was a slight increase from here up to the time of slaughter. His gains picked up after two periods so that when he was slaughtered he was making fairly large gains again.

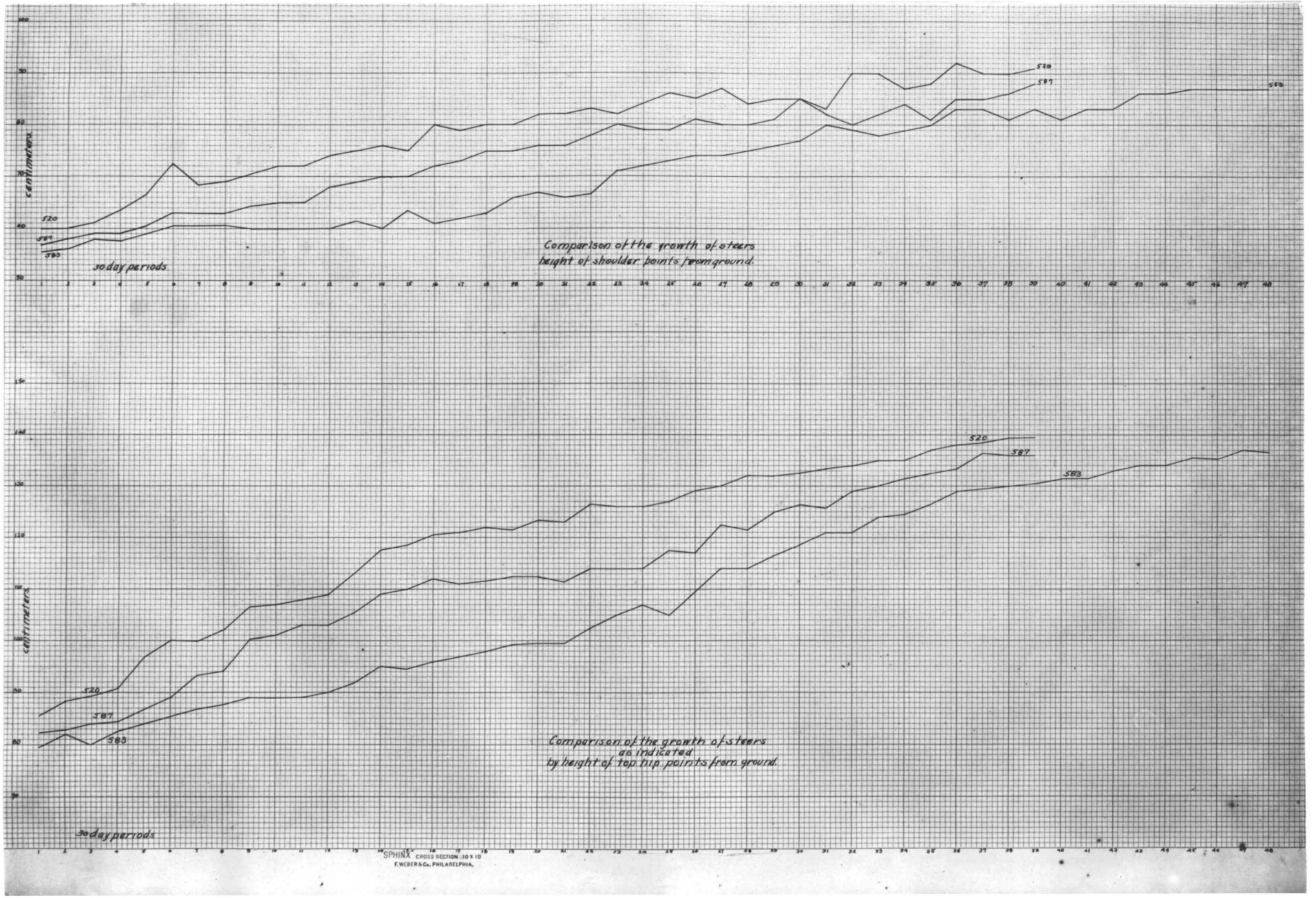
Neither No. 587 nor 520 during their life had any noticeable decrease in the amount of their grain or roughage. This is true up to the last five or six thirty-day periods of the lives of these animals. After that time their feed dropped toward the end, altho their gains were fairly constant. This would indicate that these two steers had gotten to the point where they continued to make fairly constant gains on a decreased ration.

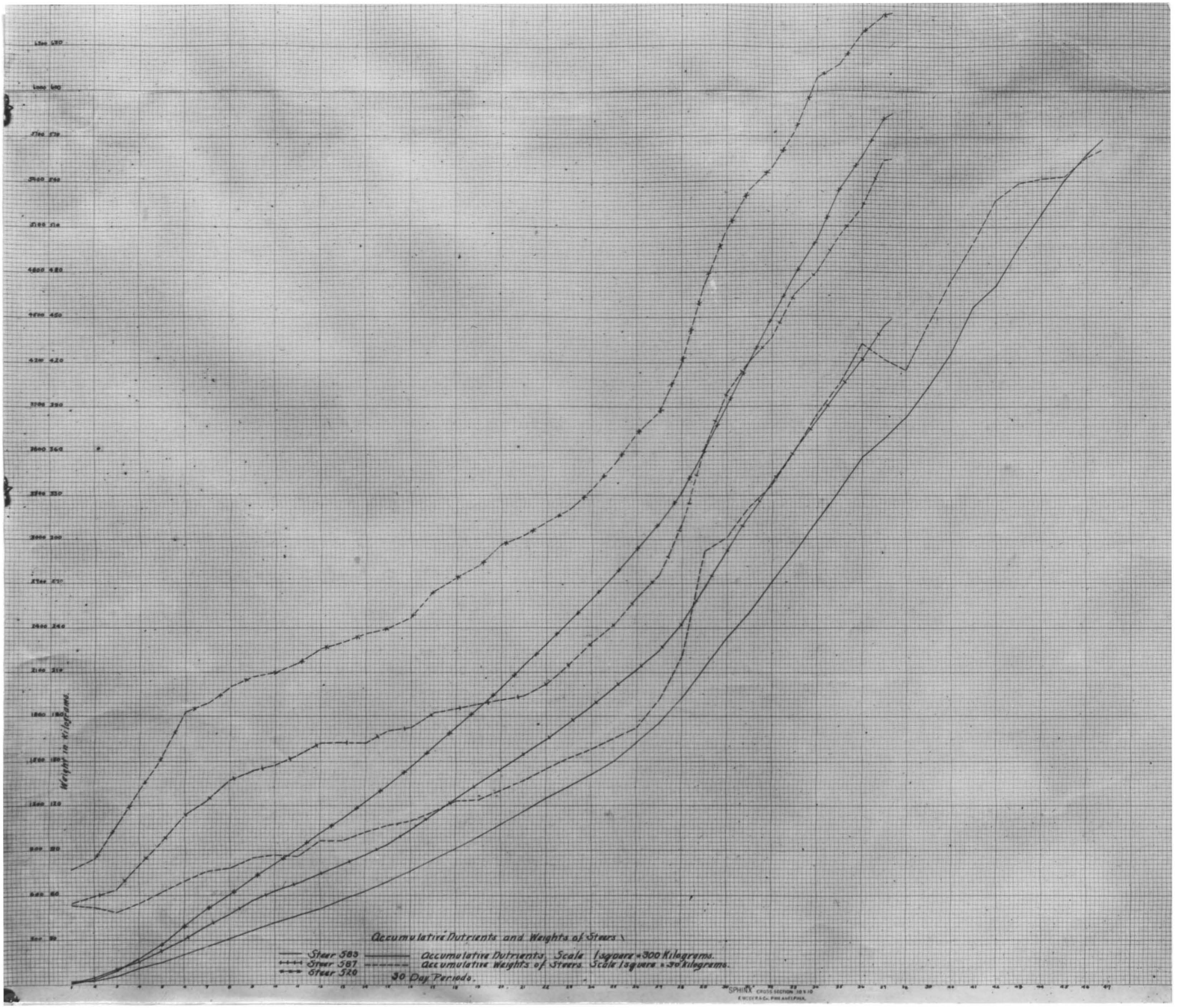
The total nutrient curves for the three steers are shown directly below the curves of the thirty day gains of each steer. Both curves are plotted in kilograms. From these curves can be seen what gain each steer made on the total nutrients of each period. The term <u>nutrient</u> as here used is the sum of the protein, fat, crude fiber, and nitrogen-free extract in the feeds. The term <u>total nutrients</u> for a thirty-day period would mean




520
587
588
Centimeters
Comparison of growth of steers
depth of chest
30 day periods
520
587
588
Centimeters
Comparison of growth of the steers
measuring from withers to point between hips
30 day periods
SPHINX CROSS SECTION 50 X 10
E. WEBER & Co. PHILADELPHIA.


Comparison of the growth of steers
measuring the width of hips.
centimeters
30 day periods
520
587
583
Comparison of the growth of steers
circumference of the shin bone.
centimeters
30 day periods
520
587
583
Comparison of the growth of steers
measuring the width of chest.
centimeters
30 day periods
520
587
583
Comparison of the growth of the steers
measuring the height at withers.
centimeters
30 day periods
520
587
583
SPHINX CROSS SECTION 30 X 10
F. WEBER & Co., PHILADELPHIA.


Comparison of the growth of steers
height of shoulder points from ground.
30 day periods.
centimeters
520
587
583
Comparison of the growth of steers
as indicated
by height of top hip points from ground.
30 day periods
centimeters
520
587
583
SPHINX CROSS SECTION 10 X 10
F. WEBER & Co. PHILADELPHIA.


Weight in Kilograms.
Accumulative Nutrients and Weights of Steers
Steer 583
Steer 587
Steer 520
Accumulative Nutrients. Scale 1 square = 300 Kilograms.
Accumulative Weights of Steers. Scale 1 square = 30 Kilograms.
30 Day Periods.

the sum of these four in the feed of a thirty-day period. The curves plotting the total nutrients for each thirty-day period and the gain for each thirty-day period are drawn to the same scale and are drawn so that the feed for a period and the gain for the same period may be compared. From these curves it is seen that the trend of the feed and gain curves of the different animals follow each other to a large extent. The general rise in feeds is followed by a rise in gains, and a general lowering of nutrients is usually accompanied by a general falling off of the gains.

The curves plotting the accumulative weights of steers and of nutrients are plotted on a scale of one to ten, i.e., the nutrients are plotted on a scale ten times that of the weights of the steers. It can be seen that after the twenty-fourth period there was a decided rise in the curve of nutrients, indicating that the fattening period began at this point. Toward the end of these curves there is a curve showing a less amount of nutrients while the weight curves keep up. This indicates the ability of a steer to make his gains on a smaller amount of feed after a certain point is reached.

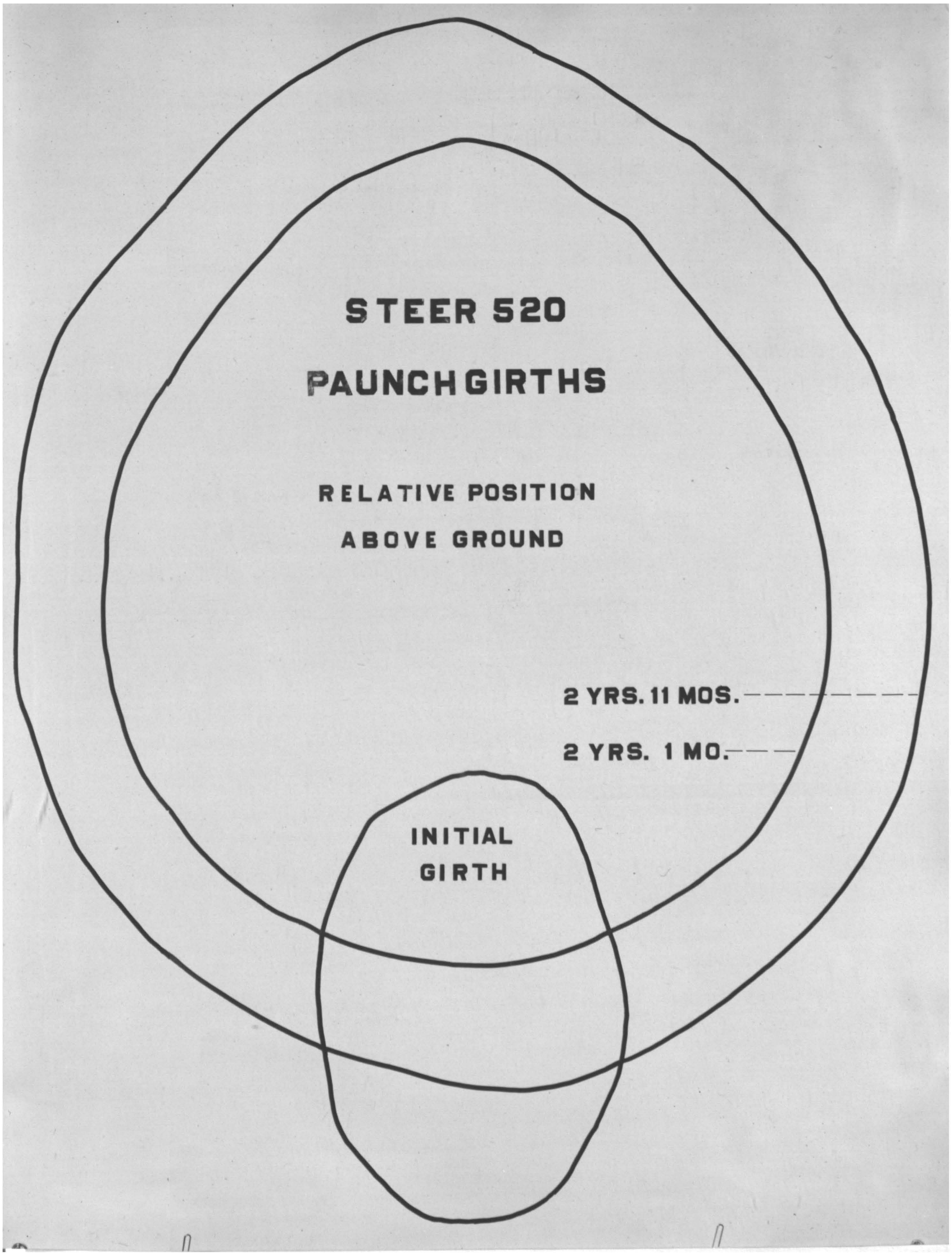
In the accompanying curves of No. 583 are seen the breaks and a slow rise, indicating the periods in which he had his set-backs.

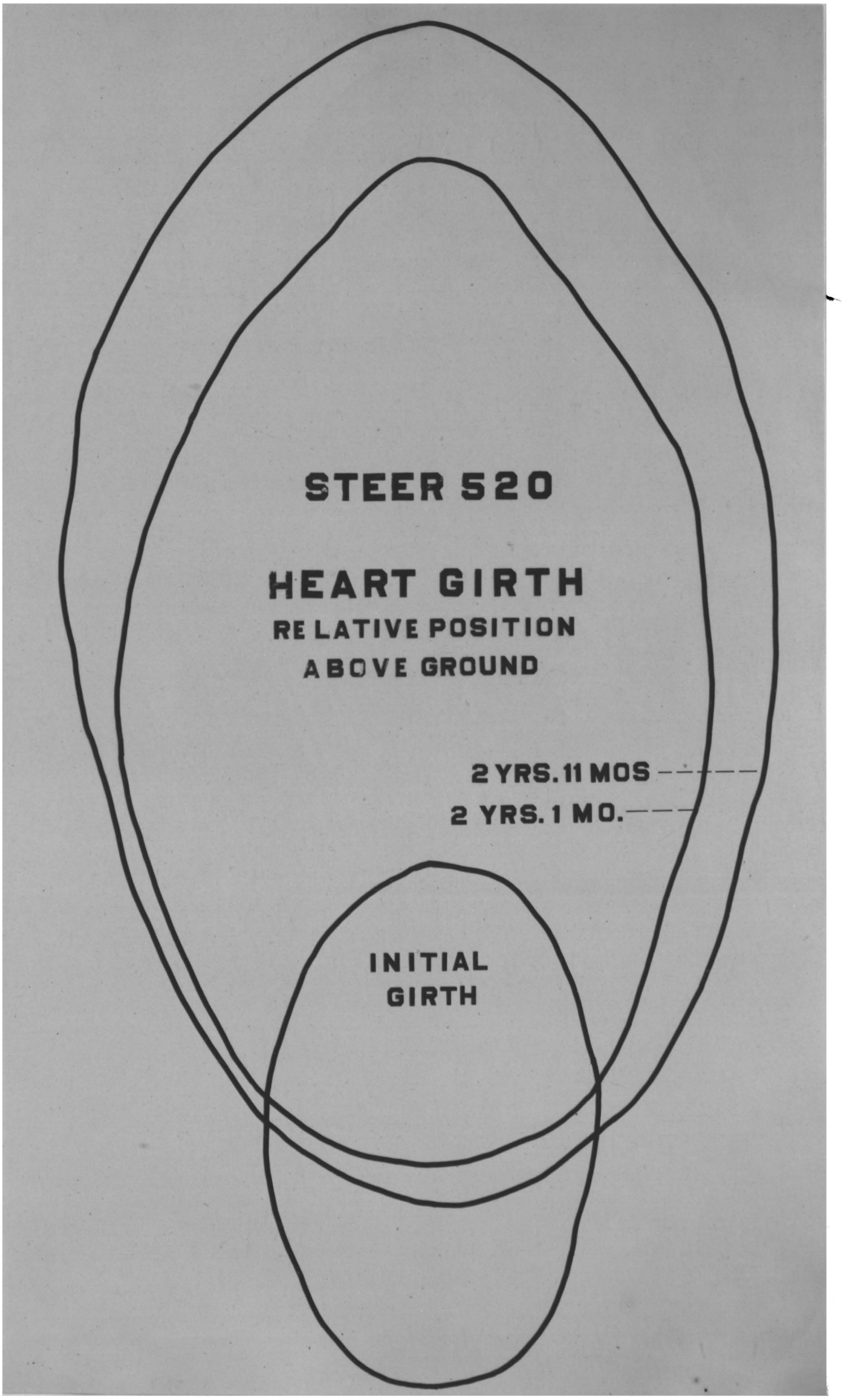
Despite the fact that the plane of nutrition of No.

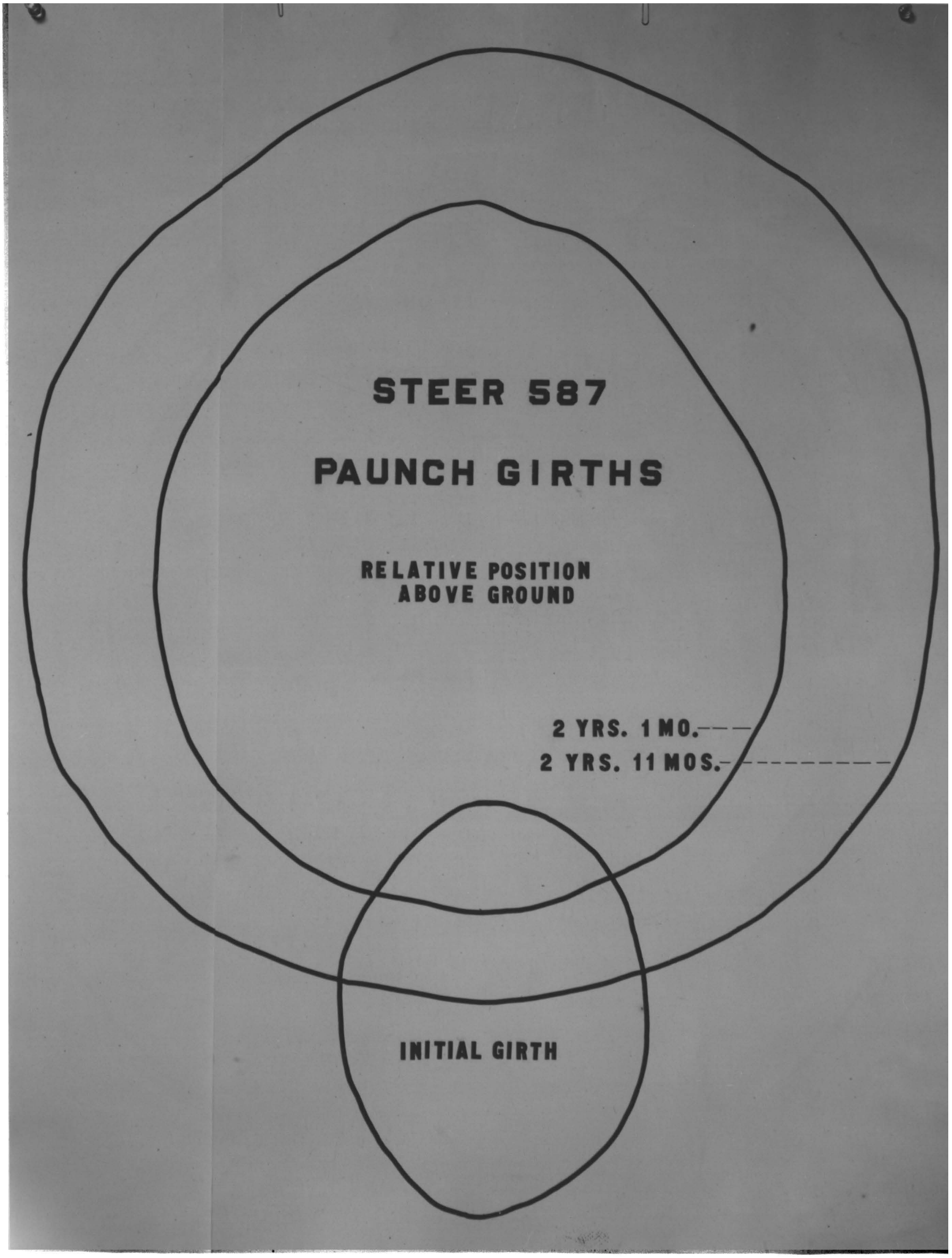
583 was a low one, the curves plotting the measurements indicating skeletal growth show a general tendency upward from the very beginning. This shows that, altho not at all well fed, No. 583 was growing steadily all the time. The curves during the last periods of his life still show this upward trend, which indicates that tho he was on full feed and presumably should be filling out he was using this food for a skeletal growth up to the time of slaughtering.

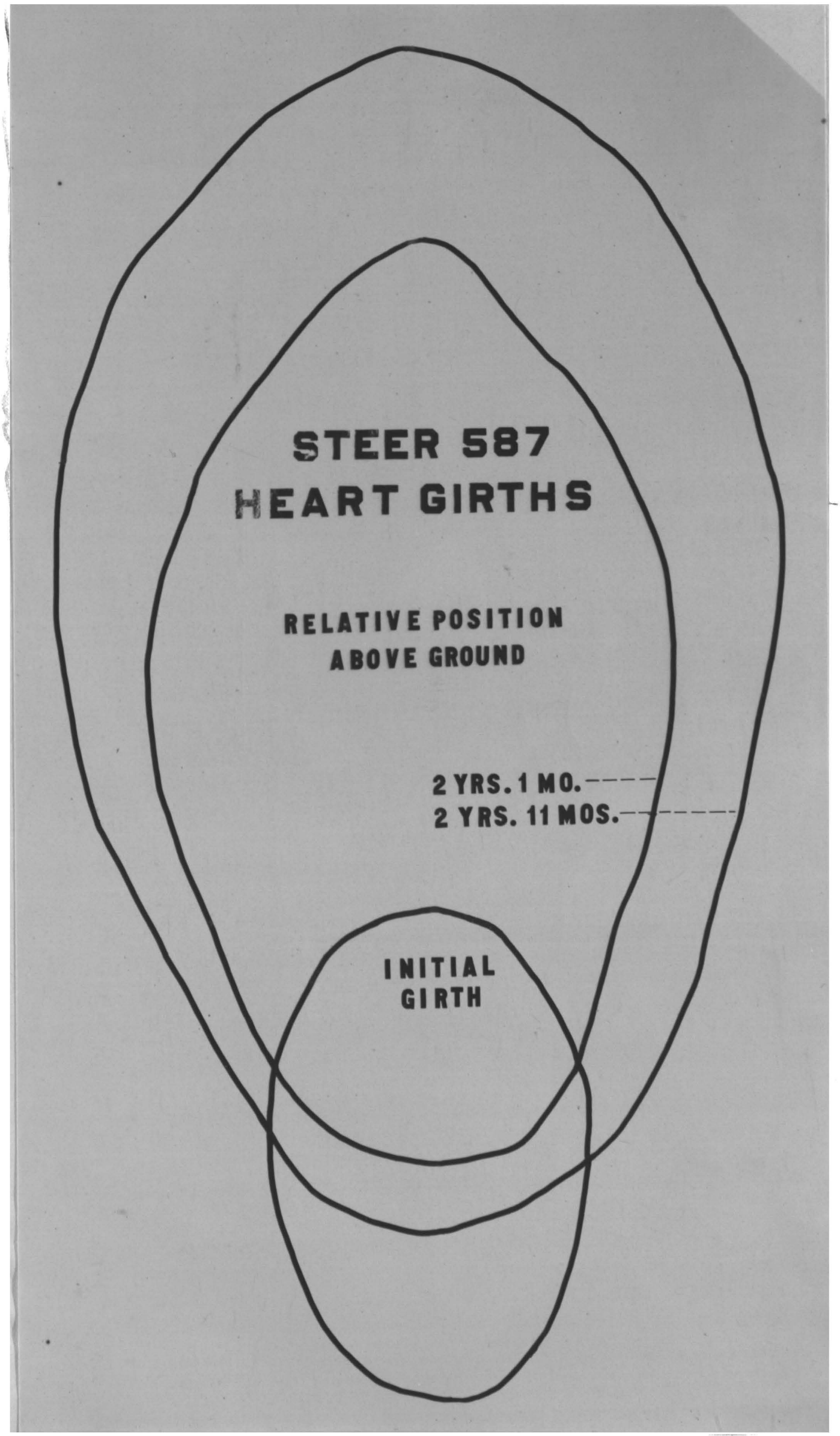
The curves of the other two animals show considerable divergence. The majority of these fluctuations are probably due to an unavoidable error in measuring. It is a rather hard proposition to measure these animals at exactly the same place each time and to establish the same points of measurement. Even considering this, there is a variance either way from a regular curve that is not found to such an extent in No. 583.

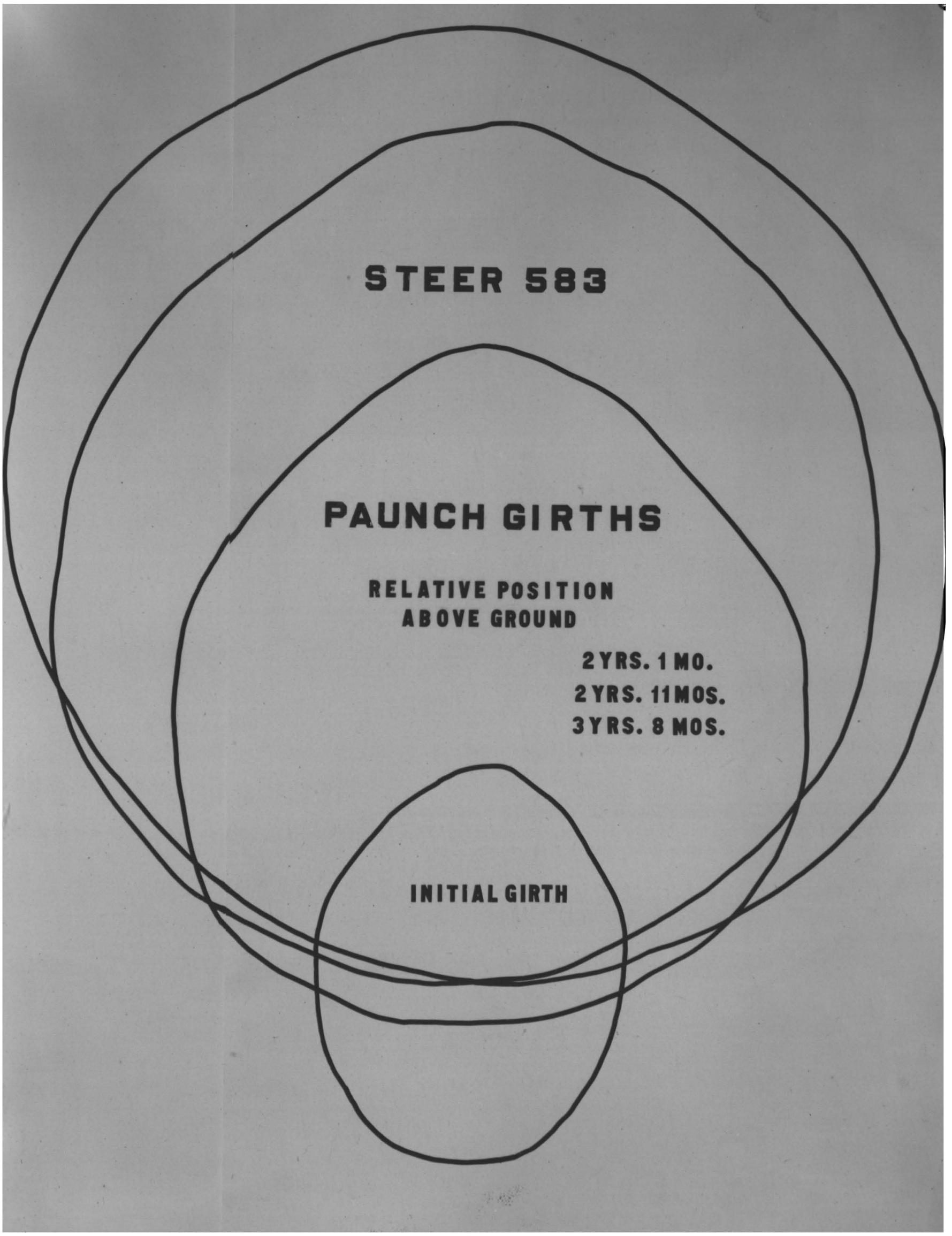
The plates showing the heart and paunch girths give the girths for the first set of measurements, at about the beginning of the fattening period, and the last measurement before slaughtering. In addition to these, No. 583 has the girths plotted which were taken at the time of slaughtering No. 520 and No. 587. As it is stated on the charts, the measurements are so drawn that they show the relative height from the ground of the steers at the time of the different measurements.

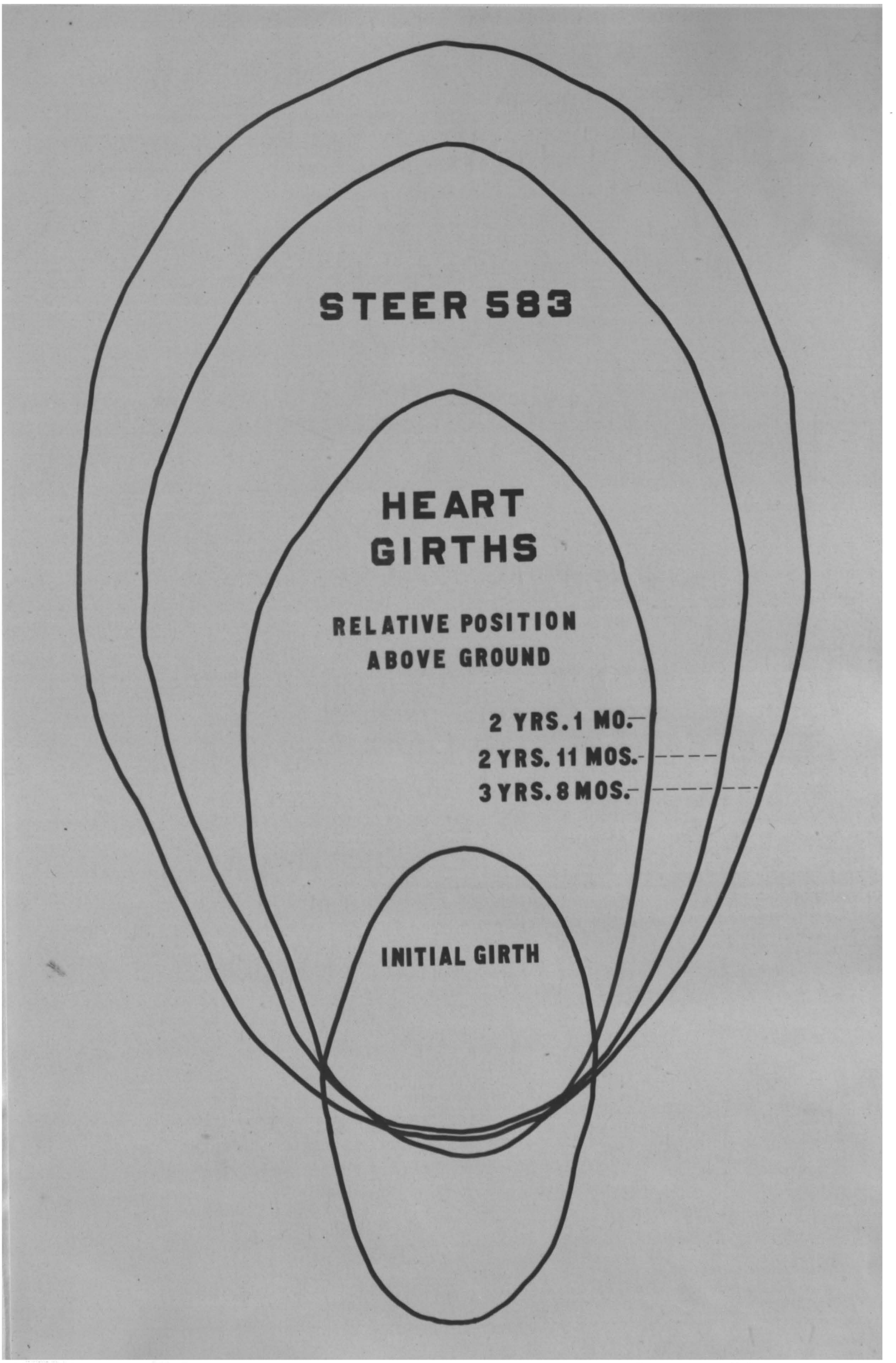

STEER 520
PAUNCH GIRTHS
RELATIVE POSITION
ABOVE GROUND
2 YRS. 11 MOS.
2 YRS. 1 MO.
INITIAL
GIRTH


STEER 520
HEART GIRTH
RELATIVE POSITION
ABOVE GROUND
2 YRS. 11 MOS
2 YRS. 1 MO.
INITIAL
GIRTH


STEER 587
PAUNCH GIRTHS
RELATIVE POSITION
ABOVE GROUND
2 YRS. 1 MO.
2 YRS. 11 MOS.
INITIAL GIRTH


STEER 587
HEART GIRTHS
RELATIVE POSITION
ABOVE GROUND
2 YRS. 1 MO.
2 YRS. 11 MOS.
INITIAL
GIRTH


STEER 583
PAUNCH GIRTHS
RELATIVE POSITION
ABOVE GROUND
2 YRS. 1 MO.
2 YRS. 11 MOS.
3 YRS. 8 MOS.
INITIAL GIRTH


STEER 583
HEART GIRTHS
RELATIVE POSITION ABOVE GROUND
2 YRS. 1 MO.
2 YRS. 11 MOS.
3 YRS. 8 MOS.
INITIAL GIRTH

The charts show that No. 520 and No. 587 both filled out; that is, their outlines after they were put on a fattening ration extend up at the back and below at the belly, showing that the two animals filled out faster than they grew. The growth of leg was not fast enough to offset the downward movement of the belly line. No. 583, however, shows that he grew after being put on a fattening ration to such an extent that his belly line went up instead of down. It is seen that the two lines of the girths at the time of slaughter of No. 520 and No. 587 and at the time of his own slaughter are higher than when he went on a fattening ration, indicating a growth in leg which was faster than his fattening out.

The photographs shown at the end are put there with the purpose of showing the relative conditions of the three animals thruout their life in the investigation. While the photographs were taken every three months, an interval of six months has been left in the photographs used.

Cost of Feeding

In calculating the cost of feeding these three animals no attempt has been made to average the market price of the feed stuffs during the lives of these animals in the investigation. The prices taken are the current

prices for the spring of 1918. Using the values given below, the discussion shows which of the three steers in comparison with the other two was produced most cheaply.

Corn	$1.60 a bushel	Milk Skim	$0.50 per cwt.
Bran	$30.00 a ton	Whole	3.00 per cwt.
Linseed Meal	60.00 a ton	Timothy	30.00 a ton
Alfalfa Hay	30.00 a ton		
Oats Straw	8.00 a ton		

Remembering that the grain was six parts corn chop, three parts bran, and one part linseed meal, from the above figures it is calculated that the grain ration costs $0.025 a pound. Similarly, the roughage of six parts alfalfa hay and four parts oats straw costs $0.013 a pound, and timothy hay $0.015 a pound.

The following table shows just what each steer was fed thruout and the cost of his feed during his life in the investigation.

Table No. 9

Total Feed for Steers

	Steer 520	Steer 587	Steer 583
Milk			
Whole, pounds	121.92	167.10	240.53
Skim, pounds	3,081.68	1,869.80	1,524.87
Timothy Hay, lbs.	19.50	21.65	23.25
Alfalfa Hay and Oats Straw, lbs.	5,629.30	5,176.00	8,829.00
Grain, pounds	9,346.50	6,243.55	6,102.80

Total Cost of Feed for Steers

Milk, whole	$ 3.66	$ 5.01	$ 7.22
Milk, skim	15.41	9.35	7.62
Timothy Hay	0.29	0.33	0.35
Alfalfa Hay and Oats Straw	73.18	67.29	114.78
Grain	233.66	156.09	152.57
	$326.20	$238.07	$282.54
Cost per Pound Live Weight	$0.229	$0.195	$0.228
Cost per Pound Gain	$0.254	$0.214	$0.249

Cost of Feed of Steer 504

Milk	$25.57
Grain	149.07
Timothy	5.97
Alfalfa Hay	46.93
Total Cost	$227.54
Cost per pound live wt.	0.196
Cost per pound gain	0.226

The tables show that the total cost of raising No. 587 is less than that of either of the other two. The cost per pound of live weight of No. 587 is also less than that of either of the other two. The data of No. 504 are brought in to compare with No. 587. No. 504 was a steer full fed from birth and was in prime condition. At slaughtering he weighed 1160 pounds, at an age of about twenty-two months, and was considered to be in the very best condition and to have the best quality of flesh. Any more feed it was judged would lower the quality of the flesh. The tables show that No. 587 after a slight retardation for two years came to about the same condition as No. 504 for the same cost per pound, altho it must be remembered that he weighed 1221 pounds at the time of slaughter and was a little over three years old.

However, no farmer can afford to raise steers for the market if they are to cost him nineteen or twenty cents a pound to produce. The growth that these steers made during the summer would be made on cheaper feed than the ration used. If put on pasture at $5.00 an acre their growth would probably be just as large. Then if fattened out they could be raised at a cost considerably less than is shown here. The feeds used in this investigation had to be of the more expensive in order that uniformity might be obtained. No estimate can be made on the cost of raising steers for market. The figures worked out here are for the comparison of the steers with each other and not with actual cost of production in practice.

The following table shows the average gain and the cost of this gain in both nutrients and money for the first twenty-four periods up to the fattening period.

Table No. 10

	Steer 520	Steer 587	Steer 583
Average 30-day gains in pounds	24.18	16.09	10.35
Cost of gain for 30-day period	$5.97	$3.95	$2.82
Cost in pounds of nutrients for 30-day period	237.61	171.38	129.258
Cost of one pound gain	$0.247	$0.245	$0.272
Cost in nutrients of one pound gain	9.8	10.65	12.49

The table shows that No. 583 for the first twenty-four periods was the least expensive animal to keep. This, however, is only what could be expected, considering his plane of nutrition. Yet if the cost of one pound is taken as a basis of comparison, No. 583 is the most expensive, with No, 587 a little cheaper than No. 520. In using the nutrient cost of one pound as a basis, No. 520 was making his gains at a less cost in nutrients than either of the other two. However, it is apparent here that No. 520 was getting a larger amount of expensive concentrates. As the severity of the retardation increased the cost in nutrients per pound gain increased.

But one of the important points to be taken up in this investigation is whether or not the animals can recover from a retarded growth. The table following gives the average thirty-day gain, and the cost of this gain in nutrients and money from the beginning of the fattening period until the time of slaughter.

Table No.11

	Steer 520	Steer 587	Steer 583	Steer *583
Average 30-day gain from 24th period to morning of slaughter (pounds)	50.4	51.5	38.59	40.4
Average cost in money of gain for 30-day period	$13.07	$10.24	$9.33	$8.07
Average cost in pounds of nutrients for 30-day period	521.07	425.89	380.16	415.9
Average cost in money of one pound gain	$0.259	$0.199	$0.242	$0.199
Average cost in nutrients of one pound gain	10.33	8.27	9.85	10.29

*Up to day of slaughter of No. 520.

Table No. 9 shows very clearly that No. 587 was the cheapest animal of the three to raise in cost of nutrients and money cost. The gains of No. 583 were less expensive in money and nutrients than those of No. 520. Steer 520 seems to be the most expensive animal of the three. The first column of No. 583 indicates his average costs during his entire fattening period. His costs are enough higher than No. 587 to make him an impractical animal to raise. Yet he seems a better type than No. 520 from a production point of view.

The table seems to indicate that from the beginning of the fattening period up to the time of slaughter of

No. 520, No. 583 was recovering from the effects of retardation. It can be seen that No. 583 upon getting to a full feed was unable to handle it and promptly went off feed. Up to the time of slaughter of No. 520 he was making his gains at the same cost per pound in money as No. 587. His nutrient cost per pound gain is higher than for No. 587 and a little lower than for No. 520. No. 587, it is seen, made the better gains of the three at less cost in money or nutrients per pound than the other two.

No. 583, altho making fair gains at a cost not so much higher than the other two, in going off feed raised his average cost to a point where he was second of the three in cost of production. The point to be raised then is: had No. 583 been killed at the same time as No. 520, would he have been any more expensive than the other two? Table 11 gives the cost of No. 583 from the beginning of the fattening period to the time of slaughtering No. 520. It can be seen that during that period his average thirty-day gain was 40.4 pounds, about ten pounds less than the gain of the other two. To make this gain, his actual cost per pound was $0.199, or just the same as for No. 587. His nutrient cost for this period is larger than No. 587's, and a little less than No. 520's. From these figures it would seem that killing No. 583 at the same time as the others would save considerable money.

In order to obtain a figure as to the relative value of the steers the following prices have been assumed: No. 520, $15.00 a hundred, No. 587 and No. 583, $14.90 a hundred. From former figures given this will of course show a loss, but the animal showing the least loss will be the more profitable type to raise. This table shows the total cost, the selling price, and the loss.

Table No. 12

	Cost of Feed	Selling Price of Steer	Loss
Steer 520	$326.20	$213.45	$112.75
Steer 587	238.07	181.93	56.14
Steer 583	282.54	186.69	95.85
*Steer 583	179.89	136.86	43.03

*Figure to the time of slaughter of No. 520.

This table indicates very clearly that No. 587 was the most profitable type of animal of the three, for he shows much less loss than the other two. The second set of figures for No. 583 are the figures representing his cost and selling price if he had been slaughtered at the time of No. 520. At this time he weighed 931 pounds. It is seen that had he been sold at that time he would have lost less money than the other two. His price was taken at $14.70 a hundred, which was judged to be a good price for him at that time. He not only shows a smaller

loss and consequently a better profit for the farmer, but if the table of feeds (No. 3) is studied this thing is seen. No. 583 was fed a greater amount of roughage in relation to his grain than either of the other two and consequently from a grain standpoint made his growth more economically.

At this time, in the growing of steers for the market on a plane of nutrition similar to that of No. 583, there is this point to be thought of: by using larger amounts of roughage and less grain in steer feeding, foods which are unfit for human consumption are utilized. Corn, oats, and bran which are at this time necessary for wheat substitutes are saved for human consumption, and at the same time the steers are raised on foods which only they can use, and produce meat at a greater profit to the farmer. If this is further corroborated in this investigation a great deal will have been accomplished.

In none of the calculations is there any attempt to figure the cost of equipment, interest on the investment, cost of labor, or any other items of cost. The only figures used are the cost of the feeds and an assumed selling price. The selling prices may not represent the actual prices at this time, but they do represent the relation of the steers to each other.

From the figures on cost that have been given it has been shown that No. 587 was the most profitable type of

animal to raise. When the previous discussion of the meat side of the question is recalled, the above statement is further corroborated. No. 587 had the highest per cent of lean with a less per cent of fat and bone than the other two. The thought must be borne in mind, however, what would have been the result had No. 583 been killed with the other two? In figuring the data at hand, however, No. 587 was the most profitable animal.

Slaughtering

In June, 1917, steers Nos. 520 and 587 were thought by the Department of Animal Husbandry to be in a good finished condition. Steer 520, being Group I and having had a ration permitting a maximum growth up to the fattening period, was the smoothest of the three. No. 587 was thought to need about ten days more feeding to finish him, while No. 583 was judged to be sixty to ninety days later. Preparations were accordingly made for the slaughter of the animals and for the care of the samples. On June 15th No. 520 was slaughtered, and on June 25th No. 587 was killed, but, contrary to the opinion of the animal husbandry men, No. 583 did not finish out in sixty days and was not killed until March 26th, 1918, nine months later.

Conditions just before, during, and after slaughter were held as near the same for each animal as possible. All the animals were watered and weighed but not fed on the morning of slaughtering. The day before slaughter-

ing photographs of the side, front and rear of the animals were taken, and a complete set of measurements made. The steers were weighed again just before being taken to the killing floor. Here they were stunned, and hoisted for bleeding. The blood was caught in a tared tub, weighed, and measured for volume. Blood samples were taken for analysis as the blood ran from the throats of the animals. Corrections were afterwards made for this blood in the total weight and volume of the blood. Any blood that dropped from the carcasses during the entire operations was kept wiped up from the floor and added to the total blood.

When the bleeding was completed, the heads were skinned out and severed from the body. The head meat was cut from the head and the tongue taken out, after which the head skeleton was sawed in half and the brains removed. The right half of the head skeleton, all the head meat and brains were saved for analysis.

The carcass was then lowered to the floor and skinned about half way down the sides and on the legs. The dew claws were cut from all four legs and the fore and hind legs were taken off at the knee and hock joints. The dew claws and the lower legs were each put into tight containers. The carcass was then opened up and the caul fat removed and put into containers. In order to facilitate the removal of the internal organs the carcass was hoisted slightly and the organs were then taken out.

Each of the organs was separated and put into containers to be saved for analysis. The digestive system was weighed with the contents and adherent fat. This fat was then removed and put in with the caul fat. The stomachs were then thoroly washed and wiped. The contents were stripped from the intestines. While the internal organs and fat were being taken care of the carcass was being skinned. The hide was weighed and tied up to be taken to the laboratory.

The carcass was cut in half and taken to the coolers (without being cut into quarters), together with all the other parts. At the coolers the half carcasses were weighed and then chilled for forty-eight hours. The internal organs were taken from their separate containers and accurately weighed. They were then finely ground and thoroly mixed and put into small tight containers from which samples were taken for analysis. The intestines, in addition to being weighed, were measured for length before being ground. The digestive organs, having now been weighed empty, it was possible to get the weight of the contents by difference.

The carcass having cooled for forty-eight hours, the right side was weighed and inside and outside views taken. It was then cut up into the wholesale cuts. Pictures were taken of some of the cuts, including cross-section views, one looking at the sixth rib and one looking at

the twelfth rib. The whole cuts, after being weighed, were separated into the lean, fat, and bone, each of which parts was weighed again in order to check them with the whole weight of the cut. The lean, fat, and bone of the cuts were then finely ground and mixed to prepare them for analysis. Each of the component parts was separated for individual analysis, with the exception of the following groupings: shin and shank, chuck and neck, flank and plate, and head and feet and tail. In these the lean and fat went to make up one sample and the bone to make another. This hide was cut down the middle of the back and the right side was cut into strips from which a composite was made for analysis. Composite samples were made of the internal organs, the lean and fat flesh, the skeleton, and the hair and hide, hoofs and dew claws. The samples that were analyzed for moisture, ash, protein, fat, and phosphorus are seen in tables Nos. 20 to 26, which give the composition of the flesh, skeleton, internal organs, and the hair and hide composite.

In comparing the general appearance of the three carcasses, No. 520 had a much better appearing carcass. When slaughtered, No. 520 was nearer being a prime animal than No. 587 which was not so smoothly finished. No. 520 was fatter than No. 587, which does not coincide with the opinion of the animal husbandry men who thought No. 587 was the fatter of the two animals. In regard to

the kidney fat, No. 587 had a larger per cent of fat, but in comparing the fat in the different cuts and the external covering, No. 520 had the larger relative amounts of fat. No. 520 dressed out 62.2 per cent, while No. 587 dressed out only 60.6 per cent, less than No. 583 which dressed out 61.1 per cent. A study of table No. 13, giving a comparison of the fat of the three animals, will show how much fatter No. 520 was than the other two. A comparison of carcasses can be made from the photographs which have been introduced here.

The differences between the carcasses of Nos. 583 and 587 are not so noticeable. The carcasses were about the same weight, any advantage being in favor of No. 583 which it has been shown dressed out higher than No. 587. An inside view of the carcass showed No. 583 to have a larger amount of kidney fat than No. 587. It has been said that slow growth in an animal has a tendency to cause the piling up of a large amount of internal fat. The kidney fat and offal fat in No. 583 were both greater in amount than in No. 587, while compared to No. 520, No. 583 had more kidney fat and less offal fat.

In considering the fat of the entire animals, No. 520 is the fattest of the three, with No. 583 second, and No. 587 third.

520

520


587

587

#583

583

Table No. 13

°Per Cent of Fat

	Steer 520	Steer 587	Steer 583
Shin	7.858	7.224	7.229
Plate	42.902	37.130	35.313
Neck	28.163	21.777	17.668
Chuck	17.445	14.571	16.668
Rib	26.816	26.570	21.714
Shank	7.169	6.270	6.493
Rump	36.845	34.800	31.262
Round	15.229	13.718	14.464
Loin	35.635	30.206	44.210
Flank	63.216	64.718	64.626
Kidney Fat	*1.738	*2.391	*2.541

°Referred to entire animal.

*On basis of entire animal.

Table No. 14

*Per Cent of Lean

Cut	Steer 520	Steer 587	Steer 583
Shin	53.201	55.365	59.630
Plate	45.561	49.894	51.918
Neck	57.551	59.555	60.777
Chuck	66.125	70.180	68.643
Rib	57.348	57.791	62.294
Shank	27.574	29.189	28.355
Rump	40.806	44.336	48.297
Round	74.186	75.434	74.717
Loin	53.730	58.485	43.434
Flank	36.082	34.745	34.751

***Referred to the entire carcass.**

In relation of the fat to the lean in the cuts, it is seen from tables Nos. 13 and 14 that in nearly every case, No. 520 has a less per cent of lean and a higher per cent of fat than either of the other two steers. This might be expected since No. 520 had more fat in relation to body weight than the other two, altho he had quite a large amount of offal fat. The loin and flank are the two cuts that have less fat than the same cuts of the other two animals. These facts show that No. 520 was the fattest of the three animals.

In No. 587 and No. 583 the relation of lean and fat flesh in distribution in the cuts is not so easily seen. The following table (No. 15) shows the order (1,2, or 3) of the animals in their amounts of lean, fat, and bone.

Table No. 15

	°LEAN			°FAT			°BONE		
	Steer 520	Steer 587	Steer 583	Steer 520	Steer 587	Steer 583	Steer 520	Steer 587	Steer 583
Shin	3	2	1	1	3	2	1	2	3
Plate	3	2	1	1	2	3	3	1	2
Neck	3	2	1	1	2	3	3	2	1
Chuck	3	1	2	1	3	2	1	2	3
Rib	3	2	1	1	2	3	2	3	1
Shank	3	1	2	1	3	2	1	3	2
Rump	3	2	1	1	2	3	1	2	3
Round	3	1	2	1	3	2	3	1	2
Loin	2	1	3	2	3	1	3	2	1
Flank	1	3	2	3	1	2	1	3	2
Kidney fat				*3	2	1			

°Figured on basis of entire carcass.
*Figured on basis of entire animal.

From the foregoing table it is seen that No. 583 has a larger number of cuts with a higher percentage of lean than No. 587, and at the same time No. 583 has just a little more fat than No. 587. A study of the tables showing the per cents of fat, lean,aand bone, shows how much higher the per cents of lean are in No. 583 than in No. 587. In the more expensive cuts of meat, the loin, rib, round, and chuck, No. 587 has the higher per cent of lean with the exception of the rib. The fat in these same cuts is higher in only the rib cut of No. 587, No. 583 having the highest in the other three. This would indicate that No. 587, in the more expensive cuts of meat, was better than No. 583, for the lean meat is greater and the fat relatively smaller. In regard to the bone content of these same cuts, there is very little difference (table No. 16), for No. 587 has a little more in the chuck and round and a little less in the other two, and consequently there is little difference in the total flesh of the two. In considering the entire carcass, however, No. 583 has the most lean in proportion to a smaller amount of fat and consequently would seem to be the more desirable of the three. No. 520 has so much fat in proportion to his lean, along with the highest per cent of bone, that he is probably just a little less desirable than No. 583.

Table No. 16

*Per Cent of Bone

	Steer 520	Steer 587	Steer 583
Shin	38.941	37.416	33.141
Plate	11.538	12.976	12.769
Neck	14.286	18.666	21.555
Chuck	16.430	15.247	14.688
Rib	15.837	15.640	15.992
Shank	65.257	64.541	65.152
Rump	21.641	20.864	20.441
Round	10.585	10.848	10.818
Loin	11.176	11.308	12.356
Flank	0.701	0.536	0.622

*On basis of entire skeleton.

When the kidney fat is figured in the carcass and the figures in table No. 17 are studied No. 587 is shown to have probably the best carcass. There is a higher per cent of lean with a less amount of fat and bone. The slow growth of No. 583 caused the piling up of a large amount of internal fat. Such amounts of fat are objectionable because they represent fat that cannot be sold with the lean and must be marketed at a lower price.

When the relation of lean, fat, and bone to the body weight is considered, No. 587 is shown to be the better animal. Here the percentage of lean is higher and the relative amounts of fat and bone lower. However, the dressing out per cent enters into the discussion. No. 520 dressed 62.2 per cent, No. 583, 61.1 per cent, and No. 587, 60.6 per cent. It would appear here that No. 520 was the better animal as he dressed out higher. He is better from the packer's point of view, but from the standpoint of the desirability of the meat, a high per cent of lean with a lower per cent of fat makes better meat.

From the appearance of the different cuts of meat of the three carcasses there seems to be little difference. The lean of the three animals seems to be equally well marbled.

The photographs of the cuts of the three animals in-

Table No. 17

Comparison of Various Parts of the Animals

	Steer 520	Steer 587	Steer 583
Empty weight, pounds	1423.00	1219.70	1240.70
Weight of offal fat, pounds	105.82	69.24	80.80
Per Cent of offal fat	7.436	5.677	6.512
Weight of kidney fat, pounds	24.74	29.26	31.52
Per cent of kidney fat	1.738	2.391	2.541
Fat of entire animal, pounds	370.28	277.89	308.75
Per cent fat of entire animal	26.021	22.783	24.885
Bone of entire animal, pounds	168.79	140.12	146.72
Per cent bone of entire animal	11.862	11.488	11.825
Lean of entire animal, pounds	498.66	435.44	428.30
Per cent lean of entire animal	35.043	35.701	34.521

Comparison of Lean, Fat, and Bone of the Carcass

Weight of carcass	876.00	740.00	758.00
Weight of lean	492.28	427.94	418.74
Per cent of lean	56.196	57.829	55.243
Weight of fat	260.80	204.36	225.60
Per cent of fat	29.772	27.616	29.763
Weight of bone	129.14	107.28	109.92
Per cent of bone	14.744	14.497	14.501

troduced here show that marbling in the cuts of all three was much the same. The slight retarding of No. 587 seemed to have no effect in this respect and even the severe retarding of No. 583 had no effect. The loin, round, and chuck views shown of No. 583 were not taken of the other two animals and are introduced as additional proof that the severe retarding seemed to have no effect on the marbling.

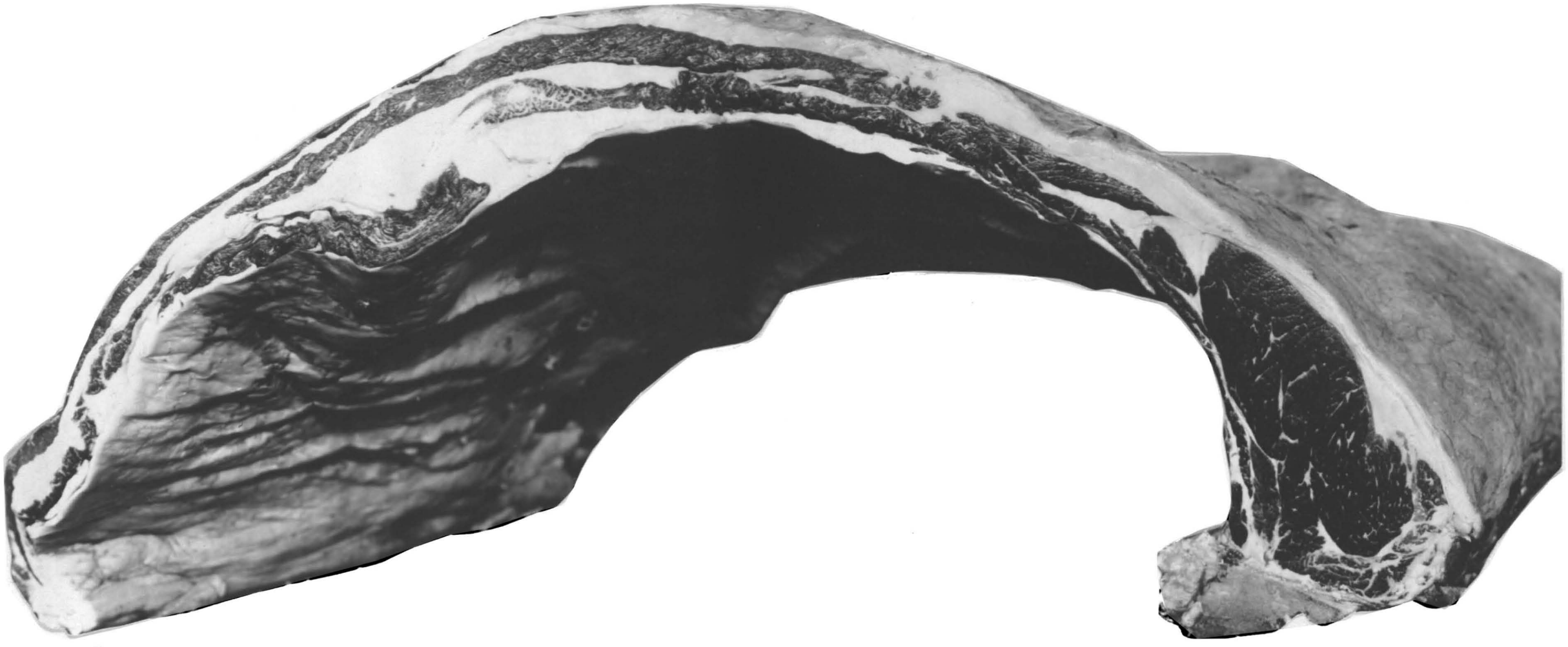
In making these comparisons the plane of nutrition of the animals should be borne in mind. No. 520, having been allowed maximum growth and then being fattened, might be expected to be fatter and bigger than the other two. No. 583, considering his plane of nutrition for the first two years, has come up and compares pretty well with the other two in lean, fat, and bone, but it must be remembered that he was nine months older and had that much longer in which to catch up with the other two,

In regard to the effects of retarding of growth upon the carcass very little can be said at this time. The investigation must go farther to show definitely the effects of retardation. One condition which may be attributed to retardation was found in No. 587. In cutting thru the shoulder blade at a point between the fifth and sixth ribs the shoulder blade was found to have not yet become completely ossified. Stunting of animals is

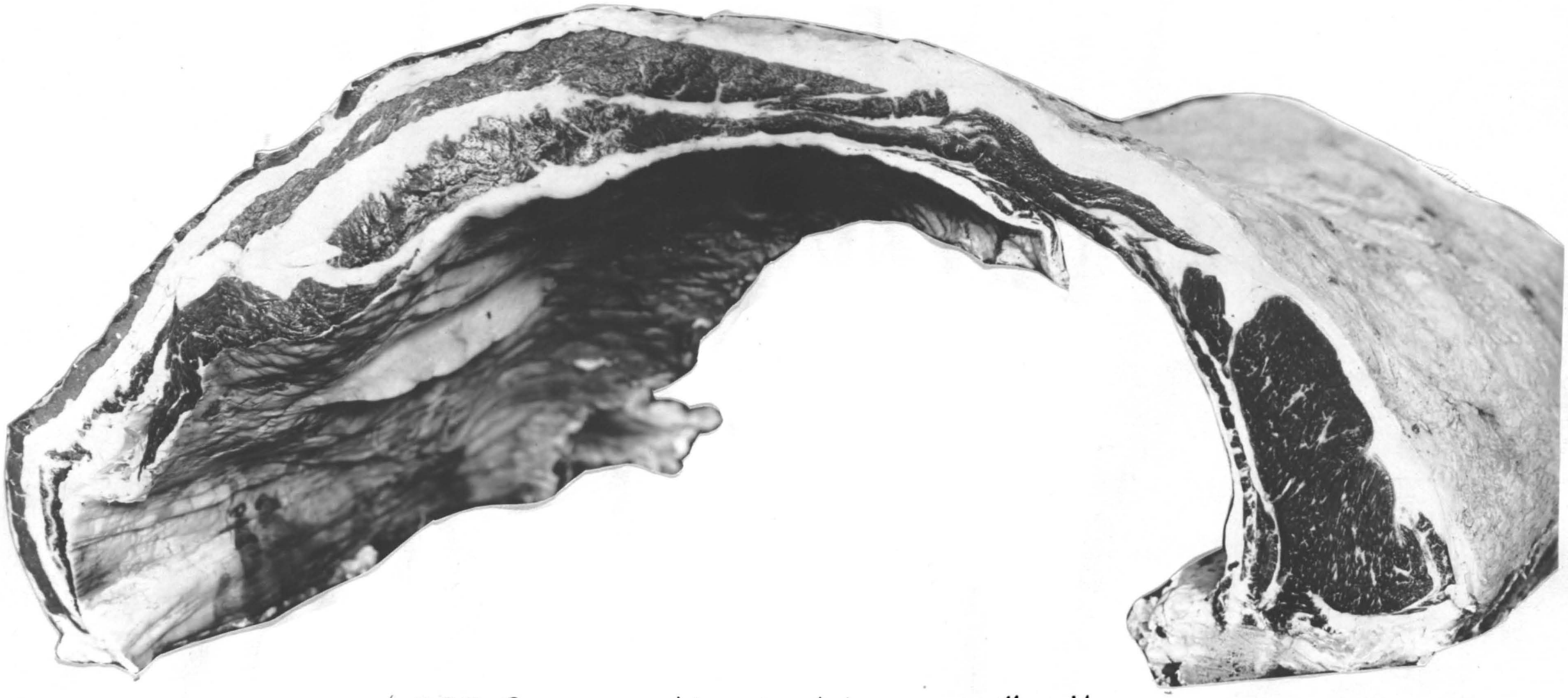
#520 Cross-section looking at 6th rib

#587 Cross-section looking at 6th rib.

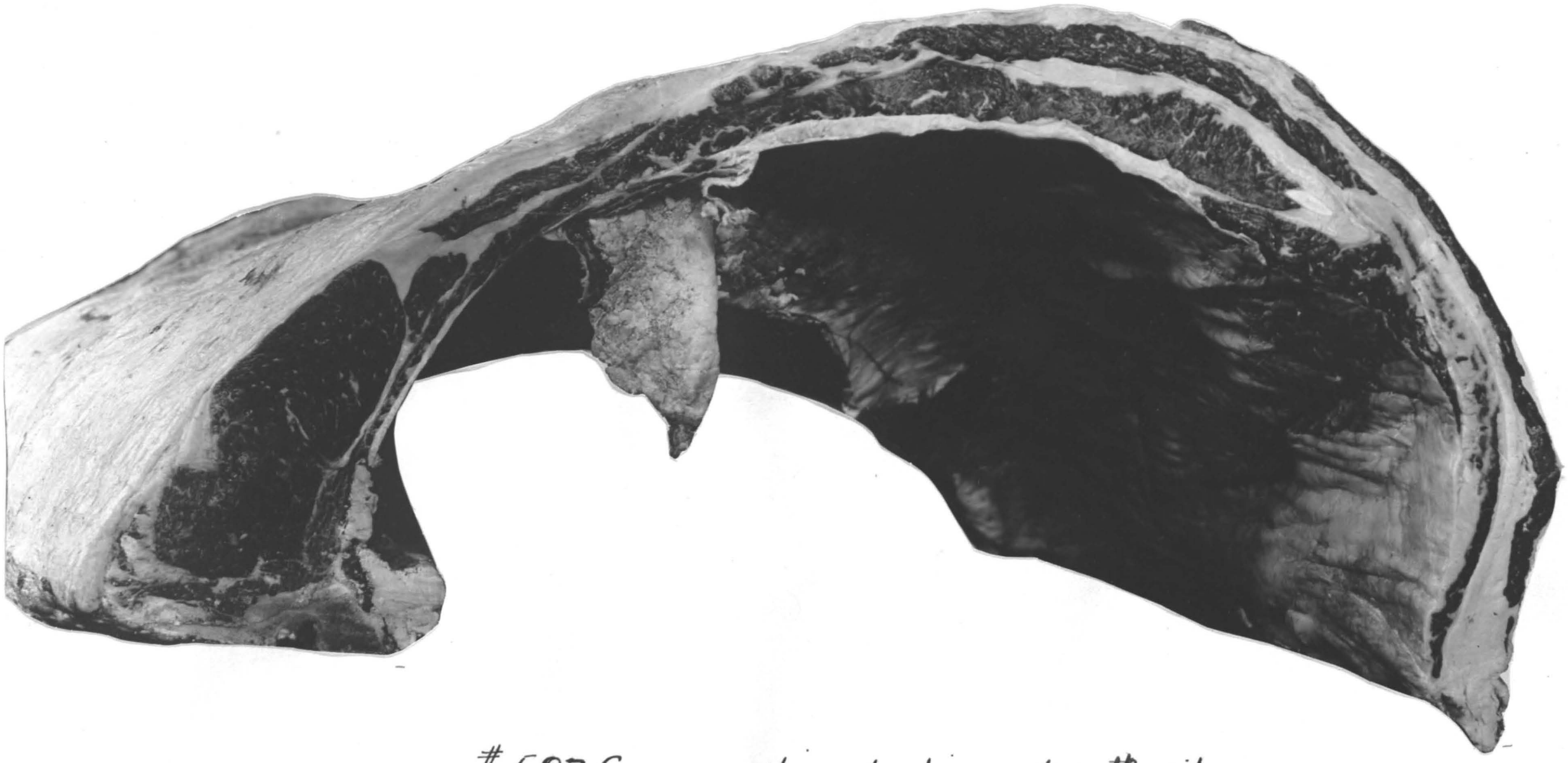
#583 Cross-section looking at 6th rib.



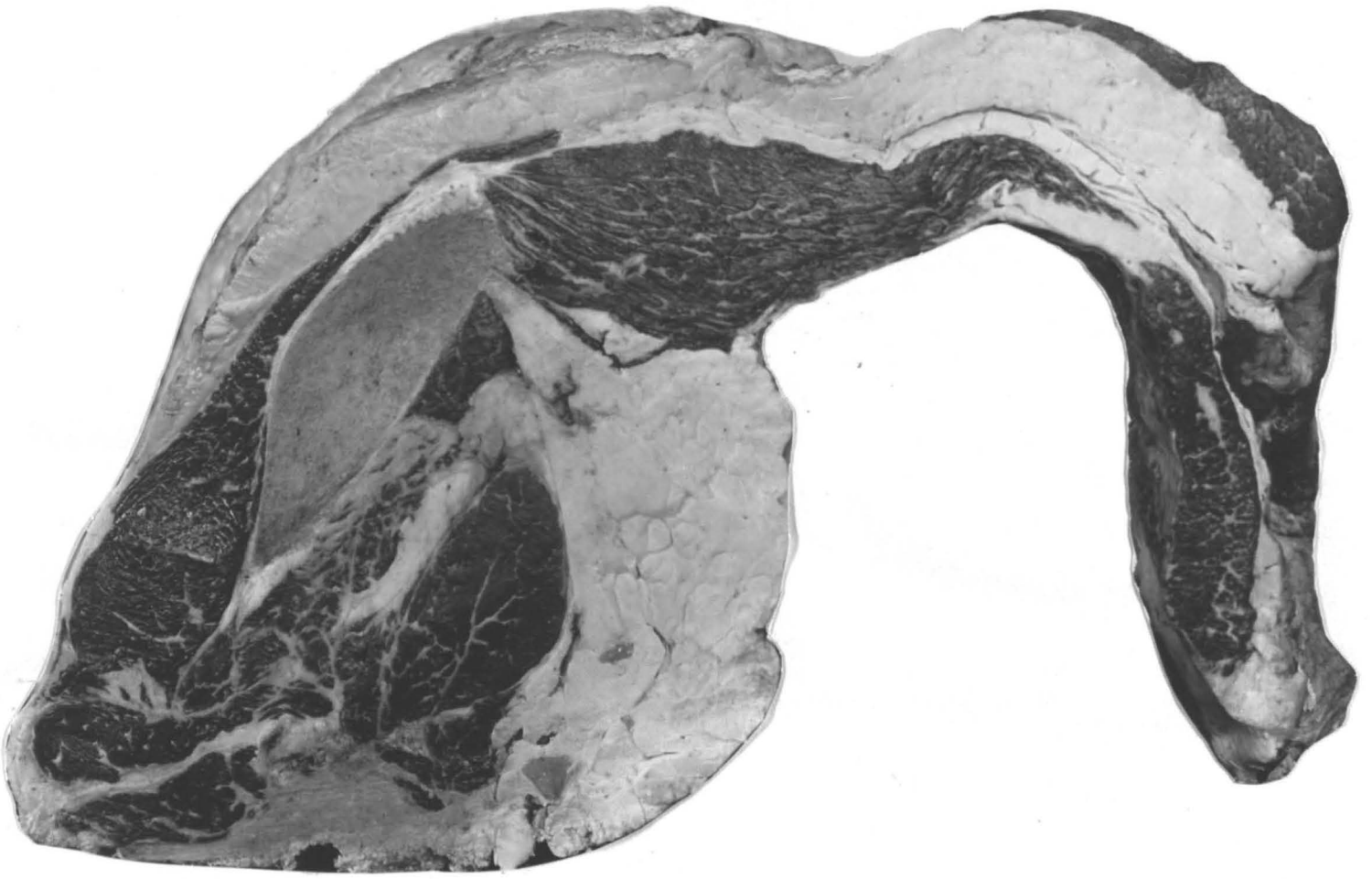
#520 Cross-section looking at 12th rib



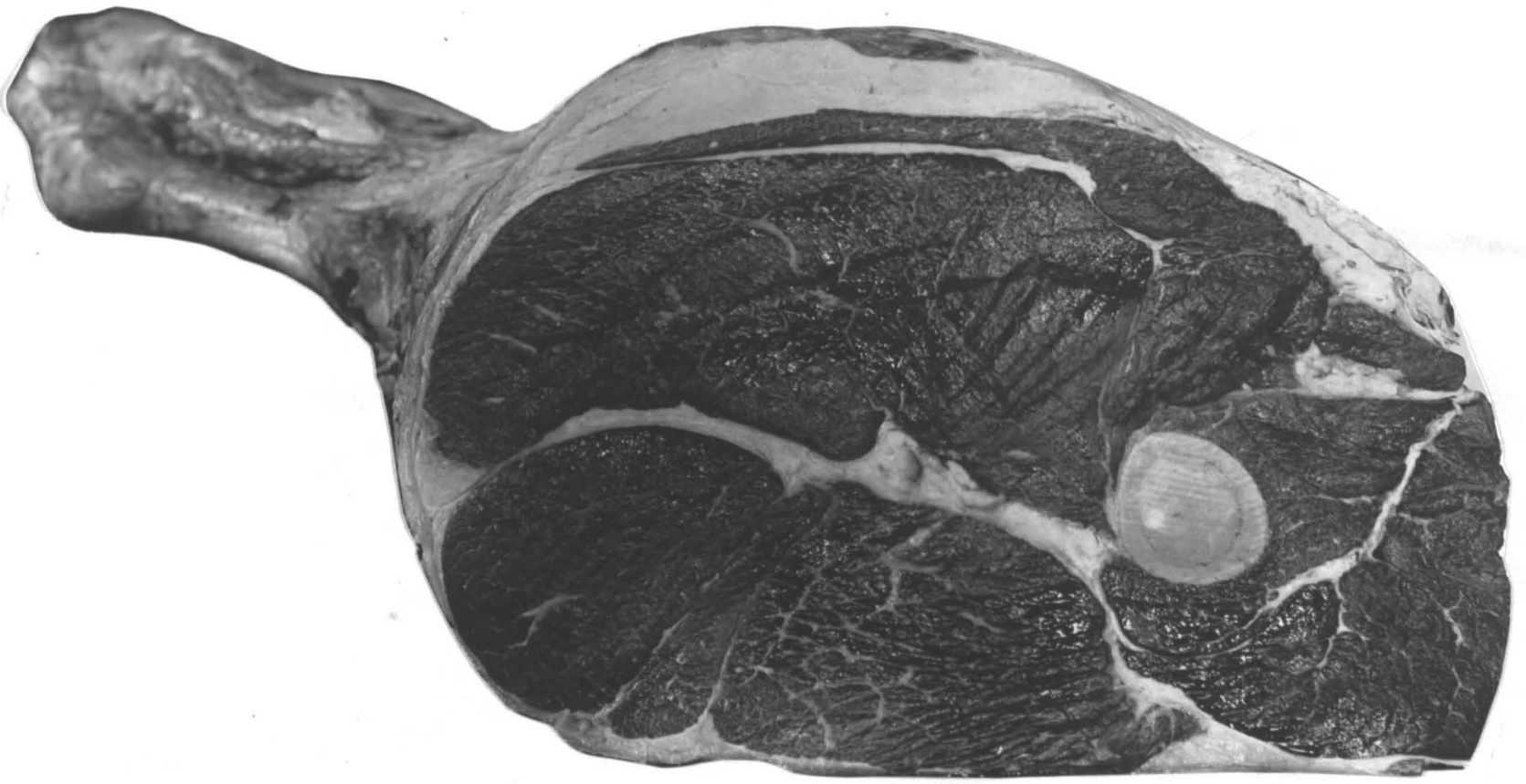
#587 Cross-section looking at 12th rib



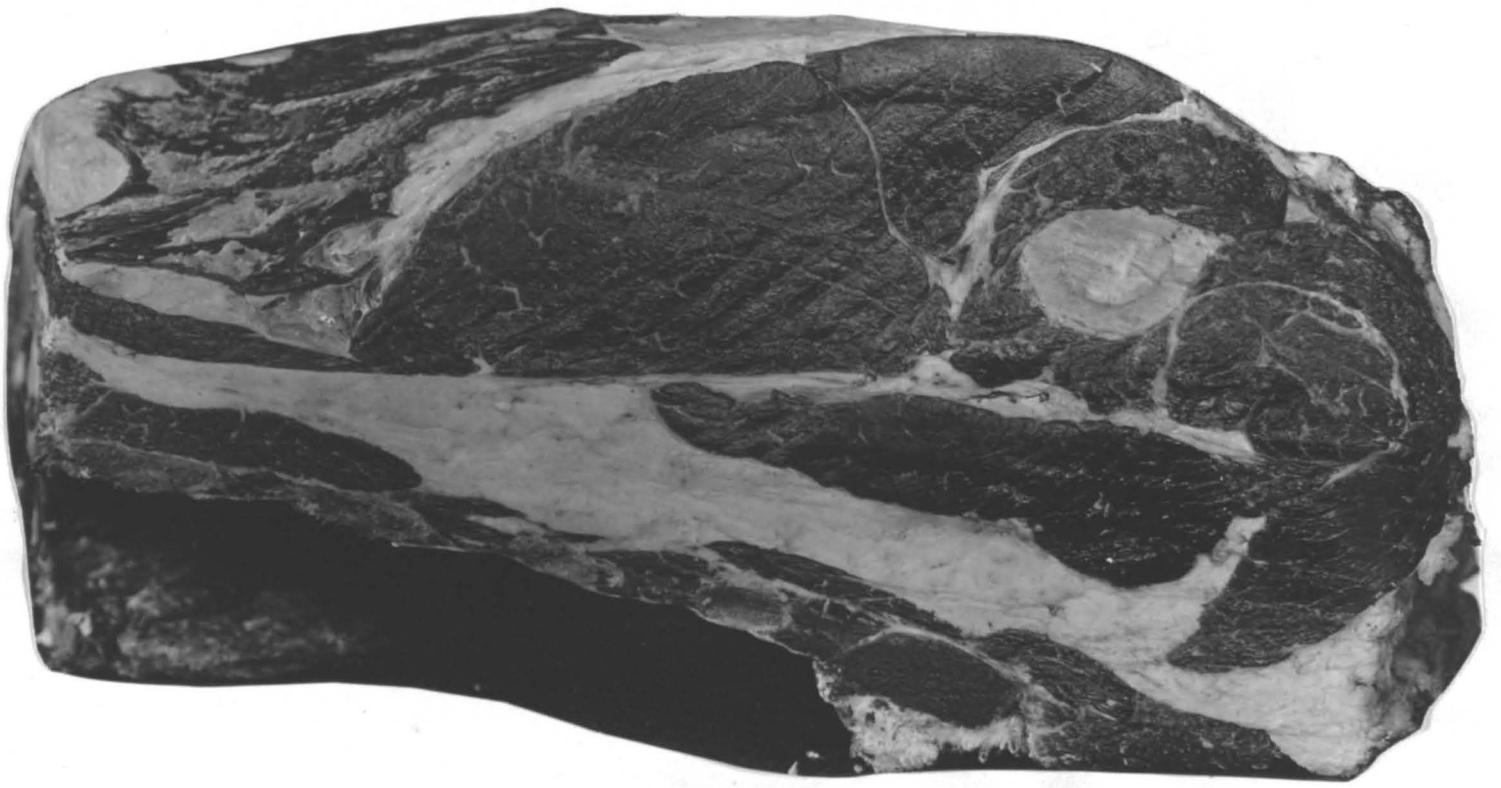
583 Cross-section looking at 12th rib



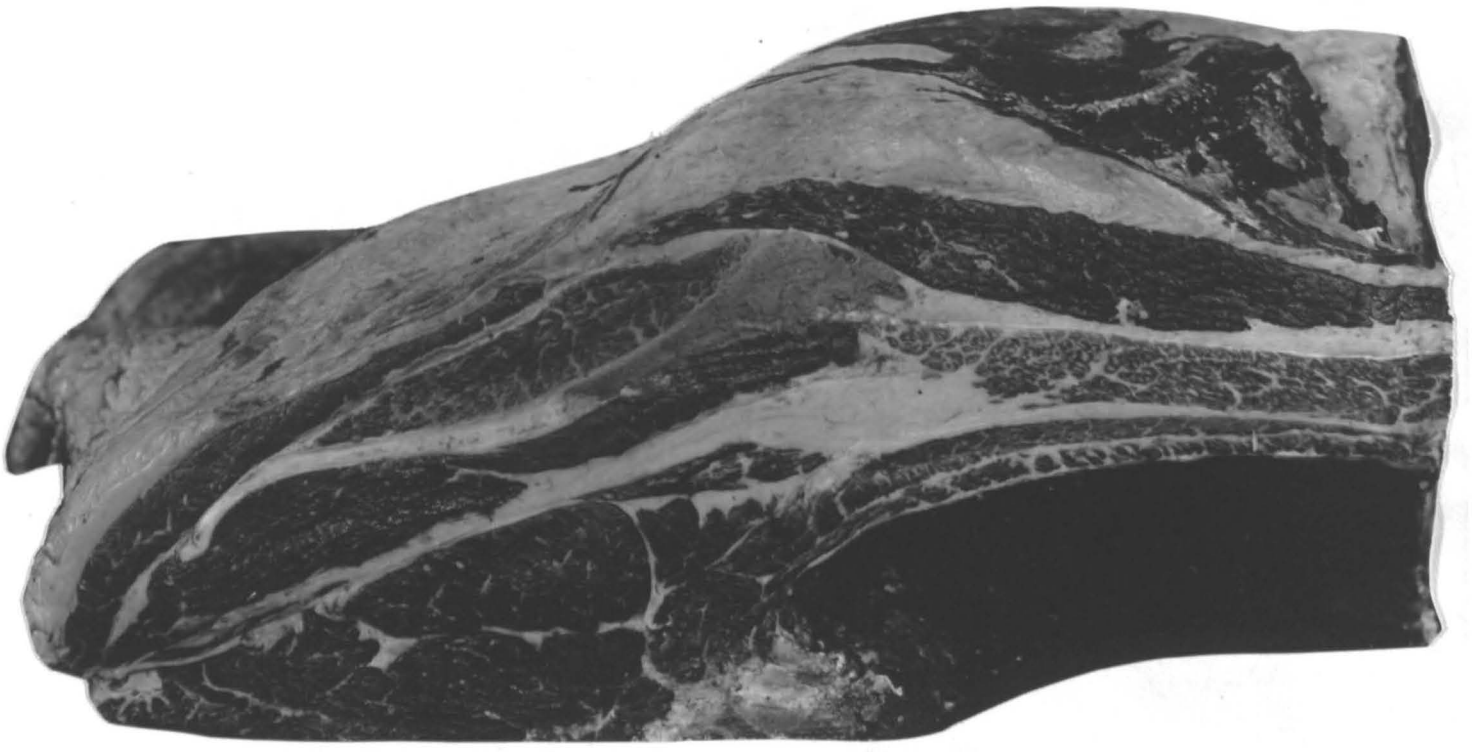
#583 Loin looking forward at pin bone.



#583 Cross-section of the round.



#583 Chuck looking at arm.



#583 Chuck looking at 5th rib

known to cause slow hardening of the bones. No comparison can be made with No. 583, for this steer was nine months older than the other two at the time of slaughter. In that time there has been chance for ossification to become more complete.

No. 583 was found to have fourteen ribs on each side. The two extra ribs were unattached at both ends.

It has been said before in this discussion that No. 583 when brought up to a full feed seemed unable to handle his feed. A study of table No. 18 may throw some light upon this point. It will be seen that in weight of stomachs and intestines No. 583 had less than either Nos. 520 or 587. When these weights are figured in per cent of the empty animal, No. 583 has less stomach and intestinal capacity than No. 587, and more stomach and less intestinal capacity than No. 520. As regards the length of the intestines, No. 583 is very much behind the other two (table No. 19).

The point arising then is whether or not this has been one of the results of the early retarding of growth. Has the lack of feed in No. 583 caused a smaller growth of digestive organs so that when he is put on full feed he can not handle it, lacking the capacity for the feed? The data seem to indicate that this is the case, but until the data of more animals are obtained there can be no positive proof one way or the other.

A comparison has been made in table No. 19 of three animals of the ''Use of Food'' experiment. The animals

Table No. 18

Comparison of Internal Organs. *Per Cent Internal Organs.

	Steer 520 Pounds	Steer 587 Pounds	Steer 583 Pounds	teer 520 Per Cent	Steer 587 Per Cent	Steer 583 Per Cent
Blood	54.52	44.91	48.73	3.83	3.68	3.93
Circulatory System	16.55	10.88	9.58	1.16	0.89	0.77
Respiratory System	8.20	7.44	7.57	0.58	0.61	0.61
Nervous System	1.46	1.57	2.69	0.10	0.13	0.22
Digestive and Excretory System, Partial						
Tongue	6.05	4.77	5.25	0.43	0.39	0.42
Gullet	1.75	1.06	1.12	0.12	0.09	0.09
Stomachs						
Rumen	14.13	15.84	13.62	0.99	1.30	1.10
Reticulum	2.58	1.94	2.12	0.18	0.16	0.17
Omasum	5.98	5.78	7.71	0.42	0.47	0.62
Abomasum	3.66	2.47	2.28	0.26	0.20	0.18
Total Stomachs	26.35	26.03	25.73	1.85	2.13	2.08
Large Intestine	6.53	5.36	5.63	0.46	0.44	0.45
Small Intestine	9.92	7.74	5.54	0.70	0.63	0.45
Total Intestine	16.45	13.10	11.17	1.16	1.07	0.90
Gall Bladder	0.69	0.40	0.69	0.05	0.03	0.06
Diaphragm and Hanging Tender	5.55	3.08	3.23	0.39	0.25	0.26
Penis	0.97	0.90	0.44	0.07	0.07	0.04
Bladder	0.50	0.40	0.50	0.04	0.03	0.04
Total of Partial Digestive and Excretory System	58.31	49.74	48.13	4.10	4.07	3.88
Sweetbreads	1.97	1.18	1.38	0.14	0.10	0.11
Liver	13.28	10.07	11.82	0.93	0.82	0.95
Spleen	3.06	1.64	1.96	0.22	0.13	0.16
Pancreas	2.22	0.97	1.02	0.16	0.08	0.08
Kidneys	2.32	2.00	2.40	0.16	0.16	0.19
Total Internal Organs	161.89	130.40	135.28	1.38	10.68	10.90

*Referred to live weight.

in that investigation were given a ration different from that of the animals in the investigation under discussion. Group I, represented by No. 501, was full fed from birth, Group II, No. 512, was on a plane of nutrition comparable to Group I of the Retarded Growth experiment, and Group III, No. 500, was on a plane of nutrition comparable to that of No. 587, Group II, of the Retarded Growth investigation. The animals were grown on their planes of nutrition and slaughtered at the end of the experiment without fattening. Groups II and III of the Use of Food experiment then correspond to Groups I and II of the Retarded Growth experiment.

It can be seen from table No. 19 that No. 520 and No. 587 have each larger digestive systems, with the exception of the length of the intestine of No. 520, than No. 512 and No. 500 of the Use of Food experiment. It would appear from these data that No. 520 and No. 587 at the period of fattening had smaller digestive systems, but on fattening developed systems which were larger than Nos. 501 and 512 which represent approximately the condition of Nos. 520 and 587 at the beginning of the fattening period. It must be borne in mind that these figures are not absolutely comparable as Nos. 501 and 512 were nearly four years old when killed while Nos. 520 and 587 were about two years old when fattening began.

Steer 501, it will be noticed, has a less per cent of digestive organs (stomachs and intestines) than No. 520.

Table No. 19

Comparison of Internal Organs

	Use of Food Experiment			Retarded Growth Experiment		
	Group I Steer 501	Group II Steer 512	Group III Steer 500	Group I Steer 520	Group II Steer 587	Group III Steer 583
Empty Weight of Steers (pounds)	1797.6	1088.1	898.3	1326.45	1103.68	1127.31
Length of Intestines (feet)	159.09	182.02	142.16	166.58	153.10	115.00
Weight of Intestines (feet)	10.75	11.73	9.99	16.45	13.10	11.17
Per Cent Intestines Referred to Empty Weight	0.598	1.078	1.112	1.240	1.187	0.991
Weight of Stomachs (pounds)	31.27	24.45	24.24	26.35	26.03	25.73
Per Cent Stomachs Referred to Empty Weight	1.741	2.245	2.696	1.987	2.358	2.282

This can be explained by the fact that fat animals have a less per cent of digestive organs to the empty weight than lean animals.

The data seem to indicate that No. 583 had an underdeveloped digestive system and when put on a heavier ration he could not handle it. Whether or not this is the case should be shown as the investigation progresses.

Chemical Data

Samples for analysis were taken from the tight containers in which they were placed after being ground, and put into weighing bottles. From these weighing bottles the weights of the samples for analysis were obtained by difference. In this way the loss of weight by evaporation was reduced to a minimum. The moisture determinations were made in glass extraction cones with the sample thoroly mixed with fat-free cotton. The vacuum method without heat was used. The cones were dried to constant weight and then extracted for fat. Five to ten gram samples were put into tared crucibles and baked and then ashed at a low heat. Phosphorus determinations were run on the ash residues. One gram samples of lean and three to five gram samples for fat were used in the nitrogen determinations which were run by the Kjeldahl method. Thirty to fifty grams of bones were put into large tared

extraction cones, weighed, and dried to constant weight in a vacuum without heat. These were then extracted for fat. The residues were then finely ground and run for moisture, fat, nitrogen, ash, and phosphorus, the results being calculated to a fresh basis. All analyses were made in triplicate.

The analyses of the samples, as well as a complete list of the samples, is given in Tables 20 to 27 inclusive, which are grouped into lean and fat, skeleton, internal organs, and the hair and hide, hoof and dew claws. It was necessary to group all fat and lean samples together, for the lean and fat for four parts--head, feet, and tail; chuck and neck; rump; and flank and plate-- were analyzed as one sample.

Steer No. 583 was not slaughtered until the last of March, 1918. The analytical data is not completed and therefore can not be discussed here.

A study of the fat percentages thruout the two animals shows that No. 587 was not as fat an animal as No. 520 altho it was contended by some that he was. The per cent of fat in pure adipose tissue is taken to be an indication of the fatness of an animal, yet here is No. 587 with a greater weight of kidney fat with a higher per cent of pure fat and No. 520 is the fatter of the two. The tables show No. 520 to have a greater weight of fat with a higher per cent of pure fat than No. 587.

Table No. 20

Steer 520. Composition of Flesh.

	Weight of Part Grams	Moisture Per Cent	Moisture Grams	Fat Per Cent	Fat Grams	Nitrogen Per Cent	Nitrogen Grams	Protein Per Cent	Protein Grams	Ash Per Cent	Ash Grams	Phosphorus Per Cent	Phosphorus Grams
Head and Tail, Lean and Fat	4,568	53.384	2,438.581	30.422	1,389.677	2.490	113.743	15.562	710,872	0.757	34.580	0.129	5.893
Flank and Plate, Lean and Fat	73,467	38.516	28,296.550	50.099	36,806.232	1.803	1,324.610	11.269	8,278.996	0.520	382.028	0.092	67.590
Rump, Lean and Fat	9,961	43.431	4,326.162	43.153	4,298.470	2.032	202.408	12.703	1,265.346	0.578	57.575	0.103	10.260
Chuck and Neck, Lean and Fat	78,829	58.461	46,084.222	24.215	19,088.442	2.604	2,052.707	16.275	12,829.420	0.818	644.821	0.148	116.667
Round Lean	52,898	71.945	38,057.466	5.567	2,944.832	3.265	1,727.120	20.406	10,794.366	0.984	520.516	0.193	102.093
Round Fat	10,859	18.761	2,037.257	75.854	8,236.986	0.865	93.930	5.406	587.038	0.262	28.451	0.035	3.801
Loin Lean	36,069	68.262	24,621.421	10.257	3,699.597	3.170	1,143.387	19.813	7,146.351	1.004	362.133	0.189	68.170
Loin Fat	23,351	11.750	2,743.743	84.605	19,756.114	0.603	140.807	3.769	880.099	0.233	54.408	0.041	9.574
Rib Lean	21,418	63.226	13,541.745	16.909	3,621.570	2.699	578.072	16.869	3,613.002	0.885	189.549	0.162	34.697
Rib Fat	10,015	11.791	1,180.869	84.579	8,464.187	0.721	72.208	4.504	451.116	0.239	23.936	0.036	3.605
Shin and Shank, Lean and Fat	12,945	65.752	8,511.596	13.781	1,783.950	3.383	437.929	21.141	2,736.702	0.875	113.269	0.147	19.029
Kidney Fat	11,222	4.390	492.646	94.661	10,622.857	0.178	19.975	1.110	124.564	0.068	7.631	0.013	1.459
Total Flesh	345,602	49.864	172,332.258	34.928	20,712.914	2.288	7,906.896	14.299	49,417.872	0.700	2,418.897	0.128	442.838

Table No. 21

Steer 520. Composition of the Skeleton

	Weight of Part Grams	Moisture Per Cent	Moisture Grams	Fat Per Cent	Fat Grams	Nitrogen Per Cent	Nitrogen Grams	Protein Per Cent	Protein Grams	Ash Per Cent	Ash Grams	Phosphorus Per Cent	Phosphorus Grams
Skeleton Feet, Head and Tail	17,979	42.910	7,714.789	12.122	2,179.414	3.414	613.803	21.338	3,836,369	21.576	3,879.149	3.882	697.945
Skeleton Shin and Shank	12,510	29.434	3,682.193	19.560	2,446.956	3.548	443.855	22.175	2,774.093	27.848	3,483.785	5.025	628.628
Skeleton Flank and Plate	9,172	43.499	4,035.588	16.125	1,478.985	3.236	296.806	20.225	1,855.037	17.696	1,623.077	3.142	288.184
Skeleton Rump	2,776	28.923	802.902	24.844	689.669	3.232	89.720	20.200	560.752	24.634	683.840	4.569	126.835
Skeleton Chuck and Neck	15,440	35.842	5,534.005	17.826	2,752.334	3.499	540.246	21.869	3,376.574	22.850	3,528.040	4.014	619.762
Skeleton Round (Incl. Marrow)	7,548	27.735	2,093.438	29.541	2,229.755	2.838	214.212	17.738	1,338.864	22.318	1,684.563	4.441	335.207
Skeleton Loin	7,421	29.326	2,176.282	24.788	1,839.517	3.165	234.875	19.781	1,467.948	25.491	1,891.687	4.503	334.168
Skeleton Rib	5,915	31.021	1,834.192	18.047	1,067.480	3.512	207.735	21.950	1,298.343	29.013	1,716.119	5.192	307.107
Teeth	708	22.572	159.810	0.327	2.215	2.063	14.606	12.894	91.290	61.597	436.107	11.779	83.395
Total Skeleton	79,469	35.276	28,033.199	18.481	14,686.325	3.342	2655.858	20.888	16,599.260	23.816	18,926.367	4.305	3,421.231

Steer 520. Composition of Hair, Hide, and Dew Claws.

Hair and Hide	40,408	61.324	24,779.802	6.337	2,560.655	5.441	2198.599	34.008	13,741.953	0.886	358.015	0.057	23.033
Horn, Hoof, and Dew Claws	1,969	45.309	892.134	0.586	11.538	8.197	161.399	51.231	1,008.738	4.277	84.214	0.651	12.818
Total	42,377	60.580	25,671.936	6.070	2,572.193	5.569	2359.998	34.808	14,750.691	1.044	442.229	0.085	35.851

Table No. 22

Steer 520. Composition of Internal Organs.

	Weight of Part Grams	Moisture Per Cent	Moisture Grams	Fat Per Cent	Fat Grams	Nitrogen Per Cent	Nitrogen Grams	Protein Per Cent	Protein Grams	Ash Per Cent	Ash Grams	Phosphorus Per Cent	Phosphorus Grams
Blood	24,730	78.854	19,500.594	0.000	0.000	3.308	818.070	20.675	5,112.927	0.761	188.195	0.026	6.430
Circulatory System	7,507	33.564	2,519.649	58.624	4,400.904	1.226	92.036	7.663	575.261	0.436	32.731	0.078	5,855
Respiratory System	3,719	79.759	2,966.237	2.413	89.739	2.590	96.322	16.187	601.994	1.006	37.413	0.184	6.843
Nervous System	662	69.069	457.237	14.260	94.401	1.656	10.963	10.350	68.517	1.788	11.837	0.429	2.840
Digestive and Excretory System (Partial)	26,448	73.717	19,496.672	12.242	3,237.764	2.034	537.952	12.713	3,362.364	0.824	217.931	0.137	36.234
Sweetbreads	894	55.508	496.242	30.951	276.702	1.967	17.585	12.394	110.802	1.234	11.030	0.296	2.646
Liver	6,024	68.245	4,111.079	2.527	152.226	3.170	190.979	19.814	1,193,595	1.380	83.131	0.364	21.927
Spleen	1,388	68.732	954.000	12.943	179.649	2.660	36.921	16.627	230.783	1.227	17.032	0.233	3.234
Pancreas	1,007	39.469	397.453	48.823	491.648	1.554	15.650	9.712	97.800	0.791	7.965	0.189	1.903
Kidneys	1,052	76.975	809.777	5.383	56.629	2.463	25.911	15.394	161.945	1.159	12.193	0.235	2.472
Offal Fat	47,998	8.065	3,871.039	90.895	43,627.782	0.199	95.516	1.244	597.095	0.086	41.278	0.015	7.200
Total Int. Organs	121,429	45.772	55,579.979	43.324	52,607.444	1.597	1,937.905	9.975	12,113.083	0.544	660.736	0.0804	97.584

Table No. 23

Steer 587. Composition of Flesh

	Weight of Part Grams	Moisture Per Cent	Moisture Grams	Fat Per Cent	Fat Grams	Nitrogen Per Cent	Nitrogen Grams	Protein Per Cent	Protein Grams	Ash Per Cent	Ash Grams	Phosphorus Per Cent	Phosphorus Grams
Head and Tail Lean and Fat	5,688	59.345	3,375.544	23.641	1,344.700	2.510	142.769	15.688	892.333	0.754	42.885	0.117	6.655
Flank and Plate Lean and Fat	57,651	41.875	24,141.356	46.454	26,781.196	1.807	1,041.754	11.294	6,511.104	0.512	295.173	0.090	51.886
Rump Lean and Fat	8,809	45.588	4,015.847	42.495	3,743.385	1.957	172.392	12.231	1,077.429	0.619	54.528	0.101	8.924
Chuck and Neck Lean and Fat	69,780	61.265	42,750.717	19.985	13,945.533	2.705	1,887.549	16.906	11,797.007	0.862	601.504	0.157	109.555
Round Lean	39,807	72.967	29,045.974	5.325	2,119.723	3.208	1,277.009	20.050	7,981.304	0.875	348.311	0.154	61.303
Round Fat	7,239	24.752	1,791.797	68.118	4,931.062	1.299	94.035	8.119	587.713	0.357	25.843	0.033	2.389
Loin Lean	34,954	68.249	23,855.755	11.619	4,061.305	3.050	1,065.957	19.060	6,662.232	1.011	353.385	0.188	65.714
Loin Fat	18,053	10.516	1,898.453	87.163	15,735.536	0.488	88.099	3.050	550.617	0.265	47.840	0.042	7.582
Rib Lean	18,035	64.547	11,641.051	15.800	2,849.530	3.099	558.905	19.368	3,493.019	0.884	159.429	0.161	29.036
Rib Fat	8,292	14.021	1,162.621	81.512	6,758.975	0.729	60.449	4.556	377.784	0.239	19.818	0.034	2.819
Kidney Fat	13,272	3.698	490.799	95.418	12,663.877	0.158	21.010	1.989	264.020	0.076	10.087	0.010	1.327
Shin and Shank Lean and Fat	10,278	66.636	6,848.845	12.337	1,267.997	3.099	318.515	19.369	1,990.746	0.985	101.238	0.164	16.856
Total Flesh	291,858	51.743	151,018.759	32.962	96,202.819	2.305	6,728.443	14.454	42,185.308	0.706	2060.041	0.125	364.046

Table No. 24

Steer 587. Composition of Skeleton.

	Weight of Part Grams	Moisture Per Cent	Moisture Grams	Fat Per Cent	Fat Grams	Nitrogen Per Cent	Nitrogen Grams	Protein Per Cent	Protein Grams	Ash Per Cent	Ash Grams	Phosphorus Per Cent	Phosphorus Grams
Skeleton Feet, Head and Tail	14,896	43.903	6,539.791	10.094	1,503.602.	3.300	491.568	20.625	3,072.300	23.003	3,426.527	4.222	628.909
Skeleton Shin and Shank	10,160	29.258	2,972.613	19.553	1,986.585	3.369	342.290	21.056	2,139.290	29.127	2,959.303	5.349	543.458
Skeleton Flank and Plate	6,178	44.673	2,759.898	12.790	790.166	3.417	211.102	21.356	1,319.374	18.255	1,127.794	3.231	199.611
Skeleton Rump	2,322	32.075	744.782	22.281	517.365	3.332	77.369	20.825	483.557	23.351	542.210	4.208	97.710
Skeleton Chuck and Neck	12,637	37.515	4,740.771	15.791	1,995.509	3.505	442.927	21.906	2,768.261	21.665	2,737.806	4.089	516.727
Skeleton Round (Inc. Marrow)	5,724	28.152	1,611.420	27.877	1,595.679	2.879	164.794	17.994	1,029.977	24.249	1,388.013	4.504	257.809
Skeleton Loin	6,758	29.986	2,026.454	25.362	1,713.964	3.131	211.593	19.569	1,322.473	23.765	1,606.039	4.414	298.298
Skeleton Rib	4,881	30,793	1,503.006	14.942	729.319	3.540	172.787	22.125	1,079.921	30.139	1,471.085	5.495	268.211
Teeth	617	26.619	164.239	0.048	0.296	1.984	12.241	12.400	76.508	58.461	360.704	11.103	68.506
Total Skeleton	64,173	35.939	23,062.974	16.880	10,832.485	3.314	2,126.671	20.712	13,291.661	24.340	15,619.481	4.487	2,879.239
					Steer 587. Composition of Hair and Hide, and Dew Claws								
Hair and Hide	39,018	62.747	24,482.624	6.697	2,613.035	5.029	1,962.215	31.431	12,263.748	1.033	403.056	0.050	19.509
Horn, Hoof, and Dew Claws	1,488	47.629	708.720	2.107	31.352	8.007	119.144	50.044	744.655	2.101	31.263	0.155	2.306
Total	40,506	62.192	25,191.344	6.529	2,644.387	5.138	2,081.359	32.155	13,008.403	1.072	434.319	0.054	21.815

Table No. 25

Steer 587. Composition of Internal Organs.

	Weight of Part Grams	Moisture Per Cent	Moisture Grams	Fat Per Cent	Fat Grams	Nitrogen Per Cent	Nitrogen Grams	Protein Per Cent	Protein Grams	Ash Per Cent	Ash Grams	Phosphorus Per Cent	Phosphorus Grams
Blood	20,371	80.561	16,411.081	0.000	0.000	2.991	609.297	18.694	3,808.155	0.834	169.894	0.026	5.296
Circulatory System	4,935	43.999	2,171.351	45.296	2,235.358	1.613	79.602	10.081	497.497	0.621	30.646	0.123	6.070
Respiratory System	3,375	81.734	2,758.523	2.555	86.231	2.603	87.851	16.269	549.079	1.034	34.898	0.188	6.345
Nervous System	712	73.251	521.547	12.242	87.163	1.737	12.367	10.856	77.295	1.741	12.395	0.429	3.054
Digestive and Excretory System (Partial)	22,562	76.341	17,224.056	10.528	2,375.327	1.968	444.020	12.300	2,775.126	0.912	205.765	0.146	32.941
Sweetbreads	535	38.134	204.017	53.539	286.434	1.166	62.380	7.288	38.988	0.816	4.366	0.360	1.926
Liver	4,568	70.775	3,233.002	3.889	177.650	3.144	143.618	19.650	897.612	1.269	57.970	0.327	14.937
Spleen	744	77.741	578.393	3.694	27.484	2.716	20.207	16.975	126.294	1.316	9.791	0.266	1.979
Pancreas	440	54.744	240.874	29.379	129.268	1.877	8.258	11.731	51.616	0.924	4.066	0.216	0.950
Kidneys	907	78.607	712.965	5.407	49.040	2.270	20.592	14.181	128.694	1.090	9.886	0.210	1.905
Offal Fat	31,407	10.412	3,270.097	87.304	27,419.567	0.191	59.987	1.194	375.000	0.133	41.771	0.009	2.827
Total Internal Organs	90,556	52.261	47,325.906	36.302	32,873.522	1.710	1,548.179	10.298	9,325.356	0.642	581.448	0.086	78.230

Table No. 26

Steer 587. Composition of Entire Animal.

	Weight of Part Grams	Moisture Per Cent	Moisture Grams	Fat Per Cent	Fat Grams	Nitrogen Per Cent	Nitrogen Grams	Protein Per Cent	Protein Grams	Ash Per Cent	Ash Grams	Phosphorus Per Cent	Phosphorus Grams
Flesh of Entire Animal	291,858	51.743	151,018.759	32.962	96,202.819	2.305	6,728.443	14.454	42,185.308	0.706	2,060.041	0.125	364.046
Skeleton of Entire Animal	64,173	35.939	23,062.974	16.880	10,832.485	3.314	2,126.671	20.712	13,291.661	24.340	15,619.481	4.487	2,879.239
Internal Organs	90,556	52.261	47,325.906	36.302	32,873.522	1.710	1,548.179	10.298	9,325.356	0.642	581.448	0.086	78.230
Hair and Hide, Hoofs, etc.	40,506	62.192	25,191.344	6.528	2,644.387	5.138	2,081.359	32.115	13,008.403	1.072	434.319	0.540	21.815
Total Animal	487,093	50.645	246,688.983	29.266	142,553.213	2.563	12,484.652	15.975	77,810.728	3.838	18,695.289	0.687	3,348.330

Steer 520. Composition of Entire Animal.

Flesh of Entire Animal	345,602	49.864	172,332.258	34.928	120,712.914	2.288	7,906.896	14.299	49,417.872	0.700	2,418.897	0.128	442.838
Skeleton of Entire Animal	79,469	35.276	28,033.199	18.481	14,686.325	3.342	2,655.858	20.888	16,599.260	23.816	18,926.367	4.305	3,421.231
Internal Organs	121,429	45.772	55,579.979	43.324	52,607.444	1.597	1,937.905	9.975	12,113.083	0.544	660.736	0.080	97.584
Hair and Hide, Hoofs, etc.	42,377	60.580	25,671.936	6.070	2,572.193	5.569	2,359.998	34.808	14,750.691	1.044	442.229	0.085	35.851
Total Animal	588,877	47.823	281,617.372	32.363	190,578.876	2.524	14,860.657	15.773	92,880.906	3.812	22,448.229	0.679	3,997.504

However, in some of the parts, No. 587 shows a greater per cent of fat as in the loin lean, fat and bone, and in the spleen. In all other cases No. 587 is lower than No. 520 in fat per cent. In a comparison of the sweetbreads of No. 520 and No. 587, No. 587 has a much larger fat content. This is probably due to the difficulty of dissecting out the glands from the surrounding fatty tissue. A comparison of the spleen of the two animals shows No.5520 to have 12.943 per cent fat while No. 587 has 3.694 per cent. This seems to be an abnormal figure. The following figures (table No. 27) are per cents of fat in the spleen of a number of animals slaughtered at this Experiment Station. No attempt is made to compare these animals for they have all been on different planes of nutrition and the last three were young animals.

Table No. 27

Comparison of Fat in Spleens

No. of Animal	Per Cent Fat in Spleen	Weight of Spleen, Grams
520	12.943	1388
587	3.694	744
501	1.953	1178
512	2.366	1255
500	5.355	1054
513	4.542	1114
502	2.420	921
509	2.126	1304
548	1.368	215
552	1.297	284
557	3.341	485

From the figures given above, No. 520 seems to be

abnormal in fat content of the spleen. This is hardly due to the manner of handling, as the spleen lends itself to separation from the other organs very readily. We have no information as to the cause of this abnormal fat content.

The pancreas of No. 587 is much larger in both actual weight and per cent of fat than that of No. 520. This, however, is likely to be a case where the manner of handling is the cause of the high fat content, for the pancreas is in the midst of a large amount of fat, and perfect separation is extremely difficult.

In direct contrast to the kidney fat which is greater in amount and in per cent of fat in No. 587 than in No. 520, the offal fat is even greater in amount proportionally in No. 520 than in No. 587. There is also a larger per cent of pure fat in the offal fat of No. 520 than in No. 587, No. 520 having 90.89 per cent, while No. 587 has 87.3 per cent, a difference of 3.5 per cent. This is only an additional fact proving that No. 520 is a fatter animal than No. 587.

In studying the per cent of fat in the lean samples it is shown that the lean of No. 520 has more fat in it in every case, with the exception of the loin, in which No. 587 has a higher per cent of pure fat in lean, fat,

and bone. This would seem to indicate that No. 520 had a better marbling of flesh than No. 587. Whether or not this is true is a matter of opinion. Certainly the difference was slight and probably in favor of No. 520.

A number of special fat samples was taken from the left side to study the effect of fattening on the adipose tissue. Both animals have a high per cent of pure fat in the samples, with No. 520 a higher per cent at one place and then No. 587.

Thruout the tables it is generally seen that where the fat content is higher in No. 520 than in No. 587 the moisture per cent in No. 520 is lower than in No. 587. A high fat content seems to go with a lower moisture content, and vice versa. This does not hold so rigidly in the internal organs, particularly the digestive organs, as in the bones and lean and fat flesh. This is in accordance with the known fact that the sums of the water and fat content of the same tissue in different animals are in a more or less constant relation to each other.

The fat per cents of the two animals seem to vary more than the other constituents of the parts of the animals. The protein of the same parts of the two animals in almost all cases is about the same, with the exception, perhaps, of the bones. There is, of course, some variation between the same parts, but this variation is more

likely to be due to the manner of handling than to any difference in composition. The variations do not seem to be great enough to conclude that they are due to an early retarded growth.

The cuts vary particularly in the per cent of protein. The rib lean of the two animals varies from 19.368 per cent in No. 587 down to 16.869 in No. 520 in protein, yet this figure does not vary enough to justify any conclusion for the entire animal. In the rib fat and bone the protein is higher in No. 587 than in No. 520, but not over one per cent.

In the ash and phosphorus per cents of the various parts of the two animals little or no variation that is abnormal is found.

The bone samples show a variation to a slight degree in the protein per cent, but this is small.

The chemical data seem to show that the slight retardation undergone by No. 587 has had little effect upon the composition of the animal

Summary and Conclusions

The Retarded Growth Investigation has not been conducted long enough to permit the drawing of any definite conclusions at this time. Attention may be called to conditions which seem to have resulted from a retarded growth. The slaughtering of a large number of animals and the collection of data from them will then prove or disprove any theories or suggestions.

Conditions which seem to have been the result of a retarded growth are hard to locate. The early retardation of Nos. 587 and 583 seems to have lowered their vitality quite noticeably. This fact is borne out by the condition of other calves on the same planes of nutrition. These calves on the lower planes of nutrition were all low in vitality and two calves of these groups died. This would seem to be the first effect of a retarded growth: a low vitality and a resulting less resistance to disease.

As to the permanency of the retardation, No. 587 seemed to show no serious ill effects of the stunting excepting a lower weight. When put on full feed he was worked up to a full feed with no large falling off. He made good gains on his feed and it has been shown that of the three he was the best type of animal. An effect of the arrested development of No. 587 was a shoulder blade not fully ossified. No comparison of No. 587 and

No. 583 can be made on this point for No. 583 was the oldest by nine months when slaughtered and had this time to allow more complete ossification of his bones. Had he been killed at the same time as No. 587 it is possible that the same condition might have been found.

No. 583 seemed to suffer from a deficient digestive system in both size and the ability to handle his feed. When No. 583 was worked up to a full feed he fell off and refused part of it and the feed had to be cut down. At the same time his gains dropped and during one of his set-backs he lost weight for two thirty-day periods. This lack of ability to handle a large amount of feed lengthened his fattening period and caused him to be the second most expensive animal.

There seemed to be no abnormal development of particular note in the two retarded animals. It was said that the slow growth of No. 583 would result in the piling up of a larger amount of internal fat. This was found to be the case when he was slaughtered.

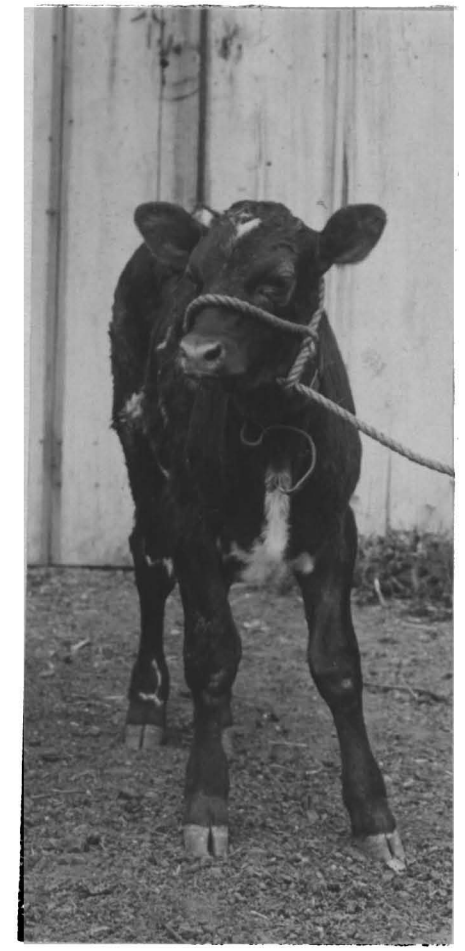
The retarded growth seemed to have had little or no ill effects upon the quality of the meat produced. No. 520 was the fattest animal and No. 587 the leanest, but there was a general uniformity in texture, and the marbling of the lean meat was just about the same.

Considering the cost of production, it has been shown that No. 587 was the cheapest and furthermore produced more

lean meat in proportion to the fat and bone than either of the other two. This would indicate that of the three No. 587 was the most profitable type of animal. Had No. 583 been slaughtered at the same time as No. 520 and No. 587, the table showing his feed costs indicates that, of the three, he was the best type of animal to raise. In addition to his low feed cost, a study of the table giving his feeds shows that he was raised on a feed containing a higher amount of roughage in proportion to his grain than Nos. 520 and 587. The fact that beef can be produced on feeds unfit for human consumption is an important one. An important point at any time, it is more so now at a time when wheat substitutes are being used.

Acknowledgement

The animals discussed in this thesis are from the Retarded Growth Experiment now being conducted at the Missouri Agricultural Experiment Station. This is a joint investigation between the Department of Animal Husbandry and the Department of Agricultural Chemistry. The author wishes to express his obligation to the members of these departments for permission to use the data herewith presented and discussed. The chemical analysis has been the authors connection with the investigation. To Dr. Trowbridge and Dr. Haigh of the Department of Agricultural Chemistry the author is under special indebtedness for suggestions and help which have been of great aid in the writing of this thesis.



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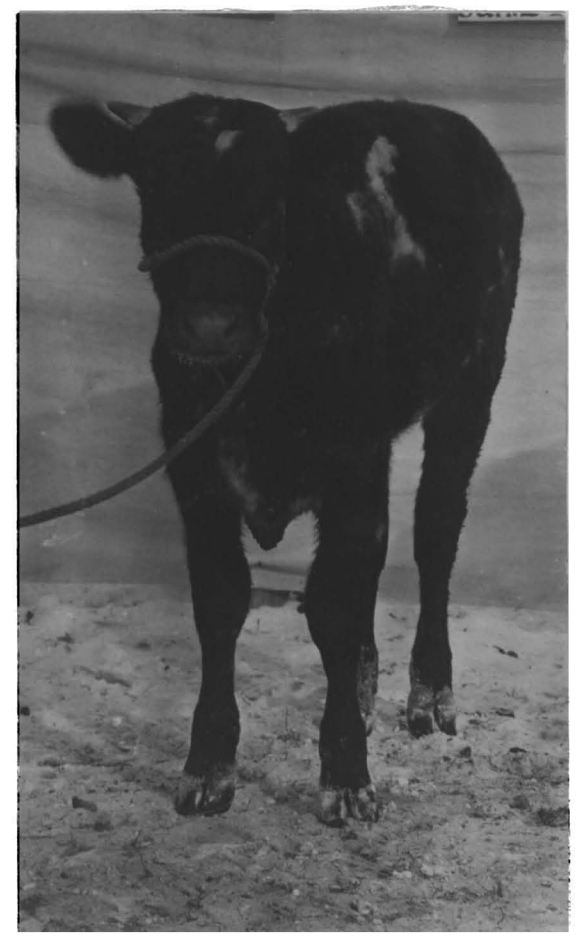

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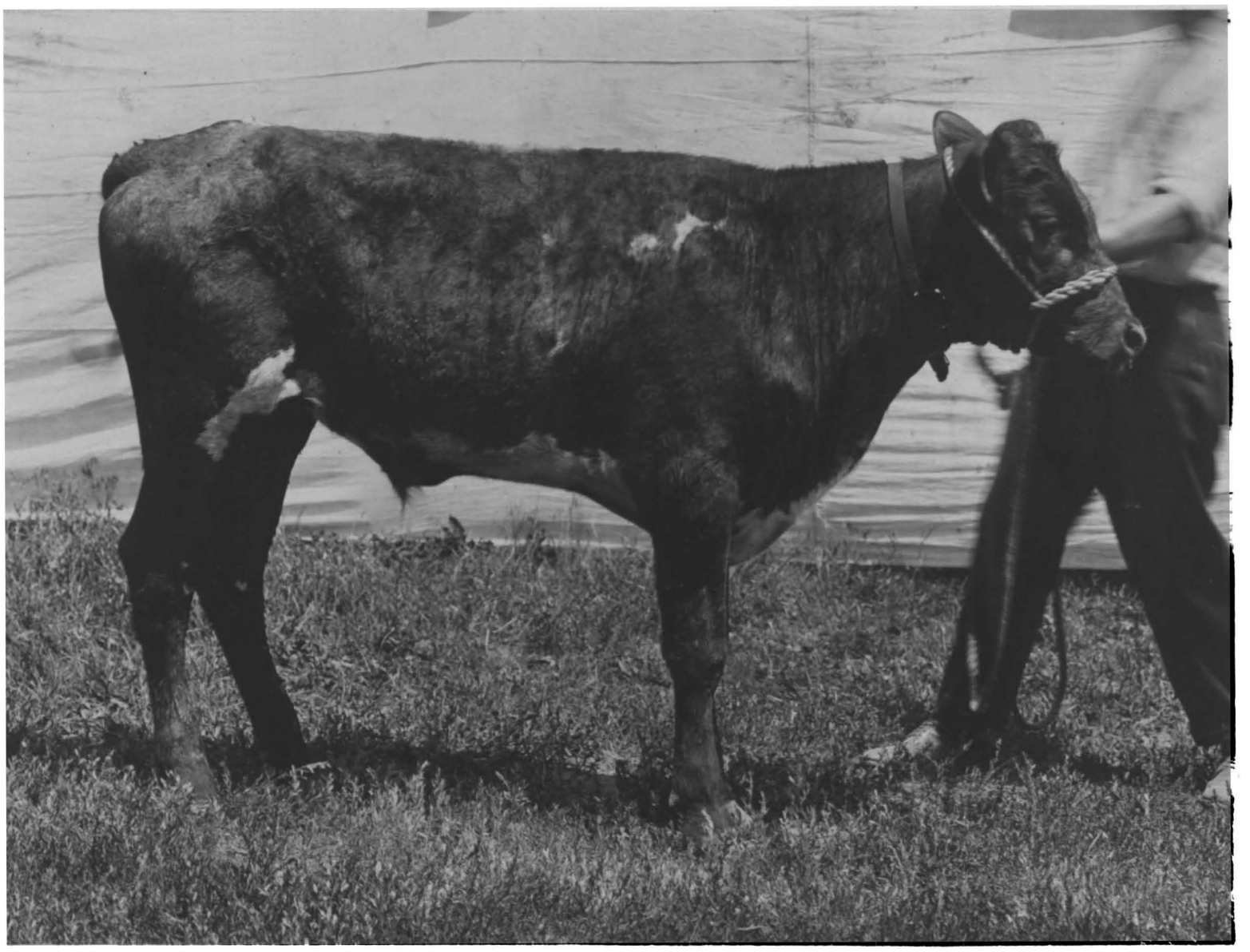

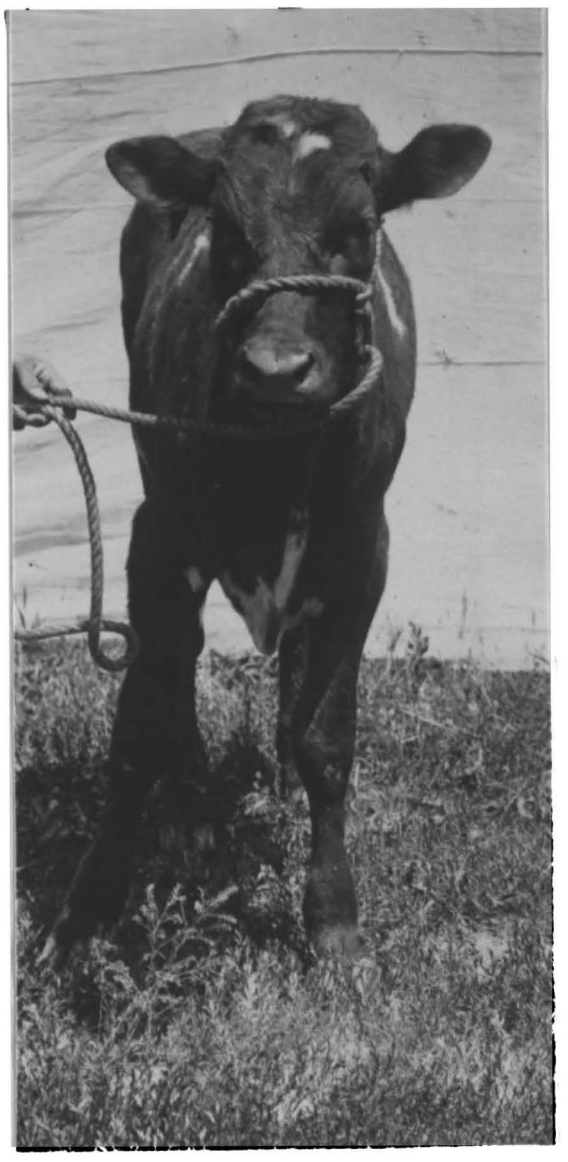

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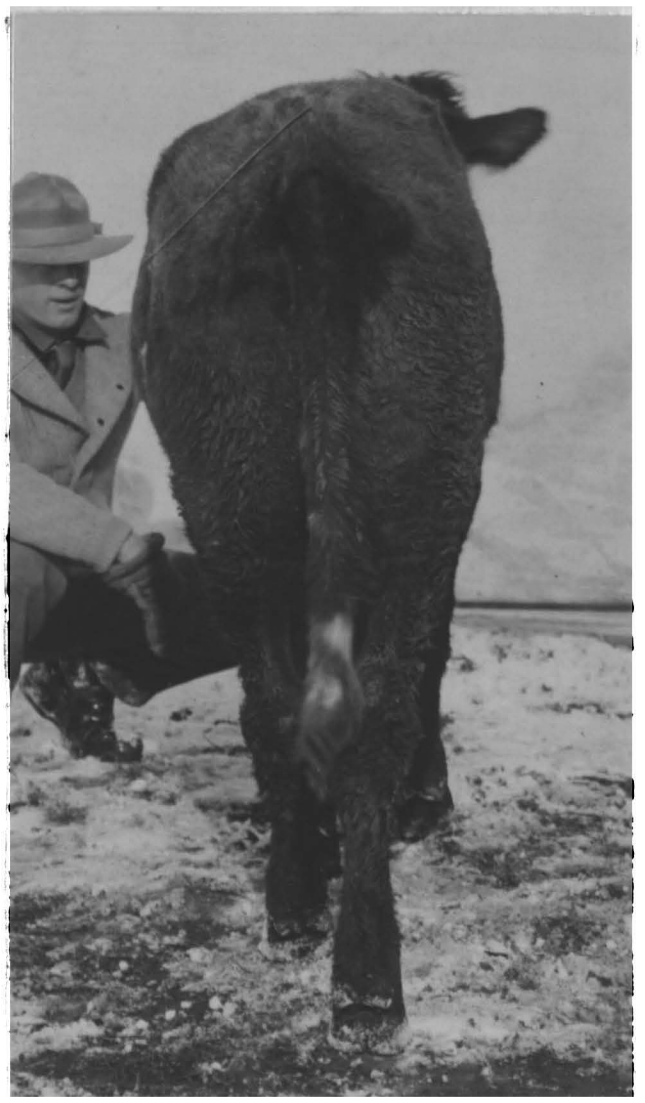

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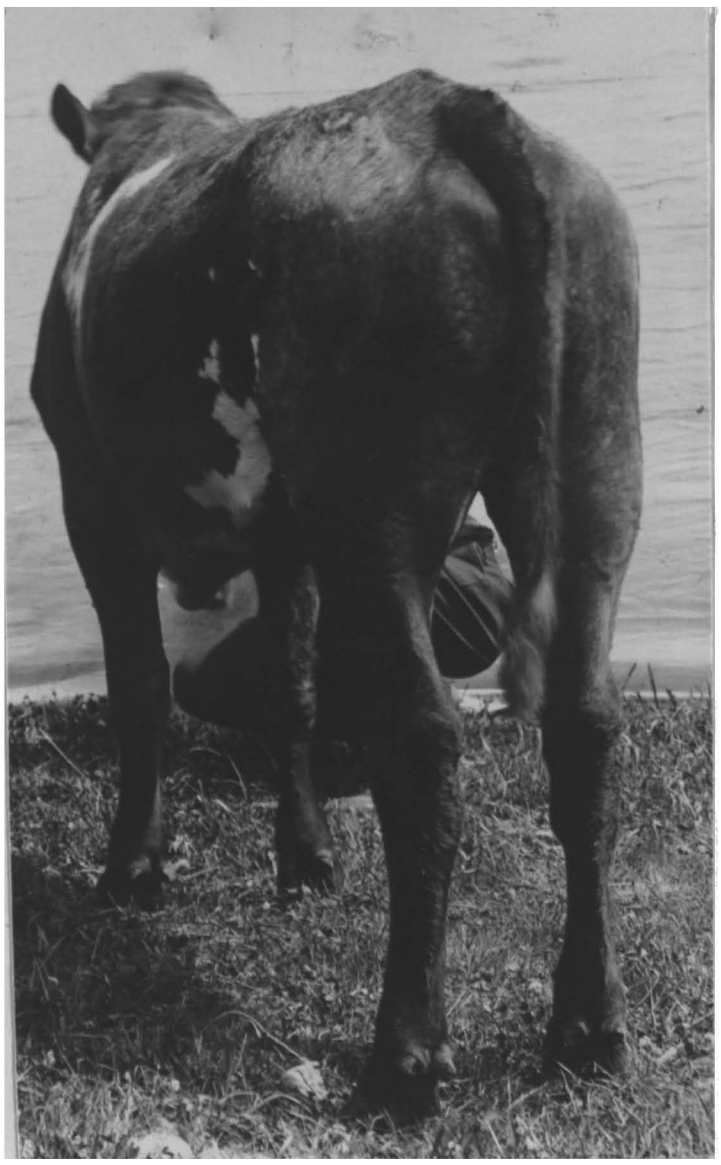

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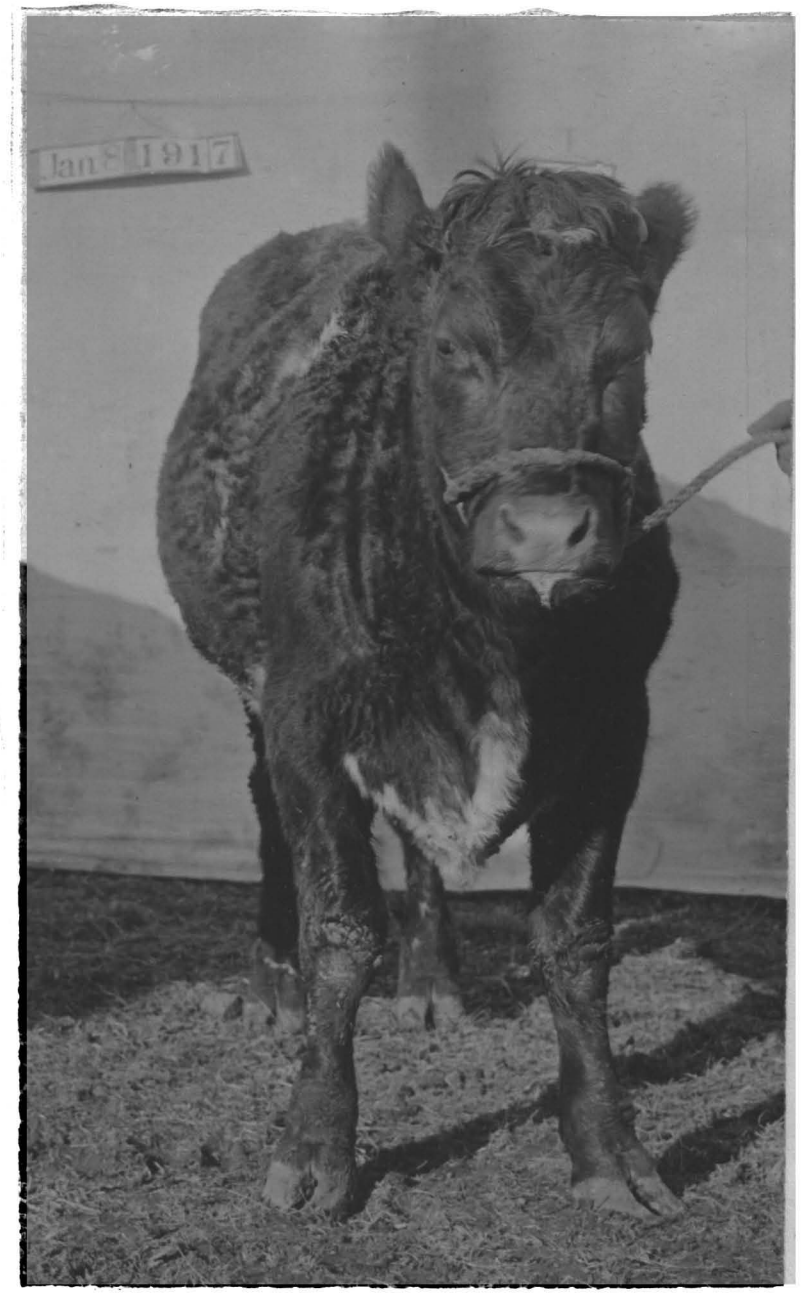

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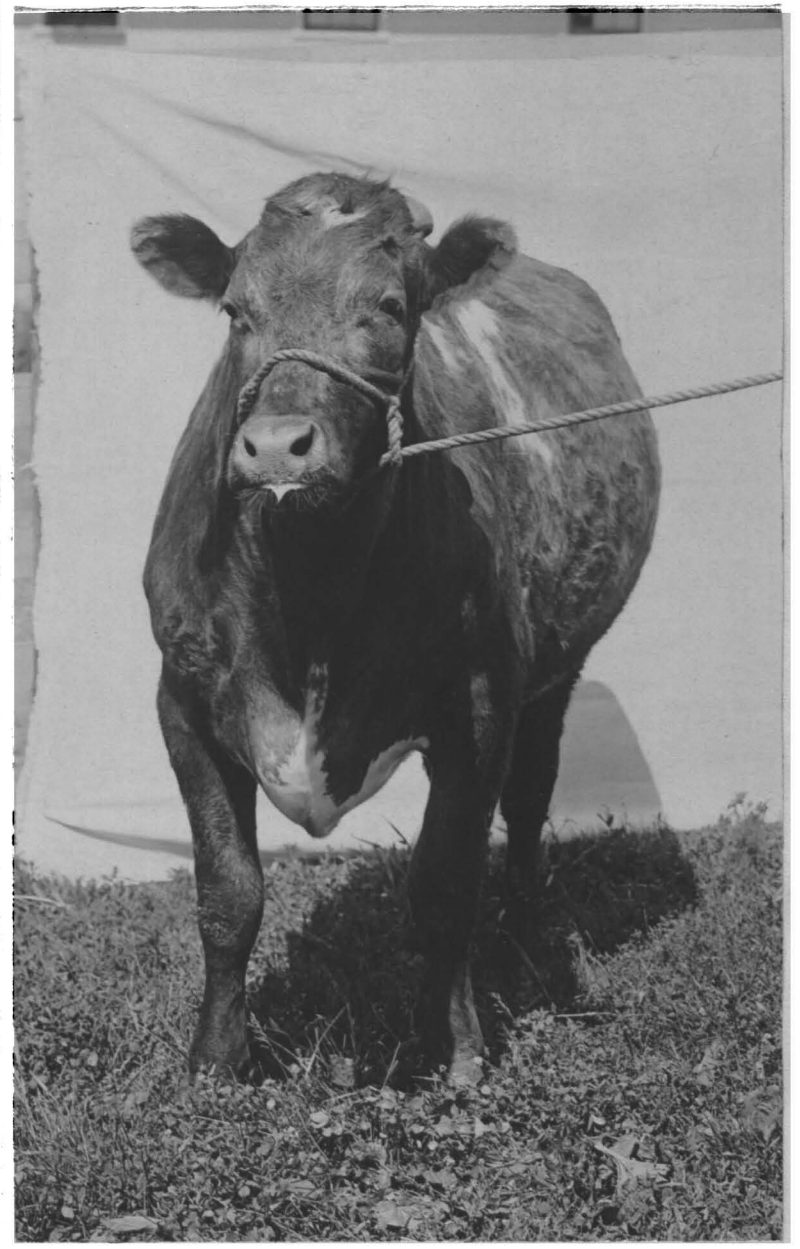

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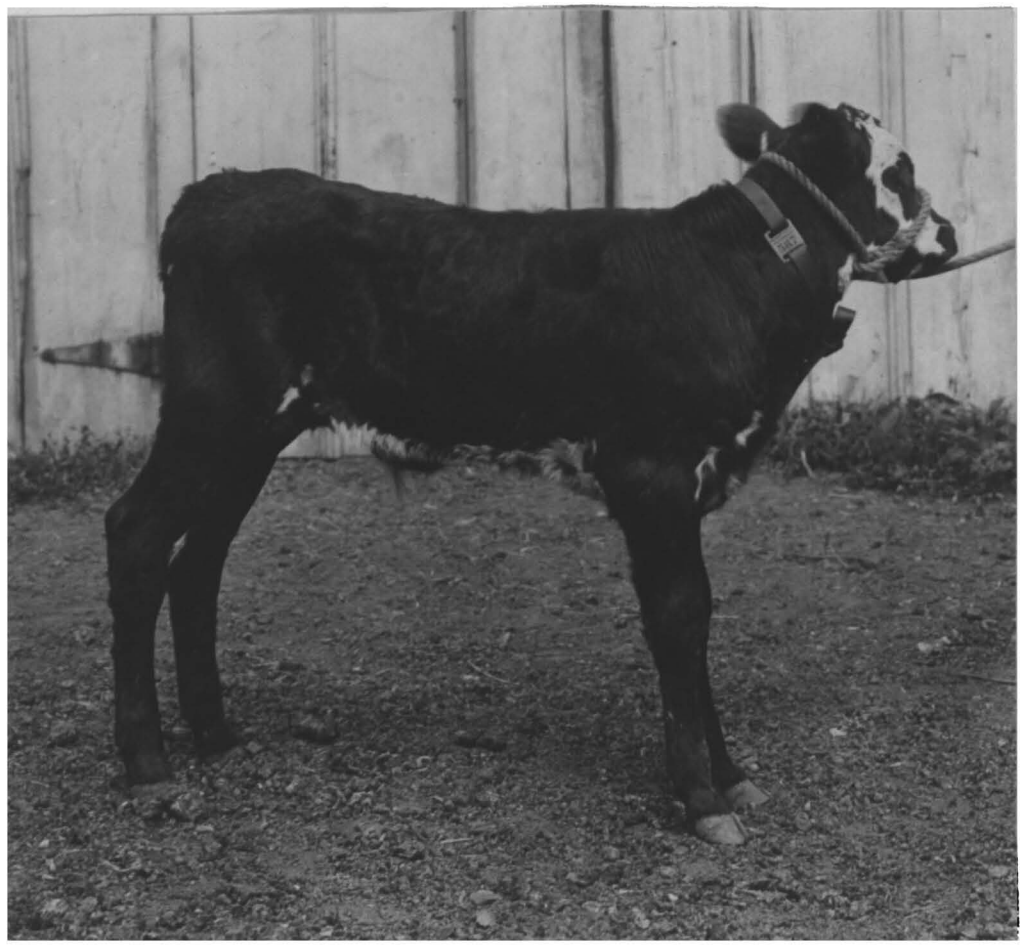

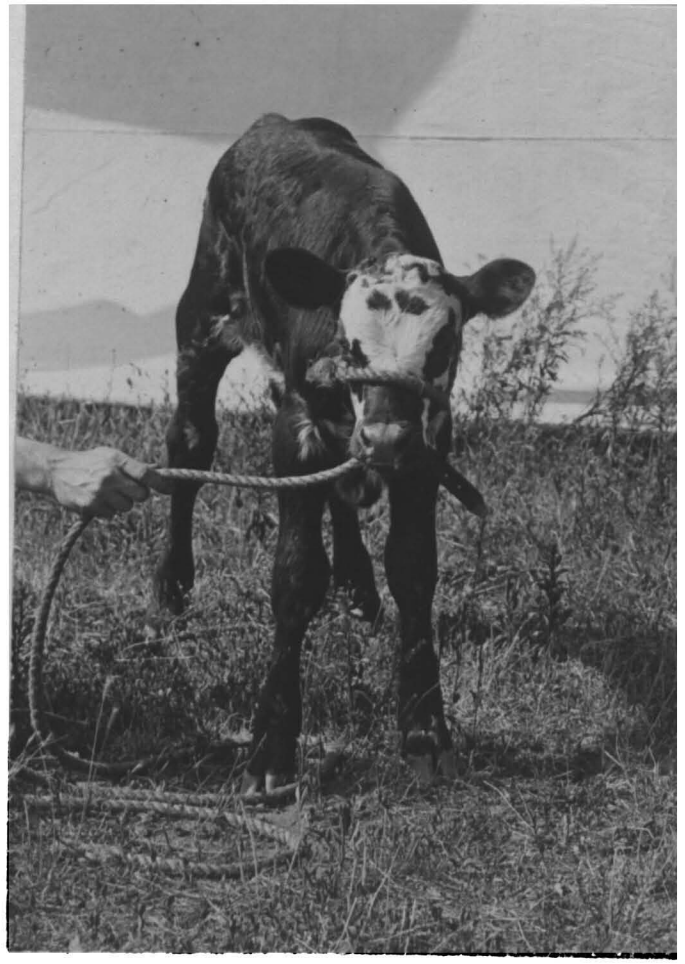

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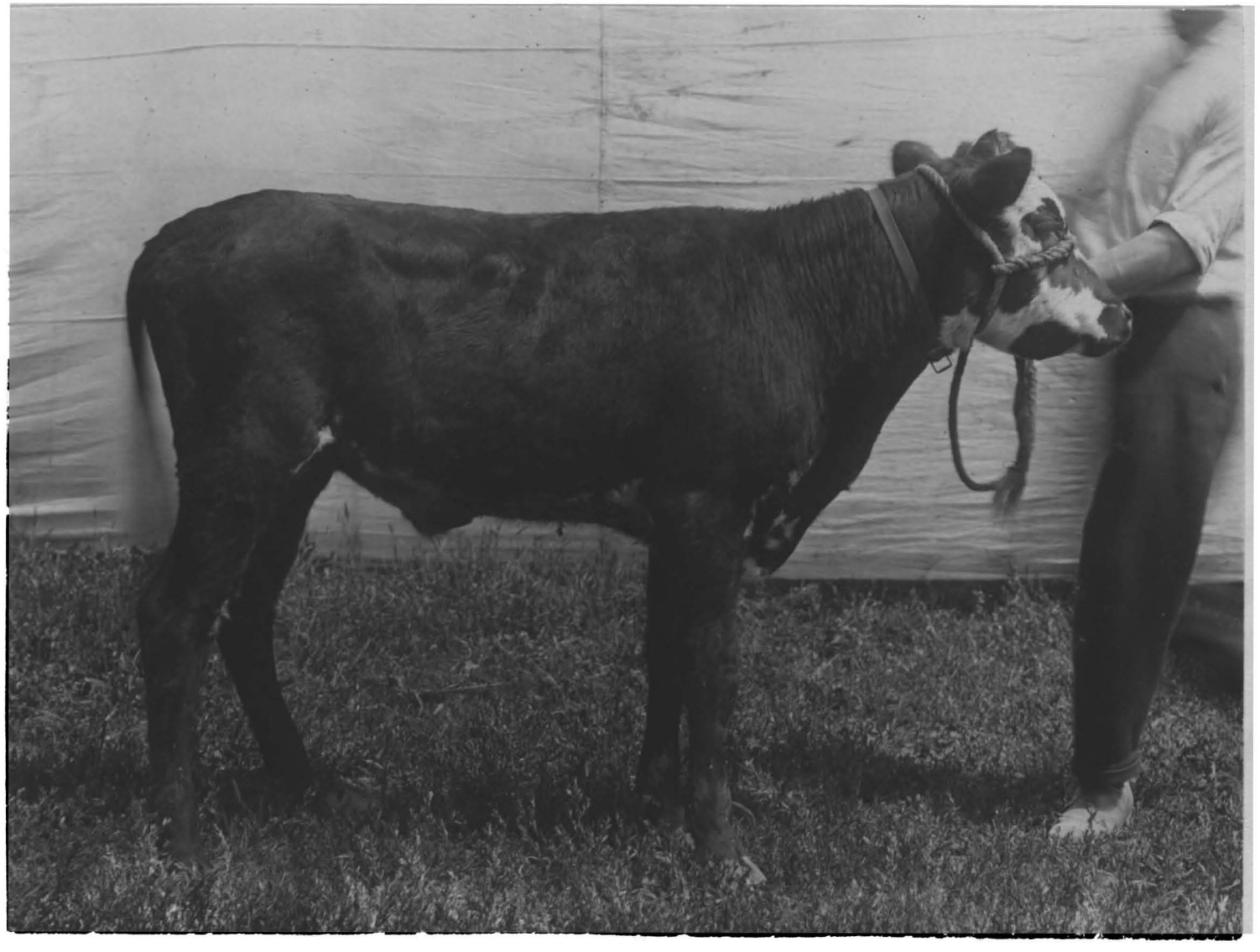

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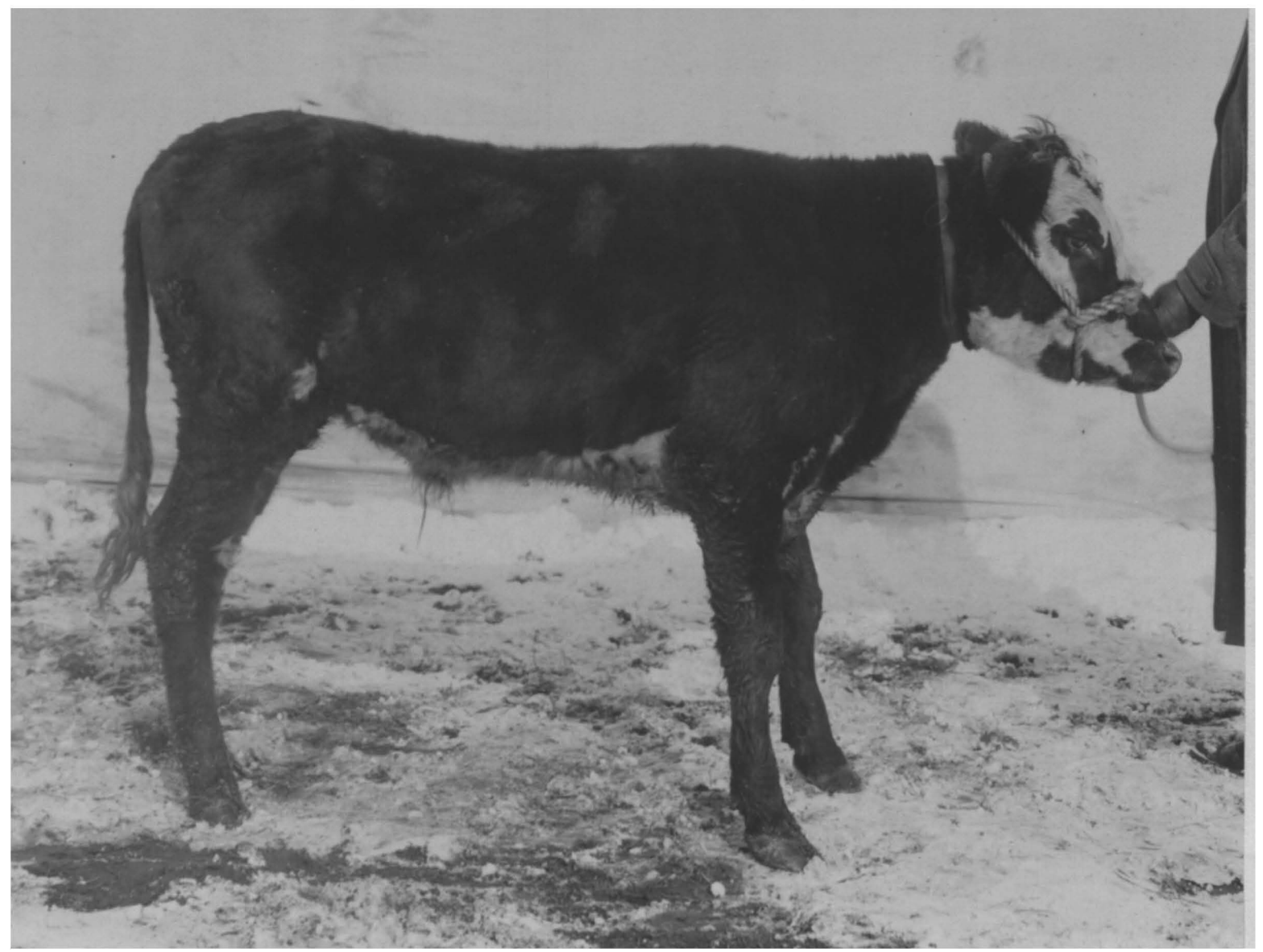

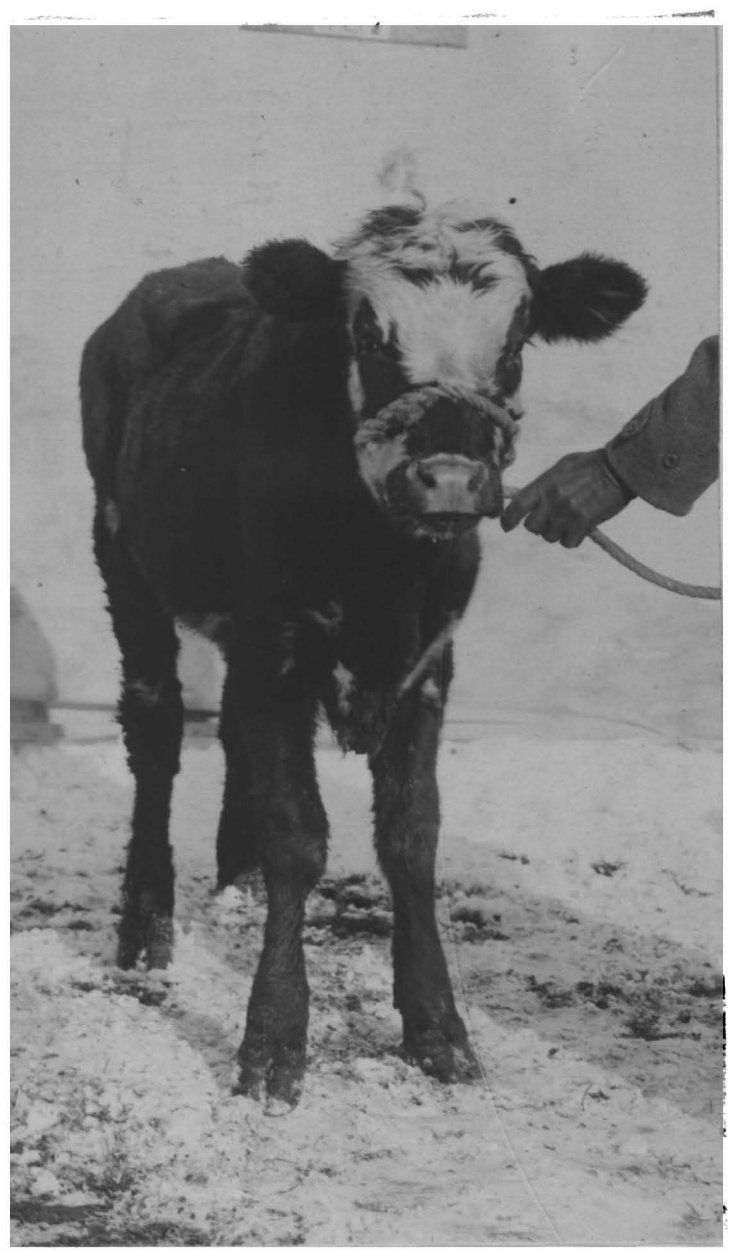

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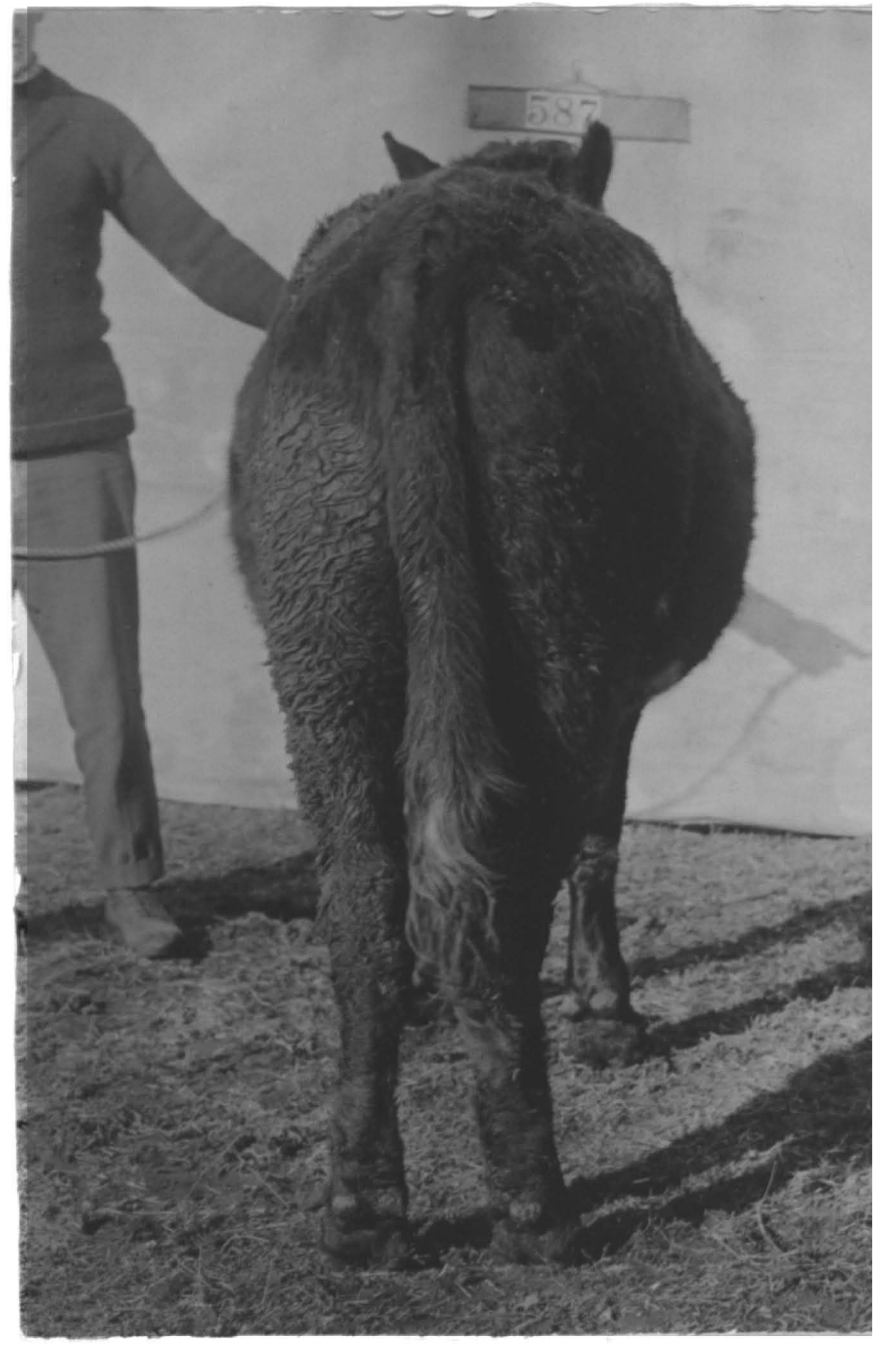

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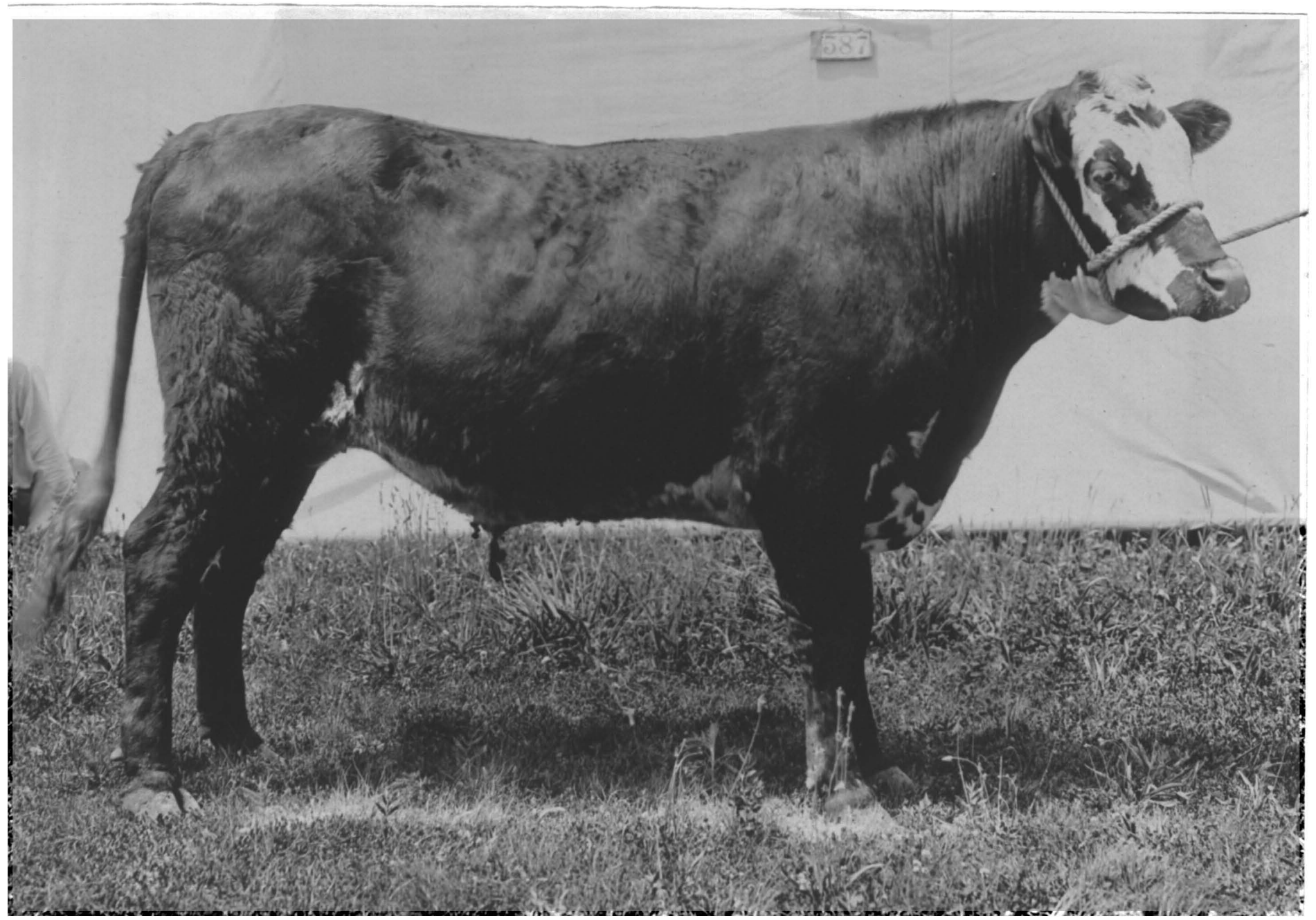

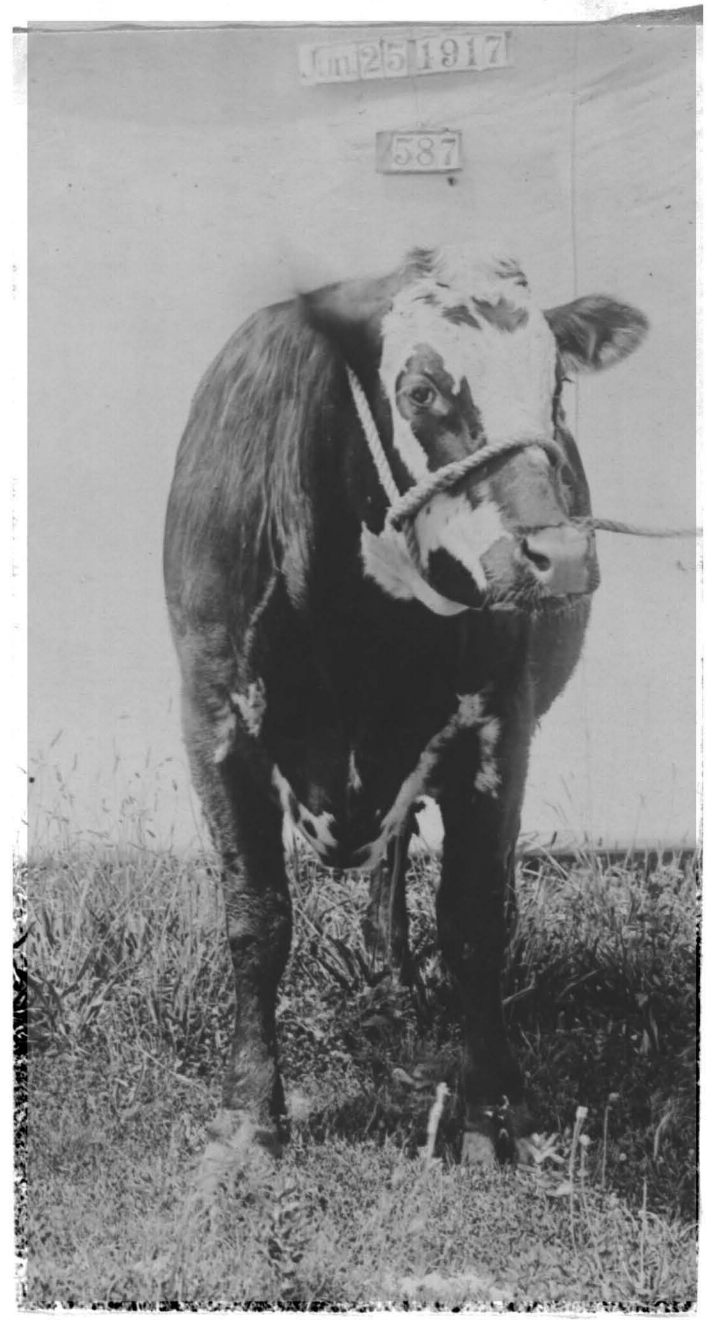

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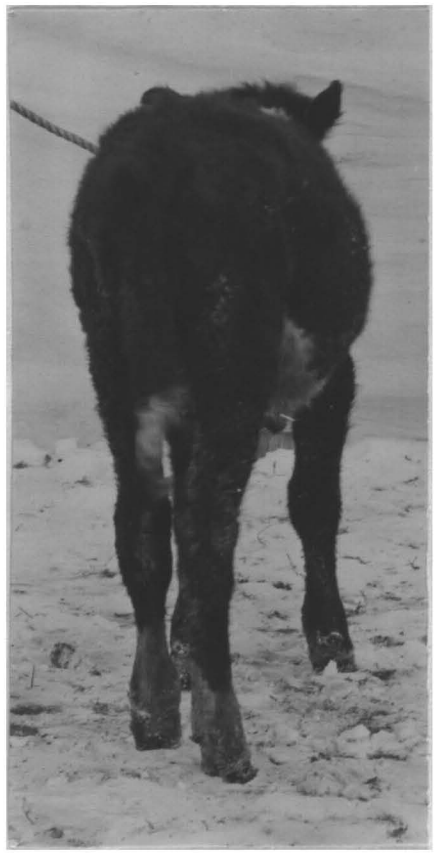

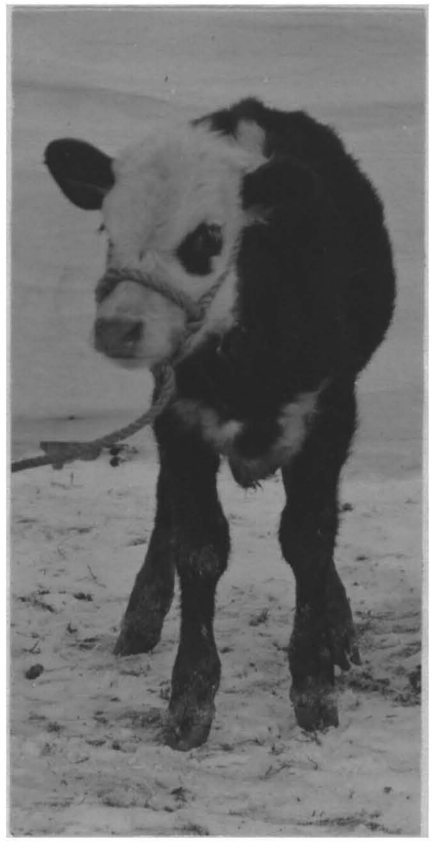

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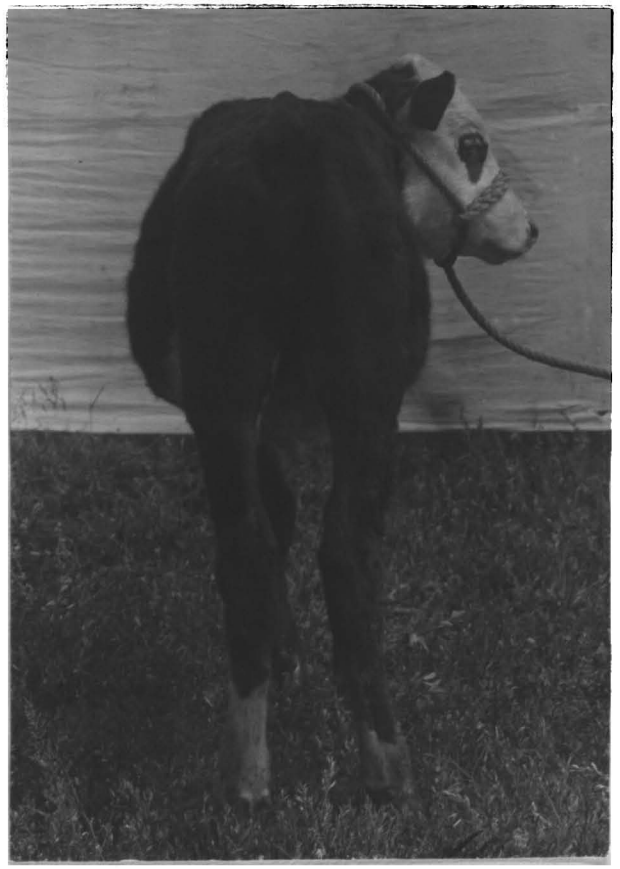

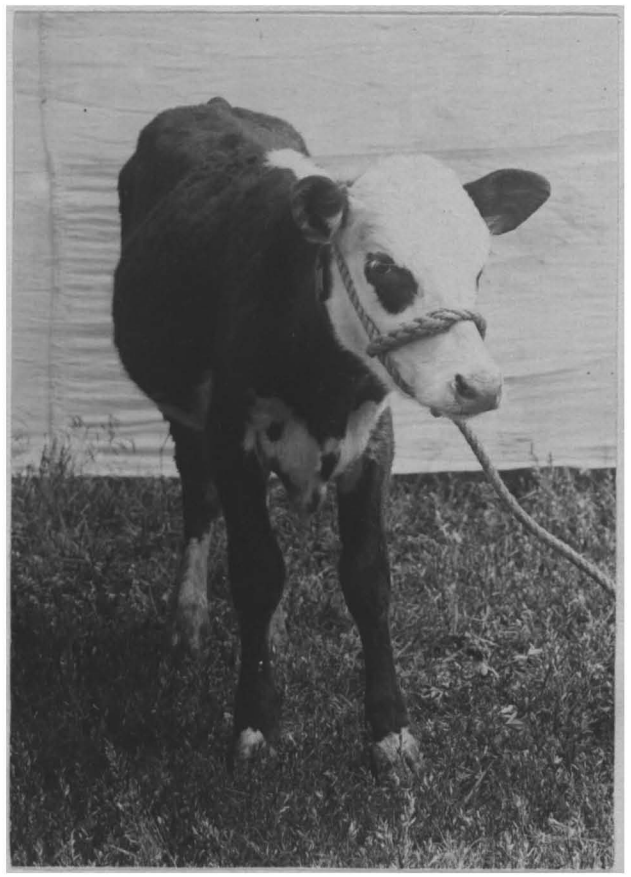

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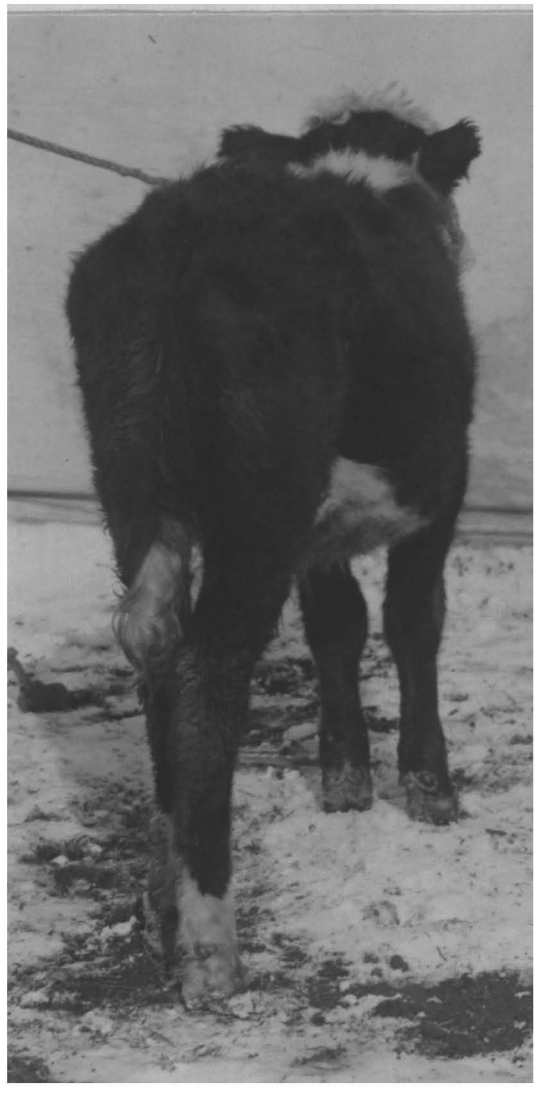

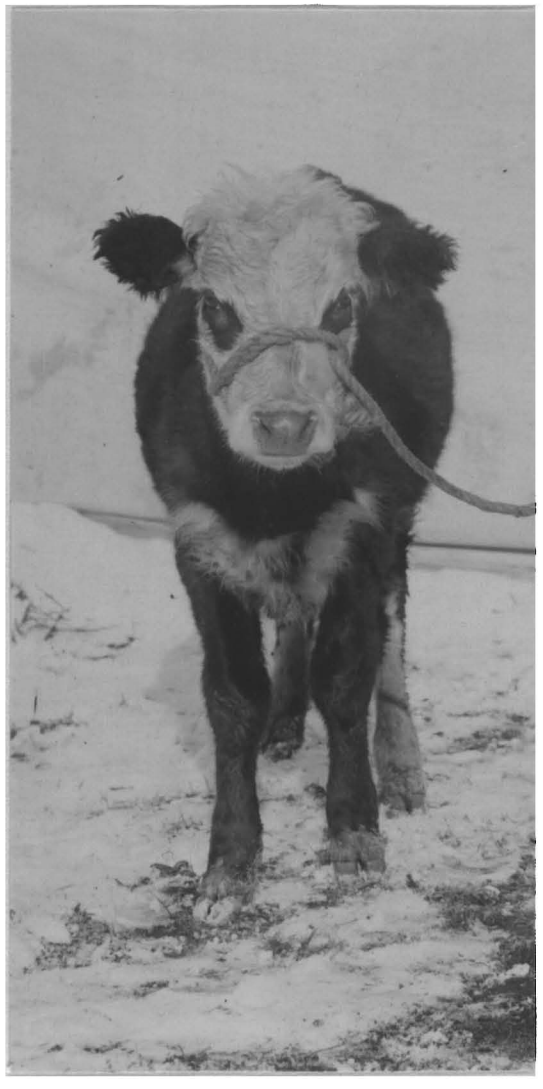

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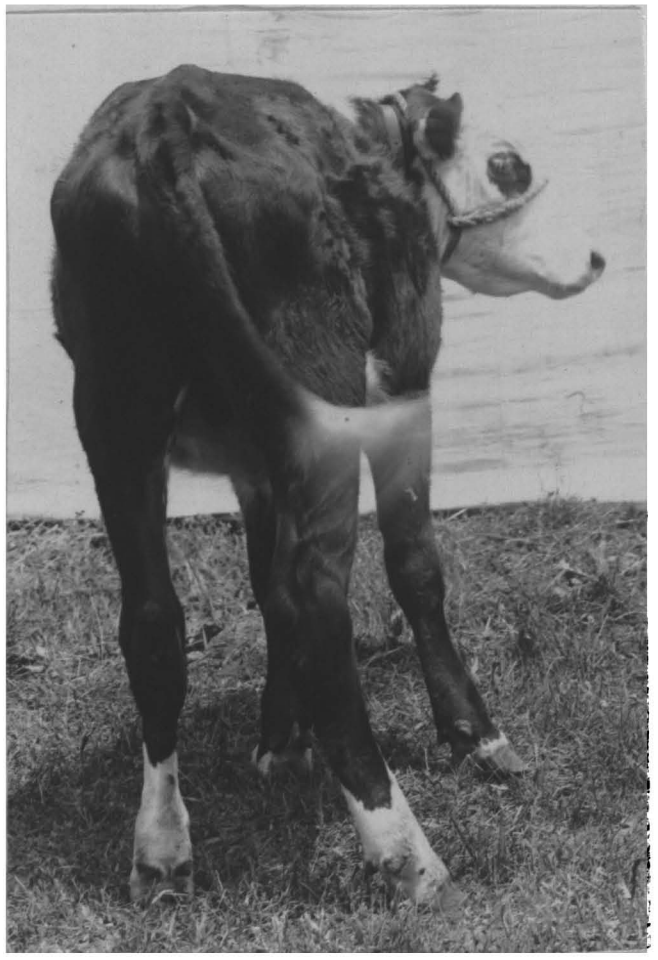

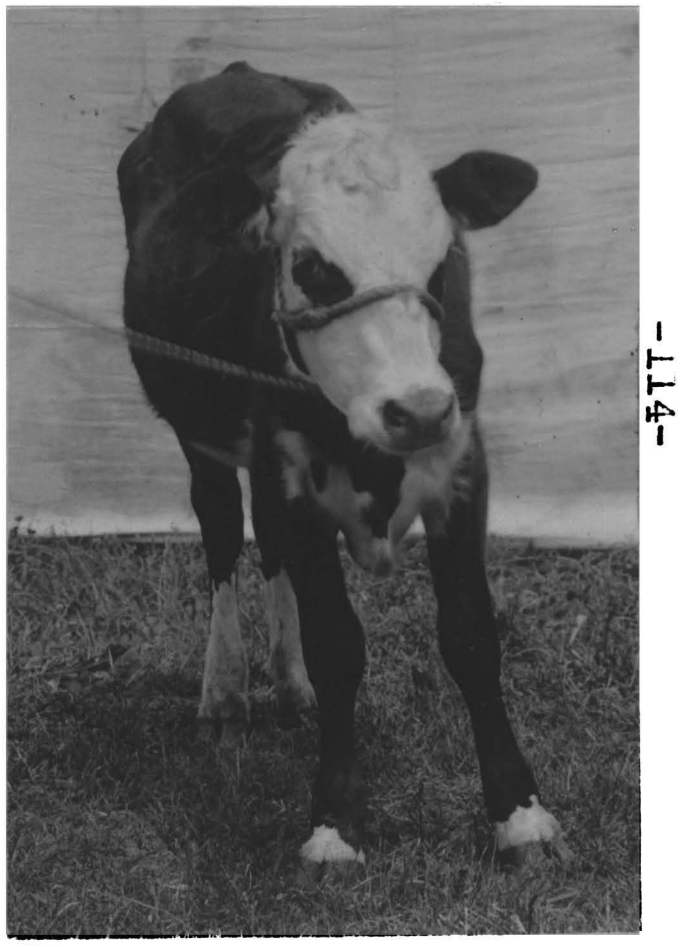

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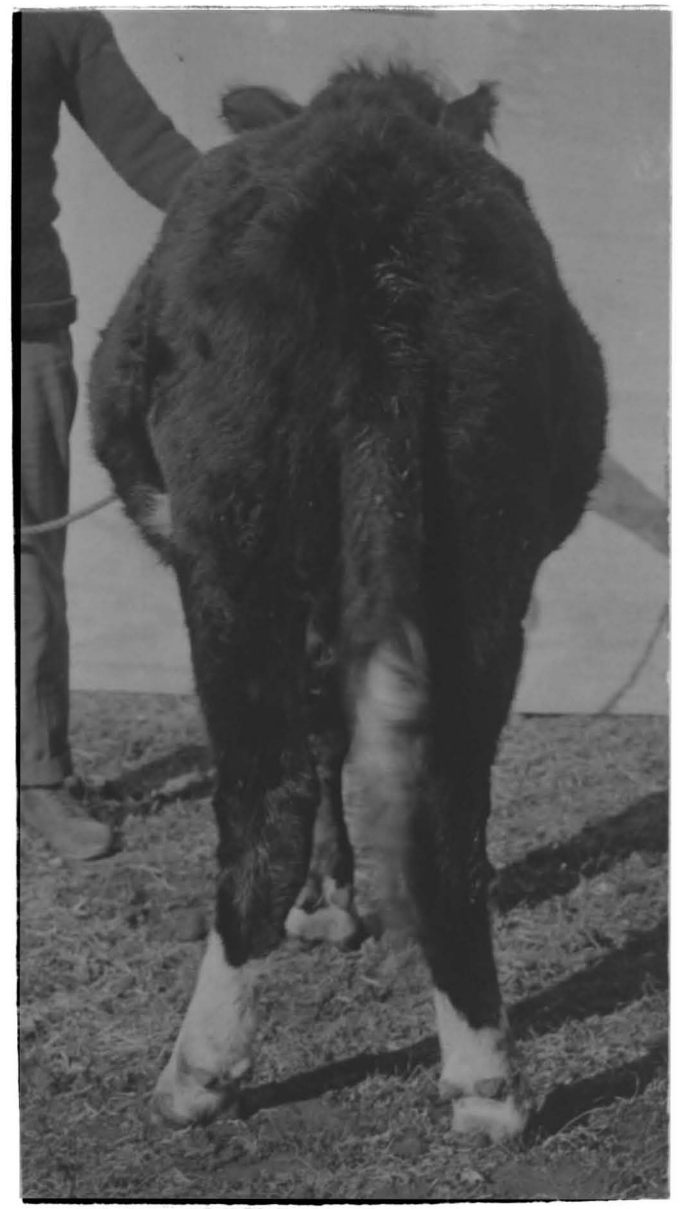

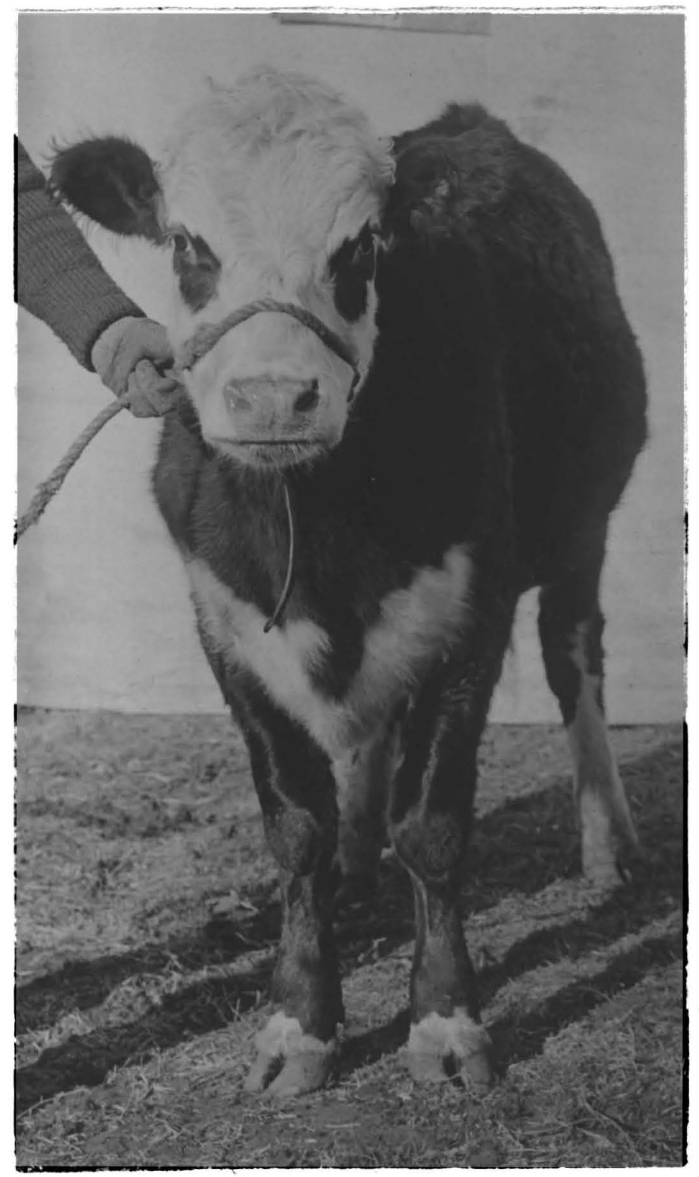

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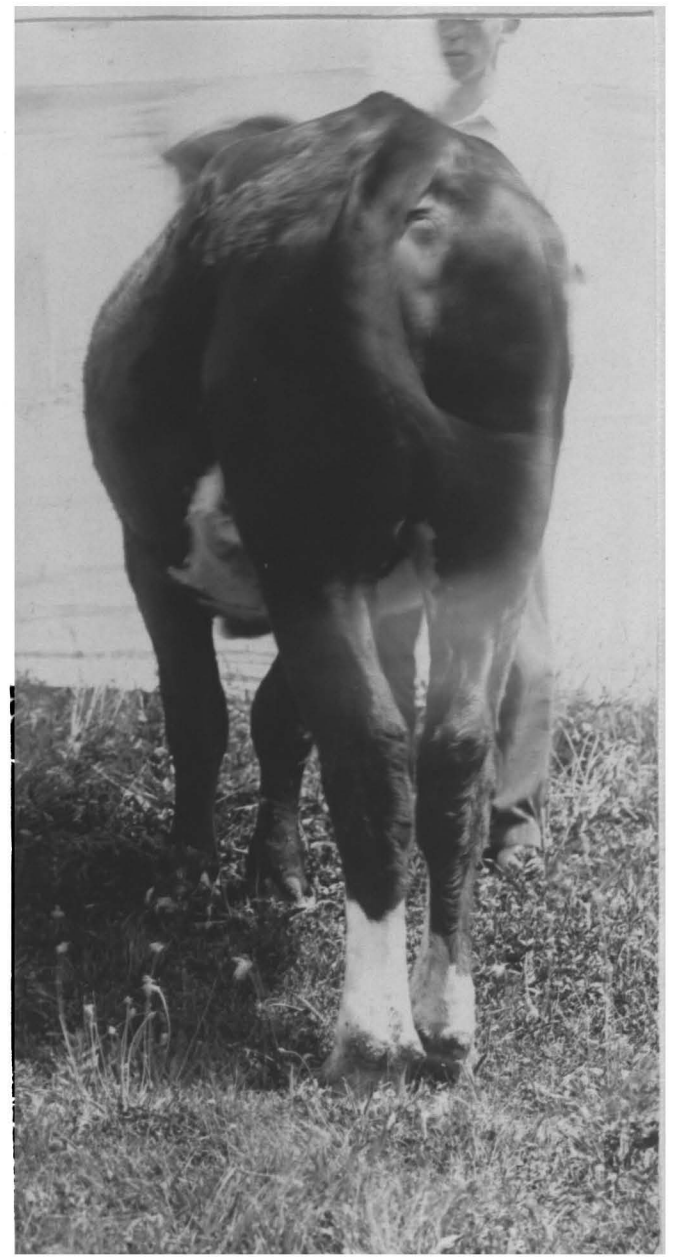

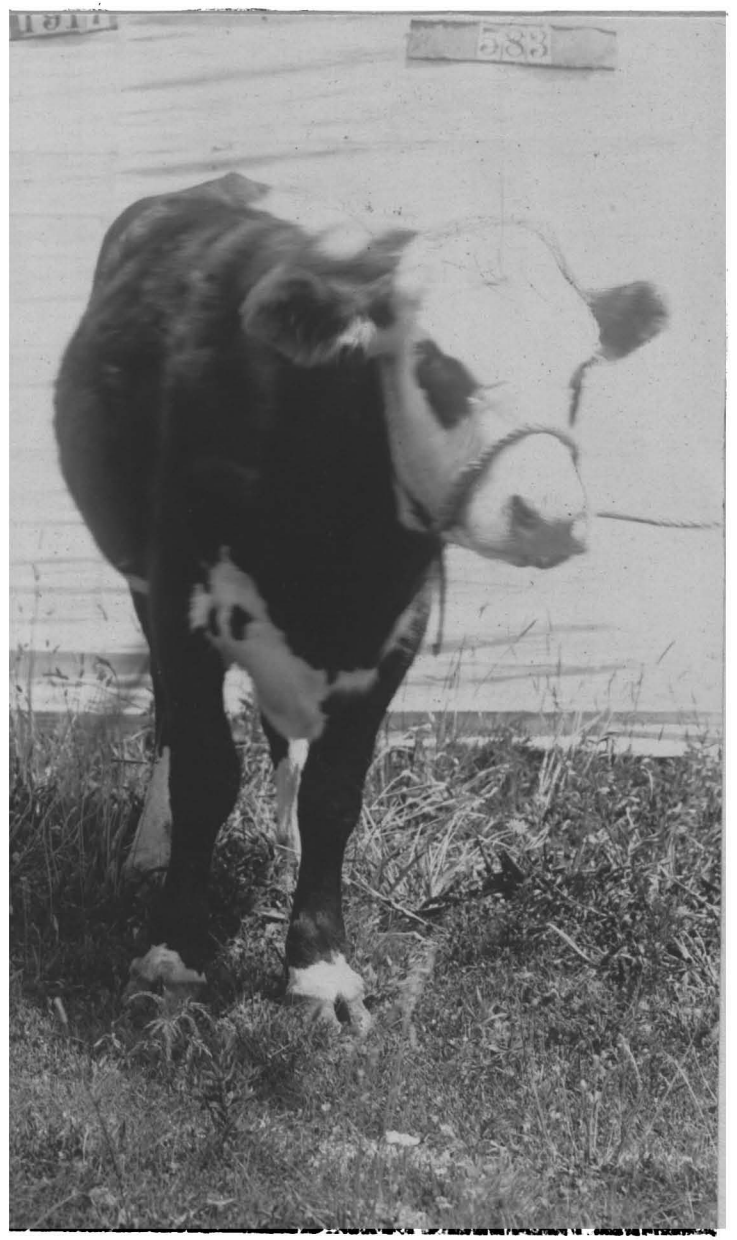

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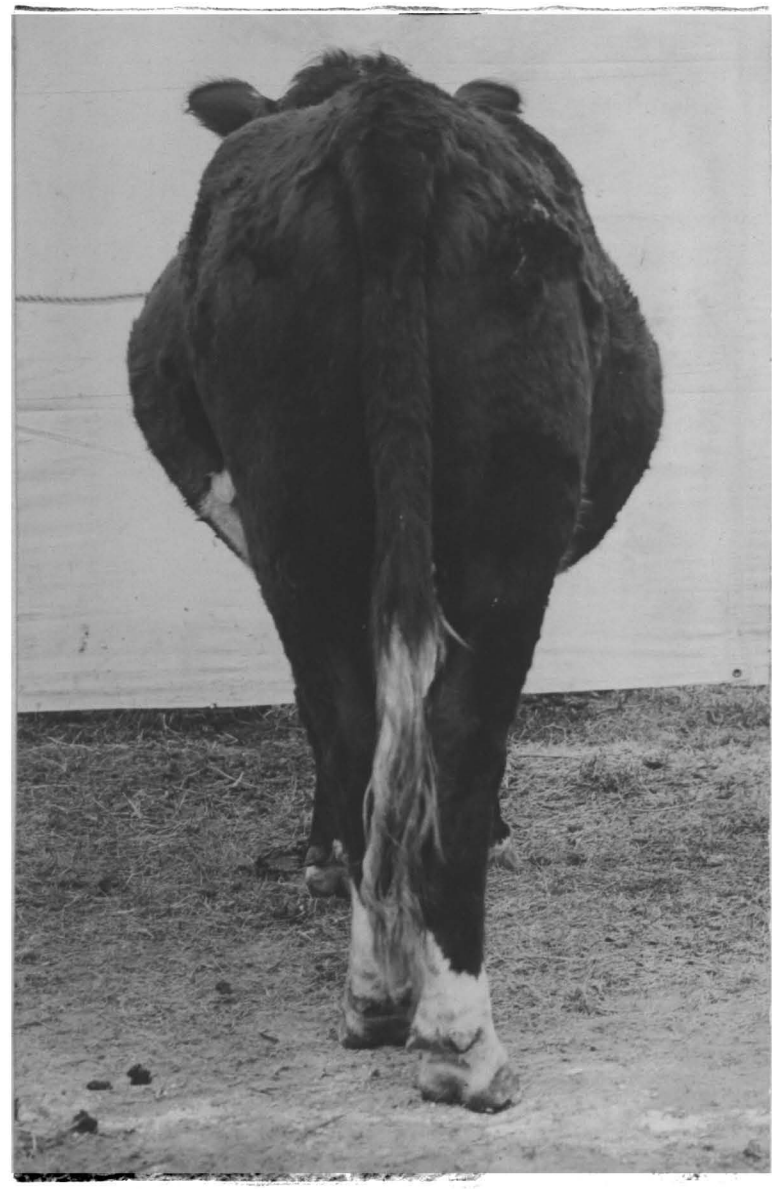

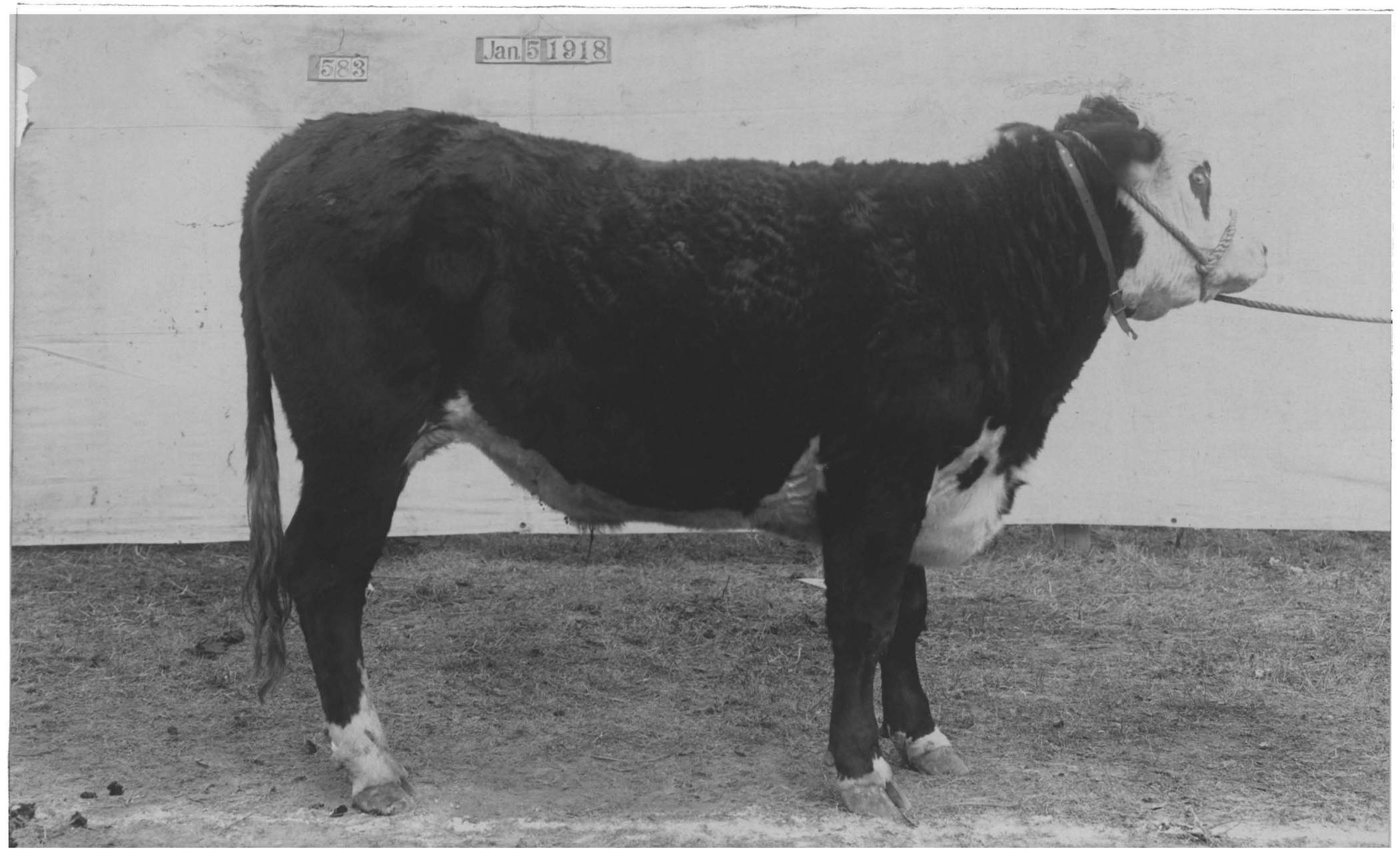

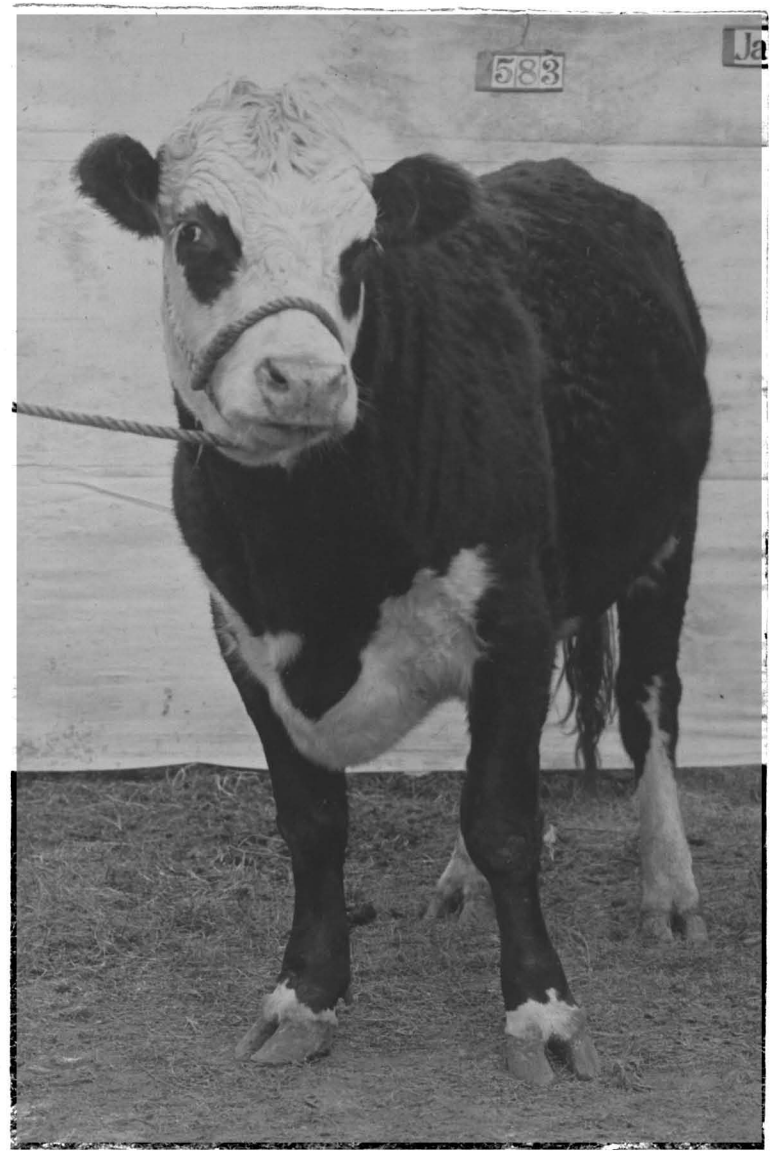

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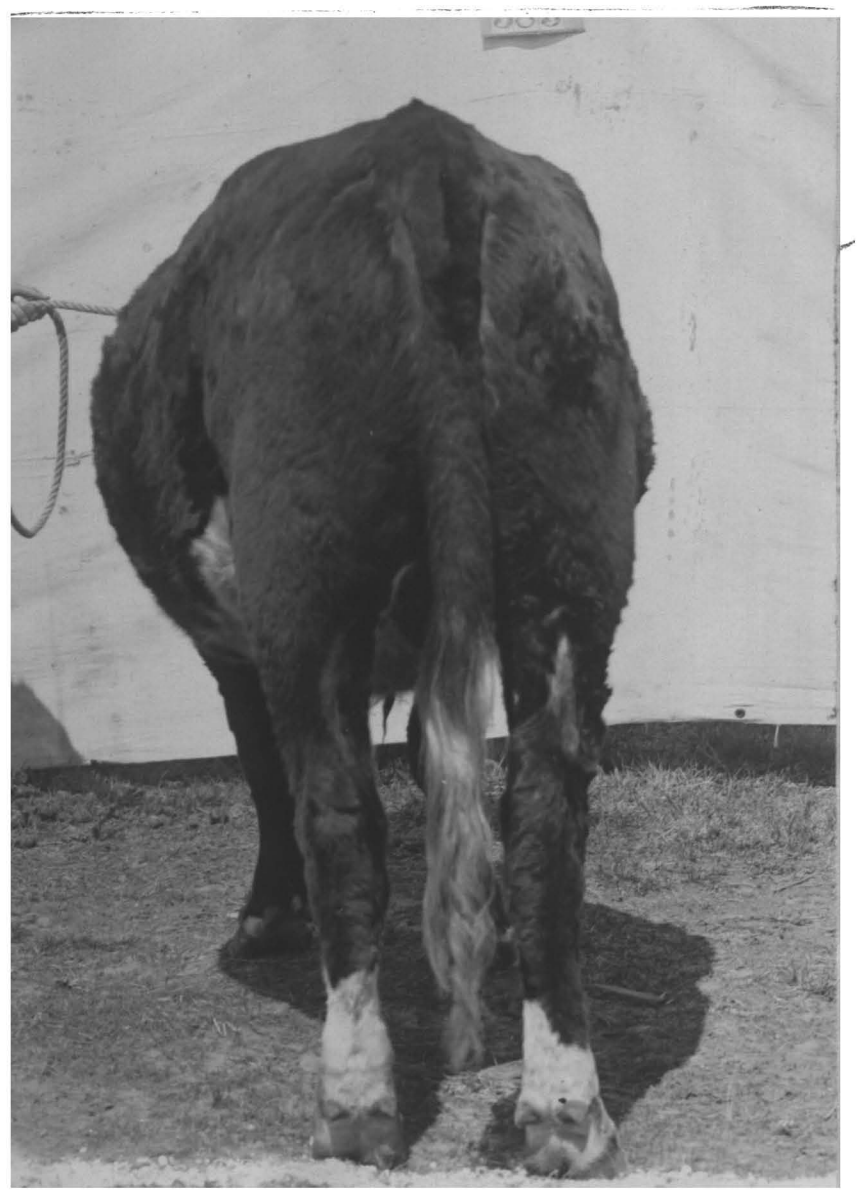

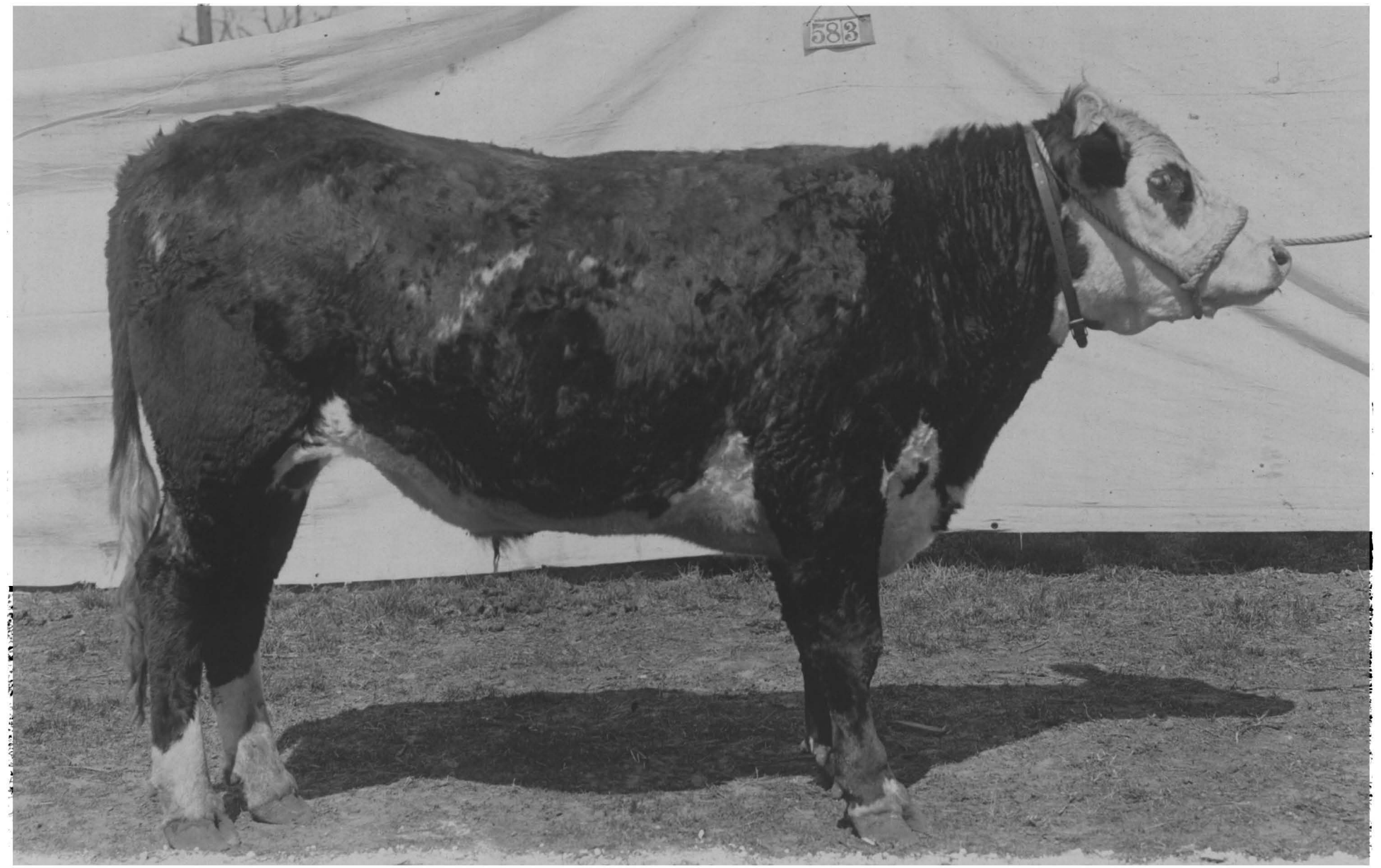

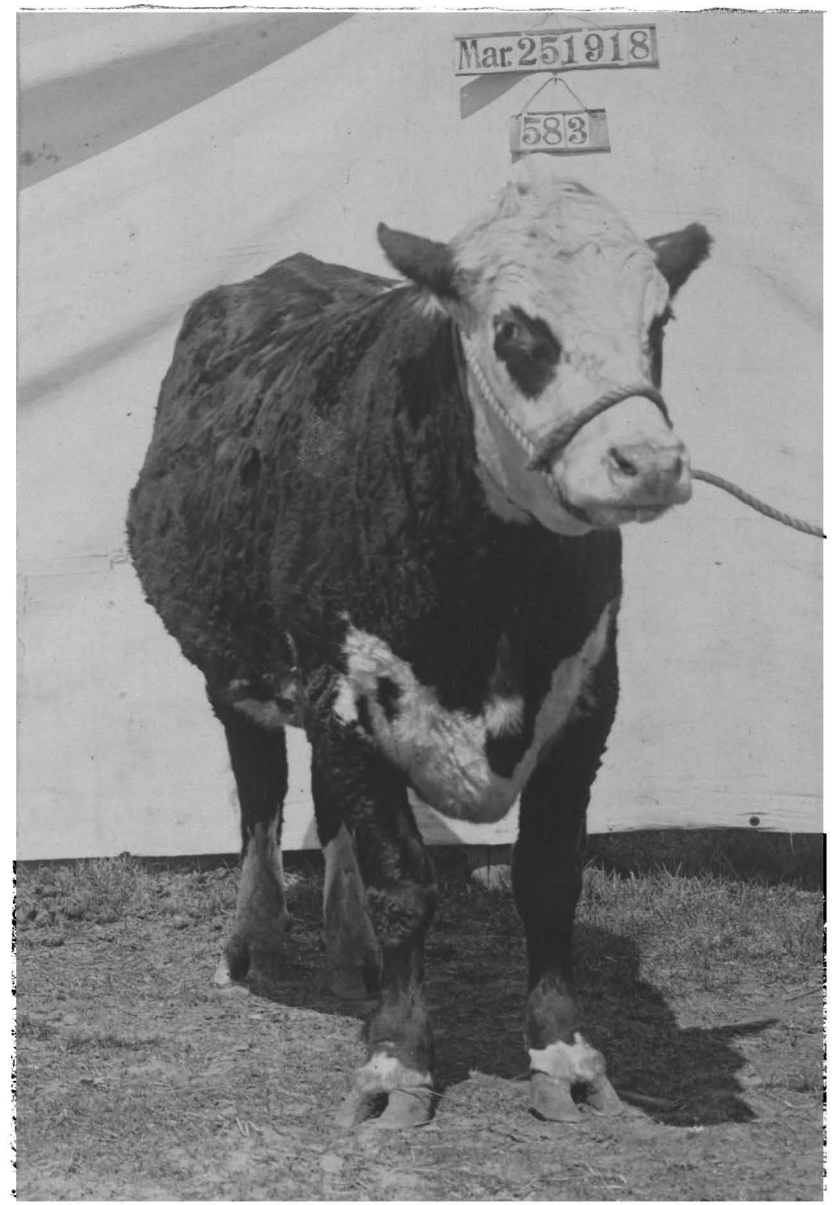

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