To the Committee on Graduate Study:

I submit herewith a thesis written by Mr. Frank D. Quillin, "Legume Silage and Artificially Dried Hay for Dairy Cattle," and recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Dairying.

L. E. Kylie
Major Professor

At the request of the
Committee on Graduate Study,
we have read this thesis,
and recommend its acceptance.

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Dean

LEGUME SILAGE AND ARTIFICIALLY DRIED HAY FOR DAIRY CATTLE

-o-

A THESIS

Submitted to the Graduate Committee

of

The University of Tennessee

in

Partial Fulfillment of the Requirements
for the degree of
Master of Science

By

Frank D. Quillin

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PREFACE

The material contained in this thesis has been collected by the writer during a year of graduate study in Dairying at the University of Tennessee.

Acknowledgment is hereby given to Professor C. E. Wylie, Head, and Mr. S. A. Hinton of the Department of Dairying at the University of Tennessee, for their valuable suggestions and assistance during the progress of the research and writing of this thesis.

---Frank D. Quillin

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CONTENTS

Page

Introduction

PART I. SURVEY OF LITERATURE

Legume Silage and Artificially Dried Hay for Dairy Cattle

Legume Silage---------- 1

Early History---------- 1

Harvesting Methods and Storage---------- 3

Silage with No Treatment---------- 5

Molasses Treatment---------- 6

A. I. V. Treatment---------- 8

Phosphoric Acid Silage---------- 11

Other Treatments---------- 13

Red Clover Silage---------- 13

Sweet Clover Silage---------- 14

Alfalfa Silage---------- 15

Soy Bean Silage---------- 17

Cowpea Silage---------- 19

Lespedeza Sericea Silage---------- 20

Cost of Silage---------- 21

Artificially Dried Hay

Early History---------- 23

Hot Air Drying---------- 24

Ventilated Mows---------- 28

Barn Cured Hay---------- 29

Cost of Artificially Dried Hay---------- 32

Summary of the Survey of Literature-------- 34

Page

PART II. ORIGINAL INVESTIGATION

SECTION A. LESPEDEZA SERICEA SILAGE VERSUS CORN SILAGE FOR DAIRY COWS

Purpose---------- 37

Plan of Experiment---------- 37

Recording Data---------- 38

Results Obtained:

Group I. (Corn silage)---------- 40

Group II. (Lespedeza Preserved with Molasses---------- 49

Group III. (Lespedeza Preserved with Phosphoric Acid---------- 58

Discussion of Results---------- 76

SECTION B. AIR DRIED HAY VERSUS FIELD CURED HAY FOR DAIRY HEIFERS

Purpose---------- 78

Plan of Experiment---------- 78

Recording Data---------- 81

Results Obtained:

Group I. (Air Cured Hay)---------- 81

Group II. (Field Cured Hay)---------- 103

Discussion of Results---------- 124

SUMMARY AND CONCLUSIONS---------- 130

BIBLIOGRAPHY---------- 131

LIST OF TABLES

		Page
I.	Physical Effect on Size and Production of Cow No. T36	42
II.	Physical Effect on Size and Production of Cow No. 320	44
III.	Physical Effect on Size and Production of Cow No. 81	46
IV.	Physical Effect on Size and Production of Cow No. 299	48
V.	Physical Effect on Size and Production of Cow No. 301	51
VI.	Physical Effect on Size and Production of Cow No. T30	53
VII.	Physical Effect on Size and Production of Cow No. T14	55
VIII.	Physical Effect on Size and Production of Cow No. 99	57
IX.	Physical Effect on Size and Production of Cow No. 304	60
X.	Physical Effect on Size and Production of Cow No. 243	62
XI.	Physical Effect on Size and Production of Cow No. T32	64
XII.	Physical Effect on Size and Production of Cow No. T12	66
XIII.	Summary Growth and Milk Chart	67
XIV.	Growth and Milk Record of Groups	73
XV.	Feed Consumption and Growth Chart	75
XVI.	Composition of Silages	76
XVII.	Total Nutrients Eaten During Experiment	77
XVIII.	Total Feed and Growth Summary	124
XIX.	Growth Summary	129

LIST OF FIGURES

		Page
1.	Scenes Where Experiment Was Conducted----------	39
2.	Photograph of Cow No. T36----------	41
3.	Photograph of Cow No. 302----------	43
4.	Photograph of Cow No. 81----------	45
5.	Photograph of Cow No. 299----------	47
6.	Photograph of Cow No. 301----------	50
7.	Photograph of Cow No. T30----------	52
8.	Photograph of Cow No. T14----------	54
9.	Photograph of Cow No. 99----------	56
10.	Photograph of Cow No. 304----------	59
11.	Photograph of Cow No. 243----------	61
12.	Photograph of Cow No. T32----------	63
13.	Photograph of Cow No. T12----------	65
14.	Milk Production----------	68
15.	Butterfat Production----------	69
16.	Average Heart Girth of Groups----------	70
17.	Average Weight of Groups----------	71
18.	Silage Consumption----------	72
19.	Duct System and Blower of Air Dried Hay System--	79
20.	Sketch Showing How a Barn Looks When the Air Dried System is Put in----------	80
21.	Photographic Growth Rate of Heifer No. T66------	83
22.	Growth Rate (height) of Heifer No. T66----------	84
23.	Growth Rate (heart girth) of Heifer No. T66-----	85
24.	Growth Rate (weight) of Heifer No. T66----------	86
25.	Photographic Growth Rate of Heifer No. T68------	87

Page

26. Growth Rate (height) of Heifer No. T68------- 88
27. Growth Rate (heart girth) of Heifer No. T68-- 89
28. Growth Rate (weight) of Heifer No. T68------- 90
29. Photographic Growth Rate of Heifer No. 322--- 91
30. Growth Rate (height) of Heifer No. 322------- 92
31. Growth Rate (heart girth) of Heifer No. 322-- 93
32. Growth Rate (weight) of Heifer No. 322------- 94
33. Photographic Growth Rate of Heifer No. T64--- 95
34. Growth Rate (height) of Heifer No. T64------- 96
35. Growth Rate (heart girth) of Heifer No. T64-- 97
36. Growth Rate (weight) of Heifer No. T64------- 98
37. Photographic Growth Rate of Heifer No. 324--- 99
38. Growth Rate (height) of Heifer No. 324------- 100
39. Growth Rate (heart girth) of Heifer No. 324-- 101
40. Growth Rate (weight) of Heifer No. 324------- 102
41. Photographic Growth Rate of Heifer No. 323--- 104
42. Growth Rate (height) of Heifer No. 323------- 105
43. Growth Rate (heart girth) of Heifer No. 323-- 106
44. Growth Rate (weight) of Heifer No. 323------- 107
45. Photographic Growth Rate of Heifer No. 319--- 108
46. Growth Rate (height) of Heifer No. 319------- 109
47. Growth Rate (heart girth) of Heifer No. 319-- 110
48. Growth Rate (weight) of Heifer No. 319------- 111
49. Photographic Growth Rate of Heifer No. T63--- 112
50. Growth Rate (height) of Heifer No. T63------- 113
51. Growth Rate (heart girth) of Heifer No. T63-- 114

Page

52. Growth Rate (weight) of Heifer No. T63------- 115

53. Photographic Growth Rate of Heifer No. T67--- 116

54. Growth Rate (height) of Heifer No. T67------- 117

55. Growth Rate (heart girth) of Heifer No. T67-- 118

56. Growth Rate (weight) of Heifer No. T67------- 119

57. Photographic Growth Rate of Heifer No. T70--- 120

58. Growth Rate (height) of Heifer No. T70------- 121

59. Growth Rate (heart girth) of Heifer No. T70-- 122

60. Growth Rate (weight) of Heifer No. T70------- 123

61. Average Growth Rate (height) of Groups------- 126

62. Average Growth Rate (heart girth) of Groups-- 127

63. Average Growth Rate (weight) of Groups------- 128

INTRODUCTION

The National Soil Conservation Program has brought about a new interest in the raising of grass and hays. On account of the heavy rainfall in the South, such roughage becomes an important part of the dairy development in this section.

The making of ensilage from hay is a comparatively new thing in this country. A great many experiment stations at the present time are working on the subject of legume silage, and to a limited extent, on the preservation of hays by drying in the barn. It is important, therefore, that legume silage and hay drying be given consideration. According to the U. S. Agricultural Statistics for 1937, there were 1,522,000 acres of hay grown in Tennessee. The total yield of hay was 1,050,180 tons.

Since Lespedeza sericea is a legume that fits into a soil building program, it would seem that some other use than cutting for hay should be made of it. With this point in mind, Lespedeza sericea was put into a silo and was fed to dairy cows in comparison with corn silage to determine its feeding value. The results are reported in this thesis.

The purpose of the barn drying hay system is to furnish the twenty-ton hay farmer with a low-cost hay drier. In order to determine the feeding value of the barn dried hay, it was fed to dairy heifers in comparison with the field cured hay. The results of this experiment are also reported in this thesis.

PART I

SURVEY OF LITERATURE

LEGUME SILAGE AND ARTIFICIALLY DRIED HAY

Legume Silage

EARLY HISTORY OF SILAGE

McBryde (48) found that silos were made centuries ago in Persian and Roman times. Varro spoke of pits in the ground made tight to exclude air and insects, and he mentions their use in Trace, Carthage, Spain, and Rome. The records mention the pitting of the grain crops and forage crops, wheat having been kept in a good state of preservation in the pits for fifty years. McBryde reasoning from historic data draws the conclusion that green crops were preserved.

There is no doubt that in the early decades of the last century pitting of green crops was not unknown to the farmers of several of the European Nations. The pits were dug as deep as twelve feet and lined with brick, stone, or wood. The ensiled or pitted material was heavily trodden and well pounded around the edges of the pit.

Goffart, of France, had the honor of having adopted the preservation of green crops to common modern use by storage above ground in stone structures known as silos. In 1876 Morris, of Maryland, built the first silo in the United States. Soon after this Dr. Bailey, of Massachusetts, constructed a concrete silo on his farm. By gatherings of the press and of public men at the opening of his silo and by free writing on the praise of the material, he created a sudden and wide interest in the new method of crop storage.

In a decade the silo came into wider use and underwent a more radical change than had occurred in the centuries of previous use.

Stone loaded on plank, earth, bags of sand, screw pressure, and other methods of weighting, quickly followed each other, until it dawned on observers that the immense weight of the forage supplied adequate pressure for all but the very top layer. The omission of weighting was followed by covering with straw or poor hay as a method of retaining the moisture in storage.

In Finland (21) there has been developed a system of preserving surplus pasture grass, and late cuttings of hay, by packing in trenches without cutting them up. The trench was covered with straw and weeds followed by a layer of dirt.

The first experimental silos in this country were erected in 1881. Since then the storing of corn and legumes for cattle has become a common and highly regarded practice.

In 1937 Hayden (21) concluded that large acreages of alfalfa, clover, or soy beans are frequently ready for harvest, when conditions are impossible for hay making. Silage can be made in weather not suitable for making hay so under these conditions the hay should be put in the silo without losing the crop.

Hayden observed that an early season hay crop can be stored in the silo and fed during the season of short pastures, and it will keep up the milk production during the midsummer slump. The silo will also be available for the

corn silage in the fall. This makes possible the double use of the silo. It also conserves the hay storing space which is usually small on most farms.

A weedy or damaged crop of legume hay may be ensiled. The quality of the silage will be better than if the crop had been made into hay.

Ensiling of legumes prevents the losses from shattering and weathering. These gains will probably more than offset the loss in molding.

In many areas it is desirable to grow more legumes because the land is poor. The growing of legumes will fit better into a soil conservation program than corn. The ensiling of legumes is very desirable in such a program.

Hayden found that the vitamin A intake of cows as well as that of humans is reduced during the winter. Through the feeding of materials potentially rich in vitamin A, the consumer will get more vitamin A. The consumption of milk will be stimulated.

Ragsdale and Turner,(43) in 1924, found that the loss in ensiling of leguminous crops was low. The average of nine silos composed of alfalfa, cowpeas, and soy beans showed a loss of dry matter of only 2.12 per cent.

HARVESTING METHODS AND STORAGE

From a questionaire(30) of three hundred eighty Northeastern farms it was found that it was best to cut down no more hay than could be put in the silo during the same half day. The sooner it is put in the silo the better. In good

weather it should not remain out in the field over two hours. If it gets too dry water should be added.

It was found that a windrower attached to the mower did the work of a rake. It costs between ten and twenty dollars, and it does not pick up stones and sticks as badly as a side delivery rake. If a tractor mower is used a side delivery rake may be pulled behind it.

From the survey it was found that modern cylinder-rake bar loaders pick up most crops directly from the swath. The loaders will handle the crop very well if it is not too heavy. If cylinder-rope loaders give trouble, they should be rebuilt by replacing original slats with heavy oak and replacing ropes with welded, machine link chain. In buying a new loader it is better to buy one that is designed for green hay. They handle both green and dry hay, and they cost only about twenty dollars more than the others.

Many of the farmers used dump trucks to haul the hay. The hay is allowed to fall from the loader without packing. If a wagon is used the hay may have to be pulled to the front a few times. Because of the weight there is little trouble in building the load.

It was found that labor could be saved by dumping the load at the silo. It is easier to throw hay into the silo filler from the ground. Stones may be more easily observed. Two men can pitch a ton of green hay into a silo filler in ten minutes or less. Almost any flywheel-type cutter will cut green hay crops. Machines with throats fourteen inches

or wider do the work faster, and with lower costs per ton. The silo filler should be set for one-fourth to one-half inch cut.

The silage should be well tramped, especially the outside edges and the top third of each filling. There is no need to fill continuously, because spoilage will not start for two or more days.

Surface spoilage is reduced by sealing the silo with a foot or more of wet sawdust, weeds, straw, or other waste materials. A layer of tar paper between silage and sealing material helped to keep out the air. Some farmers confined the spoilage to a few inches by leveling and sprinkling the top of the silage with water for a few hours.

SILAGE WITH NO TREATMENT

Morrison (30) found from a study of the normal ensiling processes of the corn plant that the reasons for failure in preserving legumes, as high quality silage, was due to the low sugar and high protein content of these plants. A low sugar content means so little acid fermentation as to permit the decomposition of the proteins by the proteolytic organism present, thus producing strong smelling and in many cases putrid silage. Cows ate the silage in some cases, but in other cases they would not eat it.

Wilson and Webb (62) found that one of the main reasons why legumes do not ensile satisfactorily is the small quantity of sugar in their tissues. There are about three times as much fermentable sugars in the non-legumes as is in

the legumes from which suitable silage can be made. Vetch and red clover have been the most satisfactory legumes for silage. They have the highest percentage of water soluble carbohydrates.

Perkins (40) says:

"It has long been known that a good grade of silage can be made from legumes alone. It has repeatedly been shown by experiment that the quality of the silage made by this method is greatly improved by partial drying, if necessary, to bring the dry-matter content above 30 per cent. However the dry matter content must not be so high that the material fails to pack well, for the air must be largely excluded to prevent excessive fermentation and decay."

MOLASSES TREATMENT

Perkins (40) found that molasses could be added to silage in order to provide the carbohydrates needed in the fermentation process. Lactic and acetic acid are formed in this process. The use of more molasses than is required for the preservation of the silage probably increases the palatability and food value of the silage. Definite data to prove this is lacking. The cost of adding molasses is relatively low, and there is more benefit from the molasses as food than from some of the other materials used as preservatives, such as, inorganic acid. The use of molasses in preserving legume silage is being advocated by the manufacturers of silo-filling machinery. Of the various means of preserving legume ensilage molasses is the most popular and most widely used. In early experiments it was found that molasses did not preserve the carotene very well, however, more carotene is being preserved according to more recent investigations.

Hamlin (18) found that:

"The nutrients of the molasses used to preserve the silage are still at least seventy-five per cent available, particularly in the form of lactic and other organic acids. Research work in Austria indicates that lactic acid has a favorable influence on the retention by animals of the calcium, phosphorus and nitrogen in their rations. The use of more molasses than is required for preservation simply adds nutrients, often at a relatively low cost. The excess molasses is retained ninety-eight per cent in its original form."

Woodward and Shepard (64) found that molasses tends to slightly increase the losses or dry matter, protein, and carotene. It, however, improved the palatibility and lowered the pH value an average of .27 for all silages.

Morrison and others (30) found that the addition of molasses to the legumes as they were being ensiled kept them from spoiling. The sugar in the molasses provided the nutrients for bacterial action, thus providing the acidity needed for preservation.

Morrison's questionaire (30) gives the following quantity of molasses for the best preservation:

Kind of Crop	Molasses per Ton
Mixed Grasses and Legumes	60 lbs. (5 gals.)
Alfalfa or Clovers	80 lbs. (7 gals.)
Soy beans	100 lbs. (8⅓ gals.)

Some farmers used more molasses than was necessary for preservation, but they made a more palatable silage and increased the feeding value at a low cost.

The molasses may be added by gravity or pump. Gravity is the simplest and easiest. This calls for a drum, two valves,

and a short piece of hose or pipe leading to the blower. Enough molasses should be added to the drum at one time to treat a load of hay. If the molasses does not flow fast enough, water may be added. The molasses should be delivered into the blower at a point inside the path of the fans in such a way that the suction created by the fans will automatically draw the molasses out of the drum. It was found that when molasses is run onto the feed table, the apron chain is so often gummed up that breakage frequently resulted.

A. I. V. TREATMENT

Hayden (21) says that:

> "A. I. V. Virtanen, an agricultural chemist in Finland, studied this process and found that a considerable part of the food material contained in the green plants was made soluble by fermentation which went on in the crude trench silo. Much of the soluble food material was lost in the large amount of juice which ran away. The fermentation which broke down the proteins making them soluble, was stopped when a certain amount of acid was developed by the fermentation. Virtanen conceived the idea of adding acids to the green material as it was ensiled, thus heading off and largely preventing the fermentation. He also found that carotene, the yellow pigment of milk and butter which is closely related to vitamin A and is found abundantly in freshly cut grass and leguminous forage crops, but was largely destroyed in the rock silos, was well preserved by his acid treatment. Virtanen's claims regarding the prevention of considerable loss of food material and the preservation of carotene and vitamin A for the conditions under which he was working have been repeatedly confirmed by other investigators."

It seems that the use of so much mineral acid would have a harmful effect on the animals, but no harmful results were found. About twenty gallons of acid were used to each ton of green material. Four cows were fed A. I. V. silage as the only roughage for one hundred and sixty days. Four

ounces of ground limestone were fed daily to each cow receiving the acid silage. There were changes in the composition and reactions of the urine. The effects, however, were not harmful to the cattle.

The cows gave about the same amount of milk on the silage as they did on the alfalfa hay, calculated on a dry matter basis. The silage was more palatable than a mediocre grade of alfalfa, but the two rations were about the same in production effiaiency.

The A. I. V. silage was superior in carotene. The cows getting as much as half their roughage from A. I. V. silage produced milk and butter high in carotene content during the winter; while cows fed on alfalfa fell to low levels of carotene.

"The proponents of A. I. V. silage claim for this process two major points of superiority: the preservation of carotene and the prevention of loss of food material in the juice running away from the silo."

In European experiments the dry matter content of the silage was usually twelve to thirteen per cent. There is a loss of fifty to one hundred gallons of juice per ton of material ensiled where the dry matter is that low. The A. I. V. method reduces solubility of food materials and prevents so much loss.

When the material is ensiled with thirty per cent dry matter, not much loss in juice will occur. Most Ameri-

can experiments have been conducted in this way; so there is no particular advantage from the standpoint of preventing loss of juice by using the A. I. V. process.

At the Ohio Station, Perkins (39) found that the treatment of immature crops of very low dry matter content as they are ensiled by this method reduced the amount of food material lost in the juice.

Perkins (40) observed that mineral acids are added to reduce the pH of the silage below 4.0. Hydrochloric and sulphuric acids are used in the A. I. V. process, and they have no food value in themselves. Wilson and Webb (5) found that the general method is to use four parts hydrochloric acid to one part of sulphuric acid. This mixture is made into a 2 N solution before being used on the silage. Wilson (61) advocates obtaining the commercial acid in carboys. Then mix the acid (12 gal. carboy) with 60 gallons of water. This mixture gives a 2 N solution.

The equipment usually used for mixing and applying the 2 N acid should consist of:

(1) A mixing tank of about 300 gallon capacity.

(2) Measuring barrel for measuring the acid.

(3) An acid resisting pump.

(4) A hose to convey the acid into the silo.

Oil drums holding fifty-five gallons make satisfactory measuring barrels. They are set on end, the tops knocked out, and the bottoms fitted with connecting drains. The drains should be coated with asphalt paint. A calibrated wooden stick is

used to measure the amount of acid in the barrels. It is advisable to have two barrels so that one can be filled while the acid is being used out of the other. The pump should be bronze or some other acid resisting material. A gear type marine pump has been found very satisfactory. All fittings should be of brass or rubber to prevent reactions to the acid. Each load of fodder is weighed and the valves are regulated so that the amount of 2 N acid indicated by the assay is applied. It is best to run the fodder through the cutter and spray the acid on in the silo.

Perkins (39) found that under farm conditions there are also practical difficulties connected with determining the amount and strength of acid to be used and some disagreeable or possibly dangerous features connected with mixing and applying these corrosive acids. At the Wisconsin College of Agriculture, Babcock (3) used amounts of acid varying from 90 liters to 120 liters per ton of green material with good results.

PHOSPHORIC ACID SILAGE

Davies (8) observed that commercial phosphoric acid is not as corrosive as other acids. It will not injure the person or clothing. It will not attack metal, and it cannot be handled in steel drums. It is not injurious to the silage cutter, which, however, should be washed after being used. Wooden barrels have added to the cost of handling and they have not been very satisfactory.

Phosphoric acid may be used with all legumes and

grasses with which it is possible to use molasses. Less heat and fermentation is produced. From a theoretical point of view less energy and food value is lost.

The maximum amount of acid needed to prevent bacterial action seems to be about 16 pounds (1½ gals.) per ton of green material. This was used with alfalfa and soy beans. The amount to use with other crops might vary. In cases of severe spoilage, the trouble could be traced to too little acid.

Most people apply the acid as it passes over the feeding table. The application of the right amount requires a great amount of care. A better method is to dilute the acid with about five times its weight of water and run it into the blower as was suggested for the molasses.

It would seem that less acid should be added to preserve mixed grasses and legumes, but the survey did not show this. It is better to add the 16 pounds of acid than take a chance on losing the silage.

The results of the survey did not indicate that this treatment was costlier than molasses. It is easier to handle, and when properly used, there is no more spoilage; it is palatable, and it gives good production results. Experts say there is no danger from the fluorine, but this has not been definitely proved.

It is thought (40) that phosphoric acid will serve the triple purpose of preserving the silage (including the

carotene), furnishing needed phosphorus in the cow's ration, and increasing the fertilizing value of the manure.

OTHER TREATMENTS

Perkins (40) treated crops with dry ice or solid carbon dioxide. A special kind of silo is required and the treatment is expensive and it adds nothing to the feeding value. It is still in the experimental stages; it does not possess any more advantages than some of the other treatments.

Nevins and Kuhlman (33) used whey powder to preserve silage, but they found that it was expensive. They also used lactic acid culture and bulgartac culture by mixing with the alfalfa at the time of ensiling. The addition of these materials would not be practical for the average farmer.

Swanson and Teague (51) used dried milk, corn meal, and sugar to increase the acid content of legume silage. The products were either too expensive or not practical.

RED CLOVER SILAGE

Smith and Blish (49) found that the making of red clover into silage has been tried at a number of experiment stations with results that seem to be fairly satisfactory, more so in the Northerly climates. When silos are of sufficient depth and silage well packed, good results from ensiling may be obtained.

The purpose of this experiment was to determine the composition of the average red clover crop when freshly cut and dried in the laboratory as well as when cured for hay.

In making the silage the clover was cut in short pieces with a silage cutter. As the silage entered the silo it was spread evenly and thoroughly tramped. The silo was filled from the middle to the latter part of September each year.

The results showed that there is a considerable loss of dry matter in the ensiling process. This is due to the breaking down of the fermentable carbohydrates and to the development of moisture from metabolic processes. There is very little change in the mineral content, and the change in the crude fiber is probably due to the decrease in the nitrogen free extract. The silage showed a higher calorific value than the fresh clover.

From experiments with a two-year-old steer it was found that when red clover was ensiled, changes in the proteins took place and this caused a noticeable lowering of the coefficient of digestibility.

Red clover may be satisfactorily ensiled where weather conditions interfere with the curing of it for hay. There is not a very serious loss in the food value or the digestibility of most of the constituents.

SWEET CLOVER SILAGE

At the North Dakota Station, Dice (11) put up two stacks of green sweet clover. The stacks rotted around the outside, excluded the air from the inside of the stack and thus formed a self-made silo. They fed one stack in feed

racks in the barnyard and it was eaten readily by the cattle. The other stack was fed to five milk cows and five heifers in comparison to corn silage for twenty day periods. They kept check on body weights, milk and butter fat production. Cows were fed the same amount and mixture of grain rations.

> "During the twenty days that the cows were fed corn silage they produced on the average of 89.15 pounds of milk a day and 3.55 pounds of butterfat as compared to 85.6 pounds of milk and 3.4 pounds of fat when on sweet clover silage. The difference in production in favor of corn silage is slight. The cattle gained at the same rate on sweet clover silage as they did on corn silage so that this short trial should seem to indicate that sweet clover silage from a stack silo, wastage considered, is approximately 85 to 90 per cent as efficient for dairy cattle as corn silage."

ALFALFA SILAGE

Nevens (34) found that first cutting alfalfa is usually difficult to cure as hay on account of the weather and coarseness of stems. The stems will be eaten when silage is made, but they will refuse them in the hay. This first cutting may be put in the silo and used in the fall to supplement short pastures.

They found that alfalfa ensiled satisfactorily under suitable conditions, and that it makes a very appetizing feed for dairy cows. It must have from 30 to 35 per cent dry matter to keep well. It kept all right without a preservative, but 40 to 60 pounds of molasses per ton improved the keeping quality.

Mold is sometimes found throughout the silo, and in some cases it is found in spots at different depths. The cause is too much air, because mold will not grow without air.

This indicates that alfalfa was dry and did not pack closely.

Eckles (12) showed that under proper conditions silage may be made from alfalfa and the loss in constituents, either total dry matter or protein, when in the silo is even less than for corn. When conditions are not properly controlled the silage is inferior in quality to a point where it is almost worthless for feed because of its strong odor and taste of decomposition.

The water content is the most important factor in determining the keeping quality of alfalfa. Alfalfa should contain about 40 per cent dry matter when put into the silo. It is necessary to cut alfalfa before it is mature, because the next cutting will not be good if it is cut too late. For this reason it is advisable to leave the alfalfa in the field after cutting until it is wilted. If it gets too dry, add water.

Tucker (53) found that where alfalfa can be grown satisfactorily, a greater tonnage can be obtained than from corn. It contains two and one-half times as much protein as an equal amount of green corn; although it does not contain quite as much total digestible nutrients. The increased tonnage makes it possible to obtain more total digestible nutrients per acre, and three to four times as much protein from alfalfa as from corn.

At the Wisconsin Station (46) alfalfa was partially dried by exposure after cutting, to 30 to 40 per cent moisture,

then tightly packed and heavily weighted. The silage was green in color, had a pleasant odor, and was readily eaten by cattle. There was a little loss in dry matter. It is doubtful that a farmer can get the hay dried to the proper degree of moisture for silage; therefore, it should not be recommended to a farmer where he can make his alfalfa into hay satisfactorily.

> "A field of alfalfa will produce two and one-half tons of cured hay per acre and will yield 10 tons of alfalfa silage. Ten tons of alfalfa silage per acre will yield between eight hundred and nine hundred pounds of protein. An equivalent yield of corn will have four hundred forty pounds of protein."

SOY BEAN SILAGE

Eckles (12) performed some experiments with six tanks three feet in diameter and six feet in height, constructed of cypress staves two inches in thickness, to preserve the silage. Wooden covers with a ring of felt around the edge were used. They were weighted down with rocks. The silos were compared with large silos in the making of corn silage, and there was no difference in them.

Two of the experimental silos were filled September 21. The soy beans were not quite mature. The dry matter was 25 per cent. The silo was opened on November 17 and the silage had a bitter disagreeable taste. Water collected on the bottom of the silo and most of the cows refused to eat the silage.

Soy beans with pods well filled were cut and put into one small silo. They were mowed at nine o'clock and put

in the silo at one o'clock. The dry matter was 37.9 when the silo was opened. The silage was of good quality and it was readily eaten by the cattle.

Soy beans, more mature, were put in the silos. The leaves were beginning to turn yellow, the pods were abundant and turning yellow, but the beans were still soft. The dry matter was 30 per cent. The silage, when opened, was of good quality and was eaten readily.

Ktting and Lamaster (13) in 1934, ensiled 38 tons of mammoth yellow soy beans which were cut in the early bloom stage and put in the silo without much wilting. One per cent of black-strap molasses, diluted with an equal weight of water, was added to the soy beans. The silo was opened in November, and the silage was of excellent quality.

The silage was fed to cows, and they ate 66 pounds per 1000 pounds live weight. They refused very little and the milk production was satisfactory during the time the silage was fed.

It was found that soy beans maybe preserved as silage, if one per cent black strap molasses is added at the time of ensiling. A high per cent of nutrients is retained and the silage is palatable. It has sufficient minerals, if it is fed with mixed grain.

At the Nebraska Station, Hathway and others (21) found that the vitamin A content of soy bean silage was lower than corn as usually preserved, or with molasses, or by the A. I. V. method. This was observed by feeding rats.

Wiggans (59) found that a combination of corn and soy beans for silage was a practice to be highly recommended to the dairymen of New York State as a means of increasing production, improving silage, reducing the amount of concentrates necessary, and adding another legume to the cropping system, all of which tends to decrease the cost per unit of production.

COWPEA SILAGE

Eckles (12) filled an experimental silo with cowpeas not yet in bloom and less mature than considered proper for cutting, when hay making. The material when put in the silo had 12.3 per cent dry matter. So much water was present that it settled to the bottom and some leaked out. The silage had a very disagreeable odor and taste.

Cowpeas containing an abundance of pods which were partially filled were ensiled. The peas were allowed to remain in the field several hours after cutting before they were put in the silo. The dry matter was 23 per cent when they were put in the silo. The silage was a little too wet, but the odor and taste was good and cows ate it readily.

It is possible to make good cowpea silage, but if it is put in the silo too green, the quality will be poor and will not be of much use. This same principle works for any legume. The crop should be allowed to reach the proper stage of maturity, but if this is not done it should be allowed to remain in the field several hours after cutting.

LESPEDEZA SERICEA SILAGE

Two experimental silos (2) were erected at the University of Tennessee dairy barn. The silos were 6 by 25 feet. They were made of wood staves with a concrete bottom and roof and they were air tight. The Lespedeza sericea was cut with a mower, and a windrower was attached to the mower so that the hay would not have to be raked.

The silage put up in the No. 1 silo was preserved with molasses. The molasses was added to the silage inside the blower, and a barrel with a hose connection was used to supply the molasses to the blower. The molasses feeding connection was the Papec type with one inch valves and pipe fittings with a one and one-fourth inch hose. It was found that this did not allow an ample flow of molasses into the cutter when operating at capacity.

When the molasses was diluted with equal parts of water the valve had to be controlled by hand in order to keep too much molasses from entering. If the right dilution is made, there should be no trouble with this, however. The diluting results in increased labor, wastage of molasses, a leakage from the fan housing, and difficulty in feeding due to roll slippage.

The Lespedeza sericea when put in the silo had a moisture content of about 62 per cent; 15,100 pounds of Lespedeza sericea was put into the silo; and 1,255 pounds of water were added. After the third load water was added directly by hose to the silage in the silo. Water was added to the first

three loads through the blower. Four hundred and sixty-six pounds of molasses were added to the silage to preserve it.

The molasses was added at the rate of 60 pounds per ton of Lespedeza sericea. Water was added to bring the moisture up to about 70 per cent, but the final moisture due to water added was approximately 77 per cent. At one time, it was estimated 50 gallons of water seeped out at the bottom of the silo, but this was all that drained out.

The silo No. 2 was filled with 12,230 pounds of Lespedeza sericea and preserved with phosphoric acid. The hay was cut in the same manner as the hay in the other silo. The moisture content of the hay was 62 per cent. Five hundred and twenty-six gallons of water were added directly into the silo by hose. One hundred and twenty-eight pounds of phosphoric acid were used and this was added through the blower.

The acid was used at the rate of 16 pounds (68 per cent acid) per ton of silage. Five pounds of acid and 63 gallons of water were added after ensiling was completed. The final moisture content was about 75 per cent.

COST OF SILAGE

At Minnesota (14) Fitch reports that the cost of 100 pounds of nutrients in the form of alfalfa hay was about 43 cents as compared with 79 cents for silage. Legume silage put up with molasses or acids will cause an extra expense of 65 to 85 cents per ton of green material. Such extra expense includes only the cost of the preserving materials.

Some extra equipment and labor would also be needed to apply the preservatives.

The cost (32) of filling silos in the North Central States was 1.41 dollars per ton when the farmer owned the equipment and $1.49 when the silage cutter was hired. It costs $1.30 per ton to fill with a field harvester.

ARTIFICIALLY DRIED HAY

EARLY HISTORY

The first reference (41) to artificial drying seems to be that recounted in "Horse-Shoeing Husbandry" by Jetho Tull, published in 1829. Tull was an Englishman. Artificial heat was used to reduce the moisture content in wheat, so that it could be stored for a long period of time. The purpose of this was to sell wheat when the price was high. One of the earliest attempts at artificial drying in the United States was for drying walnuts.

The first work on artificial curing of forage crops was carried on by the United States Department of Agriculture from 1910 through 1912, at Hayti, Missouri. In 1911, Arthur J. Mason built an experimental dryer at West Point, Mississippi. He moved near Chicago three years later and continued his work. The Bayley Blower Company of Milwaukee, Wisconsin, in 1915, built a dehydrator for the McCracken Land Company of Houston, Texas.

About 1915, the Louisville Drying Machinery Company of Louisville, Kentucky, started experimental work. From 1915 to 1925, there was little interest along this line, except the work of Mason and the Louisville Company, each of whom was making improvements on his dryers. During 1925, the interest in artificial drying gained momentum and has been getting greater each year. The United States Department of Agriculture, state agricultural experiment stations, and various individuals have each put forth considerable sums of

money, time, and effort in bringing about this development.

In Louisana in 1933, the total hay acreage was 202,000 with a farm value of $1,577,000. In the humid area of the Gulf States the average monthly rainfall for the summer months is 4.56 inches. For this reason a good quality of hay is hard to obtain. It is not uncommon to have the quality of 30 to 60 per cent of the hay in the Gulf States lowered one or two grades or completely lost because of rain.

Artificial curing gives a more uniform product, better color, higher protein content, and slightly higher percentage of leaves. The leaf loss and protein content loss are probably due to losses in the process of field curing. With alfalfa hay, Anderson found that from 58 to 75 per cent of the total protein was contained in the leaves.

Other workers found that artificially cured hays have several times as much vitamin A and vitamin E as similar hays cured in the sun. Vitamin D is lowered somewhat.

HOT AIR DRYING (16)

There are two types of hot air driers: apron conveyor type and drum drier of the single drum type.

The apron conveyor drier is a relatively low temperature drier in which the material remains for a considerable period of time. The temperature of the drying air or furnace gases entering the machine is usually held from 250 to 350 degrees F., and the period of exposure may vary from 15 to 45 minutes, depending upon the initial moisture content of the forage. The temperature of the hay remains much lower

than that of the surrounding gases, due to the cooling effect of evaporation. The temperature of the forage also tends to coincide with the wet-bulb temperature of the drying air which, in a hay drier, is much below the dry bulb temperature.

Apron conveyor driers are usually much larger machines than drum driers. Due in part to the long periods of exposure, apron conveyor driers for hay are frequently 150 to 200 feet in length with the equivalent of 10 by 10 feet in a section. The green forage is put on an endless screen wire apron and conveyed through the drying chamber, where hot air or furnace gases are circulated.

The drum drier, when used for hay, may be classed as a high temperature machine, necessitating a short period of exposure to prevent charring or burning of the hay. The temperature of the furnace gas entering the machine is usually held at from 1,000 to 1,500 degrees F., by means of adjustment on the secondary air inlet to the furnace, or by decreasing the quantity of fuel supplied to the burner. The material remains in a drier of the drum type for approximately one to three minutes or even less, depending somewhat upon the initial moisture content of the forage. The temperature of the hay is much below the temperature of the drying gases.

Forage driers may be obtained with rated capacities, ranging from approximately 1,000 to 6,000 pounds of water per hour. However, a machine capable of evaporating 3,000 pounds of water per hour approaches that lower limit of

capacity for practical purposes under the conditions under which hay driers are usually operated in the United States.

If hay is left in the swath for a few hours, its moisture content may be reduced to about 55 per cent. Under such conditions it will be necessary for the machine to evaporate approximately 1,970 pounds of water to produce a ton of hay at twelve per cent moisture.

For this type (28) of hay drier, trucks bring the hay from the field and unload it near the large drier in about the same manner as it would be put into the hay mow.

Then the hay is fed into a machine, similar to an ensilage cutter, and is blown into large pipes through which it passes at the rate of 1,500 feet in forty seconds.

The first thing to strike the hay is the exhaust from the powerful gasoline motors which furnish power for the unit. From there it is subjected to all the gases of combustion and super-heated steam, all furnished by a boiler fired by an automatic stoker.

The hay comes from the machine shredded, dried, sterlized, green in color, and fragrant in smell. Only ten per cent moisture remains in the hay and five tons of green material passes through the machine each hour of operation.

Hodgson and others (24) found on trials, conducted to determine the digestibility of air dried hay, that a mixture of 20 per cent white clover, 40 per cent English rye grass, and 40 per cent Italian rye grass, dried at a temperature as high as 350 degrees F., showed no difference. The

high temperature did not effect the calcium and phosphorus balance when the hay was fed to sheep. When hay was dried at 400 degrees F., the digestibility was reduced, and the calcium balance was impaired. The natural color was also decreased. Hodgson and Knott (25) observed that when dairy heifers were put on a strict air cured hay ration the protein digestibility coefficient was 74.29 per cent, the nitrogen free extract was 74.55 per cent, and the ether extract 21.90 per cent. They also showed a favorable balance of calcium and phosphorus when fed on the air cured hay ration. Russell (47) found that hay dried at a temperature of 127 to 129 degrees C., for thirty minutes contained seven times as much vitamin A as the same type of hay which was sun cured. An experiment was run with rats. The color of the air dried hay was a light green and the sun cured hay was brown. At the University of Tennessee, Smith (65) performed an experiment with rats to determine the presence of carotene in air dried and sun cured hay. The results were slightly in favor of the air dried hay. The field cured hay contained 8.3 units of vitamin A per gram, while the air cured hay contained 29.3 units of vitamin A per gram. Bethke and Kich (6) found that hay exposed to sun, rain, or dew for several days resulted in a loss of vitamin A. Sunlight increases the amount of vitamin D in hay, but it is not known whether or not the sun decreases the amount of vitamin A. Hauge and Aitkenhead (59) found that the loss of vitamin A

in the field cured hay was due to an enzymatic action and not to the sun.

VENTILATED MOWS

Witzel (63) indicated that where hay is chopped and stored in ventilated containers the length of cut is the main factor in determining the quality of the hay, and not the ventilation factor. Six wooden bins, varying from 3 to 6 feet wide, 8 feet long on the inside, and 10 feet deep were used. The sides and end walls were double. The inside wall was made up of 1 by 2 inch slats spaced 10 inches apart, and some of the bins were lined with poultry netting. Another container was a wooden stave silo 14 feet in diameter, equipped with a floor. It was covered with building paper to make it practically air tight. A ventilated flue three square feet was constructed in the center of the silo. There was a 3 by 3 inch connection at the bottom to one side of the doors, so as to allow free movement of air through the chute. This method did not prove very satisfactory.

Rothe (45) found that hay could be cured by ventilated mows, if stored in a compartment with one side of the hay exposed. This hay should not contain more than 30 per cent moisture when put in the mow. The hay put up in such a manner did not go above 190 degrees F., in the curing process. He thinks that the division of large mows into smaller compartments by means of alleyways or open work partitions that are not over six feet across with one side exposed or 12 feet

with two sides exposed can be satisfactorily used as mows.

BARN CURED HAY

Weaver,(56) of the Tennessee Valley Authority at Knoxville, has done most of the work on this method of curing hay. In his first work a one horse power electric motor belted to a centrifugal blower was used. Air was delivered through a duct containing a five kilowatt chromalox air blast heater. The air was forced through the hay from a central slotted chamber 9 feet long, 3 feet high, and 4 feet across. Partially cured alfalfa hay from the field, with 40 per cent moisture, was on the platform similar to a load of hay. Air was blown up through the chamber and filtered out through the hay. The hay when cured was of good uniform quality.

In June, 1935, another series of tests were started, using two electric motors and two centrifugal blowers. Air was delivered through two ducts containing electric heaters to an A form chamber located in the center of the hay wagon. Four tests were made with this set up. A good quality of hay resulted from all four of these tests, but the time required to bring the moisture content down to a safe point was too great to fit into the system outlined above, so the method was discarded.

Another series of tests were conducted in a practical application for a 20 ton hay farmer. Twenty tons of loose hay would cover a twenty by forty space approximately twelve and one-half feet deep. A main duct 16 by 16 inches and eight

lateral ducts 10 by 12 inches with sides open one inch up from the bottom were constructed to cover a floor space of twenty by forty feet. A 10 inch centrifugal blower was placed at one end of the main duct and belted to a 5 horse power electric motor. The main duct enclosed a series of adjustable gates, so that air could be blown intermittently into any combination of lacters desired. Hay of s mixture of clovers and grains with a moisture content of 38 per cent was placed over the ducts to a depth of five feet on September 20. The blower was started at five p.m., and was left running until noon September 23. Approximately 7 tons of hay were dried with a maximum demand of less than 3 horse power. Before the 1936 season, the duct system was enlarged to cover a floor space of 40 by 40 feet. The 5 horse power motor was replaced by one of 3 horse power to drive the 16 inch blower at 1300 r. p. m. In two tests, hay of good color and aroma was obtained.

This kind of system was installed at the University of Tennessee dairy barn at Knoxville in 1937. No heat was applied, but air was obtained from a boarded up space just below the tin roof, which became hot in direct sunshine. Several tons of hay were cured and very good results were obtained. They found that the air could be blown up through the hay and then sucked down, so that no moisture remained in the top of the barn. Air was blown intermittently rather than continuously, and it gave good results. Before the 1938 season, the blower was enlarged so that more air could be

blown through the hay. The hay dried was of good quality and had a much greener color than the field cured hay.

Weaver and Wylie (57) found that hay of more than 20 per cent moisture cannot be stored without undergoing heating and a decrease in quality. Hay containing 45 per cent moisture can be dried by the barn-drying system. It takes 31 hours to dry alfalfa hay under favorable conditions in the field. Only 4 hours are needed to dry the hay in the field to a point where it can be put in the barn to be dried. It can be dried in from four days to two weeks.

The first cutting can be dried, then the second and third cuttings can be stored on top of the first. The maximum height that the hay can be stored is ten feet after it has settled. Only 6 feet should be stored at one time.

> "Samples of hay analyzed by the hay, feed, and seed division of the U. S. D. A. Bureau of Agricultural Economics show barn dried hay to average 2.3 per cent more leaves, 19 per cent more green color, and a quality of about one grade and class better than field hay cut from the same field at the same time. Feeding trials of the two hays showed very little difference in animal weight and growth when fed to dairy heifers and two year old steers."

Weaver (57) has the following to say about this system of curing hay:

> "1. The kilowatt-hour consumption of electricity per dry ton varied greatly throughout the entire group of tests, dependent largely upon initial moisture content of hay, variety of hay used, air conditions, and the need for observations requiring power beyond that necessary to complete the normal drying cycle. Further observations are necessary before any definite average figure can be given, and then it will vary with the variety of hay being dried.
> "2. Little difficulty was experienced in drying clean hay

of the small stem varieties, such as, alfalfa and Lespedeza. The higher the grass content in the hay, the more difficult it was to dry. The large stem varieties of hay, such as, mammoth yellow soy beans, proved difficult in that the drying was slow and drawn out over a long time.

"3. Present indications are that drying is just as rapid with intermittent blowing as with continuous blowing. Further observations are needed to find the extent to which this is true, in order that the most efficient operation of the system can be definitely determined.

"4. Incidations with this plan of drying are that a barn with a hay mow of 20 to 40 ton capacity can be equipped for drying the season's hay crop with an investment of about $300,00, 1938 system $400.00.

"5. Most of the tests conducted to date dealt with hay of above the average grass and weed content. Weather conditions were at this time adverse; however, a period of three or four days of rain and high humidity is yet to be encountered during the critical drying period of 8 to 10 tons of hay. Further observations are believed necessary before this system can be declared entirely successful."

COST OF ARTIFICIALLY DRIED HAY

Clyde (16) gives the following data as the cost of drying 1 ton of hay with a hot air drier: 1. $2.07 for fuel; 2. $1.35 for labor; 3. power .61; 4. .17 for repairs. This gives a total of $4.20 to cure a ton of hay. In 1935 at the Lewisburg, Tennessee, Station of the Bureau of Dairy Industry, approximately 170 tons of hay were dried artificially with a commercial rotary drum drier during the 1935 season. The total cost of drying the hay, including the harvesting in the field and the moving in the barn, but not including interest or depreciation on the equipment, was $11.77 per ton of dry hay. Tucker (53) gives $15.00 as the cost of drying one ton of hay. About 50 gallons of fuel were used to dry one ton of hay. This included fuel, labor,

power, fertilizer, transportation, repair, rent, interest, and depreciation. Greene (17) gives a cost of from $2.50 to $3.00 per ton for fuel and power.

Weaver (57) gives a cost of $300.00 to equip a barn to dry 20 tons of hay annually. This included blower, motor, lumber, hardware, and the labor for putting it in. The cost of operating this system, not counting labor, in drying about 200 tons of hay over three seasons was an average of 86 cents per dry ton. Electricity was obtained at 2 cents per kilowatt-hour. The labor required is about the same as field cured hay. More labor is required to store the hay in the barn for the barn drying system, but during bad weather more labor is required in the field curing of hay.

SUMMARY OF THE SURVEY OF LITERATURE

1. The use of silos dates back to Persian and Roman times.

2. In 1876, Morris built the first silo in the United States.

3. Silage can be made from legumes without adding acid or molasses, but due to the small quantity of sugar present in legumes, it is best to use some kind of preservative.

4. Molasses is the most popular and widely used method of preservatives of any of the other treatments.

5. Molasses is added to mixed grasses and legumes at the rate of five gallons per ton of green material in many cases, but different amounts may be used.

6. Mineral acids, such as, hydrochloric, sulphuric, and phosphoric have been used to preserve silage; but it requires a knowledge of chemistry and special equipment to use them most efficiently.

7. Silage has been made from red clover, sweet clover, alfalfa, soy beans, and cowpeas, with good results.

8. Silage is a cheap source of roughage.

9. Hot air hay driers are expensive, and only the large hay farmer can afford to use them.

10. Ventilated mows for the curing of hay have not been used very much and they have not proved very satisfactory.

11. The barn cured hay system is a system that has been designed for the small hay farmers.

12. A hay drying system of 20 ton capacity can be built for about $300.00. This year several farmers are putting this system in their barns.

PART II

EXPERIMENTAL INVESTIGATION

PART II

EXPERIMENTAL INVESTIGATION

SECTION A

LESPEDEZA SERICEA SILAGE VERSUS CORN SILAGE FOR DAIRY COWS

PURPOSE

The purpose of this experiment was to determine the feeding value of Lespedeza sericea silage, preserved with molasses and phosphoric acid, as compared to that of corn silage. The Lespedeza sericea was put up by the University of Tennessee and the Tennessee Valley Authority. as described on page 20.

PLAN OF EXPERIMENT

This experiment was conducted at the University of Tennessee Dairy Barn, at Knoxville. It was carried on over a three months period from November 20, 1938, to February 17, 1939. Twelve cows were divided in three groups of four cows each. Each group contained two Jerseys and two Holsteins. The groups were divided as near equal as possible according to weight, age, lactation, milk production, and fat test.

The following rations were fed each group:

Group I. Corn silage ad libitum.

Hay, 8 pounds per animal per day.

Concentrates, 10 pounds of grain mixture per animal per day.

Grain mixture, corn and cob meal 800 pounds, 600 pounds oats, 600 pounds wheat bran, 600 pounds cottonseed meal, 40 pounds bone meal, and 40 pounds salt.

Group II. Lespedeza sericea silage, preserved with molasses. ad. libitum.

Hay, 8 pounds per animal per day.

Concentrates, 10 pounds of grain mixture per day per animal. (Same grain mixture as Group I).

Group III. Lespedeza sericea silage, preserved with phosphoric acid, ad libitum.

Hay, 8 pounds per animal per day.

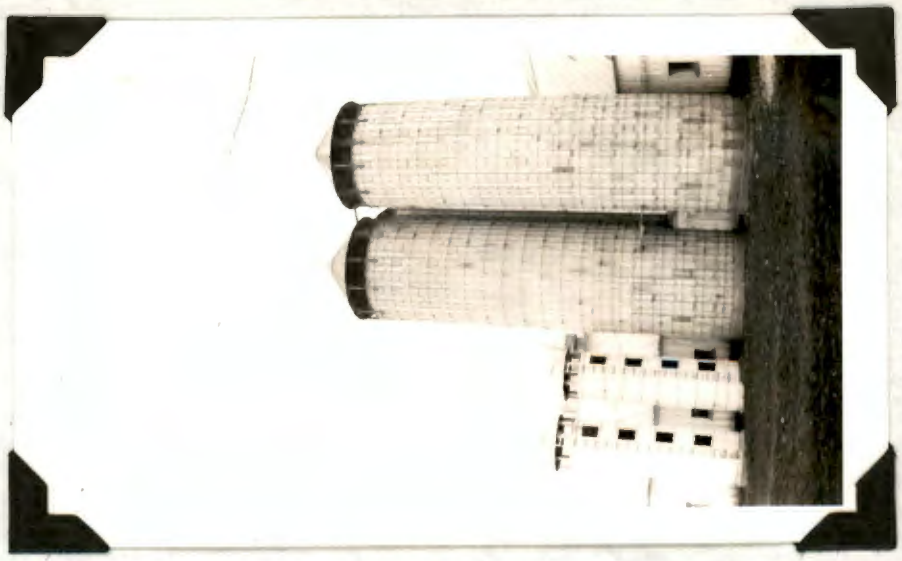
Concentrates, 10 pounds of grain mixture per animal per day. (Same grain mixture as for other groups).

The groups were kept in separate stalls. There was plenty of room for the cows, and water was available at all times. The cows were let out in a lot on pretty days. The rest of the time they were kept in the barn.

The silage and grain were fed at night and morning. The hay was fed at night, and it was ground so it could be weighed easier. The silage was weighed when it was fed in the morning and any left over was weighed back at night. The cows were not fastened in stanchions when they were fed.

RECORDING DATA

The cows were weighed three days in succession immediately before the experiment began, and they were also measured for heart girth. This was repeated every three days. Daily milk weights of each cow were kept. The cows were milked three times daily. A butterfat test was taken at the beginning of the experiment and every 15 days thereafter. The



Silos and Barn Where Experiment Was Conducted



Cows in the Barn

Figure 1. Scenes where experiment was conducted

daily feed records were kept of the silage fed and the amount refused. The weights of hay and concentrates were also kept, but these were constant most of the time. Any abnormal conditions were noted.

RESULTS OBTAINED

Group I. (Corn silage)

This group of cows gave 8,493.2 pounds of milk and 353.33 pounds of butterfat over the period of the experiment. This was an average of 2,123,3 pounds of milk and 88.33 pounds of butterfat, per cow. This group gave more milk the last month than they did the first month.

At the beginning of the experiment the group total was 286.75 inches in heart girth and 4302 pounds in weight. At the end of the experiment the group total was 303 inches in heart girth and 4,556 pounds in weight. The group gained 16.25 inches in heart girth, 280 pounds in weight or an average of 4.62 inches in heart girth and 70.27 pounds in weight, per cow.

The group consumed 18,305 pounds of silage, 2,861.5 pounds of hay, and 3,600 pounds of concentrates during the three months period. This was an average of 4,576 pounds of silage, 7,154 pounds of hay, and 900 pounds of concentrates, per cow.

The pictures of the cows at the beginning and end of the experiment are shown on the following pages. A complete record of the heart girth, weight, milk, and fat of each cow is also shown following the picture of the cows.

GROUP I



Beginning of Experiment

November 20, 1938



End of Experiment

February 17, 1939

Figure 2. Photograph of Cow No. T36

TABLE I. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. T36

GROUP I

Heart Girth--inches

		Gain or Loss
November 20, 1938	67.25	----
December 19, 1938	69.00	1.75
January 18, 1939	78.00	9.00
February 17, 1939	70.50	-7.50
Total		3.25

Weight--pounds

		Gain or Loss
November 20, 1938	959	----
December 19, 1938	988	29
January 18, 1939	987	-1
February 17, 1939	1009	22
Total		50

Milk and Fat--pounds

	Milk	Fat
November 20, 1938		----
December 19, 1938	688.3	34.42
January 18, 1939	617.2	35.47
February 17, 1939	615.3	35.02
Total	1920.8	104.91

GROUP I



Beginning of Experiment

November 20, 1938



End of Experiment

February 17, 1939

Figure 3. Photograph of Cow No. 302

TABLE II. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. 302

GROUP I

Heart Girth--inches

		Gain or Loss
November 20, 1938	72.75	----
December 19, 1938	73.00	.25
January 18, 1939	75.00	2.00
February 17, 1939	77.00	2.00
Total		4.25

Weight--pounds

		Gain or Loss
November 20, 1938	1088	-----
December 19, 1938	1134	46.00
January 18, 1939	1136	2.00
February 17, 1939	1127	-9.00
Total		39.00

Milk and Fat--pounds

	Milk	Fat
November 20, 1938	-----	-----
December 19, 1938	811.4	23.94
January 18, 1939	870.4	28.69
February 17, 1939	907.1	31.72
Total	2588.9	84.35

GROUP I



Beginning of Experiment

November 20, 1938



End of Experiment

February 17, 1939

Figure 4. Photograph of Cow No. 81

TABLE III. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. 81

GROUP I

Heart Girth--inches

		Gain or Loss
November 20, 1938	71.00	----
December 19, 1938	71.00	0.00
January 18, 1939	72.25	1.25
February 17, 1939	73.50	1.25
Total		2.50

Weight--pounds

		Gain or Loss
November 20, 1938	969	-----
December 19, 1938	1032	63.00
January 18, 1939	1037	5.00
February 17, 1939	1037	0.00
Total		68.00

Milk and Fat--pounds

	Milk	Fat
November 20, 1938	-----	-----
December 19, 1938	634.6	33.64
January 18, 1939	641.1	31.71
February 17, 1939	685.5	32.31
Total	1961.2	97.56

GROUP I



Beginning of Experiment
November 20, 1938



End of Experiment
February 17, 1939

Figure 5. Photograph of Cow No. 299

TABLE IV. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. 299

GROUP I

Heart Girth--inches

		Gain or Loss
November 20, 1938	75.75	----
December 19, 1938	77.00	1.25
January 18, 1939	77.00	0.00
February 17, 1939	82.00	5.00
Total		6.25

Weight--pounds

		Gain or Loss
November 20, 1938	1286	------
December 19, 1938	1337	51.00
January 18, 1939	1386	49.00
February 17, 1939	1410	24.00
Total		124.00

Milk and Fat--pounds

	Milk	Fat
November 20, 1938	-----	-----
December 19, 1938	651.1	20.88
January 18, 1939	691.1	22.07
February 17, 1939	680.1	23.56
Total	2022.3	66.51

Group II. (Lespedeza Sericea With Molasses)

This group gave 6,276.7 pounds of milk and 263.67 pounds of butterfat over the three months period. This was an average of 1,569.17 pounds of milk and 65.91 pounds of butterfat, per cow.

At the beginning of the experiment the group total was 295.75 inches in heart girth and 4,448 pounds in weight. At the end of three months the group total was 289 inches in heart girth and 4,268 pounds in weight. The group lost 6.75 inches in heart girth and 280 pounds in weight. This was an average loss of 1.68 inches in heart girth and 70 pounds in weight, per cow.

The group consumed 9,610.5 pounds of silage, 2,880 pounds of hay, and 3,600 pounds of concentrates. This was an average of 2,402.6 pounds of silage, 720 pounds of hay, and 900 pounds of concentrates, per cow.

The pictures of the cows at the beginning and end of the experiment are shown on the following pages. A record of heart girth, weight, milk, and fat of each cow is also shown following the pictures of the cows.

GROUP II



Beginning of Experiment

November 20, 1938



End of Experiment

February 17, 1939

Figure 6. Photograph of Cow No. 301

TABLE V. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. 301

GROUP II

Heart Girth--inches

		Gain or Loss
November 20, 1938	78.25	-----
December 19, 1938	77.00	-1.25
January 18, 1939	76.00	-1.00
February 17, 1939	74.00	-2.00
Total		-4.25

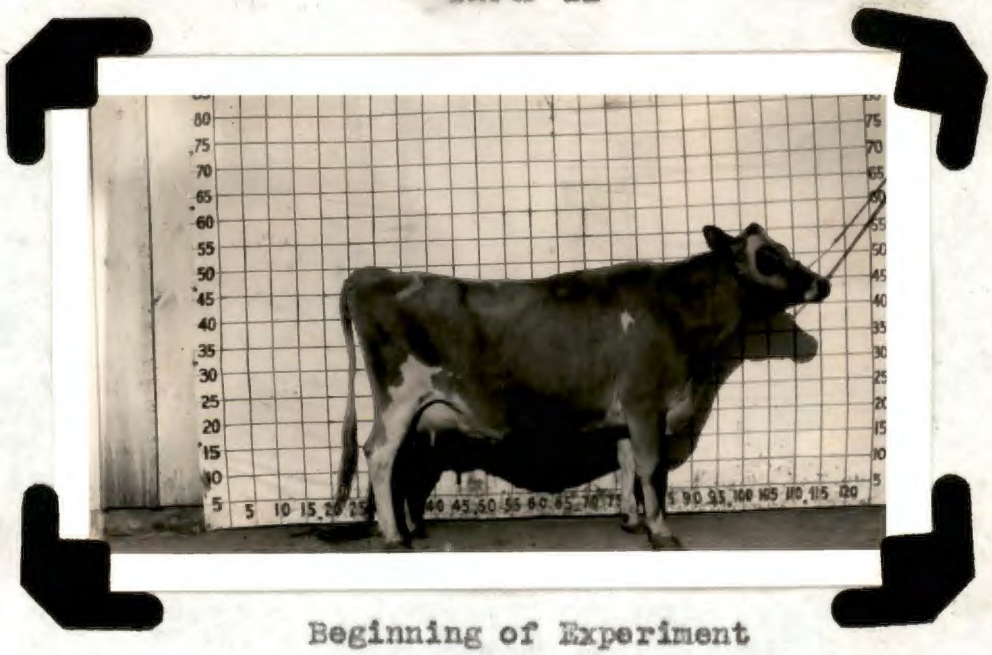
Weight--pounds

		Gain or Loss
November 20, 1938	1229	------
December 19, 1938	1182	-47.00
January 18, 1939	1171	-11.00
February 17, 1939	1151	-20.00
Total		-78.00

Milk and Fat--pounds

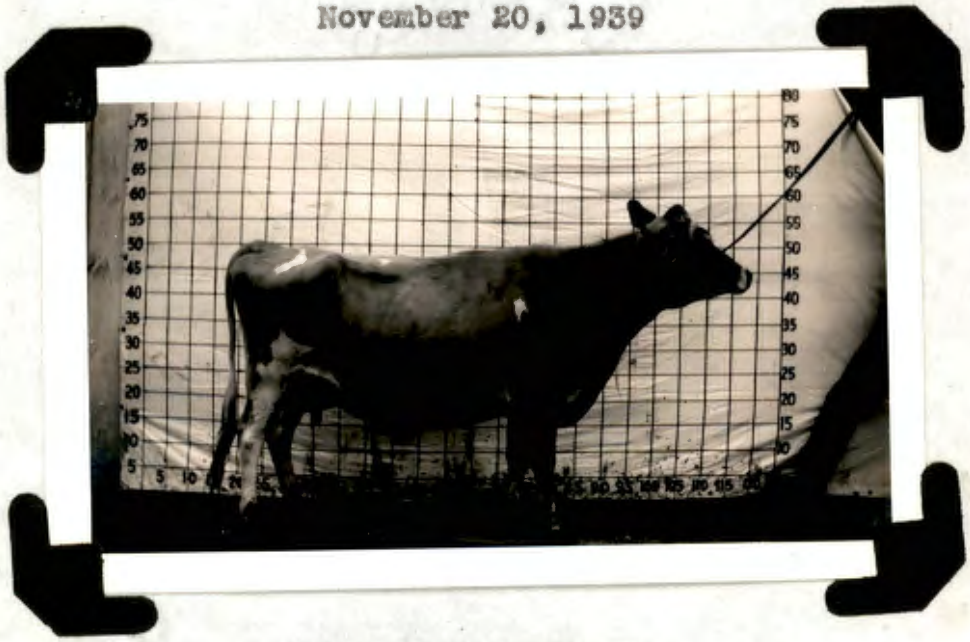
	Milk	Fat
November 20, 1938	-----	------
December 19, 1938	763.6	26.73
January 18, 1939	752.8	24.79
February 17, 1939	720.5	24.02
Total	2236.9	75.54

GROUP II



Beginning of Experiment

November 20, 1939



End of Experiment

February 17, 1939

Figure 7. Photograph of Cow No. T30

TABLE VI. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. T30

GROUP II

Heart Girth--inches

		Gain or Loss
November 20, 1938	67.5	----
December 19, 1938	66.00	-1.5
January 18, 1939	68.00	2.00
February 17, 1939	69.00	1.00
Total		1.50

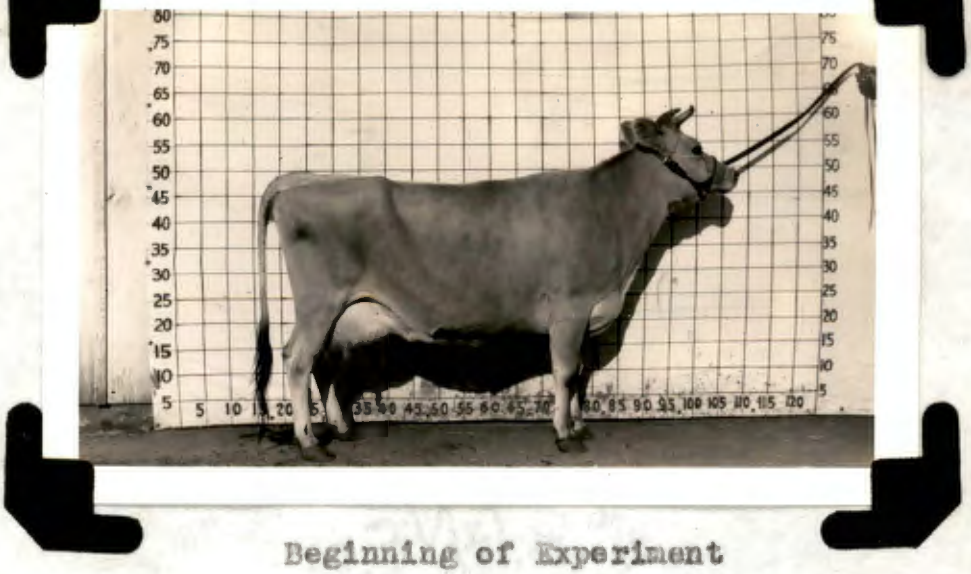
Weight--pounds

		Gain or Loss
November 20, 1938	934.00	-------
December 19, 1938	810.00	-124.00
January 18, 1939	808.00	-2.00
February 17, 1939	809.00	1.00
Total		-125.00

Milk and Fat--pounds

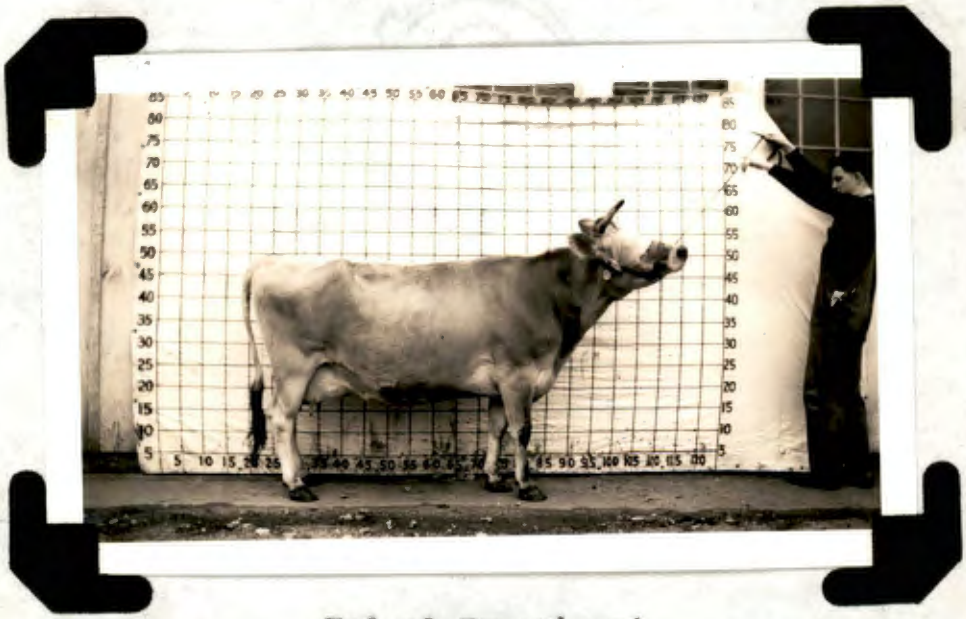
	Milk	Fat
November 20, 1938	-----	-----
December 19, 1938	577.50	27.97
January 18, 1939	473.00	19.62
February 17, 1939	443.30	17.50
Total	1493.80	65.09

GROUP II



Beginning of Experiment

November 20, 1938



End of Experiment

February 17, 1939

Figure 8. Photograph of Cow No. T14

TABLE VII. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. T14

GROUP II

Heart girth--inches

		Gain or Loss
November 20, 1938	71.00	-----
December 19, 1938	70.00	-1.00
January 18, 1939	68.00	-2.00
February 17, 1939	67.00	-1.00
Total		-4.00

Weight--pounds

		Gain or Loss
November 20, 1938	916	------
December 19, 1938	862	-54.00
January 18, 1939	862	0.00
February 17, 1939	877	15.00
Total		-39.00

Milk and Fat--pounds

	Milk	Fat
November 20, 1938	-----	-----
December 19, 1938	607.3	36.11
January 18, 1939	535.4	27.31
February 17, 1939	486.5	24.82
Total	1629.2	88.24

GROUP II



Beginning of Experiment

November 20, 1938



Cow No. 99

TABLE VIII. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. 99

GROUP II

Heart Girth--inches

		Gain or Loss
November 20, 1938	79.00	-----
December 19, 1938	77.00	-2.00
January 18, 1939	75.00	-2.00
February 17, 1939	79.00	-4.00
Total		0.00

Weight--pounds

		Gain or Loss
November 20, 1938	1369	------
December 19, 1938	1299	-70.00
January 18, 1939	1346	47.00
February 17, 1939	1431	85.00
Total		62.00

Milk and Fat--pounds

	Milk	Fat
November 20, 1938	-----	-----
December 19, 1938	427.7	15.63
January 18, 1939	327.2	11.81
February 17, 1939	161.9	7.36
Total	916.8	34.80

Group III. (Lespedeza Sericea Preserved with Phosphoric Acid)

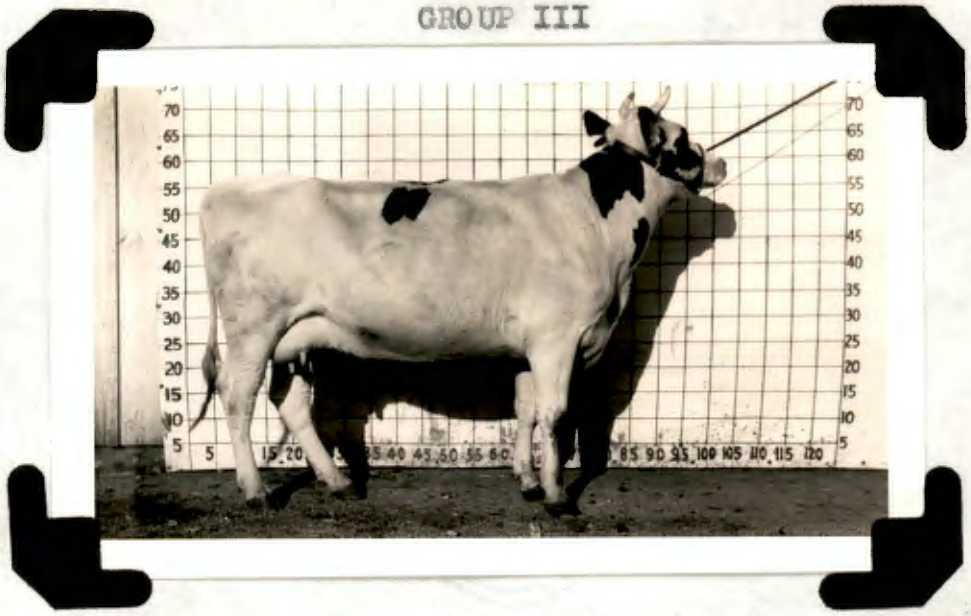
This group of cows gave 5,901.9 pounds of milk and 267.12 pounds of butterfat over the three months period. This was an average of 1,475.47 pounds of milk and 61.78 pounds of butterfat, per cow.

At the beginning of the experiment the group total was 297.25 inches in heart girth and 4,780 pounds in weight. At the end of the experiment the group total was 291 inches in heart girth and 4,399 pounds in weight. This group lost 6.25 inches in heart girth and 381 pounds in weight. This was an average loss of 1.56 inches in heart girth and 95.25 pounds in weight, per cow.

The group consumed 7,889.5 pounds of silage, 2,880 pounds of hay, and 3,600 pounds of concentrates. This is an average of 1,972.4 pounds of silage, 720 pounds of hay, and 900 pounds of concentrates, per cow

The pictures of the cows at the beginning and end of the experiment are shown on the following pages. A record of heart girth, weight, milk, and fat of each is also shown following the pictures of the cows.

GROUP III



Beginning of Experiment

November 20, 1938



End of Experiment

February 17, 1939

Figure 10. Photograph of Cow No. 304

TABLE IX. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. 304

GROUP III

Heart Girth--inches

		Gain or Loss
November 20, 1938	72.25	-----
December 19, 1938	72.00	-.25
January 18, 1939	72.50	.50
February 17, 1939	73.00	.50
Total		.75

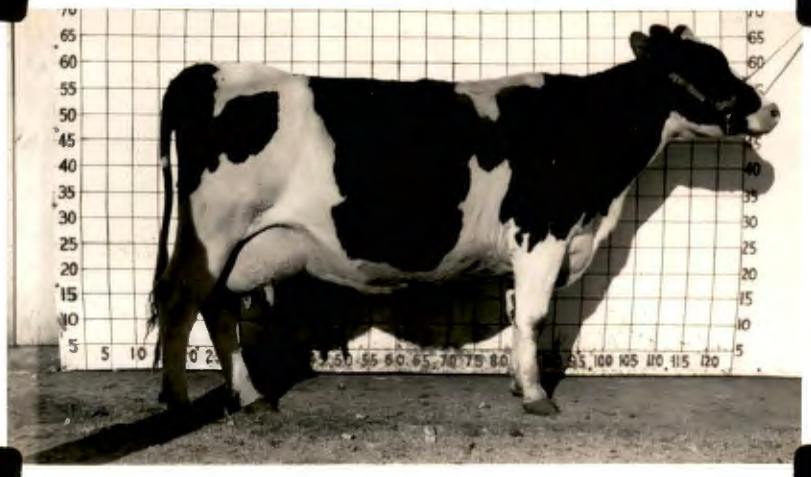
Weight--pounds

		Gain or Loss
November 20, 1938	1087	------
December 19, 1938	1038	-49.00
January 18, 1939	1028	-10.00
February 17, 1939	1025	-3.00
Total		-62.00

Milk and Fat--pounds

	Milk	Fat
November 20, 1938	-----	-----
December 19, 1938	532.1	21.78
January 18, 1939	534.5	21.37
February 17, 1939	524.4	21.87
Total	1591.0	65.02

GROUP III



Beginning of Experiment

November 20, 1938



End of Experiment

February 17, 1939

Figure 11. Photograph of Cow No. 243

TABLE X. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. 243

GROUP III

Heart Girth--inches

		Gain or Loss
November 20, 1938	80.25	-----
December 19, 1938	78.00	-2.25
January 18, 1939	76.00	-2.00
February 17, 1939	75.00	-1.00
Total		-5.25

Weight--pounds

		Gain or Loss
November 20, 1938	1544	-------
December 19, 1938	1400	-144.00
January 18, 1938	1336	-64.00
February 17, 1939	1311	-25.00
Total		-233.00

Milk and Fat--pounds

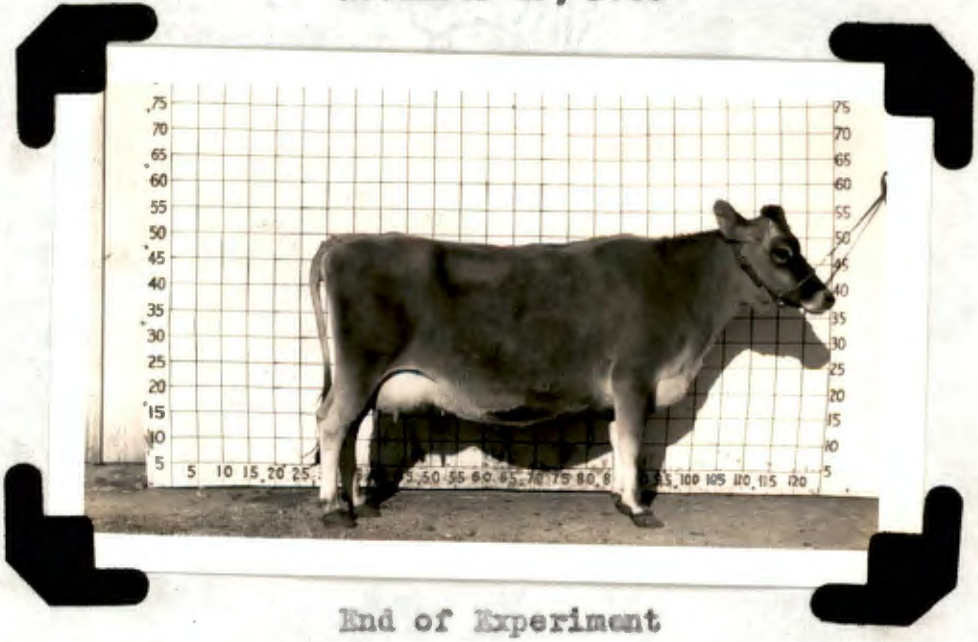
	Milk	Fat
November 20, 1938	-----	-----
December 19, 1938	1060.3	39.48
January 18, 1939	742.1	26.01
February 17, 1939	703.3	26.25
Total	2505.7	91.74

GROUP III



Beginning of Experiment

November 20, 1938



End of Experiment

February 17, 1939

Figure 12. Photograph of Cow No. T32

TABLE XI. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. T32

GROUP III

Heart Girth--inches

		Gain or Loss
November 20, 1938	72.25	-----
December 19, 1938	71.00	-1.25
January 18, 1939	71.00	0.00
February 17, 1939	72.00	1.00
Total		-0.25

Weight--pounds

		Gain or Loss
November 20, 1938	1016	-------
December 19, 1938	904	-112.00
January 18, 1939	933	29.00
February 17, 1939	931	-2.00
Total		-86.00

Milk and Fat--pounds

	Milk	Fat
November 20, 1938	-----	-----
December 19, 1938	501.9	32.08
January 18, 1939	388.7	23.71
February 17, 1939	382.8	24.09
Total	1273.4	79.88

GROUP III



Beginning of Experiment

November 20, 1938



End of Experiment

February 17, 1939

Figure 13. Photograph of Cow No. T12

TABLE XII. PHYSICAL EFFECT ON SIZE AND PRODUCTION OF COW NO. T12

GROUP III

Heart Girth--inches

		Gain or Loss
November 20, 1938	72.5	-----
December 19, 1938	73.0	0.5
January 18, 1939	73.0	0.0
February 17, 1939	71.0	-2.0
Total		-0.5

Weight--pounds

		Gain or Loss
November 20, 1938	1133	------
December 19, 1938	1046	-87.00
January 18, 1939	1102	56.00
February 17, 1939	1132	30.00
Total		1.00

Milk and Fat--pounds

	Milk	Fat
November 20, 1938	-----	-----
December 19, 1938	217.0	11.88
January 18, 1939	176.1	10.48
February 17, 1939	138.7	8.12
Total	531.8	30.48

TABLE XIII. SUMMARY GROWTH AND MILK CHART

90 Days

Group I. (Corn silage)

No.	Heart Girth inches	Weight pounds	Milk pounds	Fat pounds
299	6.25	124.00	2021.3	86.51
T36	3.25	50.00	1920.8	104.91
302	4.25	39.00	2588.9	84.35
81	2.50	68.00	1961.2	97.56

Group II. (Lespedeza preserved with molasses)

301	-4.25	-78.00	2236.9	75.54
T30	1.50	-125.00	1493.8	65.09
99	0.00	62.00	916.8	34.80
T14	-4.00	-39.00	1629.2	88.24

Group III. (Lespedeza preserved with phosphoric acid)

304	0.75	-62.00	1591.0	65.02
243	-5.25	-233.00	2505.7	91.74
T32	-0.25	-86.00	1275.4	79.88
T12	-1.50	1.00	531.8	30.48

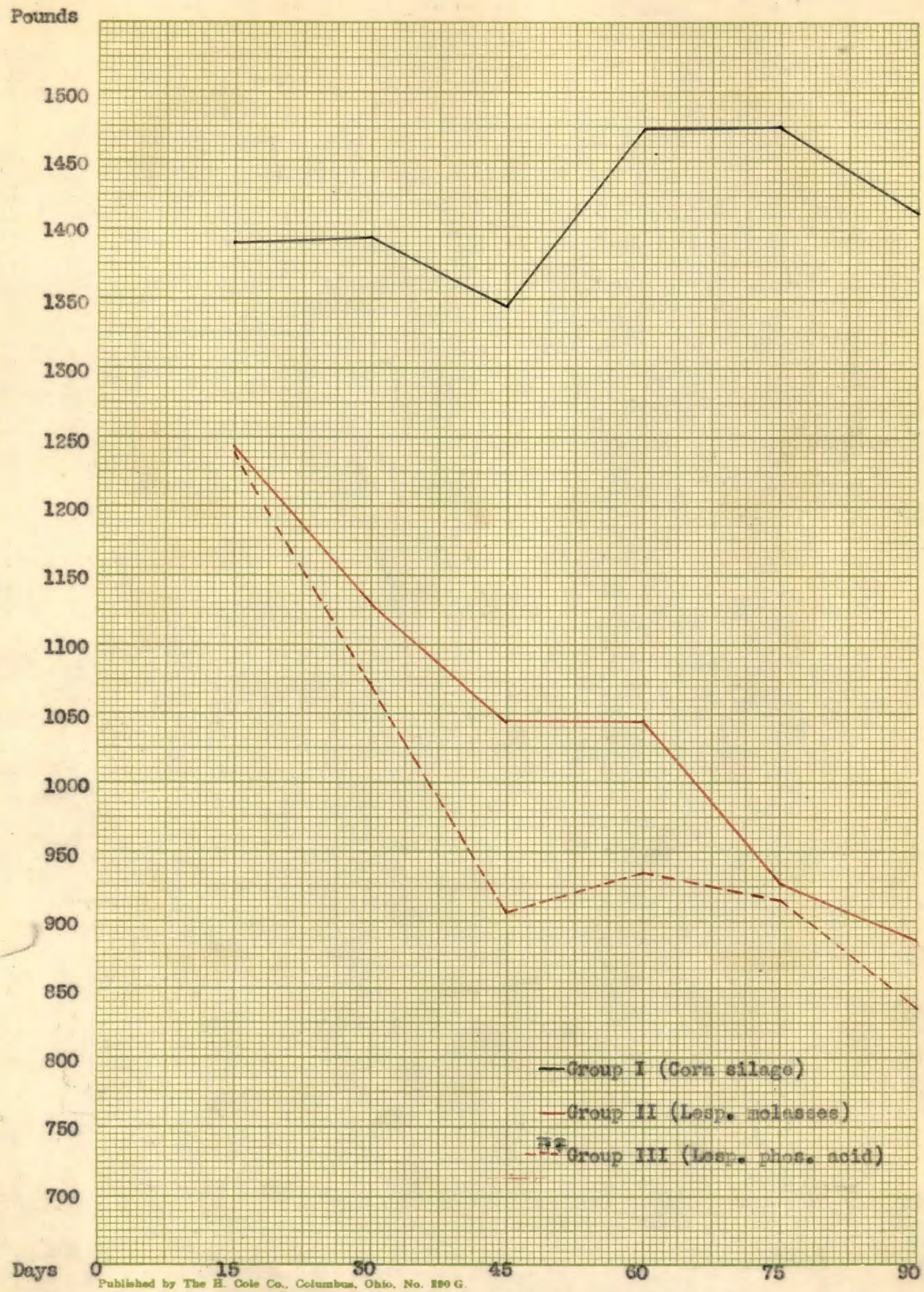


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Figure14.--Milk Production

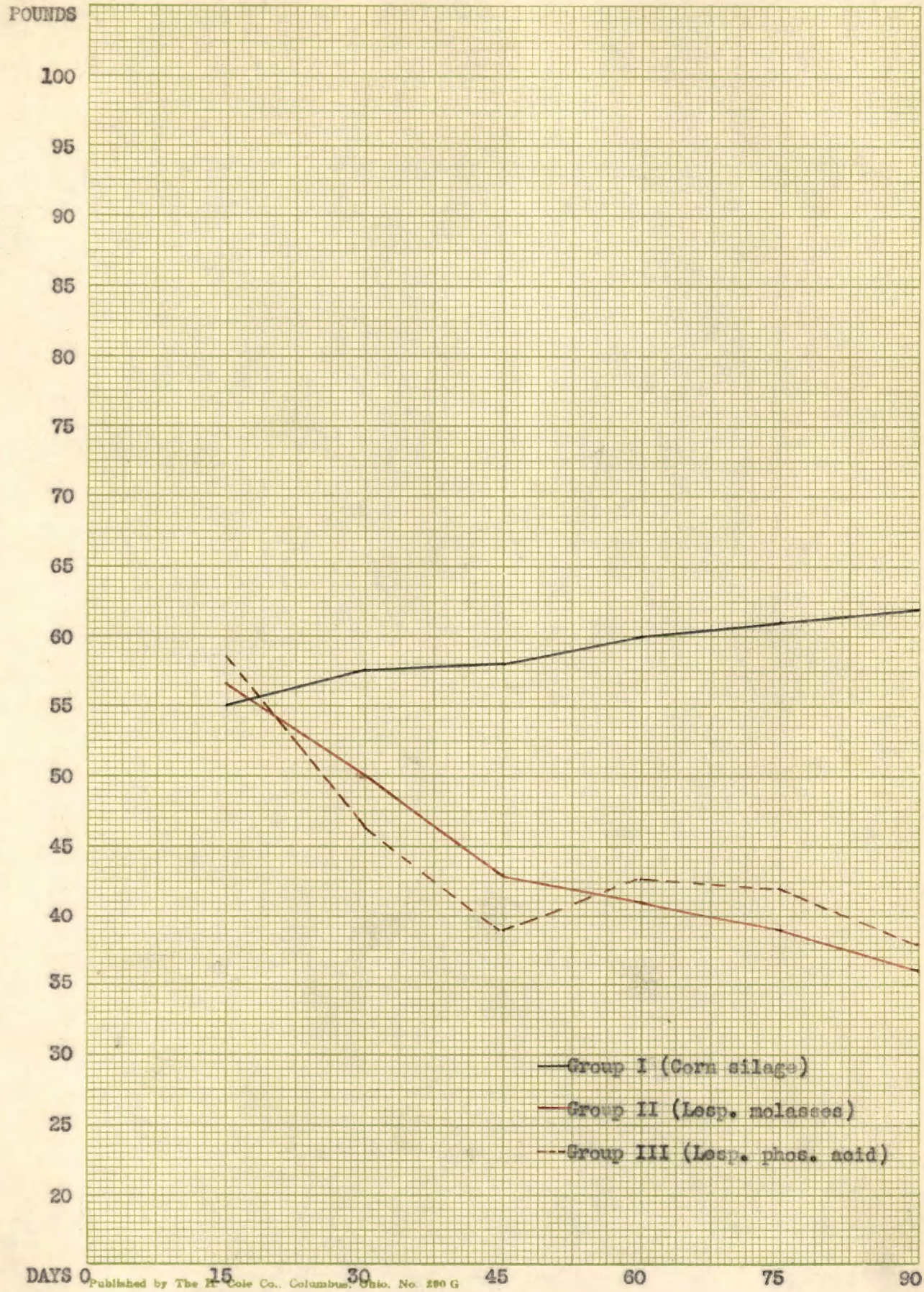

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Figure 15. Butterfat Production

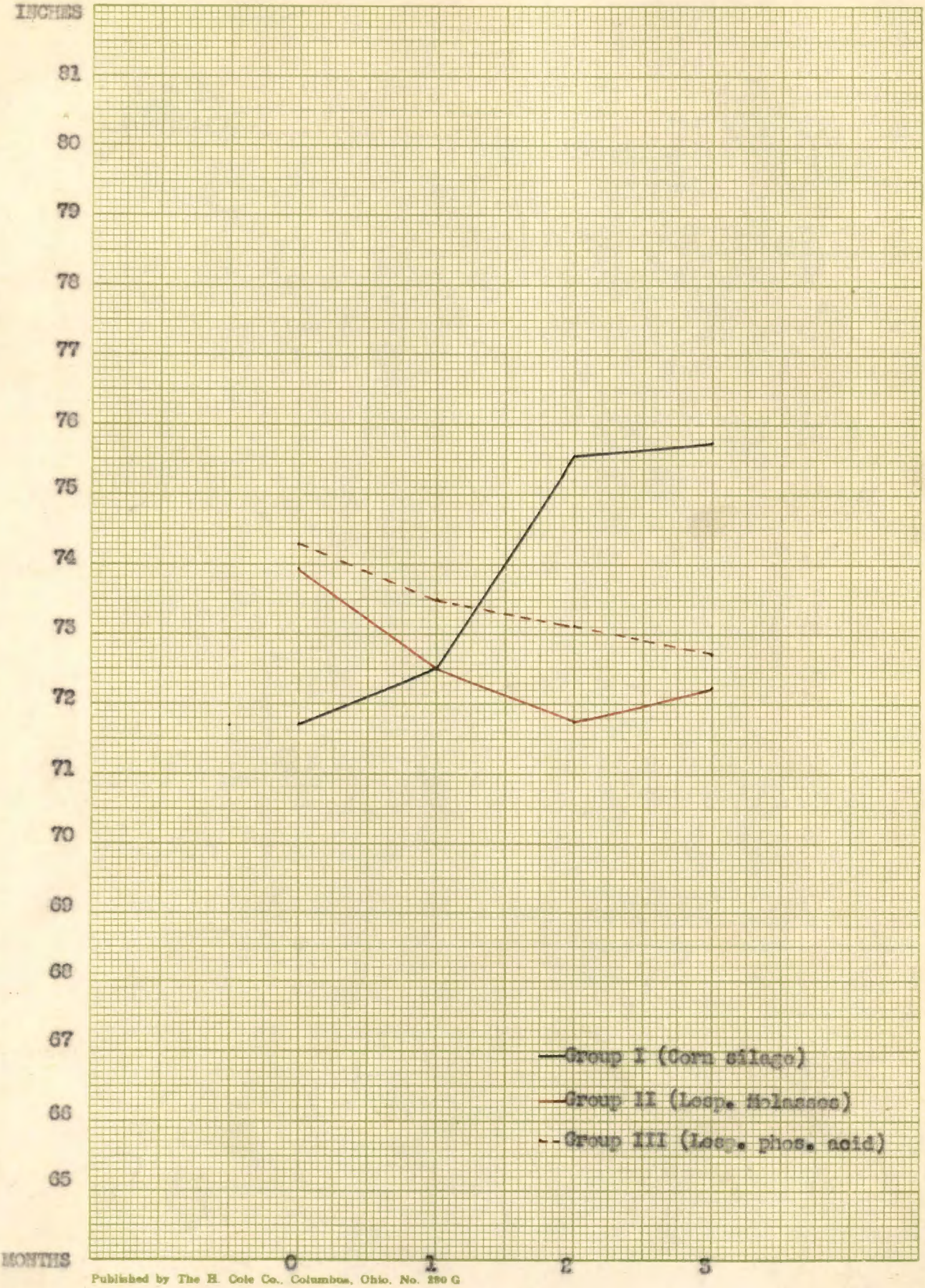

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Figure16.-Average Heart Girth of Groups

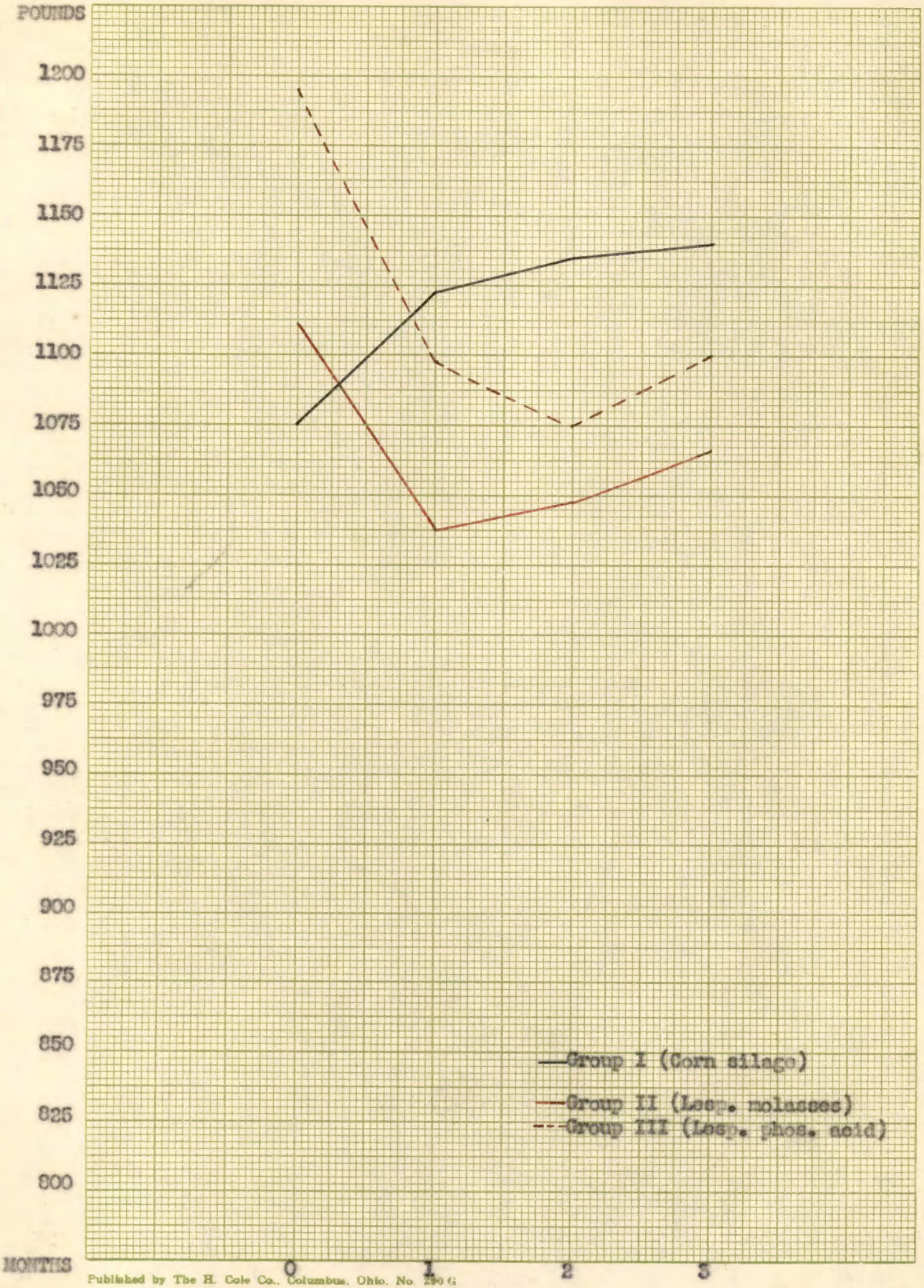

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Figure 17.-Average Weight of Groups

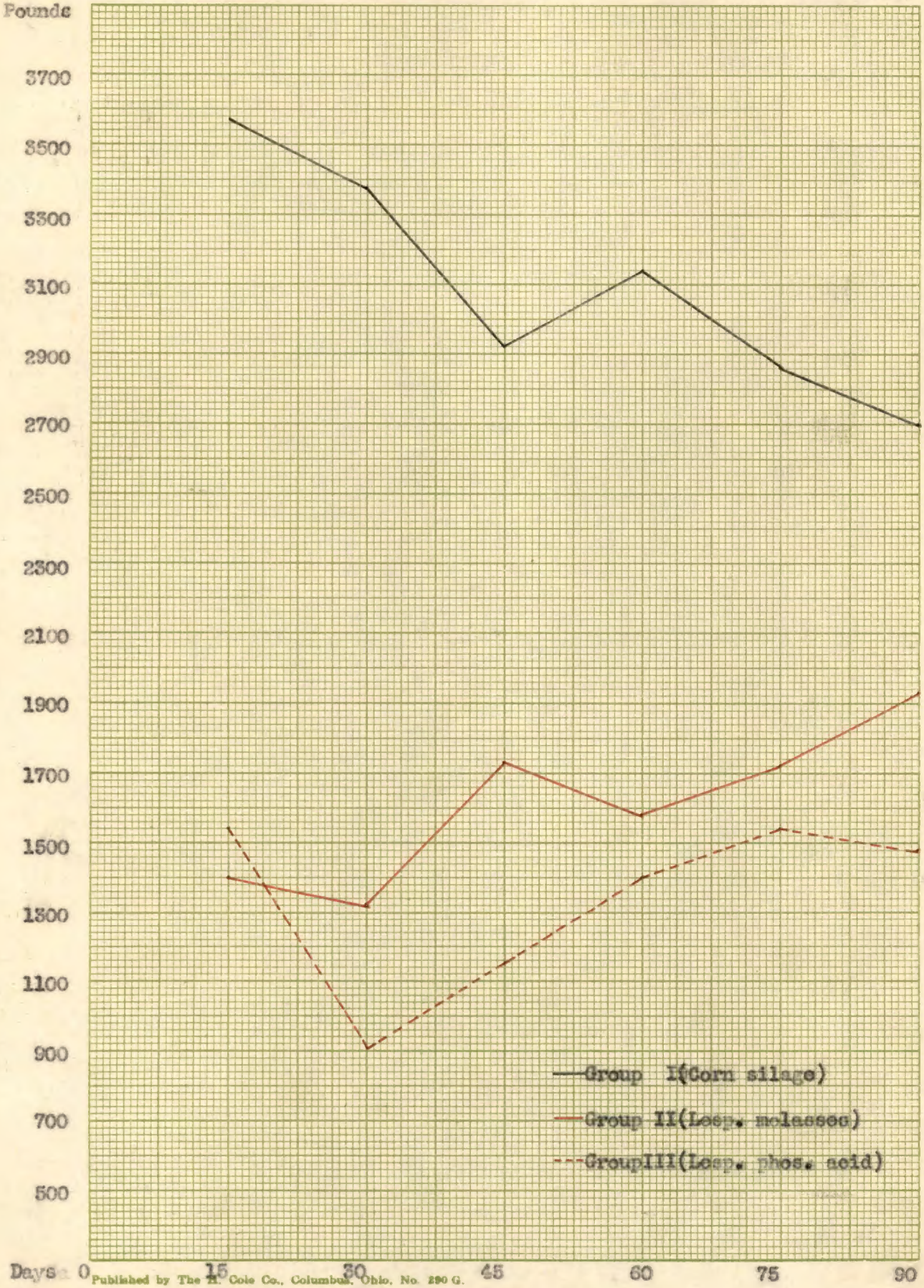

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Figure18.-- Silage Consumption

TABLE XIV. GROWTH AND MILK RECORD OF GROUPS

	Group I	Group II	Group III
Heart Girth--inches			
November 20, 1938	286.50	295.75	295.25
December 19, 1938	290.00	290.00	294.00
January 18, 1939	302.25	287.00	292.50
February 17, 1939	303.00	289.00	291.00
Total Gain	16.25	-6.75	-6.25
Average	4.62	-1.68	-1.56
Weight--pounds			
November 20, 1938	4320.00	4448.00	4780.00
December 19, 1938	4491.00	4153.00	4388.00
January 18, 1939	4546.00	4127.00	4299.00
February 17, 1939	4556.00	4268.00	4399.00
Total Gain	281.00	-280.00	-381.00
Average	70.27	-70.00	-95.25
Milk--pounds			
November 20, 1938			
December 19, 1938	2785.40	2376.10	2311.30
January 18, 1939	2819.80	2088.40	1841.40
February 17, 1939	2888.00	1812.80	1749.20
Total Milk	8493.20	6276.70	5901.90
Average	2123.30	1569.17	1475.47
Fat--pounds			
November 20, 1938			
December 19, 1938	112.88	106.44	105.21
January 18, 1939	117.94	83.52	81.57

TABLE XIV. GROWTH AND MILK RECORD OF GROUPS (CONTD).

	Group I	Group II	Group III
February 17, 1939	122.51	74.70	80.33
Total Fat	353.33	263.67	267.12
Average	88.33	65.91	66.78

DISCUSSION OF RESULTS

Group I gave more milk, produced more butterfat, and ate more silage as shown in Table XV.

TABLE XV. FEED CONSUMPTION AND GROWTH CHART

90 Days

	Group I	Group II	Group III
Total silage consumed, lbs.	18,305.00	9,610.50	7,889.50
Total Hay consumed, lbs.	2,861.50	2,880.00	2,880.00
Total concentrates consumed, lbs.	3,600.00	3,600.00	3,600.00
Total milk given, lbs.	8,493.20	6,726.00	5,901.90
Total fat production, lbs.	353.33	263.67	267.12
Gain or loss in heart girth, inches	16.25	-6.75	-6.25
Gain or loss in weight, lbs.	281.00	-280.00	-381.00

Group I gave 2,217.2 pounds more milk than Group II, 2,591.3 pounds more milk than Group III; and produced 89.66 pounds more butterfat than Group II, and 86.21 pounds more fat than Group III. Group I ate 8,694.5 more pounds of silage than Group II and 10,415.5 pounds more than Group III. The cows in Group I ate an average of 50.8 pounds of silage per cow per day; those in group II ate 26.6 pounds per cow per day; and those in Group III ate 21.9 pounds per cow per day. There was a difference in the composition of the silages as shown in Table XVI.

TABLE XVI. COMPOSITION OF SILAGES

	Corn Silage %	Sericea Preserved with Molasses %	Sericea Preserved with Phosphoric acid %
Moisture	75.82*	71.27*	64.17*
Ash	1.53	1.59	2.66
Crude Fat (Ether Ext.)	0.80	0.53	0.72
Crude Protein (% N. x 6.25)	1.46	3.44	3.91
Crude Fiber	6.46	10.49	11.74
Nitrogen Free Extract	14.11	12.68	16.80

* Average of three samples as taken at different depths in silo.

Group I gained 16.25 inches in heart girth, Group II lost 6.75 inches, and Group III lost 6.25 inches. Group I gained 281 pounds in weight, Group II lost 280 pounds and Group III lost 381. The reason that Group II and III lost weight is that they did not eat enough silage to keep up their milk flow and maintain their body weight. The cows in Group II and III did not eat the silage very well, because it was not very palatable and the silage had a small amount of mold on it. The corn silage was of good quality all the time.

TABLE XVII. TOTAL NUTRIENTS EATEN DURING EXPERIMENT

	Group I	Group II	Group III
Grain Mixture*	2,682.20	2,882.2	2,682.20
Hay**	1,528.00	1,537.9	1,537.90
Silage	4,722.48	2,761.0	2,535.93
Total Nutrients	8,932.68	6,981.1	6,756.03

*T. D. N. taken from Morrison's Feeds and Feeding.
**Nutrients taken from Table XVI because there was no T. D. N. available for the silages.

As shown in Table XVII, Group I consumed the most nutrients; but in the amount of nutrients consumed per pound of 4% milk, there was not a great deal of difference. Group I consumed 1.02 pounds nutrients per pound 4% milk, Group II 1.08, and Group III 1.06 pounds nutrients per pound 4% milk. Group I consumed 25.25 pounds nutrients per pound of fat, Group II 26.47, and Group III 25.29.

The data indicate that the experiment was not a fair one, because the legume silage was not as good quality silage as the corn silage. Due to the condition of the silage the cows would not eat enough to maintain their milk production at the level it was when the experiment began. The cows in Group II and III lost in weight and heart girth, which shows that the cows were not eating enough silage.

SECTION B

AIR DRIED HAY VERSUS FIELD CURED HAY FOR DAIRY HEIFERS

PURPOSE

The purpose of this experiment was to compare the feeding of air cured hay to similar hay, field cured, for dairy heifers. This is a cooperative project between the Tennessee Valley Authority and the University of Tennessee. The hay was cured as outlined on page 29.

PLAN OF EXPERIMENT

The experiment was conducted at the University of Tennessee Dairy Barn, at Knoxville. It was carried on over a five months period, from November 20, 1938, to April 18, 1939. Ten heifers were divided into two groups each consisting of three Jerseys and two Holsteins. The groups were divided as near equal as possible according to age, height, heart girth, and weight.

The following rations were fed to each group:

Group I. Air dried alfalfa hay ad libitum.

Concentrates, 2 pounds per animal per day--corn and cob meal 800 pounds, 600 pounds oats, 600 pounds bran, 600 pounds cottonseed meal, 40 pounds bone meal, and 40 pounds salt.

Corn silage, 10 pounds per animal per day.

Group II. Field cured alfalfa hay ad libitum.

Concentrates, 2 pounds per animal per day--same mixture as fed Group I.

Corn silage, 10 pounds per animal per day.



Duct System in Loft on Which Hay is Dried



The Motor and Blower of the System

Figure 19. Duct System and Blower of Air Dried Hay System

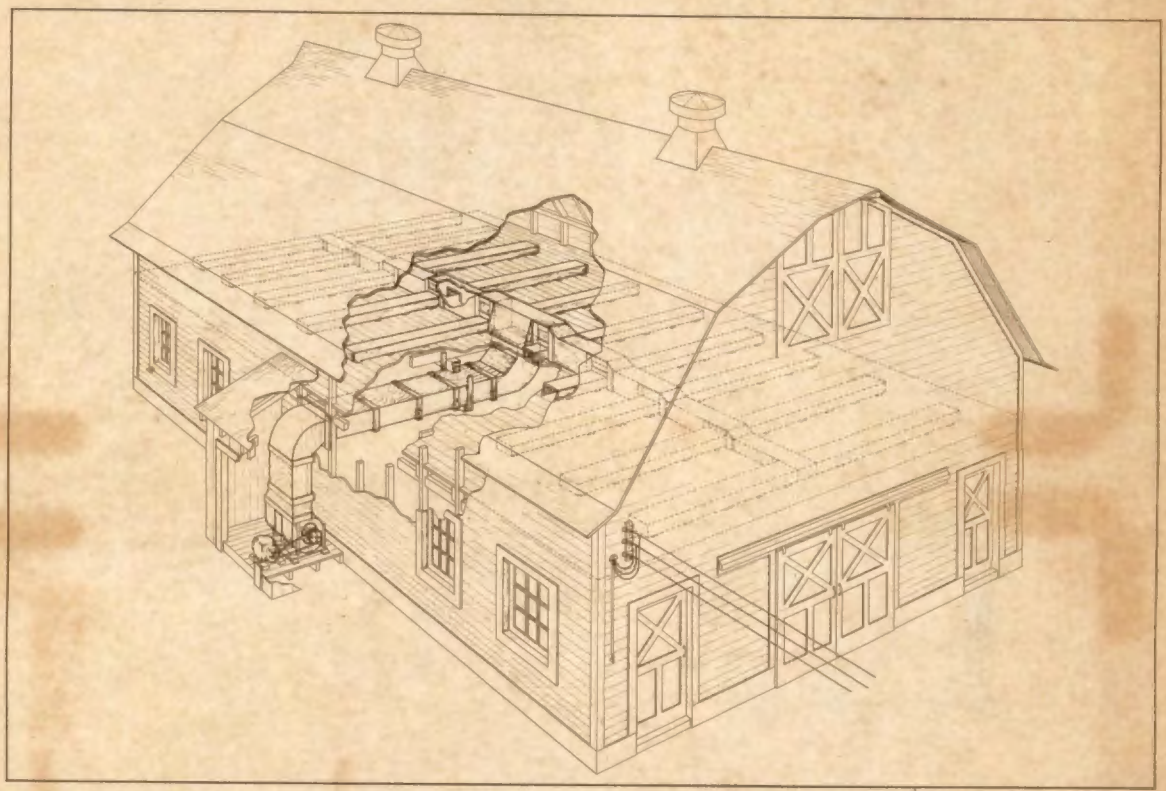


Figure 20. Sketch Showing How a Barn Looks When the Air Dried System is Put in

The heifers in each group were kept in the same stall and were allowed to run loose in the stall. Water was available at all times at drinking fountains. The heifers were let out in a lot for exercise.

Grain and silage were fed in the morning, and after they had eaten the grain and silage they were fed hay. Hay was also fed at night, and the amount not eaten was weighed back the next morning. The hay was weighed when fed, and it was ground for ease of handling.

RECORDING DATA

The heifers were weighed three days in succession at the beginning of the experiment, and they were also measured for heart girth and height at the same time. This was repeated every thirty days. Daily feed records were kept on the amount of hay fed and the amount refused. A record of the silage and grain eaten was also kept. Any abnormal condition was noted.

RESULTS OBTAINED

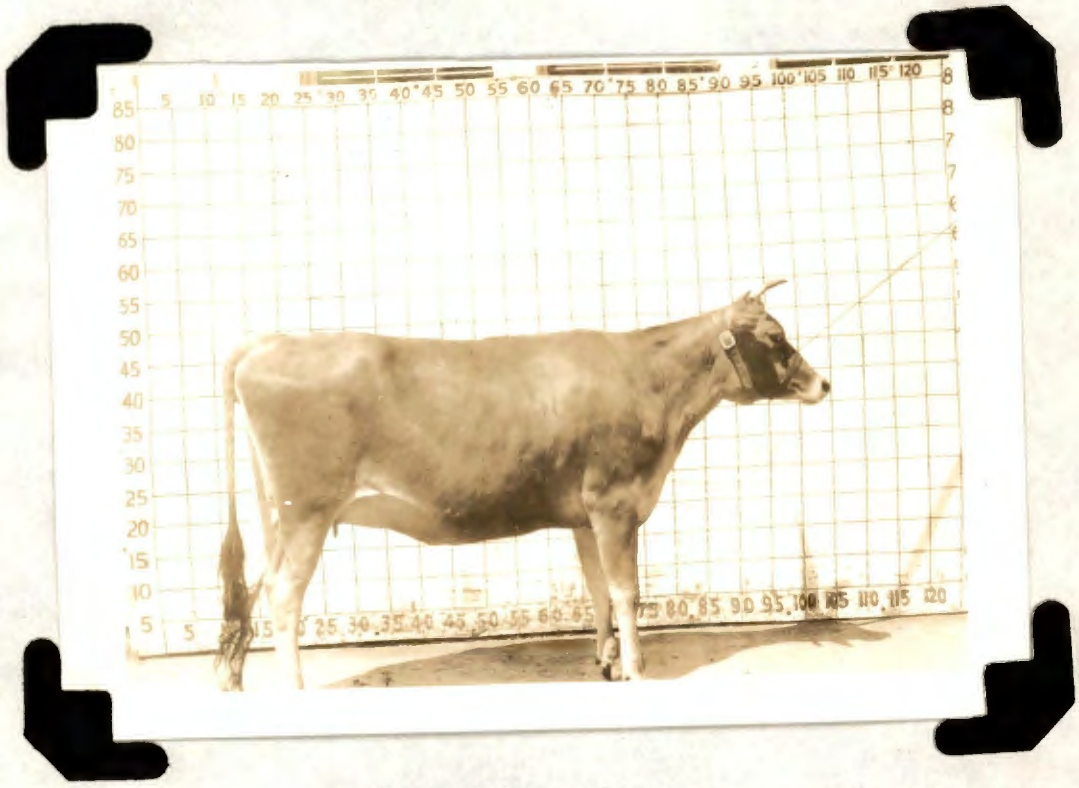
Group I. (Air Cured Hay)

At the beginning of the experiment this group averaged 44.95 inches in height, 59.4 inches in heart girth, and 565 pounds in weight. At the end of the experiment (five months later), they averaged 47.7 inches in height, 66.3 inches in heart girth, and 789 pounds in weight. They made an average gain of 2.75 inches in height, 6.9 inches in heart girth, and 224.4 pounds in weight.

The five heifers consumed 9,821 pounds of hay, 1,500 pounds of grain, and 7,500 pounds of silage during the experiment or an average of 1,964 pounds of hay, 300 pounds of grain, and 1,500 pounds of silage per animal.

The following pages show the photographic growth records of the heifers fed the air cured hay. The graphs following the pictures show the growth of the animal as compared with the normal growth of heifers of the same age and breed. The normal growth standards for heart girth, height, and weight were taken from Ragsdale, A. C., Growth Standards for Dairy Cattle, Missouri Agricultural Experiment Station Bulletin No. 336.

GROUP I



End of Experiment
Age 23 months and 25 days

Figure 21. Photographic growth rate of Heifer No. T66

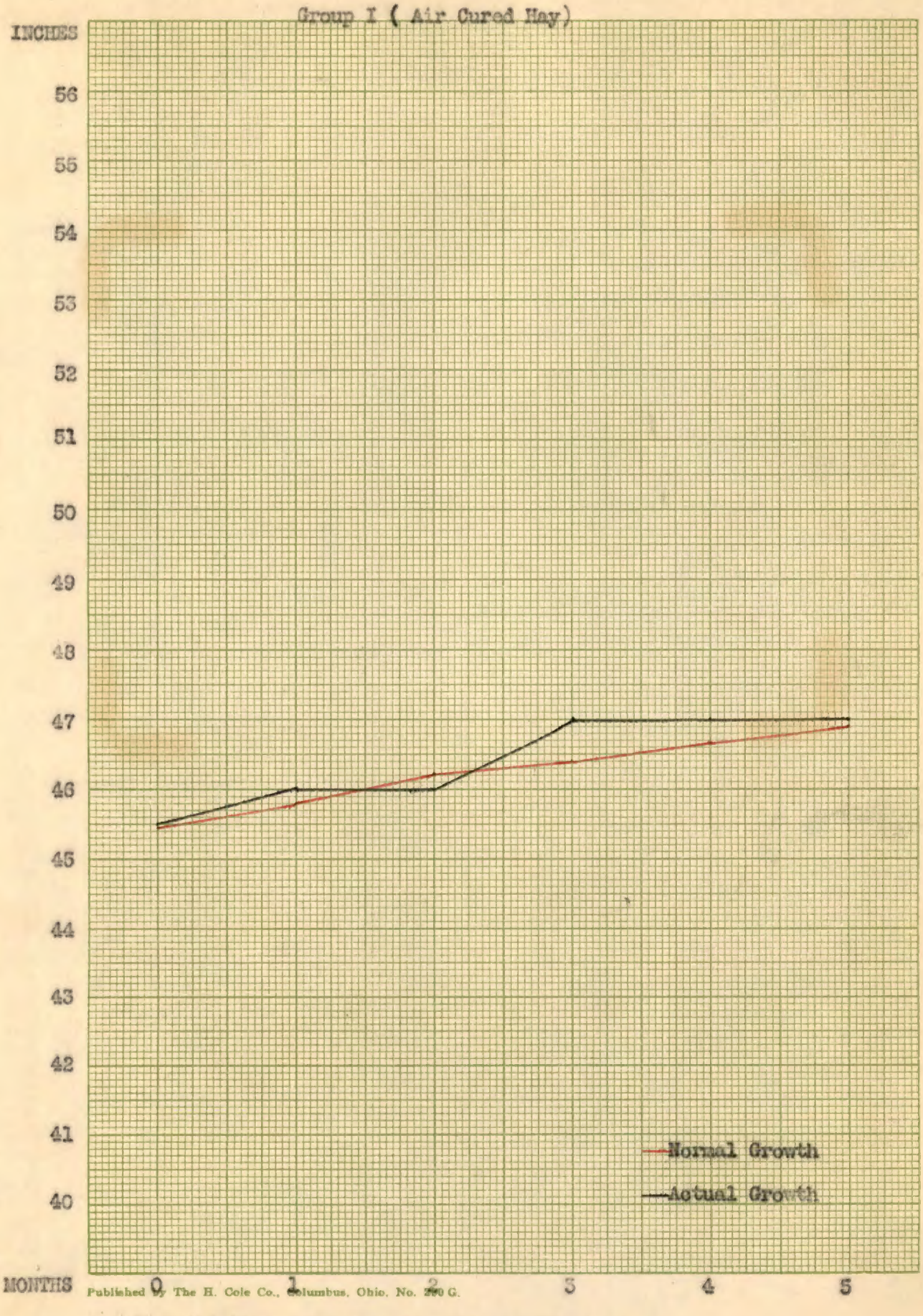


Figure 22 - Growth Rate (height) of Heifer No. T 66

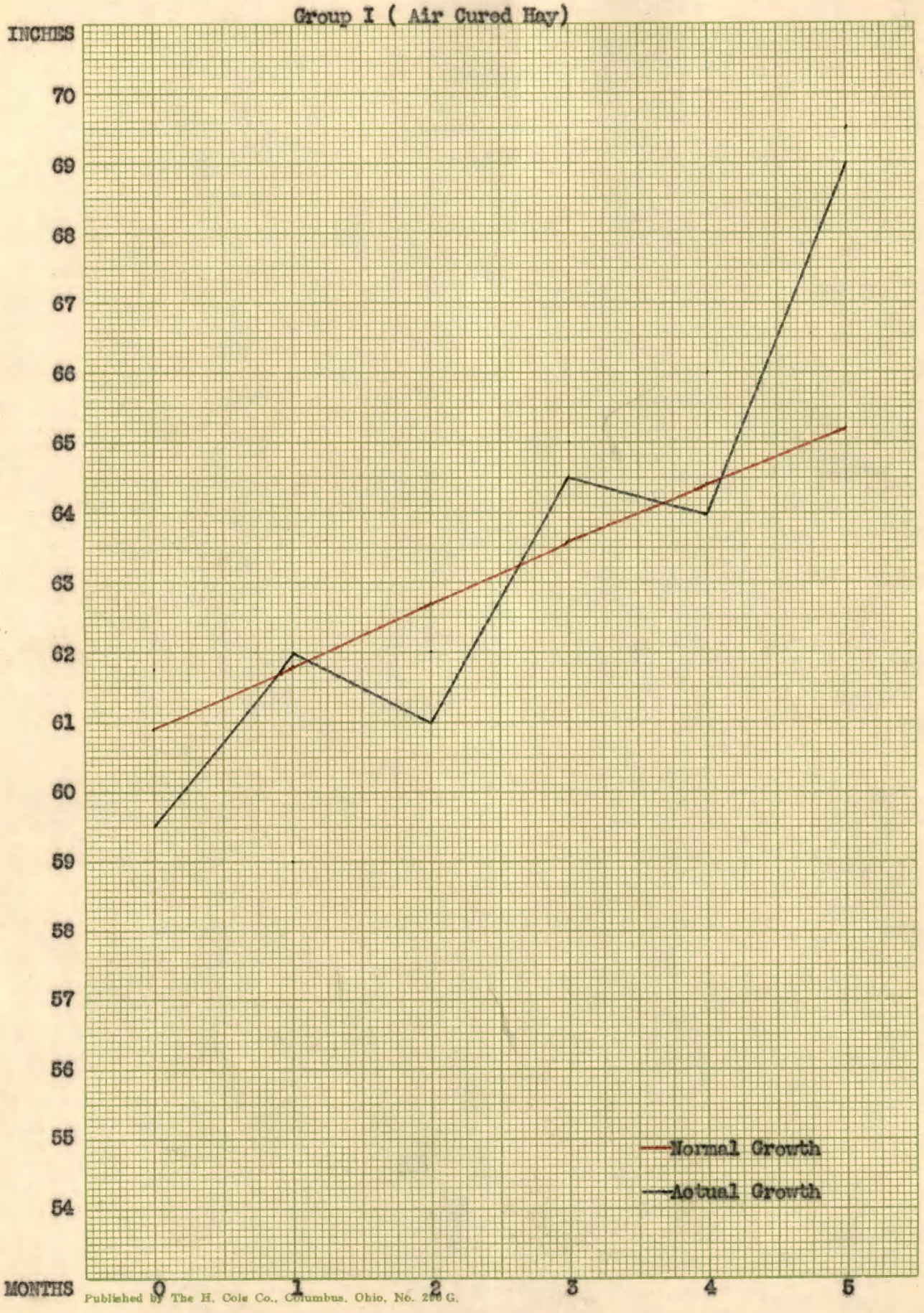


Figure 23.- Growth Rate (heart girth) of Heifer No. T 66

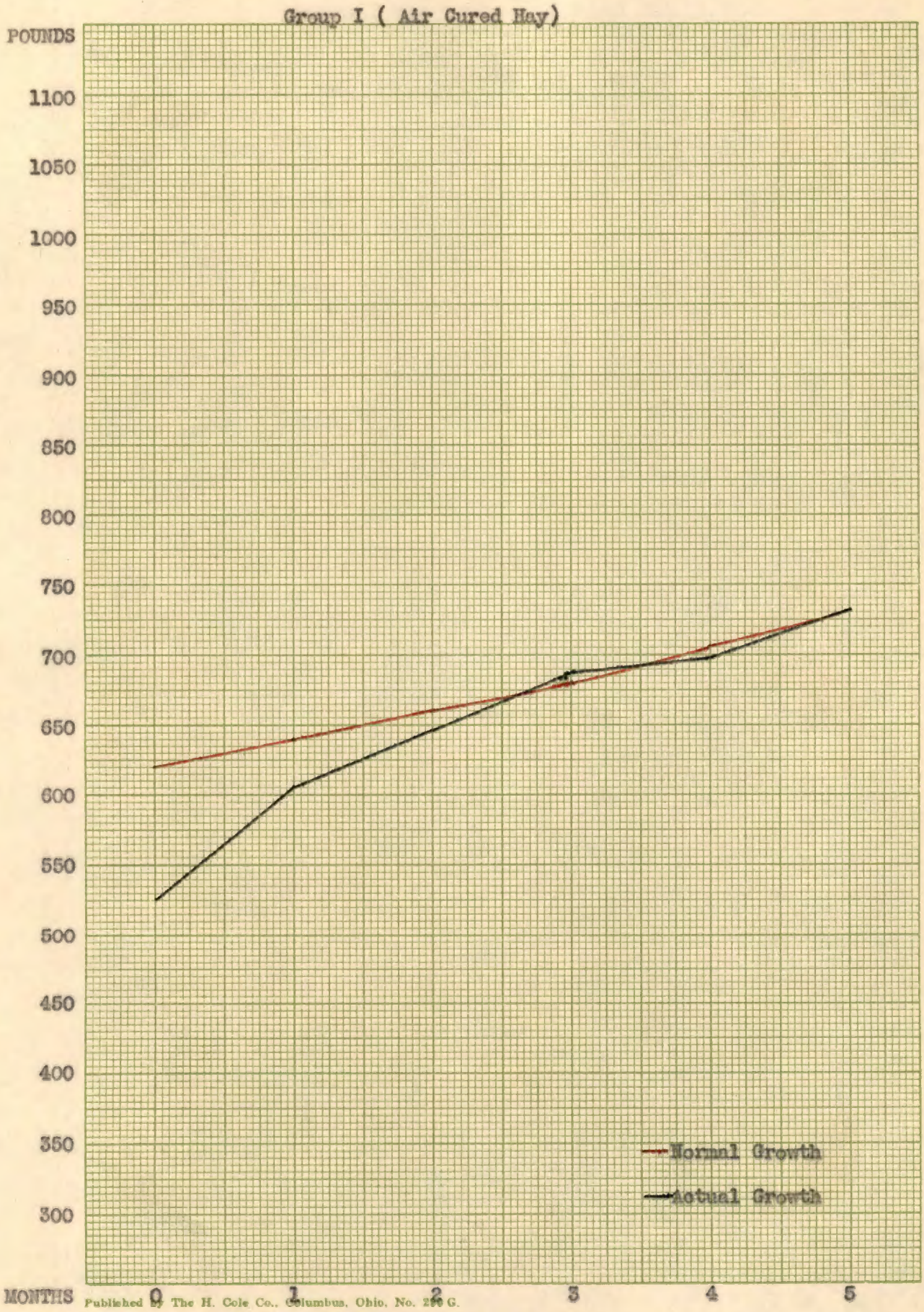
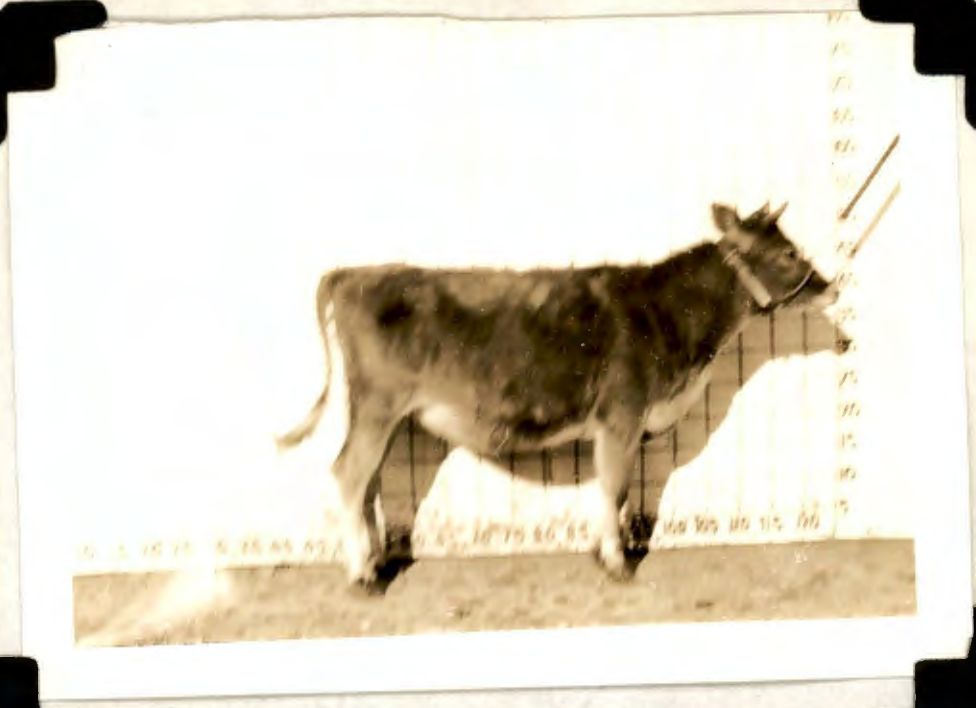
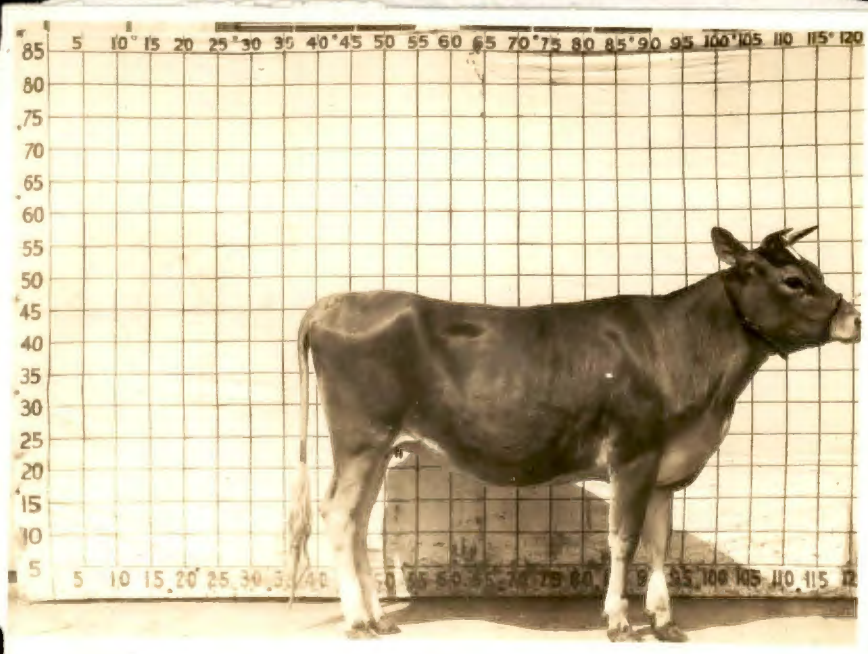


Figure24.- Growth Rate (weight) of Heifer No. T 66

GROUP I



Beginning of Experiment
Age 14 months and no days



End of Experiment
Age 19 months and no days

Figure 25. Photographic Growth Rate of Heifer No. T68

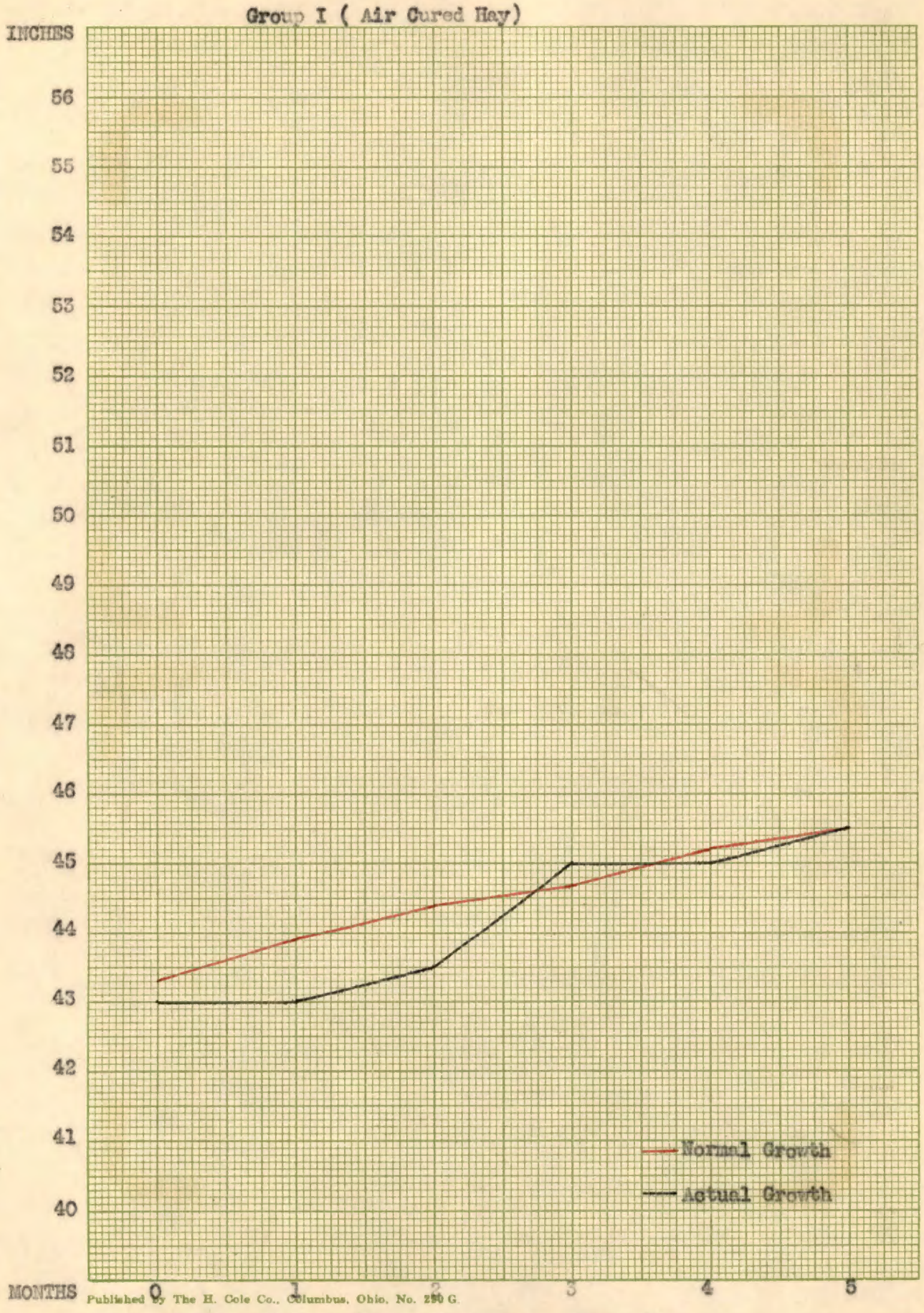


Figure 26.- Growth Rate (height) of Heifer No. T 68

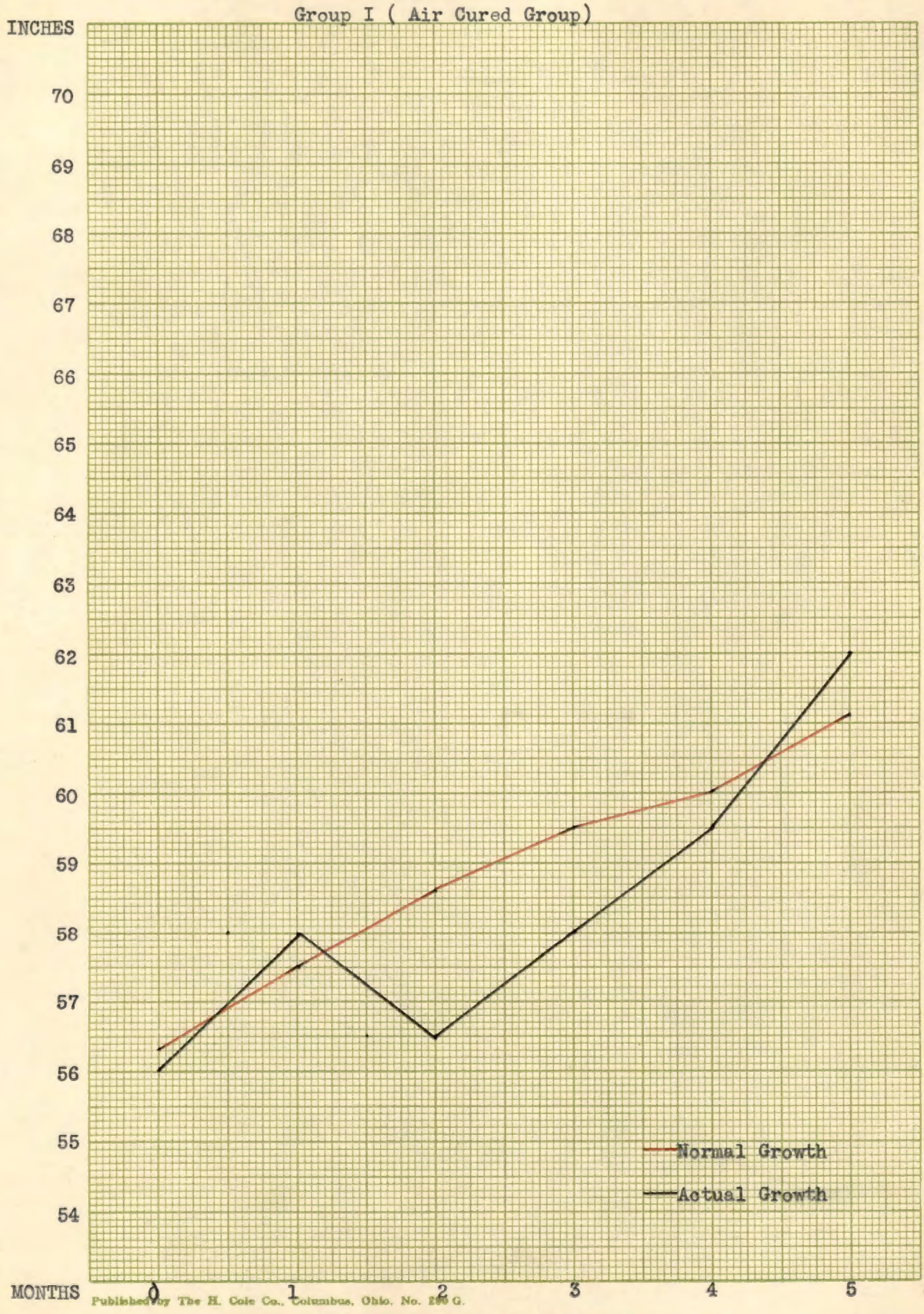


Figure27.- Growth Rate (heart girth) of Heifer No. T 68

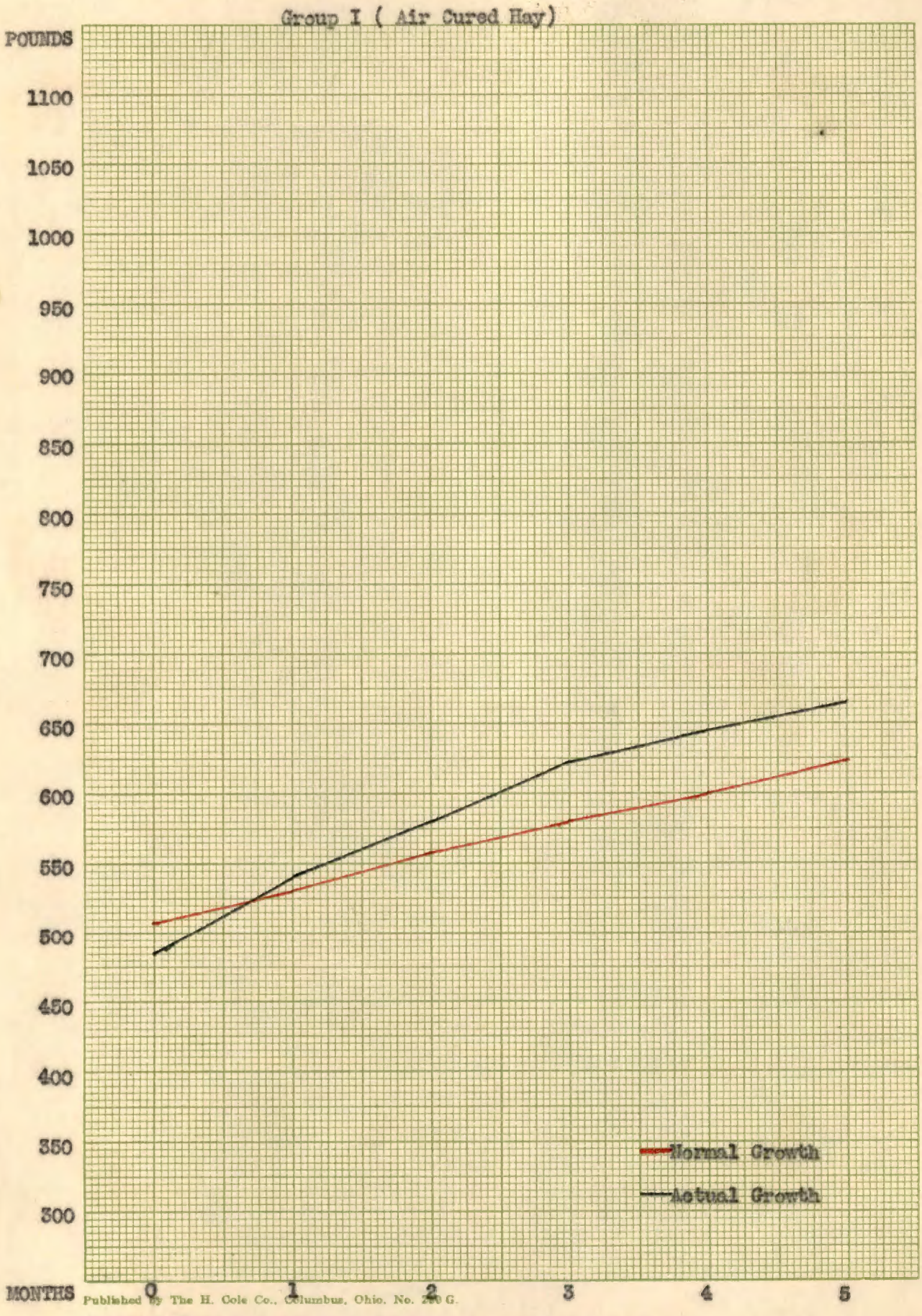


Figure 28 - Growth Rate (weight) of Heifer No. T 68

GROUP I



Beginning of Experiment
Age 13 months and 18 days



End of Experiment
Age 18 months and 18 days

Figure 29. Photographic Growth Rate of Heifer No. 322

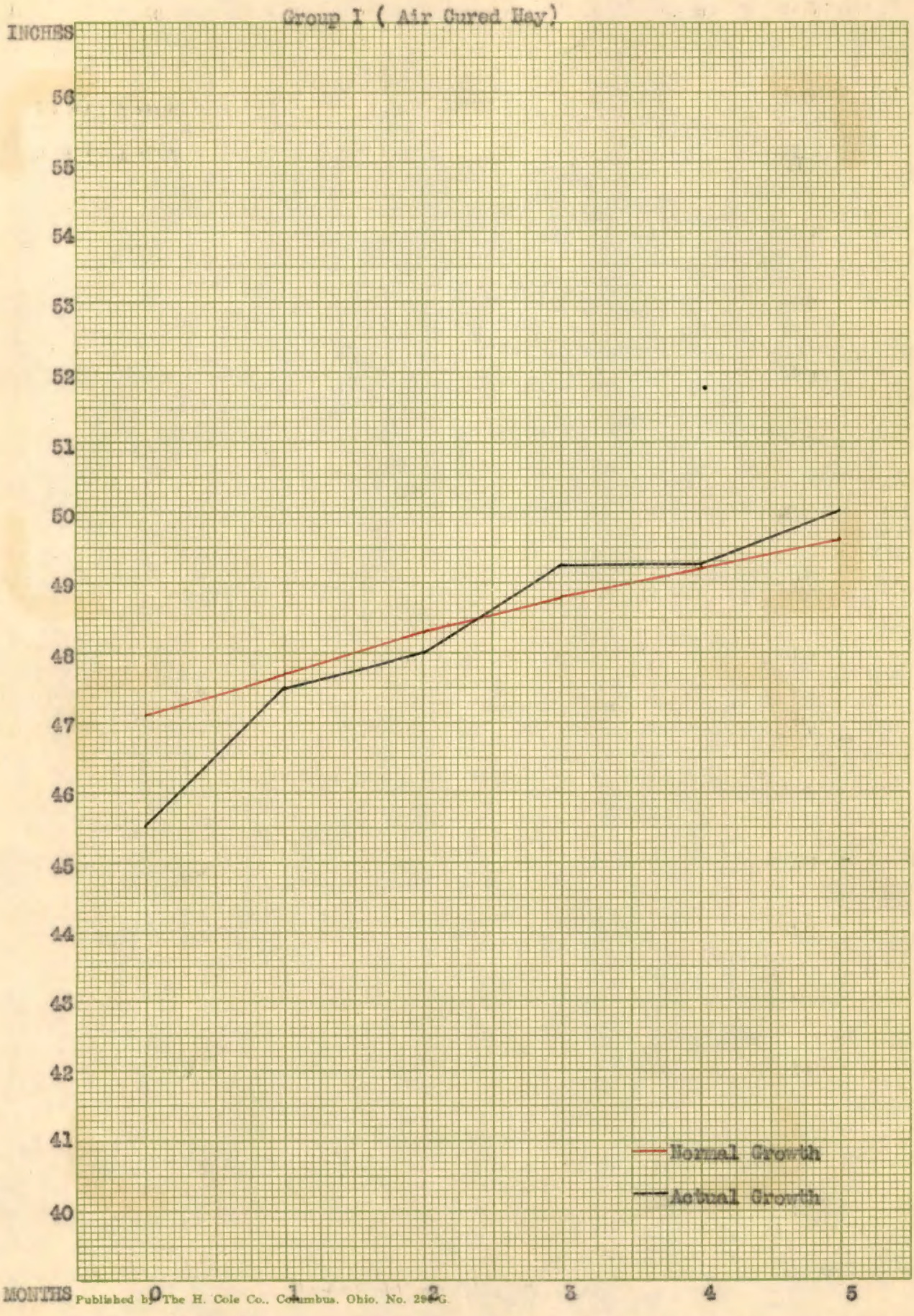


Figure30.- Growth Rate (height) of Heifer No. 322

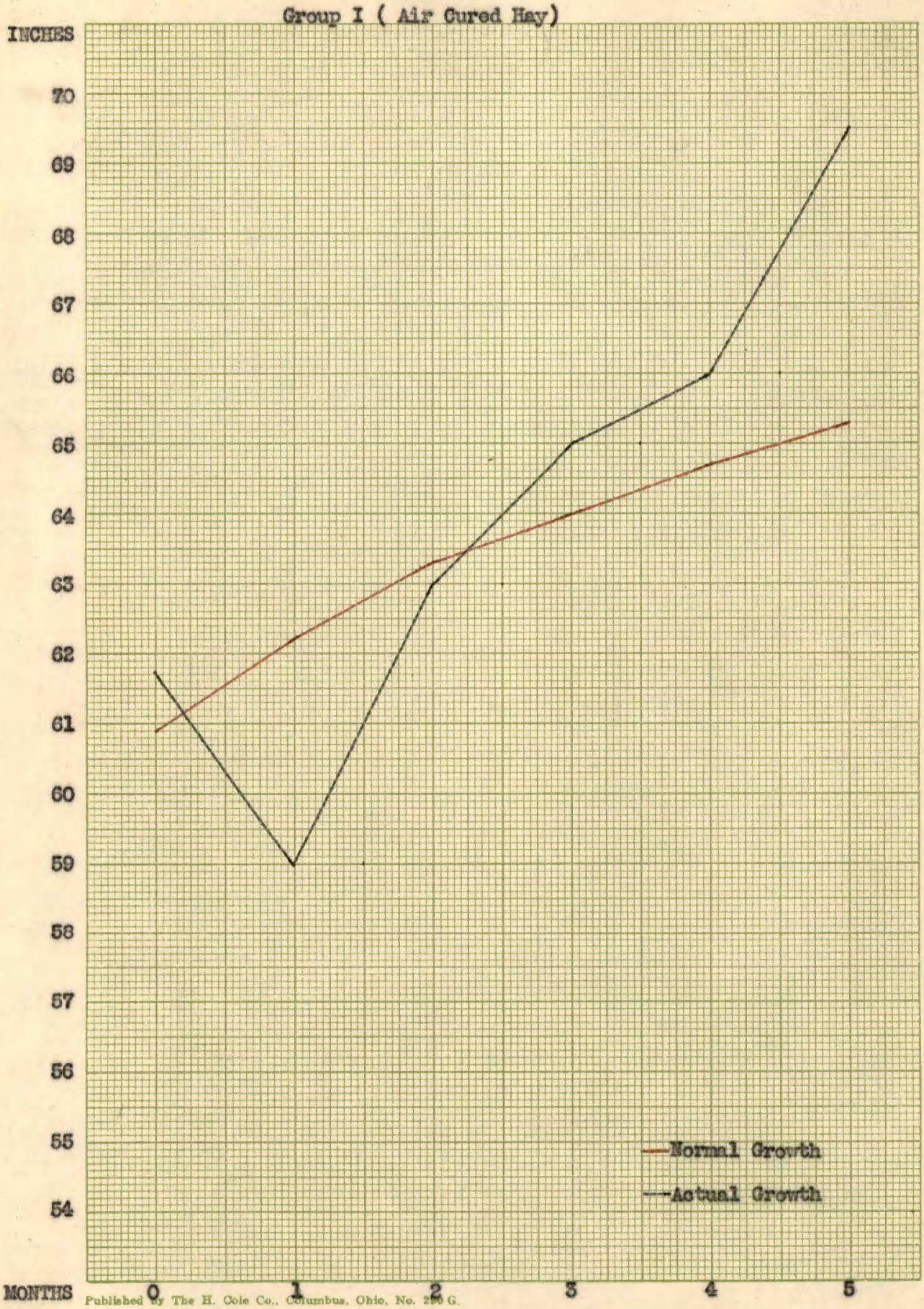


Figure 31.- Growth Rate (heart girth) of Heifer No. 322

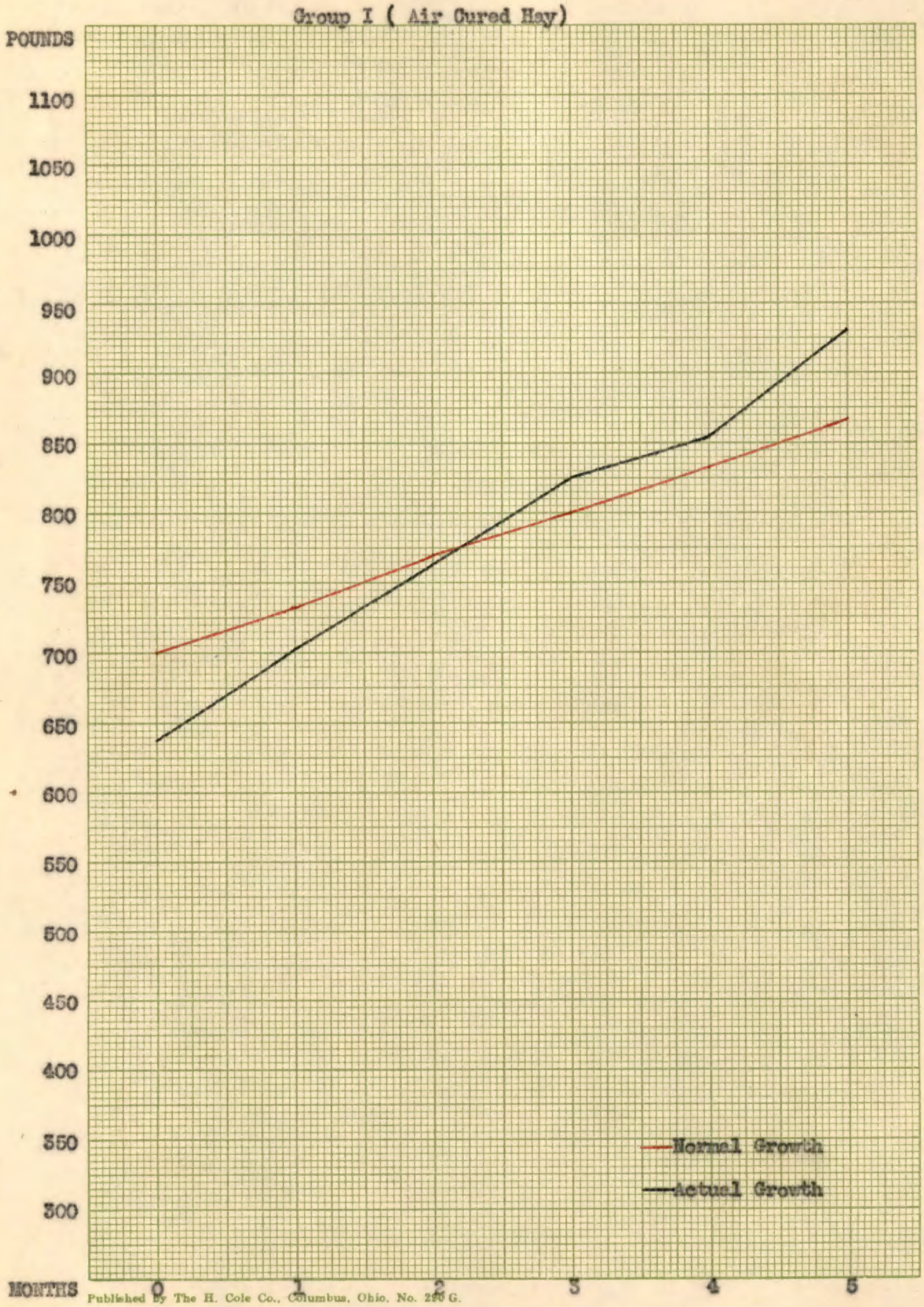
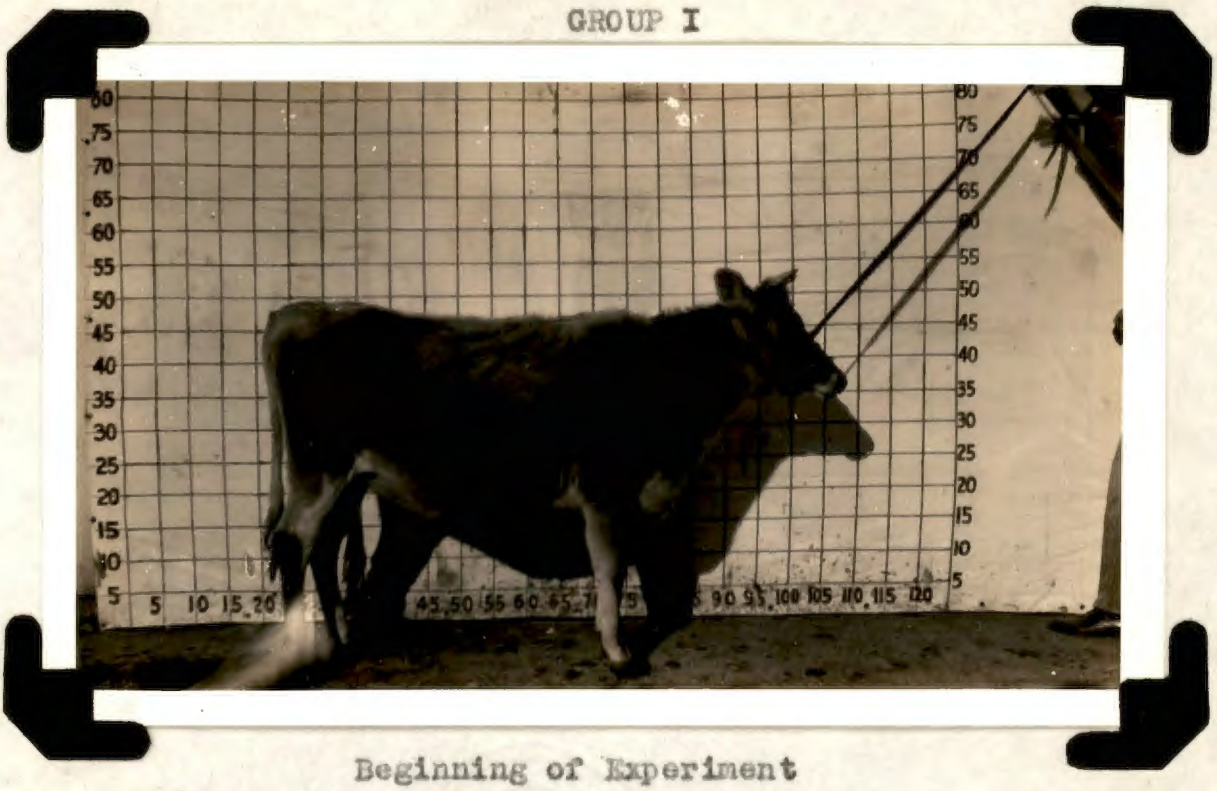
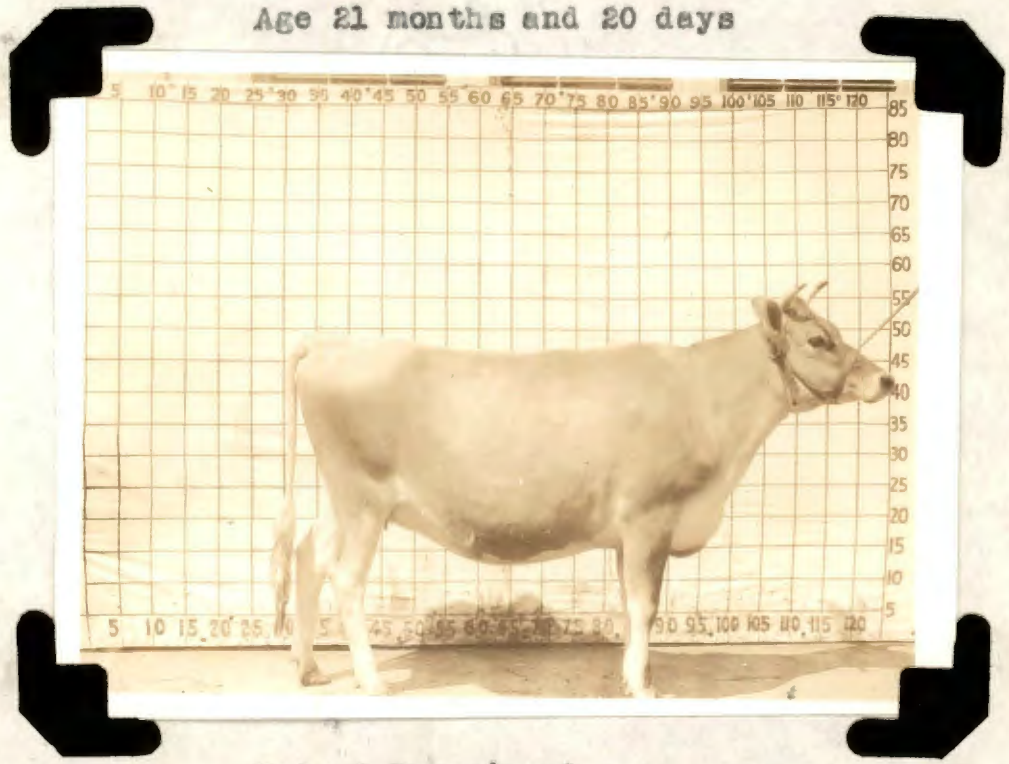


Figure 32.- Growth Rate (weight) of Heifer No. 322

GROUP I



Beginning of Experiment
Age 21 months and 20 days



End of Experiment
Age 26 months and 20 days

Figure 33. Photographic Growth Rate of Heifer No. T64

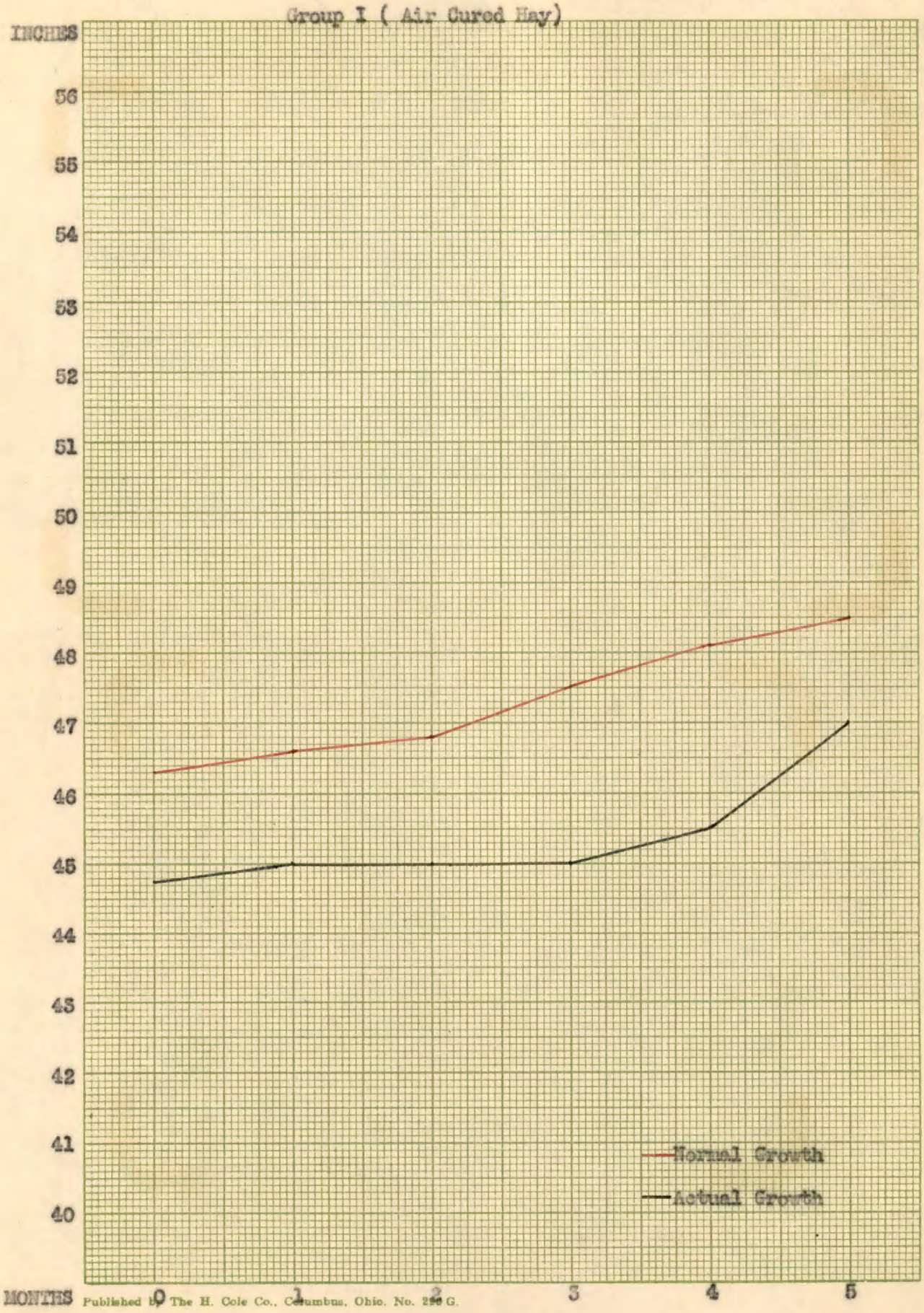


Figure34.- Growth Rate (height) of Heifer No. T 64

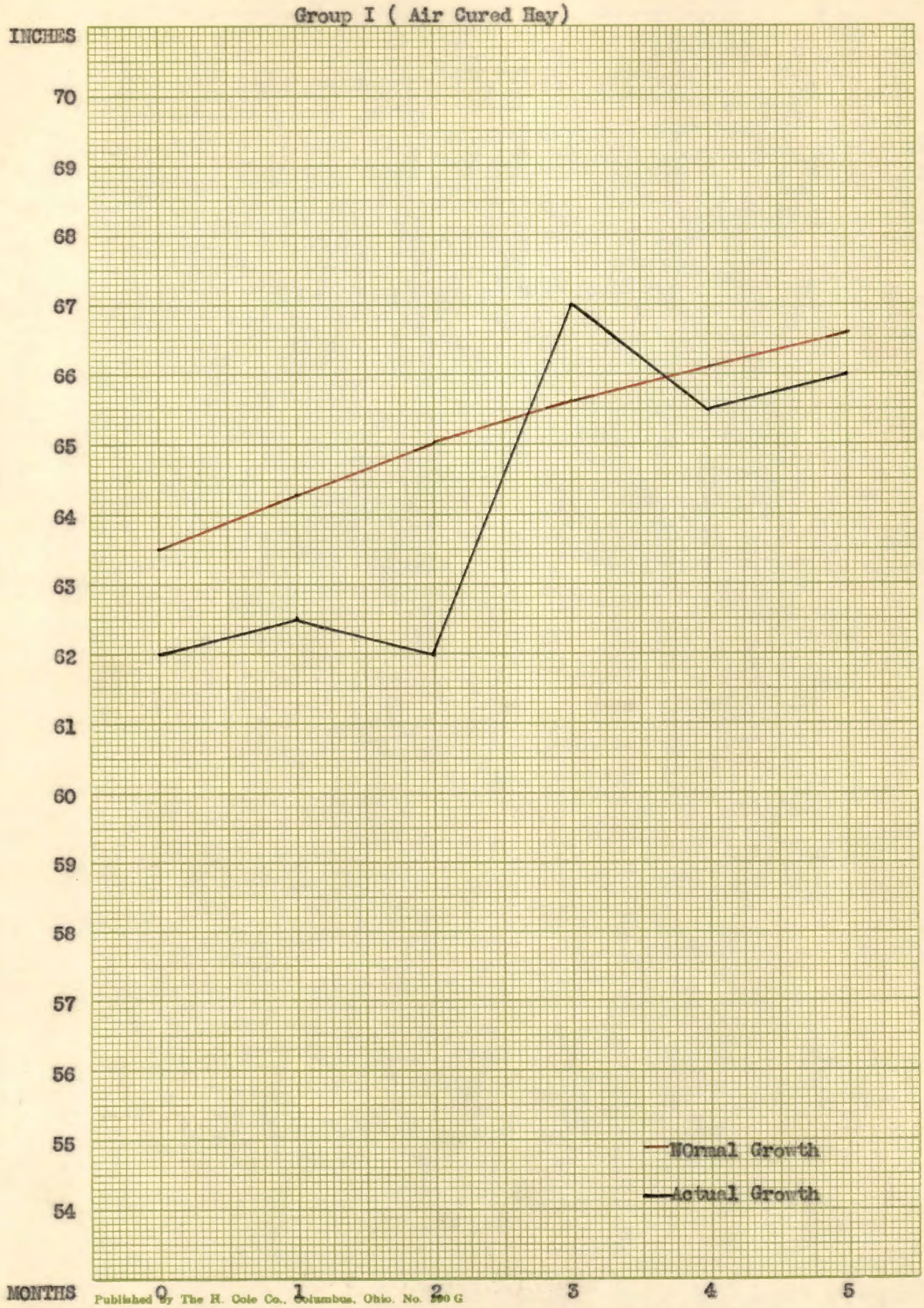


Figure35.- Growth Rate (heart girth) of Heifer No. T 64

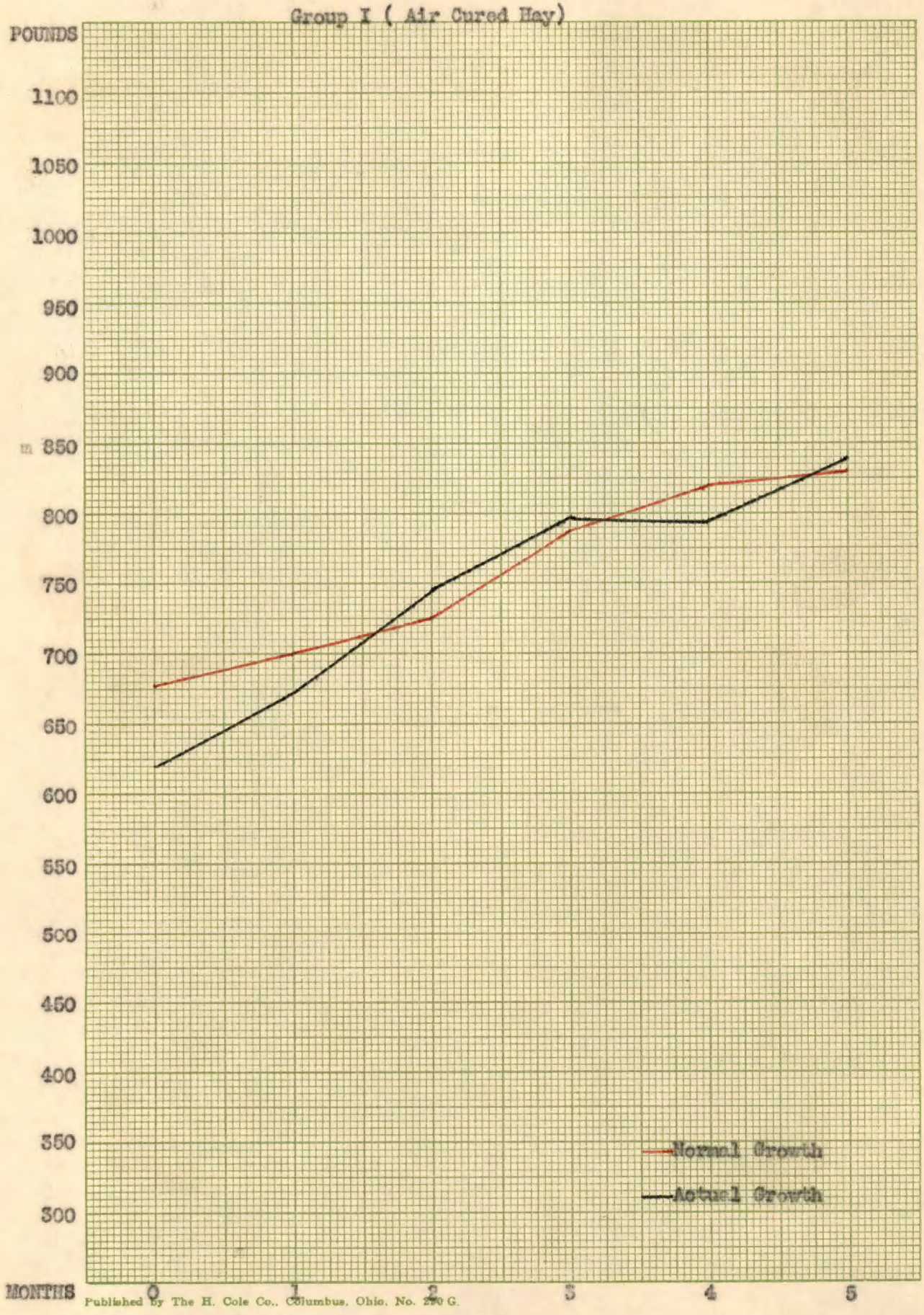


Figure 36. Growth Rate (weight) of Heifer No. T 64

GROUP I



Beginning of Experiment
Age 9 months and 12 days



End of Experiment
Age 14 months and 12 days

Figure37.. Photographic Growth Rate of Heifer No. 324

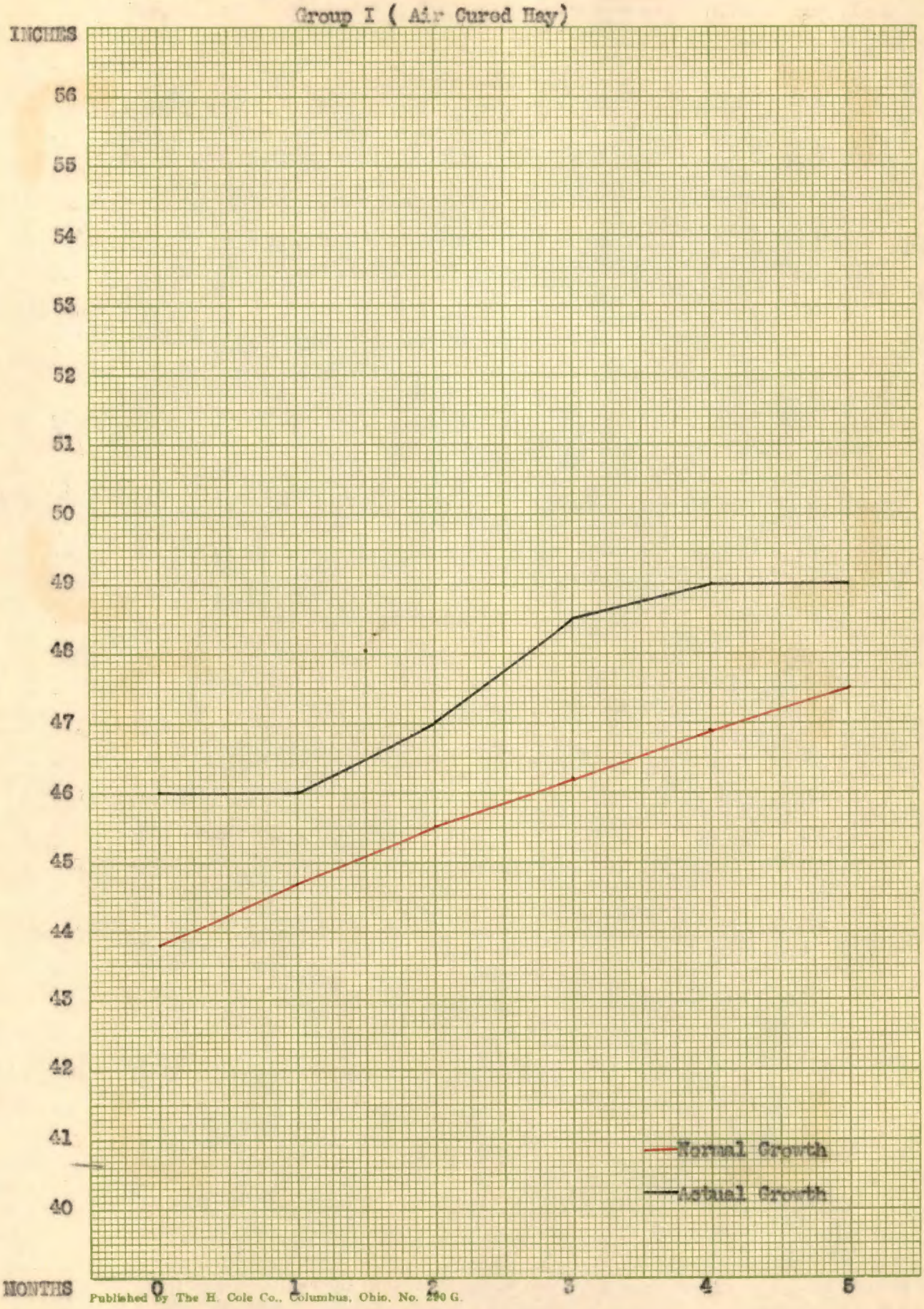


Figure 38. Growth Rate (height) of Heifer No. 324

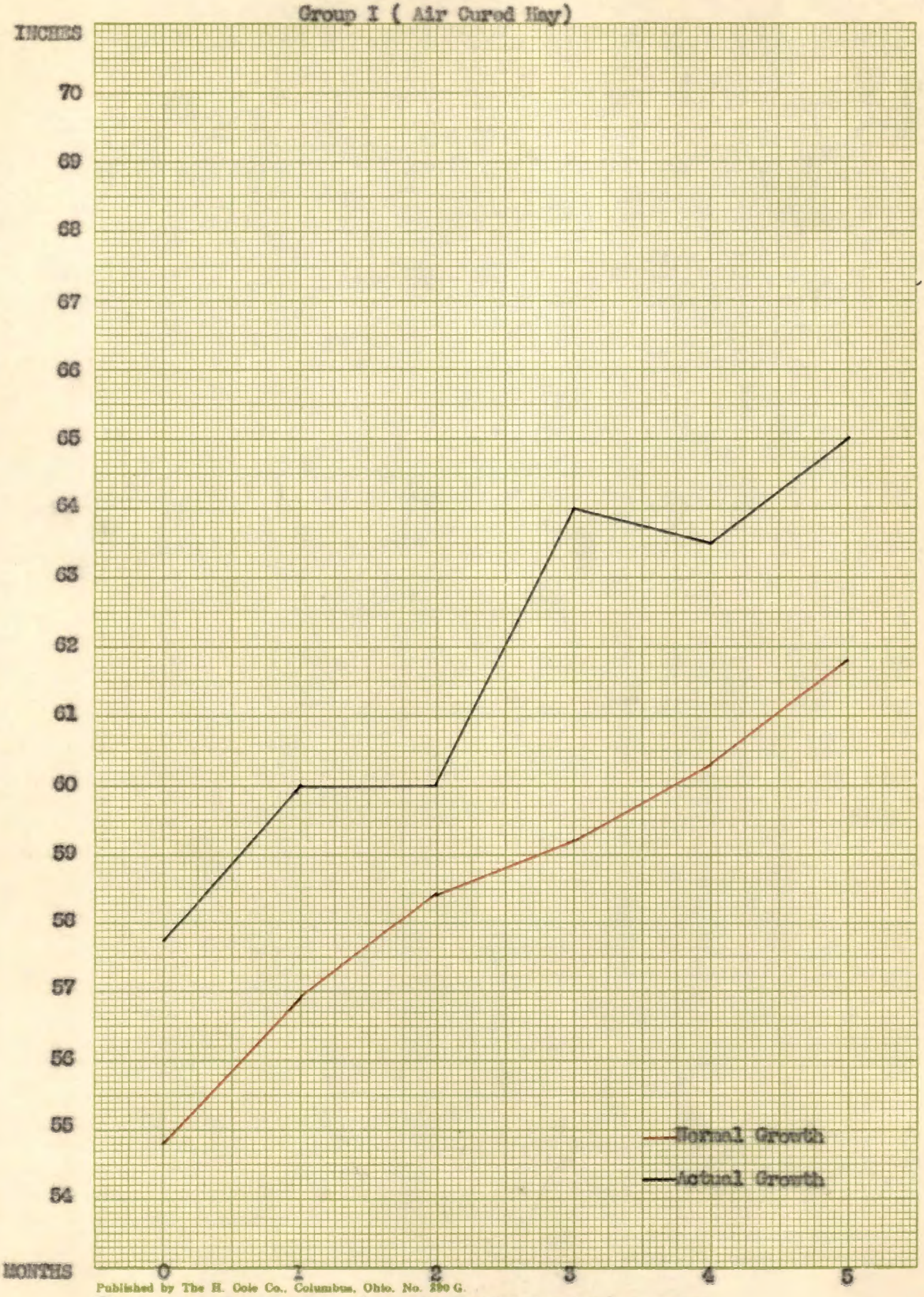


Figure 39.- Growth Rate (heart girth) of Heifer No. 324

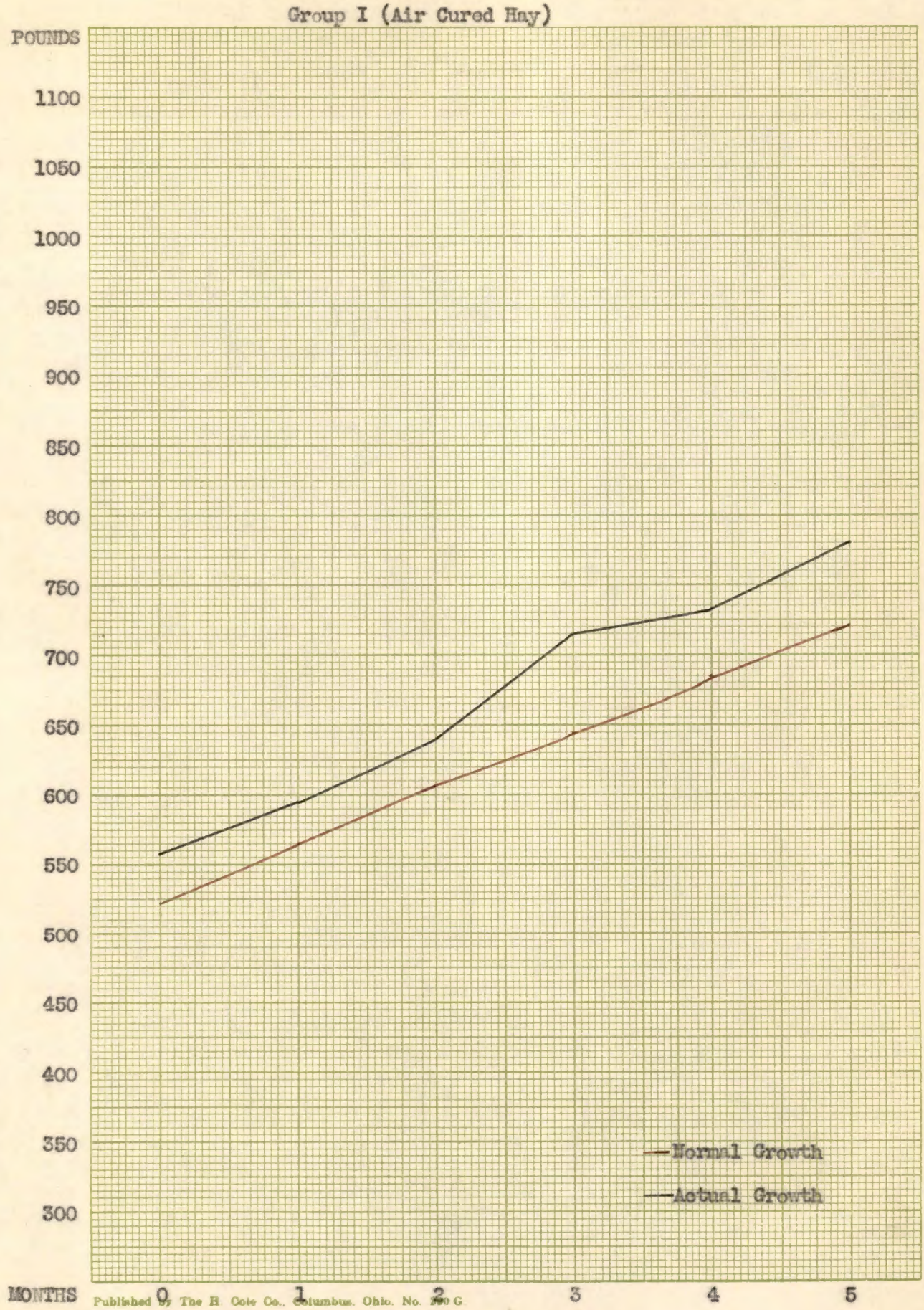


Figure40.- Growth Rate (weight) of Heifer No. 324

Group II. (Field Cured Hay)

At the beginning of the experiment this group of heifers averaged 44.25 inches in height, 57.95 inches in heart girth, and 565 pounds in weight. At the end of the experiment (five months later), they averaged 47.05 inches in height, 64 inches in heart girth, and 754 pounds in weight. They made an average gain of 2.8 inches in height, 6.05 inches in heart girth, and 189.2 pounds in weight per animal.

The five heifers consumed 8,884 pounds of hay, 1,500 pounds of grain, and 7,500 pounds of silage during the experiment or an average of 1,777 pounds of hay, 300 pounds of grain, and 1,500 pounds of silage per animal.

The following pages show the photographic growth records of the heifers fed the field cured hay. The graphs following the pictures show the growth of the animal as compared with the normal growth of heifers of the same age and breed. The normal growth standards were taken from the same bulletin as Group I.

GROUP II



Beginning of Experiment
Age 11 months and 22 days



End of Experiment
Age 16 months and 22 days

Figure 41. Photographic Growth Rate of Heifer No. 323

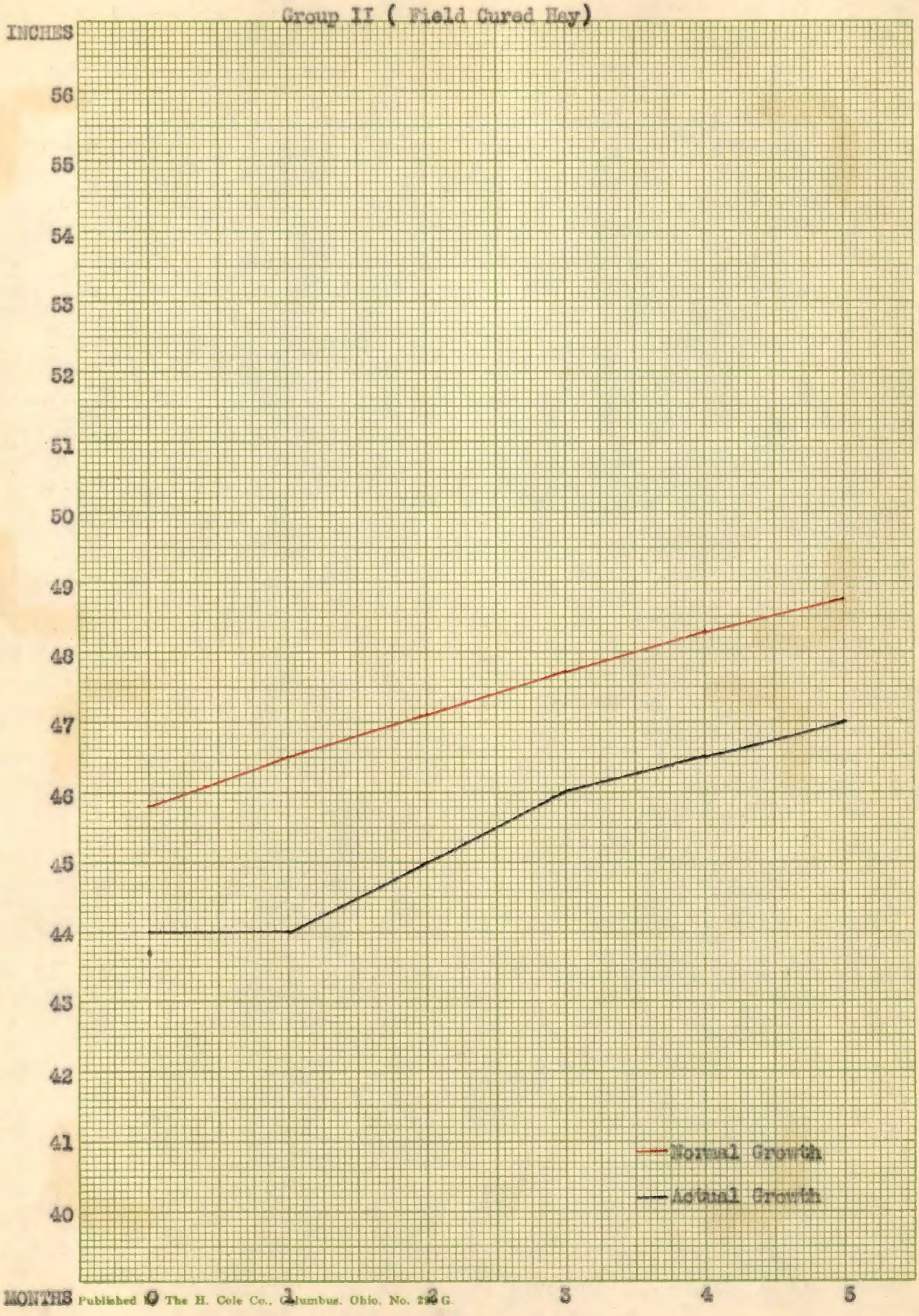


Figure 42.- Growth Rate (height) of Heifer No. 323

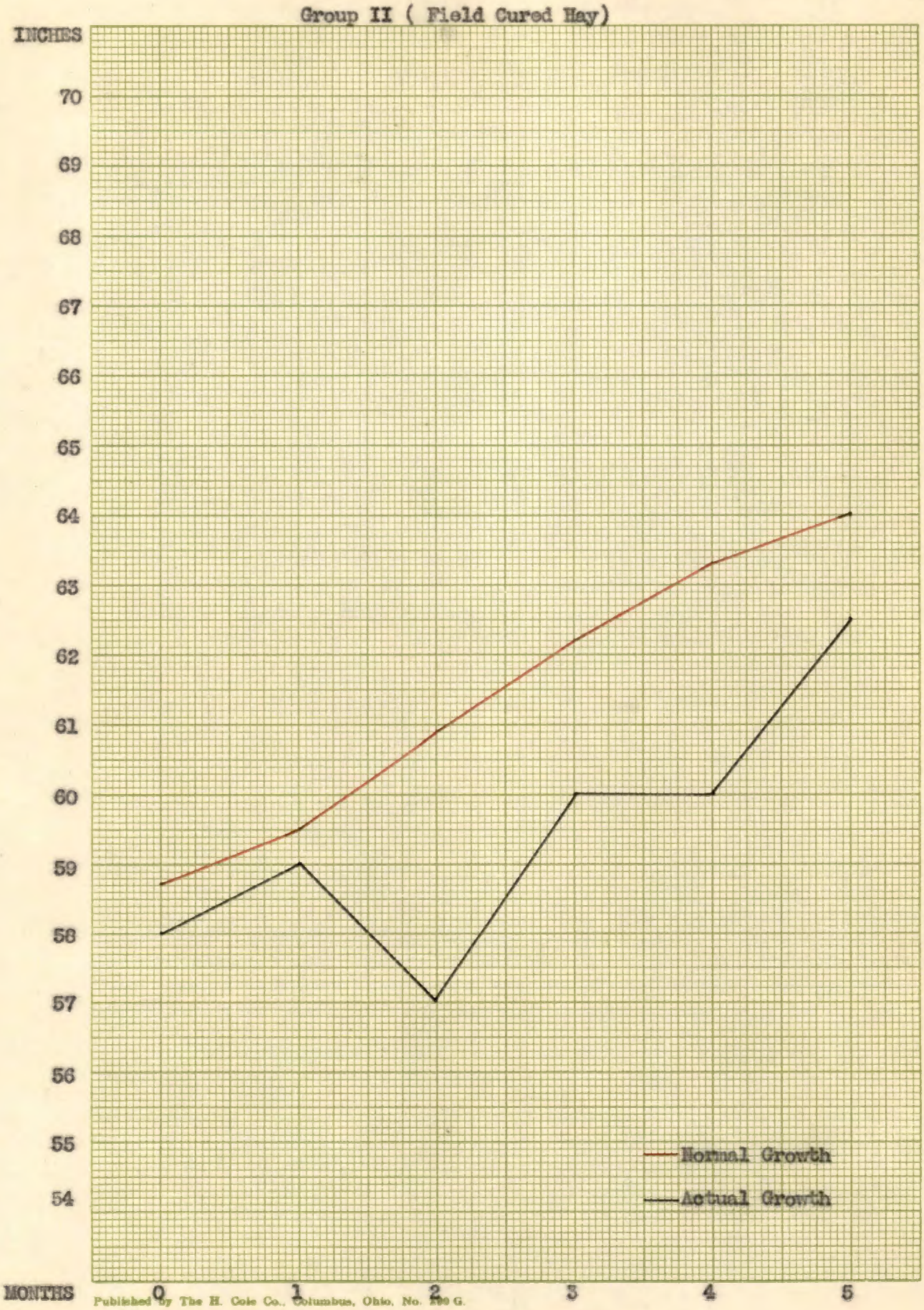


Figure 43. Growth Rate (heart girth) of Heifer No. 323

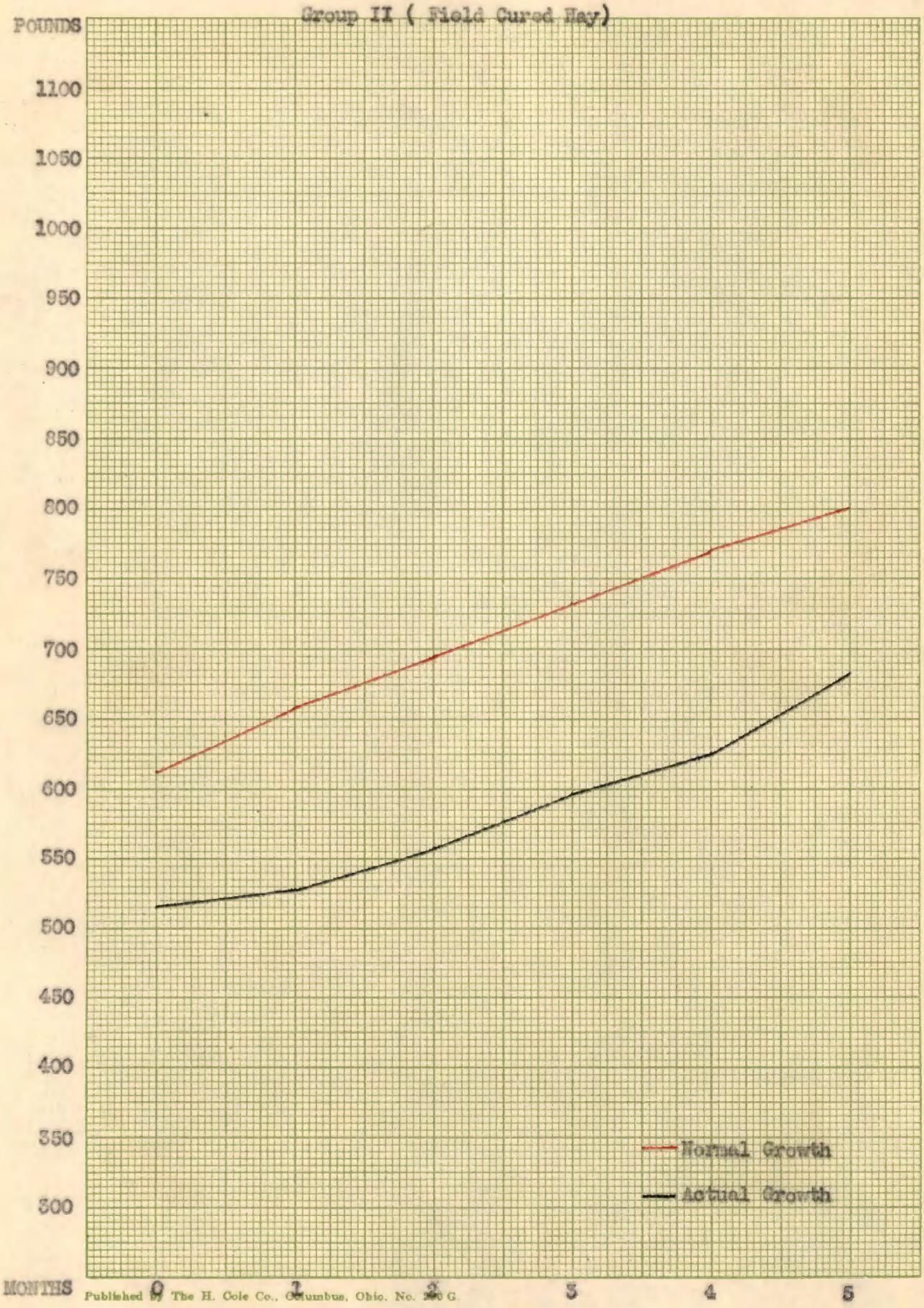
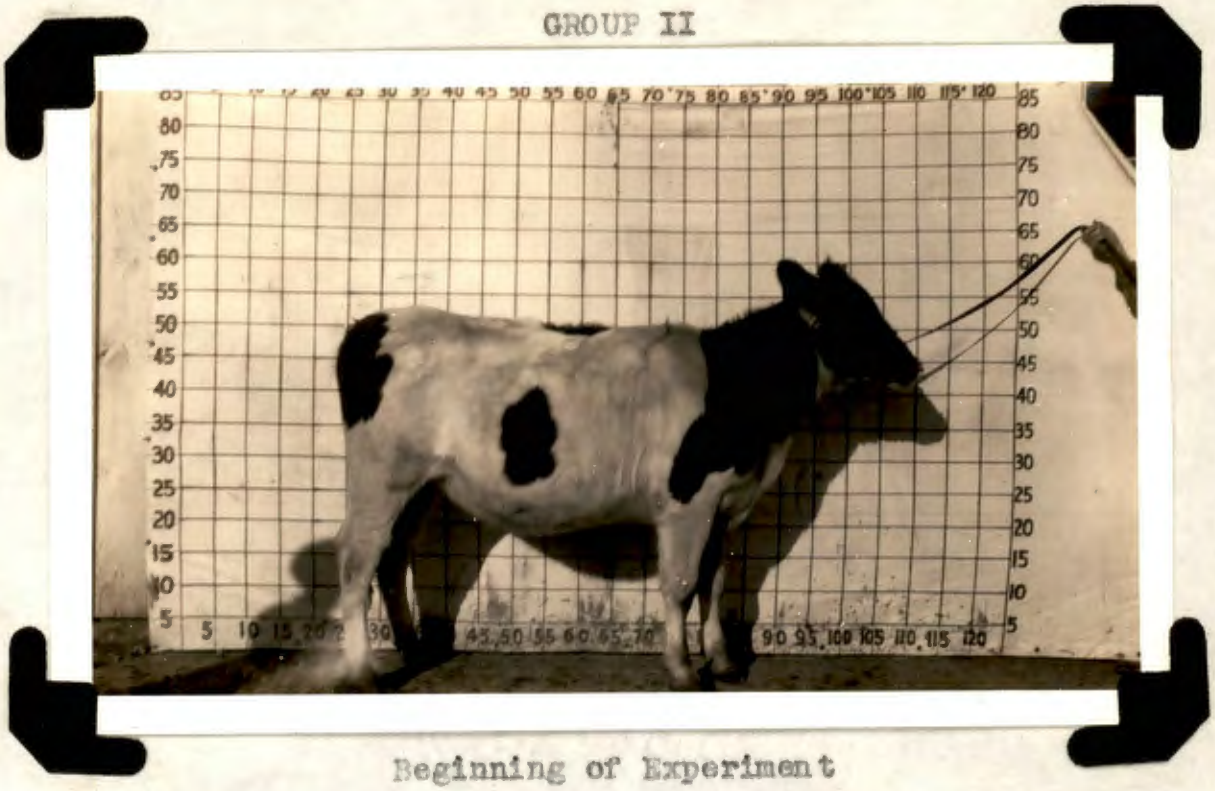


Figure 44.- Growth Rate (weight) of Heifer No. 323

GROUP II



Beginning of Experiment
Age 15 months and 26 days



End of Experiment
Age 20 months and 26 days

Figure 45. Photographic Growth Rate of Heifer No. 319

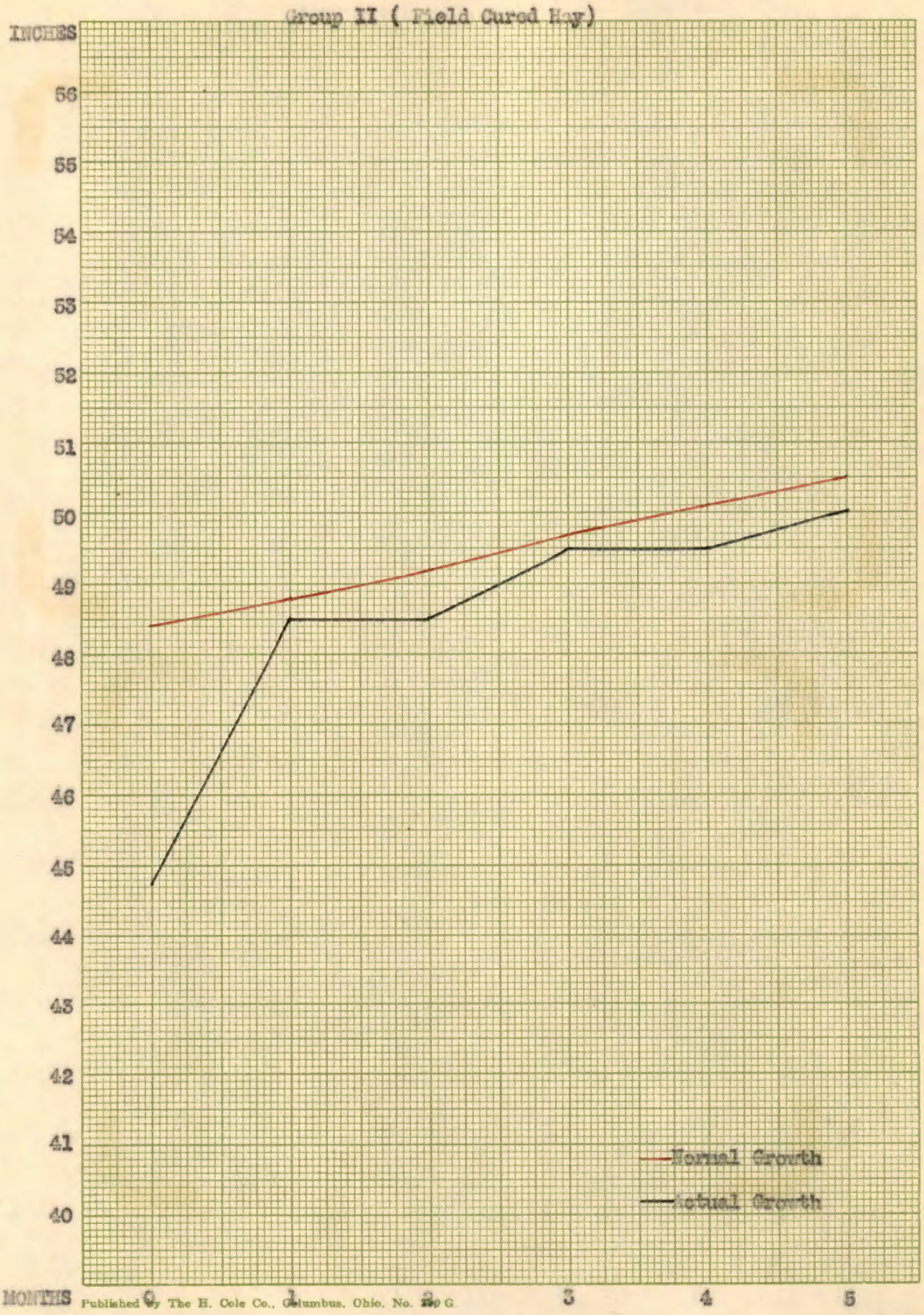


Figure 46.- Growth Rate (height) of Heifer No. 519

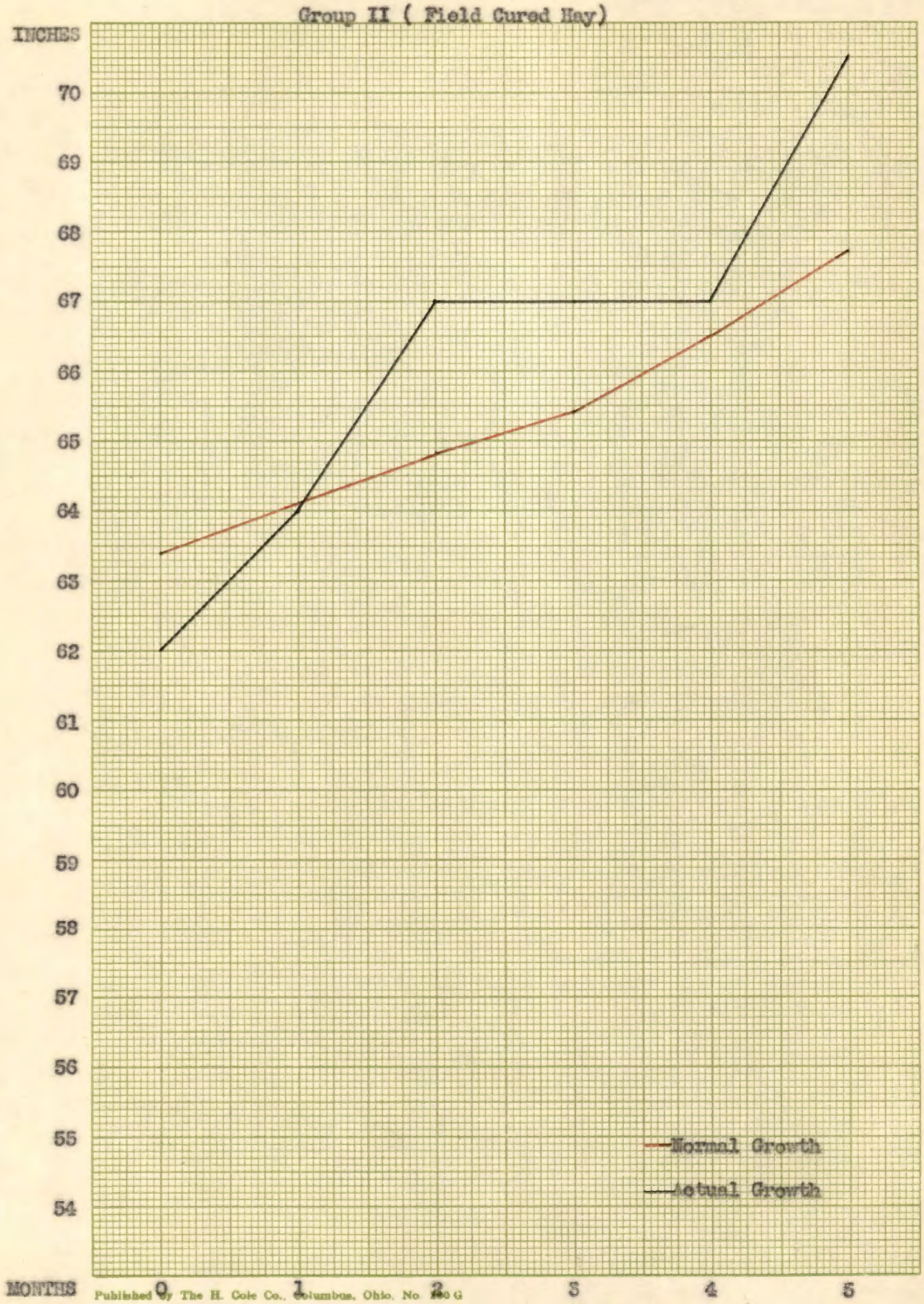


Figure 47 - Growth Rate (heart girth) of Heifer NO. 319

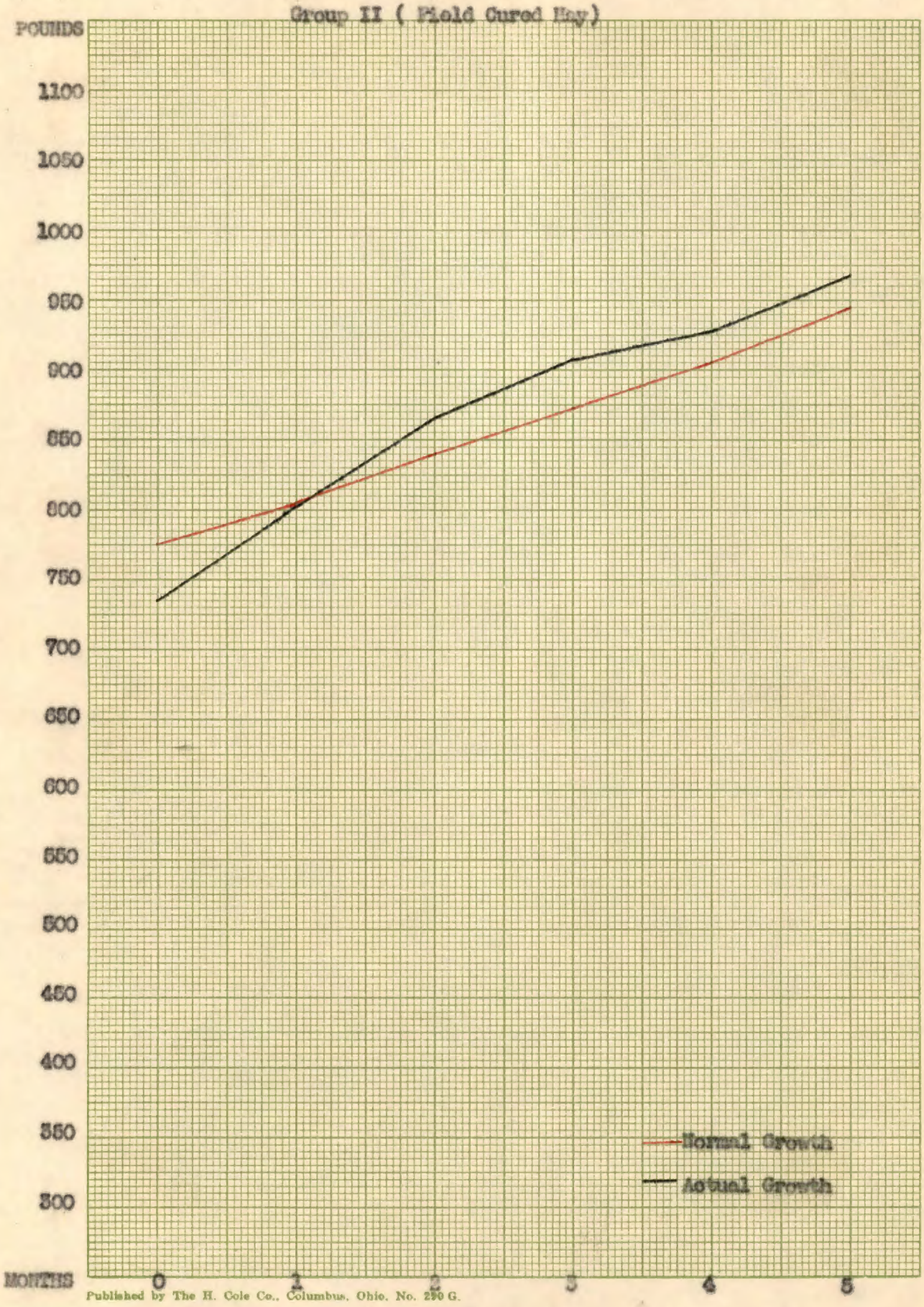
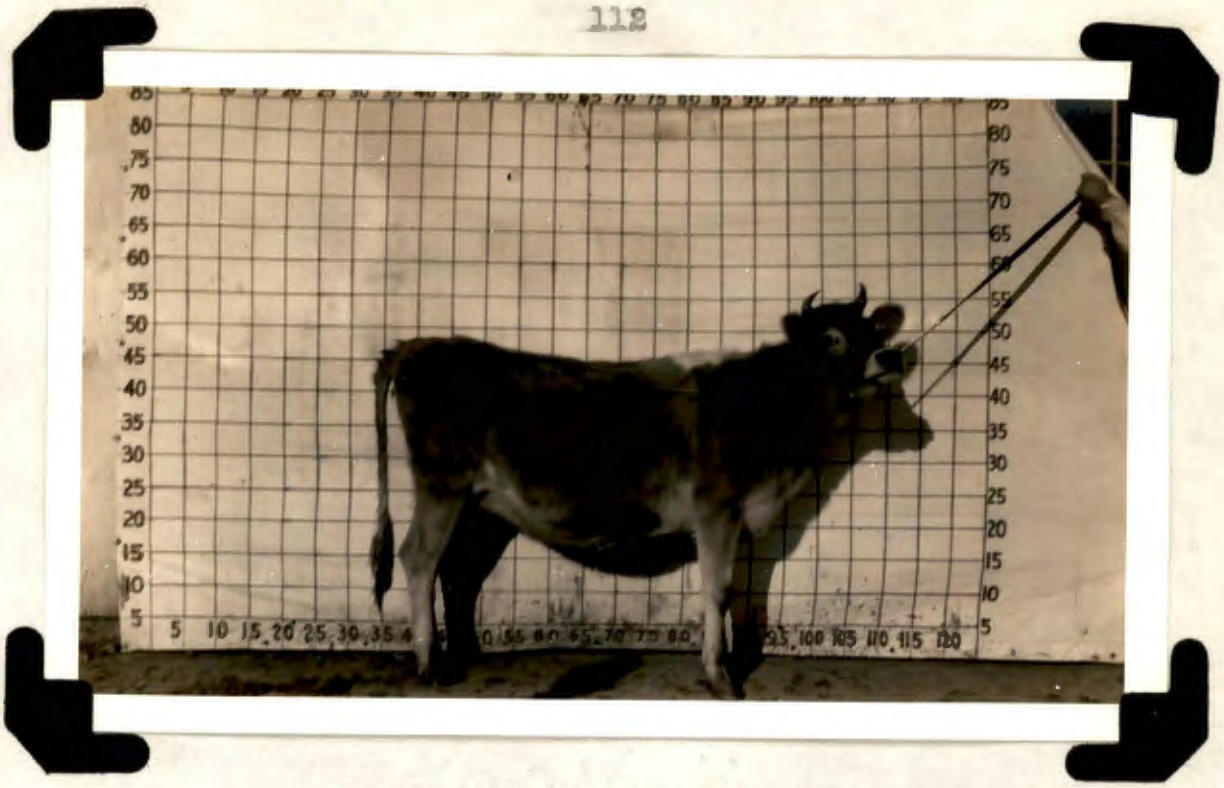
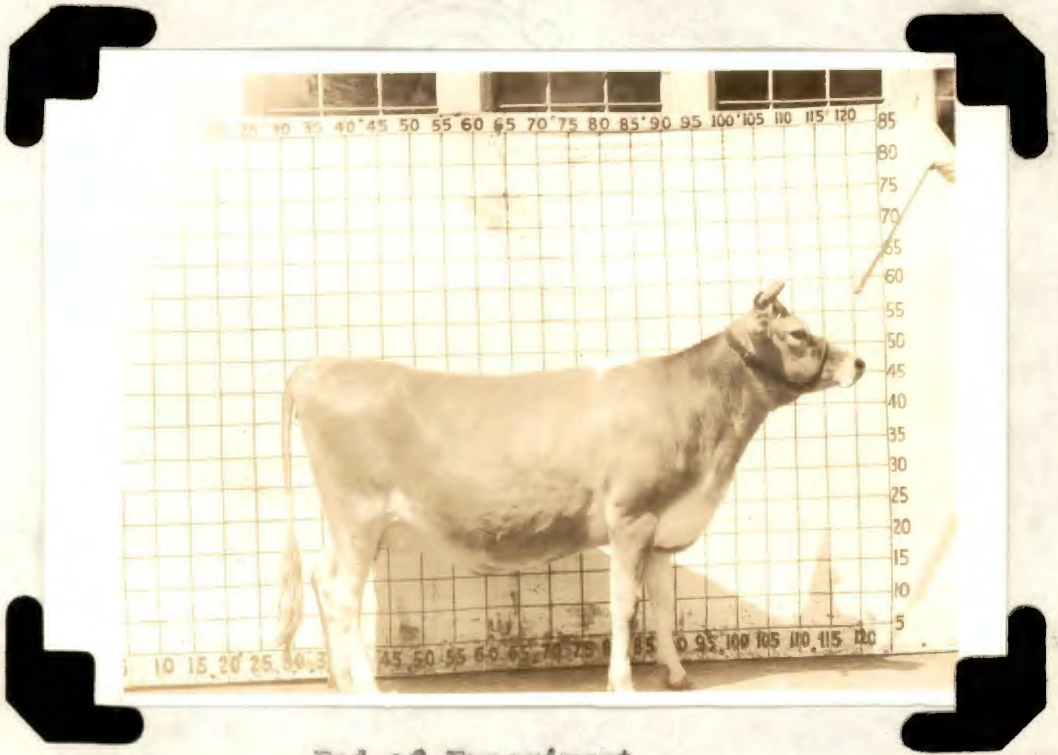


Figure 48. Growth Rate (weight) of Heifer No. 319



Beginning of Experiment
Age 22 months and no days



End of Experiment
Age 27 months and no days

Figure 49. Photographic Growth Rate of Heifer No. T63

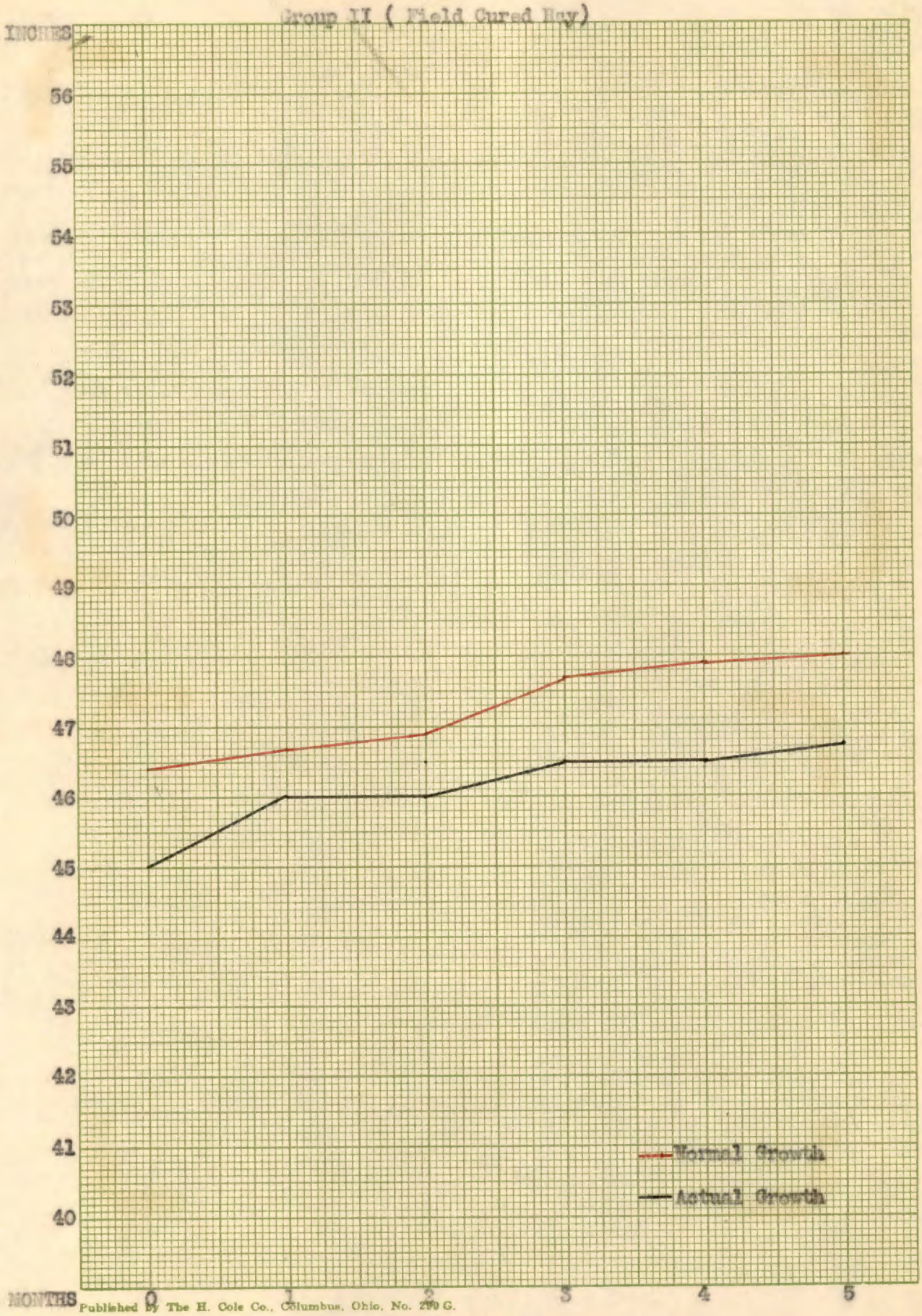


Figure 50.- Growth Rate (height) of Heifer No. T 63

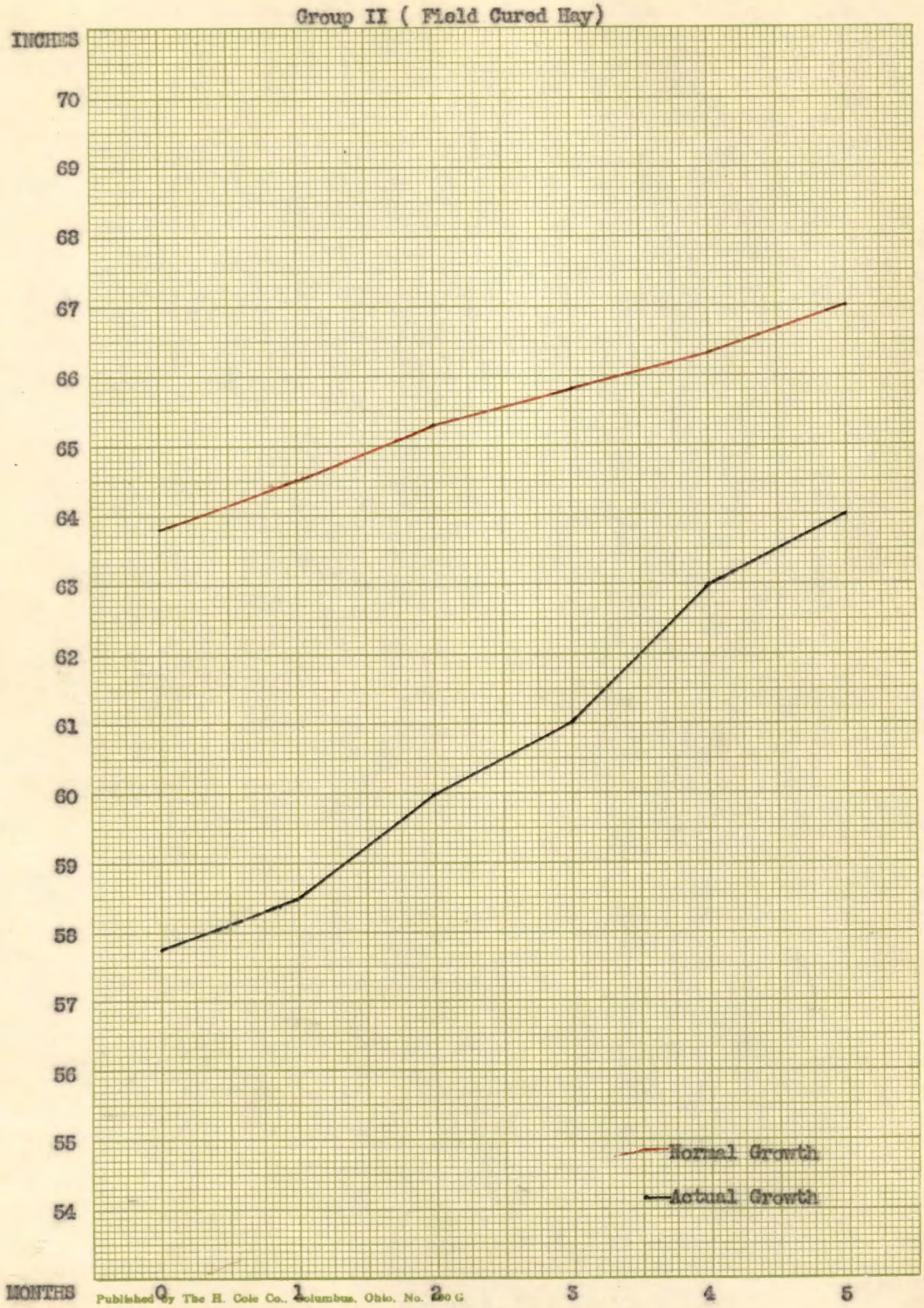


Figure 51.- Growth Rate (heart girth) of Heifer No. T 63

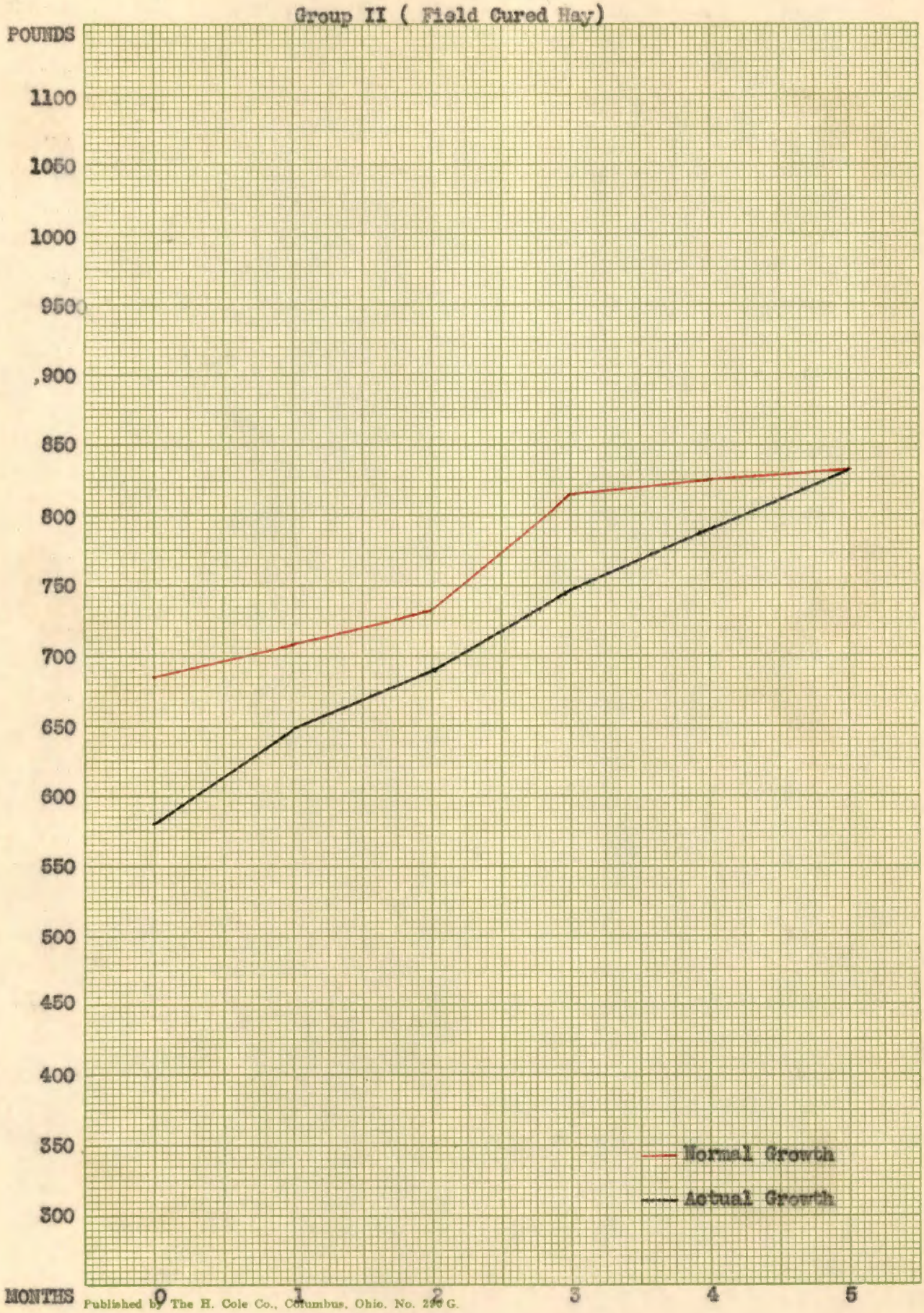


Figure52.- Growth Rate (weight) of Heifer No. T 63

GROUP II



Beginning of Experiment
Age 15 months and 22 days



End of Experiment
Age 20 months and 22 days

Figure 55. Photographic Growth Rate of Heifer No. T67

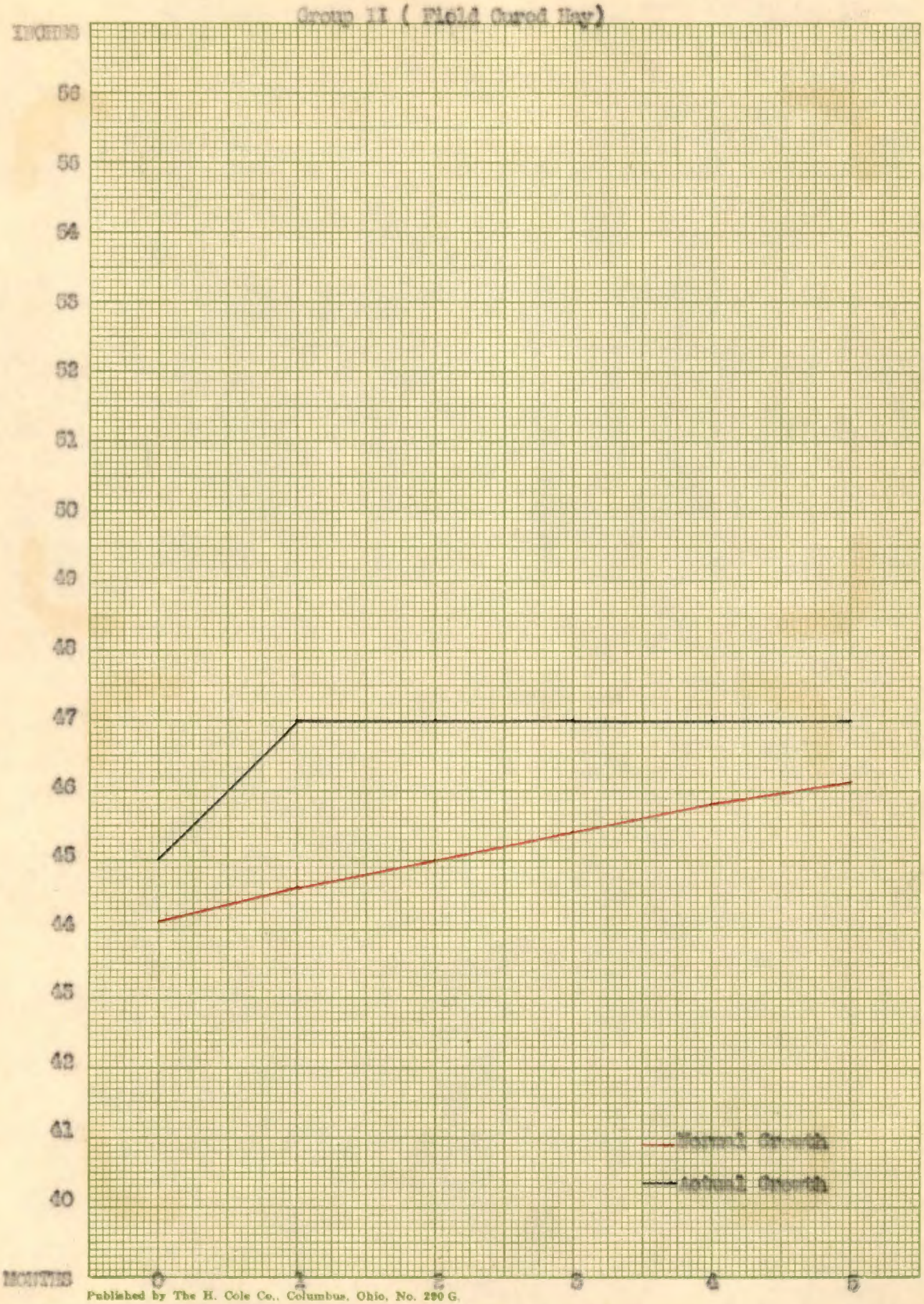


Figure 54. Growth Rate (height) of Heifer No. T 67

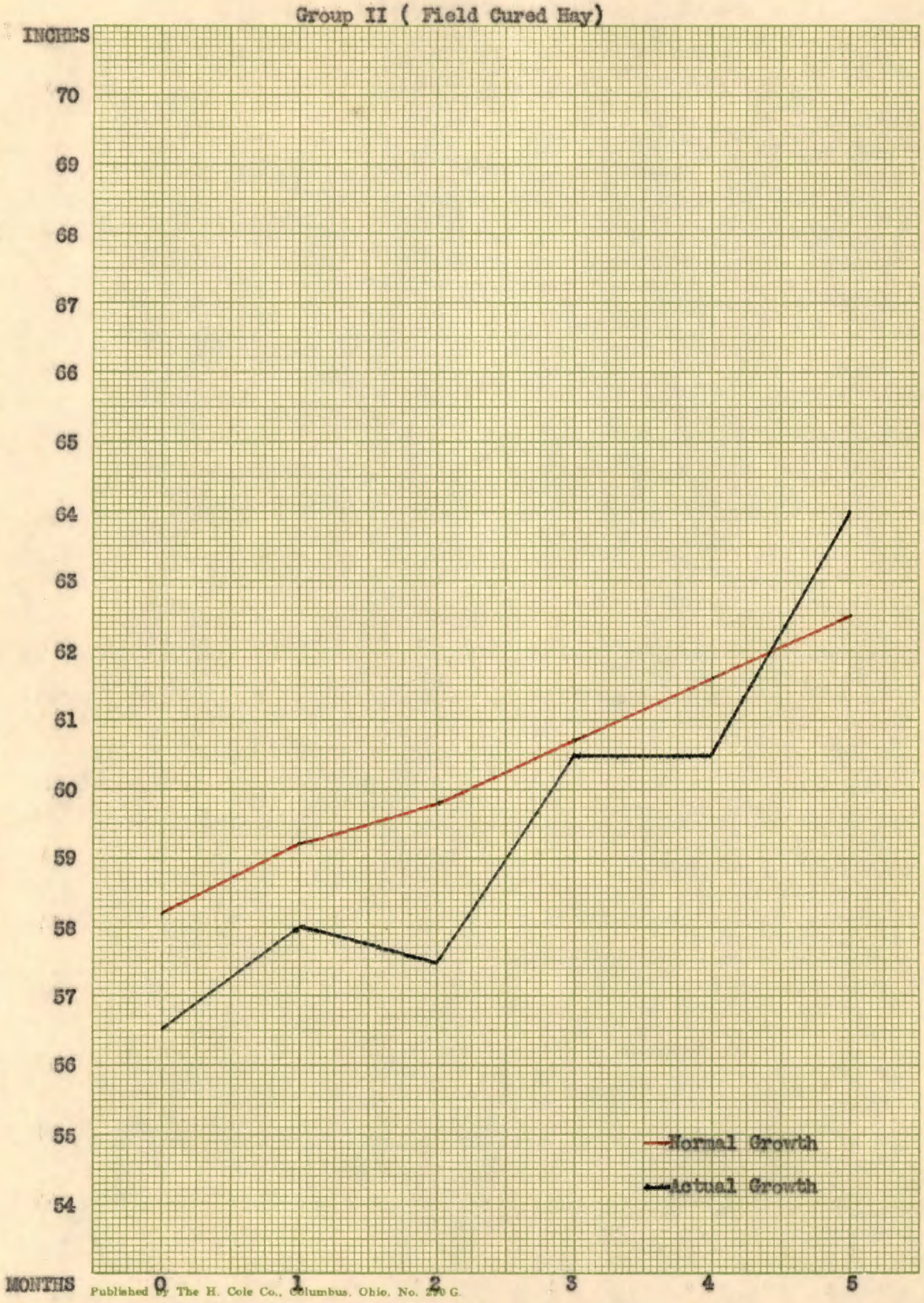


Figure 55. Growth Rate (heart girth) of Heifer No. T 67

Group II (Field Cured Hay)

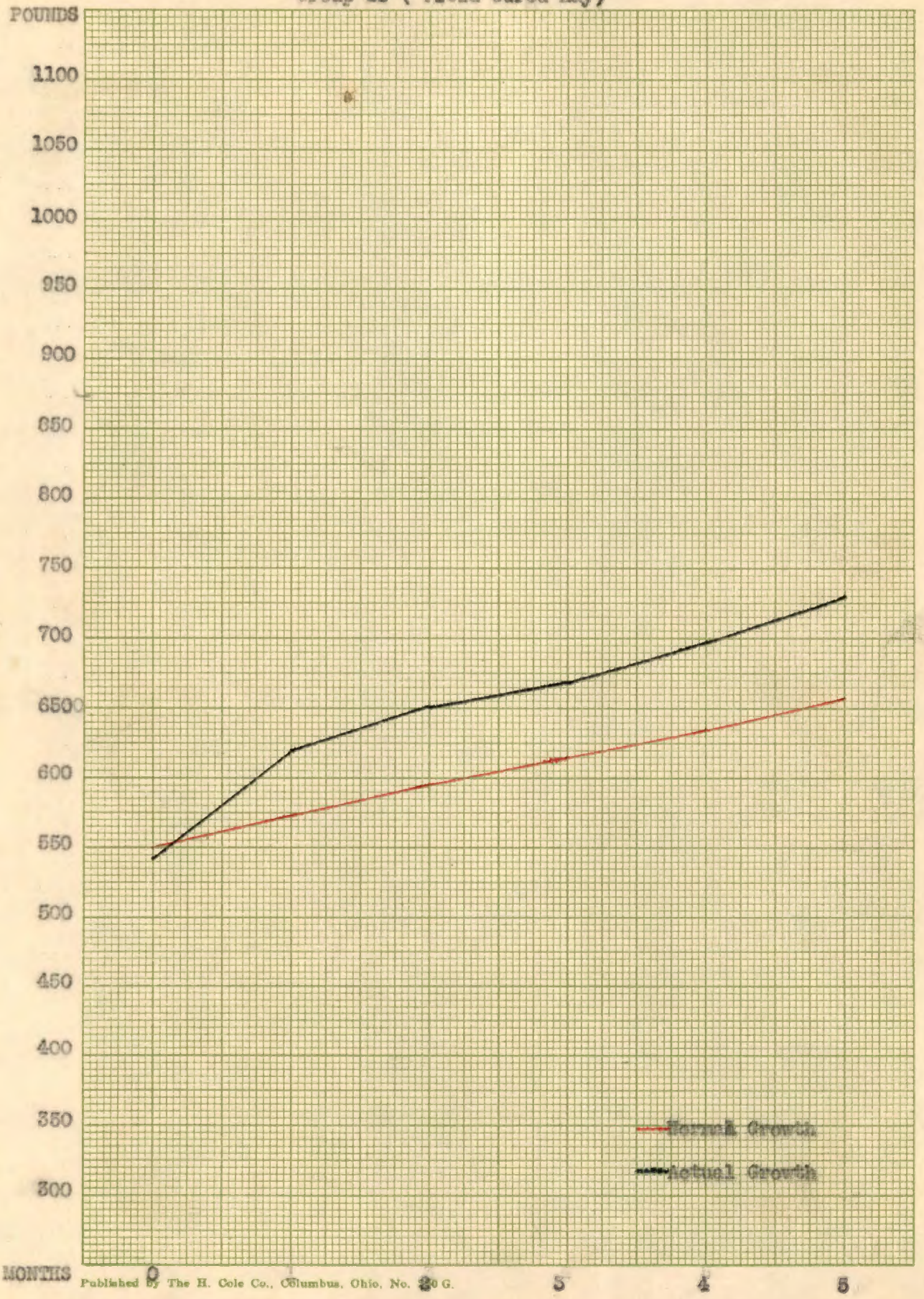
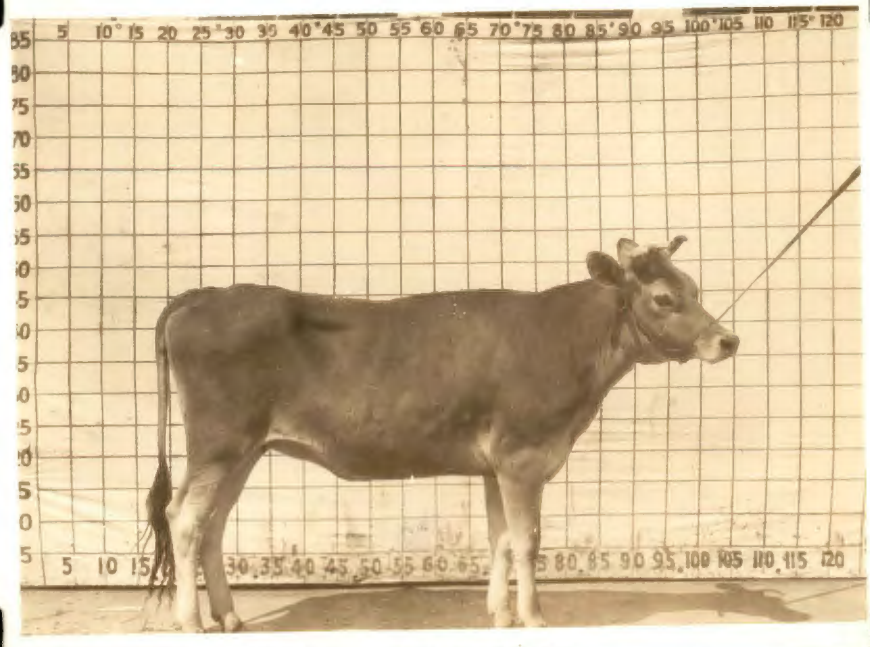


Figure 56.- Growth Rate (weight) of Heifer No. T 67

GROUP II



Beginning of Experiment
Age 12 months and 19 days



End of Experiment
Age 17 months and 19 days

Figure 57. Photographic Growth Rate of Heifer No. T70

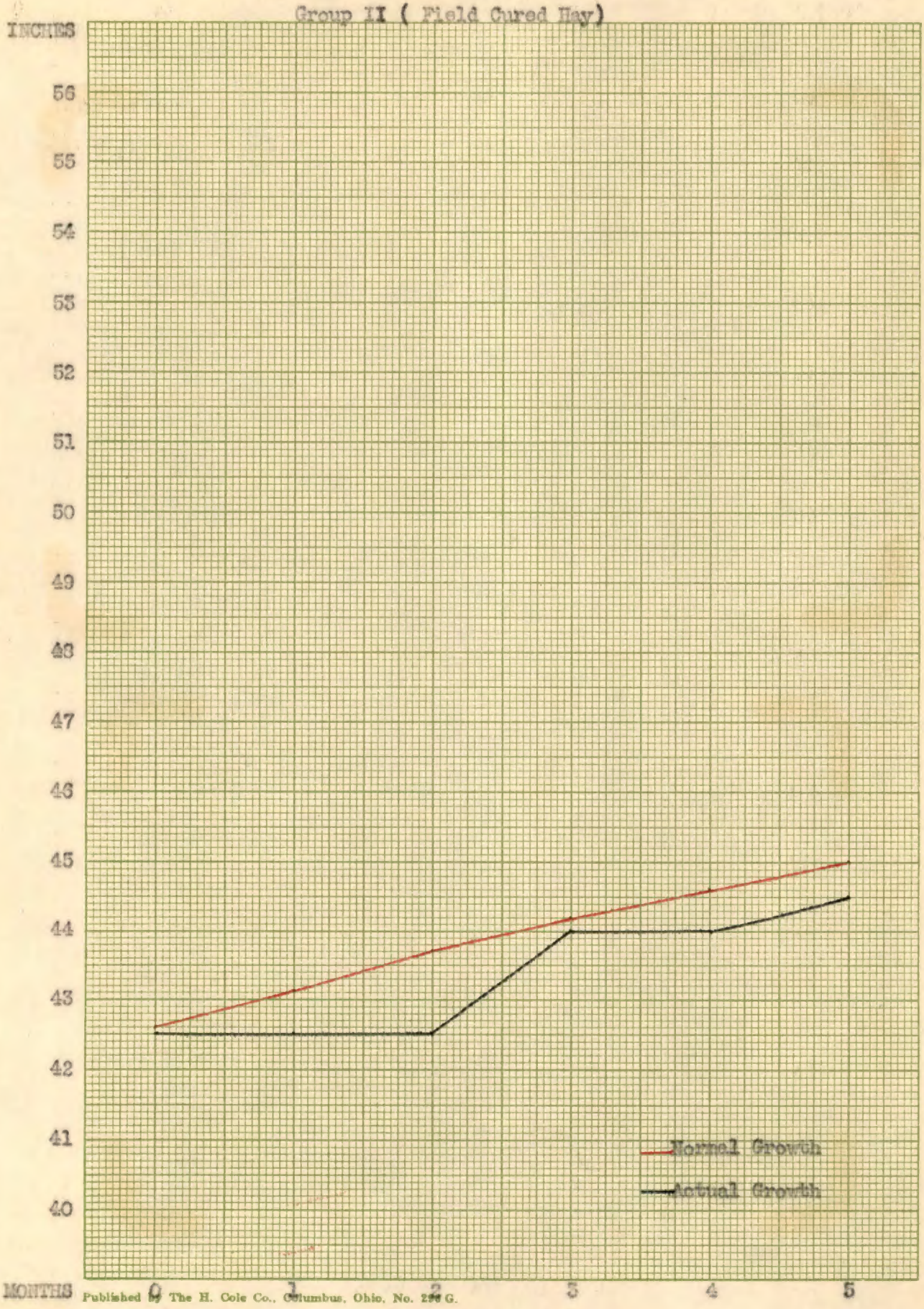


Figure58.- Growth Rate (height) of Heifer No. T 70

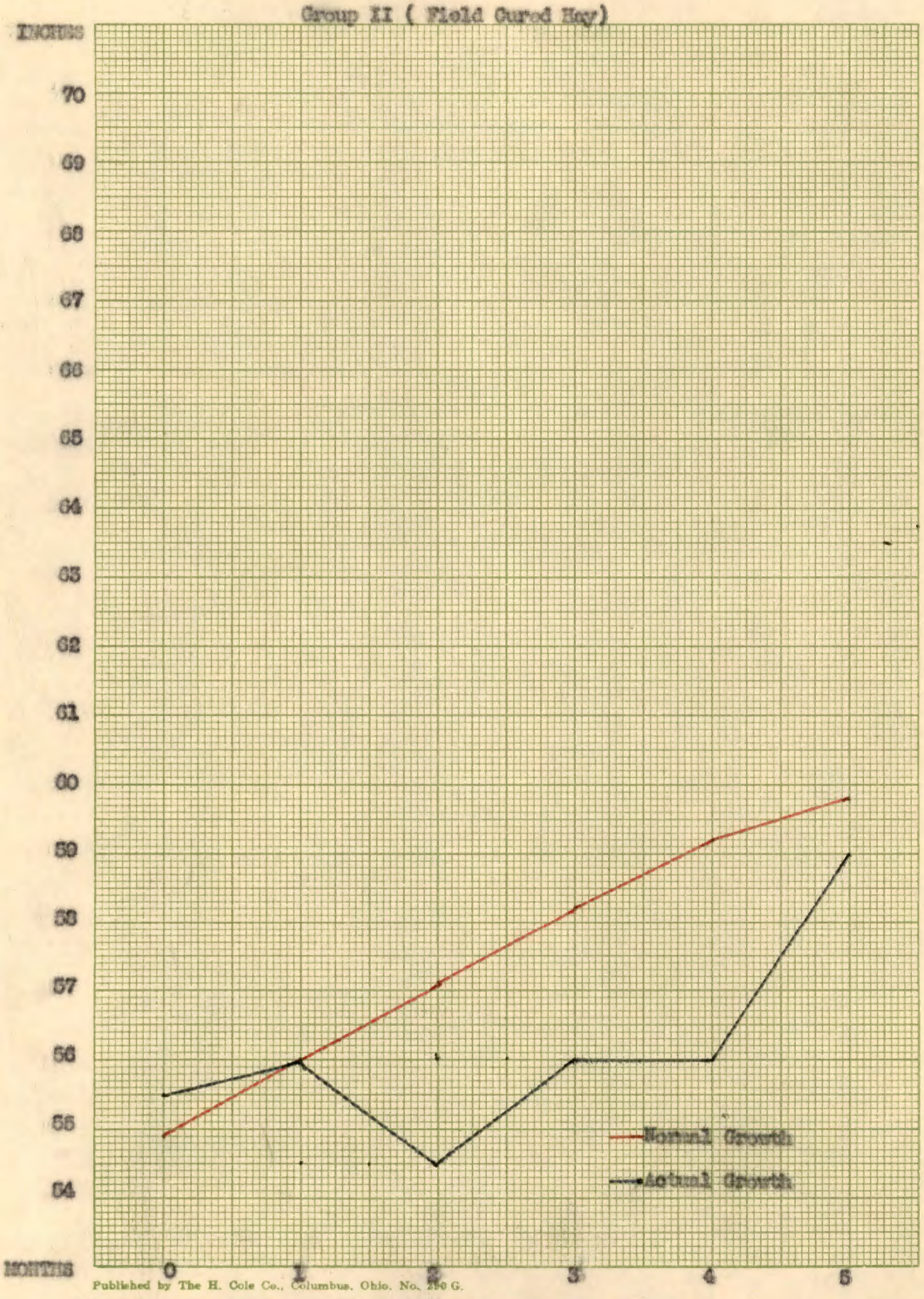


Figure 59.- Growth Rate (heart girth) of Heifer No. T 70

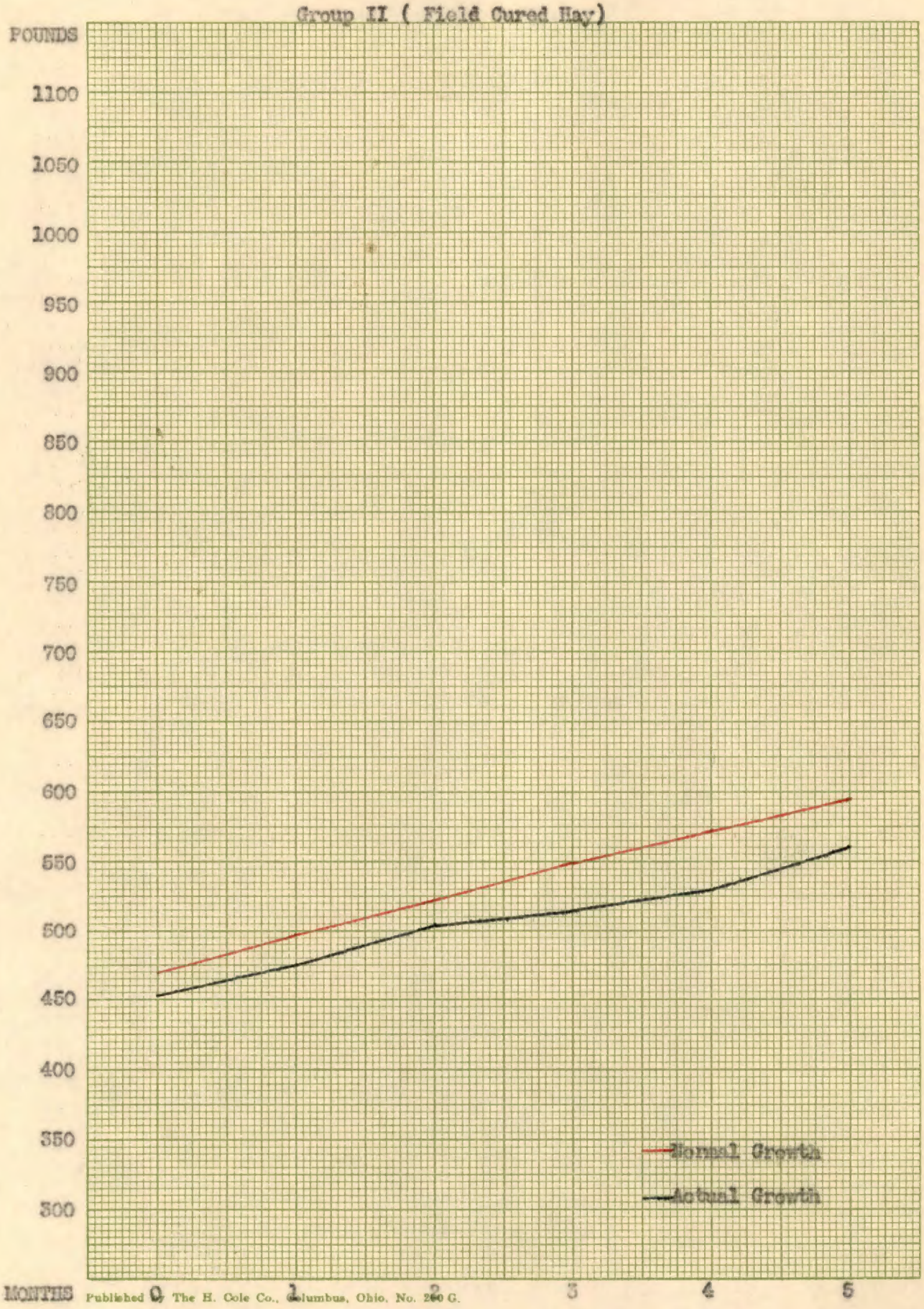


Figure 60. Growth Rate (weight) of Heifer No. T 70

DISCUSSION OF RESULTS

TABLE XVIII. TOTAL FEED AND GROWTH SUMMARY
150 Days (5 animals)

	Group I	Group II
Total hay consumed, lbs.	9,821.00	8,884.00
Total concentrates, lbs.	1,500.00	1,500.00
Total silage, lbs.	7,500.00	7,500.00
Total gain in height, inches	13.75	14.00
Total gain in heart girth, inches	34.50	30.25
Total gain in weight, lbs.	1,122.00	946.00

The results given in Table XVIII show that Group I gained 4.25 inches more than Group II in heart girth; this is not very significant. Group II grew 0.25 of an inch more than Group I. Group I gained 176 pounds more than Group II or an average of 44 pounds per animal over the period of five months. The gain in weight of Group I is the most significant difference of the two. The other differences are so slight that they might be within the range of experimental error.

Group I ate more hay than Group II. This indicates that the hay was more palatable to the heifers. For this reason one should expect a little more gain in weight. Both groups of heifers ate the same amount of silage and concentrates.

The heifers grew about normal in most cases. In weight 4 of the heifers gained below normal, one normal, and 5 above normal. The normal is how they should grow according to Ragsdale in the Missouri Bulletin 336. They grew very ir-

regularly in heart girth.

The data indicate that there was very little difference in the feeding value of the two hays for dairy heifers. The heifers fed the air dried hay gained a little more weight than those fed sun cured hay, thus causing a slight difference in the hays.

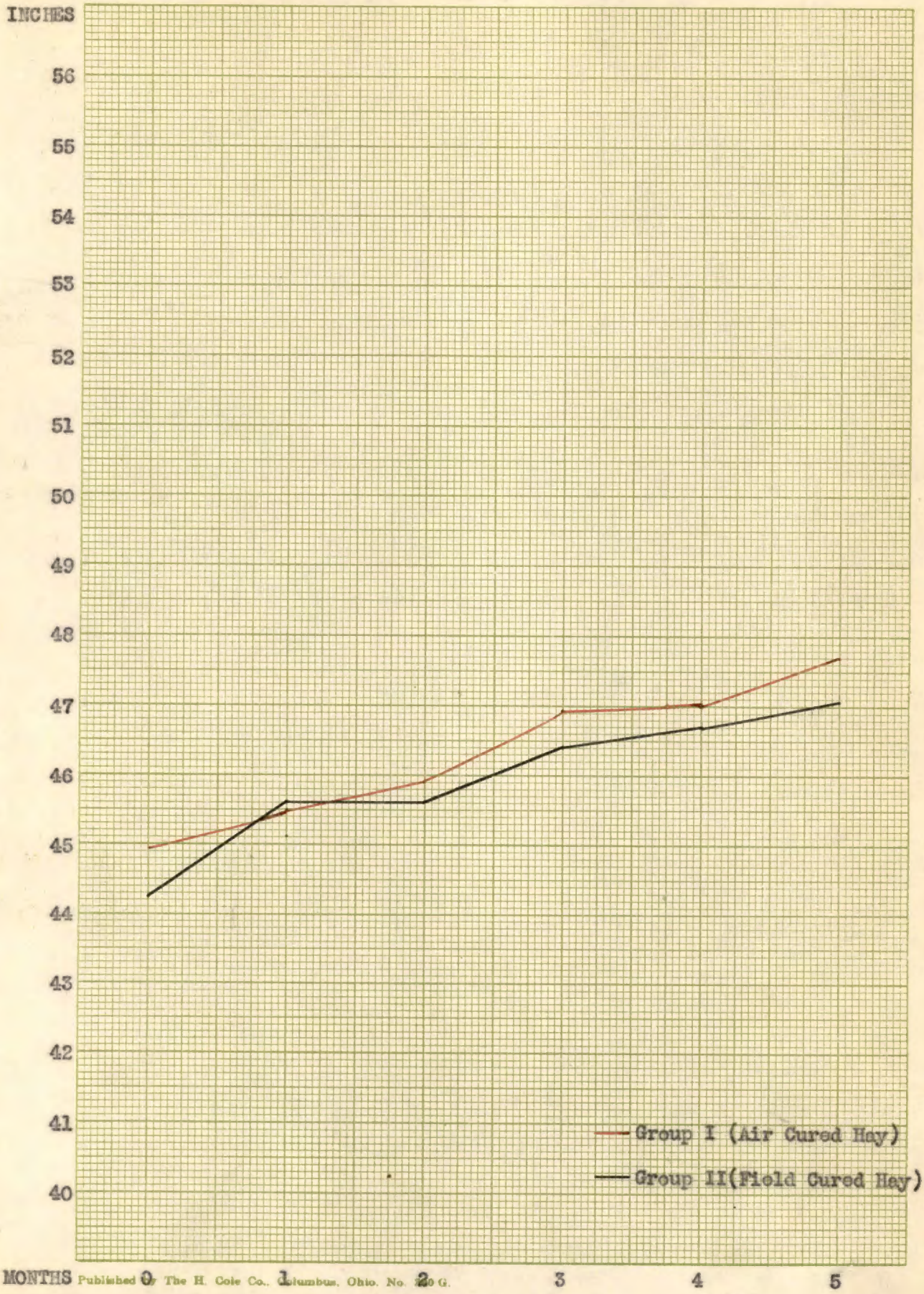


Figure61.-Average Growth Rate (height) of Groups

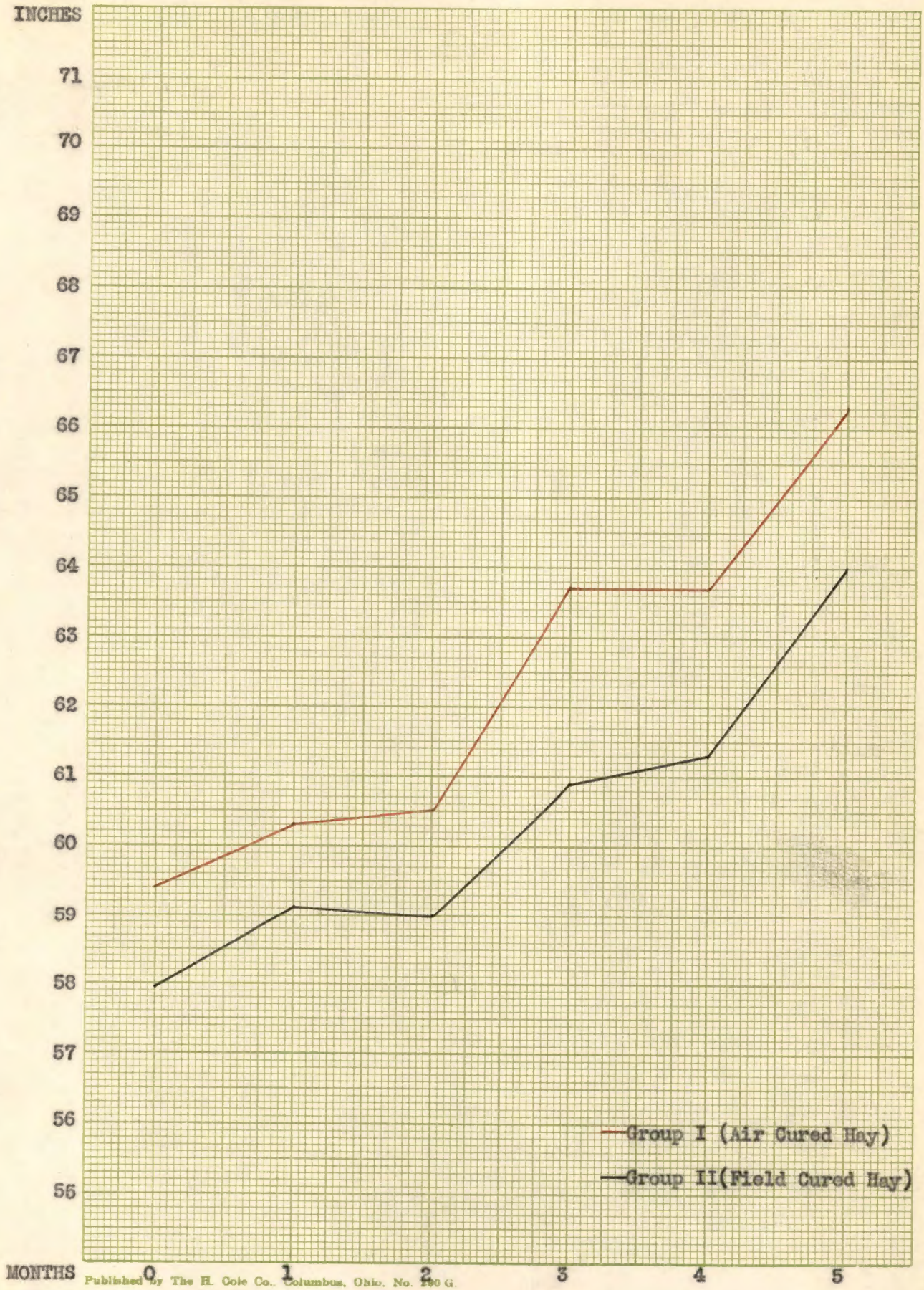


Figure 62.—Average Growth Rate (heart girth) of Groups

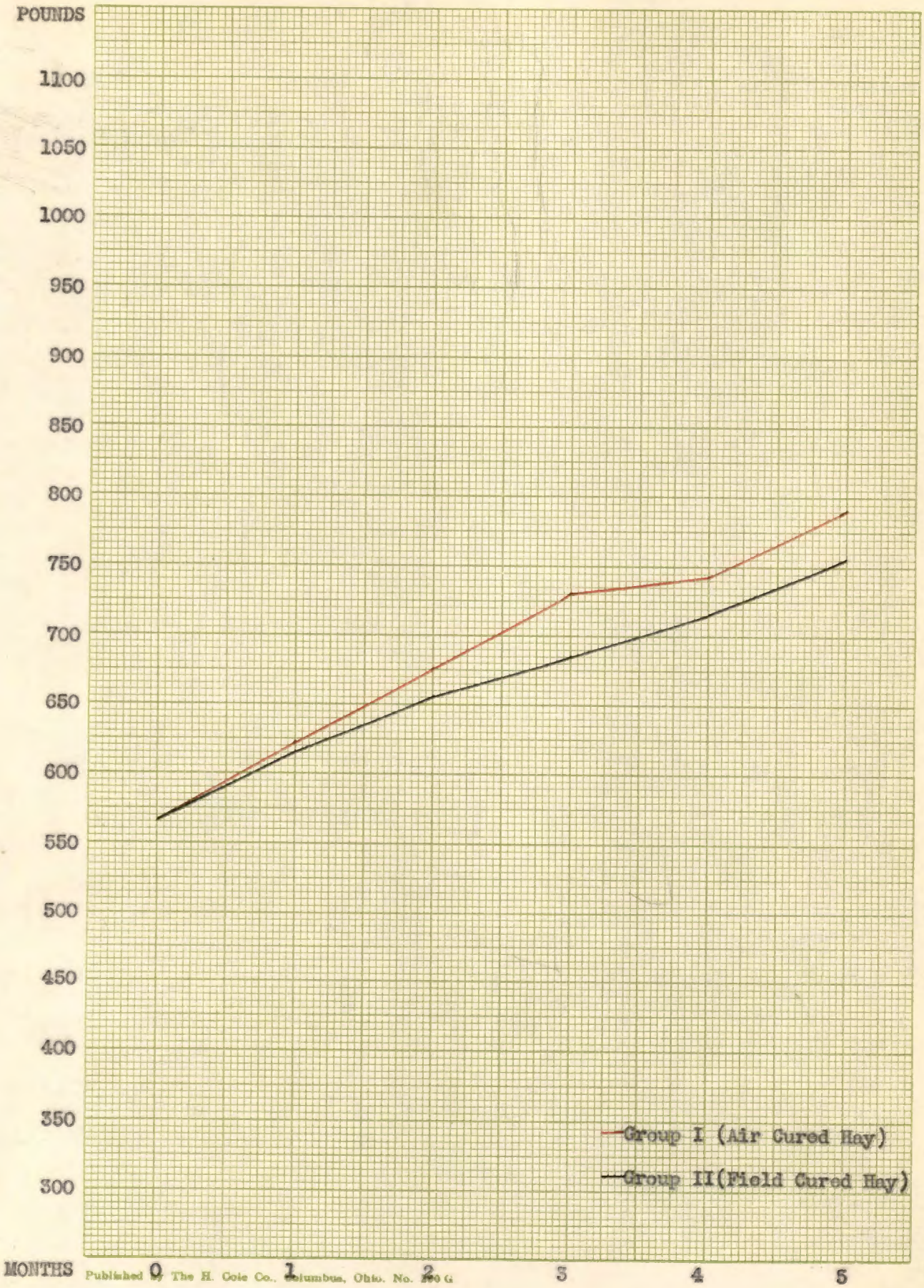


Figure63.-Average Growth Rate (weight) of Groups

TABLE XIX. GROWTH SUMMARY (5 Months)

No.	Height inches	Heart Girth inches	Weight pounds
Group I. Air Cured Hay			
T66	1.50	9.50	208.00
T68	2.50	6.00	179.00
T64	2.25	4.00	221.00
322	4.50	7.75	292.00
324	3.00	7.25	222.00
Total	13.75	34.50	1122.00
Average	2.75	6.90	224.40
Group II. Field Cured Hay			
323	3.00	4.50	167.00
319	5.25	8.50	233.00
T63	1.75	6.25	253.00
T67	2.00	7.50	186.00
T70	2.00	3.50	107.00
Total	14.00	30.25	946.00
Average	2.80	6.05	189.20

SUMMARY AND CONCLUSIONS

1. Due to the difference in the quality of the silages fed the cows, the results are not a fair test of the legume silage. Further feeding trials with good quality legume silage should be made before the true value of Lespedeza sericea as a silage can be determined.
2. The cows in Group I ate an average of 50.8 pounds of silage per animal per day; those in Group II ate 26.6 pounds per animal per day; and those in Group III ate 21.9 pounds per animal per day.
3. There was a slight difference in the feeding value of the air cured hay over the sun cured hay. The same thing was found to be true in feeding dairy heifers last year.

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