PREDICTING COMMERCIAL MILLING RESULTS BY EXPERIMENTAL MEANS

by

DINESH MEHROTRA

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Approved by:

Arlin B. Ward
Major Professor

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INTRODUCTION

"Quality evaluation" of wheat varieties is a very broad term and its meaning differs greatly from user to user. The farmer looks for a variety of wheat that has a high test weight, a high yield per acre, a high Zeleny sedimentation value, high protein, the usual agronomic characteristics such as rust resistance and winter hardiness, and is disease and insect resistant. He is helped in this quality evaluation by a team of highly qualified and experienced workers--the agronomists, plant breeders, pathologists, entomologists, geneticists, biochemists and others. Also helping him are the various testing laboratories and agencies, both private and government.

The elevator operators, grain dealers, and Board of Trade Operators consider the quality of grain in terms of being sound, clean and free of insect and rodent infestation and high in test weight. In the case of bread wheats, a high protein and Zeleny sedimentation value provide premiums. These grain handlers want the grain to leave the elevators meeting the highest possible standards of the official grain standards of the United States Department of Agriculture.

To the milling company, milling quality is a very broad term and embodies the many factors that affect the milling process. Quality wheat, as the operative miller sees it, must be sound clean wheat, free of screenings, of medium hardness, plump in size, high in test weight, whose bran cleans up easily while going through the mill. He also desires bran that does not shatter into fine particles but remains in large flakes, and has a free bolting high yield of flour (9). Since commercial milling is largely mechanical and can be altered only with difficulty, it is desirable to have wheats that conform to and mill well according to a standard method. Testing wheats for their relative milling quality is done with respect to such factors as tempering, the amount of sizing stock, the amount of power required to reduce the middling stocks, the flour yield, the ash content and the color of the resulting flour. The relative hardness or softness of the wheat is of considerable importance. A variety may mill well as an individual sample, but may not be compatible in blends with other varieties. In commerce, varieties of wheats are blended together, thus necessitating this compatibility.

Baking quality is a summation of the effects of many environmental and varietal characteristics on the production of white pan bread, such as absorption, mixing, dough development, and the acceptability of bread as regards its color, texture and volume.

Numerous tests and experiments have been conducted by various workers through the past 25 years, in search of a single or group of such tests which would bring out more clearly this quality concept of the "milling quality."

The object of this study was to find out if it is possible to predict the commercial milling value of a wheat variety by means of a simple known physical or chemical test on the wheat itself or on its milled products. The milling value of wheat is the total value in dollars assigned to the milled products produced from wheat. The Kansas State University's Pilot Flour Mill for the purpose of this study was considered as a commercial flour mill.

REVIEW OF LITERATURE

In simplest terms, the evaluation of wheat for milling involves the following considerations (40):

(a) The cleanliness of the wheat
(b) Flour Yield
(c) Type of wheat (hard or soft)
(d) Uniformity of kernel size and shape
(e) Kernel size (1000 kernel weight)
(f) Response to conditioning
(g) Thickness of bran and aleurone layer
(h) Behavior during milling.

Test weight is considered because of the assigned importance in wheat grading systems. Higher prices are paid for wheat of greater test weight because, as a general rule, test weight is indicative of potential flour-yielding capacity. However, varieties may show considerable variation in test weight, and yet not show corresponding variation in flour yield. There are many factors which influence the test-weight, such as moisture content, shape of kernel, condition of bran coat and internal air space. Flour yield depends mostly on the percentage of endosperm present. Available data show this relationship to be reliable. However, as the test weight of kernel plumpness increases, the potential flour yield decreases (22, 40, 44).

The amount of impurities or dockage---where wheat is contaminated with foreign materials, such as weedseeds and other grains or inseparable stones--its value is decreased for milling because of the cost and difficulty of cleaning, and in the loss of flour yield. Up to a certain percentage, these impurities cost as much as the wheat itself.

Hardness or softness play a vital role in determining the milling value of wheat. Some measurements of hardness must be established before milling operation takes place. This information is used in conditioning and in the alteration of grinding pressures, sifting and purifying operations (29). Tests are applied to determine the density of tempered wheat, but these are not routinely applied to untempered wheat. There are several methods employed to measure the hardness of the wheat kernel. Pearling of the wheat in a barley pearler is such a method (25).

The weight of the kernel is another measurement which is used in evaluating milling quality. It is usually reported in 1000 kernel weight, and is indicative of the size of the kernel, but does not indicate the shape. A high 1000 kernel weight is indicative of plump wheat (40).

Simply stated, milling evaluation of wheat is based on freedom from contamination, low moisture content, high test weight, and response to conditioning and millability. The aim is to obtain the highest flour yield (37).

Millers, everywhere insist that more knowledge of wheat in relation to milling be obtained and the pertinent facts be made known to wheat breeders. In the future, millers hope for improved wheat for milling purposes (40).

Of all physical tests developed and performed on the wheat to predict its milling quality, none has found as much favor as experimental milling. Experimental milling consists of milling small samples correlating the results with those of commercial milling.

According to Miller (27), "The purpose of experimental milling is no more than the gathering of evidence concerning the characteristics of given small samples of wheats." If the samples are truly representative of large lots from which a mill mix may be made using one or a blend of several, the operation can be very much worthwhile. The evidence obtained may not be of such a nature as to permit exact instructions for tempering and milling on the commercial unit, although helpful suggestions may come from a careful consideration of the facts revealed.

Human (20) stated that experimental milling testing is valuable for separating from wheat samples a definite amount of flour. This flour closely resembles, in terms of routine analytical factors, characteristics of the products of commercial milling of approximately the same extraction. Tests made on the experimentally milled flour, allow close approximation of the anticipated characteristic nature of different extractions obtained in commercial milling from the same wheat or blend.

Pascoe et al. (28) showed that there is a significant correlation coefficient (r = +0.797 ± 0.041) between experimentally and commercially milled flour, with respect to its protein content. Bailey and Markely (6) found a correlation coefficient between the flour yields of commercial and laboratory milling tests of +0.59 ± 0.07 with the laboratory relative humidity being controlled. The relative humidity of the commercial mill was not controlled.

Anderson (1), in making a comparison of experimental and commercial milling results, showed that commercial units used a greater number of grinding operations for reducing the endosperm to flour. With the experimental laboratory mills, i. e., Buhler, Allis-Chalmers, etc., with a small number of grinding operations, the grain was subjected to more severe grinding than was practiced in the commercial mills with 5 to 6 breaks.

Experimental milling requires different conditioning of the grain than for commercial milling. Therefore, a slightly different procedure is required for experimental milling. Usually a higher moisture content toughens the bran allowing it to withstand more severe grinding action. The endosperm, being softer and mellower, reduces more readily. This lessens the bran pulverization and lowers the ash content of the flours.

Experimental milling is conducted, to a large degree, according to individually formulated methods which secure the results desired by various operators. These methods are adapted to the kinds of wheat milled, the equipment available and the conditions under which the millings are conducted (3).

There is need for agreement on many factors and procedures of experimental milling. Before wheat is milled, it must be scoured and cleaned. These processes require standardization. Tempering of wheat to 16 per cent moisture for 24 hours could be used as a standard procedure. Likewise standardizing the mill room temperature to 80°F and 65 per cent relative humidity would be helpful (19).

Bayfield et al. (6) conducted studies on the affects of mill room temperature and relative humidity on the experimental flour yields and flour properties. They suggested that it is desirable to select atmospheric conditions that would tend to produce flours, as nearly as possible, identical in properties to those obtained by commercial milling.

The experimental laboratory mills fall mostly under the two groups, fully automatic and the batch system. Buhler experimental laboratory mill is an automatic type, and the Allis-Chalmers' the batch type. Much research has been done correlating the milling performance of these mills to various commercial mills.

Although the personal factor is dominant, good replication of milling results with the Buhler laboratory mill under controlled conditions and technique is possible. It has been concluded that the Buhler mill is useful for predetermining the commercial milling (5). Harris (18, 19, 20), showed that there is a great deal of uniformity in the milling results with this type of experimental mill. It can be used as a tool to give reliable information about the milling properties of the wheat. Seeborg et al. (34, 35, 36) suggests that the Buhler laboratory mill, with some modification in the feed rate and flow sheet, is effective in revealing the commercial milling quality of wheats. They further modified the Buhler mill for micro milling and stated that this detects the poor milling quality earlier in the breeding program. Comparison of micro yields with macro yields indicated that the low flour yield of the extremely poor milling varieties is magnified by the micro method.

Wheat quality workers are constantly trying to improve their methods of evaluating the merits of new varieties. Milling qualities have presented many problems arising from (a) the many factors entering into its evaluation and (b) the difficulty of measuring these factors accurately with the laboratory milling equipment. The conventional method of determining the fitness of a new wheat for milling has been to mill a small sample on one of the many laboratory mills. The miller evaluates the milling quality by one of these methods--total flour yield or yield of patent flour. These two measurements are generally used to indicate the fitness of wheat for milling. They are supplemented by observations of the miller classifying the middlings as hard or soft.

Seeborg (37) described the milling quality characteristics as follows:

(1) Feed rate	Rex	2400 G	25 Min)
	Elgin	2400 G	16 Min)

Elgin was considered best.

(2) Optimum milling moisture

Rex had to be milled below 12.5 per cent moisture while Elgin had to be milled at 14-14.5 per cent moisture. This meant a gain of 2 per cent in flour yield in favor of Elgin. This showed there was an obvious difference in response to added milling moisture, which should be considered in selecting new varieties.

(3) Both were plump and had high test weight. However, there was no evidence that one would consistently give a higher yield. Therefore, the effect of flour yield in milling value is unquestionable.

With this concept of experimental milling and its relation with the commercial milling, various workers at different times came out with different micro mills. They were capable of milling small samples from a 100 grain to 5 grain, to reveal the milling quality of the wheats (12, 14, 16, 23, 24).

Finney et al. (11) ran a comparison of the certain chemical, physical and baking properties of commercial, Buhler and Hobart milled flours. The millings were compared for flour yield, loaf volume potentialities, and other characteristics. The flours showed little difference in their properties except for the flour yield which was highest for the commercial mill. This was due to the large quantities milled on a longer system.

McCluggage et al. (24) showed that the variations of flour yield, ash and diastatic activity were greater for the Buhler mill than for the Allis-Chalmers mill when the millers were skilled and the atmospheric conditions were not controlled in the milling room.

Sibbitt (43) found a high positive correlation between the flour milled on Micro Hobart mill and Allis-Chalmers laboratory mill in relation to flour yield, flour ash and loaf volume. He suggested that a fairly reliable knowledge of milling performance may be secured by Micro millings.

Schmieder (32) draws attention to the other characteristics, in addition to the exterior features (cleanliness, moisture, insect, and microbe infestation and the organoleptical features) that influence the milling value of grain, such as broken kernels, small kernels, pest-bitten kernels, underdeveloped kernels and crushed kernels. According to him, the milling value was defined as the possibility to obtain a maximum yield of flour. The yield was considerably influenced by the ratio of the skin portion to the endosperm, and by the ash content of the endosperm. He also determined a group of correlations between numerous factors affecting milling quality, such as kernel ash, fiber, kernel size and others. He concluded that the only possible method for determining the milling quality was to apply the experimental milling test. With experimental milling as the final criteria as to the evaluation of the milling quality of wheat, a need arises for a good correlation between experimental and commercial milling results.

Johnson (21) has pointed out there must be a more unified testing program for the quality evaluation to fill the gap between experimental and commercial milling results. The relationship between flour yield, hardness, compatibility in blends, flour ash, and distribution of percentage extraction at each step in the flour has been utilized to predict what a wheat might be expected to do on the commercial unit.

Ash had been the main criteria in determining the quality of grain and its milled products. It is therefore considered to be highly correlated with flour color, acidity and the electrical conductivity of flour extracts. In other words, it is of significance in that it is highly correlated with the flour properties (10). Ash has long been used as a yardstick in the measurement of the mill performance. There can be no escape from the fact that, other things being equal, low ash is associated with good milling and high ash with poor milling. Robbins (31) has emphasized the importance of ash as the final value of flour and how it is used as indicative of the quality of products.

Wissmer (46) has suggested the use of cumulative ash tables and curves of the mill streams as a means of measuring the efficiency of the mill under consideration. The curves can be used to determine the percentages of any ash flour or the ash content of a certain percentage of the flour in the mill.

According to Shuey (41) the ash content of the flour can be used as a scale for measuring the milling characteristics and also for evaluating the performance of the mill.

Poor milling quality is not a function of flour yield alone, but is much more complex, involving the rate of milling, optimum milling moisture, total flour yield and ash content. With these factors Seeborg (37) suggested a formula for testing milling quality of Pacific Northwest Wheats.

Milling Index = 100 - (80 - yield) + 50 (Ash - 30) - (Milling Time - 15) + 0.2 (65 - % patent Flour) + 0.5 (16 - % Milling Moisture)

Seibel and Zwingelberg (38) suggested that the milling value could be obtained by the formula:

$$\text{Milling Evaluation Figure} = \frac{\text{Flour yield \% (1.00 - Ash content \% on dry basis) + reduction properties \% (100 - Semolina amount \%)}}{100} + \frac{10\ (1.00 - \text{Power consumption in kilowatts}) - \text{Break bran amount \%} \times (\text{starch content on dry basis})}{100.}$$

MATERIALS AND METHODS

Wheats used in this evaluation study were the 1961 and 1962 Hard Red Winter Wheat crops of the Hard Winter Wheat Quality Council. These crops consisted of the following varieties: Triumph, Comanche, Improved Triumph, New Improved Triumph, Super Triumph, Bison, Tascosa, Rodco, Wichita, Pawnee, Nebred, C.I. 13532, C.I. 13546, C.I. 13547 and Kaw. These varieties were grown over the states of Kansas, Texas, Nebraska, and Oklahoma.

Method of Cleaning and Tempering. All the wheat samples were cleaned on the Kansas State University's Pilot Flour Mill cleaning house (Fig. 1). The wheat cleaning flow of the Pilot Flour Mill consisted of a permanent magnet, pneumatic lift aspirator, milling separator, dry stone separator and gravity table, disc separators (oats and cockle), Entoleter scourer aspirator and duo-aspirator. Grain was conveyed pneumatically.

The wheats were received in sacks and blended in the cleaning house. The cleaning was done with the wheat flowing at the rate of 60 pounds per minute. The screenings were sacked and weighed. A sample of the clean wheat, before tempering, was submitted for analysis of protein, moisture, ash, and physical tests.

Conditioning or Tempering. All the wheat samples were conditioned to approximately 16 per cent moisture, using cold water and allowing it to have a rest period of about twenty hours. The conditioned wheat passed through a brush machine before being lifted to the pre-break roll via an Entoleter scourer aspirator.

The amount of water required to bring up the moisture content of the wheat to 16 per cent was calculated by the formula:

$$D_1W_1 = D_2W_2$$

$D_1 = (100 - m_1)$

where D_1 = Dry weight of the wheat

m_1 = Moisture of the wheat

$D_2 = (100 - m_2)$

D_2 = Dry weight of the wheat at desired moisture

m_2 = Desired moisture of the wheat

W_1 = Weight of wheat flowing per minute before addition of water

W_2 = Weight of wheat flowing per minute after addition of water

i. e. $W_2 = (W_1 + x)$ where x = amount of water added per minute

$$\frac{(100 - m_1)}{(100 - m_2)} W_1 = (W_1 + x)$$

$$\text{or } x = \frac{(100 - m_1)}{(100 - m_2)} W_1 - W_1$$

In this study, the milling results from Kansas State University's Pilot Flour Mill were studied with other physical and chemical tests on the wheat samples and their milled products.

The Kansas State University's Pilot Flour Mill consists of a five break and ten reduction system (Fig. 2). All the stock was pneumatically handled. The break rolls had the following corrugations, differential speeds and a spiral of 1/4 inches per foot.

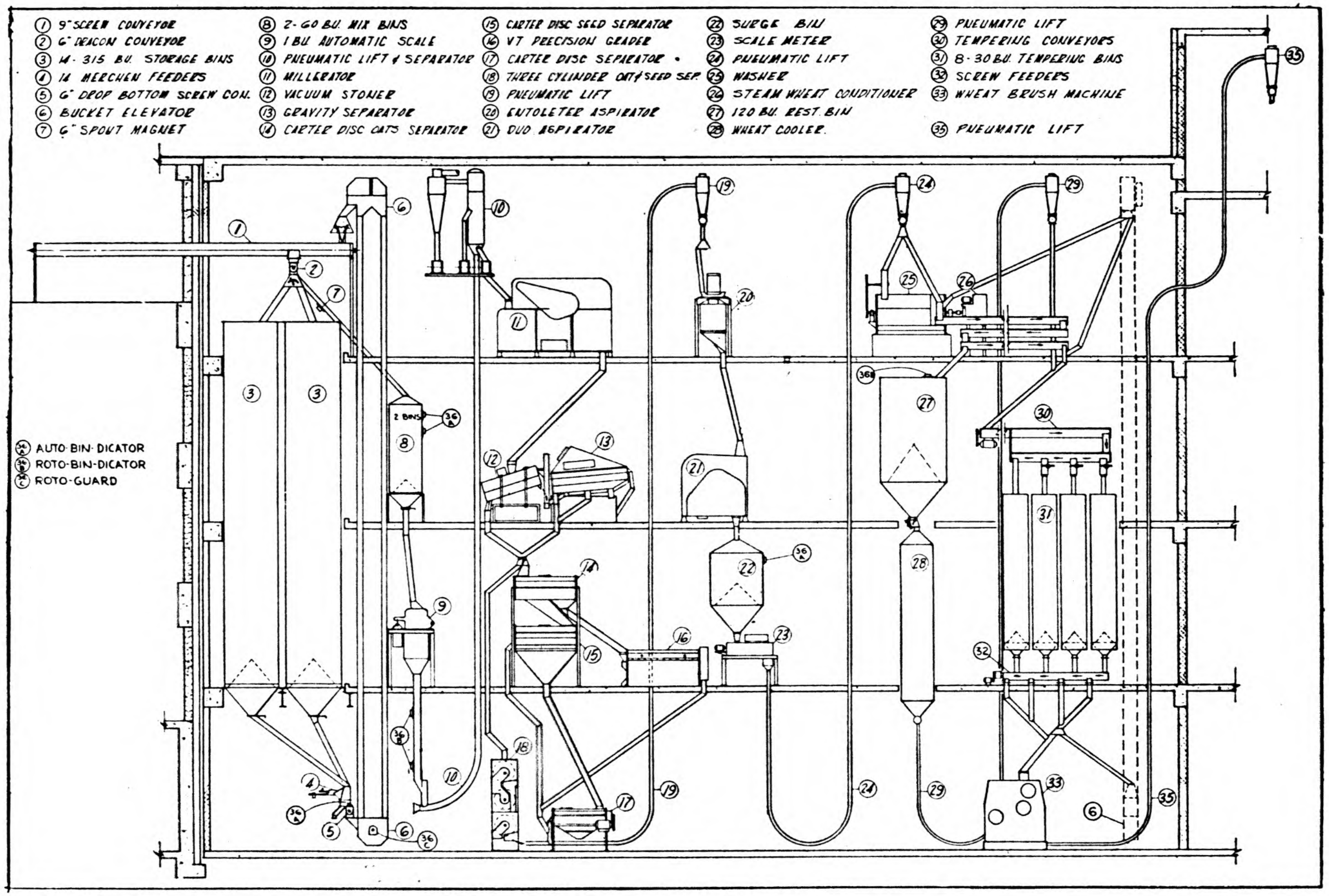
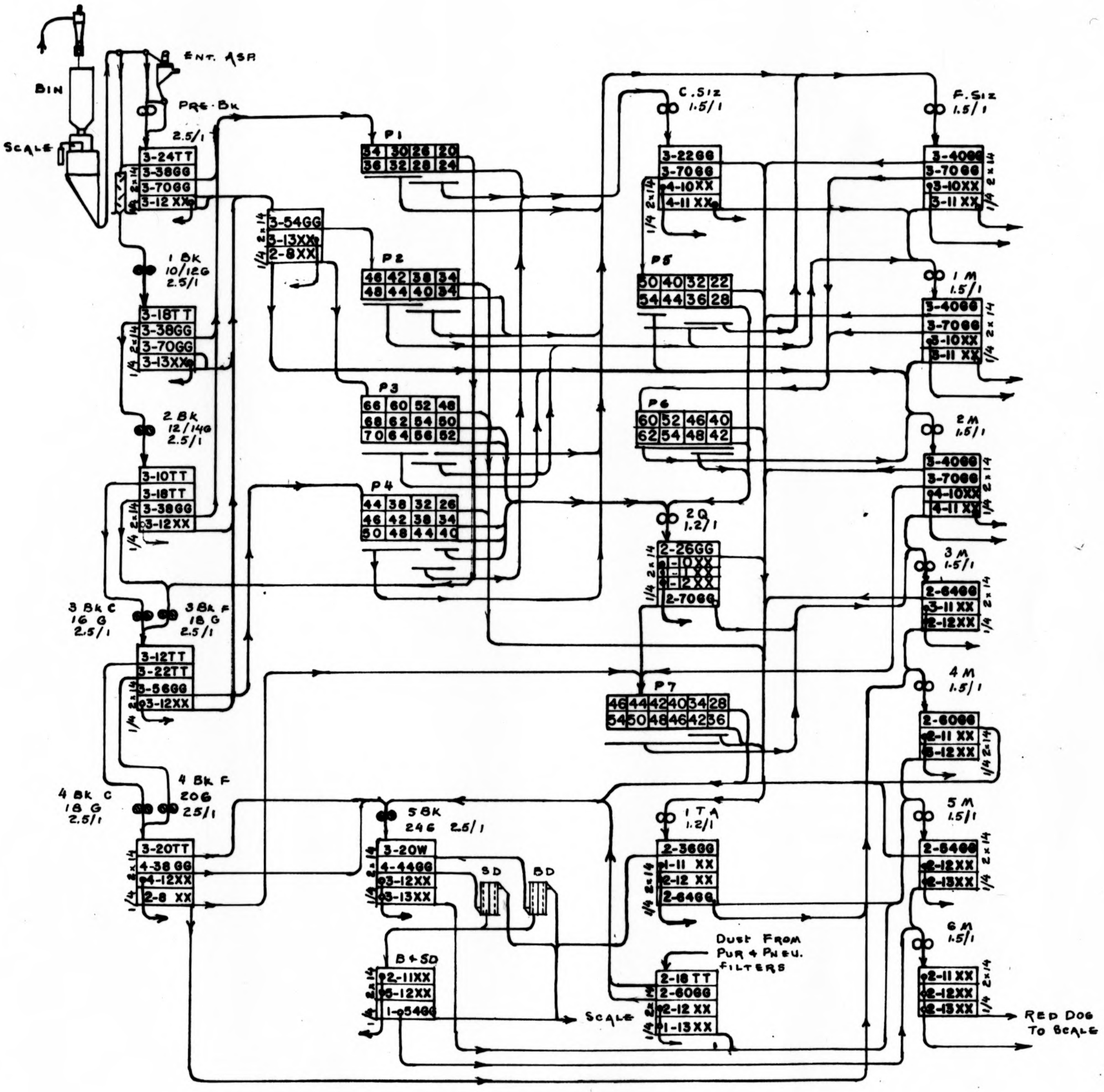


FIG. 1 Schematic Flow of Kansas State's Grain Cleaning Facilities



KANSAS STATE UNIVERSITY'S PILOT FLOUR MILL FLOW

Roll	Corrugations Per Inch	Differential Speed
Pre Break	Smooth	2.5:1
First Break	10/Fast roll 12/Slow roll	2.5:1
Second Break	12/Fast roll 14/Slow roll	2.5:1
Third Break Coarse	16	2.5:1
Third Break Fine	18	2.5:1
Fourth Break Coarse	18	2.5:1
Fourth Break Fine	20	2.5:1
Fifth Break	24	2.5:1

The reduction rolls were all smooth except the first middling roll which had 36 corrugations and a spiral of 1/2 inch per foot. The differential speed was 1.5:1 except in the case of 1T and 2Q rolls which had a 1.2:1 differential.

The sifters had a speed of 180 rpm and a four inch throw diameter.

Previous to the actual milling, control tests were made. The break rolls were set on the control wheat with the following break releases through a 20 mesh wire.

First Break	35%
Second Break	50%
Third Break Coarse	35%
Third Break Fine	70%
Fourth Break Coarse	30%
Fourth Break Fine	65%
Fifth Break	37%

After about an hour's mill operation, the samples were milled and the break releases were checked for each sample. The feed rate used was 17 bushels per hour.

On each sample, after the mill was in balance, flour stream test samples were taken. The test samples were taken for a period of five minutes. The amount collected in this period of time was recorded and the 23 stream test samples were subjected to analysis for protein, moisture and ash. The analyses are reported on a 14% moisture basis. These analyses were used in all further calculations for cumulative ash and protein in order of increasing ash and milling value.

The cleaned wheat samples were used to determine the physical and chemical tests, such as test weight, moisture, ash, protein, density, pearling, kernel size distribution and Zeleny Sedimentation value.

Methods of Determinations and Calculations. The test weight determinations were made with a quart kettle using a beam scale according to the standard method outlined by the U. S. D. A. (45). One thousand kernel count weight was determined with an electronic seed counter using 40 grams of grains, and finding from it the weight of 1000 kernels.

The liquid density of the grain was determined by the method as outlined by Sharp (39) and was reported on a moisture free basis by taking 10 grams of the grain and determining the volume of toluene displaced at 25°C in a 25 c.c. pycnometer.

The wheat sizing test as outlined by Shuey (42) was made with the use of a Ro-Tap shaker using the Tyler standard sieves, 7 mesh wire, 9 mesh wire, and 12 mesh wire. The overs were recorded as a percentage of the total weight of the sample and were assigned the following potential values for calculated flour yields. Two hundred and fifty grams of the grain formed the sample size for this test.

Overs	7 wire	(Tyler Standard Sieve)	78%
Overs	9 wire	(Tyler Standard Sieve)	73%
Overs	12 wire	(Tyler Standard Sieve)	67%

The pearling test was performed as outlined by McCluggage (25), taking 20 grains of sample grain weighing to the nearest centigram. The grain was pearled in a Strong-Scott barley pearler for 60 seconds. The remaining grain was hand sifted on a 20 wire Tyler Standard Sieve to remove all the dust and broken kernels. The remaining grain was weighed and recorded as a percentage of the original sample.

Moisture, protein and ash on wheat, as well as on milled products were determined by the procedures as outlined in Cereal Laboratory Methods (7).

The flour color was determined by the use of the Photovolt reflectance meter using the green filter. Theoretically, the higher the reading, the whiter the flour.

Particle size of straight grade flour was measured by the Fisher Sub Sieve Analyzer which gave the average particle size in microns (13).

Ash value was calculated with the formula of Seibel and

Zwingelberg (38).

$$\text{Ash value figure} = \frac{\text{Flour ash}}{\text{Flour yield}} \times 100$$

Ash index is the product of the per cent of second middlings and its ash content.

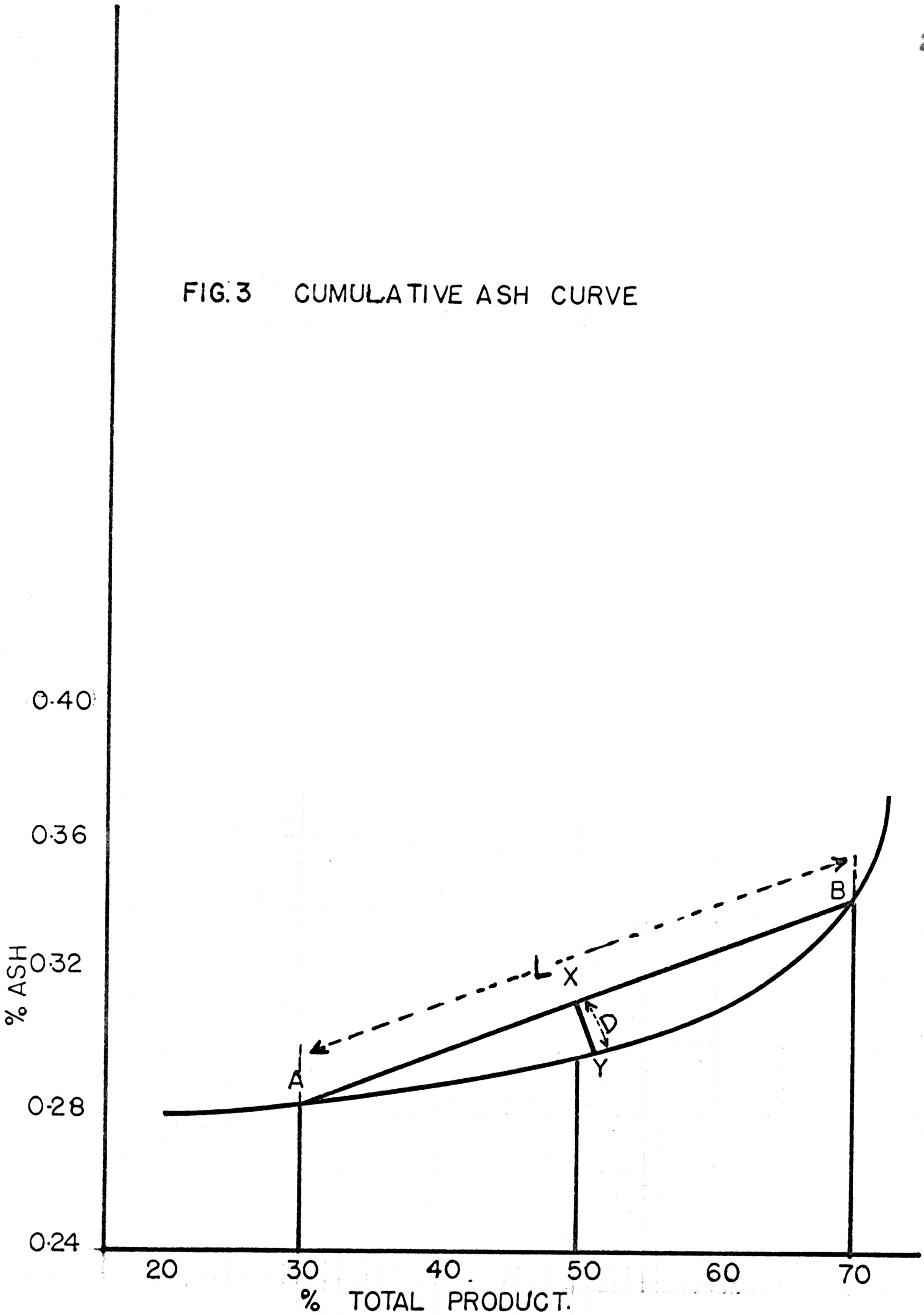
Curve Index (L-2D). The curve index figure was calculated from the cumulative ash curves for the flours (Fig.3). 'L' was the length of the chord AB intercepted between the points at 30% and 70% of total product on the curves was measured in centimeters. 'D' was the length of the perpendicular xy in centimeters dropped from the 50% total product point on the chord AB to the curve.

The curve index L-2D was calculated from these values of 'L' and 'D'.

Cumulative Ash and Protein. The ash and protein analyses for the flour streams were arranged in order of increasing ash on a 14% moisture basis. Individual percentages of each stream were calculated from the total products yield for flour. The cumulative calculations are shown on page 30. The graphs plotted are shown from pages 31 to 37.

Calculations for Flour Grades and the Milling Value. Three grades of flour were calculated on a fixed ash basis from the cumulative ash curves. The flour grades were Patent flour with an ash content of 0.38%; First clear flour ash content of 0.70%; and Second clear flour ash content of 1.20%.

FIG. 3 CUMULATIVE ASH CURVE



The following algebraic equation was used in the calculations:

Ash content of lower ash flour x per cent of flour + ash content of higher ash flour (ash) x A = desired ash content of mixed flour x (per cent of flour + A).

where A = per cent of higher ash flour required to bring up the lower ash flour to the desired ash content of flour.

Example: What percentage of 0.596 ash flour will be required to bring 67.393% of flour of 0.354 ash to 0.38 ash flour?

Ash content of lower ash flour = 0.354

Per cent of flour = 67.393

Ash content of higher ash flour = 0.596

Desired ash content of flour = 0.380

Therefore:

$$0.354 \times 67.393 + 0.596A = 0.380\ [67.393 + A]$$

$$23.857 + 0.596A = 25.609 + 0.380A$$

$$\text{or } 0.216A = 1.752$$

$$A = \frac{1.752}{0.216} = 8.11$$

8.11% of 0.596 ash flour is required.

In this way different flour grades were calculated by combining the lowest ash stream with the higher one until the required flour ash was reached. After the flour grades had been calculated, their material value was determined by assigning the following realistic monetary values.

Patent Flour	0.38 ash	at $5.00	per 100 lbs.
First Clear Flour	0.70 ash	at $4.20	per 100 lbs.
Second Clear Flour	1.20 ash	at $3.70	per 100 lbs.
Feed		at $1.70	per 100 lbs.

The total summation of these monetary values for different flour grades and the feed is the milling value in this study.

RESULTS AND DISCUSSION

The experimental results of the tests on wheat and flour are shown in Tables 1, 2, 3 and 4. Tables 5 and 6 show the calculated per cent flour grades and their total products values.

From the flour stream analysis for each sample, a cumulative curve was drawn for ash and protein, in order of increasing ash. Table 7 shows the different flour streams of the Kansas State University's Pilot Flour Mill and how they were used to calculate the cumulative ash and protein.

Since the cumulative ash content of the straight grade flours was low, the ash content of patent flour was taken to be 0.38% on a 14% moisture basis for all calculations of the milling value. The low ash content of the straight grade flour and its distribution in the mill streams is observed very clearly in the cumulative ash and protein curves in Figs. 4 to 10.

Table 1. 1961 Wheat data.

Lab No.	Variety	Pearling Value 1/	1000 Kernel Weight	Test Weight dry clean Wheat	Zeleny Sedimentation Value	Density Liquid Pycnometer 2/	Kernel Size Distribution over 7W	over 9W	over 12W	Calculated Flour Yield 3/	Moisture	Ash 14% MB 4/	Protein 14% MB 4/
		%	grams	lb/bu		grams/cc	%	%	%	%	%	%	%
61-327	Triumph	59.1	31.6	61.7	55.0	1.433	60.8	38.3	Tr	76.1	12.8	1.36	12.7
61-328	Comanche	68.5	30.4	60.7	68.0	1.448	59.2	40.4	Tr	76.0	13.0	1.48	13.4
61-329	Improved Triumph	56.5	36.4	60.8	57.0	1.439	73.2	26.0	Tr	76.7	13.0	1.35	12.5
61-330	New Improved Triumph	58.6	34.3	60.8	56.0	1.412	71.2	28.4	Tr	76.2	12.8	1.34	12.7
61-331	Super Triumph	58.0	35.0	60.4	58.0	1.425	77.6	21.6	0.8	76.8	12.7	1.30	12.8
61-332	Bison	65.5	25.3	59.3	59.0	1.459	18.4	79.2	2.4	73.8	11.8	1.77	12.5
61-333	Tascosa	67.5	22.8	61.0	52.0	1.444	26.8	68.8	4.0	71.4	11.3	1.77	13.0
61-334	Rodco	65.1	24.1	59.2	56.0	1.506	36.0	60.8	3.2	74.6	12.0	1.84	13.0
61-335	Wichita	C57.6	28.4	60.3	45.0	1.550	52.0	47.2	0.8	75.6	11.6	1.83	12.7
61-336	Pawnee	S74.5	19.7	54.9	35.0	1.378	9.6	84.8	5.6	73.2	12.1	1.56	11.4
61-337	Nebred	S76.5	15.7	52.5	29.0	1.362	7.6	78.0	13.6	72.5	11.9	1.80	10.4
61-338	C.I. 13532	65.3	29.2	58.4	50.0	1.394	46.6	51.6	1.2	75.3	11.2	1.58	13.5
61-340	C.I. 13547	64.6	25.0	58.3	44.0	1.383	32.0	66.4	1.2	74.5	13.0	1.55	12.9

C - Grain cracked when pearled.

S - Shriveled grain.

1/ Pearling value represents per cent of grain remaining after pearling.

2/ Moisture free basis.

3/ Calculated flour yields from sizing values based on assigned potential values.

overs	%
# 7W	78.0
# 9W	73.0
# 12W	67.0

4/ 14% moisture basis.

Table 2. 1962 Wheat data.

Lab No.	Variety	Pearling Value 1/	1000 Kernel Weight	Test Weight dry clean Wheat	Zeleny Sedimentation Value	Density Liquid Pycnometer 2/	Kernel Size Distribution over 7W	over 9W	over 12W	Calculated Flour Yield 3/	Moisture	Ash 14% MB 4/	Protein 14% MB 4/
		%	grams	lb/bu		grams/cc	%	%	%	%	%	%	%
62-317	New Improved Triumph	75.9	24.4	57.7	71.0	1.433	25.6	68.0	6.4	73.1	11.8	1.64	14.8
62-318	Triumph	61.3	26.9	59.5	70.1	1.444	34.4	62.4	3.2	73.7	12.0	1.56	15.1
62-319	Improved Triumph	60.9	27.4	59.3	69.0	1.438	40.4	55.6	4.0	72.4	11.7	1.48	14.8
62-320	65% Kaw and 35% Triumph	72.4	27.6	60.1	70.2	1.452	30.0	64.8	5.2	73.4	11.9	1.44	15.2
62-321	Comanche	69.9	24.8	59.6	70.9	1.467	32.0	62.8	5.2	73.7	12.4	1.57	15.8
62-322	Kaw	61.6	25.6	59.9	43.0	1.451	40.4	57.6	2.0	74.4	12.6	1.59	11.3
62-323	Wichita	48.4	28.7	58.8	40.0	1.419	60.8	38.4	0.8	75.5	15.3	1.68	10.7
62-324	25% Kaw and 75% Wichita	50.1	28.6	59.6	41.0	1.434	55.2	43.2	1.6	74.9	15.3	1.71	10.9
62-325	75% Kaw and 25% Wichita	55.1	28.2	60.3	55.0	1.449	41.6	57.2	1.2	74.6	15.7	1.65	11.0
62-326	Comanche	64.0	23.0	57.3	57.1	1.467	10.0	86.0	3.6	72.5	16.6	1.84	14.3
62-327	C.I. 13536	58.7	24.5	58.2	53.8	1.424	18.8	78.4	2.8	72.9	15.0	1.82	14.7
62-328	Bison	69.6	22.4	52.7	53.2	1.473	10.4	84.0	5.6	72.4	12.3	1.6	10.9
62-329	Pawnee	71.7	19.9	53.4	40.0	1.450	58.0	39.2	2.8	73.7	12.2	1.57	11.4
62-330	C.I. 13532	71.9	29.2	58.5	41.5	1.493	44.4	52.4	3.2	74.2	12.7	1.66	12.5
62-331	C.I. 13546	68.2	28.5	58.2	61.1	1.481	32.0	65.2	2.8	73.4	12.7	1.62	12.2
62-332	C.I. 13547	73.3	27.7	58.6	43.0	1.495	40.4	55.6	4.0	71.1	13.1	1.70	12.3

1/ Pearling value represents per cent of grain remaining after pearling.

2/ Moisture free basis.

3/ Calculated flour yields from sizing values based on assigned potential values.

Overs	%
# 7W	78.0
# 9W	73.0
# 12W	67.0

4/ 14% moisture basis.

Table 3. 1961 Winter wheats flour analysis data.

Lab No.	Variety	Protein 14 M.B. 1/	Ash 14 M.B. 1/	Yield	Feed	Color Whiteness
		%	%	%	%	%
61-327	Triumph	11.6	0.39	75.9	24.1	83.8
61-328	Comanche	12.0	0.40	75.7	24.3	81.3
61-329	Improved Triumph	11.4	0.38	75.8	24.2	82.3
61-330	New Improved Triumph	11.4	0.38	74.4	25.6	82.8
61-331	Super Triumph	11.8	0.37	75.2	24.8	82.3
61-332	Bison	11.1	0.38	71.2	28.8	84.3
61-333	Tascosa	10.6	0.36	71.7	28.3	84.2
61-334	Rodco	11.6	0.39	71.7	28.3	81.8
61-335	Wichita	11.1	0.40	71.9	28.1	81.5
61-336	Pawnee	10.2	0.36	70.2	29.8	83.3
61-337	Nebred	9.6	0.32	70.8	29.2	83.0
61-338	C.I. 13532	11.0	0.36	72.2	27.8	82.8
61-340	C.I. 13547	11.6	0.42	74.6	25.4	82.0

1/ 14% moisture basis.

Table 4. 1962 Winter wheats flour analysis data.

Lab No.	Variety	Protein 14 M.B. 1/	Ash 14 M.B. 1/	Yield	Feed	Color Whiteness
		%	%	%	%	%
62-317	New Improved Triumph	13.6	0.40	75.2	24.8	82.1
62-318	Triumph	14.6	0.36	75.5	24.5	82.5
62-319	Improved Triumph	14.1	0.37	74.9	25.1	83.0
62-320	65% Kaw and 35% Triumph	14.4	0.39	74.9	25.1	81.9
62-321	Comanche	14.4	0.41	75.3	24.7	81.5
62-322	Kaw	10.3	0.42	75.1	24.9	81.5
62-323	Wichita	9.5	0.45	74.2	25.8	83.5
62-324	25% Kaw and 75% Wichita	9.7	0.45	74.7	25.3	84.9
62-325	75% Kaw and 25% Wichita	9.9	0.44	75.8	24.2	84.5
62-326	Comanche	13.2	0.43	72.9	27.1	82.0
62-327	C.I. 13536	13.4	0.37	74.1	25.9	83.0
62-328	Bison	10.2	0.37	72.2	27.8	84.1
62-329	Pawnee	10.4	0.39	72.7	27.3	83.3
62-330	C.I. 13532	11.3	0.38	74.2	25.8	81.9
62-331	C.I. 13546	11.3	0.41	75.5	24.5	82.5
62-332	C.I. 13547	10.9	0.48	74.9	25.1	82.6

1/ 14% moisture basis.

Table 5. 1961 Calculated flour grades and extractions.

Lab No.	Variety	2nd Clear Flour 1.20 Ash	% x 3.70	1st Clear Flour 0.70 Ash	% x 4.20	Patent Flour 0.38 Ash	% x 5.00	Total Flour Value	Feed	% x 1.7	Total Product Value
		%	$	%	$	%	$	$	%	$	$
61-327	Triumph	0.61	0.02			75.24	3.76	3.78	24.15	0.41	4.19
61-328	Comanche	2.48	0.09	0.22	0.01	72.98	3.46	3.75	24.32	0.41	4.16
61-329	Improved Triumph					*75.76	3.79	3.79	24.24	0.41	4.20
61-330	New Improved Triumph	3.33	0.12			71.11	3.56	3.68	25.56	0.43	4.11
61-331	Super Triumph	1.72	0.06			73.45	3.67	3.73	24.83	0.42	4.15
61-332	Bison					*71.24	3.56	3.56	28.76	0.49	4.05
61-333	Tascosa					*71.68	3.58	3.58	28.32	0.48	4.06
61-334	Rodco	0.80	0.03			70.88	3.54	3.57	28.32	0.48	4.05
61-335	Wichita	0.82	0.03	0.84	0.04	70.20	3.51	3.58	28.14	0.48	4.05
61-336	Pawnee					*70.18	3.51	3.51	29.82	0.51	4.02
61-337	Nebred					*70.83	3.54	3.54	29.17	0.50	4.04
61-338	C.I. 13532					*72.16	3.61	3.61	27.89	0.47	4.08
61-340	C.I. 13547	0.53	0.02	0.33	0.02	73.70	3.69	3.73	25.44	0.43	4.16

*Did not reach patent flour ash.

Table 6. 1962 Calculated flour grades and extractions.

Lab No.	Variety	2nd Clear Flour 1.20 Ash		1st Clear Flour 0.70 Ash		Patent Flour 0.38 Ash		Total Flour Value	Feed		Total Product Value
		% x 3.70		% x 4.20		% x 5.00			% x 1.7		
		%	$	%	$	%	$	$	%	$	$
62-317	New Improved Triumph					*75.21	3.76	3.76	24.79	0.42	4.18
62-318	Triumph					*75.50	3.78	3.78	24.50	0.42	4.20
62-319	Improved Triumph					*74.90	3.75	3.75	25.10	0.43	4.18
62-320	65% Kaw and 35% Triumph	1.65	0.06			73.22	3.66	3.72	25.13	0.43	4.15
62-321	Comanche	1.23	0.04			74.08	3.70	3.75	24.69	0.42	4.17
62-322	Kaw	1.80	0.06	8.61	0.36	64.64	3.23	3.65	24.95	0.43	4.08
62-323	Wichita			23.25	0.96	50.95	2.25	3.51	25.80	0.44	3.95
62-324	25% Kaw and 75% Wichita			30.35	1.28	44.36	3.22	3.50	25.29	0.43	3.92
62-325	75% Kaw and 25% Wichita			7.10	0.30	68.70	3.44	3.74	24.20	0.41	4.15
62-326	Comanche	2.53	0.09	6.33	0.27	64.00	3.20	3.56	27.14	0.46	4.02
62-327	C.I. 13536					*74.10	3.71	3.71	25.90	0.44	4.14
62-328	Bison					*72.15	3.61	3.61	27.85	0.42	4.03
62-329	Pawnee					*72.67	3.63	3.63	27.33	0.47	4.10
62-330	C.I. 13532	2.94	0.11			71.26	3.56	3.67	25.80	0.44	4.11
62-331	C.I. 13546	0.93	0.04			74.60	3.73	3.77	24.47	0.43	4.19
62-332	C.I. 13547	2.56	0.11			72.40	3.62	3.72	25.04	0.43	4.15

*Did not reach patent flour ash.

Table 7. C u m u l a t i v e a s h -- Exp. No. 61-334.

	Stream Weight	Q	S of Q	A	Q X A	S of Q X A	S of Q X A / S of Q
Flour Stream	i. e. gram/ 5 min.	% of total product	Cumulative % of total products	% Ash 14% M.B.	% of total product X % Ash	Cumulative Q X A	Cumulative % of Ash
1 M(T)	4290	15.55	15.55	0.246	3.833	3.833	0.246
1 M(B)	100	0.36	15.91	0.276	0.099	3.932	0.247
FSiz(B)	130	0.47	16.38	0.276	0.130	4.062	0.248
3 M	2665	9.65	26.03	0.294	2.833	6.895	0.265
2 M(T)	1755	6.31	32.34	0.305	1.921	8.816	0.273
2 M(B)	185	0.67	33.01	0.305	0.226	9.042	0.274
FSiz(T)	1705	6.18	39.19	0.306	1.891	10.933	0.279
CSiz(B)	10	0.04	39.32	0.322	0.013	10.946	0.279
CSiz(T)	530	2.04	41.27	0.350	0.714	11.660	0.282
Redust	175	0.63	41.90	0.367	0.171	11.831	0.282
4 M	1185	4.29	46.19	0.398	1.708	13.539	0.293
5 M	1010	3.86	50.05	0.411	1.585	15.124	0.302
2 Bk	1360	4.94	54.99	0.440	2.174	17.298	0.315
3 Bk	1235	4.47	59.46	0.457	2.043	19.341	0.325
1 Bk	785	2.80	62.26	0.479	1.341	20.682	0.332
Pre Bk	15	0.05	62.31	0.510	0.026	20.708	0.332
2 Qual	135	0.49	62.80	0.510	0.250	20.958	0.334
1 T	220	0.79	63.59	0.519	0.410	21.368	0.336
4 Bk	775	2.80	66.39	0.554	1.551	22.919	0.345
Suction	5	0.01	66.40	0.600	.006	22.925	0.345
6 M	630	2.28	68.68	0.681	1.551	24.476	0.356
5 Bk	245	0.87	69.55	0.780	0.679	25.115	0.362
B.S.D.	590	2.13	71.68	1.272	2.710	27.865	0.389

Where Bk = Break; M = Middlings; T = Tailings; Qual = Quality; C = Coarse; F = Fine; Siz = Sizings; (T) = Top flour sieves; (B) = Bottom Flour sieves; and B.S.D. = Bran and shorts duster.

Q = Quantity A = Ash S = Summation

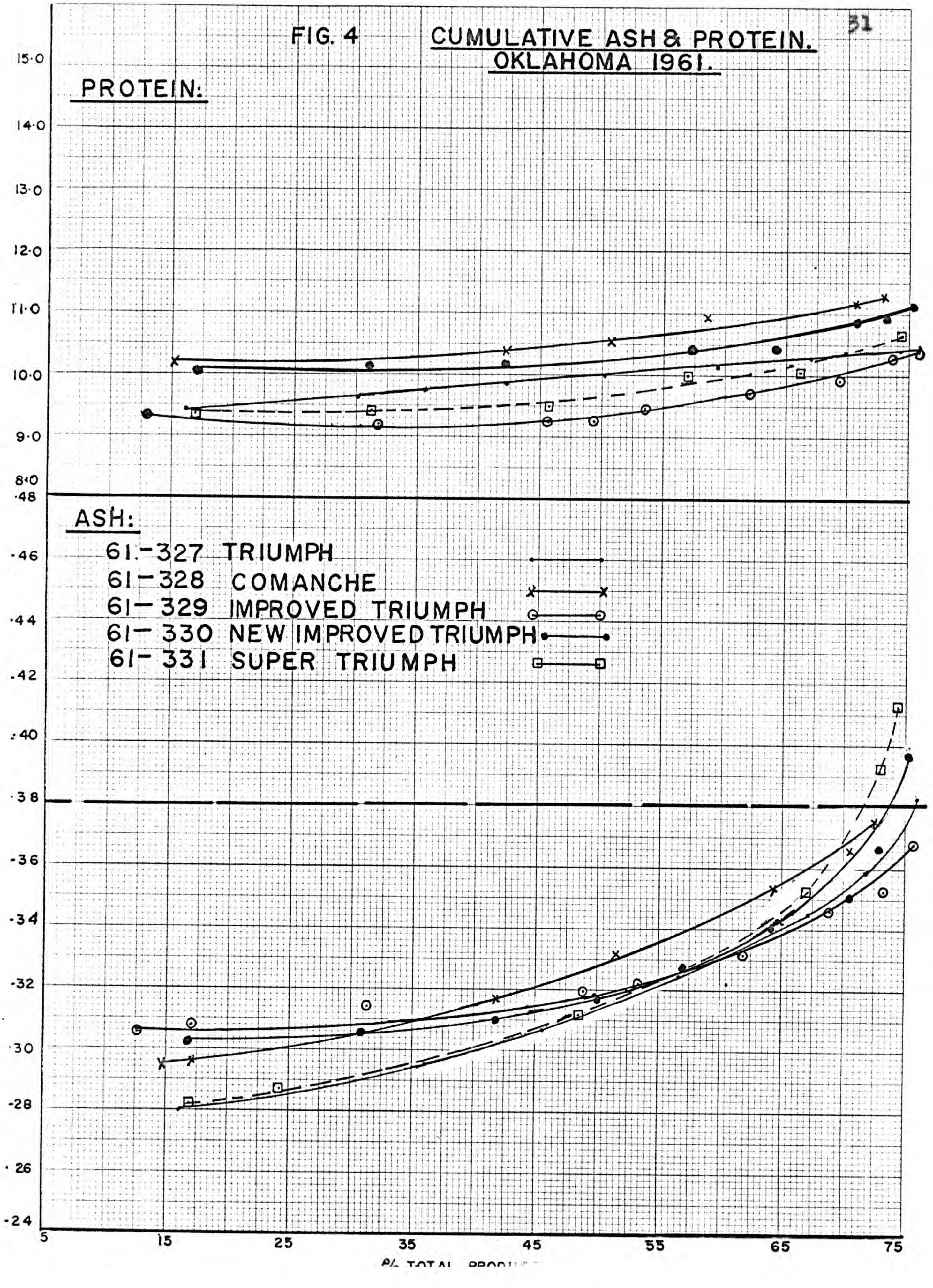
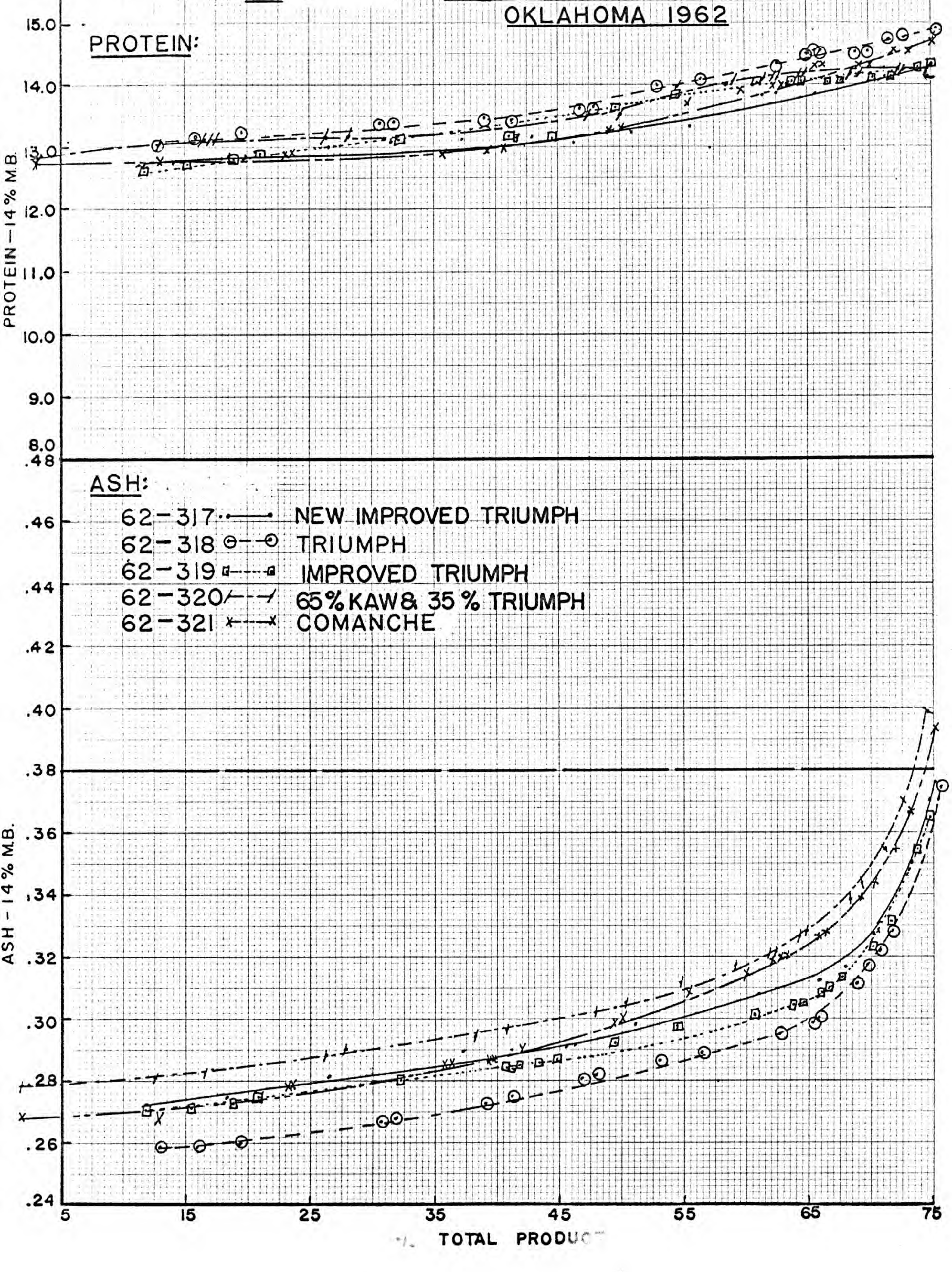


FIG. 4
CUMULATIVE ASH & PROTEIN.
OKLAHOMA 1961.
PROTEIN:
ASH:
61-327 TRIUMPH
61-328 COMANCHE
61-329 IMPROVED TRIUMPH
61-330 NEW IMPROVED TRIUMPH
61-331 SUPER TRIUMPH
15·0
14·0
13·0
12·0
11·0
10·0
9·0
8·0
·48
·46
·44
·42
·40
·38
·36
·34
·32
·30
·28
·26
·24
5
15
25
35
45
55
65
75

FIG. 5 CUMULATIVE ASH & PROTEIN OKLAHOMA 1962



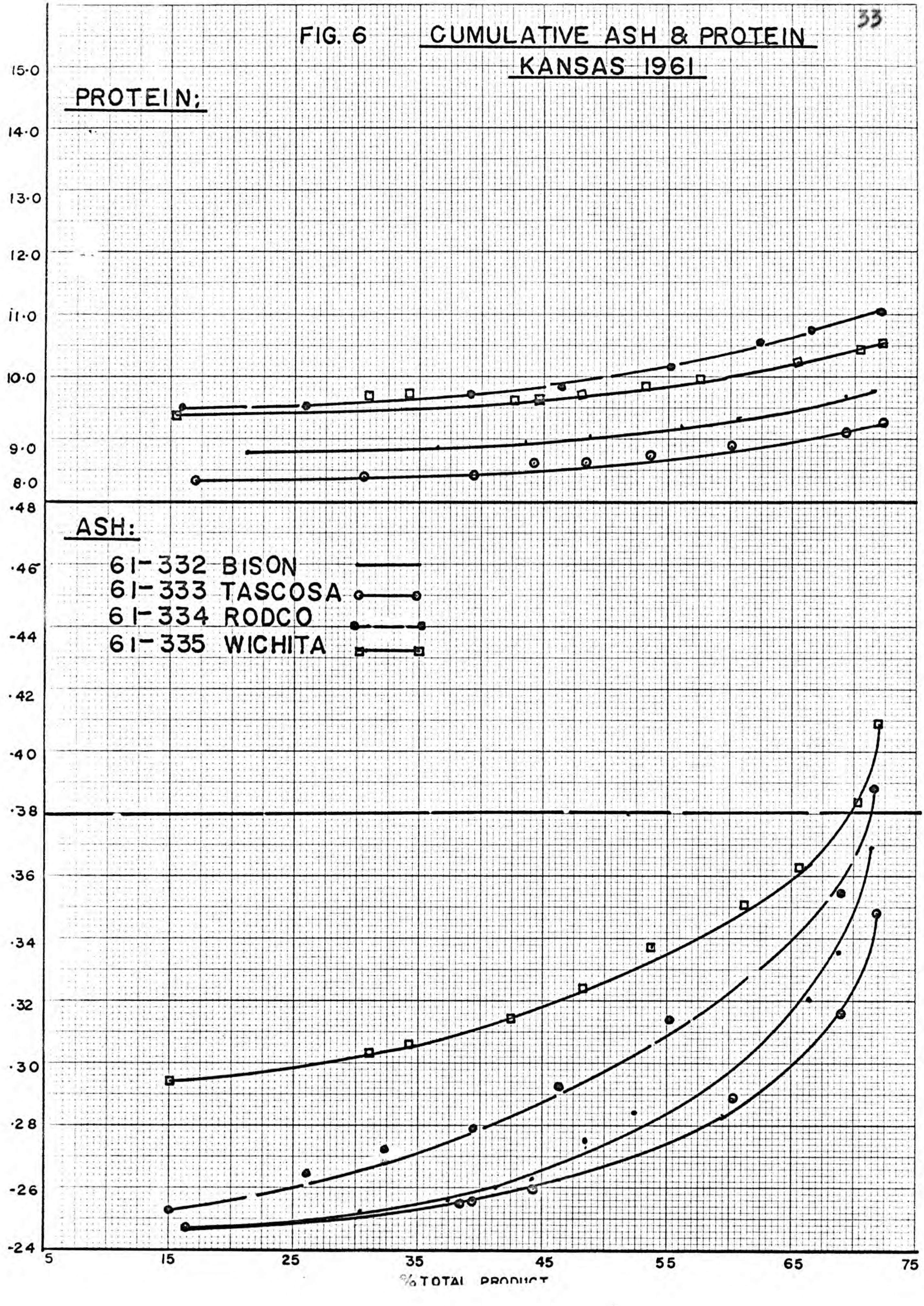


FIG. 6 CUMULATIVE ASH & PROTEIN
KANSAS 1961
PROTEIN;
ASH:
61-332 BISON
61-333 TASCOSA
61-334 RODCO
61-335 WICHITA
15·0
14·0
13·0
12·0
11·0
10·0
9·0
8·0
·48
·46
·44
·42
·40
·38
·36
·34
·32
·30
·28
·26
·24
5
15
25
35
45
55
65
75
% TOTAL PRODUCT

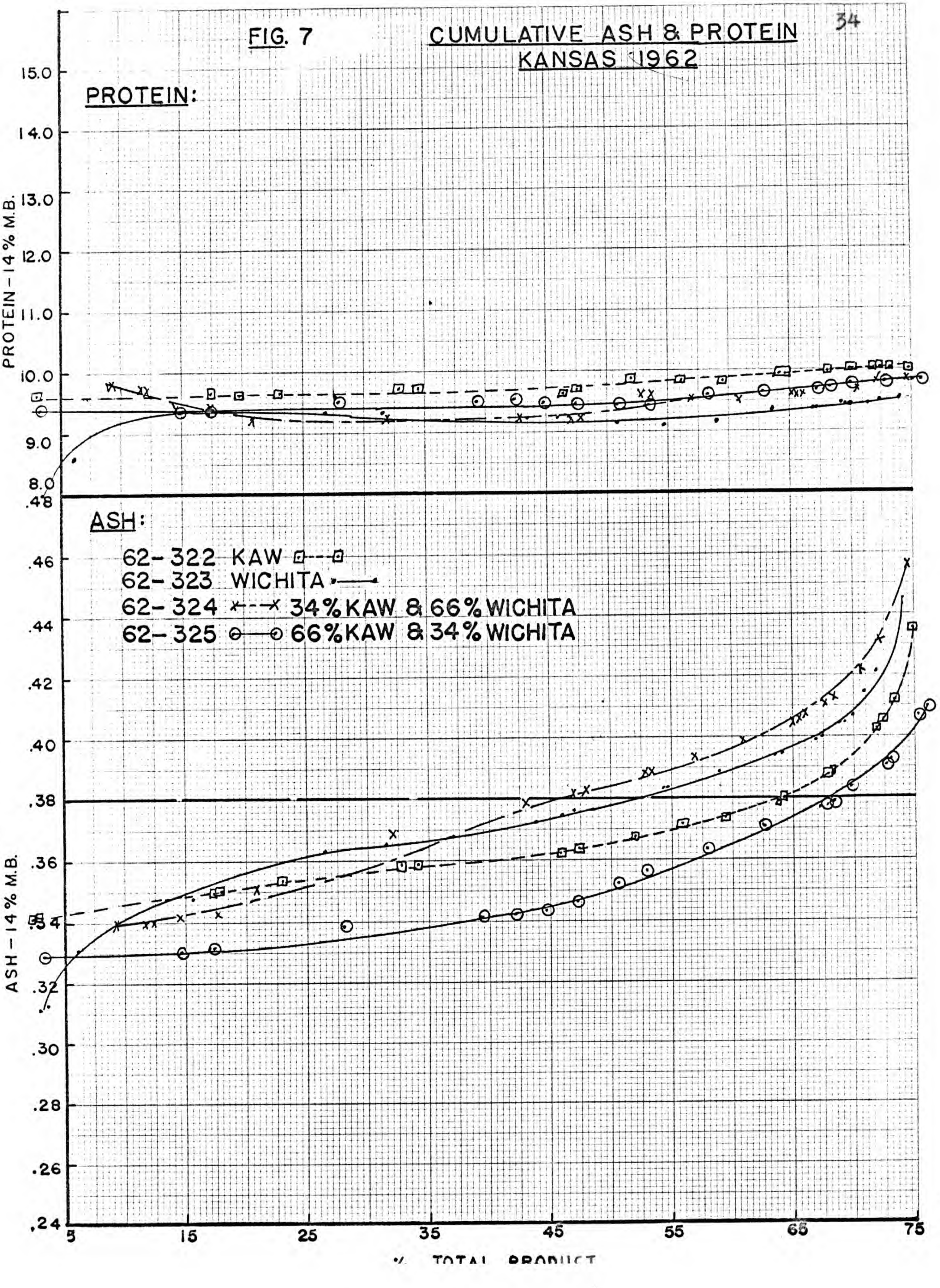


FIG. 7
CUMULATIVE ASH & PROTEIN
KANSAS 1962
PROTEIN:
PROTEIN - 14% M.B.
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
ASH:
62-322 KAW
62-323 WICHITA
62-324 34% KAW & 66% WICHITA
62-325 66% KAW & 34% WICHITA
ASH - 14% M.B.
.48
.46
.44
.42
.40
.38
.36
.34
.32
.30
.28
.26
.24
5
15
25
35
45
55
65
75
% TOTAL PRODUCT

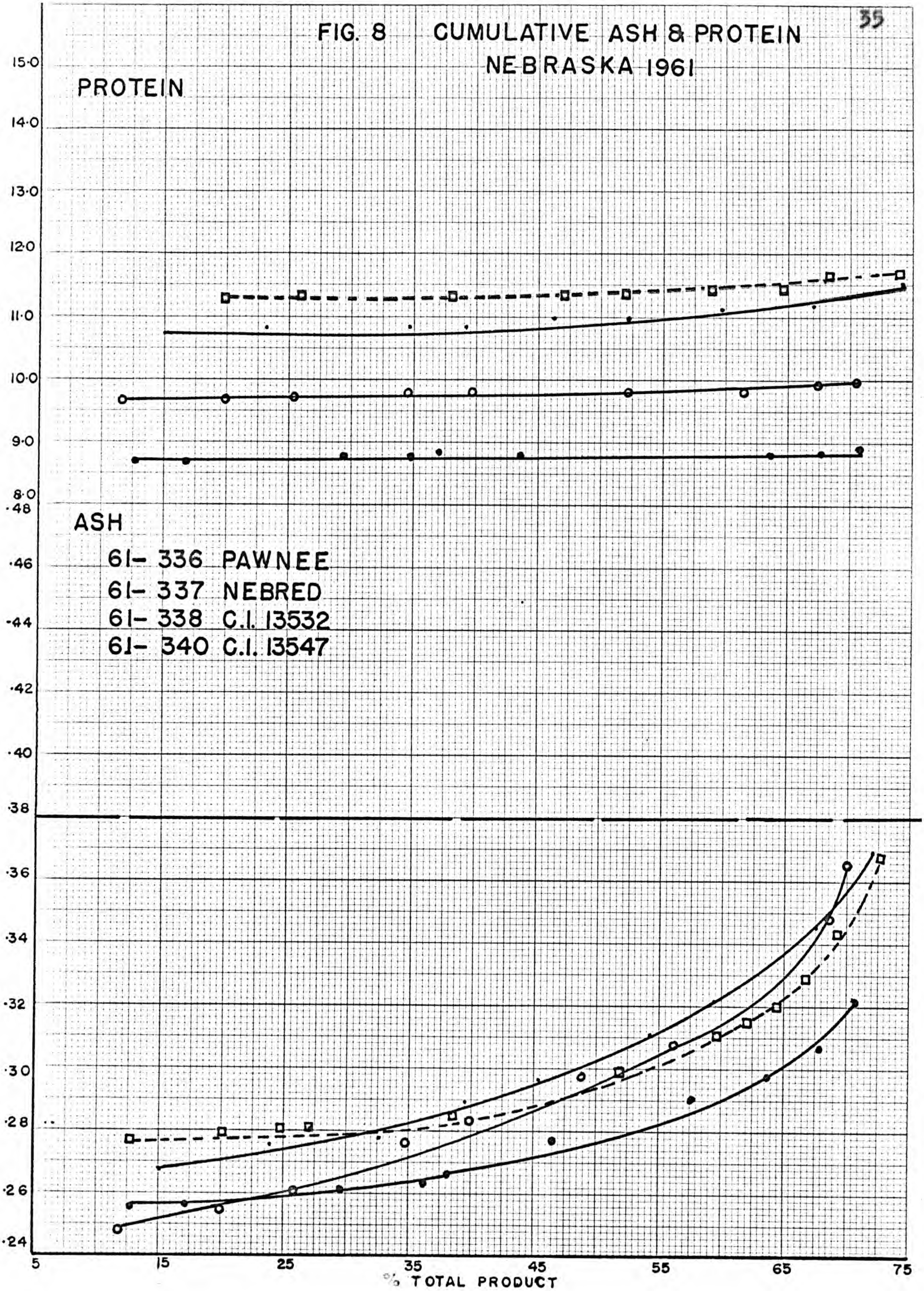


FIG. 8 CUMULATIVE ASH & PROTEIN
NEBRASKA 1961
PROTEIN
15·0
14·0
13·0
12·0
11·0
10·0
9·0
8·0
·48
ASH
61- 336 PAWNEE
61- 337 NEBRED
61- 338 C.I. 13532
61- 340 C.I. 13547
·46
·44
·42
·40
·38
·36
·34
·32
·30
·28
·26
·24
5
15
25
35
45
55
65
75
% TOTAL PRODUCT

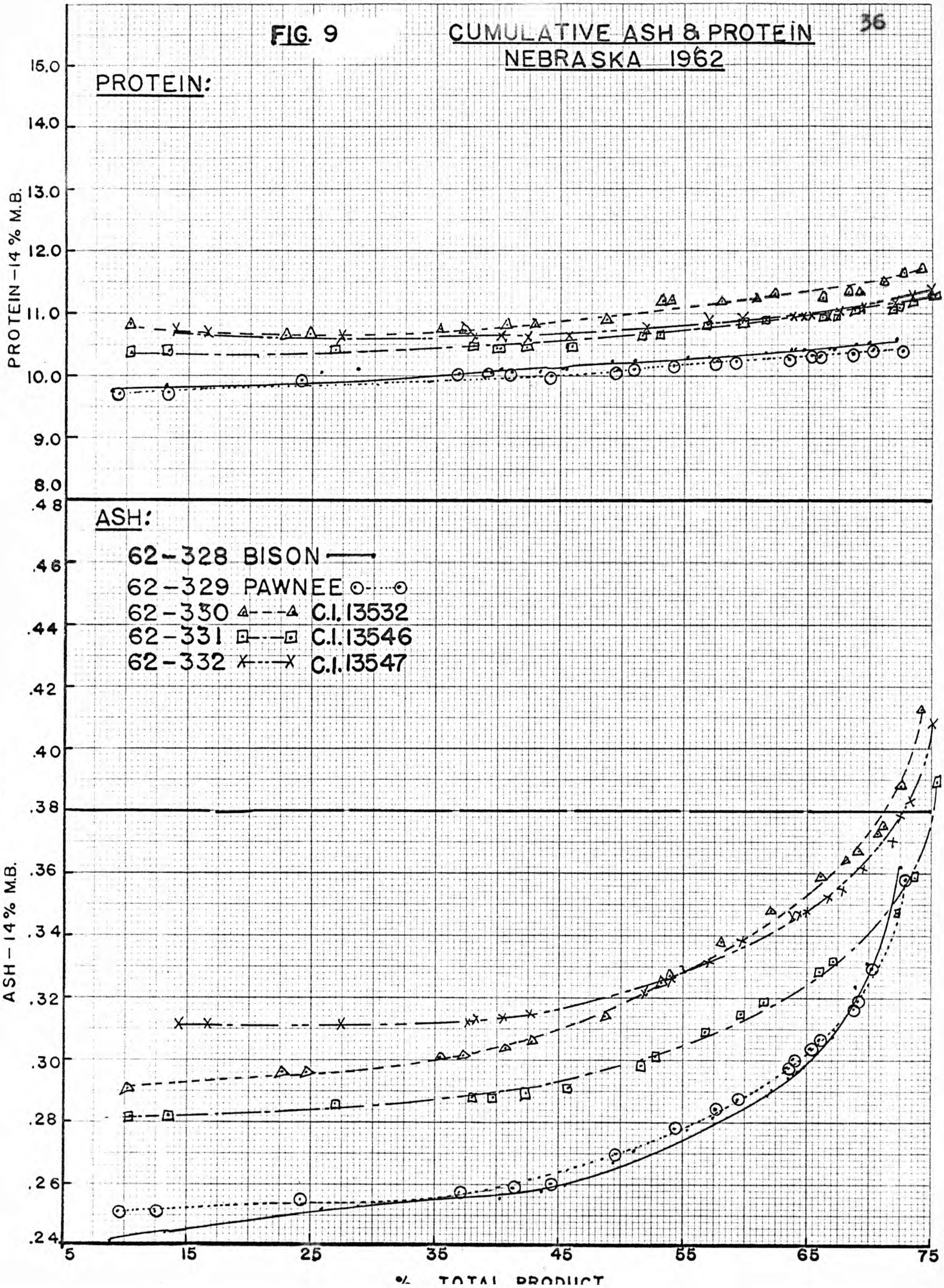


FIG. 9
CUMULATIVE ASH & PROTEIN
NEBRASKA 1962
PROTEIN:
PROTEIN - 14 % M.B.
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
ASH:
62-328 BISON
62-329 PAWNEE
62-330 C.I. 13532
62-331 C.I. 13546
62-332 C.I. 13547
ASH - 14% M.B.
.48
.46
.44
.42
.40
.38
.36
.34
.32
.30
.28
.26
.24
5
15
25
35
45
55
65
75
% TOTAL PRODUCT

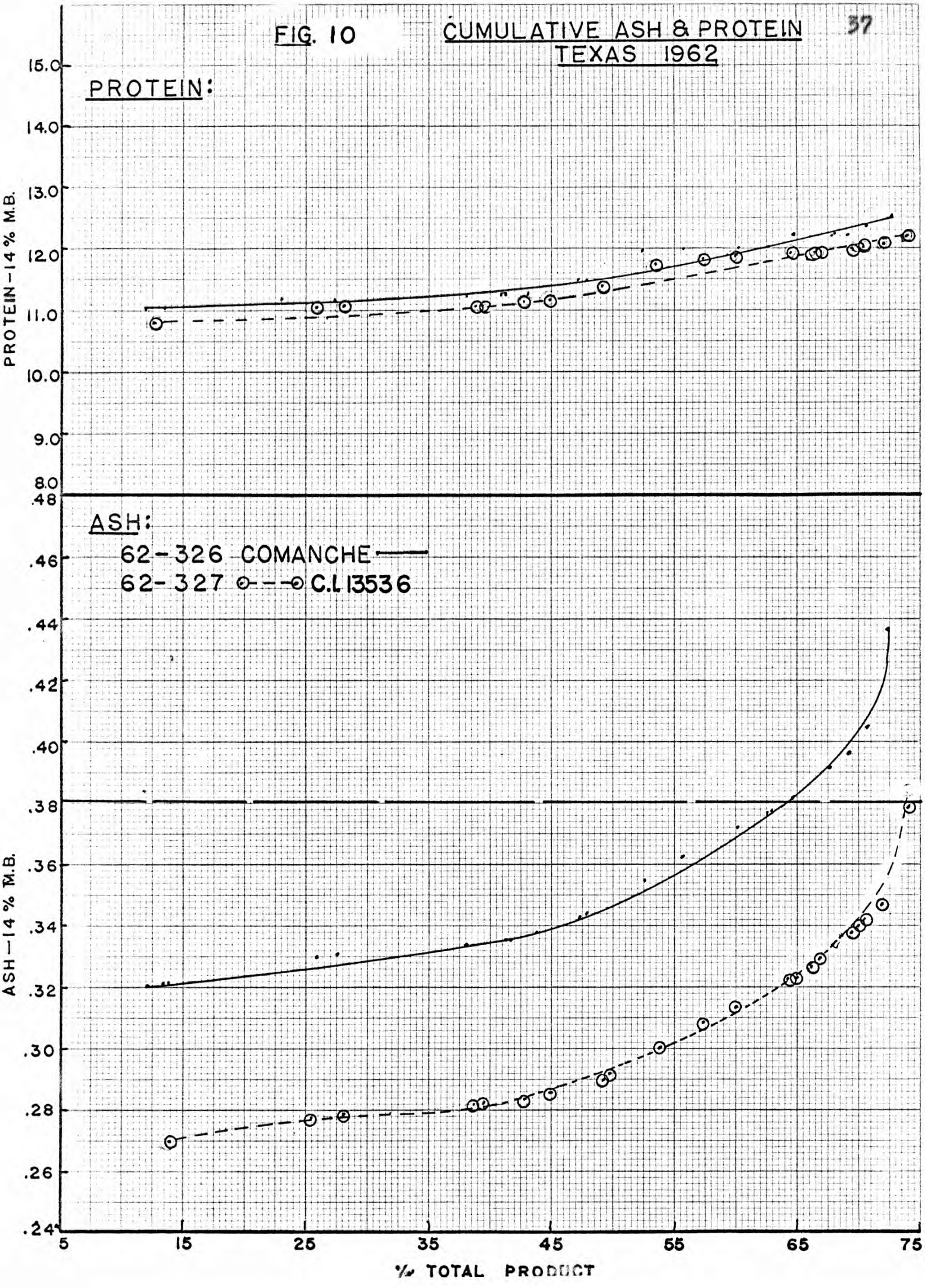


FIG. 10
CUMULATIVE ASH & PROTEIN
TEXAS 1962
PROTEIN:
PROTEIN-14 % M.B.
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
ASH:
62-326 COMANCHE
62-327 C.I. 13536
ASH-14 % M.B.
.48
.46
.44
.42
.40
.38
.36
.34
.32
.30
.28
.26
.24
5
15
25
35
45
55
65
75
% TOTAL PRODUCT

All the tests performed on wheat and its milled products were statistically analyzed to determine if there existed any linear significant relationship between these tests and the milling value or the total flour yield. Thirteen samples for 1961 and sixteen for the year 1962 were analyzed and correlated.

Table 8. Coefficients of linear correlation between wheat tests and milling value.

Wheat tests	Correlation coefficients	
	1961	1962
Test weight	+0.64*	+0.20
Wheat protein	+0.44	+0.62*
Wheat ash	-0.79*	-0.45
1000 Kernel weight	+0.75*	-0.06
Wheat density	-0.12	+0.22
Pearling	-0.58*	+0.56*
Potential flour yield	+0.69*	-0.41
Sedimentation value	+0.55*	+0.66*

*Significant at 5% level.

Table 9. Coefficients of linear correlation between tests on milled products and the milling value.

Tests on milled products	Correlation coefficients	
	1961	1962
Flour yield 1/	+0.89*	+0.50*
Flour protein 1/	+0.70*	+0.63*
Flour ash 1/	+0.45	-0.33
Flour color 1/	-0.18	-0.50
Ash value	+0.08	-0.41
Ash index	+0.29	-0.69*
Curve index	+0.21	-0.27
Flour particle size 1/	-0.05	+0.15
2 Middlings ash	+0.31	-0.59
2 Middlings protein	+0.68*	+0.63*
2 Middlings per cent	+0.11	-0.46
B.S.D. flour ash 2/	+0.18	+0.02
B.S.D. flour 2/	-0.002	-0.07
Loaf volume	-0.59*	+0.42
Total baking score	-0.25	+0.11
Absorption	+0.26	+0.58*
Patent flour yield	+0.60*	+0.89*
Patent flour protein	+0.59*	+0.66*

1/ Straight grade flour.

2/ Bran and shorts duster.

* Significant at 5% level.

Table 10. Coefficients of linear correlation between wheat tests and total flour yield.

Wheat tests	Correlation coefficients	
	1961	1962
Test weight	+0.68*	+0.84*
Wheat protein	+0.46*	+0.26
Wheat ash	-0.81*	-0.39
1000 Kernel weight	+0.82*	+0.65*
Wheat density	-0.15	-0.09
Pearling	-0.64*	-0.13
Potential flour yield	+0.77*	+0.21
Sedimentation value	+0.62*	+0.39

*Significant at 5% level.

Table 11. Coefficients of linear correlation between tests on milled products and total flour yield.

Tests on milled products	Correlation coefficients	
	1961	1962
Milling value	+0.89*	+0.50*
Flour protein%[1]	+0.77*	+0.24
Flour ash%[1]	+0.51	+0.13
Flour color[1]	-0.33	-0.19
Ash value	+0.09	-0.03
Ash index	+0.32	+0.09
Curve index	+0.19	+0.50*
Flour Particle size[1]	-0.08	-0.24
2 Middlings ash	+0.36	+0.23
2 Middlings protein	+0.70*	+0.22
2 Middlings per cent[2]	+0.12	-0.29
B.S.D. flour ash per cent	-0.06	-0.05
B.S.D. flour per cent[2]	+0.07	-0.33
Loaf volume	-0.77*	-0.17
Total baking score	-0.26	-0.14
Absorption	-0.32	-0.09
Patent flour protein	+0.65*	+0.21
Patent flour yield	+0.84*	+0.08

[1] Straight grade flour.

[2] Bran and shorts duster.

*Significant at 5% level.

The following coefficients of linear correlations at 5% level of significance were found to be significant for both the years.

Milling value and	pearling value
	Zeleny sedimentation
	Straight grade flour protein
	Straight grade flour yield
	2 Middlings protein
	Patent flour yield
	Patent flour protein
Total flour yield and	Test weight
	1000 Kernel weight
	Milling value

Those which had no significance are as follows:

Milling value and	Liquid wheat density
	Straight grade flour ash
	Straight grade flour color
	Ash value
	Particle size
	Curve index
	2 Middlings %
	Bran and shorts dust flour %
	Bran and short dust flour ash
	Total baking score
Total yield and	Wheat protein
	Wheat liquid density
	Straight grade flour ash
	Straight grade flour color
	Ash value
	Ash index
	2 Middlings ash
	2 Middlings %
	B.S.D. Flour %
	B.S.D. Flour Ash
	Total baking score
	Absorption

Some of the tests showed a coefficient of linear correlation of significance for the year 1961 and not for the year 1962. Following are the tests which were significantly linearly correlated for the year 1961 and <u>not</u> for the year 1962.

Milling value and Test weight
1000 Kernel weight
Wheat ash
Potential yield
Loaf volume

Total flour yield and Wheat ash
Pearling value
Potential yield
Zeleny sedimentation
Straight grade flour protein
2 Middlings protein
Loaf volume
Patent flour yield
Patent flour protein

The tests which had a significant coefficient of linear correlation for 1962 but not for 1961:

Milling value and Wheat protein
Ash index
2 Middlings ash
Absorption

Total flour yield and Curve index.

In general there existed a better significance of linear correlation between the milling value total flour yield and the tests on the 1961 sample than the 1962 samples. Some of the tests which had a correlation factor of significance did not have either a positive or negative relation for both the years; as the case was with the pearling value for 1961, it had a correlation factor of -0.58 and +0.56 for 1962.

Test weight is the only test in the present grain grading standards for selecting wheats, for their potential flour yielding capacity. Wheats can have the same test weights, which is the only test available, in determining the flour yield. But it does not give any indication of the distribution of products one may obtain.

This study shows that there is a difference between two varieties that will grade the same commercially, but have a difference in milling value. A good example is the varieties Comanche and C.I. 13536 for the year 1962, which have a milling value difference of 12 cents on 100 lbs. of wheat. It will be worthwhile to note the protein content of the flours is very similar.

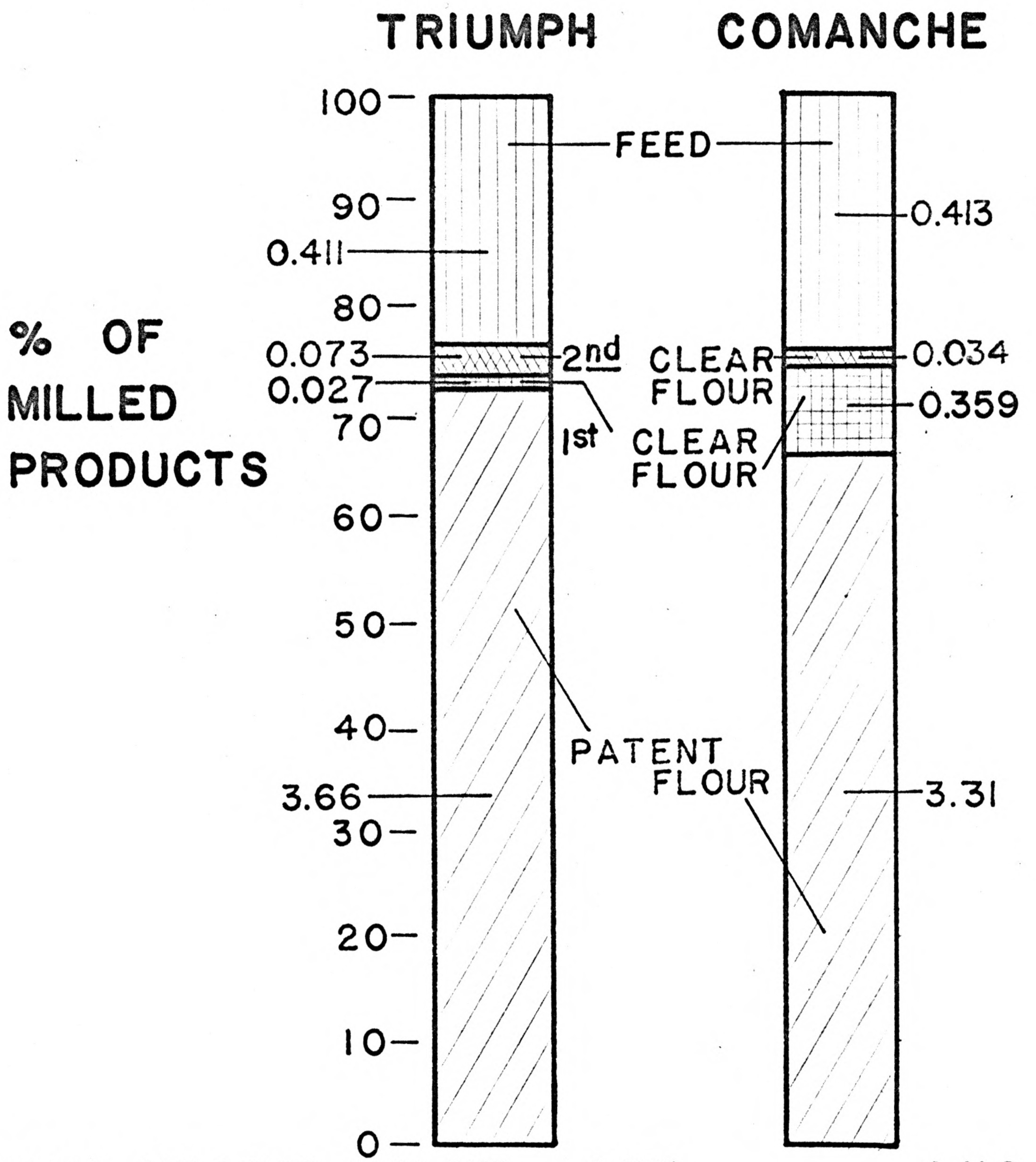
CONCLUSIONS

Two different wheat varieties having the same flour yield may not have the same milling value, which is attributed to the distribution of the milled products. It is, therefore, the distribution of these different flour grades and feed which play a major role in determining the milling value as shown in Fig. 11. Therefore, it can be safely assumed that the greater the percentage of higher grades of products, the higher would be the milling value for the variety of wheat.

This study shows that only on the analyses of the total flour yield into different grades of flour and their values can one determine the acceptability of a wheat variety on that particular flour mill without any costly alterations in the mill flow.

In general, it may be stated from this study of the various tests and their correlations with the milling value or total flour yield, that no such single test is capable of revealing the true milling value. The best known method available today to forecast the commercial milling properties of

FIG. II DISTRIBUTION OF MILLED PRODUCTS and THEIR MILLING VALUE



TOTAL MILLING VALUE **4.171** **4.116**

wheat is to apply the test milling and from it calculate the milling value figure.

SUGGESTIONS FOR FUTURE WORK

Since test milling of wheats has been the main tool for selecting wheats for commercial utilization as flour, further work should be able to establish a strong relationship between the milling value obtained from a commercial and an experimental mill or mills with a minimum sample size. This will make it possible to predict this milling value at an early stage during the variety breeding program or wheat selections for a grain processor.

More work could be done to study a number or group of such tests as performed in this study, which when combined will be capable of predicting the milling value.

ACKNOWLEDGMENTS

I wish to take this opportunity to express my sincere appreciation and gratitude to Professor A. B. Ward, for his guidance, advice, and suggestions during the research and in the preparation of the manuscript.

The author is also grateful to Dr. J. A. Shellenberger, Head, Department of Flour and Feed Milling Industries, for providing the facilities and the materials that were needed to carry out this work.

Special acknowledgment is due to Professor E. P. Farrell, who helped in and operated the Kansas State University's Pilot Flour Mill.

Last but not the least, I express my grateful appreciation to all the members of the department who most willingly gave all assistance and advice during the course of my work.

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APPENDIX

A PROPOSED METHOD OF CALCULATING THE MILLING VALUE USING THE EXPERIMENTAL MILLS

A proposed method for figuring the milling value using the experimental mills available today is discussed briefly as follows.

After the preliminary sample of wheat had been through the pilot flour mill, the test wheat was pneumatically lifted from the brush machine to fill the grinding bin. The grinding bin was emptied in cans and returned to the storage bins. The second filling of the grinding bin was considered to be the representative sample of the test wheat. It was from this second filling that the test wheat was taken out in cans to the experimental mills.

ALLIS-CHALMERS EXPERIMENTAL MILL

Allis-Chalmers' Experimental Mill is the one most widely used on a batch system of milling. Figure 12 and Plate I show the flow sheet which was followed during the course of these experiments and the mill. This milling was done in the Federal Hard Winter Wheat Quality Laboratory.

The fast roll speed was 550 rpm. The differential between the break rolls was 2.5:1, and the reduction rolls 1.5:1. The breaks, sizings, and 1st tailings rolls had the following corrugations.

First break	16 corrugations per inch
Second break	16 corrugations per inch
Third break	20 corrugations per inch
Fourth break	24 corrugations per inch
Sizing	36 corrugations per inch
1st Tailings roll	36 corrugations per inch

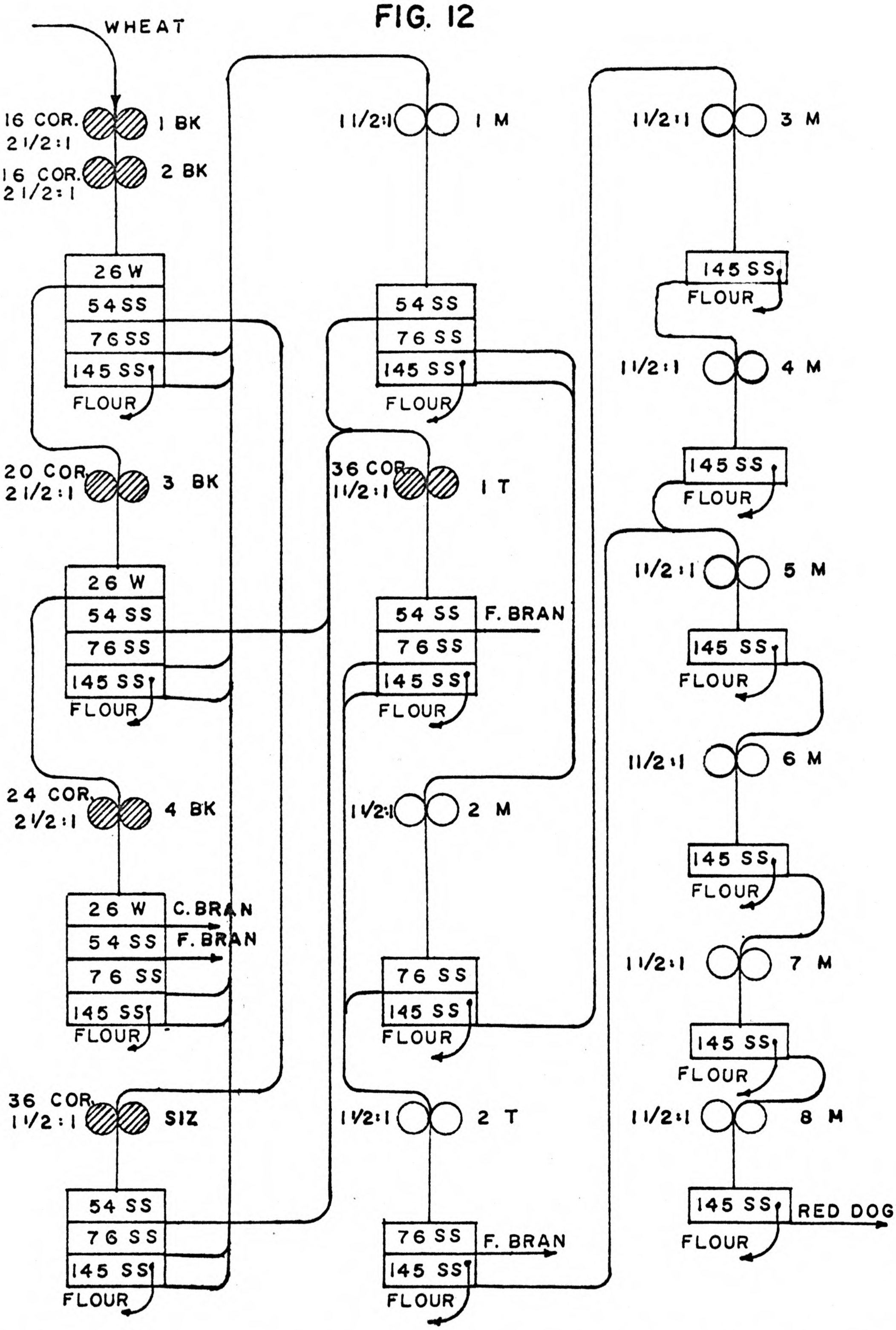
All the other rolls used had a smooth surface. The sifter used was the Allis-Chalmers' Laboratory size sifter which used a 2.4" throw.

The Break releases were

First Break	30%	(26 wire mesh, sifting time 1 minute)
Second Break	40%	(26 wire mesh, sifting time 1 minute)
Third Break	40%	(26 wire mesh, sifting time 1 minute)
Fourth Break	30%	(26 wire mesh, sifting time 1 minute)

The stock from the first two breaks was sifted on 35, 54, 76, and 145 stainless steel wires. The overs of 35 stainless steel wire was the third break stock. The overs of 54 stainless steel wire was the sizings stock and the overs of 76 and 145 stainless steel wire was the first middlings stocks. The third break stocks was sifted on the same set of sieves, the overs of 35 stainless steel wire going to the fourth break, the overs of 54 stainless steel wire formed the first tailings stock and the overs of 76 and 145 stainless steel wire went to the first middlings stock. The overs of 35 stainless steel wire on the fourth break were the coarse bran and those of 54 stainless steel wire were the fine bran.

FIG. 12



FLOW SHEET ALLIS-CHALMERS EXPERIMENTAL MILL

The first tailings derived its stock from the overs of 54 stainless steel wire on the third break sifting and the overs of 54 stainless steel wire from the sizings and first middling siftings, and the bulk appearance of it was that of germ and very fine bran.

The second tailings had its source of the stock from the overs of 76 and 145 stainless steel wire of the fourth break, first tailings and the overs of 76 stainless steel wire from the second middlings.

The middlings overs of 145 stainless steel wire were ground and reground on smooth rolls, until most of the endosperm was reduced to particles that passed through the 145 stainless steel wire. The final overs of the 145 stainless steel wire were called the "Red Dog" and it constituted only about five per cent of the total products of the milling.

The sifting time on all the streams was one minute except in the case of the third and fourth middlings; it was three minutes, and on the fifth middlings which was two minutes.

The mill was adjusted previous to each test milling by using 1000 grams of the control wheat sample. The sample size used was 4500 grams. All of the flour streams were weighed separately and analyzed for protein, moisture, and ash. The analyses are reported on a 14 per cent moisture basis. These analyses were used in all further calculations for cumulative ash and protein in order of increasing ash and in the calculation of the milling value. The straight grade flour was made by blending the individual streams, and rebolting them on a 105 stainless steel wire.

MULTOMAT EXPERIMENTAL MILL

It is one of the larger experimental mills, having a minimum sample size of approximately thirty pounds for the milling evaluation works.

The flow sheet and the mill for this study is described in Fig. 13 and Plate I. It consisted of three breaks and five reduction passages. The break rolls had a differential speed of 2:1, the fast roll running at 325 rpm and the following corrugations:

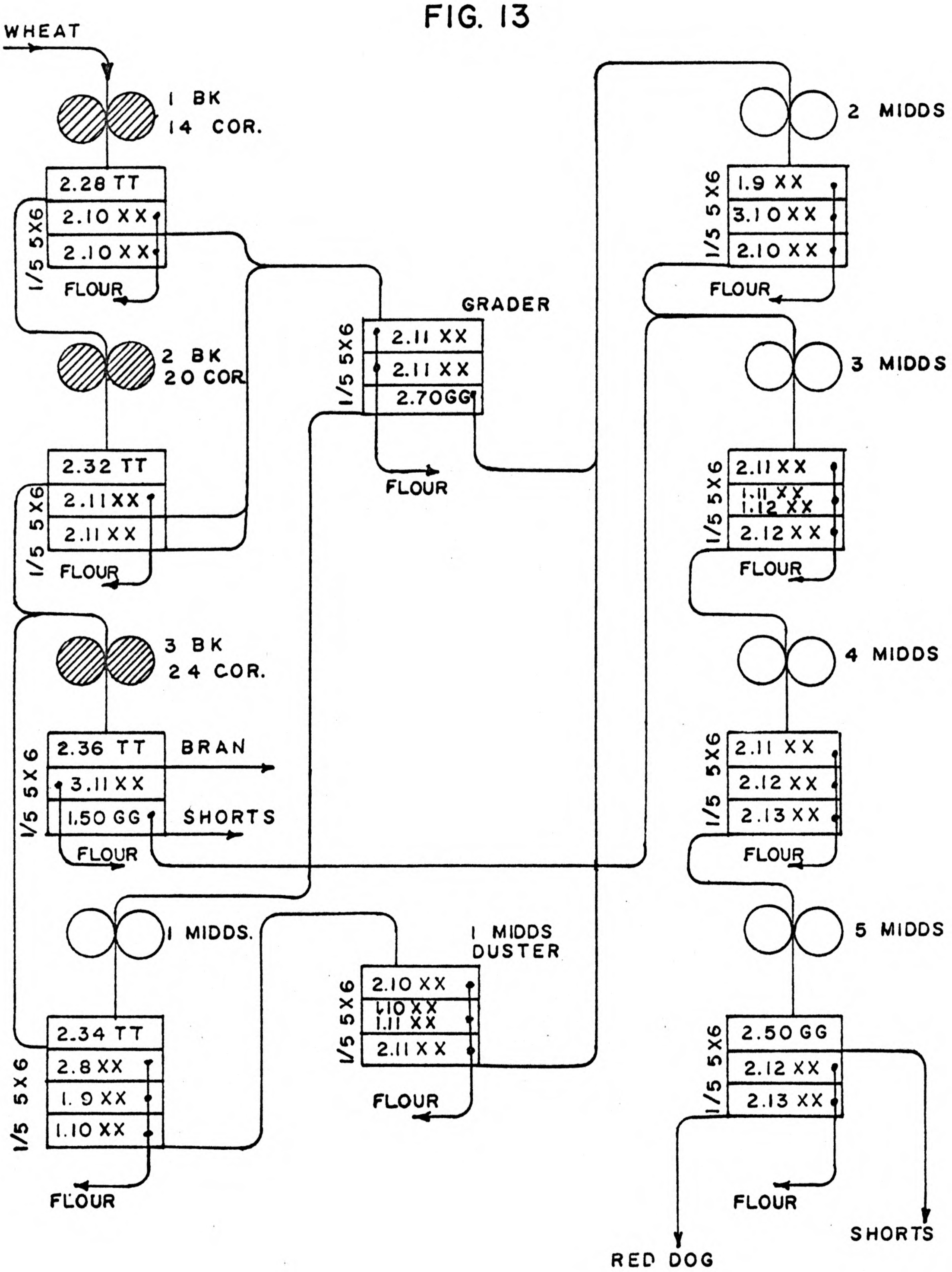
First break	14 corrugations per inch.
Second break	20 corrugations per inch.
Third break	24 corrugations per inch.

All the stock was pneumatically conveyed. It had ten flour streams, one bran, two shorts classified as break and reduction, and one "Red Dog."

A preliminary test was made previously to all test millings at a feed rate of 1000 grams per minute. The preliminary test run was also used to set the mill to a fixed extraction.

All ten flour streams and the four feed streams were weighed separately to calculate the percentages of the streams and the total flour yield. A 25 to 30 gram flour stream sample was taken and analyzed for protein, moisture and ash. These

FIG. 13



FLOW SHEET MIAG MULTOMAT EXPERIMENTAL MILL

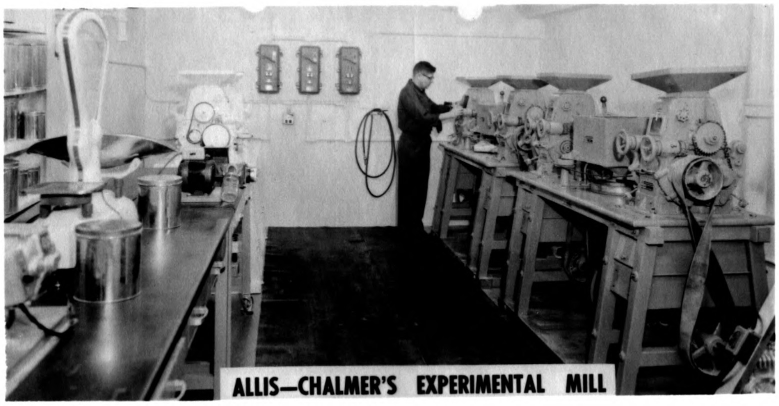
EXPLANATION OF PLATE I

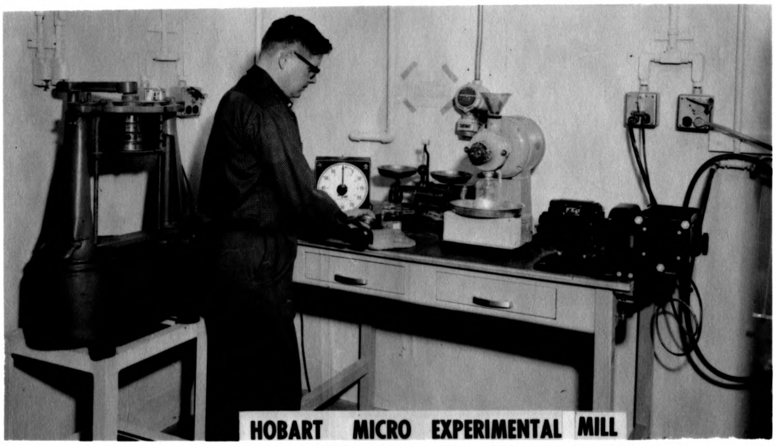
Fig. 1. A view of Allis-Chalmers' Experimental Mill.

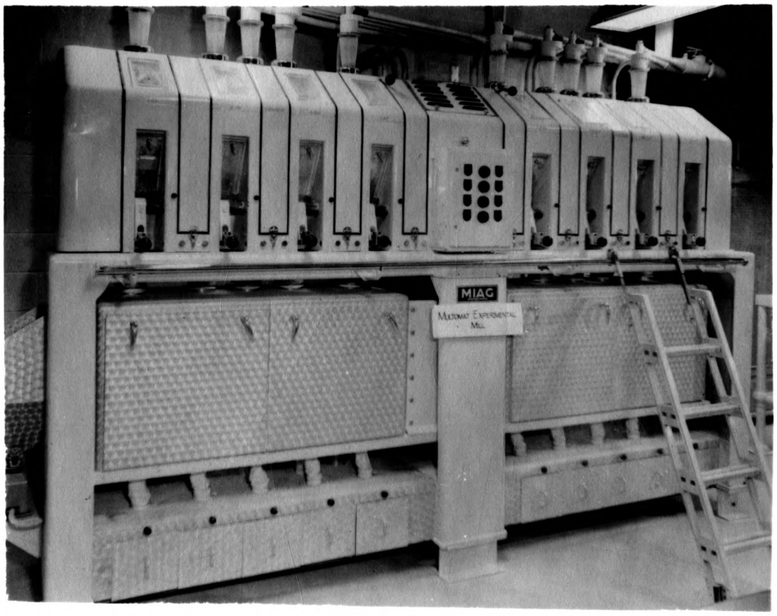
Fig. 2. A view of Hobart Micro Experimental Mill.

Fig. 3. A view of Miag Multomat Experimental Mill.

PLATE I


ALLIS—CHALMER'S EXPERIMENTAL MILL


HOBART MICRO EXPERIMENTAL MILL


MIAG

analyses are reported on a 14 per cent moisture basis and are used in all calculations.

The straight grade flour was made by blending all the individual flour streams in a laboratory type blender.

BUHLER EXPERIMENTAL MILL

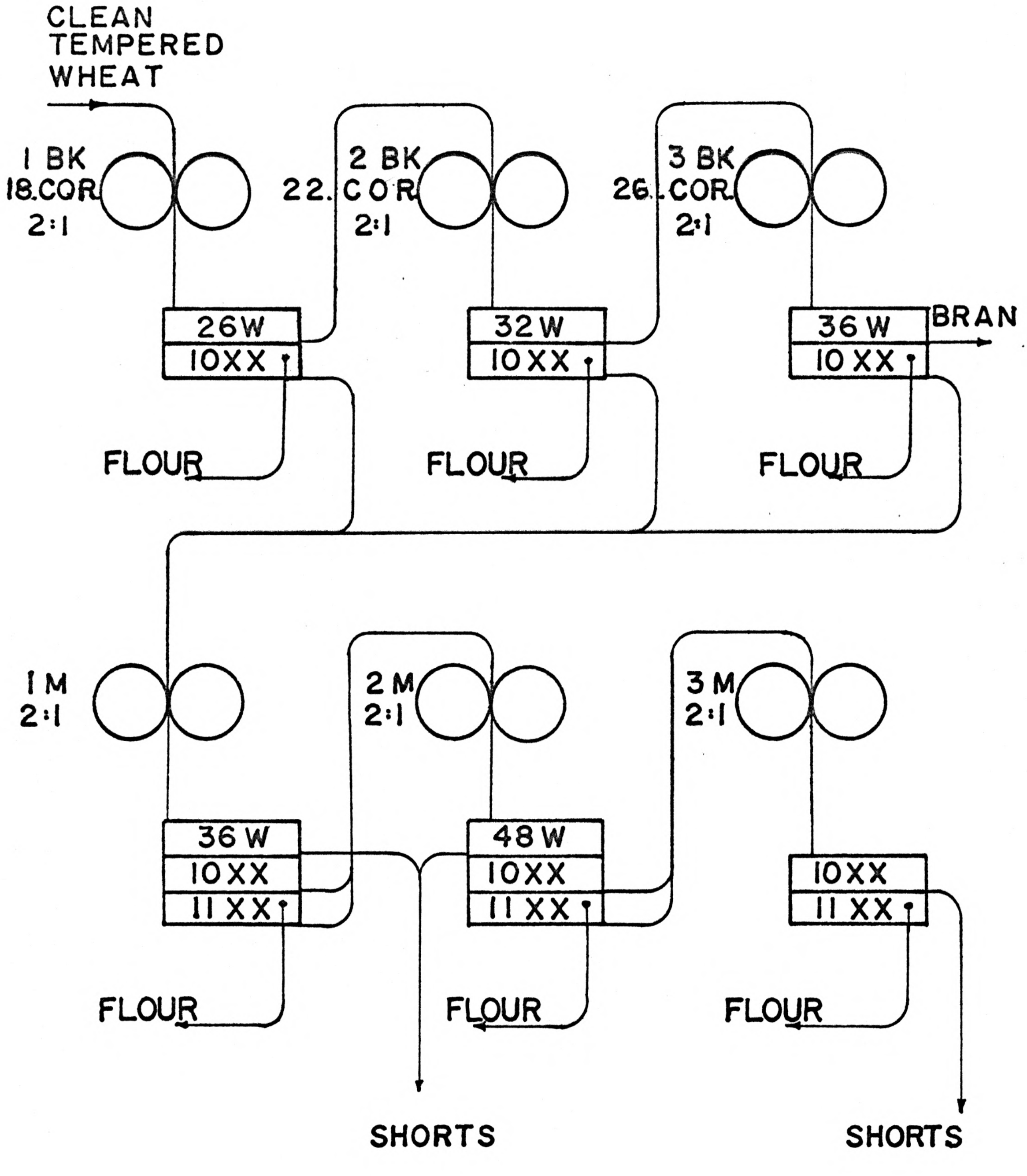
The Buhler laboratory experimental mill used in this study was of the pneumatic type. The flow sheet (Fig. 14 and Plate II), consisted of three breaks and three reduction rolls. The rolls had a differential of 2:1 with the fast roll running at 540 rpm. The break rolls had the following corrugations:

First break	18 corrugations per inch
Second break	22 corrugations per inch
Third break	26 corrugations per inch

Each flour stream (3 from the breaks and 3 from the reductions) flowed into a separate containers. The bran and shorts were also collected in separate containers.

The six flour stream samples were taken individually and analyzed for protein, moisture and ash. The straight grade flour was a blend of all the streams. The straight grade flour was rebolted on the Great Western laboratory sifter using a 9XX flour cloth. Each flour stream, bran and shorts, were weighed separately and their percentage calculated and used in all further calculations. Protein and ash values are all reported on a 14 per cent moisture basis and used in all calculations.

FIG. 14



FLOW SHEET FOR BUHLER EXPERIMENTAL MILL

QUADRUMAT JUNIOR EXPERIMENTAL MILL

The flow sheet for the Quadrumat Junior is shown in Fig. 15 and the mill in Plate II. The feed rate was 60 grams per minute.

The rolls used had the following corrugations per inch and the speed.

No. 1	12 Corrugations per inch	1240 rpm
No. 2	25 Corrugations per inch	540 rpm
No. 3	37 Corrugations per inch	1200 rpm
No. 4	40 Corrugations per inch	540 rpm

The differentials used were

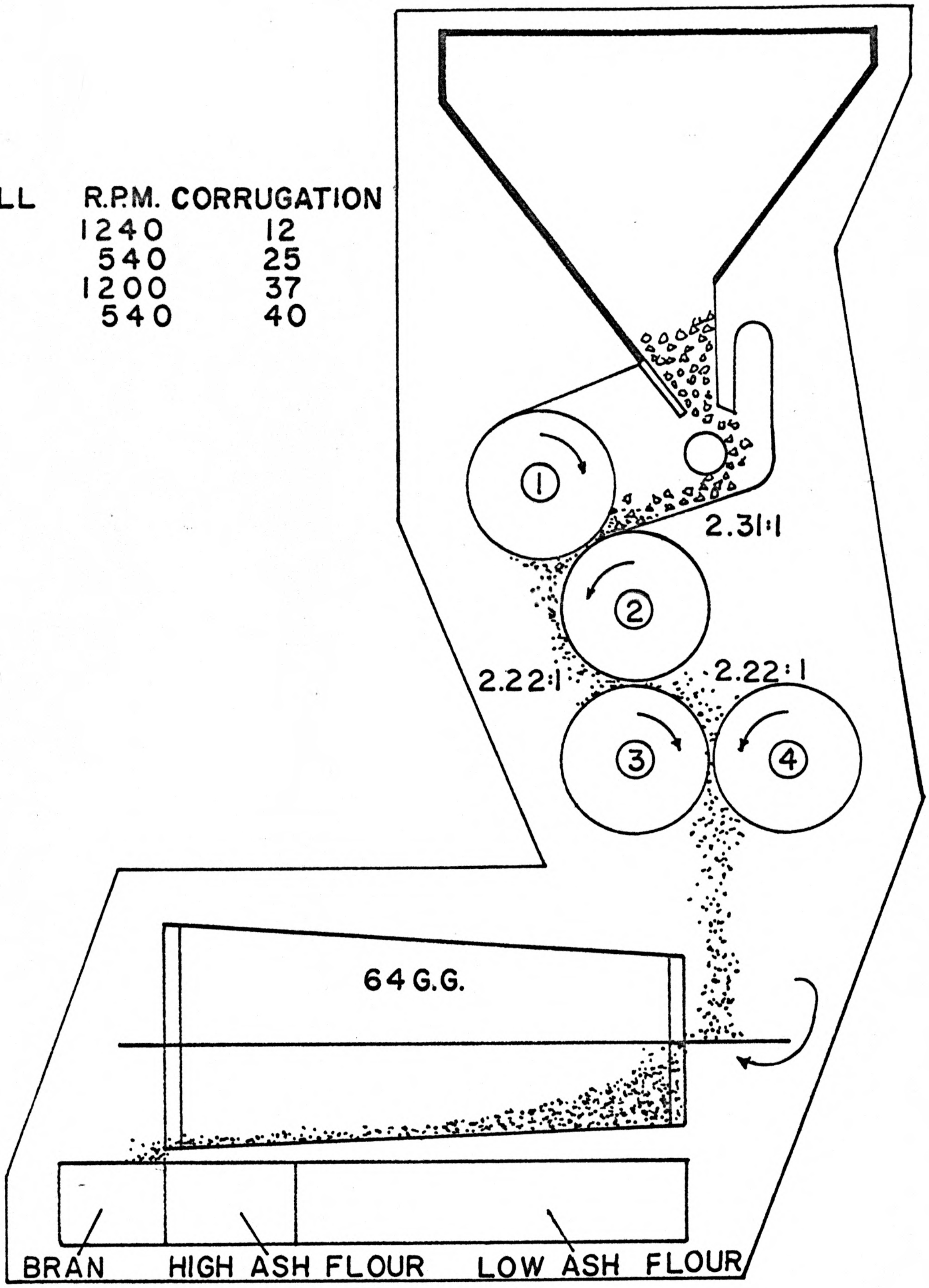
First break	(Rolls 1 x 2)	2.31:1
Second break	(Rolls 2 x 3)	2.22:1
Third break	(Rolls 3 x 4)	2.22:1

A preliminary test run was made for ten minutes before the test sample was milled.

Two flours were made from the one 64 GG reel cover which was seven inches long. The first 4 1/2 inches were used for the first flour and the last 2 1/2 inches for the second flour. After making the two flours and feed were weighed for percentage of each. These two flours were submitted together with the straight grade flour for analysis of protein, moisture, and ash. These figures are reported on a 14 per cent moisture basis. The straight grade flour was rebolted on a 9XX on a Great Western laboratory sifter.

FIG. 15

ROLL	R.P.M.	CORRUGATION
1	1240	12
2	540	25
3	1200	37
4	540	40



QUADRUMAT JUNIOR EXP. MILL

BRABENDER RAPID TEST MILL

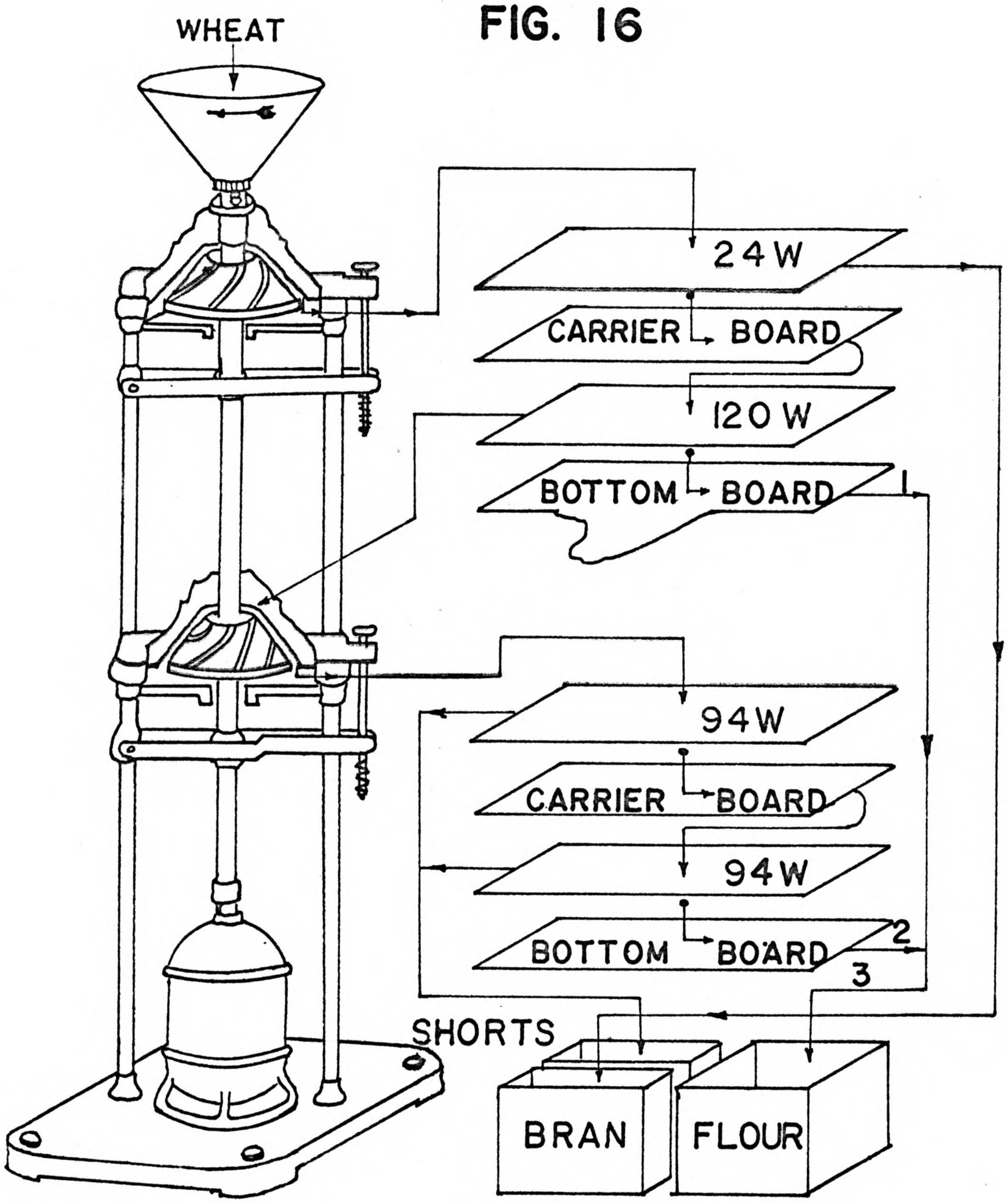
The mill and the flow sheet for the mill is described in Fig. 16 and Plate II. The grinders in this mill were of stones, each one a cone shape and resting on one another. The top set of grinders was designated as the breaks and the flour obtained from it was called the break flour. The lower set were called the reduction grinders and the flour they produced was identified as reduction flour.

A preliminary test was milled for ten minutes prior to the test milling. A feed rate of 160 grams per minute was used. The break flour was made by disconnecting the flour stocking from the break section of the sifter and collecting it in a separate container. The reduction flour was collected in a separate container. Each of these flour along with the bran and shorts were weighed to provide the production figures and percentages. These flour streams were analyzed for protein, moisture, and ash, which are reported on a 14 per cent moisture basis for the purpose of all calculations. A straight grade flour was made and rebolted using a Great Western sifter. The straight grade flour was analyzed for protein, moisture, and ash.

HOBART EXPERIMENTAL MILL

The mill and the flow sheet is described in Fig. 17 and Plate I. The tempered wheat was first ground on the Tag-Heppenstall rolls three times using the wheat shim. The sample

FIG. 16



1. BREAK FLOUR
2. REDUCTION FLOUR
3. STRAIGHT GRADE FLOUR

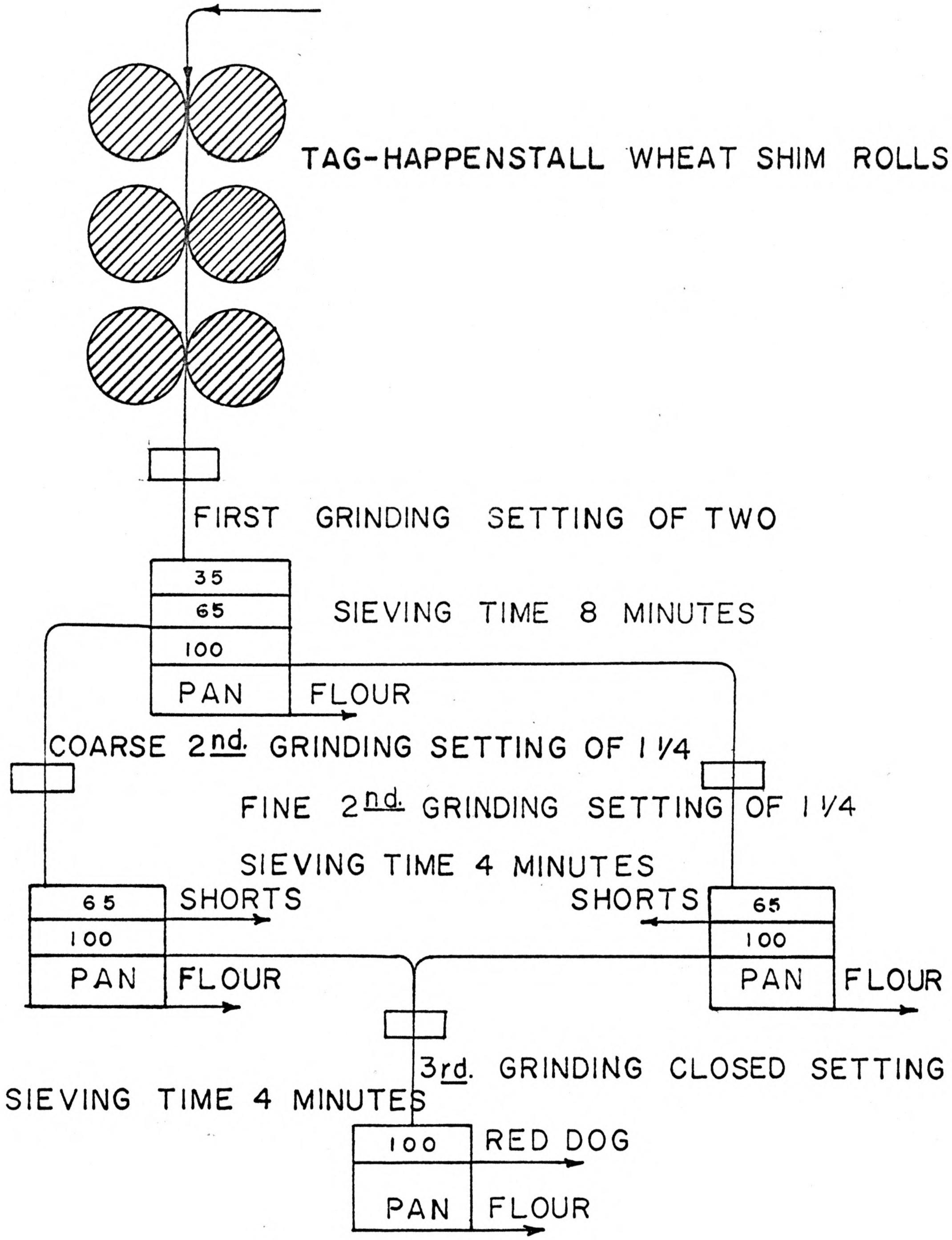
BRABENDER RAPID TEST MILL

was ground with a feed rate of 100 grams per minute with the Hobart grinder setting of 2. The ground material was sifted for two minutes on a Ro-tap shaker and the bran taken off over a 35 wire. After the bran was removed, the remainder of the stock was again sifted for two minutes on a 100 mesh sieve. The overs of the 100 mesh sieve were called the fines and were ground with a setting of 1 1/4, and were sifted for eight minutes on a 65 mesh sieve. The overs of 65 were called coarse and were reground with the setting of 1 1/4 and sifted on a 100 mesh sieve for eight minutes. Overs of this 100 mesh sieve were again reground with a close setting of less than one and sifted for eight minutes. The overs were called "Red Dog." Thus, four flour streams were available and samples of about 25 grams were taken for analysis for protein, moisture and ash. The straight grade flour was made up of the remaining stream flours. This straight grade was blended and rebolted and submitted for analysis for protein, moisture and ash. These figures for protein and ash are reported on a 14 per cent moisture basis for all calculations of cumulative ash and protein in order of increasing ash.

QUADRUMAT SENIOR EXPERIMENTAL MILL

The Quadrumat Senior pilot mill is one of the latest in the new automatic experimental test mills. It is based on the same four roll principle as the Quadrumat Junior Experimental Mill. It is fully described in Fig. 18 and Plate II. In this

FIG. 17



HOBART MICRO MILL FLOW SHEET

system, two Quadrumat heads are used, one as the break, and the other as the middlings reduction unit.

The mill flow as received was fixed for obtaining six products:

(1) Break flour

(2) Reduction flour

(3) Middlings

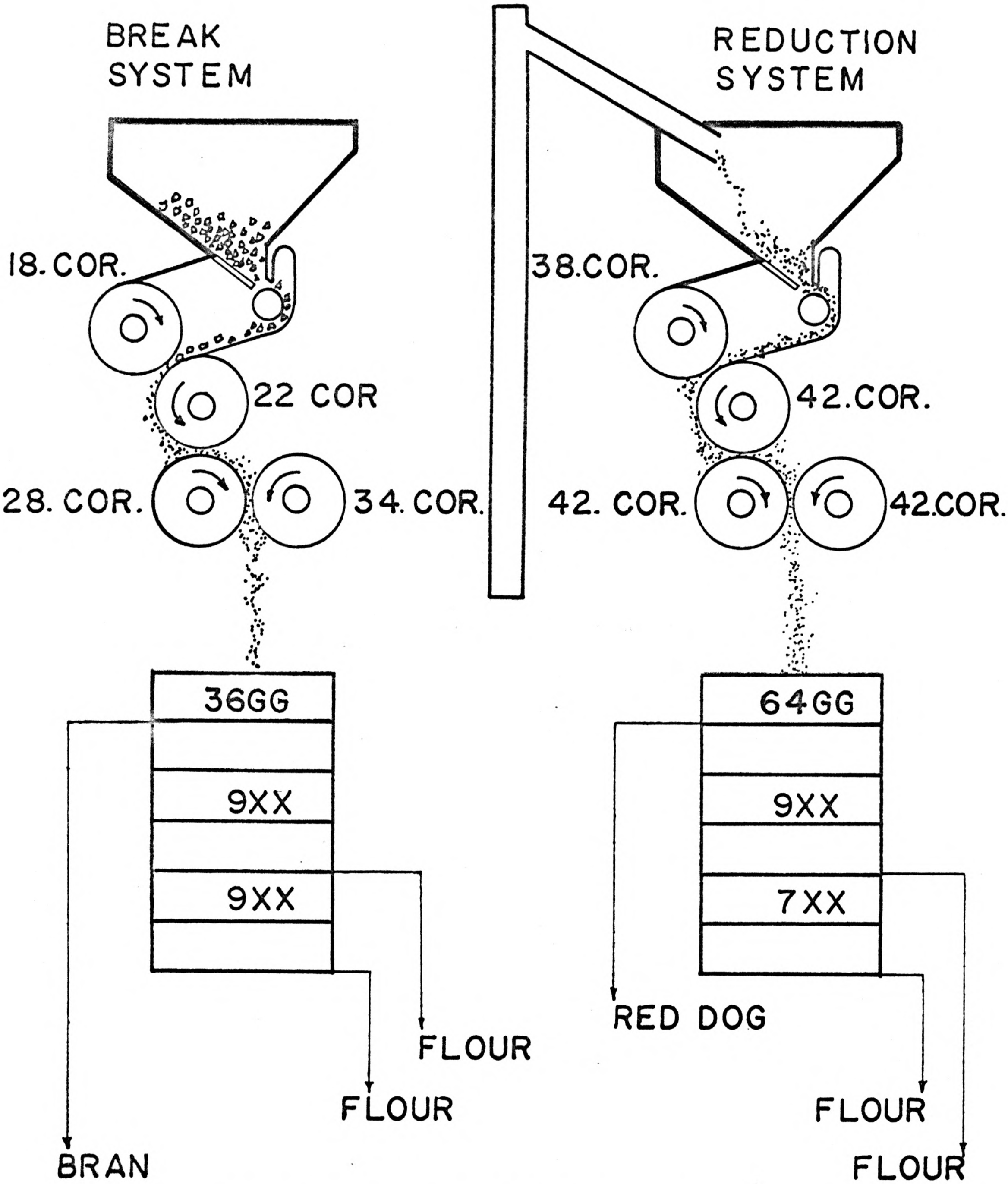
(4) Bran

(5) Shorts

(6) Fine bran, with a slight adjustment in the sifter sieve arrangement.

The sifter has two sections, one for the break and the other for reduction. This arrangement of the manufactureres allowed only two flour streams. A slight modification was made in the flow by blocking the outlets of the flour collecting on stainless steel bottom trays. In this way it was possible to obtain four flour streams, besides bran and shorts. The bran and shorts were collected in the plastic containers provided by the manufacturers of the unit. A preliminary test run was made with a sample of 500 grams of wheat prior to the sample test run. Five hundred gram samples were used to obtain the four flour streams with the feed gate open to maximum. This feeder setting gave a feet rate of approximately 150 grams/minute. These streams were weighed and samples were submitted for analysis for protein, moisture and ash. The straight grade flour was made by using another 500 gram sample.

FIG. 18



QUADRUMAT SENIOR EXP. MILL

This time all the flour was collected in one plastic container; it was weighed and rebolted before being submitted for analyses for protein, moisture, and ash. All the products were weighed for percentage calculations. The analyses are reported on a 14 per cent moisture basis and was used in the calculations of the cumulative ash and protein in order of increasing ash.

Cumulative ash curved plotted for each mill are shown in Fig. 19.

The method of calculations for the flour grades is discussed in detail under methods of determination and calculations. Table 12 shows the different flour grades calculated from each of the experimental mills and the milling value obtained for each of the mill on this variety of wheat.

EXPLANATION OF PLATE II

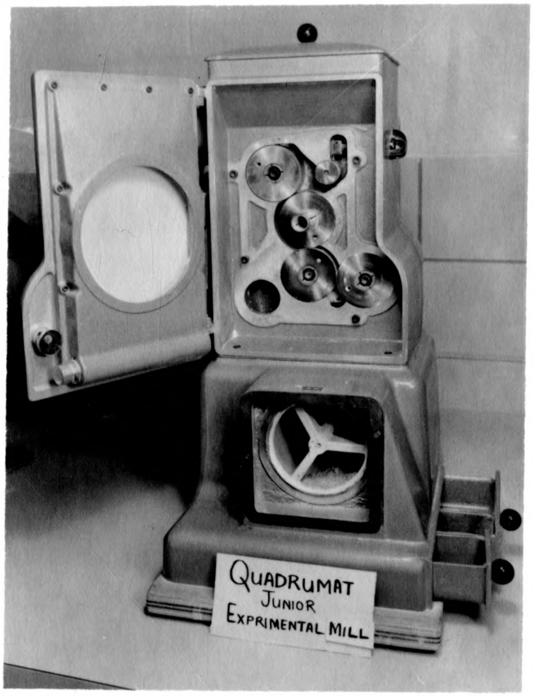
Fig. 1. A view of Quadrumat Junior Experimental Mill.

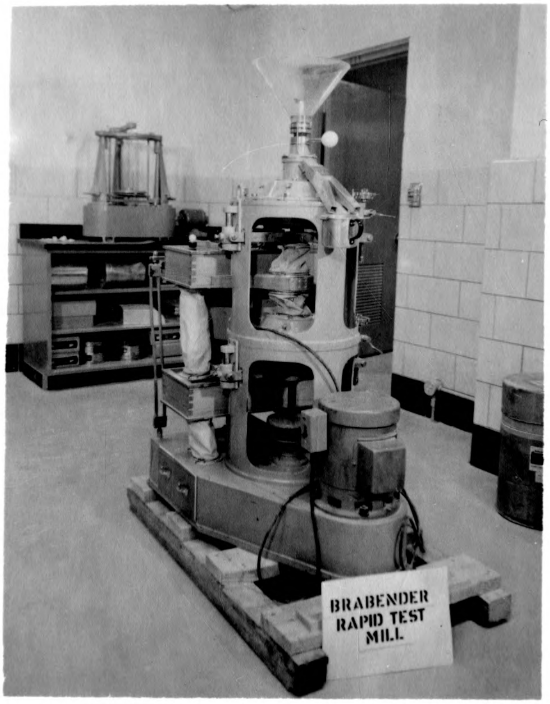
Fig. 2. A view of Brabender Rapid Test Mill.

Fig. 3. A view of Quadrumat Senior Experimental Mill.

Fig. 4. A view of Buhler Experimental Mill.

PLATE II


QUADRUMAT
JUNIOR
EXPRIMENTAL MILL


BRABENDER
RAPID TEST
MILL


QUADRUMAT
EXPERIMENTAL MILL

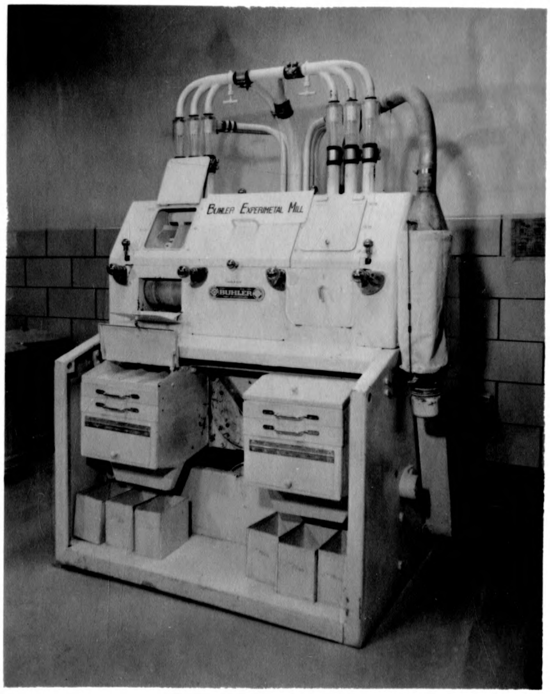

BUHLER EXPERIMENTAL MILL
BUHLER

FIG.I9 Cumulative Ash Curves

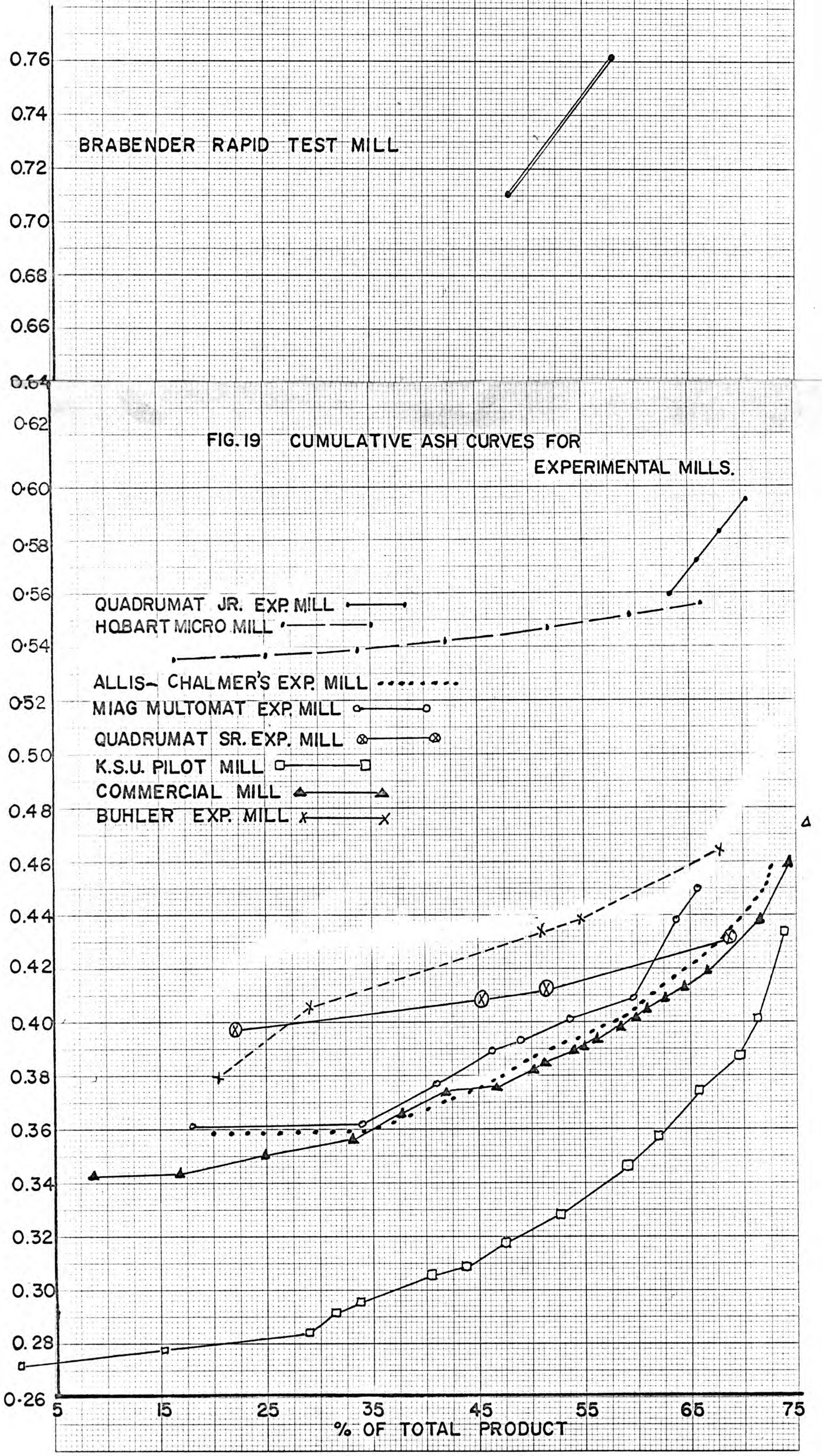

BRABENDER RAPID TEST MILL
FIG. 19 CUMULATIVE ASH CURVES FOR EXPERIMENTAL MILLS.
QUADRUMAT JR. EXP. MILL
HOBART MICRO MILL
ALLIS- CHALMER'S EXP. MILL
MIAG MULTOMAT EXP. MILL
QUADRUMAT SR. EXP. MILL
K.S.U. PILOT MILL
COMMERCIAL MILL
BUHLER EXP. MILL
0.76
0.74
0.72
0.70
0.68
0.66
0.64
0·62
0·60
0·58
0·56
0·54
0·52
0.50
0.48
0.46
0.44
0.42
0.40
0.38
0.36
0.34
0.32
0.30
0.28
0·26
5
15
25
35
45
55
65
75
% OF TOTAL PRODUCT

Table 12. Calculated flour grades and their milling value for experimental mills.

Exp. Mill	Second Clear Flour 1.20 Ash Value $3.70		First Clear Flour 0.70 Ash Value $4.20		Patent Flour 0.38 Ash Value $5.00		Total Flour Value	Feed Value $1.70		Milling Value
	%	$	%	$	%	$	$	%	$	$
Commercial	1.066	0.039	15.99	0.672	59.102	2.955	3.666	23.842	0.405	4.07
KSU Pilot Mill	3.111	0.116	--	--	70.849	3.542	3.658	26.04	0.442	4.10
Multomat	--	--	10.006	0.320	55.514	2.776	3.196	34.48	0.586	3.78
Allis-Chalmers	--	--	7.057	0.296	64.513	3.226	3.522	27.43	0.466	3.99
Buhler	--	--	14.71	0.618	53.08	2.654	3.272	32.21	0.547	3.82
Quadrumat Junior	--	--	42.787	1.797	27.703	1.385	3.182	29.51	0.502	3.68
Hobart Micro Mill	--	--	34.268	1.443	31.632	1.582	3.029	34.1	0.572	3.60
Brabender Rapid Test Mill	6.97	0.258	51.09	2.146	--	--	2.404	41.94	0.713	3.12
Quadrumat[1/] Senior	--	--	7.090	0.298	61.780	3.089	3.387	31.13	0.529	3.92

[1/] Sample not milled on the same date.

PREDICTING COMMERCIAL MILLING RESULTS BY EXPERIMENTAL MEANS

by

DINESH MEHROTRA

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The purpose of this study was to determine if it is possible to predict the milling value of wheat by means of a simple known test. Tests performed were test weight, wheat protein, wheat ash, 1000 kernel weight, per cent of patent flour, flour color, total flour yield, absorption and others; either from the wheat itself or from the milled products.

Milling value is a total dollars value of the products obtained by milling 100 pounds of wheat into flour, value being reflected by the yield of low ash flour and total flour yield. Milling value, for the purpose of this study, was determined by assigning realistic monetary values to the milled products as follows:

Patent Flour	0.38 Ash	at $5.00	per 100 Lb.
First Clear Flour	0.70 Ash	at $4.20	per 100 Lb.
Second Clear Flour	1.20 Ash	at $3.70	per 100 Lb.
Feed		at $1.70	per 100 Lb.

The milling values of 15 different wheat varieties grown in the states of Kansas, Nebraska, Oklahoma and Texas in 1961 and 1962, and their milled products, were studied with respect to their physical and analytical characteristics.

All the varieties were milled on Kansas State University's 180 cwt. Pilot Flour Mill. Each of the 23 flour streams of the mill were analyzed for protein, moisture, and ash. Cumulative ash and protein curves were plotted for each variety. This information was used in the calculation of flour grades and their material values.

Simple correlations coefficients were determined between the milling value, total flour yield, and all the physical and analytical tests which were performed in the course of this study.

None of the single tests showed a high level of significance with either the milling value or the total flour yield. The highest significant correlation was between total flour yield and milling value, followed very closely by the calculated patent flour percentage. This study shows that milling value is dependent on the distribution of milled products, i. e., different grades of flour from a wheat, rather than its total flour yield.

The protein contents of wheat and its products also show a significant correlation with milling value but not to the same degree both years.

Some tests showed a nonsignificant correlation between the milling value or total flour yield. Still other tests had a highly significant correlation coefficient with milling value or total flour yield for one year but nonsignificant for the other year. On the whole, the tests on 1961 samples showed better correlation than the tests on 1962 samples.

With these results it can be safely assumed that none of the single tests is capable of revealing or predicting the milling value of wheats for commercial utilization, except experimentally milling the wheat and evaluating its milled products.