PRE-BREAKING: DOCUMENTING ITS EFFECTS

by

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INTRODUCTION

The purpose of this study is to document the effects of a preliminary breaking of wheat kernels prior to the actual milling process. To further understand this study, a basic explanation of the processing of wheat to obtain white flour should be given.

Most flour milling operations can be divided into six systems: Break System, Middlings Reduction System, Sizings System, Purification System, Tailings System, and Low Grade System. Properly conditioned wheat is first worked upon by the Break System which functions to open the wheat kernel and release particles of endosperm known as sizings and middlings from the bran coat. The Break System can consist of three to seven passages which employ pairs of cylindrical corrugated rolls, called roller mills. The rolls rotate towards each other with one roll rotating about two and one-half times as fast as the other roll. The number of corrugations increases while the depth of the corrugations decreases after each succeeding break. After each grind, the ground material is sent to sifters consisting of sieves covered with various cloths to separate out the different particle sizes. The coarsest material, mostly bran with adhering particles of endosperm, is sent on to the next break. Chunks of endosperm from the Primary Breaks (normally First, Second and Third Breaks), varying in size and purity, are sent to the Purification, Sizing and Middling Reduction Systems. Material from the Secondary Breaks (Fourth and Fifth Breaks) which is more bran-contaminated, is sent to the Tailings and Low Grade Systems. Some flour, made incidently, is removed from each sifting.

In most mills making white flour, materials consisting of endosperm chunks and small bran chips is sent to a Purification System. Purifiers utilize both reciprocating sieves and air currents to grade the stock further by size and to purify it by lifting off the lighter bran chips. Cleaned endosperm material is then sent to the Sizings or Middlings Systems, depending on the degree of purity.

The larger chunks of endosperm with some adhering bran is sent to the Sizings System. Here, smooth or finely corrugated rolls operating at a differential of about 1.5 to 1 reduce the large particles of endosperm somewhat and at the same time remove adhering bran which is also slightly flattened. Sifters then separate the reduced endosperm chunks (to be sent to the Middlings Reduction System) from the chips of bran and germ which are sent to the Tailings System. Although some high quality flour is recovered in the Sizings System, the main function is to release the endosperm from the chunks of bran and germ and reduce these sizings to middlings.

The primary function of the Middlings Reduction System is to produce flour. Normally, middling stock is ground on smooth rollermills, operating at a differential of 1.5 to 1, set to produce the optimum amount of flour. Any small particles of bran or germ contained in the middlings stock are normally flattened by the rolls and scalped off to the Tailings System, while the middlings material that is not reduced to flour size is sent to the next middlings grind. A normal mill flow will contain four to five middling-reduction grinds with the amount of bran intrusion increasing with each successive pass.

The Tailings System receives stock that is mostly particles of bran with some adhering chunks of endosperm. The primary function is to recover any particles of endosperm to be returned to the Middlings System. The branny stock is sent to feed. A small amount of low quality flour is also recovered. Again, smooth rolls operating at a low differential are normally used here.

The Low Grade System is the "finishing" system in the mill flow. Poorer quality stock, not reduced in the Middling-Reduction System, feeds the Low Grade System. The purpose here is to recover any flour produced and send the remainder to feed.

The total objective of milling wheat into white flour is to provide an acceptable, uniform product to the customer, be it the commercial or home baker. Acceptability can be based on many different criteria depending on the customer's needs. Ultimately, the successful miller utilizes all the resources available to him to produce the maximum amount of salable flour at the least cost of production.

The purpose of this investigation is to determine whether the preliminary breaking of the wheat kernel prior to the Breaking System in the mill flow is beneficial to the miller in achieving his goals.

LITERATURE REVIEW

Pre-Breaking

Although the concept of Pre-breaking is not a new one, there is virtually no published information on the subject. Commercial milling companies that utilize pre-breaking systems developed those systems for the most part on their own, and due to the competitive nature of the flour milling business, scientific literature on these systems is not readily available.

Kozmin (1), was the first known author to report on Pre-Breaking systems in discussions of some of the very first gradual reduction milling systems. He wrote, "As regards the character of reduction, high grinding (gradual reduction grinding) may be divided into four separate categories. In the first must be placed the breaking of the berry down the crease, which allows removal of dust settled in the crease from the halves, and otherwise inextractable in the cleaning process." He stated further that the French called this passage "l'avant broyage" or preliminary break and the Germans labeled it "Hochshrot." Two of these very early flowsheets using Pre-Break systems are shown in plates 1 and 2. Flour removed from these Pre-Breaks was called "blue flour" due to the blue-grey appearance as compared to the other recovered flours. Smith (2) also reported that at the time of the introduction of the roller mill in England in 1879, first break was initially used as a cracking roll with the broken grain being sifted immediately to extract what was known as the blue flour or crease dirt. He reported that the technique was dropped due to improved wheat cleaning machinery.

In June of 1929, the National Miller (3) provided a "round table discussion" in which the topic was "Splitting the Wheat in the Crease."

PLATE 1

FLOWSHEET OF GERMAN SHORT
FLOW USING PRE-BREAK

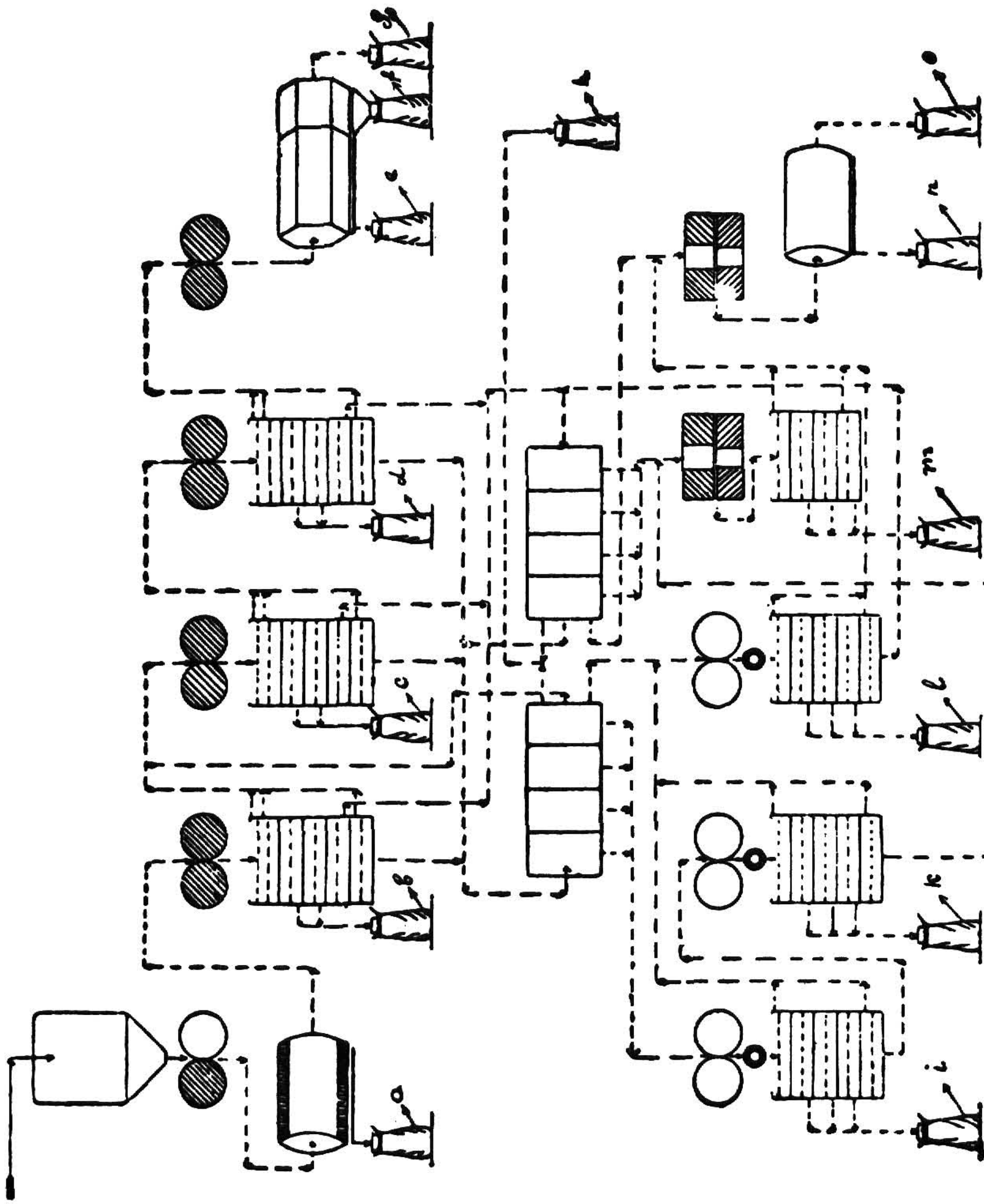


PLATE 1

PLATE 2

FLOWSHEET OF A GERMAN
ABRIDGED HIGH GRINDING FLOW
USING PRE-BREAK

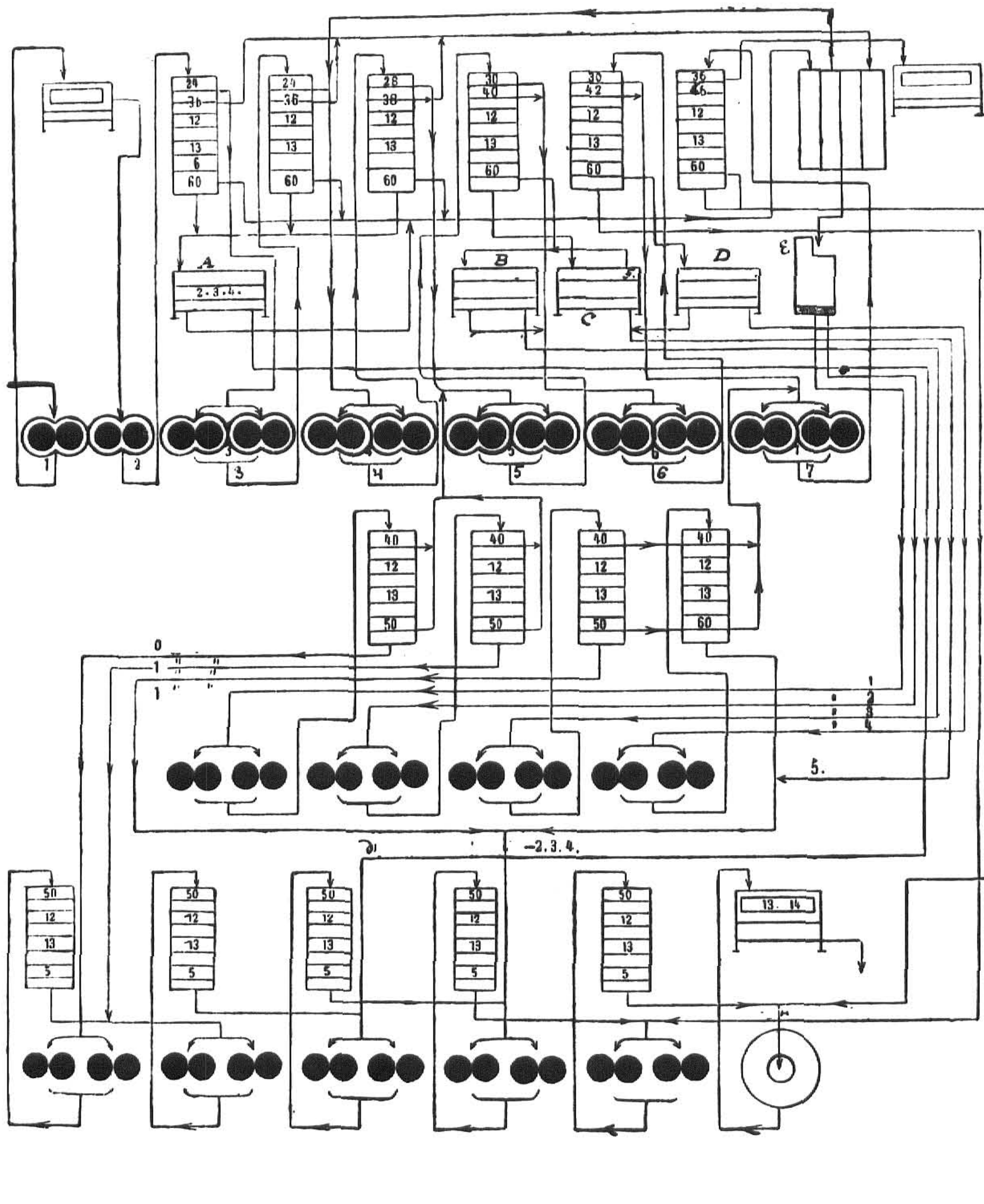


PLATE 2

Opinions of about 50 prominent millers were provided. The majority of the millers at this time felt it was not advantageous to Pre-Break the wheat. Of those that felt it would be advantageous to Pre-Break, most stated that it both removed crease dirt and made a broader bran. Two months later, August of 1929, in an article further discussing the splitting or Pre-Breaking of wheat, Reed (4) reported that the idea was sound, but that what was needed was a machine that could accurately split the wheat through the crease and remove all of the seam impurities and germ. He also finished by saying this couldn't be done.

From these early mentions of pre-breaking, there seems to be no other information published on the subject for a period of about 20 years. Even flow sheets available, dating to this period in time, do not show any use of Pre-Break Systems. In 1952, Farrell and Milner (5), in a survey of U.S. Flour Mills, found that some of the mills were using different forms of Pre-Break systems to help alleviate the problem of insect fragments in the finished flour. These systems utilized impact machines, generally known as entoleters, or rolls, or in some instances both were being used. The wheat was being cracked open by the entoleters or rolls and then followed with aspiration and/or sifting to remove small streams high in insect material. The surveyors gave no particular preference for either the rolls or entoleters but noted there were many variables influencing the effectiveness of the entoleter. Rolls were usually nine or ten inches in diameter and operated at approximately one to one differential. Roll surface was either smooth or finely corrugated with no spiral. Most importantly, the surveyors pointed out that some milling advantages other than insect fragment removal might also accrue from the practice of Pre-Breaking. They stated, "Advantages of pre-breaking claimed by some millers include increase in percentage of patent flours and increase in germ recovery with the resulting benefit of grinding less germ into the flour."

In a report on the use of impact machines for "Pre-Milling Control," Zerull (6) pointed out the advantages of such systems to be better mill balance, cleaner middlings, lower ash due to the removal of more crease and germ end dirt and due to the better recovery of germ before the breaking process.

It is not known, exactly, the percentage of Pre-Break Systems in use today in commercial flour mills. In a survey by the Association of Operative Millers Technical Committee (7), Association members were sent questionnaires asking them to provide the information necessary to construct a flow sheet for a new 5000 hundredweight of flour per day flour mill. Approximately 65 percent of those respondents reported that they would use some form of Pre-Break, either roller mills or impact machines. This may give some approximation as to the actual use of Pre-Break Systems in commercial mills today.

Experimental Milling

Since data from commercial mills is difficult to obtain, testing must be performed on smaller scale experimental mills. The question then arises, "Are experimental mills reliable enough to accurately predict the results of comparable tests on commercial mills?" Anderson (8) related it best when he stated, "The problem then in Experimental Milling resolves itself into the use of a minimum number of basic milling operations to secure results which furnish advance information concerning what will be obtained when wheat from the same mix is milled on the longer commercial system. . . ."

Miller (9) believed that experimental milling represents experimentation on a small scale; however, without it commercial milling itself would be largely experimental.

Rumold (10) stated that experimental milling can provide the miller with advanced milling data and mill chemists with material for analytical investigation. Herman (11) also believed that experimental milling can foretell in close approximation milling quality, yield of wheat and the characteristics of flour from it.

Zeleny (12) states that milling quality can be directly determined by means of experimental milling tests. He also reported that many commercial millers have been reasonably successful in adjusting and operating experimental milling equipment in such a manner that yield and quality of experimentally produced flours closely parallels the yield and quality of commercially produced flours.

The yield of flour and the ash conversion, according to Anderson (8), are two factors which should be observed in experimental milling.

The Ash Test and Cumulative Ash Curves

Once the wheat to be tested has been experimentally milled, the flours must be analyzed to determine if there are any quality differences between the control sample and the test sample. As mentioned earlier, the percentage yield of each flour stream and the ash content of each flour stream are important factors. The yield of each flour stream is self-explanatory but what is ash and why is it useful in studying milling performance and processes?

The Ash test (A.A.C.C. Cereal Laboratory Methods, 08-01) gives a measure of the mineral content of the material being tested. Since pure bran material contains, according to Swanson (13), from 20 to 25 times as much ash as the pure endosperm, the Ash test has been used as a tool in measuring the amount of bran intrusion in the flour tested.

In the milling operation, a flour is produced each time material is ground and sifted. Commercial mills may have between 20 to 40 different flours being produced at the same time, each with different characteristics, including fairly wide differences in ash content. Since each mill stock classification to be ground has a different bran-to-endosperm ratio, each grind will produce varying amounts of bran intrusion. The breaking process seems to be most critical in this area. Robbins (14) states that "in the final analysis all ash in flour, other than that contained in the pure endosperm, is caused by bran contamination released by the breaks."

The germ of the wheat kernel is also relatively high in ash content. According to MacMasters et al. (15) the ash content of wheat germ in 156 different varieties was found to vary between 4.27 to 9.47% in ash content. This would mean that any germ ground by the corrugated break rolls could also contribute to the ash content of the break flours.

The ash content of pure endosperm also varies within the kernel itself. Morris et al. (16) reported spreads from .246% to .400% ash in Hard Red Winter wheat and spreads from .206% to .564% ash in Hard Red Spring wheat within the endosperm.

Due to the obvious complication of properly applying the ash test, it has been, throughout the years since its inception, misapplied in many instances. However, if properly applied it can be a useful tool. Clark (17) states: "Combined with the knowledge of yield, percentage of extraction, grade of wheat milled, variety of wheat milled, and the equipment of the mill, flour ash may be an index of efficient wheat milling." Shuey (18) believes that when ash is properly used it can be a useful tool or yardstick for measuring milling characteristics as well as evaluating the milling performance of a mill. Swanson (13) also states, "The Ash test has a greater value than any other analytical determination for the control of the mechanical operation of the flour mill."

A simple listing of the ash content of each stream, however, is of little value. Therefore, methods of coupling the amount of ash contents with the corresponding stream weights have been devised that are of much greater value. Robbins (14) indicates that an ash analysis of the various flour mill streams in a mill when made in connection with a quantity measure of each stream is the most effective means available for studying the ash characteristics of the milling process.

Wissmar (19), believes that the Cumulative Ash Curve, developed by Professor Mohs, can be most useful to analyze mill efficiency. In this analysis, all the ash contents are arranged, lowest to highest ash, along with their corresponding percentage of the total of the milled products. Starting with the lowest ash stream, the next lowest ash stream is, in effect, blended with it to produce a new flour. This is continued until all the flour streams are added in at their corresponding percentages. Cumulated ashes can then be plotted versus their cumulated percentages to give the Cumulative Ash Curve which can be used to judge the effectiveness of milling processes given a common wheat.

PLATE 3

PHOTOGRAPH OF WHOLE HARD RED WINTER WHEAT KERNELS
COMPARED WITH WHEAT AFTER PASSING
THROUGH PRE-BREAK ROLLS

PLATE 4

PHOTOGRAPH OF A STRAIGHT GRADE HARD RED
WINTER FLOUR AS COMPARED TO FLOUR PRODUCED
FROM PRE-BREAKING FROM THE SAME WHEAT,
THE PEKAR TEST WAS USED TO SHOW
DIFFERENCE IN QUALITY

PLATE 3

Whole Wheat Pre - Broken Wheat

Straight Grade Flour Pre - Break Flour

PLATE 4

MATERIALS AND METHODS

Wheat

Several varieties of locally grown Hard Red Winter wheat were used for the milling tests. Table I shows some of the physical wheat data for the wheats used. The wheat used is typical of that used commercially for white flour production.

All wheat was cleaned in the Kansas State University Pilot Cleaning House. This flow includes a milling separator, stoner and gravity table, disc machines, Entoleter-Scourer, Aspirator and duo-aspirator. The Flow-sheet is shown in Figure I. The cleaning rate is 60 pounds per minute.

Wheat was conditioned prior to milling by adding water to bring the percentage of moisture in the wheat to about 16%. The wheat and water were thoroughly mixed and then allowed to rest for approximately 20 hours. For the large scale samples, on the Miag Multomat, the Kansas State University Tempering System (Figure I) was used. The remainder of the samples were tempered using a laboratory tempering system which consists of a small revolving drum and graduated cylinder, for metering the water. Since the capacity of the mixer is approximately 5000 grams, any sample lots needed over this amount were first mixed and then cross blended to assure even temper. Sample lots were then stored for the rest period in poly bags. Both initial moisture and moisture before milling were measured on the Tag-Heppenstal Moisture Meter.

Pre-Breaking

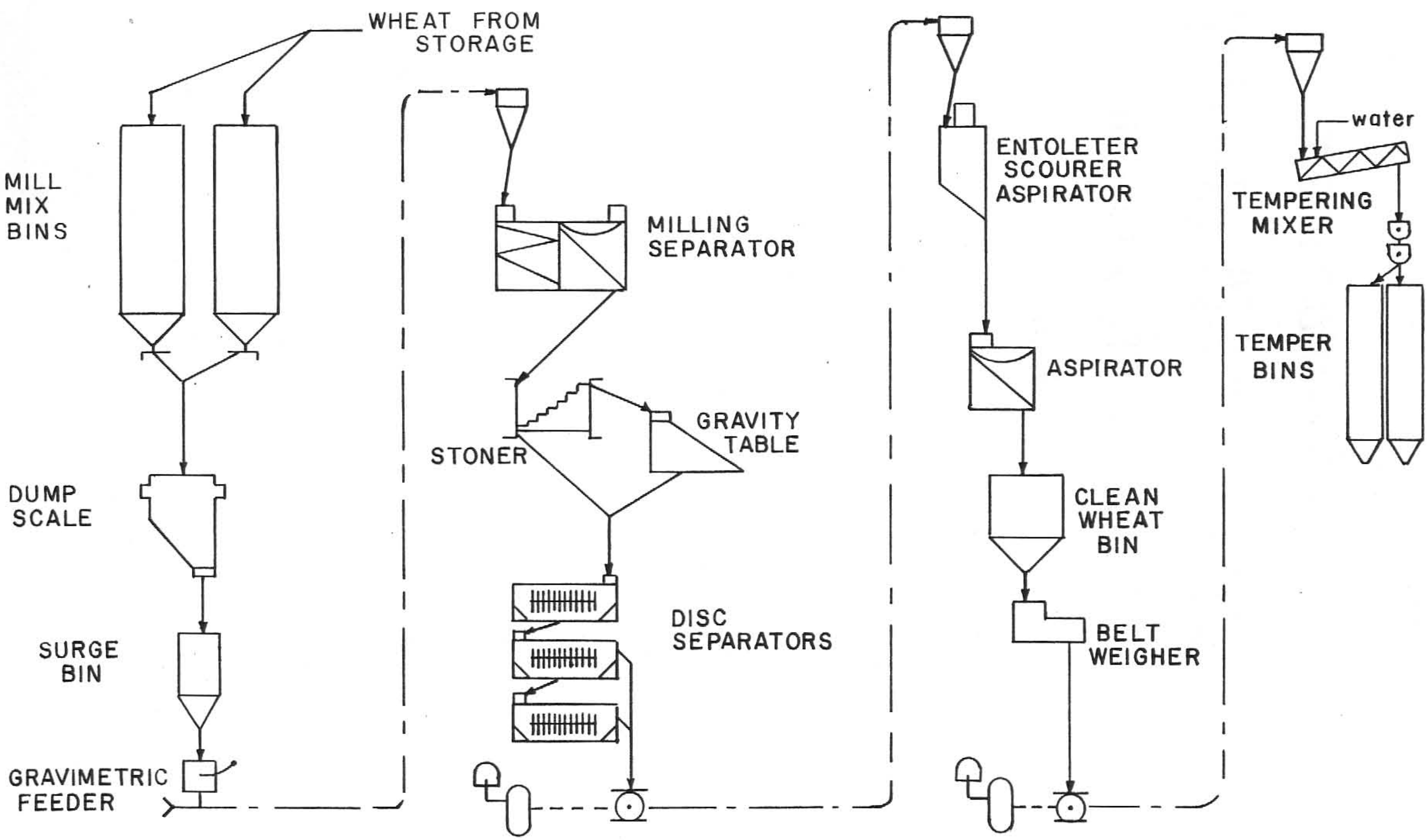
Since it was felt that there may be too many variables in the operation of an impact machine, the rollermill was selected to perform the pre-breaking. In most cases, smooth rolls were driven at approximately a one to one differential and set to ideally open all kernels at the crease.

TABLE 1

WHEAT SPECIFICATIONS

TEST	RESULTS[1]
Moisture[2]	12.4%
Protein[3]	12.5%
Ash[4]	1.5%
Test Weight[5]	62.3 lbs/bushel
1000 Kernel Weight[6]	31.3 gram/1000 kernels
Wheat Size Test[7]	
% Over 7W	70.0%
% over 9W	29.5%
% over 12W	0.5%
Theoretical Yield	76.5%
Pearling Value[8]	74.7%

1. Results given are the averaged results of three samples tested.
2. Tag-Heppenstal Moisture Tester.
3. AACC Cereal Laboratory Methods, 46-10. Expressed as percent protein on a 14% moisture basis.
4. AACC Cereal Laboratory Methods, 08-01. Expressed as percent ash on a 14% moisture basis.
5. As described in Circular No. 921, issued by the United States Department of Agriculture. Expressed as pounds, to the nearest tenth of a pound, per Winchester bushel.
6. 40 grams of whole, cleaned wheat is counted using an electronic seed counter. The number of kernels in 40 grams is then converted to the number of grams per 1000 kernels.
7. 200 grams of cleaned wheat is sifted for 1 minute using a Ro-Tap Shaker and 3 Tyler sieves of 7 wire, 9 wire, and 12 wire. The percentage remaining on each sieve is then determined, multiplied by factors of 78, 73 and 67, respectively, and summed to obtain a single number denoting the theoretical flour yield.
8. 20 grams of cleaned, whole wheat is retained for one minute in a Strong Scott Laboratory Barley Pearler equipped with a No. 30 grit stone and 1 10 mesh screen made of wire .041 inches in diameter (Tyler Code "Fijor"). Pearling value is the percent of original sample remaining over a 20 mesh wire after pearling.



Kansas State University Cleaning and Tempering System

Figure 1

Plate 3 shows wheat after passage through a pre-break versus the whole wheat.

Milling

Five different experimental mills were used in this research: Brabender Quadrumat Junior, Brabender Quadrumat Senior, Buhler Experimental Rollermill, K.S.U. Ross Walking Flow, and Miag Multomat. Since each mill employs a different method of operation and procedure of testing, each will be described separately.

(1) Brabender Quadrumat Junior (Figure 2, plate 5)

As can be seen from the flowsheet, the Quadrumat Junior makes three grinds with four corrugated rolls at a fixed gap before the stock is sifted. Normally, the ground material is sifted over a reel-type sifter that is part of the mill. To provide a better separation, the ground stock was sifted using a Great Western laboratory sifter having a speed of 180 rpm and throw of 4 inches. Sieves of 50 grits gauze, 70 grits gauze, and 9XX silk were used to make the separations, with cleaner frames below the 70GG and 9XX to aid in sifting. Sifting time was set at two minutes.

A Ross Experimental Rollstand, equipped with a pair of 9-inch diameter by 6-inch wide smooth rolls, was used to Pre-Break the wheat prior to milling on the Quadrumat Junior. The differential chain had been removed to give an approximate 1:1 differential, with the passage of the wheat turning the slow roll. A no load gap of .068 inch was chosen to perform the Pre-Breaking operation. This gap was used because it affected nearly every kernel to some extent but was not so severe that kernels were completely broken up.

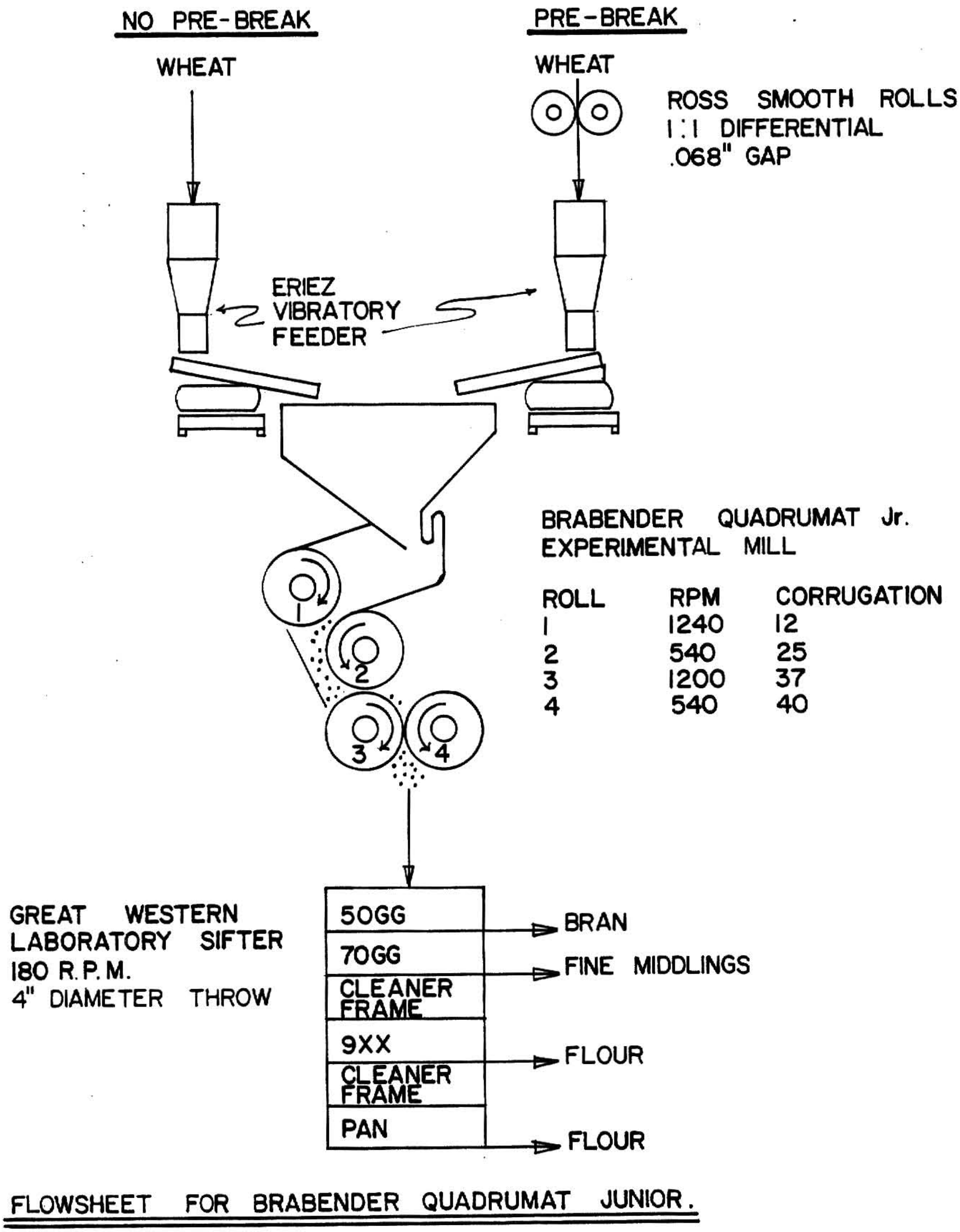

NO PRE-BREAK
PRE-BREAK
WHEAT
WHEAT
ROSS SMOOTH ROLLS
1:1 DIFFERENTIAL
.068" GAP
ERIEZ
VIBRATORY
FEEDER
BRABENDER QUADRUMAT Jr.
EXPERIMENTAL MILL
ROLL RPM CORRUGATION
1 1240 12
2 540 25
3 1200 37
4 540 40
1
2
3
4
GREAT WESTERN
LABORATORY SIFTER
180 R.P.M.
4" DIAMETER THROW
50GG
70GG
CLEANER FRAME
9XX
CLEANER FRAME
PAN
BRAN
FINE MIDDLINGS
FLOUR
FLOUR
FLOWSHEET FOR BRABENDER QUADRUMAT JUNIOR.

Figure 2

PLATE 6

VIEW OF BRABENDER QUADRUMAT
SENIOR EXPERIMENTAL MILL
SHOWING SPECIAL FEEDING SYSTEM

PLATE 5

VIEW OF BRABENDER QUADRUMAT
JUNIOR EXPERIMENTAL MILL

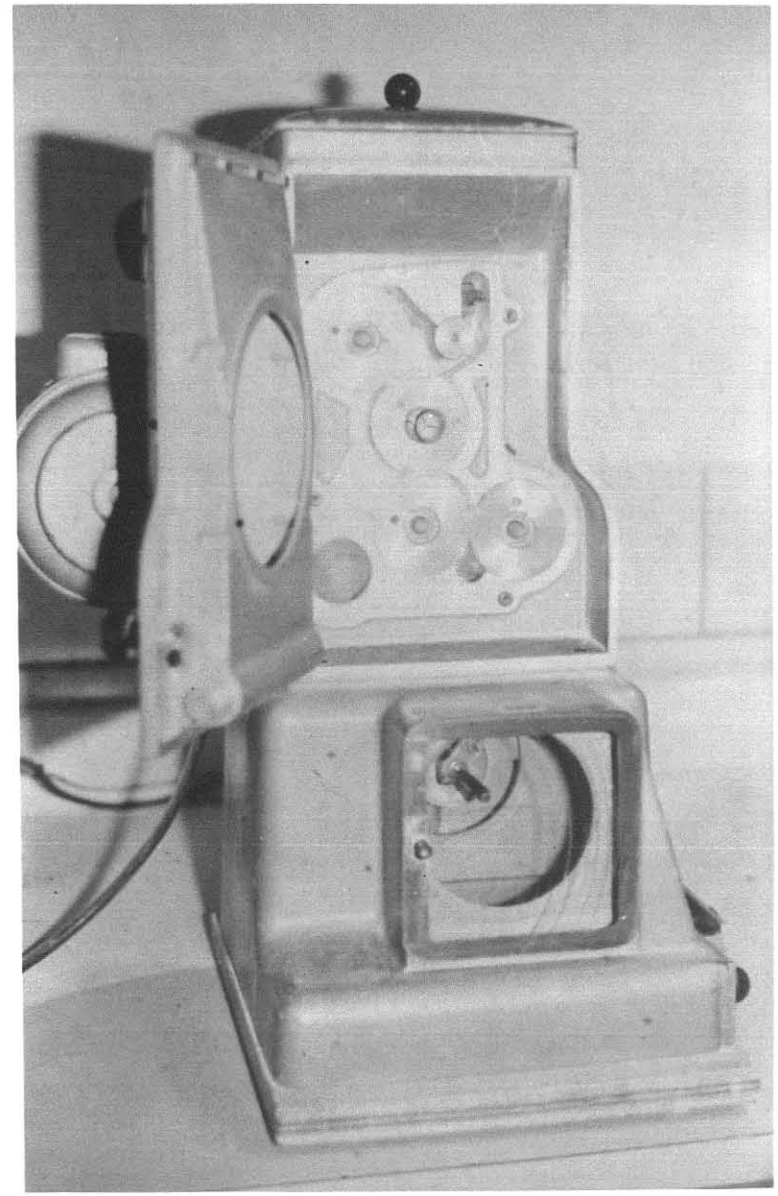


PLATE 5

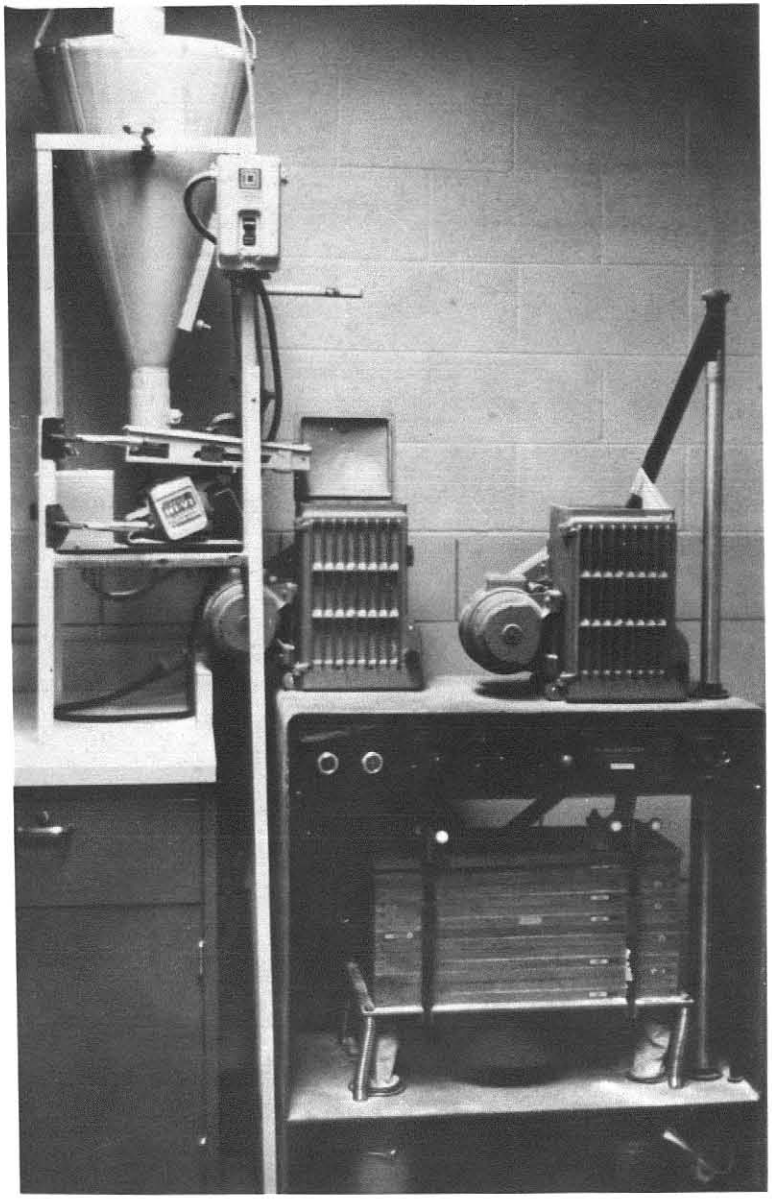
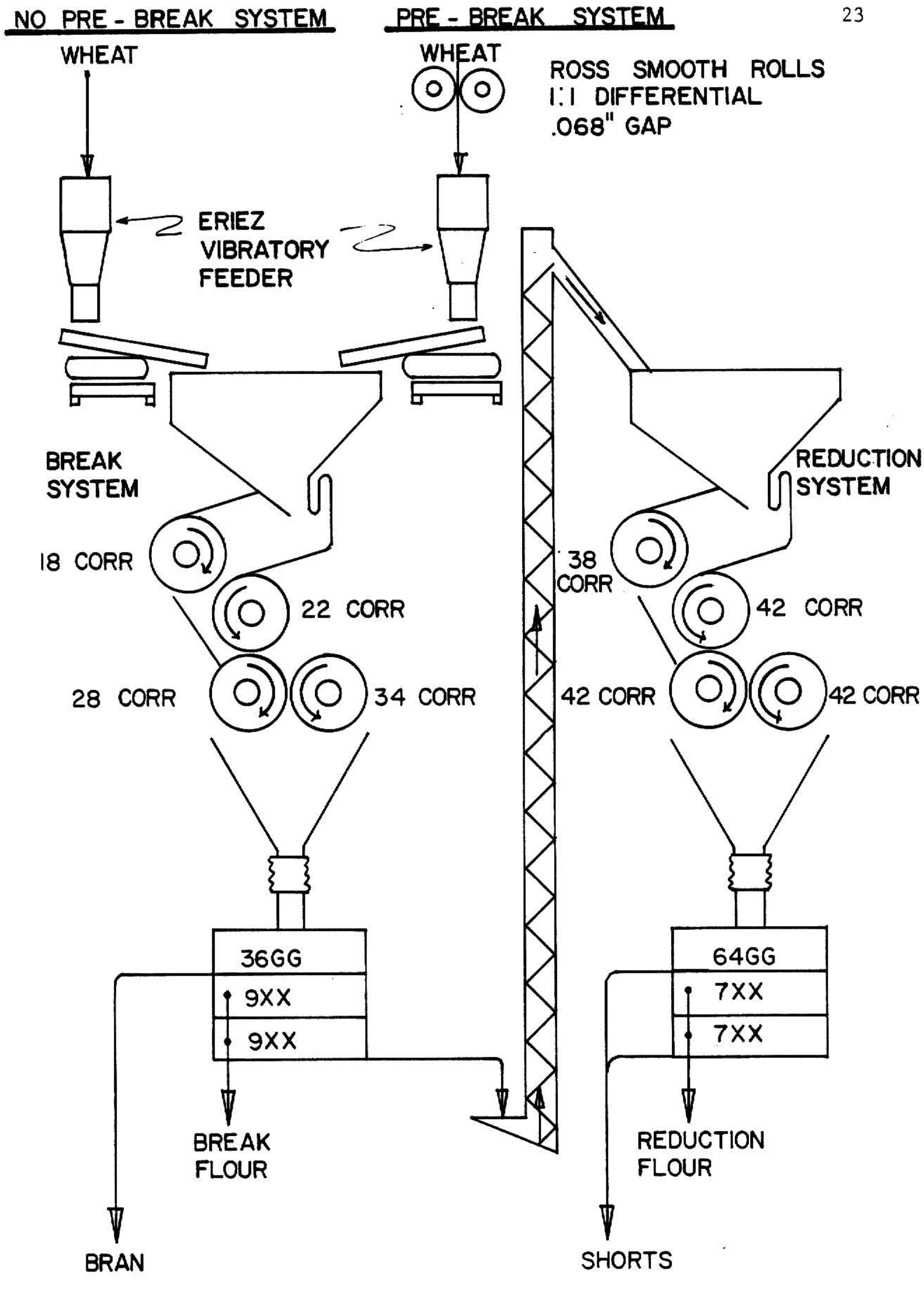


PLATE 6



FLOWSHEET FOR BRABENDER QUADRUMAT SENIOR.

Figure 3

Since the flowability of the Pre-Broken wheat changed drastically, a further modification of the Quadrumat Junior had to be made. To allow the stock to flow properly, the feeder roll had to be removed. An Eriez vibratory feeder, with variable speed control, was then used to set the flow of whole wheat or Pre-Broken wheat to the mill. A feedrate of approximately 55 grams per minute was used for the grain to the mill.

After the feed rate was established, by running one minute tests, the mill was started and the feeder was set to run for exactly five minutes. The first five minute sample was set aside as the warm-up sample. A second five minute sample was then milled and sifted on the stack of sieves. Each separation was carefully weighed and the three finest separations were sampled and submitted for laboratory moisture and ash analysis. The feeder was then reset to deliver Pre-Broken wheat at the same feed rate. Again, a warm-up sample was first milled prior to milling the test sample. The test sample was sifted and the same fractions sampled for analysis. A total of five whole wheat samples and five Pre-Broken samples were milled with warm-up samples preceding each test run.

(2) Brabender Quadrumat Senior (Figure 3, plate 6)

As can been seen from the flowsheet and photograph, the Quadrumat Senior is similar to the Quadrumat Junior but utilizes more elaborate grinding and sifting equipment. Two grinding heads are used, one for Break grinding and one for Reduction grinding. Again, all rolls are corrugated and positioned at a fixed gap. A gyratory sifter, having a speed of 240 rpm and throw of 1-3/4 inches, is equipped with specially designed sieves for maximum efficiency.

Ground material from the Break head is sifted over 36 grits gauze to remove the bran and over two 9XX silks to remove the Break flour.

Middlings stock remaining above the 9XX is conveyed, by a vertical screw conveyor to the reduction head. Ground middlings from the Reduction head are then sifted over a 64 grits gauze and two 7XX silks. Any material not passing through the 7XX as flour is considered shorts.

As in the procedure for the Quadrumat Junior, a smooth pair of Ross rolls, running at a 1:1 differential, was used to Pre-Break the wheat. The roll gap of .068 inch was again used as the roll setting.

The Eriez vibratory feeder had to be used for feeding the stock to the mill due to the flow problem of the Pre-Broken wheat as developed in the Quadrumat Junior testing. The feeder roll from the Break head was also removed.

The testing procedure itself began by adjusting the vibratory feeder to a feed rate of approximately 130 grams per minute with whole wheat. The mill was then started and wheat was fed to the Break head for warm-up. The vibratory feeder was automatically timed to stop at the end of five minutes. When feed to the mill stopped, the mill was immediately shut down under load. Material from the four product containers was removed and the containers were replaced. The mill was then restarted and wheat was re-fed to the Break head to start the test sample. Again, at the end of five minutes, the feeder was stopped and the mill was shut down under load. The product containers were removed and the materials weighed. Samples of Break flour and Reduction flour were submitted to the analytical laboratory for moisture and ash analysis.

The feeder was then readjusted to feed the Pre-Broken wheat at 130 grams per minute and the above procedure was then repeated. The whole wheat and Pre-Broken wheat each was milled a total of five times.

(3) Buhler Experimental Mill (Figure 4, plate 7)

The Buhler Experimental Mill flow is somewhat different from the mill flows previously described. In the first two mills described, all the grinding is performed before any sifting. The Buhler flow provides grinding and sifting combinations much like those of a commercial mill. There are three corrugated break rolls and three smooth reduction rolls each with their own sifter section. Material to each roll is transported pneumatically. The six flours produced are collected individually in pans as are the feed products: bran and shorts.

Besides testing the effect of not Pre-Breaking the wheat prior to milling versus the effect of Pre-Breaking, a new variable was added. Pre-broken wheat was also sifted over a 10XX flour silk before being milled. This was done to determine whether removing the small amount of flour produced by Pre-Breaking would have any different effect on total flour quality. Some Pre-Break flour is shown in plate 4 compared to a straight grade flour.

Two thousand grams of the sample to be milled was placed in the feeder hopper and the feed rate set to approximately 125 grams per minute. The mill was then started and adjusted to provide proper milling classifications. When the feeder hopper emptied, the mill was immediately shut down under load. Product in the sample pans was weighed and recorded as "warm-up." A second 2000 gram sample of the same material was then placed in the feeder hopper and the mill was restarted. Again, as soon as the sample emptied from the hopper, the mill was shut down under load. All products from this milling were carefully weighed and samples of each of the six flours were submitted for moisture and ash analysis.

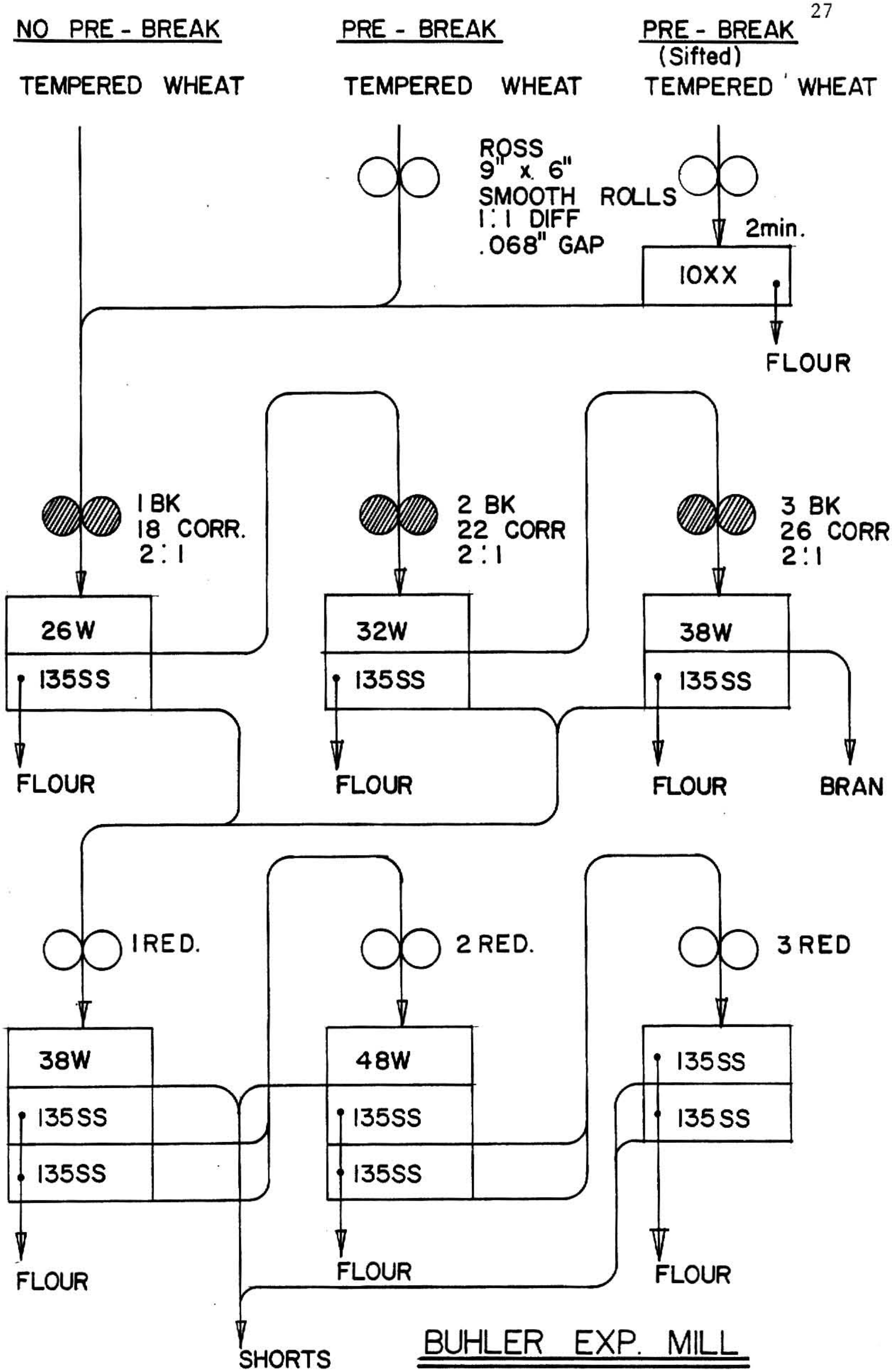

NO PRE-BREAK
PRE-BREAK
PRE-BREAK (Sifted)
TEMPERED WHEAT
TEMPERED WHEAT
TEMPERED WHEAT
ROSS 9" x 6" SMOOTH ROLLS 1:1 DIFF .068" GAP
2min.
10XX
FLOUR
1 BK 18 CORR. 2:1
2 BK 22 CORR 2:1
3 BK 26 CORR 2:1
26W
135SS
32W
135SS
38W
135SS
FLOUR
FLOUR
FLOUR
BRAN
1RED.
2 RED.
3 RED
38W
135SS
135SS
48W
135SS
135SS
135SS
135SS
FLOUR
FLOUR
FLOUR
SHORTS
BUHLER EXP. MILL

Figure 4

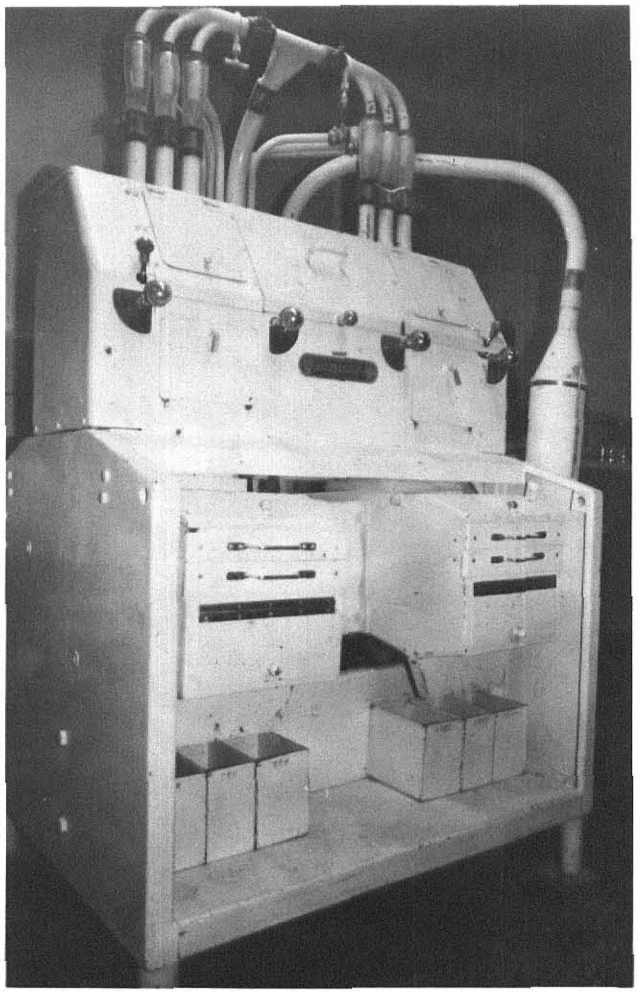
PLATE 7

VIEW OF BUHLER EXPERIMENTAL MILL

PLATE 8

VIEW OF ROSS EXPERIMENTAL
ROLL STANDS

PLATE 7



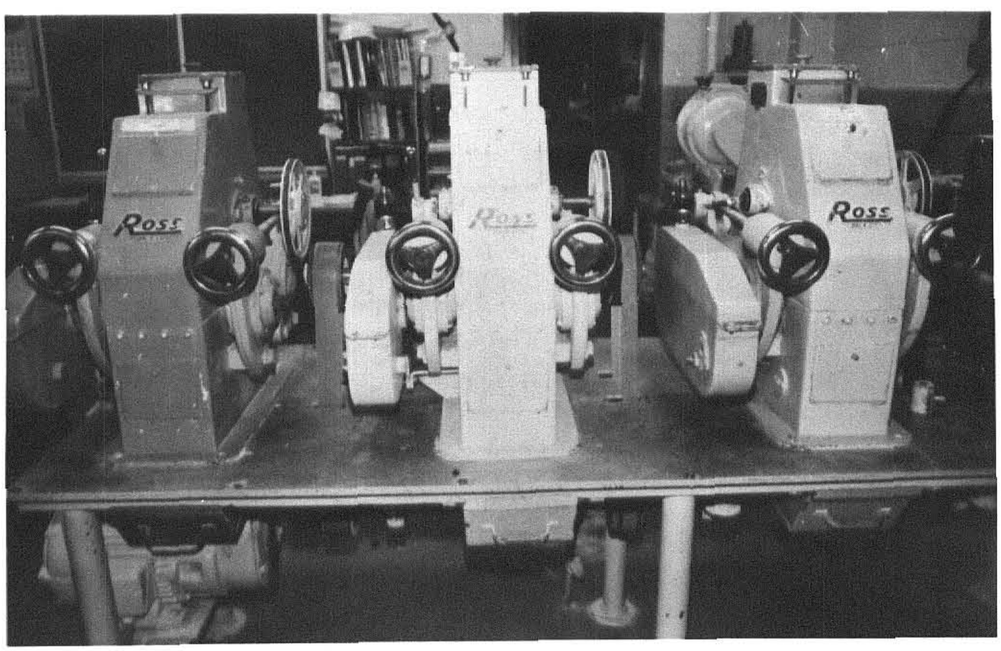


PLATE 8

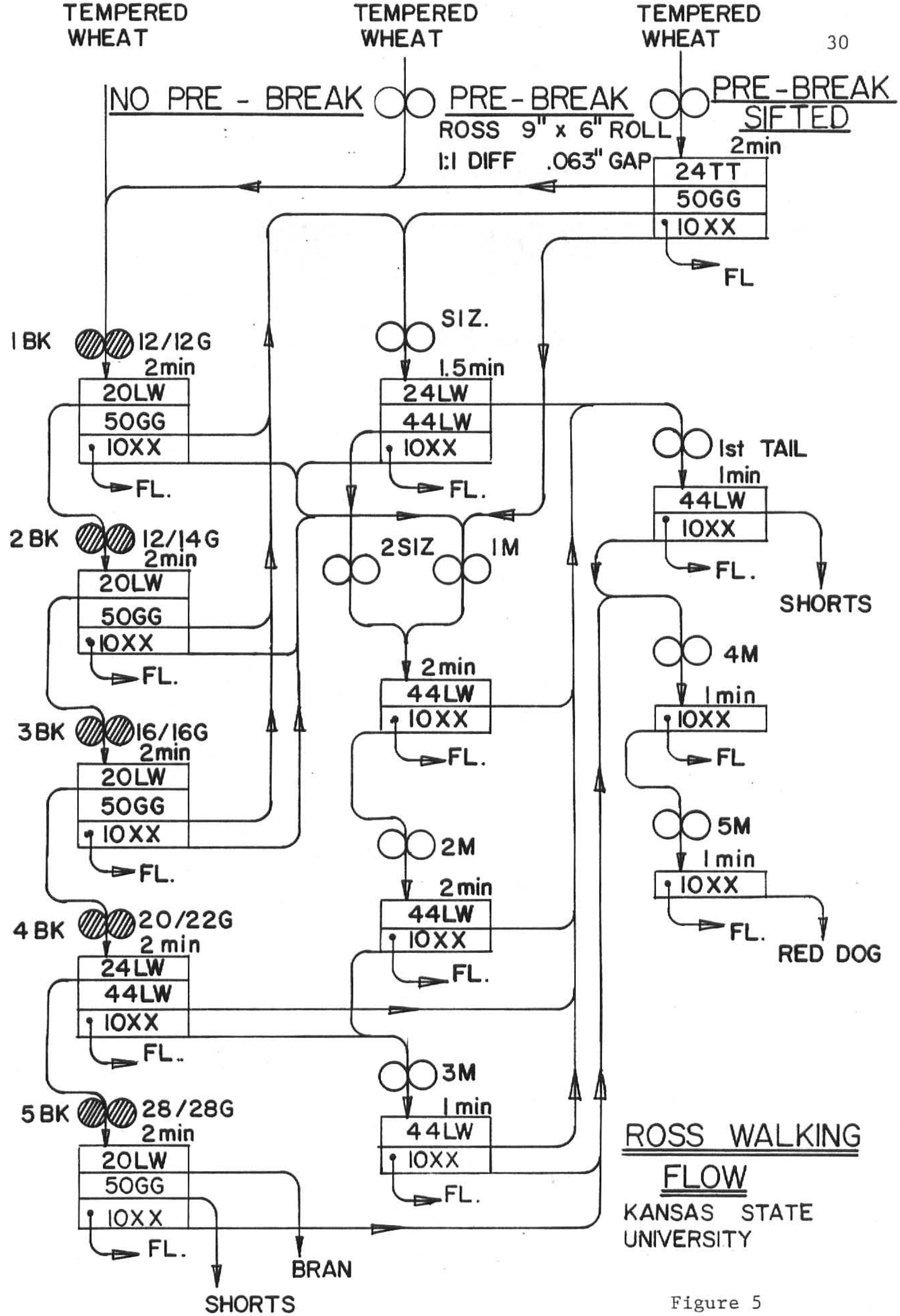

TEMPERED WHEAT
TEMPERED WHEAT
TEMPERED WHEAT
NO PRE - BREAK
PRE-BREAK
ROSS 9" x 6" ROLL
1:1 DIFF .063" GAP
PRE-BREAK SIFTED
2min
24TT
50GG
10XX
FL
1 BK
12/12G
2min
20LW
50GG
10XX
FL.
SIZ.
1.5min
24LW
44LW
10XX
FL.
1st TAIL
1min
44LW
10XX
FL.
SHORTS
2 BK
12/14G
2min
20LW
50GG
10XX
FL.
2SIZ
1M
2min
44LW
10XX
FL.
4M
1min
10XX
FL
3 BK
16/16G
2min
20LW
50GG
10XX
FL.
2M
2min
44LW
10XX
FL.
5M
1min
10XX
FL.
RED DOG
4 BK
20/22G
2 min
24LW
44LW
10XX
FL..
3M
1 min
44LW
10XX
FL.
5 BK
28/28G
2min
20LW
50GG
10XX
FL.
SHORTS
BRAN
ROSS WALKING FLOW
KANSAS STATE UNIVERSITY

Figure 5

The sequence in which the control and the two experimental samples were milled was changed for each day of milling. To provide further check on the milling, an extra sample of the first sample milled for that day was also milled. This series of four millings was performed a total of five times as follows:

<u>Test A</u>

(1) No Pre-Break
(2) Pre-Break (not sifted)
(3) Pre-Break (sifted)
(4) No Pre-Break

<u>Test B</u>

(1) Pre-Break (sifted)
(2) No Pre-Break
(3) Pre-Break (not sifted)
(4) Pre-Break (sifted)

<u>Test C</u>

(1) Pre-Break (not sifted)
(2) Pre-Break (sifted)
(3) No Pre-Break
(4) Pre-Break (not sifted)

<u>Test D</u>

(1) No Pre-Break
(2) Pre-Break (sifted)
(3) Pre-Break (not sifted)
(4) No Pre-Break

<u>Test E</u>

(1) Pre-Break (sifted)
(2) Pre-Break (not sifted)
(3) No Pre-Break
(4) Pre-Break (sifted)

Again, the smooth Ross rolls set at a .068 inch gap were used to perform the Pre-Breaking prior to milling on the Buhler Mill. A Great Western laboratory sifter was used to sift the pre-broken sample. Flour obtained from this sifting was weighed and analyzed.

(4) K.S.U. Ross Walking Flow (Figure 5, plate 8)

Although it is a batch operation rather than a continuous one, the Ross Walking Flow very closely simulates a full scale mill. As can be seen by the flowsheet, there are five Breaks and eight Reductions producing twelve flours, red dog, shorts and bran. Roll corrugations and differentials are given in the flowsheet.

Stock is fed by feeder rolls above each pair of rolls and the resulting ground material is caught in drawers below each roll stand.

The ground stock is then transferred to a sifter to make the size separations.

Break rolls were set according to a Break Release Schedule. A 100-gram sample of each Break Stock was ground on the proper roll and then sifted for 20 seconds over a 20 light wire sieve. The overs and thrus were then weighed to determine the percentage that had passed through the wire cloth, that being referred to as the amount "released." The rolls were then readjusted, if needed, to meet the desired release. The Break Release schedule used for the Roll Walking Flow is given as follows:

	% -20 L.W.
1st Break	30
2nd Break	40
3rd Break	35
4th Break	20
5th Break	±30

Sizings rolls were set at a standard gap of .005 inch while second sizings and first tailings were standardized at .003 inch gap. All other rolls were set at less than .002 inch to produce as much flour as possible without producing flakes.

Sample size was 3000 grams. Since the Great Western laboratory sifter used here could not properly sift this amount, the sample was divided into two parts for First, Second and Third Breaks, Sizings and First Midds. The sifting times are listed on the flowsheet above each sifter box designation.

All stocks waiting to be ground or sifted were kept in aluminum cans with tight lids to keep moisture loss to a minimum. Each rollermill was cleaned thoroughly above and below the rolls to keep product loss to a minimum.

Three conditions were tested using the Ross Walking Flow. First, wheat was sent directly to First Break for the "No Pre-Break" test. Second, wheat was Pre-Broken on the Ross smooth rolls at a .068 inch gap and then sent directly to First Break. Third, Pre-Broken wheat was sifted over a special stack of sieves to remove Sizings stock, Middlings stock and flour before being sent to First Break. These flows are shown in Figure 5.

All three test conditions were milled in one day. The tests were repeated a total of five times, each time milling the samples in a random order. After weighing, each flour was sampled and submitted to the analytical laboratory for moisture and ash analysis.

(5) Miag Multomat Experimental Mill (Figure 6, plates 9 and 10)

The Multomat Experimental Mill is a three-break, five-reduction pneumatic mill. There are ten sifter sections, two of which are redust sections. Speed of the sifter is 260 rpm at a 1-7/8 inch throw. The ten flour streams are collected in pans beneath the sifter sections. This being one of the largest of the experimental mills, feed rates from 700 to 1000 grams per minute may be used. The rate of wheat to the mill is set by a Draver-type Feeder, which for these tests was set to deliver approximately 780 grams per minute.

The Break rolls were set according to a Break Release Schedule during operation. One-hundred grams of each break grind was sifted over a 20 mesh light wire for 20 seconds on a Rotomatic laboratory sifter operating at 180 rpm and 1-7/8 inch throw. The amount of material passing through the sieve was determined and the rolls were set to meet the following Break Release Schedule:

First Break	45%
Second Break	50%
Third Break	±35% (clean-up)

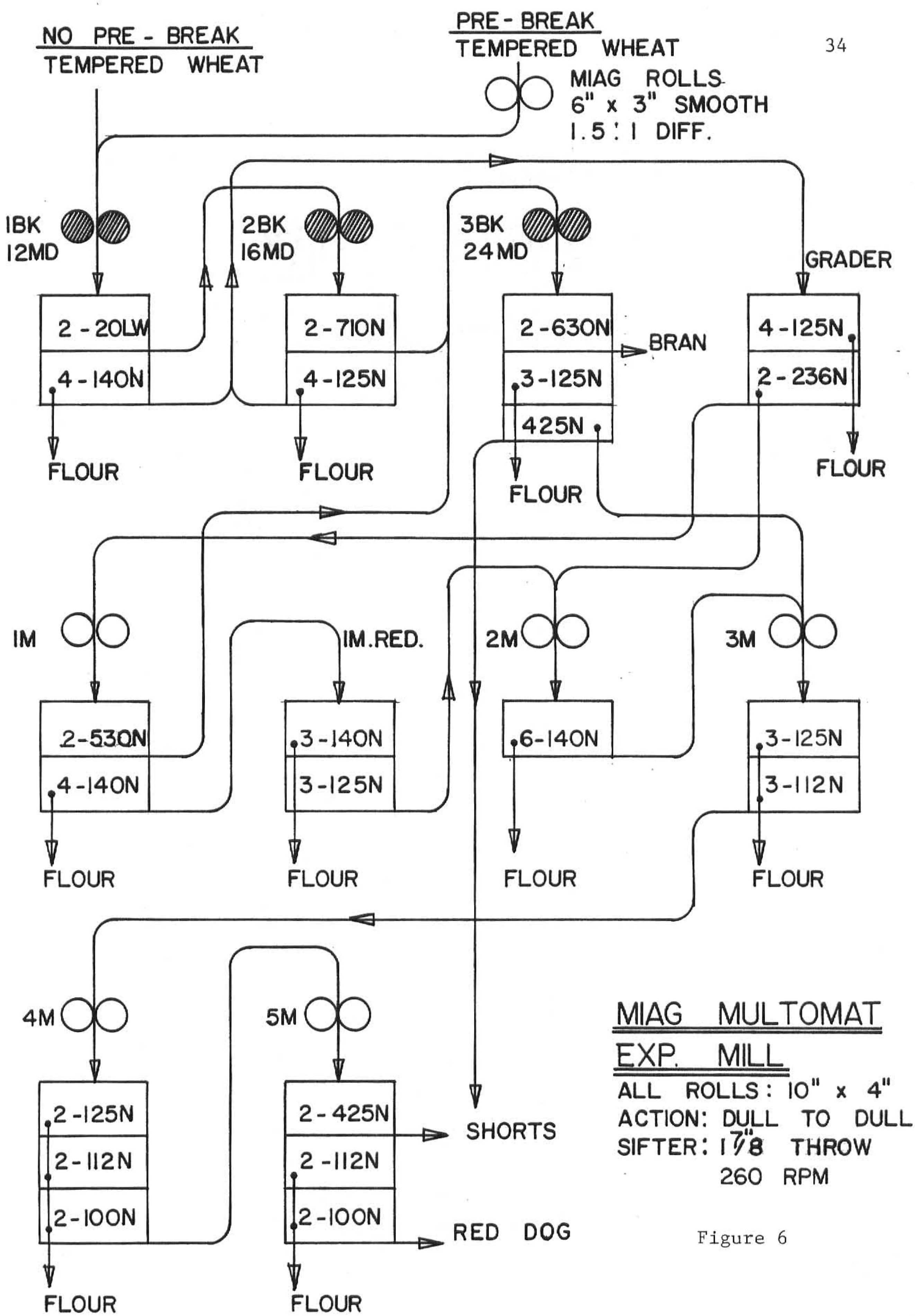

NO PRE - BREAK
TEMPERED WHEAT
PRE - BREAK
TEMPERED WHEAT
MIAG ROLLS
6" x 3" SMOOTH
1.5 : 1 DIFF.
1BK
12MD
2BK
16MD
3BK
24MD
GRADER
2 - 20LW
4 - 140N
2 - 710N
4 - 125N
2 - 630N
3 - 125N
425N
BRAN
4 - 125N
2 - 236N
FLOUR
FLOUR
FLOUR
FLOUR
1M
1M.RED.
2M
3M
2 - 530N
4 - 140N
3 - 140N
3 - 125N
6 - 140N
3 - 125N
3 - 112N
FLOUR
FLOUR
FLOUR
FLOUR
4M
5M
2 - 125N
2 - 112N
2 - 100N
2 - 425N
2 - 112N
2 - 100N
SHORTS
RED DOG
FLOUR
FLOUR
MIAG MULTOMAT
EXP. MILL
ALL ROLLS: 10" x 4"
ACTION: DULL TO DULL
SIFTER: 1 7/8" THROW
260 RPM

Figure 6

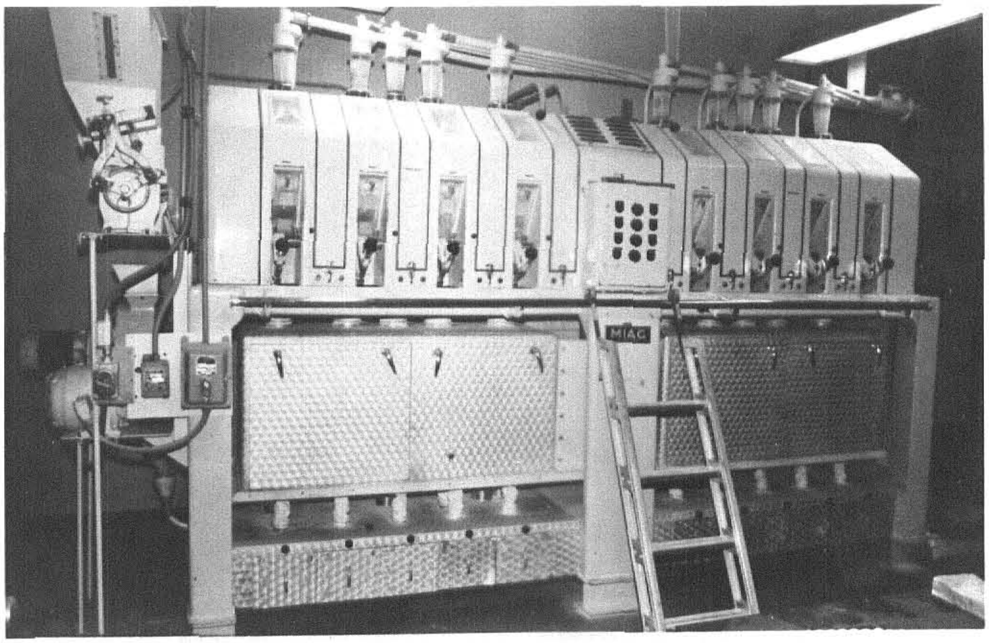
PLATE 9

PHOTOGRAPH OF THE MIAG MULTOMAT
EXPERIMENTAL MILL

PLATE 10

PHOTOGRAPH OF MIAG PRE-BREAK ROLLS
FOR THE MIAG MULTOMAT

PLATE 9



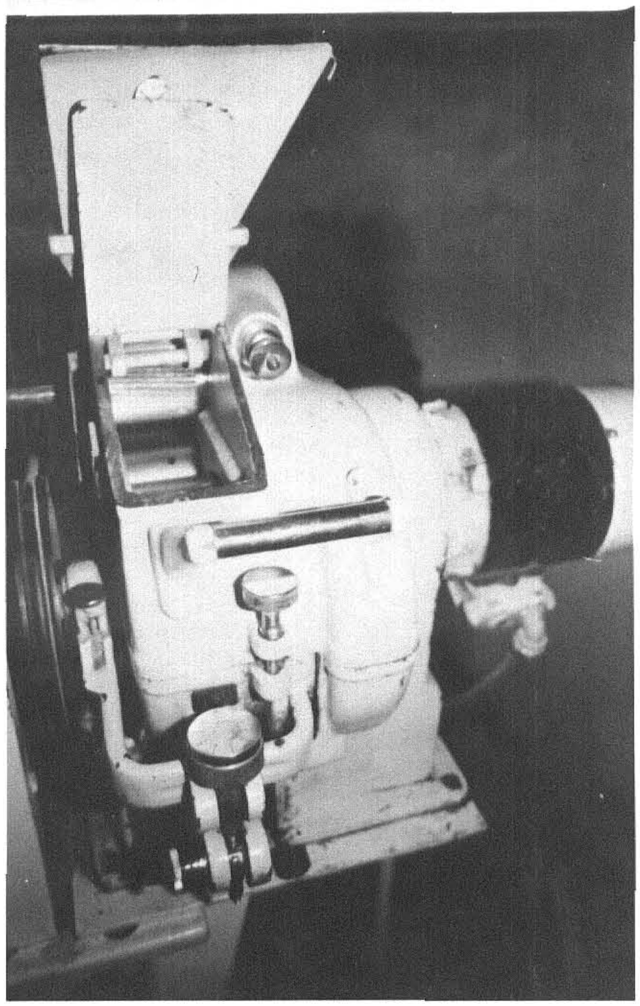


PLATE 10

Due to the relatively long reduction system on this mill, First Midds roll was set to grind to that more typical of a Sizings grind. The remaining rolls were set to produce flour.

This particular mill has been equipped with its own Pre-Break System (plate 10). Wheat from the feeder is fed directly to a pair of smooth six inch diameter by three inch wide rolls operating at a 1.5 to 1 differential. The grind on the Pre-Break roll was set with the use of a test sifter to give a two to three percent release through a 20 mesh light wire. The rolls could also be opened wide to allow the wheat to pass untouched when Pre-Breaking was not wanted.

The mill was allowed to "warm-up" on the sample being milled for a period of thirty minutes, during which time all rolls were set for proper grind. At the end of thirty minutes the wheat feeder was shut off and immediately following, the entire mill was shut down under load. All material pans were emptied and replaced. The mill was then restarted and wheat was again started to the mill. Break rolls and reduction rolls were again quickly checked for proper adjustment. At the end of forty-five minutes, the wheat feeder was shut off with the mill shut down immediately following. At this time all materials produced were carefully weighed and the flour streams were sampled for ash and moisture analysis.

The mill was again restarted and wheat fed to it. At this time, the Pre-Break rolls were either set for pre-breaking or opened fully, depending on the previous test. The above procedures of mill operation again followed. A total of five no Pre-Break/Pre-Break test series were run.

RESULTS AND DISCUSSION

Flour stream weights and their corresponding ash contents, on a 14% moisture basis, for the five millings of each of the experimental mill flows were averaged and from this, cumulative flour ash was calculated. Tables showing flour weights, their percentages of the total products and their ash contents as well as the cumulative ash calculations are given for each mill flow. Cumulative flour ash curves depicting the results are also given for each experimental mill. The summation of percentages of total product (S of Q) is given by the x-axis and the summation of the product of each stream ash times its percentage of total product dividend by the summation of percentages of total product (S of Q x A/S of Q) is given by the y-axis.

Complete stream weights, feed rates, and other miscellaneous information for each milling is listed in the appendix. Cumulative ash calculations and cumulative ash curves are also given in the appendix for each individual milling test.

(1) Brabender Quadrumat Junior.

Table 2 shows the averaged stream weights and ash contents of flours produced by the five millings as well as the cumulative ash calculations for the Quadrumat Junior. Figure 7 shows the results of the calculations graphically. The two flour streams sampled and shown are the throughs of a 70GG sieve and overs of a 9XX sieve (labeled +9XX) and the throughs of a 9XX (labeled -9XX).

As can be seen by both the calculations and cumulative ash curves, the use of Pre-Breaking prior to milling of the Quadrumat Junior provides a definite improvement in milling performance. In addition to substantially lowering the flour ash, flour yield was also improved by about .5%.

Table 2

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: QUADRUMAT JUNIOR
TEST: AVERAGE
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of Q X A	S of Q X A / S of Q
NO PRE-BREAK							
-9XX	112	38.57	38.57	.429	16.54	16.54	.429
+9XX	39	13.50	52.07	.440	5.94	22.48	.432
PRE-BREAK							
-9XX	115	39.24	39.24	.402	15.77	15.77	.402
+9XX	39	13.35	52.59	.408	5.53	21.30	.405

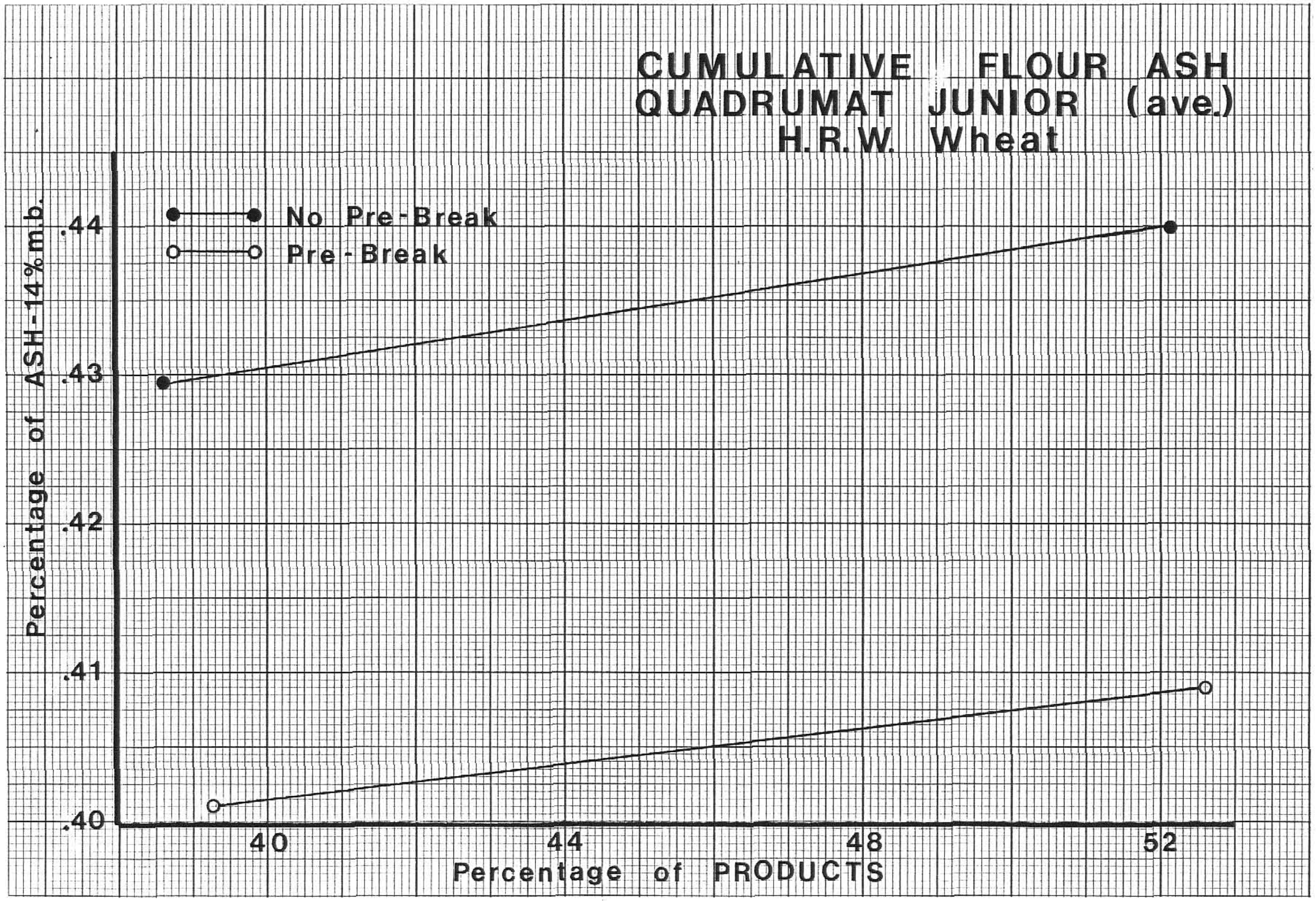

CUMULATIVE FLOUR ASH
QUADRUMAT JUNIOR (ave.)
H.R.W. Wheat
No Pre-Break
Pre-Break
Percentage of ASH-14% m.b.
.44
.43
.42
.41
.40
40
44
48
52
Percentage of PRODUCTS

Figure 7

(2) Brabender Quadrumat Senior.

Table 3 lists the cumulative ash calculations for the average of the five millings on the Quadrumat Senior. The results are shown graphically in Figure 8. Two flours were produced and analyzed. Break flour (Brk. Fl.) was the throughs of two 9XX sieves produced by the break head and Reduction Flour (Red. Fl.) was the throughs of two 7XX sieves produced by the reduction head.

As in the Quadrumat Junior tests, a definite improvement is also seen by the use of Pre-Break on the resultant flour quality produced by the Quadrumat Senior. Flour ash content was lowered significantly and flour yield was also improved, again by .5%.

Most of this improvement came with more break flour being produced at a lower ash content. Since the rolls in the Quadrumat Senior are positioned at a fixed gap, the results would indicate that the Pre-Breaking of wheat provides less severity of grind by the break rolls. More low ash break flour is produced as well as cleaner middlings (overs of the flour cloths) being sent to the reduction head, as evidenced by the lower ash of the reduction flour.

(3) Buhler Experimental Mill.

Flour stream weights for the average of the millings on the Buhler Experimental Mill and the cumulative ash calculations are given by Table 4. The resulting cumulative flour ash curves are given by Figure 9. Flour streams analyzed were as follows:

Pre-Break	(P.BK)
First Break	(1 BK)
Second Break	(2 BK)
Third Break	(3 BK)
First Reduction	(1 RED)
Second Reduction	(2 RED)
Third Reduction	(3 RED)

Table 3

Cumulative Flour Ash Calculations

A=ASH (14% Moisture Basis)
Q=QUANTITY (% of Total Products)
S=SUMMATION

MILL QUADRUMAT SENIOR
TEST AVERAGE
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK							
BRK.FL.	120	18.546	18.546	.335	6.213	6.213	.335
RED.FL.	319	49.492	68.038	.343	16.976	23.189	.341
PRE-BREAK							
BRK.FL.	133	19.946	19.946	.312	6.223	6.223	.312
RED.FL.	326	48.676	68.622	.331	16.112	22.335	.325

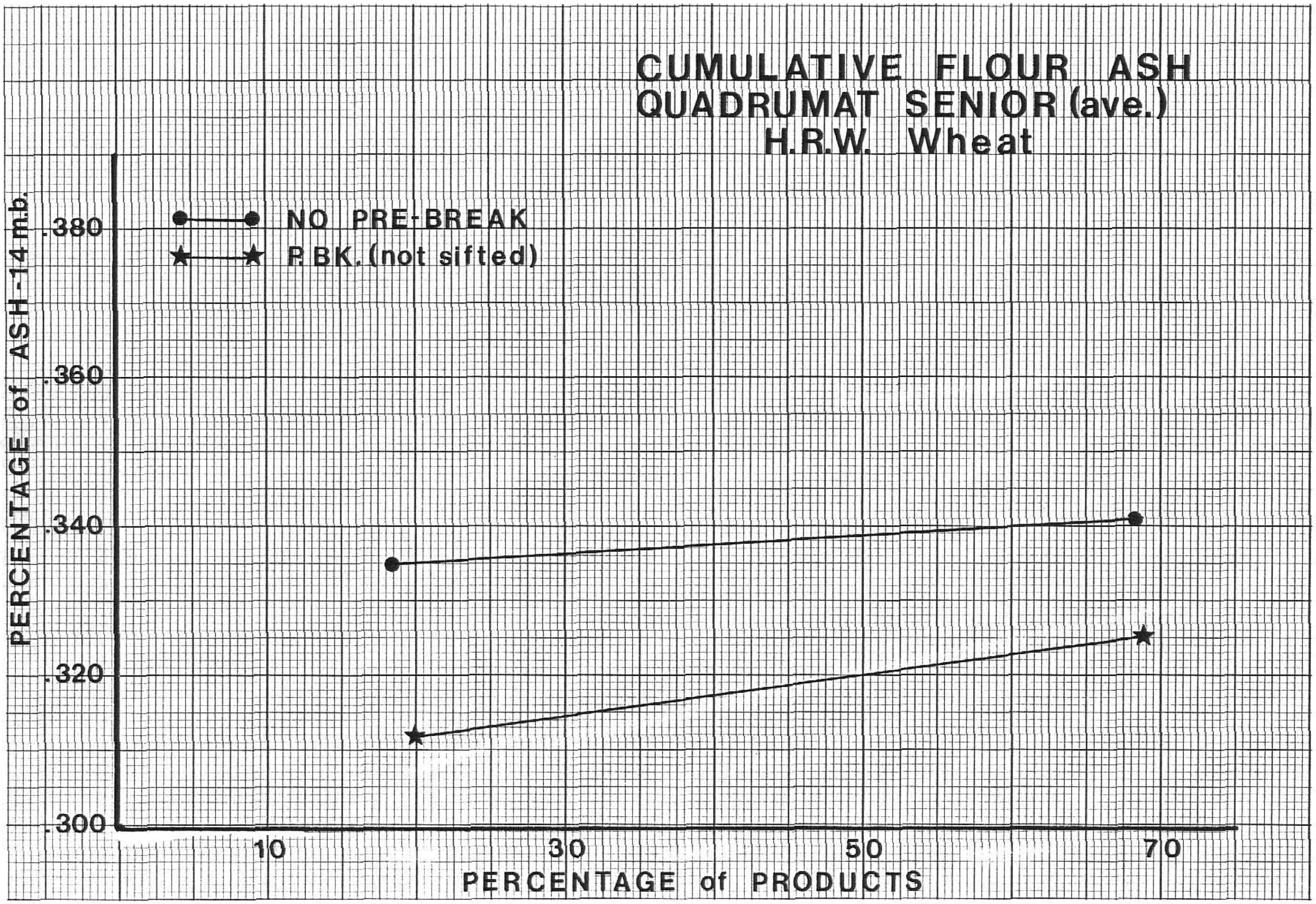

CUMULATIVE FLOUR ASH
QUADRUMAT SENIOR (ave.)
H.R.W. Wheat
NO PRE-BREAK
P. BK. (not sifted)
PERCENTAGE of ASH-14 m.b.
.380
.360
.340
.320
.300
10
30
50
70
PERCENTAGE of PRODUCTS

Figure 8

Table 4

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL BUHLER EXP. MILL
TEST AVERAGE
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK							
1 RED.	753	38.15	38.15	.333	12.704	12.704	.333
1 BK.	151	7.65	45.80	.357	2.731	15.435	.337
2 BK.	113	5.72	51.52	.366	2.094	17.529	.340
2 RED.	237	12.01	62.53	.434	5.212	22.741	.358
3 BK.	32	1.62	65.15	.546	0.885	23.626	.363
3 RED.	102	5.17	70.32	.650	3.361	26.987	.384
PRE-BREAK (NOT SIFTED)							
1 RED.	754	39.31	39.31	.312	12.265	12.265	.312
1 BK.	158	8.24	47.55	.334	2.752	15.017	.316
2 BK.	113	5.89	53.44	.355	2.091	17.108	.320
2 RED.	214	11.16	64.60	.404	4.509	21.617	.335
3 BK.	33	1.72	66.32	.525	0.903	22.520	.340
3 RED.	102	5.32	71.64	.577	3.070	25.590	.357
PRE-BREAK (SIFTED)							
1 RED.	746	39.08	39.08	.311	12.154	12.154	.311
1 BK.	146	7.65	46.73	.327	2.502	14.656	.314
2 BK.	110	5.76	52.49	.348	2.004	16.660	.317
2 RED.	215	11.26	63.75	.391	4.403	21.063	.330
3 BK.	32	1.68	65.43	.519	0.872	21.935	.335
P.BK.	9	0.47	65.90	.550	0.259	22.194	.337
3 RED.	104	5.45	71.35	.553	3.014	25.208	.353

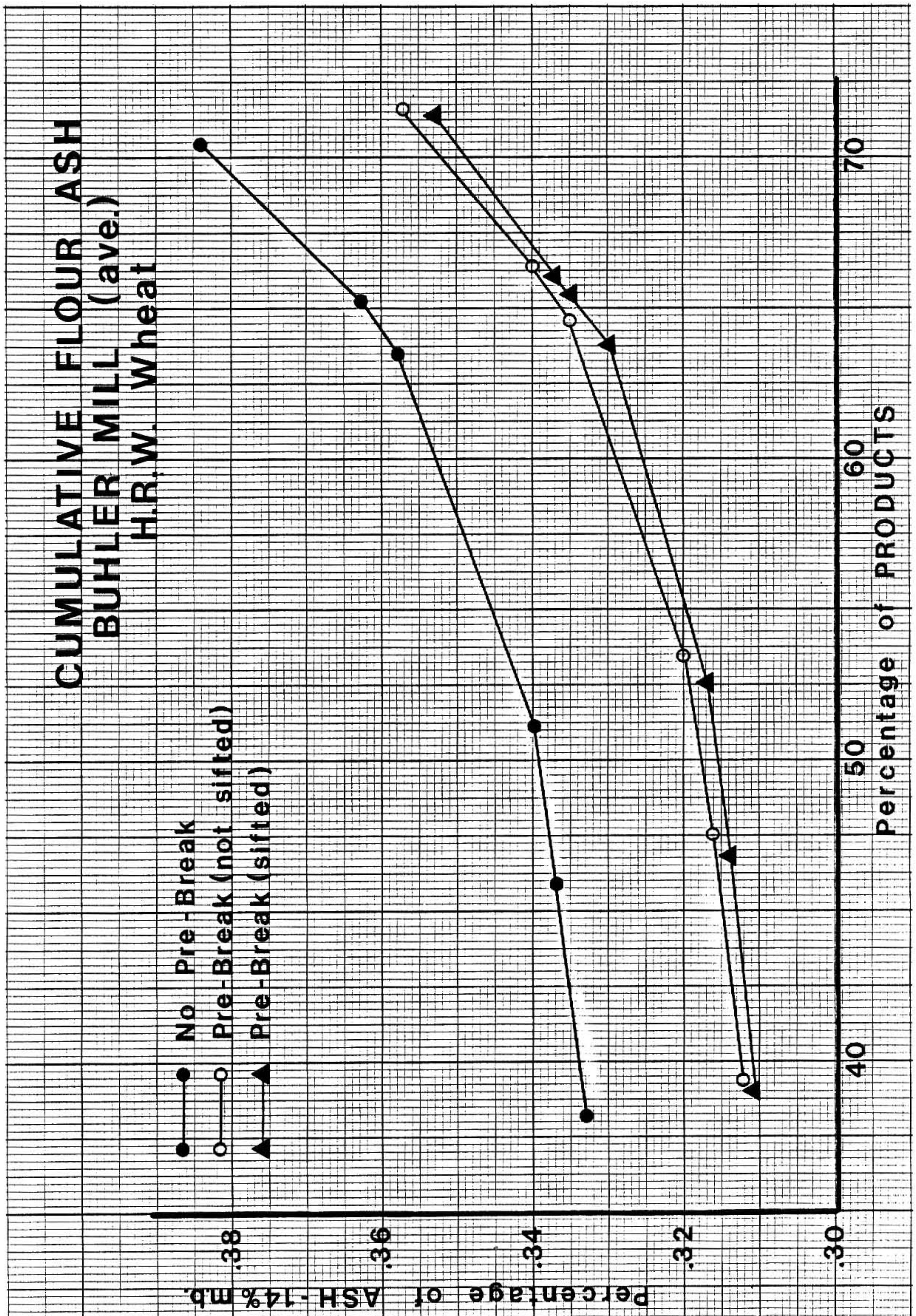

CUMULATIVE FLOUR ASH
BUHLER MILL (ave.)
H.R.W. Wheat
No Pre-Break
Pre-Break (not sifted)
Pre-Break (sifted)
Percentage of ASH - 14% m.b.
.38
.36
.34
.32
.30
40
50
60
70
Percentage of PRODUCTS

Figure 9

As mentioned in the methods, Pre-Broken wheat was both fed directly to first break on the Buhler Mill and sifted over a 9XX sieve to remove the Pre-Break flour produced before feeding to first break. As shown by the results, both methods of Pre-Breaking gave much improved milling results over not Pre-Breaking. A slight improvement is also shown by having sifted the Pre-Broken wheat prior to first break over Pre-Breaking without sifting.

All flour streams from the Pre-Break tests show improvement in ash contents and more than 1% average increase in flour extraction.

(4) Ross Walking Flow.

Table 5 gives the flour stream data and cumulative ash calculations for the average of the Ross flow millings. Figure 10 shows the cumulative flour ash curves of the plotted data. Flour streams analyzed were as follows:

Pre-Break	(P.BK)	Sizings	(SIZ)
First Break	(1 BK)	First Midds	(1 M)
Second Break	(2 BK)	Second Midds	(2 M)
Third Break	(3 BK)	Third Midds	(3 M)
Fourth Break	(4 BK)	First Tailing	(1 TA)
Fifth Break	(5 BK)	Fourth Midds	(4 M)
		Fifth Midds	(5 M)

Here again, other than feeding Pre-Broken stock directly to First Break, sifting was also performed on the stock before First Break grind. In this instance, as indicated by the flow sheet (Figure 5), the Pre-Break sifter was more elaborate. Other than removing the flour produced by Pre-Breaking, the sizings and middlings produced were also removed and sent to sizings and middlings grinds.

The cumulative ash curves again show a distinct improvement in milling performance by the use of the Pre-Breaking of the grain before actual

Table 5

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total. Products)
S = SUMMATION

MILL ROSS WALKING FLOW
TEST AVERAGE
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK							
1 M	1171	40.05	40.05	.275	11.014	11.014	.275
SIZ	197	6.75	46.80	.311	2.099	13.113	.280
2 M	244	8.34	55.14	.317	2.644	15.575	.286
3 BK	72	2.47	57.61	.383	0.946	16.703	.290
2 BK	85	2.89	60.50	.406	1.173	17.876	.295
3 M	92	3.16	63.66	.409	1.292	19.169	.301
4 BK	34	1.18	64.84	.445	0.525	19.694	.304
1 BK	109	3.72	68.56	.494	1.838	21.531	.314
1 TA	14	0.49	69.05	.578	0.283	21.815	.316
5 BK	39	1.35	70.40	.617	0.833	22.648	.322
4 M	55	1.89	72.29	.633	1.196	23.844	.330
5 M	21	0.73	73.02	1.243	0.907	24.751	.339
PRE-BREAK (NOT SIFTED)							
1 M	1150	39.51	39.51	.269	10.628	10.628	.269
SIZ	194	6.66	46.17	.295	1.965	12.593	.273
2 M	266	9.12	55.29	.295	2.690	15.283	.276
3 BK	79	2.70	57.99	.364	0.983	16.266	.280
2 BK	93	3.18	61.17	.381	1.212	17.478	.286
3 M	83	2.85	64.02	.392	1.117	18.595	.290
1 BK	127	4.35	68.37	.418	1.818	20.413	.299
4 BK	39	1.33	69.70	.427	0.568	20.981	.301
1 TA	12	0.43	70.13	.571	0.246	21.227	.303
4 M	44	1.50	71.63	.607	0.911	22.137	.309
5 BI	36	1.22	72.85	.615	0.750	22.887	.314
5 M	16	0.56	73.41	1.139	0.638	23.525	.320
PRE-BREAK (SIFTED)							
1 M	1194	40.88	40.88	.266	10.874	10.874	.266
SIZ	203	6.97	47.85	.291	2.028	12.902	.270
2 M	221	7.58	55.43	.297	2.251	15.154	.273
3 BK	80	2.74	58.17	.357	0.978	16.132	.277
2 BK	91	3.13	61.30	.374	1.171	17.302	.282
3 M	80	2.73	64.03	.389	1.062	18.364	.287
1 BK	115	3.94	67.97	.410	1.615	19.980	.294
4 BK	37	1.26	69.23	.431	0.543	20.523	.296
1 TA	11	0.38	69.61	.533	0.203	20.725	.298
5 BK	40	1.36	70.97	.601	0.817	21.543	.304
P.BK	5	0.18	71.15	.607	0.109	21.652	.304
4 M	47	1.60	72.75	.646	1.034	22.686	.312
5 M	16	0.55	73.30	1.319	0.725	23.411	.319

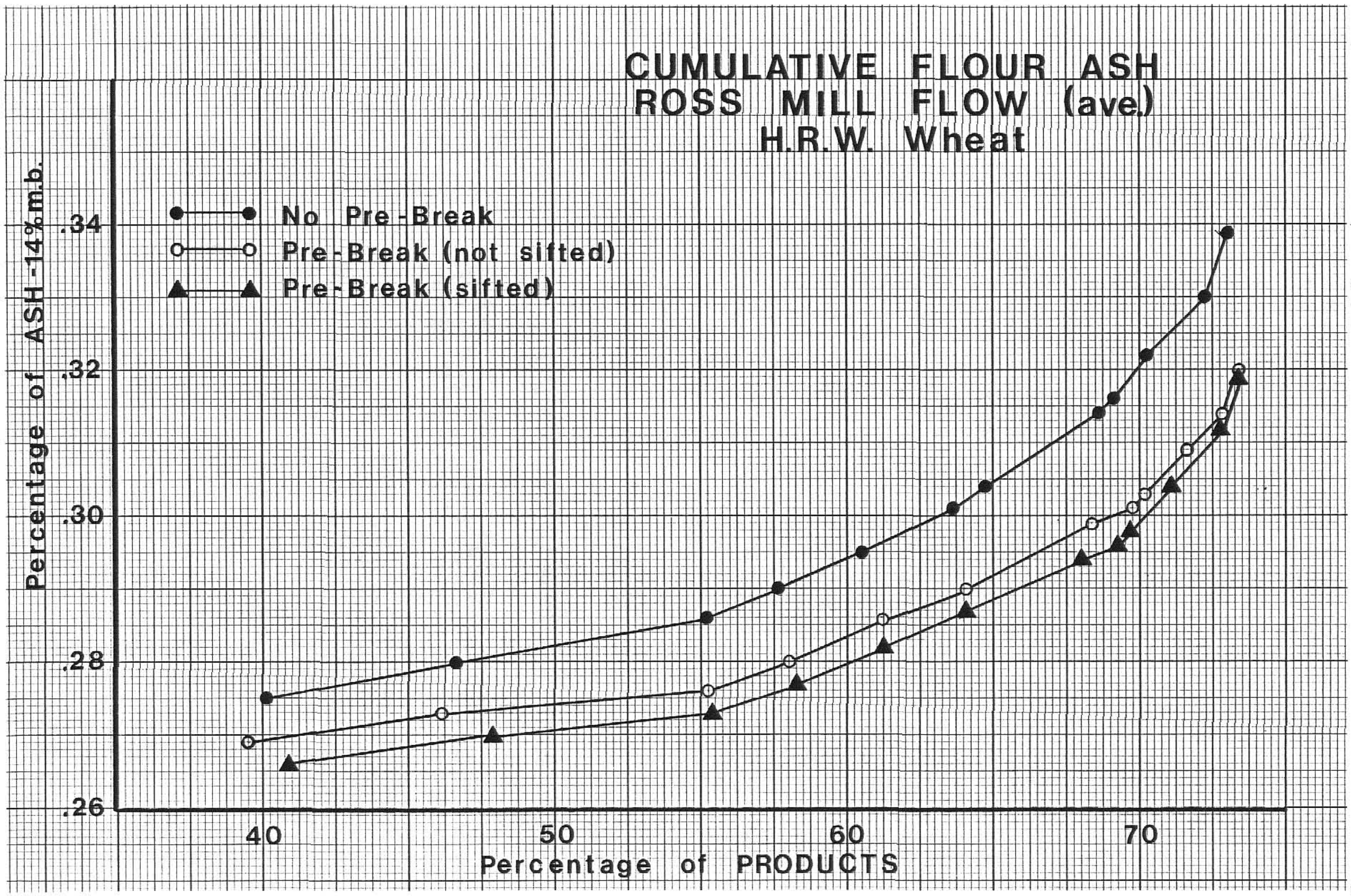

CUMULATIVE FLOUR ASH
ROSS MILL FLOW (ave.)
H.R.W. Wheat
No Pre-Break
Pre-Break (not sifted)
Pre-Break (sifted)
Percentage of ASH-14%m.b.
.34
.32
.30
.28
.26
40
50
60
70
Percentage of PRODUCTS

Figure 10

milling. The use of the Pre-Break sifter is also favored due to the slightly lower ash curve produced.

Both tests using the Pre-Break also gave slightly higher average flour extractions. Improvements of .3% to .4% were realized.

(5) Miag Multomat Mill.

Flour stream data and cumulative ash calculations are listed in Table 6 and the resulting cumulative ash curves are shown by Figure 11 for the averaged results of the millings on the Miag Multomat. Flour streams analyzed were as follows:

First Break	(1 BK)	Second Midds	(2 M)
Second Break	(2 BK)	First Midds Redust	(1 M RED)
Third Break	(3 BK)	Third Midds	(3 M)
Grader		Fourth Midds	(4 M)
First Midds	(1 M)	Fifth Midds	(5 M)

Although some improvement with the use of the Pre-Break is noticed, it does not appear as significant as in previous tests. Since this mill can be considered as relatively short on break roll surface, it would seem that the use of Pre-Break would be of great assistance in improving the flour milling performance. As indicated by the data, improvement was only slight and specific reasons for this are not known.

The actual Pre-Breaking operation, as discussed earlier, was performed on a slightly different roller mill than on the other test millings. This being a pair of 6" x 3" rolls running at a 1.5:1 differential versus 9" x 6" rolls running at a 1:1 differential. Although there is a slight difference between methods, it would not seem to be critical enough to significantly affect the results.

Feed rates for experimental mills is a critical factor in the correct operation and performance of the mills. In previous testing using the Miag Multomat, feed rates of 750 to 780 grams per minute were normally

Table 6

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: MIAG MULTOMAT
TEST: AVERAGE
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK							
1 M RED	2803	8.65	8.65	.266	2.301	2.301	.266
2 M	5900	18.19	26.84	.277	5.039	7.340	.273
1 M	2769	8.52	35.36	.284	2.420	9.760	.276
1 BK	2509	7.78	43.14	.336	2.614	12.374	.287
2 BK	2219	6.88	50.02	.347	2.387	14.761	.295
3 M	2952	9.14	59.16	.353	3.226	17.987	.304
GRADER	1504	4.74	63.90	.356	1.687	19.674	.308
4 M	1124	3.50	67.40	.442	1.547	21.221	.315
3 BK	831	2.56	69.96	.464	1.188	22.409	.320
5 M	351	1.10	71.06	1.503	1.653	24.062	.339
PRE-BREAK							
1 M RED	3007	8.79	8.79	.263	2.312	2.312	.263
1 M	2941	8.61	17.40	.267	2.299	4.611	.265
2 M	6378	18.65	36.05	.278	5.185	9.796	.272
1 BK	2673	7.80	43.85	.333	2.597	12.393	.283
2 BK	2547	7.45	51.30	.348	2.593	14.986	.292
GRADER	1670	4.88	56.18	.349	1.703	16.689	.297
3 M	2888	8.45	64.63	.361	3.050	19.739	.305
3 BK	861	2.52	67.15	.452	1.139	20.878	.311
4 M	1127	3.29	70.44	.484	1.592	22.470	.319
5 M	333	0.97	71.41	1.720	1.668	24.138	.338

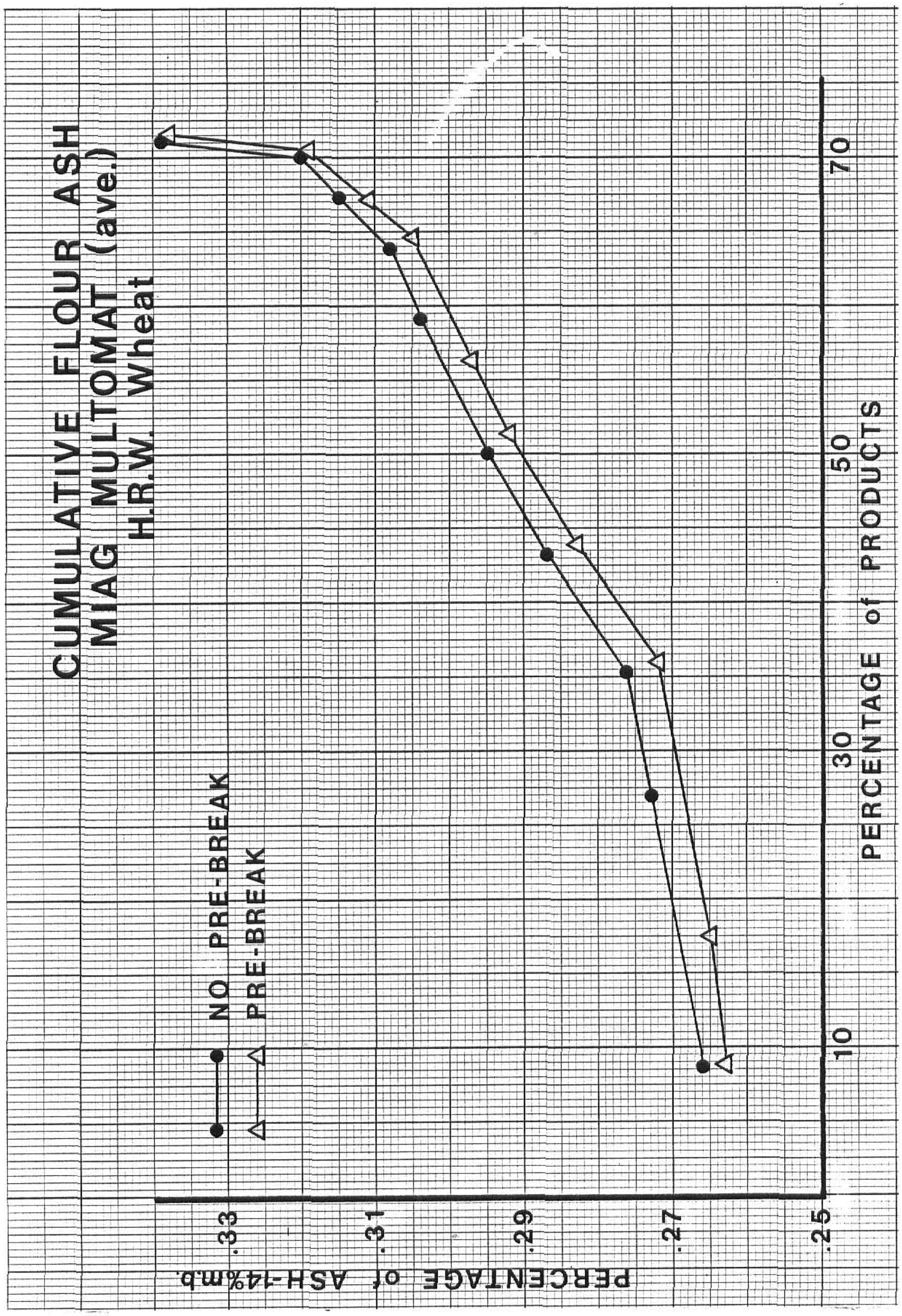

CUMULATIVE FLOUR ASH
MIAG MULTOMAT (ave.)
H.R.W. Wheat
NO PRE-BREAK
PRE-BREAK
PERCENTAGE of ASH-14%m.b.
.33
.31
.29
.27
.25
10
30
50
70
PERCENTAGE of PRODUCTS

Figure 11

used and found to give adequate results and comfortable operating conditions. Since this particular mill flow has a relatively short Break System and a relatively long Reduction System, at the feed rates the mill is normally operated at, the tail of the mill was somewhat underloaded. By using the Pre-Break, this underloaded condition may have worsened, thereby causing bare-bolting in the sifting operation and in turn causing higher ash-flour streams.

If the data in Table 6 is further analyzed, it can be shown that this underloaded condition was further aggravated by the use of Pre-Break. By accumulating only the Break flours (1st Break, 2nd Break, Grader and 3rd Break), 21.96% flour at .359% ash was produced by the test milling not using Pre-Break versus 22.65% flour at .355% ash milling with the Pre-Break. A gain of about .7% is realized with the Pre-Break at approximately the same ash. Again, by only accumulating the Primary Middlings flours (1st Midds, 2nd Midds, 1st Midd. Redust) it is seen that 35.36% flour at .276% ash is produced by the "No Pre-Break" System versus 36.05% flour at .272% ash produced with Pre-Break. This results in a .7% gain in flour, using Pre-Break at essentially the same cumulated ash content. The remainder, secondary middlings flour, when accumulated gives a resultant flour of 13.74% at .468% ash for the system without Pre-Break versus 12.71% at .496% ash produced by the system using Pre-Break. Approximately 1% more flour was produced by the mill without the Pre-Break and at a lower ash.

From this analysis, it is therefore possible that the optimum feed rate was not utilized in these tests for proper analysis of the Pre-Break. Since more break flour and primary middling flour was produced with the use of the Pre-Break, the tail end of the mill, or Secondary Middlings, was below proper loading for optimum milling performance.

SUMMARY AND CONCLUSIONS

As previously stated, the purpose of this research was to document the effect of Pre-Breaking kernels of wheat prior to the actual procedure of milling. From the data obtained by test milling, using various experimental mills, it can be concluded that Pre-Breaking results in a positive effect upon milling and flour quality.

The flour miller is continually faced with many goals and problems in trying to achieve these goals. One of the primary goals or objectives that is basic to the milling of wheat is to obtain the highest percentage of flour at the highest quality obtainable from a given lot of wheat. Solutions to meet both of these goals may be difficult.

The results of these tests on Pre-Breaking show that, if properly applied, Pre-Break Systems may aid in providing both flours at lower ash contents and at somewhat higher extractions. In all cases, with the exception of the tests using the Miag Multomat, flour ash contents were significantly lowered while slight increases in total flour extractions were also realized, when the wheat was Pre-Broken prior to milling. Tests on the Miag Multomat using Pre-Break also produced flour of lower ash contents than when not using Pre-Break, but differences were not as great. This, as mentioned before, may have been due to problems of the feed rate of wheat to the mill.

The results also indicated that sifting of the Pre-Broken wheat before milling was also beneficial. Flours obtained from test millings where the Pre-Broken stock was sifted before milling were found to be slightly lower in ash than when Pre-Break was used without sifting.

Although not based on scientific fact, several reasons may be theorized as to why Pre-Breaking produces positive effects on milling performance.

1. As can be seen in that data, milling with a Pre-Break produced higher percentages of primary break flours at lower ash contents. This could be due to the better presentation of the wheat to the corrugated break rolls in particular the first and second break rolls. Normally, the First Breaking operation must both open up the wheat berry and scrape some portions of the endosperm from the bran. The design of the corrugations and differentials of the rolls lend themselves to doing a better job of the latter. Therefore if, as when using the Pre-Break, the kernel is partially opened and somewhat flattened out before the First Break, the First Break rolls may provide better grinding action with less severity of grind, resulting in less bran contamination. Besides producing lower ash flour on the Breaks, Sizings and Middlings stock lower in ash is also being produced.

2. Although not as yet researched, one may theorize that the wheat berries being exposed to the shock of compression by the Pre-Break rolls may develop stresses along the area where the endosperm adheres to the bran. This would allow for the easier removal of the endosperm by the subsequent Break rolls.

3. The grinding of the wheat germ, since it is relatively high in ash content, can increase the ash content of the flour being produced. It was observed that, when milling with the Pre-Break, more wheat germ was being released into the Sizings fraction. Once in the Sizings System, there is better chance for recovery and less chance for the grinding of the germ into flour.

4. Where the Pre-Broken wheat was sifted before milling, slightly lower flour ashes were also noted than when it was not sifted. This may be due to the removal, by the sifter, of any foreign material lodged in the crease of the wheat berry that was not removed in the cleaning process.

SUGGESTIONS FOR FUTURE WORK

Since this work dealt mainly with documenting the effects of Pre-Breaking, the theories as to why the use of a Pre-Break result in improved milling performance need to be substantiated. Work along these lines should be, if possible, scaled up to a larger, commercial-type mill. Complete stream analysis on a large scale mill could be very revealing. To determine if pre-breaking may loosen the bonds between the bran and the endosperm, studies using the Scanning Electron Microscope may be useful.

More work should also be done to better determine the method of Pre-Breaking which provides the optimum improvement in milling performance. In this study, only smooth rolls at very low differentials were utilized. Would corrugated rolls or a combination of a corrugated and a smooth roll provide better splitting action? Is a one to one differential the optimum differential to use?

Determining the severity of Pre-Breaking to give optimum performance is also needed. If slightly opening the wheat berry at the crease presents the stock better to the Break rolls, would smashing the kernel under high compression make an even better presentation to the Break rolls?

Although not fully tested in this work, there is some evidence that by using a Pre-Break, power consumption may be lowered for the subsequent grinding operations. If it was determined that by the use of Pre-Break system both total power consumption was lowered and milling performance was improved, the milling industry would surely benefit.

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ACKNOWLEDGMENTS

The writer would like to express his sincere appreciation to Professor Arlin B. Ward, major professor, Department of Grain Science and Industry, Kansas State University, for his guidance and support of this research and especially for his dedication to the Milling Industry.

Appreciation would also like to be extended to Professor Emeritus Eugene Farrell, Doctor Dale Eustace and Professor John Wingfield, Department of Grain Science and Industry, Kansas State University, for their continued assistance and sharing of ideas during this study.

The writer would especially like to express his deep gratitude to his wife, family and friends for their support, encouragement and patience.

APPENDIX A

APPENDIX A

Appendix A contains all data from the individual tests on each experimental mill. Flowsheets of each mill are given with the stream weights entered for both flour and feed, and in the case of the Ross Walking Flow, all stream weights are given. Cumulative flour ash calculations and the resulting cumulative ash curves for each test are also shown.

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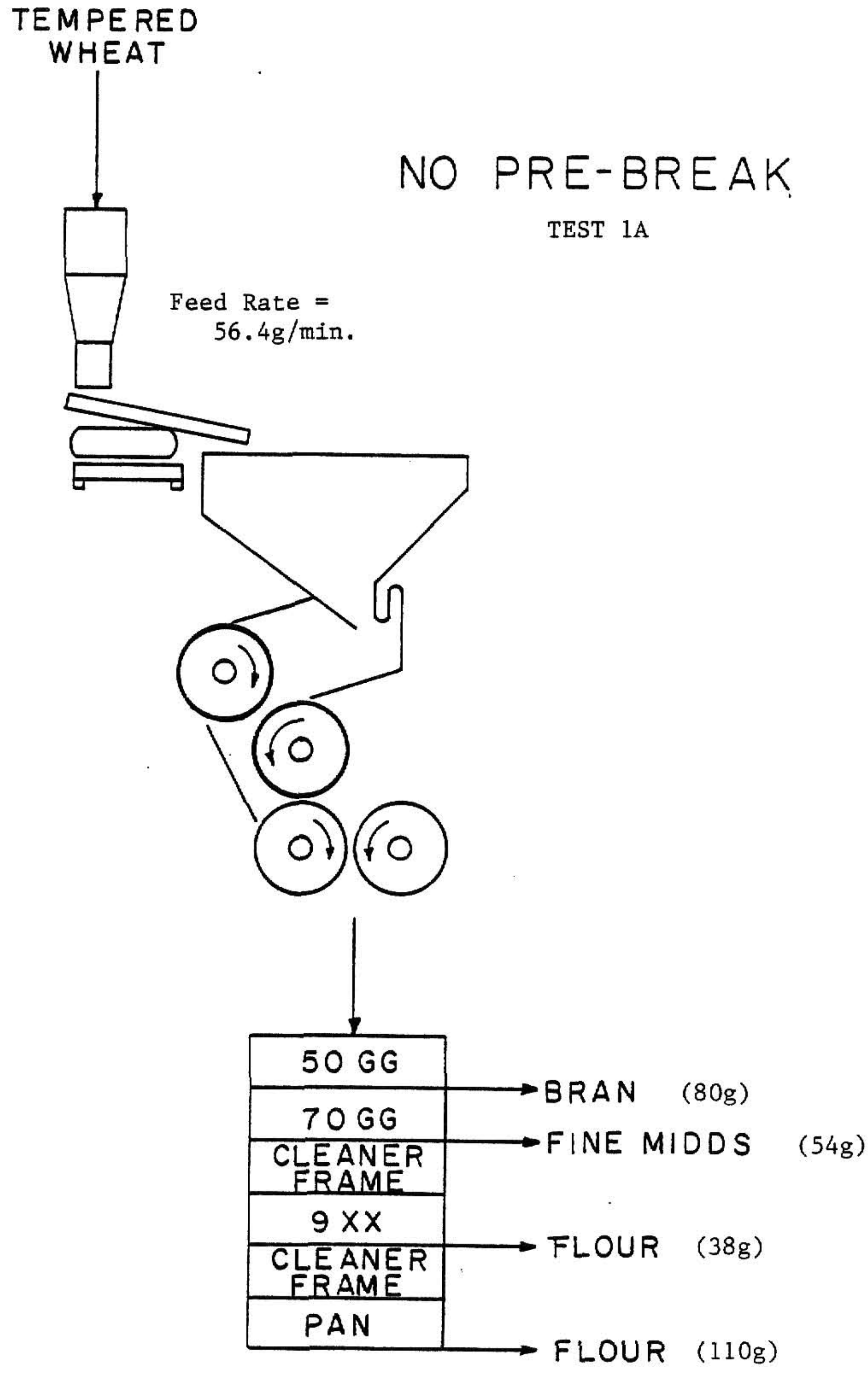
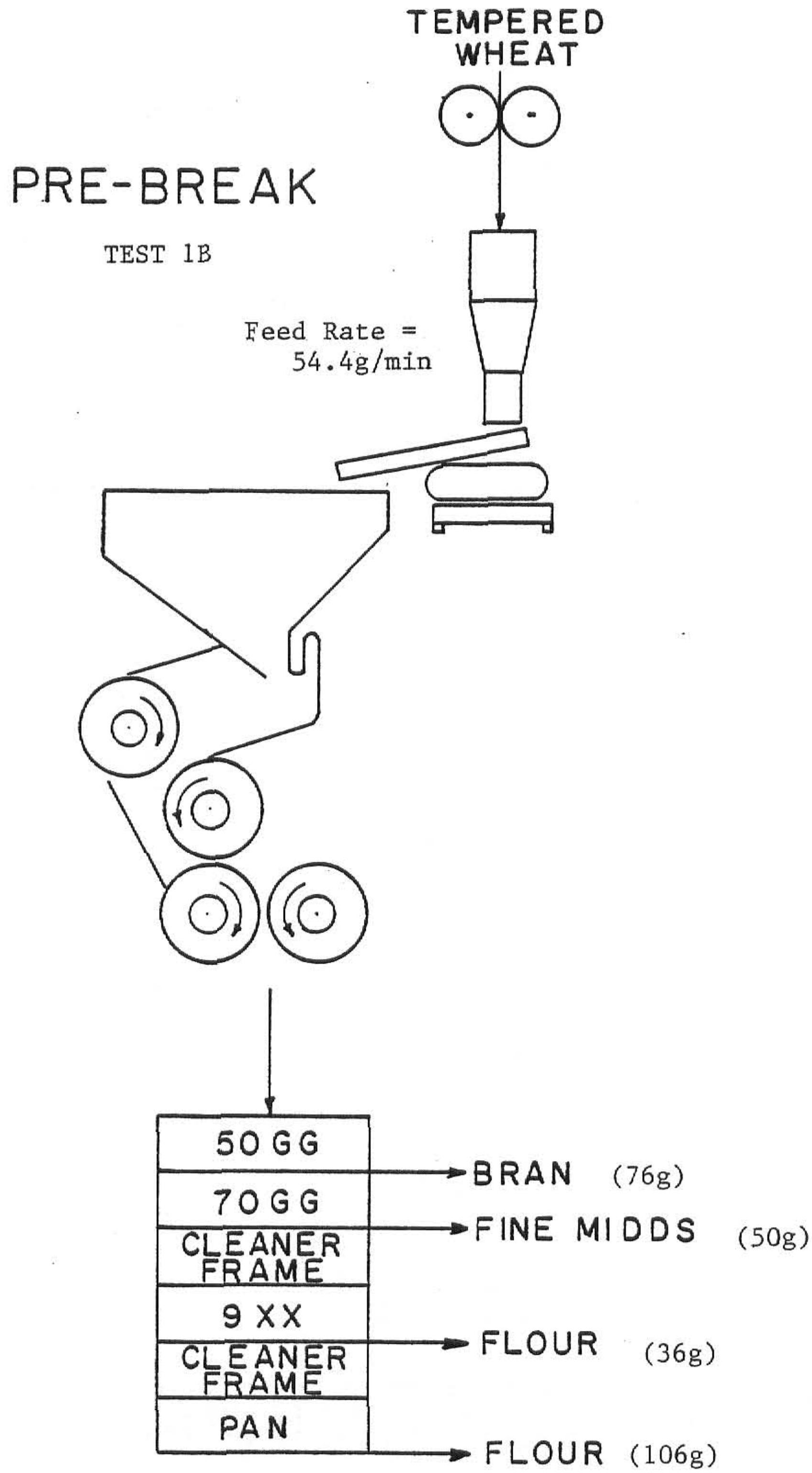
LIST OF TABLES IN APPENDIX A



QUADRUMAT JUNIOR

Figure 12



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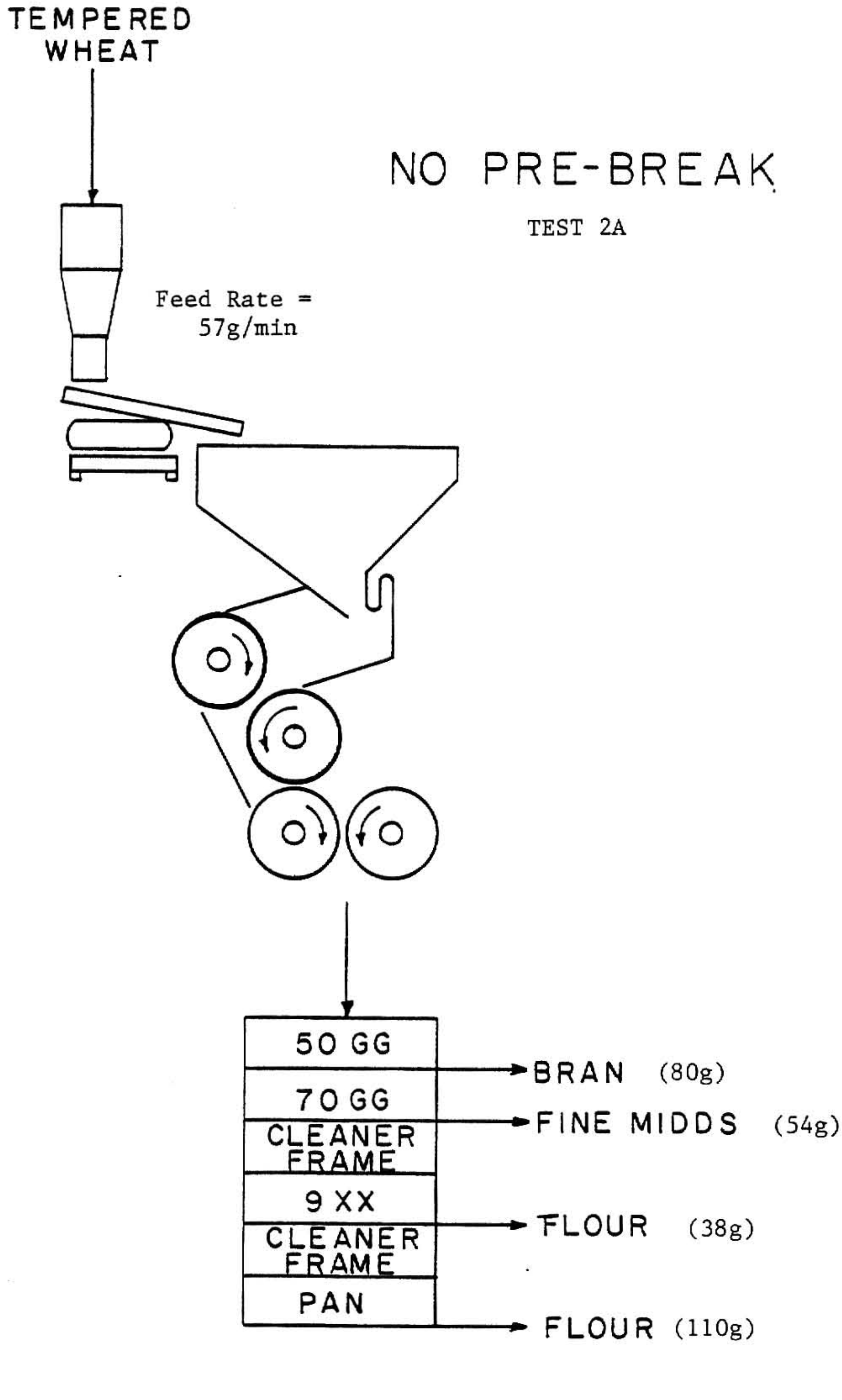
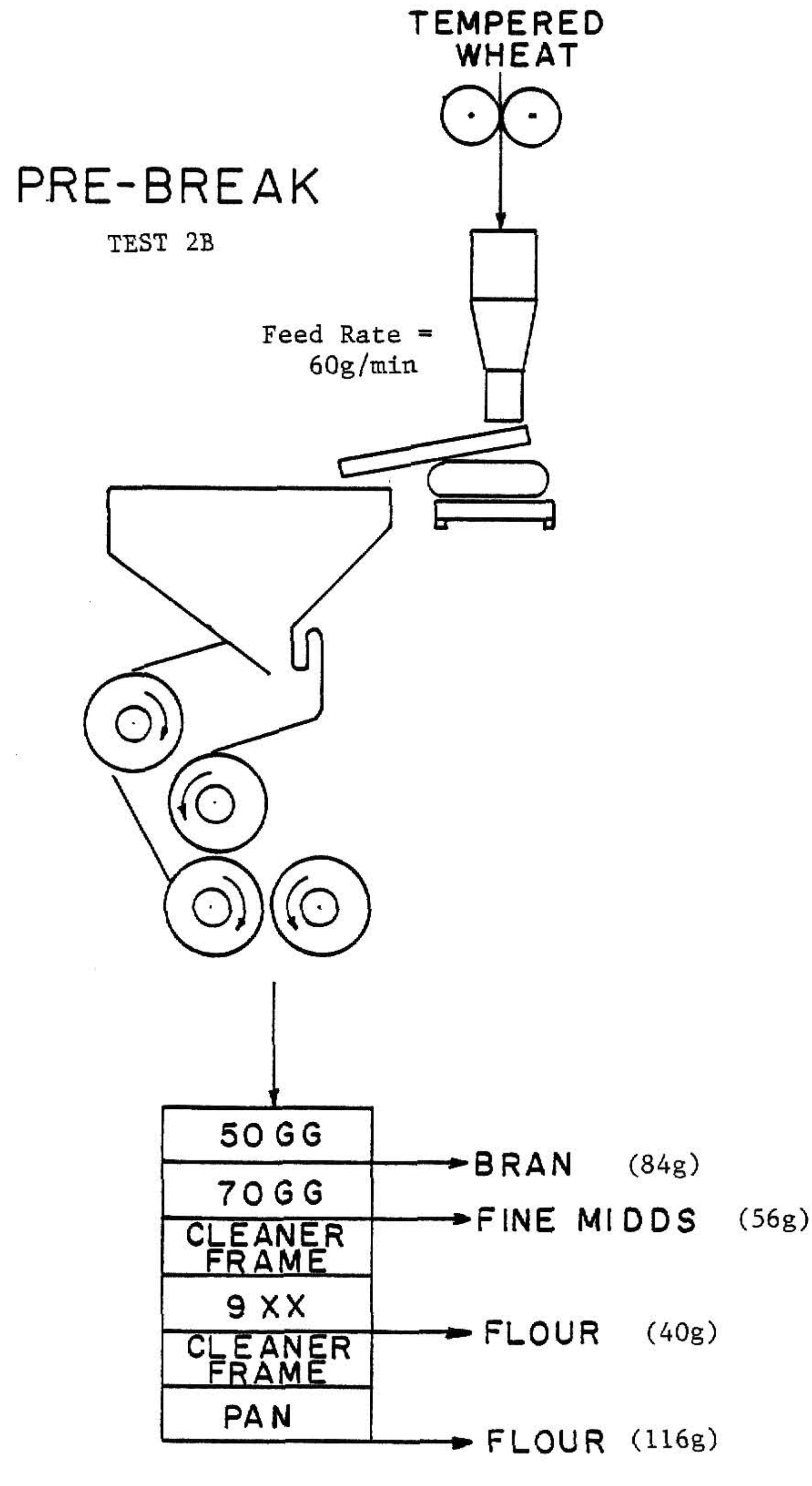
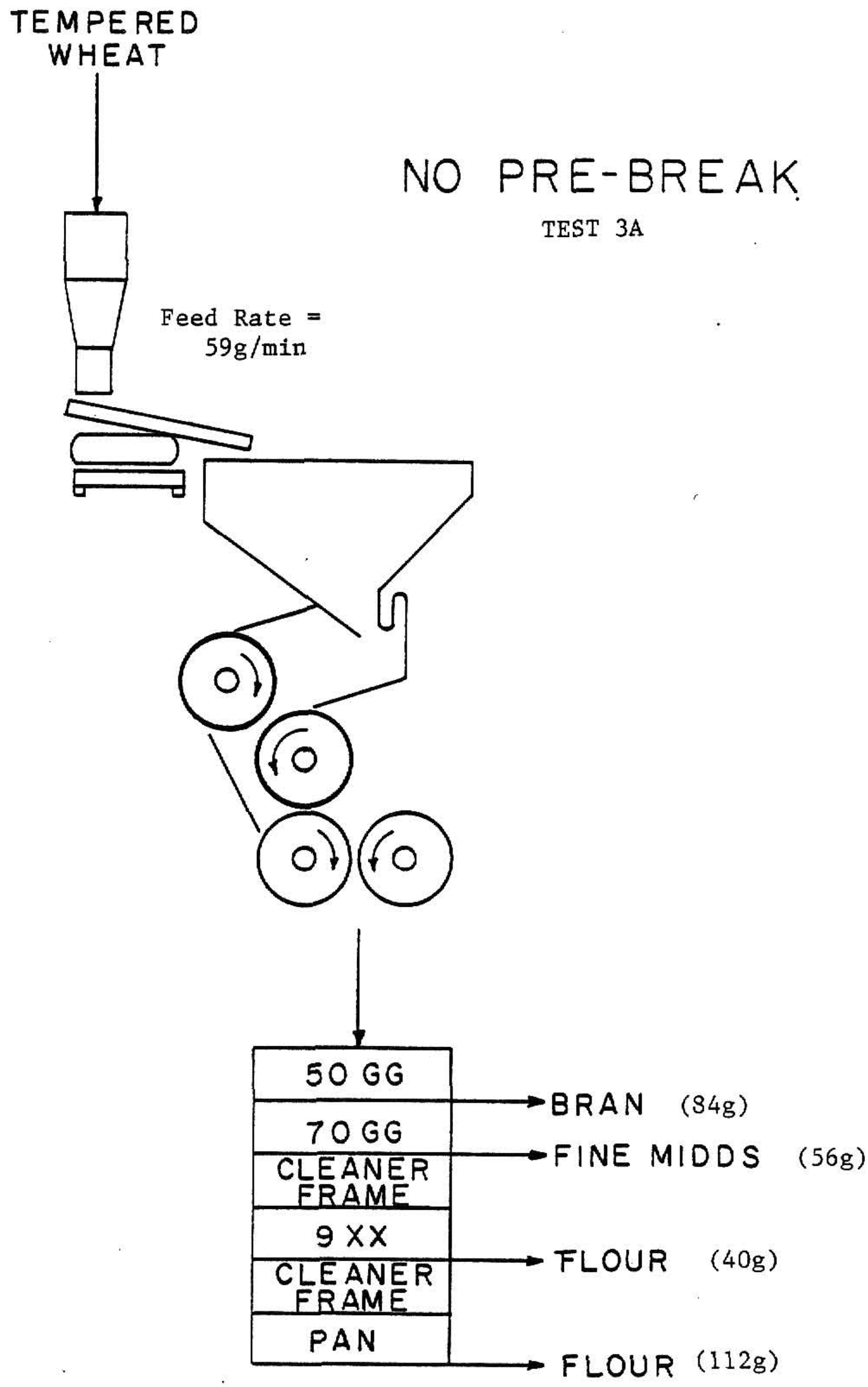


QUADRUMAT JUNIOR

Figure 14



QUADRUMAT JUNIOR Figure 15



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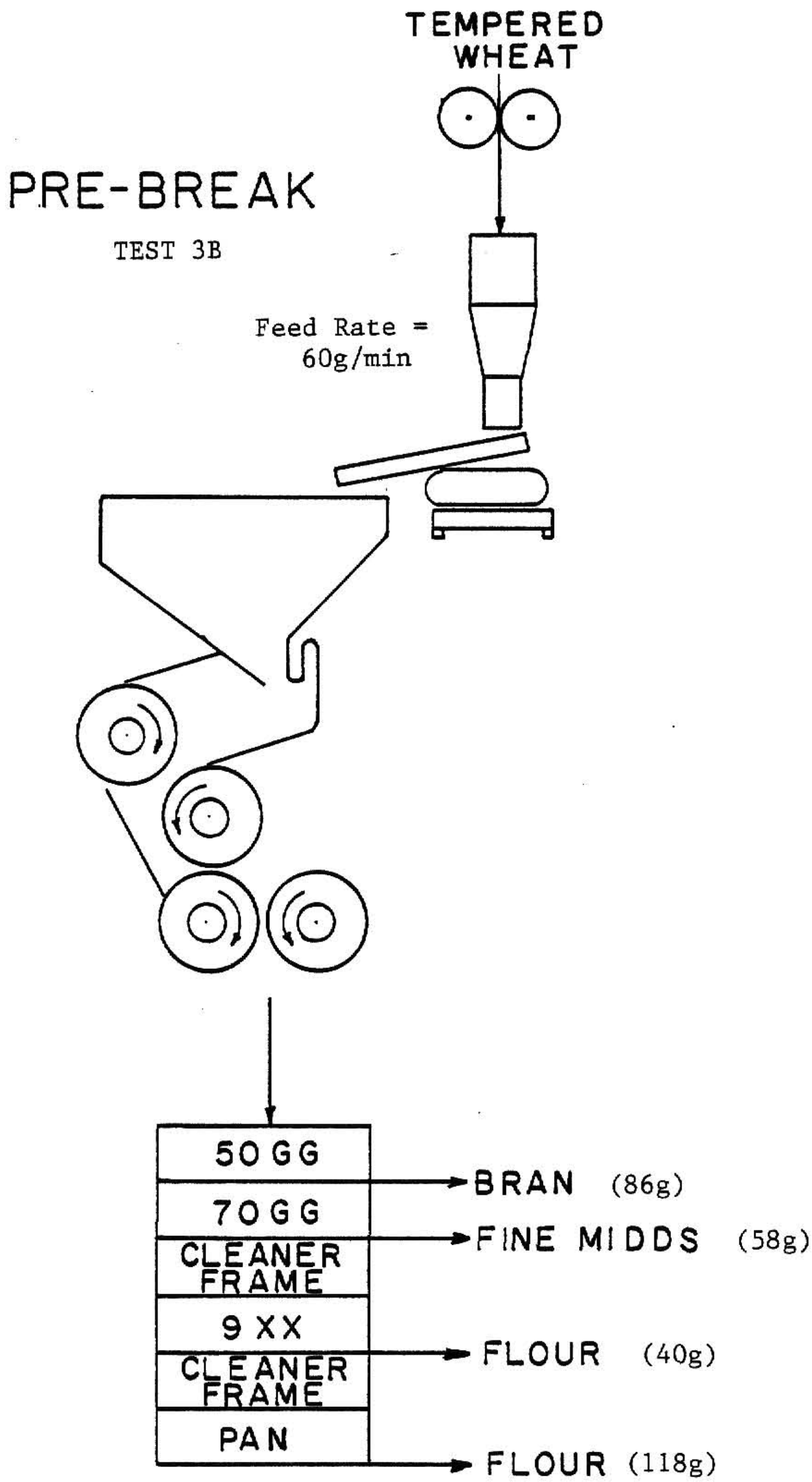
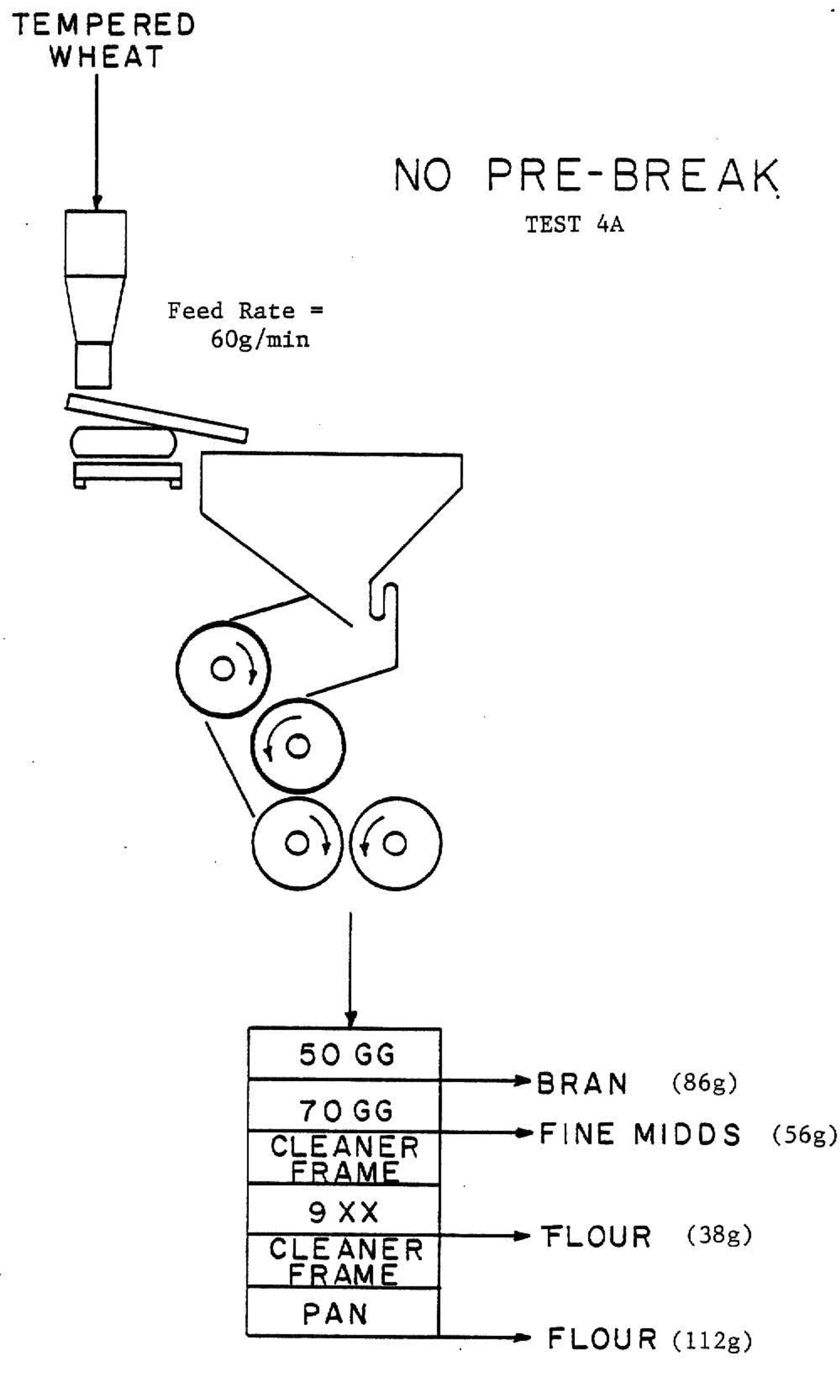


QUADRUMAT JUNIOR

Figure 17



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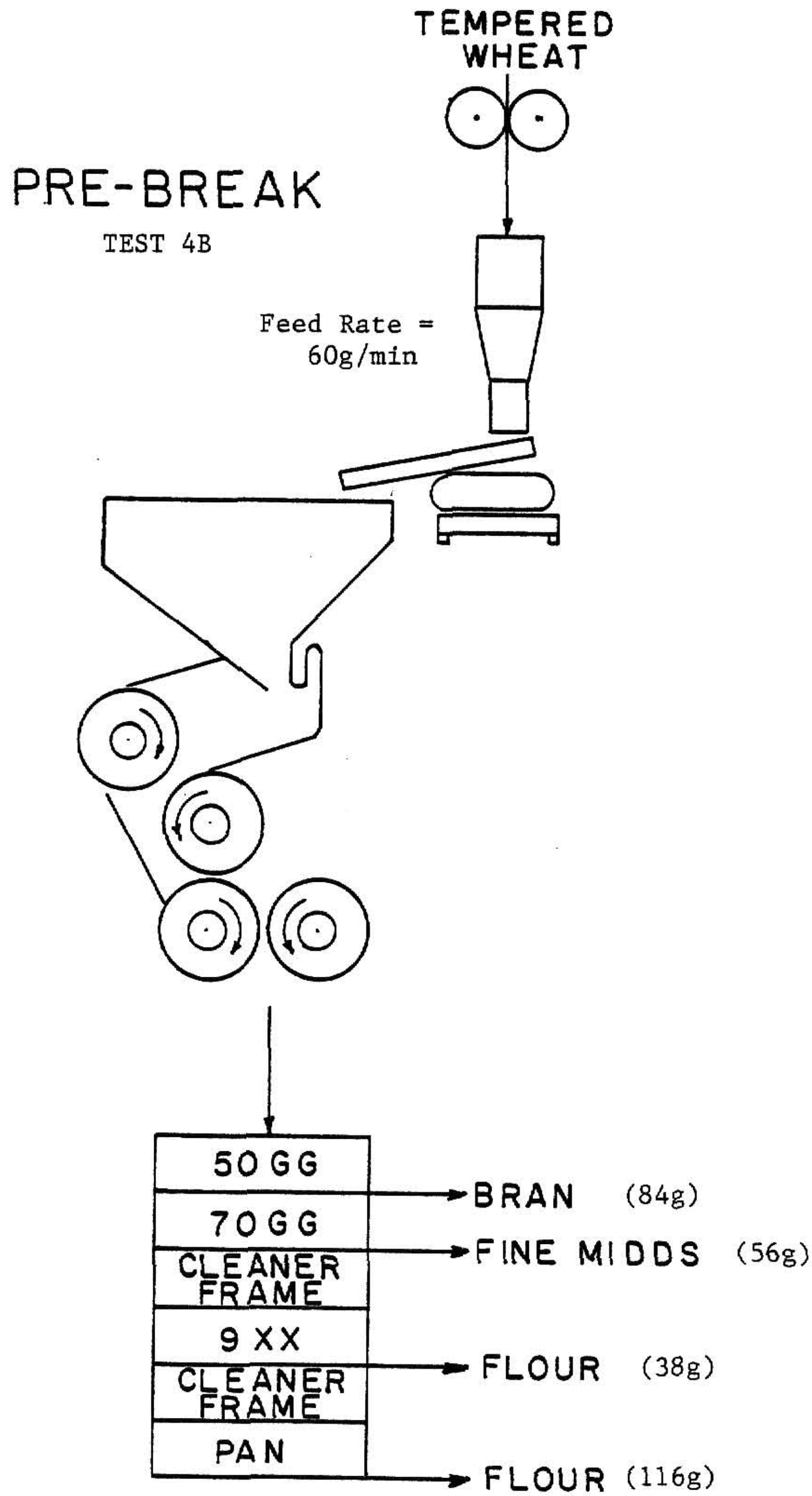

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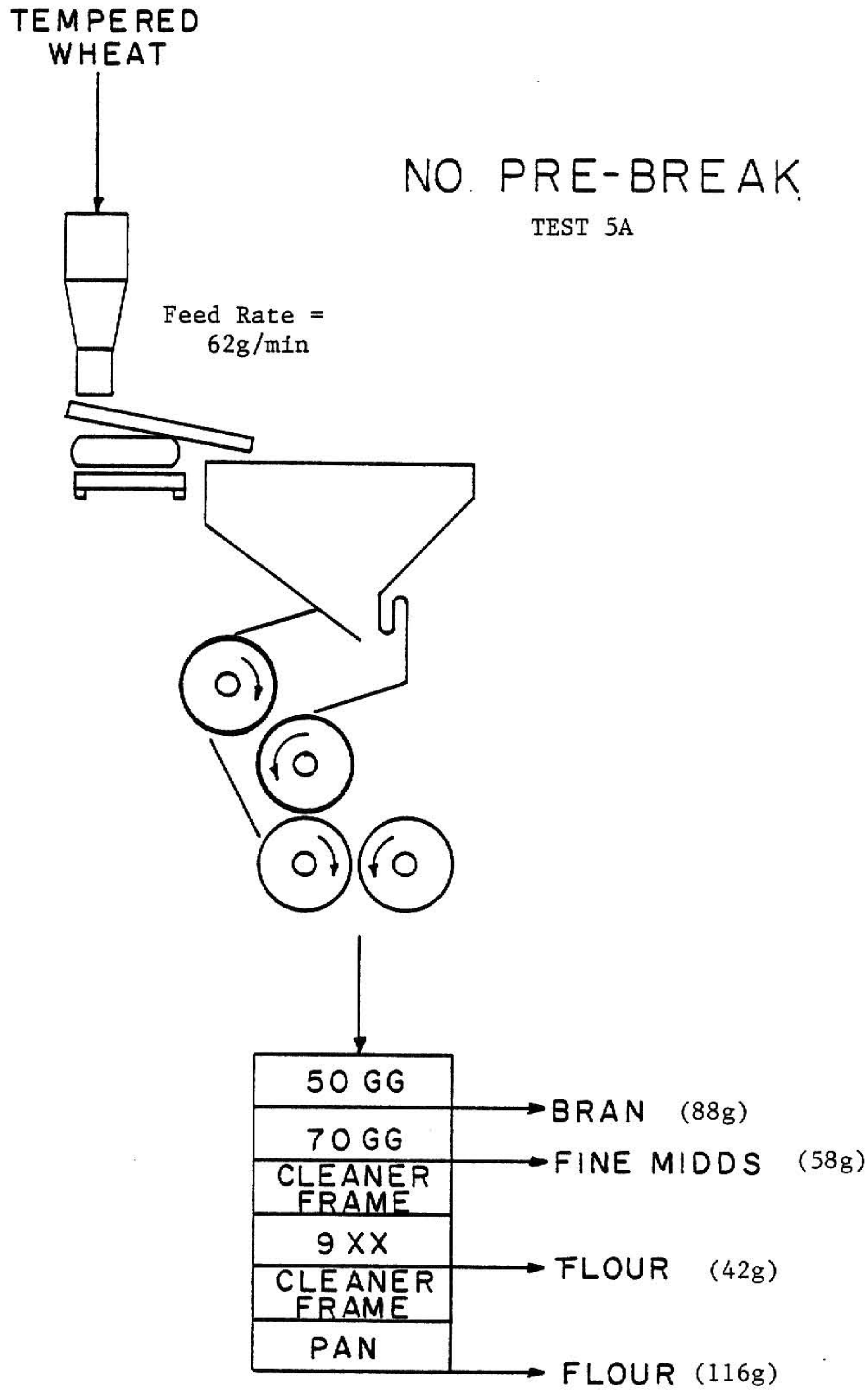
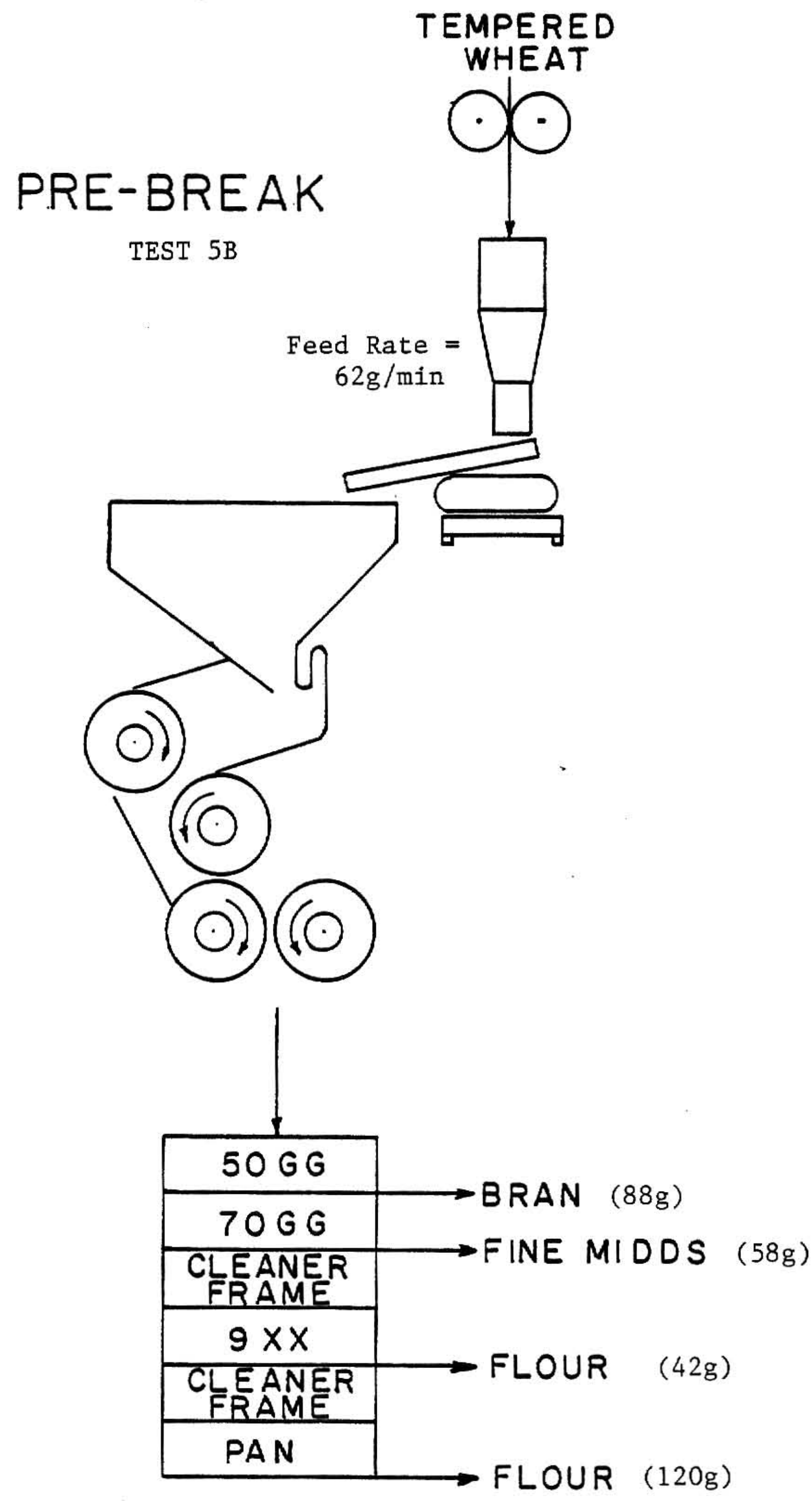


QUADRUMAT JUNIOR

Figure 20



QUADRUMAT JUNIOR

Figure 21

Table 7

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL QUADRUMAT JUNIOR
TEST A, B, C, D, E
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
TEST 1A NO PRE-BREAK							
-9XX	110	39.01	39.01	.440	17.16	17.16	.440
+9XX	38	13.48	52.49	.460	6.20	23.36	.445
TEST 1B PRE-BREAK							
-9XX	106	39.55	39.55	.408	16.14	16.14	.408
+9XX	36	13.43	52.98	.427	5.73	21.87	.413
TEST 2A NO PRE-BREAK							
+9XX	38	13.48	13.48	.428	5.77	5.77	.428
-9XX	110	39.01	52.49	.431	16.81	22.58	.430
TEST 2B PRE-BREAK							
-9XX	116	39.19	39.19	.399	15.64	15.64	.399
+9XX	40	13.51	52.70	.416	5.62	21.26	.403
TEST 3A NO PRE-BREAK							
-9XX	112	38.36	38.36	.428	16.42	16.42	.428
+9XX	40	13.70	52.06	.437	5.99	22.41	.430
TEST 3B PRE-BREAK							
-9XX	118	39.07	39.07	.409	15.98	15.98	.409
+9XX	40	13.25	52.32	.410	5.43	21.41	.409
TEST 4A NO PRE-BREAK							
-9XX	112	38.36	38.36	.429	16.46	16.46	.429
+9XX	38	13.01	51.37	.439	5.71	22.17	.432
TEST 4B PRE-BREAK							
+9XX	38	12.93	12.93	.399	5.16	5.16	.399
-9XX	116	39.46	52.39	.407	16.06	21.22	.405
TEST 5A NO PRE-BREAK							
-9XX	116	38.16	38.16	.419	15.99	15.99	.419
+9XX	42	13.82	51.98	.436	6.03	22.02	.424
TEST 5B PRE-BREAK							
-9XX	120	38.96	38.96	.388	15.12	15.12	.388
+9XX	42	13.64	52.60	.388	5.29	20.41	.388

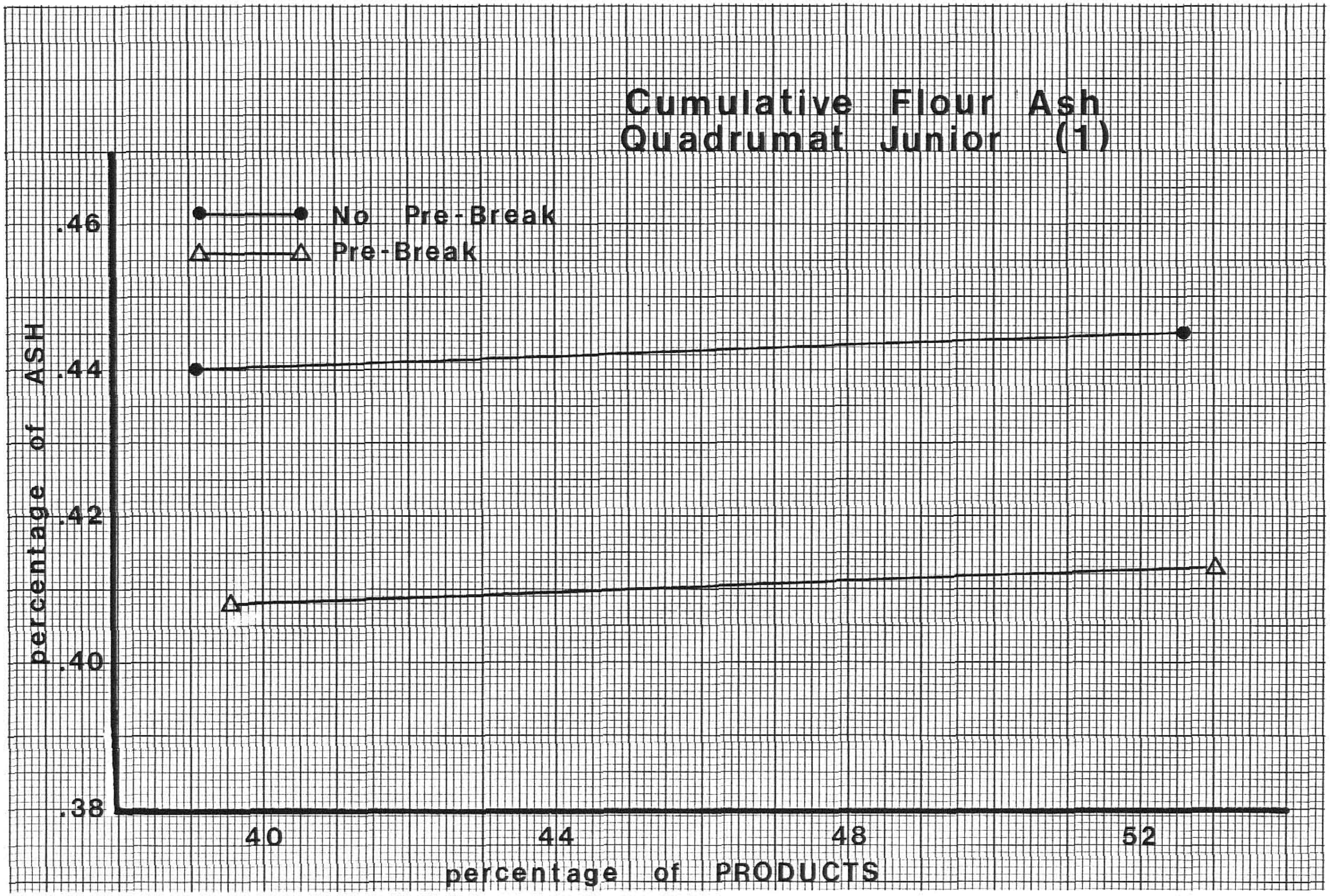

Cumulative Flour Ash
Quadrumat Junior (1)
No Pre-Break
Pre-Break
.46
.44
.42
.40
.38
percentage of ASH
40
44
48
52
percentage of PRODUCTS

Figure 22

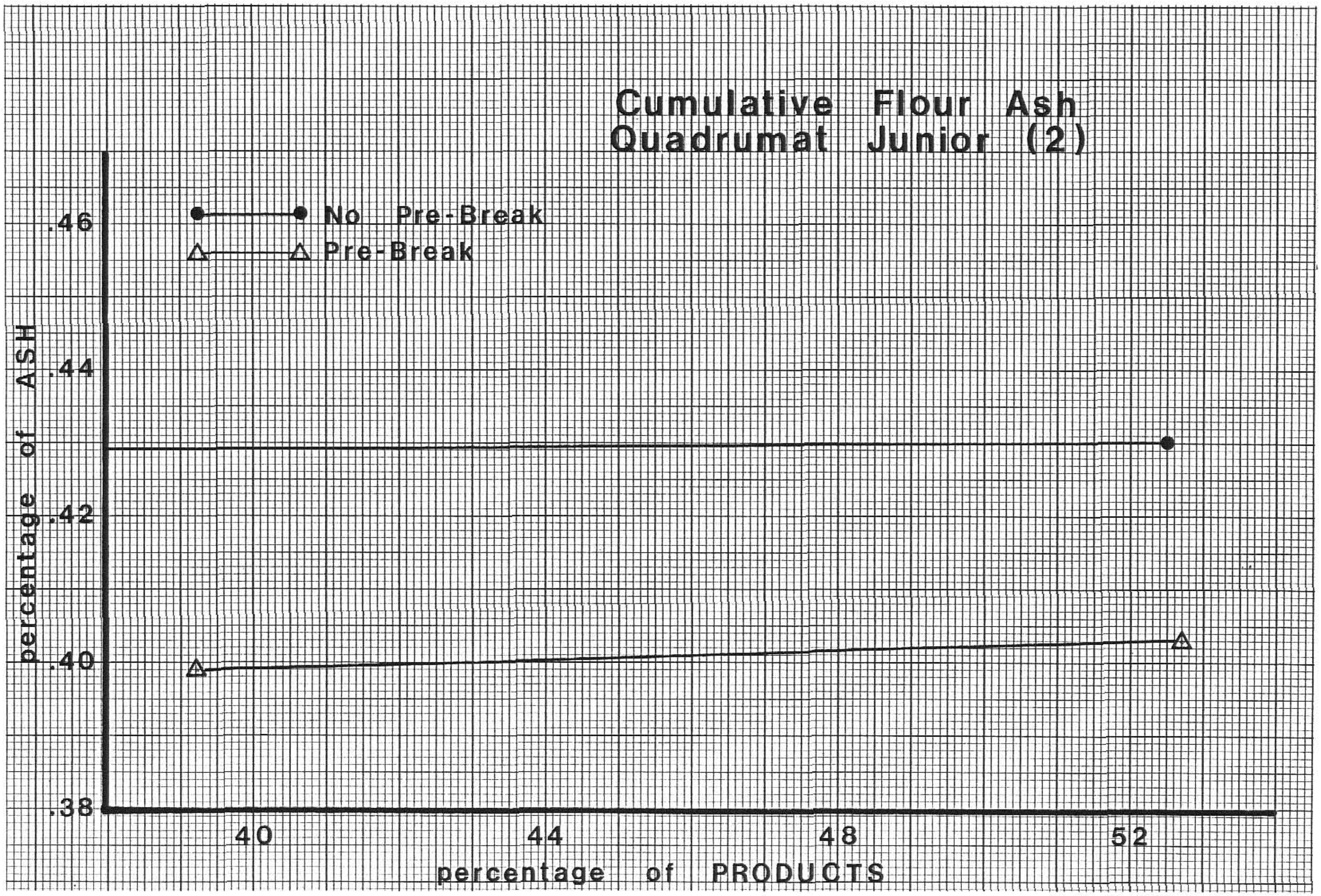
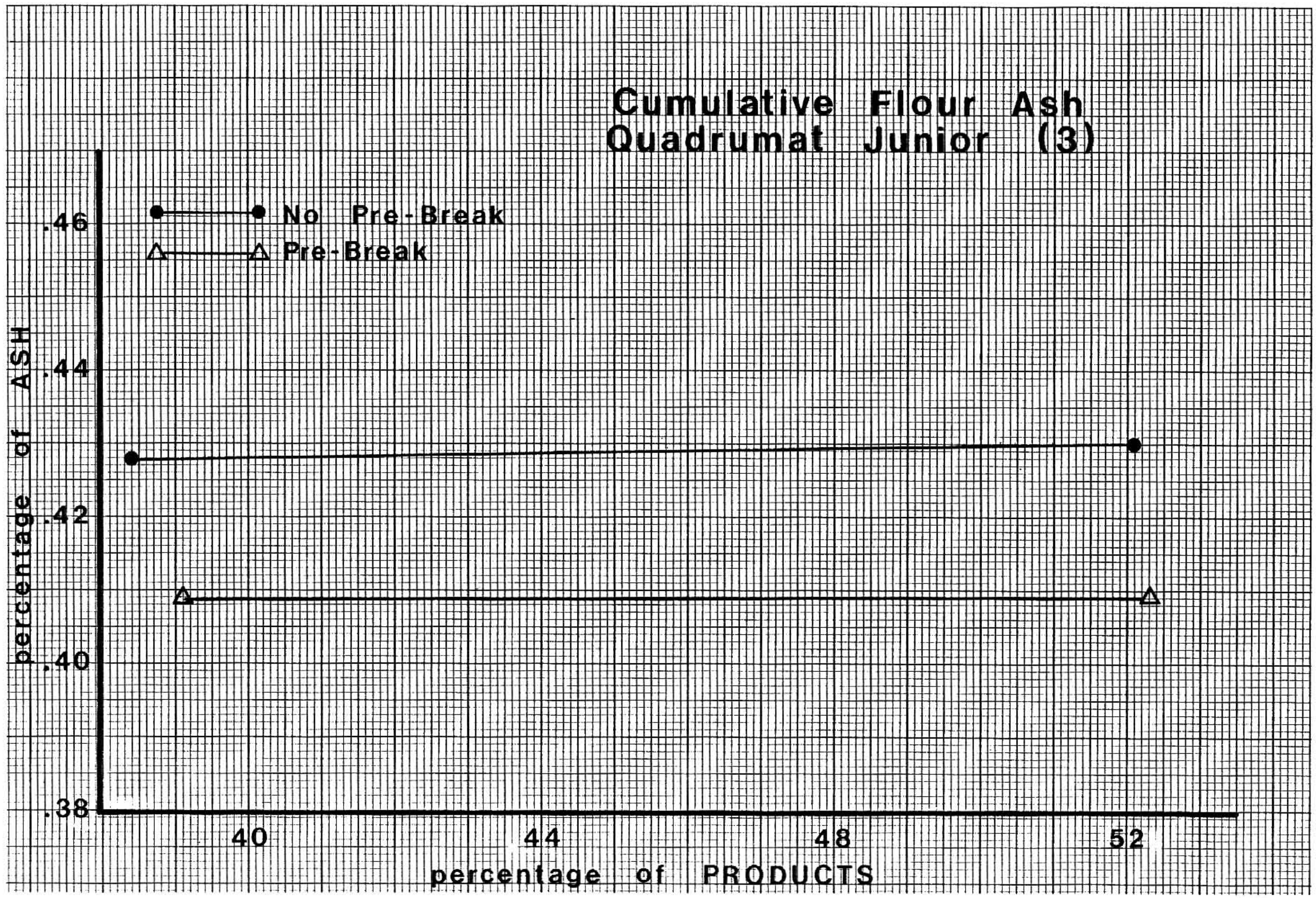

Cumulative Flour Ash
Quadrumat Junior (2)
No Pre-Break
Pre-Break
.46
.44
.42
.40
.38
percentage of ASH
40
44
48
52
percentage of PRODUCTS

Figure 23



Cumulative Flour Ash
Quadrumat Junior (3)
No Pre-Break
Pre-Break
.46
.44
.42
.40
.38
percentage of ASH
40
44
48
52
percentage of PRODUCTS

Figure 24

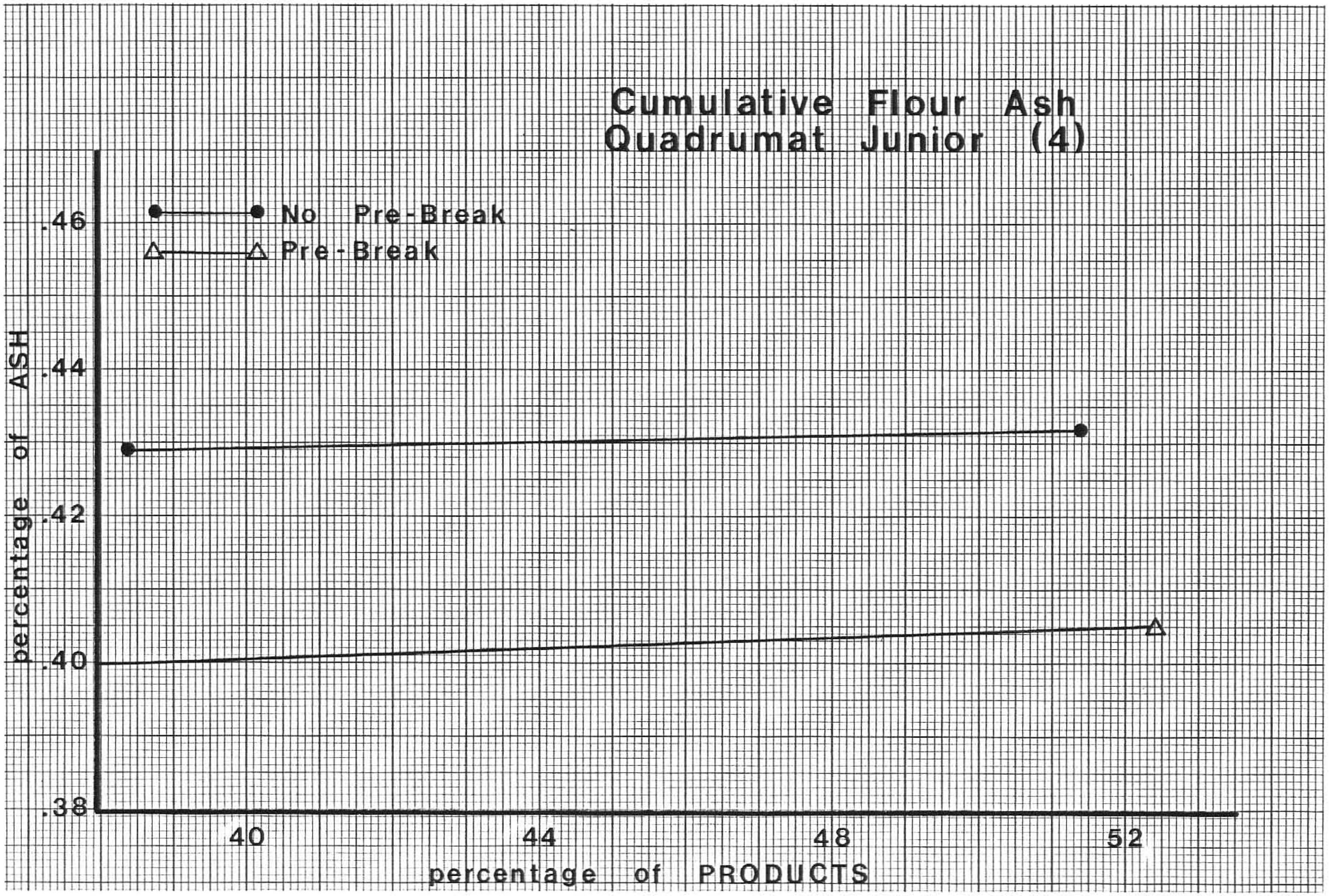

Cumulative Flour Ash
Quadrumat Junior (4)
No Pre-Break
Pre-Break
.46
.44
.42
.40
.38
percentage of ASH
40
44
48
52
percentage of PRODUCTS

Figure 25

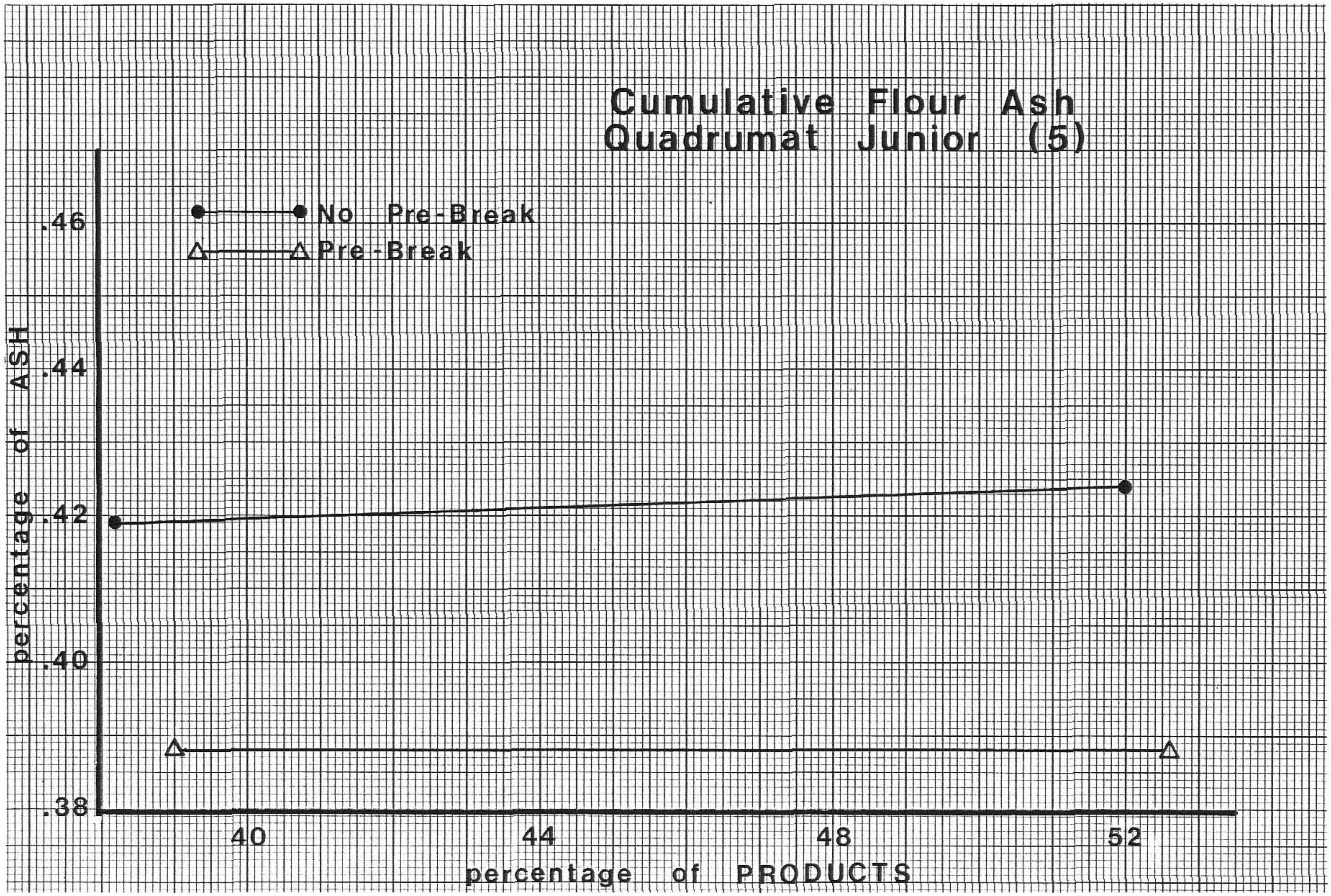

Cumulative Flour Ash
Quadrumat Junior (5)
No Pre-Break
Pre-Break
.46
.44
.42
.40
.38
percentage of ASH
40
44
48
52
percentage of PRODUCTS

Figure 26

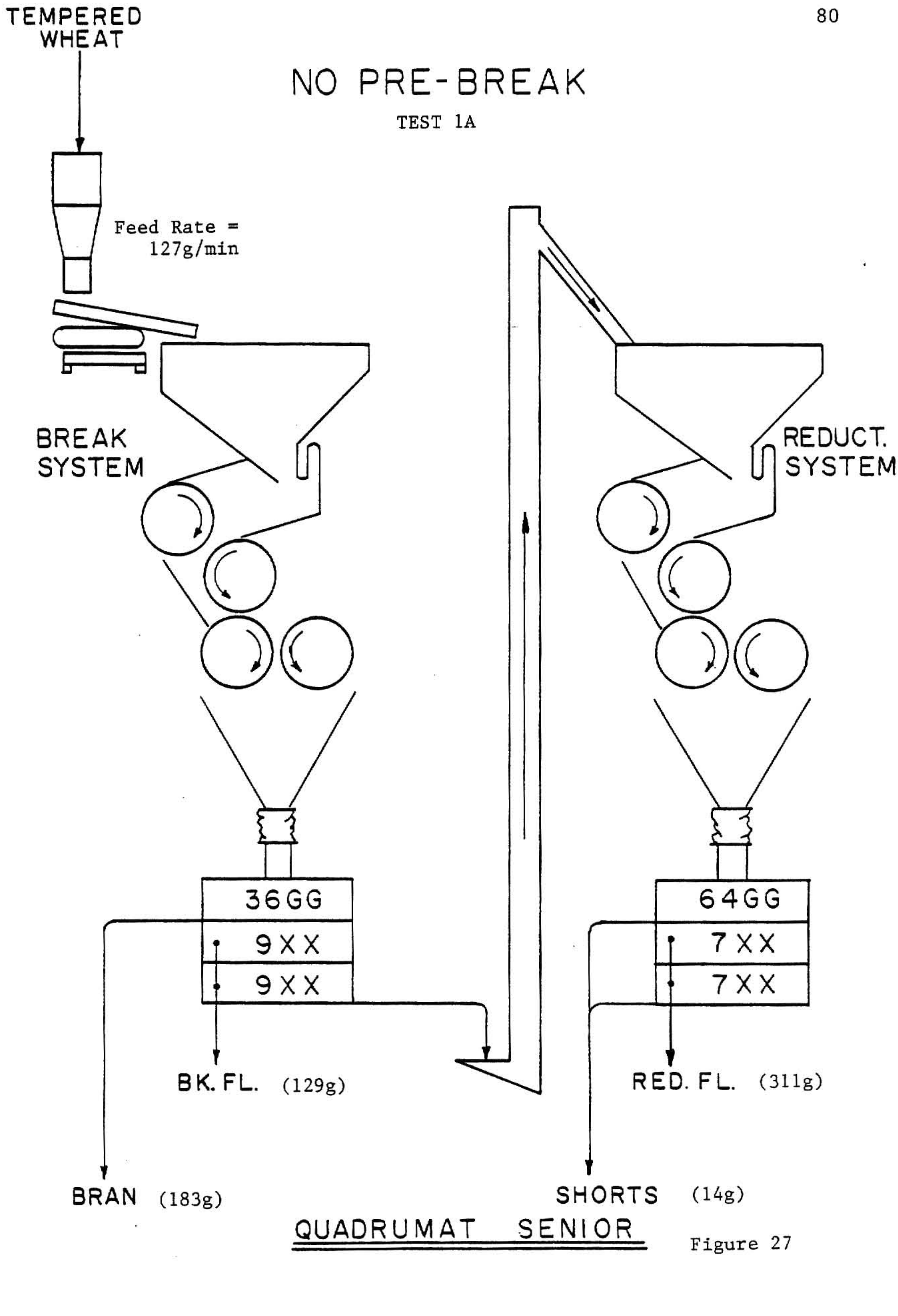

TEMPERED WHEAT
NO PRE-BREAK
TEST 1A
Feed Rate = 127g/min
BREAK SYSTEM
REDUCT. SYSTEM
36GG
9XX
9XX
64GG
7XX
7XX
BK. FL. (129g)
RED. FL. (311g)
BRAN (183g)
SHORTS (14g)
QUADRUMAT SENIOR

Figure 27

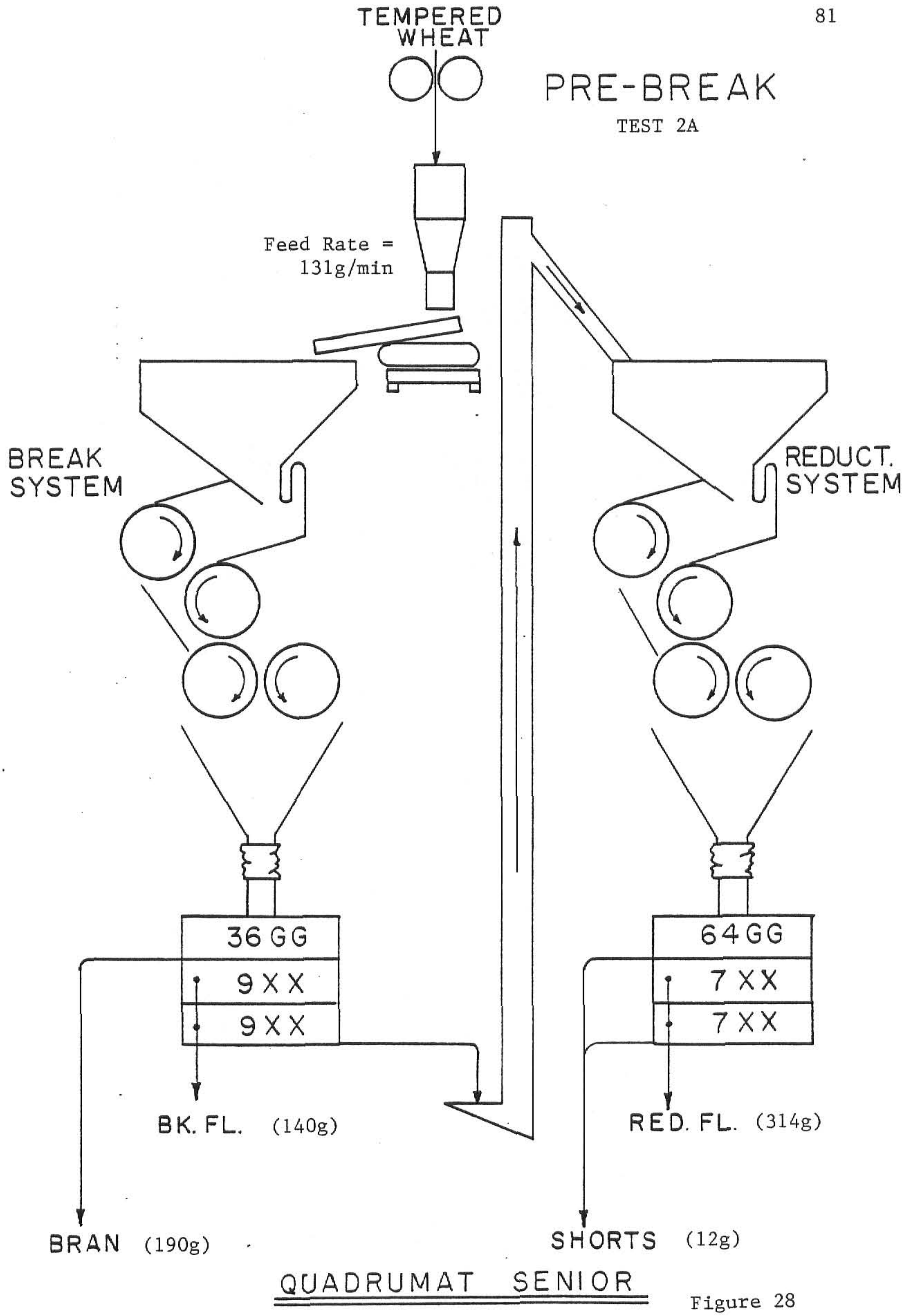

TEMPERED
WHEAT
PRE-BREAK
TEST 2A
Feed Rate =
131g/min
BREAK
SYSTEM
REDUCT.
SYSTEM
36 GG
9XX
9XX
64GG
7XX
7XX
BK. FL. (140g)
RED. FL. (314g)
BRAN (190g)
SHORTS (12g)
QUADRUMAT SENIOR

Figure 28

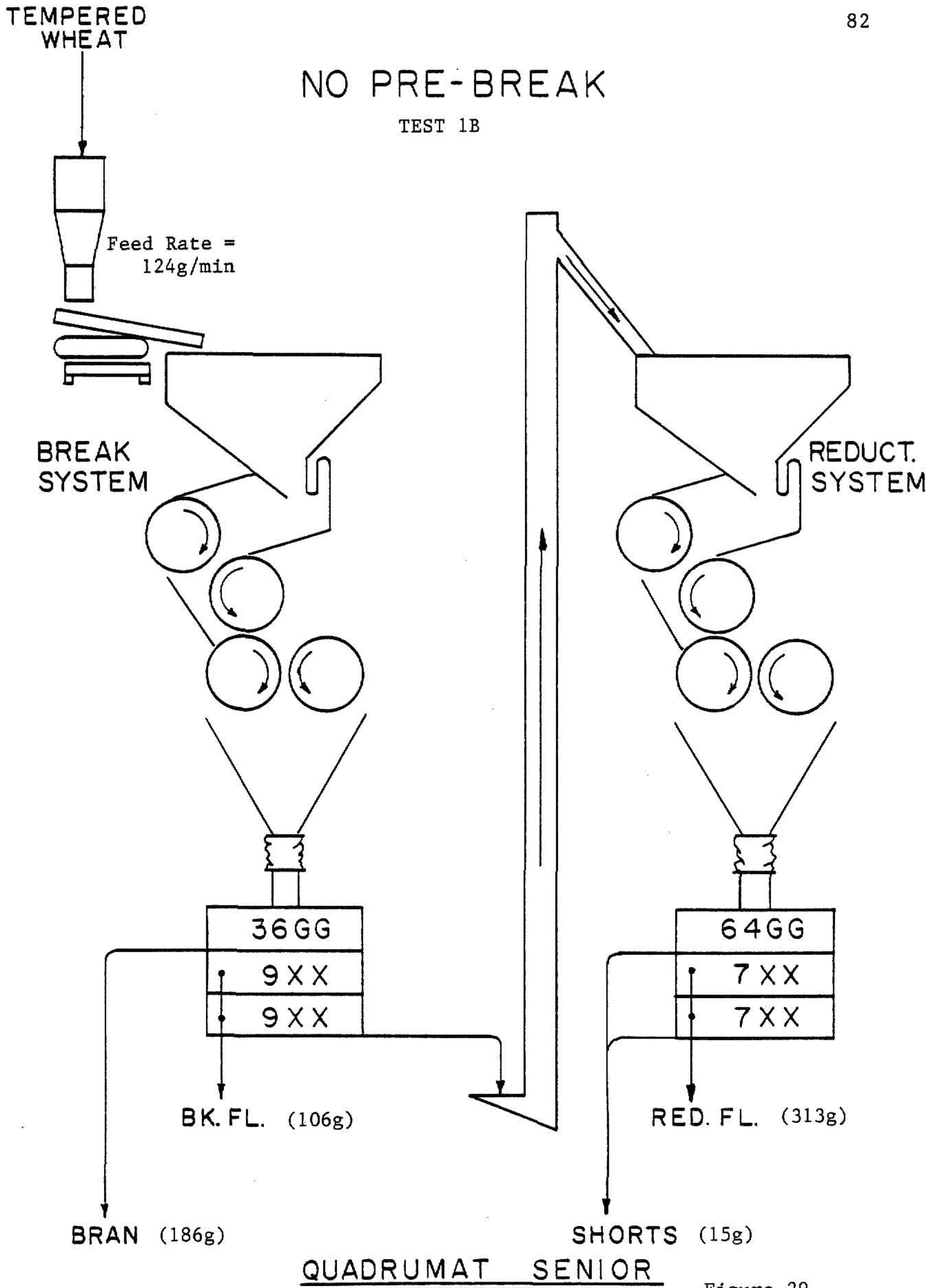

TEMPERED WHEAT
NO PRE-BREAK
TEST 1B
Feed Rate = 124g/min
BREAK SYSTEM
REDUCT. SYSTEM
36GG
9XX
9XX
64GG
7XX
7XX
BK. FL. (106g)
RED. FL. (313g)
BRAN (186g)
SHORTS (15g)
QUADRUMAT SENIOR

Figure 29

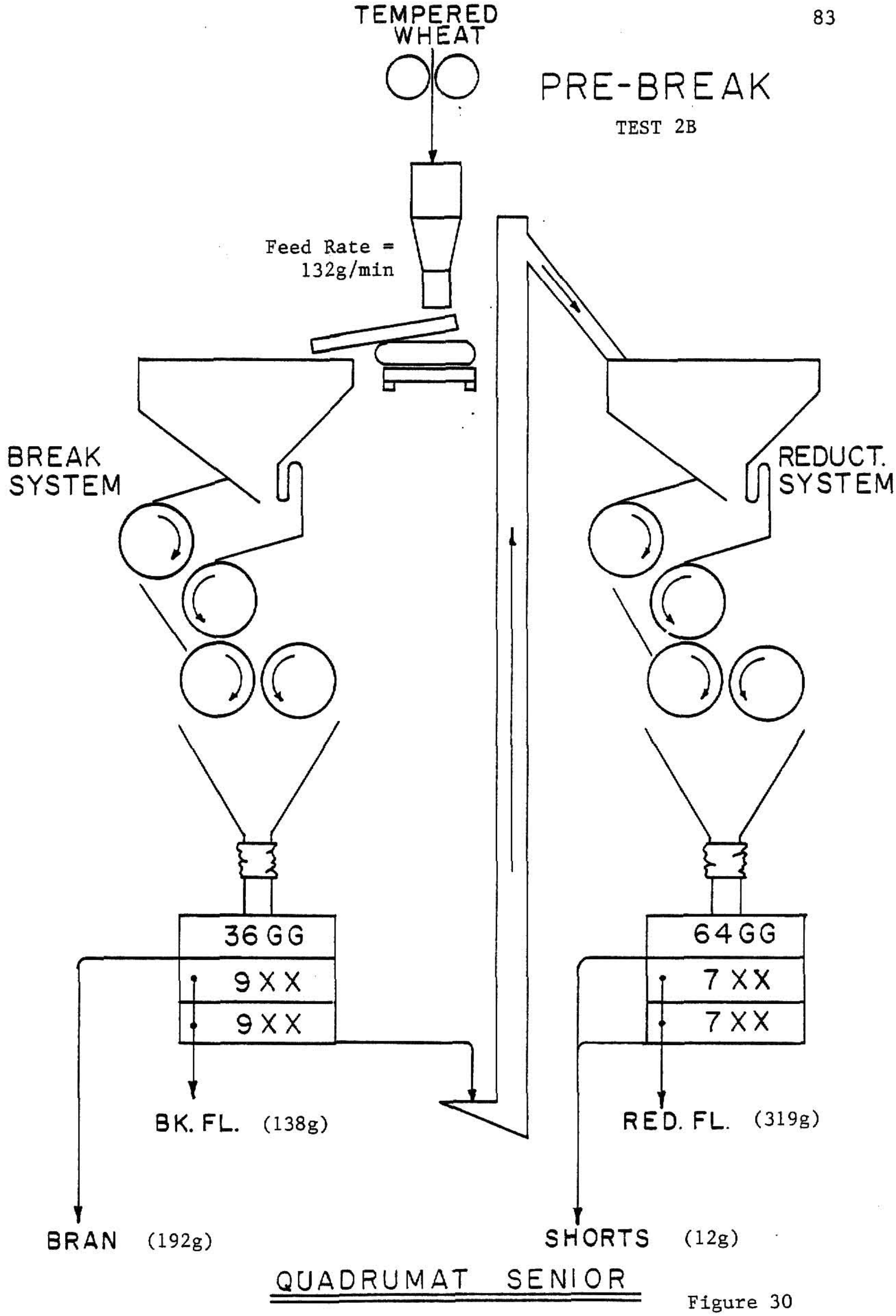

TEMPERED
WHEAT
PRE-BREAK
TEST 2B
Feed Rate =
132g/min
BREAK
SYSTEM
REDUCT.
SYSTEM
36 GG
9XX
9XX
64 GG
7XX
7XX
BK. FL. (138g)
RED. FL. (319g)
BRAN (192g)
SHORTS (12g)
QUADRUMAT SENIOR

Figure 30

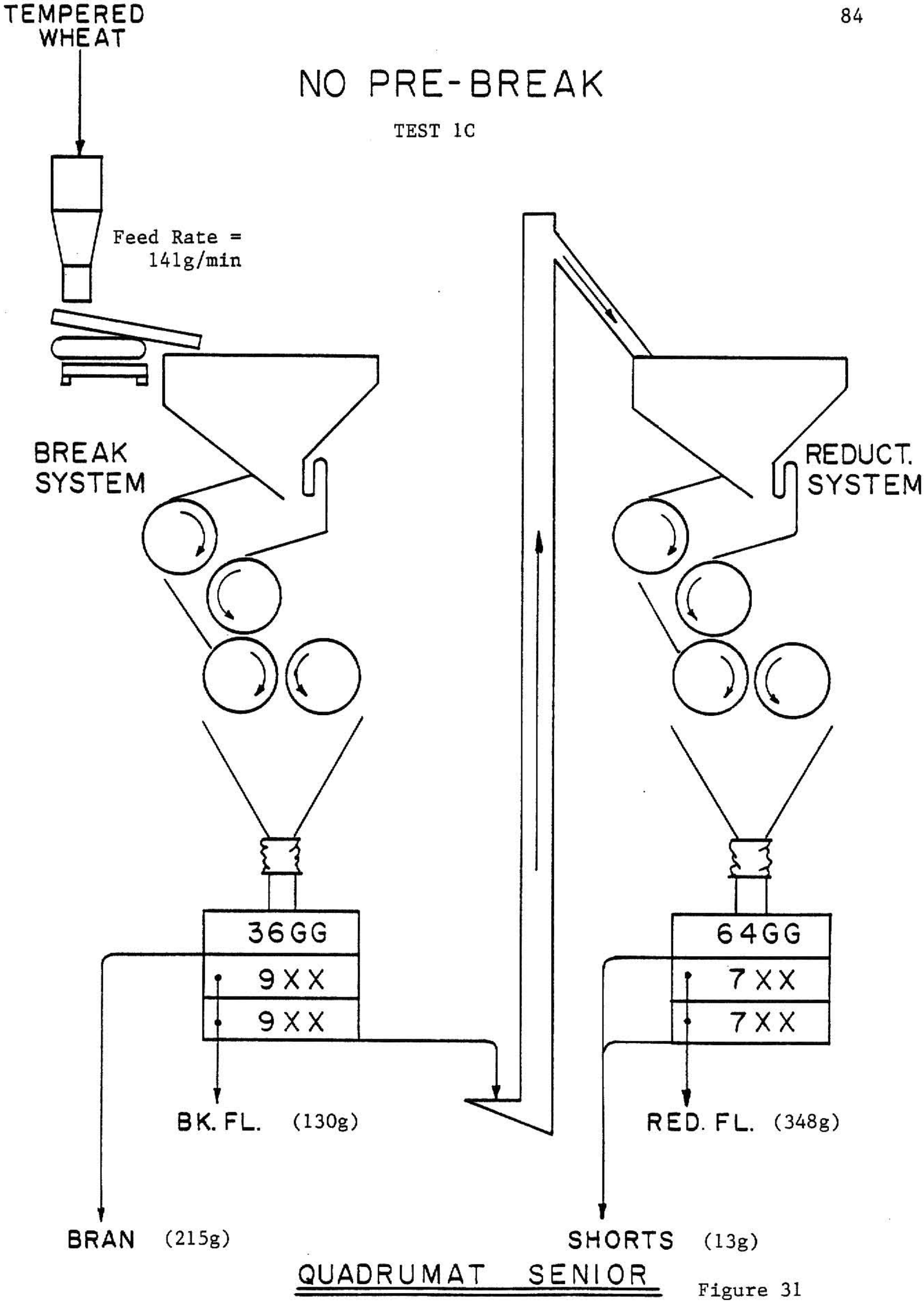

TEMPERED WHEAT
NO PRE-BREAK
TEST 1C
Feed Rate = 141g/min
BREAK SYSTEM
REDUCT. SYSTEM
36GG
9XX
9XX
64GG
7XX
7XX
BK. FL. (130g)
RED. FL. (348g)
BRAN (215g)
SHORTS (13g)
QUADRUMAT SENIOR

Figure 31

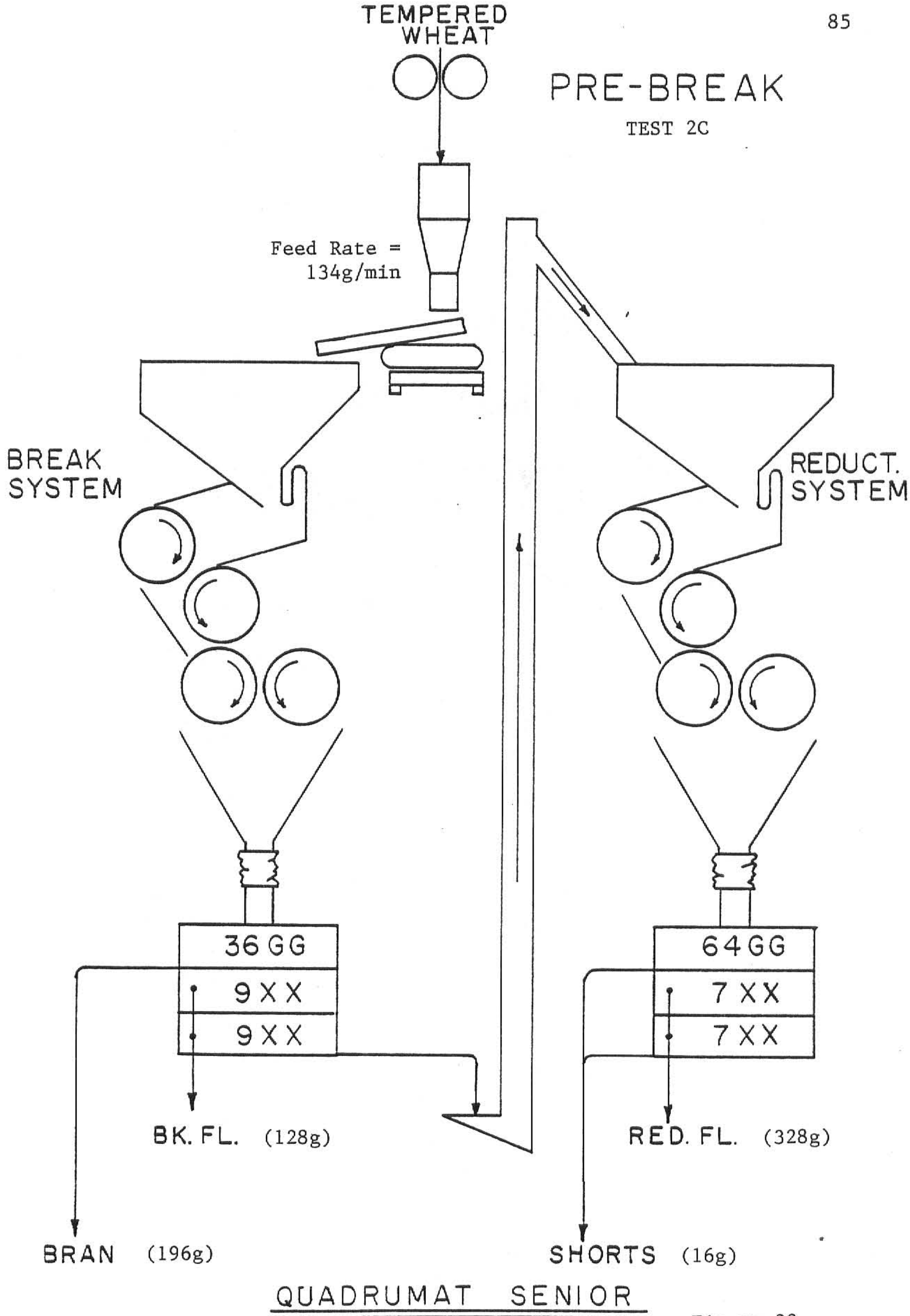
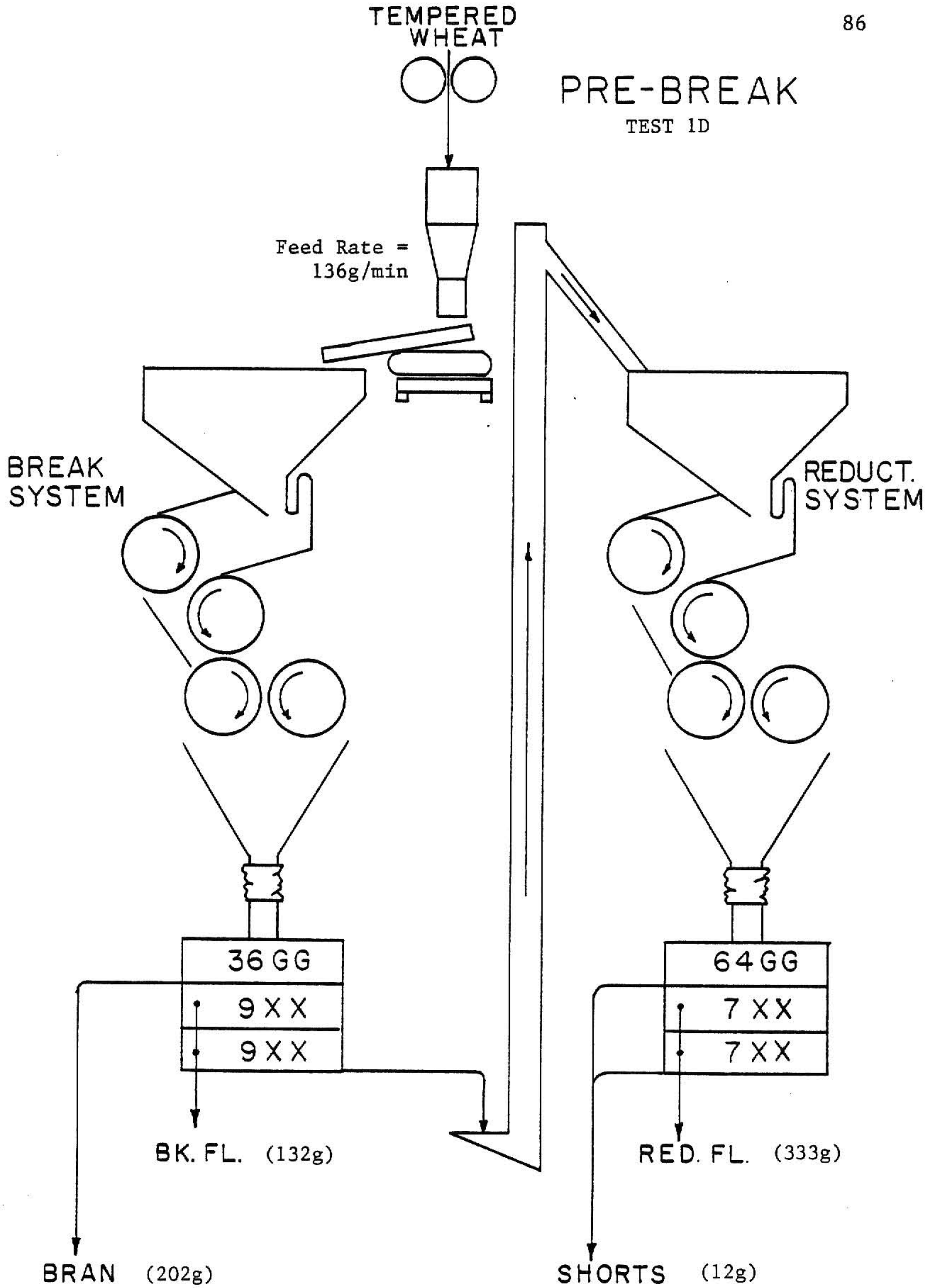

TEMPERED WHEAT
PRE-BREAK
TEST 2C
Feed Rate = 134g/min
BREAK SYSTEM
REDUCT. SYSTEM
36 GG
9XX
9XX
64 GG
7XX
7XX
BK. FL. (128g)
RED. FL. (328g)
BRAN (196g)
SHORTS (16g)
QUADRUMAT SENIOR

Figure 32



QUADRUMAT SENIOR

Figure 33

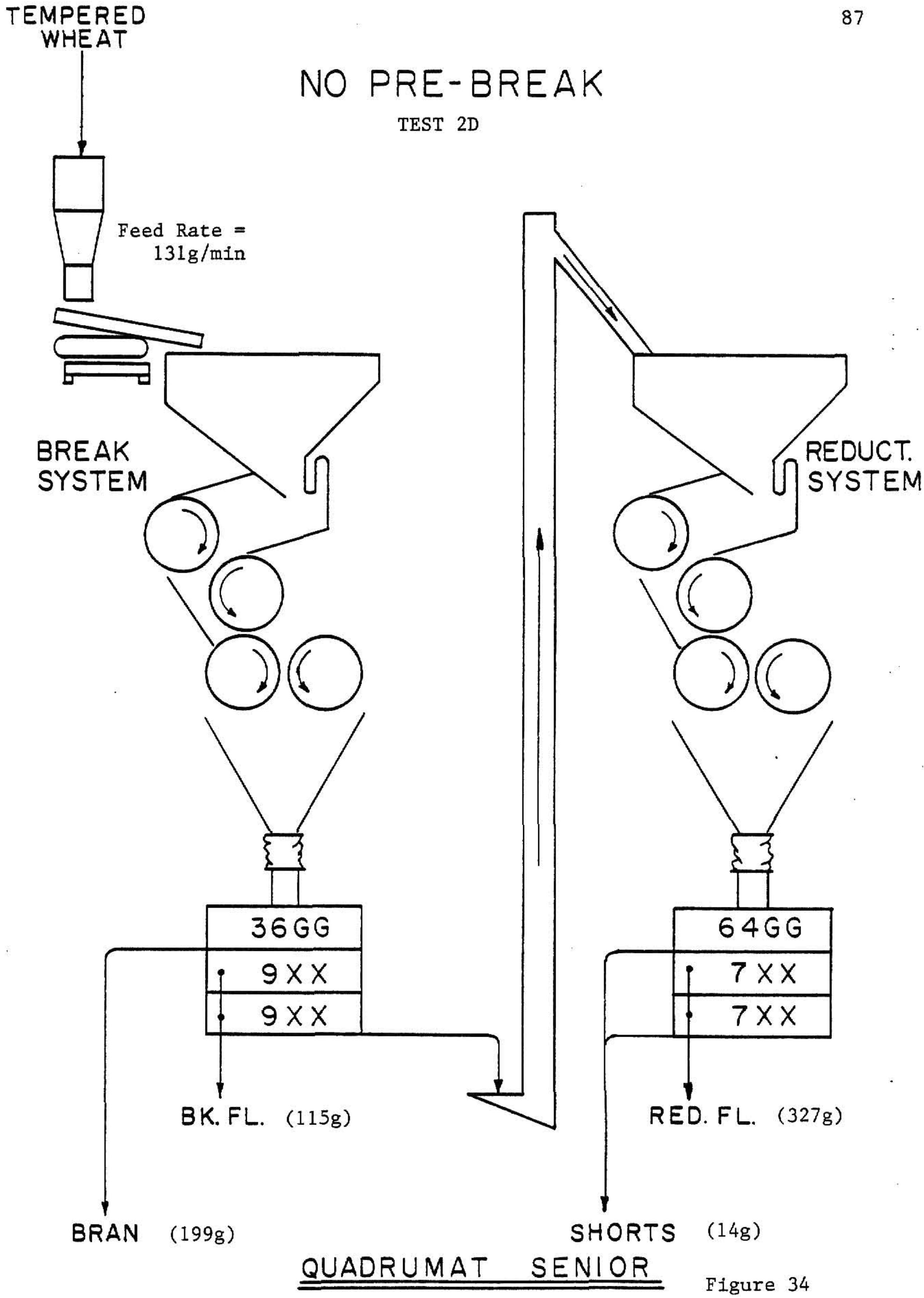

TEMPERED WHEAT
NO PRE-BREAK
TEST 2D
Feed Rate = 131g/min
BREAK SYSTEM
REDUCT. SYSTEM
36GG
9XX
9XX
64GG
7XX
7XX
BK. FL. (115g)
RED. FL. (327g)
BRAN (199g)
SHORTS (14g)
QUADRUMAT SENIOR

Figure 34

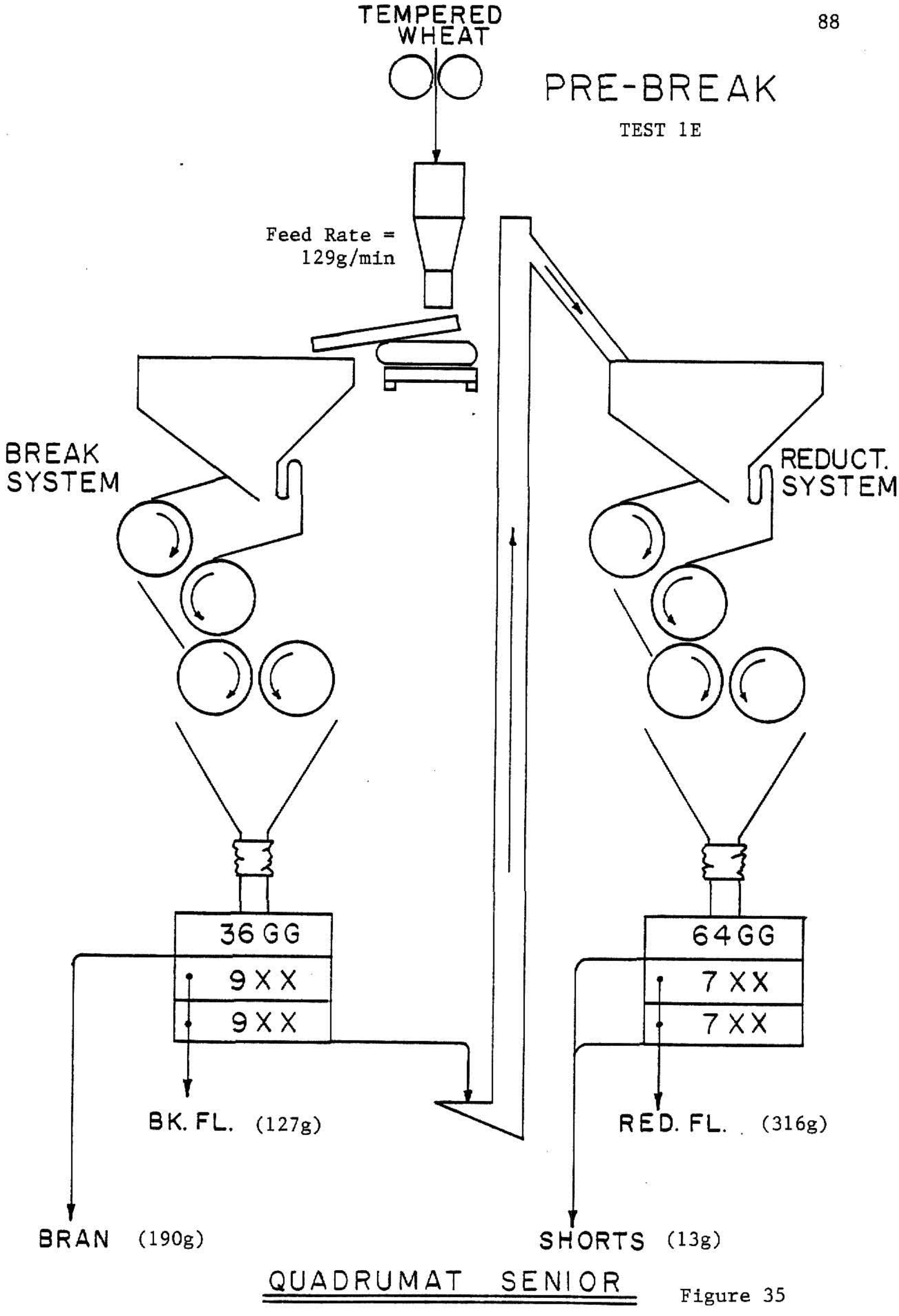
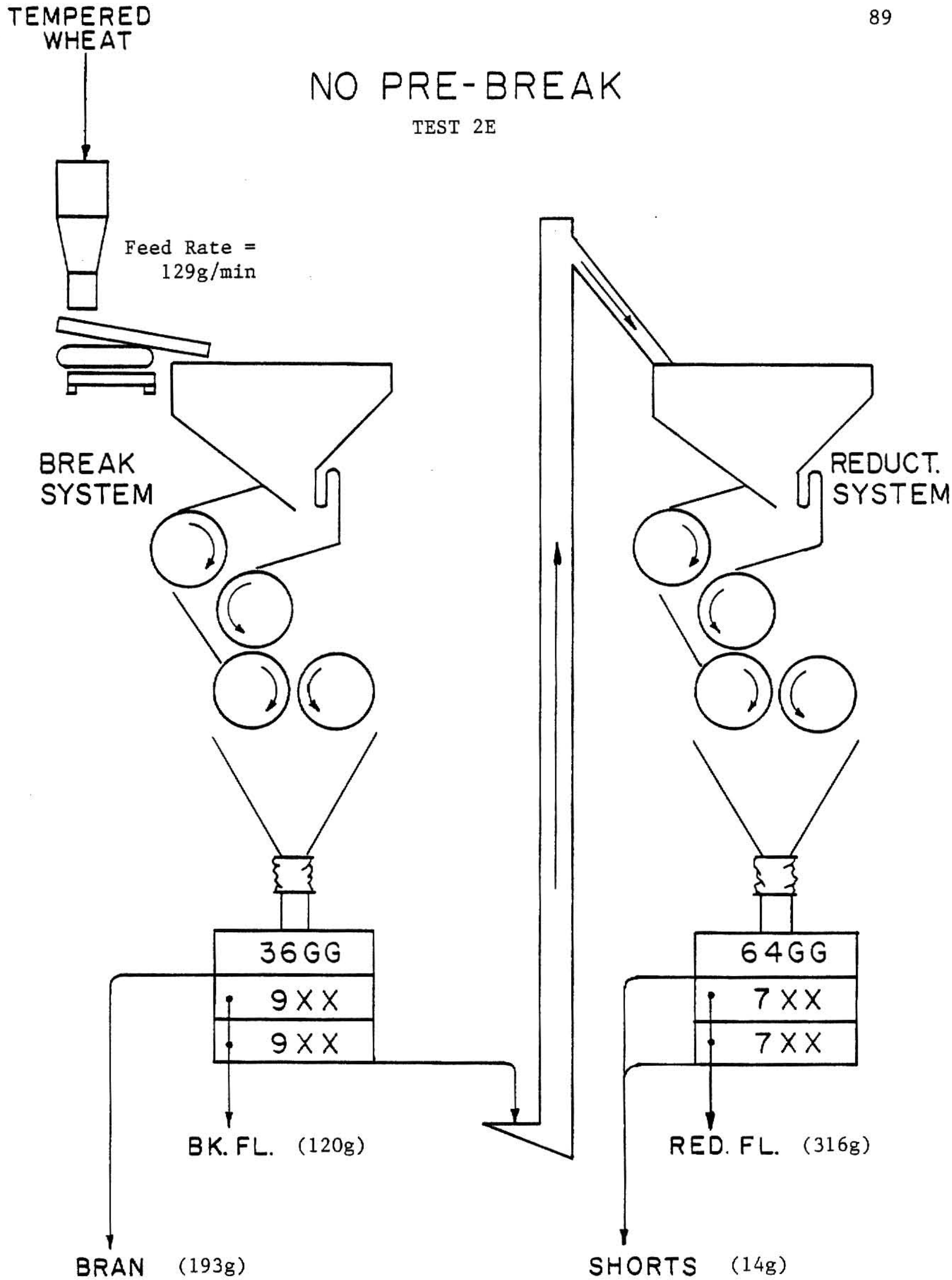

TEMPERED WHEAT
PRE-BREAK
TEST 1E
Feed Rate = 129g/min
BREAK SYSTEM
REDUCT. SYSTEM
36GG
9XX
9XX
64GG
7XX
7XX
BK. FL. (127g)
RED. FL. (316g)
BRAN (190g)
SHORTS (13g)
QUADRUMAT SENIOR

Figure 35

NO PRE-BREAK

TEST 2E



QUADRUMAT SENIOR

Figure 36

Table 8

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL QUADRUMAT SENIOR
TEST A, B, C, D, E
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
TEST 1A NO PRE-BREAK							
RED FL	311	48.82	48.82	.357	17.429	17.429	.357
BK FL	129	20.25	69.07	.369	7.472	24.901	.361
TEST 2A PRE-BREAK							
BK FL	140	21.34	21.34	.308	6.573	6.573	.308
RED FL	314	47.87	69.21	.337	16.132	22.705	.325
TEST 1B NO PRE-BREAK							
BK FL	106	17.10	17.10	.318	5.438	5.438	.318
RED FL	313	50.48	67.58	.328	16.557	21.995	.325
TEST 2B PRE-BREAK							
BK FL	138	20.88	20.88	.308	6.431	6.431	.308
RED FL	319	48.26	69.14	.328	15.829	22.260	.322
TEST 1C PRE-BREAK							
BK FL	130	18.41	18.41	.308	5.670	5.670	.308
RED FL	348	49.29	67.70	.336	16.561	22.231	.328
TEST 2C NO PRE-BREAK							
BK FL	128	19.16	19.16	.329	6.304	6.304	.329
RED FL	328	49.10	68.26	.348	17.087	23.391	.343
TEST 1D PRE-BREAK							
RED FL	333	49.04	49.04	.318	15.595	15.595	.318
BK FL	132	19.44	68.58	.319	6.201	21.796	.318
TEST 2D NO PRE-BREAK							
BK FL	115	17.56	17.56	.327	5.742	5.742	.327
RED FL	327	49.92	67.48	.335	16.723	22.465	.333
TEST 1E PRE-BREAK							
BK FL	127	19.66	19.66	.317	6.232	6.232	.317
RED FL	316	48.92	68.58	.338	16.535	22.858	.333
TEST 2E NO PRE-BREAK							
BK FL	120	18.66	18.66	.330	6.158	6.158	.330
RED FL	316	49.14	67.80	.349	17.150	23.308	.344

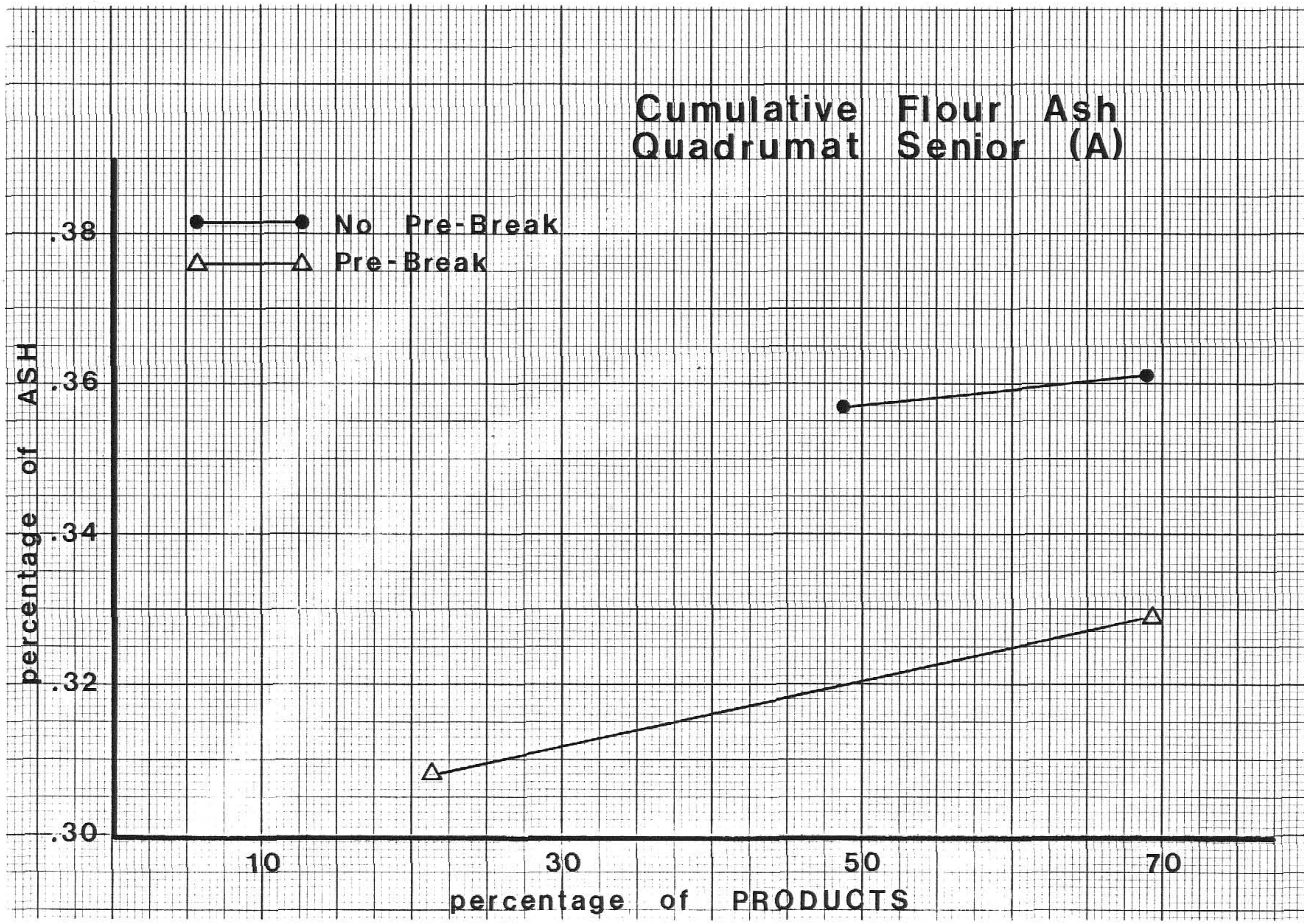

Cumulative Flour Ash
Quadrumat Senior (A)
No Pre-Break
Pre-Break
.38
.36
.34
.32
.30
percentage of ASH
10
30
50
70
percentage of PRODUCTS

Figure 37

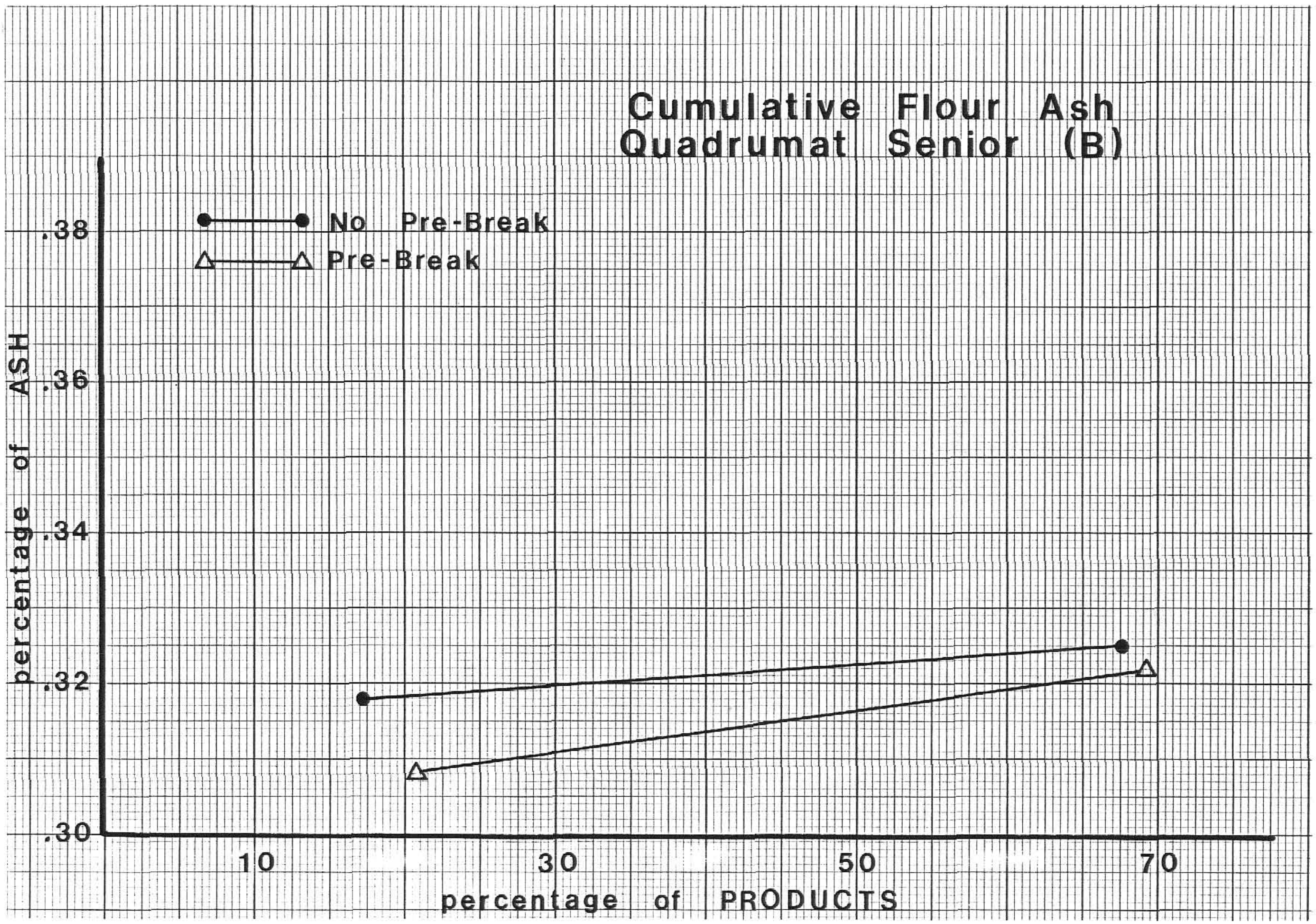

Cumulative Flour Ash
Quadrumat Senior (B)
No Pre-Break
Pre-Break
.38
.36
.34
.32
.30
percentage of ASH
10
30
50
70
percentage of PRODUCTS

Figure 38

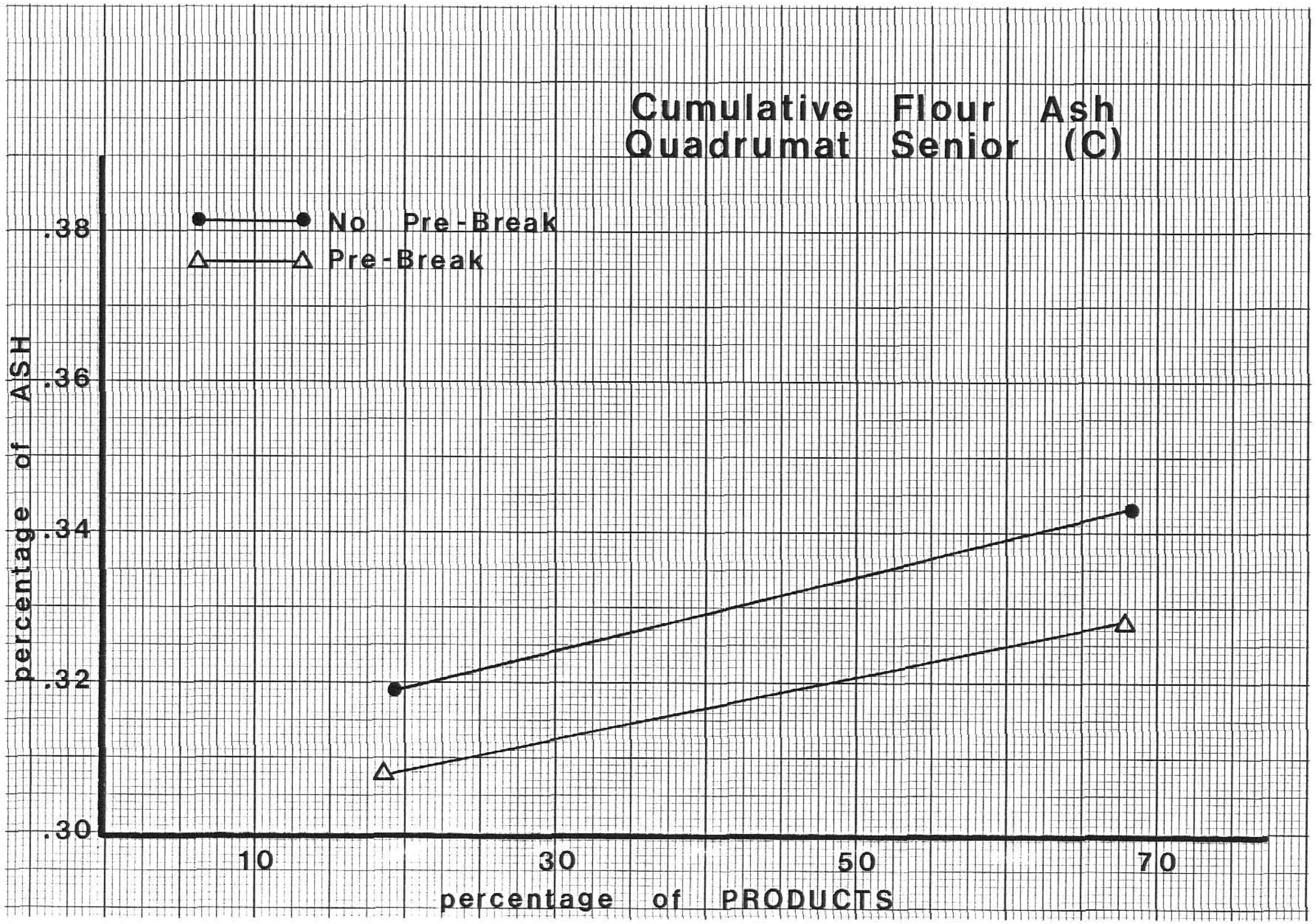
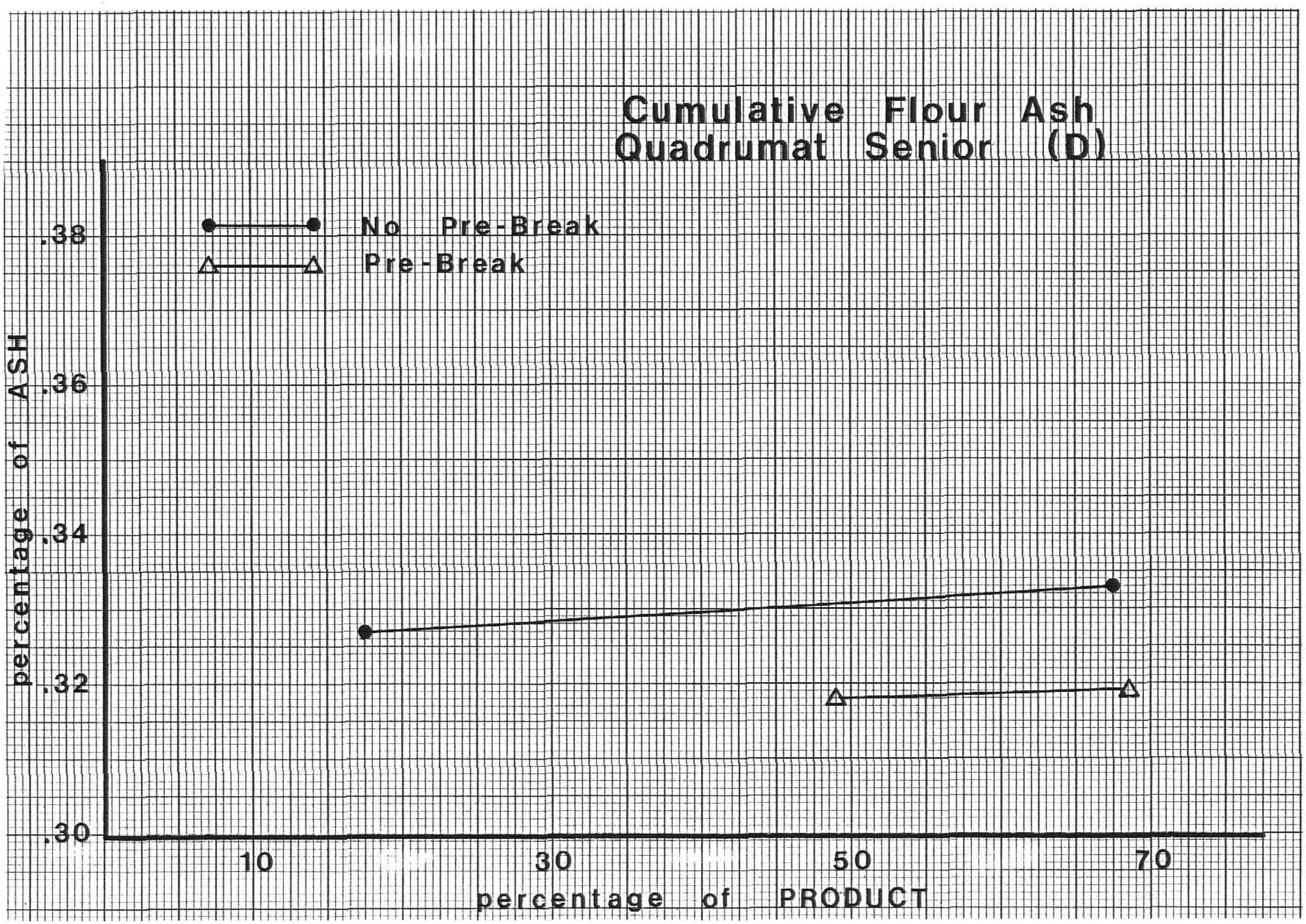

Cumulative Flour Ash
Quadrumat Senior (C)
No Pre-Break
Pre-Break
.38
.36
.34
.32
.30
percentage of ASH
10
30
50
70
percentage of PRODUCTS

Figure 39



Cumulative Flour Ash
Quadrumat Senior (D)
No Pre-Break
Pre-Break
.38
.36
.34
.32
.30
percentage of ASH
10
30
50
70
percentage of PRODUCT

Figure 40

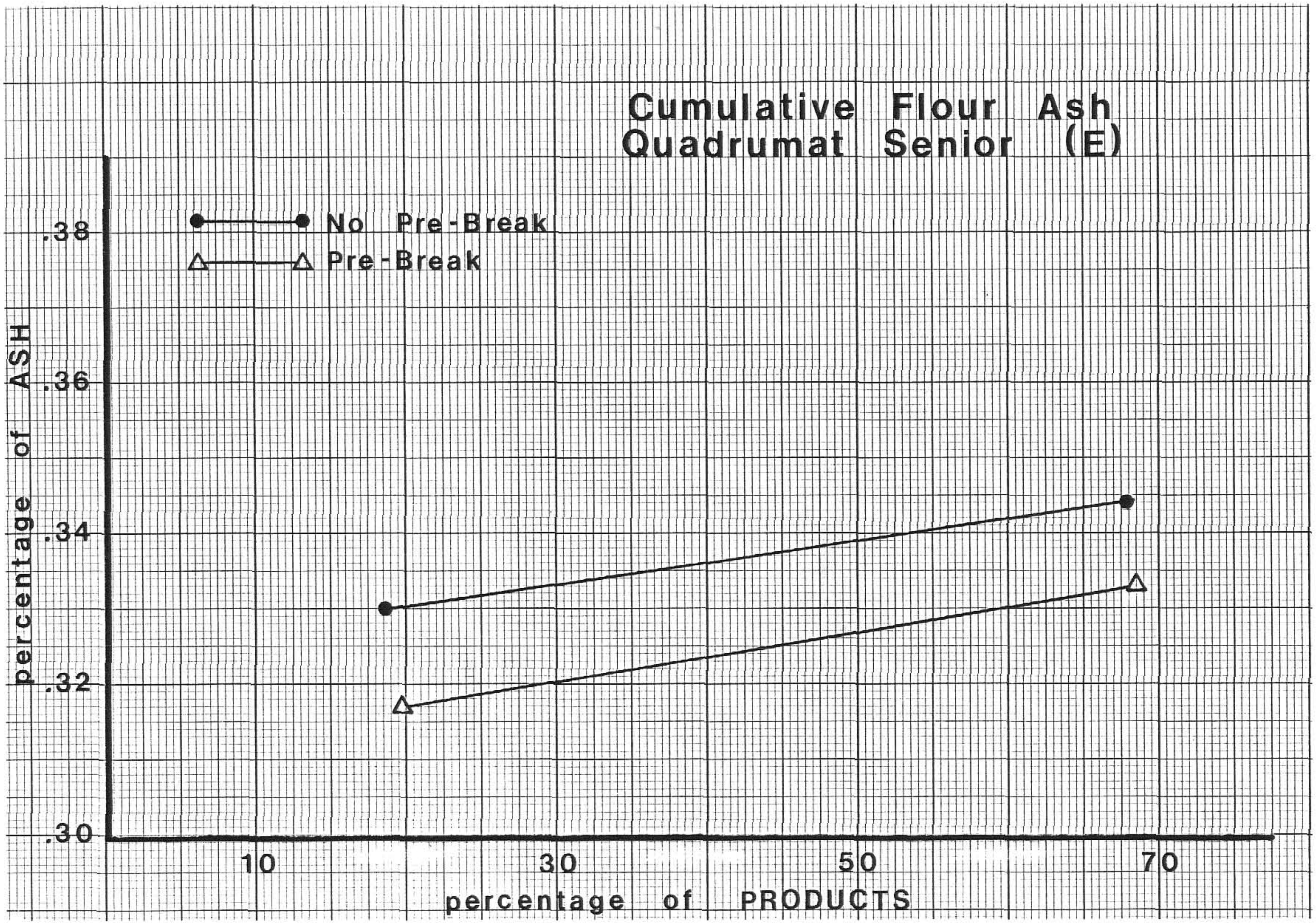

Cumulative Flour Ash
Quadrumat Senior (E)
No Pre-Break
Pre-Break
.38
.36
.34
.32
.30
percentage of ASH
10
30
50
70
percentage of PRODUCTS

Figure 41

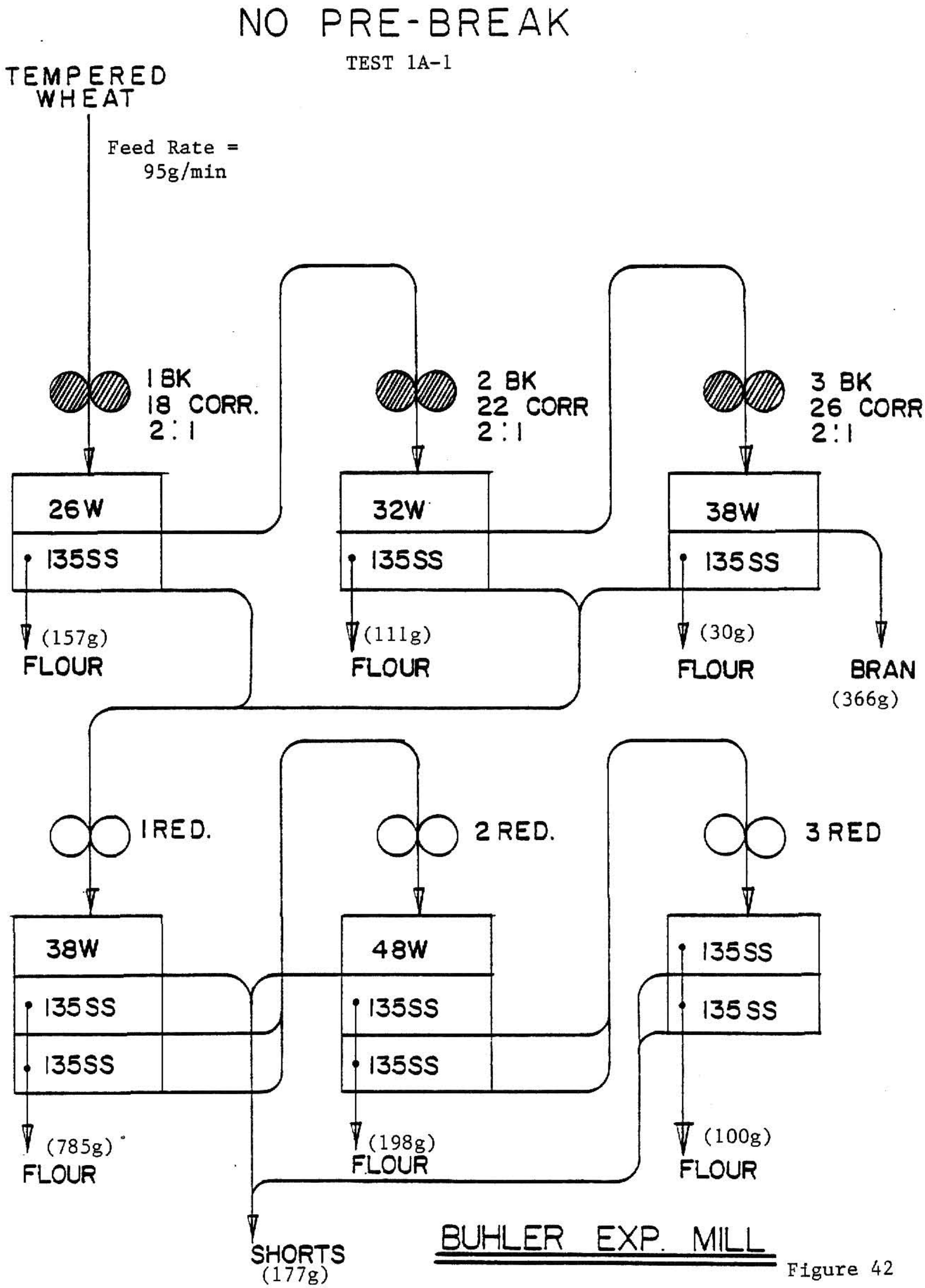

NO PRE-BREAK
TEST 1A-1
TEMPERED WHEAT
Feed Rate = 95g/min
1 BK
18 CORR.
2:1
2 BK
22 CORR
2:1
3 BK
26 CORR
2:1
26W
135SS
32W
135SS
38W
135SS
(157g)
FLOUR
(111g)
FLOUR
(30g)
FLOUR
BRAN
(366g)
1 RED.
2 RED.
3 RED
38W
135 SS
135SS
48W
135SS
135SS
135SS
135 SS
(785g)
FLOUR
(198g)
FLOUR
(100g)
FLOUR
SHORTS
(177g)
BUHLER EXP. MILL

Figure 42

PRE-BREAK

TEST 2A

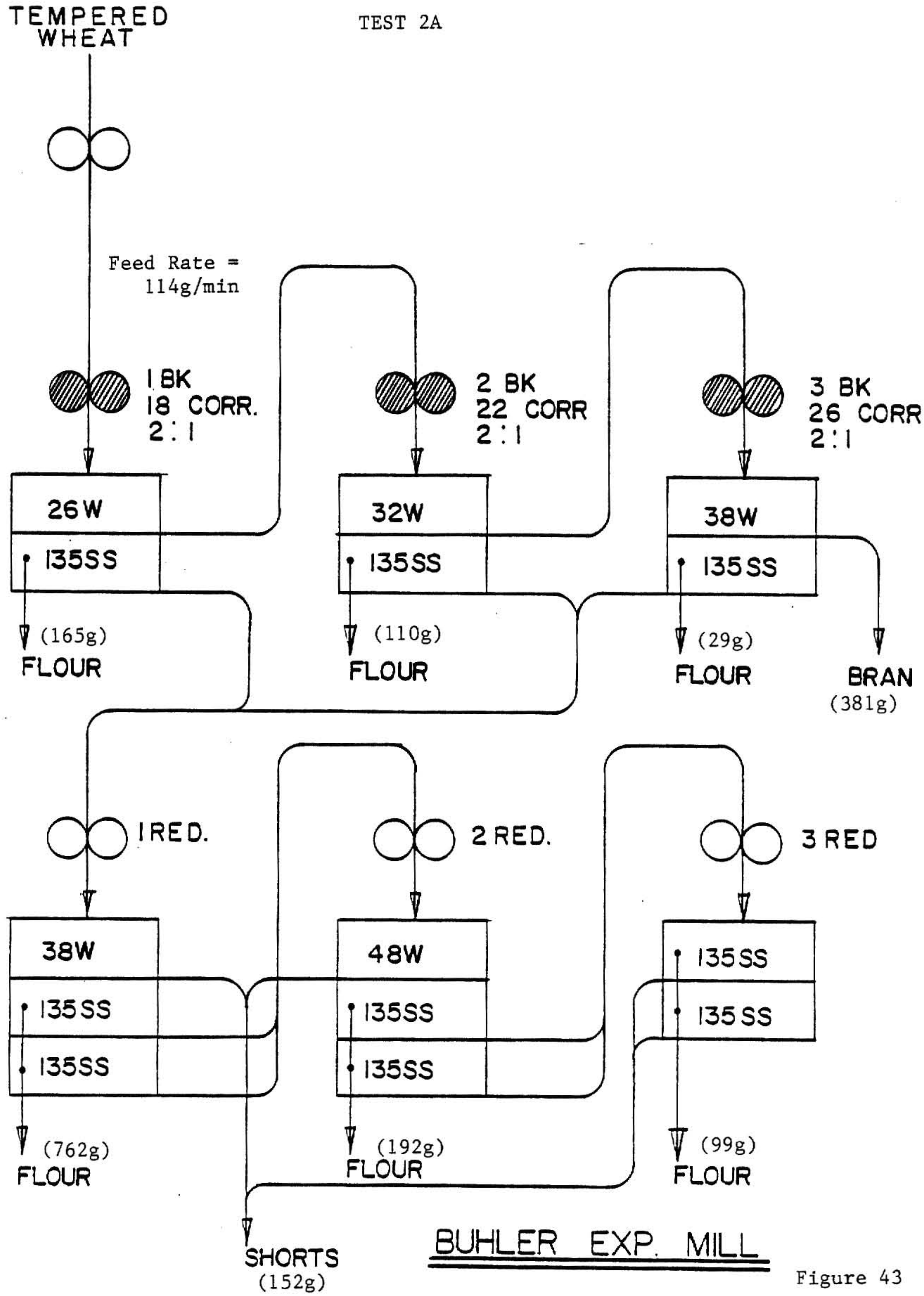


Figure 43

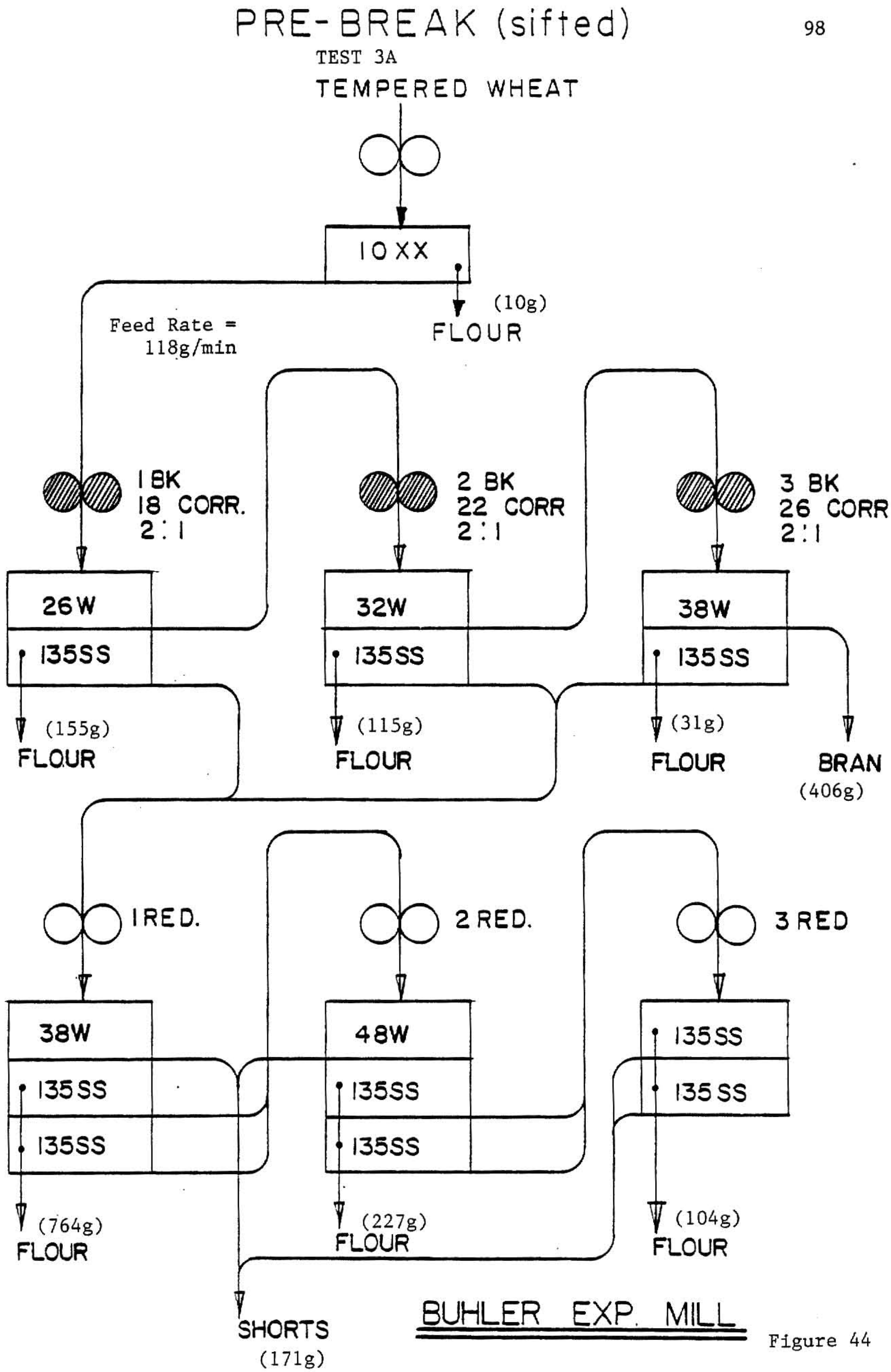

PRE-BREAK (sifted)
TEST 3A
TEMPERED WHEAT
10XX
(10g)
FLOUR
Feed Rate = 118g/min
1 BK
18 CORR.
2:1
2 BK
22 CORR
2:1
3 BK
26 CORR
2:1
26W
135SS
32W
135SS
38W
135SS
(155g)
FLOUR
(115g)
FLOUR
(31g)
FLOUR
BRAN
(406g)
1 RED.
2 RED.
3 RED
38W
135SS
135SS
48W
135SS
135SS
135SS
135 SS
(764g)
FLOUR
(227g)
FLOUR
(104g)
FLOUR
SHORTS
(171g)
BUHLER EXP. MILL

Figure 44

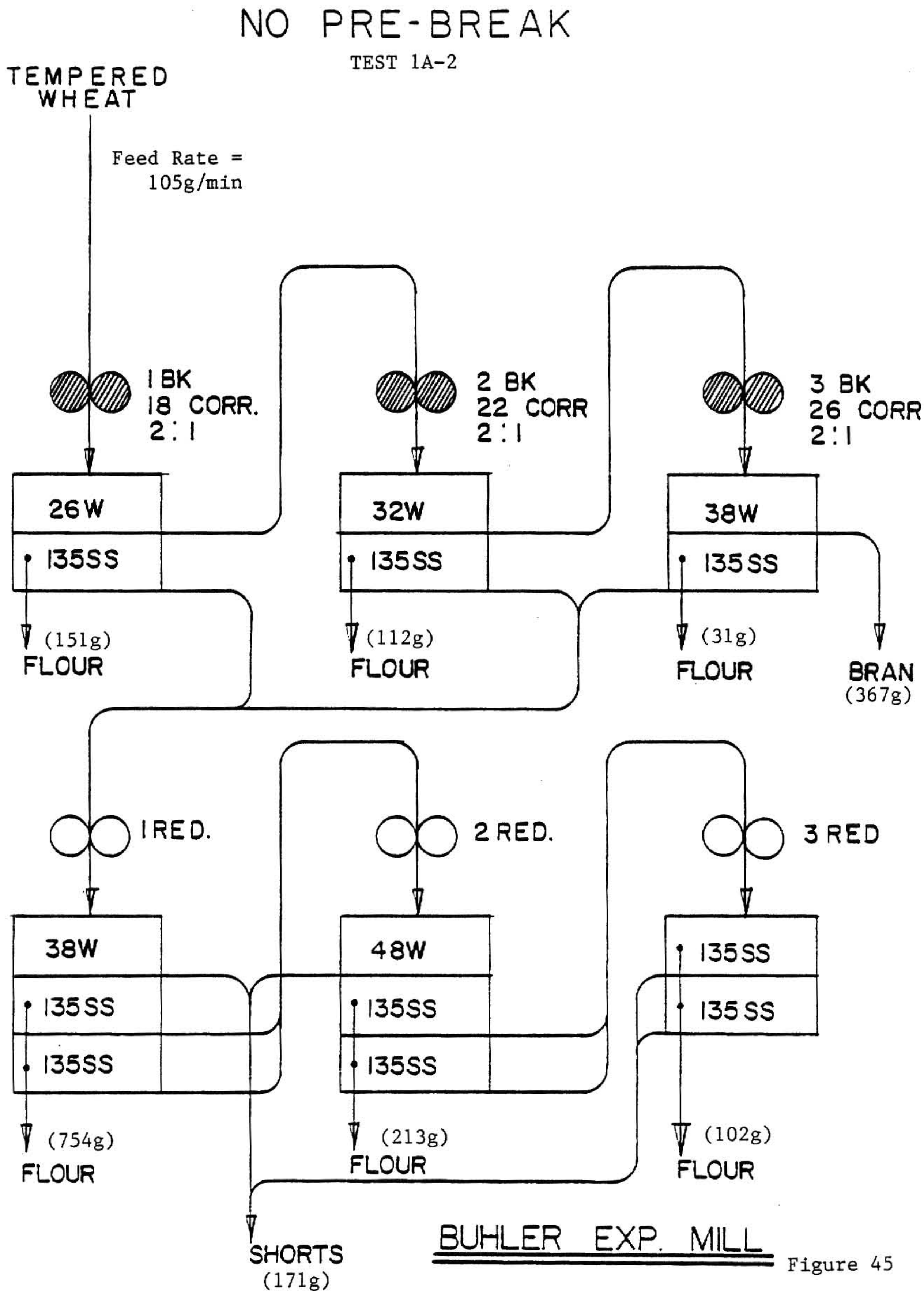

NO PRE-BREAK
TEST 1A-2
TEMPERED WHEAT
Feed Rate = 105g/min
1 BK
18 CORR.
2:1
2 BK
22 CORR
2:1
3 BK
26 CORR
2:1
26W
135SS
32W
135SS
38W
135SS
(151g)
FLOUR
(112g)
FLOUR
(31g)
FLOUR
BRAN
(367g)
1 RED.
2 RED.
3 RED
38W
135SS
135SS
48W
135SS
135SS
135SS
135SS
(754g)
FLOUR
(213g)
FLOUR
(102g)
FLOUR
SHORTS
(171g)
BUHLER EXP. MILL

Figure 45

PRE-BREAK (sifted)

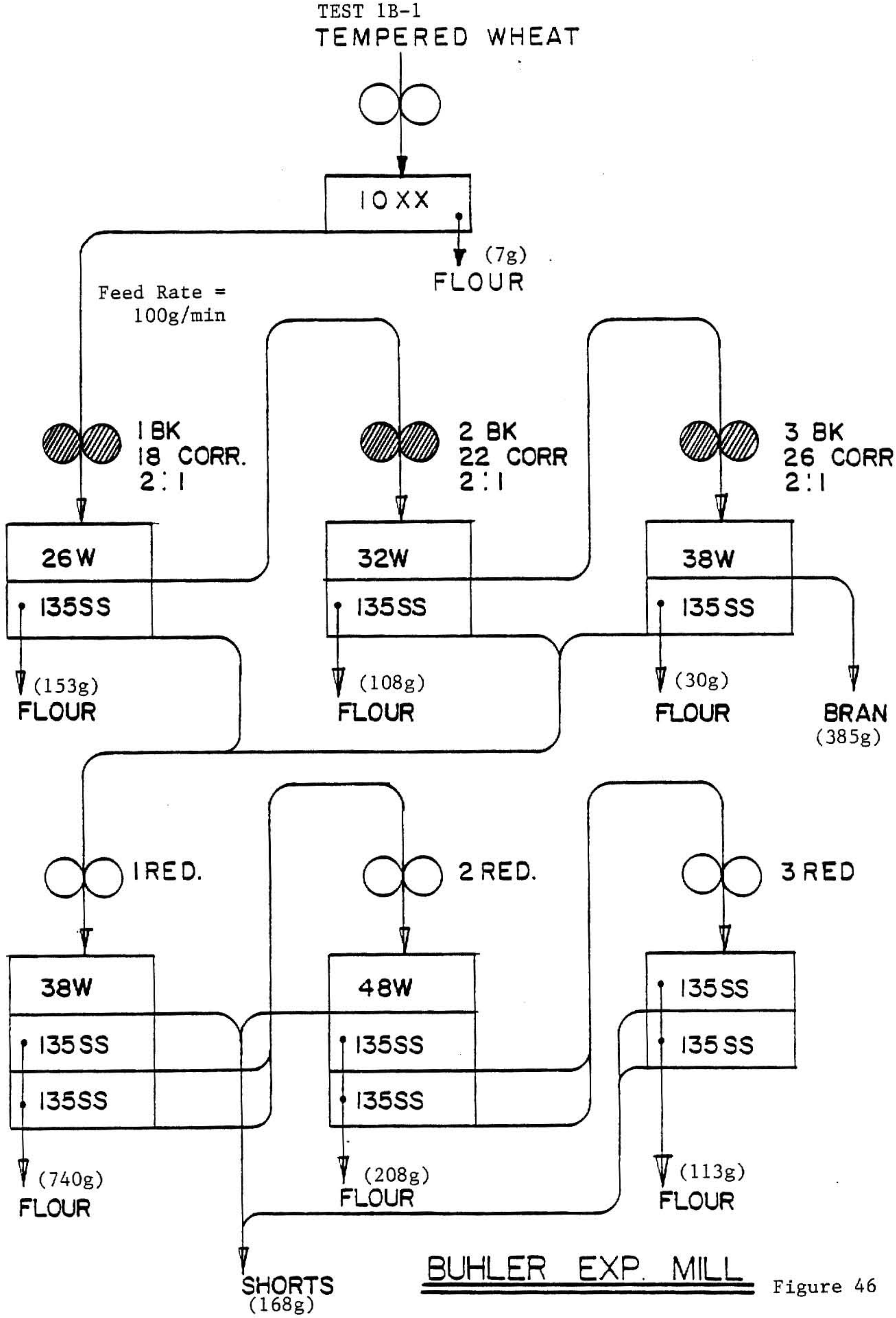


Figure 46

NO PRE-BREAK

TEST 2B

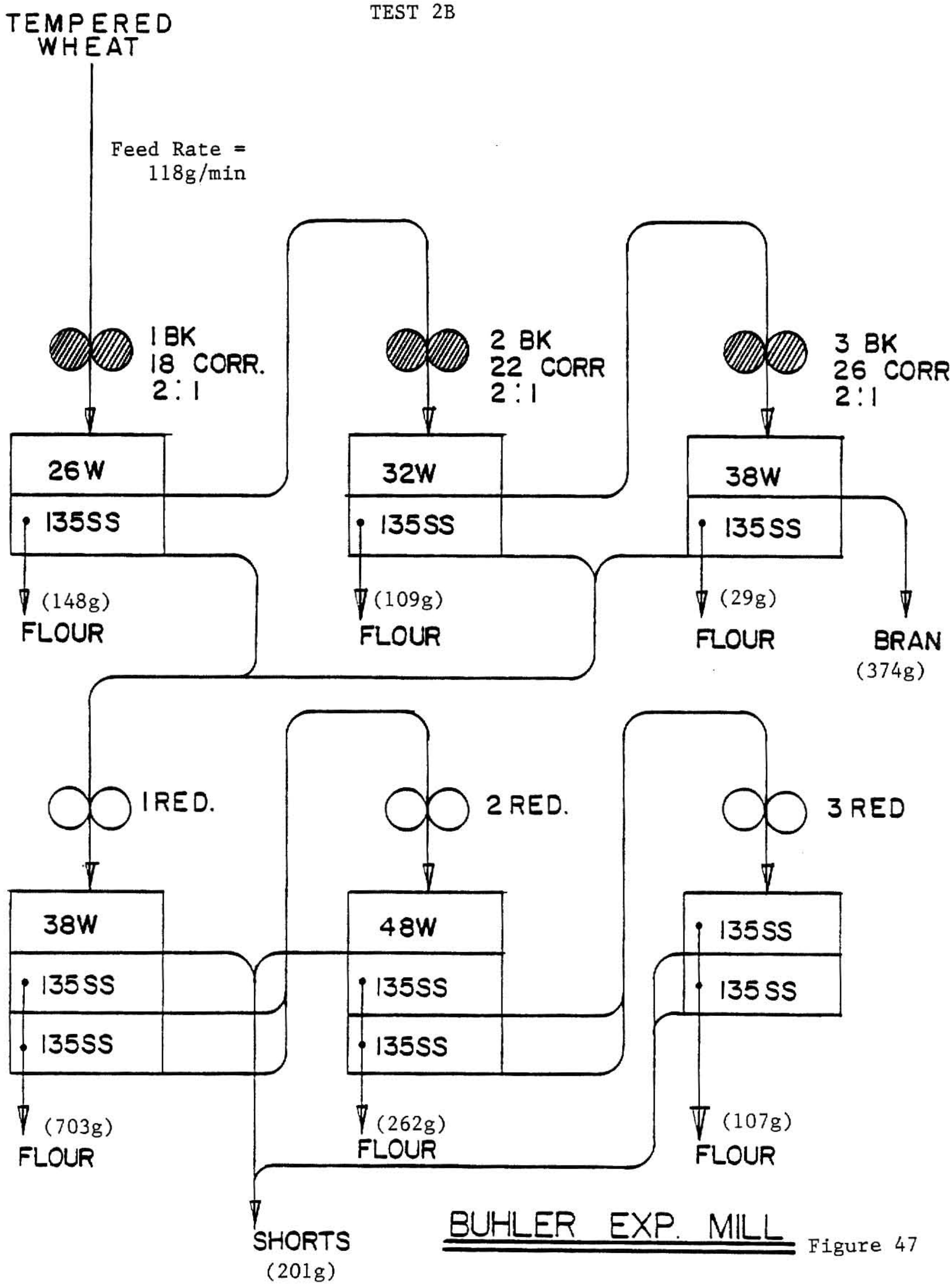


Figure 47

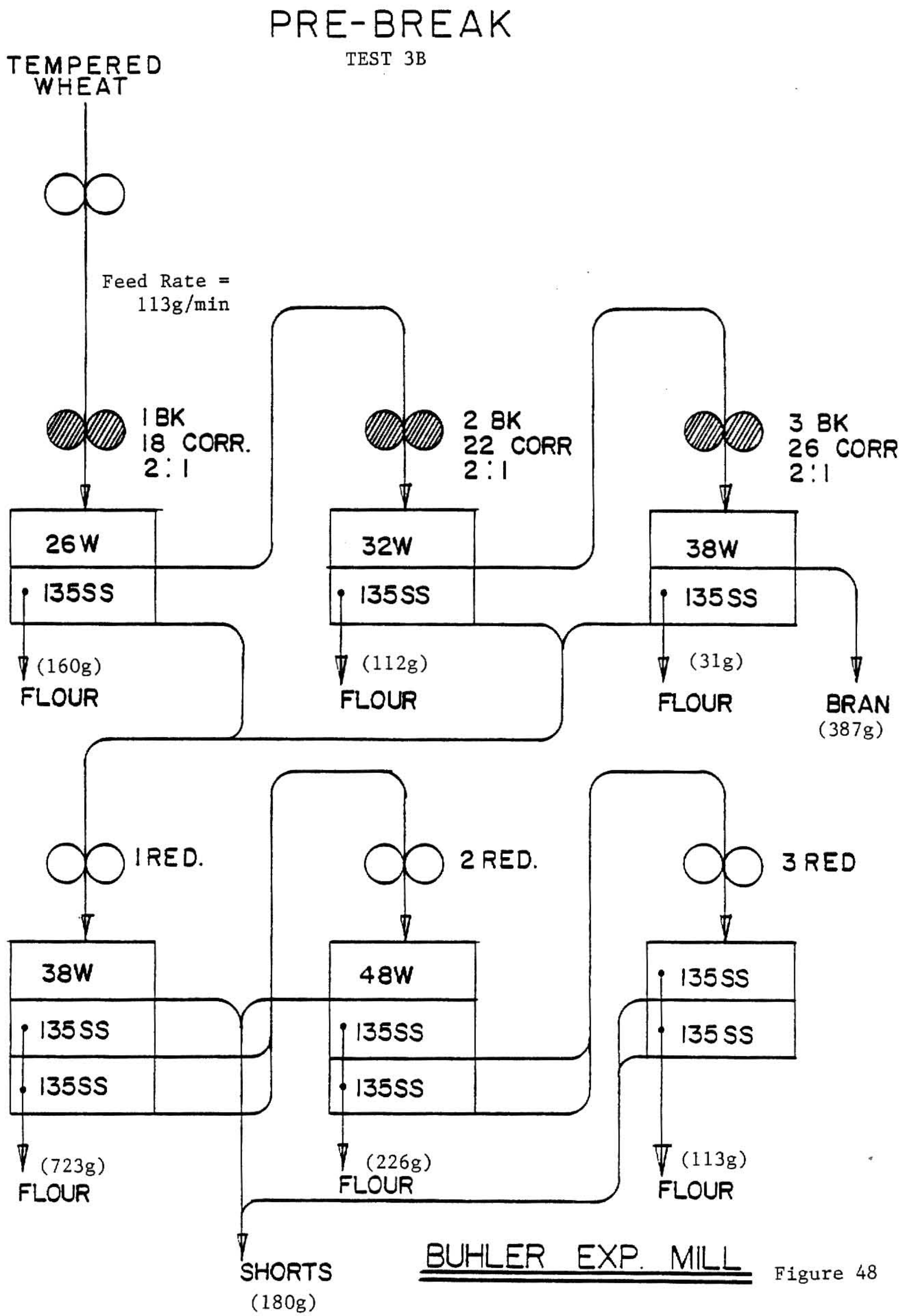

PRE-BREAK
TEST 3B
TEMPERED WHEAT
Feed Rate = 113g/min
1 BK
18 CORR.
2:1
2 BK
22 CORR
2:1
3 BK
26 CORR
2:1
26W
135SS
32W
135SS
38W
135SS
(160g)
FLOUR
(112g)
FLOUR
(31g)
FLOUR
BRAN
(387g)
1 RED.
2 RED.
3 RED
38W
135SS
135SS
48W
135SS
135SS
135SS
135SS
(723g)
FLOUR
(226g)
FLOUR
(113g)
FLOUR
SHORTS
(180g)
BUHLER EXP. MILL

Figure 48

PRE-BREAK (sifted)

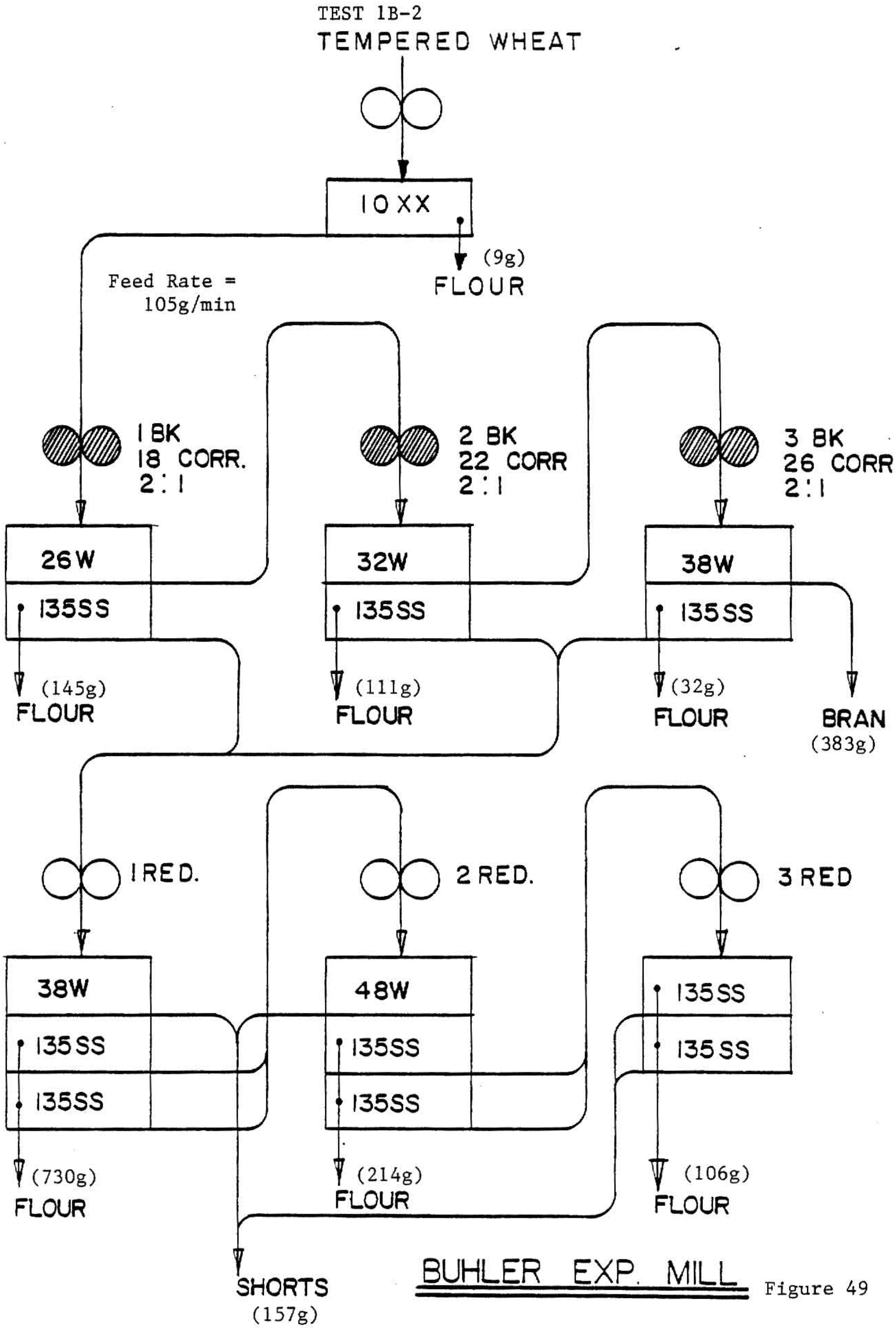


Figure 49

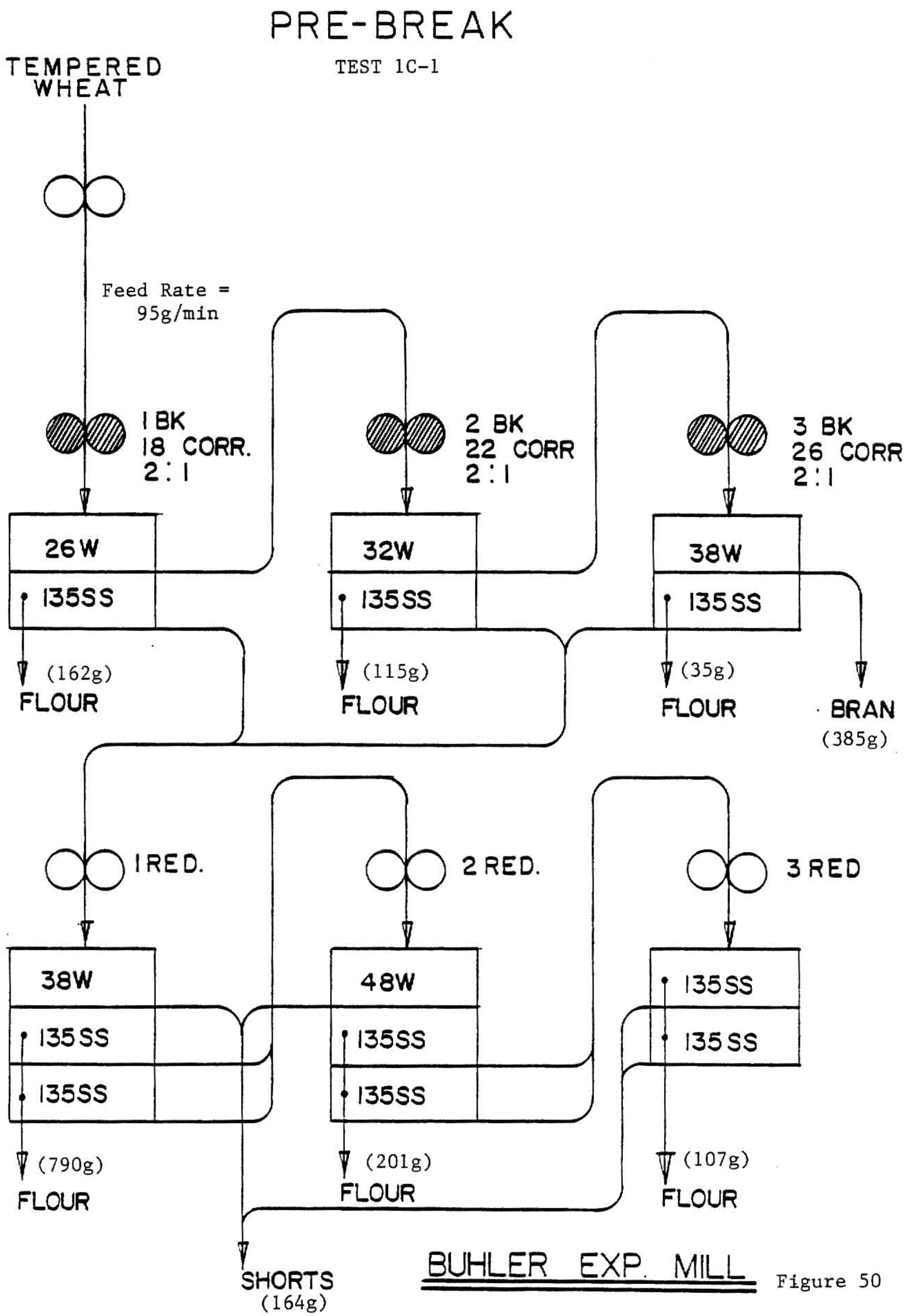

PRE-BREAK
TEST 1C-1
TEMPERED WHEAT
Feed Rate = 95g/min
1 BK
18 CORR.
2:1
2 BK
22 CORR
2:1
3 BK
26 CORR
2:1
26W
135SS
32W
135SS
38W
135SS
(162g)
FLOUR
(115g)
FLOUR
(35g)
FLOUR
BRAN
(385g)
1 RED.
2 RED.
3 RED
38W
135SS
135SS
48W
135SS
135SS
135SS
135SS
(790g)
FLOUR
(201g)
FLOUR
(107g)
FLOUR
SHORTS
(164g)
BUHLER EXP. MILL

Figure 50

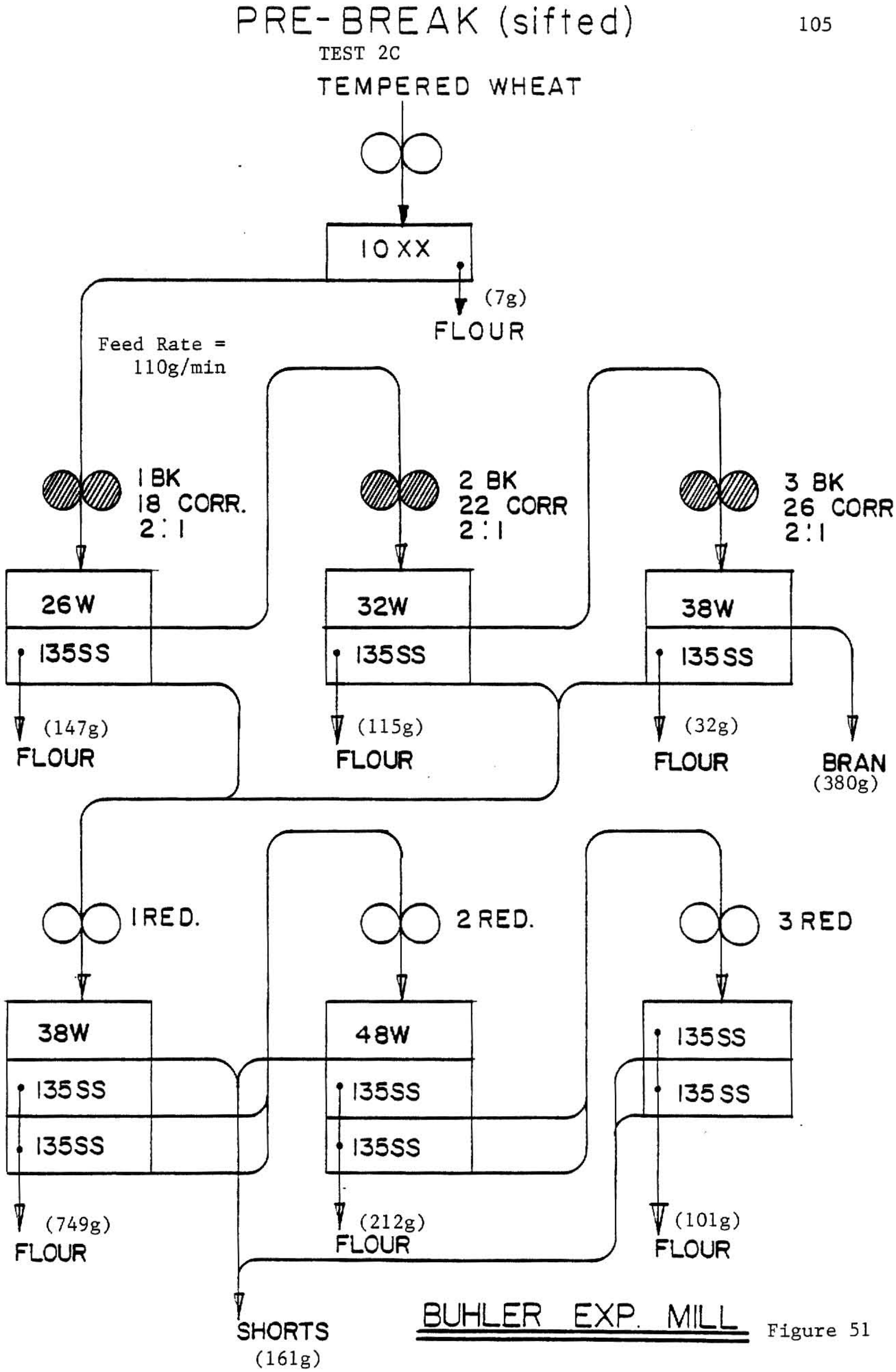

PRE-BREAK (sifted)
TEST 2C
TEMPERED WHEAT
10XX
(7g)
FLOUR
Feed Rate = 110g/min
1 BK
18 CORR.
2:1
2 BK
22 CORR
2:1
3 BK
26 CORR
2:1
26W
135SS
32W
135SS
38W
135SS
(147g)
FLOUR
(115g)
FLOUR
(32g)
FLOUR
BRAN
(380g)
1 RED.
2 RED.
3 RED
38W
135SS
135SS
48W
135SS
135SS
135SS
135SS
(749g)
FLOUR
(212g)
FLOUR
(101g)
FLOUR
SHORTS
(161g)
BUHLER EXP. MILL

Figure 51

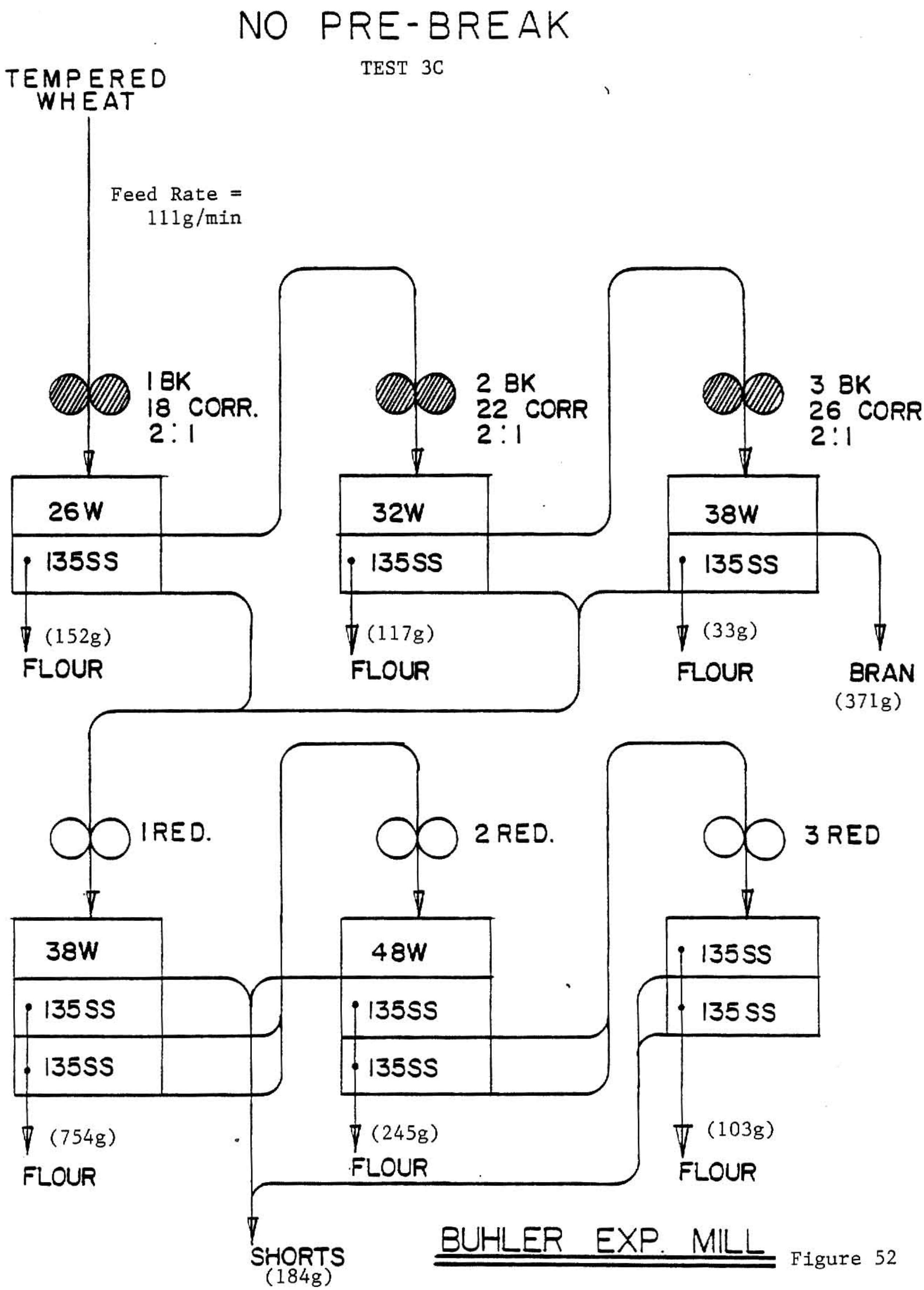
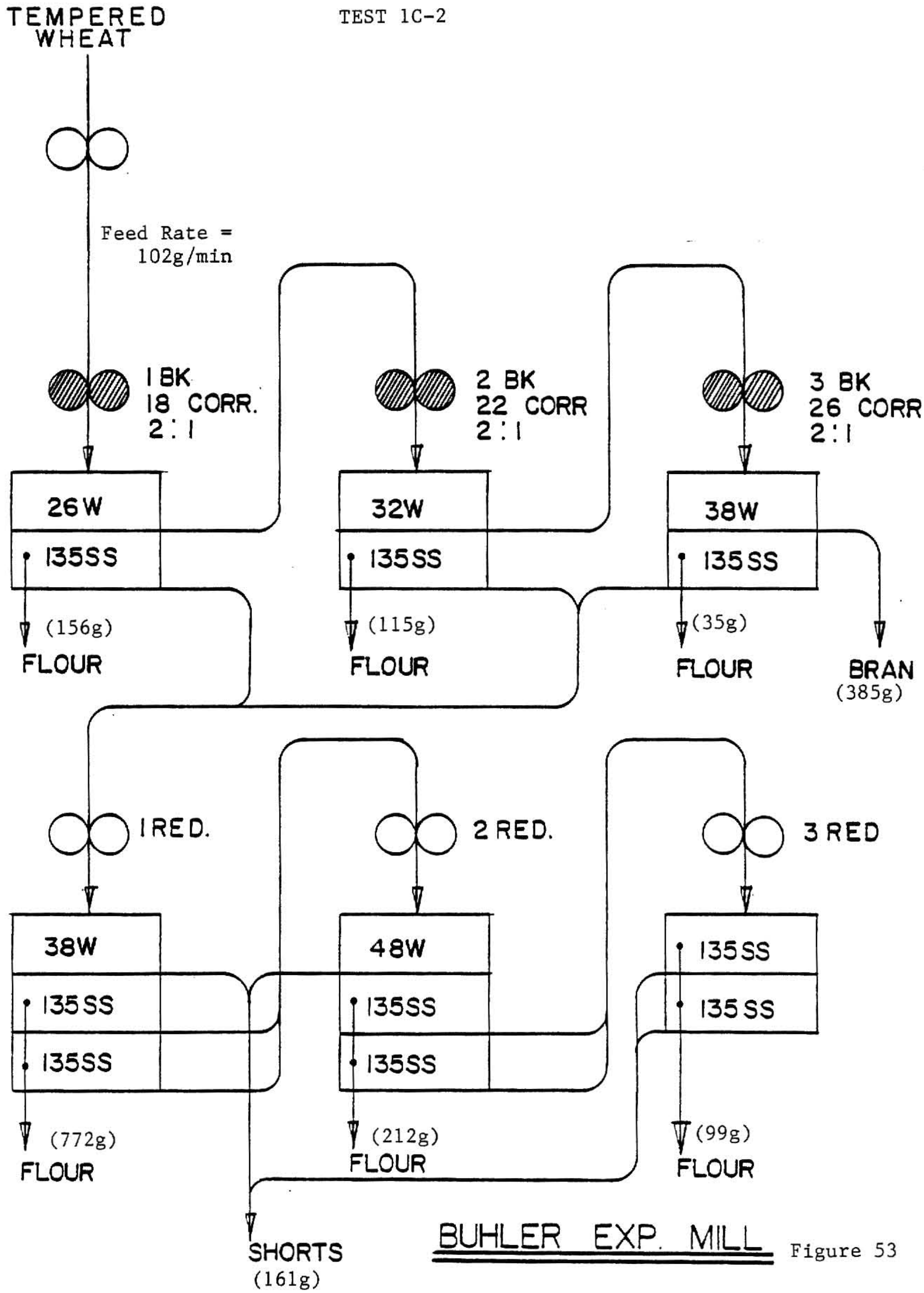

NO PRE-BREAK
TEST 3C
TEMPERED WHEAT
Feed Rate = 111g/min
1 BK
18 CORR.
2:1
2 BK
22 CORR
2:1
3 BK
26 CORR
2:1
26W
135SS
32W
135SS
38W
135SS
(152g)
FLOUR
(117g)
FLOUR
(33g)
FLOUR
BRAN
(371g)
1 RED.
2 RED.
3 RED
38W
135SS
135SS
48W
135SS
135SS
135SS
135 SS
(754g)
FLOUR
(245g)
FLOUR
(103g)
FLOUR
SHORTS
(184g)
BUHLER EXP. MILL

Figure 52

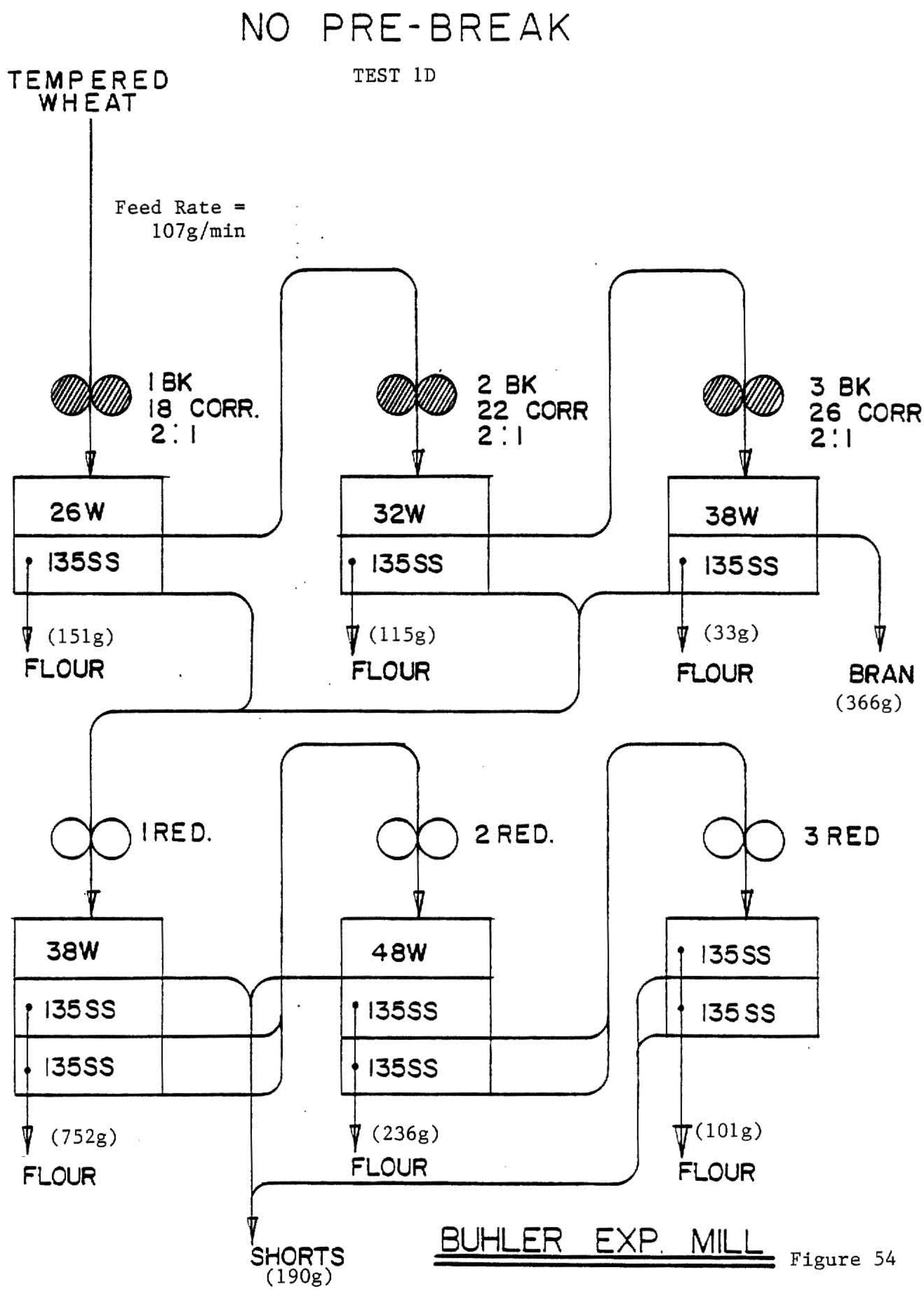
PRE-BREAK

TEST 1C-2



BUHLER EXP. MILL

Figure 53

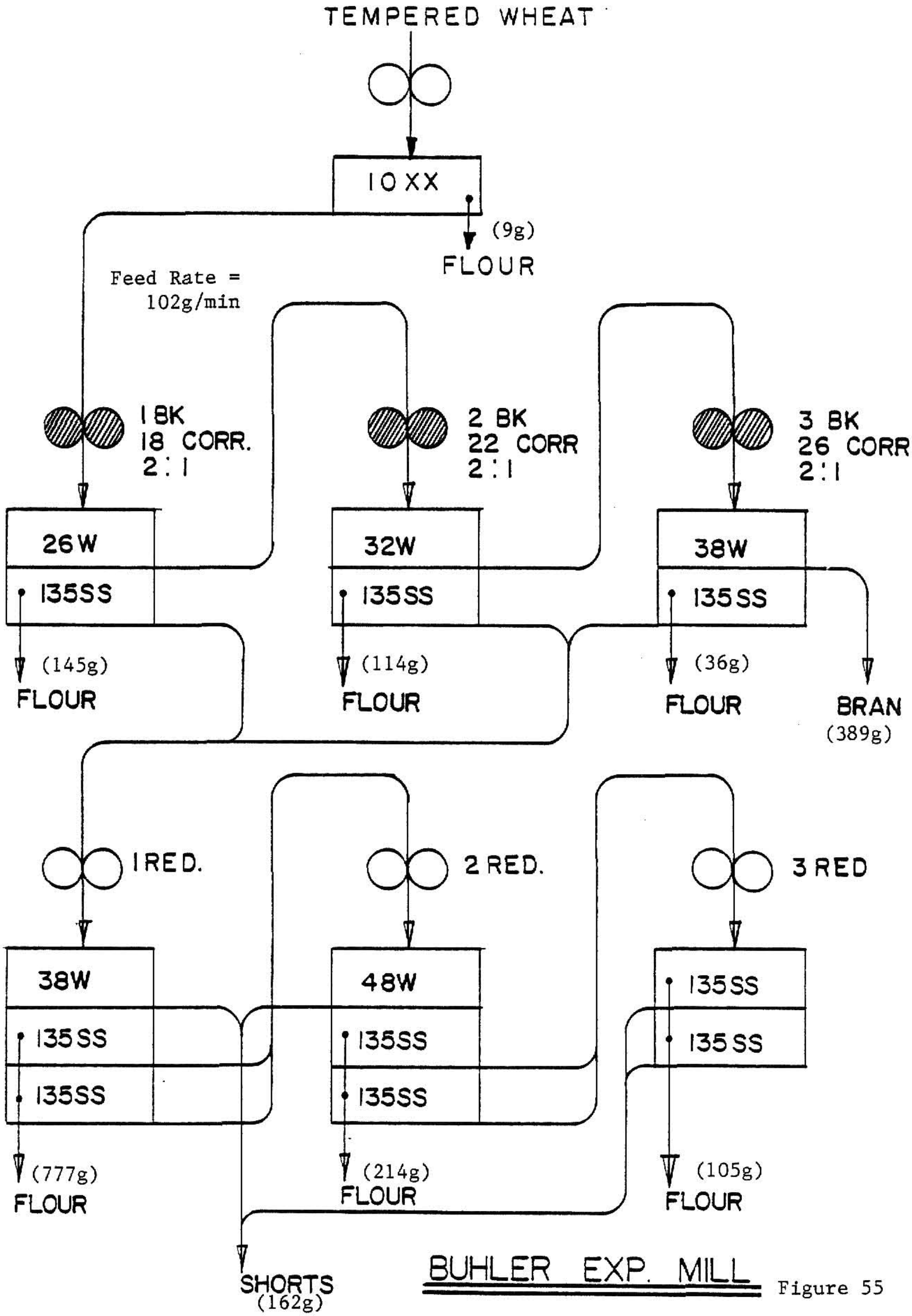


NO PRE-BREAK
TEST 1D
TEMPERED WHEAT
Feed Rate = 107g/min
1 BK
18 CORR.
2:1
2 BK
22 CORR
2:1
3 BK
26 CORR
2:1
26W
135SS
32W
135SS
38W
135SS
(151g)
FLOUR
(115g)
FLOUR
(33g)
FLOUR
BRAN
(366g)
1 RED.
2 RED.
3 RED
38W
135SS
135SS
48W
135SS
135SS
135SS
135SS
(752g)
FLOUR
(236g)
FLOUR
(101g)
FLOUR
SHORTS
(190g)
BUHLER EXP. MILL

Figure 54

PRE-BREAK (sifted)

TEST 2D



BUHLER EXP. MILL

Figure 55

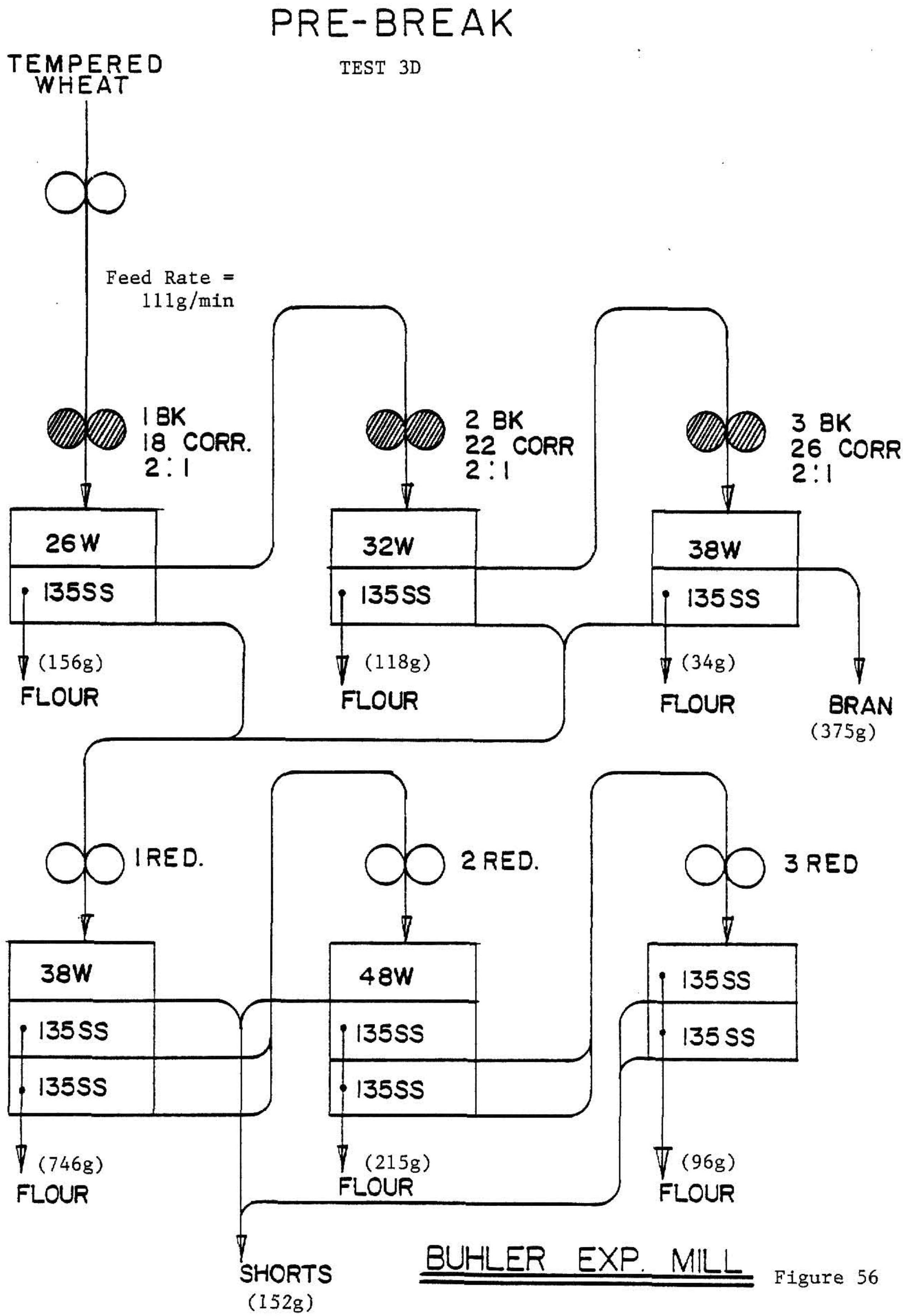

PRE-BREAK
TEST 3D
TEMPERED WHEAT
Feed Rate = 111g/min
1 BK
18 CORR.
2:1
2 BK
22 CORR
2:1
3 BK
26 CORR
2:1
26W
135SS
32W
135SS
38W
135SS
(156g)
FLOUR
(118g)
FLOUR
(34g)
FLOUR
BRAN
(375g)
1 RED.
2 RED.
3 RED
38W
135SS
135SS
48W
135SS
135SS
135SS
135SS
(746g)
FLOUR
(215g)
FLOUR
(96g)
FLOUR
SHORTS
(152g)
BUHLER EXP. MILL

Figure 56

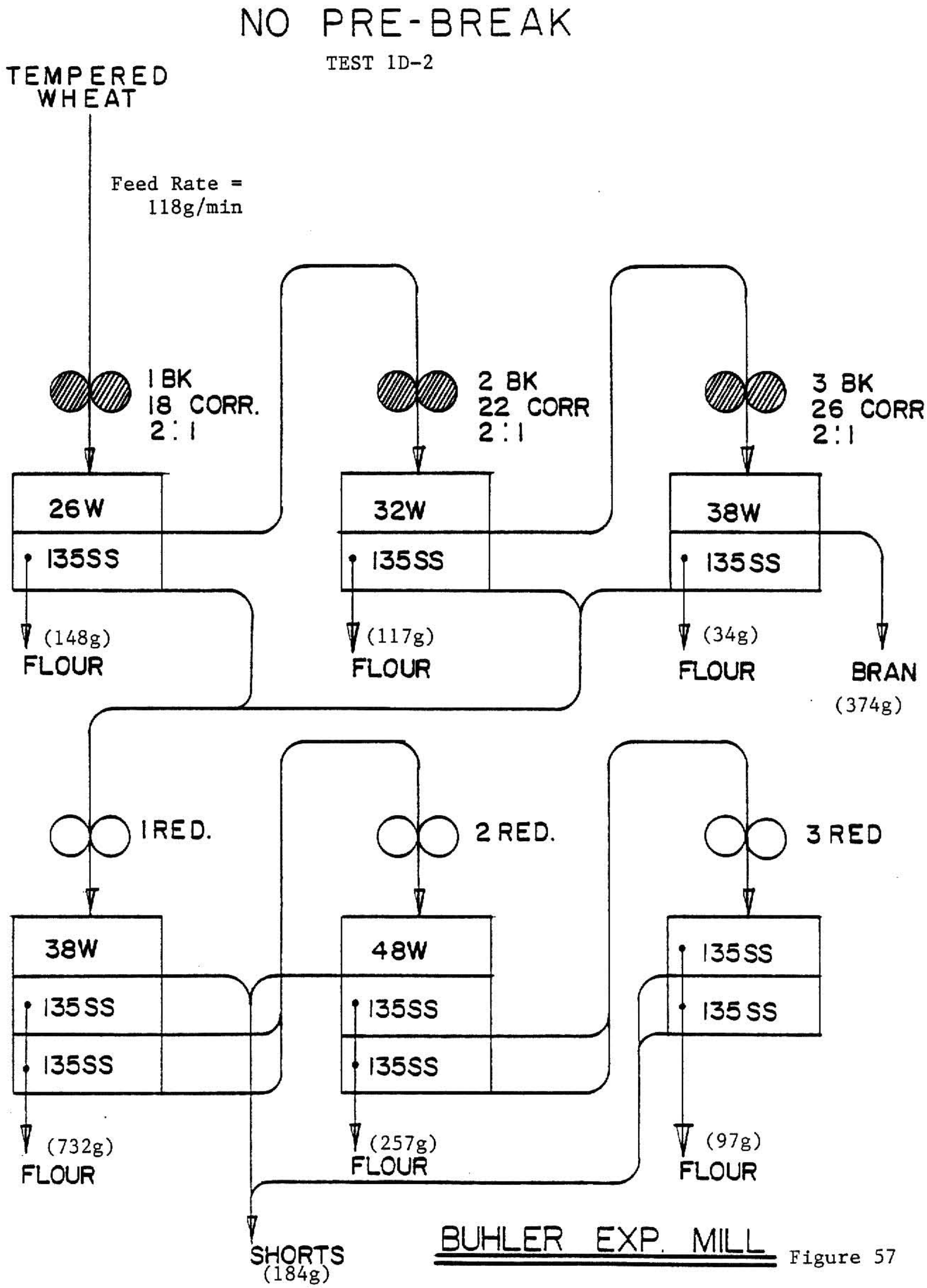
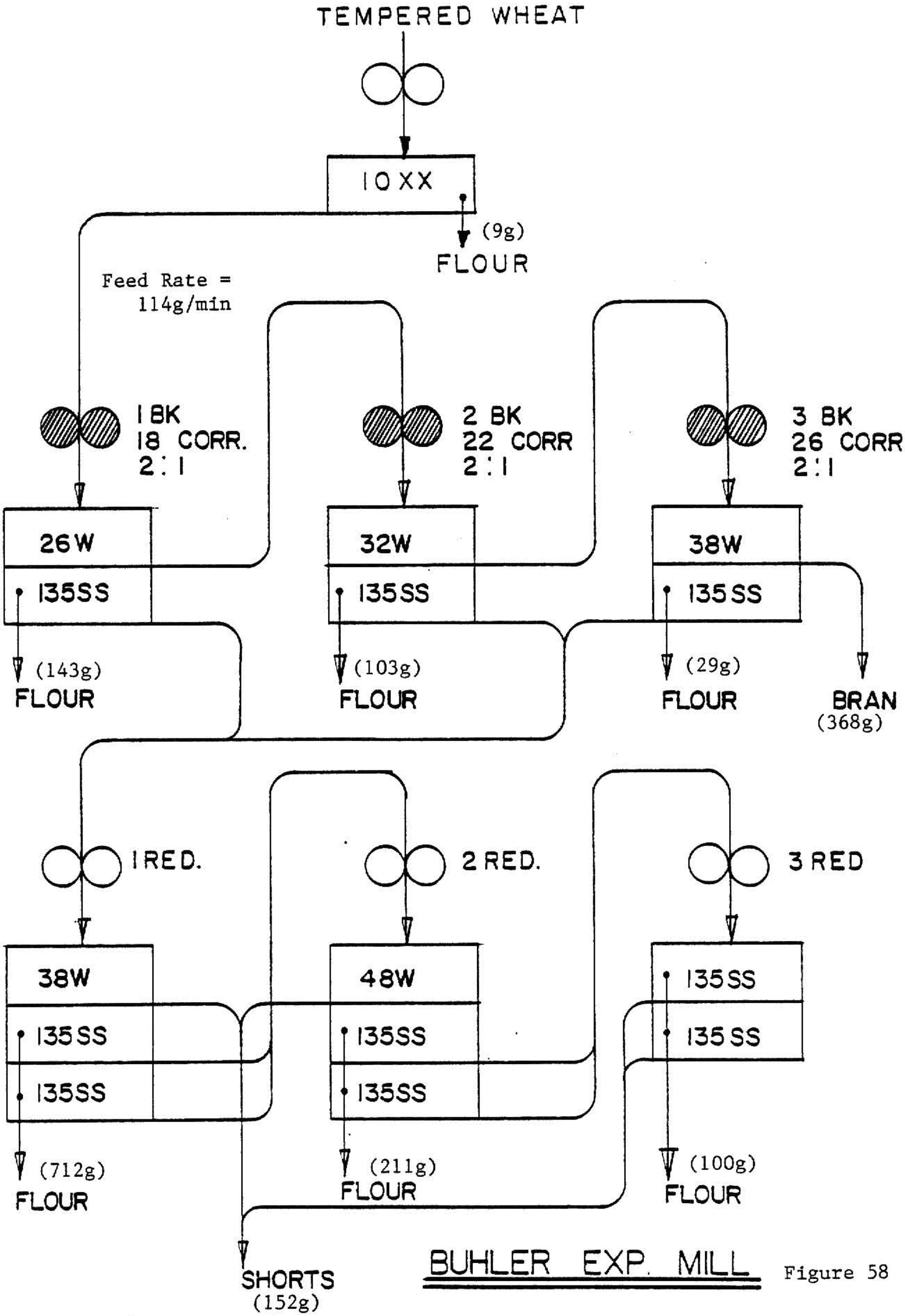

NO PRE-BREAK
TEST 1D-2
TEMPERED WHEAT
Feed Rate = 118g/min
1 BK
18 CORR.
2:1
2 BK
22 CORR
2:1
3 BK
26 CORR
2:1
26W
135SS
32W
135SS
38W
135SS
(148g)
FLOUR
(117g)
FLOUR
(34g)
FLOUR
BRAN
(374g)
1 RED.
2 RED.
3 RED
38W
135SS
135SS
48W
135SS
135SS
135SS
135SS
(732g)
FLOUR
(257g)
FLOUR
(97g)
FLOUR
SHORTS
(184g)
BUHLER EXP. MILL

Figure 57

PRE-BREAK (sifted)

TEST 1E-1



BUHLER EXP. MILL

Figure 58

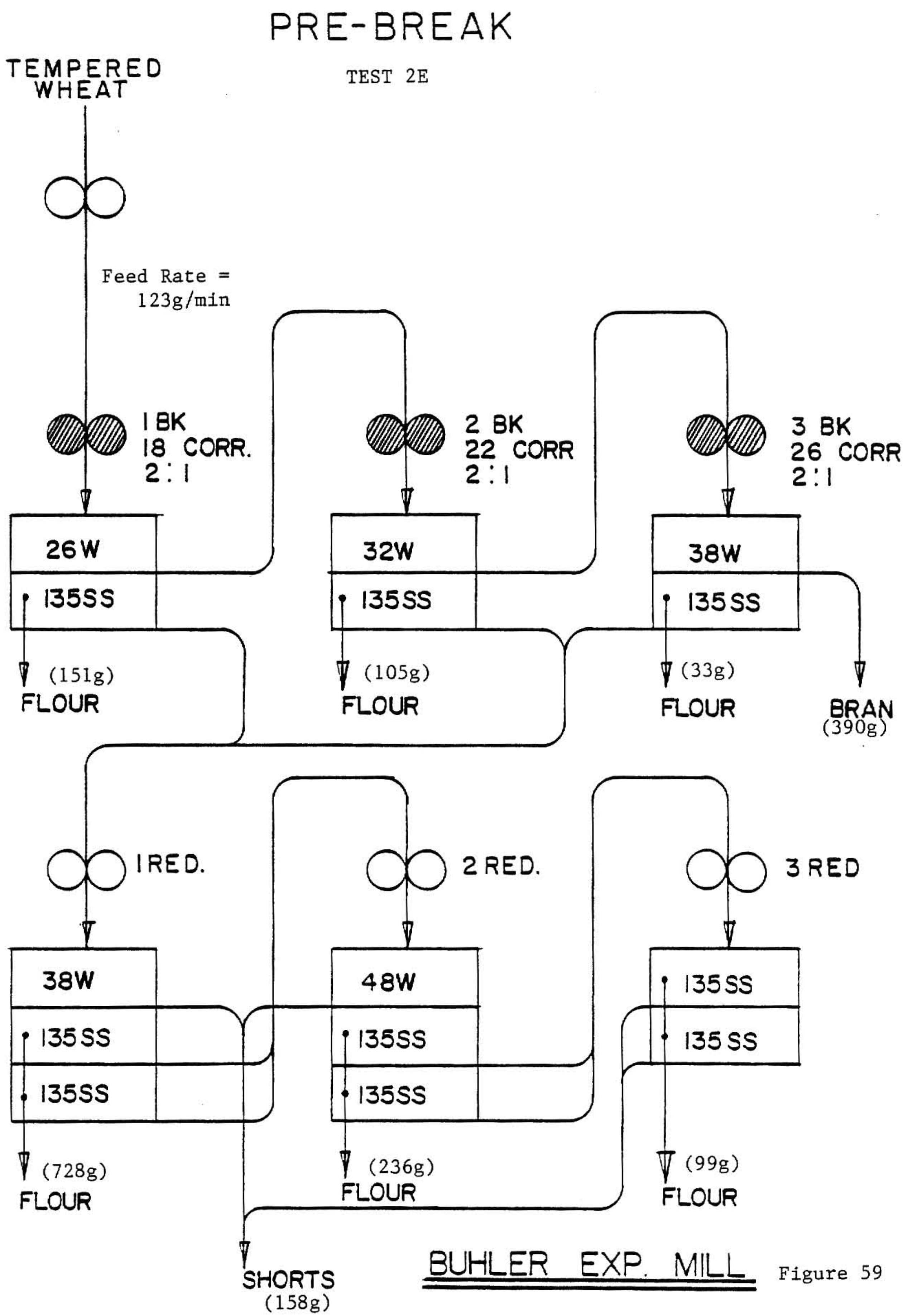

PRE-BREAK
TEST 2E
TEMPERED WHEAT
Feed Rate = 123g/min
1 BK
18 CORR.
2:1
2 BK
22 CORR
2:1
3 BK
26 CORR
2:1
26W
135SS
32W
135SS
38W
135SS
(151g)
FLOUR
(105g)
FLOUR
(33g)
FLOUR
BRAN
(390g)
1 RED.
2 RED.
3 RED
38W
135SS
135SS
48W
135SS
135SS
135SS
135SS
(728g)
FLOUR
(236g)
FLOUR
(99g)
FLOUR
SHORTS
(158g)
BUHLER EXP. MILL

Figure 59

NO PRE-BREAK

TEST 3E

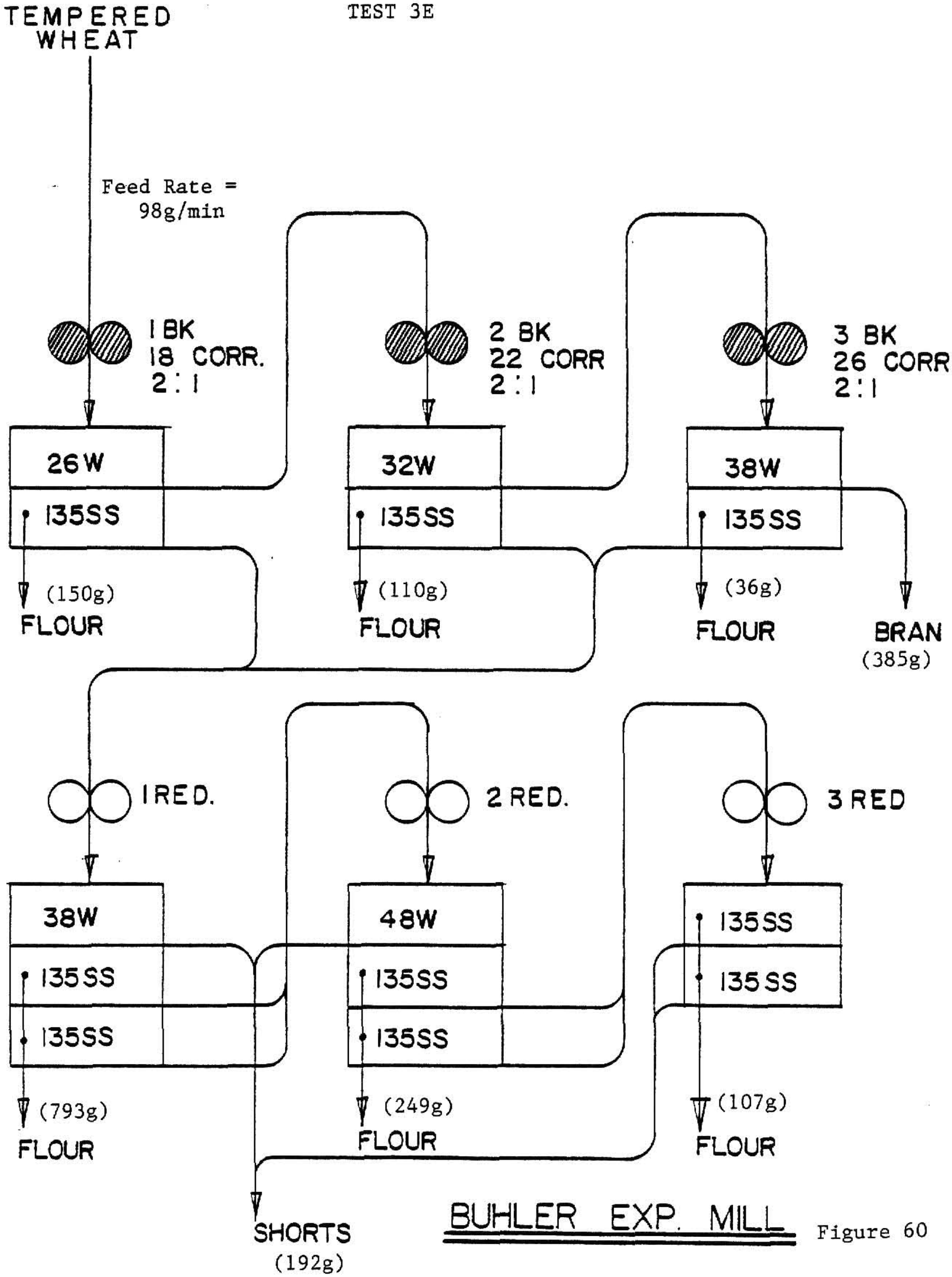


Figure 60

PRE-BREAK (sifted)

TEST 1E-2

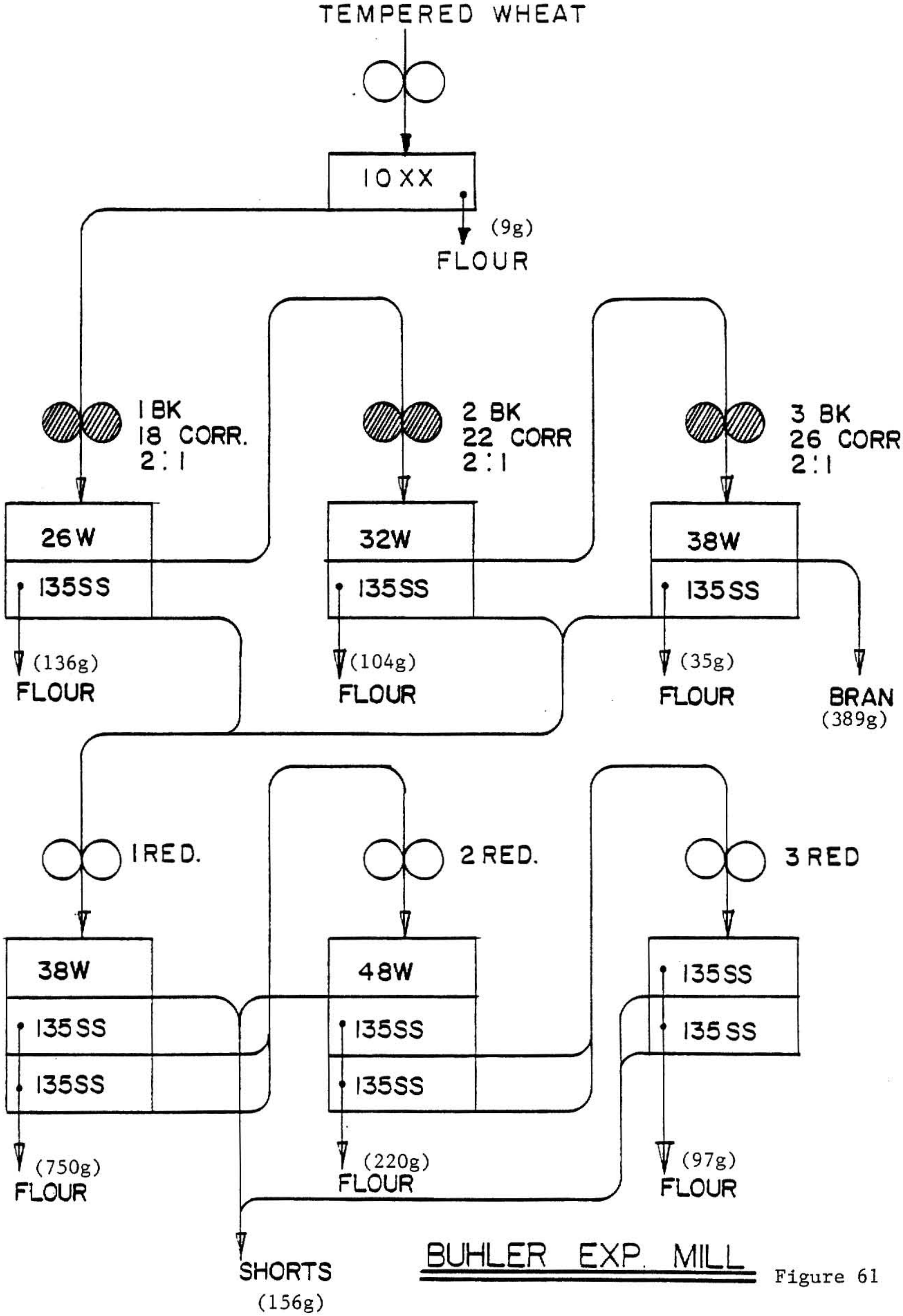


Figure 61

Table 9

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: BUHLER EXP.
TEST: A
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK (1)							
1 RED	785	40.80	40.80	.338	13.790	13.790	.338
1 BK	157	8.16	48.96	.373	3.044	16.834	.344
2 BK	111	5.77	54.73	.377	2.175	19.009	.347
2 RED	198	10.29	65.02	.455	4.682	23.691	.364
3 BK	30	1.56	66.58	.569	0.888	24.579	.369
3 RED	100	5.20	71.78	.666	3.463	28.042	.391
PRE-BREAK (NOT SIFTED)							
1 RED	762	40.32	40.32	.315	12.701	12.701	.315
1 BK	165	8.73	49.05	.340	2.968	15.669	.319
2 BK	110	5.82	54.87	.358	2.084	17.753	.324
2 RED	192	10.16	65.03	.413	4.196	21.949	.338
3 BK	29	1.53	66.56	.523	0.800	22.749	.342
3 RED	99	5.24	71.80	.607	3.181	25.930	.361
PRE-BREAK (SIFTED)							
1 RED	764	38.53	38.53	.315	12.137	12.137	.315
1 BK	155	7.82	46.35	.340	2.659	14.796	.319
2 BK	115	5.80	52.15	.356	2.065	16.861	.323
2 RED	227	11.45	63.60	.399	4.569	21.429	.337
3 BK	31	1.56	65.16	.511	0.797	22.226	.341
P BK	10	0.50	65.66	.557	0.279	22.505	.343
3 RED	104	5.24	70.90	.573	3.003	25.507	.360
NO PRE-BREAK (2)							
1 RED	754	39.66	39.66	.342	13.564	13.564	.342
1 BK	151	7.94	47.60	.362	2.874	16.438	.345
2 BK	112	5.89	53.49	.365	2.150	18.588	.348
2 RED	213	11.20	64.69	.470	5.264	23.852	.369
3 BK	31	1.63	66.32	.545	0.888	24.740	.373
3 RED	102	5.37	71.70	.733	3.936	28.676	.400

Table 10

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL BUHLER EXP.
TEST B
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of Q X A	S of QXA / S of Q
			PRE-BREAK SIFTED (1)				
1 RED	740	38.70	38.70	.309	11.958	11.958	.309
1 BK	153	8.00	46.70	.328	2.624	14.582	.312
2 BK	108	5.65	52.35	.348	1.966	16.549	.316
2 RED	208	10.88	63.23	.377	4.102	20.650	.327
3 RED	113	5.91	69.14	.498	2.943	23.593	.341
3 BK	30	1.57	70.71	.530	0.832	24.426	.345
P BK	7	0.37	71.08	.547	0.202	24.628	.346
			NO PRE-BREAK				
1 RED	703	36.37	36.37	.332	12.075	12.075	.332
1 BK	148	7.66	44.03	.349	2.673	14.748	.335
2 BK	109	5.64	49.67	.364	2.053	16.801	.338
2 RED	262	13.55	63.22	.408	5.526	22.330	.353
3 BK	29	1.50	64.72	.559	0.839	23.168	.358
3 RED	107	5.54	70.26	.580	3.213	26.381	.375
			PRE-BREAK NOT SIFTED				
1 RED	723	37.42	37.42	.308	11.525	11.525	.308
1 BK	160	8.28	45.70	.330	2.732	14.258	.312
2 BK	112	5.80	51.50	.348	2.018	16.276	.316
2 RED	226	11.70	63.20	.382	4.469	20.746	.328
3 RED	113	5.85	69.05	.526	3.077	23.823	.345
3 BK	31	1.60	70.65	.529	0.846	24.669	.349
			PRE-BREAK SIFTED (2)				
1 RED	730	38.69	38.69	.314	12.149	12.149	.314
1 BK	145	7.68	46.37	.317	2.435	14.583	.314
2 BK	111	5.88	52.25	.339	1.993	16.577	.317
2 RED	214	11.34	63.59	.403	4.570	21.147	.333
3 BK	32	1.70	65.29	.520	.884	22.031	.337
P BK	9	0.48	65.77	.547	.263	22.293	.339
3 RED	106	5.62	71.39	.602	3.383	25.676	.360

Table 11

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL BUHLER EXP.
TEST C
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
PRE-BREAK NOT SIFTED (1)							
1 RED	790	40.33	40.33	.306	12.341	12.341	.306
1 BK	162	8.27	48.60	.336	2.779	15.120	.311
2 BK	115	5.87	54.47	.354	2.078	17.198	.316
2 RED	201	10.26	64.73	.401	4.114	21.312	.329
3 BK	35	1.79	66.52	.525	0.940	22.252	.335
3 RED	107	5.46	71.98	.547	2.987	25.238	.351
PRE-BREAK SIFTED							
1 RED	749	39.34	39.34	.306	12.038	12.038	.306
1 BK	147	7.72	47.06	.325	2.509	14.547	.309
2 BK	115	6.04	53.10	.344	2.078	16.625	.313
2 RED	212	11.13	64.23	.383	4.263	20.888	.325
3 BK	32	1.68	65.91	.516	0.867	21.754	.330
P BK	7	0.37	66.28	.528	0.195	21.950	.331
3 RED	101	5.30	71.58	.557	2.952	24.902	.348
NO PRE-BREAK							
1 RED	754	38.49	38.49	.332	12.779	12.779	.332
1 BK	152	7.76	46.25	.347	2.693	15.471	.335
2 BK	117	5.97	52.22	.359	2.143	17.615	.337
2 RED	245	12.51	64.73	.433	5.417	23.031	.356
3 BK	33	1.68	66.41	.535	0.899	23.930	.360
3 RED	103	5.26	71.67	.656	3.451	27.381	.382
PRE-BREAK NOT SIFTED (2)							
1 RED	772	39.90	39.90	.312	12.449	12.449	.312
1 BK	156	8.06	47.96	.329	2.652	15.101	.315
2 BK	115	5.94	53.90	.353	2.097	17.197	.319
2 RED	212	10.96	64.86	.424	4.647	21.844	.337
3 BK	35	1.81	66.67	.526	0.952	22.796	.342
3 RED	99	5.12	71.79	.616	3.154	25.950	.361

Table 12

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL BUHLER EXP.
TEST D
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK (1)							
1 RED	752	38.68	38.68	.331	12.803	12.803	.331
1 BK	151	7.77	46.45	.352	2.735	15.538	.335
2 BK	115	5.92	52.37	.366	2.167	17.705	.338
2 RED	236	12.14	64.51	.425	5.160	22.864	.354
3 BK	33	1.70	66.21	.538	0.915	23.779	.359
3 RED	101	5.20	71.41	.615	3.198	26.977	.378
PRE-BREAK SIFTED							
1 RED	777	39.83	39.83	.322	12.825	12.825	.322
1 BK	145	7.43	47.26	.326	2.422	15.247	.323
2 BK	114	5.84	53.10	.359	2.097	17.344	.327
2 RED	214	10.97	64.07	.423	4.640	21.984	.343
3 BK	36	1.85	65.92	.531	0.982	22.967	.348
P BK	9	0.46	66.38	.540	0.248	23.215	.350
3 RED	105	5.38	71.76	.601	3.233	26.448	.369
PRE-BREAK NOT SIFTED							
1 RED	746	39.43	39.43	.326	12.854	12.854	.326
1 BK	156	8.25	47.68	.340	2.805	15.659	.328
2 BK	118	6.24	53.92	.365	2.278	17.937	.333
2 RED	215	11.36	65.28	.430	4.885	22.822	.350
3 BK	34	1.80	67.08	.536	0.965	23.786	.355
3 RED	96	5.07	72.15	.642	3.255	27.041	.375
NO PRE-BREAK (2)							
1 RED	732	37.67	37.67	.330	12.431	12.431	.330
1 BK	148	7.62	45.29	.352	2.682	15.113	.334
2 BK	117	6.02	51.31	.361	2.173	17.287	.337
2 RED	257	13.23	64.54	.432	5.715	23.002	.356
3 BK	34	1.75	66.29	.541	0.947	23.949	.361
2 RED	97	4.99	71.28	.684	3.413	27.362	.384

Table 13

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: BUHLER EXP.
TEST: E
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
PRE-BREAK SIFTED (1)							
1 RED	712	38.97	38.97	.302	11.769	11.769	.302
1 BK	143	7.83	46.80	.327	2.560	14.329	.306
2 BK	103	5.64	52.44	.345	1.946	16.275	.310
2 RED	211	11.55	63.99	.359	4.146	20.422	.319
3 RED	100	5.47	69.46	.479	2.620	23.042	.332
3 BK	29	1.59	71.05	.509	0.809	23.851	.336
P BK	9	0.49	71.54	.541	0.265	24.116	.337
PRE-BREAK NOT SIFTED							
1 RED	728	38.32	38.32	.304	11.649	11.649	.304
1 BK	151	7.95	46.27	.330	2.624	14.273	.308
2 BK	105	5.53	51.80	.351	1.941	16.214	.313
2 RED	236	12.42	64.22	.374	4.645	20.359	.325
3 BK	33	1.74	65.96	.512	0.891	21.750	.330
3 RED	99	5.21	71.17	.521	2.714	24.464	.344
NO PRE-BREAK							
1 RED	793	39.22	39.22	.326	12.786	12.786	.326
1 BK	150	7.42	46.64	.363	2.693	15.479	.332
2 BK	110	5.44	52.08	.373	2.029	17.508	.336
2 RED	249	12.31	64.39	.425	5.232	22.740	.353
3 BK	36	1.78	66.17	.532	0.947	23.687	.358
3 RED	107	5.29	71.46	.618	3.269	26.956	.377
PRE-BREAK SIFTED (2)							
1 RED	750	39.56	39.56	.311	12.303	12.303	.311
1 BK	136	7.17	46.73	.324	2.323	14.626	.313
2 BK	104	5.49	52.22	.345	1.894	16.520	.316
2 RED	220	11.60	63.82	.390	4.524	21.044	.330
3 BK	35	1.85	65.67	.513	0.949	21.993	.335
3 RED	97	5.12	70.79	.558	2.857	24.850	.351
P BK	9	0.47	71.26	.588	0.276	25.127	.353

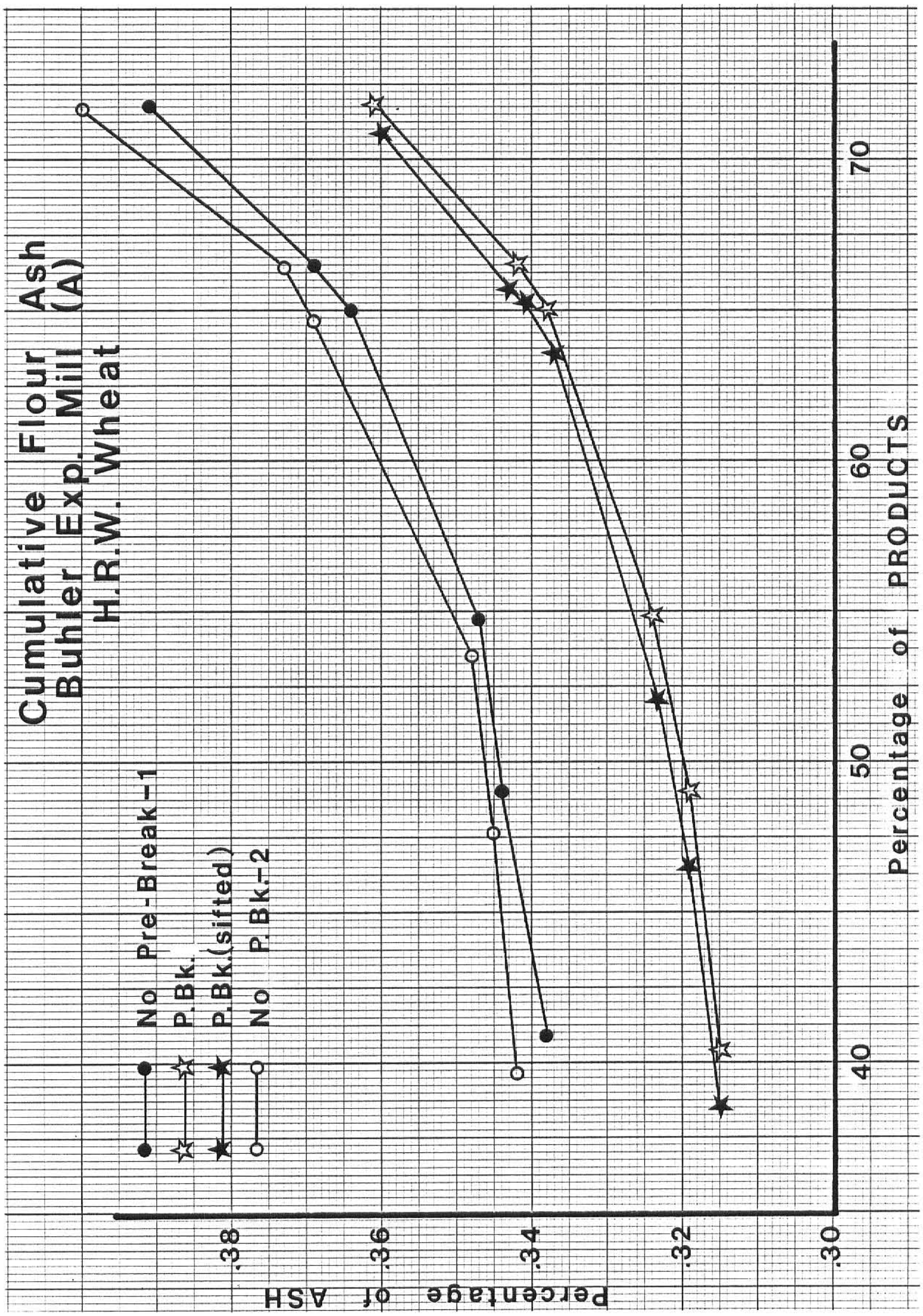
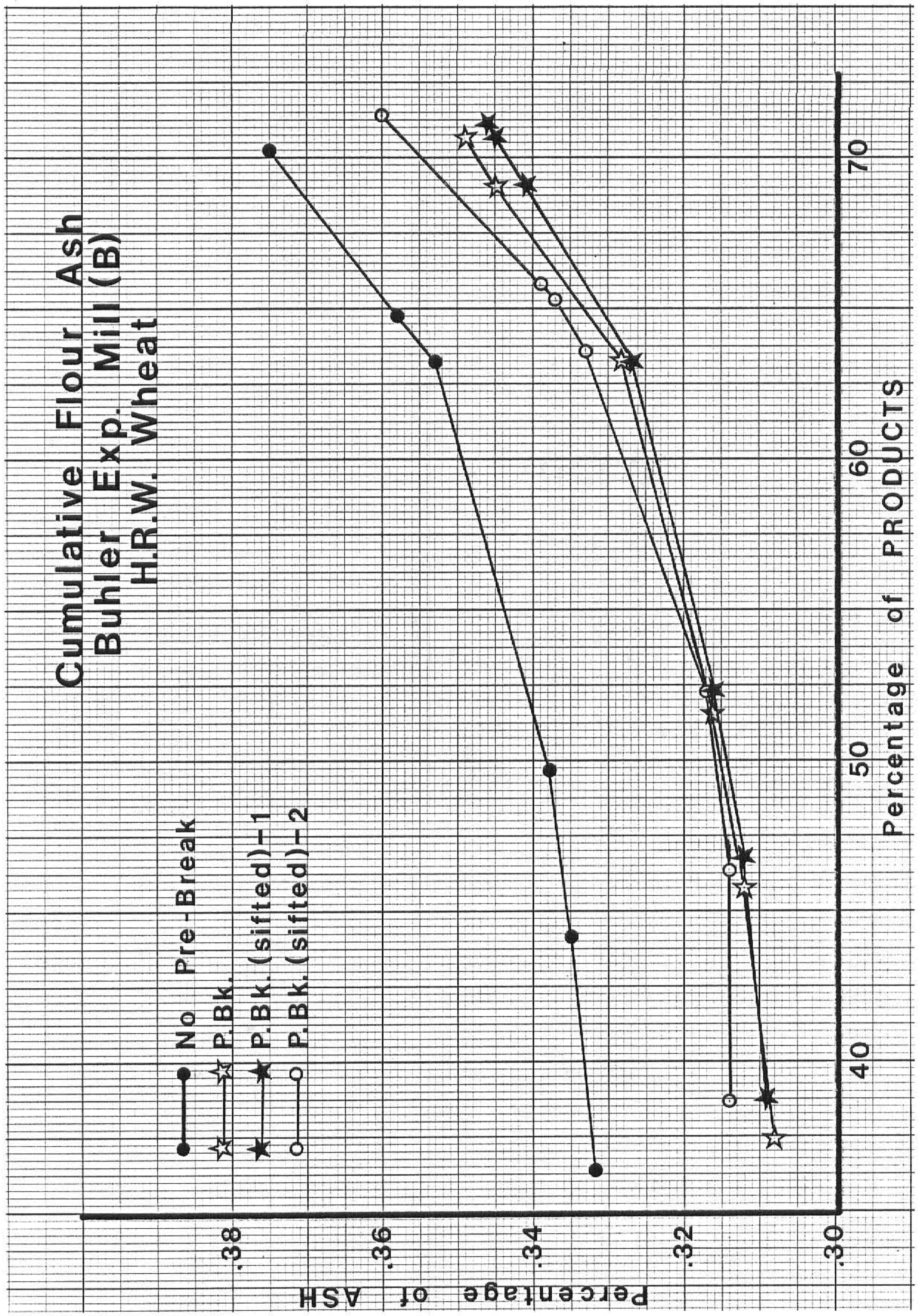

Cumulative Flour Ash
Buhler Exp. Mill (A)
H.R.W. Wheat
No Pre-Break-1
P.Bk.
P.Bk.(sifted)
No P.Bk.-2
Percentage of ASH
.38
.36
.34
.32
.30
Percentage of PRODUCTS
40
50
60
70

Figure 62



Cumulative Flour Ash
Buhler Exp. Mill (B)
H.R.W. Wheat
No Pre-Break
P.Bk.
P.Bk. (sifted)-1
P.Bk. (sifted)-2
Percentage of ASH
.38
.36
.34
.32
.30
40
50
60
70
Percentage of PRODUCTS

Figure 63

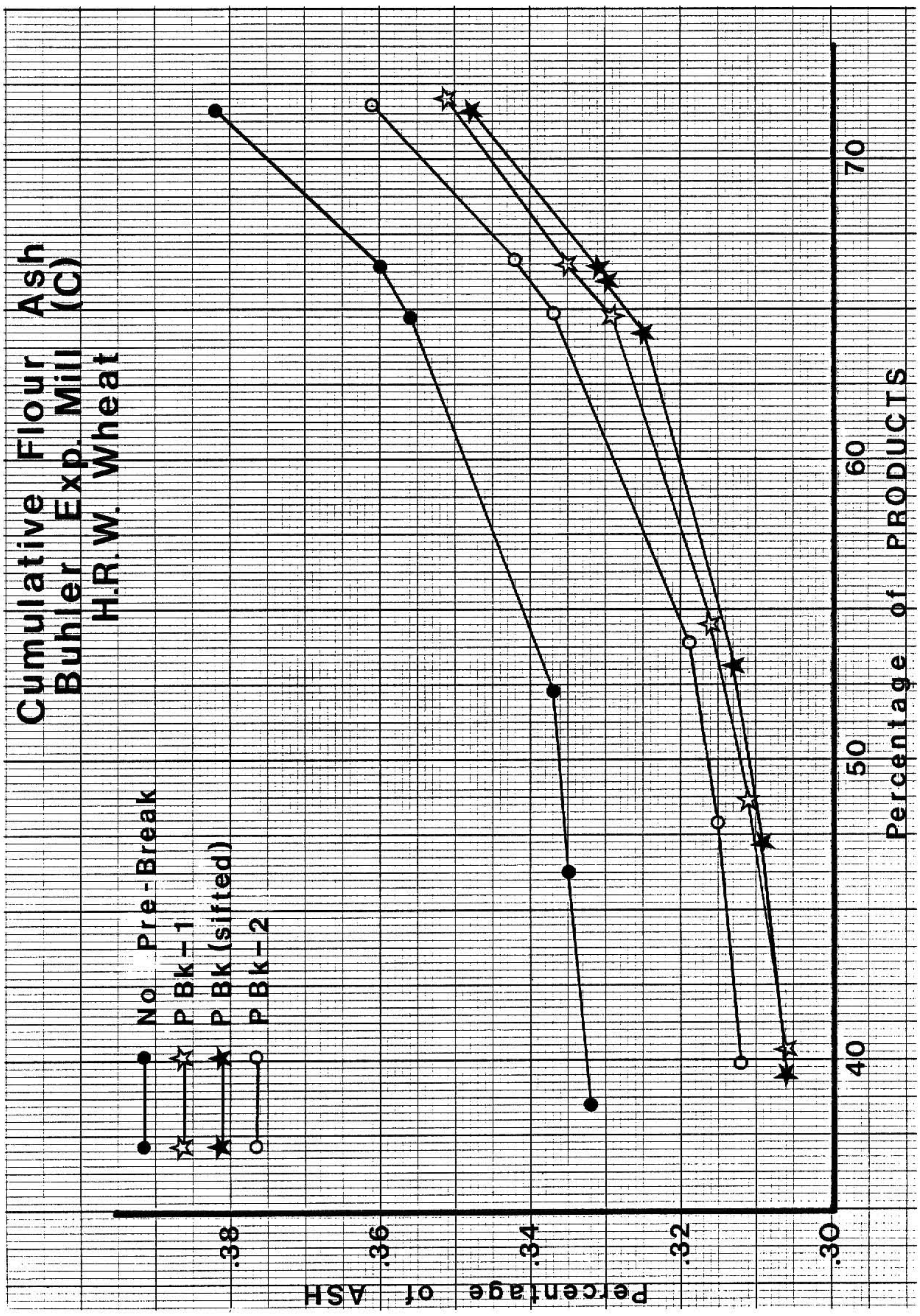

Cumulative Flour Ash
Buhler Exp. Mill (C)
H.R.W. Wheat
No Pre-Break
P Bk–1
P Bk (sifted)
P Bk–2
Percentage of ASH
.38
.36
.34
.32
.30
Percentage of PRODUCTS
40
50
60
70

Figure 64

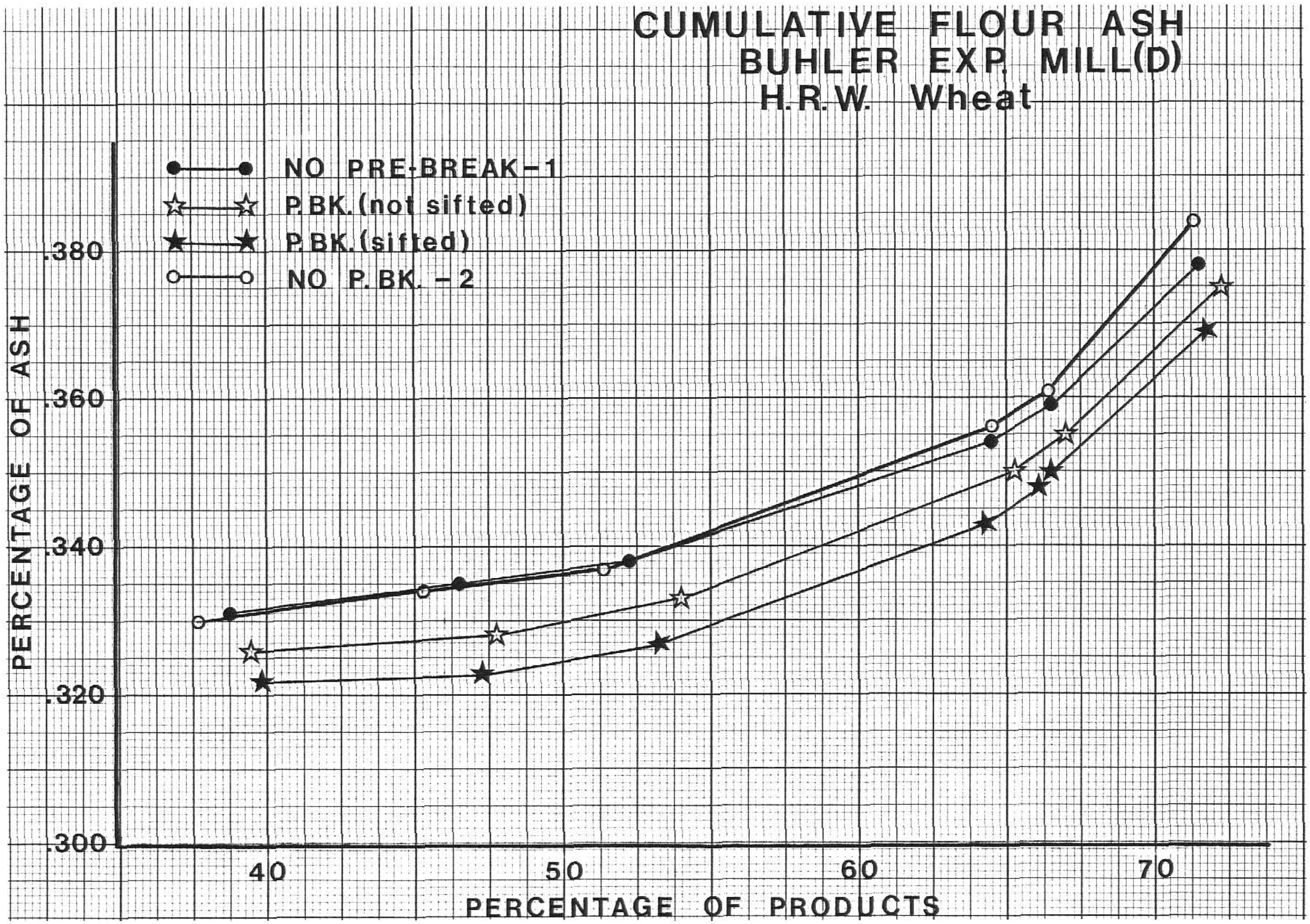

CUMULATIVE FLOUR ASH
BUHLER EXP. MILL(D)
H.R.W. Wheat
NO PRE-BREAK-1
P.BK.(not sifted)
P.BK.(sifted)
NO P.BK. -2
PERCENTAGE OF ASH
.380
.360
.340
.320
.300
40
50
60
70
PERCENTAGE OF PRODUCTS

Figure 65

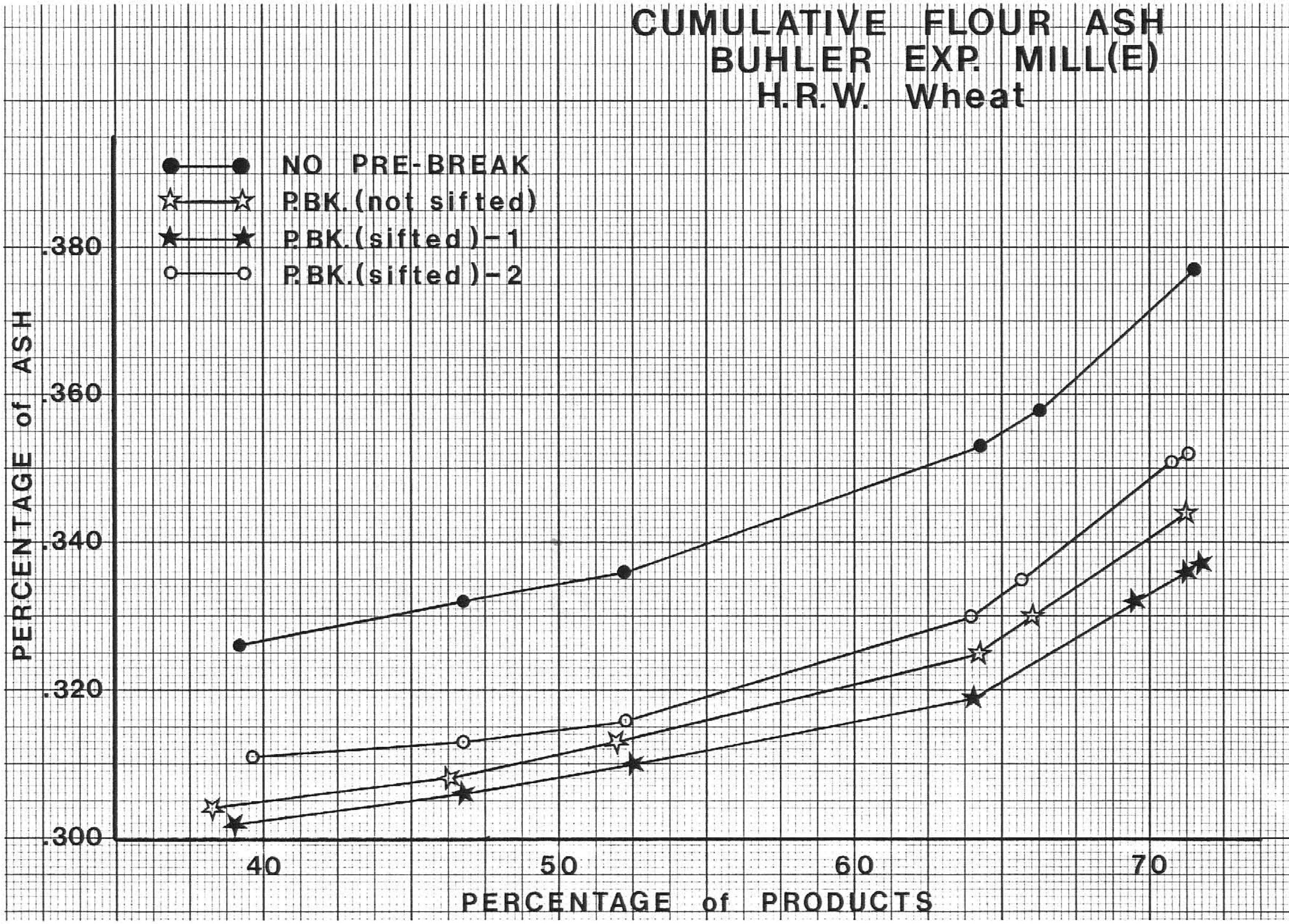

CUMULATIVE FLOUR ASH
BUHLER EXP. MILL(E)
H.R.W. Wheat
NO PRE-BREAK
P.BK.(not sifted)
P.BK.(sifted)-1
P.BK.(sifted)-2
.380
.360
.340
.320
.300
PERCENTAGE of ASH
40
50
60
70
PERCENTAGE of PRODUCTS

Figure 66

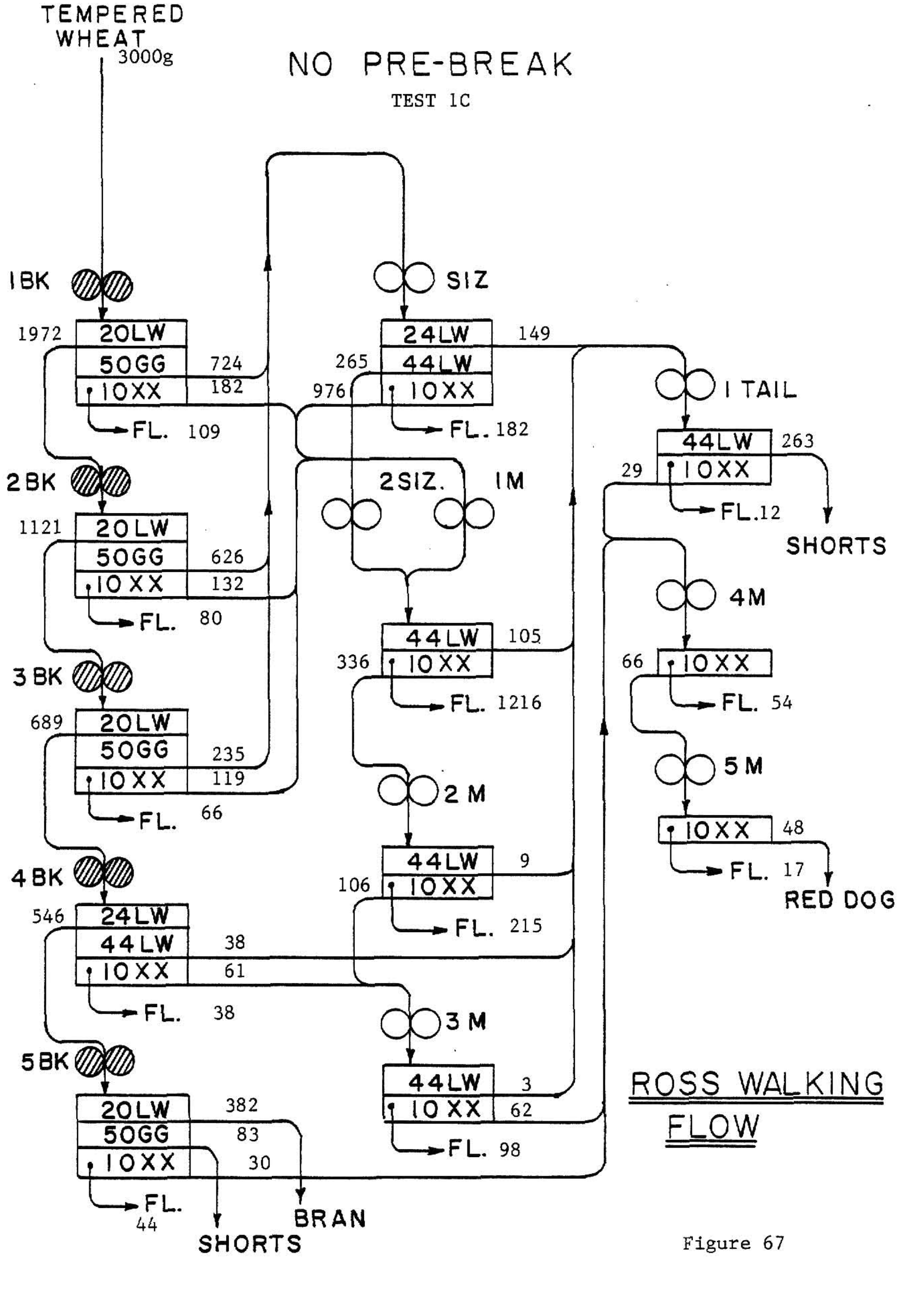

TEMPERED WHEAT
3000g
NO PRE-BREAK
TEST 1C
1BK
1972
20LW
50GG
724
10XX
182
FL. 109
2BK
1121
20LW
50GG
626
10XX
132
FL. 80
3 BK
689
20LW
50GG
235
10XX
119
FL. 66
4 BK
546
24LW
44LW
38
10XX
61
FL. 38
5BK
20LW
382
50GG
83
10XX
30
FL.
44
SHORTS
BRAN
S1Z
24LW
149
265
44LW
976
10XX
FL. 182
2SIZ.
1M
44LW
105
336
10XX
FL. 1216
2 M
44LW
9
106
10XX
FL. 215
3 M
44LW
3
10 XX
62
FL. 98
1 TAIL
44LW
263
29
10XX
FL. 12
SHORTS
4M
66
10XX
FL. 54
5 M
10XX
48
FL. 17
RED DOG
ROSS WALKING FLOW

Figure 67

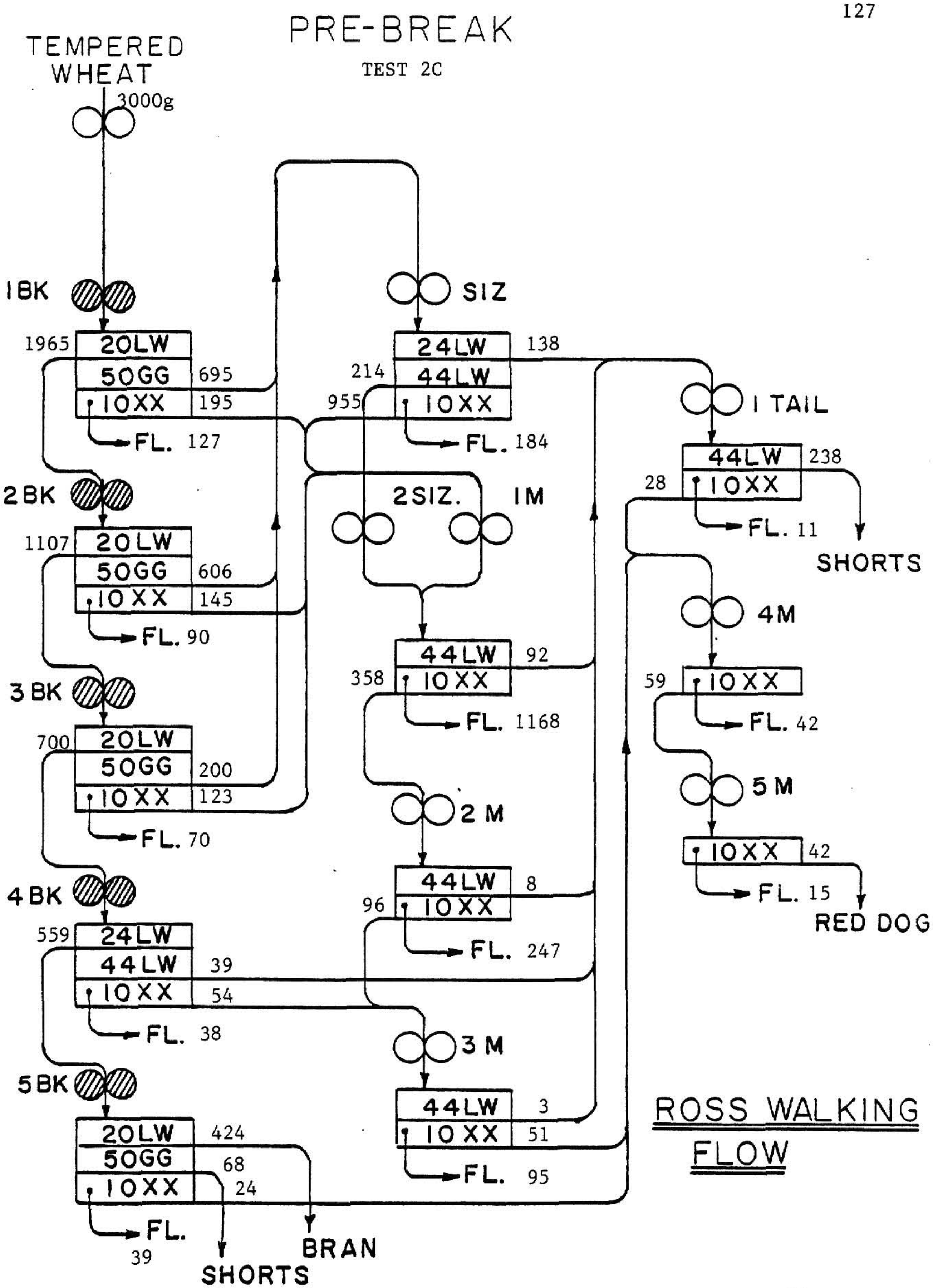

PRE-BREAK
TEST 2C
TEMPERED WHEAT
3000g
1BK
1965
20LW
50GG
695
10XX
195
FL. 127
2BK
1107
20LW
50GG
606
10XX
145
FL. 90
3 BK
700
20LW
50GG
200
10XX
123
FL. 70
4BK
559
24LW
44LW
39
10XX
54
FL. 38
5BK
20LW
424
50GG
68
10XX
24
FL.
39
SHORTS
BRAN
SIZ
24LW
138
214
44LW
955
10XX
FL. 184
2SIZ.
1M
44LW
92
358
10XX
FL. 1168
2 M
44LW
8
96
10XX
FL. 247
3 M
44LW
3
10XX
51
FL. 95
1 TAIL
44LW
238
28
10XX
FL. 11
SHORTS
4M
59
10XX
FL. 42
5 M
10XX
42
FL. 15
RED DOG
ROSS WALKING
FLOW

Figure 68

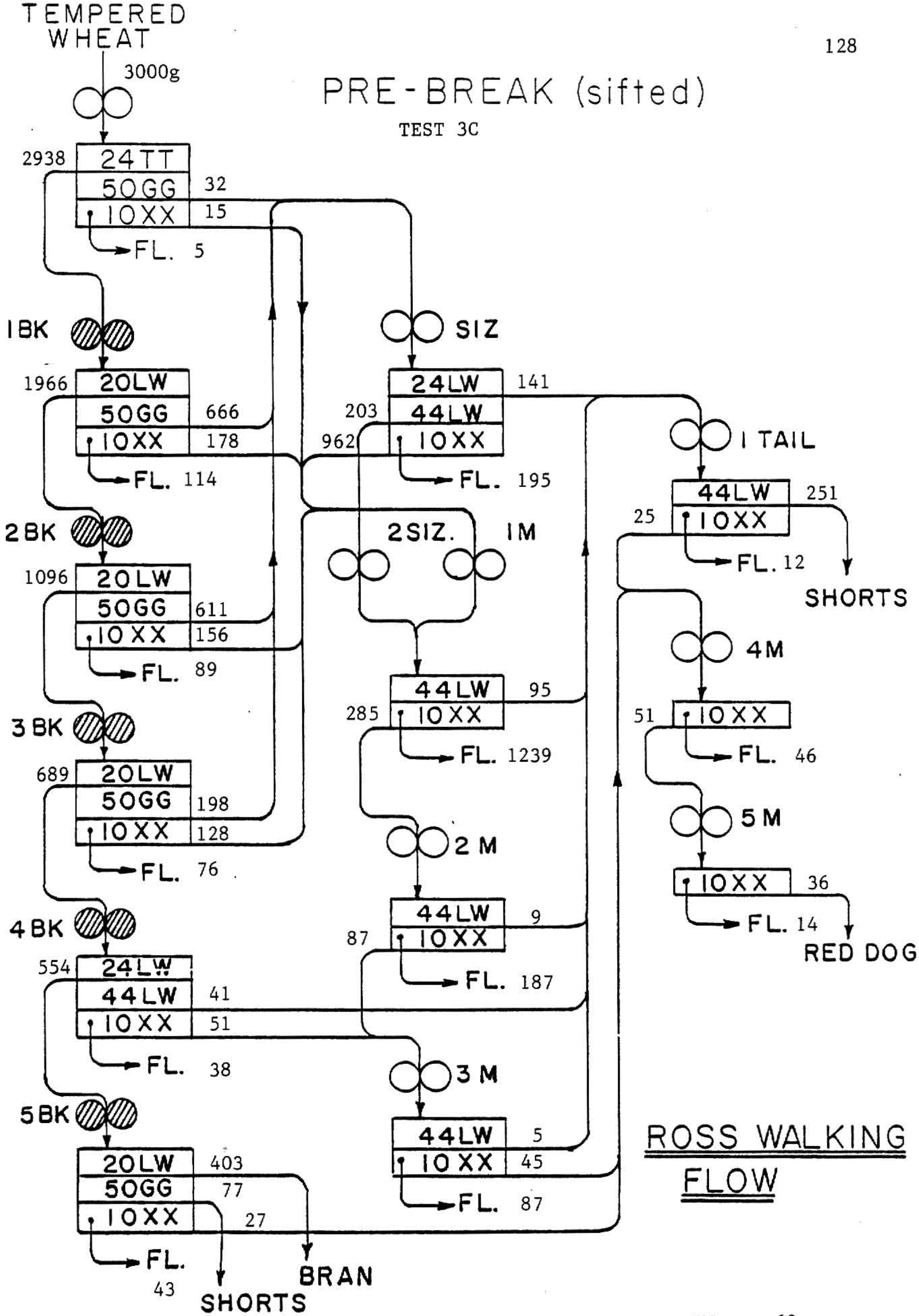
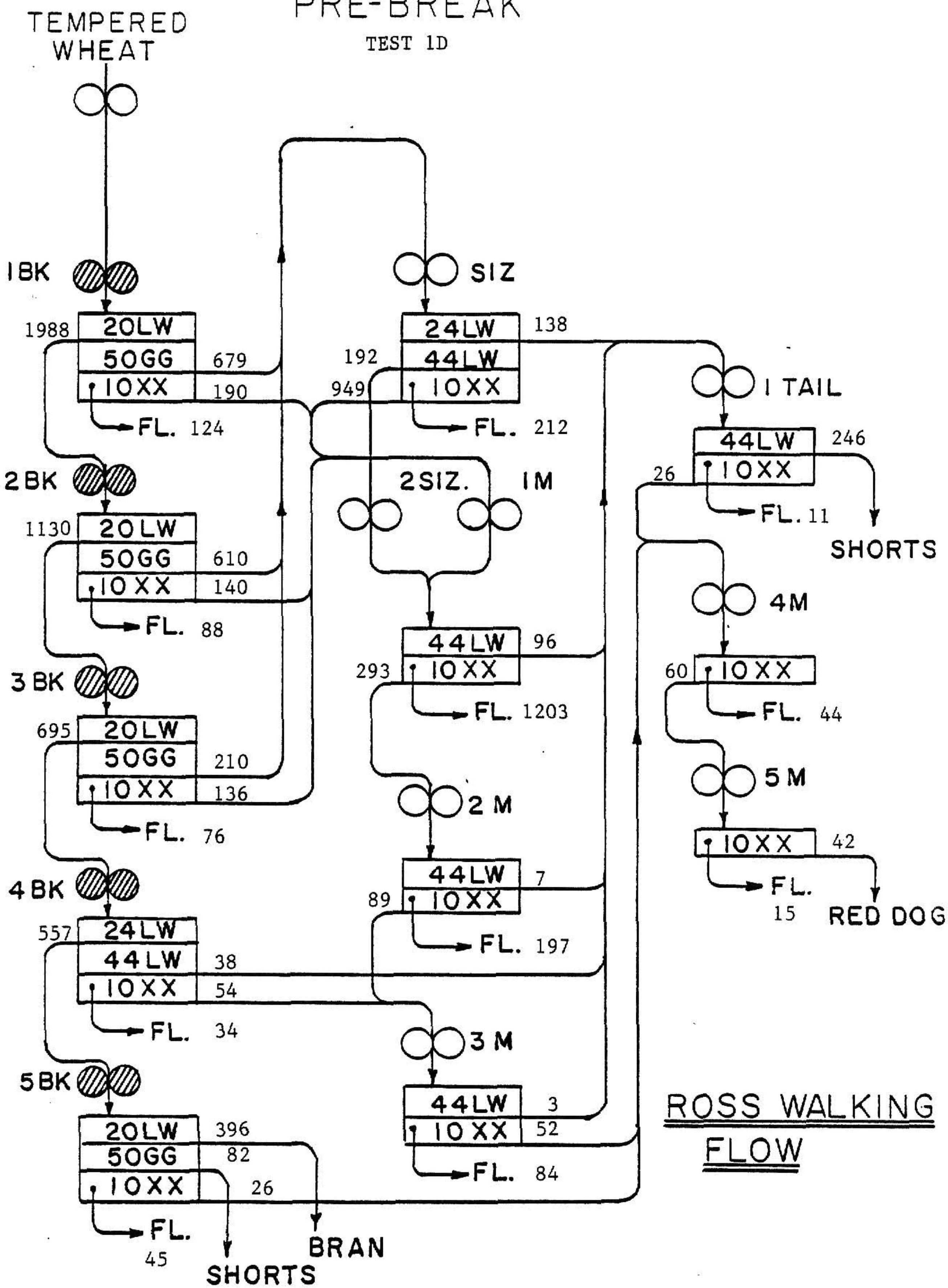

TEMPERED WHEAT
3000g
PRE-BREAK (sifted)
TEST 3C
2938
24TT
50GG 32
10XX 15
FL. 5
1BK
SIZ
1966
20LW
50GG 666
10XX 178
FL. 114
24LW 141
203
44LW
962
10XX
FL. 195
1 TAIL
44LW 251
25
10XX
FL. 12
SHORTS
2BK
2SIZ.
1M
1096
20LW
50GG 611
10XX 156
FL. 89
4M
44LW 95
285
10XX
FL. 1239
51
10XX
FL. 46
3 BK
689
20LW
50GG 198
10XX 128
FL. 76
5 M
2 M
10XX 36
FL. 14
RED DOG
4 BK
44LW 9
87
10XX
FL. 187
554
24LW
44LW 41
10XX 51
FL. 38
3 M
5BK
44LW 5
10XX 45
FL. 87
20LW 403
50GG 77
10XX 27
FL.
43
SHORTS
BRAN
ROSS WALKING FLOW

Figure 69

PRE-BREAK

TEST 1D



ROSS WALKING FLOW

Figure 70

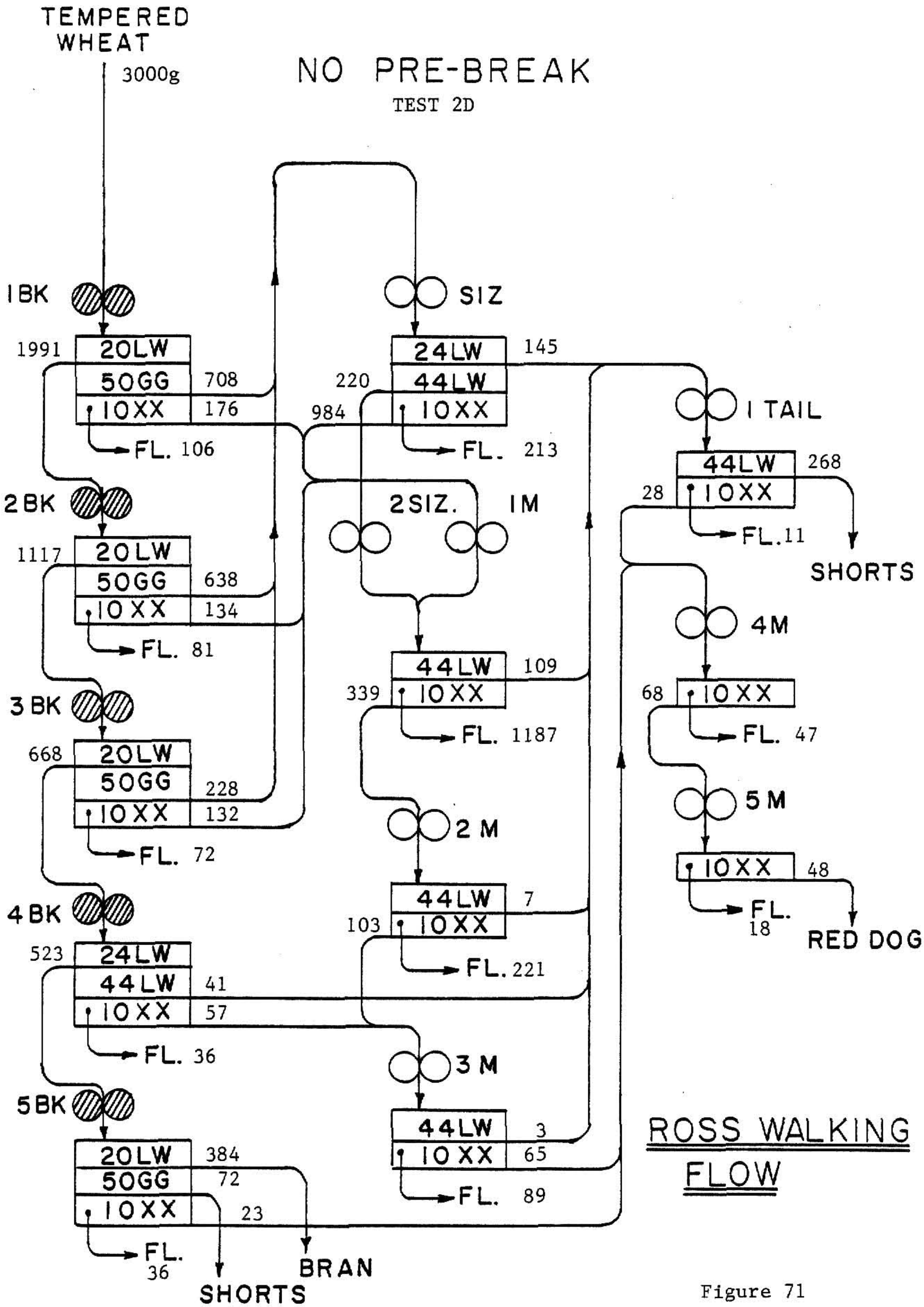

TEMPERED WHEAT
3000g
NO PRE-BREAK
TEST 2D
1BK
1991
20LW
50GG
10XX
708
176
FL. 106
SIZ
24LW
44LW
10XX
145
220
984
FL. 213
1 TAIL
44LW
10XX
268
28
FL. 11
SHORTS
2BK
1117
20LW
50GG
10XX
638
134
FL. 81
2SIZ.
1M
44LW
10XX
109
339
FL. 1187
4M
10XX
68
FL. 47
3BK
668
20LW
50GG
10XX
228
132
FL. 72
2M
44LW
10XX
7
103
FL. 221
5M
10XX
48
FL. 18
RED DOG
4BK
523
24LW
44LW
10XX
41
57
FL. 36
3M
44LW
10XX
3
65
FL. 89
5BK
20LW
50GG
10XX
384
72
23
FL. 36
SHORTS
BRAN
ROSS WALKING FLOW

Figure 71

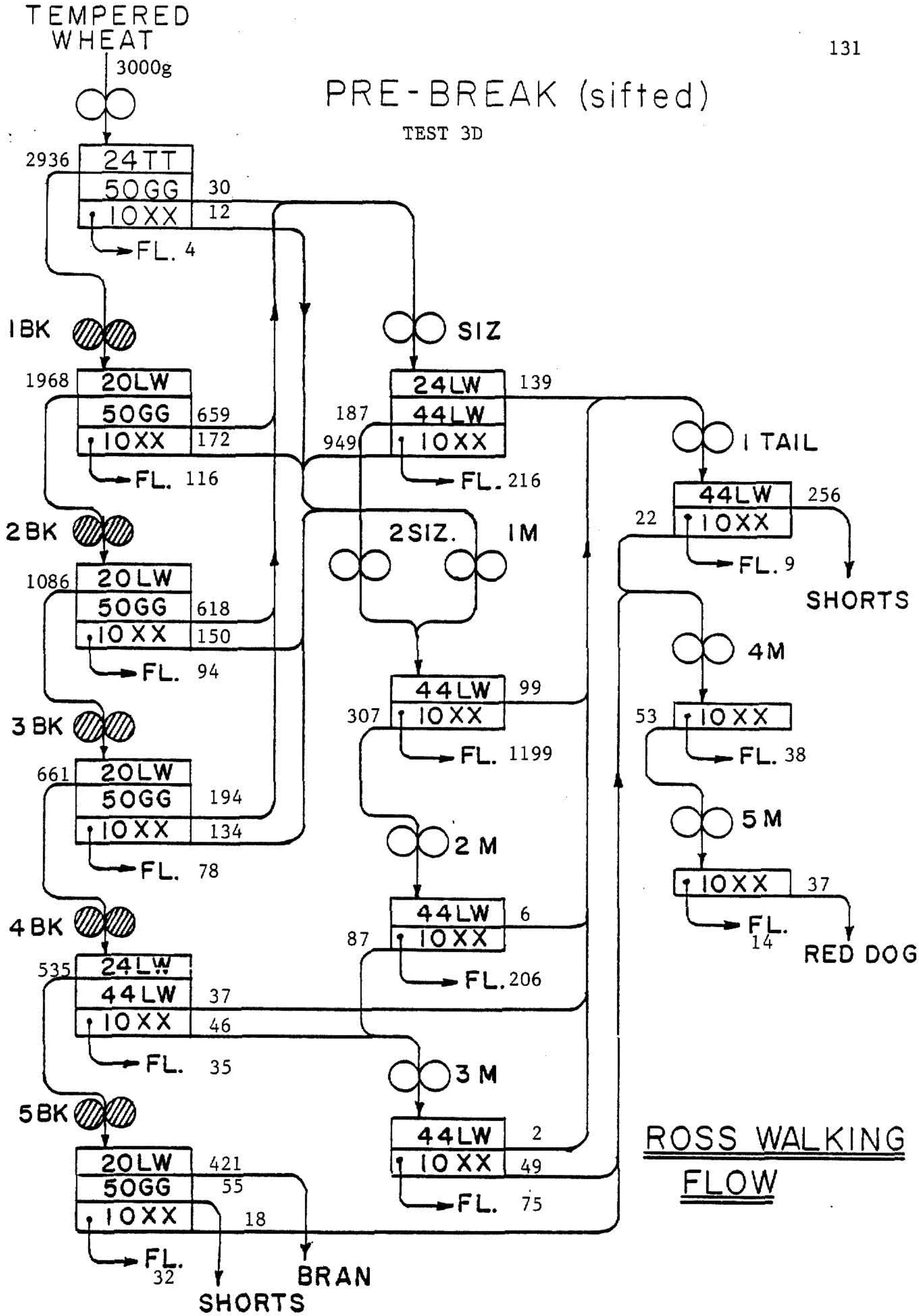
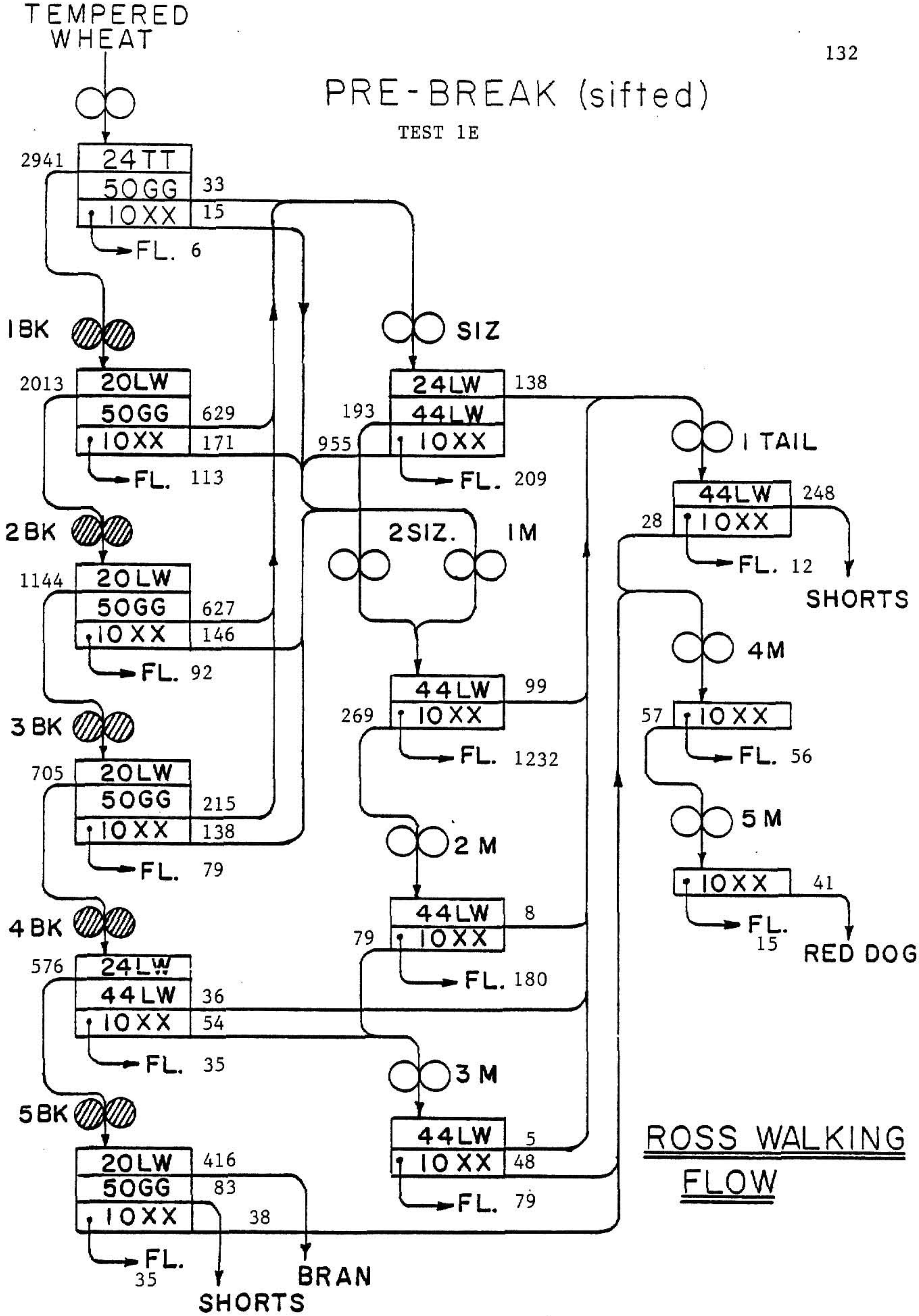

TEMPERED WHEAT
3000g
PRE-BREAK (sifted)
TEST 3D
2936
24TT
50GG
30
10XX
12
FL. 4
1BK
SIZ
1968
20LW
50GG
659
10XX
172
FL. 116
24LW
139
187
44LW
949
10XX
FL. 216
1 TAIL
44LW
256
22
10XX
FL. 9
SHORTS
2BK
2SIZ.
1M
1086
20LW
50GG
618
10XX
150
FL. 94
4M
44LW
99
307
10XX
FL. 1199
53
10XX
FL. 38
3 BK
661
20LW
50GG
194
10XX
134
FL. 78
2 M
5 M
10XX
37
FL.
14
RED DOG
44LW
6
87
10XX
FL. 206
4 BK
535
24LW
44LW
37
10XX
46
FL. 35
3 M
5BK
44LW
2
10XX
49
FL. 75
20LW
421
50GG
55
10XX
18
FL.
32
SHORTS
BRAN
ROSS WALKING FLOW

Figure 72



TEMPERED WHEAT
PRE-BREAK (sifted)
TEST 1E
2941
24TT
50GG
33
10XX
15
FL. 6
1BK
2013
20LW
50GG
629
10XX
171
FL. 113
SIZ
24LW
138
193
44LW
955
10XX
FL. 209
1 TAIL
44LW
248
28
10XX
FL. 12
SHORTS
2BK
2SIZ.
1M
1144
20LW
50GG
627
10XX
146
FL. 92
4M
44LW
99
269
10XX
FL. 1232
57
10XX
FL. 56
3 BK
705
20LW
50GG
215
10XX
138
FL. 79
5 M
2 M
10XX
41
44LW
8
79
10XX
FL. 15
RED DOG
4 BK
576
24LW
44 LW
36
10XX
54
FL. 180
FL. 35
3 M
5BK
44LW
5
10XX
48
FL. 79
20LW
416
50GG
83
10XX
38
FL. 35
SHORTS
BRAN
ROSS WALKING FLOW

Figure 73

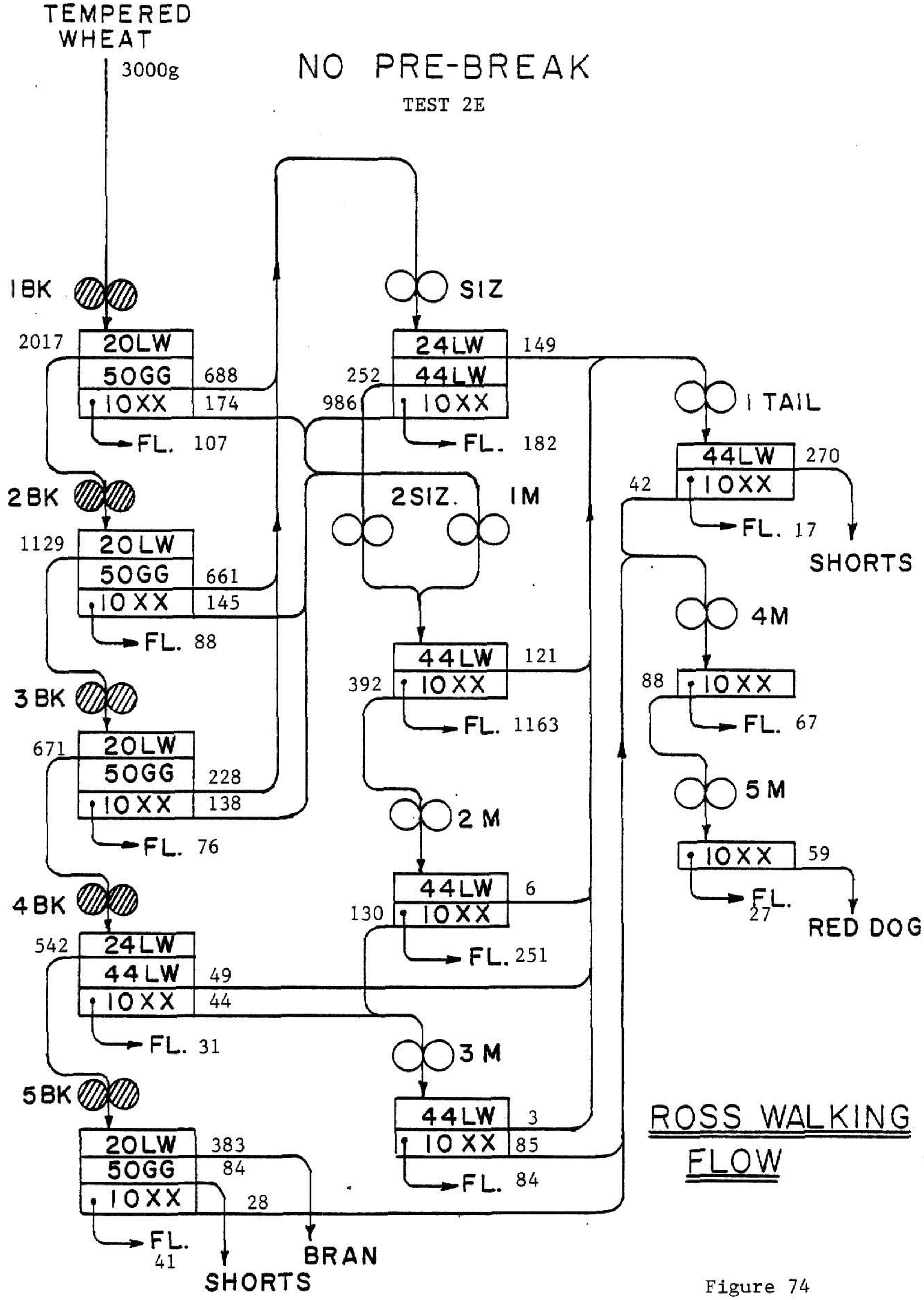

TEMPERED WHEAT
3000g
NO PRE-BREAK
TEST 2E
1BK
2017
20LW
50GG
688
10XX
174
FL. 107
SIZ
24LW
149
252
44LW
986
10XX
FL. 182
1 TAIL
44LW
270
42
10XX
FL. 17
SHORTS
2BK
1129
20LW
50GG
661
10XX
145
FL. 88
2SIZ.
1M
44LW
121
392
10XX
FL. 1163
4M
88
10XX
FL. 67
3BK
671
20LW
50GG
228
10XX
138
FL. 76
2M
5M
10XX
59
FL.
27
RED DOG
44LW
6
130
10XX
FL. 251
4BK
542
24LW
44LW
49
10XX
44
FL. 31
3M
5BK
44LW
3
10XX
85
FL. 84
20LW
383
50GG
84
10XX
28
FL.
41
SHORTS
BRAN
ROSS WALKING FLOW

Figure 74

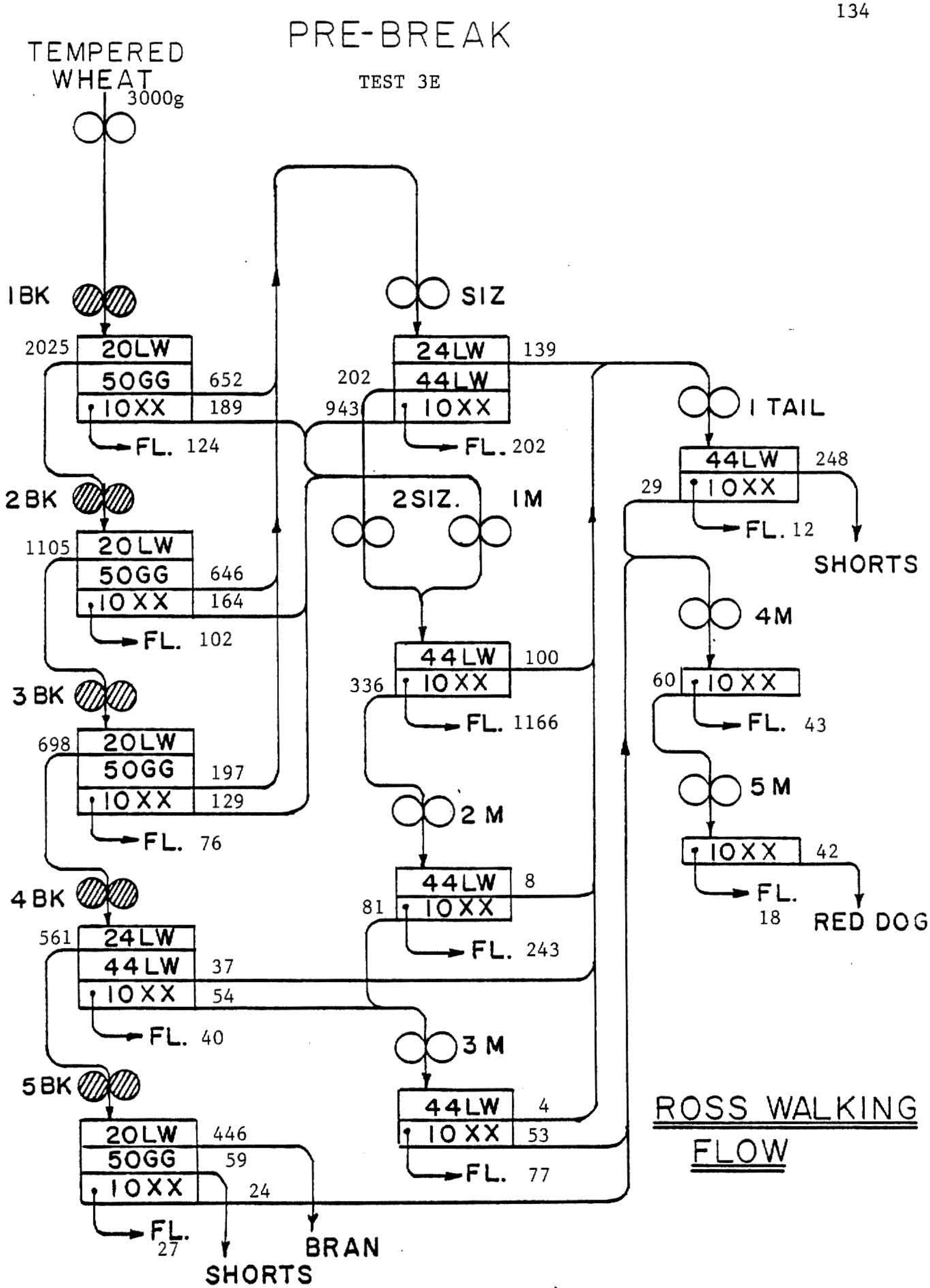

PRE-BREAK
TEST 3E
TEMPERED WHEAT
3000g
1BK
2025
20LW
50GG
652
10XX
189
FL. 124
2BK
1105
20LW
50GG
646
10XX
164
FL. 102
3BK
698
20LW
50GG
197
10XX
129
FL. 76
4BK
561
24LW
44LW
37
10XX
54
FL. 40
5BK
20LW
446
50GG
59
10XX
24
FL.
27
SHORTS
BRAN
SIZ
24LW
139
202
44LW
943
10XX
FL. 202
2SIZ.
1M
44LW
100
336
10XX
FL. 1166
2 M
44LW
8
81
10XX
FL. 243
3 M
44LW
4
10XX
53
FL. 77
1 TAIL
44LW
248
29
10XX
FL. 12
SHORTS
4M
60
10XX
FL. 43
5 M
10XX
42
FL.
18
RED DOG
ROSS WALKING FLOW

Figure 75

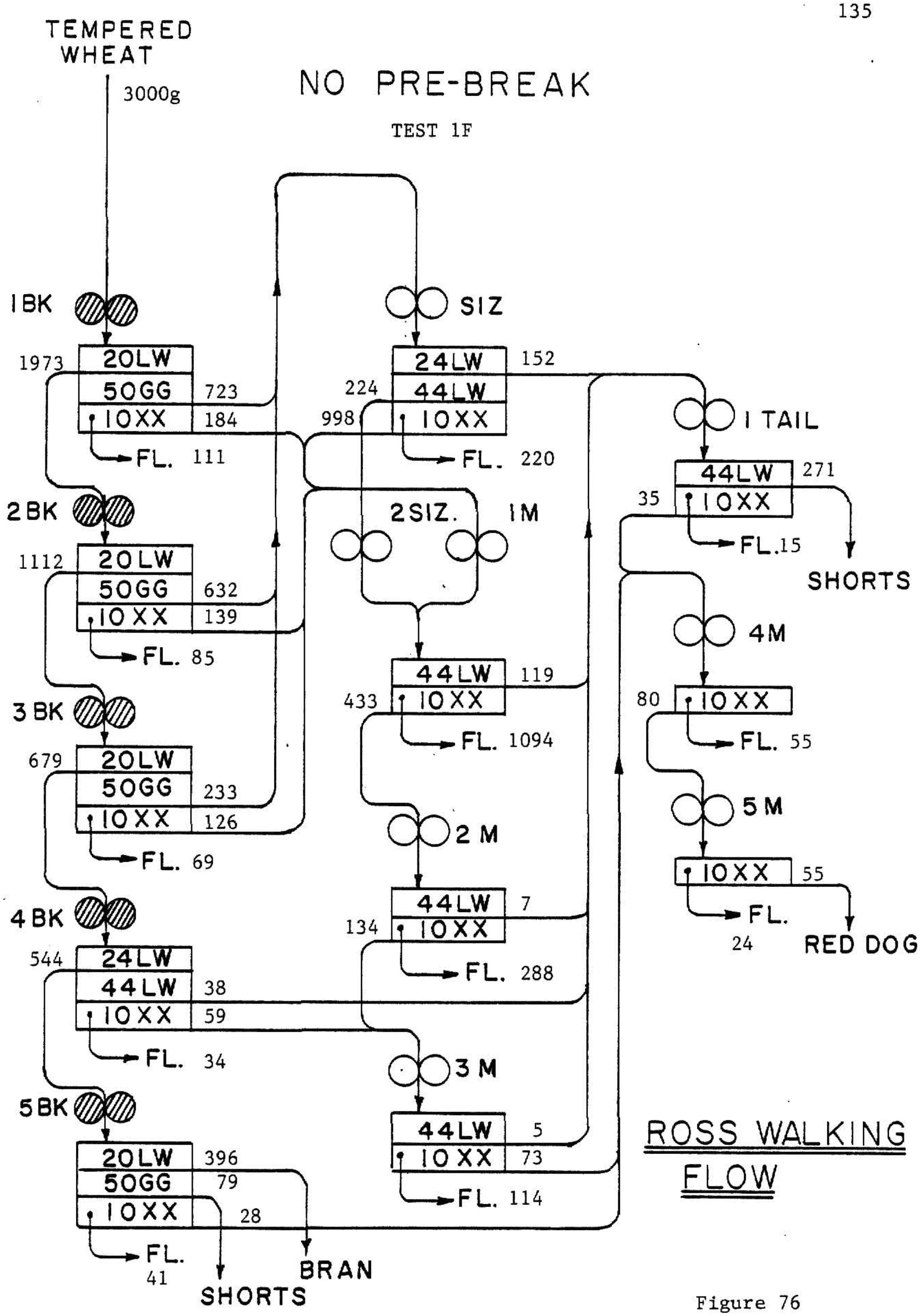
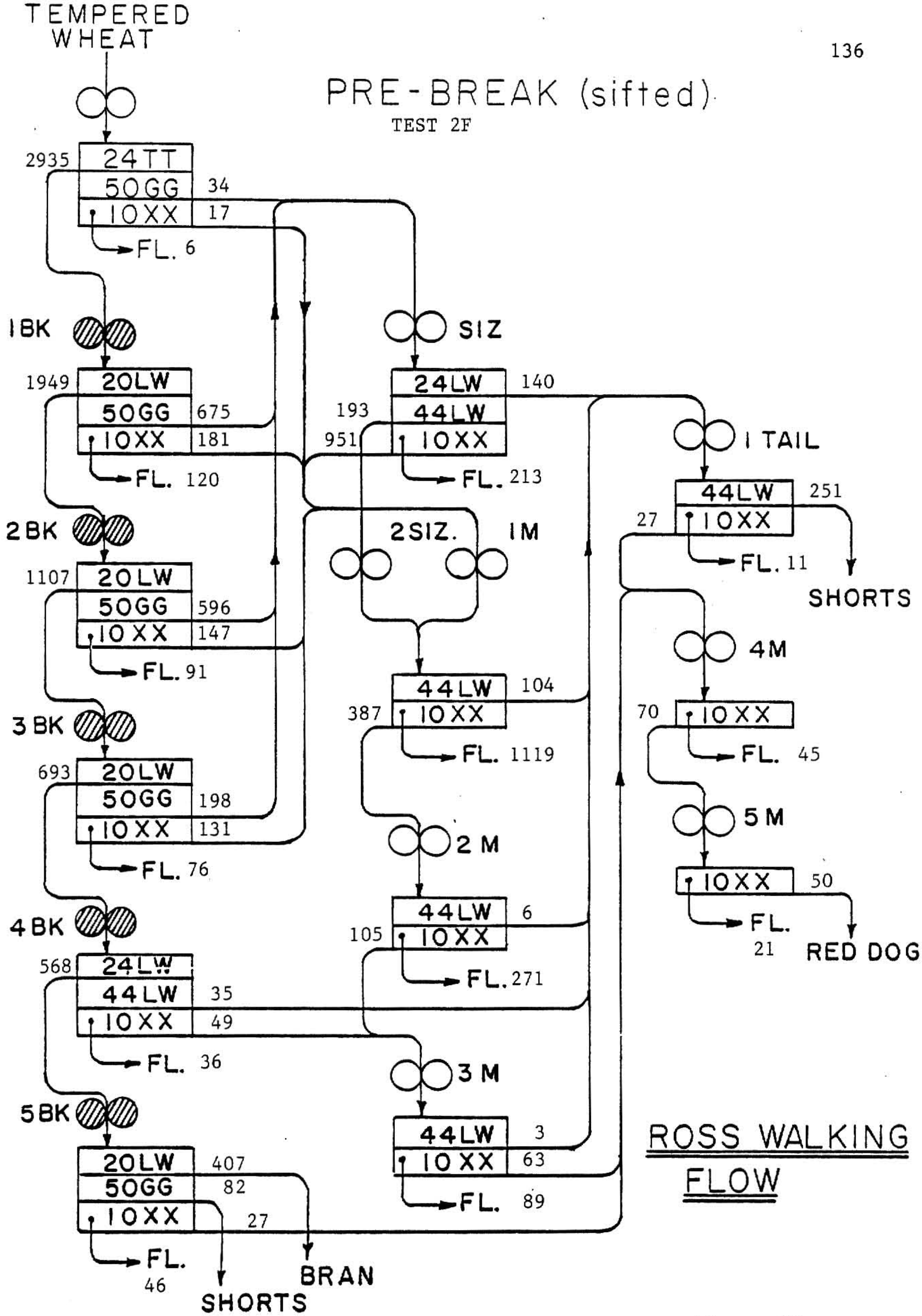

TEMPERED WHEAT
3000g
NO PRE-BREAK
TEST 1F
1BK
1973
20LW
50GG
723
10XX
184
FL. 111
SIZ
24LW
152
224
44LW
998
10XX
FL. 220
1 TAIL
44LW
271
35
10XX
FL.15
SHORTS
2BK
1112
20LW
50GG
632
10XX
139
FL. 85
2SIZ.
1M
44LW
119
433
10XX
FL. 1094
4M
80
10XX
FL. 55
3BK
679
20LW
50GG
233
10XX
126
FL. 69
2 M
44LW
7
134
10XX
FL. 288
5 M
10XX
55
FL.
24
RED DOG
4BK
544
24LW
44LW
38
10XX
59
FL. 34
3 M
44LW
5
10XX
73
FL. 114
5BK
20LW
396
50GG
79
10XX
28
FL.
41
SHORTS
BRAN
ROSS WALKING FLOW

Figure 76

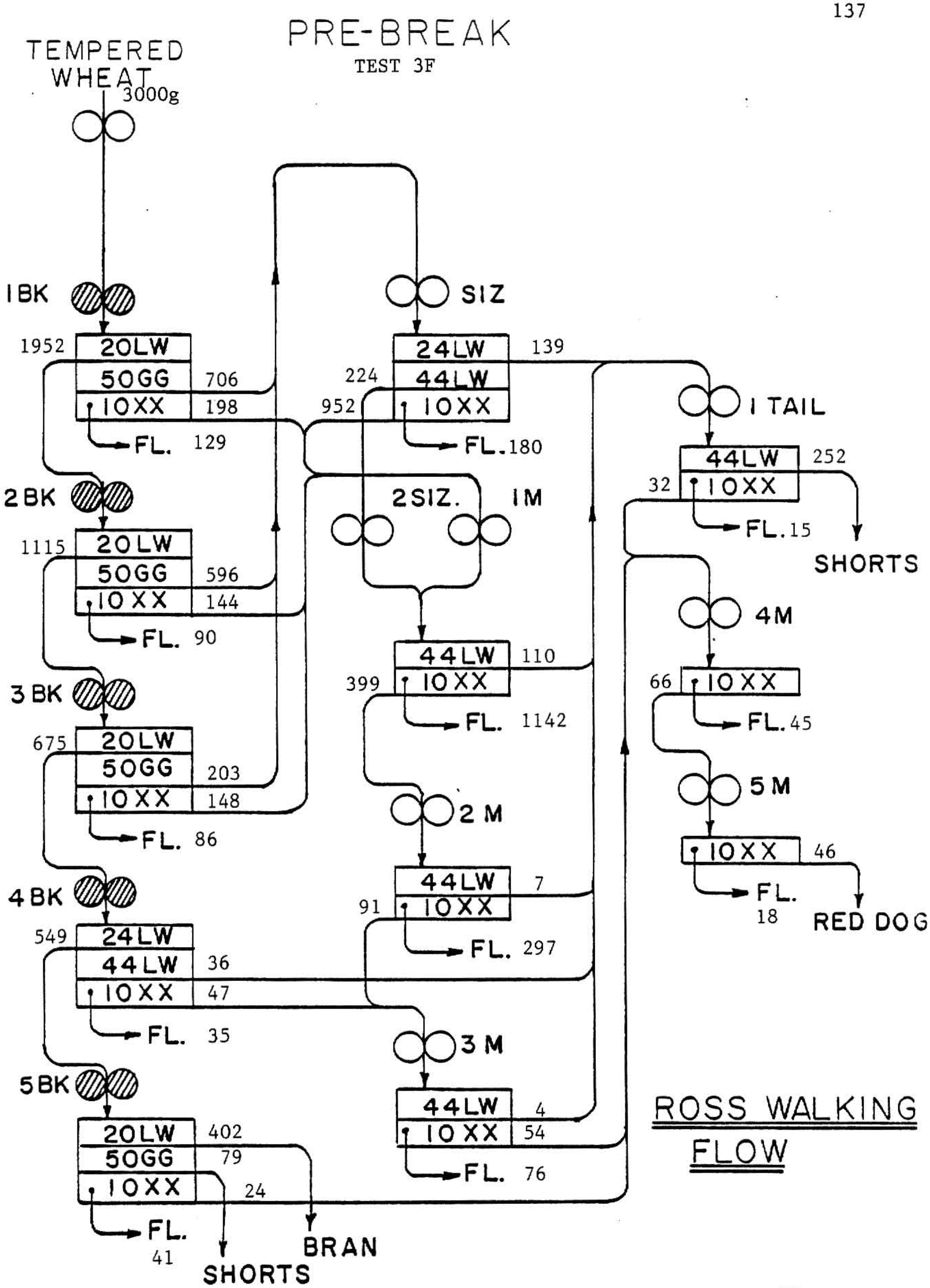
PRE-BREAK (sifted)

TEST 2F



ROSS WALKING FLOW

Figure 77



PRE-BREAK
TEST 3F
TEMPERED WHEAT 3000g
1BK
1952
20LW
50GG 706
10XX 198
FL. 129
2BK
1115
20LW
50GG 596
10XX 144
FL. 90
3 BK
675
20LW
50GG 203
10XX 148
FL. 86
4 BK
549
24LW
44LW 36
10XX 47
FL. 35
5BK
20LW 402
50GG 79
10XX 24
FL. 41
SHORTS
BRAN
SIZ
24LW 139
224 44LW
952 10XX
FL. 180
2SIZ.
1M
44LW 110
399 10XX
FL. 1142
2 M
44LW 7
91 10XX
FL. 297
3 M
44LW 4
10XX 54
FL. 76
1 TAIL
44LW 252
32 10XX
FL. 15
SHORTS
4M
66 10XX
FL. 45
5 M
10XX 46
FL. 18
RED DOG
ROSS WALKING FLOW

Figure 78

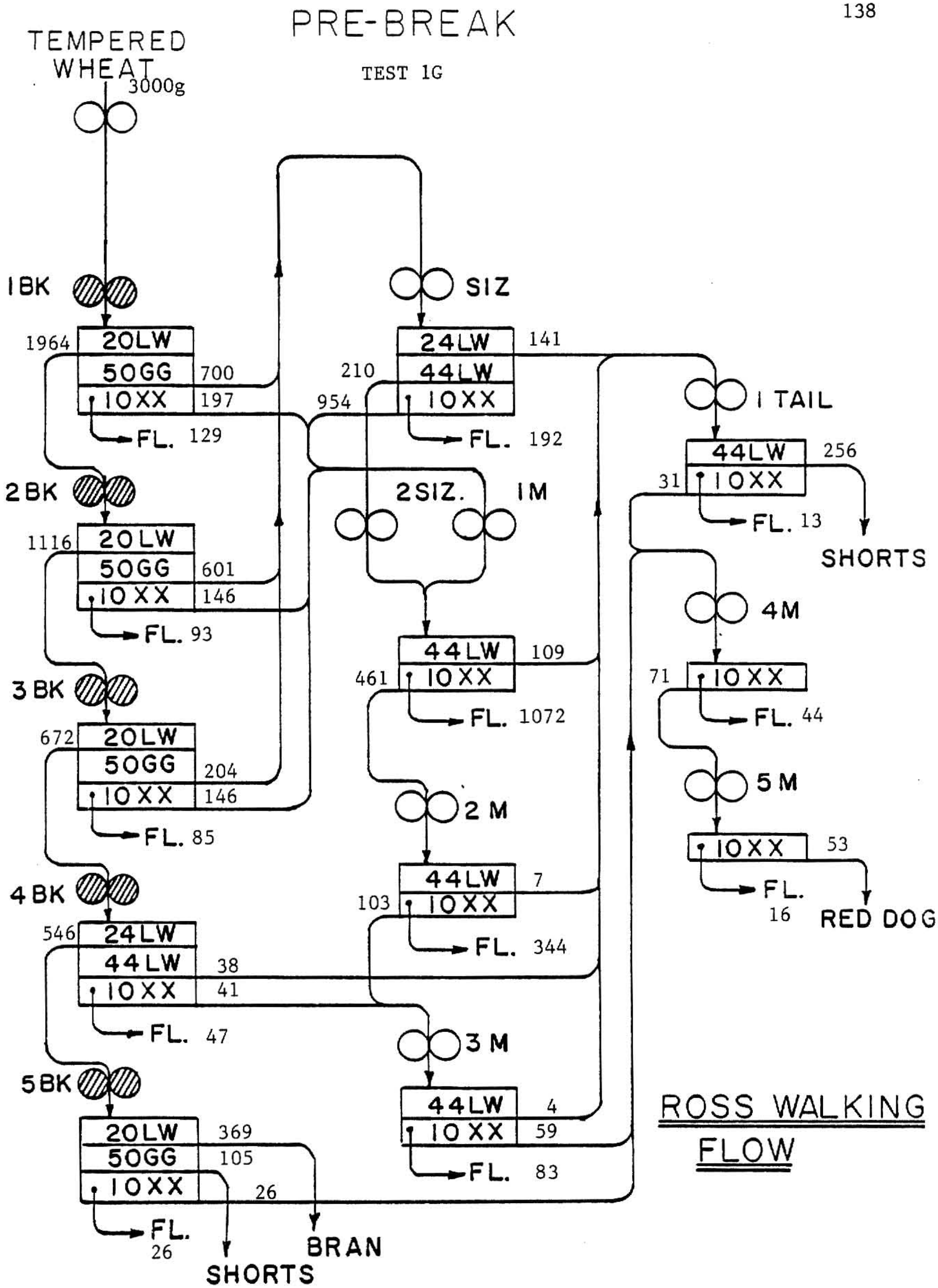

PRE-BREAK
TEST 1G
TEMPERED WHEAT
3000g
1BK
1964
20LW
50GG
700
10XX
197
FL. 129
SIZ
24LW
141
210
44LW
954
10XX
FL. 192
1 TAIL
44LW
256
31
10XX
FL. 13
SHORTS
2BK
1116
20LW
50GG
601
10XX
146
FL. 93
2SIZ.
1M
44LW
109
461
10XX
FL. 1072
4M
71
10XX
FL. 44
3BK
672
20LW
50GG
204
10XX
146
FL. 85
2M
5M
10XX
53
FL.
16
RED DOG
4BK
546
24LW
44LW
38
10XX
41
FL. 47
44LW
7
103
10XX
FL. 344
3M
5BK
20LW
369
50GG
105
10XX
26
FL.
26
SHORTS
BRAN
44LW
4
10XX
59
FL. 83
ROSS WALKING FLOW

Figure 79

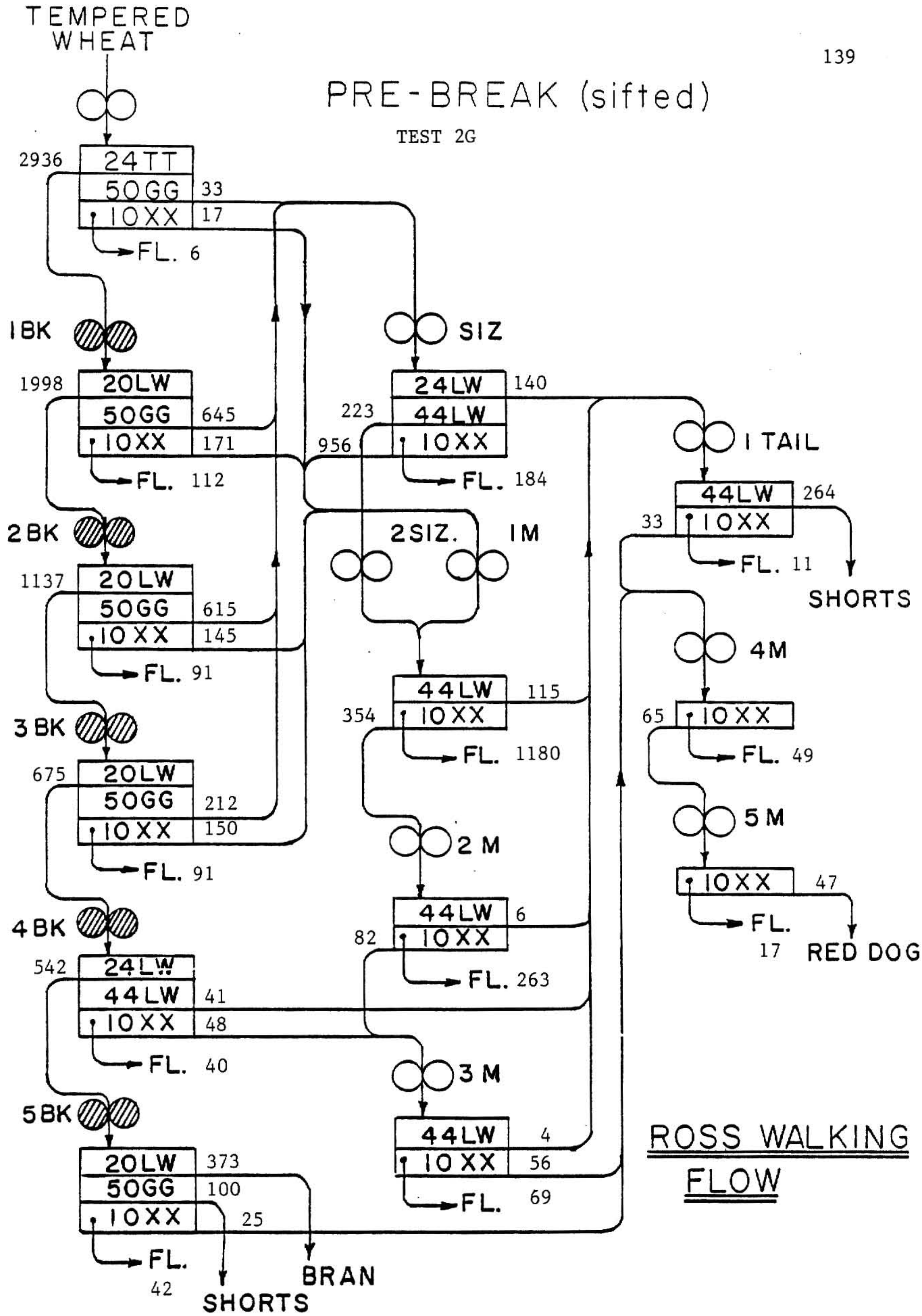

TEMPERED WHEAT
PRE-BREAK (sifted)
TEST 2G
2936
24TT
50GG 33
10XX 17
FL. 6
1BK
SIZ
1998
20LW
50GG 645
10XX 171
FL. 112
24LW 140
223
44LW
956
10XX
FL. 184
1 TAIL
44LW 264
33
10XX
FL. 11
SHORTS
2BK
2SIZ.
1M
1137
20LW
50GG 615
10XX 145
FL. 91
4M
44LW 115
354
10XX
FL. 1180
65
10XX
FL. 49
3BK
675
20LW
50GG 212
10XX 150
FL. 91
5M
2 M
10XX 47
FL.
17
RED DOG
44LW 6
82
10XX
FL. 263
4BK
542
24LW
44LW 41
10XX 48
FL. 40
3 M
5BK
44LW 4
10XX 56
FL. 69
20LW 373
50GG 100
10XX 25
FL.
42
SHORTS
BRAN
ROSS WALKING FLOW

Figure 80

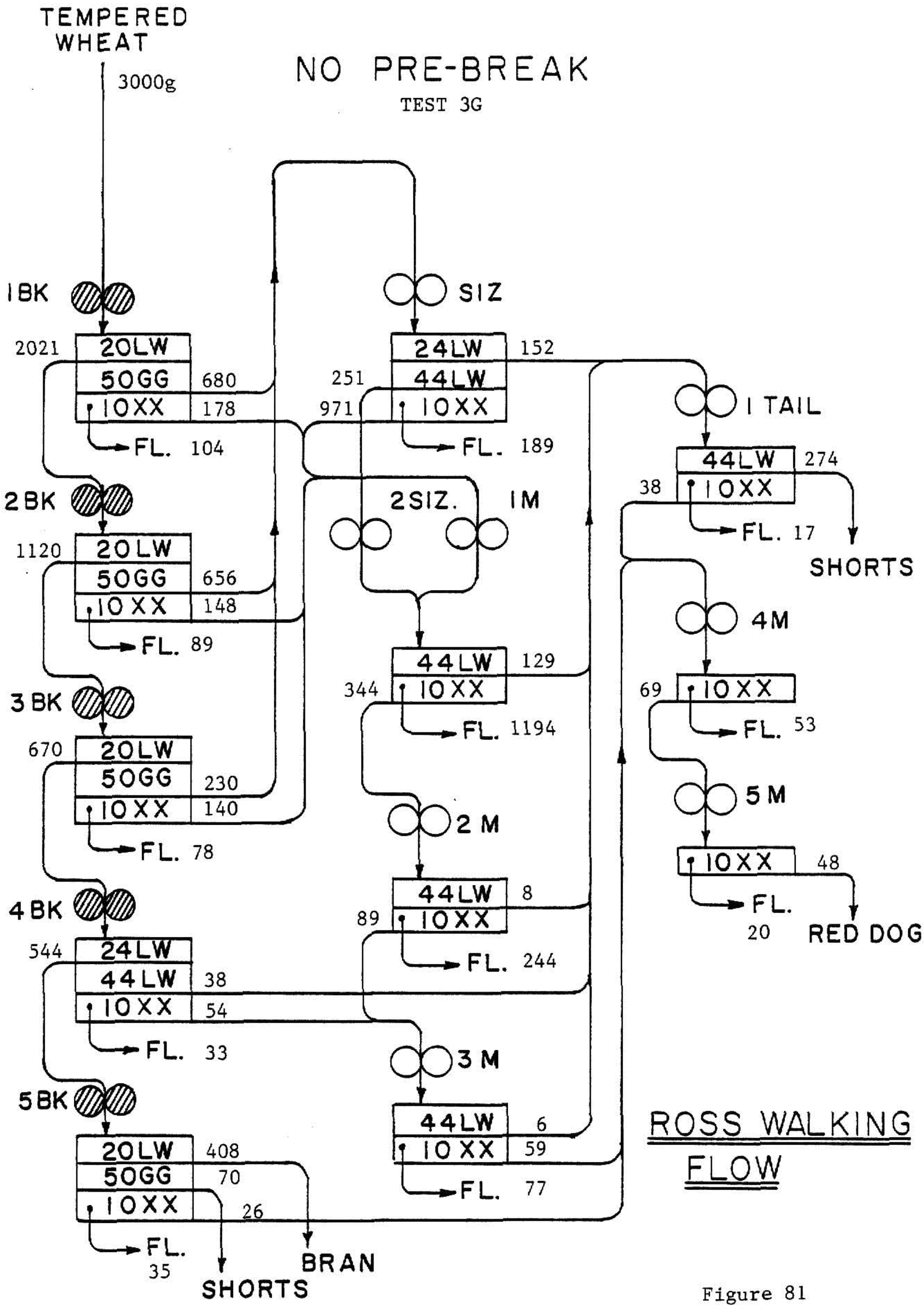

TEMPERED WHEAT
3000g
NO PRE-BREAK
TEST 3G
1BK
2021
20LW
50GG
680
10XX
178
FL. 104
2BK
1120
20LW
50GG
656
10XX
148
FL. 89
3BK
670
20LW
50GG
230
10XX
140
FL. 78
4BK
544
24LW
44LW
38
10XX
54
FL. 33
5BK
20LW
408
50GG
70
10XX
26
FL.
35
SHORTS
BRAN
SIZ
24LW
152
251
44LW
971
10XX
FL. 189
2SIZ.
1M
44LW
129
344
10XX
FL. 1194
2M
44LW
8
89
10XX
FL. 244
3M
44LW
6
10XX
59
FL. 77
1 TAIL
44LW
274
38
10XX
FL. 17
SHORTS
4M
69
10XX
FL. 53
5M
10XX
48
FL.
20
RED DOG
ROSS WALKING FLOW

Figure 81

Table 14

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: ROSS FLOW
TEST: C
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK							
1 M	1216	41.83	41.83	.284	11.880	11.880	.284
SIZ	182	6.26	48.09	.315	1.972	13.852	.288
2 M	215	7.40	55.49	.319	2.361	16.213	.292
3 BK	66	2.27	57.76	.393	0.892	17.105	.296
2 BK	80	2.75	60.51	.413	1.136	18.241	.301
3 M	98	3.37	63.88	.417	1.405	19.646	.308
4 BK	38	1.31	65.19	.452	0.592	20.238	.310
1 BK	109	3.75	68.94	.496	1.860	22.098	.321
1 TA	12	0.41	69.35	.575	0.236	22.334	.322
5 BK	44	1.51	70.86	.644	0.972	23.306	.329
4 M	54	1.86	72.72	.714	1.328	24.634	.339
5 M	17	0.58	73.30	1.463	0.849	25.483	.348
PRE-BREAK NOT SIFTED							
1 M	1168	40.30	40.30	.269	10.841	10.841	.269
2 M	247	8.52	48.82	.293	2.496	13.337	.273
SIZ	184	6.35	55.17	.298	1.892	15.229	.276
3 BK	70	2.42	57.59	.369	0.893	16.122	.280
2 BK	90	3.11	60.70	.380	1.182	17.304	.285
3 M	95	3.28	63.98	.393	1.289	18.593	.291
1 BK	127	4.38	68.36	.418	1.831	20.424	.299
4 BK	38	1.31	69.67	.429	0.562	20.986	.301
5 BK	39	1.35	71.02	.557	0.752	21.738	.306
1 TA	11	0.38	71.40	.575	0.219	21.956	.308
4 M	42	1.45	72.35	.601	0.871	22.828	.313
5 M	15	0.52	73.37	1.085	0.564	23.392	.319
PRE-BREAK SIFTED							
1 M	1239	42.55	42.55	.284	12.084	12.084	.284
2 M	187	6.42	46.97	.308	1.977	14.062	.287
SIZ	195	6.70	55.67	.311	2.084	16.145	.290
3 BK	76	2.61	58.28	.354	0.924	17.069	.293
2 BK	89	3.06	61.34	.360	1.102	18.171	.296
1 BK	114	3.91	65.25	.398	1.556	19.727	.302
3 M	87	2.99	68.24	.410	1.226	20.953	.307
4 BK	38	1.30	69.54	.448	0.582	21.535	.310
1 TA	12	0.41	69.95	.540	0.221	21.757	.311
P BK	5	0.17	70.12	.600	0.102	21.859	.312
5 BK	43	1.48	71.60	.601	0.889	22.748	.318
4 M	46	1.58	73.18	.728	1.150	23.898	.327
5 M	14	0.48	73.66	1.627	0.781	24.679	.335

Table 15

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL ROSS FLOW
TEST D
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
PRE-BREAK NOT SIFTED							
1 M	1203	41.89	41.89	.274	11.748	11.748	.274
2 M	197	6.86	48.75	.296	2.031	13.508	.277
SIZ	212	7.38	56.13	.300	2.214	15.722	.280
3 BK	76	2.65	58.78	.369	0.978	16.700	.284
2 BK	88	3.06	61.84	.388	1.187	17.888	.289
3 M	84	2.92	64.76	.392	1.145	19.032	.294
1 BK	124	4.32	69.08	.422	1.823	20.855	.302
4 BK	34	1.18	70.26	.432	0.510	21.365	.304
1 TA	11	0.38	70.64	.555	0.211	21.576	.305
5 BK	45	1.57	72.21	.632	0.992	22.568	.313
4 M	44	1.53	73.74	.641	0.981	23.549	.319
5 M	15	0.52	74.26	1.415	0.736	24.285	.327
NO PRE-BREAK							
1 M	1187	41.09	41.09	.279	11.464	11.464	.279
SIZ	213	7.37	48.46	.302	2.226	13.690	.283
2 M	221	7.65	56.11	.328	2.509	16.199	.289
3 BK	72	2.49	58.60	.379	.994	17.193	.293
2 BK	81	2.80	61.40	.406	1.137	18.330	.299
3 M	89	3.08	64.48	.441	1.358	19.688	.305
4 BK	36	1.25	65.73	.450	0.563	20.251	.308
1 BK	106	3.67	69.40	.487	1.787	22.038	.318
1 TA	11	0.38	69.78	.608	0.231	22.269	.319
5 BK	36	1.25	71.03	.625	0.781	23.050	.325
4 M	47	1.63	72.66	.717	1.169	24.219	.333
5 M	18	0.62	73.28	1.402	0.869	25.088	.342
PRE-BREAK SIFTED							
1 M	1199	41.56	41.56	.266	11.055	11.055	.266
SIZ	216	7.49	49.05	.290	2.172	13.227	.270
2M	206	7.14	56.19	.300	2.142	15.369	.274
3 BK	78	2.70	58.89	.367	0.991	16.360	.278
2 BK	94	3.26	62.15	.376	1.226	17.586	.283
1 BK	116	4.02	66.17	.410	1.648	19.234	.291
3 M	75	2.60	68.77	.417	1.084	20.318	.295
4 BK	35	1.21	69.98	.452	0.547	20.865	.298
1 TA	9	0.31	70.29	.562	0.174	21.039	.299
5 BK	32	1.11	71.40	.575	0.638	21.677	.304
P BK	4	0.14	71.54	.614	0.086	21.763	.304
4 M	38	1.32	72.86	.666	0.879	22.642	.311
5 M	14	0.49	73.35	1.446	0.709	23.351	.318

Table 16

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL ROSS FLOW
TEST E
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
PRE-BREAK SIFTED							
1 M	1232	42.03	42.03	.264	11.096	11.096	.264
SIZ	209	7.13	49.16	.288	2.053	13.149	.267
2 M	180	6.14	55.30	.293	1.799	14.948	.270
3 BK	79	2.70	58.00	.357	0.964	15.912	.274
3 M	79	2.70	60.70	.375	1.013	16.925	.279
2 BK	92	3.14	63.84	.378	1.187	18.112	.284
1 BK	113	3.86	67.70	.415	1.602	19.714	.291
4 BK	35	1.19	68.89	.421	0.501	20.215	.293
1 TA	12	0.41	69.30	.544	0.223	20.433	.295
5 BK	35	1.19	70.49	.566	0.674	21.111	.299
P BK	6	0.20	70.69	.600	0.120	21.231	.300
4 M	56	1.91	72.60	.636	1.215	22.446	.309
5 M	15	0.51	73.11	1.263	0.644	23.090	.316
NO PRE-BREAK							
1 M	1163	39.69	39.69	.266	10.558	10.558	.266
SIZ	182	6.21	45.90	.316	1.962	12.520	.273
2 M	251	8.57	54.47	.316	2.708	15.228	.280
3 M	84	2.87	57.34	.373	1.071	16.299	.284
3 BK	76	2.59	59.93	.382	0.989	17.288	.288
2 BK	88	3.00	62.93	.397	1.191	18.479	.294
4 BK	31	1.06	63.99	.449	0.476	18.955	.296
1 BK	107	3.65	67.64	.494	1.803	20.758	.307
4 M	67	2.29	69.93	.576	1.319	22.077	.316
1 TA	17	0.58	70.51	.586	0.340	22.417	.318
5 BK	41	1.40	71.91	.637	0.892	23.309	.324
5 M	27	0.92	72.83	1.057	0.972	24.281	.333
PRE-BREAK NOT SIFTED							
1 M	1166	39.86	39.86	.267	10.643	10.643	.267
SIZ	202	6.91	46.77	.288	1.990	12.633	.270
2 M	243	8.31	55.08	.300	2.493	15.126	.275
3 BK	76	2.60	57.68	.364	0.946	16.072	.279
2 BK	102	3.49	61.17	.378	1.319	17.391	.284
3 M	77	2.63	63.80	.394	1.036	18.428	.289
1 BK	124	4.24	68.04	.415	1.760	20.187	.297
4 BK	40	1.37	69.41	.417	0.571	20.758	.299
5 BK	27	0.92	70.33	.523	0.481	21.240	.302
4 M	43	1.47	71.80	.580	0.853	22.092	.308
1 TA	12	0.41	72.21	.588	0.241	22.333	.309
5 M	18	0.62	72.83	1.081	0.670	23.003	.316

Table 17

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: ROSS FLOW
TEST: F
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK							
1 M	1094	37.07	37.07	.277	10.268	10.268	.277
2 M	288	9.76	46.83	.299	2.918	13.187	.282
SIZ	220	7.46	54.29	.311	2.320	15.507	.286
3 BK	69	2.34	56.63	.381	0.892	16.398	.290
3 M	114	3.86	60.49	.382	1.475	17.873	.295
2 BK	85	2.88	63.37	.411	1.184	19.056	.301
4 BK	34	1.15	64.52	.417	0.480	19.536	.303
1 BK	111	3.76	68.28	.501	1.884	21.420	.314
4 M	55	1.86	70.14	.554	1.030	22.450	.320
1 TA	15	0.51	70.65	.569	0.290	22.740	.322
5 BK	41	1.39	72.04	.598	0.831	23.572	.327
5 M	24	0.81	72.85	1.014	0.821	24.393	.335
PRE-BREAK SIFTED							
1 M	1119	38.14	38.14	.254	9.688	9.688	.254
SIZ	213	7.26	45.40	.277	2.011	11.699	.258
2 M	271	9.24	54.64	.279	2.578	14.277	.261
3 BK	76	2.59	57.23	.351	0.909	15.186	.265
3 M	89	3.03	60.26	.356	1.079	16.264	.270
2 BK	91	3.10	63.36	.386	1.197	17.461	.276
4 BK	36	1.23	64.59	.411	0.506	17.966	.278
1 BK	120	4.09	68.68	.412	1.639	19.656	.286
1 TA	11	0.37	69.05	.502	0.186	19.841	.287
4 M	45	1.53	70.58	.537	0.822	20.663	.293
5 BK	46	1.57	72.15	.581	0.912	21.575	.299
P BK	6	0.20	72.35	.646	0.129	21.704	.300
5 M	21	0.72	73.07	.939	0.676	22.380	.306
PRE-BREAK NOT SIFTED							
1 M	1142	38.94	38.94	.261	10.163	10.163	.261
SIZ	180	6.14	45.08	.292	1.793	11.956	.265
2 M	297	10.13	55.21	.292	2.958	14.914	.270
3 BK	86	2.93	58.14	.356	1.043	15.957	.274
2 BK	90	3.07	61.21	.374	1.148	17.105	.279
3 M	76	2.59	63.80	.398	1.031	18.136	.284
1 BK	129	4.40	68.20	.413	1.817	19.953	.293
4 BK	35	1.19	69.39	.423	0.503	20.456	.295
1 TA	15	0.51	69.90	.583	0.297	20.753	.297
4 M	45	1.53	71.43	.597	0.913	21.666	.303
5 BK	41	1.40	72.83	.679	0.951	22.617	.311
5 M	18	0.61	73.44	1.073	0.655	23.272	.317

Table 18

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: ROSS FLOW
TEST: G
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
PRE-BREAK NOT SIFTED							
1 M	1072	36.62	36.62	.274	10.034	10.034	.274
2 M	344	11.75	48.37	.294	3.455	13.488	.279
SIZ	192	6.56	54.93	.298	1.955	15.443	.281
3 BK	85	2.90	57.83	.363	1.053	16.496	.285
3 M	83	2.84	60.67	.381	1.082	17.578	.290
2 BK	93	3.18	63.85	.383	1.218	18.796	.294
1 BK	129	4.41	68.26	.423	1.865	20.661	.303
4 BK	47	1.61	69.87	.434	0.699	21.360	.306
1 TA	13	0.44	70.31	.561	0.247	21.607	.307
4 M	44	1.50	71.81	.617	0.926	22.532	.314
5 BK	26	0.89	72.70	.686	0.611	23.143	.318
5 M	16	0.55	73.25	1.039	0.571	23.714	.324
PRE-BREAK SIFTED							
1 M	1180	40.15	40.15	.262	10.519	10.519	.262
SIZ	184	6.26	46.41	.288	1.803	12.322	.266
2 M	263	8.95	55.36	.306	2.739	15.061	.272
3 BK	91	3.10	58.46	.356	1.104	16.164	.277
2 BK	91	3.10	61.56	.368	1.141	17.305	.281
3 M	69	2.35	63.91	.387	0.909	18.215	.285
1 BK	112	3.81	67.72	.413	1.574	19.788	.292
4 BK	40	1.36	69.08	.432	0.588	20.376	.295
1 TA	11	0.37	69.45	.516	0.191	20.567	.296
P BK	6	0.20	69.65	.576	0.115	20.682	.297
4 M	49	1.67	71.32	.661	1.104	21.786	.305
5 BK	42	1.43	72.75	.680	0.972	22.758	.313
5 M	17	0.58	73.33	1.319	0.765	23.523	.321
NO PRE-BREAK							
1 M	1194	40.63	40.63	.268	10.889	10.889	.268
SIZ	189	6.43	47.06	.312	2.006	12.895	.274
2 M	244	8.30	55.36	.325	2.698	15.593	.282
3 BK	78	2.65	58.01	.381	1.010	16.602	.286
2 BK	89	3.03	61.04	.401	1.215	17.817	.292
3 M	77	2.62	63.66	.433	1.134	18.952	.298
4 BK	33	1.12	64.78	.456	0.511	19.462	.300
1 BK	110	3.74	68.52	.492	1.840	21.302	.311
1 TA	17	0.58	69.10	.560	0.325	21.627	.313
5 BK	35	1.19	70.29	.579	0.689	22.316	.317
4 M	53	1.80	72.09	.606	1.091	23.407	.325
5 M	20	0.68	72.77	1.279	0.870	24.277	.334

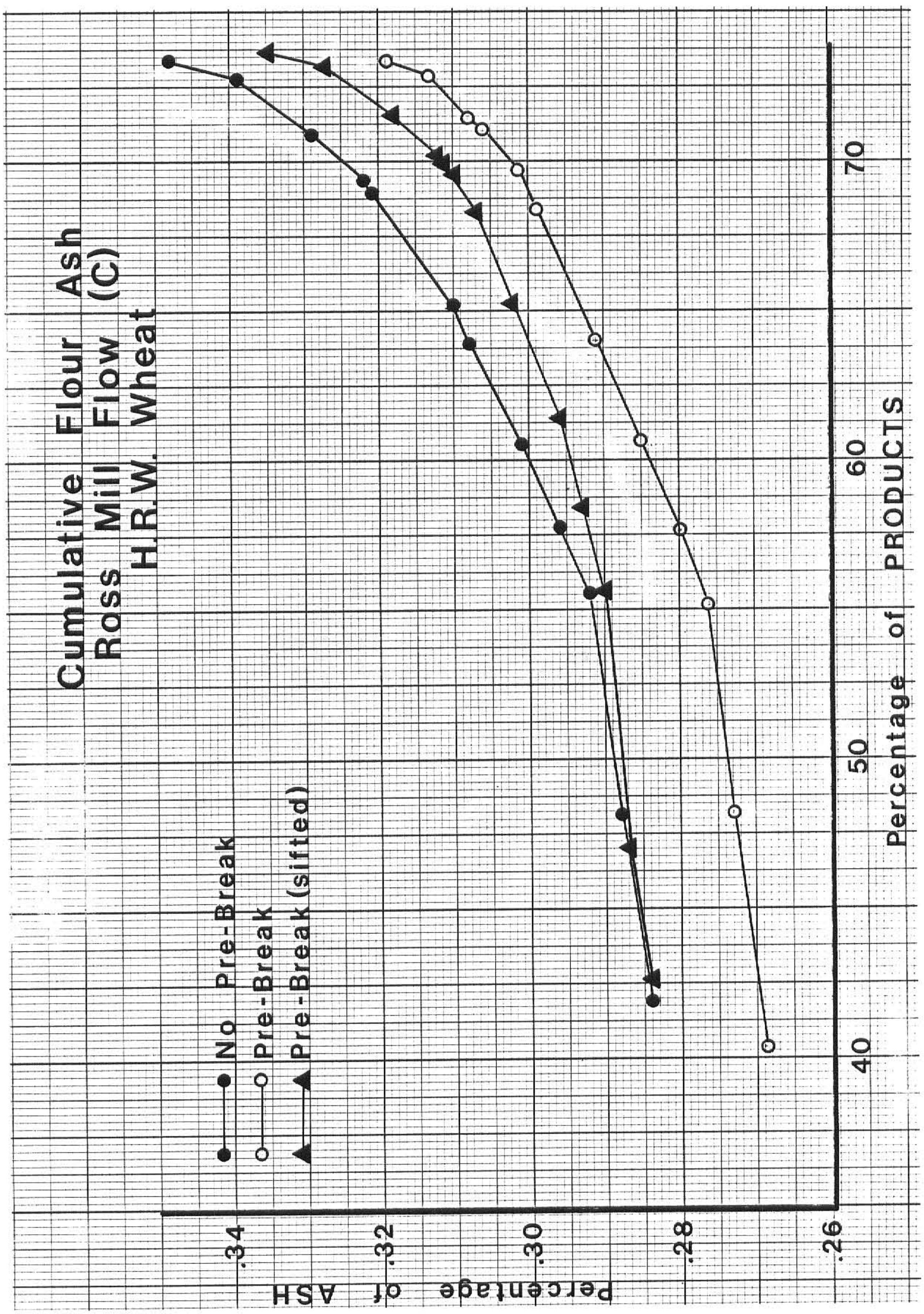

Cumulative Flour Ash
Ross Mill Flow (C)
H.R.W. Wheat
No Pre-Break
Pre-Break
Pre-Break (sifted)
Percentage of ASH
.34
.32
.30
.28
.26
40
50
60
70
Percentage of PRODUCTS

Figure 82

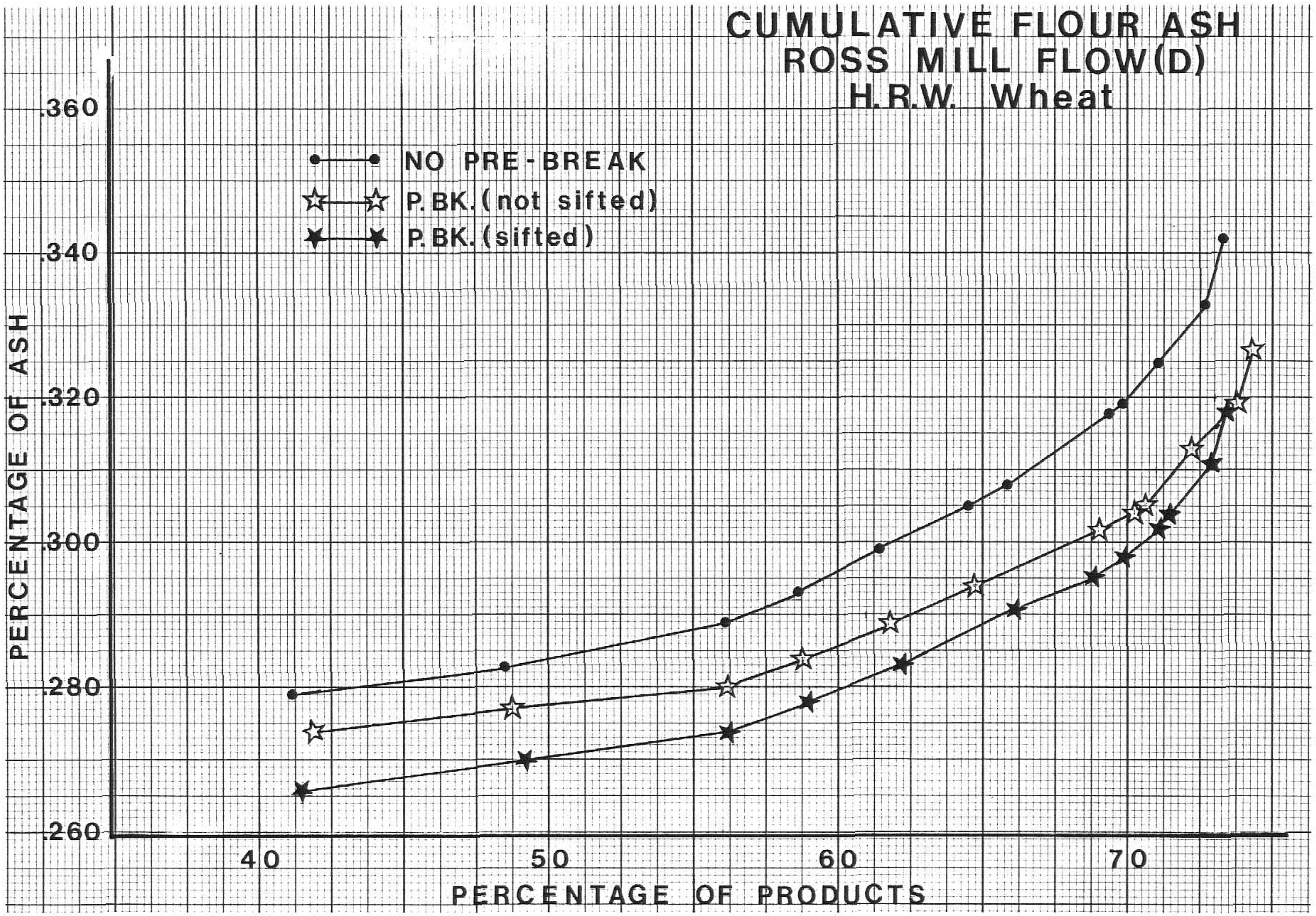
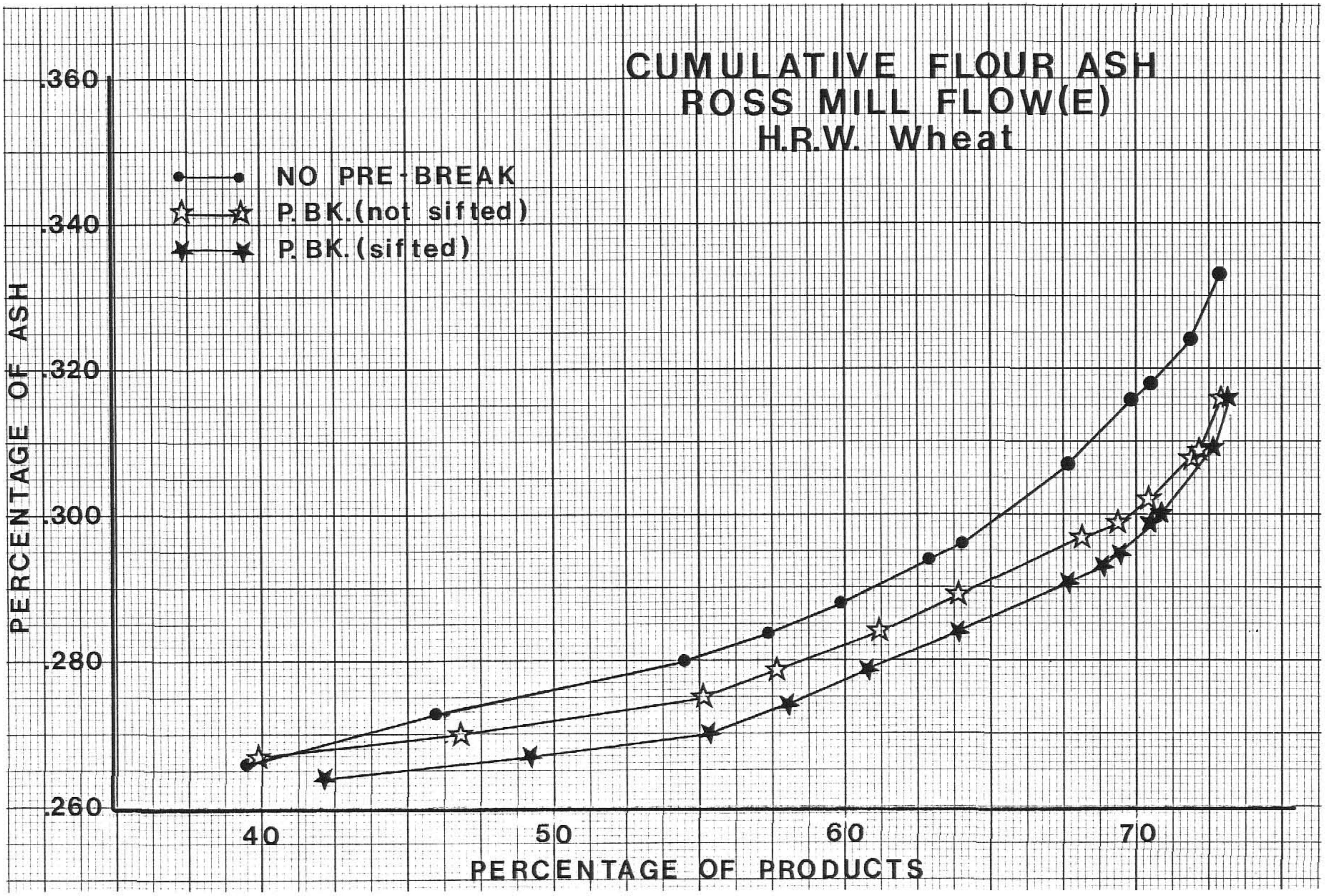
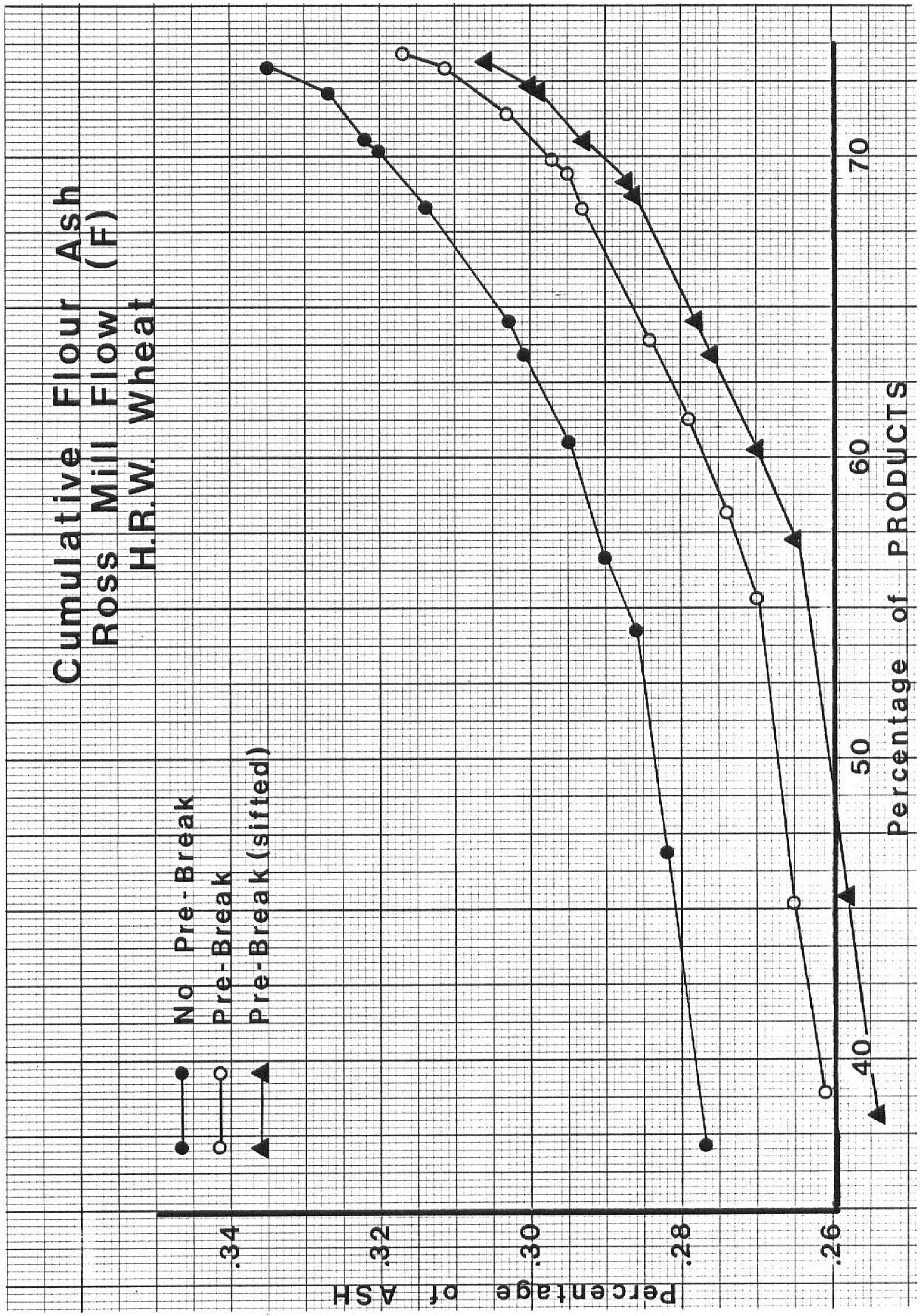

CUMULATIVE FLOUR ASH
ROSS MILL FLOW(D)
H.R.W. Wheat
NO PRE-BREAK
P. BK. (not sifted)
P. BK. (sifted)
PERCENTAGE OF ASH
.360
.340
.320
.300
.280
.260
40
50
60
70
PERCENTAGE OF PRODUCTS

Figure 83



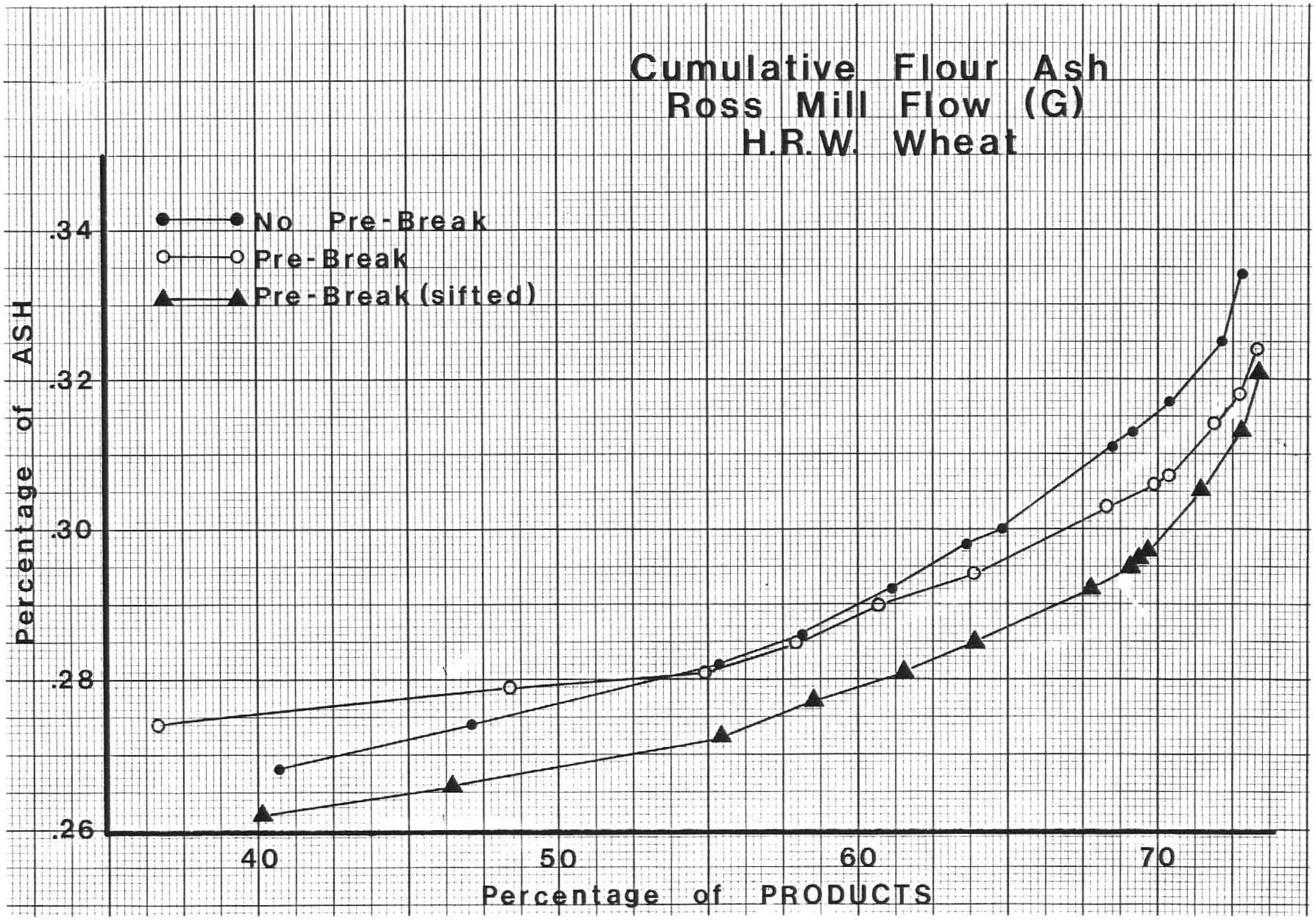
CUMULATIVE FLOUR ASH
ROSS MILL FLOW(E)
H.R.W. Wheat
NO PRE-BREAK
P. BK. (not sifted)
P. BK. (sifted)
PERCENTAGE OF ASH
.360
.340
.320
.300
.280
.260
PERCENTAGE OF PRODUCTS
40
50
60
70

Figure 84



Cumulative Flour Ash
Ross Mill Flow (F)
H.R.W. Wheat
No Pre-Break
Pre-Break
Pre-Break (sifted)
Percentage of ASH
.34
.32
.30
.28
.26
Percentage of PRODUCTS
40
50
60
70

Figure 85



Cumulative Flour Ash
Ross Mill Flow (G)
H.R.W. Wheat
No Pre-Break
Pre-Break
Pre-Break (sifted)
.34
.32
.30
.28
.26
Percentage of ASH
40
50
60
70
Percentage of PRODUCTS

Figure 86

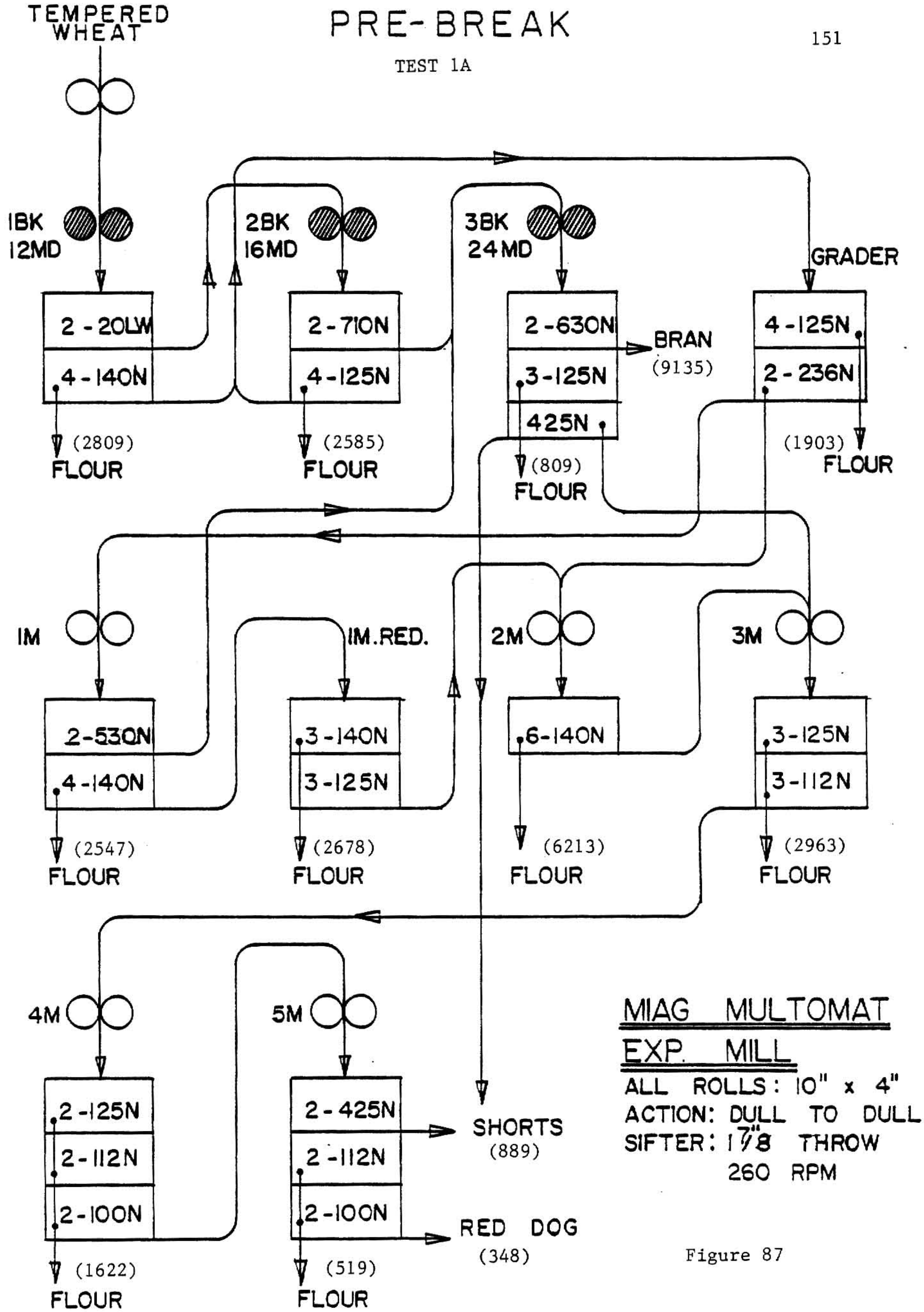

TEMPERED WHEAT
PRE-BREAK
TEST 1A
1BK 12MD
2BK 16MD
3BK 24MD
GRADER
2-20LW
4-140N
2-710N
4-125N
2-630N
3-125N
425N
4-125N
2-236N
BRAN (9135)
(2809) FLOUR
(2585) FLOUR
(809) FLOUR
(1903) FLOUR
1M
1M.RED.
2M
3M
2-530N
4-140N
3-140N
3-125N
6-140N
3-125N
3-112N
(2547) FLOUR
(2678) FLOUR
(6213) FLOUR
(2963) FLOUR
4M
5M
2-125N
2-112N
2-100N
2-425N
2-112N
2-100N
SHORTS (889)
RED DOG (348)
(1622) FLOUR
(519) FLOUR
MIAG MULTOMAT
EXP. MILL
ALL ROLLS: 10" x 4"
ACTION: DULL TO DULL
SIFTER: 1 7/8 THROW
260 RPM

Figure 87

NO PRE-BREAK

TEST 2A

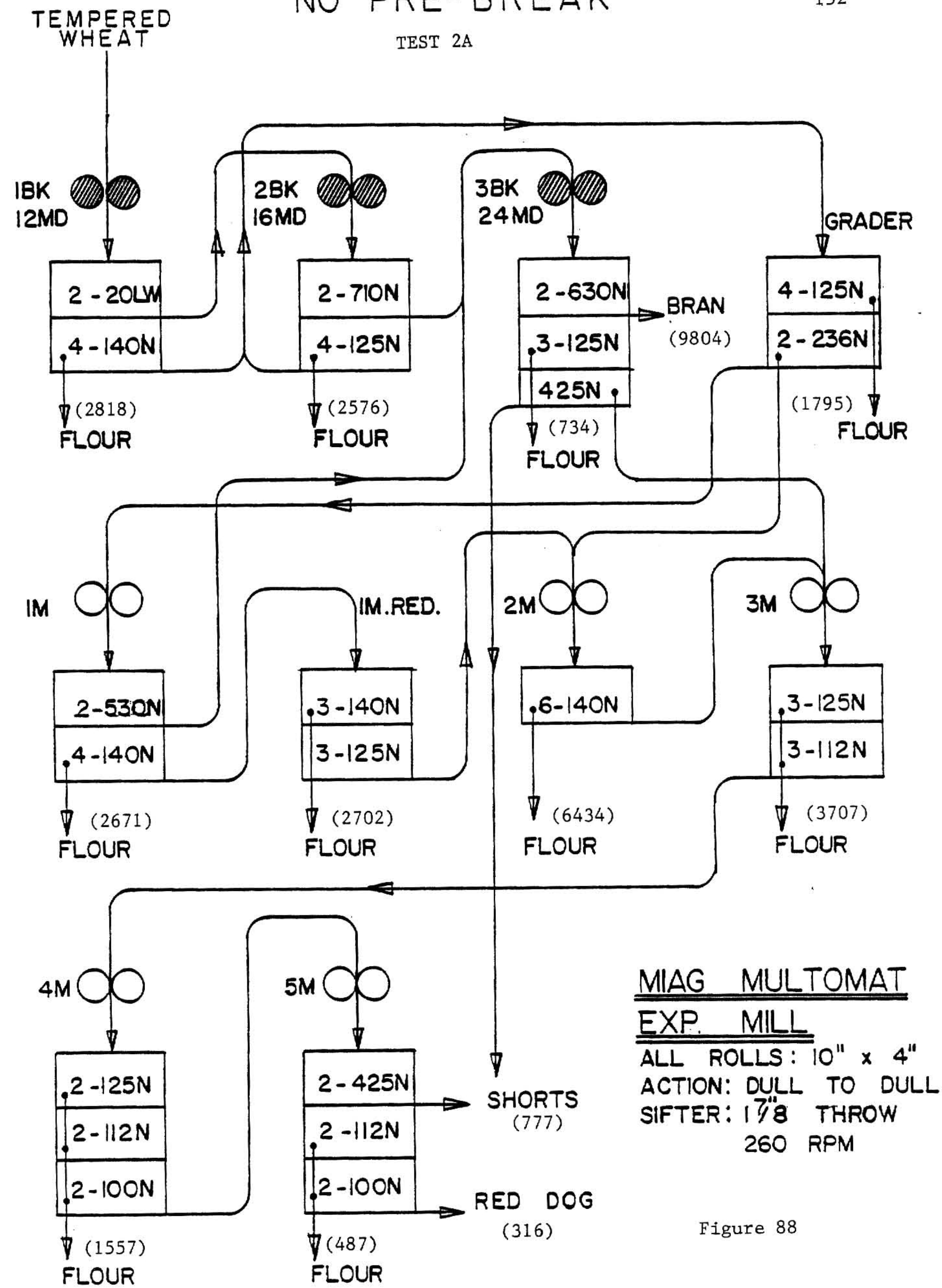


Figure 88

NO PRE-BREAK

TEST 1B

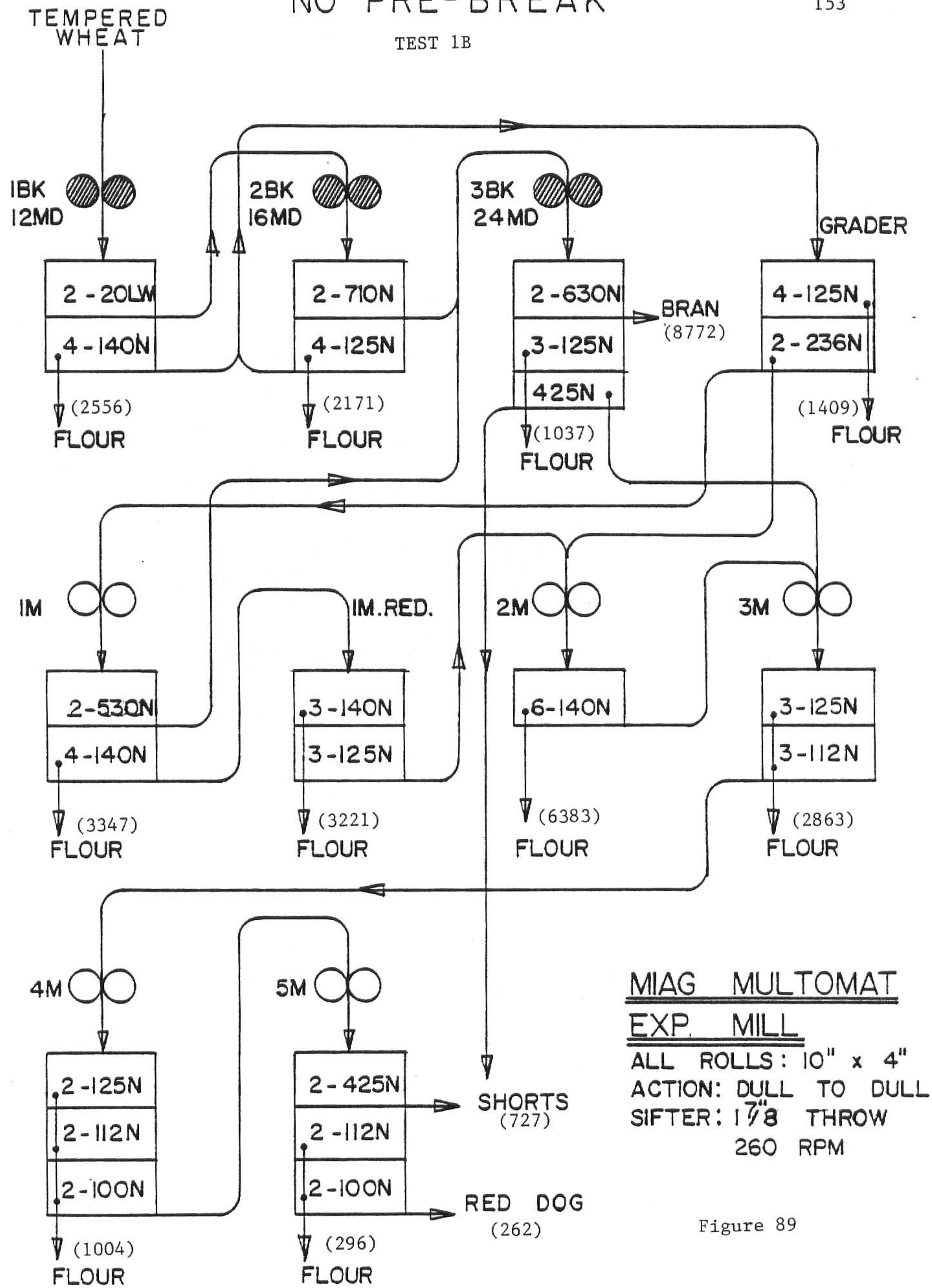


Figure 89

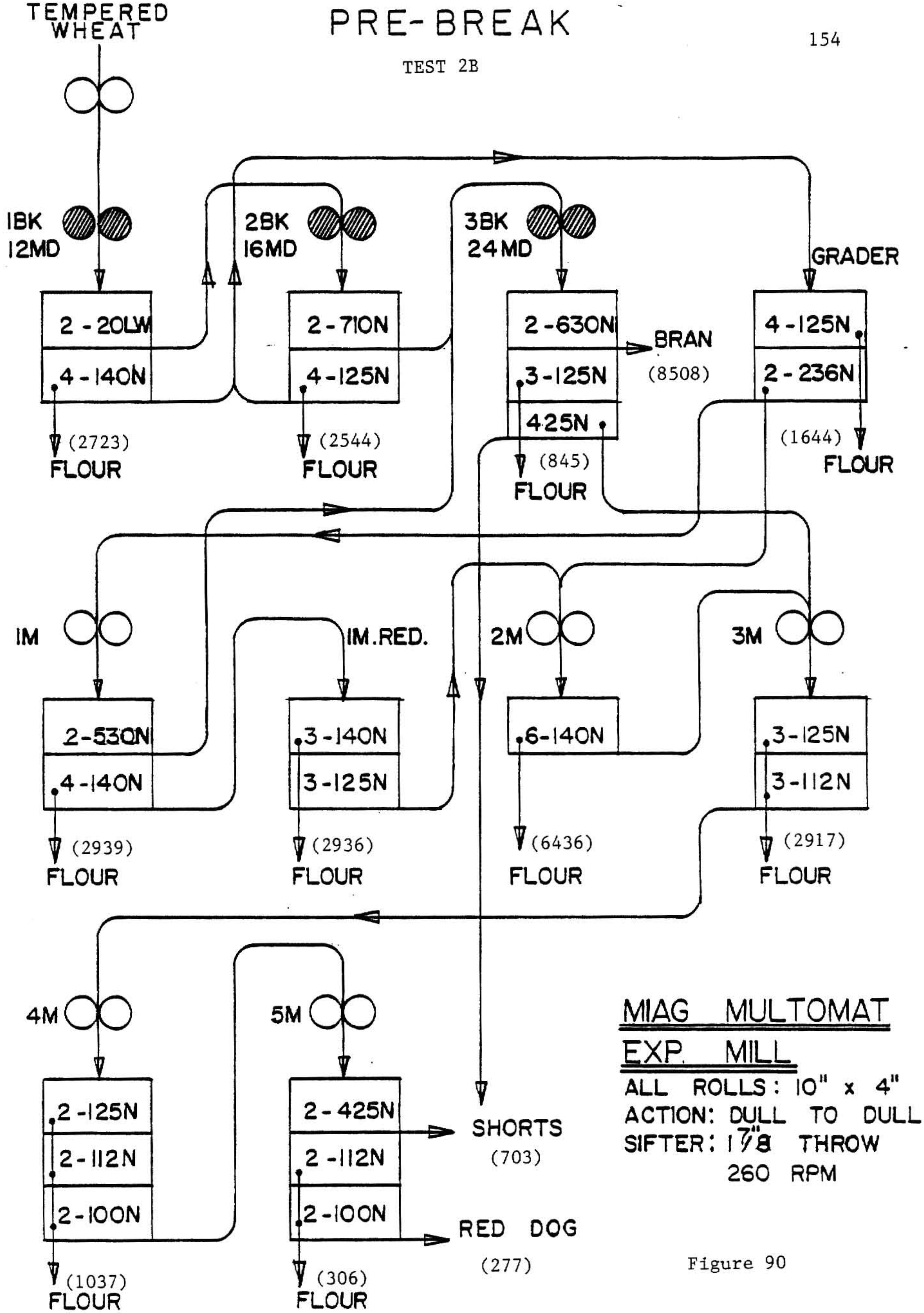

PRE-BREAK
TEST 2B
TEMPERED WHEAT
1BK 12MD
2BK 16MD
3BK 24MD
GRADER
2-20LW
4-140N
2-710N
4-125N
2-630N
3-125N
425N
BRAN
(8508)
4-125N
2-236N
(2723)
FLOUR
(2544)
FLOUR
(845)
FLOUR
(1644)
FLOUR
1M
1M.RED.
2M
3M
2-530N
4-140N
3-140N
3-125N
6-140N
3-125N
3-112N
(2939)
FLOUR
(2936)
FLOUR
(6436)
FLOUR
(2917)
FLOUR
4M
5M
2-125N
2-112N
2-100N
2-425N
2-112N
2-100N
SHORTS
(703)
RED DOG
(277)
(1037)
FLOUR
(306)
FLOUR
MIAG MULTOMAT
EXP. MILL
ALL ROLLS: 10" x 4"
ACTION: DULL TO DULL
SIFTER: 1 7/8" THROW
260 RPM

Figure 90

NO PRE-BREAK

TEST 1C

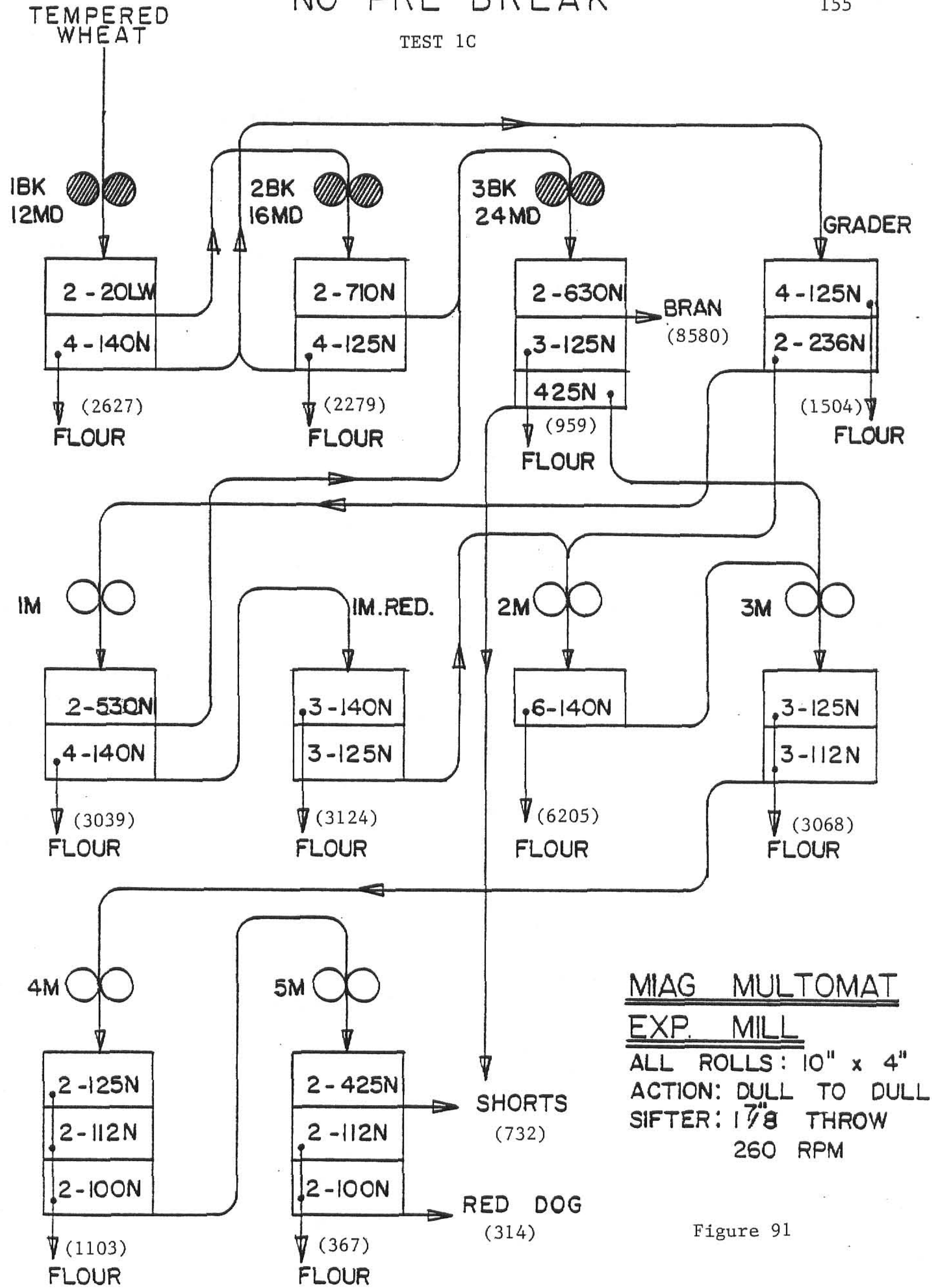


Figure 91

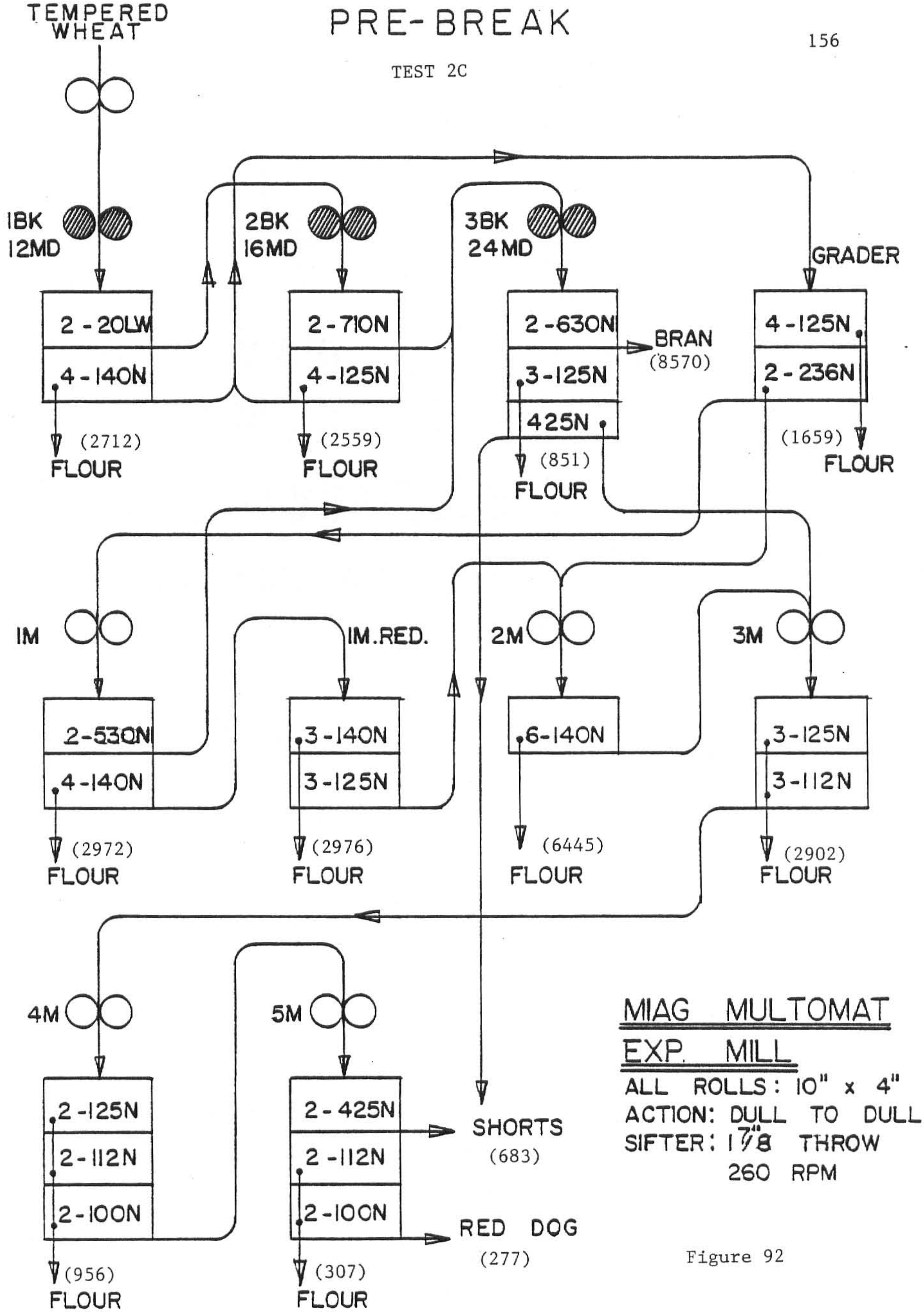

TEMPERED WHEAT
PRE-BREAK
TEST 2C
1BK 12MD
2BK 16MD
3BK 24MD
GRADER
2-20LW
4-140N
2-710N
4-125N
2-630N
3-125N
425N
BRAN
(8570)
4-125N
2-236N
(2712)
FLOUR
(2559)
FLOUR
(851)
FLOUR
(1659)
FLOUR
1M
1M.RED.
2M
3M
2-530N
4-140N
3-140N
3-125N
6-140N
3-125N
3-112N
(2972)
FLOUR
(2976)
FLOUR
(6445)
FLOUR
(2902)
FLOUR
4M
5M
2-125N
2-112N
2-100N
2-425N
2-112N
2-100N
SHORTS
(683)
RED DOG
(277)
(956)
FLOUR
(307)
FLOUR
MIAG MULTOMAT
EXP. MILL
ALL ROLLS: 10" x 4"
ACTION: DULL TO DULL
SIFTER: 1 7/8 THROW
260 RPM

Figure 92

NO PRE-BREAK

TEST 1D

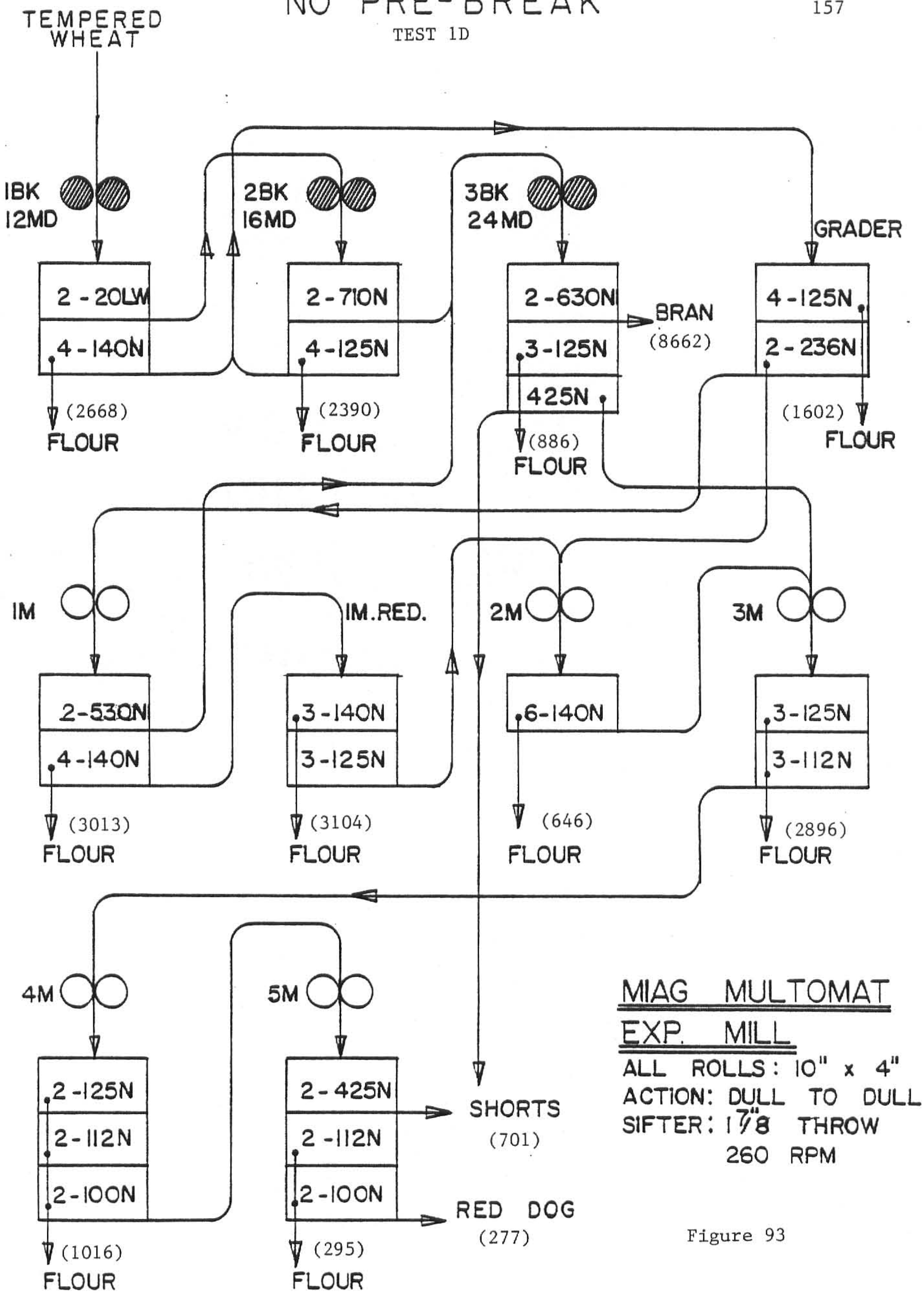


Figure 93

PRE-BREAK

TEST 2D

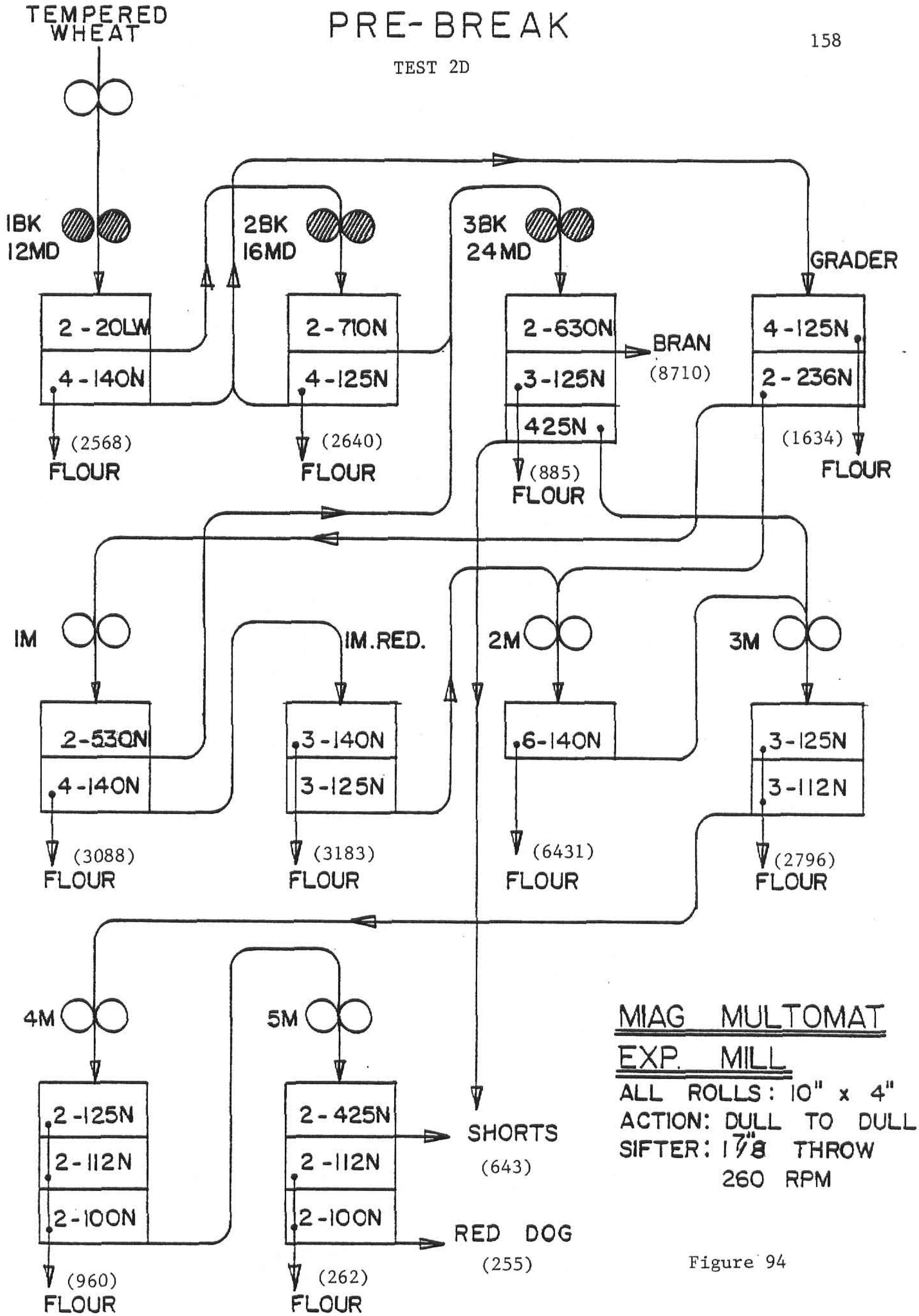


Figure 94

NO PRE-BREAK

TEST 1E

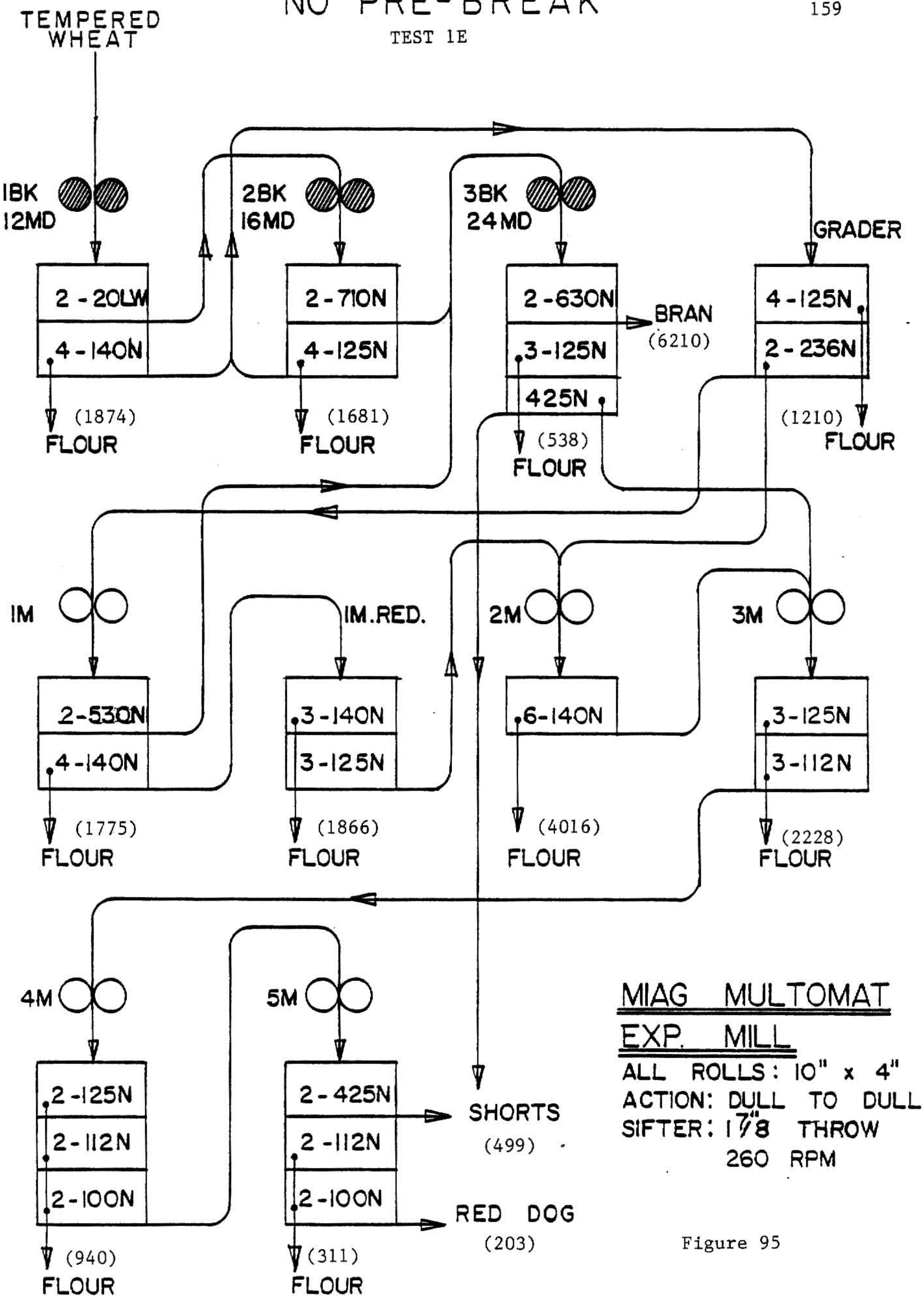
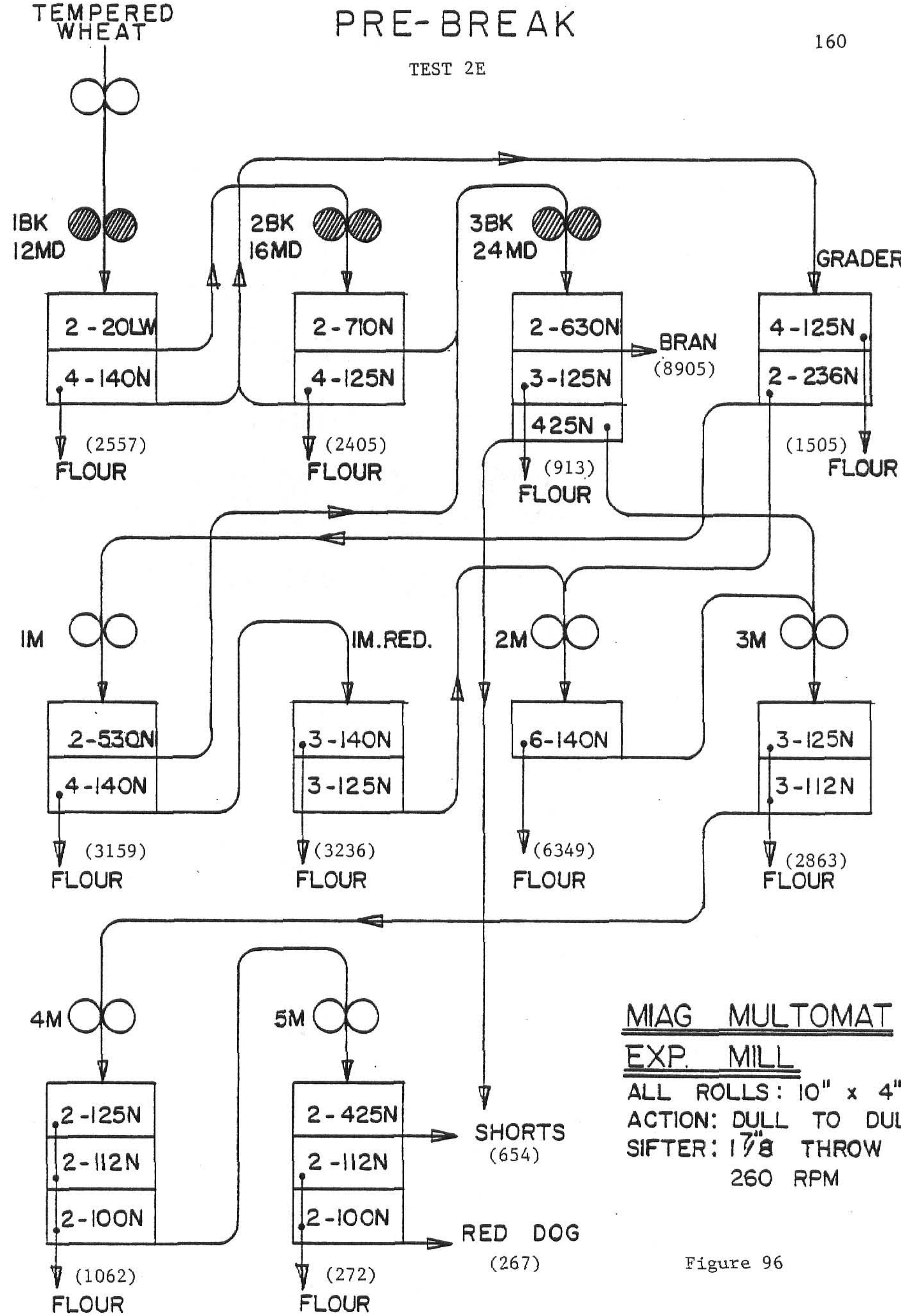


Figure 95

PRE-BREAK

TEST 2E



MIAG MULTOMAT
EXP. MILL
ALL ROLLS: 10" x 4"
ACTION: DULL TO DULL
SIFTER: 1 7/8" THROW
260 RPM

Figure 96

Table 19

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: MIAG MULTOMAT
TEST: A
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
			PRE-BREAK				
1 M RED	2678	7.65	7.65	.261	1.997	1.997	.261
1 M	2547	7.27	14.92	.282	2.050	4.047	.271
2 M	6213	17.74	32.66	.291	5.162	9.209	.282
1 BK	2809	8.02	40.68	.305	2.446	11.655	.287
3 M	2963	8.46	49.14	.339	2.868	14.523	.296
2 BK	2585	7.38	56.52	.344	2.539	17.062	.302
GRADER	1903	5.43	61.95	.364	1.977	19.038	.307
4 M	1622	4.63	66.58	.378	1.750	20.789	.312
3 BK	809	2.31	68.89	.470	1.086	21.874	.318
5 M	519	1.48	70.37	1.181	1.748	23.622	.336
			NO PRE-BREAK				
1 M RED	2702	7.43	7.43	.261	1.939	1.939	.261
2 M	6434	17.69	25.12	.280	4.953	6.892	.274
1 M	2671	7.34	32.46	.290	2.129	9.021	.278
3 M	3707	10.19	42.65	.328	3.342	12.363	.290
1 BK	2818	7.75	50.40	.334	2.589	14.952	.297
GRADER	1795	4.93	55.33	.353	1.740	16.692	.302
2 BK	2576	7.08	62.41	.354	2.506	19.198	.308
4 M	1557	4.28	66.69	.386	1.652	20.851	.313
3 BK	734	2.02	68.71	.456	0.921	21.772	.317
5 M	487	1.34	70.05	1.178	1.579	23.350	.333

Table 20

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: MIAG MULTOMAT
TEST: B
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK							
1 M RED	3221	9.46	9.46	.261	2.469	2.469	.261
2 M	6383	18.75	28.21	.280	5.250	7.719	.274
1 M	3347	9.83	38.04	.281	2.762	10.481	.276
2 BK	2171	6.38	44.42	.333	2.125	12.606	.284
1 BK	2556	7.51	51.93	.344	2.583	15.189	.292
GRADER	1409	4.14	56.07	.352	1.457	16.647	.297
3 M	2863	8.41	64.48	.359	3.019	19.666	.305
3 BK	1037	3.05	67.53	.449	1.369	21.035	.311
4 M	1004	2.95	70.48	.457	1.348	22.383	.318
5 M	296	0.87	71.35	1.667	1.450	23.834	.334
PRE-BREAK							
1 M RED	2936	8.68	8.68	.259	2.248	2.248	.259
2 M	6436	19.03	27.71	.279	5.309	7.557	.273
1 M	2939	8.69	36.40	.279	2.425	9.982	.274
1 BK	2723	8.05	44.45	.332	2.673	12.655	.285
2 BK	2544	7.52	51.97	.342	2.572	15.226	.293
GRADER	1644	4.86	56.83	.352	1.711	16.937	.298
3 M	2917	8.63	65.46	.365	3.150	20.087	.307
4 M	1037	3.07	68.53	.471	1.446	21.533	.314
3 BK	845	2.50	71.03	.486	1.215	22.748	.320
5 M	306	0.90	71.93	1.747	1.572	24.320	.338

Table 21

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: MIAG MULTOMAT
TEST: C
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
			NO PRE-BREAK				
2 M	6205	18.30	18.30	.279	5.106	5.106	.279
1 M RED	3124	9.22	27.52	.280	2.582	7.688	.279
1 M	3039	8.96	36.48	.290	2.598	10.286	.282
1 BK	2627	7.75	44.23	.344	2.666	12.952	.293
2 BK	2279	6.72	50.95	.363	2.439	15.391	.302
GRADER	1504	4.44	55.39	.372	1.652	17.043	.308
3 M	3068	9.05	64.44	.386	3.493	20.536	.319
4 M	1103	3.25	67.69	.473	1.537	22.073	.326
3 BK	959	2.83	70.52	.487	1.378	23.451	.333
5 M	367	1.08	71.60	1.565	1.690	25.141	.351
			PRE-BREAK				
1 M	2972	8.77	8.77	.269	2.359	2.359	.269
1 M RED	2976	8.79	17.56	.269	2.365	4.724	.269
2 M	6445	19.03	36.59	.278	5.290	10.014	.274
1 BK	2712	8.01	44.60	.333	2.667	12.681	.284
GRADER	1659	4.90	49.50	.340	1.666	14.347	.290
2 BK	2559	7.56	57.06	.343	2.593	16.940	.297
3 M	2902	8.57	65.63	.375	3.214	20.154	.307
3 BK	851	2.51	68.14	.479	1.202	21.356	.313
4 M	956	2.82	70.96	.491	1.385	21.741	.320
5 M	307	0.91	71.87	1.720	1.565	23.306	.324

Table 22

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL MIAG MULTOMAT
TEST D
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
			NO PRE-BREAK				
1 M RED	3104	9.14	9.14	.259	2.367	2.367	.259
2 M	6461	19.02	28.16	.268	5.097	7.465	.265
1 M	3013	8.87	37.03	.279	2.475	9.939	.268
1 BK	2668	7.85	44.88	.333	2.614	12.553	.280
2 BK	2390	7.04	51.92	.341	2.401	14.954	.288
GRADER	1602	4.72	56.64	.350	1.652	16.606	.293
3 M	2896	8.52	65.16	.365	3.110	19.716	.303
3 BK	886	2.61	67.77	.474	1.237	20.953	.309
4 M	1016	2.99	70.76	.509	1.522	22.475	.318
5 M	295	0.87	71.63	1.933	1.682	24.157	.337
			PRE-BREAK				
1 M	3088	9.07	9.07	.248	2.249	2.249	.248
1 M RED	3183	9.35	18.42	.268	2.506	4.755	.258
2 M	6431	18.88	37.30	.287	5.419	10.174	.273
1 BK	2568	7.54	44.84	.333	2.511	12.685	.283
GRADER	1634	4.80	49.64	.349	1.675	14.360	.289
2 BK	2640	7.75	57.39	.352	2.728	17.088	.298
3 M	2796	8.21	65.60	.364	2.988	20.076	.306
3 BK	885	2.60	68.20	.474	1.232	21.309	.312
4 M	960	2.82	71.02	.538	1.517	22.826	.321
5 M	262	0.77	71.79	1.922	1.480	24.306	.339

Table 23

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL MIAG MULTOMAT
TEST E
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
			NO PRE-BREAK				
1 M RED	1866	7.99	7.99	.270	2.157	2.157	.270
1 M	1775	7.60	15.59	.278	2.113	4.270	.274
2 M	4016	17.20	32.79	.279	4.799	9.069	.277
1 BK	1874	8.03	40.82	.323	2.594	11.663	.286
3 M	2228	9.54	50.36	.327	3.120	14.782	.294
2 BK	1681	7.20	57.56	.342	2.462	17.245	.300
GRADER	1210	5.18	62.74	.353	1.829	19.073	.304
4 M	940	4.03	66.77	.386	1.556	20.629	.309
3 BK	538	2.30	69.07	.455	1.047	21.675	.314
5 M	311	1.33	70.40	1.174	1.561	23.237	.330
			PRE-BREAK				
1 M	3159	9.25	9.25	.248	2.294	2.294	.248
1 M RED	3236	9.48	18.73	.258	2.446	4.740	.253
2 M	6349	18.59	37.32	.265	4.926	9.666	.259
1 BK	2557	7.49	44.81	.332	2.487	12.153	.271
GRADER	1505	4.41	49.22	.350	1.544	13.696	.278
2 BK	2405	7.04	56.26	.351	2.471	16.167	.287
3 M	2863	8.38	64.64	.373	3.126	19.293	.298
3 BK	913	2.67	67.31	.463	1.236	20.529	.305
4 M	1062	3.11	70.42	.536	1.667	22.196	.315
5 M	272	0.80	71.22	2.010	1.608	23.804	.334

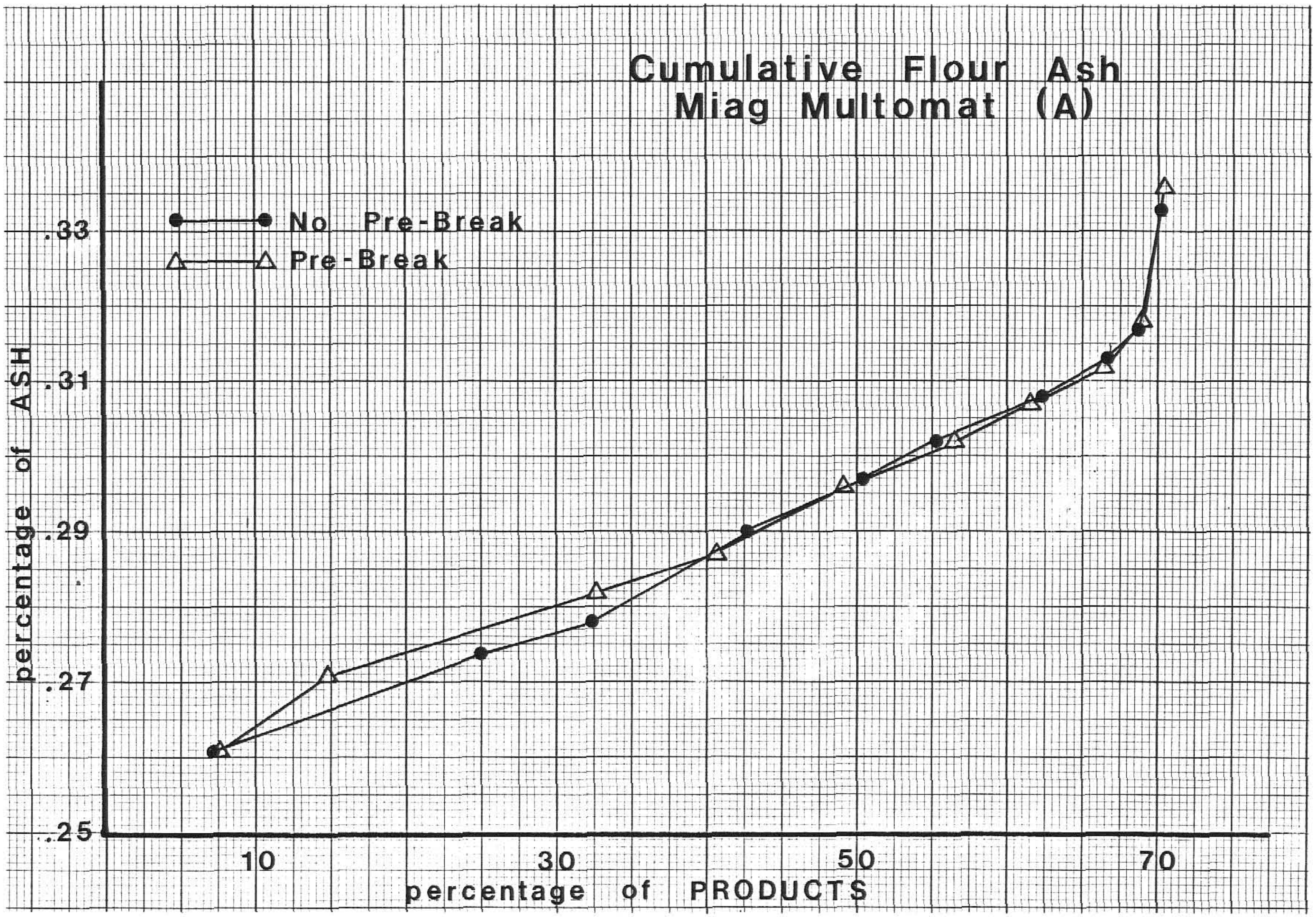

Cumulative Flour Ash
Miag Multomat (A)
No Pre-Break
Pre-Break
.33
.31
.29
.27
.25
percentage of ASH
10
30
50
70
percentage of PRODUCTS

Figure 97

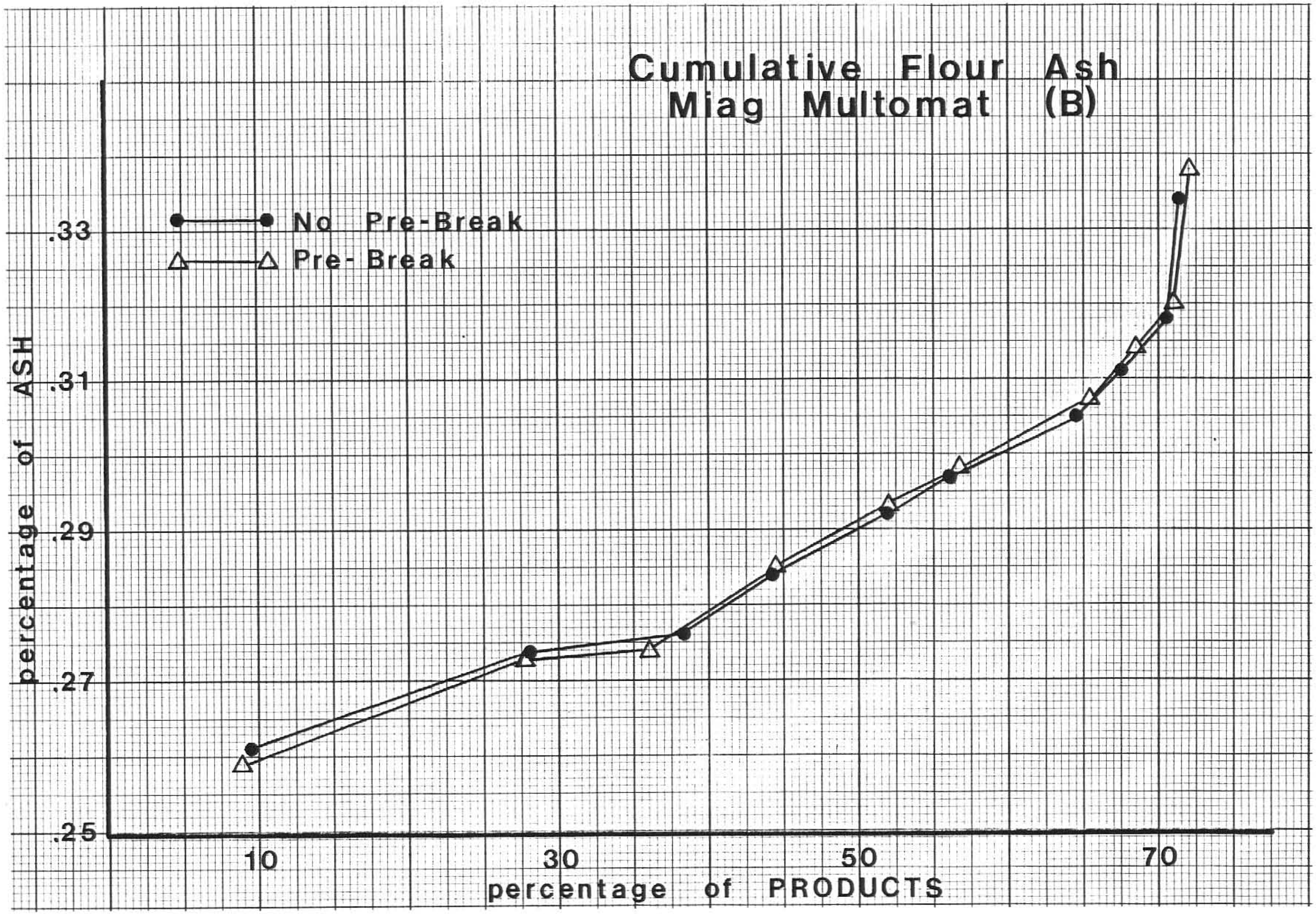

Cumulative Flour Ash
Miag Multomat (B)
No Pre-Break
Pre- Break
.33
.31
.29
.27
.25
percentage of ASH
10
30
50
70
percentage of PRODUCTS

Figure 98

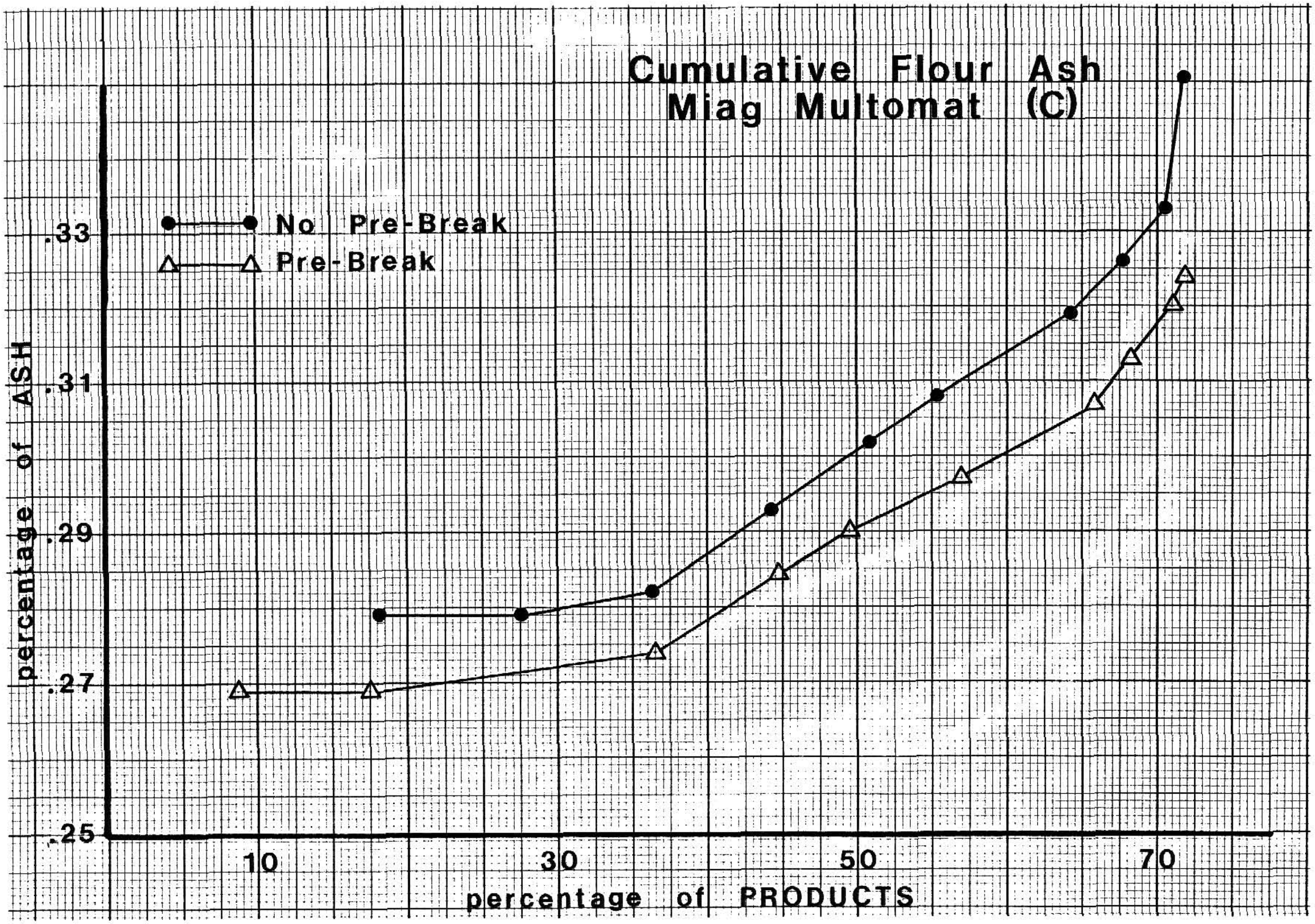

Cumulative Flour Ash
Miag Multomat (C)
No Pre-Break
Pre-Break
.33
.31
.29
.27
.25
percentage of ASH
10
30
50
70
percentage of PRODUCTS

Figure 99

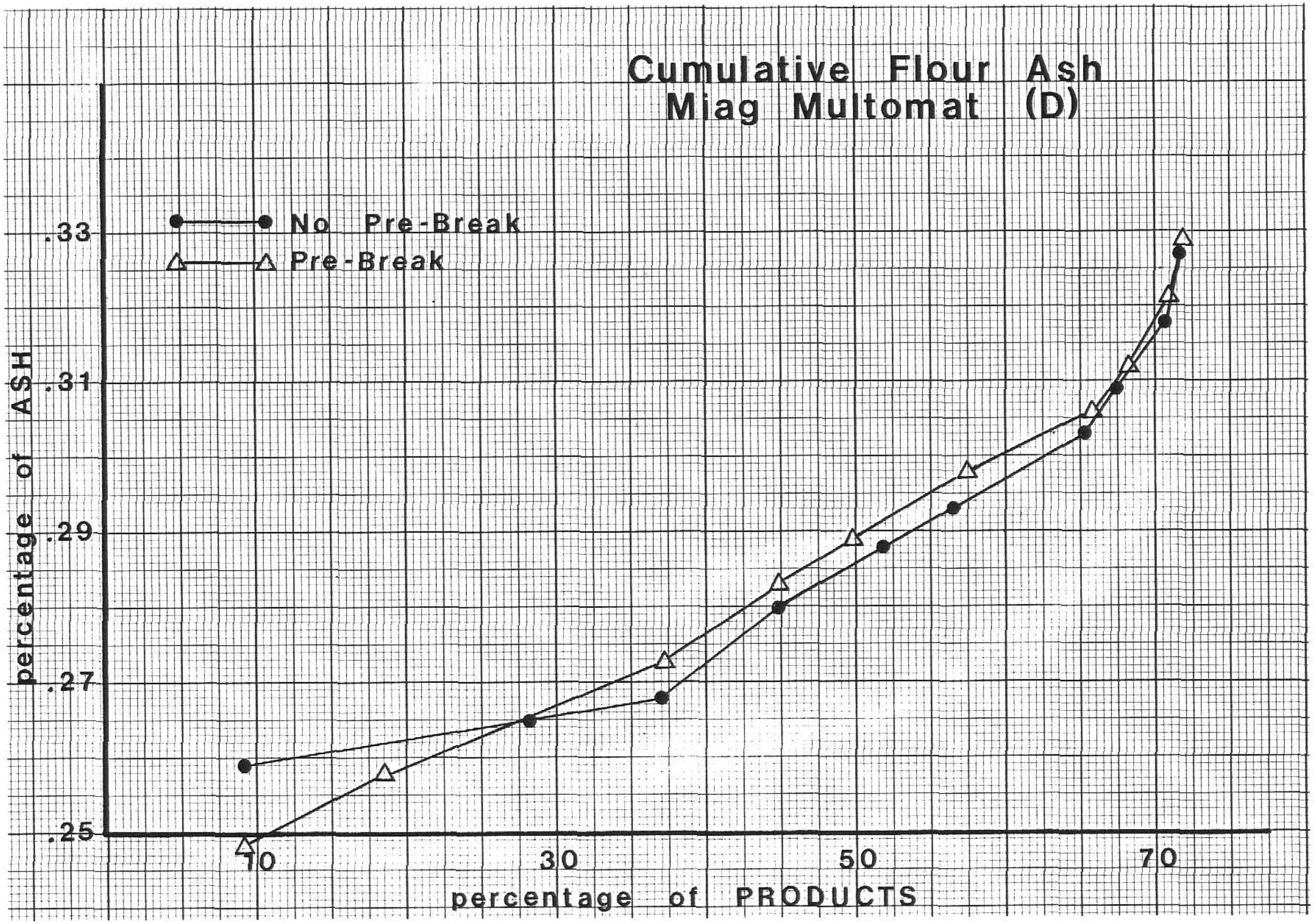

Cumulative Flour Ash
Miag Multomat (D)
No Pre-Break
Pre-Break
.33
.31
.29
.27
.25
percentage of ASH
10
30
50
70
percentage of PRODUCTS

Figure 100

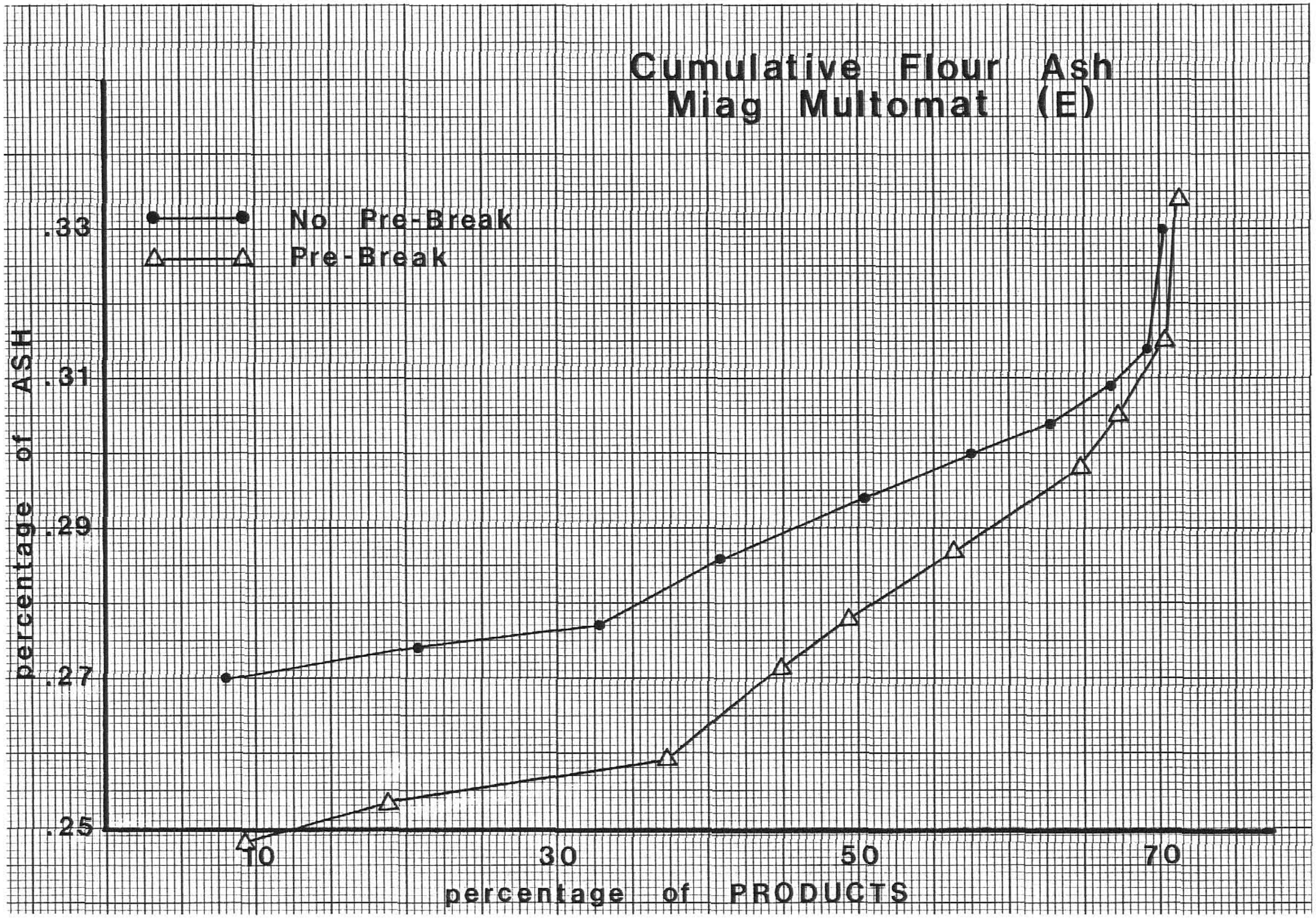

Cumulative Flour Ash
Miag Multomat (E)
No Pre-Break
Pre-Break
percentage of ASH
.33
.31
.29
.27
.25
10
30
50
70
percentage of PRODUCTS

Figure 101

APPENDIX B

APPENDIX B

Preliminary Tests of Pre-Break on the Kansas State University Pilot Flour Mill

Preliminary testing of the use of Pre-Break on a large scale was initiated using the Kansas State University Pilot Flour Mill.

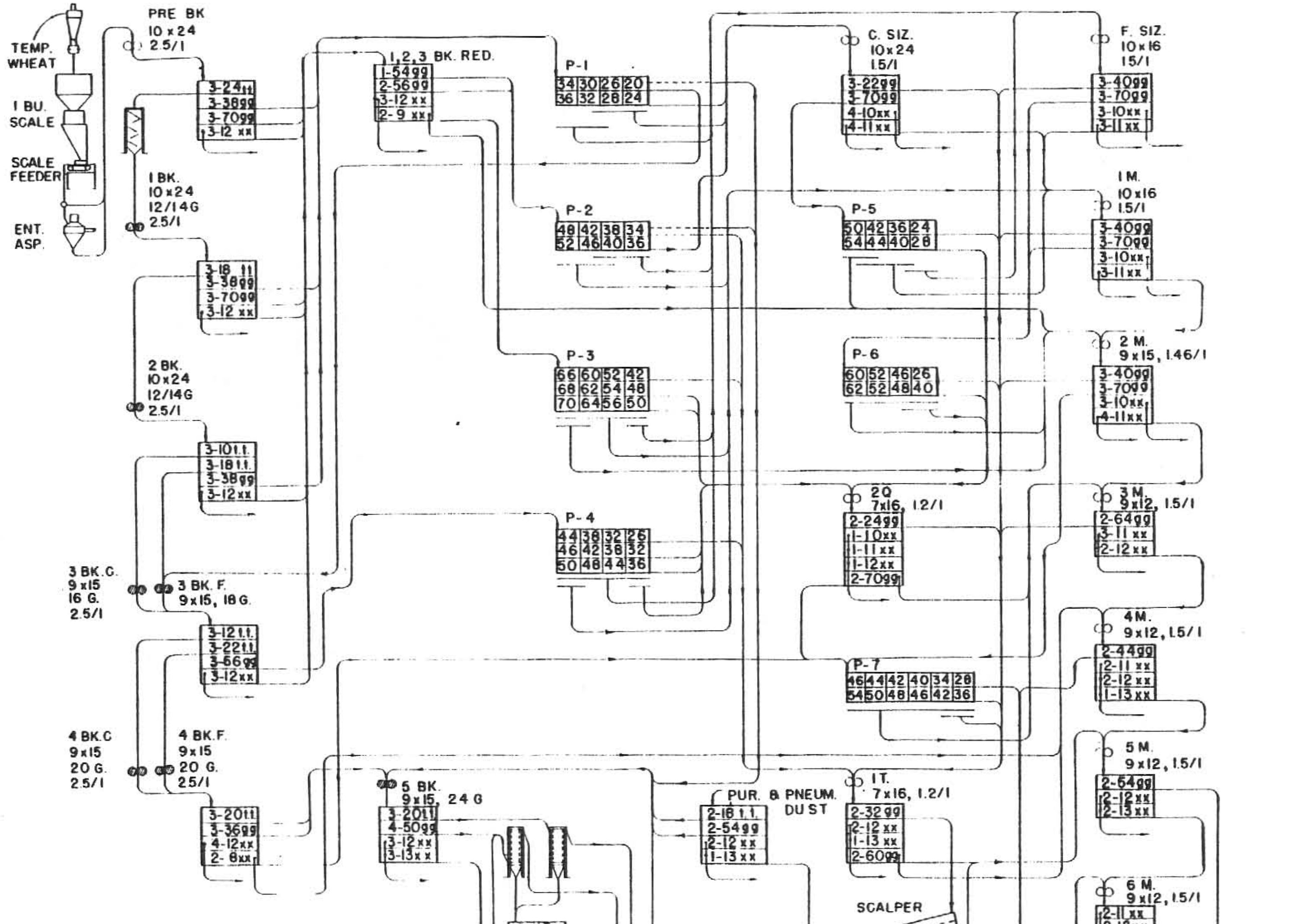
The KSU Pilot Mill has a capacity of approximately 200 hundredweights of flour in 24 hours. Although this is small in comparison to commercial mills, the equipment is scaled down to give comparable performance.

The Pilot Mill Flow (Figure 102) consists of 5 pairs of corrugated Breaks rolls, 10 pairs of smooth reduction rolls, 5 two-section free-swinging sifters and 5 purifiers (4 double, 1 single). Twenty-three separate flour streams are produced simulatneously with the capability of sampling each stream during mill operation. By obtaining 5-minute stream weights of each flour stream and sampling each for laboratory analysis of moisture and ash, milling performance for each mill run can be measured.

The Pre-Break System incorporated into the Pilot Mill Flow is shown in Figure 103. Tempered wheat from a belt scale feeder, to set the feed rate to the mill, can pass through an Entoleter-Scourer-Aspirator or directly to Pre-Break or First Break rolls. If Pre-Break is used, the Pre-Broken stock is sifted and the overs of a 24 light wire sieve are sent to an aspirator and then to First Break. Other separators from the sifter include sizings stock to purifier one, middlings stock to a Break Redust section and a small amount of flour.

Pre-Breaking itself is accomplished with a pair of smooth, 10 inch diameter by 24 inch length, Buhler rolls. Differential is created by a chain and sprocket drive. Initially, the roll was set up for a 2.5 to 1 differential, therefore the first two tests were run using this differential. The chain was then removed for the remaining tests to give approximately a one to one differential with the flow of the wheat turning the free roll.

Data from these preliminary tests along with the resulting cumulative flour ash curves for each test are given in the following tables and figures.



NOTE: EACH SIFTER BOX SHOWN REPRESENTS 1/4 2 x 14 SIFTER

Figure 102

HARD WHEAT FLOW

200 CWT FLOUR MILL

KANSAS STATE UNIVERSITY

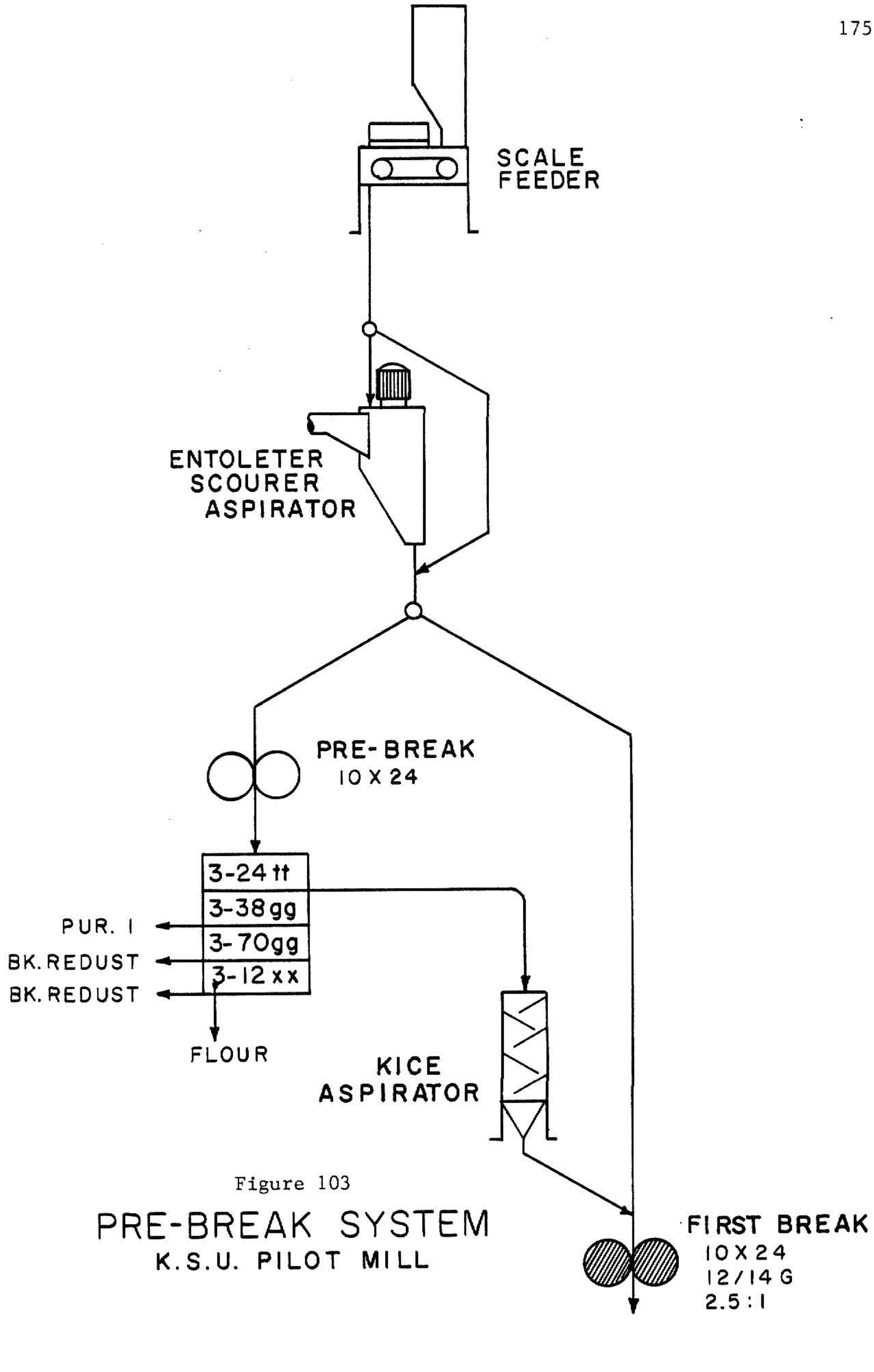


Figure 103

PRE-BREAK SYSTEM
K.S.U. PILOT MILL

Table 24

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 1A 2.5:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK							
1 MB	1280	2.78	2.78	.254	0.706	0.706	.254
1 MT	4737	10.29	13.07	.263	2.706	3.412	.261
FSB	735	1.60	14.67	.264	0.422	3.835	.261
FST	3046	6.62	21.29	.274	1.814	5.649	.265
2 MB	1205	2.62	23.91	.283	0.741	6.390	.267
2 MT	4782	10.39	34.30	.293	3.044	9.434	.275
3 M	3361	7.30	41.60	.323	2.358	11.792	.283
2 Q	556	1.21	42.81	.325	0.393	12.186	.285
CST	12	0.03	42.84	.357	0.011	12.196	.285
CSB	266	0.58	43.42	.377	0.219	12.415	.286
2 BK	1689	3.67	47.09	.377	1.384	13.799	.293
4 M	2696	5.86	52.95	.382	2.239	16.037	.303
BK.RED	1388	3.02	55.97	.388	1.172	17.209	.307
3 BK	1638	3.56	59.53	.396	1.410	18.619	.313
1 BK	823	1.78	61.31	.408	0.726	19.435	.316
1 T	262	0.57	61.88	.475	0.271	19.616	.317
4 BK	778	1.69	63.57	.487	0.823	20.439	.322
5 M	1851	4.02	67.59	.530	2.131	22.569	.334
SUC	66	0.14	67.73	.645	0.090	22.659	.335
5 BK	658	1.43	69.16	.737	1.054	23.713	.343
6 M	810	1.76	70.92	1.194	2.101	25.815	.364
B&SD	724	1.57	72.49	1.309	2.055	27.870	.384

Table 25

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 2A 2.5:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
HEAVY PRE-BREAK							
1 MB	1442	2.88	2.88	.243	0.700	0.700	.243
1 MT	4711	9.40	12.28	.243	2.284	2.984	.243
FST	3126	6.24	18.52	.253	1.579	4.563	.246
FSB	683	1.36	19.88	.254	0.345	4.908	.247
2 MB	1400	2.79	22.67	.262	0.731	5.639	.249
2 MT	5851	11.68	34.35	.262	3.060	8.699	.253
3 M	4010	8.00	42.35	.291	2.328	11.027	.260
2 Q	458	0.91	43.26	.293	0.267	11.294	.261
CST	16	0.03	43.29	.306	0.009	11.303	.261
BK.RED	1371	2.74	46.03	.315	0.863	12.166	.264
CSB	238	0.48	46.51	.325	0.156	12.322	.265
2 BK	1907	3.81	50.32	.326	1.242	13.564	.270
1 BK	875	1.75	52.07	.327	0.572	14.137	.271
4 M	2858	5.71	57.78	.341	1.947	16.084	.279
3 BK	1667	3.33	61.11	.355	1.182	17.266	.283
P.BK	190	0.38	61.49	.396	0.150	17.416	.283
1 T	317	0.63	62.12	.442	0.278	17.695	.285
4 BK	835	1.67	63.79	.446	0.745	18.440	.289
5 M	1937	3.87	67.66	.498	1.927	20.367	.301
SUC	45	0.09	67.75	.637	0.057	20.424	.301
5 BK	715	1.43	69.18	.675	0.965	21.389	.309
BSD	803	1.60	70.78	1.108	1.773	23.162	.327
6 M	745	1.49	72.27	1.189	1.772	24.934	.345

Table 26

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 3A 2.5:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
LIGHT PRE-BREAK							
1 MB	1402	2.90	2.90	.252	0.731	0.731	.252
FST	2733	5.65	8.55	.252	1.424	2.155	.252
1 MT	5081	10.50	19.05	.252	2.646	4.801	.252
FSB	814	1.68	20.73	.253	0.425	5.226	.252
2 MB	1235	2.55	23.28	.282	0.719	5.945	.255
2 MT	5775	11.94	35.22	.282	3.367	9.312	.264
CST	14	0.03	35.25	.316	0.009	9.321	.264
2 Q	472	0.98	36.23	.324	0.318	9.639	.266
2 BK	1887	3.90	40.13	.334	1.303	10.941	.273
3 M	3475	7.18	47.31	.341	2.448	13.390	.283
CSB	267	0.55	47.86	.345	0.190	13.580	.284
BK.RED	1718	3.55	51.41	.346	1.228	14.808	.288
1 BK	974	2.01	53.42	.357	0.718	15.525	.291
4 M	2520	5.21	58.63	.400	2.084	17.609	.300
3 BK	1895	3.92	62.55	.406	1.592	19.201	.307
P.BK	47	0.10	62.65	.436	0.044	19.245	.307
1 T	335	0.69	63.34	.473	0.326	19.571	.309
5 M	1505	3.11	66.45	.517	1.608	21.179	.319
4 BK	719	1.49	67.94	.547	0.815	21.994	.324
SUC	38	0.08	68.02	.599	0.048	22.042	.324
5 BK	652	1.35	69.37	.766	1.034	23.076	.333
6 M	723	1.49	70.86	1.185	1.766	24.841	.351
BSD	662	1.37	72.23	1.206	1.652	26.494	.367

Table 27

Cumulative Flour Ash Calculations

A=ASH (14% Moisture Basis)
Q=QUANTITY (% of Total Products)
S=SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 1B 2.5:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
LIGHT PRE-BREAK							
FSB	1194	2.46	2.46	.253	0.622	0.622	.253
1 MB	1234	2.55	5.01	.253	0.645	1.268	.253
1 MT	4837	9.98	14.99	.253	2.525	3.792	.253
FST	4126	8.51	23.50	.262	2.230	6.022	.256
2 MT	5746	11.85	35.35	.271	3.211	9.233	.261
2 MB	1227	2.53	37.88	.272	0.688	9.922	.262
CST	13	0.03	37.91	.330	0.010	9.932	.262
3 M	3625	7.48	45.39	.331	2.476	12.407	.273
2 BK	1725	3.56	48.95	.346	1.232	13.639	.279
CSB	289	0.60	49.55	.362	0.217	13.856	.280
BK.RED	1582	3.26	52.81	.366	1.193	15.050	.285
1 BK	954	1.97	54.78	.367	0.723	15.772	.288
3 BK	1794	3.70	58.58	.396	1.465	17.238	.295
2 Q	243	0.50	58.98	.429	0.215	17.452	.296
4 M	1947	4.02	63.00	.438	1.761	19.213	.305
P.BK	54	0.11	63.11	.471	0.520	19.265	.305
4 BK	695	1.43	64.54	.525	0.751	20.016	.310
1 T	290	0.60	65.14	.567	0.340	20.356	.312
SUC	3	0.01	65.15	.598	0.006	20.362	.313
5 M	1478	3.05	68.20	.611	1.864	22.225	.326
6 M	1268	2.62	70.82	.648	1.698	23.923	.339
5 BK	619	1.28	72.10	.885	1.133	25.056	.348
BSD	681	1.40	73.50	1.387	1.942	26.998	.367

Table 28

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 3B 2.5:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK							
1 MT	5136	10.68	10.68	.250	2.670	2.670	.250
FSB	1155	2.40	13.08	.251	0.602	3.272	.250
FST	3893	8.10	21.18	.261	2.114	5.387	.254
2 MT	5847	12.16	33.34	.276	3.356	8.743	.262
2 MB	1205	2.51	35.85	.280	0.703	9.445	.263
1 MB	1447	3.01	38.86	.290	0.873	10.318	.266
CST	10	0.02	38.88	.345	0.007	10.325	.266
2 BK	1861	3.87	42.75	.346	1.339	11.664	.273
3 M	3969	8.25	51.00	.358	2.954	14.618	.287
BK.RED	1527	3.18	54.18	.375	1.193	15.810	.292
1 BK	972	2.02	56.20	.386	0.780	16.590	.295
3 BK	1736	3.61	59.81	.404	1.458	18.048	.302
CSB	280	0.58	60.39	.411	0.238	18.287	.303
2 Q	322	0.67	61.06	.448	0.300	18.587	.304
4 M	2122	4.41	65.47	.466	2.055	20.642	.315
4 BK	756	1.57	67.04	.511	0.802	21.444	.320
1 T	383	0.80	67.84	.557	0.446	21.890	.323
SUC	35	0.07	67.91	.576	0.040	21.930	.323
5 BK	730	1.52	69.43	.952	1.447	23.377	.337
5 M	1388	2.89	72.32	.985	2.847	26.224	.363
BSD	677	1.41	73.73	1.788	2.521	28.745	.390
6 M	441	0.92	74.65	3.009	2.768	31.513	.422

Table 29

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 2B 2.5:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
HEAVY PRE-BREAK							
1 MB	1355	2.92	2.92	.251	0.733	0.733	.251
FSB	1218	2.62	5.54	.251	0.658	1.391	.251
1 MT	5074	10.92	16.46	.251	2.741	4.131	.251
FST	4109	8.84	25.30	.262	2.316	6.448	.255
2 MB	1113	2.40	27.70	.271	0.650	7.098	.256
2 MT	5859	12.61	40.31	.271	3.417	10.515	.261
CST	10	0.02	40.33	.309	0.006	10.521	.261
3 BK	1870	4.40	44.73	.325	1.430	11.951	.267
BK.RED	1667	3.59	48.32	.335	1.203	13.154	.272
1 BK	917	1.97	50.29	.346	0.682	13.836	.275
3 M	3568	7.68	57.97	.348	2.673	16.508	.285
CSB	253	0.54	58.51	.351	0.190	16.698	.285
3 BK	1870	4.03	62.54	.384	1.548	18.245	.292
P.BK	203	0.44	62.98	.393	0.173	18.418	.292
2 Q	228	0.49	63.47	.457	0.224	18.642	.294
4 BK	899	1.94	65.41	.474	0.920	19.562	.299
4 M	1788	3.85	69.26	.505	1.944	21.506	.311
SUC	32	0.07	69.33	.577	0.040	21.546	.311
1 T	302	0.65	69.98	.615	0.400	21.946	.314
5 BK	746	1.61	71.59	.912	1.468	23.415	.327
5 M	916	1.97	73.56	1.178	2.321	25.735	.350
BSD	744	1.60	75.16	1.591	2.546	28.281	.376
6 M	372	0.80	75.96	2.615	2.092	30.373	.400

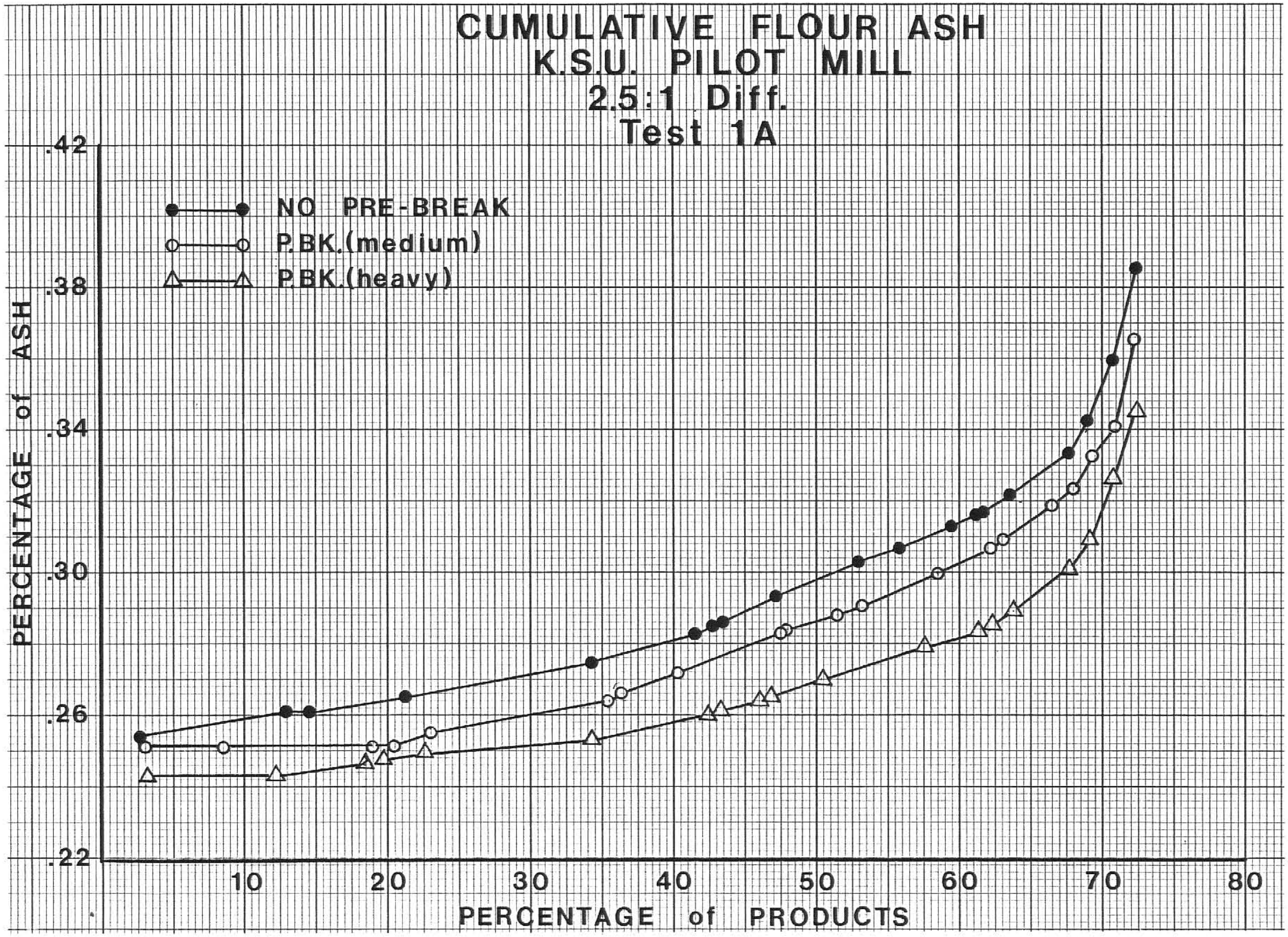

CUMULATIVE FLOUR ASH
K.S.U. PILOT MILL
2.5:1 Diff.
Test 1A
NO PRE-BREAK
P.BK.(medium)
P.BK.(heavy)
.42
.38
.34
.30
.26
.22
PERCENTAGE of ASH
10
20
30
40
50
60
70
80
PERCENTAGE of PRODUCTS

Figure 104

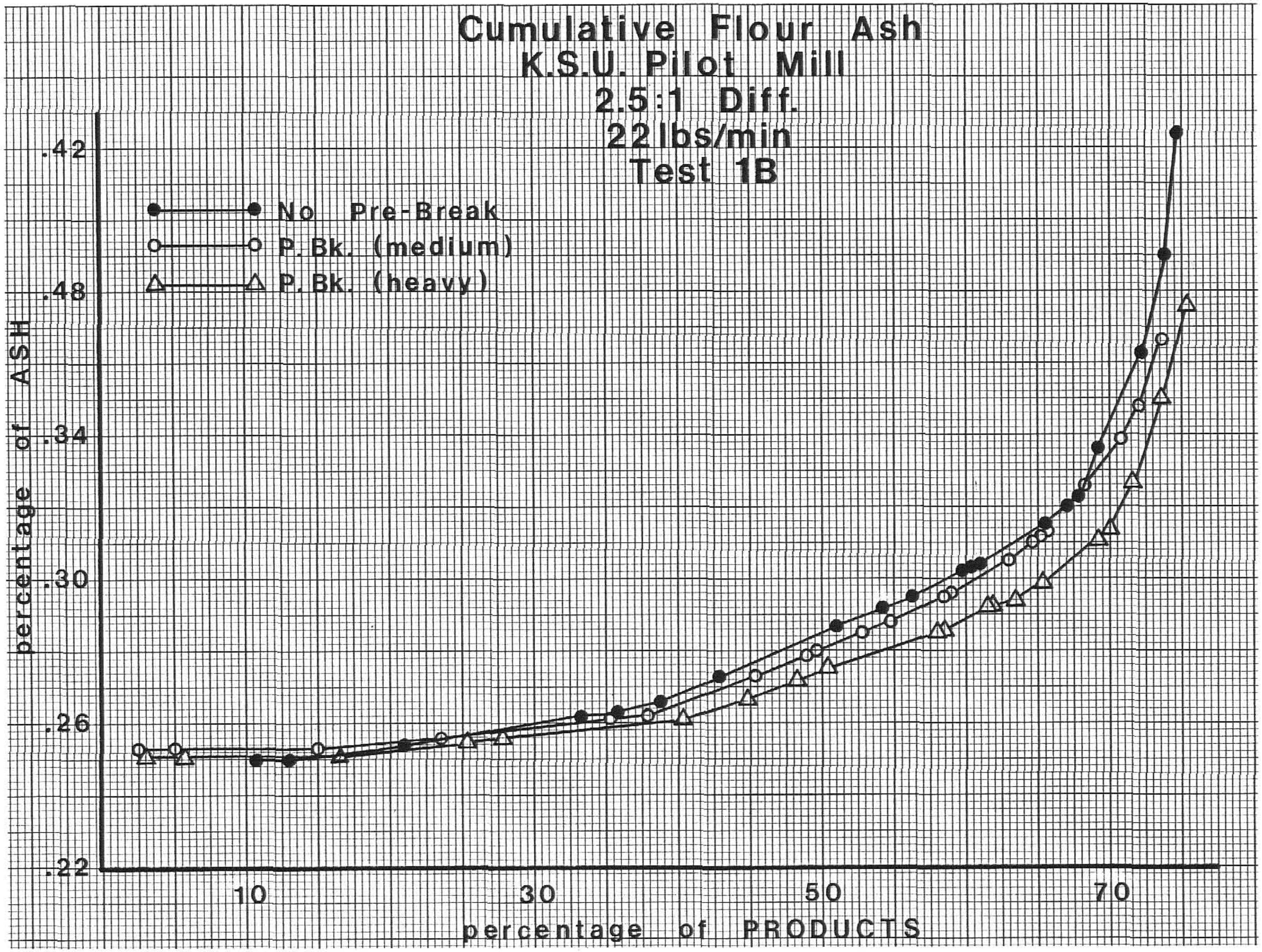

Cumulative Flour Ash
K.S.U. Pilot Mill
2.5:1 Diff.
22 lbs/min
Test 1B
No Pre-Break
P. Bk. (medium)
P. Bk. (heavy)
.42
.48
.34
.30
.26
.22
percentage of ASH
10
30
50
70
percentage of PRODUCTS

Figure 105

Table 30

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: K.S.U. PILOT MILL
TEST: NO. 2A 1:1 DIFF
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
LIGHT PRE-BREAK							
1 MT	6180	13.69	13.69	.258	3.532	3.532	.258
1 MB	1093	2.42	16.11	.259	0.627	4.159	.258
FSB	742	1.64	17.75	.269	0.441	4.600	.259
FST	3934	8.71	26.46	.270	2.352	6.952	.263
2 MT	5683	12.59	39.05	.287	3.613	10.565	.271
2 MB	381	0.84	39.89	.296	0.249	10.814	.271
BK.RED	1570	3.48	43.37	.344	1.197	12.011	.277
2 BK	1985	4.40	47.77	.345	1.518	13.529	.283
3 M	3412	7.56	55.33	.362	2.737	16.266	.294
1 BK	944	2.09	57.42	.366	0.765	17.030	.297
3 BK	1594	3.53	60.95	.384	1.356	18.386	.302
CSB	14	0.03	60.98	.392	0.012	18.398	.302
CST	252	0.56	61.54	.407	0.228	18.626	.303
2 Q	333	0.74	62.28	.453	0.335	18.961	.304
P.BK	31	0.07	62.35	.474	0.033	18.994	.305
4 BK	826	1.83	64.18	.479	0.877	19.871	.310
4 M	1432	3.17	67.35	.505	1.601	21.471	.319
SUC	130	0.29	67.64	.594	0.172	21.644	.320
1 T	403	0.89	68.53	.607	0.540	22.184	.324
5 BK	708	1.57	70.10	.735	1.154	23.338	.333
5 M	947	2.10	72.20	1.160	2.436	25.774	.357
BSD	592	1.31	73.51	1.370	1.795	27.569	.375
6 M	343	0.76	74.27	2.386	1.813	29.382	.396

Table 31

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 3A 1:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
MEDIUM PRE-BREAK							
FSB	739	1.66	1.66	.258	0.428	0.428	.258
1 MB	1041	2.34	4.00	.258	0.604	1.032	.258
1 MT	6087	13.68	17.68	.258	3.529	4.561	.258
FST	3793	8.53	26.21	.269	2.295	6.856	.262
2 MT	5676	12.76	38.97	.286	3.649	10.505	.270
2 MB	353	0.79	39.76	.305	0.241	10.746	.270
2 BK	1934	4.35	44.11	.334	1.453	12.199	.277
BK.RED	1726	3.88	47.99	.343	1.331	13.530	.282
1 BK	914	2.05	50.04	.344	0.705	14.235	.284
CSB	18	0.04	50.08	.352	0.014	14.249	.285
3 M	3078	6.92	57.00	.362	2.505	16.754	.294
3 BK	1857	4.17	61.17	.383	1.597	18.351	.300
CST	255	0.57	61.74	.395	0.225	18.577	.301
P.BK	151	0.34	62.08	.429	0.146	18.723	.302
2 Q	314	0.71	62.79	.481	0.342	19.064	.304
4 M	1365	3.07	65.86	.495	1.520	20.584	.313
4 BK	792	1.78	67.64	.519	0.942	21.507	.318
SUC	160	0.36	68.00	.521	0.188	21.695	.319
1 T	389	0.87	68.87	.616	0.536	22.231	.323
5 BK	601	1.35	70.22	.762	1.029	23.260	.331
5 M	985	2.21	72.43	1.156	2.555	25.814	.356
B&SD	626	1.41	73.84	1.269	1.789	27.604	.374
6 M	357	0.80	74.64	2.100	1.680	29.284	.392

Table 32

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 4A 1:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
HEAVY PRE-BREAK							
FSB	615	1.37	1.37	.256	0.351	0.351	.256
1 MB	1004	2.24	3.61	.256	0.573	0.924	.256
1 MT	5830	13.02	16.63	.266	3.463	4.387	.264
2 MT	5386	12.03	28.66	.285	3.429	7.816	.273
FST	3808	8.51	37.17	.297	2.527	10.344	.278
2 MB	278	0.62	37.79	.302	0.187	10.531	.279
CST	164	0.37	38.16	.313	0.116	10.647	.279
BK.RED	1737	3.88	42.04	.320	1.242	11.888	.283
1 BK	847	1.89	43.93	.321	0.607	12.495	.284
2 BK	2220	4.96	48.89	.322	1.597	14.092	.288
3 BK	1758	3.93	52.82	.368	1.446	15.538	.294
CSB	10	0.02	52.84	.369	0.007	15.546	.294
P.BK	289	0.65	53.49	.380	0.247	15.793	.295
3 M	2649	5.92	59.41	.389	2.303	18.095	.305
4 BK	942	2.10	61.51	.487	1.023	19.118	.311
2 Q	263	0.59	62.10	.496	0.293	19.411	.313
4 M	1299	2.90	65.00	.541	1.569	20.980	.320
SUC	102	0.23	65.23	.562	0.129	21.109	.324
1 T	378	0.84	66.07	.650	0.546	21.655	.328
5 BK	693	1.55	67.62	.699	1.083	22.730	.336
BSD	811	1.81	69.43	1.073	1.942	24.681	.355
5 M	903	2.02	71.45	1.341	2.709	27.389	.383
6 M	371	0.83	72.28	2.091	1.736	29.125	.403

Table 33

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 5A 1:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK							
1 MB	1181	2.64	2.64	.257	0.678	0.678	.257
FSB	747	1.67	4.31	.258	0.431	1.109	.257
1 MT	6086	13.63	17.94	.267	3.639	4.749	.265
FST	3682	8.25	26.19	.277	2.285	7.034	.269
2 MT	5731	12.83	39.02	.295	3.785	10.819	.277
2 MB	453	1.01	40.03	.303	0.306	11.125	.278
2 BK	1868	4.18	44.21	.373	1.559	12.684	.287
3 M	3963	8.87	53.08	.379	3.362	16.046	.302
BK.RED	1597	3.58	56.66	.392	1.403	17.449	.309
CSB	13	0.03	56.69	.399	0.012	17.461	.309
1 BK	748	1.67	58.36	.403	0.673	18.134	.311
3 BK	1767	3.96	62.32	.411	1.628	19.761	.317
CST	259	0.58	62.90	.473	0.274	20.036	.319
2 Q	331	0.74	63.64	.508	0.376	20.412	.321
4 BK	803	1.80	65.44	.515	0.927	21.339	.326
4 M	1340	3.00	68.44	.530	1.590	22.929	.335
SUC	192	0.43	68.87	.552	0.237	23.166	.336
1 T	415	0.93	69.80	.643	0.598	23.764	.340
5 BK	639	1.43	71.23	.799	1.143	24.907	.350
5 M	967	2.17	73.40	1.244	2.699	27.606	.376
B&SD	680	1.52	74.92	1.262	1.918	29.524	.394
6 M	440	0.99	75.91	2.081	2.060	31.585	.416

Table 34

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 1B 1:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
NO PRE-BREAK							
1 MB	1463	2.83	2.83	.269	0.761	0.761	.269
1 MT	6163	11.91	14.74	.270	3.216	3.977	.270
FSB	1527	2.95	17.69	.280	0.826	4.803	.272
FST	6224	12.03	29.72	.291	3.501	8.304	.279
2 MB	444	0.86	30.58	.307	0.264	8.568	.280
2 MT	5839	11.29	41.87	.308	3.477	12.045	.288
CSB	12	0.02	41.89	.356	0.007	12.052	.288
3 M	3518	6.80	48.69	.375	2.550	14.602	.300
BK.RED	1349	2.61	51.30	.395	1.031	15.633	.305
2 BK	1829	3.54	54.84	.396	1.402	17.035	.311
CST	503	0.97	55.81	.430	0.417	17.452	.313
3 BK	1770	3.42	59.23	.434	1.484	18.936	.320
1 BK	1058	2.05	61.28	.437	0.896	19.832	.324
2 Q	411	0.79	62.07	.466	0.368	20.200	.325
4 M	2221	4.29	66.36	.473	2.029	22.229	.335
4 BK	945	1.83	68.19	.593	1.085	23.315	.342
1 T	385	0.74	68.93	.681	0.504	23.819	.346
SUC	56	0.11	69.04	.757	0.083	23.902	.346
5 M	914	1.77	70.81	.804	1.423	25.325	.358
5 BK	609	1.18	71.99	.928	1.095	26.420	.367
6 M	786	1.52	73.51	1.558	2.368	28.788	.392
BSD	646	1.25	74.76	1.781	2.226	31.014	.415

Table 35

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 2B 1:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of Q X A	S of QXA / S of Q
MEDIUM PRE-BREAK							
FSB	1369	2.69	2.69	.239	0.643	0.643	.239
1 MB	1420	2.78	5.47	.248	0.689	1.332	.244
1 MT	6040	11.83	17.30	.259	3.064	4.396	.254
FST	5527	10.83	28.13	.270	2.924	7.320	.260
2 MT	6113	11.97	40.10	.287	3.435	10.756	.268
2 MB	767	1.50	41.60	.287	0.431	11.186	.269
CSB	11	0.02	41.62	.316	0.006	11.193	.269
BK.RED	1614	3.16	44.78	.344	1.087	12.280	.274
2 BK	1993	3.90	48.68	.355	1.385	13.664	.281
3 M	3581	7.01	55.69	.363	2.545	16.209	.291
1 BK	1233	2.42	58.11	.366	0.886	17.095	.294
CST	463	0.91	59.02	.369	0.336	17.430	.295
3 BK	2026	3.97	62.99	.404	1.604	19.034	.302
P.BK	258	0.51	63.50	.421	0.215	19.249	.303
2 Q	339	0.66	64.16	.454	0.300	19.549	.305
4 M	1973	3.86	68.02	.566	2.185	21.733	.320
4 BK	879	1.72	69.74	.609	1.047	22.781	.327
1 T	372	0.73	70.47	.686	0.501	23.282	.330
SUC	3	0.01	70.48	.759	0.008	23.289	.330
5 BK	497	0.97	71.45	.928	0.900	24.189	.339
5 M	635	1.24	72.69	.972	1.205	25.395	.349
BSD	626	1.23	73.92	1.560	1.919	27.313	.369
6 M	556	1.09	75.01	1.826	1.990	29.304	.391

Table 36

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 3B 1:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
HEAVY PRE-BREAK							
FSB	1168	2.31	2.31	.268	0.619	0.619	.268
1 MT	5569	11.03	13.34	.269	2.967	3.586	.269
FST	5249	10.40	23.74	.278	2.891	6.447	.273
2 MB	687	1.36	25.10	.287	0.390	6.868	.274
2 MT	6103	12.09	37.19	.288	3.482	10.350	.276
1 MB	1525	3.02	40.21	.298	0.900	11.250	.280
1 BK	1196	2.37	42.58	.342	0.811	12.060	.283
2 BK	2119	4.20	46.78	.342	1.436	13.496	.289
BK.RED	1989	3.94	50.72	.346	1.363	14.860	.293
P.BK	39	0.08	50.80	.361	0.029	14.889	.293
CSB	10	0.02	50.82	.363	0.007	14.896	.293
3 BK	1995	3.95	54.77	.371	1.465	16.361	.299
3 M	3077	6.10	60.87	.392	2.391	18.753	.308
CST	362	0.72	61.59	.409	0.294	19.047	.309
2 Q	396	0.78	62.37	.453	0.353	19.400	.311
4 BK	971	1.92	64.29	.561	1.077	20.477	.319
4 M	1622	3.21	67.50	.576	1.849	22.326	.331
SUC	317	0.63	68.13	.653	0.411	22.738	.334
1 T	342	0.68	68.81	.715	0.486	23.224	.338
5 BK	710	1.41	70.22	.822	1.159	24.383	.347
5 M	842	1.67	71.89	1.068	1.784	26.167	.364
BSD	785	1.56	73.45	1.275	1.989	28.156	.383
6 M	642	1.27	74.72	1.830	2.324	30.480	.408

Table 37

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL: K.S.U. PILOT MILL
TEST: NO. 1C 1:1 DIFF
WHEAT: HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
MEDIUM PRE-BREAK							
FSB	1272	2.61	2.61	.23	0.60	0.60	.230
1 MT	5163	10.58	13.19	.25	2.65	3.25	.246
1 MB	692	1.42	14.61	.25	0.36	3.60	.246
FST	5091	10.43	25.04	.27	2.82	6.42	.256
2 MT	5293	10.84	35.88	.27	2.93	9.34	.260
2 MB	445	0.91	36.79	.29	0.26	9.61	.261
3 M	3733	7.65	44.44	.31	2.37	11.98	.270
CSB	13	0.03	44.47	.33	0.01	11.99	.270
2 Q	768	1.57	46.04	.33	0.52	12.51	.272
BK.RED	1172	2.40	48.44	.34	0.82	13.32	.275
4 M	2148	4.40	52.84	.36	1.58	14.91	.282
2 BK	1577	3.23	56.07	.37	1.23	16.14	.287
3 BK	1563	3.20	59.27	.37	1.18	17.32	.292
CST	381	0.78	60.05	.37	0.29	17.61	.293
1 BK	1110	2.27	62.32	.38	0.86	18.47	.296
P.BK	154	0.32	62.64	.43	0.14	18.61	.297
4 BK	987	2.02	64.66	.44	0.89	19.50	.301
1 T	451	0.92	65.58	.53	0.49	19.98	.304
SUC	137	0.28	65.85	.53	0.15	20.14	.305
5 M	700	1.43	67.29	.69	0.99	21.12	.313
5 BK	1047	2.14	69.43	.70	1.50	22.62	.325
6 M	880	1.80	71.23	1.07	1.93	24.54	.344
BSD	825	1.69	72.92	1.38	2.33	26.88	.368

Table 38

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 2C 1:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of QXA	S of QXA / S of Q
HEAVY PRE-BREAK							
FSB	1083	2.21	2.21	.24	0.53	0.53	.240
1 MT	5392	11.02	13.23	.25	2.76	3.29	.249
1 MB	824	1.68	14.91	.25	0.42	3.71	.249
FST	5213	10.65	25.56	.26	2.77	6.47	.253
2 MT	4984	10.19	35.75	.28	2.85	9.33	.261
2 MB	320	0.65	36.40	.29	0.19	9.52	.262
2 BK	1950	3.99	40.39	.31	1.24	10.75	.266
BK.RED	1583	3.24	43.63	.31	1.00	11.76	.270
1 BK	949	1.94	45.57	.33	0.64	12.40	.272
CSB	13	0.03	45.60	.35	0.01	12.41	.272
3 BK	1937	3.96	49.56	.35	1.39	13.79	.278
P.BK	700	1.43	50.99	.36	0.51	14.31	.281
3 M	2825	5.77	56.76	.37	2.13	16.44	.290
2 Q	299	0.61	57.37	.39	0.24	16.68	.291
CST	237	0.48	57.85	.41	0.20	16.88	.292
4 BK	1010	2.06	59.91	.46	0.95	17.83	.298
4 M	1488	3.04	62.95	.49	1.49	19.32	.307
SUC	120	0.25	63.20	.52	0.13	19.45	.308
1 T	384	0.78	63.98	.62	0.48	19.93	.311
5 BK	935	1.91	65.89	.72	1.38	21.31	.323
5 M	569	1.16	67.05	.75	0.87	22.18	.331
6 M	1106	2.26	69.31	.97	2.19	24.37	.352
BSD	1099	2.25	71.56	1.09	2.45	26.82	.375

Table 39

Cumulative Flour Ash Calculations

A = ASH (14% Moisture Basis)
Q = QUANTITY (% of Total Products)
S = SUMMATION

MILL K.S.U. PILOT MILL
TEST NO. 3C 1:1 DIFF
WHEAT HARD RED WINTER

STREAM	WEIGHT (grams)	Q	S of Q	A	Q X A	S of Q X A	S of Q X A / S of Q
NO PRE-BREAK							
1 MT	5645	11.66	11.66	.23	2.682	2.682	.230
1 MB	780	1.61	13.27	.25	0.403	3.084	.232
FSB	1275	2.63	15.90	.26	0.684	3.768	.237
FST	5433	11.22	27.12	.27	3.029	6.798	.251
2 MT	4895	10.11	37.23	.30	3.033	9.831	.264
2 MB	241	0.50	37.73	.31	0.155	9.986	.265
3 M	4009	8.28	46.01	.32	2.650	12.635	.275
CSB	16	0.03	46.04	.35	0.011	12.646	.275
2 Q	613	1.27	47.31	.36	0.457	13.103	.277
2 BK	1374	2.84	50.15	.38	1.079	14.182	.283
BK.RED	1031	2.13	52.28	.38	0.809	14.991	.287
4 M	2200	4.55	56.83	.39	1.775	16.766	.295
3 BK	1360	2.81	59.64	.40	1.124	17.890	.300
1 BK	960	1.98	61.62	.41	0.812	18.702	.304
CST	392	0.81	62.43	.43	0.348	19.050	.305
4 BK	854	1.76	64.19	.46	0.810	19.860	.309
SUC	173	0.36	64.55	.53	0.191	20.050	.311
1 T	435	0.90	65.45	.54	0.486	20.536	.314
5 M	1352	2.79	68.24	.59	1.646	22.183	.325
5 BK	1097	2.27	70.51	.61	1.385	23.567	.334
6 M	972	2.01	75.52	1.16	2.332	25.899	.357
BSO	763	1.58	74.10	1.48	2.338	28.237	.381

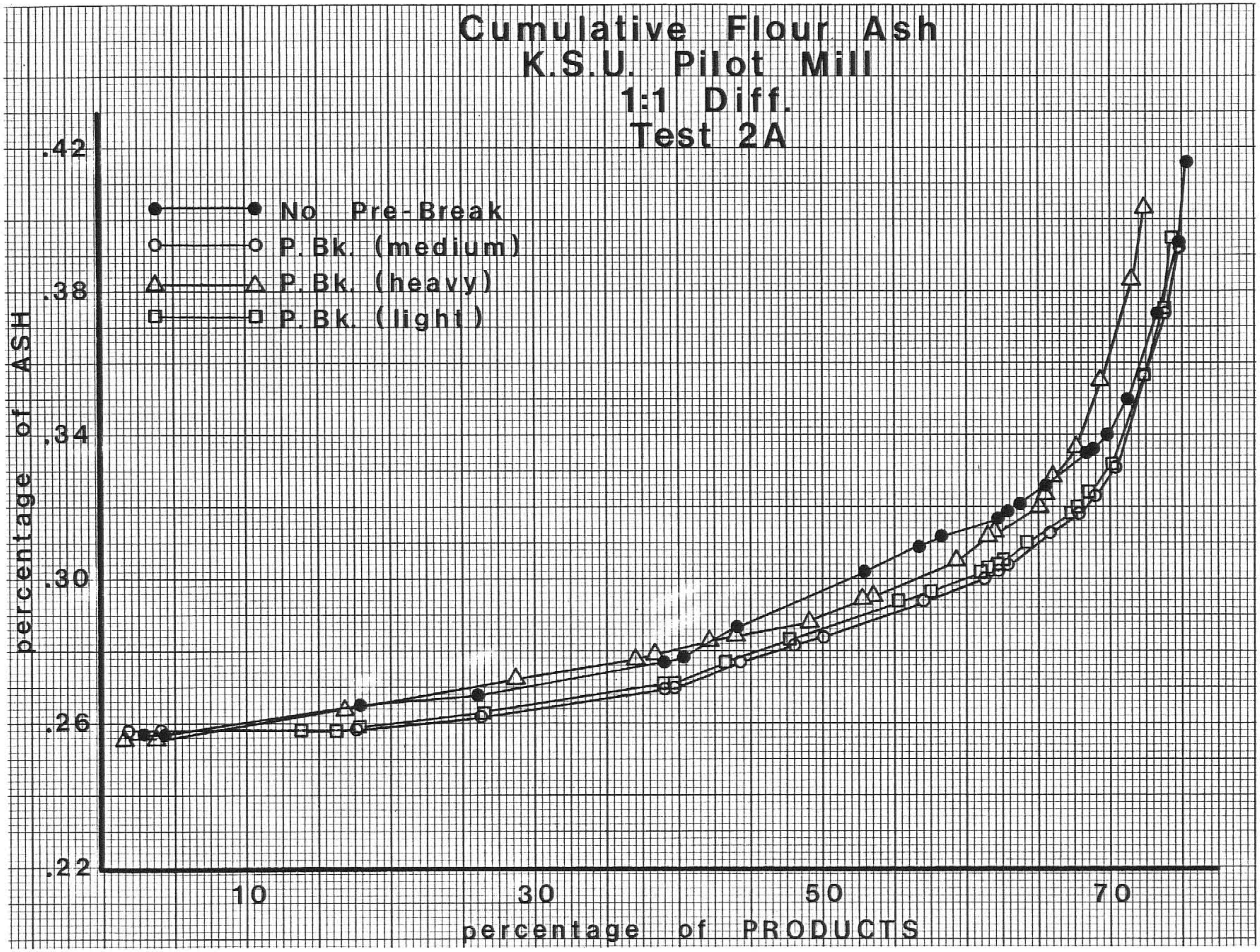

Cumulative Flour Ash
K.S.U. Pilot Mill
1:1 Diff.
Test 2A
No Pre-Break
P. Bk. (medium)
P. Bk. (heavy)
P. Bk. (light)
.42
.38
.34
.30
.26
.22
percentage of ASH
10
30
50
70
percentage of PRODUCTS

Figure 106

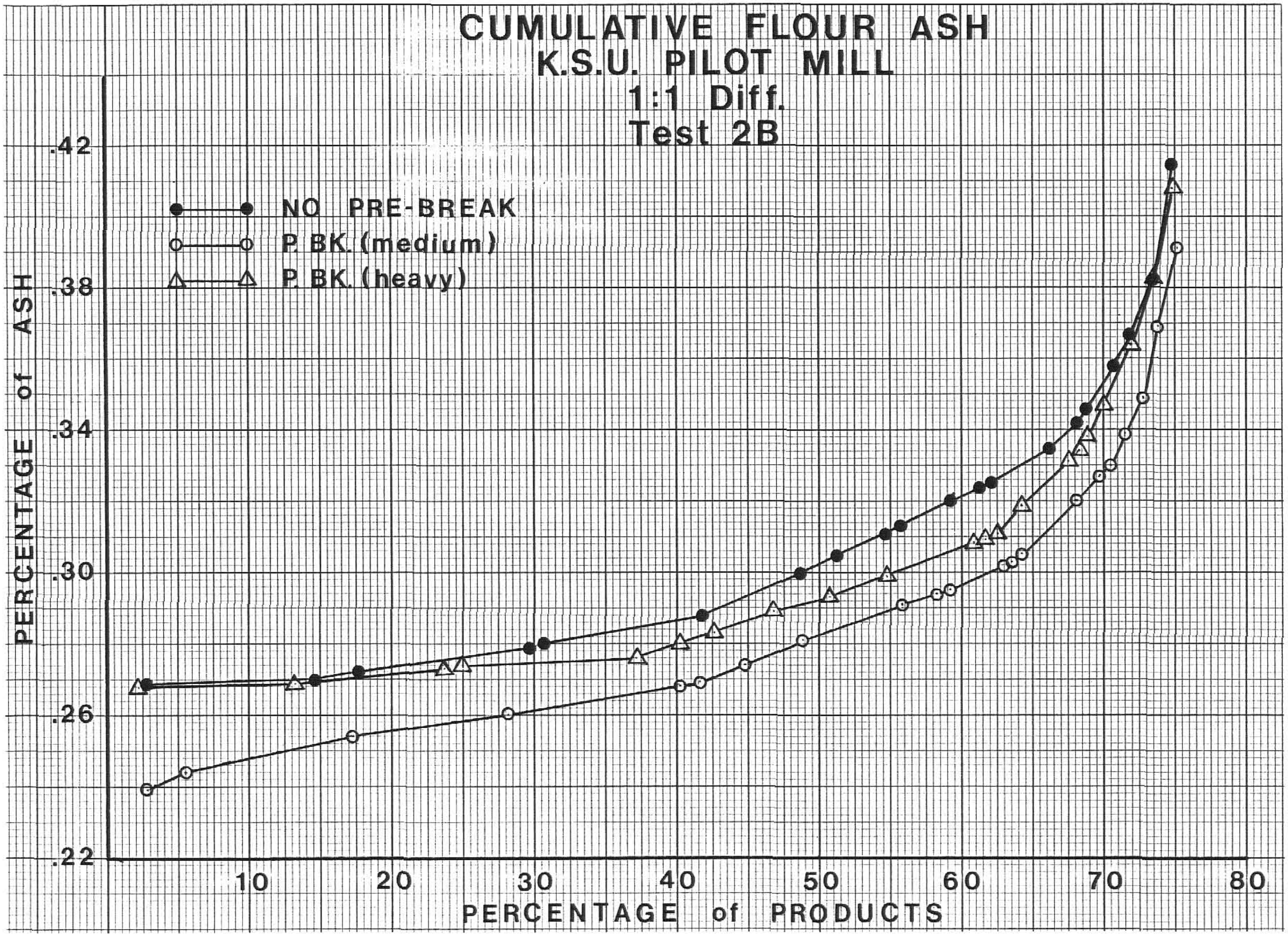

CUMULATIVE FLOUR ASH
K.S.U. PILOT MILL
1:1 Diff.
Test 2B
NO PRE-BREAK
P. BK. (medium)
P. BK. (heavy)
PERCENTAGE of ASH
.42
.38
.34
.30
.26
.22
10
20
30
40
50
60
70
80
PERCENTAGE of PRODUCTS

Figure 107

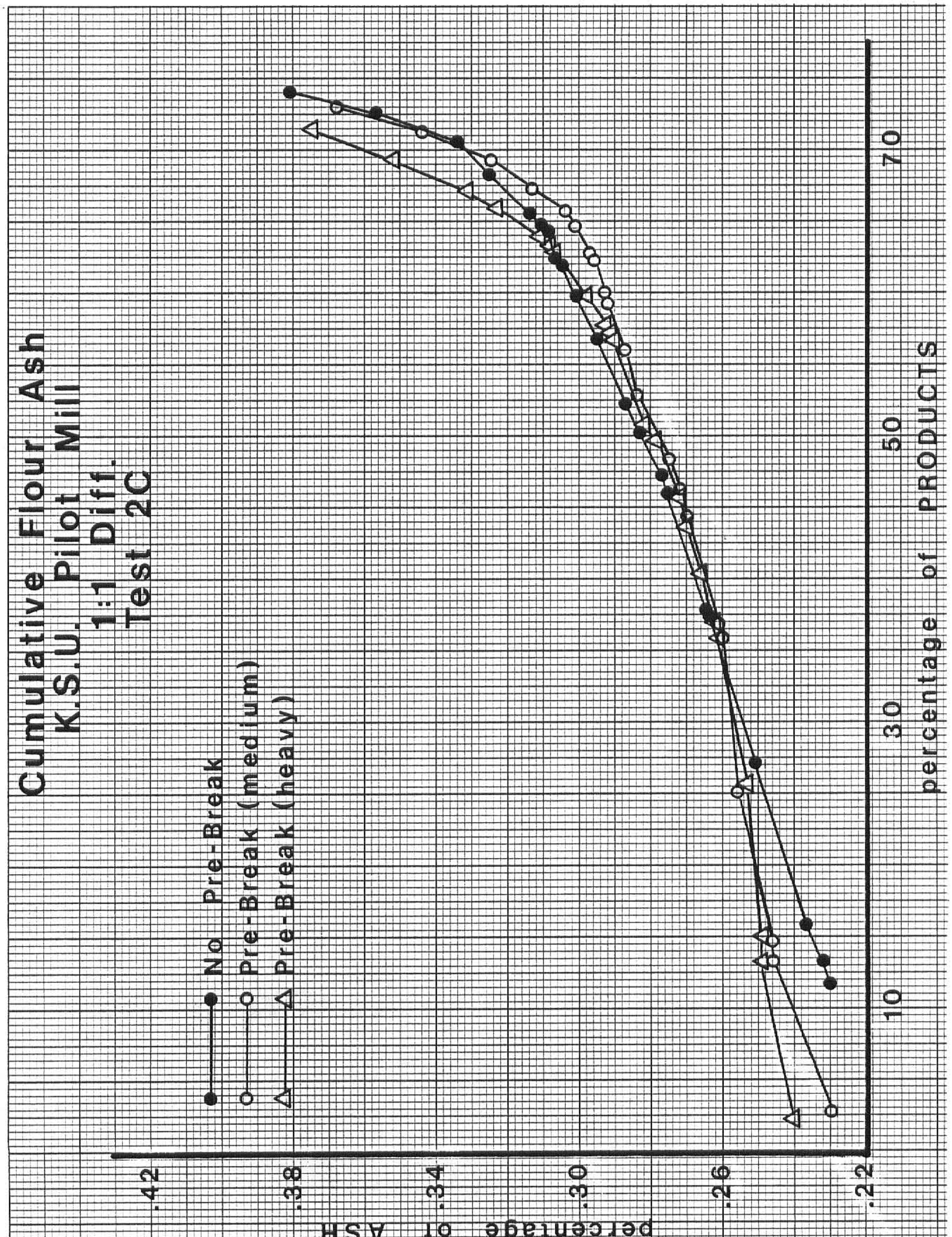

Cumulative Flour Ash
K.S.U. Pilot Mill
1:1 Diff.
Test 2C
No Pre-Break
Pre-Break (medium)
Pre-Break (heavy)
percentage of ASH
.42
.38
.34
.30
.26
.22
10
30
50
70
percentage of PRODUCTS

Figure 108

PRE-BREAKING: DOCUMENTING ITS EFFECTS

by

STEVEN P. CURRAN

B.S., Kansas State University, 1974

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Grain Science and Industry

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1982

The purpose of this research was to document the effect of Pre-Breaking wheat kernels prior to the actual milling process. Five different types of experimental mills were used for the testing. A Hard Red Winter Wheat was used for all of the milling.

The five experimental mills which were utilized for the testing are as follows:

1. Brabender Quadrumat Junior
2. Brabender Quadrumat Senior
3. Buhler Experimental Mill
4. Ross Mill Walking Flow
5. Miag Multomat

Testing on each mill involved milling with the whole wheat kernels going directly to the First Breaking operation, as in a normal milling operation, and milling with the whole kernels being slightly broken, or opened at the crease of the kernel, before proceeding to the First Break. This Pre-Breaking was accomplished using, in most cases, smooth 9" x 6" rolls operating at a one to one differential. Where possible the Pre-Broken stock was also sifted prior to milling; this being done to determine if sifting of the Pre-Broken wheat had any effects other than just simple Pre-Breaking.

Flours from each milling were weighed and analyzed for both moisture and ash content. Cumulative flour ash was then calculated for each milling. To analyze the effect Pre-Breaking had on milling quality for each test, cumulative flour ash was plotted against the cumulative percentage of total products.

The analysis of the test results showed that, in all cases, milling performance of the same wheat mix was improved by Pre-Breaking the wheat prior to milling. Flour ash content was significantly lowered and a slight improvement in total extraction was realized for the samples that were Pre-Broken. Where sifting of the Pre-Broken wheat was done prior to milling, improvement was noticed over the samples that were Pre-Broken and not sifted.