FLOUR MILL BREAK EXTRACTIONS

by

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B.S., Kansas State University, 1950

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Grain Science and Industries

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

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INTRODUCTION

The milling of white flour from wheat involves the separation of the outer, pigmented bran coat from the enclosed, white endosperm. The released endosperm material is graded into various sizes, mechanically treated in various ways to complete the endosperm/bran separation and, subsequently, reduced to a fineness that is universally called flour. The total manufacturing system used in a modern flour mill is quite complex in order to take advantage of all the various physical characteristics of the wheat and its milled fractions to obtain a white, bright, uniform flour in the most economical way possible.

Rollermills are used to make the primary bran/endosperm separation. These rollermills employ two rotating steel cylindrical rolls running at different speeds towards a common gap or nip between the two. Spiralling flutes or corrugations are cut into the surface of these rolls to obtain the desired cutting or shearing action. This operation is called breaking and several breaking operations are necessary to obtain the desired separation. The individual breaking passages are called breaks and are numbered 1st break, 2nd break, 3rd break, etc., to as many passages as are used. Five breaks is the most common number used but it can vary from three to seven. The number of corrugations increase and their depth decreases on each subsequent passage. The material separated at each break passage is sifted to obtain a series of products that vary in size and in purity or freedom from bran. The coarsest material consists of the bran with attached endosperm and is sent on to the next break passage until all of the endosperm is removed. A relatively small amount of flour is produced in the breaking process and it is removed in the sifters.

The balance of the released material is granular in nature and is called middlings. These middlings are graded into several size ranges for further processing.

The coarsest middlings may still have bran attached to them and are sent to rollermills for a special treatment called sizing. The passage is called sizings and may be further classified into coarse and fine sizings. The endosperm particle is crushed lightly between the rotating rolls to facilitate the further removal of bran.

The relatively free-from-bran middlings produced in the finer granulations on the first three breaks are combined with the sized particles from sizings for a series of grinding-sifting passages designed to produce an optimum amount of white flour. This process is called reducing. The passages are called middlings reductions in the United States with the word, reductions, usually being dropped for the sake of brevity. They are further classified into coarse and fine. (In Europe these passages are given alphabetical designations.) The use of air purifiers is optional to the process but are found in a majority of white flour mills. These machines enhance the removal of unattached bran chips thru the use of combined sifting and air current treatments.

The main concern of the miller is to provide a uniform flour having the characteristics desired by the baker or housewife. Whiteness, keeping quality (as regards the amount of rancidity-prone germ contained in the flour) and protein content are among the quality considerations given to the finished flour.

The secondary concern of the miller is to gain maximum productivity thru such things as proper load distribution to the many rollermills,

sifters and purifiers and to maintain an acceptable total extraction or yield of white flour per pound or bushel or ton of wheat ground.

The purpose of this study is to vary the amount of material extracted on three different break passages, using three different wheat classes, to determine how these variations affect particle size distributions, load distributions, bran removal efficiencies and protein distributions in the intermediate and final milling products, and how different classes of wheat, having different structures and degrees of hardness, react to similar break extractions as regards the same testing methods.

SURVEY OF LITERATURE

Due to the proprietary nature of the milling process, very little scientific literature on this subject has been released over the years. Generalizations are also difficult to find due to the complexity of the industry as it relates to the variety of wheat types milled, the variety of milling techniques used and the many variables affecting the overall milling results. Even the language of milling is sufficiently different between mills and between milling communities to produce a certain amount of confusion and unreliability in interpreting published data.

Breaking Process

The distance between the opposing rolls in the break rollermills is adjustable while in operation. This allows the operator freedom to vary this gap and thereby change the amount of material released on each rollermill. Factors affecting the amount of release desired include such things as wheat softness or hardness as affected by such things as wheat class and moisture content, machine loading as affected by weight and density of the stock to the roll, and the amount of bran coat disruption that can be tolerated by the ensuing break, sizings and middlings reduction passages.

To enable the miller to control the amount of release, a procedure is used whereby a sample of the material that has passed thru the rolls is sifted on a small sifter. A cloth having a predetermined aperature - opening, usually having the same size sieve openings as are in the full scale sifter being used, is placed in the sifter to obtain an overs or scalp and a thrus of the cloth. The material that passes thru the sieve is called the release. The amount of material released is recorded in two ways.

The first method of reporting is called the "percent of release" in most literature but is also referred to as "roll set" by some. This is the amount of material released by a roll as a percent of the material coming to that roll.

Release = Unit Extraction = % of load to roll released through test screen.

The second method of reporting is called "percent of extraction." This is the amount of material released expressed as a percent of the wheat being milled.

Extraction = Total Extraction = % of load to 1st break through test screen or screens.

Percent release is used by the miller to set his individual rolls and is an indicator of the amount of work being done by an individual machine or unit.

Percent extraction is the measurement used to determine the amount of work done by a milling passage in relation to the overall milling process.

An example of these two relationships follows:

System	% Load to System	% Release	% Extraction	Calculation of Release $\frac{\% \text{ Extraction}}{\text{Load to System}}$ X 100 =
1st Break	100	25	25	$\frac{25}{100}$ X 100 = 25
2nd Break	(100-25) = 75	40	30	$\frac{30}{75}$ X 100 = 40
3rd Break	(75-30) = 45	37.8	17	$\frac{17}{45}$ X 100 = 37.8

Around 1900 the milling industry came of age. With the advent of roller-mills and the building of large, complex milling facilities, it became increasingly important to maintain control. The famous miller's touch was no longer adequate for the task.

An early reference to this problem was made by Howe (1), who gave the following break release schedule for a commercial mill having a total of five break passages:

1st Break - 30% thru 18W

2nd Break - 47% thru 20W

3rd Break - 45% thru 24W

(These are equivalent to break extractions of 30%, 32.9% and 16.7%, respectively, for a total of 79.6%. It should be noted that the above extractions are considered quite high for modern milling requirements. They are shown here because it is one of the earliest American references to break extractions).

Pence (2) outlined the need to control break extractions for overall mill balance and gave the following extractions as averages for five soft wheat commercial mills and five hard wheat commercial mills.

	1st Break Thru 18W	2nd Break Thru 20W	3rd Break Thru 22W	Total
Soft wheat mills	28.0%	32.6%	15.3%	75.9%
Hard wheat mills	19.8%	30.6%	18.1%	68.5%

This indicated the rather wide range of extractions in practice in the 1930's.

Equivalent break releases would be

	1st Break Thru 18W	2nd Break Thru 20W	3rd Break Thru 22W
Soft wheat mills	28.0	45.3	38.8
Hard wheat mills	19.8	38.1	43.0

It is also noted there is no standard wire size used for determining the amount of release and this makes it somewhat difficult to make direct comparisons.

Feese (3) experimented with break extractions on his mill and gave his reasons for maintaining break extractions for better mill balance and uniformity. The releases which worked best for the mill in question were:

First break - 20% Thru 18W

Second break - 37% Thru 18W

Third break - 40% Thru 20W

Equivalent extraction rates would be:

First break -	20.0%
Second break -	29.6%
Third break -	20.0%
Total	69.6%

These early references make no attempt to substantiate the results in numbers but rely on judgmental factors only. These judgments were possibly right, however.

Robbins (4) made an extensive study of granulation changes as affected by variances in break extractions. His study used three different 1st break extractions. He then used three pre-set roll gap settings on both 2nd and 3rd break to obtain a "coarse, medium and fine" result. The total extraction for the series varied between 75.7% for the "coarse, coarse, coarse" extractions of 17.6%, 38.0% and 20.1%, and 81.4% for the "fine, fine, fine" settings of 44.6%, 26.9% and 9.9%. This work was done on an Allis-Chalmers experimental mill. Robbins also pointed out that 2nd break is greatly self-compensating on combined 1st and 2nd break extractions when 2nd break is kept at a constant roll gap setting while changing the extraction on 1st break on a commercial mill. The range was as follows:

	1st break %	2nd break %	Total %
Maximum 1st break	46.7	11.2	57.9
Minimum 1st break	13.6	40.3	53.9

Vilm (5) pointed out that there is no set rule of just what the (break) extractions should be in a given mill.

Peterson (6) recognized that controlled break extractions are unquestionably one of the most important factors in mill control.

The importance of break extractions has been recognized throughout the world. In England, Lockwood (7) gives the following recommended approximate releases.

First Break - 30% Thru 20W
Second Break - 52% Thru 20W
Third Break - 35% Thru 28W

(These are equivalent to 30%, 36% and 12% extractions for a total of 78%). In Russia, Kuprits (8) gives the following ranges of extractions.

First Break - 8-15% Thru 19W
Second Break - 45-55% Thru 19W
Third Break - 40-50% Thru 24W

He further explains that with these extraction values a maximum amount of the best middlings and dusts (fine middlings) is obtained and a minimum amount of (Break) flour. The lower limits are for mealy (soft) wheats, the upper limits apply to hard and vitreous wheats.

The Association of Operative Miller's Correspondence Course (9) sums up the situation quite well by stating that set percentages of extraction may become highly controversial.

Particle Size Distribution of Milled Products

(Granulation)

The manner in which the wheat endosperm breaks down during the milling process has been the subject of several investigations.

The importance of granulation to the milling process lies in the distribution of the graded products to the various points of process in the mill. The ability to predict the amount of material that will be sifted out between any given set of sieve cloths having different aperature openings is very important to the design of new mills and the optimization of existing mills. The amount of material produced in any given particle size range will change with changes in break extractions. Due to the change in roll corrugations used for different break passages and, possibly also due to changes in cell size characteristics as the stock is stripped of endosperm, the granularity will be different at the same extraction rates on the different break passages.

In 1935 Rozsa (10, 11) made two studies concerning the granularity of mill products or fractions. He made the statement, "Through tests on granulation changes alone it is possible to control the efficiency of the mill."

Rozsa refers to Dr. Ing O. Haltmeier as the person who introduced the characteristic granulation curve.

Rozsa further states, "For uniformly efficient operation, the (granulation) curves must remain identical from one day to another."

Farrell, et al, (12) in their complete analysis of a mill, show how the granulation curve can be used to compare the performance of existing mills with the pilot mill tested.

Ash Content of Milled Products

A white, bright flour is preferred by much of the world's population over a dull, gray flour. The brightness of flour is due to some extent to the way the particles refract light and, therefore, the apparent color changes with granularity. An off color is produced when bran and germ remain in the flour produced as these products contain various pigments not found in the endosperm.

One of the early discoveries on the composition of milled products was that the mineral content of the flour and bran vary quite widely. Shellenberger (13) indicates that on an average, the germ contains about 4.8 percent ash, the bran 8.6 percent ash, and the endosperm about 0.4 percent ash.

Snyder (14) (15) was possibly the first person to point out the potential of the ash test as an indicator of bran content in flour. The same Snyder (16) was a leading opponent of those wishing to make the ash test an official grade standard, pointing out the variations in wheat ash, lack of uniformity in the milling process and the inability to distinguish differences in proportion to commercial value.

Thus the miller was caught in a dilemma that originated at the turn of the century and from which he has not yet fully escaped. That dilemma concerns the usefulness of the ash test to the miller in analyzing mills and its misuse by the baker as a flour specification.

Swanson(17) indicates that, "The primary value of 'ash' determination is to measure the thoroughness of the separation of the bran coat from the endosperm." He further points out that, "No system of milling can make a low ash flour from a high ash wheat. When the cause of high ash is in the wheat, the high ash flour (produced) may have a better baking performance than the low(er) ash flour, both having the same extraction."

Pratt (18) states, "The mineral content of a flour, per se, is not related to final performance."

The ash test has also been replaced or supplemented by such things as colorimetric reflectance meters and a most promising new development in Near Infrared Reflectance indicates that cellulose detection may be of more positive value than either ash or color (19).

All mills make a number of flours simultaneously. One flour is produced at each break, sizing and reduction operation. There may be 20 to 30 or more individual flours coming from a given wheat mix that may be blended to produce one or more flour grades or mixtures having the special characteristics desired. Two, three or more flour grades may be made simultaneously. Ash is often used to determine which streams go to each flour grade because ash content is still used - and misused - as a main parameter in flour specifications given the miller by the baker. Widmar (20) shows how cumulative ash curves are used to determine the manner in which individual flour streams should be blended to form divides or grades on an ash content basis.

To further complicate the use of ash as an indicator of bran inclusion in flour, we know that the ash or mineral content of the endosperm varies within the wheat berry. Morris, et al, (21) indicate that a spread from

.246% to .400% ash exists in Hard Red Winter and a spread of from .206% to .564% in ash exists in Hard Red Spring wheats. This would be the equivalent of adding about 4% of pure bran to the lowest ash endosperms. This is over twice the amount of bran that would be found in even the worst of white flours. Without knowing the "pure" endosperm ash in the product being tested, it is impossible to use ash content as a measure of bran inclusion. This is confirmed by Morris, et al, who state that in a study of mill streams vs. dissections "there is little evidence that the incorporation of bran was an important factor in the determination of ash content of those streams." As an example, the following table was given.

"Table III

Wheat Class	Dissected Endosperm		vs.	Mill Stream	
	Yield	Ash		Yield	Ash
HRW	64.3	.51		68.0	.43
HRS	56.3	.49		62.4	.46
SRW	60.6	.48		66.8	.41"

This indicates that the milling system actually reduces the net ash content despite the fact that high ash bran is found in the mill stream flours and not in the dissected endosperm material.

MacMasters, et al, (22) also found spreads in ash from bran free endosperm within the wheat berry as follows:

Wheat No.	Lowest Ash %	Highest Ash %	Spread %
3	.28	.40	.12
4	.43	.56	.13
5	.24	.53	.29
6	.31	.57	.26
7	.40	.55	.15

It is also of interest to note the wide spread in the lowest ash content of from .28% to .43% in wheats #3 and #4, respectively.

The question then is, "Why is ash used in this report?" The answer is that when using the same carefully blended wheat lots, an increase in ash will indicate an increase in bran content. As the same wheats were used in each test series, it is assumed that the ash base remained the same, even though the internal ash variance might be distributed in the milled products in different ways.

The second reason it was used was to face the reality that ash is still a widely used specification for flour and its manipulation is still of technical interest to the miller.

Protein Content of Milled Products

The protein content of flour is important from both a functional and nutritional aspect. Higher protein flours are used in baked products requiring dough strength, such as bread, buns and rolls. Lower protein flours are used for baked products requiring weaker doughs, such as cakes, cookies and crackers.

Each flour stream in a mill has a different protein content and the blending techniques described above for ash can also be used to obtain various grades of flours having different protein contents from the same wheat mix.

When it is important to obtain as wide a variance in protein contents of the individual flour streams as is possible, it is important to take advantage of the protein content variations within the wheat endosperm structure insofar as possible.

Endosperm protein content increases from the cheek center towards the bran coat. Morris, et al, (21) found a gradient of from 8.6% to 14.1% in hard red winter wheats whose overall protein level only varied from 12.0% to 12.8%. In soft red wheat, the endosperm protein varied from 6.5% to

11.4% in wheats that only exhibited a spread of 9.3% to 9.7% in the grain. MacMasters, et al, (22) likewise show protein ranges within the berry endosperm of as high as 6.5% with an average of 4.5% found in seven different wheat dissections. It was also noted in this study that 72% of the total wheat protein is in the endosperm. This compares to 20% of the total minerals of a wheat being found in the endosperm.

Protein content is, therefore, included in this study due to its use by the miller to produce the specialized use flours demanded by the baker for specialized baked products and for the miller who is often faced with producing wide spreads of flour protein from rather limited wheat protein spreads.

MATERIALS AND METHODS

Three wheat mixes representing three main classes of wheat were used. These are Hard Red Winter, Hard Red Spring and Soft White Spring.

Hard Spring wheat, in general, is more vitreous and of higher protein than Hard Winter wheat. Hard Winter wheat, in turn, is generally more vitreous and of higher protein than soft wheat.

The wheats selected are commercial milling quality and are typical of the types used by commercial mills, although it must be recognized that wide variations exist within classes. Table #1 outlines the specifications of the three wheats.

A flow sheet was established as typified in Figure #1. This flow sheet was designed to produce data for the first three break passages, fine and coarse sizings and fine and coarse middlings reductions. This is sometimes referred to as the "head of the mill". The cloth aperature openings were selected to obtain approximately the same amount of four sizes of middlings, plus a scalp, plus a flour, from each break.

Table #1

Wheat Specifications

Wheat Class	1 Moisture %	2 Protein %	3 Ash %	4 Pearling Value %	5 Test Weight #/bu.
Hard Red Spring	11.9	13.7	1.45	72.5	60.5
Hard Red Winter	10.9	11.8	1.65	70.0	60.3
Soft White Spring	11.1	10.7	1.53	60.0	62.6

1. Motomco #50 Moisture Tester.
2. AACC Cereal Laboratory Methods, 46-10.

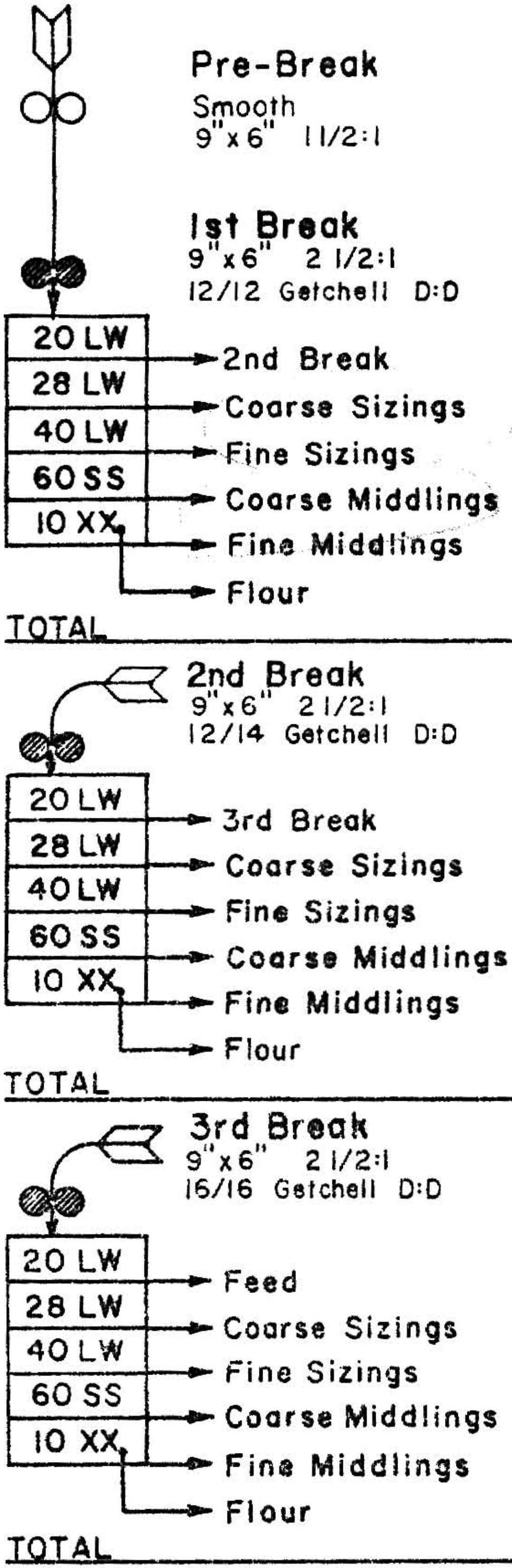
   The total nitrogen content is multiplied by 5.7 and the results are expressed as percent protein on a 14% moisture basis.
3. AACC Cereal Laboratory Methods, 08-01.

   The percent remaining after ignition is expressed as percent ash on a 14% moisture basis.
4. Twenty (20) grams of wheat with all foreign material and broken kernels removed is retained for one minute in a Strong Scott Laboratory Barley Pearler equipped with a No. 30 grit stone and a 10 mesh screen made of wire .041" in diameter (Tyler Code " Fijor"). Pearling value is percent of original sample remaining over a 20 mesh wire after pearling.
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.

FLOW SHEET
BREAKS

Type of Wheat HARD RED WINTER
Test Number 1

	% Release	% Extraction
1st Break	22.5	22.5
2nd Break	42.6	33.0
3rd Break	34.5	15.3



		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	2nd Break	----	----	12.5	2.00
28 LW	Coarse Sizings	7.8	7.9	9.6	.65
40 LW	Fine Sizings	4.0	4.0	9.3	.55
60 SS	Coarse Middlings	4.1	4.1	9.1	.47
10 XX	Fine Middlings	4.7	4.7	9.0	.47
	Flour	1.9	1.9	9.7	.48
TOTAL		22.5	22.6		
20 LW	3rd Break	----	----	13.2	3.04
28 LW	Coarse Sizings	13.7	10.6	10.6	.98
40 LW	Fine Sizings	11.4	8.8	9.5	.44
60 SS	Coarse Middlings	8.7	6.8	10.2	.40
10 XX	Fine Middlings	6.5	5.0	9.5	.39
	Flour	2.3	1.8	10.6	.45
TOTAL		42.6	33.0		
20 LW	Feed	----	----	13.8	4.50
28 LW	Coarse Sizings	5.6	2.5	15.8	3.40
40 LW	Fine Sizings	5.4	2.4	11.1	.80
60 SS	Coarse Middlings	11.2	5.0	11.4	.43
10 XX	Fine Middlings	9.8	4.4	11.3	.38
	Flour	2.5	1.1	11.6	.42
TOTAL		34.5	15.3		

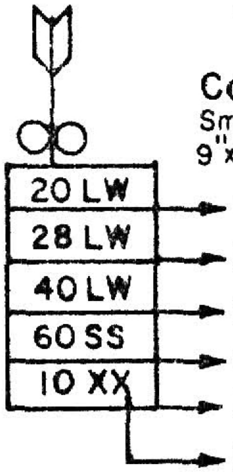
Fig. 1

FLOW SHEET
SIZINGS AND REDUCTIONS

Type of /Wheat HARD RED WINTER
Test Number 1

Coarse Sizings

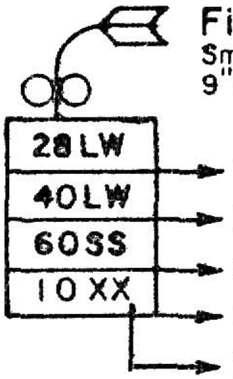
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	8.1	1.7	16.6	3.62
Bottom Scalp	17.1	3.6	12.9	2.60
Fine Sizings	12.4	2.6	9.5	.91
Coarse Middlings	32.9	6.9	9.6	.34
Fine Middlings	24.3	5.1	9.3	.32
Flour	5.2	1.1	9.8	.38
Total	100.0	21.0	10.7	1.06

Fine Sizings

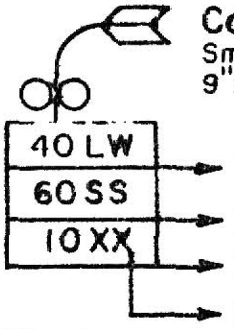
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	3.9	0.7	----	----
Bottom Scalp	10.1	1.8	10.9	1.70
Coarse Middlings	28.1	5.0	9.8	.46
Fine Middlings	49.4	8.8	9.6	.31
Flour	8.4	1.5	9.9	.36
Total	100.0	17.8	9.8	.55

Coarse Middlings

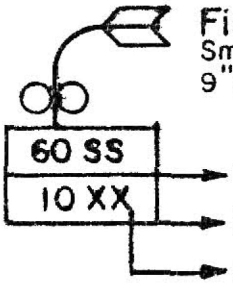
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	2.5	0.7	----	----
Bottom Scalp	8.0	2.2	10.7	1.20
Fine Middlings	42.6	11.8	9.9	.34
Flour	46.9	13.0	9.7	.32
Total	100.0	27.7	9.9	.40

Fine Middlings

Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	.4	0.2	----	----
Bottom Scalp	37.6	16.6	10.3	.45
Flour	62.0	27.4	9.8	.30
Total	100.0	44.2	10.0	.36

Fig. #1

The wheat was cleaned twice on a Carter dockage tester to remove foreign grains, seeds, unhusked wheat, large stones, sand and broken and shrunken kernels. Air aspiration removed light dust and dirt.

The wheat was then cleaned on a Forster horizontal beater scourer with aspiration to remove crease dirt and any loose branny material (Bees wing). A final cleaning on the Carter machine was then performed.

The cleaned wheats were brought to the proper milling conditions by the addition of water and sufficient rest time to allow the water to fully penetrate the berry. The final moisture content was 16.0% for Hard Red Spring and Hard Red Winter and 15.0% for the Soft White Spring. All wheats were rested for 20 hours before milling.

The mill used consisted of Ross Machine Company batch type rollermills with a 9" diameter by 6" long rolls. The sifter was a Great Western laboratory model using a 4" throw at 180 rpms. The roll diameter and sifter throw and speed duplicate commercial practice. The corrugations used are shown on the flow sheet. All corrugations had a ½"/Ft. spiral.

The 1st break extractions were chosen to test the range of low, medium, and high percentages encountered in the industry. 2nd break extractions were chosen to also test a high, medium and low extraction rate, while at the same time making a combined 1st and 2nd break extraction of approximately 60%. The 3rd break extraction was run at a rate sufficient to obtain approximately a 73% extraction for all three breaks. As a range was being explored in all cases, it was not necessary to obtain exactly the same extraction levels for each wheat class. The rolls were set by converting the extraction rates to release rates. The overall release percentages are shown in Table #2

Table #2

Release Table Percent

(Unit Extraction)

Hard Red Winter

	1st Break %	2nd Break %	3rd Break %
Test #1	22.5	42.6	34.5
Test #2	35.0	41.2	33.4
Test #3	47.8	27.3	27.1
Hard Red Spring			
Test #1	25.4	42.0	35.9
Test #2	36.1	39.9	30.6
Test #3	46.7	28.8	28.7
Soft White Spring			
Test #1	28.4	40.0	37.4
Test #2	36.1	38.1	29.2
Test #3	47.5	29.7	30.0

and the overall extraction percentages and combination percentages are shown in Table #3.

The no-load roll gaps for each extraction were noted and are shown on the flow sheets. It should be noted that these gaps will open up during grinding as the rolls are spring loaded.

The sizings and reduction middlings operations were made with a uniform no-load roll gap setting for all tests.

The various fractions were weighed after each operation. These weights were then converted to percent release and then to percent extraction. No accounting was made for material losses due to moisture reductions or thru dust-to-atmosphere loss.

A sufficient quantity of each fraction was obtained for laboratory analysis of protein, ash and moisture content.

RESULTS AND DISCUSSION

Hard Red Winter Wheat

Figures #1, #2 and #3 show the flow sheets and test results for the various break extraction combinations previously given in Table #3.

Particle Size Distribution
(Granularity)

Figure #4 shows the granulation curves obtained from 1st break fractions.

The ordinate is marked off in microns.

The abcissa is marked off in accumulative percent of material over each sieve having the aperature opening indicated.

Vertical lines are made to indicate the micron opening of the meshes for each sieve used in the flow.

Table #3

Extraction Tables Percent

(Total Extraction)

	1st Break %	2nd Break %	1st Break + 2nd Break %	3rd Break %	1st Break + 2nd Break + 3rd Break %
Hard Red Winter					
Test #1	22.5	33.0	55.5	15.4	70.9
Test #2	35.0	26.8	61.8	12.8	74.6
Test #3	47.6	14.2	61.8	10.3	72.1
Hard Red Spring					
Test #1	25.4	31.3	56.7	15.5	73.0
Test #2	36.1	25.5	61.6	11.8	73.4
Test #3	46.7	15.4	62.1	10.9	73.0
Soft White Spring					
Test #1	28.4	28.6	57.0	16.1	73.1
Test #2	36.1	24.3	61.4	11.6	72.0
Test #3	47.5	15.6	63.1	11.1	74.2

FLOW SHEET
BREAKS

Type of Wheat HARD RED WINTER
Test Number 2

	% Release	% Extraction
1st Break	35.0	35.0
2nd Break	41.2	26.8
3rd Break	33.4	12.8

Pre-Break
Smooth
9"x6" 1 1/2:1

1st Break
9"x6" 2 1/2:1
12/12 Getchell D:D

		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	2nd Break	----	----	13.2	2.14
28 LW	Coarse Sizings	12.6	12.6	9.8	.70
40 LW	Fine Sizings	6.4	6.4	9.4	.53
60 SS	Coarse Middlings	5.9	5.9	9.2	.50
10 XX	Fine Middlings	6.8	6.8	9.0	.44
	Flour	3.4	3.4	9.6	.45
TOTAL		35.0	35.0		

2nd Break
9"x6" 2 1/2:1
12/14 Getchell D:D

		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	3rd Break	----	----	14.1	3.28
28 LW	Coarse Sizings	8.5	5.5	11.0	1.23
40 LW	Fine Sizings	10.4	6.8	10.4	.47
60 SS	Coarse Middlings	11.1	7.2	10.7	.38
10 XX	Fine Middlings	8.3	5.4	10.4	.39
	Flour	2.9	1.9	11.1	.45
TOTAL		41.2	26.8		

3rd Break
9"x6" 2 1/2:1
16/16 Getchell D:D

		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	Feed	----	----	13.9	4.40
28 LW	Coarse Sizings	6.0	2.3	15.9	3.38
40 LW	Fine Sizings	4.8	1.8	11.5	.98
60 SS	Coarse Middlings	10.2	3.9	11.6	.44
10 XX	Fine Middlings	9.9	3.8	11.6	.41
	Flour	2.5	1.0	12.0	.44
TOTAL		33.4	12.8		

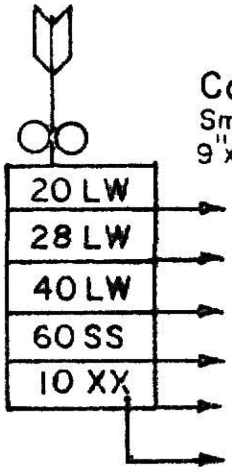
FLOW SHEET

SIZINGS AND REDUCTIONS

Type of /Wheat HARD RED WINTER
Test Number 2

Coarse Sizings

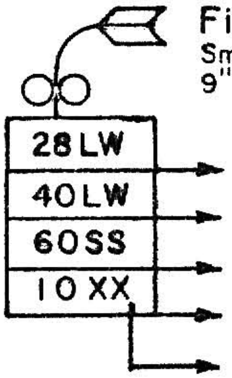
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	7.6	1.5	16.9	3.55
Bottom Scalp	15.3	3.1	13.3	2.85
Fine Sizings	9.7	2.0	9.7	.94
Coarse Middlings	28.0	5.7	9.2	.37
Fine Middlings	32.0	6.5	9.3	.28
Flour	7.4	1.5	9.9	.36
Total	100.0	20.3	10.5	1.02

Fine Sizings

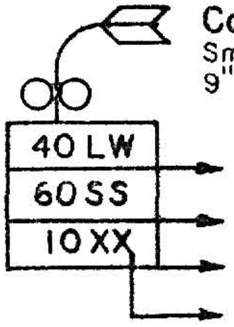
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	3.0	.5	----	----
Bottom Scalp	9.0	1.5	11.4	2.02
Coarse Middlings	16.6	2.8	9.9	.61
Fine Middlings	59.7	10.2	9.6	.31
Flour	11.7	2.0	9.8	.34
Total	100.0	17.0	8.5	.57

Coarse Middlings

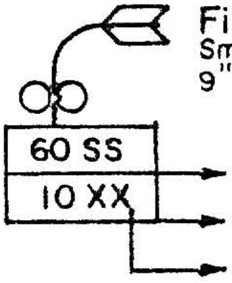
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	2.4	.6	----	----
Bottom Scalp	8.0	2.0	11.0	1.41
Fine Middlings	42.6	10.9	10.2	.36
Flour	47.0	12.0	9.7	.30
Total	100.0	25.5	8.9	.44

Fine Middlings

Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	1.7	0.4	----	----
Bottom Scalp	47.5	12.7	10.3	.52
Flour	50.8	30.5	9.6	.30
Total	100.0	43.6	9.7	.36

Fig. #2

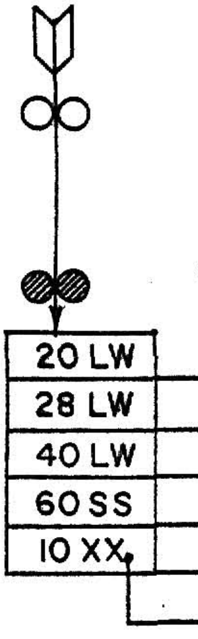
FLOW SHEET
BREAKS

Type of Wheat HARD RED WINTER
Test Number 3

	% Release	% Extraction
1st Break	47.8	47.6
2nd Break	27.3	14.2
3rd Break	27.1	10.3

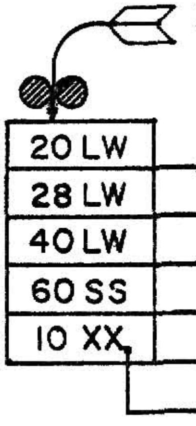
Pre-Break
Smooth
9"x6" 11/2:1

1st Break
9"x6" 2 1/2:1
12/12 Getchell D:D



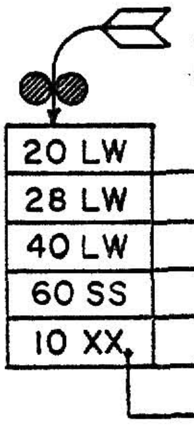
	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
2nd Break	----	----	13.6	2.54
Coarse Sizings	13.8	13.8	10.3	.81
Fine Sizings	10.4	10.4	9.6	.47
Coarse Middlings	9.1	9.1	9.5	.45
Fine Middlings	9.7	9.7	9.3	.43
Flour	4.8	4.8	9.8	.43
TOTAL	47.8	47.8		

2nd Break
9"x6" 2 1/2:1
12/14 Getchell D:D



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
3rd Break	----	----	13.5	3.36
Coarse Sizings	6.1	3.2	12.7	1.54
Fine Sizings	6.7	3.5	10.8	.48
Coarse Middlings	7.1	3.7	11.2	.40
Fine Middlings	5.6	2.9	11.1	.42
Flour	1.8	.9	11.4	.48
TOTAL	27.3	14.2		

3rd Break
9"x6" 2 1/2:1
16/16 Getchell D:D

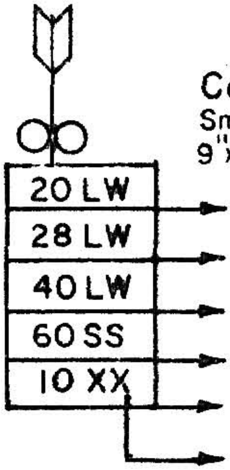


	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Feed	----	----	15.3	4.41
Coarse Sizings	5.0	1.9	16.6	3.58
Fine Sizings	3.4	1.3	11.7	1.22
Coarse Middlings	8.0	3.0	11.7	.51
Fine Middlings	8.1	3.1	11.8	.42
Flour	2.6	1.0	12.0	.46
TOTAL	27.1	10.3		

FLOW SHEET
SIZINGS AND REDUCTIONS

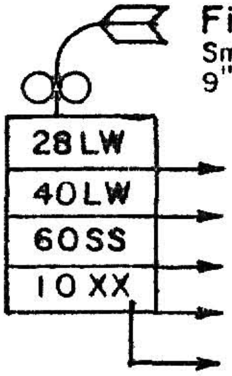
Type of /Wheat HARD RED WINTER
Test Number 3

Coarse Sizings
Smooth
9"x6" 1 1/2:1



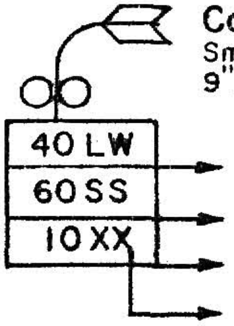
	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	8.0	1.6	17.7	3.66
Bottom Scalp	17.8	3.3	13.5	2.85
Fine Sizings	10.1	1.3	10.0	1.12
Coarse Middlings	28.2	5.3	9.3	.37
Fine Middlings	29.6	5.6	9.3	.33
Flour	6.3	1.2	9.8	.38
Total	100.0	18.9	10.8	1.14

Fine Sizings
Smooth
9"x6" 1 1/2:1



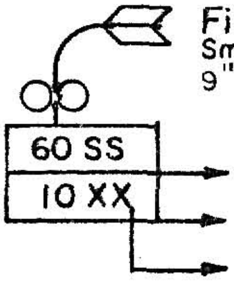
	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	3.6	.6	----	----
Bottom Scalp	9.9	1.7	11.4	2.02
Coarse Middlings	18.7	3.2	9.7	.49
Fine Middlings	57.5	9.9	9.7	.30
Flour	10.3	1.7	9.7	.34
Total	100.0	17.1	9.9	.57

Coarse Middlings
Smooth
9"x6" 1 1/2:1



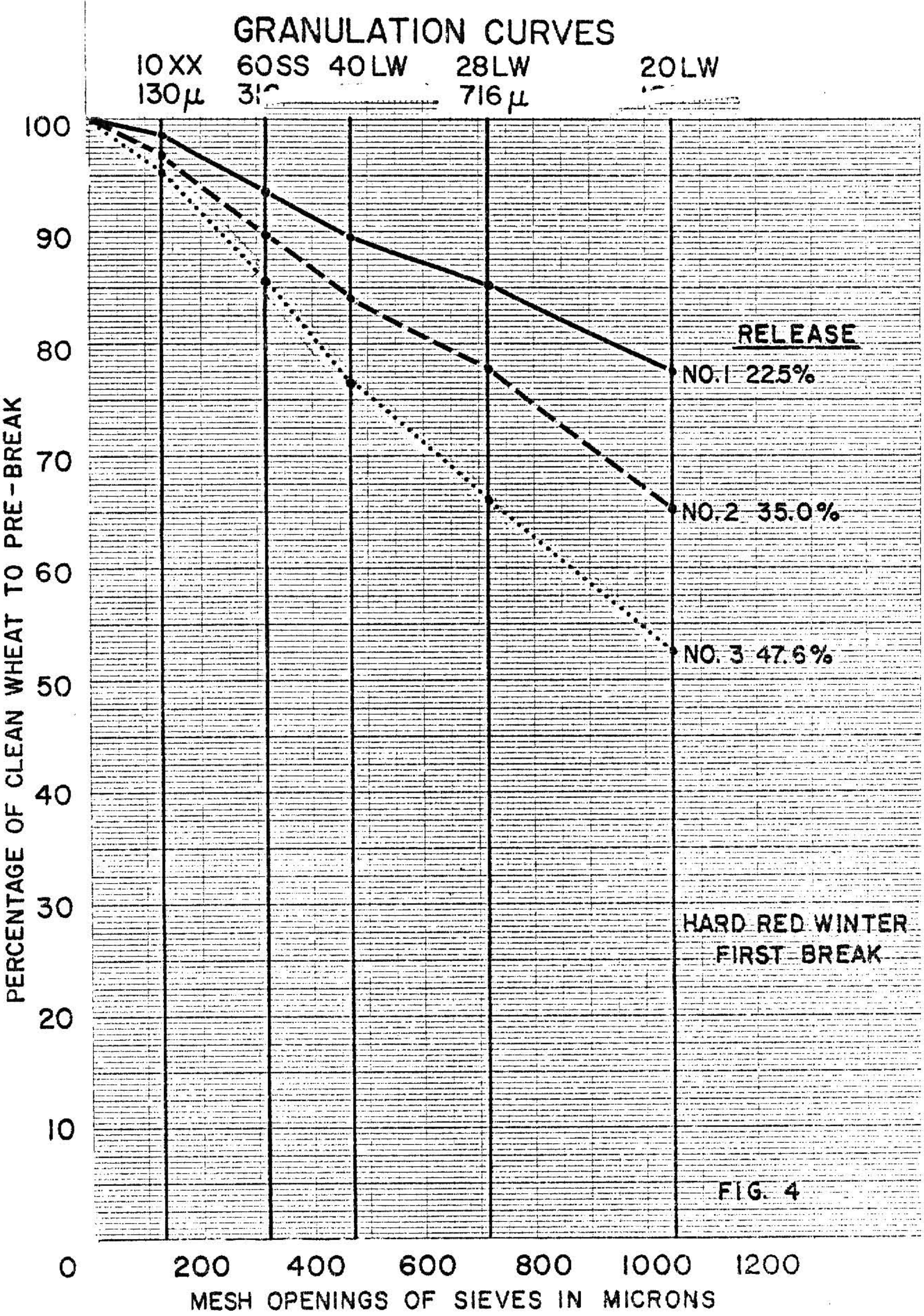
	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	2.6	.6	----	----
Bottom Scalp	7.2	1.7	11.0	1.41
Fine Middlings	43.8	10.7	10.2	.37
Flour	46.4	11.3	9.7	.30
Total	100.0	24.3	10.0	.44

Fine Middlings
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	1.1	.5	----	----
Bottom Scalp	30.9	12.9	10.5	.51
Flour	68.0	28.5	9.8	.31
Total	100.0	41.9	10.0	.37

Fig. #3



GRANULATION CURVES

FIG. 4

The plots were made with 100% of all material being over 0 microns in size. The amount of material left on each sieve was obtained from the test results and accumulatively subtracted, starting with 100%.

As an example, for Test #1:

First Break

Sieve Mesh	Opening Micron	Percent on Each Sieve	Accumulative Percent Over Each Sieve
Blank		1.9	100.0
10XX	130	4.6	(100-1.9) = 98.1
60SS	316	4.1	(98.1-4.6)= 93.5
40LW	471	4.0	(93.5-4.1)= 89.4
28LW	716	7.9	(89.4-4.0)= 85.4
20LW	1050	77.5	(85.4-7.9)= 77.5

The granulation curve thus established is used by the mill designer to predict load distributions in new mill designs and is used by the miller to establish sifter clothing numbers in existing mills for maximizing machine utilization. The curves will also be useful to the computer programmer in understanding the relationship of break extractions to granularity and thus to mill load distribution.

First Break

Figure #4 shows the test results for the three 1st break releases indicated. All curves will start at 100% over 0 micron sieve and will end at 100 minus the break release obtained. The characteristic curve for breaks is obtained showing different rates of production in certain size ranges. The purpose of the breaking procedure in hard wheats is to produce a maximum amount of granular middlings with a minimum amount of flour. It is not desirable to produce flour during the breaking procedure as this requires close, high extraction settings on the roll which disrupts the bran coat and produces fine bran particles of flour size. These particles end up in the flour with no practical way to remove them. The curves, therefore, show a reduction in the accumulative rate of material produced that will pass thru a 10XX sieve, the sieve size normally used to separate flour from the other products.

Second Break

Figure #5 shows the test results for the three 2nd break releases indicated. These curves have a more distinctive reverse "S" shape, showing the increase in production of the middle range middlings as compared to both the fine flour size particles and the coarsest, sizings grade of particles. The two tests made at similar releases of 41.2% and 42.6% show very little dissimilarity despite the change in extraction rate which reflects back on the amount of material available to the break. It must be realized that the limiting factor to any break release percentage figure is the amount of material left on the bran. It would be impossible to release any more endosperm than what is available for release. What is not so well understood is how intermediate release rates are affected by differing amounts of endosperm available for releasing.

Third Break

Figure #6 shows the test results for each of the three 3rd break releases indicated. A very rapid increase in the amount of middlings in the range of 130 microns to 470 microns can be detected, with the percentage dropping off again at the flour size of <130 microns.

As shown on the flow sheet, the number of corrugations per inch of roll surface increases from 12 per inch on 1st break to 12 per inch on the fast roll and 14 per inch on the slow roll for 2nd break and then to 16 per inch on 3rd break. When run at the same RPMs, this has the effect of producing more corrugation contacts as the break stock progresses thru the mill. In addition to this, the corrugations also have less depth as the number of corrugations per inch increases. This combination of factors, number of corrugations and depth of corrugations, affects the size of the middlings produced, with smaller middlings increasing as the number of

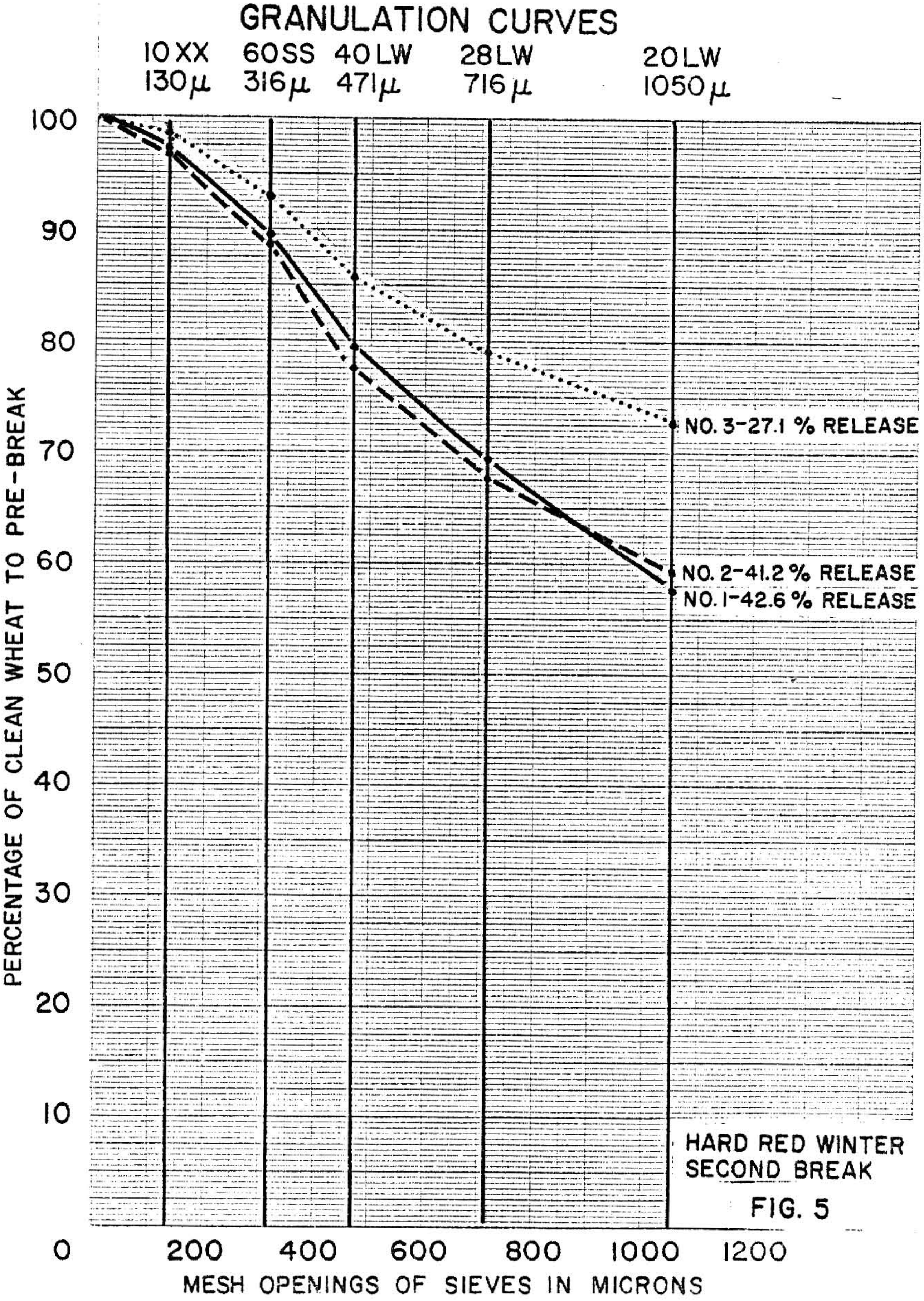

GRANULATION CURVES
10XX 130μ
60SS 316μ
40LW 471μ
28LW 716μ
20LW 1050μ
100
90
80
70
60
50
40
30
20
10
0
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
200
400
600
800
1000
1200
MESH OPENINGS OF SIEVES IN MICRONS
NO. 3-27.1 % RELEASE
NO. 2-41.2 % RELEASE
NO. 1-42.6 % RELEASE
HARD RED WINTER
SECOND BREAK

FIG. 5

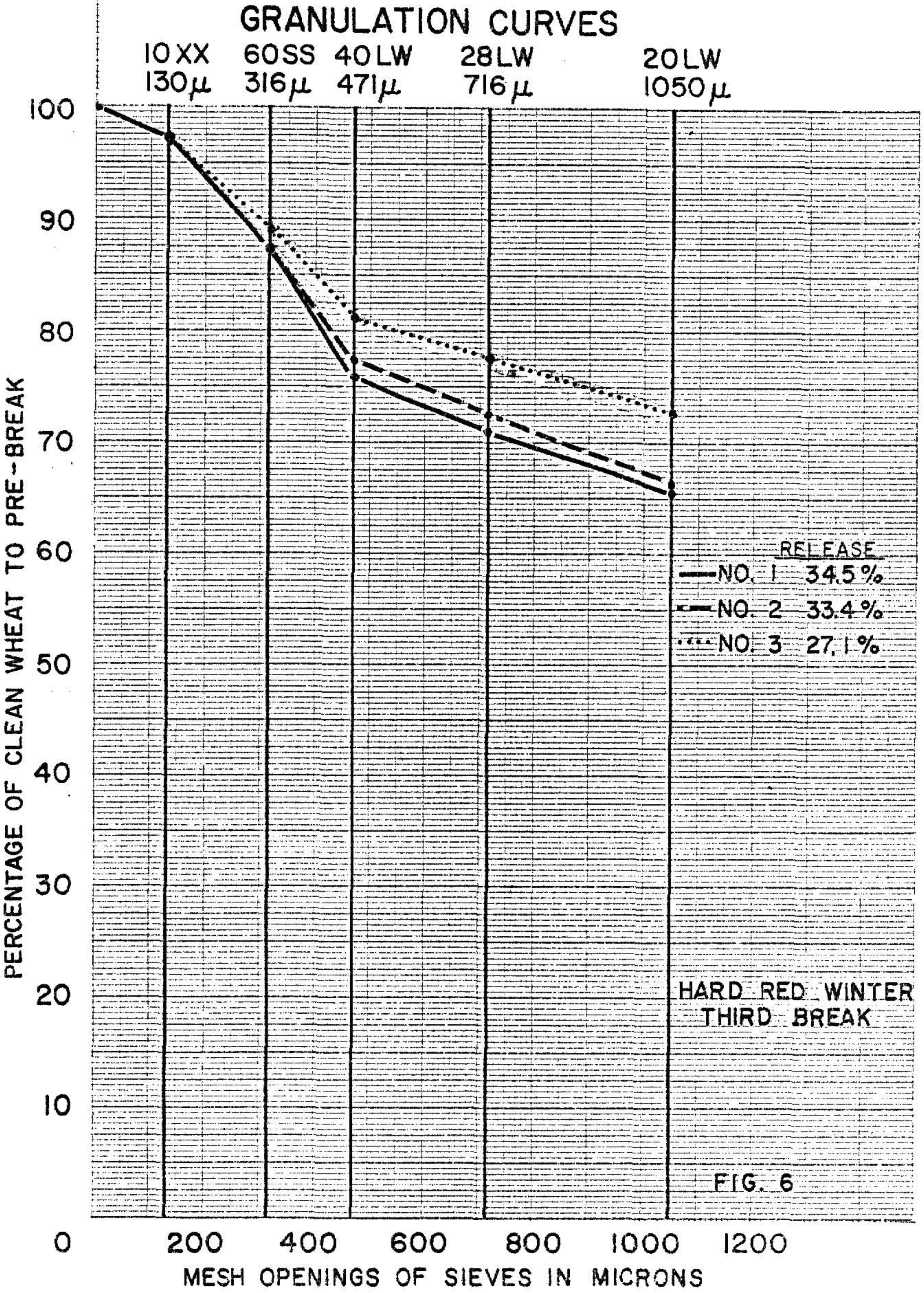

GRANULATION CURVES
10XX 130μ
60SS 316μ
40LW 471μ
28LW 716μ
20LW 1050μ
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
MESH OPENINGS OF SIEVES IN MICRONS
RELEASE
NO. 1 34.5%
NO. 2 33.4%
NO. 3 27.1%
HARD RED WINTER
THIRD BREAK

FIG. 6

corrugations per inch increases, at a given release rate. Again, the two similar releases of 33.4% and 34.5% exhibit very similar granulation curves despite a change in extraction level, caused in turn by differences in the amount of material removed prior to 3rd break.

Baseline Granularity Curves

Figures #7, #8, and #9 were developed to compare the relative amounts of material produced in each size range at different release and extraction levels. By plotting each test as the percent of material passing thru each sieve, the effects of quantity differences are eliminated and all that is shown is the change, if any, in the overall size distribution. This method is new and should be of interest. This type of presentation may also be of particular use to computer programmers as a baseline performance curve that need only be multiplied by the percent release desired to convert back to the information needed for load distribution purposes.

First Break

Figure #7 shows a remarkable similarity in relative size distribution for tests #1 and #2. The decrease in flour size particle production is again shown. A steady rate of particle generation is indicated from 130 microns to 470 microns, then a decrease in rate between 470 microns to 716 microns and then a return to the higher rate of generation. It is not understood why this lag in the 470 to 716 micron range occurs.

Test #3 indicates a deviation in the pattern established by Tests #1 and #2. A higher percentage of material will pass thru the coarser mesh sieves of over 500 microns on this test. This is indicative of the close roll gap setting needed for this high rate of release which creates a more intense crushing action on the passing material. The no-load roll gaps used were

BASELINE GRANULARITY CURVES
HARD RED WINTER FIRST BREAK

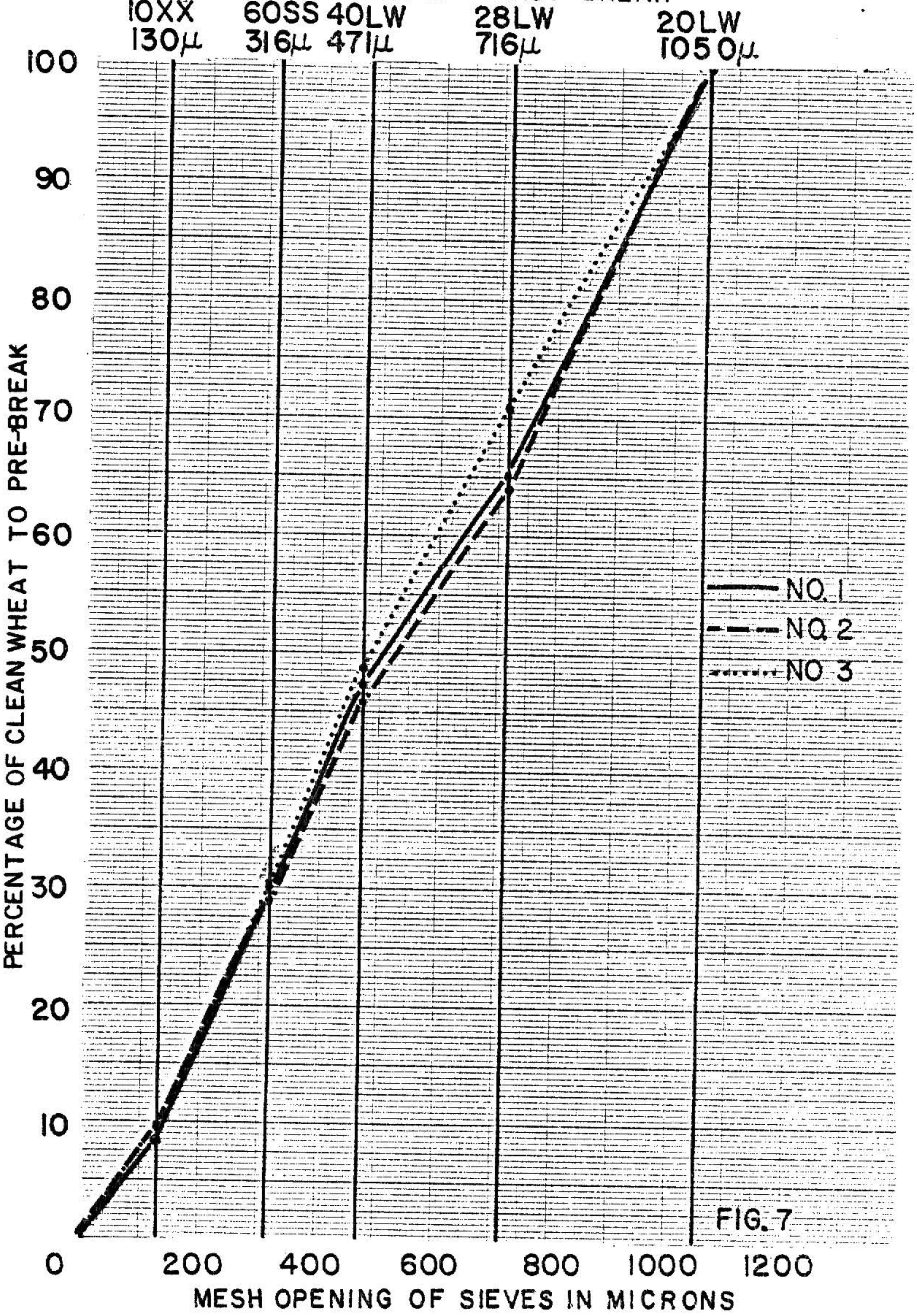


FIG. 7

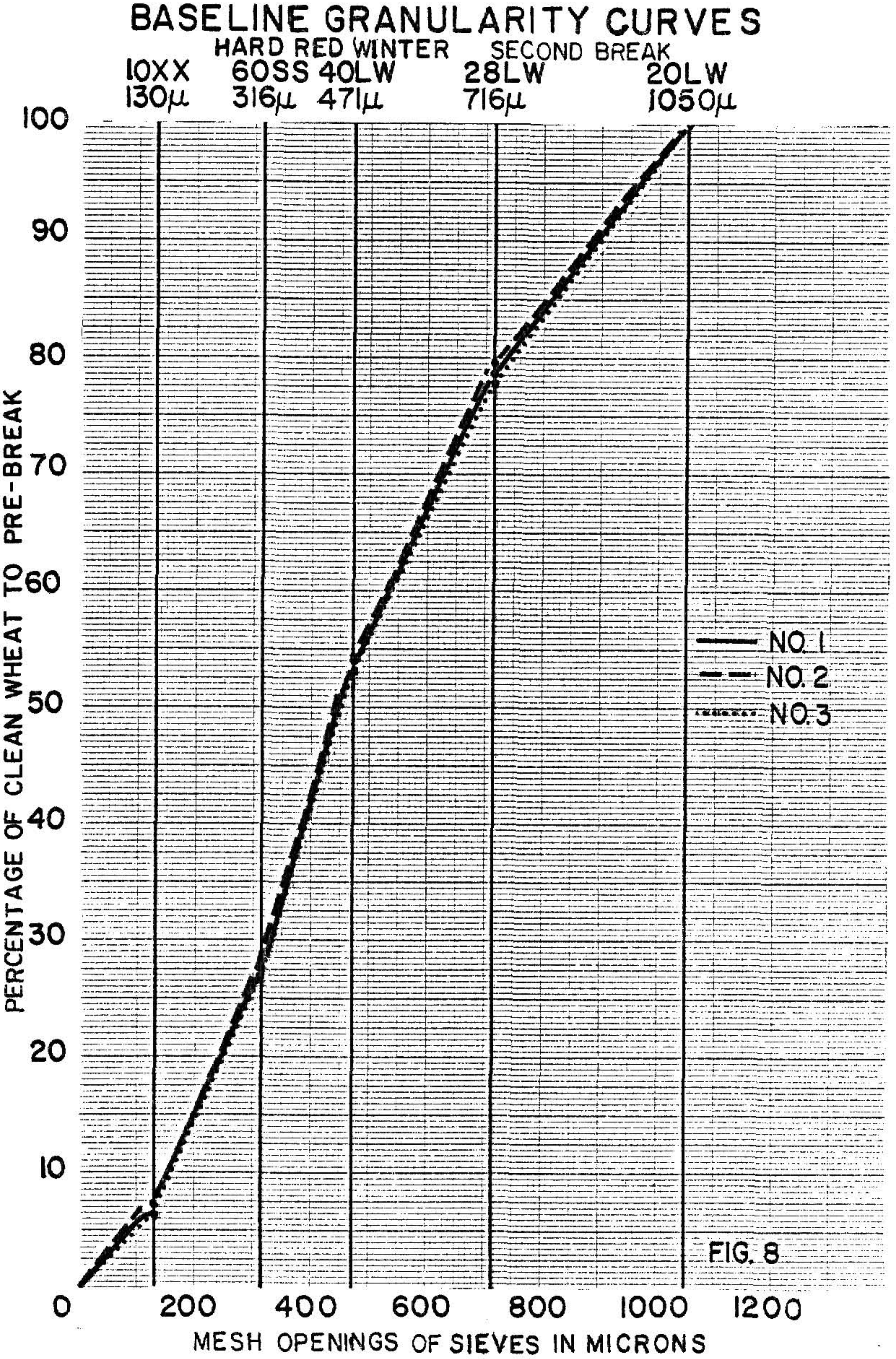

BASELINE GRANULARITY CURVES
HARD RED WINTER SECOND BREAK
10XX 130μ
60SS 316μ
40LW 471μ
28LW 716μ
20LW 1050μ
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
MESH OPENINGS OF SIEVES IN MICRONS
NO. 1
NO. 2
NO. 3

FIG. 8

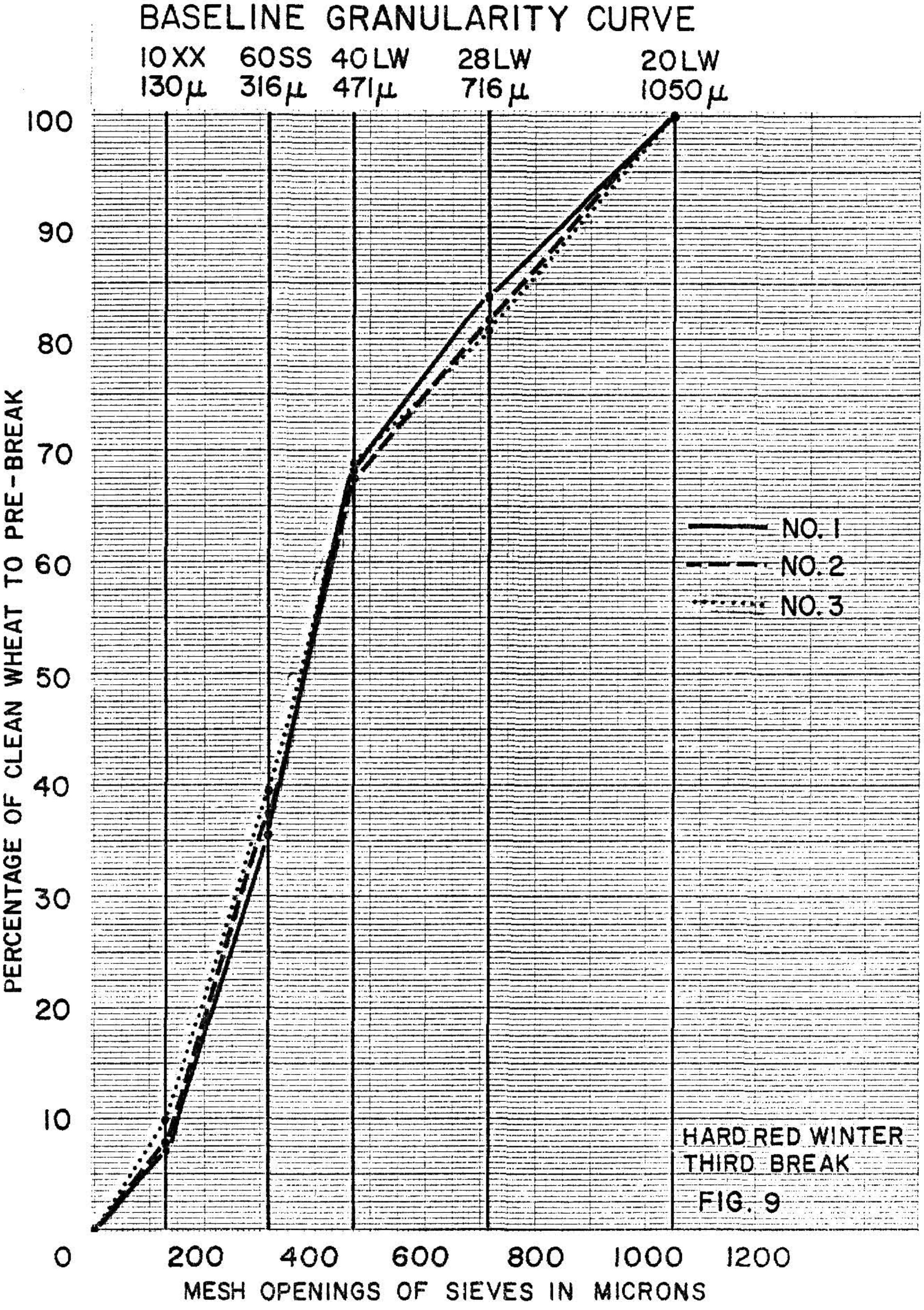

BASELINE GRANULARITY CURVE
10XX 130μ
60SS 316μ
40LW 471μ
28LW 716μ
20LW 1050μ
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
0
10
20
30
40
50
60
70
80
90
100
200
400
600
800
1000
1200
MESH OPENINGS OF SIEVES IN MICRONS
NO. 1
NO. 2
NO. 3
HARD RED WINTER
THIRD BREAK

FIG. 9

.024", .022" and .016" for tests #1, #2 and #3, respectively. The basic action of the corrugated rolls is a shearing, cutting force created by the crossing of one corrugation over another with both corrugations at an angle to the other at a 2.5:1 differential. This has often been described as a scissors action. When the endosperm material is crowded into a very narrow passageway, as in Test #3, a finer material is produced by the roll to material and material to material crushing action created, in addition to the cutting action found at the more open settings.

Second Break

Figure #8 shows the almost indistinguishable difference in curves for 2nd break. This indicates that within the ranges tested, the same relative relationship exists between particle sizes no matter how much material is released. Again, this type of baseline curve should prove of great help to computer programmers who can use this information as the multiplicant in the conversion to actual stock quantity at any extraction level desired.

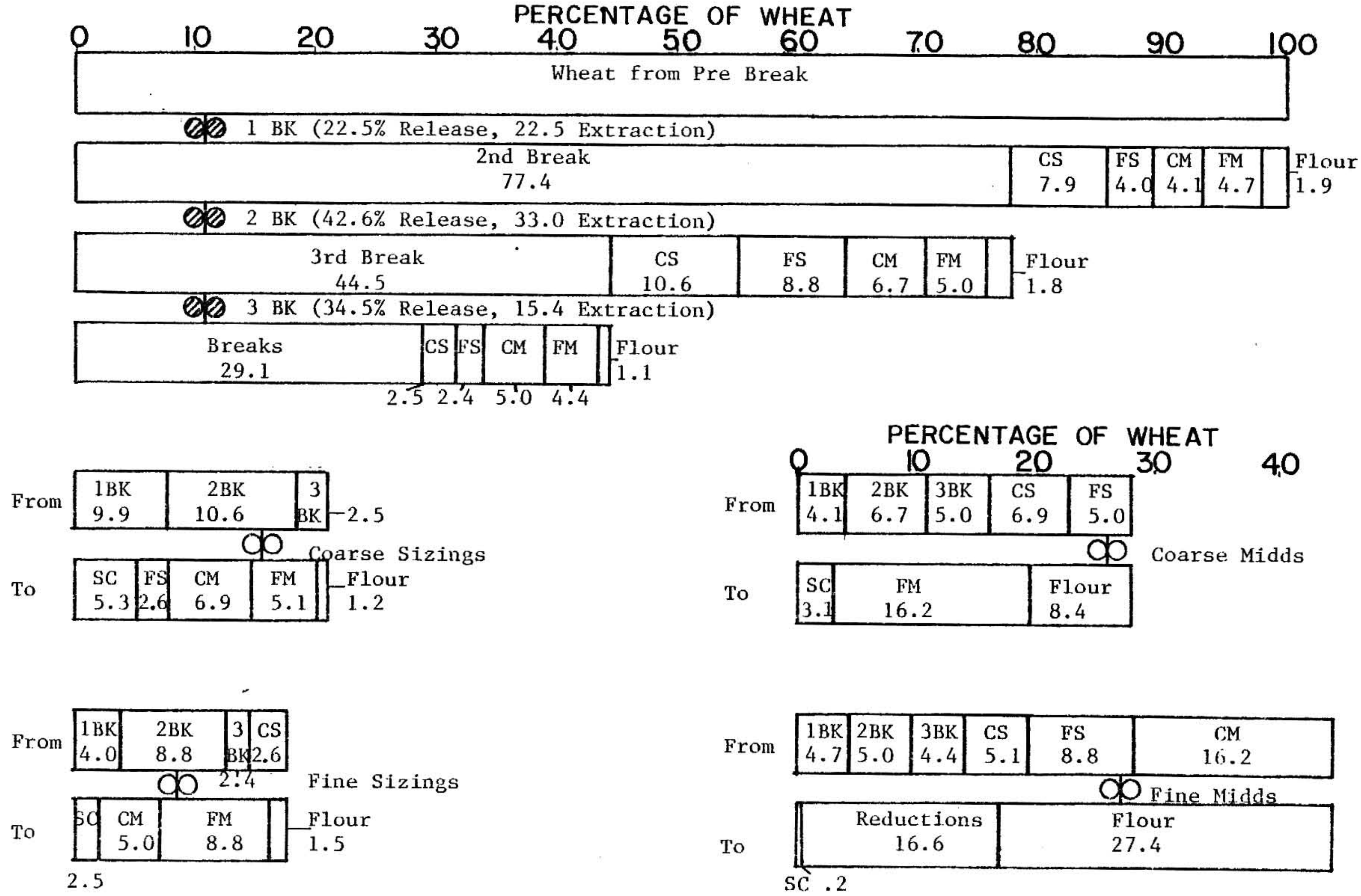
The rate of generation is rather constant from 130 microns to 716 microns with a decrease in the sub 130 micron flour range and over 716 micron coarse sizings range.

It is believed that the relative reduction in coarse middlings is due to the finer corrugations used which limits particle size due to a shallower corrugation depth.

Material Balance Charts

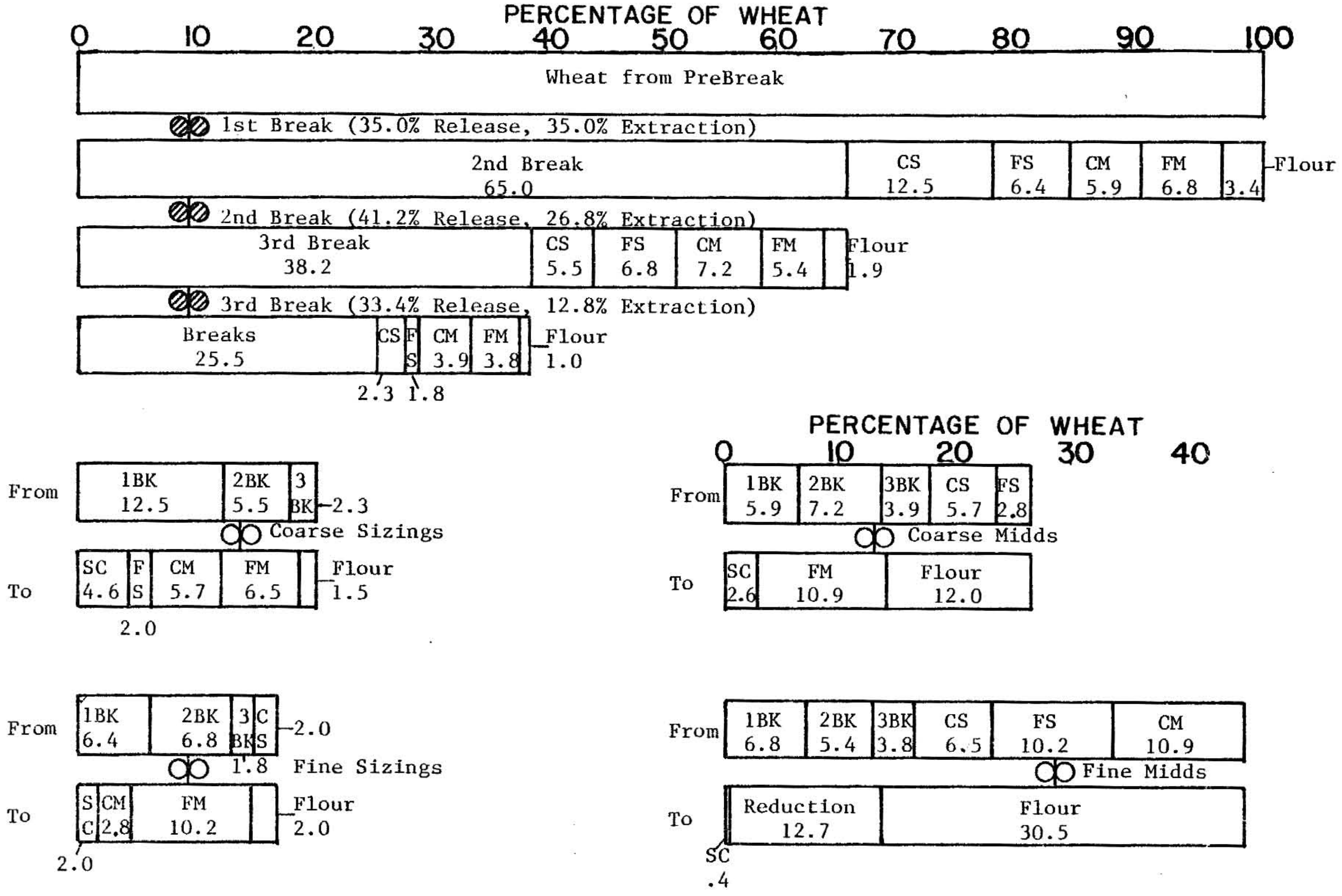
Figures #10, #11 and #12 are provided to show the manner in which materials are gathered and shifted in the simple flow used in this experiment.

Flour mills are quite complex in nature in order to obtain the maximum amount of products having the highest market value. The technology to do this requires the separation of the removed endosperm into several size groups.



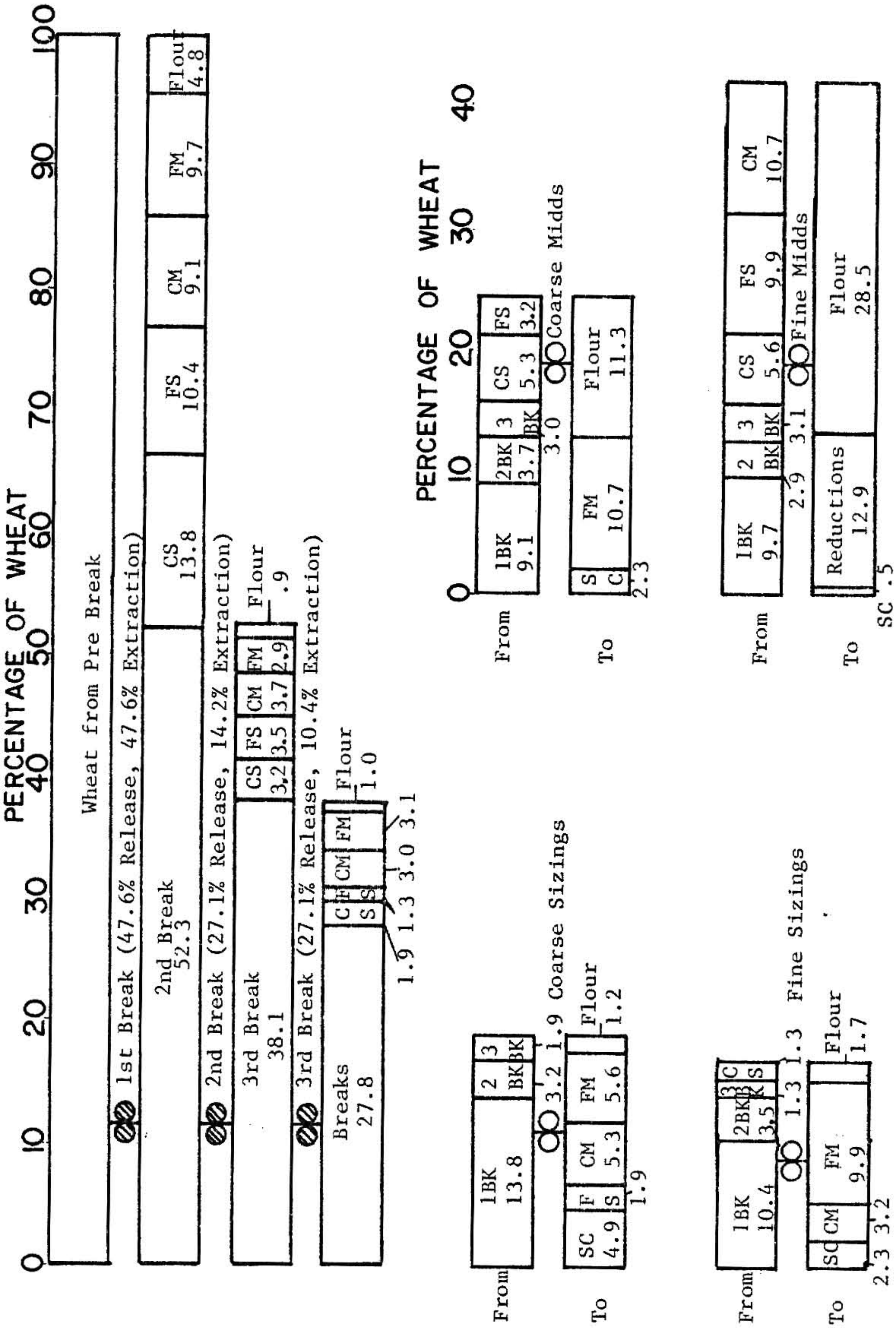
MATERIAL BALANCE CHART-HARD RED WINTER
TEST NO. 1

FIG. 10



MATERIAL BALANCE CHART- HARD RED WINTER
TEST NO. 2

FIG. II



MATERIAL BALANCE CHART-HARD RED WINTER
TEST NO. 3

FIG. 12

This allows special treatment on purifiers, sizings and reduction rolls and sifters and other auxiliary equipment.

It is felt that the format used in these figures may help milling students and practitioners visualize the way size groups are generated in the break systems, resized in the sizings system and finally regrouped for the first steps in the reduction system, and to further visualize how these systems change with changes in break extractions and with changes in classes of wheat.

An item of note is the relative stability in the amount of material presented to each sizing and reduction step despite the wide spread change in extraction rates. As an example, we see that the material to coarse sizings is 21.0% of the wheat in Test #1, 20.3% in Test #2 and 18.9% in Test #3. However, the difference between the high and low percentage is 2.1% which is 10% of the higher figure. A 10% load change on a rollstand may not be unreasonable but it would certainly affect its efficiency to the extent that the miller would want to readjust the rollstand(s) involved.

A cathode-ray tube (CRT) display of this type, along with the necessary quality information, would be most helpful in guiding a miller towards the most equitable set of break extractions for each wheat mix on the mill.

Break Release Bar Charts

Figures #13, #14 and #15 are included to dramatize the changes in the quantity of material produced by each break at different extraction levels. These bar charts also point out some phenomena that are not quite so discernable in the other presentations.

First Break

It can be noted that the increased release for Test #3 shows up mostly in the fine sizings and coarse middlings due to the crushing action noted

PERCENTAGE EXTRACTION FROM FIRST BREAK FOR EACH PRODUCT
HARD RED WINTER

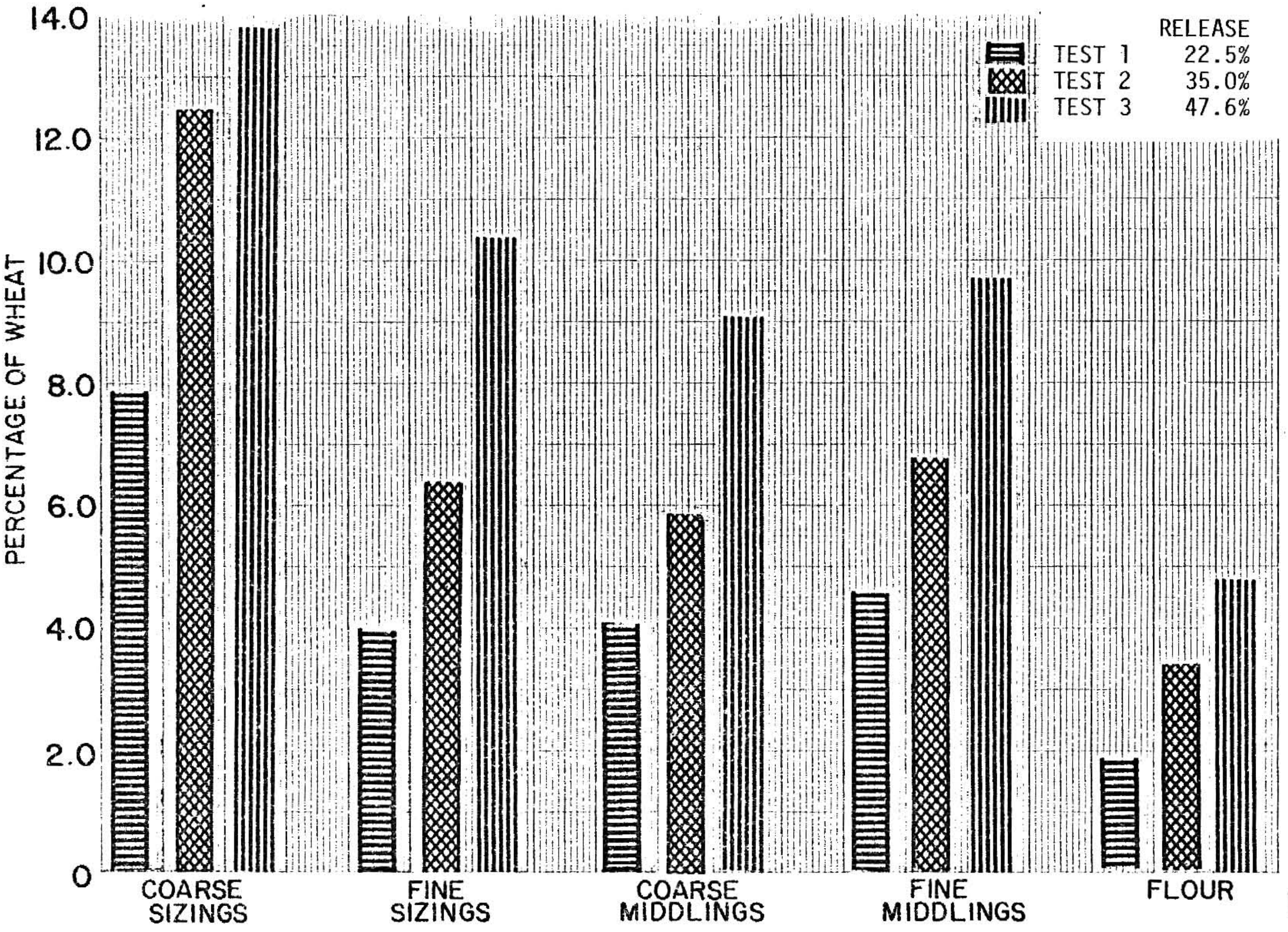


FIG. 13

PERCENTAGE EXTRACTION FROM SECOND BREAK FOR EACH PRODUCT
HARD RED WINTER

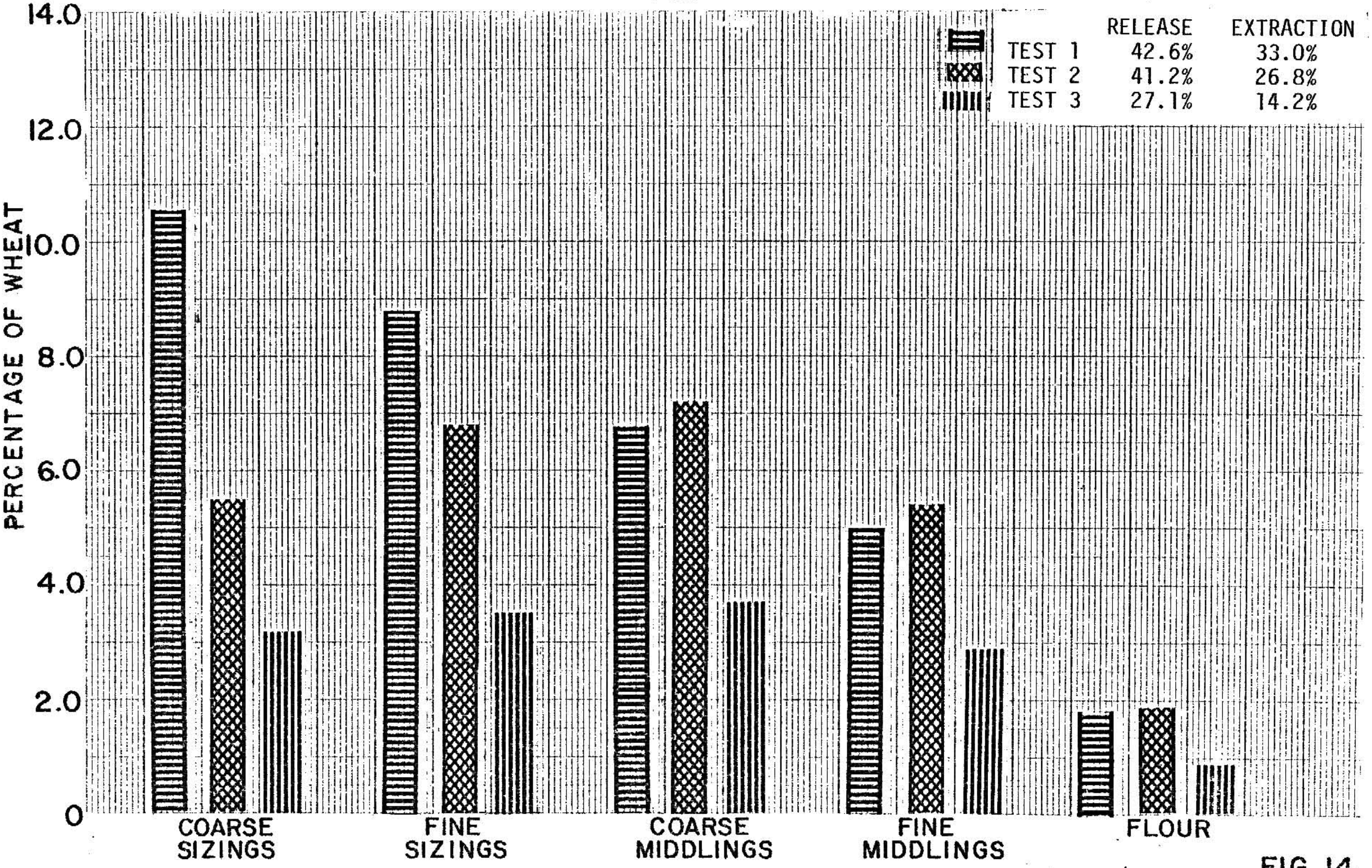


FIG. 14

PERCENTAGE EXTRACTION FROM THIRD BREAK FOR EACH PRODUCT
HARD RED WINTER

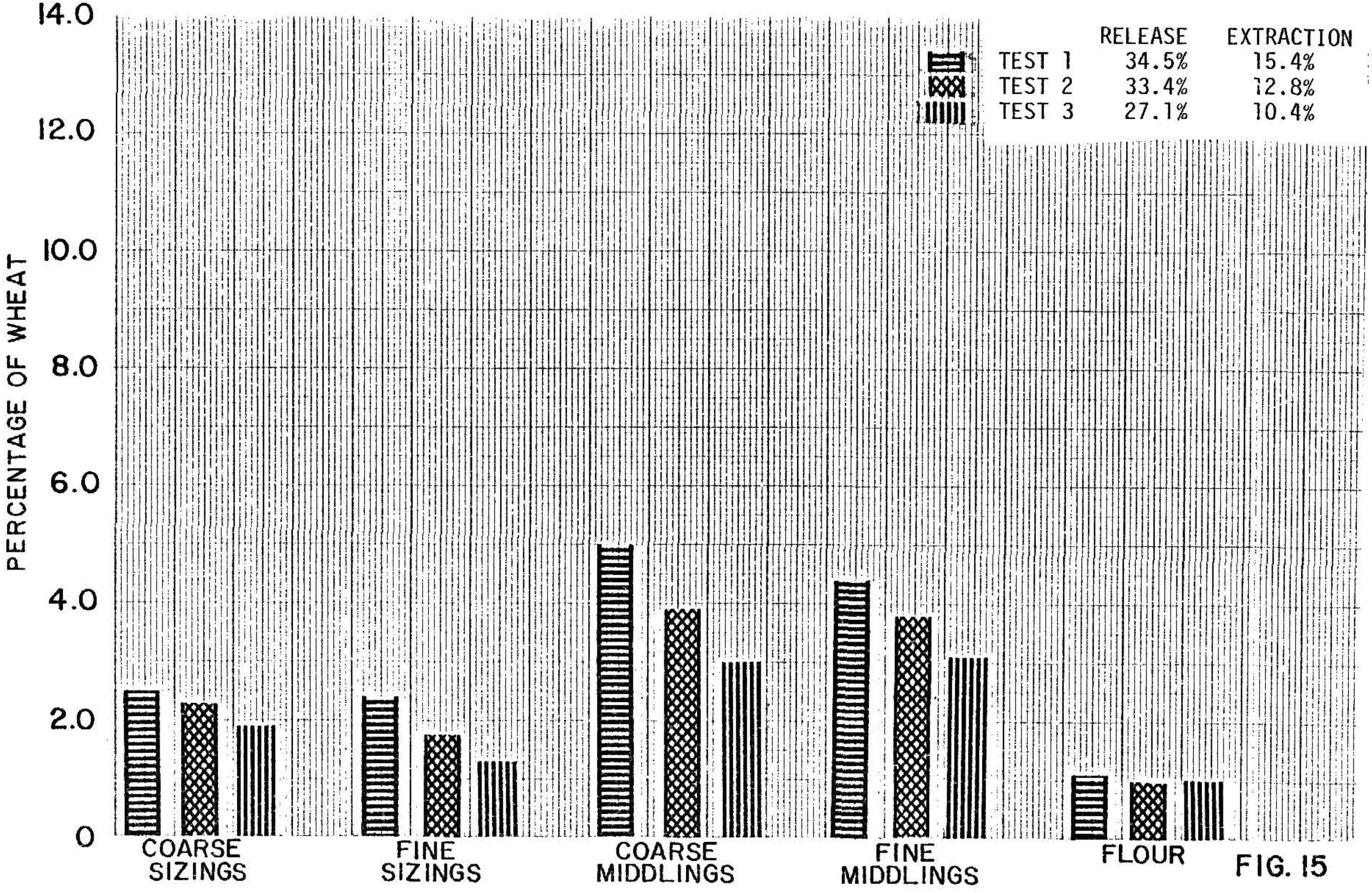


FIG. 15

previously. The balance of the size separations in all three tests progress in relationship to the total increase in extractions.

Ash

In observing Figures #1, #2 and #3, it can be seen that the ash content of the various products from the break sifters shows a general trend of increasing ash from the fine middlings to coarse sizings. For the most part, this is indicative of the amount of bran that is in each product. The coarser the material the more bran included. The fact that bran does not break up in the same ratio as the endosperm is what allows the manufacture of white flour. The bran is tougher due to its fibrous makeup and this is strengthened by tempering the wheat with water before milling. An exception to this general trend is in the ash of the flours produced on the breaks. In every case the flour is higher in ash than the next coarsest separation. This is not due to bran but due to the high amount of interstitial minerals that is released which is of sufficient fineness to pass thru the flour silk at 10XX size. The same situation occurs in the sizings sections where additional interstitial minerals are released.

When the high production of flours begins in the middlings reduction sections, the flours show lower ash than the next coarsest separation because high amounts of starch are being released, leaving behind a great deal of the high ash bran. In observing the order which all break products line up from low to high ash in Tables #4, #5 and #6, it will be noticed that 2nd break fine and coarse middlings are always one of the lowest ash streams produced. Third break fine middlings is also one of the lowest ash stocks produced.

The sharp increase in ash contents of products having more than .50 ash can also be noticed in all tests. These products include the coarse

CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation **ALL BREAK RELEASE PRODUCTS**

Type of Wheat
HARD RED WINTER

TEST #	STREAM		A	Q	Q×A	S of Q×A	S of Q	S of Q×A / S of Q
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
1	3BK	F.M.	.38	4.4	.0167	.0167	4.4	.380
	2BK	C.M.	.39	6.7	.0261	.0428	11.1	.386
	2BK	F.M.	.40	5.0	.0200	.0628	16.1	.390
	3BK	Flour	.42	1.1	.0046	.0674	17.2	.392
	3BK	C.M.	.43	5.0	.0215	.0889	22.2	.400
	2BK	F.S.	.44	8.8	.0387	.1276	31.0	.412
	2BK	Flour	.45	1.8	.0081	.1357	32.8	.414
	1BK	C.M.	.47	4.1	.0193	.1550	36.4	.426
	1BK	F.M.	.47	4.7	.0221	.1771	41.6	.426
	1BK	Flour	.48	1.9	.0091	.1862	43.5	.428
	1BK	F.S.	.55	4.0	.0220	.2082	47.5	.438
	1BK	C.S.	.65	7.9	.0514	.2596	55.4	.469
	3BK	F.S.	.80	2.4	.0192	.2788	57.8	.482
	2BK	C.S.	.98	10.6	.1039	.3827	68.4	.560
	3BK	C.S.	3.40	2.5	.0850	.4677	70.9	.660

TABLE # 4

CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation **ALL BREAK RELEASE PRODUCTS**

Type of Wheat
HARD RED WINTER

TEST #	STREAM		A	Q	Q×A	S of Q×A	S of Q	S of Q×A / S of Q
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
2	2BK	C.M.	.38	7.2	.0274	.0274	7.2	.380
	2BK	F.M.	.39	5.4	.0211	.0485	12.6	.385
	3BK	F.M.	.41	3.8	.0156	.0641	16.4	.391
	3BK	C.M.	.44	3.9	.0171	.0812	20.3	.400
	3BK	Flour	.44	1.0	.0044	.0856	21.3	.402
	1BK	F.M.	.44	6.8	.0300	.1156	28.1	.411
	1BK	Flour	.45	3.4	.0153	.1309	31.5	.416
	2BK	Flour	.46	1.9	.0114	.1423	33.4	.426
	2BK	F.S.	.47	6.8	.0320	.1743	40.2	.433
	1BK	C.M.	.50	5.9	.0295	.2038	46.1	.442
	1BK	F.S.	.53	6.4	.0339	.2377	52.5	.453
	1BK	C.S.	.70	12.5	.0875	.3252	65.0	.500
	3BK	F.S.	.98	1.8	.0176	.3428	66.8	.513
	2BK	C.S.	1.23	5.5	.0677	.4105	72.3	.568
	3BK	C.S.	3.38	2.3	.0777	.4882	74.6	.654

TABLE # 5

CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation **ALL BREAK RELEASE PRODUCTS**

Type of Wheat
HARD RED WINTER

TEST #	STREAM		A	Q	Q×A	S of Q×A	S of Q	S of Q×A / S of Q
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
3	2BK	C.M.	.40	3.7	.0148	.0148	3.7	.400
	2BK	F.M.	.42	2.9	.0122	.0270	6.6	.409
	3BK	F.M.	.42	3.1	.0130	.0400	9.7	.412
	1BK	F.M.	.43	9.7	.0417	.0817	19.4	.421
	1BK	Flour	.43	4.8	.0206	.1024	24.2	.423
	1BK	C.M.	.45	9.1	.0410	.1434	33.3	.431
	3BK	Flour	.46	1.0	.0046	.1480	34.3	.431
	1BK	F.S.	.47	10.4	.0489	.1969	44.7	.440
	2BK	F.S.	.48	3.5	.0168	.2137	48.2	.443
	2BK	Flour	.48	.9	.0043	.2180	49.1	.444
	3BK	C.M.	.51	3.0	.0153	.2333	52.1	.448
	1BK	C.S.	.81	13.8	.1118	.3451	65.9	.524
	3BK	F.S.	1.22	1.3	.0159	.3610	67.2	.537
	2BK	C.S.	1.54	3.2	.0493	.4103	70.4	.586
	3BK	C.S.	3.58	1.9	.0680	.4783	72.3	.662

TABLE # 6

sizings from all three breaks and the fine sizings from 3rd break. These are all high bran content streams, with the bran content increasing from 1st break thru 2nd break to 3rd break in all tests.

When the results are plotted in Figure #16, the similarity in ash increase is seen. However, at the 71% extraction level, there is a significant difference in the cumulative ashes of .660% for Test #1, .585% for Test #3 and .555% for Test #2. Assuming that the most desirable series of break extractions is one that does the least amount of damage to the bran coat at a given extraction, the ranking of tests in order of desirability would be:

Test #2 - Best
Test #3 - Next Best
Test #1 - Worst

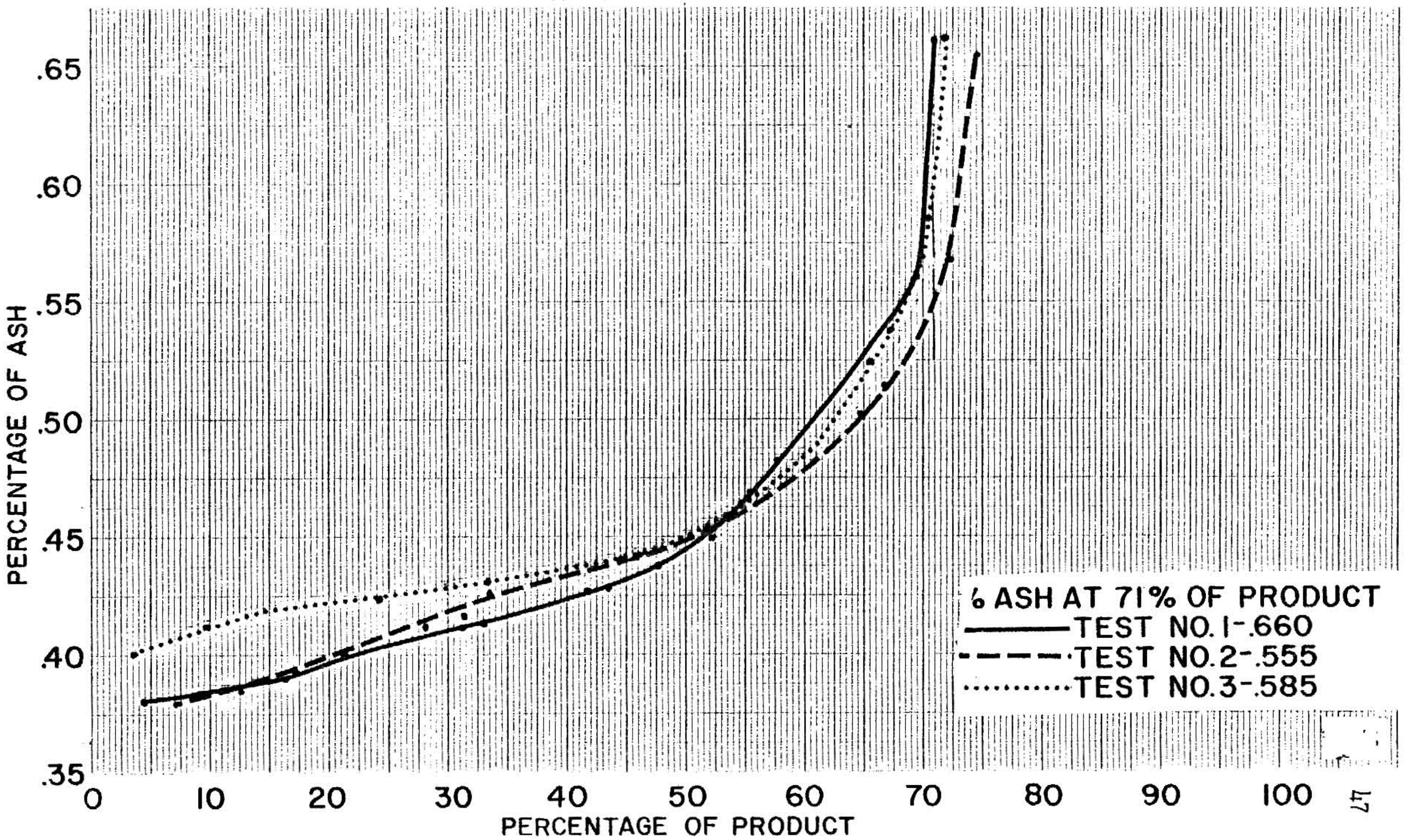
The flours produced in the total flow used are aligned in order on Table #7 for all three tests. The lowest ash flours are from the middlings, next highest from the sizings and highest are the break flours in all tests. The relationship of 1st break flour ash changes with extraction, becoming lower in ash as extraction increases. This, again, is due to the higher production of starchy fines at the higher extractions which dilute the freed minerals obtained from the interstitial area.

When these results are plotted on Figure #17, the ash contents at 48% extraction are .325% for Test #1, .320% for Test #3 and .311% for Test #2. Assuming the lowest ash flour is the most desirable flour from a marketing standpoint, if not from a quality standpoint, the ranking would be as follows:

Test #2 - Best
Test #3 - Next Best
Test #1 - Worst

This is the same order as was determined by the cumulative ash of the

CUMULATIVE ASH
BREAK RELEASE PRODUCTS
HARD RED WINTER



CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation FLOURS ONLY

Type of Wheat
HARD RED WINTER

TEST #	STREAM		A	Q	Q x A	S of Q x A	S of Q	S of Q x A / S of Q
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
1	F.M.	Flour	.30	27.4	.0822	.0822	27.4	.300
	C.M.	"	.32	13.0	.0416	.1238	40.4	.306
	F.S.	"	.36	1.5	.0054	.1292	41.9	.308
	C.S.	"	.38	1.2	.0046	.1338	43.1	.310
	3BK	"	.42	1.1	.0046	.1384	44.2	.313
	2BK	"	.45	1.8	.0081	.1465	46.0	.318
	1BK	"	.48	1.9	.0091	.1556	47.9	.325
2	F.M.	Flour	.30	29.7	.0891	.0891	29.7	.300
	C.M.	"	.30	12.0	.0360	.1251	41.7	.300
	F.S.	"	.34	2.0	.0068	.1319	43.7	.302
	C.S.	"	.36	1.5	.0054	.1373	45.2	.304
	3BK	"	.44	1.0	.0044	.1417	46.2	.306
	1BK	"	.45	3.4	.0153	.1570	49.6	.317
	2BK	"	.46	1.9	.0087	.1657	51.5	.322
3	C.M.	Flour	.30	11.3	.0339	.0339	11.3	.300
	F.M.	"	.30	28.5	.0855	.1194	39.8	.300
	F.S.	"	.34	1.7	.0058	.1252	41.5	.302
	C.S.	"	.38	1.2	.0046	.1298	42.7	.304
	1BK	"	.43	4.8	.0206	.1504	47.5	.317
	3BK	"	.46	1.0	.0046	.1550	48.5	.320
	2BK	"	.48	.9	.0043	.1593	49.4	.322

TABLE # 7

CUMULATIVE ASH
FLOURS
HARD RED WINTER

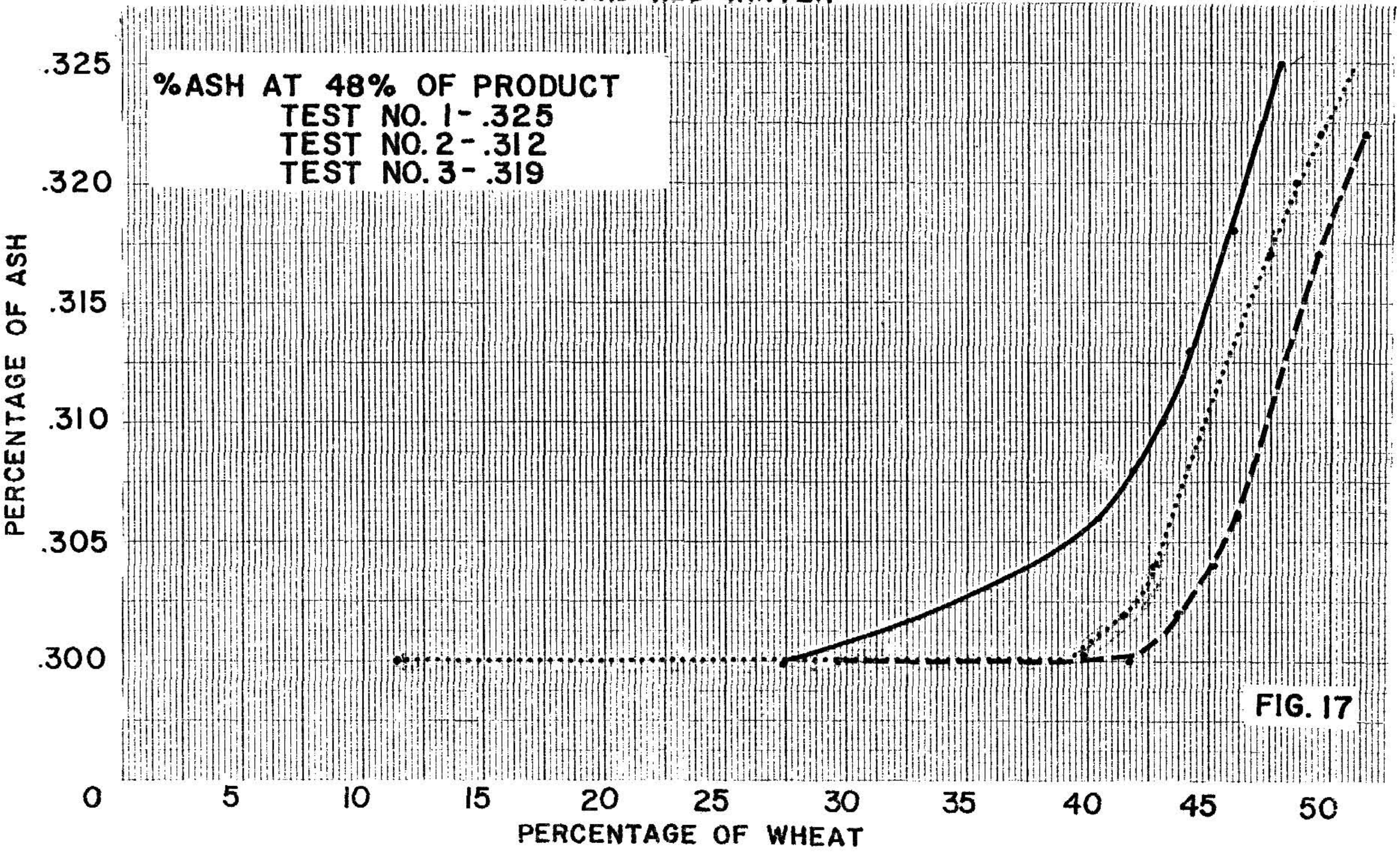


FIG. 17

break products. This seems to substantiate the idea that the amount of bran released in the breaking process will directly affect the amount of bran, and therefore the ash, in the finished flours.

It was hoped that some simple key indicators might appear that would predict the cumulative ash results, but not one was found.

Protein

By observing the proteins shown in Figures #1, #2 and #3, it will be noticed that coarse sizings and flour exhibit the highest protein levels of the released material in all breaks for all tests. The high protein in the coarse sizings is due to the higher levels of bran included with the endosperm. The high protein in the flour is due to the separation of interstitial protein as a result of the breaking process. This protein is probably unattached and drops thru the fine aperatures of the 10XX. The protein of the intermediate middling and sizings separations exhibit similar protein levels in no particular order.

With one exception, the flours produced in the coarse and fine sizings operations were higher in protein than the next coarsest separation. This is also due to a separation of interstitial protein.

The high production of flour in the middlings reductions covered up any preferential protein separation by the larger amounts of starchy materials reduced to flour size.

Tables #8, #9 and #10 show the break streams arranged in order of protein content. It is very obvious that a general line up of 1st break stocks, 2nd break stocks and 3rd break stocks occurs, going from low to high protein on all tests. This substantiates the findings reported earlier on the protein gradient that occurs in wheat. The 1st break is generally taking material from the cheek area, 2nd break from the intermediate area and

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation

Type of Wheat
HARD RED WINTER

ALL BREAK RELEASE PRODUCTS
(Lowest Protein to Highest Protein)

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of Q x P / S of Q
	FROM	TO	% Protein (14%M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
1	1BK	F.M.	9.0	4.6	.4140	.4140	4.6	9.00
	1BK	C.M.	9.1	4.2	.3822	.7962	8.8	9.05
	1BK	F.S.	9.3	4.0	.3720	1.1682	12.8	9.13
	2BK	F.M.	9.5	5.0	.4750	1.6432	17.8	9.23
	2BK	F.S.	9.5	8.8	.8360	2.4792	26.6	9.32
	1BK	C.S.	9.6	7.9	.7584	3.2376	34.5	9.38
	1BK	Flour	9.7	1.9	.1843	3.4219	36.4	9.40
	2BK	C.M.	10.2	6.7	.6834	4.1053	43.1	9.53
	2BK	C.S.	10.6	10.6	1.1236	5.2289	53.7	9.74
	2BK	Flour	10.6	1.8	.1908	5.4197	55.5	9.77
	3BK	F.S.	11.1	2.4	.2664	5.6861	57.9	9.82
	3BK	F.M.	11.3	4.4	.4972	6.1833	62.3	9.93
	3BK	C.M.	11.4	5.0	.5700	6.7533	67.3	10.03
	3BK	Flour	11.6	1.1	.1276	6.8809	68.4	10.06
	3BK	C.S.	15.8	2.5	.3950	7.2759	70.9	10.26

TABLE # 8

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)

Q=Quantity (% of Wheat to Pre-Break)

S=Summation ALL BREAK RELEASE PRODUCTS (Lowest to Highest Protein)

Type of Wheat HARD RED WINTER

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of Q x P / S of Q
	FROM	TO	% Protein (14% M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
2	1BK	F.M.	9.0	6.8	.6120	.6120	6.8	9.00
	1BK	C.M.	9.2	5.9	.5428	1.1548	12.7	9.09
	1BK	F.S.	9.4	6.4	.6016	1.7564	19.1	9.20
	1BK	Flour	9.6	3.4	.3264	2.0828	22.5	9.26
	1BK	C.S.	9.8	12.5	1.2250	3.3078	35.0	9.45
	2BK	F.S.	10.4	6.8	.7072	4.0150	41.8	9.61
	2BK	F.M.	10.4	5.4	.5616	4.5766	47.2	9.70
	2BK	C.M.	10.7	1.2	.7704	5.3470	54.4	9.83
	2BK	C.S.	11.0	5.5	.6050	5.9520	59.9	9.94
	2BK	Flour	11.1	1.9	.2109	6.1629	61.8	9.97
	3BK	F.S.	11.5	1.8	.2070	6.3699	63.6	10.02
	3BK	F.M.	11.6	3.8	.4408	6.8109	67.4	10.11
	3BK	C.M.	11.6	3.9	.4524	7.2631	71.3	10.19
	3BK	Flour	12.0	1.0	.1200	7.3831	72.3	10.21
	3BK	C.S.	15.9	2.3	.3659	7.7490	74.6	10.39

TABLE # 9

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation **ALL BREAK RELEASE PRODUCTS (Lowest to Highest Protein)**

Type of Wheat
HARD RED WINTER

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of Q x P / S of Q
	FROM	TO	% Protein (14% M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
3	1BK	F.M.	9.3	9.7	.9021	.9021	9.7	9.30
	1BK	C.M.	9.5	9.1	.8645	1.7666	18.8	9.40
	1BK	F.S.	9.6	10.4	.9984	2.7650	29.2	9.47
	1BK	Flour	9.8	4.8	.4704	3.2354	34.0	9.52
	1BK	C.S.	10.3	13.8	1.4214	4.6568	47.8	9.74
	2BK	F.S.	10.8	3.5	.3780	5.0348	51.3	9.81
	2BK	F.M.	11.1	2.9	.3219	5.3567	54.2	9.88
	2BK	C.M.	11.2	3.7	.4144	5.7711	57.9	9.97
	2BK	Flour	11.4	.9	.1026	5.8737	58.8	9.99
	3BK	C.M.	11.7	3.0	.3510	6.2247	61.8	10.07
	3BK	F.S.	11.7	1.3	.1521	6.3768	63.1	10.11
	3BK	F.M.	11.8	3.1	.3658	6.7426	66.2	10.19
	3BK	Flour	12.0	1.0	.1200	6.8626	67.2	10.21
	2BK	C.S.	12.7	3.2	.4064	7.2690	70.4	10.33
	3BK	C.S.	16.6	1.9	.3154	7.5844	72.3	10.49

TABLE # 10

3rd break from the outer or subaleurone area.

The cumulative protein curve of Figure #18 shows a very close relationship between the three tests. At the 70% extraction level, Test #3 shows a 10.35% protein, Test #1, 10.20% protein and Test #2, a 10.14% protein. The difference between Tests #1 and #2 are not significant. Test #3 shows a slightly higher level than Tests #1 and #2. If protein recovery is the objective, the results of Test #3 would be considered the most desirable, assuming this protein will end up in the flour.

In Figure #19 the cumulative protein curve as derived from Table #11 is shown for all of the milled flours. Tests #1 and #3 are practically the same. Test #2 is considerably lower in protein at all percentages. Again, considering protein recovery only, Tests #1 and #3 would be preferable to Test #2.

There does not seem to be any close relationship between comparative protein levels in the break release products and the flours produced from them. The results do suggest that certain break extractions may be more favorable to protein recovery than others.

Tables #12, #13 and #14 and Figure #20 are provided to show the almost inverse relationship of cumulative ash to cumulative protein. When the break streams are arranged in order of their ascending ash but with protein percentages used for calculations, the resultant graphs are extremely irregular with a downward trend until the last very high ash and also high protein fractions bring the curves upward.

As the literature cited has indicated that the ash and protein gradients follow each other from low to high as the material is extracted from the inner to outer endosperm levels, one would expect a better relationship. A possible explanation for the results shown is that the amount of bran in each fraction masks the gradient in the ash tests due to the higher differences between "pure" endosperm and "pure" bran ash levels. As the protein differential

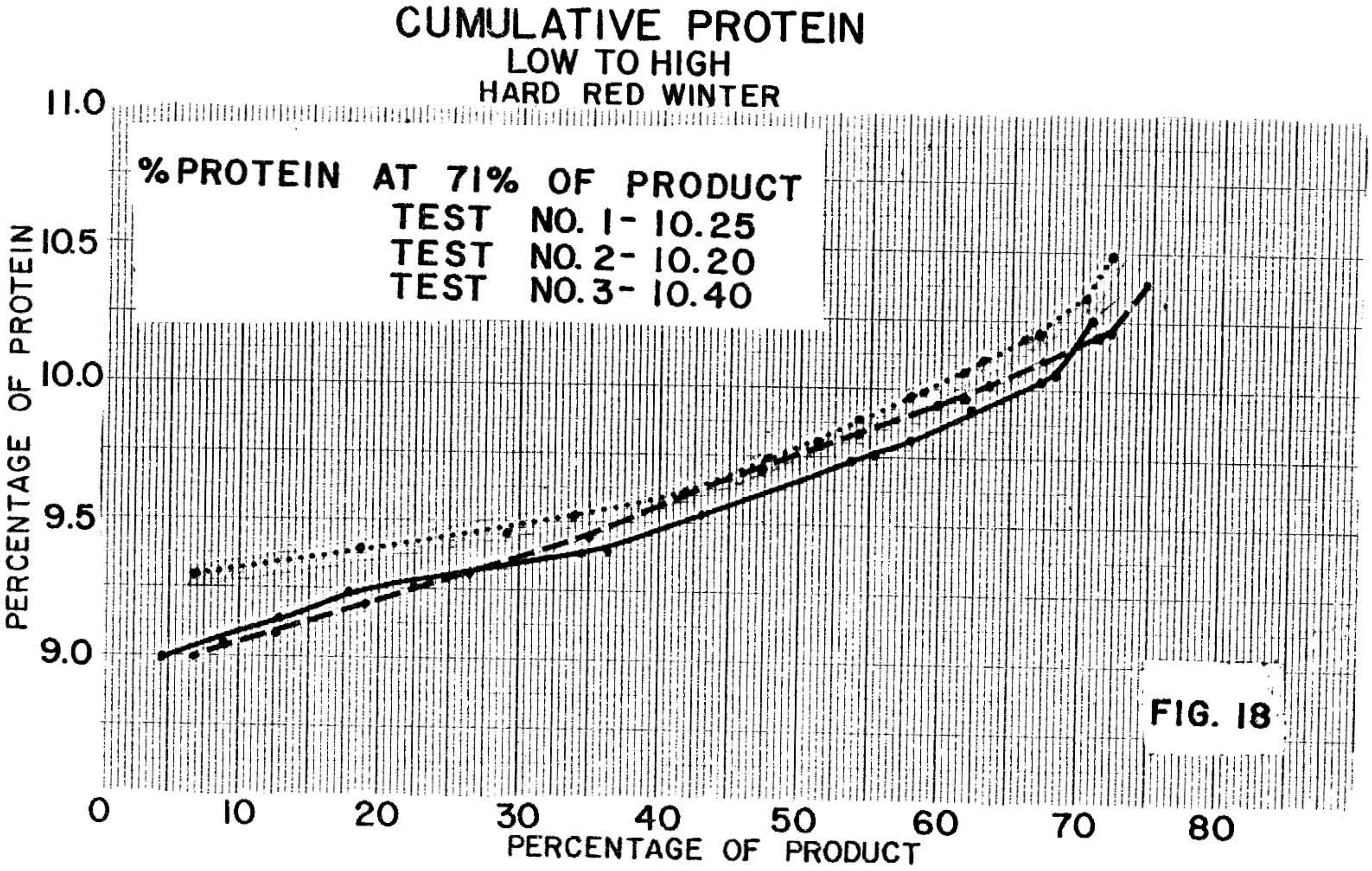

CUMULATIVE PROTEIN
LOW TO HIGH
HARD RED WINTER
%PROTEIN AT 71% OF PRODUCT
TEST NO. 1- 10.25
TEST NO. 2- 10.20
TEST NO. 3- 10.40
11.0
10.5
10.0
9.5
9.0
PERCENTAGE OF PROTEIN
0
10
20
30
40
50
60
70
80
PERCENTAGE OF PRODUCT

FIG. 18

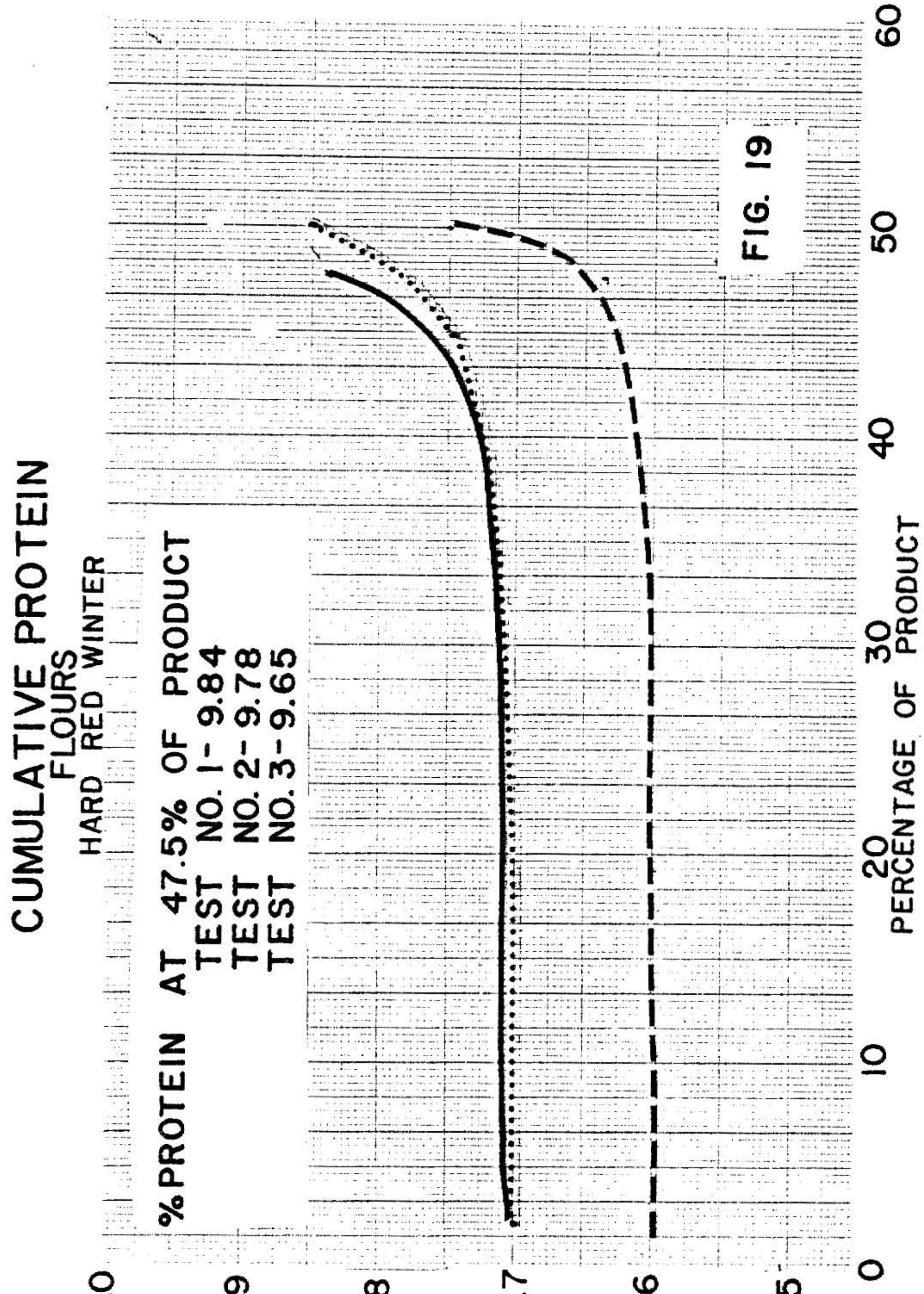


FIG. 19
CUMULATIVE PROTEIN
FLOURS
HARD RED WINTER
% PROTEIN AT 47.5% OF PRODUCT
TEST NO. 1- 9.84
TEST NO. 2- 9.78
TEST NO. 3- 9.65
PERCENTAGE OF PROTEIN
10.0
9.9
9.8
9.7
9.6
9.5
PERCENTAGE OF PRODUCT
0
10
20
30
40
50
60

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation **FLOURS ONLY**

Type of Wheat
HARD RED WINTER

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of QxP / S of Q
	FROM	TO	% Protein (14% M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
1	1BK	Flour	9.7	1.9	.1843	.1843	1.9	9.70
	C.M.	"	9.7	13.0	1.2610	1.4453	14.9	9.70
	C.S.	"	9.8	1.2	.1176	1.5629	16.1	9.71
	F.M.	"	9.8	27.4	2.6852	4.2481	43.5	9.77
	F.S.	"	9.9	1.5	.1485	4.3966	45.0	9.77
	2BK	"	10.6	1.8	.1908	4.5874	46.8	9.80
	3BK	"	11.6	1.1	.1276	4.7150	47.9	9.84
2	1BK	Flour	9.6	3.4	.3264	.3264	3.4	9.60
	F.M.	"	9.6	28.5	2.7360	3.0624	31.9	9.60
	C.M.	"	9.7	12.0	1.1640	4.2264	43.9	9.63
	F.S.	"	9.8	2.0	.1960	4.4224	45.9	9.63
	C.S.	"	9.9	1.5	.1485	4.5709	47.4	9.64
	2BK	"	11.1	1.9	.2109	4.7818	49.3	9.70
	3BK	"	12.0	1.0	.1200	4.9018	50.3	9.75
3	F.S.	Flour	9.7	1.7	.1649	.1649	1.7	9.70
	C.M.	"	9.7	11.3	1.0961	1.2610	13.0	9.70
	F.M.	"	9.8	28.5	2.7930	4.0540	41.5	9.77
	1BK	"	9.8	4.8	.4704	4.5244	46.3	9.77
	C.S.	"	9.8	1.2	.1176	4.6420	47.5	9.77
	2BK	"	11.4	.9	.1026	4.7446	48.4	9.80
	3BK	"	12.0	1.0	.1200	4.8646	49.4	9.85

TABLE # 11

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)

Q=Quantity (% of Wheat to Pre-Break)

S=Summation ALL BREAK RELEASE PRODUCTS
(In Same Order as Cumulative Ash)

Type of Wheat
HARD RED WINTER

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of Q x P / S of Q
	FROM	TO	% Protein (14% M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
1	3BK	F.M.	11.3	4.4	.4972	.4972	4.4	11.30
	2BK	C.M.	10.2	6.7	.6834	1.1806	11.1	10.64
	2BK	F.M.	9.5	5.0	.4750	1.6556	16.1	10.28
	3BK	Flour	11.6	1.1	.1276	1.7832	17.2	10.36
	3BK	C.M.	11.4	5.0	.5700	2.3532	22.2	10.60
	2BK	F.S.	9.5	8.8	.8360	3.1892	31.0	10.29
	2BK	Flour	10.6	1.8	.1908	3.3800	32.8	10.30
	1BK	C.M.	9.1	4.2	.3822	3.7622	37.0	10.17
	1BK	F.M.	9.0	4.6	.4140	4.1762	41.6	10.04
	1BK	Flour	9.7	1.9	.1843	4.3605	43.5	10.02
	1BK	F.S.	9.3	4.0	.3720	4.7325	47.5	9.96
	1BK	C.S.	9.6	7.9	.7584	5.4909	55.4	9.91
	3BK	F.S.	11.1	2.4	.2664	5.7573	57.8	9.96
	2BK	C.S.	10.6	10.6	1.1236	6.8809	68.4	10.06
	3BK	C.S.	15.8	2.5	.3950	7.2759	70.9	10.26

TABLE # 12

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation

ALL BREAK RELEASE PRODUCTS
(In Same Order as Cumulative Ash)

Type of Wheat
HARD RED WINTER

TEST #	STREAM		P	Q	Q x P	Sof Q x P	S of Q	Sof QxP / S of Q
	FROM	TO	% Protein (14%M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
2	2BK	C.M.	10.7	7.2	.7704	.7704	7.2	10.70
	2BK	F.M.	10.4	5.4	.5616	1.3332	12.6	10.58
	3BK	F.M.	11.6	3.8	.4408	1.7728	16.4	10.81
	3BK	C.M.	11.6	3.9	.4524	2.2252	20.3	10.96
	3BK	Flour	12.0	1.0	.1200	2.3452	21.3	11.01
	1BK	F.M.	9.0	6.8	.6120	2.9572	28.1	10.52
	1BK	Flour	9.6	3.4	.3264	3.2836	31.5	10.42
	2BK	Flour	11.1	1.9	.2109	3.4945	33.4	10.46
	2BK	F.S.	10.4	6.8	.7072	4.2017	40.2	10.45
	1BK	C.M.	9.2	5.9	.5428	4.7445	46.1	10.29
	1BK	F.S.	9.4	6.4	.6016	5.3461	52.5	10.18
	1BK	C.S.	9.8	12.5	1.2250	6.5111	65.0	10.11
	3BK	F.S.	11.5	1.8	.2070	6.7781	66.8	10.15
	2BK	C.S.	11.0	5.5	.6050	7.3831	72.3	10.21
	3BK	C.S.	15.9	2.3	.3659	7.7490	74.6	10.39

TABLE # 13

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation

Type of Wheat
HARD RED WINTER

ALL BREAK RELEASE PRODUCTS
(In same order as Cumulative Ash)

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of Q x P / S of Q
	FROM	TO	% Protein (14%M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
3	2BK	C.M.	11.2	3.7	.4144	.4144	3.7	11.20
	3BK	F.M.	11.8	3.1	.3658	.7802	6.8	11.47
	2BK	F.M.	11.1	2.9	.3219	1.1021	9.7	11.36
	1BK	F.M.	9.3	9.7	.9021	2.0042	19.4	10.33
	1BK	Flour	9.8	4.8	.4704	2.4746	24.2	10.23
	1BK	C.M.	9.5	9.1	.8645	3.3339	33.3	10.01
	3BK	Flour	12.0	1.0	.1200	3.4591	34.3	10.08
	1BK	F.S.	9.6	10.4	.9984	4.4575	44.7	9.97
	2BK	F.S.	10.8	3.5	.3780	4.8355	48.2	10.03
	2BK	Flour	11.4	.9	.1026	4.9381	49.1	10.06
	3BK	C.M.	11.7	3.0	.3510	5.2891	52.1	10.15
	1BK	C.S.	10.3	13.8	1.4214	6.7105	65.9	10.18
	3BK	F.S.	11.7	1.3	.1521	6.8626	67.2	10.21
	2BK	C.S.	12.7	3.2	.4064	7.2690	70.4	10.33
	3BK	C.S.	16.6	1.9	.3154	7.5844	72.3	10.49

TABLE # 14

CUMULATIVE PROTEIN
BREAK RELEASE PRODUCTS
HARD RED WINTER

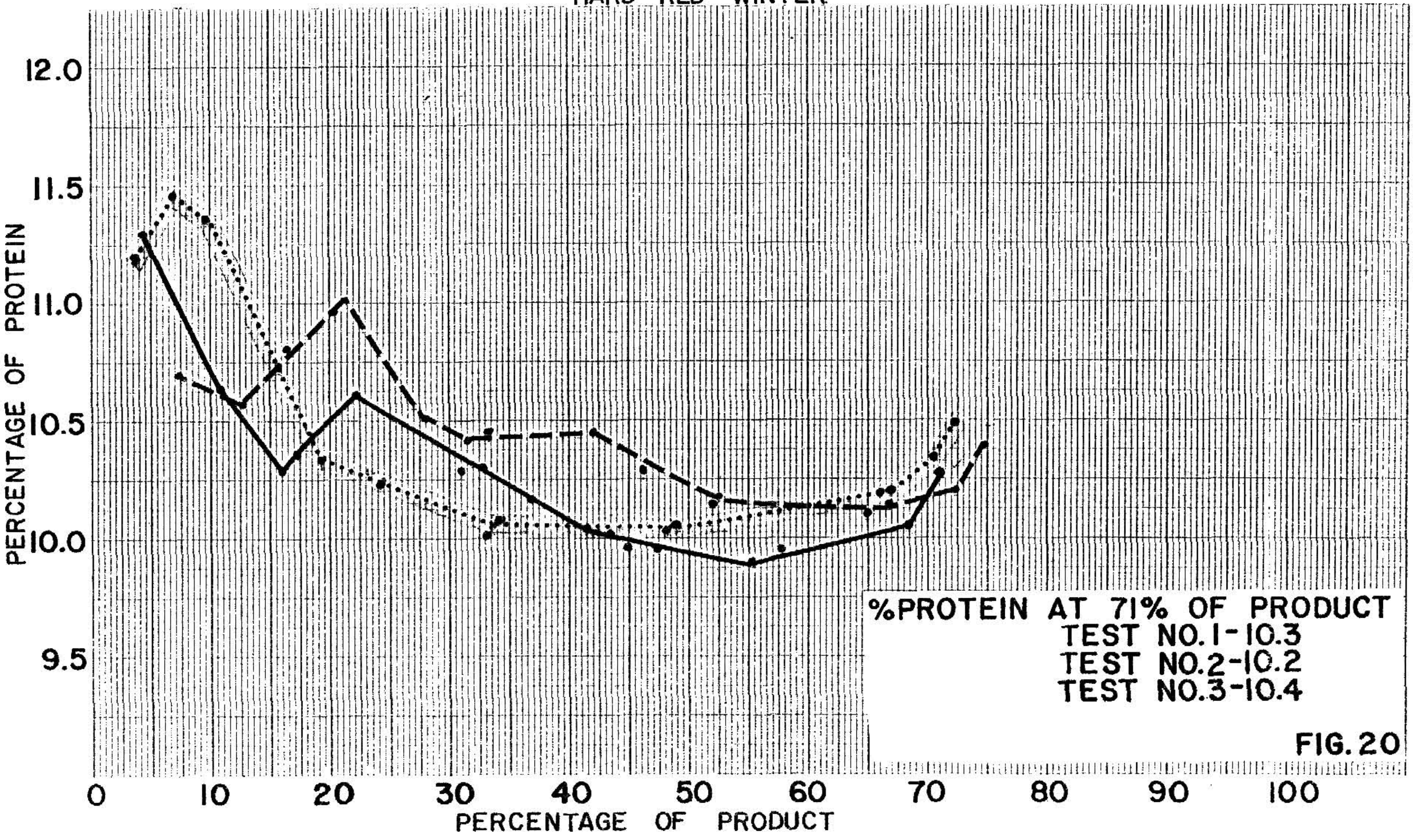


FIG. 20

between "pure" endosperm and "pure" bran is not so great, the internal gradient is distinguishable and not distorted to a great extent by the presence of bran in the endosperm material.

The protein content of a flour has a direct relationship to its gluten strength. Generally speaking, the higher the protein content of a flour, the greater will be its gluten or dough strength.

In many cases a mill is obliged to make flours having a wide range of protein contents for such wide-ranging products as cakes, cookies, donuts, crackers, biscuit, all purpose, pan bread, buns and hearth bread. The availability of wheats having the necessary protein spreads may not be economically acceptable. It is, therefore, of some importance to produce the widest spread of proteins from the common wheats readily available at an acceptable price. The air classification of flours is one method to produce a wide range of flour proteins from one protein wheat. This involves shifting the protein by air currents as the protein has different aerodynamic properties than the starch. Another approach is to make stream selections in the flour mill that take advantage of the natural difference in protein content of the flours produced at each milling point. This protein difference reflects back on the gradient within the wheat berry as found by MacMasters, et al. Those mills desiring this type of protein spreading may want to take better advantage of stock selections within the flow sheet to maximize the spread in flour proteins.

Without regard to quantities, the differences in proteins can be appreciated by the following comparisons:

Protein Spreads
Break Release Products
Hard Red Winter Wheat

Test #1

Stock To	From 1 BK %	From 2 BK %	From 3 BK %	Maximum Difference %
CS	9.6	10.6	15.8	6.2
FS	9.3	9.5	11.1	1.8
CM	9.1	10.2	11.4	2.3
FM	9.0	9.5	11.3	2.3
Flour	9.7	10.6	11.6	1.9

Test #2

CS	9.8	11.0	15.9	6.1
FS	9.4	10.4	11.5	2.1
CM	9.2	10.7	11.6	2.4
FM	9.0	10.4	11.6	2.6
Flour	9.6	11.1	12.0	2.4

Test #3

CS	10.3	12.7	16.6	6.3
FS	9.6	10.8	11.7	2.1
CM	9.5	11.2	11.7	2.2
FM	9.3	11.1	11.8	2.5
Flour	9.8	11.4	12.0	2.2

This array shows that protein can be spread thru selective use of break releases. The flour protein spreads obtained indicate that this protein difference finds its way to the flour.

Hard Red Spring Wheat

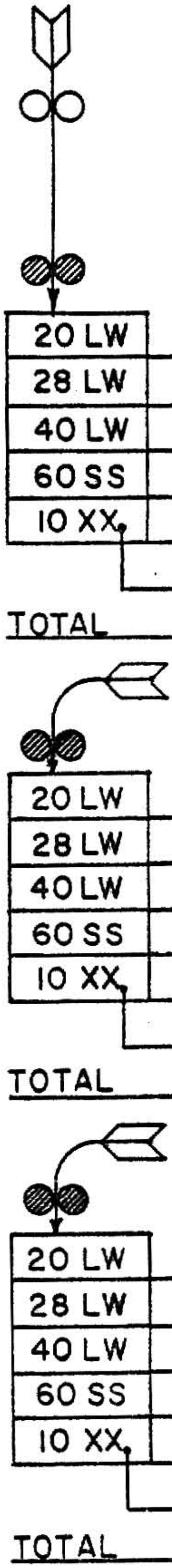
Figures #21, #22 and #23 show the flow sheets and test results for this class of wheat. The break extractions and releases used are resummarized below.

Test #	Break Releases % Release			and	Extractions % Extraction				
	1BK	2BK	3BK		1BK	2BK	1BK+2BK	3BK	1 + 2 + 3 BK Tot
1	25.4	42.0	35.9		25.4	31.3	56.7	15.5	72.2
2	36.1	39.9	30.6		36.1	25.5	61.6	11.8	73.4
3	46.7	28.8	28.7		46.7	15.4	62.1	10.9	73.0

FLOW SHEET
BREAKS

Type of Wheat: HARD RED SPRING
Test Number 1

	% Release	% Extraction
1st Break	25.4	25.4
2nd Break	42.0	31.3
3rd Break	35.9	15.5



Pre-Break
Smooth
9"x6" 11/2:1

1st Break
9"x6" 2 1/2:1
12/12 Getchell D:D

		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	2nd Break	----	----	14.8	1.83
28 LW	Coarse Sizings	10.4	10.4	11.5	.66
40 LW	Fine Sizings	4.3	4.3	11.5	.58
60 SS	Coarse Middlings	3.6	3.6	12.0	.52
10 XX	Fine Middlings	4.8	4.8	12.9	.52
	Flour	2.3	2.3	15.7	.54
TOTAL		25.4	25.4		

2nd Break
9"x6" 2 1/2:1
12/14 Getchell D:D

		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	3rd Break	----	----	16.3	2.64
28 LW	Coarse Sizings	16.7	12.5	12.2	.90
40 LW	Fine Sizings	10.8	8.1	12.0	.46
60 SS	Coarse Middlings	6.5	4.8	12.7	.44
10 XX	Fine Middlings	5.6	4.1	13.4	.44
	Flour	2.4	1.8	16.6	.52
TOTAL		42.0	31.3		

3rd Break
9"x6" 2 1/2:1
16/16 Getchell D:D

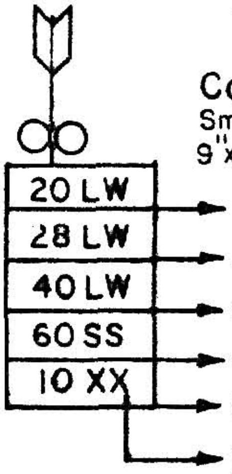
		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	Feed	----	----	16.9	3.57
28 LW	Coarse Sizings	8.0	3.5	15.4	2.44
40 LW	Fine Sizings	7.5	3.2	12.9	.72
60 SS	Coarse Middlings	9.8	4.2	13.6	.43
10 XX	Fine Middlings	8.0	3.5	14.6	.42
	Flour	2.6	1.1	16.9	.48
TOTAL		35.9	15.5		

Fig. 21

FLOW SHEET
SIZINGS AND REDUCTIONS

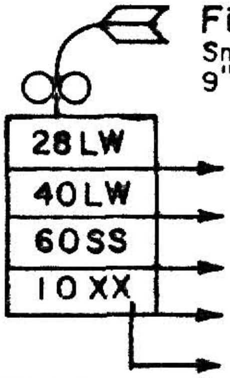
Type of /Wheat HARD RED SPRING
Test Number 1

Coarse Sizings
Smooth
9"x6" 1 1/2:1



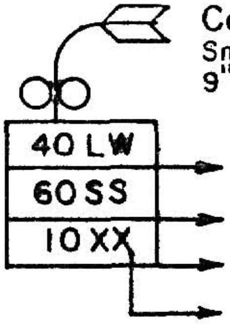
	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	7.0	1.0	18.8	3.24
Bottom Scalp	17.4	4.6	15.0	2.62
Fine Sizings	10.2	2.7	11.1	1.01
Coarse Middlings	24.8	6.5	10.9	.39
Fine Middlings	33.6	9.0	11.3	.31
Flour	7.0	1.8	12.5	.39
Total	100.0	26.4	12.4	.94

Fine Sizings
Smooth
9"x6" 1 1/2:1



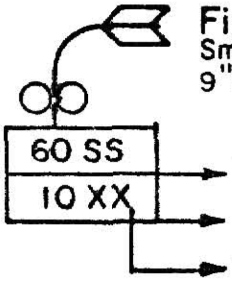
	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	5.1	0.9	----	----
Bottom Scalp	10.6	2.0	13.3	2.60
Coarse Middlings	18.8	3.4	11.3	1.40
Fine Middlings	56.6	10.4	11.6	.33
Flour	8.9	1.6	12.5	.37
Total	100.0	18.3	11.9	.89

Coarse Middlings
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	3.0	0.7	----	----
Bottom Scalp	8.8	2.0	12.7	1.41
Fine Middlings	54.7	12.3	11.8	.36
Flour	33.5	7.5	11.9	.31
Total	100.0	22.5	11.9	.47

Fine Middlings
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	0.8	0.3	----	----
Bottom Scalp	42.8	18.9	12.5	.44
Flour	56.4	24.9	12.1	.31
Total	100.0	44.1	12.3	.37

Fig. #21

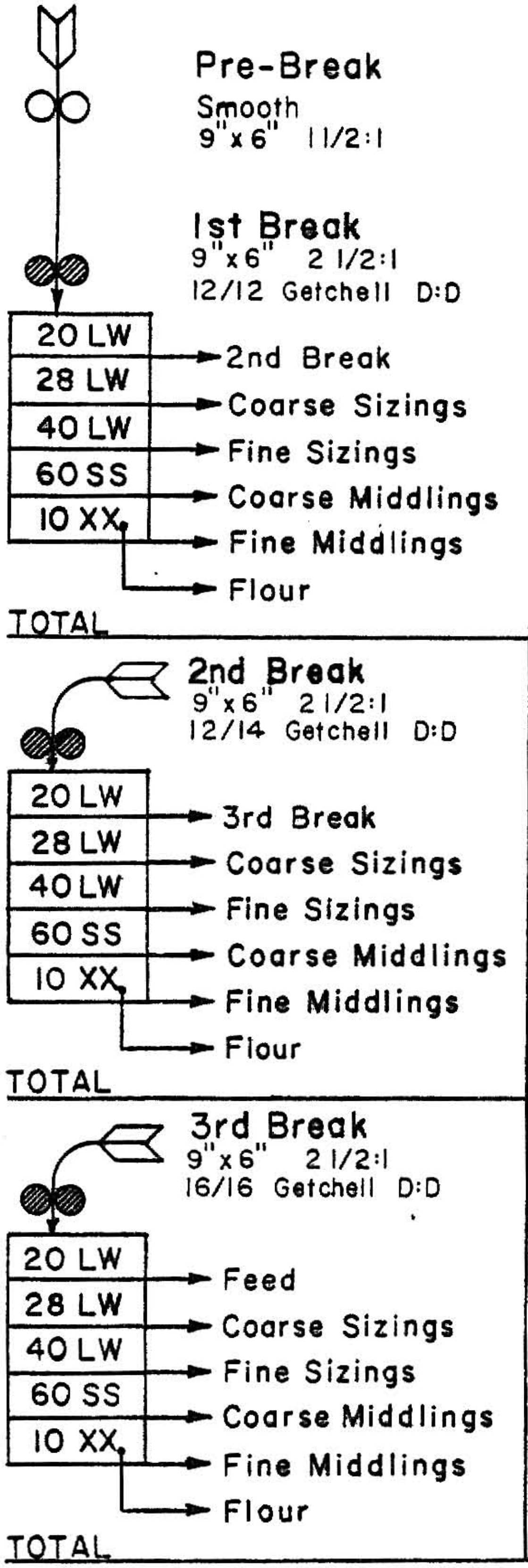
FLOW SHEET

BREAKS

Type of Wheat HARD RED SPRING

Test Number 2

	% Release	% Extraction
1st Break	36.1	36.1
2nd Break	39.9	25.5
3rd Break	30.6	11.7



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
1st Break				
2nd Break	----	----	15.0	2.05
Coarse Sizings	14.4	14.4	11.5	.69
Fine Sizings	6.6	6.6	11.5	.59
Coarse Middlings	5.3	5.3	11.9	.59
Fine Middlings	6.4	6.4	12.9	.52
Flour	3.4	3.4	15.0	.53
TOTAL	36.1	36.1		
2nd Break				
3rd Break	----	----	16.9	2.87
Coarse Sizings	14.4	9.2	13.2	1.12
Fine Sizings	10.5	6.7	12.0	.50
Coarse Middlings	7.0	4.5	12.8	.46
Fine Middlings	5.8	3.7	13.5	.46
Flour	2.2	1.4	16.6	.52
TOTAL	39.9	25.5		
3rd Break				
Feed	----	----	16.8	3.73
Coarse Sizings	7.4	2.8	15.8	2.52
Fine Sizings	5.9	2.3	12.9	.83
Coarse Middlings	8.2	3.2	13.7	.46
Fine Middlings	6.9	2.6	14.8	.44
Flour	2.2	.8	17.3	.50
TOTAL	30.6	11.7		

Fig. 22

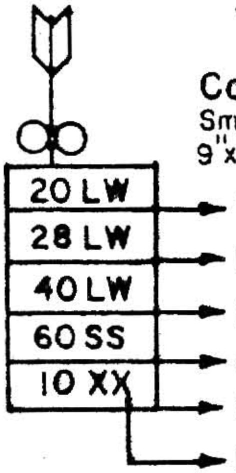
FLOW SHEET

SIZINGS AND REDUCTIONS

Type of /Wheat HARD RED SPRING
Test Number 2

Coarse Sizings

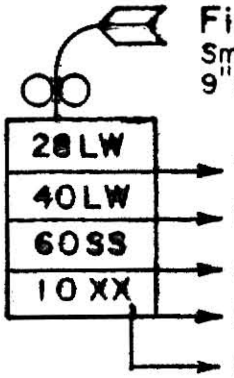
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	7.0	2.2	13.5	3.22
Bottom Scalp	18.5	4.4	14.7	2.42
Fine Sizings	11.3	3.0	10.9	.86
Coarse Middlings	28.8	7.6	11.0	.38
Fine Middlings	28.7	7.6	11.5	.33
Flour	5.7	1.5	13.3	.40
Total	100.0	26.4	12.1	1.01

Fine Sizings

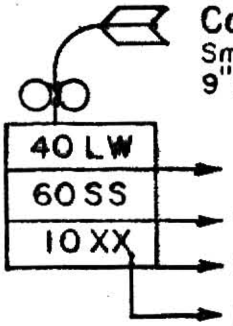
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	5.0	1.0	----	----
Bottom Scalp	11.0	2.0	13.1	2.22
Coarse Middlings	20.1	3.7	11.2	1.10
Fine Middlings	55.7	10.4	11.6	.31
Flour	8.3	1.5	12.6	.36
Total	100.0	18.6	11.6	.78

Coarse Middlings

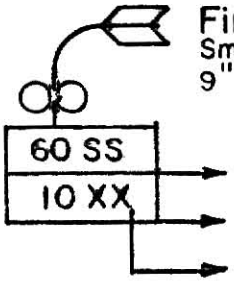
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	3.3	.8	----	----
Bottom Scalp	9.5	2.3	12.4	1.30
Fine Middlings	57.0	13.8	11.8	.35
Flour	30.2	7.3	12.2	.32
Total	100.0	24.2	12.0	.46

Fine Middlings

Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	.7	.3	----	----
Bottom Scalp	52.4	23.3	12.4	.42
Flour	46.9	20.9	12.2	.31
Total	100.0	44.5	12.3	.36

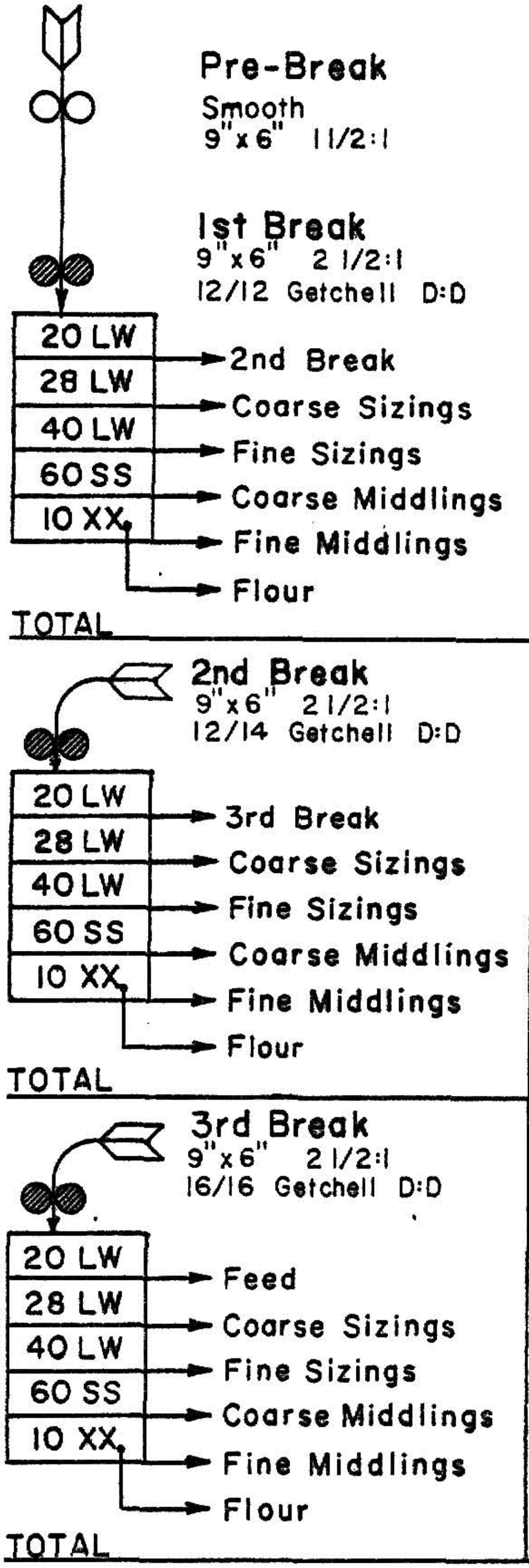
Fig. #22

FLOW SHEET

BREAKS

Type of Wheat HARD RED SPRING
Test Number 3

	% Release	% Extraction
1st Break	46.7	46.7
2nd Break	28.9	15.3
3rd Break	28.6	10.9



Pre-Break
Smooth
9"x6" 1 1/2:1

1st Break
9"x6" 2 1/2:1
12/12 Getchell D:D

		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	2nd Break	----	----	15.2	2.33
28 LW	Coarse Sizings	17.2	17.2	11.6	.76
40 LW	Fine Sizings	9.6	9.6	11.7	.53
60 SS	Coarse Middlings	7.4	7.4	12.1	.51
10 XX	Fine Middlings	8.4	8.4	12.6	.47
	Flour	4.1	4.1	15.9	.48
TOTAL		46.7	46.7		

2nd Break
9"x6" 2 1/2:1
12/14 Getchell D:D

		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	3rd Break	----	----	16.5	3.04
28 LW	Coarse Sizings	10.4	5.4	14.1	1.21
40 LW	Fine Sizings	7.4	3.9	12.3	.49
60 SS	Coarse Middlings	5.2	2.8	13.2	.48
10 XX	Fine Middlings	4.3	2.3	14.1	.48
	Flour	1.6	.9	17.0	.55
TOTAL		28.9	15.3		

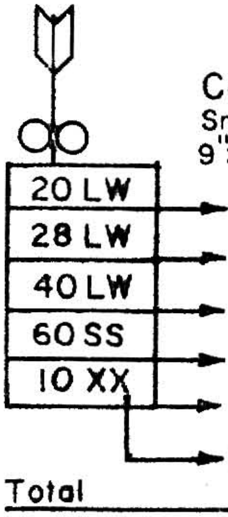
3rd Break
9"x6" 2 1/2:1
16/16 Getchell D:D

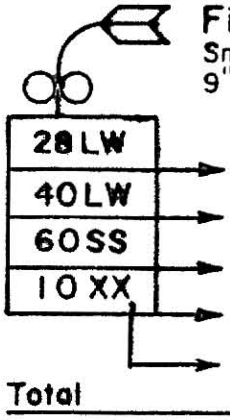
		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	Feed	----	----	16.7	3.77
28 LW	Coarse Sizings	7.2	2.7	17.2	2.74
40 LW	Fine Sizings	5.3	2.0	13.2	.96
60 SS	Coarse Middlings	7.0	2.7	13.9	.47
10 XX	Fine Middlings	6.8	2.6	15.0	.45
	Flour	2.3	.9	17.6	.47
TOTAL		28.6	10.9		

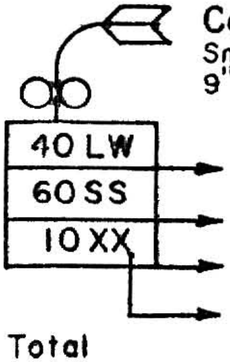
Fig. 23

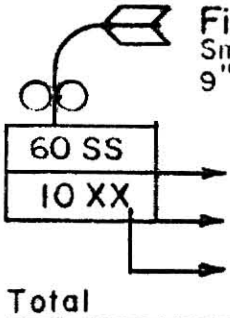
FLOW SHEET
SIZINGS AND REDUCTIONS

Type of /Wheat HARD RED SPRING
Test Number 3









	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Coarse Sizings Smooth 9"x6" 1 1/2:1				
Top Scalp	8.0	2.0	18.9	3.31
Bottom Scalp	18.3	4.6	15.1	2.72
Fine Sizings	10.2	2.6	11.4	1.00
Coarse Middlings	24.3	6.1	10.9	.38
Fine Middlings	33.0	8.4	11.5	.32
Flour	6.2	1.6	13.0	.37
Total	100.0	25.3	12.7	1.11
Fine Sizings Smooth 9"x6" 1 1/2:1				
Top Scalp	5.7	1.0	----	----
Bottom Scalp	11.6	2.1	13.5	1.91
Coarse Middlings	20.5	3.7	11.4	.47
Fine Middlings	54.1	9.8	11.9	.30
Flour	8.1	1.5	12.9	.34
Total	100.0	18.1	12.2	.61
Coarse Middlings Smooth 9"x6" 1 1/2:1				
Top Scalp	3.6	.8	----	----
Bottom Scalp	9.5	2.2	12.6	1.30
Fine Middlings	54.8	12.4	12.0	.34
Flour	32.1	7.3	12.2	.31
Total	100.0	22.7	12.1	.46
Fine Middlings Smooth 9"x6" 1 1/2:1				
Top Scalp	1.0	.4	----	----
Bottom Scalp	49.3	21.6	12.4	.42
Flour	49.7	21.9	12.2	.30
Total	100.0	43.9	12.3	.36

Fig. #23

Granulation Series

As with the Hard Red Winter wheat tests, the break extractions chosen represent the extraction ranges one would expect to see in commercial milling.

First Break

Figure #24 shows the accumulative granulation curves for each 1st break release of 25.4%, 36.1% and 46.7%. These curves are obtained from the amount of material retained on each sieve size. The screen openings are indicated on the ordinate at the same micron openings reported for Hard Red Winter wheat. By interpolation, the amount of material that would be retained at any level of extraction between 46.7% and 25.4% can be determined.

The granulations are not linear. The rate of increase between 1050 microns and 716 microns decreases slightly between 716 microns and 130 microns and then decreases again from 130 microns to pan or blank.

Figure #25 shows the close granular relationship of the released (-20LW) material.in all three tests over a wide release range (25.4% to 46.7%). The slight increase of material thru the 28LW can be attributed to the crushing action of the closer roll gap used to obtain the higher release rate. The no-load roll gap settings for the three tests were .025", .019" and .016" for Tests #1, #2 and #3, respectively. These curves are called base-line granularity curves. (See Hard Red Winter wheat).

Second Break

Figure #26 shows the accumulative percent overs for 2nd break. The rate of accumulation is fairly uniform from 1050 Microns to 316 microns. A slight decrease in rate is noted from 316 microns to 130 microns and an additional decrease in the flour protion from 130 microns down. The two

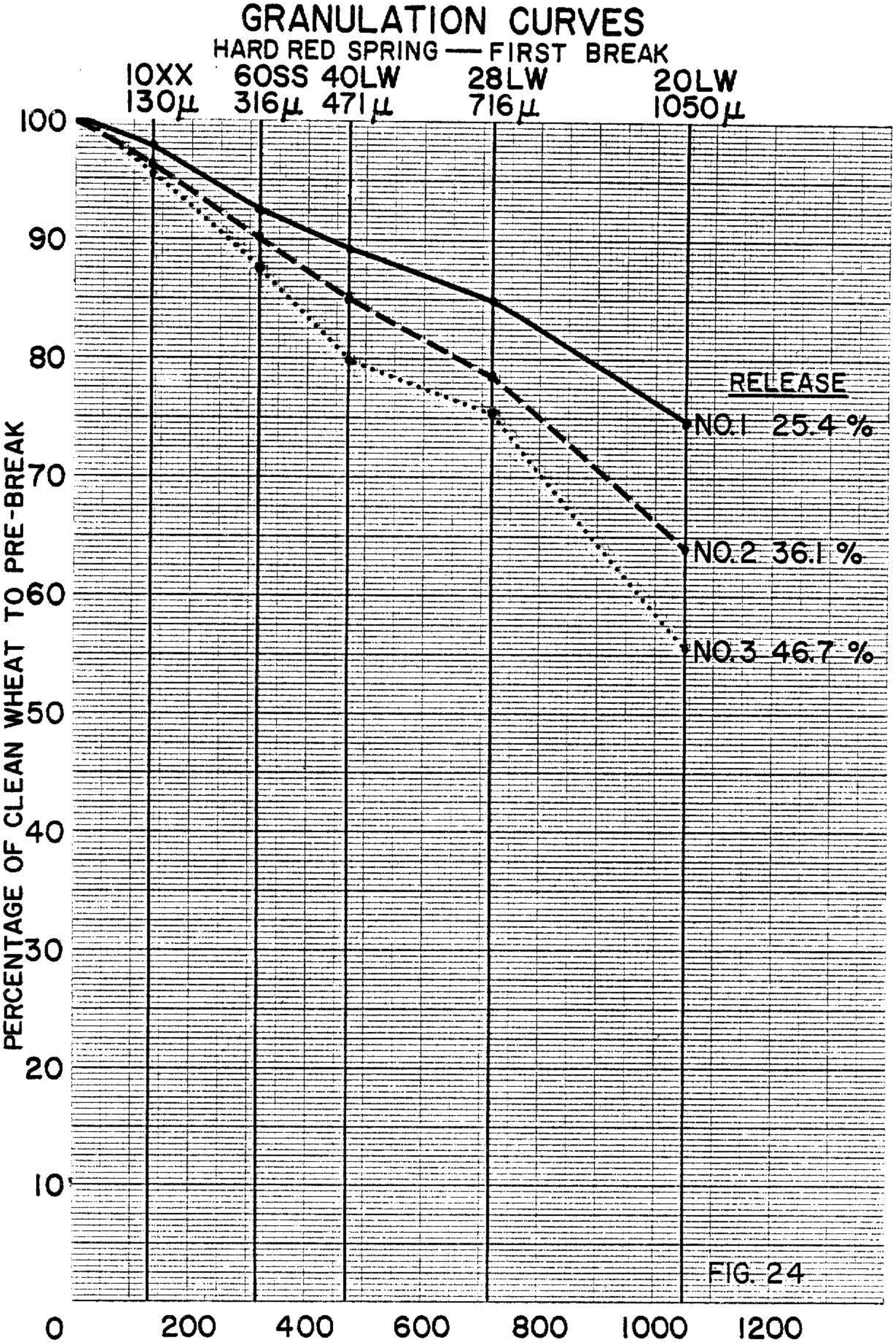
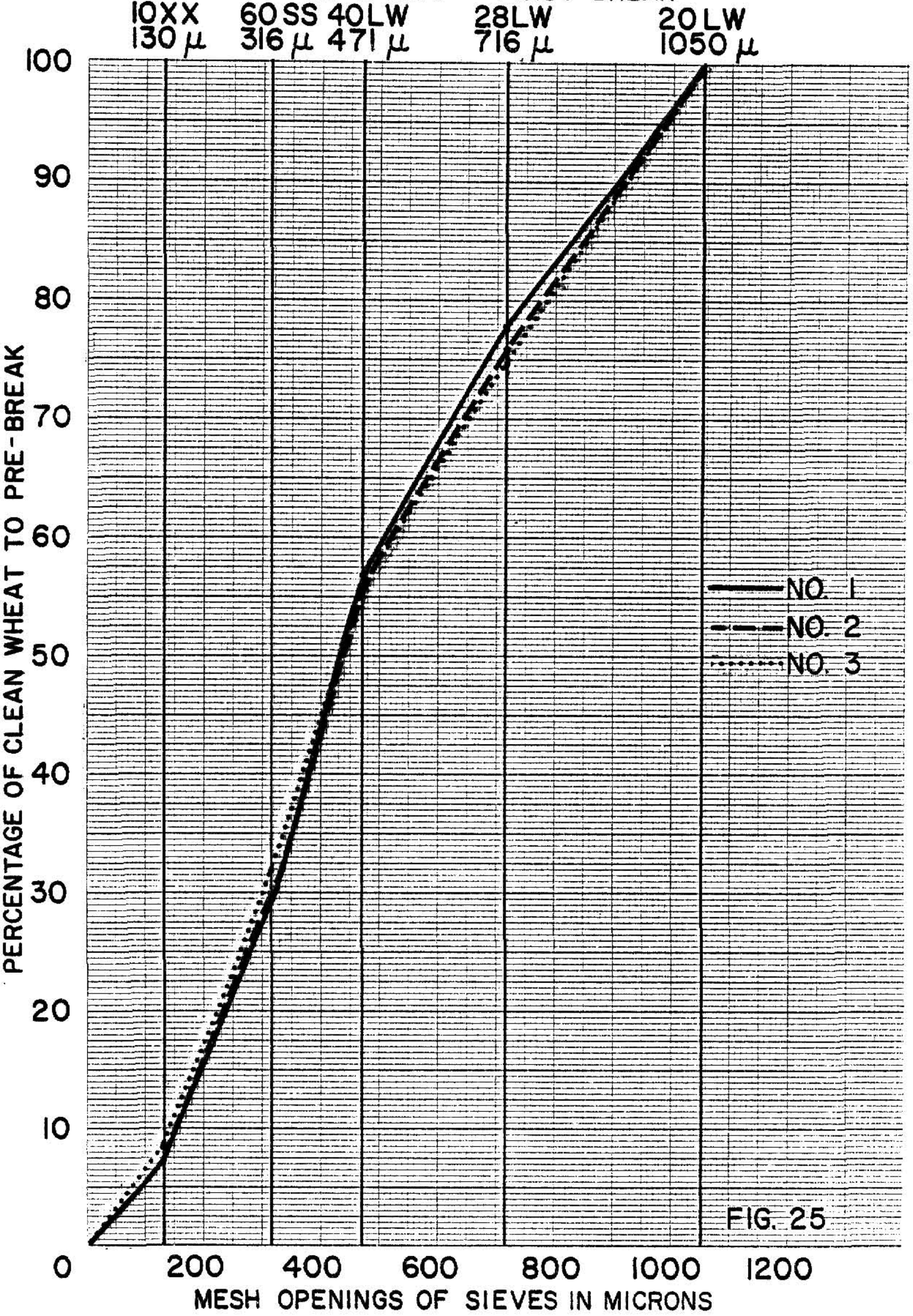

GRANULATION CURVES
HARD RED SPRING — FIRST BREAK
10XX 130μ
60SS 316μ
40LW 471μ
28LW 716μ
20LW 1050μ
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
MESH OPENINGS OF SIEVES IN MICRONS
RELEASE
NO.1 25.4 %
NO.2 36.1 %
NO.3 46.7 %

FIG. 24



BASELINE GRANULARITY CURVES
HARD RED SPRING — FIRST BREAK

FIG. 25

GRANULATION CURVES

HARD RED SPRING—SECOND BREAK

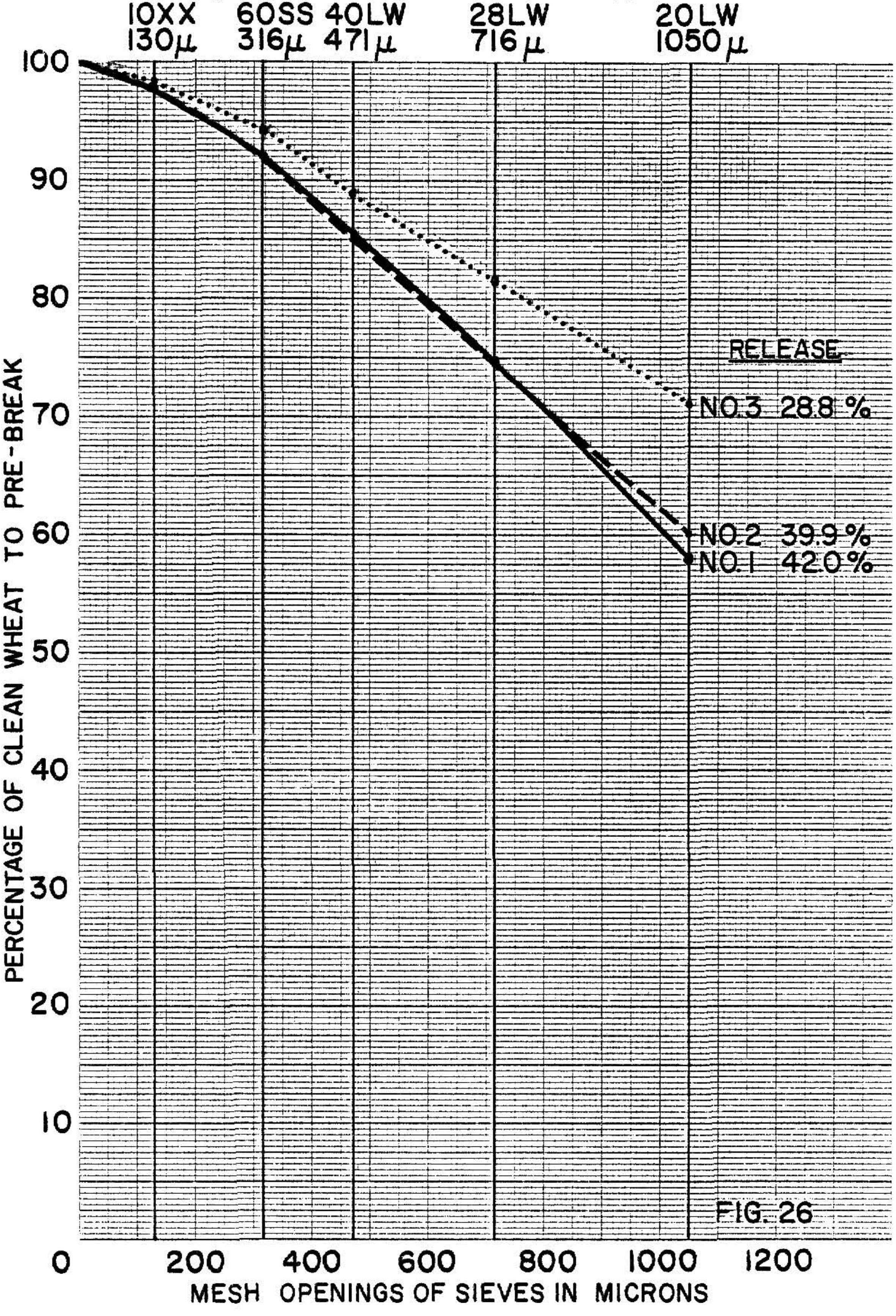


FIG. 26

break settings of 39.9% and 42.0% show very similar curves despite the difference in in-feed material of 10.7% less wheat berry for Test #2.

Figure #27 indicates some differences in the granularity of the three releases (-20LW). There is no apparent explanation for these differences. The no-load roll gap settings were .014", .0125" and .010" for Tests #1, #2 and #3, respectively.

Third Break

Figure #28 indicates the increasingly fine material produced by the finer, more numerous corrugations on the 3rd break roll. There is a distinct increase in the rate of accumulation between 471 microns and 130 microns with a decrease in the flour range.

Figure #29 shows a great similarity in the granulation sizes of the release material. (-20LW). The increase in material thru the 28LW may indicate a crushing effect. The no-load roll gaps used were .009", .008" and .008" for Tests #1, #2 and #3 respectively. The crushing action would have occurred due to a greater thickness of material in the feed stock to Test #1. Test #1 received 43.3% of the wheat berry compared to 38.4% and 37.9% on Tests #2 and #3.

Material Balances

The complete material balances for the three Hard Red Spring tests are presented in Figures #30, #31 and #32.

Comparative Quantities

For emphasis on the change in stock quantities produced with different break extractions, the Figures #33, #34 and #35 are given.

BASELINE GRANULARITY CURVES

HARD RED SPRING—SECOND BREAK

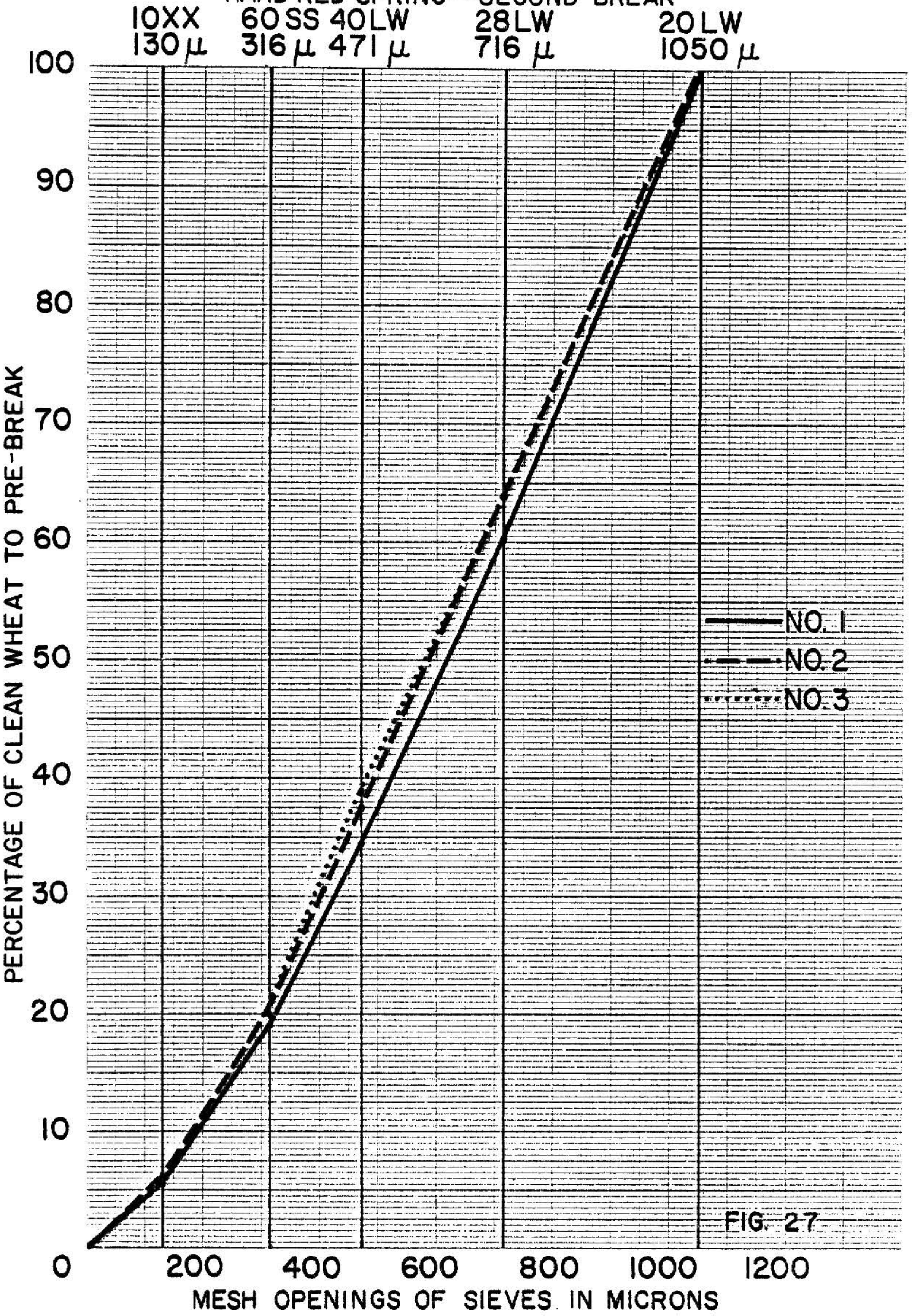


FIG. 27

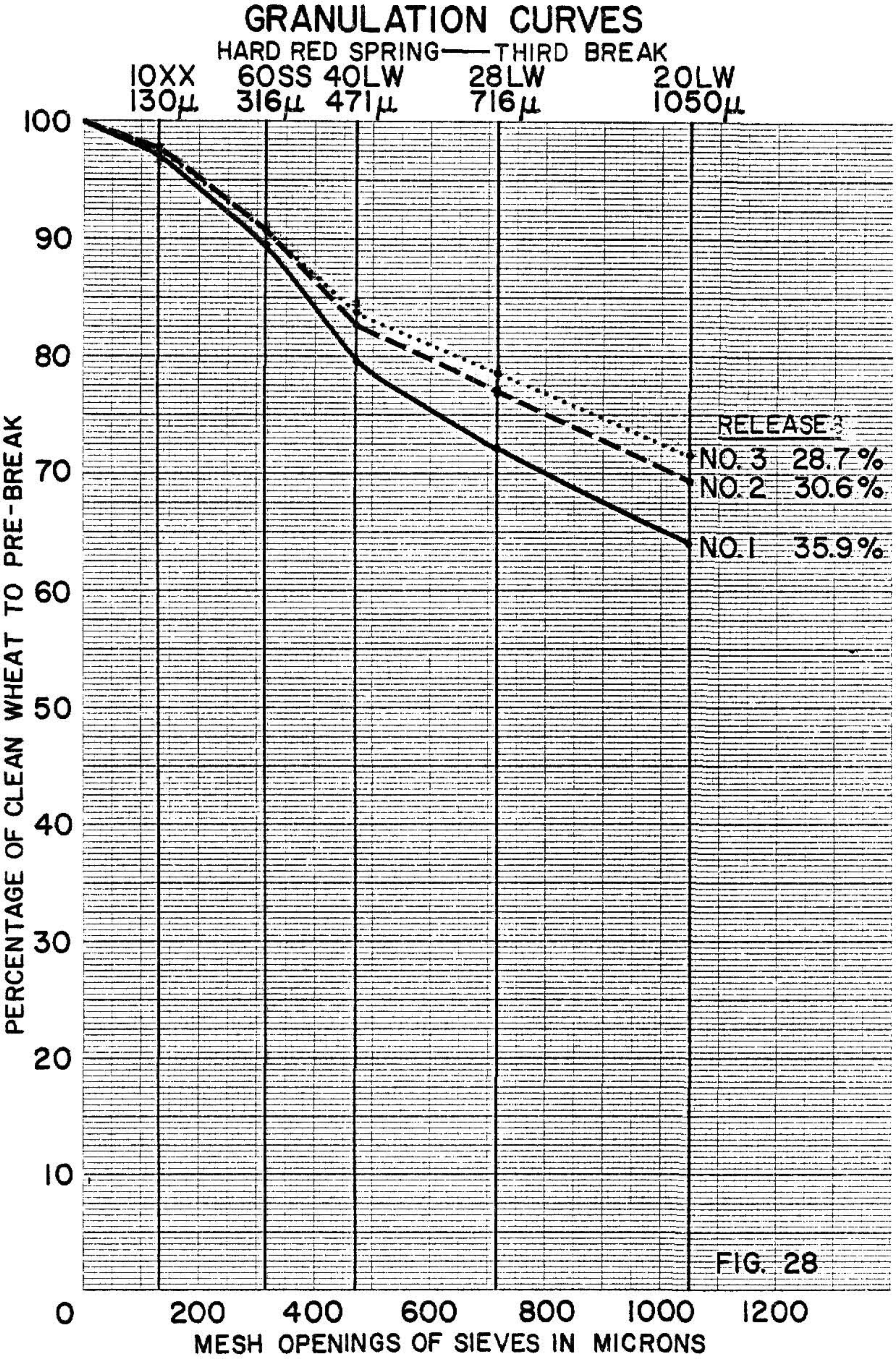

GRANULATION CURVES
HARD RED SPRING——THIRD BREAK
10XX 130μ
60SS 316μ
40LW 471μ
28LW 716μ
20LW 1050μ
RELEASES
NO. 3 28.7 %
NO. 2 30.6 %
NO. 1 35.9 %
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
MESH OPENINGS OF SIEVES IN MICRONS

FIG. 28

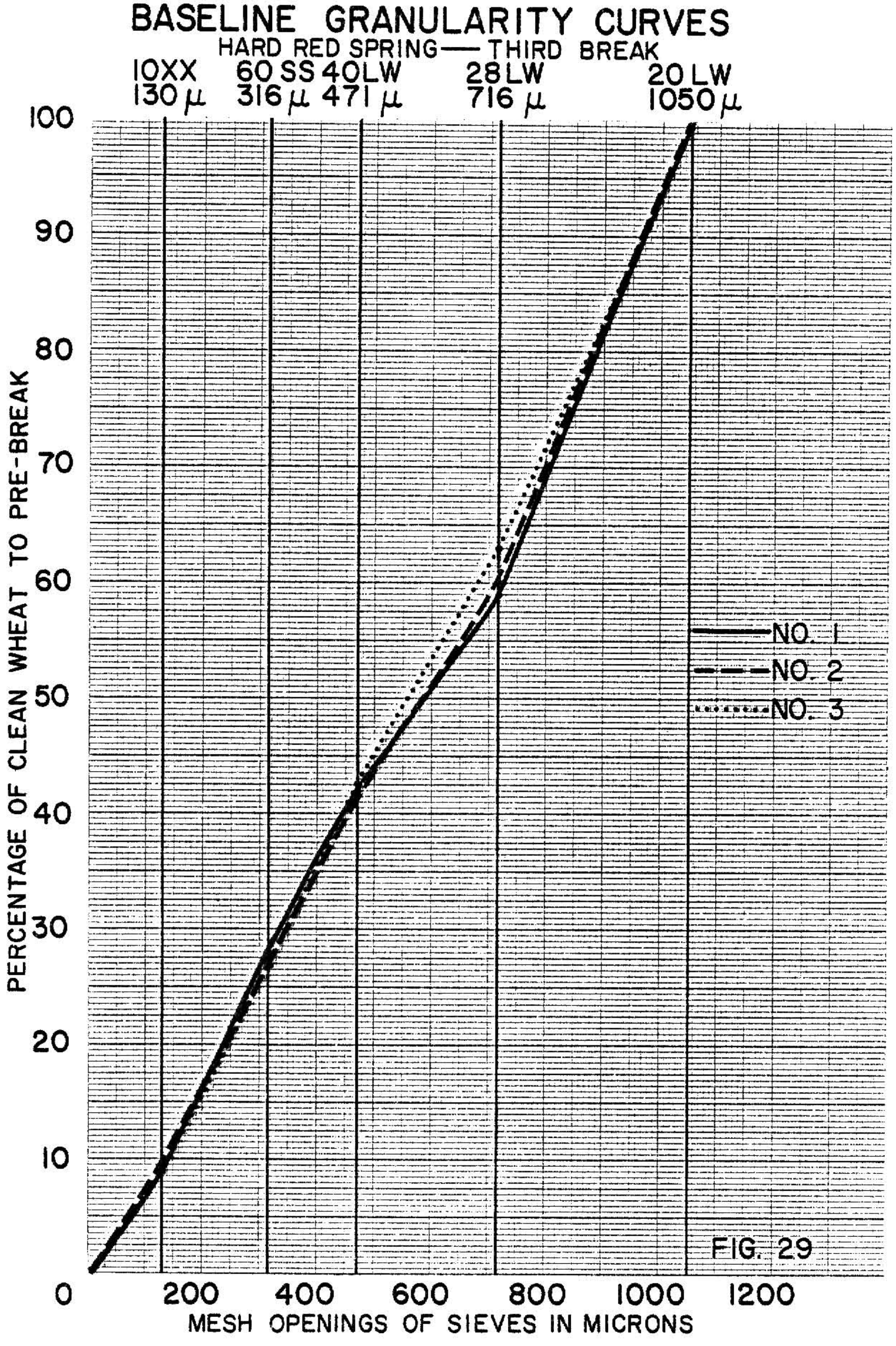
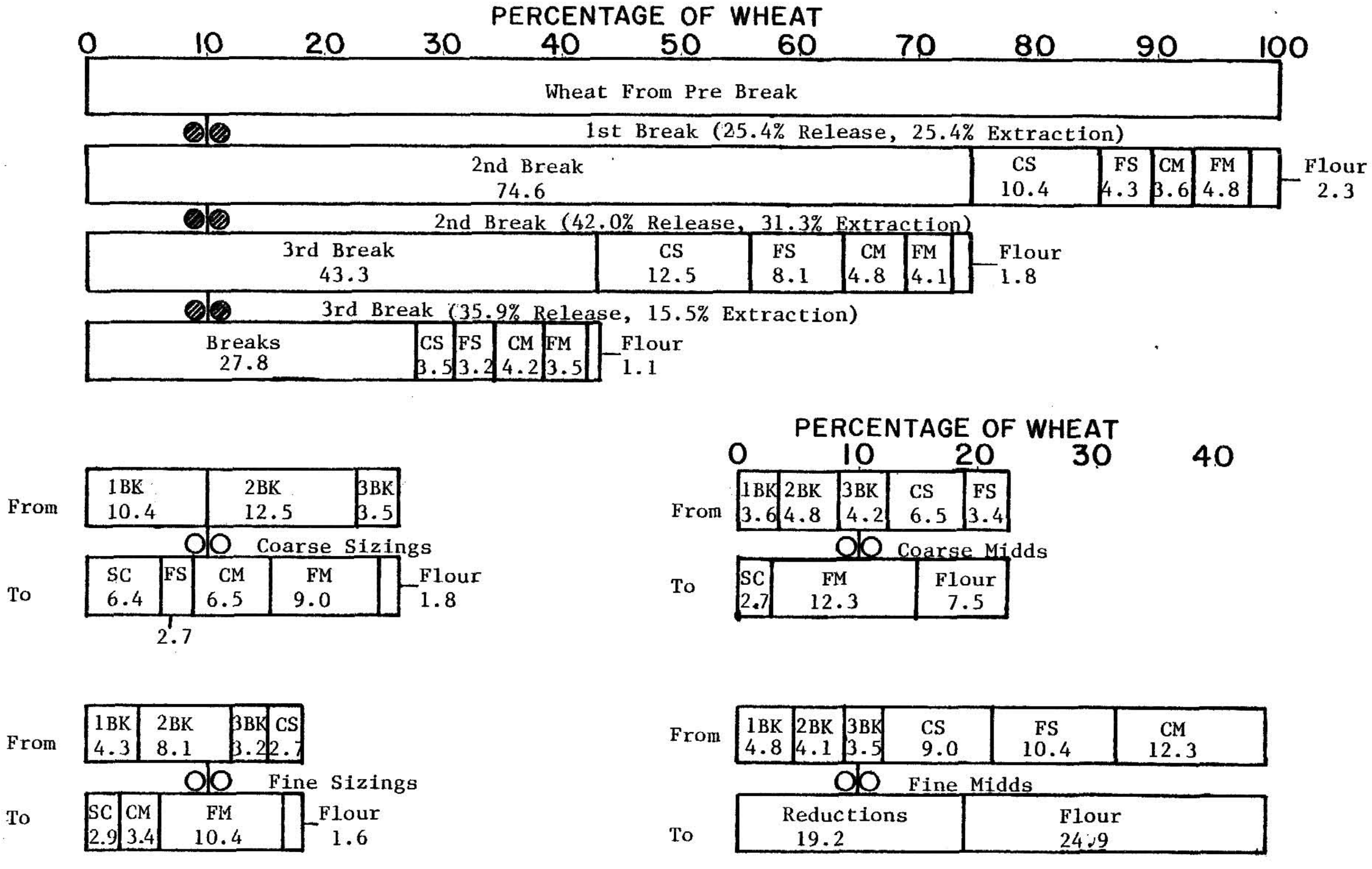
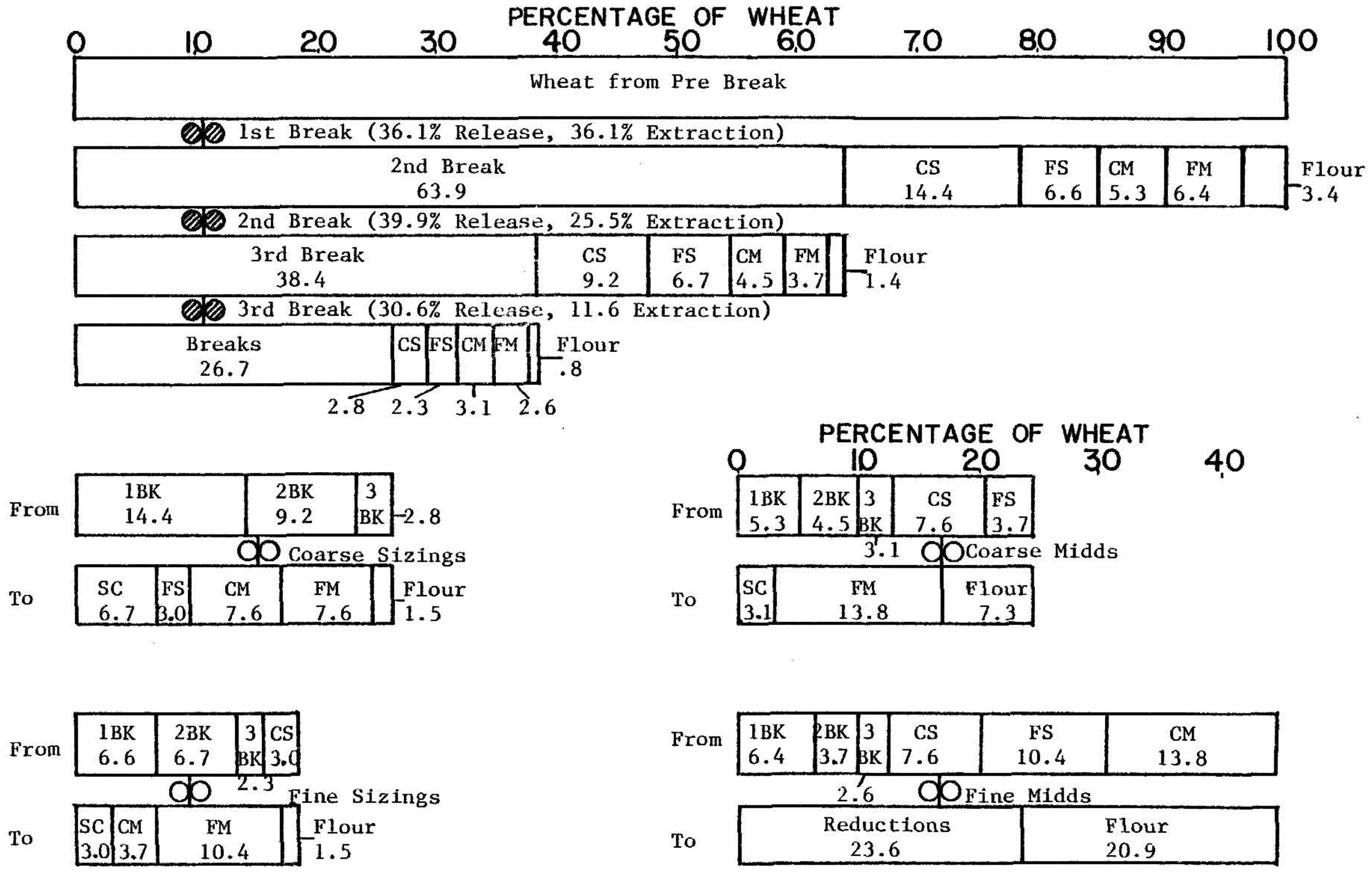

BASELINE GRANULARITY CURVES
HARD RED SPRING — THIRD BREAK
10XX 130 μ
60 SS 316 μ
40LW 471 μ
28 LW 716 μ
20 LW 1050 μ
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
0
10
20
30
40
50
60
70
80
90
100
200
400
600
800
1000
1200
MESH OPENINGS OF SIEVES IN MICRONS
NO. 1
NO. 2
NO. 3

FIG. 29



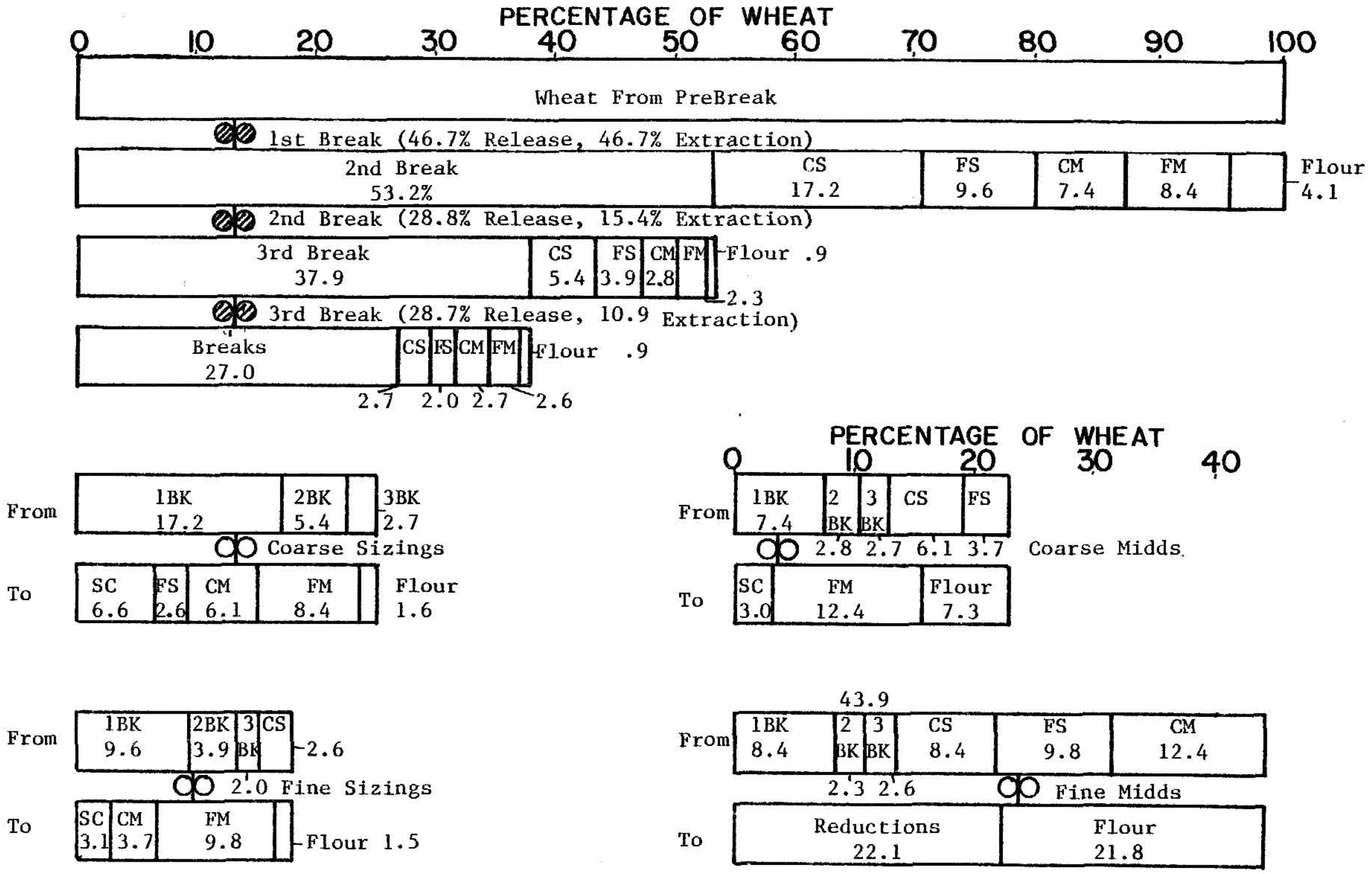
MATERIAL BALANCE CHART - HARD RED SPRING
TEST NO. 1

FIG. 30



MATERIAL BALANCE CHART-HARD RED SPRING
TEST NO. 2

FIG. 31



MATERIAL BALANCE CHART-HARD RED SPRING
TEST NO. 3

FIG. 32

PERCENTAGE EXTRACTION FROM FIRST BREAK FOR EACH PRODUCT
HARD RED SPRING

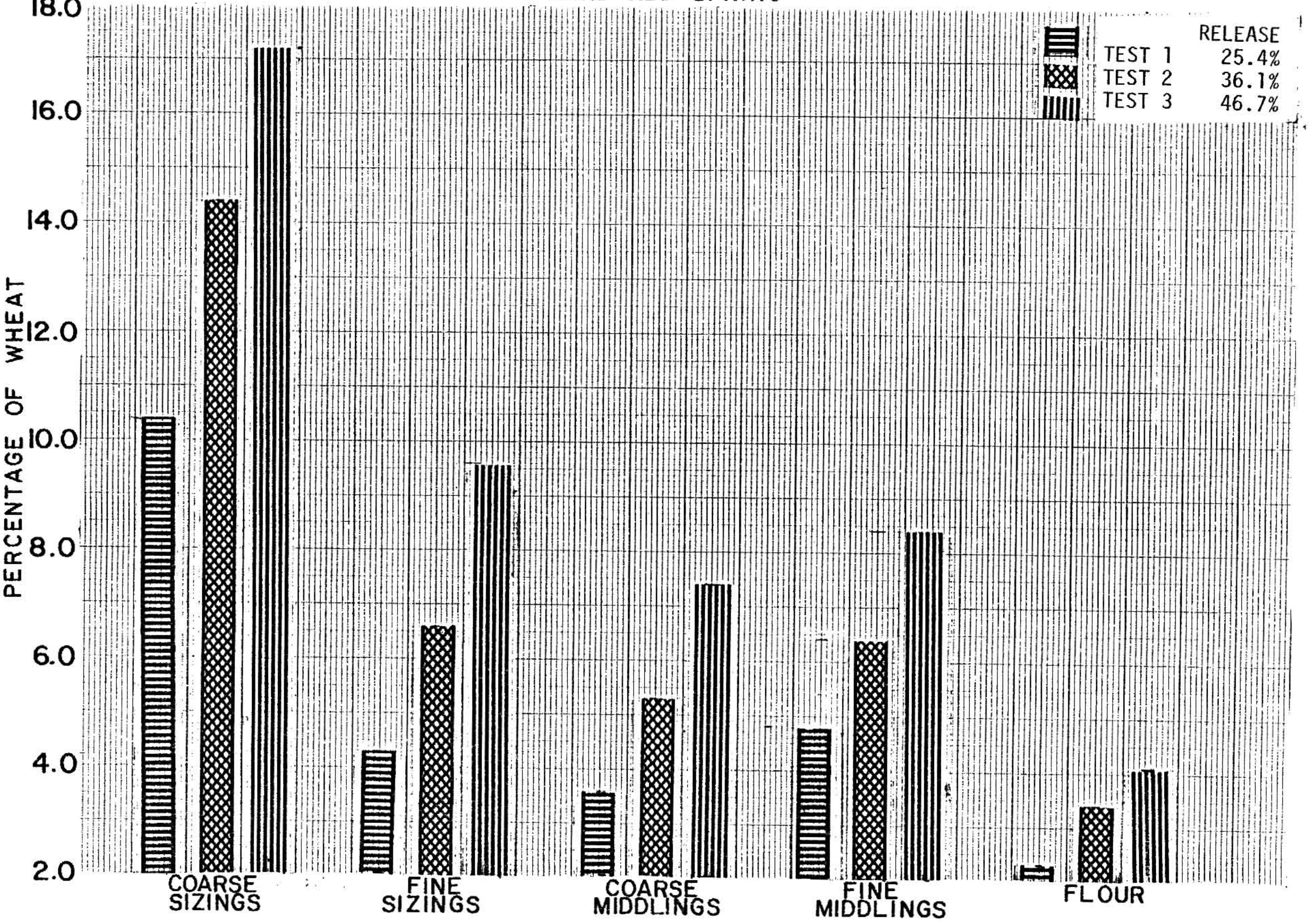
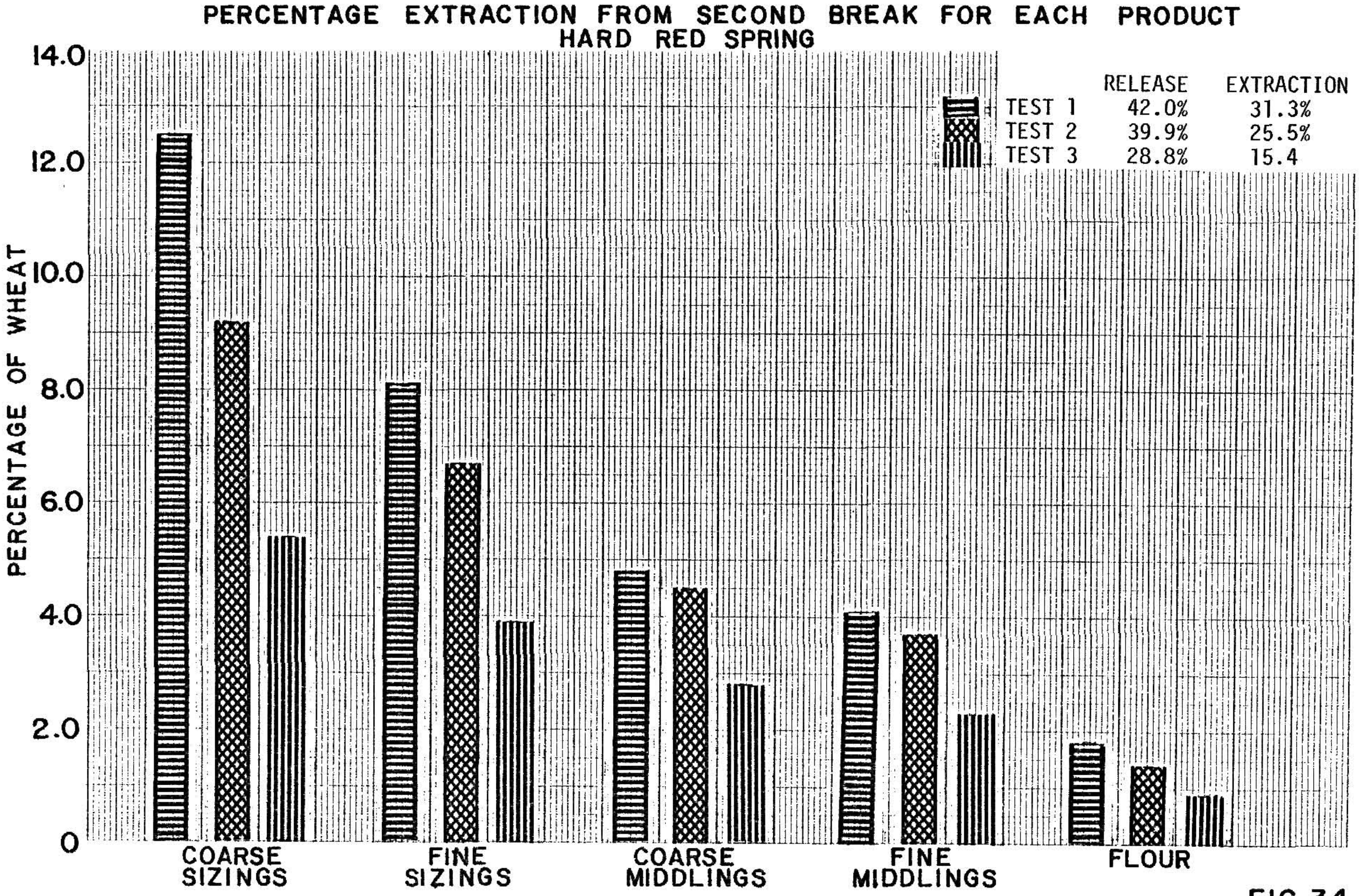


FIG. 33



PERCENTAGE EXTRACTION FROM SECOND BREAK FOR EACH PRODUCT
HARD RED SPRING

FIG. 34

PERCENTAGE EXTRACTION FROM THIRD BREAK FOR EACH PRODUCT
HARD RED SPRING

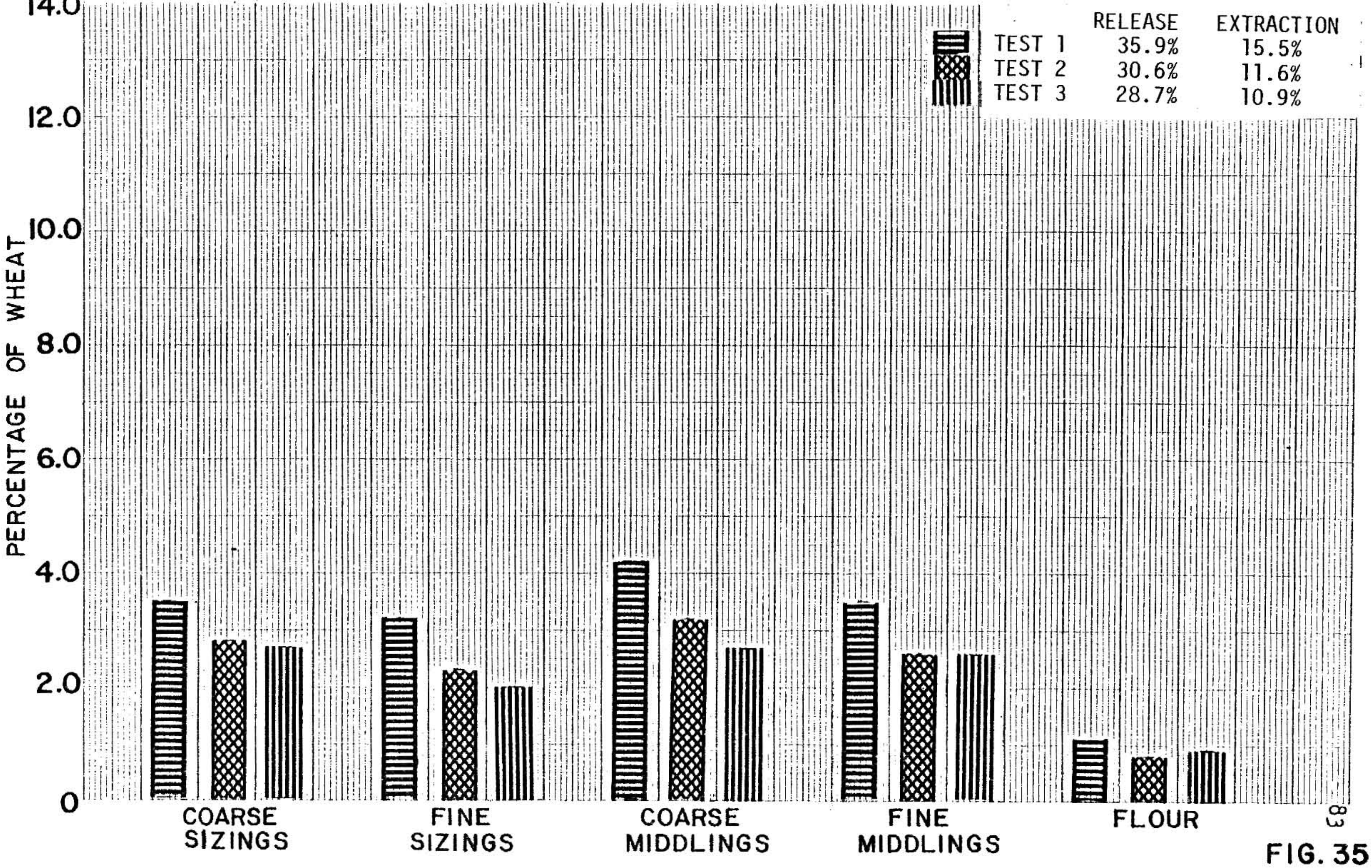


FIG. 35

Ash Content

Figures #21, #22 and #23 given previously show the manner in which ash, as a percentage of each product, changes thruout the flow.

The increase in ash of the scalps as endosperm is removed is typified in the 1.83% ash of scalp to 2nd break and the 3.57% ash of scalp to feed (or, in commercial mills, to 4th break) for Test #1. This material comes from the original whole wheat ash of 1.45%.

The same general trend of decreasing ash with decreasing fineness that was noted previously can be observed here.

The same exception of a higher ash content in the break and sizings flours than in the next coarsest group is also seen.

Tables #15, #16 and #17 show each break stream aligned in order of ascending ash content. The high ash shown by 3rd break coarse sizings in each test is a combination of bran content and subaleurone high ash endosperm.

The appearance of fine middlings from 3rd break as the lowest ash stream does not have a logical explanation. As this break is working on the supposedly higher ash material close to the bran, it would be expected that all 3rd break material might be higher in ash than 1st and 2nd break. The ash jumps quite rapidly in 3rd break going from coarse middlings to fine sizings.

Figure #36 shows the plotted results of cumulative ash for all break release products. Assuming again that the lowest ash result may be the most desirable situation, it can be seen that Test #1 would have first ranking. Tests #2 and #3 show very similar final ash figures.

Table #18 shows the seven flour streams aligned in order of ascending ash content. The middlings flours are the lowest progressing upwards thru the sizings to the breaks.

CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation BREAK RELEASE PRODUCTS

Type of Wheat
HARD RED SPRING

TEST #	STREAM		A	Q	Q×A	S of Q×A	S of Q	S of Q×A / S of Q
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
1	3BK	F.M.	.42	3.5	.0147	.0147	3.5	.420
	3BK	C.M.	.43	4.2	.0181	.0328	7.7	.426
	2BK	C.M.	.44	4.8	.0212	.0540	12.5	.432
	2BK	F.M.	.44	4.1	.0180	.0720	16.6	.434
	2BK	F.S.	.46	8.1	.0373	.1093	24.7	.443
	3BK	Flour	.48	1.1	.0053	.1146	25.8	.444
	2BK	Flour	.52	1.8	.0094	.1240	27.6	.449
	1BK	C.M.	.52	4.8	.0250	.1490	32.4	.460
	1BK	F.M.	.52	3.6	.0186	.1676	36.0	.466
	1BK	Flour	.54	2.3	.0124	.1800	38.3	.470
	1BK	F.S.	.58	4.3	.0249	.2049	42.6	.481
	1BK	C.S.	.66	10.4	.0686	.2735	53.0	.516
	3BK	F.S.	.72	3.2	.0230	.2965	56.2	.528
	2BK	C.S.	.90	12.5	.1125	.4090	68.7	.595
	3BK	C.S.	2.44	3.5	.0854	.4994	72.2	.685

TABLE # 15

CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation BREAK RELEASE PRODUCTS

Type of Wheat
HARD RED SPRING

TEST #	STREAM		A	Q	Q x A	S of Q x A	S of Q	S of Q x A / S of Q
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
2	3BK	F.M.	.44	2.6	.0114	.0114	2.6	.440
	3BK	C.M.	.46	3.2	.0147	.0261	5.8	.450
	2BK	C.M.	.46	4.5	.0207	.0468	10.3	.454
	2BK	F.M.	.46	3.7	.0170	.0638	14.0	.456
	2BK	F.S.	.50	6.7	.0335	.0973	20.7	.470
	3BK	Flour	.50	.8	.0040	.1013	21.5	.471
	2BK	Flour	.52	1.4	.0073	.1086	22.9	.474
	1BK	F.M.	.52	6.4	.0333	.1419	29.3	.484
	1BK	Flour	.53	3.4	.0180	.1599	32.7	.489
	1BK	F.S.	.59	6.6	.0389	.1988	39.3	.506
	1BK	C.M.	.59	5.3	.0313	.2301	44.6	.516
	1BK	C.S.	.69	14.4	.0994	.3295	59.0	.558
	3BK	F.S.	.83	2.3	.0191	.3486	61.3	.569
	2BK	C.S.	1.12	9.2	.1030	.4516	70.5	.641
	3BK	C.S.	2.52	2.8	.0706	.5222	73.3	.712

TABLE # 16

CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation BREAK RELEASE PRODUCTS

Type of Wheat
HARD RED SPRING

TEST #	STREAM		A	Q	Q×A	S of Q×A	S of Q	$\frac{\text{S of Q×A}}{\text{S of Q}}$
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
3	3BK	F.M.	.45	2.6	.0117	.0117	2.6	.450
	3BK	C.M.	.47	2.7	.0127	.0244	5.3	.460
	3BK	Flour	.47	.9	.0042	.0286	6.2	.461
	1BK	F.M.	.47	8.4	.0395	.0681	14.6	.466
	1BK	Flour	.48	4.1	.0197	.0878	18.7	.470
	2BK	F.M.	.48	2.3	.0110	.0988	21.0	.470
	2BK	C.M.	.48	2.8	.0134	.1125	23.8	.473
	2BK	F.S.	.49	3.9	.0191	.1316	27.7	.475
	1BK	C.M.	.51	7.4	.0377	.1693	35.1	.482
	1BK	F.S.	.53	9.6	.0509	.2202	44.7	.493
	2BK	Flour	.55	.9	.0050	.2252	45.6	.494
	1BK	C.S.	.76	17.2	.1307	.3559	62.8	.567
	3BK	F.S.	.96	2.0	.0192	.3751	64.8	.579
	2BK	C.S.	1.21	5.4	.0653	.4404	70.2	.627
	3BK	C.S.	2.74	2.7	.0740	.5144	72.9	.706

TABLE # 17

CUMULATIVE ASH
BREAK RELEASE PRODUCTS
HARD RED SPRING

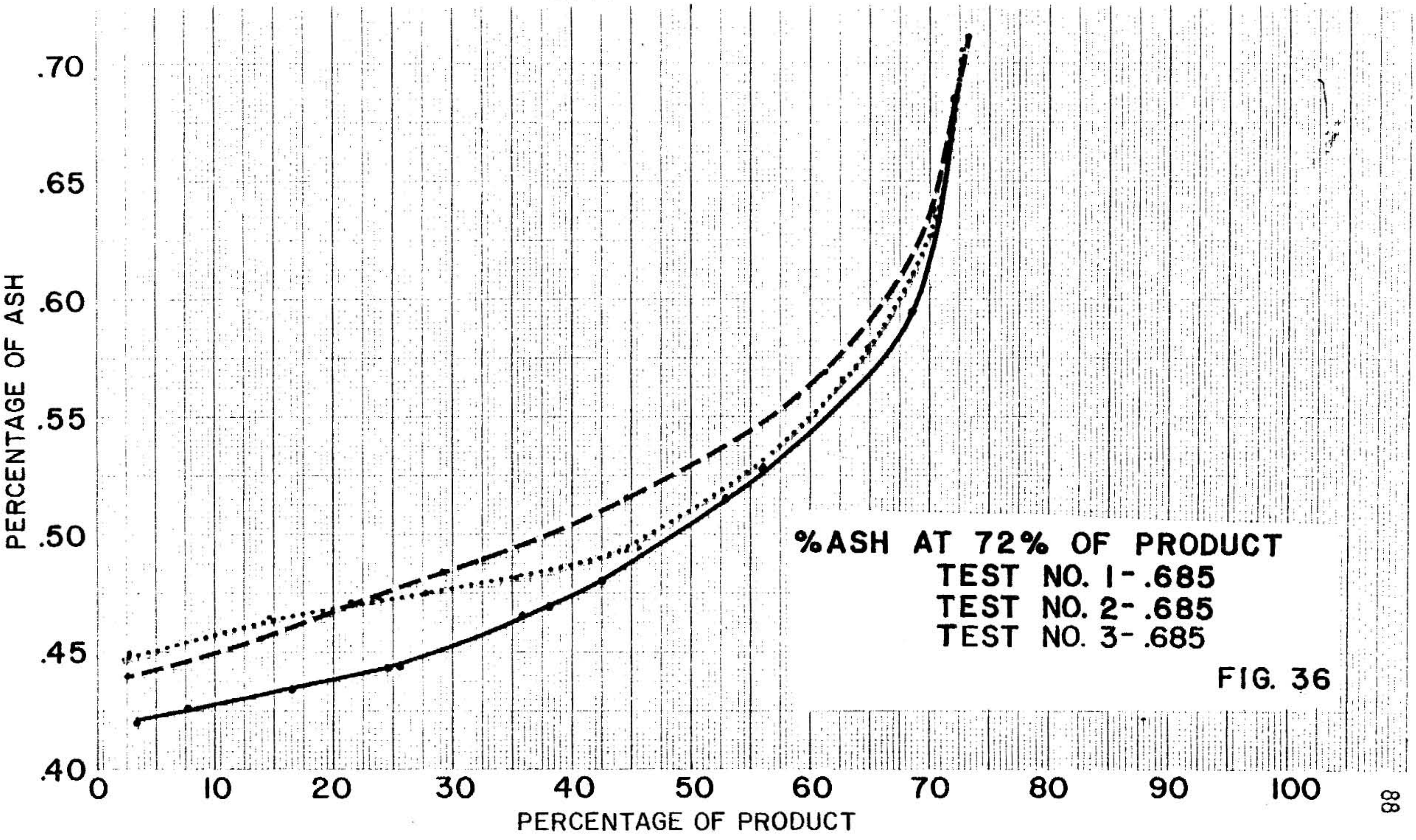


FIG. 36

CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation FLOURS ONLY

Type of Wheat
HARD RED SPRING

TEST #	STREAM		A	Q	Q×A	S of Q×A	S of Q	S of Q×A / S of Q
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
1	F.M.	Flour	.31	24.9	.0772	.0772	24.9	.310
	C.M.	"	.31	7.5	.0233	.1005	32.4	.310
	F.S.	"	.37	1.6	.0059	.1064	34.0	.313
	C.S.	"	.39	1.8	.0070	.1134	35.8	.317
	3BK	"	.48	1.1	.0053	.1187	36.9	.322
	2BK	"	.52	1.8	.0094	.1281	38.7	.331
	1BK	"	.54	2.3	.0124	.1405	41.0	.342
2	F.M.	Flour	.31	20.9	.0648	.0648	20.9	.310
	C.M.	"	.32	7.3	.0234	.0882	28.2	.313
	F.M.	"	.36	1.5	.0054	.0932	29.7	.314
	C.S.	"	.40	1.5	.0060	.0992	31.2	.318
	3BK	"	.50	.8	.0040	.1032	32.0	.323
	2BK	"	.52	1.4	.0073	.1105	33.4	.335
	1BK	"	.53	3.4	.0180	.1285	36.8	.349
3	F.M.	Flour	.31	21.8	.0676	.0676	21.8	.310
	C.M.	"	.31	7.3	.0226	.0902	29.1	.310
	F.S.	"	.34	1.5	.0051	.0953	30.6	.311
	C.S.	"	.37	1.6	.0059	.1012	32.2	.314
	3BK	"	.47	.9	.0042	.1054	33.1	.318
	1BK	"	.48	4.1	.0197	.1251	37.2	.336
	2BK	"	.55	.9	.0050	.1301	38.2	.341

TABLE # 18

Figure #37 shows the cumulative ash curves obtained on the flours. A more defined separation in ash content occurs here than with the break release products. Test #1 is the lowest ash setting as it was in the break release comparison. Test #3 shows a well separated improvement over Test #2.

The overall preference for the tests performed as regards the production of low ash flours is:

Test #1 - Best
Test #3 - Next Best
Test #2 - Worst

This is not the same order as found with Winter wheat.

In this wheat class there did appear a possible key to predicting quickly the best break extraction for producing low ash products. This is the actual ash obtained when all coarse sizings products are added. The numbers shows in the QXA column of Tables #15, #16 and #17 are used.

Total QXA for coarse sizings:

Test #1 - .2665
Test #3 - .2700
Test #2 - .2730

This is in the same order as the cumulative ash tests indicated earlier.

Protein Content

Figures #21, #22 and #23 are again referred to for observation of the manner in which protein is split.

The break scalps exhibit the high proteins expected. It is interesting to note the high protein of 3rd break coarse sizings. This would indicate a protein concentration in this material that might be explored for those

CUMULATIVE ASH
FLOURS
HARD RED SPRING

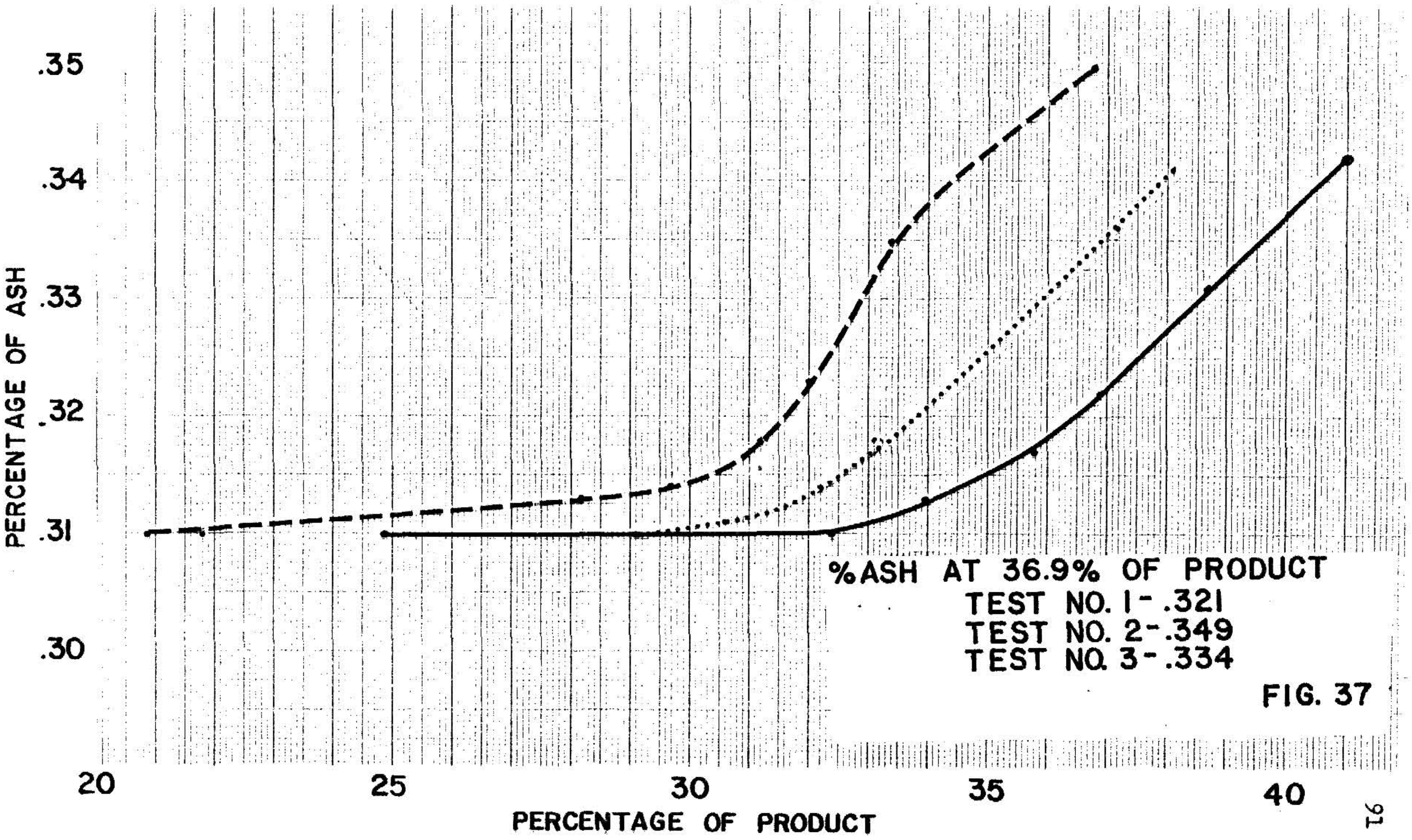


FIG. 37

desiring a wide spread in protein contents. The break and sizings flours exhibit an even more pronounced shifting of protein in the flours than was observed in the winter wheat. This would seem logical in the light of a higher protein wheat in Spring and a likelihood that interstitial protein would, in turn, be higher in quantity than in Winter.

Tables #19, #20 and #21 show each break release product aligned in order of ascending protein.

The very distinctive groupings of 1st break products with lower proteins, 2nd break products with mid-range proteins and 3rd break products with higher protein contents are noticeable. The wide range of protein contents is also noticeable and should be of interest to those desiring wider protein spreads in the finished flours.

Figure #38 shows graphically the cumulative protein results. Test #3 indicates a higher range thruout the curve length than tests #1 and #2.

Table #22 shows the seven flours produced on each test in ascending order of protein content.

Figure #39 shows the cumulative flour protein curves for each test.

Tests #1 and #3 gave higher protein results than Test #2.

These protein results indicate that it is possible to manipulate milled product protein contents by varying the break extractions.

Soft White Spring

Figures #40, #41 and #42 show the flow and test results for three separate millings of Soft White Spring.

The Break Release and Extraction Schedule from Tables #2 and #3 are shown below.

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation BREAK RELEASE PRODUCTS

Type of Wheat
HARD RED SPRING

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of Q x P / S of Q
	FROM	TO	% Protein (14% M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
1	1BK	C.S.	11.5	10.4	1.1960	1.1960	10.4	11.50
	1BK	F.S.	11.5	4.3	.4945	1.6905	14.7	11.50
	1BK	C.M.	12.0	3.6	.4320	2.1225	18.3	11.60
	2BK	F.S.	12.0	8.1	.9720	3.0945	26.4	11.72
	2BK	C.S.	12.2	12.5	1.5250	4.6195	38.9	11.88
	2BK	C.M.	12.7	4.8	.6096	5.2291	43.7	11.97
	1BK	F.M.	12.9	4.8	.6192	5.8483	48.5	12.06
	3BK	F.S.	12.9	3.2	.4128	6.2611	51.7	12.11
	2BK	F.M.	13.4	4.1	.5994	6.8105	55.8	12.21
	3BK	C.M.	13.6	4.2	.5712	7.3817	60.0	12.30
	3BK	F.M.	14.6	3.5	.5110	7.8927	63.5	12.43
	3BK	C.S.	15.4	3.5	.5390	8.4317	67.0	12.58
	1BK	Flour	15.7	2.3	.3611	8.7928	69.3	12.69
	2BK	Flour	16.6	1.8	.2988	9.0916	71.1	12.79
	3BK	Flour	16.9	1.1	.1859	9.2775	72.2	12.85

TABLE # 19

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation

Type of Wheat
Hard Red Spring

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of Q x P / S of Q
	FROM	TO	% Protein (14%M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
2	1 BK	C.S.	14.4	14.4	11.5	1.6560	1.6500	11.50
	1 BK	F.S.	6.6	21.0	11.5	.7590	2.4150	11.50
	1 BK	C.M.	5.3	26.3	11.9	.6307	3.0457	11.58
	2 BK	F.S.	6.7	33.0	12.0	.8040	3.8497	11.67
	2 BK	C.M.	4.5	37.5	12.8	.5760	4.4257	11.80
	1 BK	F.M.	6.4	43.9	12.9	.8256	5.2513	11.96
	3 BK	F.S.	2.3	46.2	12.9	.2967	5.5480	12.01
	2 BK	C.S.	9.2	55.4	13.2	1.2144	6.7624	12.21
	2 BK	F.M.	3.7	59.1	13.5	.4995	7.2619	12.29
	3 BK	C.M.	3.2	62.3	13.7	.4384	7.7003	12.36
	3 BK	F.M.	2.6	64.9	14.8	.3848	8.0851	12.46
	1 BK	Flour	3.4	68.3	15.0	.5100	8.5951	12.58
	3 BK	C.S.	2.8	71.1	15.8	.4424	9.0375	12.71
	2 BK	Flour	1.4	72.5	16.6	.2324	9.2699	12.79
	3 BK	Flour	.8	73.5	17.3	.1384	9.4083	12.84

TABLE # 20

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation **BREAK RELEASE PRODUCTS**

Type of Wheat
HARD RED SPRING

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of Q x P / S of Q
	FROM	TO	% Protein (14% M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
3	1BK	C.S.	11.6	17.2	1.9952	1.9952	17.2	11.60
	1BK	F.S.	11.7	9.6	1.1232	3.1184	26.8	11.64
	1BK	C.M.	12.1	7.4	.8954	4.0138	34.2	11.74
	2BK	F.S.	12.3	3.9	.4797	4.4935	38.1	11.79
	1BK	F.M.	12.6	8.4	1.0584	5.5519	46.5	11.94
	2BK	C.M.	13.2	2.8	.3696	5.9215	49.3	12.01
	3BK	F.S.	13.2	2.0	.2640	6.1855	51.3	12.06
	3BK	C.M.	13.9	2.7	.3753	6.5608	54.0	12.15
	2BK	C.S.	14.1	5.4	.7614	7.3222	59.4	12.33
	2BK	F.M.	14.1	2.3	.3243	7.6465	61.7	12.39
	3BK	F.M.	15.0	2.6	.3900	8.0365	64.3	12.50
	1BK	Flour	15.9	4.1	.6519	8.6884	68.4	12.70
	2BK	Flour	17.0	.9	.1530	8.8414	69.3	12.76
	3BK	C.S.	17.2	2.7	.4644	9.3058	72.0	12.92
	3BK	Flour	17.6	.9	.1584	9.4642	72.9	12.98

TABLE# 21

CUMULATIVE PROTEIN
BREAK RELEASE PRODUCTS
HARD RED SPRING

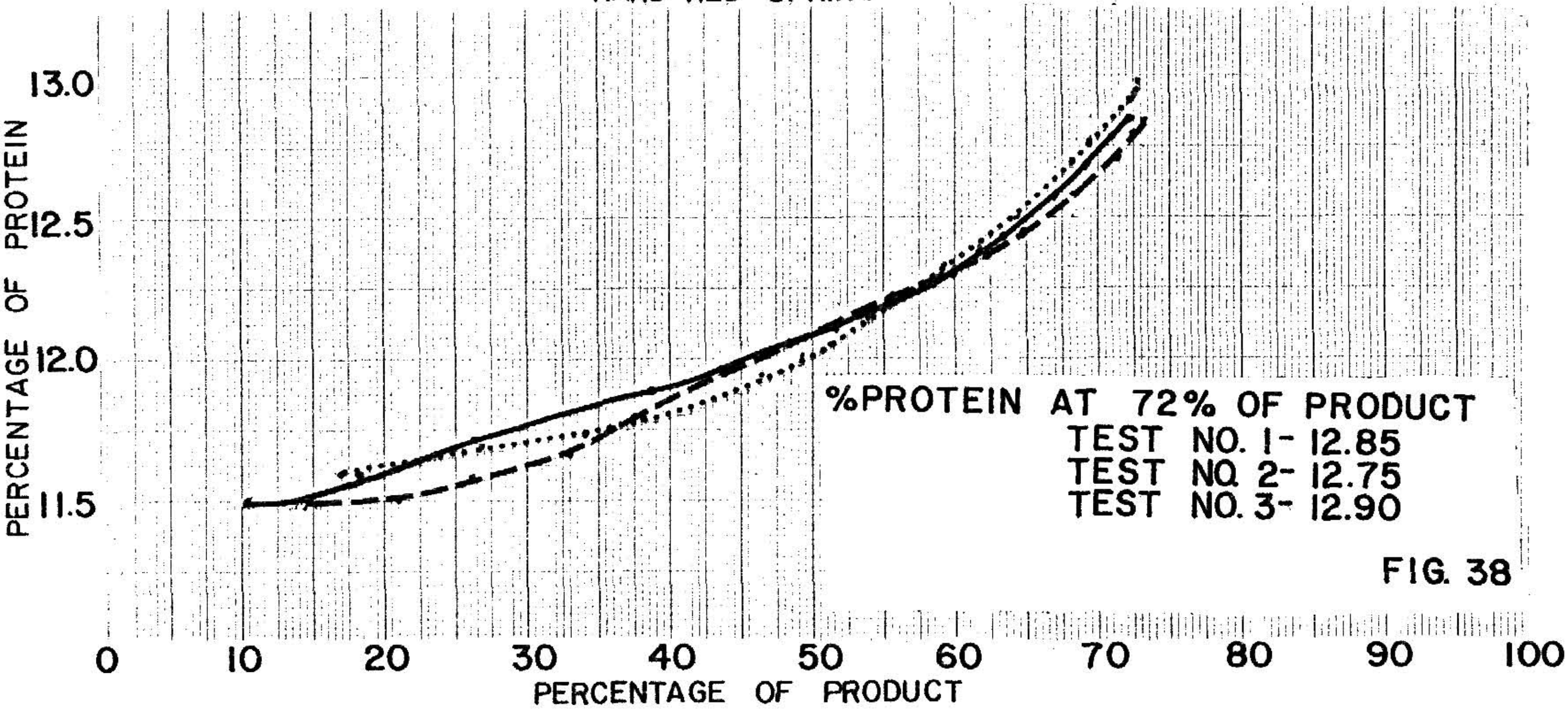


FIG. 38

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation FLOUR ONLY

Type of Wheat
HARD RED SPRING

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of QxP / S of Q
	FROM	TO	% Protein (14% M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
1	C.M.	Flour	11.9	7.5	.8925	.8925	7.5	11.90
	F.M.	"	12.1	24.9	3.0129	3.9054	32.4	12.05
	C.S.	"	12.1	1.8	.2178	4.1232	34.2	12.06
	F.S.	"	12.5	1.6	.2000	4.3232	35.8	12.08
	1BK	"	15.7	2.3	.3611	4.6843	38.1	12.29
	2BK	"	16.6	1.8	.2988	4.9831	39.9	12.49
	3BK	"	16.9	1.1	.1859	5.1690	41.0	12.61
2	F.M.	Flour	12.2	20.9	2.5498	2.5498	20.9	12.20
	C.M.	"	12.2	7.3	.8906	3.4404	28.2	12.20
	F.S.	"	12.6	1.5	.1890	3.6294	29.7	12.22
	C.S.	"	13.3	1.5	.1995	3.8289	31.2	12.27
	1BK	"	15.0	3.4	.5100	4.3389	34.6	12.54
	2BK	"	16.6	1.4	.2324	4.5713	36.0	12.70
	3BK	"	17.3	.8	.1384	4.7097	36.8	12.80
3	F.M.	Flour	12.2	21.8	2.6596	2.6596	21.8	12.20
	C.M.	"	12.2	7.3	.8906	3.5502	29.1	12.20
	F.S.	"	12.9	1.5	.1935	3.7437	30.6	12.23
	C.S.	"	13.0	1.6	.2080	3.9487	32.2	12.26
	1BK	"	15.9	4.1	.6519	4.6006	36.3	12.67
	2BK	"	17.0	.9	.1530	4.7536	36.9	12.88
	3BK	"	17.6	.9	.1584	4.9120	37.8	12.99

TABLE # 22

CUMULATIVE PROTEIN
FLOURS
HARD RED SPRING

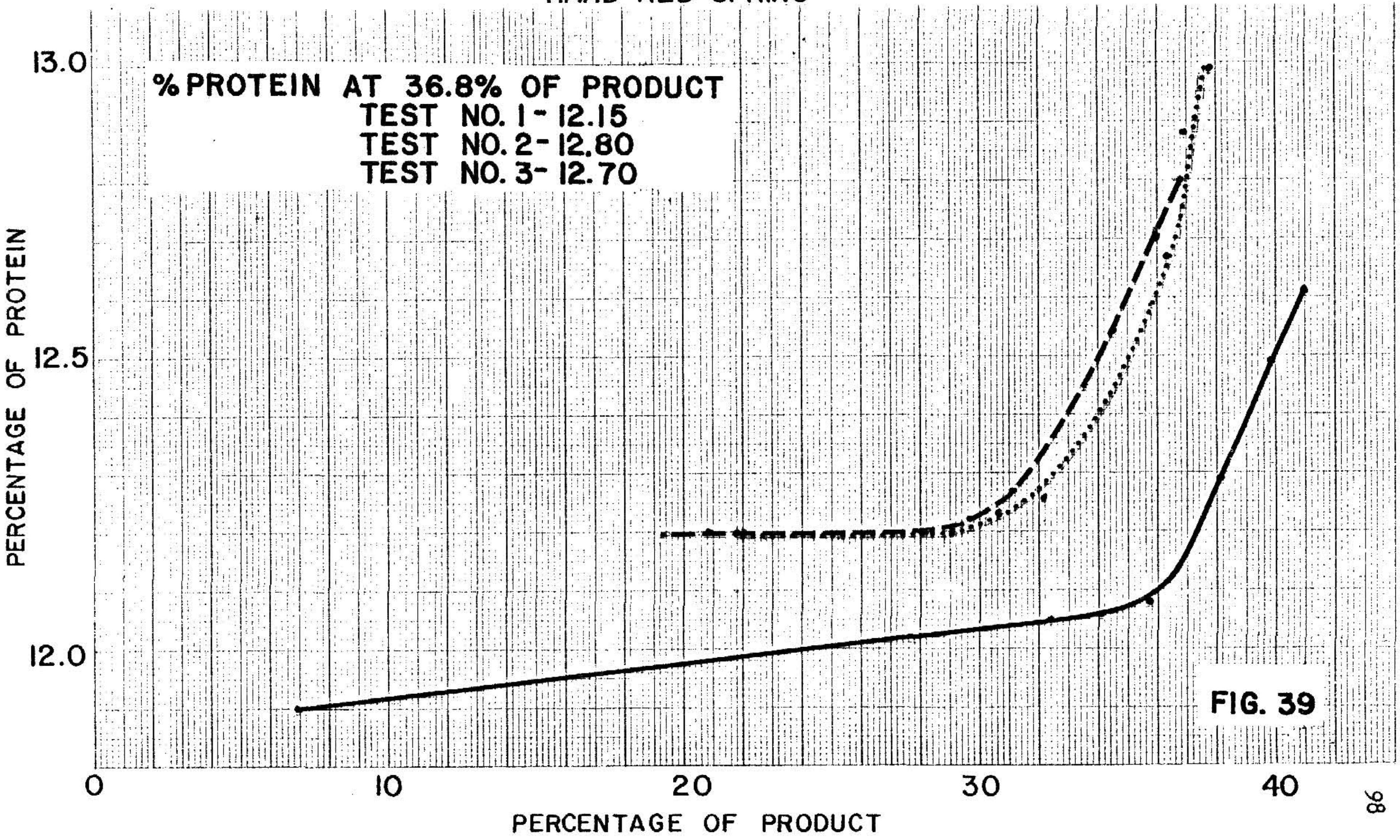


FIG. 39

FLOW SHEET
BREAKS

Type of Wheat Soft White Spring
Test Number 1

	% Release	% Extraction
1st Break	28.4	28.4
2nd Break	40.0	28.6
3rd Break	37.4	16.1

Pre-Break
Smooth
9"x6" 11/2:1

1st Break
9"x6" 2 1/2:1
12/12 Getchell D:D

		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	2nd Break	---	---	12.3	1.91
28 LW	Coarse Sizings	8.5	8.5	8.2	.60
40 LW	Fine Sizings	5.0	5.0	7.6	.42
60 SS	Coarse Middlings	5.1	5.1	7.6	.36
10 XX	Fine Middlings	6.3	6.3	8.0	.33
	Flour	3.5	3.5	6.8	.33
TOTAL		28.4	28.4		

2nd Break
9"x6" 2 1/2:1
12/14 Getchell D:D

		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	3rd Break	---	---	13.6	2.82
28 LW	Coarse Sizings	8.5	6.1	10.9	1.21
40 LW	Fine Sizings	9.1	6.5	8.9	.38
60 SS	Coarse Middlings	9.3	6.7	9.2	.32
10 XX	Fine Middlings	9.1	6.4	8.9	.31
	Flour	4.0	2.9	7.4	.32
TOTAL		40.0	28.6		

3rd Break
9"x6" 2 1/2:1
16/16 Getchell D:D

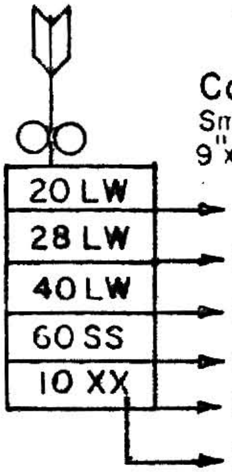
		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
20 LW	Feed	---	---	15.2	3.12
28 LW	Coarse Sizings	6.9	3.0	15.8	2.42
40 LW	Fine Sizings	3.6	1.5	12.4	1.49
60 SS	Coarse Middlings	7.0	3.0	11.2	.58
10 XX	Fine Middlings	13.5	5.8	11.8	.36
	Flour	6.4	2.8	10.0	.37
TOTAL		37.4	16.1		

Fig 40

FLOW SHEET
SIZINGS AND REDUCTIONS

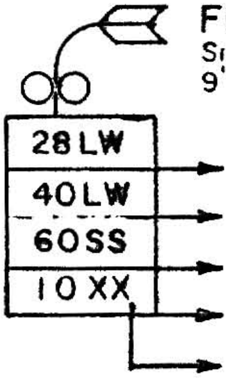
Type of /Wheat SOFT WHITE SPRING
Test Number 1

Coarse Sizings
Smooth
9"x6" 1 1/2:1



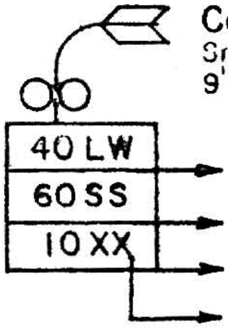
	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	11.8	2.1	14.4	3.01
Bottom Scalp	28.0	4.9	9.7	2.42
Fine Sizings	13.5	2.4	7.8	.93
Coarse Middlings	22.9	4.0	7.8	.34
Fine Middlings	19.1	3.4	8.2	.34
Flour	4.7	.8	7.4	.30
Total	100.0	17.6	9.2	1.37

Fine Sizings
Smooth
9"x6" 1 1/2:1



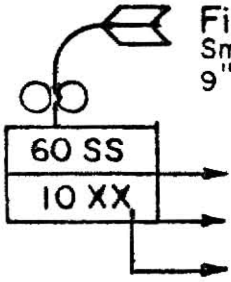
	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	6.2	.9	----	----
Bottom Scalp	14.9	2.3	11.9	1.80
Coarse Middlings	19.7	3.0	8.8	.57
Fine Middlings	48.4	7.6	8.5	.26
Flour	10.7	1.6	6.8	.28
Total	100.0	15.4	9.1	.64

Coarse Middlings
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	2.9	.6	----	----
Bottom Scalp	9.9	2.2	10.3	1.10
Fine Middlings	50.8	11.1	9.6	.29
Flour	36.4	7.9	7.4	.25
Total	100.0	21.8	8.9	.38

Fine Middlings
Smooth
9"x6" 1 1/2:1



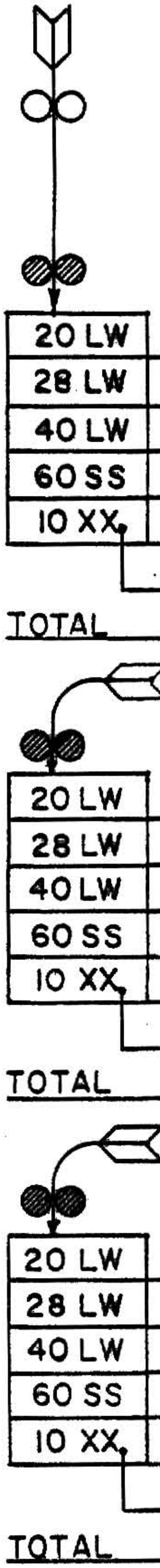
	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	1.1	.4	----	----
Bottom Scalp	62.0	25.2	10.0	.33
Flour	36.9	15.0	8.5	.26
Total	100.0	40.6	9.5	.30

Fig. #40

FLOW SHEET
BREAKS

Type of Wheat Soft White Spring
Test Number 2

	% Release	% Extraction
1st Break	36.1	36.1
2nd Break	38.4	24.3
3rd Break	29.2	11.6



Pre-Break
Smooth
9"x6" 1 1/2:1

1st Break
9"x6" 2 1/2:1
12/12 Getchell D:D

	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
2nd Break	---	---	12.6	2.10
Coarse Sizings	10.4	10.4	8.7	.54
Fine Sizings	6.5	6.5	7.7	.40
Coarse Middlings	6.6	6.6	7.6	.34
Fine Middlings	7.9	7.9	8.1	.33
Flour	4.7	4.7	6.6	.33
TOTAL	36.1	36.1		

2nd Break
9"x6" 2 1/2:1
12/14 Getchell D:D

	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
3rd Break	---	---	14.2	2.92
Coarse Sizings	7.2	4.6	12.5	1.61
Fine Sizings	8.0	5.1	9.4	.42
Coarse Middlings	9.4	5.9	9.5	.34
Fine Middlings	9.4	5.9	9.4	.33
Flour	4.4	2.8	7.3	.33
TOTAL	38.4	24.3		

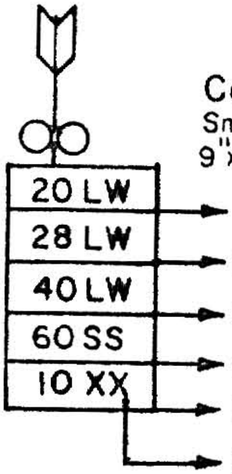
3rd Break
9"x6" 2 1/2:1
16/16 Getchell D:D

	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Feed	---	---	15.1	3.71
Coarse Sizings	5.5	2.2	16.2	3.10
Fine Sizings	2.7	1.1	12.8	1.70
Coarse Middlings	5.4	2.1	11.4	.54
Fine Middlings	10.0	4.0	11.7	.36
Flour	5.6	2.2	8.8	.34
TOTAL	29.2	11.6		

Fig. 41

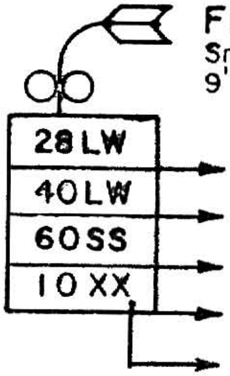
FLOW SHEET
SIZINGS AND REDUCTIONS

Type of/Wheat SOFT WHITE SPRING
Test Number 2



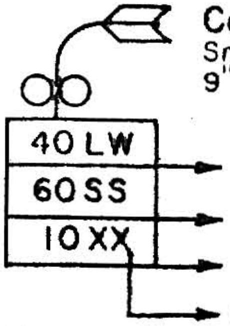
Coarse Sizings
Smooth
9"x6" 1 1/2:1

	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	10.9	1.9	16.3	3.00
Bottom Scalp	22.5	3.9	13.4	2.30
Fine Sizings	12.8	2.2	8.4	.68
Coarse Middlings	25.7	4.5	7.7	.28
Fine Middlings	22.7	3.9	8.1	.26
Flour	5.4	.9	6.6	.28
Total	100.0	17.3	10.0	1.14



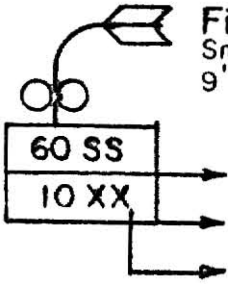
Fine Sizings
Smooth
9"x6" 1 1/2:1

	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	6.0	.9	----	----
Bottom Scalp	13.4	2.0	10.1	1.30
Coarse Middlings	22.1	3.3	8.4	.35
Fine Middlings	48.4	7.2	8.6	.26
Flour	10.1	1.5	6.5	.27
Total	100.0	14.9	8.6	.49



Coarse Middlings
Smooth
9"x6" 1 1/2:1

	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	3.4	.8	----	----
Bottom Scalp	11.1	2.5	9.6	.93
Fine Middlings	56.4	12.7	9.2	.28
Flour	29.1	6.5	7.1	.26
Total	100.0	22.5	8.6	.37



Fine Middlings
Smooth
9"x6" 1 1/2:1

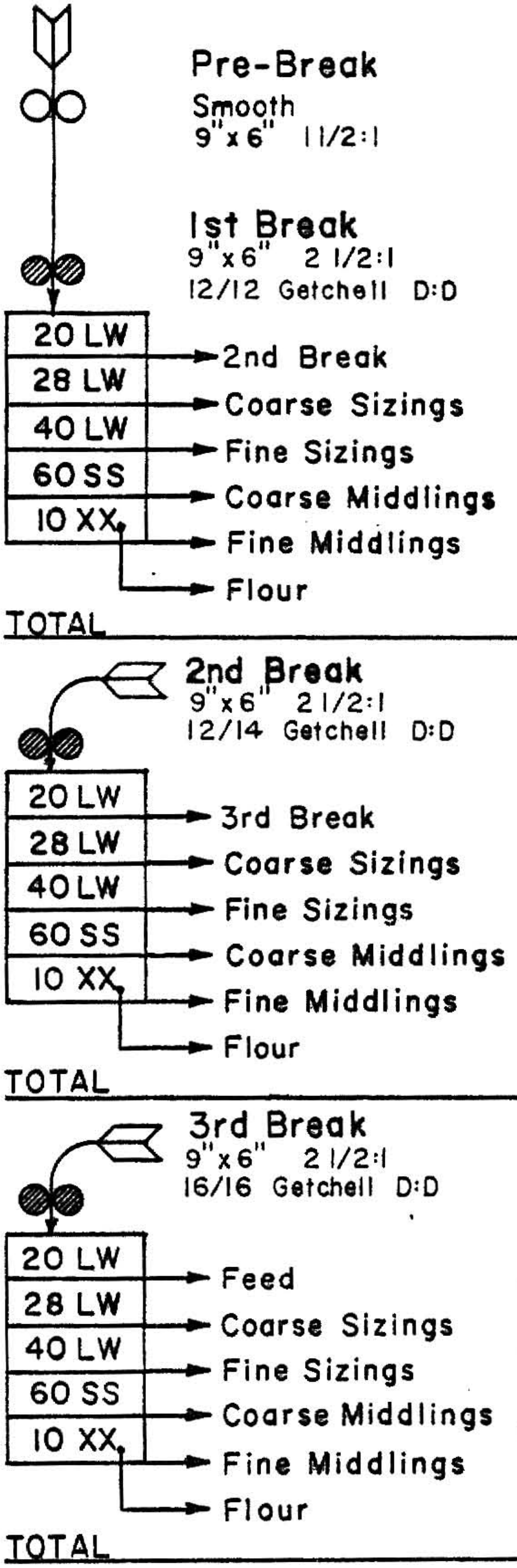
	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	.7	.2	----	----
Bottom Scalp	59.6	24.8	9.0	.31
Flour	39.7	16.6	8.1	.27
Total	100.0	41.6	8.6	.30

Fig. #41

FLOW SHEET
BREAKS

Type of Wheat Soft White Spring
Test Number 3

	% Release	% Extraction
1st Break	47.5	47.5
2nd Break	29.7	15.6
3rd Break	30.0	11.1



Pre-Break
Smooth
9"x6" 1 1/2:1

		% RELEASE	% EXTRACTION	% PROTEIN	% ASH
1st Break 9"x6" 2 1/2:1 12/12 Getchell D:D					
20 LW	2nd Break	---	---	12.8	2.54
28 LW	Coarse Sizings	11.1	11.1	9.0	.77
40 LW	Fine Sizings	9.1	9.1	8.1	.39
60 SS	Coarse Middlings	9.5	9.5	7.8	.36
10 XX	Fine Middlings	11.2	11.2	8.2	.32
	Flour	6.6	6.6	6.6	.33
TOTAL		47.5	47.5		
2nd Break 9"x6" 2 1/2:1 12/14 Getchell D:D					
20 LW	3rd Break	---	---	14.0	3.14
28 LW	Coarse Sizings	5.7	3.0	13.6	2.10
40 LW	Fine Sizings	5.4	2.8	9.9	.53
60 SS	Coarse Middlings	6.8	3.6	10.2	.36
10 XX	Fine Middlings	7.7	4.1	9.9	.34
	Flour	4.1	2.1	7.3	.33
TOTAL		29.7	15.6		
3rd Break 9"x6" 2 1/2:1 16/16 Getchell D:D					
20 LW	Feed	---	---	15.0	3.93
28 LW	Coarse Sizings	6.5	2.4	16.2	3.00
40 LW	Fine Sizings	3.1	1.1	13.6	1.99
60 SS	Coarse Middlings	4.9	1.8	11.8	.63
10 XX	Fine Middlings	10.6	4.0	12.2	.39
	Flour	4.9	1.8	8.8	.35
TOTAL		30.0	11.1		

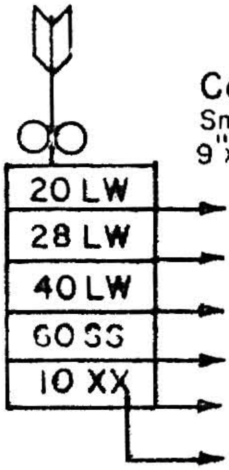
Fig. 42

FLOW SHEET
SIZINGS AND REDUCTIONS

Type of /Wheat SOFT WHITE SPRING
Test Number 3

Coarse Sizings

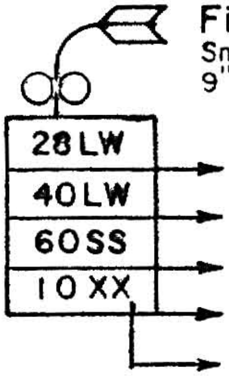
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	11.9	2.0	16.3	3.09
Bottom Scalp	21.9	3.6	13.7	2.40
Fine Sizings	11.1	1.8	8.7	.80
Coarse Middlings	22.7	3.8	8.0	.31
Fine Middlings	25.3	4.2	8.2	.27
Flour	7.1	1.2	6.7	.29
Total	100.0	16.6	10.3	1.17

Fine Sizings

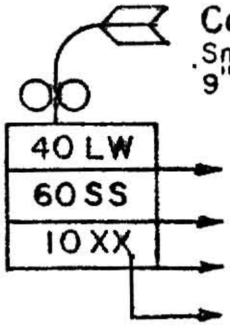
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	6.6	.9	----	----
Bottom Scalp	11.4	1.7	10.3	1.40
Coarse Middlings	18.4	2.7	8.6	.39
Fine Middlings	51.1	7.6	8.6	.26
Flour	12.5	1.9	6.5	.27
Total	100.0	14.8	8.6	.49

Coarse Middlings

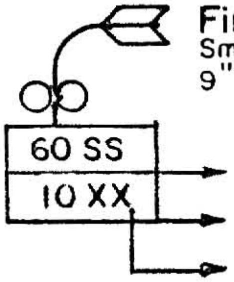
Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	3.7	.8	----	----
Bottom Scalp	8.9	1.9	9.9	1.00
Fine Middlings	50.5	10.8	9.4	.29
Flour	37.0	7.9	7.1	.25
Total	100.0	21.4	8.6	.36

Fine Middlings

Smooth
9"x6" 1 1/2:1



	% RELEASE	% EXTRACTION	% PROTEIN	% ASH
Top Scalp	2.4	1.0	----	----
Bottom Scalp	48.8	20.3	10.0	.35
Flour	48.8	20.4	8.4	.28
Total	100.0	41.7	9.2	.31

Fig. #42

Test #	Break Releases % Release			and		Extractions % Extraction		
	1BK	2BK	3BK	1BK	2BK	1BK+2BK	3BK	1+2+3BK Total
1	28.4	40.0	37.4	28.4	28.6	57.0	16.5	73.5
2	36.1	38.1	29.2	36.1	24.3	60.4	11.6	72.0
3	47.5	29.7	30.0	47.5	15.6	63.1	11.1	74.2

Granulation Series

As in the previous two test series with Hard Red Winter and Hard Red Spring, a range of break releases and combined extractions was chosen for white wheat to represent the range of releases and extractions that would be representative of commercial practice.

First Break Granulations

Figure #43 shows the accumulative granulations for all three 1st break releases. The reverse "S" shape curve is evident here as in the other tests. The higher rate of increase in overs between 700 microns and 1000 microns is due to a greater cutting up of the bran coat at the highest release rate. Interpolation between the maximum release of 47.5% thru the minimum release of 28.4% will result in approximate release percentages for any intermediate release percentage. The subtraction of accumulative percent overs between any two micron openings will result in the percent of material thru the larger micron size and over the finer size. This can be used to predict material distributions for any flow within the release rates shown.

Figure #44 shows the close relationship of the -20LW granulations for the first two tests. Test #3 shows the same phenomena observed in the Hard Red Winter and Hard Red Spring tests where the higher release at the narrowest roll gap shows an increase in the percent of thrus at the larger

GRANULATION CURVES

SOFT WHITE SPRING——FIRST BREAK

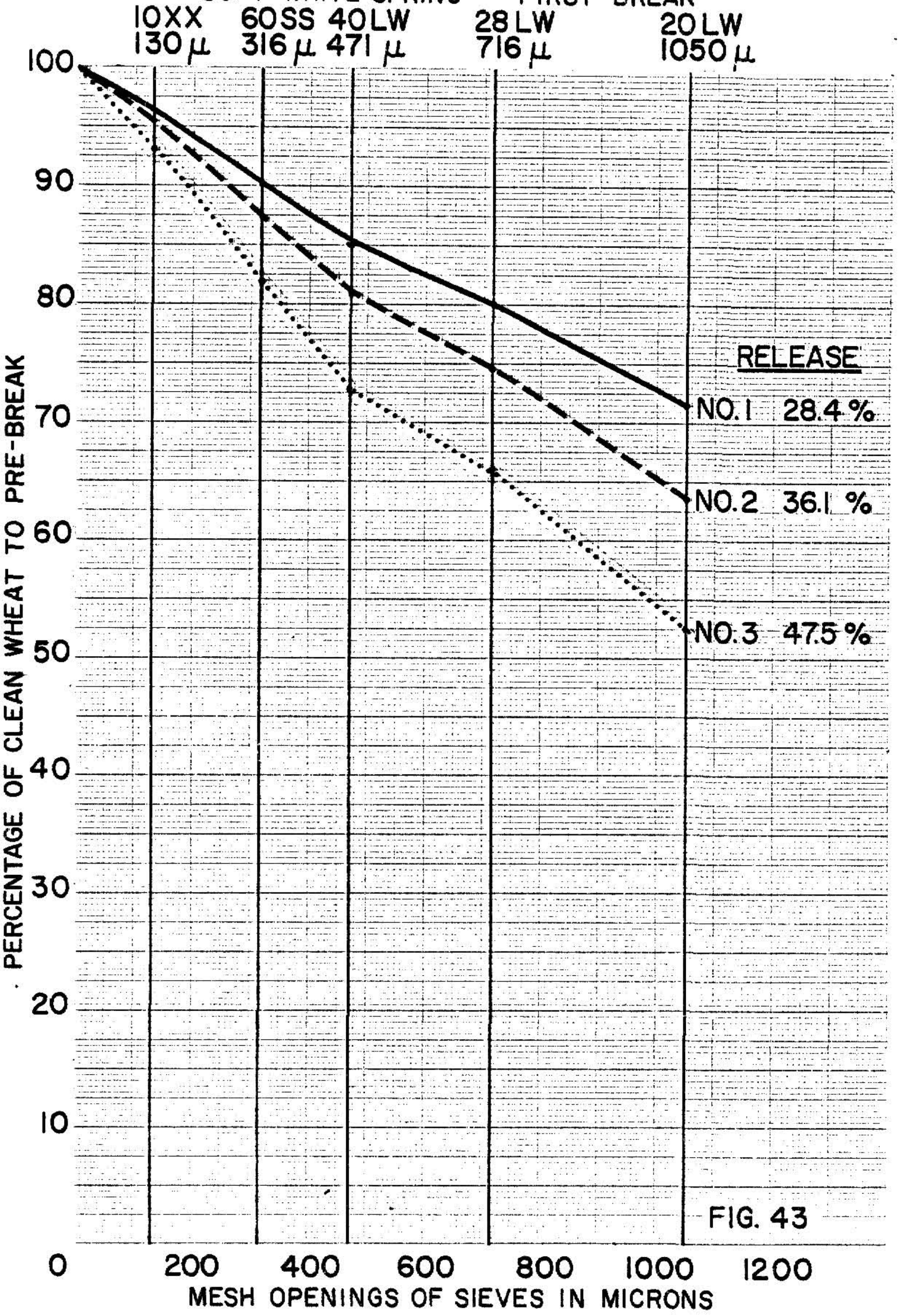


FIG. 43

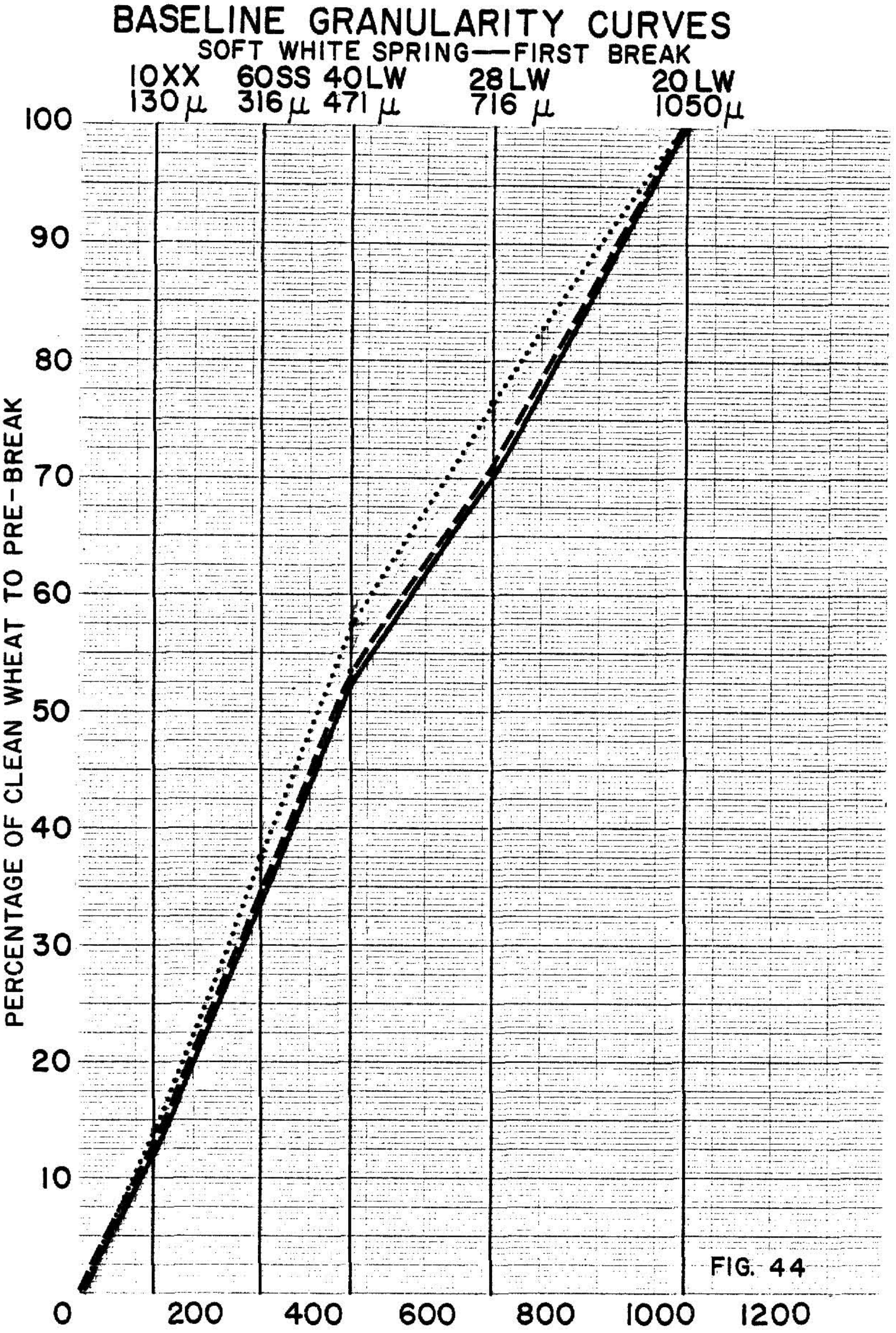

BASELINE GRANULARITY CURVES
SOFT WHITE SPRING—FIRST BREAK
10XX 130μ
60SS 316μ
40LW 471μ
28LW 716μ
20LW 1050μ
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
MESH OPENINGS OF SIEVES IN MICRONS

FIG. 44

micron size openings. This is attributed to a crushing action brought about by the limited roll gap area. No-load roll gaps for the three tests were: Test #1, .025", Test #2, .022" and Test #3, .016".

This crushing action is more pronounced in the Soft White Spring test than for Hard Red Winter and Hard Red Spring. This could be expected from the softer, more fragile endosperm material in the Soft White Wheat kernel.

2nd Break Granulations

Figure #45 shows the accumulative percent overs for the 2nd break tests. The two tests for similar releases of 38.1% and 40.0% would indicate that the amount of endosperm in the stock to each test did not noticeably affect the granularity.

Figure #46 shows an increasing fineness for the -20LW material from Test #1 to Test #2 and Test #3.

The no-load roll gaps used were: Test #1, .012", Test #2, .010" and Test #3, .007". The decreasing roll gap clearance is felt to be the reason for the decreasing fineness from Test #1 thru #2 to Test #3.

3rd Break Granulations

Figure #47 shows the deeper curve which indicates s shift to finer material produced by the finer, more numerous 3rd break corrugations

Figure #48 shows the stronger deviation from linearity found in all 3rd break tests. This is again due to the increase in fine material below 500 microns.

The no-load roll gaps used were: Test #1, .004", Test #2, .007" and Test #3, .007". It is again cautioned that these openings may not be reliable indicators as the rate of feed was not metered. The greater difficulty of feeding the soft wheat stock may have contributed to differences in feed rates. These gaps are less than those used for the Hard Red Winter and Hard Red Spring tests on 3rd break, which indicates the increased difficulty

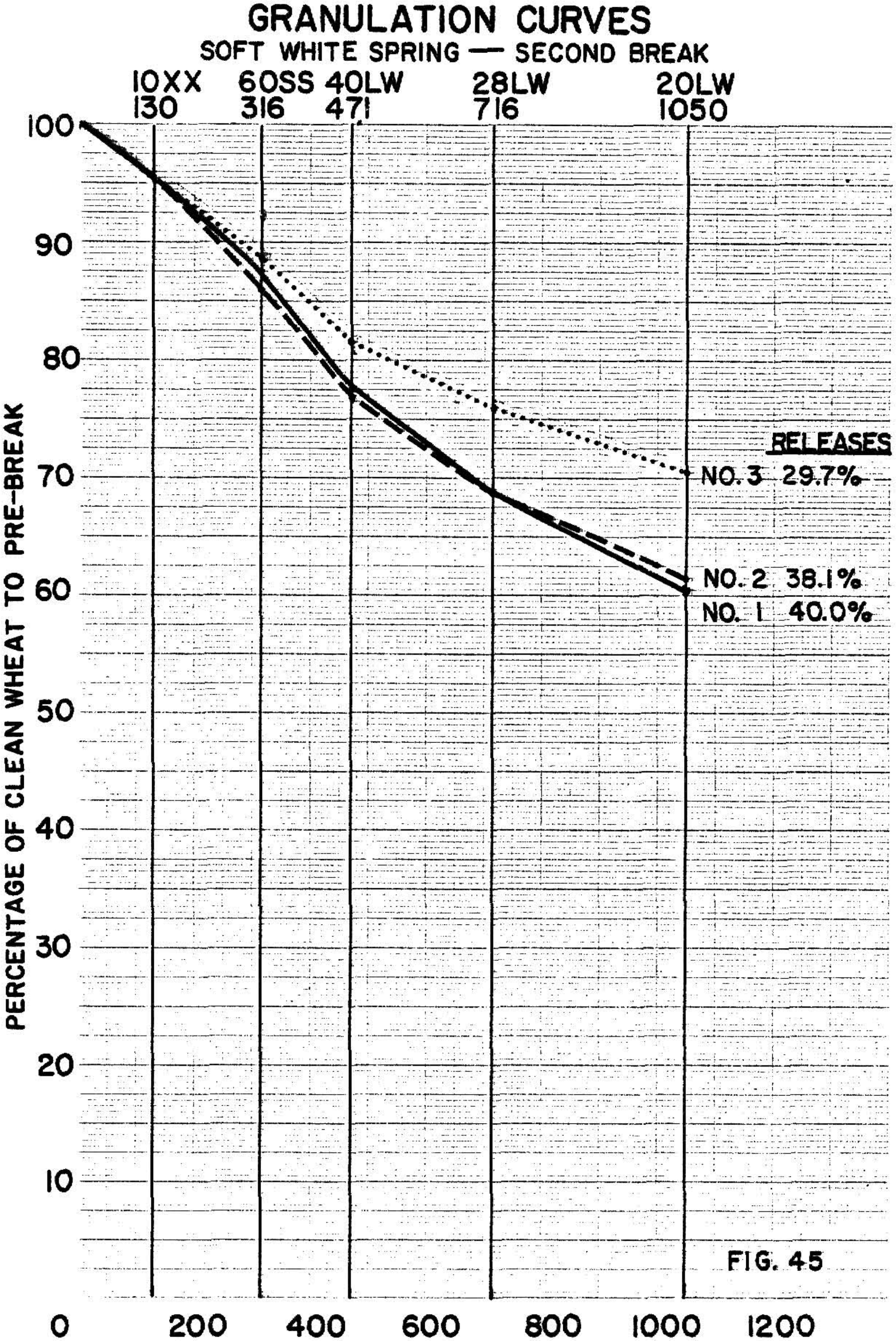

GRANULATION CURVES
SOFT WHITE SPRING — SECOND BREAK
10XX 130
60SS 316
40LW 471
28LW 716
20LW 1050
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
MESH OPENINGS OF SIEVES IN MICRONS
RELEASES
NO. 3 29.7%
NO. 2 38.1%
NO. 1 40.0%

FIG. 45

BASELINE GRANULARITY CURVES
SOFT WHITE SPRING—SECOND BREAK

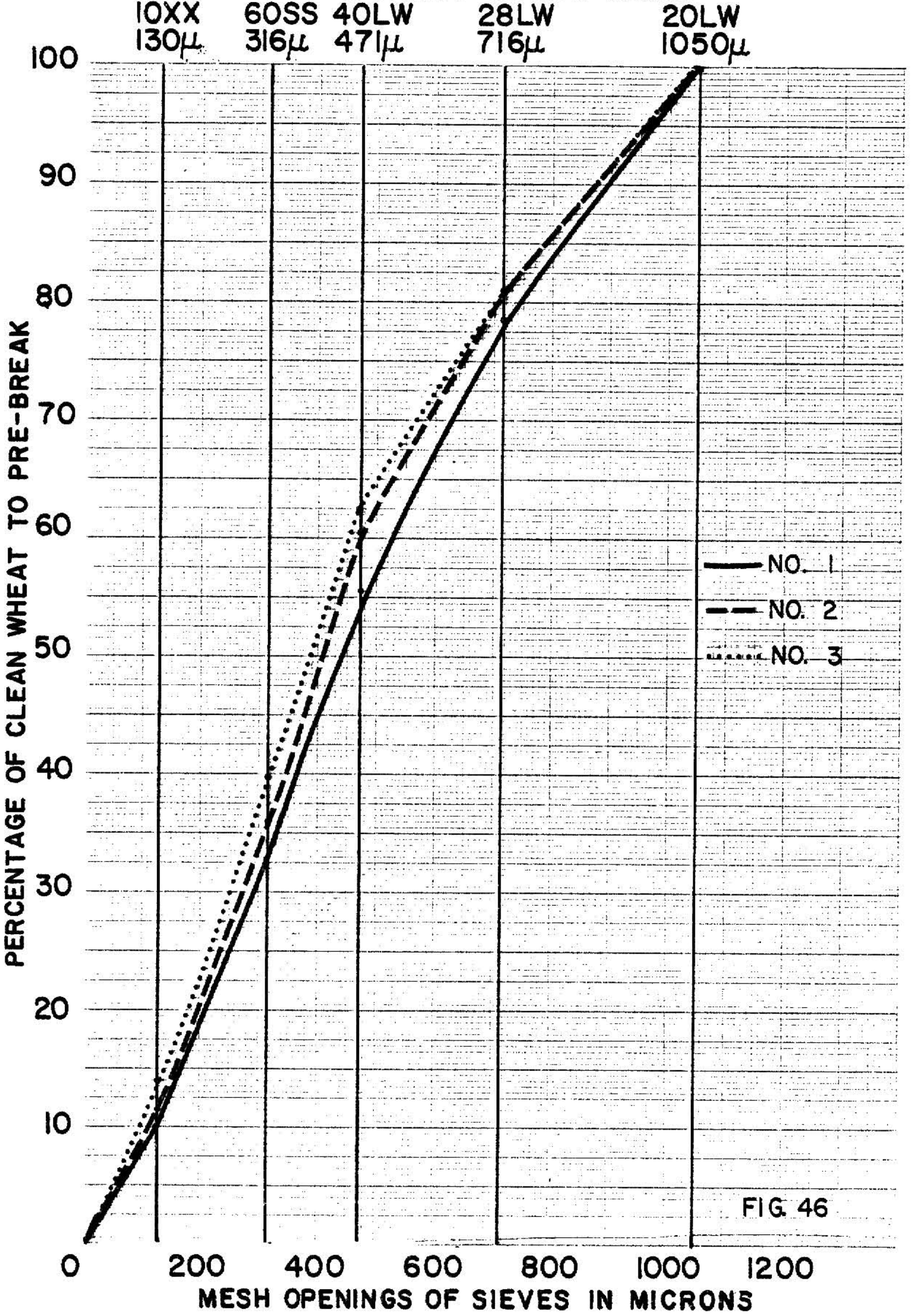


FIG. 46

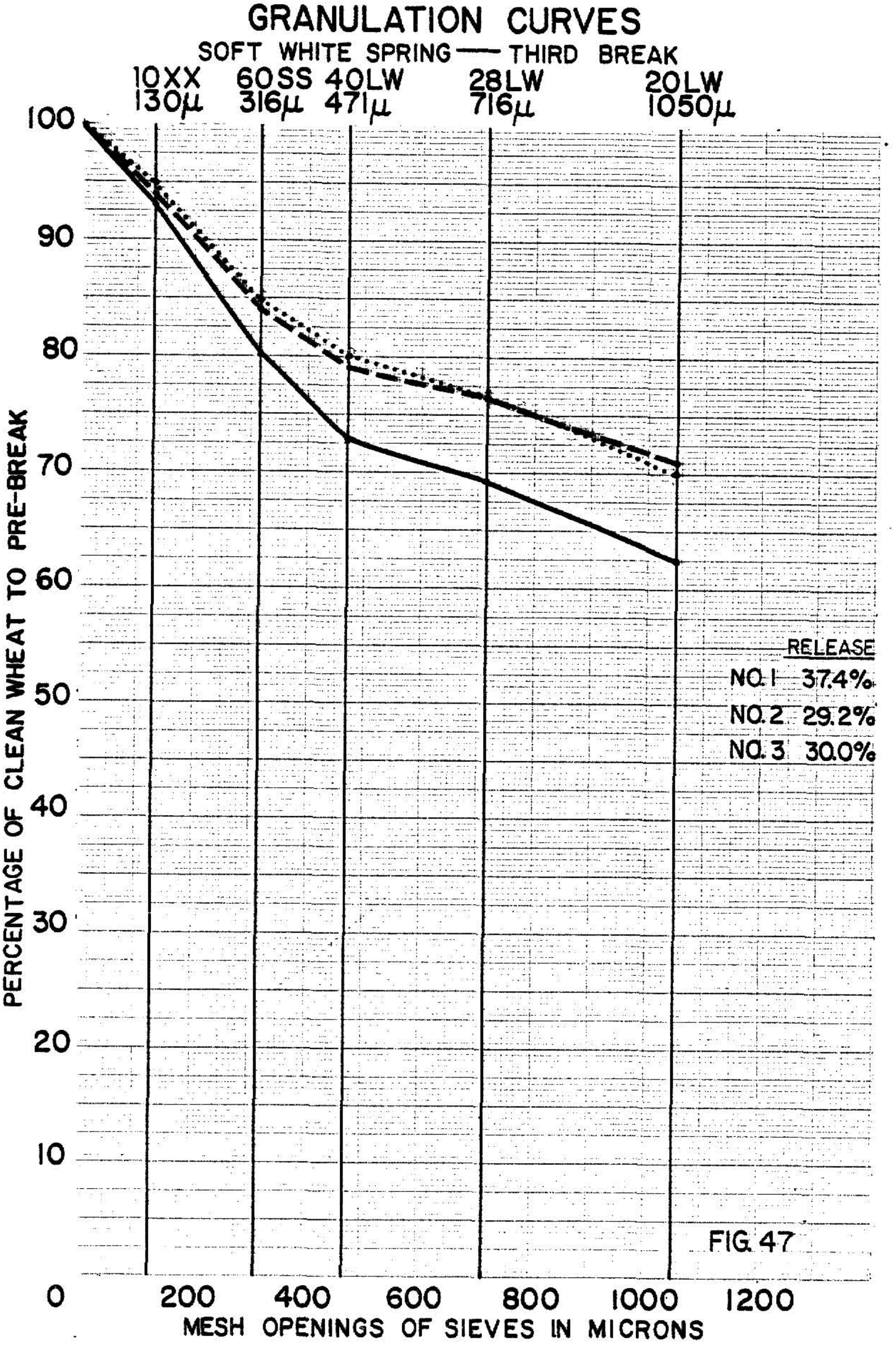

GRANULATION CURVES
SOFT WHITE SPRING — THIRD BREAK
10XX 130μ
60SS 316μ
40LW 471μ
28LW 716μ
20LW 1050μ
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
MESH OPENINGS OF SIEVES IN MICRONS
RELEASE
NO.1 37.4%
NO.2 29.2%
NO.3 30.0%

FIG. 47

BASELINE GRANULARITY CURVES

SOFT WHITE SPRING – THIRD BREAK

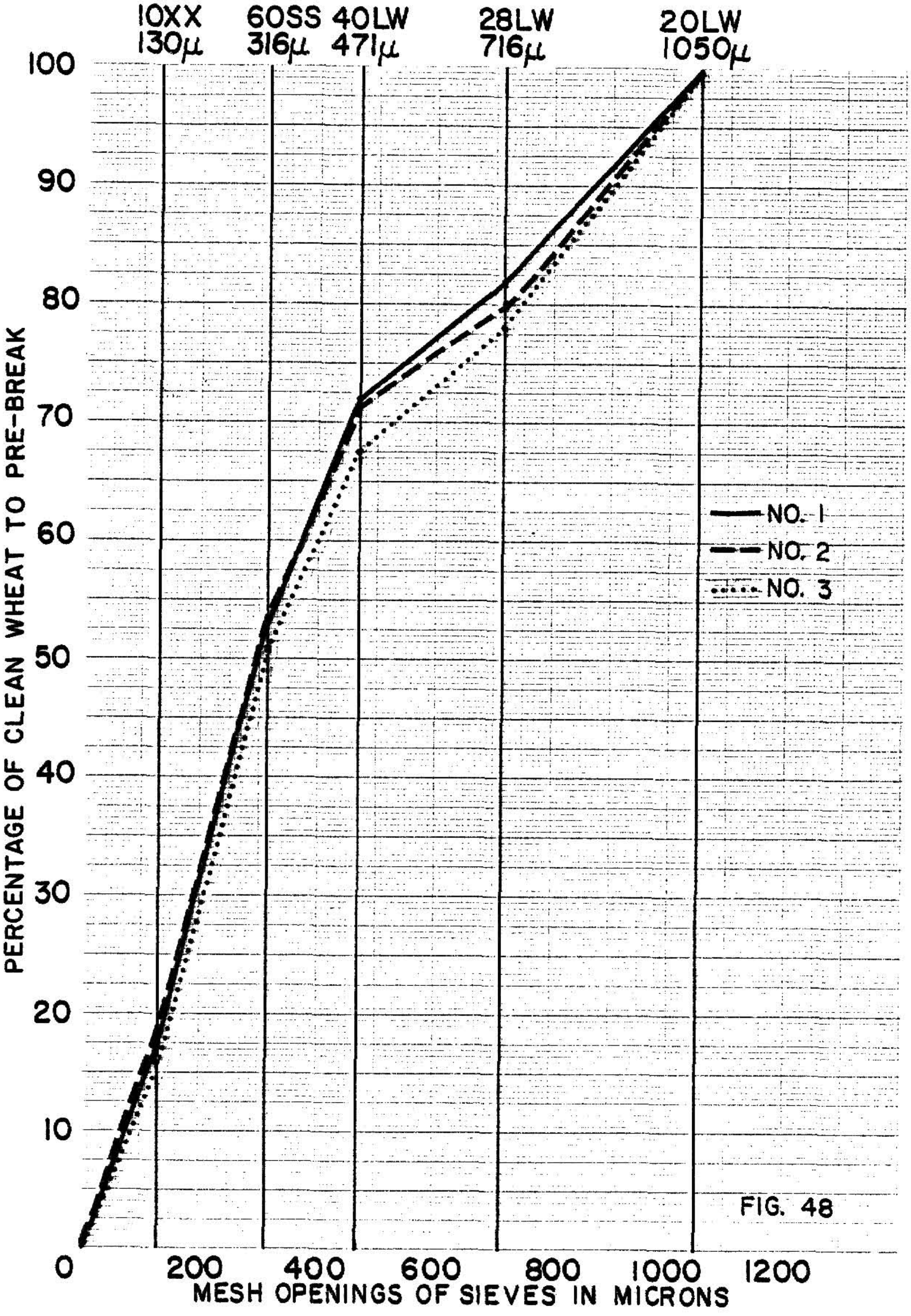


FIG. 48

of removing the outer endosperm material from soft wheat. This is a phenomenon common to soft wheat and confirmed by commercial experience.

Material Balance

Complete material balances for the three white wheat millings are shown in Figure #49, #50 and #51. This type of presentation will be helpful in developing models for computer use. This may help establish the complex changes that occur in the milling process when break extractions are varied.

Figures #52, #53 and #54 emphasize the differences in quantities of material released of each size group with changes in break extractions.

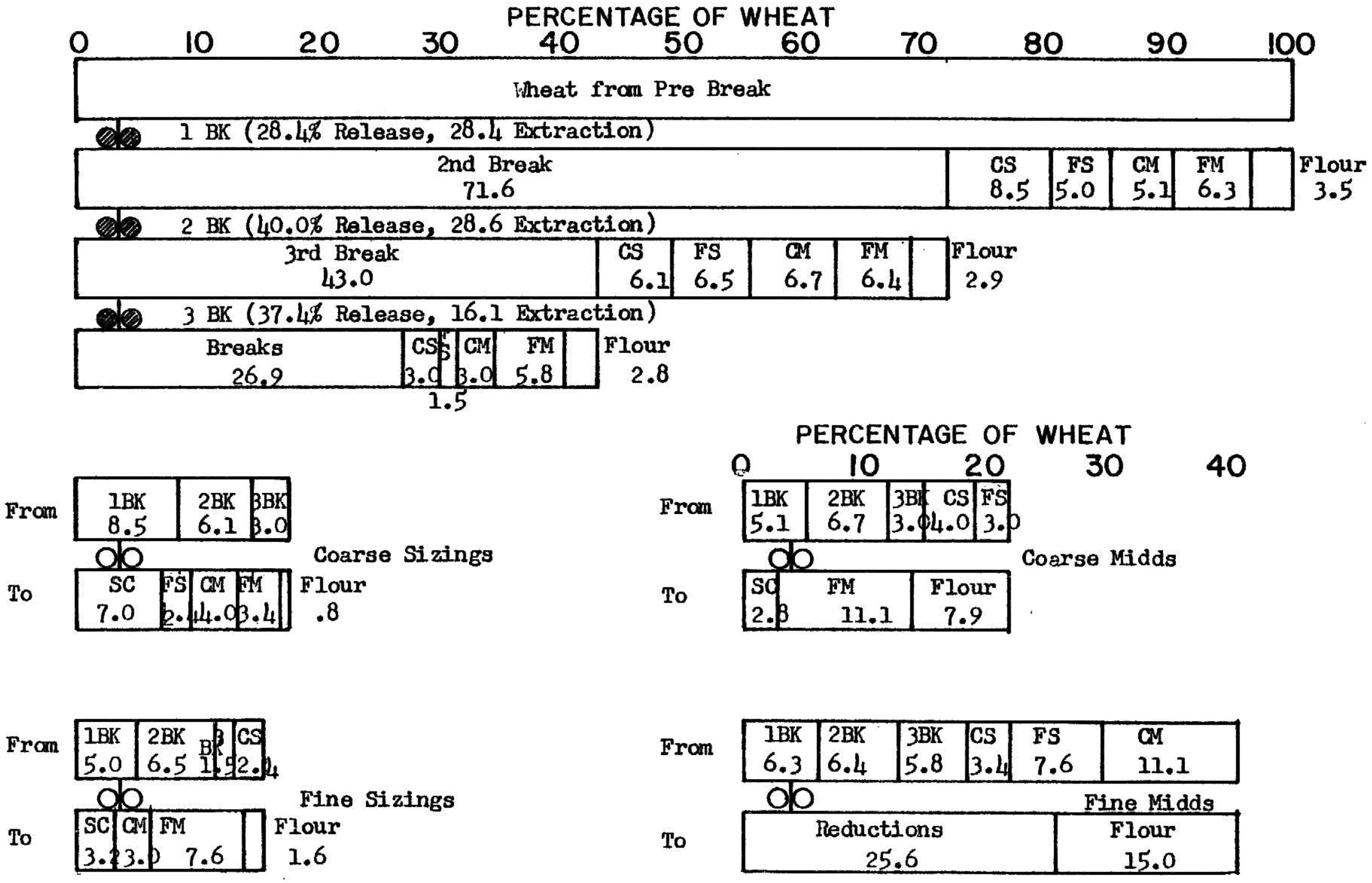
Ash Content

Figures #40, #41 and #42 shown previously can be inspected for a picture of how the wheat ash is distributed.

As with the hard wheats, there is a trend of decreasing ash as the particle size becomes smaller, reflecting the degree of bran intrusion, for the most part.

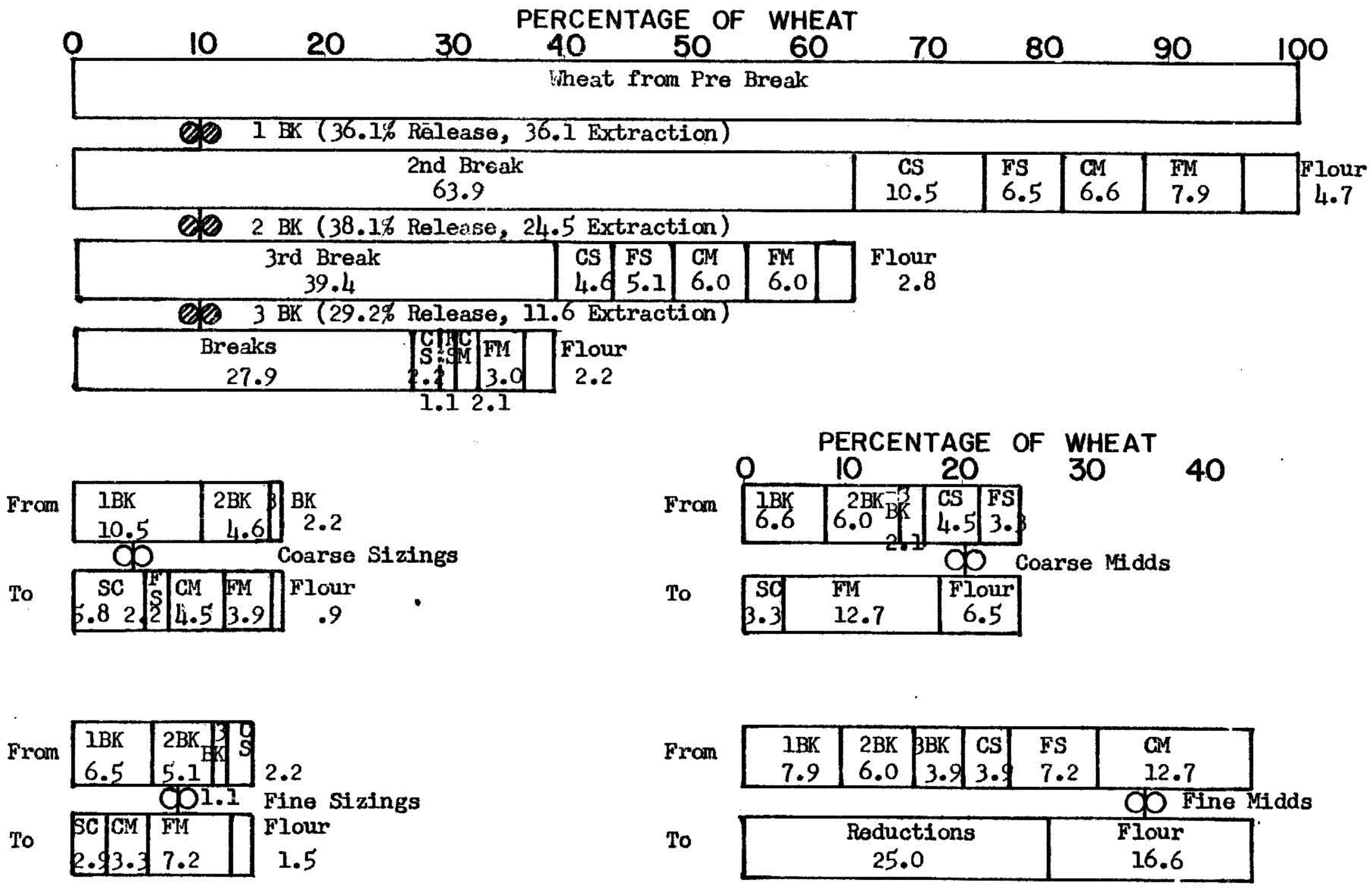
The previously noted exception to this of increased ash in the break and sizings flours over the next coarsest size group is still prevalent. The increasing ash content of the bran as endosperm is removed from it can be noted by observing the overs of the 20LW sieve.

Tables #23, #24 and #25 list all of the break release products in ascending order of ash content. Third break coarse sizings material is the highest ash stream in all three tests, reflecting the amount of bran that is cut up on the break and finds its way thru a 20LW sieve. Second break fine midds is the lowest ash in Tests #1 and #2. First break fine midds is the lowest in Test #3. This probably reflects on the high first



MATERIAL BALANCE CHART-SOFT WHITE SPRING
TEST NO. I

FIG. 49



MATERIAL BALANCE CHART-SOFT WHITE SPRING
TEST NO. 2

FIG. 50

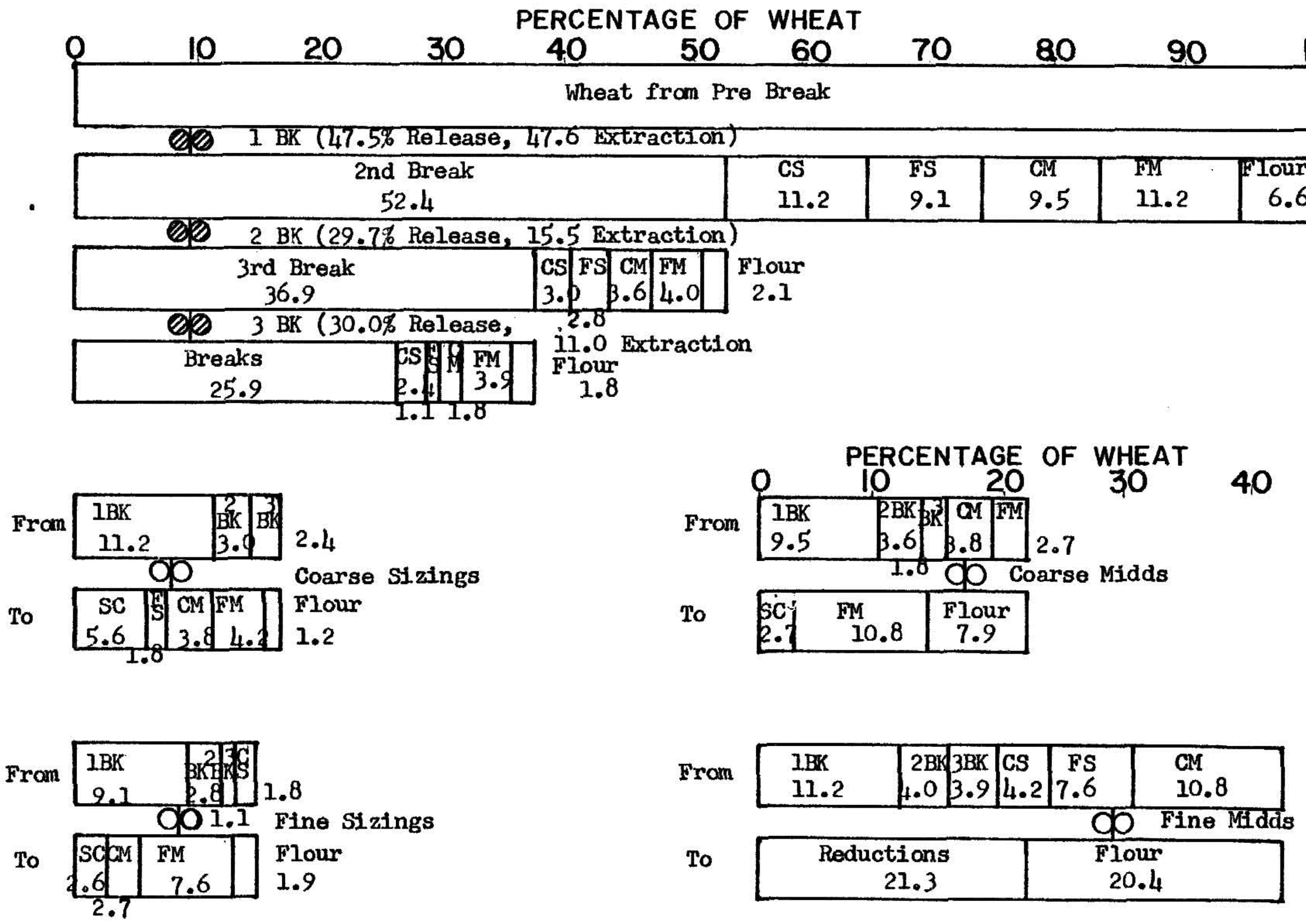


FIG. 51

MATERIAL BALANCE CHART-SOFT WHITE SPRING
TEST NO. 3

PERCENTAGE EXTRACTION FROM FIRST BREAK FOR EACH PRODUCT
SOFT WHITE SPRING

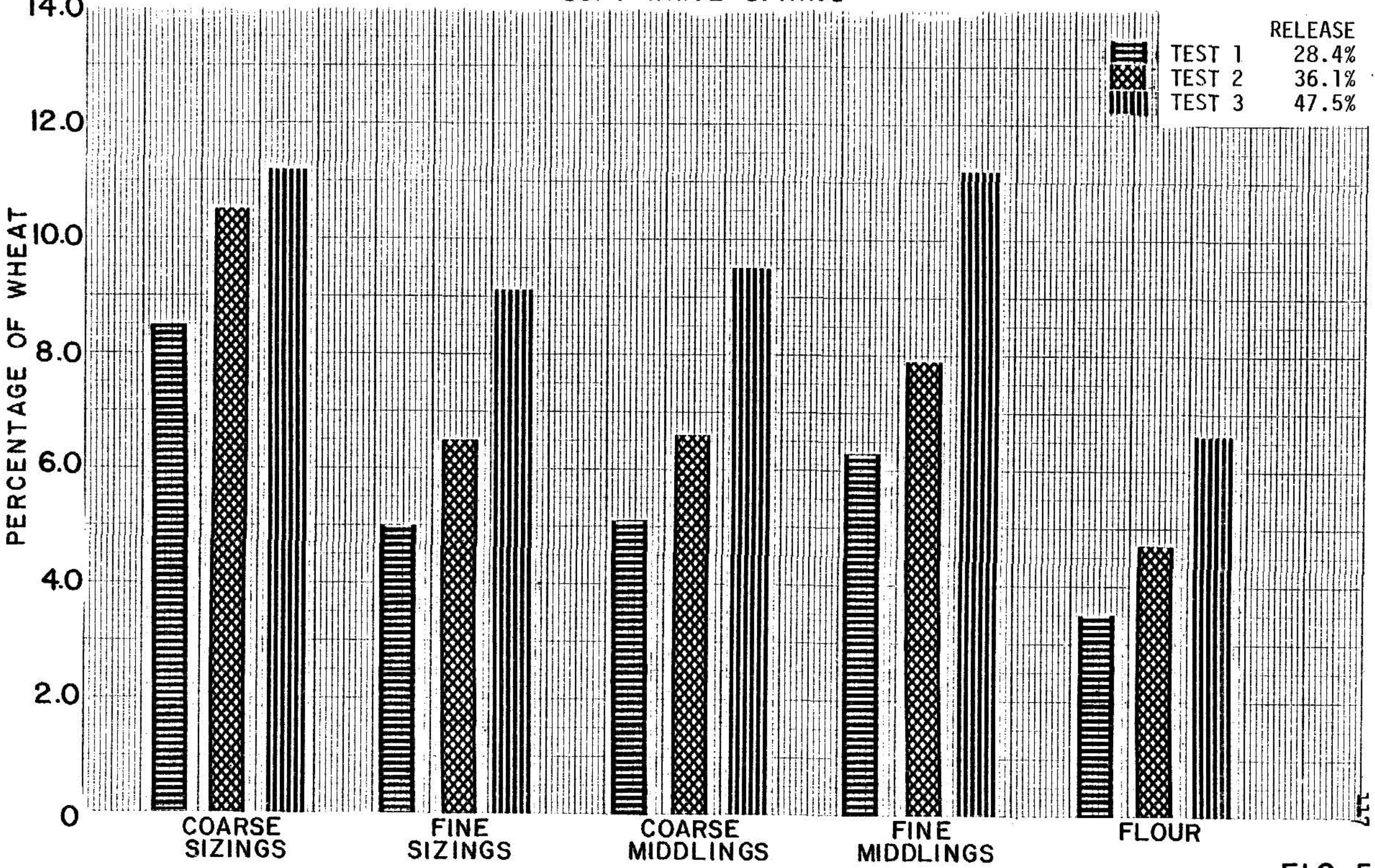


FIG. 52

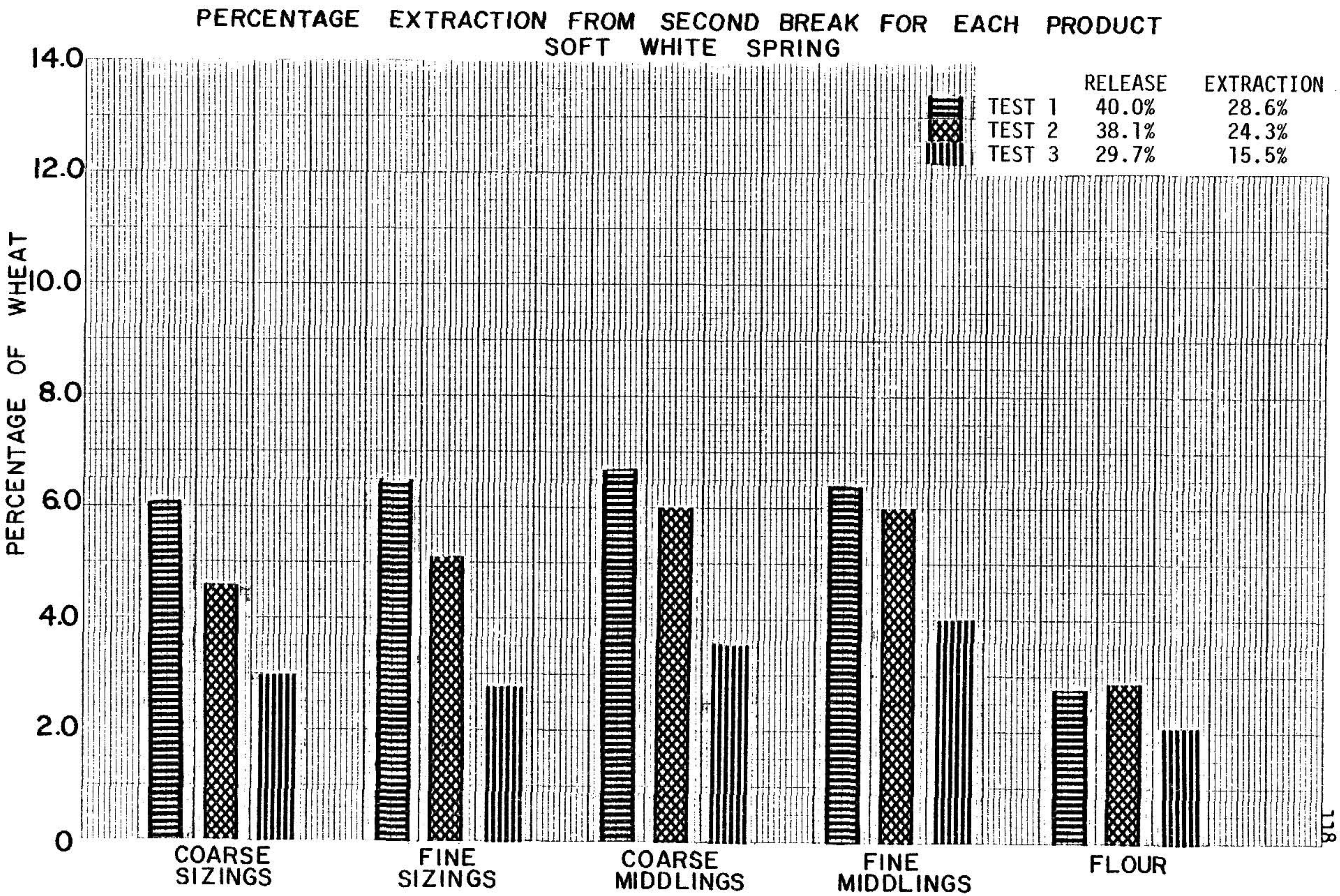

PERCENTAGE EXTRACTION FROM SECOND BREAK FOR EACH PRODUCT
SOFT WHITE SPRING
RELEASE
EXTRACTION
TEST 1 40.0% 28.6%
TEST 2 38.1% 24.3%
TEST 3 29.7% 15.5%
PERCENTAGE OF WHEAT
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0
COARSE SIZINGS
FINE SIZINGS
COARSE MIDDLINGS
FINE MIDDLINGS
FLOUR

FIG. 53

PERCENTAGE EXTRACTION FROM THIRD BREAK FOR EACH PRODUCT
SOFT WHITE SPRING

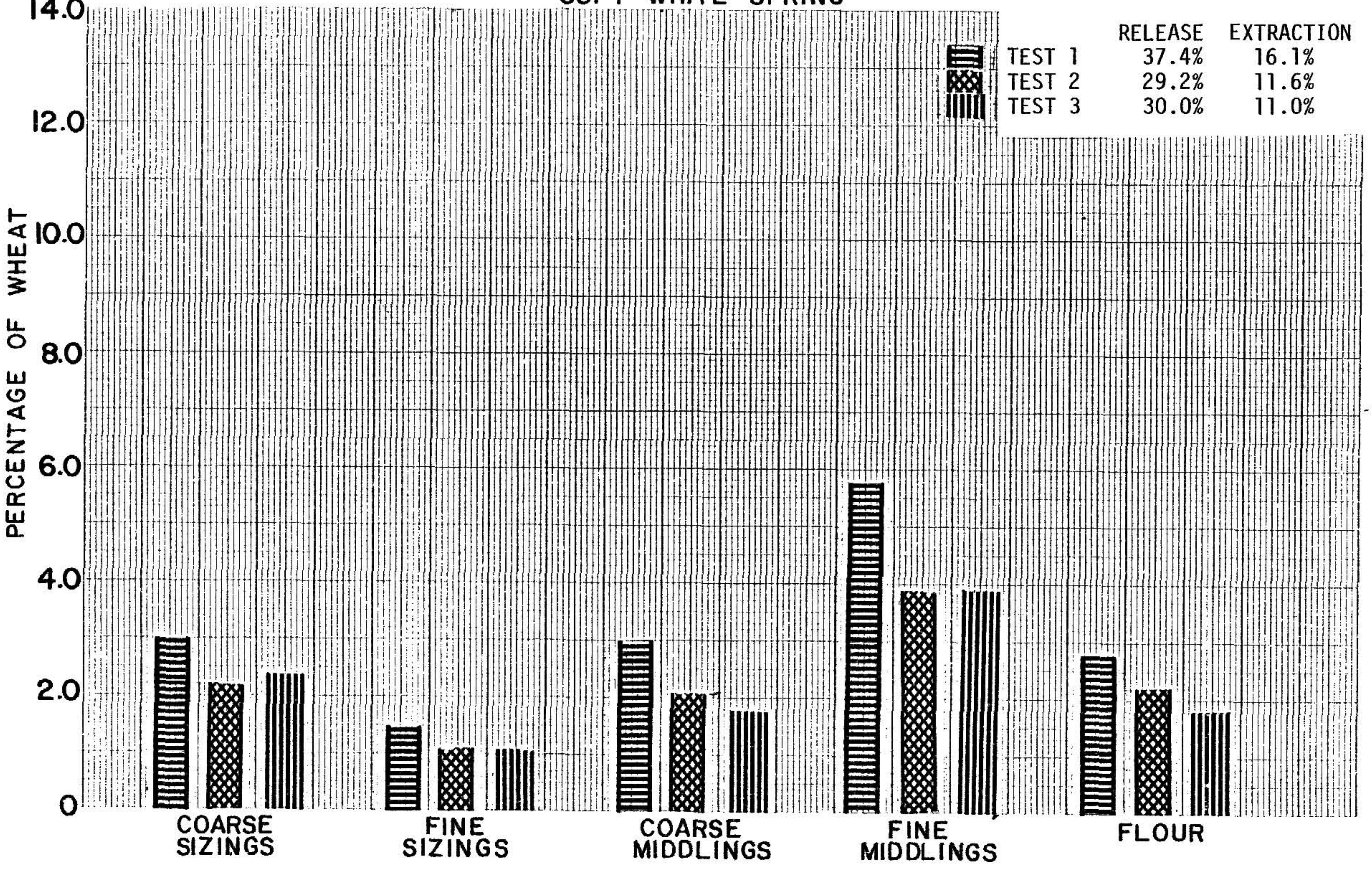


FIG. 54

CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation BREAK RELEASE PRODUCTS

Type of Wheat
SOFT WHITE SPRING

TEST #	STREAM		A	Q	Q×A	S of Q×A	S of Q	S of Q×A / S of Q
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
1	2BK	F.M.	.31	6.4	.0198	.0198	6.4	.310
	2BK	C.M.	.32	6.7	.0214	.0412	13.1	.314
	2BK	Flour	.32	2.9	.0093	.0505	16.0	.316
	1BK	F.M.	.33	6.3	.0208	.0713	22.3	.320
	1BK	Flour	.33	3.5	.0116	.0828	25.8	.321
	1BK	C.M.	.36	5.1	.0184	.1012	30.9	.328
	3BK	F.M.	.36	5.8	.0208	.1220	36.7	.330
	3BK	Flour	.37	2.8	.0104	.1324	39.5	.335
	2BK	F.S.	.38	6.5	.0247	.1571	46.0	.342
	1BK	F.S.	.42	5.0	.0210	.1781	51.0	.349
	3BK	C.M.	.58	3.0	.0174	.1955	54.0	.362
	1BK	C.S.	.60	8.5	.0510	.2465	62.5	.394
	2BK	C.S.	1.21	6.1	.0738	.3203	68.6	.467
	3BK	F.S.	1.49	1.5	.0224	.3427	70.1	.489
	3BK	C.S.	2.42	3.0	.0726	.4153	73.1	.568

TABLE # 23

CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation BREAK RELEASE PRODUCTS

Type of Wheat
SOFT WHITE SPRING

TEST #	STREAM		A	Q	Q x A	S of Q x A	S of Q	S of Q x A / S of Q
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
2	1BK	F.M.	.33	7.9	.0261	.0261	7.9	.330
	1BK	Flour	.33	4.7	.0155	.0416	12.6	.330
	2BK	F.M.	.33	6.0	.0198	.0614	18.6	.330
	2BK	Flour	.33	2.8	.0092	.0706	21.4	.330
	1BK	C.M.	.34	6.6	.0224	.0930	28.0	.332
	2BK	C.M.	.34	6.0	.0204	.1134	34.0	.334
	3BK	Flour	.34	2.2	.0075	.1209	36.2	.334
	3BK	F.M.	.36	3.9	.0140	.1349	40.1	.336
	1BK	F.M.	.40	6.5	.0260	.1609	46.6	.345
	2BK	F.S.	.42	5.1	.0214	.1823	51.7	.353
	3BK	C.M.	.54	2.1	.0113	.1936	53.8	.360
	1BK	C.S.	.54	10.5	.0567	.2503	64.3	.389
	2BK	C.S.	1.61	4.6	.0741	.3244	68.9	.471
	3BK	F.S.	1.70	1.1	.0187	.3431	70.0	.490
	3BK	C.S.	3.10	2.2	.0682	.4113	72.2	.572

TABLE # 24

CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation **BREAK RELEASE PRODUCTS**

Type of Wheat
SOFT WHITE SPRING

TEST #	STREAM		A	Q	Q x A	S of Q x A	S of Q	S of Q x A / S of Q
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
3	1BK	F.M.	.32	11.0	.0352	.0352	11.0	.320
	1BK	Flour	.33	6.6	.0218	.0570	17.6	.324
	2BK	Flour	.33	2.1	.0069	.0639	19.7	.324
	2BK	F.M.	.34	3.6	.0122	.0761	23.3	.327
	3BK	Flour	.35	1.8	.0063	.0824	25.1	.328
	1BK	C.M.	.36	9.5	.0342	.1166	34.6	.336
	2BK	C.M.	.36	3.6	.0130	.1296	38.2	.339
	1BK	F.S.	.39	9.1	.0355	.1651	47.3	.349
	3BK	F.M.	.39	3.9	.0152	.1803	51.2	.352
	2BK	F.S.	.53	2.8	.0148	.1951	54.0	.361
	3BK	C.M.	.63	1.8	.0113	.2064	55.8	.370
	1BK	C.S.	.77	11.2	.0862	.2926	67.0	.437
	3BK	F.S.	1.99	1.1	.0219	.3145	68.1	.462
	2BK	C.S.	2.10	3.0	.0630	.3775	71.1	.531
	3BK	C.S.	3.00	2.4	.0720	.4495	73.5	.612

TABLE # 25

break extraction rate for Test #3, which causes it to take more of the endosperm that 2nd break took in the first two tests.

Figure #55 shows the curves formed by plotting the cumulative ash results. The results show a very close relationship until the steep portion of the curve is reached. In total, Test #1 gave the lowest ash result. Test #2 was the next best and Test #3, the highest in ash.

Table #26 shows shows the flour ashes arranged in ascending order.

Figure #56 shows these results graphically. The order of preference is the same as occurred in the break release study.

Test #1 - Best (Lowest Ash)
Test #2 - Next Best
Test #3 - Worst (Highest Ash)

As with spring wheat, the QXA ash content of coarse sizings from each milling also fell into the same order.

Test #1 - .1974
Test #2 - .2103
Test #3 - .2212

This, again, is a good indication that the amount of bran released during the breaking process is directly related to the amount of bran that will end up in the flour.

Protein Content

Figures #40, #41 and #42, referred to previously, show how the protein is distributed in the various millings.

The overs of the various top sieves increase in protein as endosperm is removed.

The middlings do not exhibit any particular trend.

The flours from the breaks and sizings show the opposite effect found with the hard wheat millings, in that the proteins are lower than the next

CUMULATIVE ASH
BREAK RELEASE PRODUCTS
SOFT WHITE SPRING

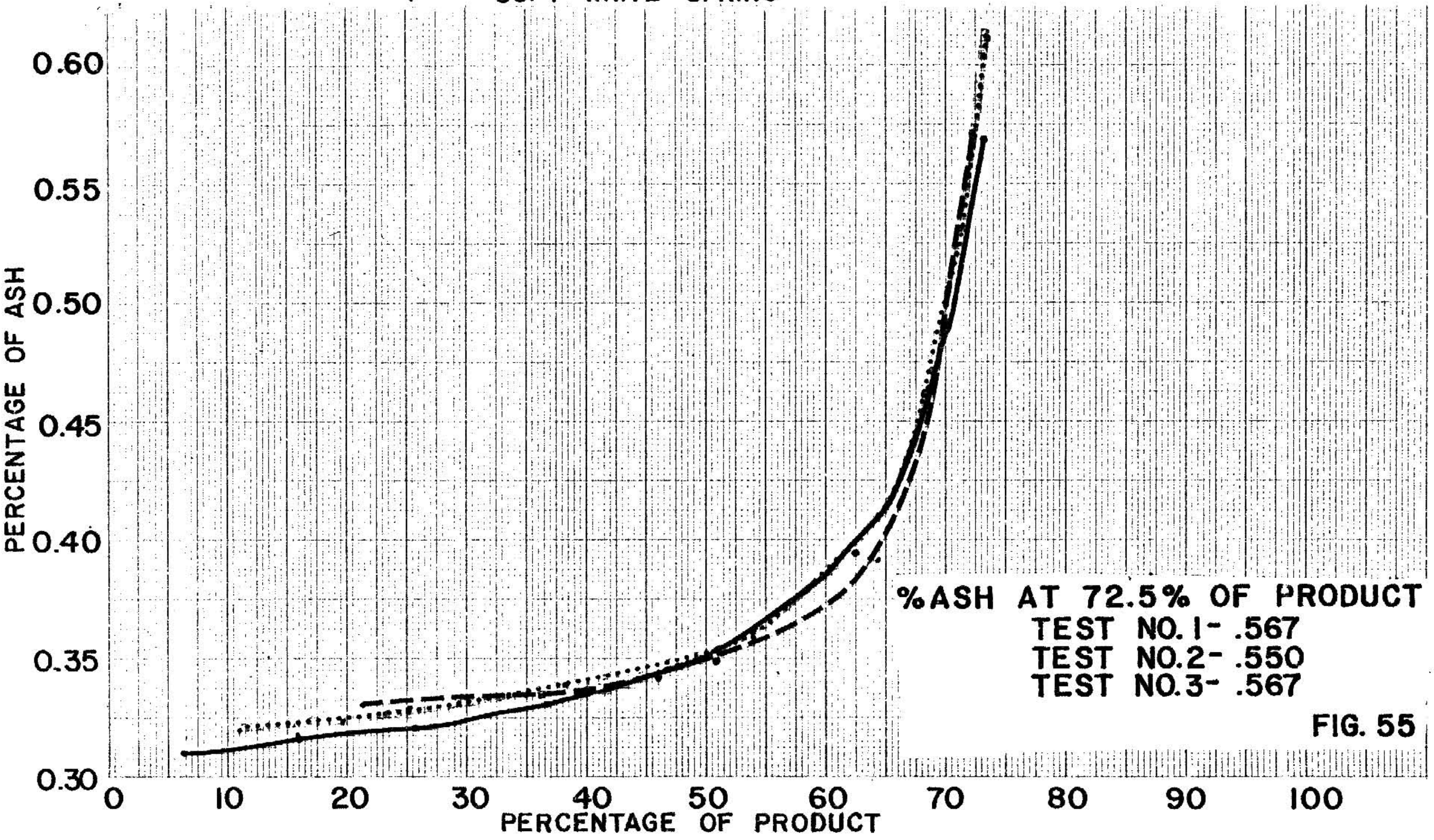


FIG. 55

CUMULATIVE ASH CALCULATIONS

A=Ash (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation FLOURS ONLY

Type of Wheat
SOFT WHITE SPRING

TEST #	STREAM		A	Q	Q x A	S of Q x A	S of Q	S of Q x A / S of Q
	FROM	TO	% Ash (14% M.B.)	% of Wheat	% of Wheat x % Ash	Cumulative Q x A	Cumulative % of Wheat	Cumulative % of Ash
1	C.M.	Flour	.25	7.9	.0198	.0198	7.9	.250
	F.M.	"	.26	15.0	.0390	.0588	22.9	.257
	F.S.	"	.28	1.6	.0045	.0633	24.5	.258
	C.S.	"	.30	.8	.0024	.0657	25.3	.260
	2BK	"	.32	2.9	.0093	.0750	28.2	.266
	1BK	"	.33	3.5	.0116	.0866	31.7	.273
	3BK	"	.37	2.8	.0104	.0970	34.5	.281
2	C.M.	Flour	.25	6.5	.0163	.0163	6.5	.250
	F.M.	"	.27	16.6	.0448	.0611	23.1	.265
	F.S.	"	.27	1.5	.0041	.0652	24.6	.265
	C.S.	"	.28	.9	.0025	.0677	25.5	.265
	2BK	"	.33	2.8	.0092	.0769	28.3	.272
	1BK	"	.33	4.7	.0155	.0924	33.0	.280
	3BK	"	.34	2.2	.0075	.0999	35.2	.284
3	C.M.	Flour	.26	7.9	.0205	.0205	7.9	.260
	F.S.	"	.27	1.9	.0051	.0256	9.8	.261
	F.M.	"	.28	20.4	.0571	.0827	30.2	.274
	C.S.	"	.29	1.2	.0035	.0866	31.4	.276
	2BK	"	.33	2.1	.0069	.0935	33.5	.279
	1BK	"	.33	6.6	.0218	.1153	40.1	.288
	3BK	"	.35	1.8	.0063	.1216	41.9	.290

TABLE # 26

CUMULATIVE ASH
FLOURS
SOFT WHITE SPRING

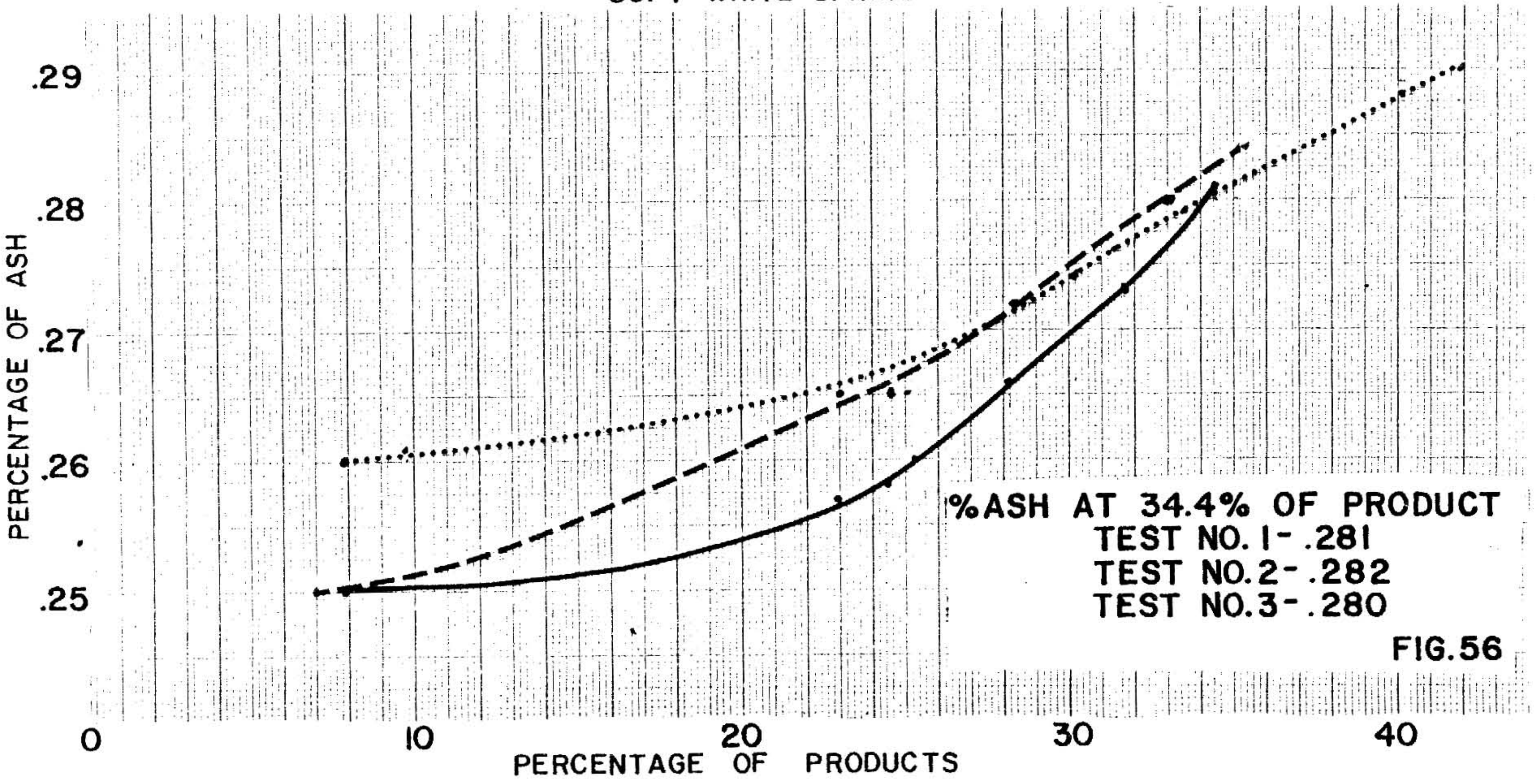


FIG. 56

coarsest middlings group. This signifies the weak starch cells found in softer wheats have broken down into flour size rapidly enough to mask any interstitial protein that may also have been separated. Soft wheats exhibit a fluffy or mealy consistency compared to the sharp, granular consistency of the harder flours. This was recently confirmed by Blakney, et al, (23). They state that the hard wheat flour "consisted mainly of angular material which cleaved neatly along the lines of the cell wall." The soft flour "was mainly a collection of broken cell fragments and fine starch granules. Very little recognizable endosperm cell structure could be found."

The tests also show that higher amounts of break flours are produced at the same approximate release rates as on hard wheat.

Tables #27, #28 and #29 arrange all of the break release products in ascending order of protein. The distinct alignment of 1st break in the lower proteins, 2nd break in the medium proteins and 3rd break in the higher proteins is noticeable.

Figure #57 shows the cumulative protein results graphically. Tests #1 and #2 are identical at the finished extraction levels. Test #3 is lower than either #1 or #2. As low protein is often the goal in soft wheat milling - just the opposite of protein recovery in hard wheat milling - the extractions used in Test #3 would indicate a preferred arrangement.

Table #30 aligns the seven flours produced in each milling in order of ascending protein content.

Figure #58 shows these results graphically. A more distinct separation of results was obtained with flours. Again, assuming that the lower proteins might be more desirable in commercial milling, the order of preference is:

Test #3 - Best

Test #2 - Next Best

Test #1 - Worst

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation BREAK RELEASE PRODUCTS

Type of Wheat
SOFT WHITE SPRING

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of Q x P / S of Q
	FROM	TO	% Protein (14% M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
1	1BK	Flour	6.8	3.5	.2380	.2380	3.5	6.80
	2BK	Flour	7.4	2.9	.2146	.4526	6.4	7.07
	1BK	F.S.	7.6	5.0	.3800	.8326	11.4	7.30
	1BK	C.M.	7.6	5.1	.3876	1.2202	16.5	7.40
	1BK	F.M.	8.0	6.3	.5040	1.7242	22.8	7.56
	1BK	C.S.	8.2	8.5	.6970	2.4212	31.3	7.74
	2BK	F.S.	8.9	6.5	.5785	2.9997	37.8	7.94
	2BK	F.M.	8.9	6.4	.5696	3.5693	44.2	8.08
	2BK	C.M.	9.2	6.7	.6164	4.1857	50.9	8.22
	3BK	Flour	10.0	2.8	.2800	4.4657	53.7	8.32
	2BK	C.S.	10.9	6.1	.6649	5.1306	59.8	8.58
	3BK	C.M.	11.2	3.0	.3360	5.4666	62.8	8.70
	3BK	F.M.	11.8	5.8	.6844	6.1510	68.6	8.97
	3BK	F.S.	12.4	1.5	.1860	6.3370	70.1	9.04
	3BK	C.S.	15.8	3.0	.4740	6.8110	73.1	9.32

TABLE# 27

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation **BREAK RELEASE PRODUCTS**

Type of Wheat
SOFT WHITE WHEAT

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	$\frac{\text{S of Q x P}}{\text{S of Q}}$
	FROM	TO	% Protein (14%M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
2	1BK	Flour	6.2	4.7	.2914	.2914	4.7	6.20
	2BK	Flour	7.3	2.8	.2044	.4958	7.5	6.61
	1BK	C.M.	7.6	6.6	.5016	.9974	14.1	7.07
	1BK	F.S.	7.7	6.5	.5005	1.4979	20.6	7.27
	1BK	F.M.	8.1	7.9	.6399	2.1619	28.5	7.59
	1BK	C.S.	8.7	10.5	.9135	3.0754	39.0	7.89
	3BK	Flour	8.8	2.2	.1936	3.2690	41.2	7.93
	2BK	F.S.	9.4	5.1	.4794	3.7484	46.3	8.10
	2BK	F.M.	9.4	6.0	.5640	4.3124	52.3	8.25
	2BK	C.M.	9.5	6.0	.5700	4.8824	58.3	8.37
	3BK	C.M.	11.4	2.1	.2394	5.1218	60.4	8.48
	3BK	F.M.	11.7	3.9	.4563	5.5781	64.3	8.68
	2BK	C.S.	12.5	4.6	.5750	6.1531	68.9	8.93
	3BK	F.S.	12.8	1.1	.1408	6.2939	70.0	8.99
	3BK	C.S.	16.2	2.2	.3564	6.6503	72.2	9.21

TABLE # 28

CUMULATIVE PROTEIN CALCULATIONS

P=Protein (14% Moisture Basis)

Q=Quantity (% of Wheat to Pre-Break)

S=Summation BREAK RELEASE PRODUCTS

Type of Wheat
SOFT WHITE SPRING

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	S of Q x P / S of Q
	FROM	TO	% Protein (14% M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
3	1BK	Flour	6.6	6.6	.4356	.4356	6.6	6.60
	2BK	Flour	7.3	2.1	.1533	.5889	8.7	6.76
	1BK	C.M.	7.8	9.5	.7410	1.3299	18.2	7.31
	1BK	F.S.	8.1	9.1	.7371	2.0670	27.3	7.57
	1BK	F.M.	8.2	11.2	.9184	2.9854	38.5	7.75
	3BK	Flour	8.8	1.8	.1584	3.1438	40.3	7.80
	1BK	C.S.	9.0	11.2	1.0080	4.1518	51.5	8.06
	2BK	F.S.	9.9	2.8	.2772	4.4290	54.3	8.16
	2BK	F.M.	9.9	4.0	.3960	4.8250	58.3	8.28
	2BK	C.M.	10.2	3.6	.3672	5.1922	61.9	8.39
	3BK	C.M.	11.8	1.8	.2124	5.4046	63.7	8.48
	3BK	F.M.	12.2	3.9	.4758	5.8804	67.6	8.70
	2BK	C.S.	13.6	3.0	.4080	6.2884	70.6	8.91
	3BK	F.S.	13.6	1.1	.1496	6.4380	71.7	8.98
	3BK	C.S.	16.2	2.4	.3888	6.8268	74.1	9.21

TABLE # 29

CUMULATIVE PROTEIN
BREAK RELEASE PRODUCTS
SOFT WHITE SPRING

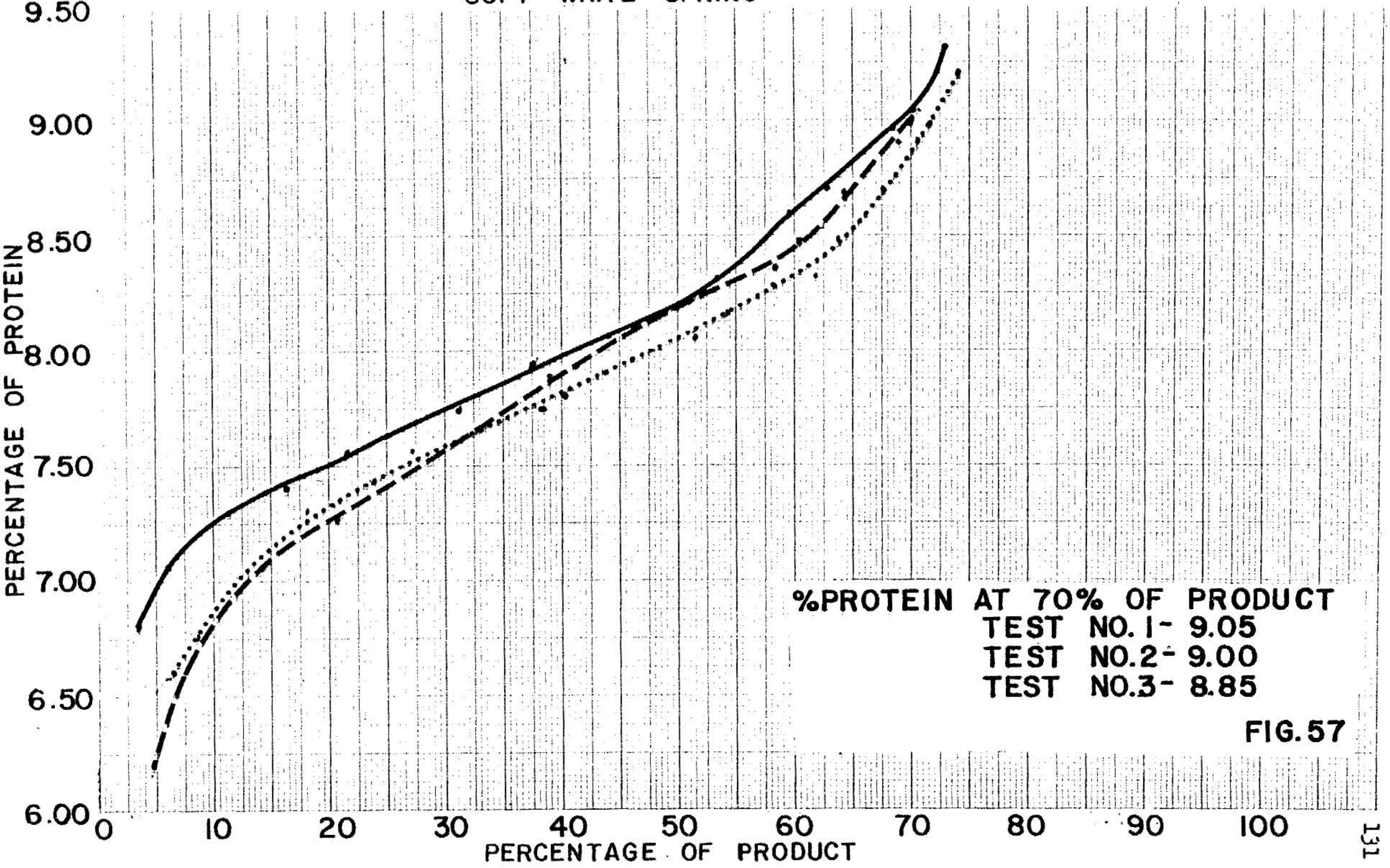


FIG. 57

CUMULATIVE PROTEIN CALCULATIONS

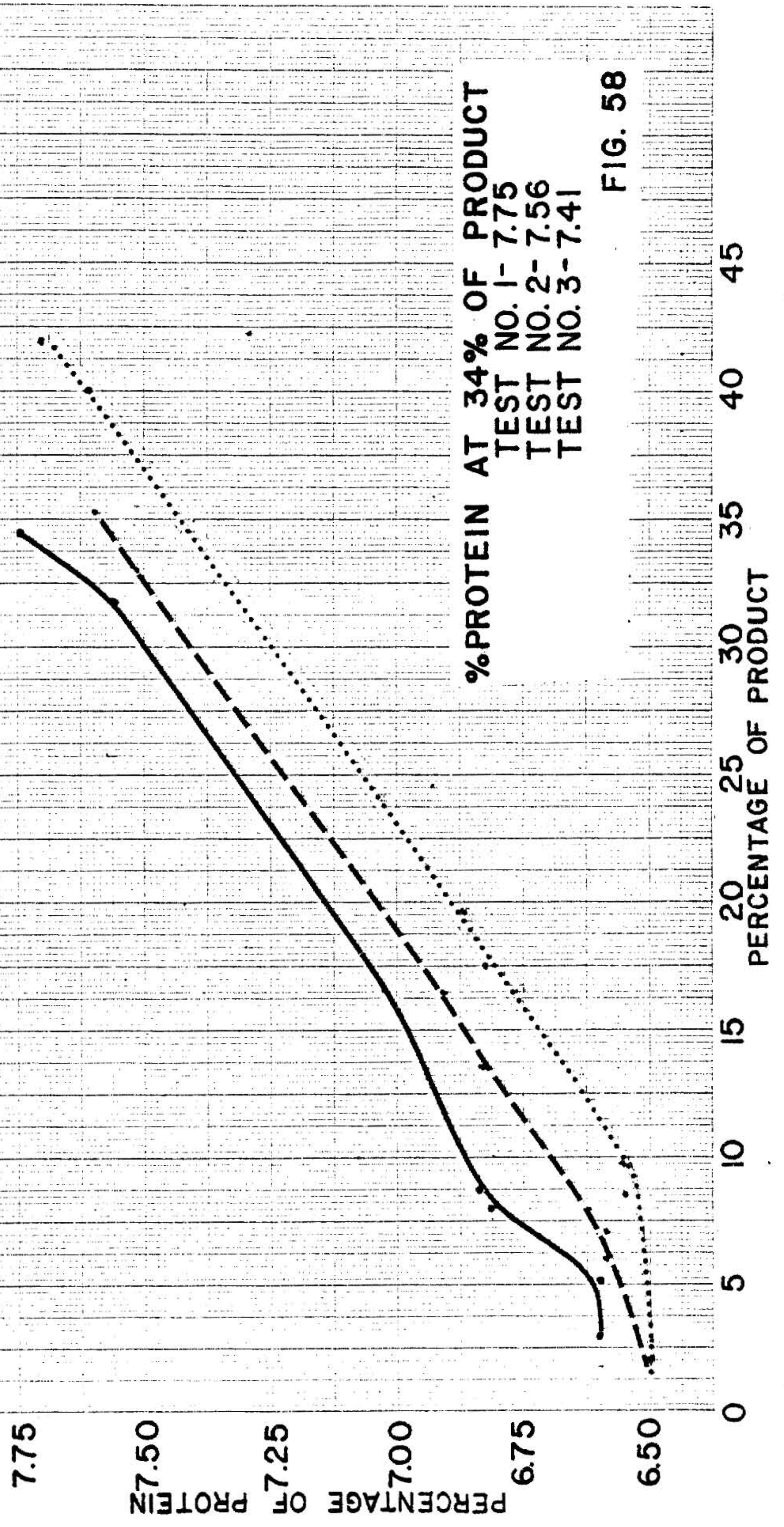
P=Protein (14% Moisture Basis)
Q=Quantity (% of Wheat to Pre-Break)
S=Summation FLOURS ONLY

Type of Wheat
SOFT WHITE SPRING

TEST #	STREAM		P	Q	Q x P	S of Q x P	S of Q	$\frac{\text{S of Q x P}}{\text{S of Q}}$
	FROM	TO	% Protein (14%M.B.)	% of Wheat	% of Wheat x % Protein	Cumulative Q x P	Cumulative % of Wheat	Cumulative % Protein
1	1BK	Flour	6.6	3.5	.2310	.2310	3.5	6.60
	F.S.	"	6.6	1.6	.1056	.3366	5.1	6.60
	2BK	"	7.2	2.9	.2088	.5454	8.0	6.82
	C.S.	"	7.2	.8	.0576	.6030	8.8	6.85
	C.M.	"	7.2	7.9	.5688	1.1718	16.7	7.02
	F.M.	"	8.2	15.0	1.2300	2.4018	31.7	7.58
	3BK	"	9.7	2.8	.2716	2.6734	34.5	7.74
2	F.S.	Flour	6.5	1.5	.0975	.0975	1.5	6.50
	1BK	"	6.6	4.7	.3102	.4077	6.2	6.58
	C.S.	"	6.6	.9	.0594	.4671	7.1	6.58
	C.M.	"	7.1	6.5	.4616	.9287	13.6	6.83
	2BK	"	7.3	2.8	.2044	1.1331	16.4	6.91
	F.M.	"	8.1	16.6	1.3446	2.4777	33.0	7.51
	3BK	"	8.8	2.2	.1936	2.6713	35.2	7.59
3	F.S.	Flour	6.5	1.9	.1235	.1235	1.9	6.50
	1BK	"	6.6	6.6	.4356	.5591	8.5	6.58
	C.S.	"	6.7	1.2	.0804	.6395	9.7	6.59
	C.M.	"	7.1	7.9	.5609	1.2004	17.6	6.82
	2BK	"	7.3	2.1	.1533	1.3537	19.7	6.87
	F.M.	"	8.4	20.4	1.7136	3.0673	40.1	7.65
	3BK	"	8.8	1.8	.1584	3.2257	41.9	7.70

TABLE# 30

CUMULATIVE PROTEIN
FLOURS
SOFT WHITE SPRING



%PROTEIN AT 34% OF PRODUCT
TEST NO. 1- 7.75
TEST NO. 2- 7.56
TEST NO. 3- 7.41

FIG. 58

Comparisons of the Various Tests among Hard Red Winter, Hard Red Spring and Soft White Spring

In commercial practice, flour mills must be flowed differently for optimum results when grinding winter, spring or soft wheats. The differences in hardness of these three wheats require different machine performances. The amount of roll, purifier and sifter surface varies. The type of roll corrugation and differential changes. The allocation of roll surface to various functions varies. The number of sifter cloths and their aperature size varies. The use of purifiers varies.

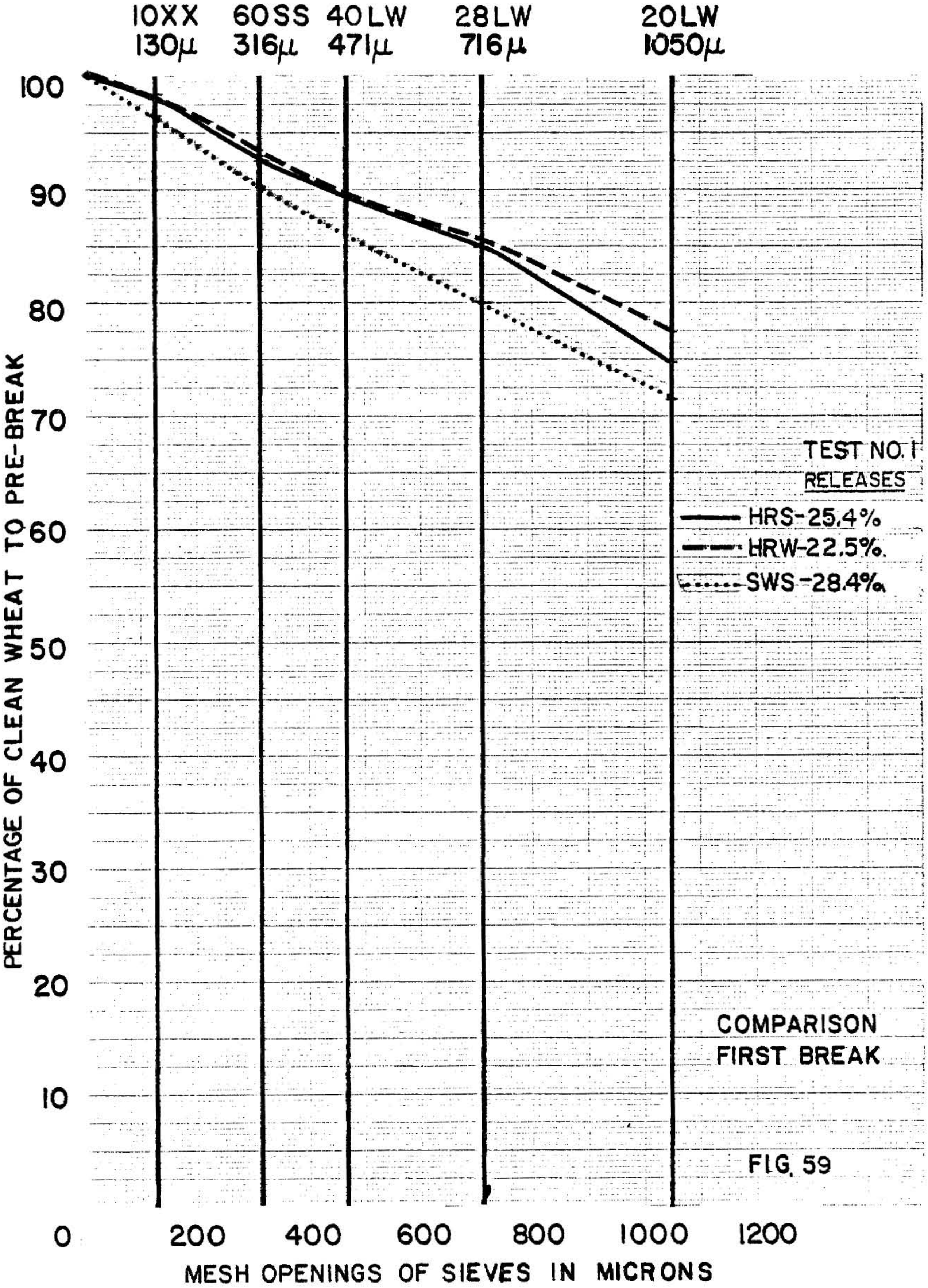
Some mills are grinding all three wheat types on the same mill but this requires the compromise of overall milling results. It is of some interest, therefore, to see how the results of these tests differ (or remain constant) for the purpose of understanding what considerations might be given to the design of mills using different classes of wheat.

Granulation

First Break

Figure #59 shows the accumulative overs of all 1st break granulations. The release rates were all in the 22% to 29% range. The closer relationship of granulations in noticeable between Hard Red Winter and Hard Red Spring. Even with the slightly higher release for Soft White Spring, the difference in granularity compared to the harder wheats is quite evident, with a shift to the finer particle sizes.

The difference in granulation breakdown is more easily discerned in Figure #60. The decreasing granularity size from Hard Red Spring, to Hard Red Winter to Soft White Spring is graphically portrayed. They all show


GRANULATION CURVES

TEST NO. I

COMPARISON
FIRST BREAK

FIG. 59

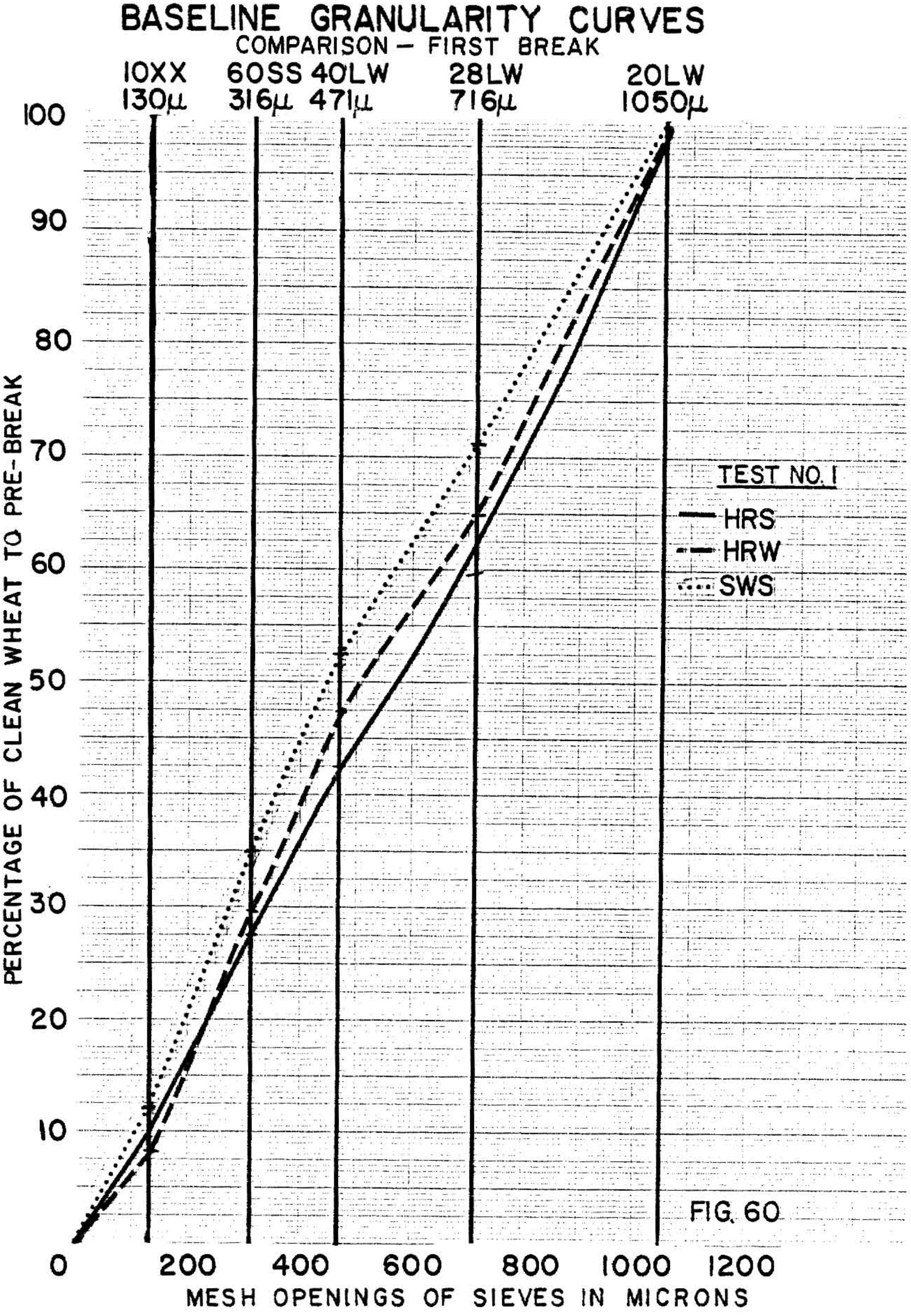

BASELINE GRANULARITY CURVES
COMPARISON – FIRST BREAK
10XX 130μ
60SS 316μ
40LW 471μ
28LW 716μ
20LW 1050μ
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
MESH OPENINGS OF SIEVES IN MICRONS
TEST NO. 1
HRS
HRW
SWS

FIG. 60

the same relative shape of curve.

Second Break

Figure #61 shows the granularity differences in 2nd break. The differences are apparent.

Figure #62 portrays the same shift towards fineness as was seen on 1st break when going from Hard Red Spring to Hard Red Winter to Soft White Spring. The Soft White Spring again shows a more radical dissimilarity than the Hard Red Spring and Hard Red Winter comparisons.

Third Break

Figure #63 compares the three classes of wheat as they respond in granularity to a close 3rd break release comparison of 34.5%, 35.9% and 37.4%.

The differences are much the same as with the 1st break and 2nd break comparisons.

Figure #64 again points out that the hardness of the wheat determines the granularity of the release.

The changes portrayed in these experimental mill tests quantify the changes known thru experience in commercial practice.

Sizings and Middlings

Figures #65, #66 and #67 are made to give a comparison of the sizings and middlings as affected by the different classes of wheat.

The percent deviation from Hard Red Winter are tabulated. Compared to Hard Red Winter, the Hard Red Spring groupings for Tests #1 show a large increase in CS stock, a large decrease in CM stock and a significant decrease in FM stock.

The Soft White Spring results show a significant decrease in the amounts of CS and FS stocks produced when compared to Hard Red Winter and a large increase in FM stock.

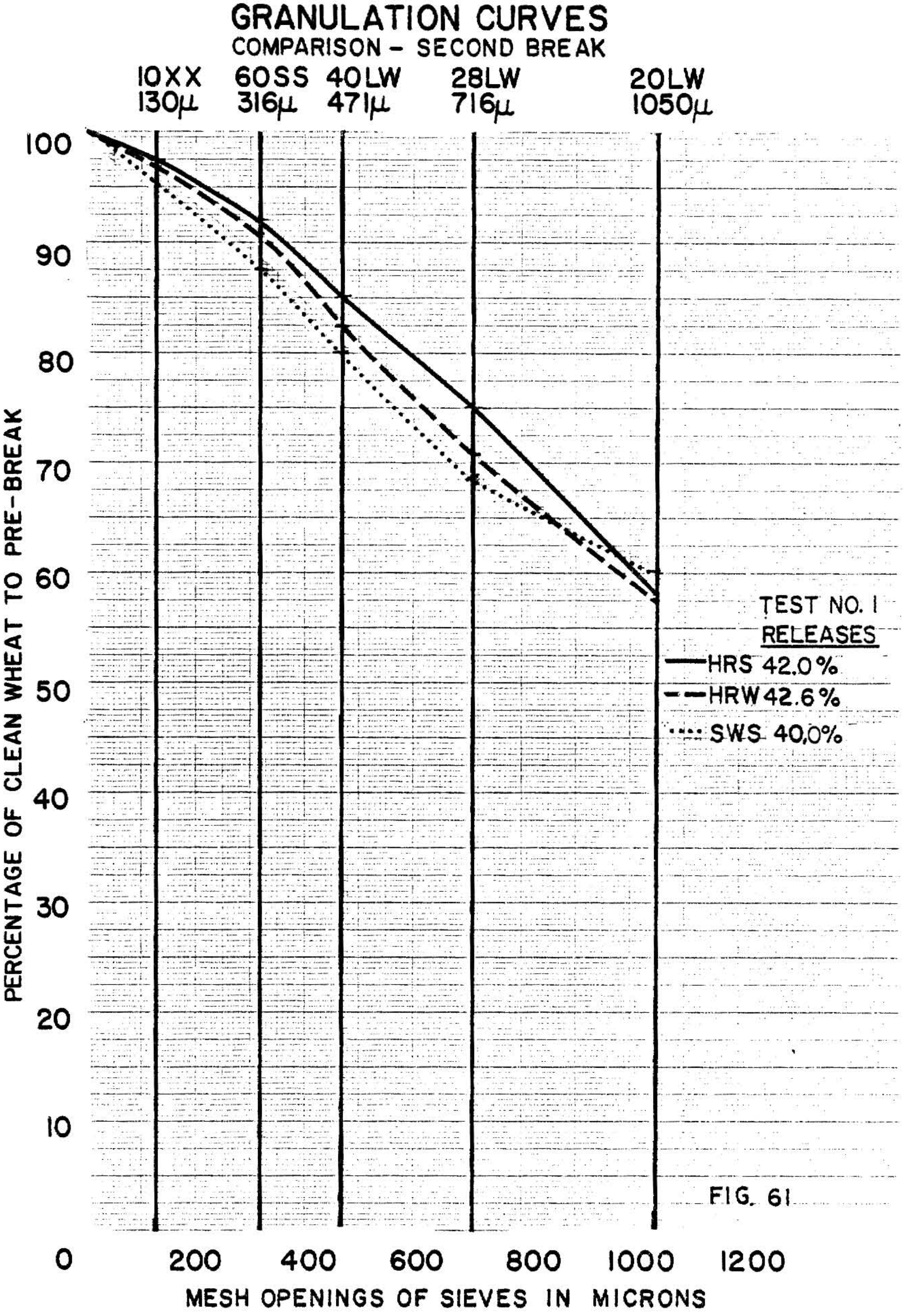

GRANULATION CURVES
COMPARISON - SECOND BREAK
10XX 130μ
60SS 316μ
40LW 471μ
28LW 716μ
20LW 1050μ
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
MESH OPENINGS OF SIEVES IN MICRONS
TEST NO. 1
RELEASES
HRS 42.0%
HRW 42.6%
SWS 40.0%

FIG. 61

BASELINE GRANULARITY CURVES

COMPARISON-SECOND BREAK

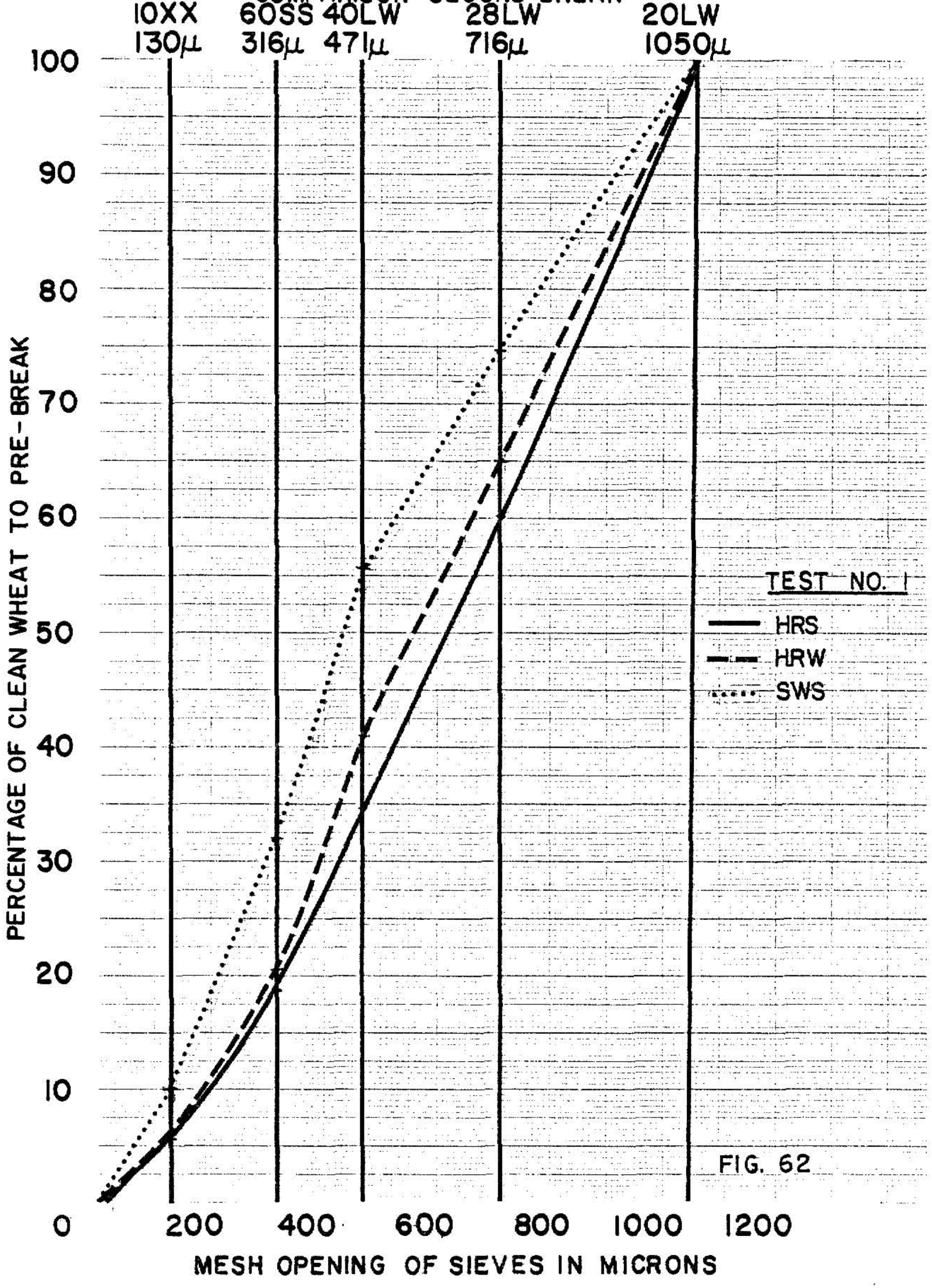


FIG. 62

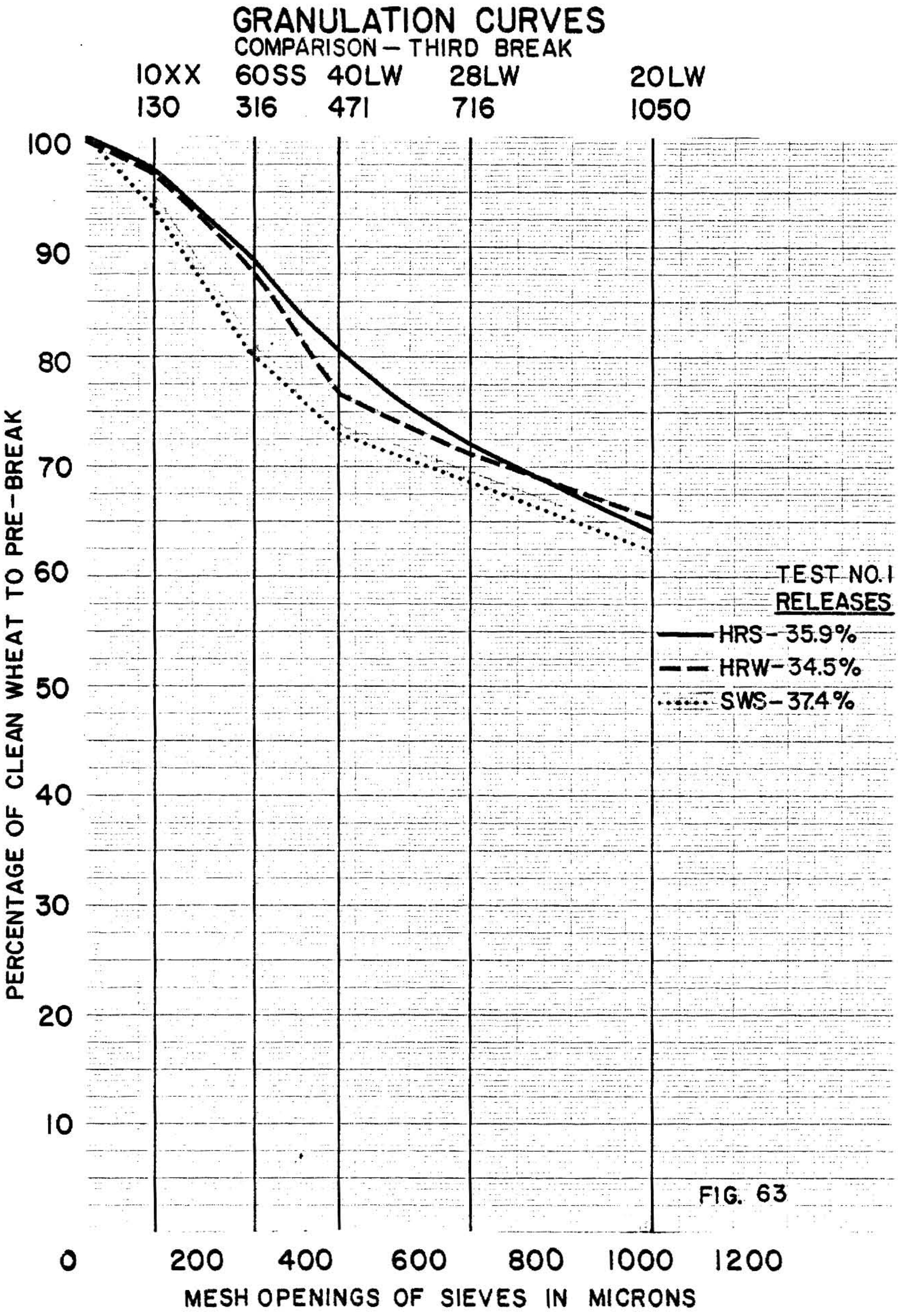

GRANULATION CURVES
COMPARISON — THIRD BREAK
10XX
130
60SS
316
40LW
471
28LW
716
20LW
1050
100
90
80
70
60
50
40
30
20
10
0
200
400
600
800
1000
1200
PERCENTAGE OF CLEAN WHEAT TO PRE-BREAK
MESH OPENINGS OF SIEVES IN MICRONS
TEST NO. I
RELEASES
HRS - 35.9%
HRW - 34.5%
SWS - 37.4%

FIG. 63

BASELINE GRANULARITY CURVES

COMPARISON – THIRD BREAK

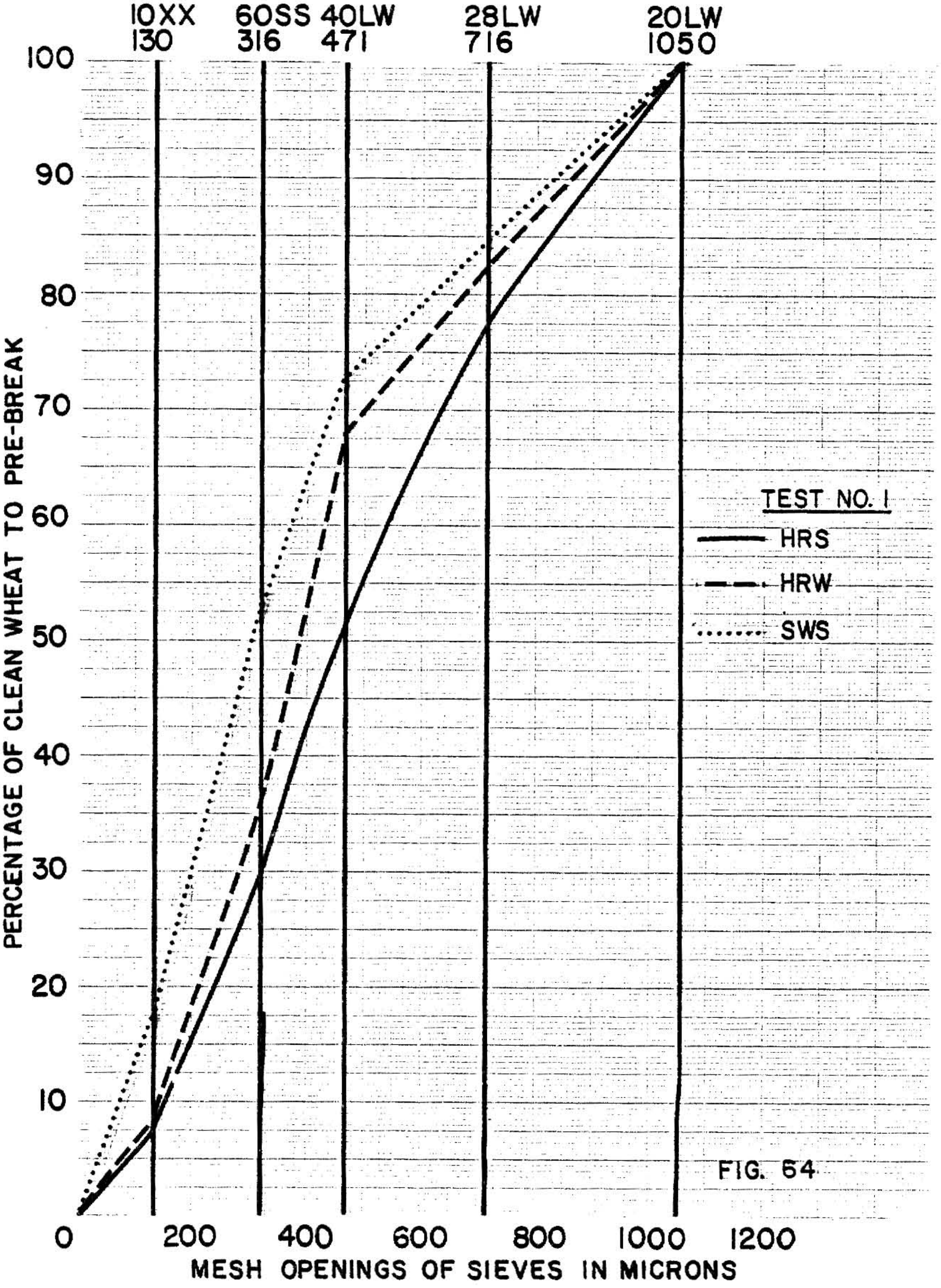


FIG. 64

SIZINGS AND MIDDS COMPARISONS

BREAKS ONLY- TEST NO. I

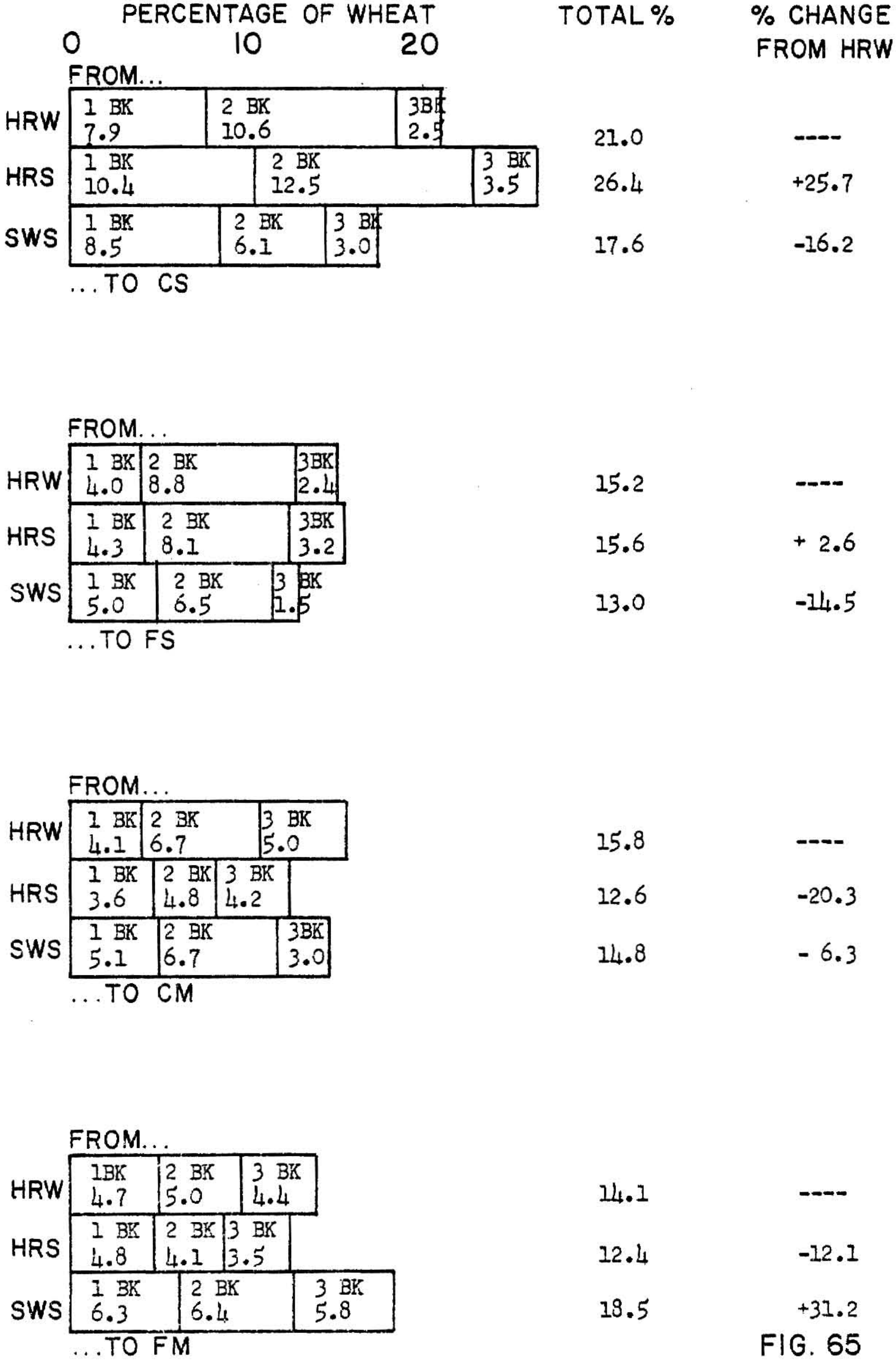


FIG. 65

SIZINGS AND MIDDS COMPARISONS

BREAKS ONLY-TEST NO. 2

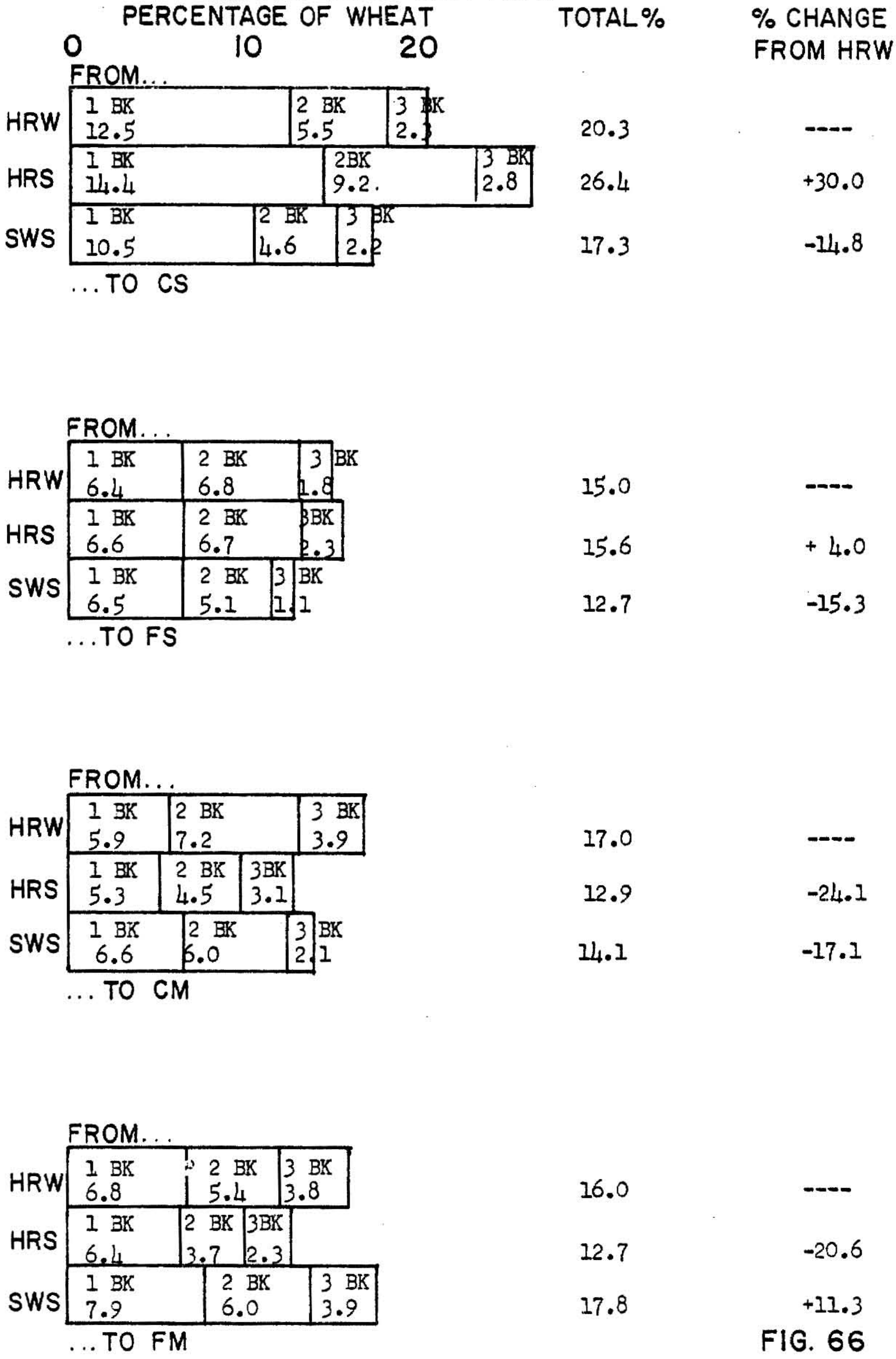


FIG. 66

SIZINGS AND MIDDS COMPARISONS

BREAKS ONLY-TEST NO. 3

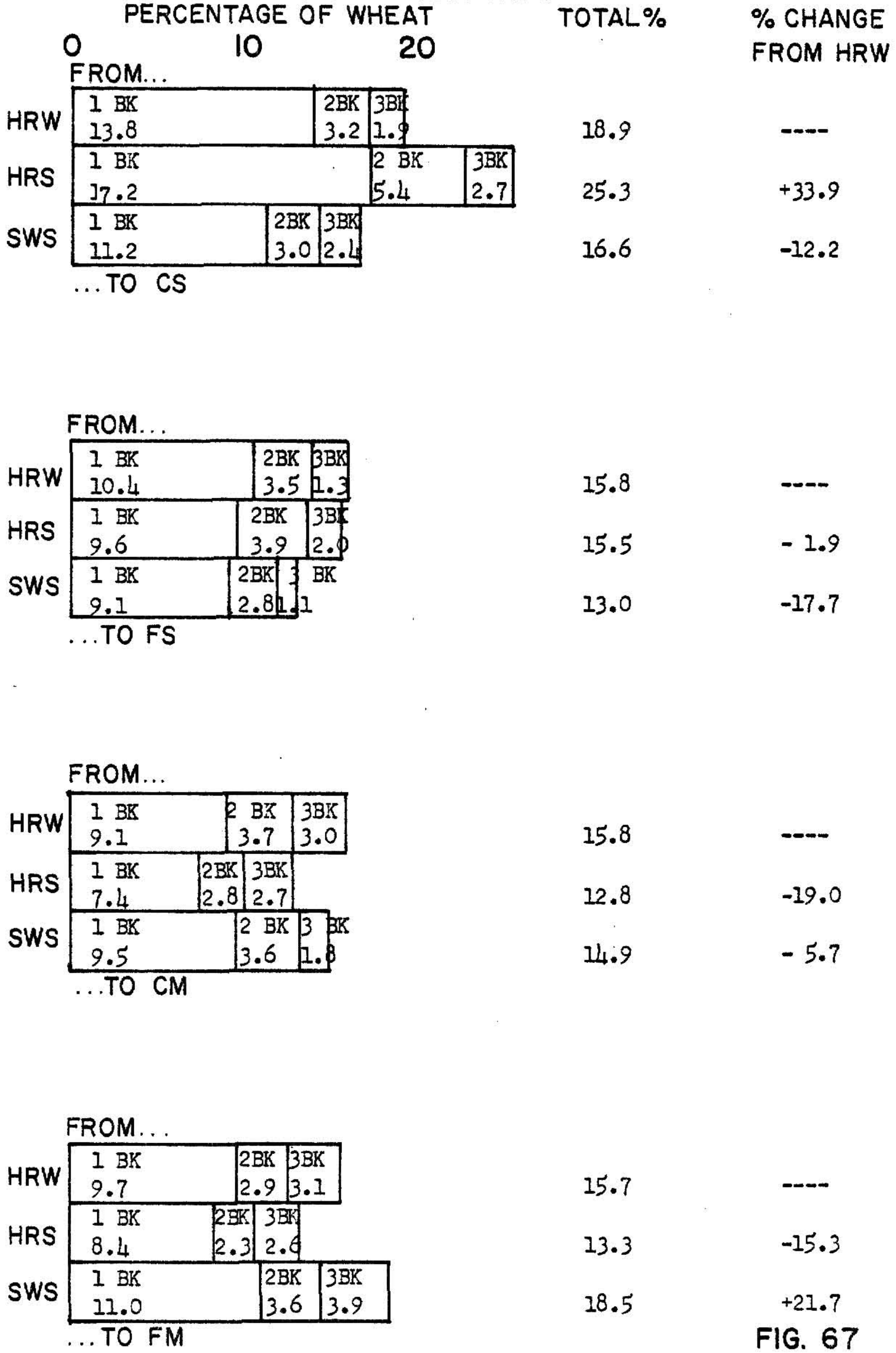


FIG. 67

These changes should affect the manner in which a mill is flowed, as machine loads would be affected by these variations in granulation.

Figure #66 shows a very similar change in size groups for the #2 Tests to those found in the #1 Tests.

Chart #67 for the #3 Tests again indicates the size grouping changes are similar between breaks.

These results indicate that for similar release percentages, the granularity changes in a similar manner between Hard Red Winter, Hard Red Spring and Soft White Spring.

Figures #68, #69 and #70 show how the three classes of wheat differ in size groupings when flour is included in the comparisons. The very large increase in flour production for Soft White Spring is quite evident.

Ash Content

A comparison of figures #16, #36 and #55 show differences in the ash distribution of the break release products.

The Hard Red Spring tests were the highest in ash content; Hard Red Winter was next lowest and Soft White Spring was lowest. This does not follow the wheat ash differences of 1.45% for Hard Red Spring, 1.65% for Hard Red Winter and 1.53% for Soft White Spring. The gradient obtained could be due to the differences between the ash of the bran and the ash of the endosperm.

The differences between the 3rd break bran ash and 3rd break fine midds for Tests #1 are:

Class	% Bran Ash	% FM Ash	Difference %
Hard Red Spring	3.57	.42	3.15
Hard Red Winter	4.50	.43	4.07
Soft White Spring	3.12	.36	2.78

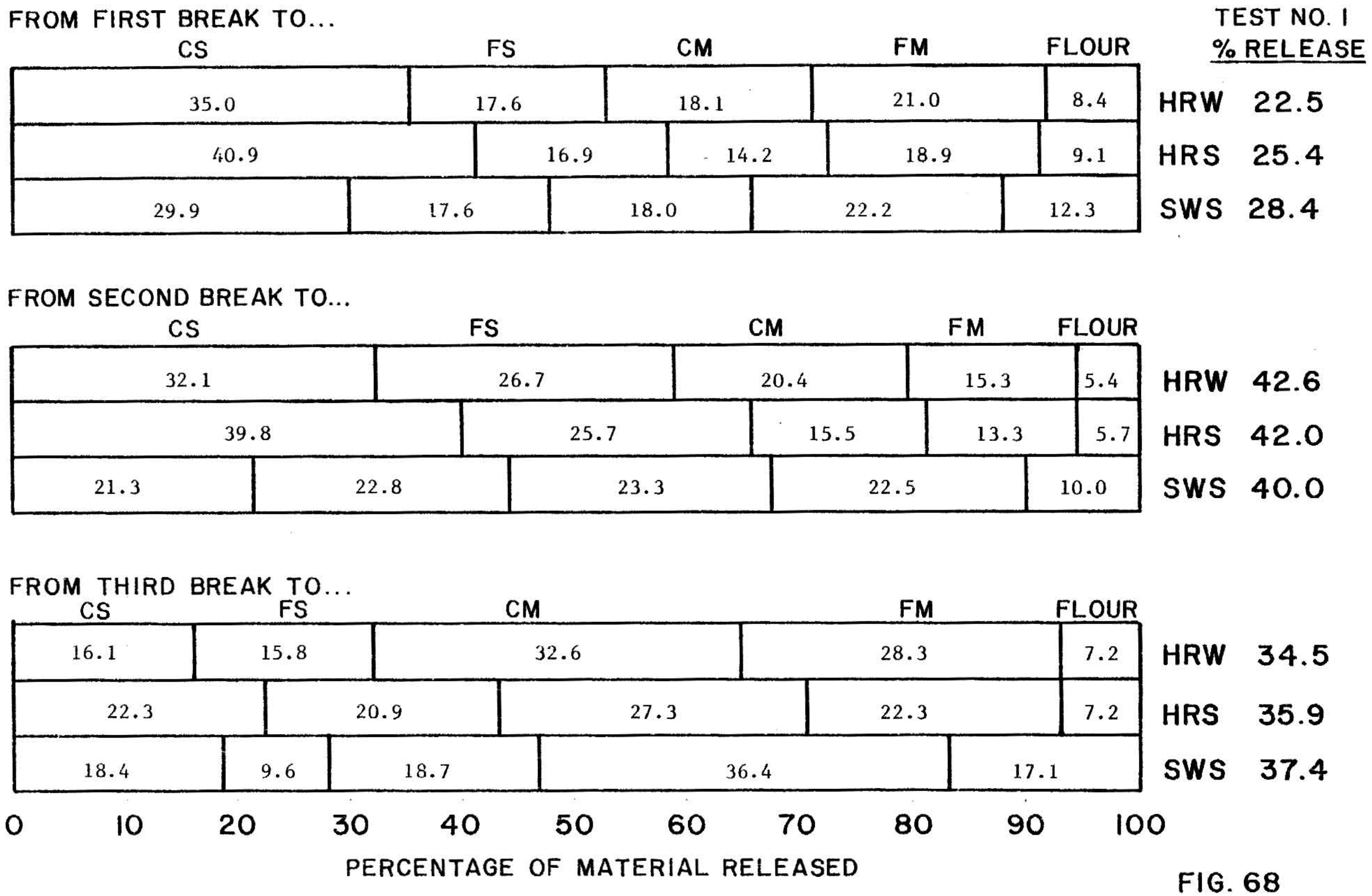

FROM FIRST BREAK TO...
CS
FS
CM
FM
FLOUR
TEST NO. I
% RELEASE
35.0
17.6
18.1
21.0
8.4
HRW 22.5
40.9
16.9
14.2
18.9
9.1
HRS 25.4
29.9
17.6
18.0
22.2
12.3
SWS 28.4
FROM SECOND BREAK TO...
CS
FS
CM
FM
FLOUR
32.1
26.7
20.4
15.3
5.4
HRW 42.6
39.8
25.7
15.5
13.3
5.7
HRS 42.0
21.3
22.8
23.3
22.5
10.0
SWS 40.0
FROM THIRD BREAK TO...
CS
FS
CM
FM
FLOUR
16.1
15.8
32.6
28.3
7.2
HRW 34.5
22.3
20.9
27.3
22.3
7.2
HRS 35.9
18.4
9.6
18.7
36.4
17.1
SWS 37.4
0
10
20
30
40
50
60
70
80
90
100
PERCENTAGE OF MATERIAL RELEASED

FIG. 68

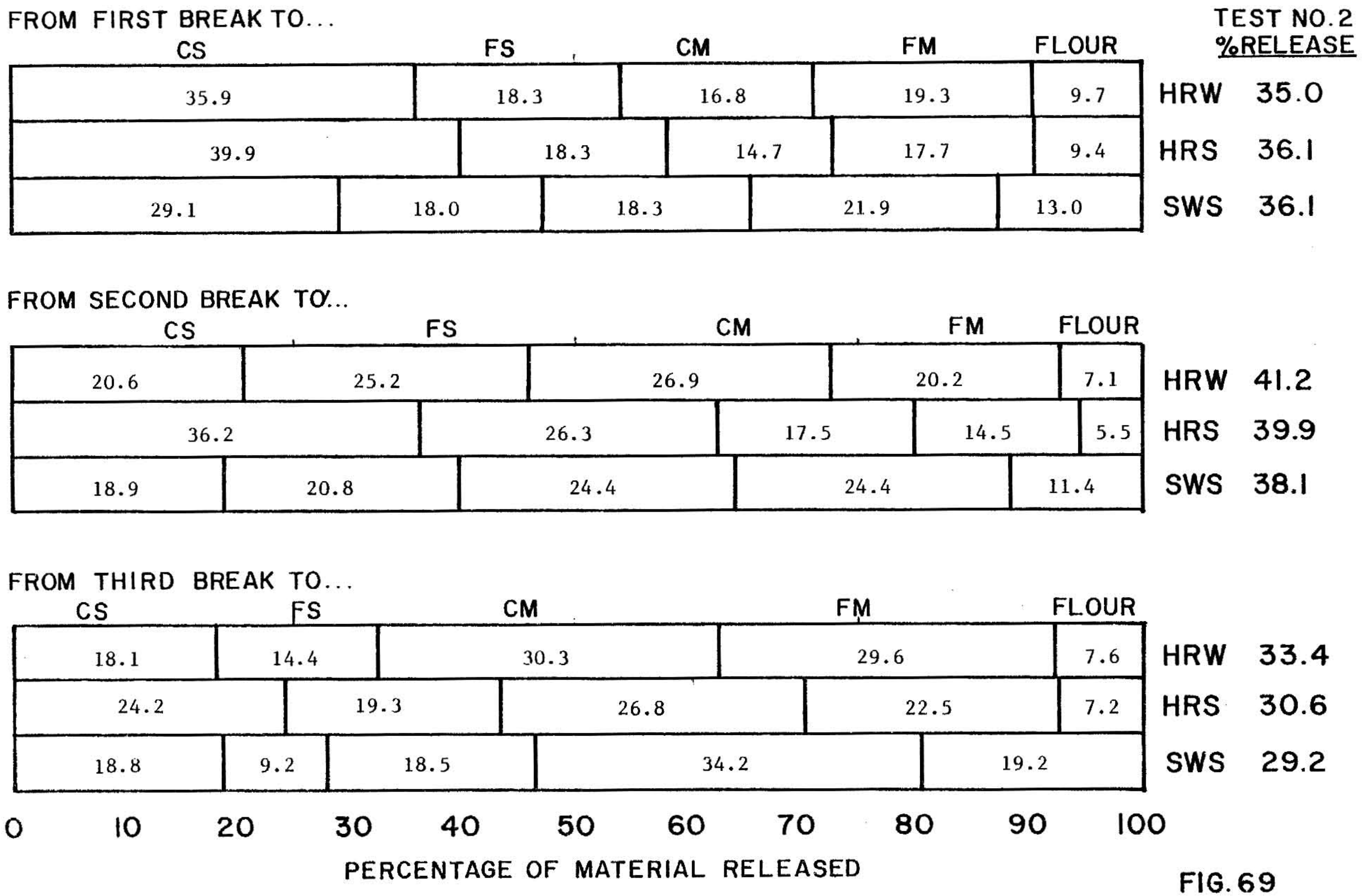

FROM FIRST BREAK TO...
CS
FS
CM
FM
FLOUR
TEST NO.2
%RELEASE
35.9
18.3
16.8
19.3
9.7
HRW
35.0
39.9
18.3
14.7
17.7
9.4
HRS
36.1
29.1
18.0
18.3
21.9
13.0
SWS
36.1
FROM SECOND BREAK TO...
CS
FS
CM
FM
FLOUR
20.6
25.2
26.9
20.2
7.1
HRW
41.2
36.2
26.3
17.5
14.5
5.5
HRS
39.9
18.9
20.8
24.4
24.4
11.4
SWS
38.1
FROM THIRD BREAK TO...
CS
FS
CM
FM
FLOUR
18.1
14.4
30.3
29.6
7.6
HRW
33.4
24.2
19.3
26.8
22.5
7.2
HRS
30.6
18.8
9.2
18.5
34.2
19.2
SWS
29.2
0
10
20
30
40
50
60
70
80
90
100
PERCENTAGE OF MATERIAL RELEASED

FIG. 69

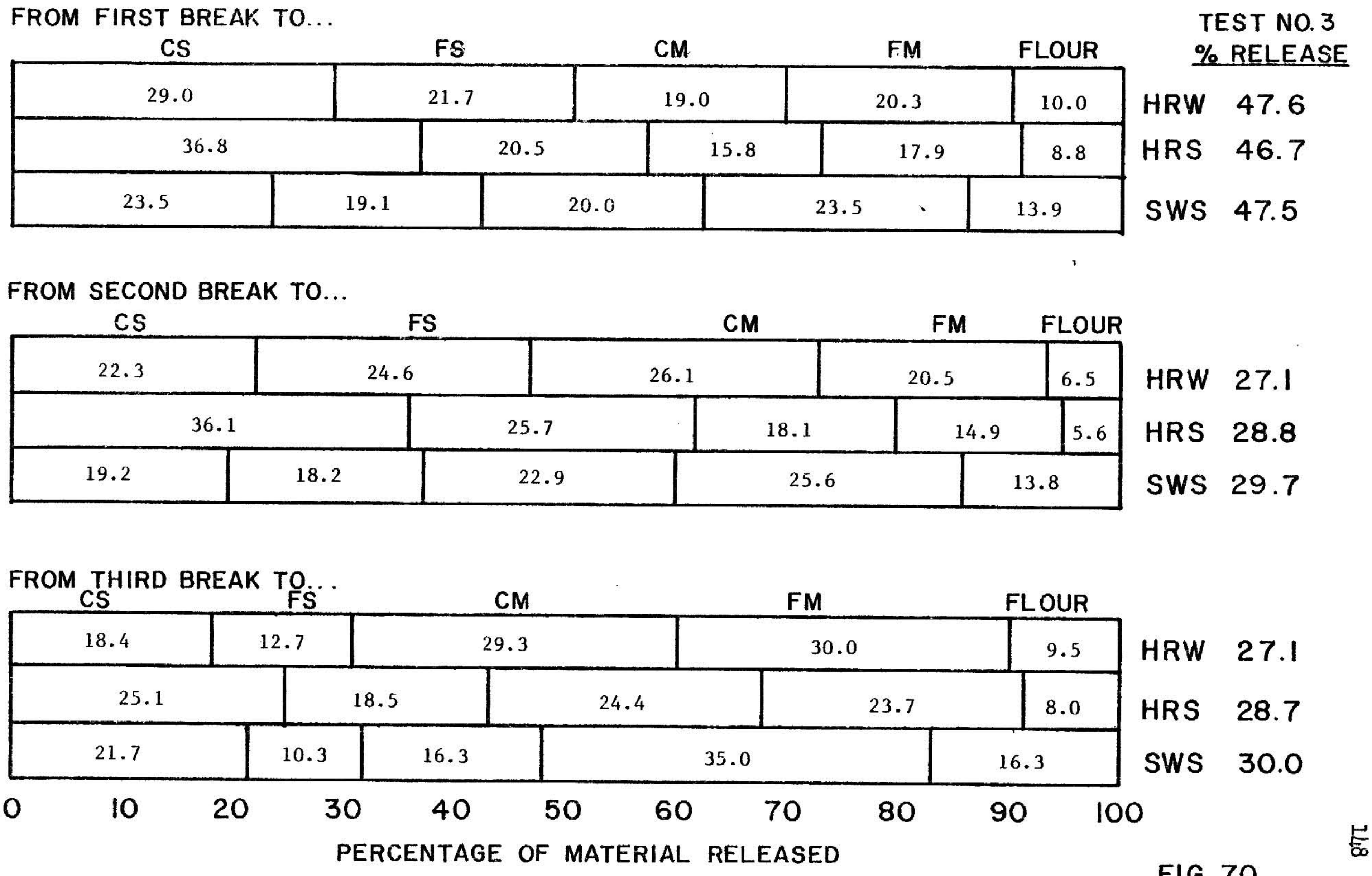

FROM FIRST BREAK TO...
CS
FS
CM
FM
FLOUR
29.0
21.7
19.0
20.3
10.0
36.8
20.5
15.8
17.9
8.8
23.5
19.1
20.0
23.5
13.9
TEST NO. 3
% RELEASE
HRW 47.6
HRS 46.7
SWS 47.5
FROM SECOND BREAK TO...
CS
FS
CM
FM
FLOUR
22.3
24.6
26.1
20.5
6.5
36.1
25.7
18.1
14.9
5.6
19.2
18.2
22.9
25.6
13.8
HRW 27.1
HRS 28.8
SWS 29.7
FROM THIRD BREAK TO...
CS
FS
CM
FM
FLOUR
18.4
12.7
29.3
30.0
9.5
25.1
18.5
24.4
23.7
8.0
21.7
10.3
16.3
35.0
16.3
HRW 27.1
HRS 28.7
SWS 30.0
0
10
20
30
40
50
60
70
80
90
100
PERCENTAGE OF MATERIAL RELEASED

FIG. 70

This does not substantiate that hypothesis as the Hard Red Winter has the highest bran to endosperm ash ratio.

The results could be due to the amount of high ash subaluerone material in each class. The differences in ash between Coarse Sizings from 3rd break and Fine Middlings from 3rd break for Tests #1 are as follows:

Class	C.S. % Ash	F.M. % Ash	Difference
Hard Red Spring	2.44	.42	2.02
Hard Red Winter	3.40	.38	3.02
Soft White Spring	2.42	.36	2.06

This substantiates the high ash gradient evidently present in the Hard Red Winter endosperm used in these tests. This has the effect of producing lower ash break release products than the Spring, despite a higher wheat and bran ash. As expected, the lower bran ash of soft wheat allows for lower ash break release products than either Hard Red Winter or Hard Red Spring.

The ash contents of the flours also reflect this same relationship of ash content with the Hard Red Spring flour being the highest, Hard Red Winter next highest and Soft White Spring the lowest in ash. This, of course, points out the worthlessness of ash as a quality indicator as the flours from each of these millings would be considered very acceptable for the special purposes for which they might be used.

Protein Content

The cumulative protein curves of break release products for Hard Red Winter and Hard Red Spring are quite similar in general characteristics. The Soft White Spring wheat curve is quite different, covering a broader range and having an "S" shape instead of a gentle upward swing.

The cumulative protein curves of flours shows a sharp upward swing for Hard Red Spring, a flat curve with late turn up for Hard Red Winter and a straight incline for Soft White Spring. Obviously the protein distributions follow different patterns in the three wheat classes tested.

SUMMARY AND CONCLUSIONS

Particle Size Distribution

For each wheat class tested, a distinct particle size distribution exists for each break passage and for each rate of extraction. This profile, when plotted by using the accumulated percent of material over the various screen sizes used, gives a reliable method of predicting the particle size distribution of any intermediate release by interpolation.

When the granularity of the thrus of the top sieve wire is plotted by accumulating the percent of thrus for each screen size, with the thrus of the 20LW being 100% in each case, a baseline curve is established that shows the relative distribution of particle sizes. This was quite uniform for each break over the full range of extractions. An increase in fineness was observed in all three wheat classes for the highest 1st break release percentage. It is possible that this change is brought about by the much reduced roll gap clearance, which would have a crushing or pulverizing effect on the endosperm.

In all cases the overall granularity decreases in size from 1st break to 2nd break and from 2nd break to 3rd break. This is undoubtedly caused by the manner in which the rolls are corrugated. The corrugations or flutes are more numerous, closer spaced, and have less depth on 2nd break than on 1st break and on 3rd break than on 2nd break. This will have the effect of producing smaller particles at given release percentages from 1st thru 3rd break.

The material balances give a visual presentation of how the wheat kernel is first subject to the breaking or separating operation to remove the endosperm; how that endosperm material can be separated in size groups; how those size groups change from one extraction rate to another and from one breaking operation to another; how the makeup of the sizing and reduction stocks is accomplished; the contribution to those parent stocks by the various breaks, sizings and middlings reductions previously performed; and how the sizings and reduction operations reduce the granular stock to finer middlings and the desired flours.

These types of presentations may be used as models for computer programming in the future to allow automatic control of the mill functions thru simulated material balance programming. They may also be of benefit as an education tool to help visualize the rather complex mill flow diagram as it relates to stock quantities.

Ash Content

The ash curves established for each test as an accumulative amount from lowest to highest ash for flour and for the total break release products indicate that a preferential selection of break releases can influence the ash distribution. It is assumed that these ash comparisons are an indication of the amount of bran intrusion in the products. This assumption is based on the logic that if the milling samples were uniform, any differences in ash content caused by a kernel to kernel ash difference or by the ash gradient within the endosperm of each wheat kernel would be canceled out. Therefore, any differences in ash curves obtained in this testing procedure must be due to the amount of the higher ash content bran being present.

The quality of flour, as it relates to freedom from bran intrusion, can be controlled by proper and predictable selection of break releases.

It was shown that a correlation exists between the amount of branny material released in the breaking process to the amount of branny material appearing in the flours milled from those released products as measured by ash.

No correlation was found between the three wheat classes on the best combination of break releases for ash. It would appear that each wheat class reacts differently to similar break extractions.

A possible predictor of overall ash results was found for the Hard Red Spring and Soft White Spring wheats using the total ash of the coarse sizings. This predictor did not work with Hard Red Winter in this test series.

Protein Content

The cumulative protein curves for the three classes of wheat are all influenced by the settings made on the break extractions. This was true for both the flours and break release products although the distinction was more noticeable with the flours. The same relationship existed between test results when using either flour or break release products.

It was found that the break settings producing the most desirable protein curve was not from the same test series for each class of wheat.

Ash/Protein Relationship

It was determined that the most favorable break setting for ash content might not be the most favorable setting for protein results.

There is a negative relationship in the changes that occurred in ash content and protein content in all cases. Suggestions for possible explanations of this negative relationship are given in the main text.

These results suggest that millers and bakers must continue their efforts to replace the ash test as a flour specification so that the miller can concentrate on endosperm protein manipulation. Protein forms the basis for many economic decisions and by using the wheats for their best protein efficiency, all persons in this important food chain should benefit. It should also be the effort in finding replacements for the ash specification that the new measuring stick not be just a reflection of ash but a genuine flour quality indicator.

SUGGESTIONS FOR FUTURE STUDY

The number of studies that might be made in regards to the effect of break extractions on granulation, ash and protein are plentiful.

Further studies directly in line with the one reported herein could involve an expansion of wheat types. This could be done on a basis of wheat ash contents, wheat protein contents and wheat hardness, as examples.

The same type of study shown herein might be expanded by including other procedures of analysis such as color testing, fiber analysis, air purification and various levels of microscopic examination.

Milling tests could be made on each individual stream rather than combining them for reduction as was done in this report. Milling tests could be scaled up by using the Miag Multomat or the Kansas State University pilot mill for a more complete mill analysis.

There are almost countless variables that would be interesting subjects of experimentation regarding rates of extractions. Most test work as been done in changing a variable and holding the extraction rate or possibly the roll gap constant. Very little work exists on how changing such variables as roll speed, differential, corrugation style, corrugation spiral, size of corrugation, feed rate, speed of feed material and roll diameters affects granularity, ash and protein using a range of extractions.

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ACKNOWLEDGMENTS

The writer wishes to express his sincere appreciation to Professor Eugene Farrell, major professor, Department of Grain Science and Industries, Kansas State University, for his suggestions, review and support of this research.

Appreciation is also extended to Professor Arlin Ward, Department of Grain Science and Industries, Kansas State University, for his constant sharing of new ideas thruout the years that has led to this research.

The writer is deeply grateful to his wife, Barbara, for the many hours required to edit and type this manuscript as well as lending encouragement and suggesting improvements as the work progressed.

VITA

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FLOUR MILL BREAK EXTRACTIONS

by

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B.S., Kansas State University, 1950

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 Industries

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1980

Three wheat classes representing commercial milling quality Hard Red Winter, Hard Red Spring and Soft White Spring were experimentally milled to determine how changes in break extraction rates affect the granularity, protein content, and ash content of the milled fractions.

Three combinations of break extractions were used which represent the ranges of extractions found in commercial milling practice. Each wheat class was milled with these same extraction rate combinations.

The results are shown in a variety of forms.

1. Flow sheets showing the percent release, percent extraction, percent protein and percent ash of each of the 33 products obtained from each milling.

2. Comparative granulation curves for the combined products of each break test.

3. Comparative baseline granularity curves for the released products of each break test.

4. Bar graphs depicting the percentage change of products from each break when extraction rates are changed.

5. Material balance bar graphs depicting the complete loadings to and from all parts of the flow for each test.

6. Cumulative ash calculations and graphs for all break release products.

7. Cumulative ash calculations and graphs for the flour portions only.

8. Cumulative protein calculations and graphs for all break release products.

9. Cumulative protein calculations and graphs for the flour portions only.

10. Cumulative protein graphs with products aligned in ascending order of protein content compared to cumulative proteins when products are aligned in ascending order of ash.

11. Comparative data in the form of graphs and charts showing the relationships of test results between wheat types.

Among the findings reported are the following.

1. Each break extraction setting for each break passage and for each wheat class gave distinctive, non-linear, granulation curves.

2. Particle size of the released products decreases from 1st break thru 2nd break to 3rd break. This is attributed to the increased fineness of the roll corrugations from 1st to 3rd break.

3. Within a wheat class, the relative particle sizes of the released products remain quite similar over a wide range of break extractions for each break passage.

4. For similar extraction rates on each break passage, the different wheat classes exhibited different degrees of fineness of the released products. This is attributed to the structural differences of the three wheat classes from vitreous in Hard Red Spring to soft in Soft White Spring with Hard Red Winter in a middle position.

5. Break extractions have an important function as concerns mill design, mill control and quality of the flours produced. Changes in break extractions affect load distributions as well as the ash and protein relationships of the released products. Finished flour quality as measured by ash and protein contents is also affected by break extraction rates.

6. A possible predictor of optimum break extraction settings for minimum ash content was found for Hard Red Spring and Soft White Spring wheats.

7. Optimum break extraction settings for low ash results will not produce the best protein spreads in the flours. Ash specifications as a quality indicator for flour have doubtful use and are perhaps counterproductive.

8. The differences in quality characteristics within the wheat endosperm structure are captured by the milling process thru gradual milling and the separation of products in the grading system. Break release schedules can affect these distributions of quality characteristics.

The basic work shown in this study suggests many subjects for future study. The relationships of breaking functions as they affect mill balance and product quality and how these functions are, in turn, affected by the many variables that are found in the wheats, the wheat preparation, the milling flow and the milling equipment specifications have not been adequately documented. A better understanding of these relationships will benefit all levels of the farm-to-table chain of wheat usage, but will be of particular interest to the converter.