A static run on the continuous processor was also conducted, and it was calculated that the apparatus (13.5-kw. input) would cook approximately 3 pounds of ground pork per minute (Table II).

Calculations. Weight of meat under copper rings (density = 0.034 pound per cubic inch), 0.52 pound.

Time of run = 10 minutes

$$\left(\frac{0.52 \text{ pound}}{10 \text{ seconds}}\right)(60 \text{ seconds/minute}) = 3.12 \text{ pounds per minute}$$

Table II. Results of Static Runs on Continuous Processor

Type of Circuit	Time, Sec.	Temp., ° F.
Low resistance	...	No cooking noticed
Direct pass matched	...	Warm, but did not cook
Multipass matched (wt. of meat approx. 3 lb.)		
A	[a]	
B[b]	10.4	Av. 120

[a] Meat cooked so rapidly that time was not recorded. Burning also occurred.
[b] Power input, 1.5 amperes, 9 kv.

Practical Evaluation of Results

Thus, the rate and uniformity of thermal energy increase that this unit can effect are its outstanding features. This allows a sample of meat to be sterilized without overcooking any portion of it. This could be applied to any situation where close temperature control without a gradient was necessary.

An approximate cost analysis indicated an electricity cost of $0.00328 per pound of meat against a steam cost of $0.00118 per pound of meat based on a 2000-pound batch. Because of the sliding scale for electricity, a large volume of meat would bring the costs closer together. In addition, the dielectric continuous process would not involve any losses between batches as would the steam. The processing cost using steam and the amount of water, electricity, air, and cleanup associated with this process might bring the cost of processing by steam closer to that of the dielectric process, because the dielectric process should use less cleanup, water, and air.

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Received for review July 30, 1953. Accepted August 24, 1953. Journal Paper 75, American Meat Institute Foundation. Research sponsored by the Quartermaster Food and Container Institute for the Armed Forces, assigned number 440 in the series of papers approved for publication. Views and conclusions contained in this report are those of the authors and are not to be construed as necessarily reflecting the views or endorsement of the Department of Defense.

Absorption Qualities of Feeds Estimated as Basis for Molasses Use

FEED EVALUATION

Determination of Absorption Capacity and Fibrous Material of Pith and Certain Feed Constituents

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The usefulness of agricultural residue materials employed as ingredients in commercial livestock feeds depends not only on their nutrient value but also on their relative absorption capacity and particle-size distribution. Their absorption capacity is affected adversely by fiber characteristics, small particles, and dirt contamination. The absorption value is of great importance today, when feed manufacturers are being urged to increase the molasses content of all ruminant feeds.

The Northern Regional Research Laboratory has developed procedures for evaluating both absorption capacity and particle-size distribution. Pith separated from sugar cane bagasse was used in the development of these methods. Most of the equipment and apparatus needed may be purchased directly or fabricated from supplies sold by laboratory supply companies.

Other possible tests of quality, such as molasses absorption, bulk density, and drying rate, were investigated but were rejected as unreliable.

Absorption Capacity

The test of absorption capacity utilizes the principle of capillary action to determine the relative amounts of water that air-dry cellulosic materials can absorb. The material is deaerated by compression

To increase the molasses content of feeds, as feed manufacturers desire, a supplement of higher absorption capacity than present fibrous feed supplements is needed. Methods were developed for determining the relative absorption capacity and particle size of present or potential fibrous supplements, to help solve this feed problem. The particle size of fibrous absorbents affects absorption capacity and pelleting characteristics; it is satisfactorily determined by the Bauer-McNett method of fiber fractionation. Replicable results are obtained. Pith particles from sugar-cane bagasse or cornstalks are suggested as having some feeding value and of probable high absorption capacity. Pith obtained in various ways from bagasse has absorption capacities much greater than those of ingredients now in use, and its particle size is of the general order of present ingredients.

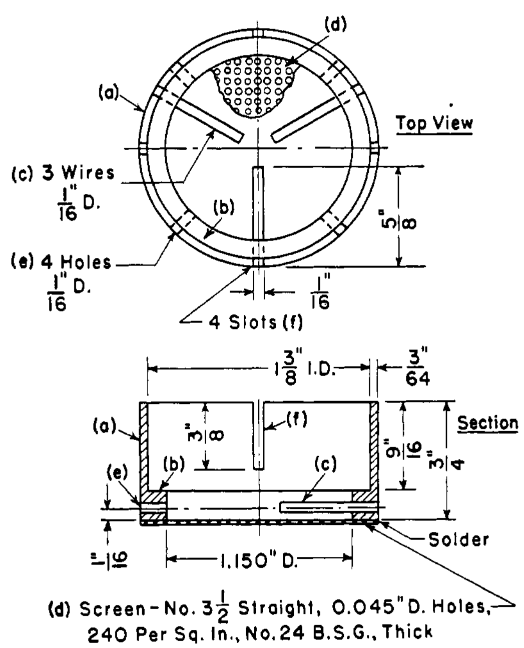
and allowed to absorb water, and the volume of water absorbed is measured. The test gives reproducible results and significant differences in absorption values between various samples of bagasse pith can be determined. No relationship has been established between the absorption value of pith for water and for molasses under small scale test conditions because of the difficulty of reproducibly measuring the absorption of molasses. However, laboratory tests suggest that the water value can serve to indicate approximately the amount of molasses that a given material might absorb.

Apparatus The apparatus used for the absorption test consists essentially of a water-holding system and a machined brass cap of special design, the bottom of which is covered with perforated metal screen. The cap is made to fit over 35-mm. glass tubing. Auxiliary equipment includes a laboratory balance, a press capable of producing a pressure of 15,000 pounds per square inch, and a pellet mold 1.125 inches in diameter. This mold produces pellets which expand to a diameter of 1.14 inches when released.

The brass cap, shown in Figure 1, *a*, is

Figure 1. Apparatus

All parts brass



designed to support the pellet while it is absorbing water. The pellet fits inside ring *b*, whose inside diameter is 1.15 inches; the larger diameter is needed to provide room for expansion of the pellet. The pellet rests on three brass wires or pins, *c*, $^{1}/_{16}$ inch in diameter, which are inserted about $^{1}/_{16}$ inch from the bottom of the ring. The pins keep the pellet from resting on the bottom of the cap, so that the occluded air can escape through the vent holes, *e*, and permit the pellet to be wetted uniformly across the bottom. A perforated metal screen, *d*, having holes 0.045 inch in diameter, is soldered to the bottom edge of the cap and ring. Four small vent holes, *e*, $^{1}/_{16}$ inch in diameter, are drilled into the bottom edge of the cap in the same plane in which the three pins are located. Four slots, *f*, cut in the upper part of the cap, provide a slight compression on the end of the glass tube.

The water-holding system (Figure 2) consists of an open glass cylinder, approximately 8 inches long and 1.75 inches in diameter, and a standard 50-ml. leveling buret. The bottom of the glass cylinder is closed by a rubber stopper which is pierced by a glass tube. A rubber hose connects this tube to the bottom of the buret. A small horizontal scribe mark is filed into the outer surface of the water-holding glass cylinder 2 or 3 inches from the top.

Preparation of Sample All samples to be tested were conditioned at least 16 hours at 73° F. and 50% relative humidity in order to produce a material having a uniform moisture content. The equilibrium moisture content obtained was in the range of 7 to 10%.

Preliminary tests have shown that the absorption test can best be made with a sample weighing 3 grams. In forming the pellet by compression, a pressure of 15,000 pounds per square inch was adopted as optimum. At this pressure, most of the materials formed firm, compact pellets which had little tendency to disintegrate on handling.

Method Three grams of the preconditioned material to be tested are placed in the pellet mold and pressed at 15,000 pounds per square inch to form a pellet. This pellet is placed on the three small pins at the bottom of the brass cap, and the 35-mm. glass tube is inserted over and around the pellet.

Water is then added to the water-holding system as shown in Figure 2. The buret is raised or lowered until the meniscus in the large tube is aligned with the scribe mark and the reading of the buret is recorded.

The small glass tube, cap, and pellet are then lowered into the water cylinder, 1.75 inches in diameter and supported by a clamp about $^{1}/_{4}$ inch above the adjusted surface of the water. The buret is elevated carefully until the water rises around the cap, but only to the upper level of the pins supporting the pellet. Care must be taken that the water does not rise too rapidly and float the pellet out of the supporting ring. The level must be brought up quickly enough, however, to obtain even contact across the bottom of the pellet.

The pellet begins to absorb water as soon as contact is made. The buret now must be raised steadily to maintain the water level in the tube at the pins. The pellet expands upward as it takes up water. (If the pellet becomes tilted and binds on the side of the tube, the absorption value thus indicated is generally low and must be disregarded.)

The completion of absorption is judged visually by the appearance of the pellet and the relative degree of movement of the water level in the buret. The time required for maximum absorption varies greatly with the type of material. It is general practice to hold the water in contact with the pellet for 1 minute after the absorption appears to be complete. The test should be complete in about 2 minutes, but malt sprouts required as long as 50 minutes.

When the absorption is completed, the buret is lowered and the meniscus is again aligned with the scribe mark. A buret reading is taken and the difference between the initial and final reading is recorded as the amount of water absorbed by the 3-gram sample. The absorption apparatus at the completion of the test is shown in Figure 3.

Discussion of Results Both wet-separated and dry-separated bagasse piths were used. Wet-separated bagasse pith was obtained by subjecting whole bagasse to a rubbing action in a water suspension to loosen the pith from the fiber, and pumping the two components over a screen for separation.

Dry-separated pith was obtained either by direct screening of dry bagasse or by subjecting the bagasse to a hammering action prior to separating the dry components by screening. The quality of both the separated fiber and pith derived by this method was inferior to that obtained by the wet process.

The materials actually used for this evaluation of absorption capacity were:

Three types of pith obtained from the wet separation method.

Samples of dry-screened pith supplied by various sugar companies.

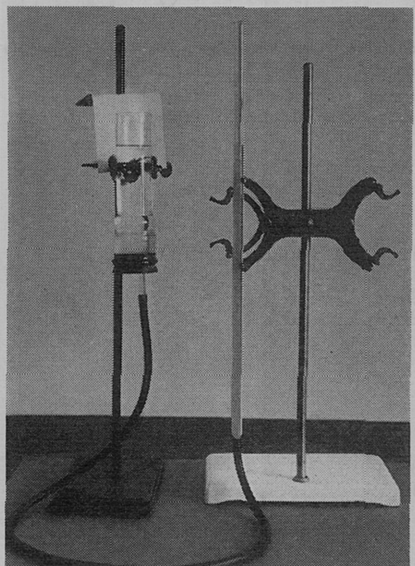
Commercial absorptive materials used by several large feed processors, such as wheat and elevator dust, pin oats, barley dust, ground grain screenings, extracted soybean meal, cottonseed meal, and dehydrated alfalfa meal.

One of the first problems was the possible effect of preliminary drying temperature on both the absorption rate and capacity of wet-screened pith. To check this, a series of samples of wet-screened pith was dried to constant weight in ovens, at 10° C. intervals from 80° to 120° C., and conditioned for 16 hours to secure a uniform moisture content.

Differences in temperature of drying did not affect the total absorption capacity, but the time required for maximum absorption increased sharply when the materials had been heated, to constant weight, above 90° C. If the material had been dried uniformly to a moisture content of approximately 10% rather than to constant weight, the slower rate of absorption would not have been encountered because the changes in rewetting characteristics of cellulosic material occur in the latter stages of drying.

A study also was made to determine whether duplicate results could be obtained from the same sample and whether small differences in absorption capacity could be determined. The average absorption capacity for six samples of both single- and double-screened pith is shown in Table I. Results were obtained in duplicate, and the small difference in absorption capacity between the two types of pith was found to be significant. The absorption capacity of the pith passing through the first screen was improved by removing the short fiber bundles by a second screening. These short fiber bundles were not as absorbent as the rescreened pith.

Figure 2. Water holding system



The absorption capacity of pith obtained from Hawaiian, Puerto Rican, and Florida bagasse by three different schemes of wet separation is shown in Table II. These samples show small differences in absorption. The high value of 29.5 grams of water absorbed was obtained by a preliminary double screening and special de-watering process. The pith from Puerto Rico has the highest absorption capacity and that from Florida the least. The time for complete absorption was from 40 to 100 seconds. The density of the air-dry pith varied from 2 to 3.7 pounds per cubic foot.

The absorption capacity of dry-screened pith (Table II) was considerably lower than that of wet-screened pith, but the time required for absorption was about the same. The density of the dry-screened pith varied from 4.2 to 5.7 pounds per cubic foot.

The absorption capacity of representative commercial feed absorbents is shown in Table III. Most of the materials were rather dense and some contained residual oil. These materials had low and varying absorption values. The time required for maximum absorption was, however, high, some material requiring 50 minutes. Extracted linseed meal never appeared to become completely saturated. The density of the commercial absorbents ranged from 8 to 40 pounds per cubic foot.

As an index of the relation between molasses and water absorption, a mixture of barley dust, having an absorption capacity of 9, and blackstrap molasses in 50:50 proportions was found to be sticky after 15 minutes of mixing. A pellet formed from the mixture at 400 pounds per square inch extruded a slight amount of molasses during pressing. On the contrary, a mixture of wet-separated bagasse pith, having an absorption capacity of 26, and blackstrap molasses also in 50:50 proportions was not sticky. A pellet formed at 4000 pounds per square inch did not extrude molasses during the pressing operation.

Particle-Size Classification of Feeds

The fiber particle size of feeds can be determined readily by separating the feeds into four fractions according to size.

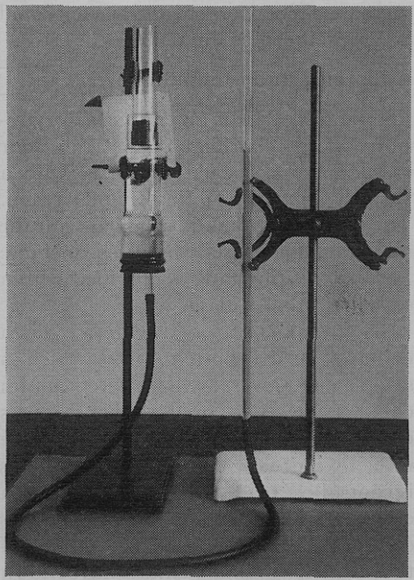


Figure 3. Absorption apparatus at completion of test

This analysis should not be confused with the standard crude fiber analysis, which is a measure of the nondigestible material in feedstuffs with no regard to the size or physical proportions of the insoluble material. The term "fiber" used in this report refers to that part of the agricultural residue material having elongated, fibrous physical character.

As a feed containing large amounts of either fine or coarse fiber particles does not have as great absorption capacity as one having small amounts of both, feed manufacturers could use a rapid method of determining the fiber particle size to advantage.

This fiber particle-size separation can be achieved in a dilute water suspension, utilizing four cascading tanks, fitted with successively smaller screens. The fraction retained on each screen is dried, weighed, and reported as per cent of the original dry sample. The combined percentages are an index of the total actual fiber. Losses represent solubles. This is a simple, quickly executed test which appears to be a sensitive and reliable

Table I. Absorption Capacity of Two Closely Related Hawaiian Pith Samples Obtained by Wet Screening (Scheme 1)

Grams of Water Absorbed per 3-Gram Sample	
Single pass through screen	Second pass through finer screen
25.3	26.2
25.9	26.6
23.9	27.8
25.0	27.4
24.2	27.3
26.9	27.8
Av. 25.2	27.2

Screen was used to separate pith from fiber.

measure of fiber content and as such could be used in feed evaluation.

Apparatus and Method The Bauer-McNett classifier (Figure 4) has given satisfactory results. This classifier consists of four cascading tanks, each equipped with a vertical agitator rotating at 600 r.p.m. The top or first tank is supplied with the screen having the largest mesh opening. Each succeeding tank is provided with a screen of smaller mesh.

Each tank is provided with a $^3/_4$-inch opening in the bottom, into which a sample cup, covered with a tared muslin cloth, is screwed. Small rubber stoppers close the opening during the run. The rate of water flow through the four tanks is controlled at 3 gallons per minute by a constant-head inlet tank. This flow is continued during the entire 15 minutes of the test. Preliminary studies have shown that satisfactory results can be obtained by using 8-, 14-, 100-, and 200-mesh screens.

Ten grams of sample (oven-dry basis) are mixed with 1000 ml. of water and the mixture is slowly introduced into the top cascade tank. The vertical agitator keeps the sample in suspension and prevents the material from collecting on the screen. The particles smaller in size than the screen opening are free to move down into the next tank, while the larger ones are retained. At the end of 15 minutes, the water is turned off and the agitators are operated until the water ceases to flow over the bottom screen. The stoppers at the bottom are removed and the material remaining in the tank is washed onto the tared cloth. These cloths are pressed to remove excess water, dried, and weighed.

That fraction of fiber retained on each cloth is reported as per cent of the original oven-dry weight. The amount passing through the 200-mesh screen was found to be mostly water-solubles and is designated as loss.

Discussion of Results Fiber classification data for single-screened pith, double-screened pith, tailings or fine fiber, and combinations of the three are listed in Table IV. The Bauer-McNett classifier was able to detect the variation in fiber content brought about by carefully blending the dry pith and fine fiber listed above.

Additional data on fiber classification of pith obtained from Hawaiian, Puerto Rican, and Florida bagasse by three different techniques of wet-separation methods are listed in Table II.

Scheme 1 pith appeared to have the least amount of fiber retained on the +8-mesh and the most on the −14,

Table II. Data on Absorption Capacity and Particle-Size Classification of Bagasse Pith

	Absorption			Particle-Size Classification, Bauer-McNett Analysis Based on Sample as Received, % Retained on Each Screen				
	Apparent density, lb./cu. foot	Av. absorption, g. water/3-g. sample	Time for absorption, sec.	+8-mesh	−8-mesh +14-mesh	−14-mesh +100-mesh	−100-mesh +200-mesh	Loss
Wet-separated bagasse pith prepared by NRRL								
Scheme 1								
Hawaiian bagasse	2.6	26.0	40	3.8	23.0	68.2	2.0	3.0
Hawaiian bagasse specially screened	2.0	29.5	50	2.9	18.4	65.6	8.0	5.1
Puerto Rican bagasse	2.2	25.8	58	6.9	21.2	66.2	0.5	5.2
Florida bagasse	2.5	24.3	42	3.4	18.7	71.6	0.3	6.0
Scheme 2								
Hawaiian bagasse	3.0	24.5	42	2.0	13.3	72.6	9.2	2.9
Puerto Rican bagasse	3.3	26.2	50	10.8	37.1	44.0	0.6	7.5
Florida bagasse	3.5	23.1	39	6.1	28.5	55.0	2.1	8.4
Scheme 3								
Hawaiian bagasse	3.4	24.9	68	22.3	28.6	39.7	2.5	6.9
Puerto Rican bagasse	3.3	26.2	100	16.8	22.5	48.1	3.9	8.7
Florida bagasse	3.7	25.5	59	19.9	25.8	42.9	3.1	8.3
Dry-screened pith from various sugar companies								
Company A dehydrated fines	4.8	15.3	60	27.9	26.3	38.2	1.8	5.8
Company A screen dust	5.4	13.6	110	25.6	23.7	43.4	2.2	5.1
Company A dust from dust collector	4.2	14.6	111	35.1	23.4	40.3	1.2	0
Company B 40-mesh dust	4.5	13.7	...	0.3	0.5	60.4	16.5	22.3
Company B screened pith	5.7	20.3	...	9.1	31.2	56.3	0.6	2.8
Company E Rotex screened, 10-mesh	4.7	21.9	...	24.6	22.6	43.4	3.0	6.4

Table III. Data on Absorption Capacity and Particle-Size Classification of Feed Absorbents Used in Livestock Feed

	Absorption			Particle-Size Classification, Bauer-McNett Analysis Based on Sample as Received, % Retained on Each Screen				
	Apparent density, lb./cu. foot	Av. absorption, g. water/3-g. sample	Time for absorption, sec.	+8-mesh	−8-mesh +14-mesh	−14-mesh +100-mesh	−100-mesh +200-mesh	Loss
Alfalfa meal, 17% dehydrated	18.5	7.7	400	0.2	1.1	43.0	8.3	47.4
Barley chaff	15.0	8.9	210	0.2	1.5	74.3	8.4	15.6
Barley dust	13.1	10.6	250	0.1	0.8	57.5	12.7	28.4
Beet pulp	14.6	14.4	270	84.7	8.2	2.0	0.1	5.0
Cottonseed meal	33.0	6.5	500	6.8	16.8	36.4	5.9	52.1
Gluten feed	25.7	6.8	27	2.2	12.6	40.6	2.7	41.9
Linseed meal, extracted	30.4	8.2	...	0.6	11.0	52.7	1.0	34.7
Malt sprouts	15.9	14.9	3200	21.9	24.7	16.7	0.2	36.5
Oat feed, No. 9 or B grade	18.7	7.9	25	1.9	22.2	46.8	2.2	26.9
Pin oats, hulls, and dust	8.0	11.7	160	3.7	10.7	69.7	6.6	10.0
Oats, pulverized	24.8	5.5	1860	...	...	...	...	...
Screenings, ground grain	19.1	6.7	63	0.5	2.5	67.4	6.1	23.5
Screenings, lightweight No. a	16.8	8.2	25	0.2	3.1	50.5	12.3	33.8
Screenings, lightweight No. b	17.5	7.7	45	0.2	2.6	58.4	6.7	32.0
Screenings, soybean	22.7	12.0	260	0.1	9.2	63.9	4.4	22.4
Soybean meal, extracted	40.3	6.0	40	11.6	36.4	21.6	0.4	30.0
Wheat bran	11.4	11.4	82	11.5	49.5	8.9	0.9	29.2
Wheat and elevator dust	10.0	13.6	75	2.2	0.5	65.0	13.1	19.3
Wheat hulls and dust	14.4	11.1	65	0.1	1.3	49.7	14.4	34.4

+100-mesh, while scheme 3 pith had most on the +8 and least on the −14, +100-mesh. The loss (solubles) during the analysis varied from 3 to 8.7%.

Considerable amounts of fiber were obtained on the +8-mesh screen from most of the dry-screened pith samples. The pith from company B's 40-mesh dust contained very little fiber on the +8-mesh. The loss during the analysis varied from 0 to 22.3%.

To relate the absorption capacity of pith to fiber content, the amount of residual fibers in pith has been arbitrarily defined as the percentage retained on the +8-mesh screen. Only a general correlation exists between this +8-mesh value and the absorption value. The best agreement seems to be between the absorption capacity and the sum of the percentages retained on the +14- and +100-mesh screens. This reflects the effect of the dirt and fines as well as fibers on the absorption capacity.

Fiber classification data for various feed absorbents used in livestock feeds are listed in Table IV. Most of these absorbents were finely ground and, therefore, very little fiber was retained on the +8- and −8, +14-mesh screens. High losses, from 5 to 52%, were noted for most of these absorbents. The water discharged from the +200-mesh screen was cloudy, showing some of the materials to be soluble in water or reduced to colloidal suspension.

The cold water solubility of commercial absorbents having the highest absorptive capacity is listed in Table V. The solubility varied from 4% for beet pulp to 41% for malt sprouts. These values are considerably higher than that obtained for wet-separated bagasse pith, which averaged around 2 to 3%. Most of the sugars and other solubles were removed prior to and during the wet separation.

Summary and Conclusions

A method developed for determining the absorption capacity of feed ingredients, including pith, gives statistically significant results.

The absorption capacity of pith from Hawaiian, Puerto Rican, and Florida bagasse as measured by three different techniques of wet separation was of the same general order. Absorption values were considerably higher for wet-screened than for dry-screened pith. Dry-screened pith contained more fiber and dirt, which contributed to the lower absorption value. The time for complete absorption was practically the same for both piths. The density of wet-screened pith was one half to two thirds that of dry-screened pith.

The absorption capacities of the commercial feed ingredients were found to be from one third to one half that of wet-screened pith. Absorption capacity appeared to vary inversely with the density, which varied from 8 to 40 pounds per cubic foot. Most commercial absorbents required much longer time for attaining complete absorption than pith. Wet-screened bagasse pith required 40 to 100 seconds, whereas one commercial absorbent, malt sprouts, required 50 minutes.

A 50:50 mixture of barley dust, absorption value 9, with molasses was sticky and extruded molasses on forming a pellet at 400 pounds per square inch. A similar composition using wet-screened pith, absorption value 26, was not sticky and did not extrude molasses during pelleting even at 4000 pounds per square inch.

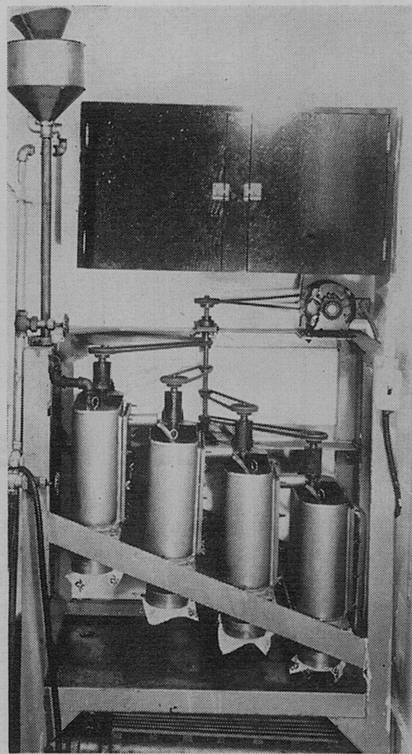


Figure 4. Classifier assembly

The Bauer-McNett method of particle-size classification was used successfully in classifying wet-screened and dry-screened bagasse pith samples. Samples, having large amounts of fiber retained on the +8-mesh and −8,+14-mesh screens, generally had a low absorption capacity, as did samples having very high amounts of material on the +200-mesh screen, owing to large amounts of dirt and ruptured pith cells.

Most commercial absorbents were received as pulverized samples, so that only small amounts of fiber were retained on the +8- and −8,+14-mesh screens. Losses due to water solubility were high.

Received for review August 17, 1953. Accepted September 3, 1953.

Table IV. Particle-Size Classification Study on Hawaiian Bagasse Pith and Short Fiber

(Bauer-McNett method)

	% Retained on Screens Based on Original Sample				
	+8-mesh	−8-mesh +14-mesh	−14-mesh +100-mesh	−100-mesh +200-mesh	Loss
Single-screened pith	2.8	14.3	69.8	11.7	1.4
Double-screened pith	6.6	29.0	61.0	1.9	1.5
Combination of single- and double-screened pith	4.1	20.0	66.8	8.4	0.7
Short fibers, removed from pith by riffle	12.7	35.9	48.2	1.7	1.5
Combination of all pith and short fiber	7.2	23.5	61.0	6.6	1.7

Table V. Cold Water Solubility for Feed Absorbents Having Highest Absorption Capacity

	Density, Lb./Cu. Foot	Av. Absorption, Grams Water/3-Gram Sample	Cold Water Solubility, 24 Hours, %	Bauer-McNett Classification Based on Sample as Received, % Retained on Each Screen				
				+8-mesh	−8-mesh +14-mesh	−14-mesh +100-mesh	−100-mesh +200-mesh	Loss
Wheat and elevator dust	10.0	13.6	11.6	2.2	0.5	65.0	13.1	19.3
Wheat hulls	14.4	11.1	14.6	0.1	1.3	49.7	14.4	34.4
Pin oats and dust	8.0	11.7	8.2	3.7	10.7	69.7	6.6	10.0
Soybean screenings	22.2	12.0	17.0	0.1	9.2	63.9	4.4	22.4
Beet pulp	14.6	14.4	4.0	84.7	8.2	2.0	0.1	5.0
Malt sprouts	15.9	14.9	40.8	21.9	24.7	16.7	0.2	36.5
Wheat bran	11.4	11.4	25.9	11.5	49.5	8.9	0.9	29.2
Pith from Hawaiian bagasse, scheme 1	2.6	26.0	2.9	3.8	23.0	68.2	2.0	3.0