RECOVERY AND REUSE OF WASTEPAPER FROM SHREDDED HOUSEHOLD TRASH

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ABSTRACT

Describes the research and development of the dry process originated at the Forest Products Laboratory for separating wastepaper from shredded household trash. The process, based on air classification, provides for removal of thermoplastic films. It also permits separation of the wastepaper by grade. Indications are that the recovered paper can be used successfully in a variety of products.

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By

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Introduction

Throughout its history, the mission of the Forest Products Laboratory has been to conduct research directed toward wiser and more efficient utilization of wood, and thereby aid in conservation of the Nation's forest resources. Realizing that forest products are discarded at some point, the Laboratory became interested in recycling. Paper was of prime concern because it is a forest product that is often discarded after a single use; furthermore, the recycling rate was steadily declining in the paper industry, averaging only slightly above half of the rate during the mid-1940's. This declining paper recycle rate is associated with an uneconomic handling, sorting, and transportation system that depends on a large amount of hand labor. Research into new concepts was almost certain to produce beneficial results.

To produce a material suitable for recycle, individual materials in the trash must somehow be separated. But how? Individuals in their households could separate paper, glass, and metals from their trash; office workers could direct paper by grades to specified containers; and supermarkets could keep their containers separated from produce waste. All of this could lead to a greater utilization of wastepaper, glass, and metals. Unfortunately, the general public does not seem enamored with such tasks, and we are forced to develop separation techniques for much of our solid waste. After due consideration, the Forest Products Laboratory concentrated on a dry separation system using household trash as the source material.

Pilot-Scale Demonstration Plant

Since 1967 the City of Madison, Wis., has been operating a refuse reduction plant where household trash is shredded, the ferrous metals have been recovered since February 1972, and the remainder used for landfill. In the fall of 1970, the Forest Products Laboratory cooperated with the City and some equipment manufacturers to initiate a pilot-scale demonstration project at the plant.

Flexibility was of utmost importance in our design, which included such operations as air classification, drying, screening, conveying, and baling. Equipment was so installed that 14 different continuous flows could be obtained by simple relocation of the equipment (fig. 1). By the fall of 1971, all equipment except the dryer and its associated feeder and cyclone was installed. The

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

absence of the dryer severely restricted our choice of continuous flows, although it was eventually installed during the spring of 1973.

An overall view of all equipment is shown in figure 2. The three cyclones and the dryer were installed to be stationary while the air conveying lines, belt conveyors, baler, screen, and air classifier were installed to be moved easily.

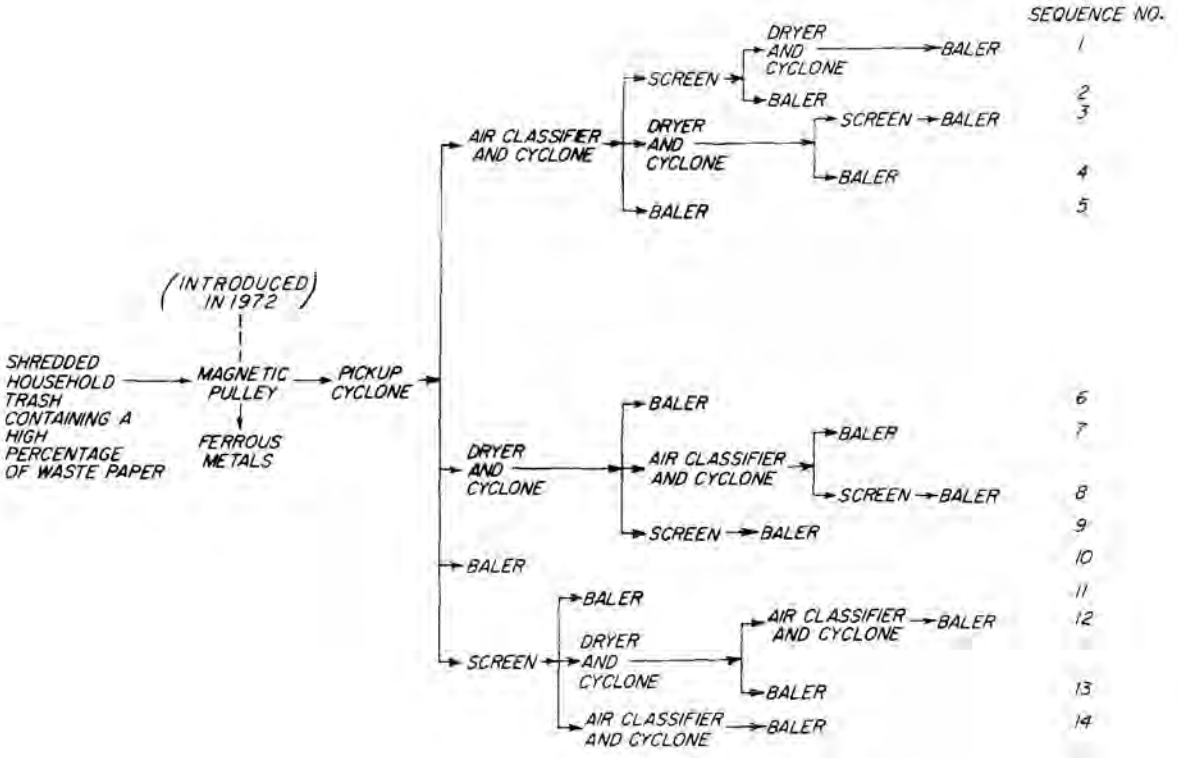

Figure 1. - Some alternative sequences for continuous flow operation of the pilot plant - alternatives made possible by simple relocution of equipment.

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Preliminary Trials

Initially. two objectives were established. The first was to determine the effectiveness of air classification to separate the paper products from shredded household trash. The second was to determine the effectiveness of air classification to separate the recovered paper products into various components to obtain various grades of pulps. Most of our early studies of the basic separation of the paper products from the other materials in shredded household trash were made using continuous flow sequence No. 2, figure 1. This involves shredding, ferrous metals separation, vacuum pickup, air classification, screening, and baling. We found the basic separation could be accomplished easily and successfully with this arrangement.

The main problem was that the separated papers were heavily contaminated with film and foam plastics, because these materials behave the same as papers during air classification. This problem was solved with the development of a dry process of separation, based on heat shrinking the thermoplastics followed by either air classification or screening.[2,3]

[2] Laundrie, J.F., and Klungness, J.H. Effective Dry Methods of Separating Thermoplastic Films from Wastepapers. USDA Forest Service Research Paper FPL 200. Forest Products Lab., Madison, Wis. 1973.

[3] Laundrie, J.F. U.S. Patent 3,814,240. 1974.

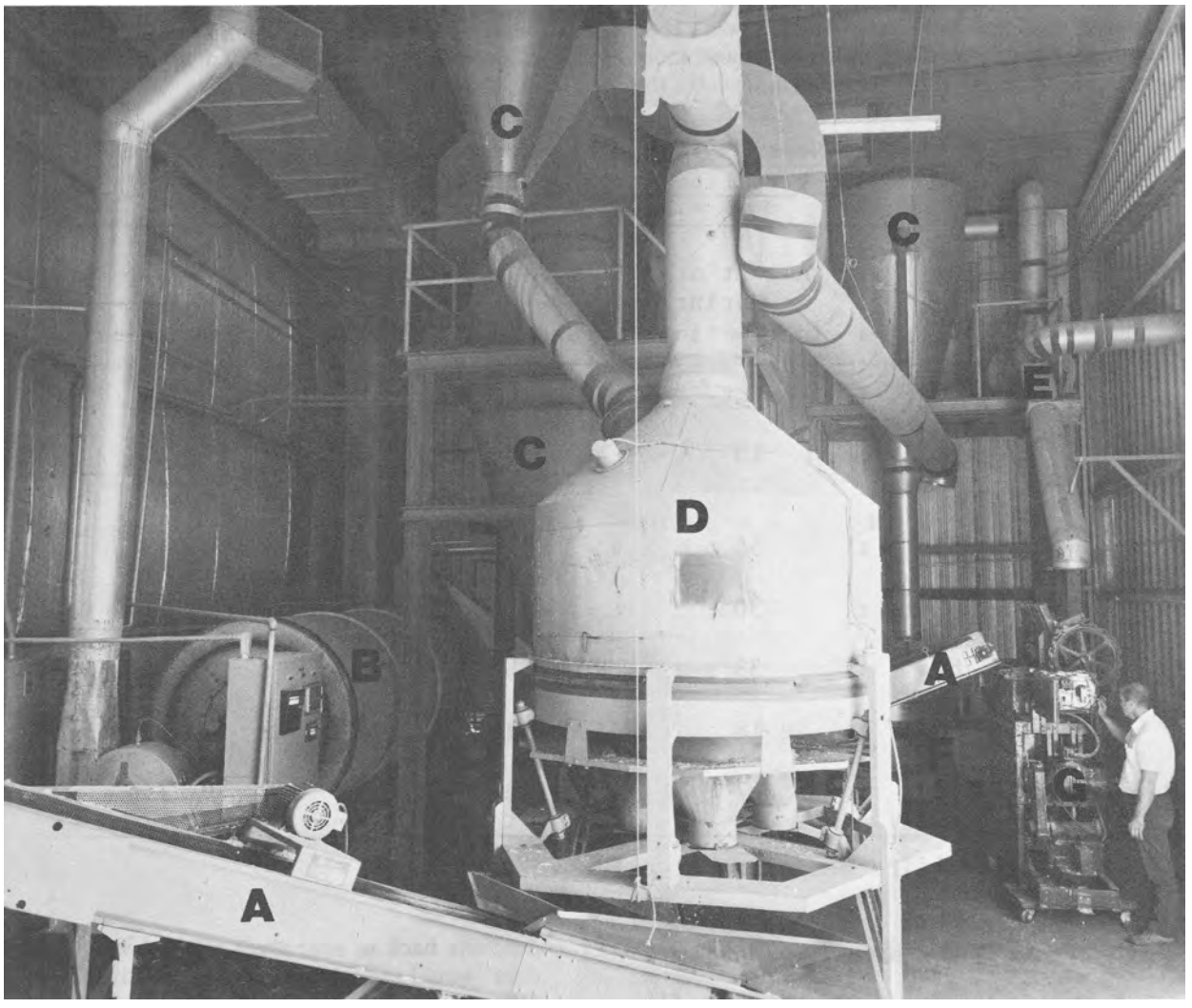

Figure 2. - Equipment in pilot-scale demonstration plant: A, belt conveyors: B, dryer; C, cyclones; D, air classifer; E, pickup fan; F, screen; and G, baler.

To determine the feasibility of further separating papers by air classification, a shredded mixture of computer printout paper and carbon paper was used. These papers had a basis weight ratio of 2.16:l with the computer printout paper being the heavier. These two papers were separated easily by air classification. The work then expanded into the separation of the whole plastic-free paper fraction from shredded household trash.

The whole plastic-free paper fraction was air classified into six arbitrary fractions by first drawing off the lightest fraction with only a small amount of air; then the residual heavier portion was again air classified with an increased air flow. This procedure was repeated with increasing amounts of air until the six fractions were obtained. Samples of each fraction were hand sorted to determine the amount of newsprint, and each sample was also repulped to determine fiber type. The results of these analyses are given in table 1.

As might be expected, the lightest and heaviest fractions contained only a small amount of newsprint. The lightest fraction contained mostly tissue-type papers, carbon paper, and dust. The heaviest fraction contained mostly corrugated boxes, milk cartons, and other heavier paper boards. This is also reflected in the pulp analysis, which shows a high concentration of chemical pulp and neutral sulfite semichemical (NSSC) pulp in the heaviest fraction. Most newsprint was found in

the four middle fractions, which were then combined. By air classifying twice to remove more light materials and more heavier materials, the concentration of newsprint in the remaining middle fraction was increased to 70 percent.

Table 1.--Newsprint and fiber types in air separated fractions of shredded household trash

Fraction	Amount of newsprint in fraction	Fiber type		
		Chemical	NSSC[1]	Mechanical
Pct	Pct	Pct	Pct	Pct
0 - 14 (lightest)	10	39	4	57
14 - 37	56	35	7	58
37 - 61	50	44	1	55
61 - 80	33	53	8	39
80 - 89	18	58	7	35
89 - 100	7	72	14	14

[1]Neutral sulfite semichemical pulp.

Recovery of News-Rich Paper

A large segment of the secondary fiber industry is based on the reuse of old newspapers. Many of the companies that work in this area expressed an interest in evaluating the news-rich paper fraction that could be recovered from shredded household trash. To collect the large quantities needed for commercial evaluation, a continuous pilot system was designed for possible installation at the City of Madison's reduction plant. This design (fig. 3) called for a control on the shredded particle size before recovery of ferrous metals and separate handling of materials ballistically rejected from the hammermill. These steps were needed to protect the subsequent processing equipment. After ferrous metals separation, the remaining shredded household trash would be separated into a light fraction and a heavy fraction by either a simple vacuum pickup or an air classifier. The advantage of the air classifier is that it could be controlled more closely.

The light fraction thus obtained would then be dried to accomplish three desirable effects. First, to dry the material and thereby convert all the paper products back to near their original weight. This then would enable us to take advantage of differences in basis weights of the various papers in subsequent air classification operations. The second desirable effect would be effective sterilization of the material (Table 2). Third would be shrinkage of the thermoplastic films and foams for subsequent separation during air classification.

After drying, the material would be air classified to remove heavy papers and paperboards, the shrunken thermoplastics, and any other miscellaneous heavy materials that may have carried along during the initial vacuum pickup.

Before air classifying again, the material would be screened to remove fines - mostly grass, leaves, small paper particles, and dust. Air classifying would then remove such light papers as tissues and carbon papers and any light fines that may not have been separated during screening.

The rejects from both stages of air classification and screening would be combined and used for fuel.

This proposed continuous system for obtaining a news-rich paper fraction from shredded household trash was never installed. The same end

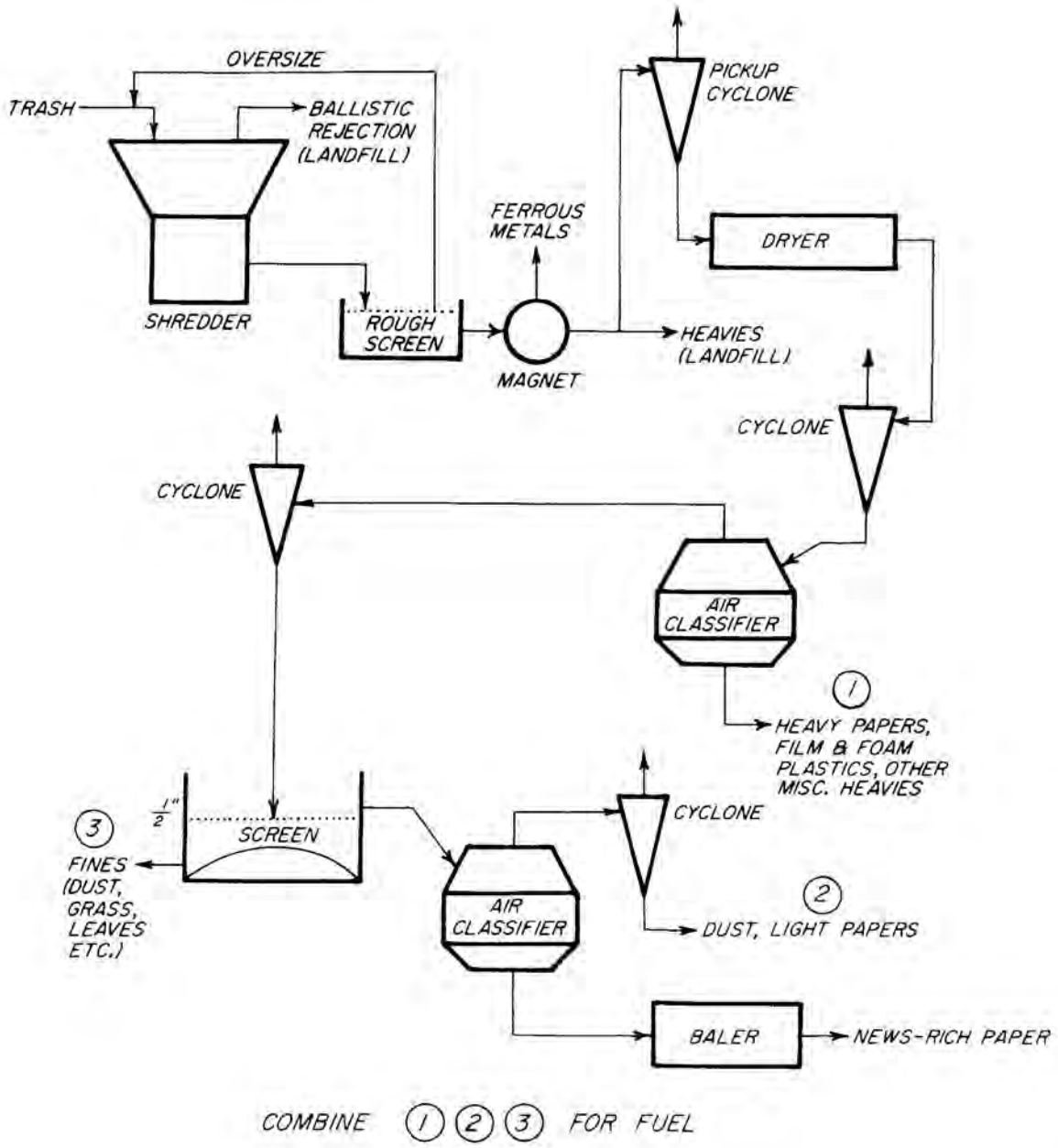

Figure 3. - Continuous system for obtaining a news-rich paper fraction from shredded household trash.

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result was accomplished, however, by operating the pilot scale demonstration plant in two stages (fig. 4) utilizing the same air classifier in both stages. The system (fig. 4) was used to establish material balances and collect large quantities of the news-rich paper fraction for commercial evaluation.

Material Balances

Material balances were made on the system (fig. 4) on three days: Thursday, June 27, 1974; Friday, June 28, 1974; and Wednesday, July 10, 1974. The results of these material balances are given in figure 5. Based on the dry weight of the

Table 2.--Effect of drying on biological analysis[1] of light fraction of shredded household trash

Test	Before Drying	After Drying
Aerobic plate count (g) (35° C)	1,300,000,000	16,000
Coliform count (g)	11,000	23
Escherichia coli (g)	11,000	<3
Staphylococcus aureus count (g)	410,000	<10
8-hemolytic streptococci (g)	580,000	270
Salmonella-Shigella (25 g)	none	none
Mold count (g)	9,200,000	3,300

[1] Tests performed by Wisconsin Alumni Research Foundation Institute, Inc., Madison, Wis.

light fraction received from the vacuum pickup, the average yield of news-rich paper was 42.3 percent.

Material balances were also made substituting the air classifier for the vacuum pickup. Three runs were made using 7,000 cubic feet per minute of air through the air classifier and three more runs were made at 9,600 cubic feet per minute. The runs at 7,000 cubic feet per minute were made on Monday, February 11, 1974: Wednesday, February 13, 1974: and Thursday, February 14, 1974. The results of these material balances are given in figure 6. On the basis of the dry light material separated, the average yield of news-rich paper was 53.7 percent. However, based on the dry weight of the shredded household trash fed to the air classifier, the average yield of news-rich paper was 15.3 percent.

The runs at 9,600 cubic feet per minute through the air classifier, were made on Wednesday, March 6, 1974; Thursday, March 7, 1974: and Wednesday, June 26, 1974. The results of these material balances are given in figure 7. On the basis of the dry light material separated, the average yield of news-rich paper was 41.6 percent. However, based on the dry weight of the shredded household trash fed to the air classifier, the average yield of news-rich paper was 18.9 percent.

Considering these results and the amounts of material handled, it appears that a simple vacuum pickup is as effective as an air classifier in processing the whole stream of shredded household trash. A comparison of the results of using 7,000 versus 9,600 cubic feet per minute indicates no yield advantage in separating out an excess of light materials initially. In a commercial system, further work would be needed to optimize the initial separation to obtain the highest yield of a news-rich paper fraction, with a minimum amount of air and without overloading other components of the system.

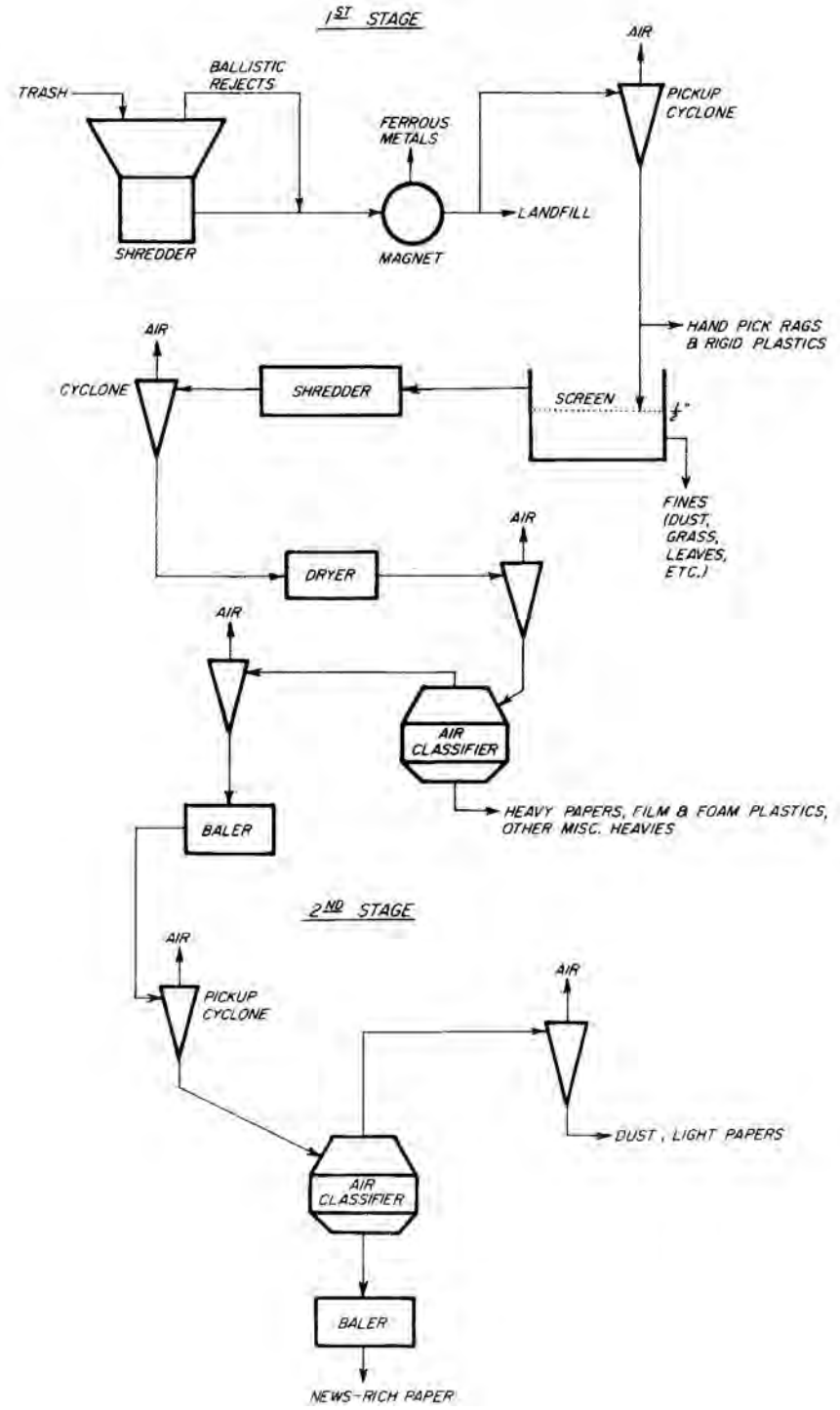

Figure 4. - Two-stage continuous system for obtaining a news-rich paper fraction from shredded household trash.

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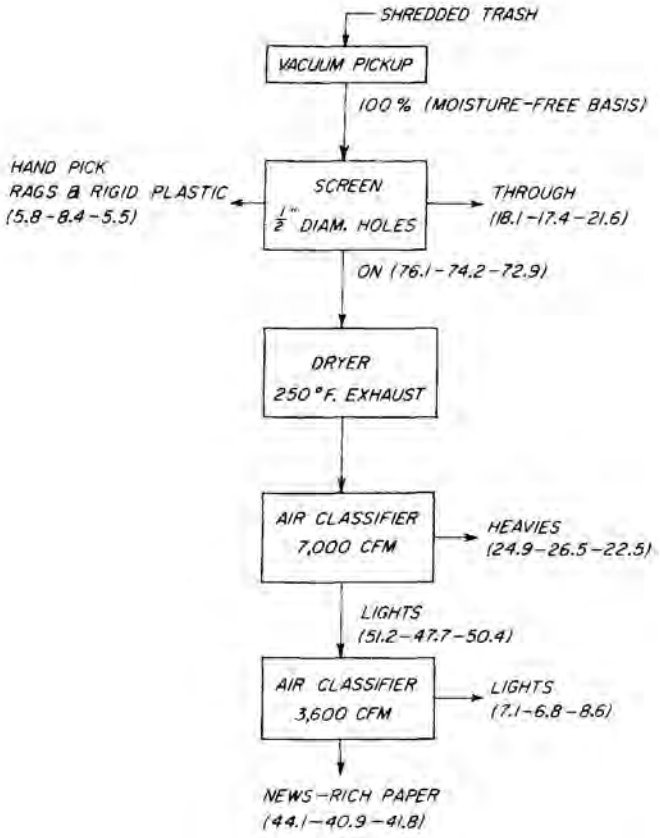

Figure 5. - Material balances of continuous system using the vacuum pickup.

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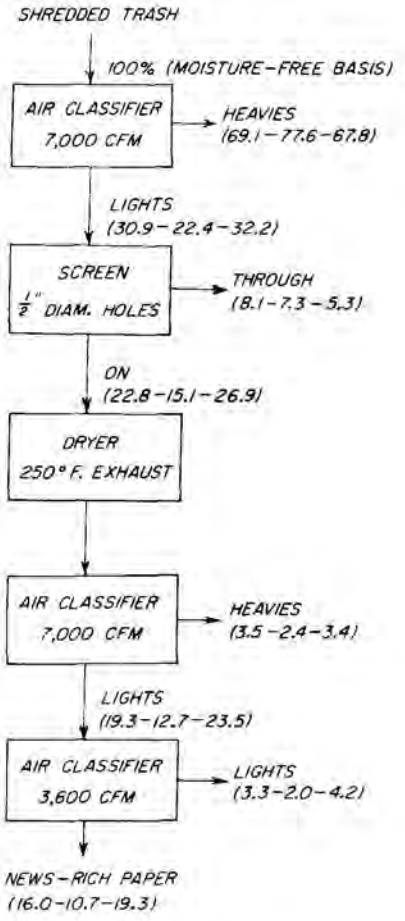

Figure 6. - Material balances of continuous system using the air classifier with 7,000 CFM as a substitute for the vacuum pickup.

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Equipment Performance

Passing the shredded household trash through the material handling fan presented no particular problem. Although large fabric pieces would occasionally hang up in the fan, these would eventually be shredded and pass on to the cyclone. At no time was the material handling fan ever dismantled for cleanout.

The screen was unsuitable for processing shredded household trash. The main problems were flooding and, hence, low capacity.

The small dryer used in the pilot-scale denionstration was not entirely satisfactory. Plastics were not retained in the dryer long enough to shrink them sufficiently so the thermoplastic films and foams could be completely separated. Also in this dryer the flame was too close to the feed spout. Numerous tires were encountered until modifications were made to limit the flame size. Furthermore, the feed spout on this dryer was too small for handling shredded household trash. None of these problems occurred during earlier work with a larger dryer of the same type.

The air classifier performed well in separating light from heavy materials. The only problem encountered with the air classifier was draping of rags and wire on the bars supporting the bearings on the distributor disk shaft. These materials would accumulate and eventually the heavy discharge spouts would become completely plugged.

Reuse of News-Rich Paper

Tonnage quantities were collected for a wide variety of products including newsprint, medium-density hardboard, boxboard, building board, corrugating medium, and cattle bedding. One of our objectives has always been to make the highest value product from this resource. Therefore, products such as molded products and roofing felt, where the quality requirements are not as stringent, were not made.

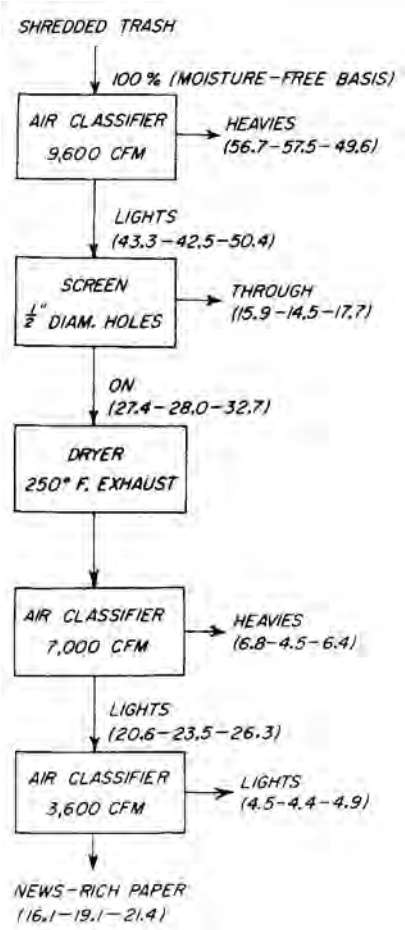

Figure 7. - Material balances of continuous system using the air classifier with 9,600 CFM as a substitute for the vacuum pickup.
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Newsprint. - In cooperation with a newsprint manufacturer, a large quantity of the news-rich paper was evaluated for newsprint production using their special deinking process. Quantitative results are not available, but according to the technical staff of the newsprint manufacturer, a good quality newsprint was made with only minor changes in stock preparation.

Medium-density hardboard. - A shredded news-rich paper fraction from household trash was also included in a Forest Products Laboratory evaluation of a variety of urban wood resources for manufacturing dry-formed medium-density hardboard. The addition of the news-rich paper from household trash performed equally as well as similar amounts of old newspapers. Dry-formed medium-density hardboards made with either 25 percent of old newspapers or 25 percent of the news-rich paper and 75 percent aspen fiber met minimum standards established for this product.[4]

Boxboard and building board. - In cooperation with a manufacturer of laminated paper building board, various weight boxboards were made from the news-rich paper using a Multi-former. Stock preparation consisted of slushing in a beater for 30 minutes, jordaning lightly, and passing the pulp through a screen with 0.020-inch slots. The freeness of the stock to the headbox was 260 Canadian Standard Freeness. The properties of one board weighing 24 pounds per 1,000 square feet are given in table 3. According to the building board manufacturer, the properties of the individual boxboards made from the news-rich paper were adequate for use in this product.

Corrugating medium. - The use of the news-rich paper for the production of corrugating medium was investigated in another research study conducted by the Forest Products Laboratory. The details of this study have been published.[5] Properties of the corrugating mediums made are given in table 4.

With the addition of 0.9 percent starch at the size press of the paper machine or blending the waste fiber with commercial NSSC pulp in a 1:1 ratio, good quality corrugating mediums were made that met commercial standards and had excellent runnability characteristics on the corrugating machine.

Cattle bedding. - In cooperation with the Research Division of the University of Wisconsin College of Agricultural and Life Sciences, the shredded news-rich paper was evaluated by spreading material daily for 18 days as a Jersey cow's bed at the University's Dairy Cattle center. Five to 6 pounds per day were used, about 2 pounds less than the usual application rate for straw or wood shavings under similar circumstances.

This evaluation showed that the shredded news-rich paper was fully acceptable. It stayed in place well and formed a satisfactory bed. Conversely, straw bedding without added wood shavings tends to disperse in a stanchion stall. The shredded news-rich paper also mixed well with manure in the barn cleaning system, a favorable characteristic for spreading the manure on the land.[6]

[4] Laundrie, J.F., and McNatt, J. Dobbin. Dry-formed, Medium-density Hardboards from Urban Forest Materials. USDA Forest Service Research Paper FPL 254. Forest Prod. Lab., Madison, Wis. 1975.

[5] Mohaupt, A.A., and Koning, J.W. Corrugating Medium from Household Trash. Tappi 57(11): 56-58. 1974.

[6] University of Wisconsin. Trash for Livestock Bedding Feasible. News, Univ. Wis. Ext., Col. of Agricultural and Life Sciences, Madison, Wis. 1974.

Table 3.--Properties of boxboard made from news-rich paper

Freeness (Canadian Standard) . . . . . .ml	:	260
Basis weight . . . . . .lb/1,000 ft^2	:	24.0
Caliper . . . . . .mils	:	10.2
Density . . . . . .g/cc	:	0.47
Burst . . . . . .pt	:	16.3
Tear (MD) . . . . . g	:	64.1
Tensile (MD) . . . . . lb/in. width	:	21.6
Brightness . . . . . pct	:	34.8

Conclusions

A technically feasible dry process has been developed for the recovery of wastepaper from shredded household trash. This process is based on air classification and includes provisions for the removal of thermoplastic films and foams and for further separation of the wastepaper by grade. The recovered wastepaper can be successfully used in a wide variety of products. Further analysis is needed to determine the economic feasibility of this process.

Table 4.--Properties of corrugating medium made from news-rich paper

Mediums	Freeness[1]	CMT	Water[2] absorbency	Burst	Tear	Double folds	Ring crush	Tensile: Maximum strength	Tensile: Modulus of elasticity	Tensile: Strain to failure	Flat crush
	Ml	Lb	Sec	Pt	G		Lb	Lb/in.^{2}	1,000 lb/in.^{2}	Pct	Lb/in.^{2}
Commercial NSSC	410	65	12	40							27.4
Machine					70	7	62	4,157	539	1.57	
Cross					78	8	51	2,275	263	2.80	
100 pct waste fiber:											
(1st run)	300	43	100	33							16.8
Machine					114	107	54	3,760	580	1.15	
Cross					122	32	39	1,940	258	3.32	
100 pct waste fiber:											
(2d run)	310	48	14	33							18.4
Machine					103	29	53	3,900	713	1.02	
Cross					99	25	41	2,157	310	2.93	
100 pct waste fiber:											
without starch	250	55	87	39							--
Machine					97	39	57	4,514	859	1.12	
Cross					90	19	42	2,257	324	3.21	
100 pct waste fiber:											
with starch	250	63	79	42							24.2
Machine					88	32	54	4,503	885	.92	
Cross					90	36	41	2,633	357	3.40	
50 pct waste fiber											
plus 50 pct NSSC	350	63	31	43							24.2
Machine					69	10	68	5,183	700	1.47	
Cross					76	10	51	2,531	289	2.93	

[1] Canadian Standard Freeness.

[2] 0.1 ml water.

Acknowledgments

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