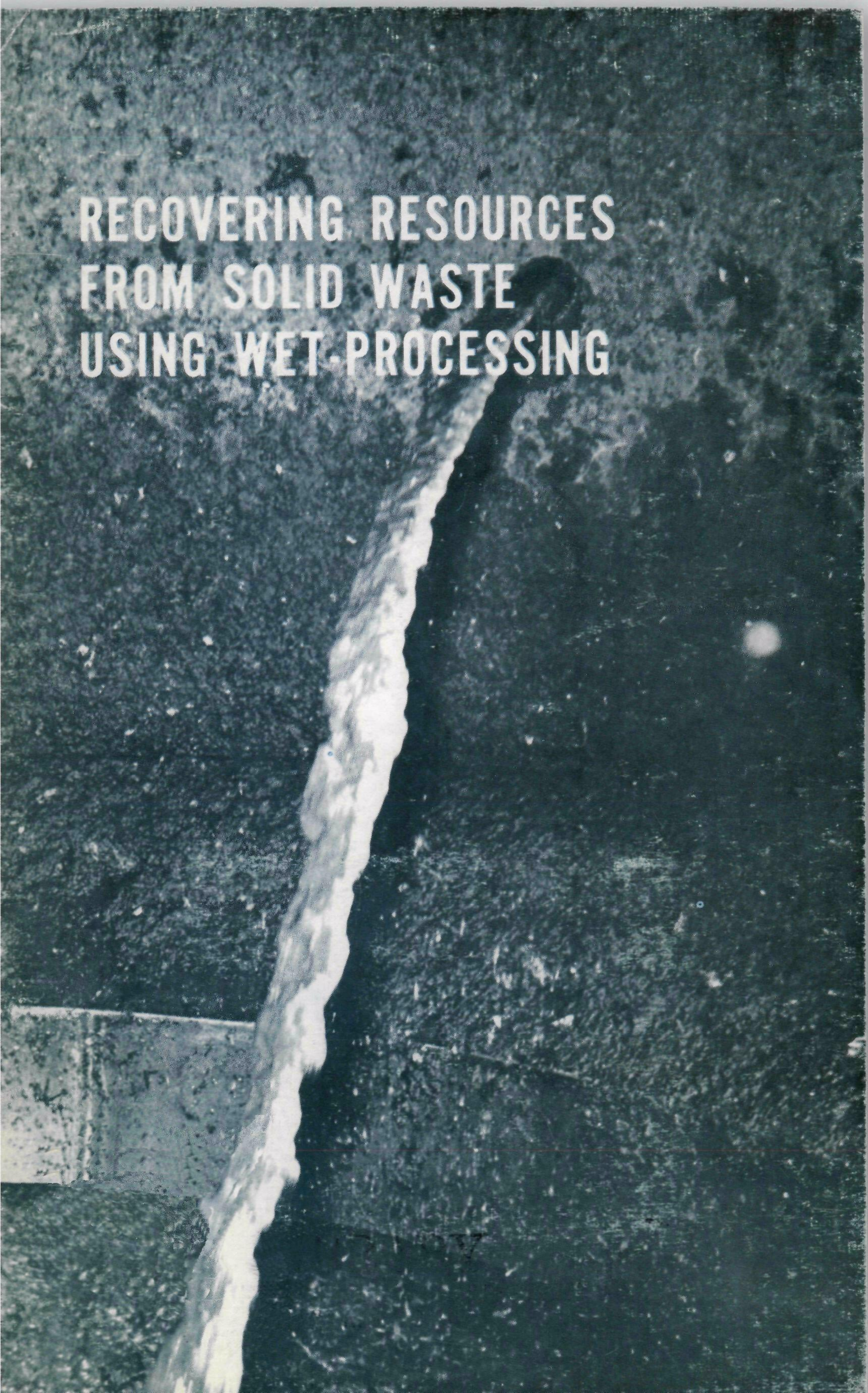
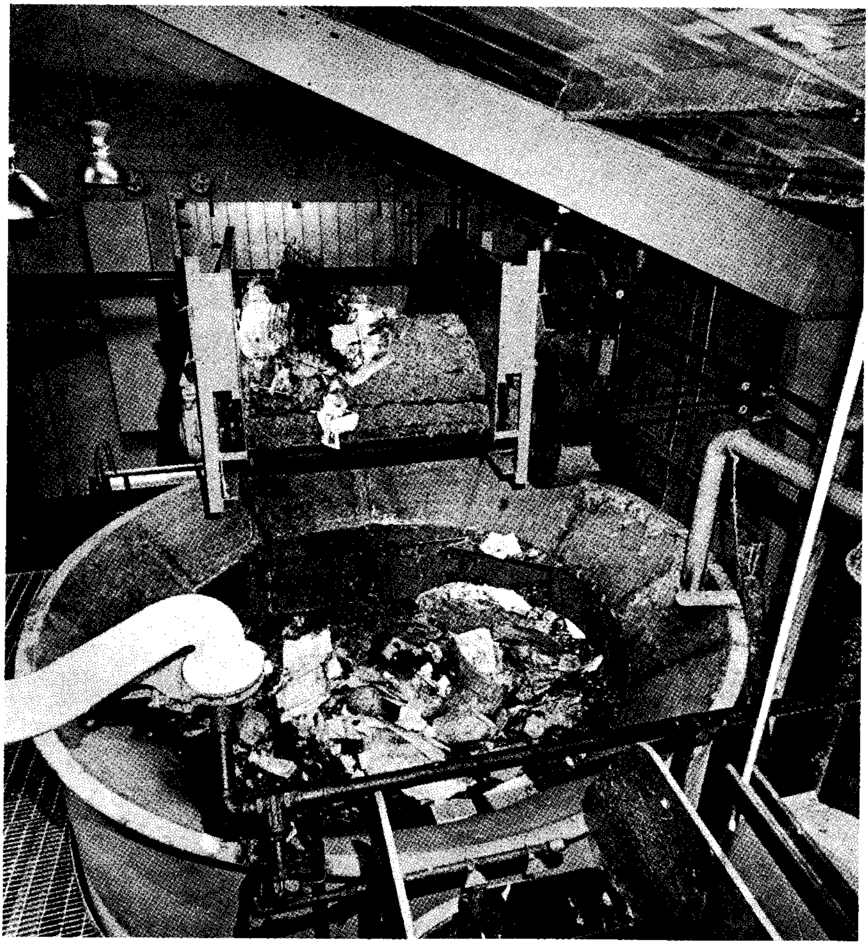
RECOVERING RESOURCES FROM SOLID WASTE USING WET-PROCESSING





Cover and inside cover photos: Municipal solid waste is dumped into the wet-pulper at the Franklin plant. Water is added to improve handling in the resource recovery processes.

RECOVERING RESOURCES FROM SOLID WASTE USING WET-PROCESSING

EPA'S Franklin, Ohio Demonstration Project

This summary report (SW-47d) on work performed under Federal solid waste management demonstration grant No. G06-EC-00194 to the City of Franklin, Ohio, was written by DAVID G. ARELLA.

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AT PRESENT, nearly everywhere in this country, everything that goes into the municipal waste stream is buried, incinerated, or thrown onto open dumps. Large amounts of recyclable materials and energy are thus discarded. The systematic recovery of materials and energy from wastes clearly represents a major goal in resource conservation. It also offers a means of "disposing" of wastes in an environmentally acceptable way. And, in view of the rising costs of conventional waste disposal methods, resource recovery systems are more and more likely to be cost-competitive with these methods.

As authorized by the Solid Waste Disposal Act of 1965 and its amending legislation, the Resource Recovery Act of 1970, the U.S. Environmental Protection Agency has been aiding local governments and private enterprise in the development and demonstration of various systems of resource recovery. The Franklin, Ohio, project is one of the first successful efforts. This pilot plant is a commercially operated facility that recovers paper, metals, and glass from the city's solid wastes and disposes of the remainder, together with municipal sewage sludge, by methods that do not pollute the land, water, or air.

The city of Franklin became actively concerned about solid waste disposal problems in 1967 when it realized that its landfill space was running out. Proposals for new sites met with opposition from residents who did not want a landfill near their property. Spurred by this situation, the city applied for a Federal grant to demonstrate the innovative process involving wet-grinding, fluid separation, resource recovery, and incineration developed by the Black-Clawson Company. The project was particularly attractive to the community because it would handle a number of the city's disposal problems <u>and</u> recover resources from their solid wastes.

Figure 1. The Franklin plant is the sole solid waste disposal facility for the city and adjacent areas.

The Franklin facility has been in operation since June 1971. Although the plant is relatively small, it uses commercial-scale equipment and operates on a daily basis as the sole solid waste disposal facility for the city and adjacent areas. The plant in 1974 was recovering ferrous metals, paper fibers, and color-sorted glass. Recovery of aluminum and other nonferrous metal is also being developed. The plant is designed to recover about three-fourths of the minerals and one-half of the paper content in the incoming solid waste stream.

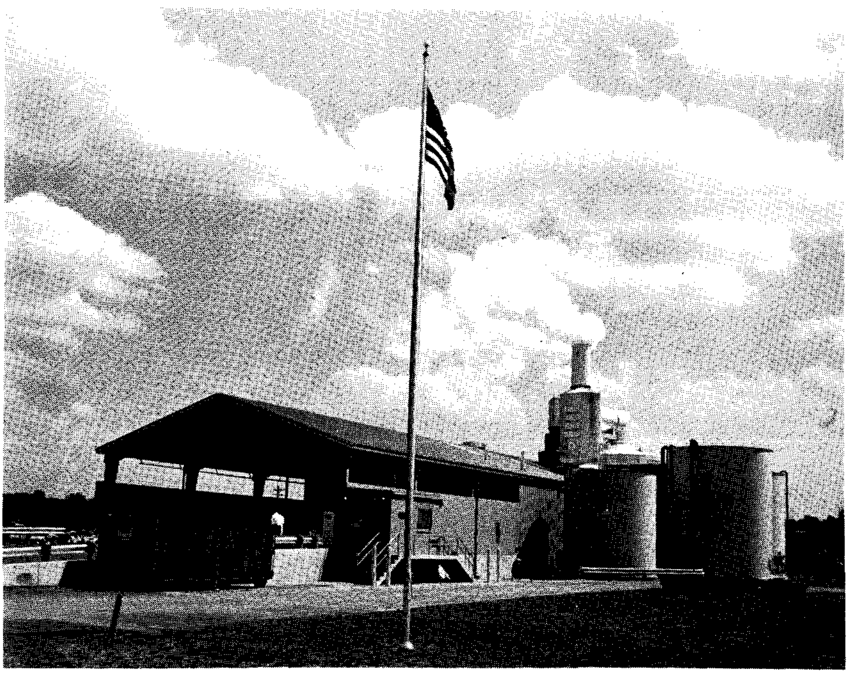

Figure 2. The plant is one of the first EPA projects demonstrating resource recovery from solid waste; it has been in operation since 1971.

The project has demonstrated the technical feasibility of adding water and pulping the solid wastes into a slurry as a way to improve the handling, processing, and separating capabilities, as well as the housekeeping, of the facility. This technique may have significant benefits when compared to more conventional dry-shredding techniques.

The Franklin project's successes offer the solid waste management field an increased array of technological options to consider in implementing systems to recover resources from solid waste and to reduce various waste disposal problems. A number of the larger cities in this country and other countries are considering the project results as possible solutions to their own solid waste management problems.

SUMMARY

The major accomplishments of the Franklin project, resulting from more than 2 years of daily operation and development, are briefly summarized as follows: (1) municipal solid waste is being successfully wet-pulped and separated; (2) the volume of material going to landfill has been reduced by over 95 percent; (3) the plant has been so reliable that it has never been necessary to divert collection trucks to the former landfill for the disposal of Franklin's solid wastes; (4) ferrous metals are being magnetically separated and sold for reuse; (5) recyclable paper fibers are being removed from the slurry and sold to a nearby paper plant for making felt paper for asphalt roofing shingles; (6) the nonrecovered combustible material is combined with raw sewage sludge and the mixture is being burned in the fluid bed incinerator without the need for auxiliary fuel. The exhaust gases from the incinerator were tested for particulates and found to be within Federal air emission standards; (7) the plant has demonstrated the mutual benefits that can be derived from integrating solid waste disposal and sewage treatment; (8) a system to recover color-sorted glass and recyclable aluminum was installed in August 1973 and was being evaluated in 1974; (9) projections indicate that, in terms of cost, larger plants of this type would be competitive with conventional incineration or with sanitary landfilling where a long haul to the landfill site is required. Plants no larger than the Franklin plant would probably be uneconomical; (10) follow-on studies and the development of auxiliary concepts and equipment are increasing the applicability and flexibility of the basic wet-processing concept.

SYSTEM DESCRIPTION

Franklin's solid waste processing facility, with a design capacity of 150 tons per 24 hours, is made up of three separate subsystems: a processing and disposal system for solid waste and sewage sludge, with recovery of ferrous metal; a glass and aluminum recovery system; and a paper fiber recovery system (Figure 4).

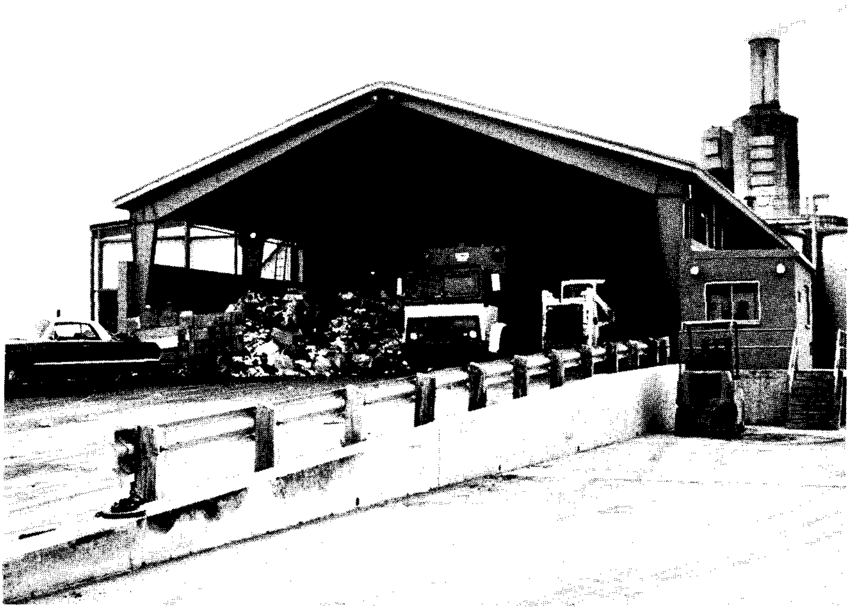

Figure 3a. Residential solid waste is delivered to the plant by standard collection trucks and by private cars and trucks and deposited on a dumping pad.

Disposal and Ferrous Metal Recovery System

The so-called "Hydrasposal System" consists primarily of a wet-pulper ("Hydrapulper"), a liquid cyclone, and a fluidized bed incinerator. Much of the equipment in this system has been used in the papermaking industry for many years, although various units have been modified to handle solid wastes. Residential solid waste is fed by a conveyor into the wet-pulper. This pulper, which might be likened to a kitchen sink disposal unit, consists of a tub 12 feet in diameter with a high-speed cutting blade in the bottom driven by a 300-horsepower motor (Figures 5a and 5b). Water is mixed with the solid wastes in the pulper, and all soft and brittle materials are ground into a slurry. Large pieces of metal, cans, and other nonpulpable materials are thrown out

Figure 3b. The waste is pushed by a small front-end loader into a shallow pit in one corner of the receiving building.

Figure 3c. From the pit the wastes are fed by a conveyor into the wet-pulper.

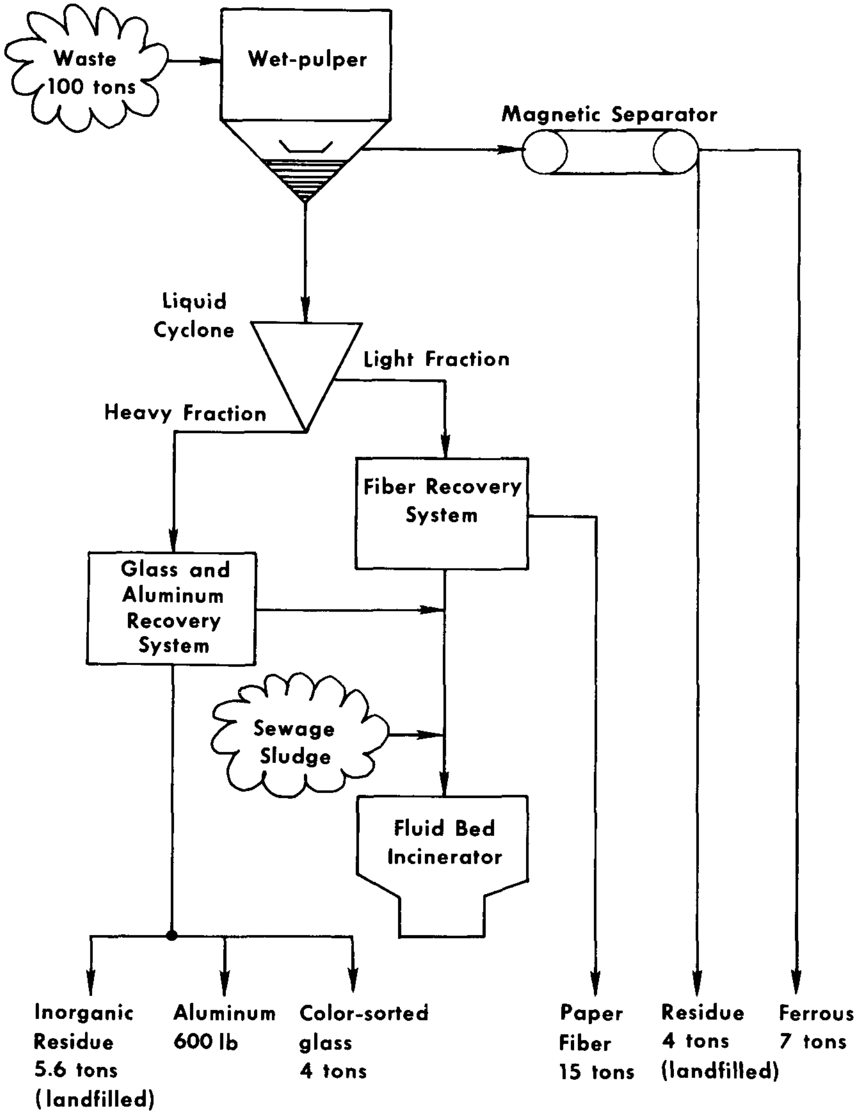

Figure 4. A simplified flow chart of the process at Franklin shows the approximate tonnage of materials that may be expected from 100 tons of solid waste with composition typical for U.S. communities (as estimated by EPA). The plant consists of three subsystems: a solid waste disposal system that includes a ferrous metal separator, a paper fiber recovery system, and a glass and aluminum recovery system.

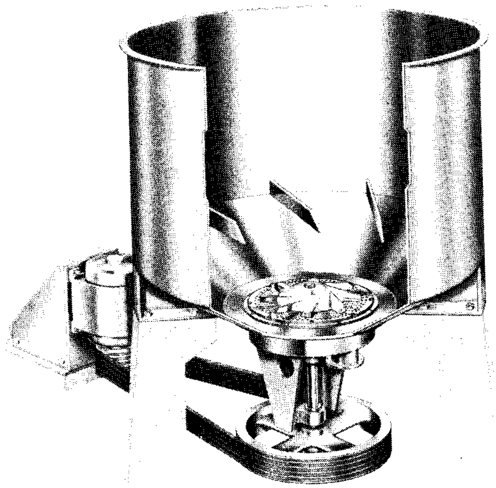

Figure 5a. The wet-pulper is a tub 12 feet in diameter with a high-speed cutting blade in the bottom driven by a 300-horsepower motor. This cutaway view shows the blade and the perforated plate beneath it through which the slurry leaves the pulper.

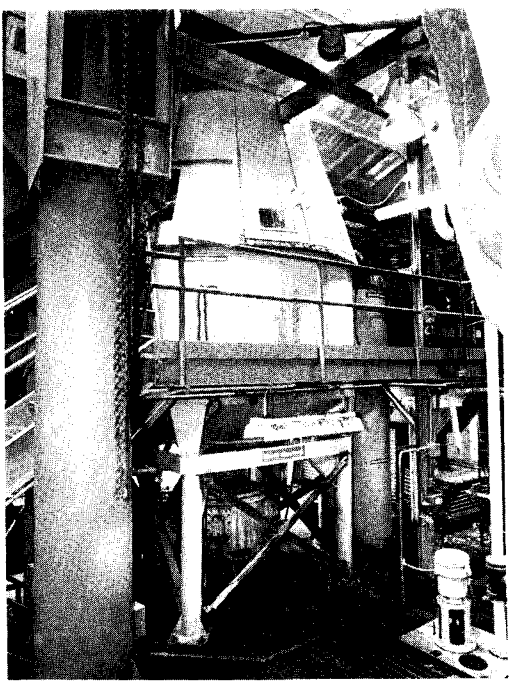

Figure 5b. The wet-pulper has been fitted with a conical hood to prevent splashing. The rectangular ports allow viewing of the pulper in operation.

of the pulper and down a chute that leads to a specially designed bucket elevator known as the "Junk Remover." These nonpulpable materials are washed and then conveyed to a magnetic belt where steel cans and other ferrous objects are removed for recycling (Figure 6). The nonmagnetic materials are collected and buried in the plant's sanitary landfill. Black–Clawson has been studying the feasibility of upgrading these nonmagnetic materials for sale as mixed nonferrous metal.

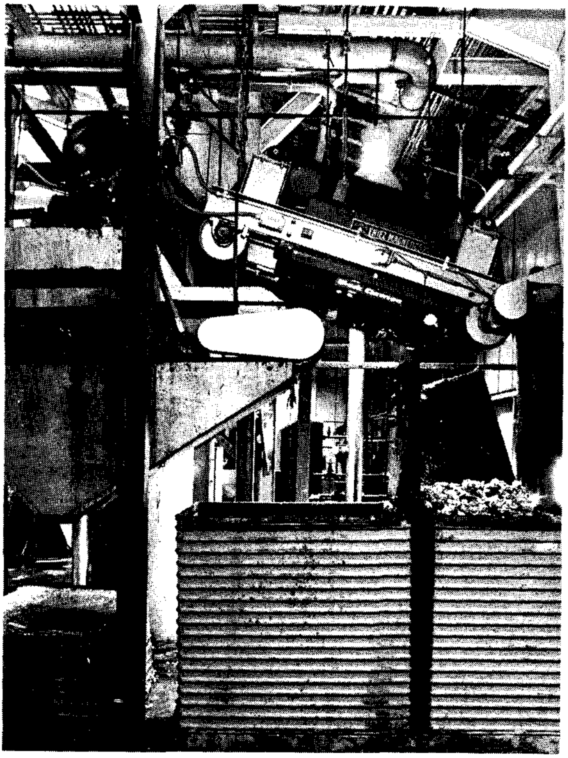

Figure 6. The nonpulpable materials, such as tin cans and other metal objects, are ejected from the pulper, washed, and then conveyed beneath a suspended magnet. The ferrous metals are picked up by the magnet, carried from left to right, and then dropped into the collection bin on right. The nonferrous materials are not affected by the magnet and drop straight down into the collection bin in the center.

The slurry, which contains almost all of the paper and organic materials, as well as the glass, small pieces of metal, ceramics, and much of the aluminum, leaves the pulper through a perforated plate beneath the blade (Figure 7). The slurry is then pumped to the liquid cyclone, where the heavier, mostly noncombustible materials, such as glass, metals, ceramics, and stones are separated from the lighter fibrous material by centrifugal action (Figure 8). The heavier fraction goes into the glass and aluminum recovery system. The lighter fraction

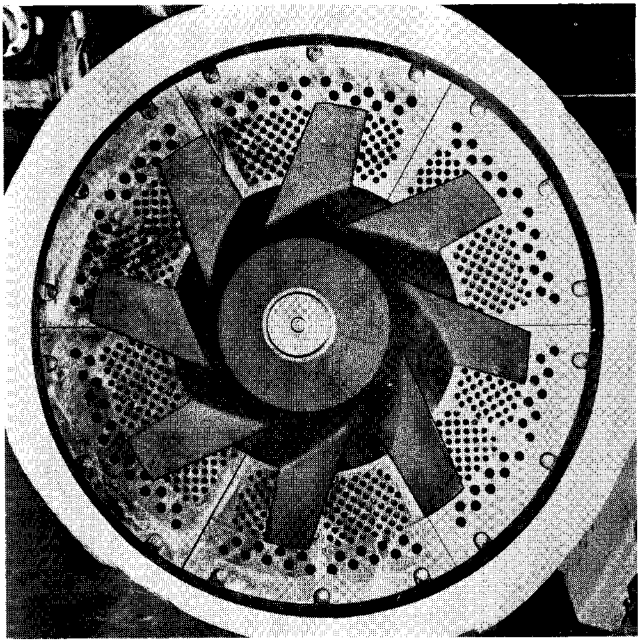

Figure 7. The slurry leaves the pulper through a perforated plate beneath the rotor blade. The slurry contains almost all of the paper and organic materials, as well as the glass, small pieces of metal, ceramics, and much of the aluminum. The diameter of the openings in the plate is about 7/8 inch.

goes into the fiber recovery system. The combustible residues from both these systems are mixed with dewatered sludge and sent to the fluid bed incinerator (Figure 9).

The incinerator is a vertical cylindrical unit with a 25-foot inside diameter. It was supplied by Dorr-Oliver, Inc. In the incinerator, air is blown upward through a layer of hot sand. The combustible wastes are blown into the "fluidized" bed of sand, where the combustibles burn completely. These wastes have enough heat value to maintain their own combustion without the need for auxiliary fuel. The exhaust gases pass through a scrubber that removes the ash particles so that the gases discharged to the atmosphere meet Federal air quality standards for particulate emissions.

Nonprocessable items and the other nonrecovered, noncombustible materials (approximately 10 percent by weight of the total incoming wastes) are disposed of in a small sanitary landfill adjacent to the plant.

Sludge Disposal

A valuable feature of the Franklin facility is the tie-in between the solid waste handling facility and the adjacent sewage treatment plant. These two

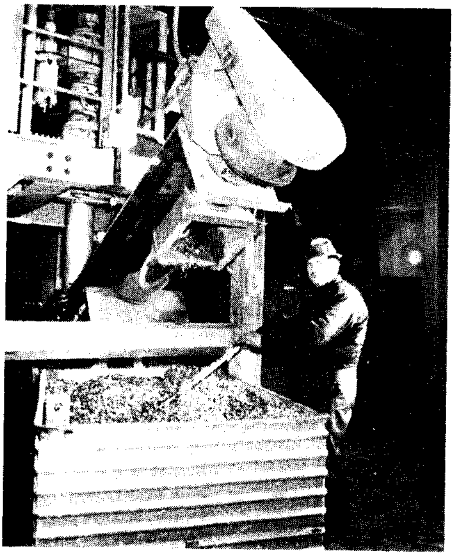

Figure 8. The liquid cyclone extracts the heavier materials, such as glass, metals, and stones, from the slurry. This material is further processed in order to recover the glass and aluminum for recycling.

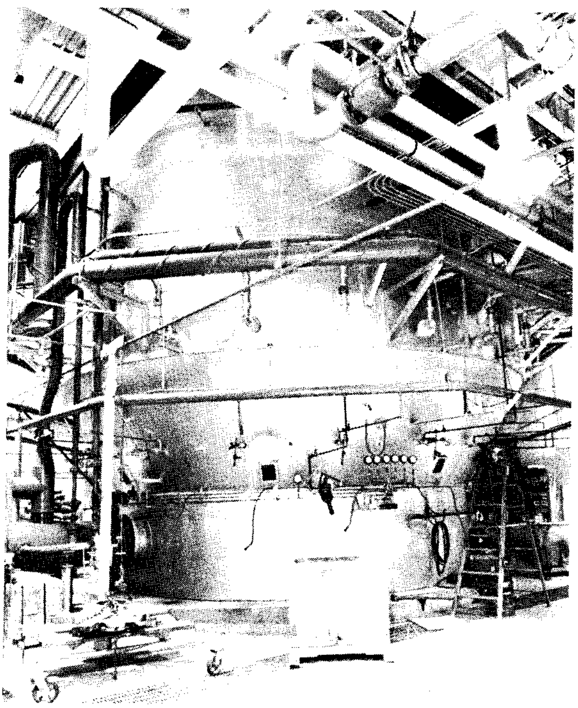

Figure 9. The fluid bed incinerator is used to dispose of all of the nonrecovered combustible materials and sewage sludge. This unit is about 25 feet in diameter. The exhaust gases meet Federal air quality standards.

plants were constructed with lines connecting them in such a way as to complement each other's disposal needs. The most important of these connections is for pumping raw sewage sludge from the sewage treatment plant to the solid waste processing plant. There the sludge is mixed with the combustible wastes and mechanically dewatered. After dewatering, the mixture is burned in the fluid bed incinerator, thereby eliminating the need for costly sludge digestion and disposal equipment. This sludge disposal service does not increase the cost of operating the solid waste plant and actually improves the operation of the incinerator by helping to maintain the optimum operating temperature. The sewage treatment plant pays the solid waste plant a $25 service fee for every ton of sludge burned (dry weight basis). This service has been significant because environmentally acceptable methods for disposing of sewage sludge are becoming increasingly expensive. Sludge digestion, drying, and incineration can cost as much as $40 to $60 per ton.

There are two additional linkages. First, the water that has been squeezed out of the recovered paper fiber is returned to the sewage plant for treatment. Secondly, the wet-pulping system uses clarified effluent from the sewage treatment plant as make-up water in its pulping operation.

Glass and Aluminum Recovery System

The heavier materials extracted from the slurry by the liquid cyclone are conveyed to the glass and aluminum recovery system, which was developed by the Glass Container Manufacturers Institute. This system uses a complex series of mechanical screening and classifying operations to extract extraneous materials and to produce a glass-rich stream and an aluminum-rich stream. The stream of glass particles is then passed through an optical sorting device, developed by the Sortex Company of North America, which separates the glass into clear, amber, and green fractions suitable for use in making new bottles.

Any combustible rejects from this process are sent to the fluid bed incinerator for disposal.

Fiber Recovery System

The lighter, combustible material leaves the liquid cyclone in a slurry and is piped to a series of screening and cleaning operations that also have been adapted from the paper industry (Figure 11). The longer paper fibers are mechanically separated from the shorter fibers and from other nonpaper materials such as paper coatings and fillers, rubber, leather, food and yard wastes, and very small pieces of glass, dirt, and sand (Figure 12). These nonrecovered

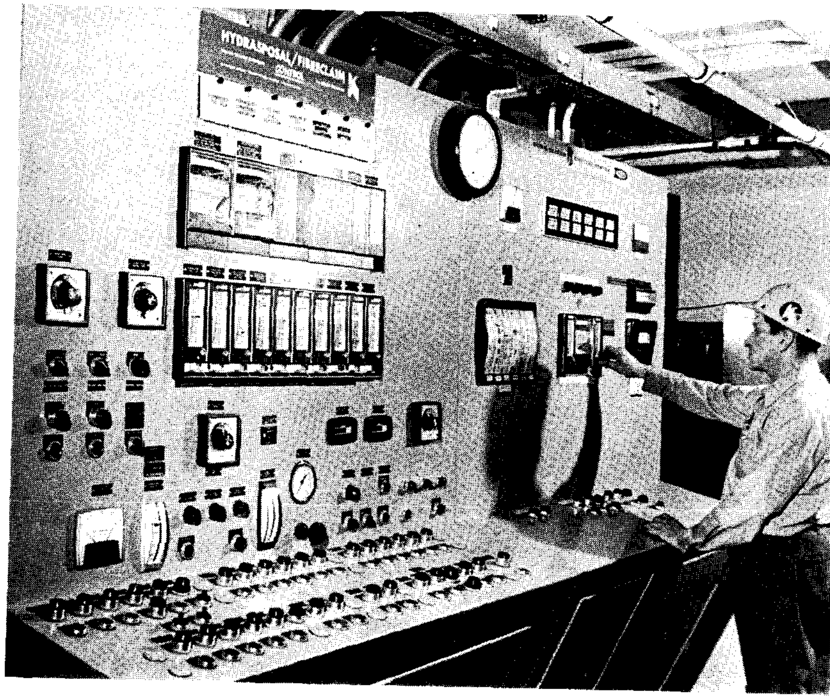

Figure 10. A central control panel regulates the operation of the entire plant.

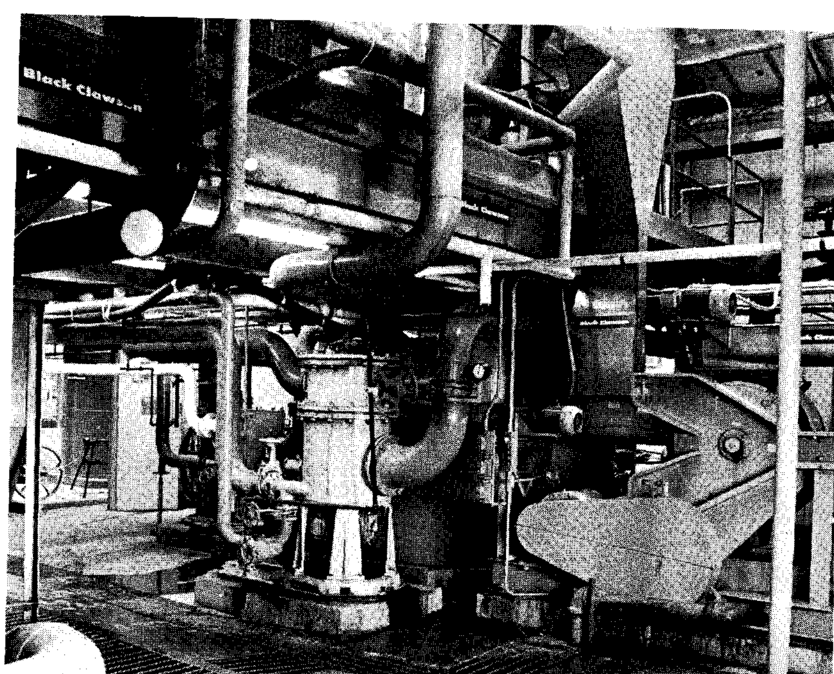

Figure 11. The slurry from the liquid cyclone is piped to a series of screening and cleaning operations which make up the fiber recovery system.

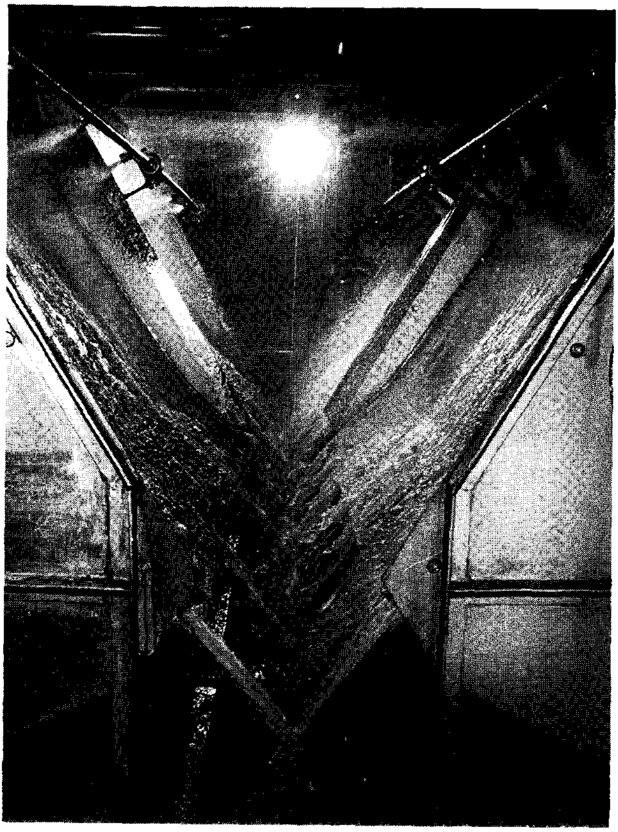

Figure 12. In the final step of the fiber recovery system, the slurry flows down two rows of screens which have very narrow horizontal slots. The longer, more valuable paper fibers remain on top of the screen and are washed by the sprayers into a trough in the center. The shorter fibers pass through the slanted screens and are collected beneath them.

materials are sent to the fluid bed incinerator for disposal. The recovered fibers are pumped in an underground pipe to the Logan-Long Company, about a half mile away, for use in making felt paper for asphalt roofing shingles.

OPERATING EXPERIENCE

The wet-pulping/disposal system and the fiber recovery system began operating in June 1971. These two systems are in operation daily, processing about 50 tons of municipal solid waste per 8-hour day. This facility has been the primary disposal method for all of the solid waste generated by the city of Franklin and several small communities in the area.

Figure 13. The recovered fiber is suitable for use in construction papers not subject to high-quality specifications.

The project has demonstrated the technical feasibility and reliability of the wet-pulping/disposal system. The volume of material going to the landfill has been reduced by about 95 percent. Between June 1971 and this reporting date (May 1974) the plant never had to divert collection trucks to the former landfill for the disposal of the community's solid wastes.

The wet-pulper has operated regularly in excess of its hourly design capacity. Maintenance required by this unit has been significantly less than that required by the more conventional dry-shredders. The wet-pulping operation eliminates the dust problem inherent in dry-shredders, and the water medium absorbs the shock of exploding aerosol cans. These two factors have eliminated the fire and explosion hazard that is frequently present when dry-shredders are used.

The wet-pulping and liquid cyclone operations have produced a good separation between combustibles and noncombustibles. (This type of separation is important in producing a solid waste "fuel" product with a low ash content for generating steam or electricity.)

Relatively small hard-to-grind items, such as tin cans, are being effectively removed from the slurry in the wet-pulper. About 95 percent of the ferrous metals are recovered. From June 1971 through March 1974 approximately 2,000 tons of ferrous metal were recovered and sold.

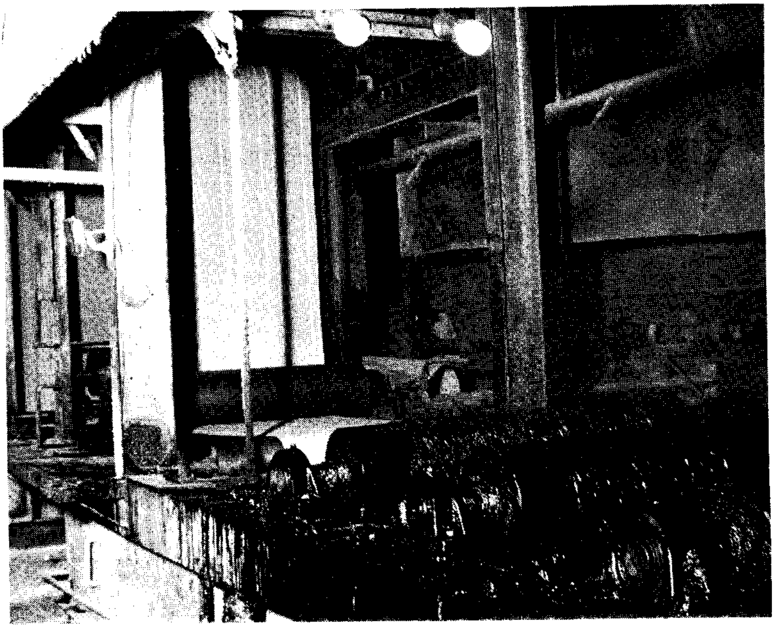

Figure 14a. At the Logan-Long plant the recovered fibers are blended with other paper fibers and made into thick felt-type paper. The rolls of paper are then impregnated with asphalt and coated with sand.

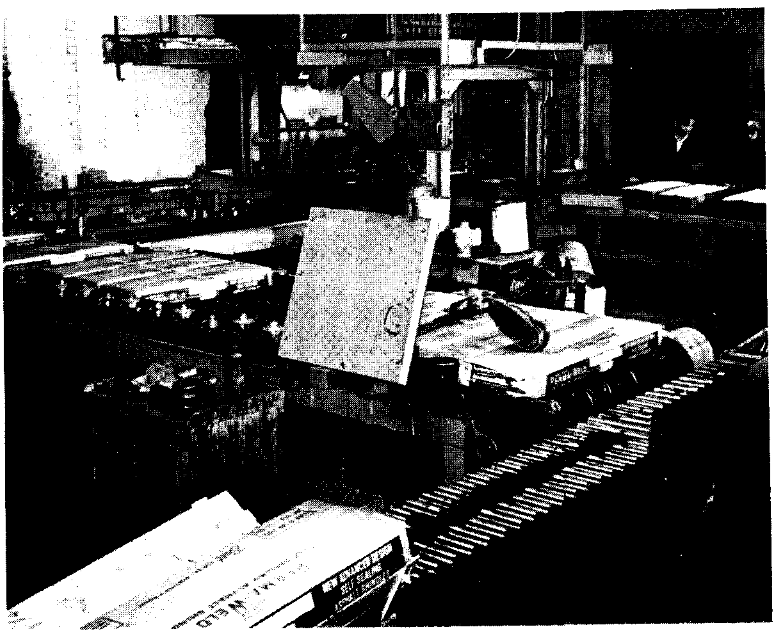

Figure 14b. The paper is cut into shingles and packaged for distribution.

The fluid bed incinerator has performed efficiently. Its good burning characteristics and the air pollution control equipment have reduced the emissions below EPA's allowable limits. The project has demonstrated the feasibility of pneumatically transporting pulped solid wastes into the incinerator with minimal transport or abrasion problems. (This information is valuable for the consideration of using pulped waste as fuel for producing energy. Pneumatic transport is also being demonstrated as a method of introducing waste in dry-shredded form into boilers,* but pipeline abrasion problems and maintenance costs are still significant.)

The project has demonstrated that raw sewage sludge from the adjacent sewage treatment plant can be combined with the nonrecovered combustible solid wastes, dewatered, and burned efficiently in the fluid bed incinerator, thereby eliminating the need for costly sludge digestion and disposal equipment.

The fiber recovery system has demonstrated the technical feasibility of recovering paper fibers from the wet-ground solid wastes. Between June 1971 and March 1974, about 1,000 tons of fiber had been recovered and sold.

Construction of the glass and aluminum recovery system was completed in July 1973 and shakedown operations began in August 1973. This system also uses commercial-scale equipment, but it has had considerable debugging problems. As of March 1974, only about 40 tons of color-sorted glass had been recovered for sale.

The aluminum recovery process was still in the technology development stage at this writing.

DESCRIPTION OF RECOVERED MATERIALS AND MARKETING

As of March 1974 the plant was recovering ferrous metals, paper fiber, and color-sorted glass, with aluminum recovery anticipated. The plant is designed to recover almost all of the ferrous metals, about one-half of the glass, and one-half of the paper content in the solid waste stream. This represents a recovery of over 25 tons of material from each 100 tons of solid waste delivered to the plant (Table 1). Since water contributes about 25 percent of the incoming weight, the amount recovered is actually about one-third of the total available material. The residual nonrecovered material consists of the short, less valuable paper fibers, plastics, leather, and food and yard wastes, which are of minimal value except as a source of energy. In future implementations of this concept, this residual material, which is presently being incinerated at

*Robert A. Lowe. Energy recovery from waste. Washington, U.S. Government Printing Office, 1973. 24 p.

TABLE 1

Summary of Inputs and Outputs, Franklin Plant*
(in tons, based on 100 tons of residential solid waste)

Inputs			Outputs
Glass	9.7	4†	Color-sorted glass
Ferrous metals	10.1	9.7	Ferrous metals
Nonferrous metals	0.6	0.3†	Aluminum
Paper	26	13	Paper fiber
Plastics, leather, textiles, wood	6.1	34	Organics burned
Food and yard waste	17		
Miscellaneous inorganics	2.5		
Moisture	28	28	Water vapor
		11	Residue to landfill
Total	100	100	

*The composition of the waste (inputs) at Franklin is slightly different from that estimated to be typical for the U.S. The outputs shown here therefore differ from those shown on Figure 4, which are based on the national estimate.

†Anticipated output.

Franklin, might alternatively be used as a supplemental fuel for existing utility boilers or as the sole fuel for new steam or steam/electric boilers. Franklin does not employ energy recovery because the plant operates on a single shift while energy converting equipment operates best on a round-the-clock basis. Also, the capital investment for energy conversion could be justified only for a plant with a larger capacity.

The Logan-Long Company, which buys the paper fiber for making roofing shingles, is located about one-half mile from the solid waste processing plant. In their manufacturing process, Logan-Long uses a variety of fiber sources to make up their raw material requirements, including old corrugated boxes, newspaper, mixed paper, sawdust, wood chips, and logs as well as the recovered fiber from the Franklin plant. As of March 1974, Logan-Long had bought about 1,000 tons of fiber from Franklin. The company has been satisfied with the performance of the Franklin fiber and feels that it is equivalent in quality to the combination of corrugated, mixed paper, and newspaper that they normally use. The price it pays for the Franklin fiber is based on the prices of these other secondary fiber sources. Since the Franklin fiber has already been pulped, however, Logan-Long adds a premium of 10 percent. In other words, if the average price of the corrugated, newspaper, and mixed paper that Logan-Long buys is $30 per ton, then the company pays $33 per ton for the Franklin fiber.

Because the price for the Franklin fiber is based on the price of the other secondary fibers and because in early 1974, the nation began to experience fiber shortages, the value of the Franklin fiber increased dramatically. In 1971 the price hovered around $25 per ton. During the last quarter of 1973, the price was nearly $34 per ton, and in April 1974 it was over $60 per ton. The secondary paper market has fluctuated notoriously over the years and therefore prices cannot be easily predicted; however, the best estimates indicate that although prices may fall below the 1974 record-high levels, they are not expected to return to the depressed levels that existed in previous years.

Franklin's fiber recovery system was designed to produce a secondary fiber that would be suitable for the Logan-Long plant. Since fiber for roofing shingles can be allowed a fairly high degree of contamination, the fiber recovery system was designed to produce only a lower grade of fiber (Table 2). Such a fiber would also be suitable for other construction paper grades not subject to high quality specifications.

The Black-Clawson Company reports that the recovered fiber could be upgraded to meet higher specifications. The company estimates that the cost of the additional processing would be small in comparison to the increase in

TABLE 2

Quantities, Quality, Purchasers, and Prices of Recovered Materials, Franklin Plant, June 1971–April 1974

Product	Amount recovered as percent of solid waste (dry weight basis)	Quality	Purchaser	Prices per ton*
Ferrous metals	9.7	Roughly equivalent to a No. 2 bundle	Armco Steel Company Middletown, Ohio (June 1971–March 1974)	$ 13-25
		Generally free of nonmetallics	Gillerman Steel Corporation St. Louis, Mo. (Since April 1974)	
		Density might be increased for steelmaking		
Paper fiber	13	Generally considered a lower grade paper fiber	Logan-Long Roofing Plant Franklin, Ohio	25-65
		Color, grease, and bacterial contaminants are similar to those of mixed paper but fibers are longer and there is less shrinkage		
		Suitable for use in making roofing felt and other construction papers		
		Contaminants can be removed and fibers upgraded for use in higher grades of paper		
Glass	4†	Expected to be clean and sorted by color	Various glass bottle manufacturing plants in the area	12-20
Aluminum	0.3†	Quality unsure at present	Alcoa	200
		Developmental work still underway		

*Prices at the plant. Transportation from plant is paid for by purchaser.
†Anticipated output.

value of the final fiber product. Black-Clawson believes that, within limits, the fiber recovery system can be designed to meet various purchasers' requirements. EPA will be conducting tests to verify these points in late 1974.

The ferrous metals recovered at the plant were originally sold to the Armco Steel Company in Middletown, Ohio, for around $15 per ton. This scrap metal was used in Armco's open hearth furnace, but since the quantities available from Franklin were so small (2,000 tons between June 1971 and March 1974) in comparison to their other scrap metal supplies, Armco did not perform any quality testing of the ferrous scrap recovered at Franklin. It appears to be generally free of nonmetallic material. The density may not be as high as would be desirable for steelmaking.

In April 1974 a new arrangement for the sale of the recovered ferrous metals was established with the Gillerman Steel Corporation of St. Louis, Missouri. Gillerman agreed to a purchase price which would float in relation to other ferrous scrap prices in the scrap metal market. The current price being paid by steel mills for a No. 2 bundle (a standard unit of a particular quality of ferrous scrap) is published monthly in trade journals. Gillerman agreed to pay Franklin at the rate of one-half the price of a No. 2 bundle minus $5 per ton for transportation. The May 1974 price for a No. 2 bundle was around $60, and so, by the above formula, the Franklin plant was receiving around $25 per ton. As of March 1974, no report had been received from Gillerman on the quality of the Franklin scrap and its use.

The glass and aluminum products are to be evaluated during the second half of 1974. As of March 1974 about 40 tons of color-sorted glass had been sold to a number of glass bottle manufacturing plants in the area at a price of $12 per ton. Alcoa presented a purchase order to Franklin for the aluminum scrap ($200 a ton), but none had been sold at this writing. A report on the quality and marketing of these products was expected by the end of 1974.

Adaptability of Modular Technology

The type of plant demonstrated at Franklin can provide different services and products depending upon the array of subsystems incorporated. For instance, the wet-pulping/disposal system can readily operate alone as an efficient incineration system for solid waste and sewage sludge. It can also operate alone to produce a solid waste "fuel" for producing energy. An engineering feasibility study indicated that this system could also be adapted to burn nonaqueous liquid industrial wastes such as oils and paint sludges.

If markets exist within a reasonable distance, the fiber and/or the glass and aluminum recovery modules could be added. The decision to incorporate any or all of the above variations depends on marketing factors (price, quantity, quality required, transportation costs, etc.) peculiar to the specific locale.

ENVIRONMENTAL CONSIDERATIONS

Land

The Franklin plant has had a very positive impact on the local environment. Only about 10 percent by weight of the incoming waste requires land disposal; and because the wastes are processed, the volume that requires land disposal represents less than 5 percent of the incoming volume.

Air

The exhaust gases from the fluid bed incinerator were tested and found to be in compliance with Federal air emission standards. The incinerator also serves the purpose of safely disposing of municipal sewage sludge, which often presents a difficult and costly disposal problem.

Water

The Franklin plant has two wastewater streams. The ash-laden scrubber water is pumped to the sewage treatment plant's industrial clarifier.

Waste process water is bled from the fiber recovery system and treated in the sewage treatment plant. Black-Clawson reports that future installations could recirculate this water within the plant and thereby eliminate any water effluent that would require treatment.

ECONOMICS

On the basis of approximately 3 years' operating experience at Franklin, the wet separation of solid wastes into recoverable products appears to represent an economically attractive option for resource recovery and waste disposal. This judgment, of course, depends upon the costs of other means of disposal. Indications are that in terms of cost the system at Franklin will be competitive with incineration and in some situations may even be competitive with long haul to distant sanitary landfills.

In general, the larger the solid waste processing/recovery plant, the more likely it is to be economically competitive with alternate disposal methods. This generalization stems from the fact that resource recovery systems are usually capital-intensive facilities, and their cost per ton becomes lower as the investment costs are spread over larger throughputs. A small plant, such as Franklin's (150 tons per 24-hour day), would therefore have a high cost per ton and would probably not be appropriate. Franklin's net costs are only about $7 per ton because the Federal grant covered two-thirds of the plant's capital cost.

Projected Economics for a Larger Plant

Sufficient data has been accumulated to permit reasonable projections of the costs and revenue for Franklin-type systems with capacities much larger than the pilot plant. Since the projections are derived from the experience at Franklin, however, they reflect conditions specific to that area. Actual costs could vary significantly according to the location of the plants.

For this report, projections were calculated for a 500-ton-per-day facility. Operating 300 days a year, 24 hours a day, such a plant could service a community of roughly 350,000 people. This particular size was selected for purposes of illustrating the economics for a larger plant and not because it is a model size or the size at which this system is known to become economical. It should be noted, however, that much larger sizes are thought to be feasible—Black-Clawson is currently proposing plants with capacities ranging up to 2,500 tons per day.

For the system of waste processing/disposal and ferrous metal recovery alone, the projected capital cost for a 500-ton-per-day plant was $5.9 million (Table 3). This includes costs for design, engineering, site preparation, buildings, equipment, and installation at 1974 prices. The cost of land is not included, since it is assumed that facilities would be built on land already owned by the city or on land which the city would be required to purchase for any comparable solid waste or sewage treatment process. The projected capital recovery and interest cost per year was calculated to be $570,000 based on an assumed economic lifespan of 15 years and a combined interest and capital recovery rate of 5 percent per year. The projected annual operating and maintenance cost was $1,140,000. This figure was based on projections made by the Black-Clawson Company and reviewed by A. M. Kinney, Inc., Consulting Engineers, and EPA. With revenues of $260,000 per year for ferrous metals and $150,000 for sludge disposal, the net cost per year would be $1,300,000 or $8.70 per ton of solid waste processed.

Using the same procedures and assumptions, costs and revenues were projected for the systems for fiber recovery and glass and aluminum recovery. The capital cost of adding on the fiber recovery system to the basic system would be $3.1 million ($290,000 per year); added operating and maintenance costs would total $450,000. A price of $34 a ton for the fiber would bring in $800,000 a year, resulting in a net profit of $60,000 for the fiber recovery system. This amounts to a credit of $0.40 per ton of solid waste processed. If the fiber were sold for $60 a ton, the level reached in 1974, the yearly

TABLE 3

Projected Economics of the Wet-Processing/Recovery Subsystems*
(500 tons per day, 300 days per year)

	Revenues per year	Cost (profit) per year	Cost (credit) per ton input
I. Hydrasposal system			
Capital cost–$5.9 million		$ 570,000	$3.80
Operating and maintenance cost		1,140,000	7.60
Credits			
Ferrous metals sold for $25/ton	$ 260,000		(1.70)
Sludge disposal service at $25/ton	150,000		(1.00)
Net costs		1,300,000	8.70
II. Fiber recovery system†			
Added capital cost–$3.1 million		290,000	1.90
Added operating and maintenance cost		450,000	3.00
Credits			
Paper fibers sold for $34/ton	800,000		(5.30)
Incremental net profit		(60,000)	(0.40)
Paper fibers sold for $60/ton	1,350,000		(9.00)
Incremental net profit		(610,000)	(4.10)
III. Glass and aluminum recovery system†, ‡			
Added capital cost–$1 million		96,000	0.65
Added operating and maintenance cost		60,000	0.40
Credits			
Glass sold for $12/ton	85,000		(0.55)
Aluminum sold for $200/ton	120,000		(0.80)
Incremental net profit		(50,000)	(0.30)

* Projected from experience of the Franklin plant.

† System's economic success is a function of recovery rates, market prices, and economic lifespan of the hardware.

‡ Preliminary economic analysis–April 1974.

revenue would be $1,350,000, the profit for the fiber recovery system would be $610,000, and the profit to be credited per ton of solid waste processed would be $4.10.

The cost information on the glass and aluminum recovery system was still quite preliminary as of March 1974. Nevertheless an attempt was made to estimate the economics for this module. The projected capital cost for adding on the glass and aluminum recovery system was expected to be around $1 million, or $96,000 per year. The added operating and maintenance cost would be $60,000 per year. The projected revenue from the sale of glass was $85,000; for the aluminum, $120,000. This resulted in a net profit of $50,000, or a credit per ton of solid waste of $0.30.

On the basis of the projections, the net cost could range from $4.20 to $11.40 per ton, depending on the modules added to the basic disposal system (Figure 15). An energy recovery module might further reduce the net cost. Obviously, the system's economic viability is a function of recovery rates, economic lifespan of the hardware, operating costs, and market prices for the products.

ECONOMIC EFFECT OF ADDING MODULES TO THE BASIC SYSTEM

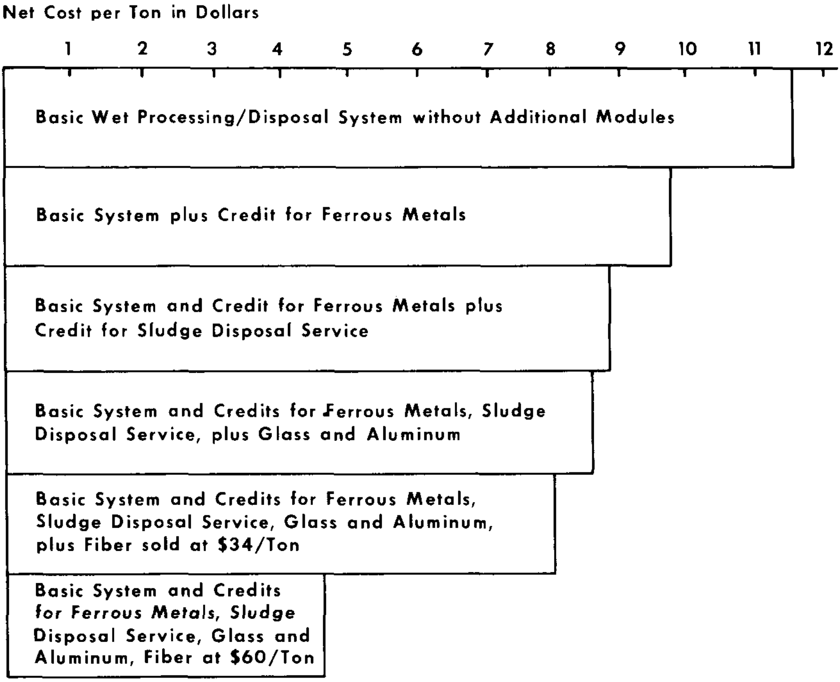

Figure 15. The addition of various modules to the basic wet-processing and disposal system reduces the net cost per ton by various degrees. The addition of an energy recovery module may further reduce the net cost.

FURTHER DEVELOPMENTS

This project has been supplemented by additional studies and by the development of auxiliary concepts and equipment. Some of these studies include the search for new markets for the recovered materials and the development of new subsystems to recover that fraction of the nonferrous metals that were being landfilled.

The prospect of using the nonrecovered combustible material as a source of energy is most promising. This fuel product has a low sulfur content and a dry weight heating value about two-thirds that of coal. An ongoing EPA demonstration project in St. Louis, Missouri*, and developmental efforts by various private concerns indicate that this material could be burned in a boiler for the production of steam or electricity. Of course, the presence of moisture in solid waste reduces its effective heating value as a fuel. In contrast to

*Lowe, Energy recovery from waste.

the more conventional dry-processing methods, the wet-processing method aggravates this situation, but there are a number of apparent advantages to wet-processing, already alluded to in this report, which may mitigate or even outweigh the loss in available energy. After considerable testing of this concept, the Black-Clawson Company has been making proposals to several cities across the country to build systems that are like the Franklin plant but on a larger scale and incorporating energy production. EPA has also been evaluating the concept.

Research work has also been underway to investigate the feasibility of combining solid wastes with sewage sludge, digesting the mixture, and capturing its energy value through the production of methane for use as a fuel gas. In this application, wet-processing may be advantageous because small particle sizes and large quantities of water are needed to create optimum conditions for decomposition.

With the addition of an energy recovery component, the Franklin project plan would provide for the recovery of over 90 percent of the material or energy values in the solid waste stream. The revenue from the sale of the energy output could further reduce the net cost of the system.

Studies have reportedly been done in The Netherlands on the feasibility of composting nonrecovered organic materials similar to that incinerated at the Franklin plant. The humus product would be used to improve the sandy soil reclaimed from the ocean.

Finally, plans are well underway to expand the Franklin facility to handle the disposal of industrial oils and solvents. As of this writing these were being dumped in significant quantities into sewers and streams and onto lands that were draining into the rivers in the Franklin area. Some of the liquids were being burned improperly, contributing to air pollution. To solve this problem, an engineering study commissioned by the local water conservancy recommended that a regional disposal facility for handling these liquid industrial wastes be built at Franklin to take advantage of the fluid bed incinerator. The study found that the fluid bed incinerator can burn many of these industrial liquid wastes that could not be treated at the sewage plant. A pretreatment plant was established in mid 1974 which operates in conjunction with the sewage treatment plant, and implementation of the incineration capability was also under development in 1974.

Thus the Franklin project, which has brought together techniques originally developed in various industries and modified them for application to solid waste, is also serving as a basis for further developments in the field of resource recovery and residuals management.

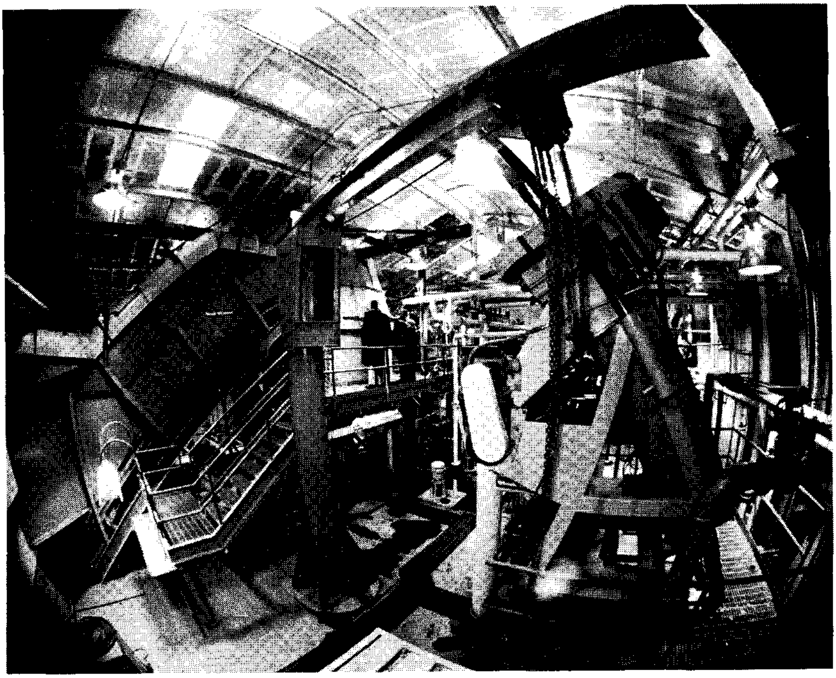

Figure 16. The Franklin solid waste processing and resource recovery complex uses equipment and concepts developed in other industries and modified for use on solid waste. It represents a significant advance in the state of the art in resource recovery and residuals management.

FOR MORE INFORMATION ABOUT THE FRANKLIN PLANT

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