A Solid Waste Utilization System for St. Louis

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ABSTRACT

This paper describes the waste processing and boiler feed facilities which serve as the prototype for Union Electric Company's proposed Solid Waste Utilization System for recycling essentially all the solid waste generated in the metropolitan St. Louis Area. The recently announced system, capable of processing up to 8,000 tons of raw refuse per day and estimated to cost $70 million, will be built and operated without government subsidy. Solid waste will be processed for the recovery of recyclible noncombustibles and use as a supplementary fuel to electric utility boilers.

INTRODUCTION

Since April of 1972 the City of St. Louis, Missouri and Union Electric Company have participated in a test program to determine the suitability of burning processed household refuse in an electric utility boiler.

The designers of the test project proposed to test the hypothesis that domestic solid waste, milled inexpensively to a small particle size, could serve as a supplementary fuel for firing in a utility boiler. Furthermore, by replacing only a small percentage of the total fuel fired, there would be little difference in effect on the boiler than if 100 percent coal were burned.

The resulting solid waste test processing facility is located adjacent to the South one of the two City incinerators, and has been jointly financed by the City of St. Louis and the U.S. Environmental Protection Agency. The boiler firing facilities are located at the Meramec Plant, which is some 20 miles from the processing facility, and have been completely financed by Union Electric Company.

During the first year of operation the prototype performed satisfactorily with the exception of the milled solid waste mechanical handling systems. Throughout this period only magnetic metals were separated from the milled refuse prior to firing to the boiler. Glass or other solid non-magnetic particles were an occasional cause of jamming in the feed mechanism supplying the material to the pneumatic transport system. The quantity of non-combustibles removed with the boiler bottom ash was excessive and finally abrasive wear was evident at the pneumatic transport piping bends and elbows. These problems were identified soon after the initial operation.

Late in 1973 a mechanical air density separator (air classifier) was added to the processing plant following the milling operation. The air classifier, in operation since mid-November 1973, has alleviated the equipment jamming and bottom ash problems.

The prototype has demonstrated that the designer's basic hypotheses were valid. To date the material has presented no insuperable operating problems at the processing plant or in the utility boiler.

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The processed solid waste, with a heat value of around 5,000 Btu/lb, has been a suitable supplementary boiler fuel.

THE PROTOTYPE PROCESSING FACILITIES

The City of St. Louis is responsible for processing the solid waste and transporting the combustible fraction to the Meramec Plant. The City facility is designed to process the raw refuse at the rate of 45 tons per hour or 300 tons for an 8-hour shift. The one shift operation of the City' plant will supply supplementary fuel for replacement of 10 percent of the coal requirement of the Meramec boiler for 24 hours.

The hammermill is a horizontal shaft mill powered by a direct-connected 1,250 hp, 900 r/min. motor. The mill grate has openings of 2¼ inches by 3¼ inches, but most milled particles are less than 1½ inches in size. The milled material will vary greatly in density depending on moisture and the degree of compaction, from a low of 4 lbs/ft^3 to a high of 12 lbs/ft^3.

Figure 1 provides a schematic flow diagram of the City processing facility.

The milled refuse is conveyed to the air classifier metering and surge bin which provides a controlled feed into the entrance of the air classifier. A cross section of the classifier is shown in Figure 2. The light burnable components of the milled refuse are carried with the air flow and discharged through the top of the classifier, while the heavy particles fall out the bottom onto a conveyor belt. The heavies are conveyed under a magnetic belt separator for removal of magnetic metals. A 100 hp vertical "nuggetizing" mill increases the density of the magnetics to about 65 lbs/ft^3. The dense nuggetized metal then passes over a magnetic drum for final separation of any remaining nonmagnetic metal.

The magnetic metal is transported to the Granite City Steel Company for use as scrap for charging blast furnaces.

The heavy fraction remaining after removal of the magnetics is currently being taken to landfill. However, plans are underway to provide for separation of the glass, organics, and nonferrous metals into separate components.

The light fraction from the classifier is carried by air to a cyclone separator and discharged to a conveyor belt to the storage bin. Loading the storage bin from the top and withdrawing from the bottom provides for first in, first out scheduling. The material withdrawn from the bin is compacted into conventional 75 yd^3, self-unloading transfer trailer trucks and transported approximately 20 miles to the Meramec Plant.

THE PROTOTYPE RECEIVING AND FIRING FACILITIES AT MERAMEC

Union Electric Company is responsible for the operation of the system starting with the surge bin at the Meramec Plant. Figure 3 is a diagram of the facilities at the power plant. The combustible portion of the solid waste is discharged from the trucks into a live bottom receiving bin, and pneumatically conveyed to the surge bin. The surge bin is equipped with four sweep bucket trains and four drag chain unloading conveyors which are built into troughs in the bin floor.

The material is fed through rotary air locks into the four pneumatic feeders. Each feeder conveys the supplementary fuel through a separate pipeline to a firing port in each corner of the boiler furnace. These four pipelines are each about 700 feet long. Air velocities are approximately 85 ft/s and the particle velocities, depending upon their mass, are approximately 50 to 70 ft/s. Initial pipeline pressures normally range from 1 to 3 psig.

Figure 4 is an illustration of the type boiler used at the Meramec Plant for the refuse burning. The Combustion Engineering, Inc. unit is tangentially-fired, with four pulverized coal burners in each corner, and burns about 56.5 tons/h of bituminous coal at a nominal rated load of 125 MW. The furnace is about 28 feet by 38 feet in cross section, with a total inside height of about 100 feet. At full load, the quantity of refuse burned, equivalent in heating value to 10 percent of the coal, is about 12.5 tons/h, or 300 tons/24-hour day.

The only modifications made to the furnace were the refuse burning ports installed in each corner, between the two middle tangential coal burners. The solid waste is burned in suspension with the same flame pattern as coal or gas. The nonburnable particles and the particles too large to be fully consumed within the time they are exposed in the furnace fall to the bottom ash hopper and are dumped with the bottom ash.

With the prepared refuse firing at a constant rate, combustion controls on the boiler automatically vary the rate of firing the pulverized coal in order to maintain the heat requirements of the boiler. If for any reason the boiler trips suddenly, an electrical interlock immediately stops the feeding of refuse.

It appears that firing rates equal to 10-20 percent of the total heat input to the boiler are practical

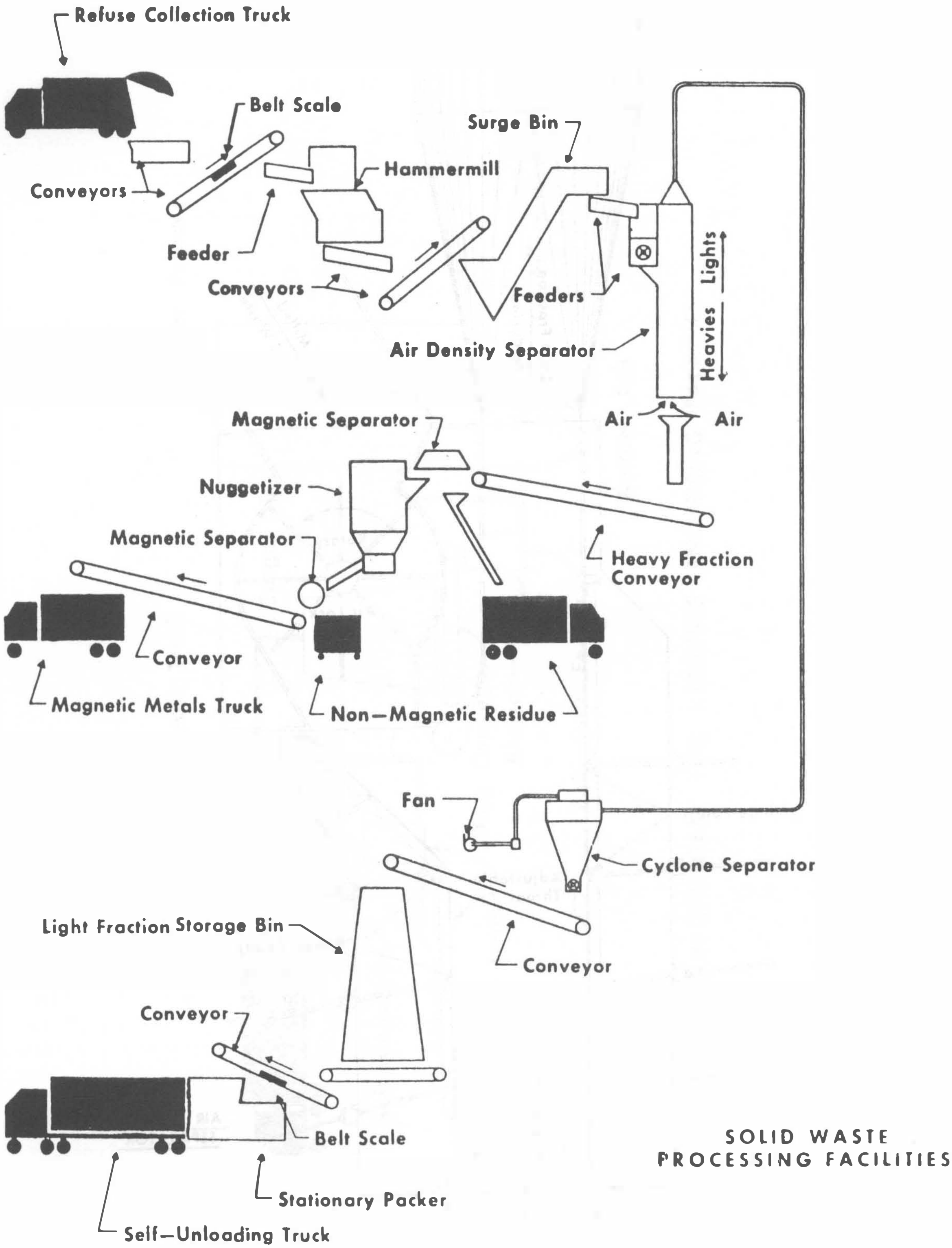

Refuse Collection Truck
Belt Scale
Conveyors
Hammermill
Feeder
Conveyors
Surge Bin
Feeders
Lights
Heavies
Air Density Separator
Air
Air
Magnetic Separator
Nuggetizer
Magnetic Separator
Heavy Fraction Conveyor
Conveyor
Magnetic Metals Truck
Non—Magnetic Residue
Fan
Cyclone Separator
Light Fraction Storage Bin
Conveyor
Conveyor
Belt Scale
Stationary Packer
Self—Unloading Truck
SOLID WASTE
PROCESSING FACILITIES

FIGURE 1

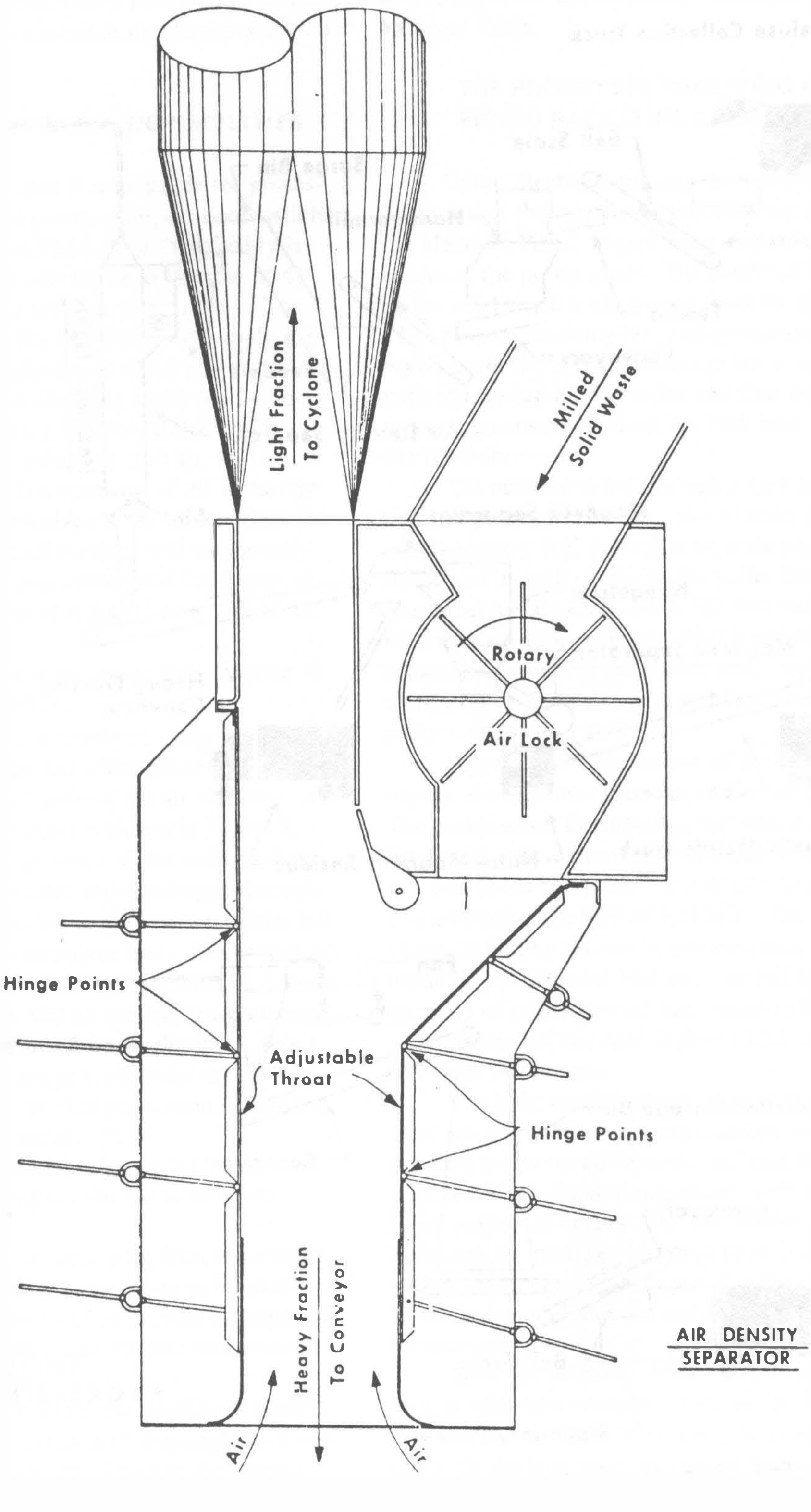
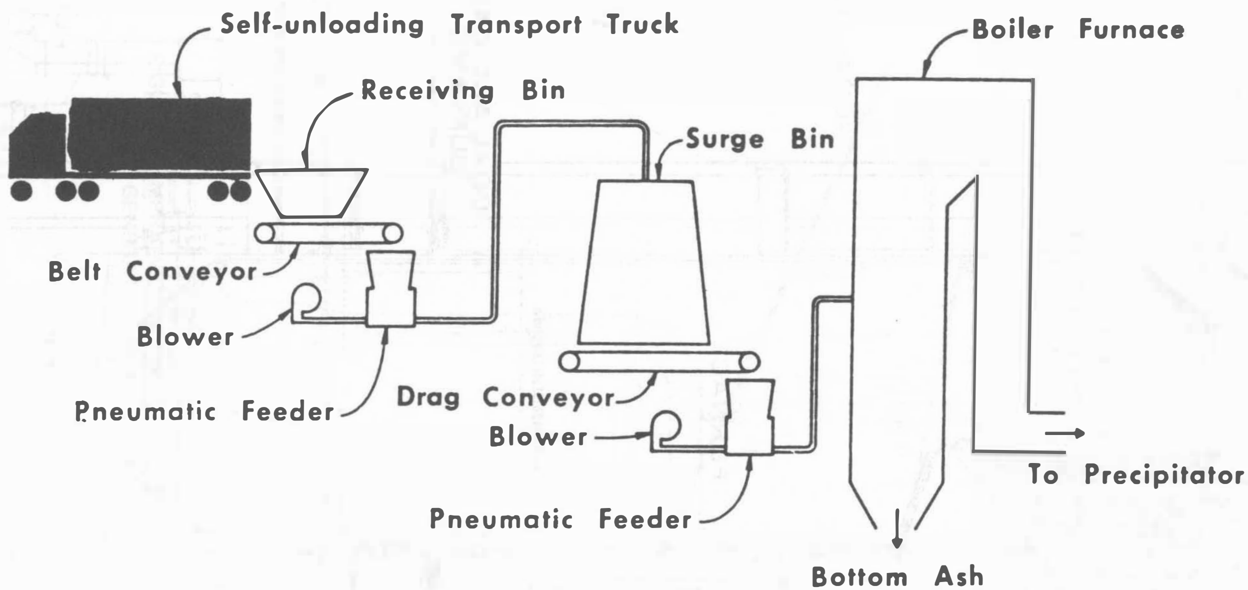
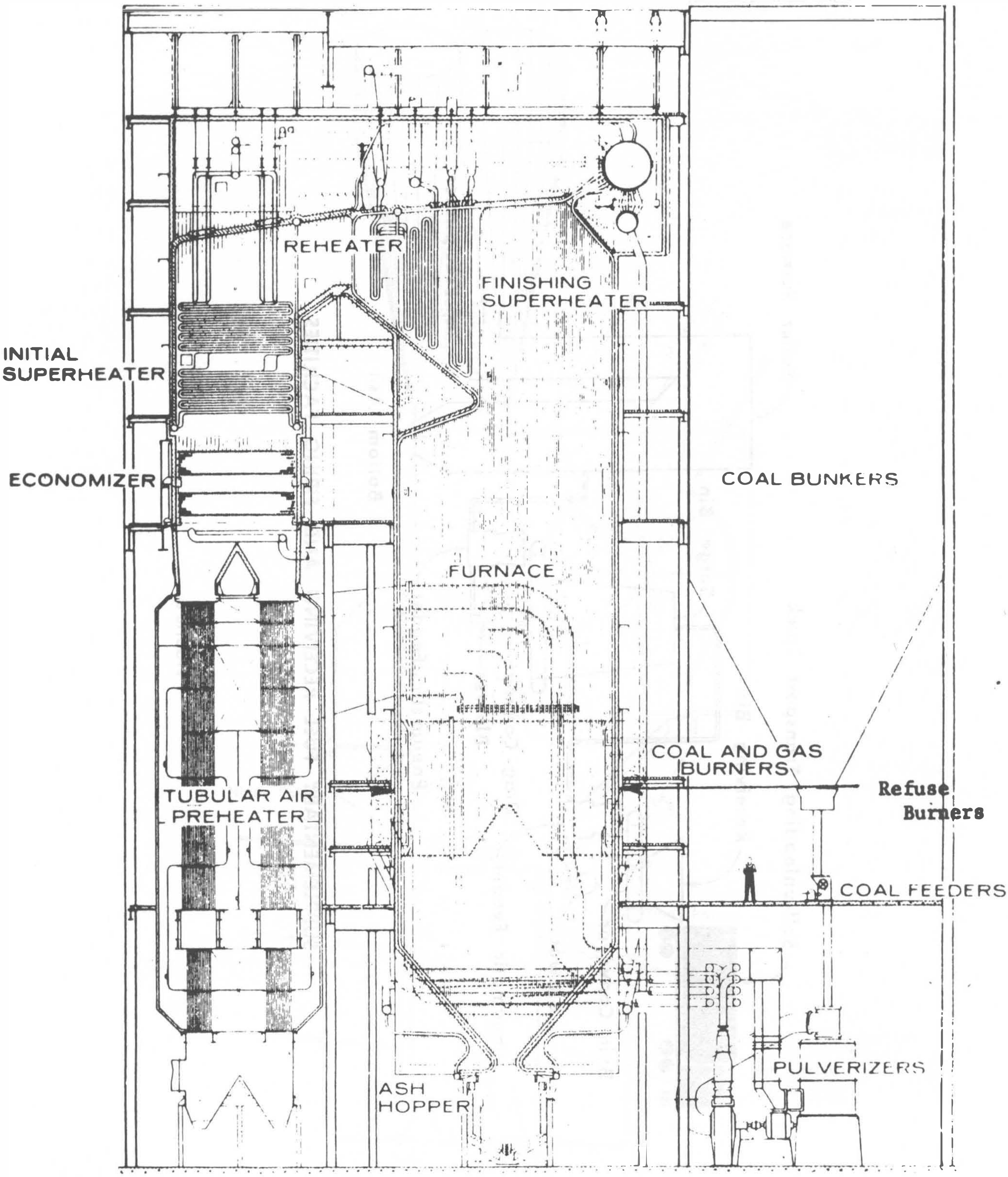

Light Fraction
To Cyclone
Milled
Solid Waste
Rotary
Air Lock
Hinge Points
Adjustable
Throat
Hinge Points
Heavy Fraction
To Conveyor
Air
Air
AIR DENSITY
SEPARATOR

FIGURE 2



SUPPLEMENTARY FUEL RECEIVING AND FIRING FACILITIES

FIGURE 3



MERAMEC UNIT NO. 1

FIGURE 4

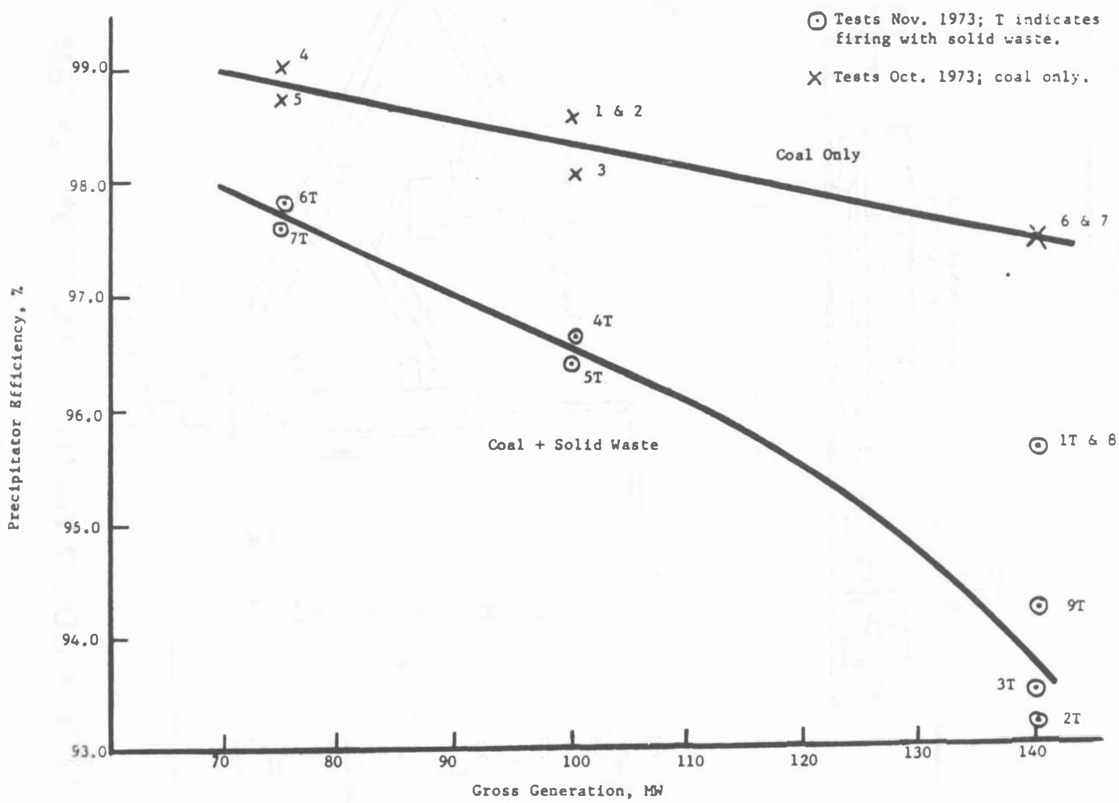
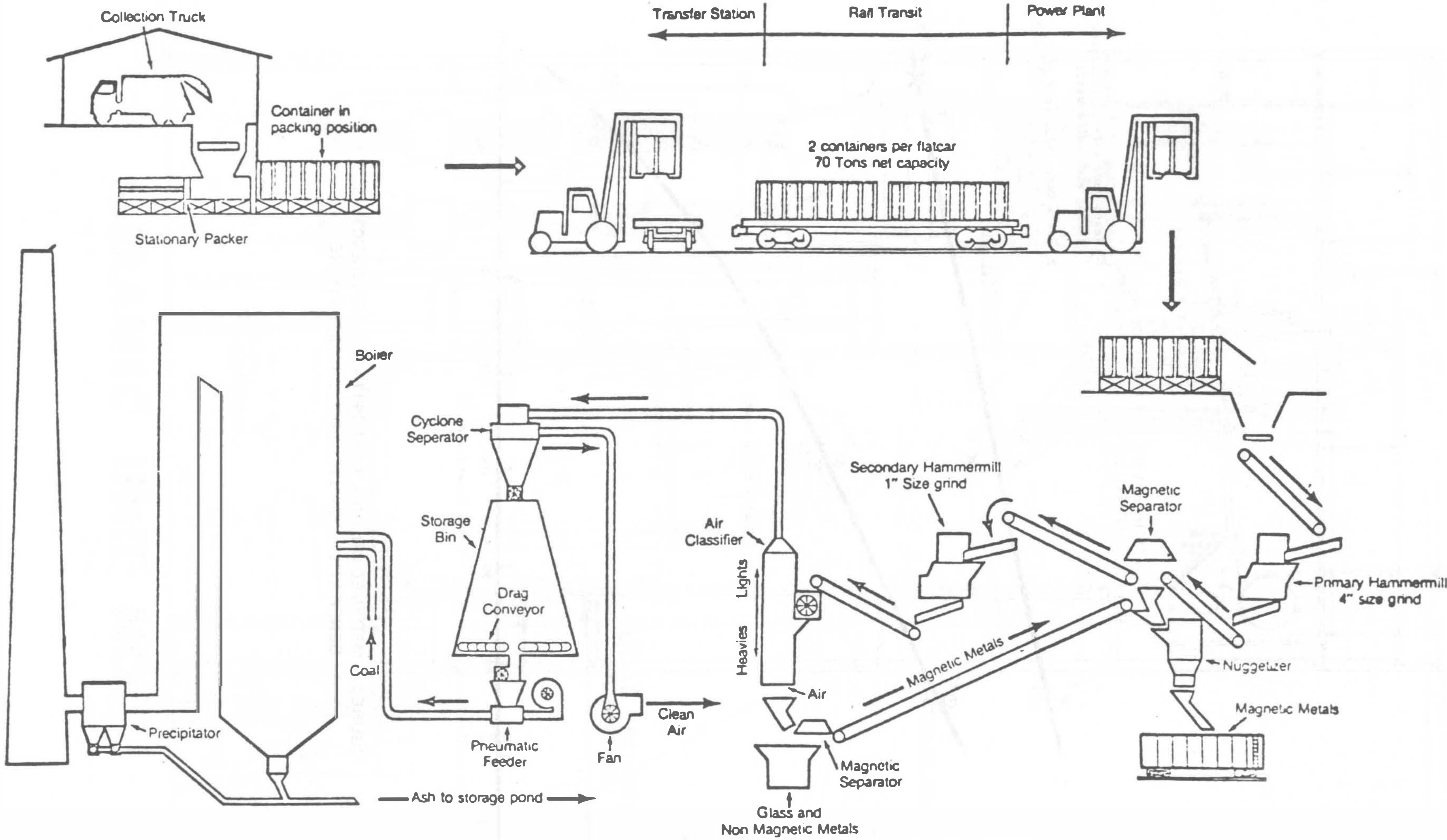


FIGURE 5 – MERAMEC UNIT NO. 1 PRECIPITATOR EFFICIENCY VS. GENERATION COAL AND SOLID WASTE FIRING



UNION ELECTRIC CO. • SOLID WASTE UTILIZATION SYSTEM

FIGURE 6

with the classified-milled solid waste. Since the installation of the classifier about 12,000 tons of processed refuse have been burned. Altogether since April 1972 about 28,000 tons of supplementary fuel have been delivered to the Meramec plant and fired. There is no evidence of short-term corrosion of furnace fireside or convection section gas-side surfaces. Long-term corrosion studies are still underway and should be complete by spring of 1975.

ENVIRONMENTAL EFFECTS

Comprehensive environmental testing by Union Electric and the USEPA is continuing. To date there are no indications of excessively adverse effects on the environment.

Analyses of the milled, classified solid waste are shown in Table I. The solid waste samples were taken prior to loading into the transport truck. The analyses include 234 samples taken from November 1973 to May 1974. Analysis techniques conformed insofar as possible to standard American Society for Testing Materials procedures for analyzing coal and coal ash.

While the solid waste is low in sulfur and visual observation of the stack has shown no dramatic increase in the particle emissions, it must be recognized

TABLE I

Air Classified Refuse Analyses

234 samples taken November 9, 1973 through May 29, 1974

	As Received Basis					
	Moisture (%)	Ash (%)	Sulfur (%)	Total Chlorides (%)	NaCl (%)	Btu/lb
Average	29.9	17.6	0.09	0.39	0.33	4,937
Maximum	66.3	31.3	0.28	0.94	0.59	7,593
Minimum	11.1	7.6	0.02	0.14	0.11	2,293

Air Classified Refuse Ash
(%)

	Average	Maximum	Minimum
P_2O_5	1.38	2.04	0.92
SiO_2	50.6	56.7	39.9
Al_2O_3	10.92	26.90	5.30
TiO_2	0.83	1.52	0.07
Fe_2O_3	7.66	22.19	3.03
CaO	12.06	15.80	8.51
MgO	1.29	2.48	0.22
SO_3	1.45	3.75	0.54
K_2O	1.56	2.91	0.89
Na_2O	8.50	19.20	3.11
SnO_2	0.05	0.10	0.02
CuO	0.30	1.74	0.05
ZnO	0.38	2.25	0.09
PbO	0.19	0.73	0.04

that the ash content of the classified refuse is higher than that of many coals and therefore incrementally increased dust loadings are probable.

During November 1973 an effort was made to determine the effect of firing refuse on precipitator performance. Meramec Unit No. 1 was operated at selected load conditions with coal firing only as well as various levels of supplementary refuse firing. Tests were run in accordance with the ASME Power Test Code 27. Figure 5 shows the comparative precipitator performance test results. This precipitator was designed for 97.5 percent efficiency at 411, 500 ACFM, which corresponds to 122 megawatts gross generation, when firing coal having 3½ percent sulfur. Interpolation of the test results to this same condition indicates precipitator efficiency when firing refuse is 95.9 percent, down but 1.6 percent from design. This modest reduction in precipitator performance demonstrates that this system of refuse firing is practical insofar as particulate emissions are concerned.

This winter additional precipator tests are planned. At this time, tests will be run using a more highly processed refuse product, such as would be expected from a full scale system.

Extensive analysis of water from the refuse ash pond influent and effluent as compared to water from a typical bottom ash pond shows some increase in oxygen demanding solids. A study is now underway to better define the problem, and determine which among a number of corrective solutions is most appropriate.

The emission standards for refuse burning utility boilers have not yet been established. It is hoped that the regulatory authorities will recognize that, while there may be an increase in point source emissions, a substantial net reduction in overall area pollution will result.

A FULL SCALE SOLID WASTE UTILIZATION SYSTEM

On February 28, 1974, Union Electric Company announced plans for the development of a Solid Waste Utilization System capable of handling essentially all of the solid waste generated in the metropolitan St. Louis region. The system is scheduled for full scale operation by mid 1977. Figure 6 presents a schematic flow diagram of Union Electric's proposed system.

Under the plan, Union Electric will establish and operate five to seven strategically located collection-transfer centers capable of handling a total of 2.5 to 3.0 million tons of waste annually. Refuse will be received from private and public haulers at these centers and transferred to closed containers for rail shipment to processing facilities at the Company's Meramec and Labadie power plants. Refuse will also be received directly from the haulers at both processing plants.

Meramec Plant includes two 125 MW C.E. boilers; a 270 MW Foster Wheeler front fired pulverized coal boiler; and a 300 MW Foster Wheeler front fired pulverized coal boiler. All four units will be equipped to burn processed waste at a rate equal to 20 percent of the units full load heat input.

Labadie Plant includes four 600 MW C.E. tangentially fired pulverized coal fired steam-electric generating units. All four units will be equipped to burn processed waste. The two plants will provide an aggregate refuse burning capability of twice that generated in the area.

The raw waste, including household wastes, appliances, commercial wastes, demolition lumber, and selected industrial solid and liquid wastes will be received at both power plants by rail. Two stages of hammermilling will reduce the solid waste to a particle size of one inch or smaller.

Following air classification, the burnable fraction will be pneumatically transported to the waste firing burners in the boiler furnaces. Redundancy is designed into all stages of the process to insure availability of waste processing facilities at all times at each plant.

The heavy fraction from the process air classifiers will be separated into organic, glass, magnetic, and nonmagnetic metal fractions. The organics will be returned to the hammermills for further size reduction and ultimate transfer to the burnable fractions, which will preclude the need to dispose of these materials in landfill. Magnetic and nonmagnetic metals will be recovered and recycled as will the glass if suitable separation techniques and markets can be developed.

Composition of the waste to be received by the system is difficult to predict. A rough estimate of the waste composition is listed below:

	Percent by Weight
Burnable	80
Glass	10
Magnetic metals	8
Non-Magnetic metals	1
Rock, gravel, etc.	1
Total	100

ECONOMICS OF THE PROPOSED SYSTEM

The economic evaluation of the proposed Solid Waste Utilization System is premised on the similar processing of refuse as is done with the prototype, but with an enlargement in scale and equipment, and generally more efficient materials handling systems.

The critical factors in the economic evaluation of the process are:

1) Federal, state, and local regulation of solid waste landfills.
2) Regulatory standards for stack emissions, fuel, and waste water discharge.
3) Cost of transport of solid waste from the point of origin through processing and to the boiler.
4) Cost of alternate, environmentally acceptable methods of solid waste utilization and disposal.
5) Dumping fees at collection centers.
6) Value of recovered materials such as magnetic and non-magnetic metals.
7) Cost of Fuel.

Capital investments, revenues, expenses, depreciation schedules and taxes are forecast for each year. The annual net after tax cash flows is determined. Finally, the mathematics of rate-of-return and net present value analysis is applied to the after tax cash flow values. The project becomes economically attractive when the rate-of-return exceeds the cost of capital, or the project, discounted at cost of capital, is evaluated to have a positive net present value.

Obviously, a number of estimates are made before determination of the various cash flows. One such estimate, crucial to the analysis, is that of the regulatory requirements. For example, unrealistic emission standards, with the associated increase in capital investment, could cause the Solid Wate Utilization System to be economically unfeasible.

Consequently, the management of Union Electric has requested of the regulatory authorities that they diligently strive for definitive standards for this project. The spending of the substantial sum of money needed to achieve the Solid Waste Utilization System is predicted on the expectation that reasonable standards will be established.

A PROGRESS REPORT

Efforts to complete the project are continuing.

After determining the feasibility of the project Union Electric notified the various state regulatory bodies of its plan. These authorities made very clear that the electric utility customer was in no way to subsidize this undertaking. Consequently, the project is to be built and operated by Union Colliery Company, a wholly owned subsidiary of Union Electric. The cost of all new construction and modifications to existing facilities will be borne by Union Colliery Company. Should the project fail, no burden will result to Union Electric's electric customers.

Favorable tax exept financing is being sought. On April 17, 1974 the State Environmental Improvement Authority of the State of Missouri issued a resolution approving action toward issuance of bonds for this solid waste disposal project. Soon a request will be filed with the Internal Revenue Service for a ruling that interest on these bonds issued by the authority will be excludable from the gross taxable income of the purchasers thereof.

Expenditures and commitments are being made.

1. In August, Union Colliery signed a contract with the St. Louis based consulting firm of Horner & Shifrin for engineering and design services for the project. This firm is particularly qualified since they were consultants for the City's portion of the prototype.

2. Also in August a contract was signed with Rader Pneumatics of Memphis, Tennessee for the design and construction of the air density separation and pneumatic transport systems. The value of this contract is in excess of $4 million.

3. Negotiations are continuing for the purchase of five storage bins and unloading systems, to be located at the processing plants. Announcement of this purchase is expected very soon.

4. The accumulation of tracts of land for three collection-transfer stations is virtually complete. Sites for additional stations are under study.

CONCLUSION

The authors do not suggest the system described in this paper and being developed for the St. Louis area is the only practical solution to the solid waste problem. However, the fact that a Solid Waste Utilization System can be economically attractive is certainly a landmark of progress.

The problem of refuse disposal and the attendant air and water pollution and land degradation is now superseded with the opportunity to develop the solid waste resource for society's benefit by salvaging or recycling scarce materials and conserving limited natural resources.

ACKNOWLEDGMENTS

The Union Electric Company wishes to acknowledge the contributions and continued cooperation of the City of St. Louis and Horner and Shifrin Consulting Engineers, the U.S. Environmental Protection Agency, Granite City Steel Company, the American Iron and Steel Institute, and Reynolds Metals Co.

The following companies provided services and major pieces of equipment for the prototype and continue to cooperate in the development of this process.

For the City of St. Louis:

Hammermill–Gruendler Crusher & Pulverizer Co.; Conveyors–Continental Conveyor Co.; Vibrating conveyors–Stephens-Adamson Division, Borg Warner Corp.; Storage bin, St. Louis –Miller-Hoft Corp.; Stationary packer and transfer trucks–Heil Corp.; Pneumatic transport equipment and air classification equipment–Rader Pneumatics Inc.; Magnetic metal "Nuggetizer"–Eidal Corporation.

For Union Electric Company:

Boilers–Combustion Engineering Inc.; Storage bin–Atlas Systems Inc.; Pneumatic transport equipment–Rader Pneumatics Inc.; Refuse and refuse ash analysis–Ralston Purina-Research 900.

REFERENCES

[1] Earl K. Dille, David L. Klumb, and G. Wayne Sutterfield, "Recycling Solid Waste for Utility Fuel and Recovery of Other Resources," Oklahoma State University Frontiers of Power Technology, October 10-11, 1973.

[2] Robert A. Lowe, "Energy Recovery from Waste." Washington, D.C., *U.S. Environmental Protection Agency*, 1973.

[3] David L. Klumb, "Solid Waste Prototype for Recovery of Utility Fuel and Other Resources," Denver, Colorado, American Pollution Control Association, June 11, 1974.

[4] David L. Klumb and Paul R. Brendel, "Union Electric's Solid Waste Utilization System," Salt Lake City, Utah, American Institute of Chemical Engineers, August 19, 1974.