for materials in solid wastes

THE COVER

The crowned dragon that eats its own tail, the World Snake, or Uroboros, is an ancient alchemical symbol of self renewal and regeneration, similar in concept to the Phoenix, the mythical bird that rises from its own ashes. The crown signifies completeness while the act of self-consumption symbolizes autonomy and self reliance. This ancient symbol has a modern counterpart in the concepts of recycling and ecology which are frequently represented by a modern circular symbol. The illustration on the cover was adapted from an alchemical text: Abraham Eleazar (Abraham the Jew), *Urlates chymisches Werk,* Leipzig, 1760, as reproduced in Jung, C. G. *Psychology and Alchemy.* Translated by R.F.C. Hull. New York, Pantheon Books, 1953. p. 99.

SW29C

SALVAGE MARKETS
for materials in solid wastes

This economic study (SW-29c) was written for the
Federal solid waste management program
by ARSEN DARNAY and WILLIAM E. FRANKLIN
Midsest Research Institute, Kansas City, Missouri,
under Contract No. CPE 69-3

U.S. ENVIRONMENTAL PROTECTION AGENCY
1972

NOTES TO THE FIRST EDITION

Typesetting for the present edition of this report was the responsibility of neither the U.S. Government Printing Office nor the Midwest Research Institute. Rather, a new typesetting method was tried, unsuccessfully. We are publishing the book despite the many typographical errors, since the data is accurate and we want to make it widely available now. The typographical errors and lack of type uniformity will be corrected in the second edition.

The report does not necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of commercial products constitute endorsement by the U.S. Government.

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FOREWORD

The Resource Recovery Act, adopted in 1970, amended the Solid Waste Disposal Act to add emphasis to recovery, recycling, and reuse of materials and energy. A year and a half earlier the Federal solid waste management program had initiated a contract study to identify and describe the markets for materials recovered from solid waste, recognizing that the availability of markets is critical to increased materials recovery.

The present report by Midwest Research Institute, Inc., is the result of that study. It gives a realistic evaluation of the markets for so-called secondary materials, which are recycled fabrication or consumption wastes in contrast to primary or virgin materials, which are derived from mine or forest. The report provides industry-by-industry data on raw materials consumption and the mix between virgin and secondary materials use. It also gives the first full insight into the structure of the secondary materials market in metropolitan areas and identifies the participants and their roles. In the face of our desire for increased recovery of materials and energy, the report explains why the national trend has been in the opposite direction. Thus recycling has, over the years, declined in importance.

Even while the study was underway, there was rising a groundswell of popular interest in resource recovery. Spontaneous school and community drives for the collection of bottles, cans, and paper for recycling have occurred, and in some instances citizen groups have established recovery centers for more sustained efforts at collecting materials which are potentially recyclable. All of these moves serve to increase the supplies of secondary materials but have no direct effect on the basic demand for the materials.

Citizen interest has shown itself in another way. Beverage containers are an all too visible component of litter. While these containers have traditionally been reusable, the current growth in the market, particularly for soft drinks, has been accompanied by a general move away from reusable bottles toward single use containers of glass, steel and aluminum. In striking a double blow for the environment — to promote resource recovery and to reduce litter — concerned citizens have strongly urged their State legislatures and city councils to ban or tax nonreturnable containers. The pressure for legislation has in turn caused industry to take a fresh interest in recovery of materials. Thus recycling centers have been established at aluminum, glass container, can manufacturing, and bottling plants, among others.

Time will tell whether the new approaches to recycling will become an accepted and significant part of the market. Meanwhile an important start to bringing about a sustained increase in the demand for recycled materials has been taken through Federal, State, and local changes in purchase specifications beginning with paper products. The U.S. Environmental Protection Agency is, in accordance with the amended Solid Waste Disposal Act, itself giving greater impetus to research and investigations leading to recommendations for national incentives needed to bring about increased resource recovery.

Events are moving faster than the present study on the economics of the salvage market could encompass. While some of the developments are touched on in the report, it concentrates on the structure and operation of the traditional market. An understanding of this market is vital to significant progress in resource recovery. The report makes an outstanding contribution to this understanding.

—SAMUEL HALE, JR.
Deputy Assistant Administrator
for Solid Waste Management

PREFACE

This report on recycling and salvage markets for materials in municipal solid waste was prepared by Midwest Research Institute under Contract No. CPE 69-3 with the U.S. Environmental Protection Agency. Work was carried out from May 1969 to November 1970. The statements, findings, and conclusions in this report are those of the authors and do not necessarily reflect the views of the Environmental Protection Agency.

The principal investigators and report authors were Arsen Darnay (project manager) and William E. Franklin. Valuable staff support was provided and special investigations were carried out by Howard Gadberry, Donald Heiman, and Gary Nuss. Research assistance was provided by Donna Ecton, Barbara Vicik, Sandy Harper, Sally Sharp, and Linda Crosswhite. John McKelvey, Vice President, Economics and Management Science, was responsible for general supervision of the project.

ACKNOWLEDGMENTS

A study of this nature, which deals with many manufacturing industries, the secondary materials industries, and the solid waste management establishment, could not have been undertaken in the quiet of a research library. The work depended to a great extent on the active participation and assistance of many companies, associations, government agencies, and individuals. We are pleased to acknowledge our indebtedness for the value of this report to all who participated while claiming full responsibility for any omissions or errors in the report itself.

In particular we wish to thank Leander B. Lovell, who was the Federal project monitor for this work. His guidance, assistance, patience, and interest were invaluable in making this a timely and, hopefully, useful look at the role of recycling and reuse of materials in municipal solid waste.

Several other persons provided the MRI team with special information and insight most valuable in developing a basic understanding of recycling and of the emerging concept of "resource conservation." In particular we cite the following individuals: E. W. Arnold, St. Regis Technical Center, West Nyack, New York; William E. Bartlett, National Committee for Paper Stock Conservation, St. Louis, Missouri; Charles G. Depew, Owens-Illinois, Toledo, Ohio; Charles Imel, Los Angeles Bureau of Sanitation, Los Angeles, California; M. J. Mighdoll, National Association of Secondary Material Industries, Inc., New York, New York; Henry Munde, Southwest Factories, Inc., Oklahoma City, Oklahoma; Carl Sexton, Los Angeles By-Products Company, Vernon, California; Curtis M. Snow, Monsanto Chemical Company, St. Louis, Missouri; William S. Story, Institute of Scrap Iron and Steel, Washington, D. C.; Harry Teasley, Coca-Cola USA, Atlanta, Georgia; Leo Weaver, American Public Works Association Institute for Solid Wastes, Washington, D. C.; and Lloyd E. Williams, Container Corporation of America, Chicago, Illinois.

Many other individuals with companies, industrial associations, and governmental units contributed useful information and spent valuable time with our project team. Organizations that helped with general information about governmental and industrial practices are listed below. We gratefully acknowledge their assistance. Finally, our case study interviews brought us into contact with more than 100 other organizations and several hundred individuals who provided general and proprietary information in the case-study cities. In order to protect the private nature of certain of that information, we have not listed these participants individually, but we wish gratefully to acknowledge their participation.

Companies

Armco Steel Company, Kansas City, Missouri; B. F. Goodrich Chemical Company, Cleveland, Ohio; Butler Manufacturing Company, Kansas City, Missouri; Coca-Cola, USA, Atlanta, Georgia; Container Corporation of America, Chicago, Illinois; Cook Paint and Varnish Company, Kansas City, Missouri; Crimsco, Inc., Kansas City, Missouri; Dickson Paper Fibre, Inc., Philadelphia, Pennsylvania; Garden State Paper Company, Garfield,

New Jersey; Gillerman Steel Trading Company, St. Louis, Missouri; Hallmark Cards, Kansas City, Missouri; IMCO Container Company, Kansas City, Missouri; Industrial Services of America, Louisville, Kentucky; U.S. Caster Company, Kansas City, Missouri; International Paper Company, New York, New York; Lab-Can Company, Kansas City, Missouri; Los Angeles By-Products Company, Vernon, California; Monsanto Chemical Company, St. Louis, Missouri; Owens-Illinois, Inc., Toledo, Ohio; Peterson Manufacturing Company, Kansas City, Missouri; Pioneer Paper Stock Company, Chicago, Illinois; Reynolds Metals Company, Richmond, Virginia; Royal Paper Stock Company, Columbus, Ohio; Sortex Company of North America, Inc., Lowell, Michigan; Southwest Factories, Inc., Oklahoma City, Oklahoma; St. Regis Paper Company, Technical Center, West Nyack, New York; The Black Clawson Company, Middletown, Ohio; Universal By-Products Company, Sun Valley, California; Waste Management, Inc., Hinsdale, Illinois;

Industry Associations

The Aluminum Association, New York, New York; American Paper Institute, New York, New York; American Public Works Research Foundation, Washington, D.C.; Glass Container Manufacturers Institute, New York, New York; Institute of Scrap Iron and Steel, Inc., Washington, D.C.; National Association of Secondary Materials Industries, Inc., New York, New York; National Association of Wiping Cloth Manufacturers, Chicago, Illinois; National Solid Waste Management Association, Washington, D.C.; The Society of the Plastics Industry, Inc., New York, New York;

Governmental Units

Bureau of Mines, U.S. Department of the Interior, College Park, Maryland and Washington, D.C.; Bureau of Sanitation, Department of Streets and Sanitation, City of Chicago, Chicago, Illinois; City Sanitation Department, Public Works Division, City of Amarillo, Amarillo, Texas; Department of Sanitation, City of New Orleans, New Orleans, Louisiana;

Department of Sanitation, The City of New York, New York, New York; Division of Waste Collection, Department of Public Works, City of Cincinnati, Cincinnati, Ohio; Forest Products and Packaging Division, U.S. Department of Commerce, Washington, D.C.; Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, Madison, Wisconsin; Gainesville Municipal Waste Conversion Authority, Gainesville, Florida; Los Angeles Air Pollution Control District, Los Angeles, California; Los Angeles Bureau of Sanitation, Los Angeles Department of Public Works, Los Angeles, California; Louisville Sanitary Department, City of Louisville, Louisville, Kentucky; Public Works Department, City of Madison, Madison, Wisconsin; Public Works Department, City of Mobile, Mobile, Alabama; Public Works Department, Berlin, Connecticut; Public Works Department, Darien, Connecticut; Public Works Department, New Britain, Connecticut; Public Works Department, New Canaan, Connecticut; Public Works Department, Waste Control Department, City of Gainesville, Gainesville, Florida; Refuse Disposal Division, City of Houston, Houston, Texas; Refuse Division, Department of Streets, City of St. Louis, St. Louis, Missouri; Sanitation Department, City of Atlanta, Atlanta, Georgia;

Others

Copper Data Center, Battelle Memorial Institute, Columbus, Ohio; Goodwill Industries, Cincinnati, Ohio, Bridgeport, Connecticut, Gainsville, Florida, Los Angeles, California, Madison, Wisconsin, Mobile, Alabama, Brooklyn, New York; William Russell, Consultant, St. Louis, Missouri; The Salvation Army, Amarillo, Texas, Cincinnati, Ohio, Bridgeport, Connecticut, Houston, Texas, Madison, Wisconsin, Mobile, Alabama, New York, New York; Volunteers of America, Cincinnati, Ohio, Long Island City, New York; William A. Xanten, Consulting Sanitary Engineer, Washington, D.C.

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SUMMARY

This document presents the findings of a study to evaluate salvage markets for commodities entering the solid waste stream. Emphasis was placed on paper, ferrous metals, nonferrous metals, glass, textiles, rubber, and plastics, but other materials are also discussed in the report.

Recycling Today

In the 1967-1968 period, 190 million tons of the major manufactured materials — paper, metals, glass, textiles, and rubber — were consumed yearly. In the same period, 48 million tons of these same materials were recycled through the market annually. Recycled materials were either fabrication wastes or obsolete, discarded products returned to industry for reprocessing. The rate of recycling in the period was 25.2 percent of consumption. Recycling rates varied by commodities, as follows:

Material	Total Consumption (million tons)	Total Recycled (million tons)	Recycling as Percent of Consumption
Paper	53.110	10.124	19.0
Iron and steel	105.900	33.100	31.2
Aluminum	4.009	.733	18.3
Copper	2.913	1.447	49.7
Lead	1.261	.625	49.6
Zinc	1.592	.201	12.6
Glass	12.820	.600	4.2
Textiles	5.672	.246	4.3
Rubber	3.943	1.032	26.2
Total	191.220	48.108	25.2

Factors Affecting Recycling

It is reasonable to assume that a secondary material, one that has already been processed, should be a more attractive raw material to industry than a virgin material that must be extracted or harvested and processed. Why, then, the relatively low recycling rate found in the United States today? The low rate is the result of the action of a number of forces, among them the following:

(1) The cost of virgin raw materials to the manufacturer is almost as low as the cost of secondary materials, and virgin materials are usually qualitatively superior to salvage. Consequently, demand for secondary materials is limited.

(2) Natural resources are abundant and manufacturing industries have deployed their operations and perfected their technologies to exploit these. No corresponding deployments and technology to exploit wastes have developed.

(3) Natural resources occur in concentrations while wastes occur in a dispersed manner. Consequently, acquisition of wastes for recycling is costly.

(4) Virgin materials, even in unprocessed form, tend to be more homogeneous in composition than waste materials. Sorting of wastes is costly and, in an age of affluence and convenience, repugnant to those who would have to engage in it — the urban householders.

(5) The advent of synthetic materials made from hydrocarbons, and their combination with natural materials, cause contamination of the latter, limiting their recovery. The synthetics themselves are virtually impossible to sort and recover economically.

Participants in Salvage Activities

Secondary Materials Industry. In 1967, some 8,000 companies, employing 79,000 people, and ringing up sales of $4.6 billion comprised the secondary materials industry.

These companies collect and sometimes process waste materials. The bulk of the materials they handle come from industrial or commercial operations. The exceptions are newspapers, purchased from schools or other civic organizations, and textiles, purchased from social welfare agencies such as the Salvation Army or Goodwill Industries.

As a rough average, secondary materials companies spend between $10 and $20 per ton on the physical acquisition and processing of wastes. They also incur other costs, among them payment for the waste and delivery of the waste to users.

Secondary materials companies can do little to influence the demand for the commodities they sell. Instead, they bend their efforts to the control of supplies, encouraging or discouraging collection of wastes depending on demand. Because of wide price fluctuations, they tend to hold down inventories.

Secondary Materials Consumers. Consumers are either companies that depend almost exclusively on waste materials inputs and often produce relatively low quality products (like roofing papers) or companies that buy small quantities of wastes to supplement their virgin materials inputs; these latter generally produce higher quality products (like printing paper).

In several industries — paper, textiles, rubber — the sectors based on secondary materials are losing markets to sectors based on virgin materials. In these areas, the quantitites of secondary materials available are growing while the demand for these materials is decreasing.

Some industries, like glass container manufacturers and steel producers, are capable of using much more waste than they use in fact. Their recycling rate is held low because sufficient quantities of qualitatively acceptable secondary materials are not available at costs competitive with virgin raw materials. Steel producers are also limited by the fact that some of their furnaces cannot accept scrap steel at high rates.

Industries that consume nonferrous metals accept virtually all wastes produced provided these can be delivered to them at an acceptable cost.

Solid Waste Management Organizations (SWMO). SWMO's are only peripherally involved in salvage. The retrieval of resaleable or recoverable items at dumps and landfills by independent scavengers or by contractors and the recovery of steel cans from incinerator residues are two forms of recovery practice encountered most frequently.

In 1969 and early 1970, most SWMO's viewed salvage as a nuisance. It was said to interfere with the organizations' principal mission — collection and sanitary disposal of waste. It yielded little or no net revenue, and quantities recovered were small. More recently, late 1970 and 1971, SWMO's appear to be showing new interest in salvage, prompted by the promise of Federal assistance to overcome technical and market problems — the promise being implicit in the 1970 Resource Recovery Act.

Municipal Salvage Techniques

Recovery of wastes for recycling requires that they be separated into basic materials classes — paper, ferrous metals, clear glass, dark glass, etc. The traditional technique of separation has been manual. This technique costs more than $16 per ton; revenues range between $4 and $9 per ton; consequently hand sorting of mixed municipal waste for recovery is uneconomical.

Technology to overcome this problem is under development. Most advanced are two systems. One, a system developed by the Black Clawson Company, accepts mixed municipal wastes and separates these automatically into reclaimable fiber, metals, and glass. The system, now in demonstration stage, is an adaptation of paper pulping technology to waste sorting. The other system, developed by the Bureau of Mines, separates metals and glass from incinerator residues using various materials handling techniques developed in the mining industry. Both systems appear to be sound in an engineering sense and have economical possibilities.

Other technology is also being developed — optical and magnetic sorting of broken glass; sorting of mixed, shredded waste by air classification; sorting of commercial wastes by mechanical conveyor systems; and the conversion of waste commodities into useable products like glass into road aggregate, organic wastes into animal feeds, combustible materials into oils, etc. These techniques are not yet sufficiently well developed to permit a judgment of their potential.

The availability of some new technology and the emergence of others, however, does not solve the fundamental problem of salvage — the absence of markets for these commodities.

Paper

Paper is the largest component — 40 to 50 percent by weight — of municipal waste collected. Fairly large quantities of paper are recycled. In 1969, 53 million tons of fibrous materials were consumed in paper making; of this, 10.1 million tons, or 19 percent, was waste paper. But paper's recycling rate has been declining steadily since 1945. Generation of paper waste is growing more rapidly than waste paper consumption. Mills using virgin pulp have been built in preference to those consuming waste paper to tap abundant sources of low cost virgin raw materials — trees.

The demand for products made of virgin fiber has increased about three times as rapidly as the demand for products made of secondary fiber in the past 15 years.

Virgin fibers are also used to upgrade the appearance of products that have traditionally been made exclusively of waste.

Higher recycling rates in paper are limited by economics (virgin fiber is cheap in relation to waste paper), logistics (manufacturing plants are far from cities where waste paper occurs), and the fundamental virgin materials orientation of the paper industry and its customers.

Ferrous Metals

Approximately 7 percent of collected municipal waste is ferrous metal.

The iron and steel industry uses large quantities of scrap metal in its operations; 33 million tons of purchased scrap supplied 31 percent of the industry's total metallics demand of nearly 106 million tons in 1967. In addition to this demand, 7.6 million tons of scrap were exported.

Of the 33 million tons of domestic scrap demand, obsolete scrap, such as automobile hulks and other discarded iron and steel objects and structures, accounted for 21.4 million tons, equivalent to 20 percent of total domestic metallics demand. The rest was supplied by fabrication wastes.

In addition to some 33 million tons of scrap acquired by the industry from external sources, it also used 52 million tons of internally generated scrap in 1967, called "home" scrap. Over the past decade, home scrap use has increased at the expense of obsolete scrap.

Ferrous metals occurring in municipal waste consist largely of tin-coated steel cans. These materials are not suitable for recycling in steel furnaces because the tin cannot be removed from the cans and contaminates the furnace products. Small quantities of obsolete steel cans are consumed in copper mining operations in the refining of low-grade copper. The demand for cans in this application is not sufficiently large to consume more than a small fraction of cans occurring.

Total demand for iron and steel scrap by industry here and abroad falls short of the tonnage actually available. In 1967, between 52 and 68 million tons of obsolete scrap were available by our estimate. Total domestic and export demand for obsolete scrap was 29 million tons. Closing the gap between available scrap supply and demand requires lower rates of iron ore consumption. At this time, ore-based operations are more economical than scrap-based operations for most of the industry. Collection of scrap occurring in dispersed locations and removal of impurities (such as tin) are more costly than mining and processing ores.

Nonferrous Metals

The major nonferrous metals — aluminum, copper, zinc, and lead — constitute less than 1 percent of collected municipal waste. All of these materials are valuable as scrap and are recycled within economic limits. In 1967, nearly 9.8 million tons of these materials were consumed; 30.8 percent of this consumption, 3 million tons, was provided by recycled materials.

Aluminum is the only nonferrous metal encountered in municipal waste in significant quantities. Approximately 680,000 tons of aluminum cans, food trays, and packaging foils were part of such waste in 1968. As a consequence of various legislative pressures on the packaging industry, three aluminum companies have entered the field of aluminum packaging reclamation by starting can reclamation centers.

These programs depend on delivery of the cans by the public to a central collection point where they are processed for shipment to a smelter. Success of the programs turns on these points: (1) collection must be by the public; (2) sufficiently high quantities must be brought in to operate the collection centers economically; (3) the aluminum is valuable, worth about $200 per ton, thus permitting processing. Reynolds Metals has the oldest successful program in operation. A "successful" program is unlikely to recover more than 10 to 15 percent of available aluminum packaging in an area.

Glass

Glass, largely discarded containers, makes up about 6 percent of collected municipal waste.

All segments of the glass industry use waste glass known as "cullet." But most of the cullet is derived from internal plant operations. Very little comes from outside sources. Cullet is an accepted component in glass making provided that it is clean, free of contaminants, and color sorted.

Glass containers constitute by far the largest share of total glass production tonnage (about 70 percent) and represent about 90 percent of the glass found in municipal waste.

In 1967, 12.8 million tons of glass were consumed. Of this total, 600,000 tons were purchased cullet from external sources equivalent to 4.2 percent of consumption.

The use of purchased cullet has declined because predictable supplies at prices competitive with basic raw materials (sand, limestone, and soda ash) have all but disappeared. The few surviving cullet dealers face rising costs and dwindling supplies.

It is not economically or technically feasible to recover glass from mixed wastes at present. However, technology for separation is being tested. The glass industry could absorb large quantities of cullet if the various technical and economic problems of cullet supply could be overcome, and indeed glass collection centers have been organized recently at glass container plants around the country under the leadership of the Glass Container Manufacturers Institute to induce the return of waste glass by consumers. Incentives for increased glass cullet use by industry are not present — virgin raw materials are cheap and abundant.

Textiles

The occurrence of textiles in waste is relatively low — about 0.6 percent of collected municipal wastes. Textile wastes are not normally returned to the industries that produce them with the exception of a small amount of wool that is rewoven. The chief uses of textile wastes are in paper and board products; furniture stuffings, fillings, and backings; export for resale; production of wiping cloths; and resale in second hand stores. In 1968, nearly 5.7 million tons of textiles were consumed and 246,000 tons of textiles were recycled, a recycling rate of 4.3 percent of consumption.

Rubber

Rubber is around 1 percent by weight of collected municipal wastes.

Tires are the principal source of waste rubber. About 1 million tons of rubber were recovered in 1969, 26.2 percent of a total consumption of 3.9 million tons. Retreading is the principal form of rubber recycling (75 percent); rubber reclaiming accounts for a substantial share (24 percent); tire splitters — who cut tires into various products like gaskets — take less than 1 percent of the recovered tonnage.

There are definite technical limitations to recycled rubber since it cannot be successfully mixed with virgin rubber in large percentages or substituted for virgin rubber. Retread tires are losing markets to new tires, and this decline is expected to continue; rubber reclaiming is also in decline.

Since rubber recycling is experiencing decline as markets dwindle, the rubber content of solid waste can be expected to rise. Use of waste rubber to produce new materials (e.g. oils) or energy appears to offer the best hope for recovery of this waste category.

Plastics

Plastics are increasing rapidly in waste because these materials are growing in a number of consumer product markets. Obsolete plastics are not recycled. The immense number of different formulations of plastics and the near impossibility of sorting these materials after discard prevents their reuse. A small market exists for fabrication wastes. These are purchased by waste plastics processors who regrind, color blend, and remelt plastics for low grade applications. The demand for secondary plastics made from fabrication wastes falls short of the total supply of such wastes so that many fabricators haul their wastes to dumps and landfills.

Legislative and Policy Considerations

The situation in recycling today is one whereby normal free market forces are causing a decreasing use of secondary materials — which have difficulty competing against virgin resources. In instance after instance, the relatively low cost of virgin materials — and the consequent absence of demand for secondary materials — explains why waste materials are not recovered. On the surface, it appears that legislation to cause increased use of wastes would merely cause the consumer higher costs.

In actuality, the reason why virgin materials costs are relatively low and secondary materials costs are relatively high appears to be that the market mechanism does not reflect the true socioeconomic costs of virgin materials use nor does it credit recycled materials with creating social benefits.

Virgin materials producers enjoy depletion allowances, do not pay the full costs of environmental degradation created by their mining, harvesting, transportation, and processing activities; and are not charged for generating solid wastes. By contrast, secondary materials are not credited with conservation of natural resources, favorable contributions to foreign trade balance, low pollution generation in reprocessing, and removal of materials from the solid waste stream. This situation results in a distorted picture of the relative total costs of these two types of materials.

Legislation to increase the quantities of waste materials recycled thus appears justified if the total socioeconomic costs of using virgin raw materials are higher than the costs of the alternative use of secondary materials.

Legislative decision making is hampered by the absence of information on the total or "systems" impact of our materials use practices. Such information, however, can be developed and could serve to justify legislative intervention to create materials use practices that conserve our total national resources in the best way.

SALVAGE MARKETS
for materials in solid wastes

CHAPTER I Introductory Considerations

The Study in Perspective

The salvage of commodities in solid wastes is an attractive approach to solid waste management: it reduces the quantity of waste that must be handled for disposal. But salvage has not traditionally been viewed as a solution to waste management problems. It has always been a necessity, pursued for its own sake. Man has recovered waste materials throughout history and still does. Wastes were always subjected to scrutiny, and whatever materials of value could be extracted from the waste stream were extracted, for the simple reason that scarcity of valuable processed materials was a fact of life, and the human energy required for salvage of processed materials was lower than the energy needed for obtaining and processing virgin raw materials.

In the latter half of the 20th century, in a few highly developed countries of the world, modern technology and the use of fossil fuels have created a situation wherein the relative cost of producing materials from virgin sources is frequently lower than the cost of producing materials from wastes. One consequence of this development has been an increasing discard of commodities that, in earlier times, would have been recovered. The observable decline in salvage since the 1940's is a result of complex technoeconomic factors, but the basic issues are the relative value of virgin resources and secondary materials and the absence of demand for waste commodities.

This study concerns itself with the economics of salvage. Its underlying purpose is to elucidate the value relations between virgin materials and secondary materials so that intelligent planning and action can take place to salvage recoverable materials, thereby reducing the quantities of waste going to ultimate disposal. Needless to say, the current situation in salvage is not purely an economic or technoeconomic matter. Historical forces, public attitudes, purchase specifications, legislative constraints, and a variety of considerations that cannot be expressed in dollars and cents play a part in making salvage activity what it is. These factors are also described and analyzed.

As a whole, salvage has been declining for many years. It has never been a major activity of mankind (like transportation, agriculture, construction) but it could always be found on the margins of major activities. For this reason, it is a somewhat mysterious activity, poorly lighted by statistical facts and reporting systems. It is a world of small entrepreneurial enterprise — sometimes the part-time business of one man — poor records, prices that shift like quicksand, and a demand-supply picture dependent on innumerable unique conditions at the local level. Salvage is also an activity in transition, characterized by the disappearance of traditional structures and the emergence of new ones.

The study does not deal with all aspects of salvage or with all aspects in the same detail. Subjects eliminated from consideration by our contract are automotive scrap recovery and production and sale of compost. The central focus, however, is on the recovery of commodities encountered in municipal wastes, and the most detailed treatment is devoted to those manufactured nonfood materials that occur in the largest quantities in waste — paper, metals, and glass — those commodities that are salvaged from commercial and residential sources, but which also contribute most of the municipal waste.[1]

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[1] Detailed studies of industrial waste generation and salvage have been conducted, or are under way, under sponsorship of the Office of Solid Waste Management Programs (OSWMP), U.S. Environmental Protection Agency.

Study Approach

The study was conducted in three parts: (I) special studies of each major material class; (2) a survey of 13 communities and one multicommunity area (these surveys are referred to as "case studies" in this report); and (3) a mail survey of 2,005 communities with populations over 10,000.

Special Studies. Special studies were accomplished by statistical data acquisition and analysis, literature review, and interviews with corporations and governmental agencies directly concerned with the recovery of a material class. In addition to providing information about the recovery of a material, these studies served to orient the research staff for case study work in the field.

Case Studies. Visits were made to 13 cities and one group of communities to study at first hand salvage practices in these areas. Our original intent was to study the total picture of the supply of and demand for secondary materials in each of 10 cities and four market areas. This original objective proved both undesirable and impossible. The amount of time available for the surveys was not sufficient to establish an overview of the total salvage activity in each material class, partly because of the fragmented nature of salvage activity, partly because of the size of the communities visited, and partly because information was denied the investigators. As a whole, however, the case studies illuminate salvage activities in the cities visited.

Preliminary survey efforts were conducted to develop an effective approach to the case studies; using this experience we developed an approach involving interviews with municipal sanitation officials, with private refuse haulers, secondary materials dealers, social service agencies such as the Salvation Army, and with companies that consume secondary materials. Between two and three man-weeks were spent in each of 10 areas; three additional cities were visited to investigate specific salvage projects.

Mail Survey. Following completion of the case studies, a questionnaire was developed to be used in a mail survey of salvage activities in all cities with a population of 10,000 and above. In all, 2,005 questionnaires were mailed out; a second mailing was conducted to reach again cities that had not responded to the initial effort. The intent of this effort was to fulfill the contractual obligation to create a "catalog of municipal salvage projects." The results of the survey are presented in Chapter XII.

Basic Definitions

Some definitions are set forth below to clarify the meaning of terms used in the secondary materials industry:

Conversion is the process of chemical change in secondary materials so that the identity of the original material is lost. Examples are the recovery of energy from organics by combustion and biological conversion of cellulose to sugars (see also "processing").

Junk is used interchangeably with "secondary materials" and means the same thing. Junk dealers, however, prefer to be called "secondary materials dealers," and this excellent Middle English word is consequently losing its currency.

Municipal waste is a general term used in the report to designate all types of waste likely to be collected and delivered to a public or private disposal site such as a dump, landfill, or incinerator. A similar term sometimes used is "urban waste." Municipal waste includes mixed household wastes, commercial and institutional waste, industrial plant wastes, street refuse, bulky wastes, demolition materials, dead animals, and other special wastes.

Primary recycling is the return of a secondary material to the same industry from which it came and processing of the secondary material so that it will yield the same or similar product which it was as a secondary material. Examples are the return of broken glass containers to glass container manufacturing plants for making new containers and the recycling of sheet steel scrap to steel furnaces for the manufacture of new steel.

Recovery is the same as salvage. It also means the acquisition of an energy value from incineration or other chemical conversion.

Reprocessing is the activity of changing the condition of secondary materials whether the change is minor such as crushing or shredding or major such as biochemical conversion of cellulose into yeast.

Recycling is an activity whereby a secondary material is introduced as a raw material into an industrial process in which it is transformed into a new product in such a manner that its original identity as a product is lost.

Reuse is the return of a commodity or product into the economic stream for use in exactly the same kind of application as before, without any change in its identity. The classic example is the returnable beverage container which is washed, refilled, and once more carries product to market.

Salvage as an activity is the act of saving or obtaining a secondary material, be it by pickup, sorting, disassembly, or some other activity. This term is also used more broadly to mean the entire activity of recovery and use and the process necessary for both, as in the phrase "salvage of materials has declined," which means that the removal of materials has declined and secondary materials are not used in the same quantities as heretofore. "Salvage" is sometimes used synonymously with *recovery, reclamation,* and *extraction.*

Salvage as a material is a technical term meaning a quantity of materials, sometimes of mixed composition, no longer useful in its present condition or at its present location, but capable of being recycled, reused, or used in other applications. Salvage also refers to materials recovered after a calamity, such as materials obtained from a ship wrecked at sea or a building destroyed by fire.

Scrap as a noun is a technical term for manufacturing wastes or rejected products of manufacturing processes. In the secondary materials trade the term is often restricted to iron and steel wastes, including those derived from obsolete products as well as those occurring in the manufacturing process.

Scrap as an adjective is a term used in cases where a specialized term for the waste material is not applied or does not exist such as scrap plastics or scrap rubber.

Secondary materials are materials generally handled by dealers and brokers that (1) have fulfilled their useful function and cannot be used further in their present form or composition and (2) materials that occur as waste from the manufacturing or conversion of products. The term "secondary materials" usually implies more than one type of material.

Secondary recycling is the use of a secondary material in an industrial application for recycling other than that in which the material originated. An example is the reprocessing of newspapers and old corrugated boxes into combination board for packaging or into construction paper. Another example is the pulping of cotton linters to make printing paper.

Secondary use is the use of a material in an application other than that in which it originated; however, the material is not changed significantly by processing and retains its identity. Examples are cotton clothing articles that are converted into wiping rags by being washed and cut to size; the use of steel cans in copper precipitation; and the use of rubber tires as dock bumpers. Materials used in this mode end up as waste after their secondary use is complete.

Usables is a secondary materials trade term meaning those items recovered from discards that are salable in their existing form as second-hand goods. Examples are steel piping, sinks, door handles, appliances, and clothing.

Virgin materials is a term denoting a material derived wholly or predominatly from substances mined from the earth, grown on the soil, or extracted from water bodies or the atmosphere. In the trade, virgin materials are juxtaposed to secondary materials.

Waste as an adjective in the secondary materials industry is used to differentiate between virgin materials and secondary materials, as in the phrase *waste paper.* The word is used in this sense as a substitute for words like *secondary, scrap,* or *junk.* Some people apply the term *waste* to materials in the process of being made acceptable for industrial consumption. Thus paper may be *waste paper* as recovered but becomes *paper stock* when it has been graded and baled for shipment to a paper mill.

Special Research Problems

In the course of this research, we encountered a number of problems, some of which could not be solved entirely to our satisfaction.

In order to form a quantitatively accurate picture of the extent to which salvage is practiced in the United States today, three elements of information are needed: (1) an accurate measure of the quantitites of waste generated, those collected and disposed by the generators, those collected and disposed by others, and those retained by the generators; (2) the composition of wastes; and (3) the quantity of secondary materials obtained by the salvage industry from industrial manufacturing and conversion activities and from obsolete sources.

The only information available on a national basis on quantities of waste generated is the 1968 National Survey of Community Solid Waste Practices, hereafter referred to as the "National Survey." According to this survey, 5.32 pounds of waste were collected per capita each day by municipal and private collection forces. Using a population figure of 199.5 million in 1968, a total of 194 million tons were collected.[2] The National Survey, although the best source available and an indispensable tool in solid waste management research, is not an entirely reliable source for national figures because the average above is based entirely on the small sample of communities that actually weighed their waste.

The composition of municipal wastes has been measured numerous times, and a selected list of such studies and their results is given in Appendix A.

It would be most pleasing if waste composition data, when applied to data from total waste generation or collection quantities, yielded a believable picture. Unfortunately, this is not so. The key problem occurs when the percentages of specific materials in solid waste are applied to waste collection figures. This problem is described in detail in Appendix A.

Another problem we encountered is the relative absence of precise data to show what quantities of secondary materials are obtained from obsolete materials as compared with conversion wastes. Secondary materials dealers typically handle materials derived both from industrial conversion activities and from obsolete sources, and industry statistics seldom make a distinction as to source. Government statistics on salvage are no better.

In order to obtain our own estimates of the magnitude of recycling from obsolete sources, we had to reconstruct the flow of materials in each of the key industries and to estimate, on the basis of inputs and outputs, the quantities of industrial waste that resulted and were recycled; this quantity was then deducted from total secondary materials consumption by the industry to yield an estimated tonnage of materials obtained from obsolete sources.

Linked to this difficulty is the broader problem of the absence of reliable, extrapolatable information about salvage in general, which results from the following six factors.

(1) Whether or not to use secondary materials is a question that industrial concerns decide on the basis of many considerations, which vary from place to place. With few exceptions, secondary materials are a "lowest cost" substitute for virgin materials. There is no force that impels a company to buy waste products; it has many alternatives to their use; consequently, no general rule of thumb can be used such as X percent of the input materials of a glass company must be purchased cullet.

(2) Secondary materials act as a balance wheel for virgin materials. In times of good demand, secondary materials are "turned on" to supply a missing proportion of total industrial inputs. In times of declining demand, secondary materials can be "turned off." This compensatory role of secondary materials prevents hard estimates of the secondary materials consumption necessary to maintain a certain level of economic activity.

(3) The secondary materials industry is oriented to the short range. Long-range planning is foreign to most dealers and brokers, and analytical work to determine future demand by the study of past trends is almost nonexistent in the industry.

(4) Secondary materials processors tend to have a local orientation and are adapted to local conditions. With some exceptions, their generalizations about secondary materials movements nationwide are not usually accurate.

(5) For the reasons cited, price information available on most bulk commodities in the secondary materials trade press is unreliable as precision data. Prices vary from location to location, day to day, and dealer to dealer, and it is not possible to say with certainty what the value of a particular commodity is in the United States.

(6) The economics of salvage are deceptive because the industry rests in part on economically marginal operations and various hidden subsidies. For instance, much waste is collected by scavengers who earn less than the minimum wage but who work in this area because they want to do so or cannot get other work. Collection systems that involve gathering of materials by students or Scouts could not be duplicated economically using paid labor and trucks. Social welfare agencies that do not pay the minimum wage are very active in textile, paper, and metal recovery.

For these reasons, all generalizations made in this report, and they are unavoidable, must be viewed as approximations. Anyone familiar with the salvage

[2] The figures cited are in contrast to other estimates of the quantities of waste generated in the United States by major source categories, i.e., 360 million tons of urban and industrial waste, 550 million tons of agricultural waste, 1,500 million tons of animal wastes, and 3,500 million tons of mineral wastes.

industry can find a dozen examples where conditions, prices, and practices described do not pertain.

Units of Measurement Used

Throughout this report, all material weights and corresponding costs and prices are given in net tons of 2,000 pounds. This is desirable because it enables us to present a uniform picture of salvage activities in units of measurement that can be compared with solid waste management data. Uniformity is achieved by violating some industry customs. Steel scrap prices, for instance, are always given in gross tons (2,240 pounds) in trade sources. To convert our data on steel scrap back to gross ton data, the reader must multiply the price or weight data by 1.12. Nonferrous metal prices are quoted in cents per pound and textile prices are usually quoted in cents per pound or dollars per hundredweight; we have used dollars per ton throughout.

Report Organization

Presentation of the materials moves from the general to the particular. The next chapter, Chapter II, presents a picture of the salvage industry, the sanitation establishment which supplies secondary materials at times, industrial buyers and sellers of secondary commodities, and public attitudes toward salvage. Various facts and trends that are general to salvage activity as a whole are presented.

Chapter III discusses salvage operations and operating costs, including emerging patterns in salvage. The objective is to present cost data in one place and to identify the emergence of new technology (in the hardware sense) and new developments (in the socioecomonic sense) which together promise to introduce changes into salvage.

Chapters IV through IX contain detailed discussions of commodity classes: paper, ferrous metals, nonferrous metals, glass, textiles, rubber and plastics, and other materials.

Chapter X presents a discussion of legislative and policy considerations related to salvage and recovery and summarizes and interprets various findings developed earlier in the report from the legislative point of view.

Chapter XI is the report of case studies conducted in 13 communities and one multicommunity region. The concluding chapter, Chapter XII, presents the findings of the mail survey.

CHAPTER II

PARTICIPANTS IN SALVAGE AND RECOVERY

In this chapter, we discuss the salvage industry itself (dealers and processors), the public and private sanitation establishments, and commercial and industrial generators and buyers of secondary materials. The chapter concludes with a brief look at public attitudes toward materials recovery.

The Salvage Industry

The salvage industry in the United States in 1967 consisted of just under 8,000 establishments, employing 79,000 people, with sales of $4.6 billion.[3] Around 80 million tons of secondary materials were handled by this sector of our economy.[4]

This is the "formal" structure of the salvage industry — the dealers, processors, and brokers who accept secondary materials from generating sources, sometimes process the materials in some way, and then sell them to secondary materials consumers. Around 1,400 of the companies are fairly large (over $500,000 in sales); the remainder are small operators.

The commercial organizations that comprise the formal secondary materials industry are supported by a vast army of individual scavengers, collectors, and junkmen who are independent operators and acquire waste products from many sources. Social service organizations such as the Salvation Army, some private refuse haulers, a few municipalities, automotive disassemblers, and demolition firms all contribute waste products to the industry.

Metals are the lifeblood of the industry; 74 percent of dollar sales and 73 percent of the tonnage of the industry were in ferrous and nonferrous metals in 1963, with iron and steel being the dominant materials class among metals. But virtually every other material is also sold: paper and board, textiles, glass, rubber and plastics, and feathers and hair. Paper accounted for 15 percent of tonnage, textiles for 3 percent, and all other materials for 9 percent in 1963 (Tables 1 and 2).

Not all of the waste materials recovered or sold pass through the hands of the traditional salvage industry. Most of the glass and much of the metal recycled in the United States is recycled without salvage industry participation because it is derived directly from the basic manufacturing process and returned directly for recycling without leaving its point of origin. The rendering industry, which accepts organic wastes for reprocessing, is usually excluded from this group. Numerous waste products sold, such as metallurgical slag, fly ash, and rubber tires, do not involve junk dealers or brokers.

Participants in the Industry. The salvage industry has three layers (Figure 1). At the bottom are the junkmen or scavengers — individuals who support themselves in part or entirely by picking up waste materials from a variety of sources and selling these to secondary materials dealers. Sources tapped by these individuals can be small machine shops or printing shops where they pick up presegregated metal turnings or printing wastes. Junkmen may work at municipal or private dumps, retrieving commodities disgorged from waste collection trucks. They sometimes forage for cardboard in commercial wastes before it is picked up by refuse haulers. They may own one or two wrecked automobiles which they disassemble. The two most important characteristics of the scavenger are that he is an independent operator,

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[3] U.S. Bureau of the Census. 1967 Census of business. Wholesale trade, area statistics; United States summary. Series BC67-WA-1. Washington, U.S. Government Printing Office, [May 1970].

[4] This should not be understood as 80 million tons recovered. Census data on which this tonnage is based counts dealer-to-dealer transactions as well as transactions to the final purchaser.

not affiliated with any company, and that his participation in the salvage business is usually a part-time activity, and only marginally economical.

A special form of the junkman is the small (one man) private refuse hauling entrepreneur who segregates salable materials from wastes as these are dumped into compactor trucks. The wastes are usually accumulated in the cab of the truck or hung on the side of the truck and are sold to salvage dealers from time to time.

The next layer is represented by small salvage dealers. These dealers usually handle metals, paper, and textiles and obtain a part of their input materials from junkmen; a part from industrial sources using dealer labor and vehicles for pickup; and a part from refuse haulers, social service organizations, and civic groups. These smaller dealers seldom handle quantities of materials large enough to make it worth their while to develop farflung contacts with industrial buyers of salvage. They accumulate quantities of materials and then sell these through a broker to an industrial buyer or they sell their accumulation directly to a larger dealer. Small dealers perform some sorting of the waste products acquired to upgrade these. For instance, they may separate cast iron from rolled steel products. But they seldom have the capacity for such large scale processing as metal shredding or high density paper baling. These dealers are found in smaller population centers that will not support specialized materials businesses and in large industrial centers dominated by large commodity specialist dealers.

Above the small dealers are the secondary materials processors, essentially large dealers who have extensive mill connections and combine brokerage work with actual physical handling of commodities. At this level, some degree of specialization is the rule. Usually, the processor will be in only one of three businesses — metals, paper, or textiles. Many processors have grown to their present stature from humbler beginnings, and, consequently, they may still handle small quantities of metal and textiles if they are paper dealers or paper and textiles if they are in metals. The processor usually acquires materials from industrial and commercial sources, charitable and social welfare organizations (if he is in paper and textiles), smaller dealers, as well as junkmen. He does more processing and upgrading and delivers products directly to consumers. If he can obtain materials in sufficient quantities from smaller dealers and if the materials are sufficiently processed, he will perform a brokerage function only, never actually handling the commodities. He may also resell products to another dealer.

On the same plane with the dealer-processor is the specialist dealer. This dealer is one who, for instance, handles only nonferrous metals, wools, synthetic textiles, or cotton rags. In the paper industry some specialists handle only pulp-substitute grade papers. The contribution of the specialist to the business is his intimate knowledge of a specific commodity and the market for that commodity. The large dealer-processor whose principal commodity, for instance, is steel scrap, may not find it profitable to develop the contacts and to hire the labor necessary to process a small quantity of nonferrous scrap. He is better off selling nonferrous accumulations to a specialist. The specialist sorts, grades, and prepares materials for sale to end users.

Secondary materials brokers are distinguished from dealers, processors, and specialists in that they do not physically handle the commodities they buy and sell. They are agents whose services are sought because they know the market place. In practice, brokerage is performed by most processors and specialists; however, the 8,000 companies that comprised the salvage industry in 1967 included 114 companies that did only brokerage work.

Glass dealers and some rubber dealers do not conform entirely to the picture described above, probably because both of these commodities occur only in small quantities on the open market. Dealers for these commodities are, in essence, specialized refuse removal firms that sell the wastes they pick up. Glass cullet comes from bottling operations or flat glass plants; the cullet dealer acquires the glass, processes it, and sells it to a buyer. Glass cullet dealers can usually sell all of the cullet they acquire because of their limited sources of supply. All of the Nation's cullet dealers are of roughly the same size. Rubber dealers are usually the only link between filling stations and garages, where tires are accumulated, and rubber reclaimers who buy the tires. Rubber dealers are sometimes forced to dispose of tire accumulations at landfills.

In an intermediate position between the junkman and the small dealer are three types of organizations — private refuse haulers, social service agencies, and civic organizations — that collect salvage commodities from industrial, commercial, and residential sources and sell materials to the salvage industry. These organizations are not normally considered part of the secondary materials industry.

Private refuse haulers usually service retail stores, warehouses, and industrial organizations that discard large quantities of corrugated board. In some of the nation's large waste paper consuming areas, refuse haulers sometimes deliver concentrated loads of old corrugated containers and occasionally other waste paper to paper dealers or sort such paper from their loads for sale. In a few cases, refuse haulers salvage metals in addition to paperboard. Operations of this type are corporate in nature and should not be confused with scavenging by truck drivers.

Probably the most extensive secondary materials collection activity taking place outside the formal salvage industry is conducted by social service agencies. Best known of these organizations are the Salvation Army, Goodwill Industries, Volunteers of America, and Society of St. Vincent de Paul. Most waste textiles collected in the United States, together with some of the waste paper and small quantities of metals, are collected by such organizations.

Social service organizations typically make residential calls to pick up usable, resalable commodities whose sale in second-hand shops in part supports the charitable and rehabilitative work of the agencies. Some commodities are picked up from bins placed by the agencies in parking lots of shopping centers. A portion of the goods obtained is usually beyond repair and is sold as junk or simply discarded as waste. In addition, some agencies also acquire paper from industrial and commercial sources. The usual procedure is to "pay" for the paper by executing a certificate that the contributing organization may use to claim the fair market value of the paper as a charitable deduction on business tax returns (under guidelines established by the Internal Revenue Service). No cash passes hands. Some social service agencies are in competition with salvage dealers in that they perform sorting and processing of wastes and bypass dealers to sell commodities to the end user. As a rule such organizations pay labor at rates below minimum wage, either because they are sheltered workshops exempted from the minimum wage law requirements or because the labor performed is quasi-voluntary.

Finally, various civic organizations, including churches and schools, participate in waste collections. Newspapers are the chief commodity collected, although recently civic groups in Los Angeles and elsewhere have also been collecting aluminum cans and glass containers. Civic organizations collect commodities on an irregular basis, perhaps once or twice a year, in "drives." Members of the organizations are notified that a drive will take place on such and such a date. Members acquire the commodities from their families, neighbors, and friends and deliver them free of charge to a central collection point. Materials are sold to a dealer — at whose initiative drives may have taken place — and the proceeds are used by the organization for projects.

Materials Acquisition. It is an axiom in the salvage industry that "scrap is not sold, it is bought." The skilled secondary materials dealer is a skilled buyer. His selling price is beyond his control because he sells a raw material substitute and demand determines price. Demand in turn is influenced by the general economic conditions and the relative availability and cost of virgin resources. Knowing in advance what his selling price is likely to be, the dealer must endeavor to buy materials at a cost low enough to allow for the costs of acquisition and processing plus a profit.

Because demand and prices fluctuate, the dealer is sometimes forced to tap every conceivable source for salvage to satisfy demand; at other times he must "turn off" many of his sources. Sources are hierarchically ranked in the dealer's mind. "Best" sources provide large quantities of the highest grades of scrap on a continuous basis; high grades, which most resemble virgin materials, can almost always be sold. In times of low demand, dealers buy only from their best sources to protect these from the effects of a down-turn. In exchange, these sources usually resist competitive offers by other dealers in high-demand periods. Best sources are almost invariably industrial materials converters.

The worst sources provide small quantities of low grade scrap: office buildings that generate mixed paper, for example, or junkmen selling dump metals. Mixed municipal waste is viewed as an undesirable source of scrap by both dealers and industry.

In an intermediate position between "best" and "worst" sources are organizations that provide large quantities of low-grade salvage, small quantities of high-grade scrap, and gradations between. Two sources with identical quantities and grades may not be equally desirable. One source may be nearer to the dealer or more accessible to the street; he may bale his material while the other does not.

The successful dealer maintains contacts with all types of sources, knows how to cultivate the best and the intermediate types, and how to turn on or turn off the worst. This is done by buying at the appropriate price, avoiding any long-range purchase commitments, especially with poor sources, and avoiding long-range supply contracts unless the sales price is negotiated at a high level or is pegged just above a published market price.

Faced with a variable demand, the dealer must maintain a flexible supply structure; consequently, those participants in the industry tagged "worst" sources here cannot rely on income from salvage as a fixed contributor to their budget. Marginally involved individuals must have supplementary occupations, and organizations must be prepared to dispose of their waste products at their own expense rather than by selling them.

Salvage dealers are often accused of buying materials cheaply at times of low demand and selling them dearly when demand picks up. This is the exception. What sometimes happens is that dealers buy materials (reluctantly) when there is no demand for these to protect their supply sources and then sell these later at going prices. We find that the majority of dealers "ride the market" — they buy only what they know they can sell and sell what they buy, maintaining themselves in business by keeping a safe margin between acquisition cost and sales price. Inventories are kept to a minimum.

Unless the materials are ready to be sold by brokered transaction (i.e., baled and in truck or carload quantity) they are delivered to the dealer's yard where they are weighed and deposited to await processing. Scrap may be brought in passenger cars, pickup trucks, trailer trucks, or railcar; delivery may be by scavengers, by the originator's crew and vehicles, or by the dealer's own trucks or trailers. Quantities of a few pounds, weighed on manually operated scales, up to several tons weighed on truck scales may be received, and the material may be loose or baled.

Materials Characteristics. The three characteristics of interest to the dealer are concentration or purity, grade, and quantity. He shies away from "dirty" scrap, be it high in contaminants or moisture; he prefers high grades to low because high grades are more salable; he prefers buying in quantities large enough to resell to buying quantities that must be accumulated before shipment.

These factors are relative. The worst combination, of course, is a "dirty" low-grade material acquired in small quantities; the best is a pure high grade substance in carload lots. High grades can absorb much more processing cost than can low grades; for example, IBM cards and nonferrous metals permit manual sorting and grading; the dealer cannot afford to sort mixed office wastes or to disassemble appliances. The relationship between grade and quantity is even fixed in the industry's terminology. Thus, "bulk grade" papers are low grade papers, indicating that they must be acquired in quantity to be economically desirable. High grade materials can be acquired a few pounds at a time.

The ultimate value of the product determines the tradeoff between factors. The typical margin between prices paid by a dealer and price received by the dealer is $10 per ton for heavy melting steel; but the margin applicable to No. 1 copper wire may be $230 per ton. The margin for IBM cards may be $25 per ton; for newspapers $10 to $14 per ton.

Mixed municipal wastes are clearly an undesirable input material for the industry. They are virtually devoid of attractive concentrations of high grade commodities which, because they are high grade, are seldom discarded. Bulk grades are "dirty" and cannot be cleaned up within economic constraints. In addition, putrescible materials and other unrecoverable wastes must be handled at additional cost.

Salvage dealers seldom buy materials in which the salvable portion is below 80 percent of the material weight. Most salvage industry inputs are 90 to 95 percent concentrations of one material or a combination of two or more materials, each of which can be sold. Some materials are not accepted at all because they appear in combination with an unacceptable contaminant; there are exceptions to this: some specialists have equipment to remove the impurities. Typical of unacceptable materials are tin coated steel cans and papers coated with plastics. Magazines are undesirable in paper salvage because water resistant glues are used to bind them and because magazine papers include a high proportion of clay which is washed away in repulping, leading to a large weight loss.

Processing. In the salvage industry, processing usually begins with a material that has already been presorted and concentrated. If its value is high, the material may be sorted for upgrading. If it is in a bulk commodity, a minimum amount of processing is accomplished to remove contaminants (e.g., removing magazines from newspapers) and then the material is prepared for shipment by bundling or baling. Size reduction by cutting or shredding is sometimes required.

Upgrading consists of separating two or more types of materials into grades one or more of which has a higher value than the others. Example: a dealer may have bought scrap aluminum from a scavenger for $200 a ton consisting 75 percent of old aluminum sheeting and 25 percent of new clippings. The clippings will bring $345, the old sheeting $254 per ton. By segregating the material, the dealer can get an average of $285 for a ton of this material, thus improving his selling price by $20 a ton compared to selling the lot as old aluminum.

Virtually all other processing is accomplished to obtain a product that is acceptable to a buyer in terms of quality, density, and size and to obtain a product that can be shipped at least cost. Specific processing operations are discussed in Chapter III.

Ship and railroad salvage and the demolition of structures such as refineries, chemical plants, and steel buildings are specialized recovery activities where processing consists primarily of disassembly and sorting. Automobile dismantlers, whose business it is to sell auto parts, do not properly belong to the secondary materials industry; their wastes, however, enter the salvage industry as automotive hulks.

Distribution and Logistics. Salvage commodities are purchased like other raw materials with the exception that long-term, fixed-price purchase contracts are seldom executed. Secondary materials are bought and sold on a weekly or monthly basis, and the price can and usually does change from week to week and from month to month. The sales transaction is usually a verbal arrangement, made by telephone, between a dealer or broker and a purchasing agent. In times of heavy demand, a purchasing agent may speak to a dealer several times a day and negotiate several shipments of product at varying prices. Verbal arrangements are then formalized by sales contracts and purchase orders.

Materials are usually bought in carload or truckload lots and are shipped by rail, truck, and barge. The ultimate value of the material determines the relative distance a commodity can be transported. The vast quantity of all secondary materials is consumed at plants no more than 500 miles from the originating point. High-value commodities, such as nonferrous metals and wiping rags, travel long distances, sometimes 1,000 or more miles. Nearly all low-value materials, newspapers, corrugated board, No. 2 steel bundles, and glass cullet, are sold to points within 75 miles of the originating site.

In the paper industry, the buyer usually pays the freight and commodities are sold f.o.b. truck or rail car. In other material categories, freight is paid by the seller. Freight rates vary from $2 to $40 per ton depending on distance and type of scrap. The average freight charge per ton of salvage sold is probably between $2 and $5 per ton; the average railroad revenue per ton of steel scrap moved was $2.94 in 1967, and this single material is a large part of total secondary materials tonnage moved; wiping rag producers, on the other hand, paid nearly $36 per ton to ship their products to consumers.

Trends and Developments. The salvage industry is changing, and some of the key trends and developments will be identified here and developed in greater detail in later chapters.

Perhaps the most important change is a centralization of the industry. In 1958, 9,491 salvage companies were in operation; by 1963, the number had declined to 8,288; and in 1967, there were 7,927. Although Bureau of the Census data for subsequent years are not available, the number of establishments in 1970 was probably around 7,600. In the 1958-to-1967 period, sales of the industry increased from $3.13 billion to $4.63 billion; and employment increased from just under 74,000 to nearly 80,000. Salvage companies have become bigger.

In the 1958 to 1963 period (for which detailed census data are available), the number of companies with sales under $100,000 a year decreased by 1,698; the total decrease of companies in the industry was 1,203. The number of companies with sales in the $500,000 to $1.9 million range increased by 179, and the number of firms with sales exceeding $2 million grew by 110 (Table 3).

The trend toward bigger companies in the salvage industry is in part a result of economic and technological pressures. Economic pressure has been brought on the industry by the disappearance of cheap labor with the coming of minimum wage legislation, which has made all labor-intensive operations like sorting and waste acquisition expensive. To remain competitive, salvage companies must use technology to increase labor productivity. Producers of virgin materials have introduced new technology into materials extraction, and to maintain a competitive position vis-a-vis virgin resources, salvage companies have had to follow suit.

In the ferrous scrap business, the pressure has resulted in the invention of large metal shredders that can reduce automobile hulks into fist-sized bits of metal that can be separated into ferrous and nonferrous portions by magnetic separation equipment. When these units first appeared, they cost several million dollars to install; more recently, units costing $400,000 and capable of shredding 25,000 cars per year have appeared.

Shredders are working a revolution in the scrap business. They permit upgrading of a plentiful scrap source, auto hulks, which are usually bundled and sold for $18 per ton as No.2 bundles, into a high grade scrap selling for $34 per ton. At an acquisition cost for the hulks of $14 per ton and a processing cost of $9 per ton (including freight), a dealer can realize a profit of $8 per ton selling shredded metal; the same dealer, without a shredder, has a total margin of $4 per ton and still must burn the hulk, hydraulically compress it, and ship it to the end user.

To use a shredder efficiently, however, a dealer must have sales of around $500,000 per year, and preferably well above this minimum. In 1963, nearly 76 percent of the 1,921 ferrous scrap dealers with processing equipment had sales below this level; in 1958, 84 percent of 2,781 dealers were in that category.

The auto shredder is only one example of technologically fueled change in the scrap business. In 1963, 2,167 dealers had no processing equipment at all; most of them were small (with less than $50,000 in sales) and all of them were reliant on scrap that could be handled without processing. To be able to compete in the most lucrative markets, these companies are increasingly forced to begin some sort of processing, and to achieve the appropriate size to justify investment in equipment, they merge or acquire other companies thereby acquiring new scrap sources and outlets.

In the paper business the single most important innovation has been the high density baler, costing around $120,000 and capable of handling 30,000 tons of paper per year. These machines reduce freight costs by up to $5 per ton on trips of 500 miles, generally facilitate materials handling, and provide a better product to the mills (because of handling/weight relations). Only a few of these installations, however, were in operation in mid-1970. To use such machinery efficiently, companies must have sales of around $600,000 a year. In 1963, 88 percent of 1,120 companies in the business had sales of under $500,000. To take advantage of the new technology available, centralization has also been taking place in this business.

Economic pressures in the textile salvage industry have taken four basic forms — decline of overseas sales of waste textiles, rising labor costs, decline in the percentage of pure cottons in waste textiles, and competition from paper and new nonwoven fabrics in the wiping field. Many companies in this field have disappeared. Between 1958 and 1963, the number of textile dealers dropped by 103 from 983 to 880, an 11 percent decline. In textiles, companies tend to go out of business rather than combine with stronger dealers.

The recovery of other waste materials has been declining for various technical and economic reasons. Nearly half the companies dealing in glass, rubber, feathers, hair, bones, and other wastes have disappeared in the 1958-1963 period; their numbers shrank from 1,387 to 710 in the period, and the decline was only beginning in the early 1960's.

Centralization is also brought about by the disappearance of family-owned businesses. The sons of dealers go to college and are reluctant to take over small businesses where day-to-day operations include haggling with junkmen, taking or placing dozens of telephone calls a day, and dealing with a continually changing, unskilled labor force. Instead, they choose laboratories, management suites, or government offices, and the family business is sold for lack of heirs.

In salvage as elsewhere modern management techniques based on computers and careful cost accounting have made inroads to the competitive advantage of those dealers large enough to be able to afford corporate staffs. These larger, well managed corporations find it easier to borrow money, to attract new talent, and to protect lucrative scrap generators in times of demand downturn.

The ratio of scrap materials consumed to total new products made has been declining in nearly all basic manufacturing industries. As a result of this decline, relatively more scrap is available than is needed. The industries consuming scrap materials can be far more selective in their purchasing; they can and do insist on higher quality secondary materials. At the same time, the obsolete products that are a part of salvage industry resources, as well as industrial conversion wastes, are generally more contaminated because base materials like steel, paper fiber, wool, cotton, rubber, and glass are combined with materials in manufacturing that are incompatible to the raw material processing steps. To provide the raw materials processing industry with pure scrap, the salvage dealer must choose his sources more carefully; or he must do more processing, which favors larger dealers with the capability to invest in technology.

The Sanitation Establishment

In this report, which is concerned with the recovery of commodities in municipal wastes, discussion of the sanitation establishment is in place so that subsequent information can be presented against the background of trends, developments, and attitudes in waste management circles. The term "establishment" is used to solve a linguistic problem presented by the discussion of an activity that is in part a public and in part a private industry.

General Characteristics. The sanitation establishment exists for one purpose only: to collect and to dispose of solid waste materials in a manner consistent with good health and environmental practice. Impassioned discussions of resource recovery sometimes miss this basic point, namely that waste managers must *collect and dispose* of wastes and that their mission does not include resource recovery as a goal.

The establishment handles in excess of 194 million tons of waste yearly, which occurs with great regularity and must be managed on a day-to-day basis. Approximately half the tonnage is collected by public forces, half by private companies. Annual expenditures on this service are around \$3.5 billion, about \$1 billion less than salvage industry sales. More than 330,000 laborers are involved in collection and disposal; almost 100,000 compactor trucks and 180,000 other vehicles are used to move this tonnage (Table 4).

Wastes are deposited in some 12,000 disposal sites, of which roughly 600 are operated properly as sanitary landfills. Some of the wastes are processed through 300 municipally operated incinerators (when they are operating); the number of private waste burners (those owned by private waste collectors, or industrial and commercial establishments) is unknown, but is probably in the thousands. A few compost plants exist, but it is difficult to establish whether any or how many operate at any one point in time.

Wastes handled by the establishment include: (1) mixed household refuse containing garbage, yard wastes, paper, glass, small metallic products, plastics, rubber, leather, textiles, ashes, and dirt in a compacted mixture; (2) combination of household refuse with commercial refuse, which usually means more paper content; (3) commercial wastes that generally resemble household refuse but may have much more paper (from offices) and cardboard (from stores and warehouses); (4) industrial refuse, usually high in paper but typically consisting of loads of nearly homogeneous materials (plastics, broken glass, wood, Fiberglas, etc.); (5) street sweepings; (6) building demolition wastes, consisting of concrete, metal, wood, bricks, and the like; (7) dead animals; and (8) bulky items, such as old furniture, refrigerators, tires, washers and driers, rugs, and the like.

Public bodies handle more residential and combined residential/commercial loads; private haulers handle more commercial and most of the industrial wastes that are not self-hauled by industry.

Public Sector Activities. If you ask a public sanitation official if his organization recovers commodities, the usual answer is "No." If you ask why, you will hear a variant of this statement:

> "The department used to sell some metals before my time. The stuff was sold to ABC Scrap Company and they sold it to a steel mill in X. The price fell so low we stopped the practice. It wasn't worth the effort it took to handle the metal. Lately we've had one or two offers from various people, but when they had studied the idea a little, they backed out."

Exploring the situation further might reveal that one or more of the following conditions were present: (1) the department did minimal processing of the wastes, usually involving manual labor; (2) the product was of the lowest quality — contaminated with dirt, poorly segregated, unprocessed (no shredding or baling); (3) the facilities where recovery had been practiced had either been closed down because of obsolescence or were ill suited to reclaiming; (4) segregated waste collection had been terminated; (5) exploiting this waste resource had been the marginal activity of a local dealer who had chosen to drop it; (6) private concerns had failed to bid on salvage contracts or had turned in very low bids; (7) all the initiatives for recovery came from outsiders, with the department taking no positive steps to locate markets or to explore techniques to upgrade the waste materials; (8) recovery had been viewed as a nuisance before being discontinued and discontinuation was seen as a step forward; (9) salvage buyers had changed their specifications to shut out highly contaminated materials; (10) the city is located a prohibitive distance from markets that accept low quality secondary materials; (11) the department was not in any position financially to undertake market development, experimentation, or construction to make reclamation possible.

It is usual to encounter a negative attitude toward reclaiming on the part of waste handling agencies, reinforced by the disappearance of markets for low quality salvage and the absence of technology or initiatives to create new markets.

The same forces that have driven manufacturing industries to concentrate on virgin raw materials as inputs to their plants act to drive waste management agencies to eliminate waste recovery from their operations. It is simpler to pick up, transport, and process a single mass of waste than to split the waste into two or more streams, each requiring specialized treatment techniques, technology, management and labor skills, collection and distribution networks, markets, and ultimate disposal arrangements. Streamlining of the waste management process is taking place, and there is thus a tendency to eliminate marginal operations that interfere with the rational organization of the system.

Today's situation is not solely a result of the decline of salvage markets. A number of other developments have pushed or enticed waste disposal agencies in the direction of simplified and more efficient waste disposal practices, among them the following.

(1) Per capita waste generation has risen, in part because consumption has increased and in part because on-site disposal by burning has been outlawed in many cities to ease air pollution problems. Waste processing agencies have had to handle ever larger loads, often without correspondingly expanded budgets.

(2) The introduction of the compactor truck in the 1950's and 1960's — which makes waste segregation during collection impossible but permits much larger loads to be carried — prohibits salvage because wastes are commingled and contaminated.

(3) The rise of combined waste collection has had the same effect; segregated collection has been forced out by popular demand and by other factors, among them the decline in the value of salvage.

(4) Hog feeding has declined and garbage grinders have been widely accepted. Hog feeding disappeared in many places; the requirement to cook garbage before feeding it to animals introduced a new cost that closed down virtually all feeding lots based on garbage. Garbage grinding diverts organic solid wastes into the waste water stream.

(5) Sanitary landfilling, which requires better control and scheduling of activities and calls for heavy equipment at the erstwhile dump, came into use after World War II. Scavenging activities at landfills interfere with efficient operations and are more hazardous.

Today salvage must show an overwhelming advantage before it is considered by the more efficient and well-organized public waste management agencies. Financial incentive is not sufficient. Income from a small percentage of the waste is readily sacrificed if it interferes with the disposal of the bulk of the waste — even if the recovery operation is a stable and profit-making venture. The financial returns from salvage or recovery, therefore, must be very substantial to counteract the tendency toward rationalization of waste management practices.

Municipal waste management practice, characterized as it is by bureaucratic regularity, presents a poor fit to the usually roller-coaster operations of the salvage business, where supplies must be "turned off" quickly one day and "brought out" a month later. City officials have learned by past experience that salvage dealers are not "reliable" buyers of scrap. This view is exacerbated by the fact that cities seldom deal with large dealers, whose interest in municipal waste salvage is nil; their contracts tend to be with operators on the margins of the salvage industry who are gambling on good returns from a project and, if they lose, are apt to exit from the scene by way of bankruptcy.

While the attitudes described above are almost universal, one can also detect the emergence of a counter trend that seems to be the result of ecological publicity.

We found a marked difference in the attitudes of public officials as these were expressed before and after the publicity barrage that led up to and accompanied Earth Day, April 22, 1970. After Earth Day, officials were either more cautious in condemning salvage (e.g., "Not now, but maybe someday" instead of "Over my dead body") or they were hopeful that new ways of recovering wastes might be developed in the near future. Hopeful attitudes were based on the future availability of Federal funding to build new types of facilities; information about new efforts by industry to find ways of reclaiming materials was also making some respondents optimistic. In many instances the intense pressure of disappearing landfill space and the unavailability of replacement sites are driving officials to consider anew salvage proposals simply to conserve scarce space at the landfill.

Salvage Practices. Virtually the only large-scale salvage practiced by municipalities we observed is the recovery of steel cans from incinerator residues. Such programs exist in Louisville, Chicago, and Atlanta. One impressive paper recovery program is under way in Madison, Wisconsin, based on collection of separated newspapers by city crews. The most usual and widespread form of salvage is at dumps and landfills; the largest such operation is in New York. Dump salvage may be controlled: one scavenging company or individual has salvage rights. Usually it is uncontrolled: scavengers are permitted to enter the facility and to remove whatever they find of value.

Private Sector Views and Activities. The attitudes expressed by public sanitation officials are generally shared by private refuse haulers. Private company officials look at salvage from a profitability point of view. There are a few well publicized exceptions such as in the San Francisco area, but private haulers generally find that reclamation of wastes is seldom profitable. Private haulers try salvage from time to time, especially when waste paper prices are high, but they give up such efforts because they are not profitable.

Private haulers handle more commercial wastes than public agencies, including sources rich in corrugated board Private haulers' salvage activities, if any, are usually based on these sources of corrugated.

A few companies have sought to recover household newspapers by requesting that customers place them separately with their mixed waste. A financial incentive may be offered to the householder by excluding newspapers from disposal costs especially where charges are based on volume or weight. In general, these activities realize much better public participation than the refuse hauling firm is prepared for, and unless the hauler has exceptionally low handling costs and volume outlets he may end up disposing of the newspapers at the disposal site. This is but one example of private haulers taking a serious look at new techniques and opportunities for salvage from waste.

Private haulers appear to be quicker to react to economic incentive in salvage than are municipal officials. Private haulers will adopt new operating procedures to achieve lower costs, to reduce disposal volumes, or to realize a profit on sale. However, the economic benefits must clearly outweigh the costs or the private haulers also pursue only the primary solid waste mission when it is most convenient to their operation to do so.

We were told by a number of refuse haulers that rising labor costs, especially the requirement to pay a minumum wage, virtually eliminated salvage activity. Before the 1950's, haulers frequently paid workers at rates below minimum wage levels; the payment was by route or by day. Workers had to supplement their income by salvage. Since then, court rulings have brought private refuse haulers under the Fair Labor Standards Act, with the interpretation that any refuse hauler who serves a corporation or industry that is engaged in interstate trade is itself engaged in interstate trade and must pay the minimum wage. In the private sector, this development led to efforts to improve labor productivity by use of compactor trucks and the conversion to hourly rates versus payment by route. These steps have acted to eliminate salvage.

Requirements imposed on larger refuse-hauling enterprises by Interstate Commerce Commission actions have not touched individual refuse-hauling entrepreneurs or companies where only family members are working. Such companies continue to engage in salvage on a small scale, with recovery largely limited to cardboard and metals.

In the private refuse removal industry, as in the salvage industry, there is a trend toward larger companies and a decline of small (one-truck) entrepreneurs. The usual method for growth is by acquisition of small companies and their customers and by timely acquisition of disposal sites so that wastes collected can be deposited in wholly owned facilities.

Salvage at private dumps, landfills, and incinerators resembles such activities on the public sector side. In Chicago, where steel cans are recovered from municipal incinerators, private incinerator operators also recover cans. Dump salvage by scavengers is as usual at private facilities as at public.

Industrial and Commercial Participation in Salvage

Industrial Waste Generation. All industrial operations generate waste materials, and industrial plant managers usually try to reuse or sell as much of the waste as possible, to produce income rather than to pay the expense of having wastes removed. For this reason, homogeneous process or manufacturing wastes are kept free of contaminating materials, are processed if necessary, and are accumulated for delivery to salvage dealers (as in the case of paper products) or for internal recycling (as in the case of broken glass). Virtually any solid substance occurring in sufficient quantity can be sold, although the quantity of waste generated may exceed market requirements.

Industrial wastes are favored in salvage markets by purity, consistency, large quantity occurrence, known materials composition, and regularity of generation. These wastes represent the bulk of all secondary materials traded, and virtually all high grade salvage commodities come from industrial sources.

Sale of salvage commodities is usually the responsibility of purchasing agents who are in an ideal position to regulate salvage. They also buy the raw materials used in their operations and have some control over the nature of packaging used to deliver these. Furthermore, purchasing agents can and do require that suppliers accept back production wastes at fixed prices as part of the purchase contract. In smaller operations, sale of wastes is handled by the plant manager.

Commercial Waste Generation. Commercial establishments, including wholesale and retail outlets, warehouses, offices, hotels, apartment houses, restaurants, and the like, generate wastes similar to those occurring in homes, with the exception that proportionately more paper and board occurs in the waste and organics are a lower percentage. Corrugated board and mixed office paper are the only two materials sold in any quantity, and mixed papers only sporadically when demand for waste paper is high.

Industrial Buyers of Salvage. A distinction can be made between two types of industrial salvage buyers: those that depend on secondary raw materials as their principal or only input and those that use relatively small quantities in order to keep production costs low or to obtain optimal technical results.

Examples of the first group are combination board manufacturers, deinking mills, roofing paper mills, wool reweavers, electric steel furnace operators, secondary metals smelters, certain glass producers who use only glass cullet (ash tray manufacturers, for example), rendering plants, and rubber reclaimers. These operations depend on secondary materials and must obtain them on the open market. They are the backbone of the salvage industry, and their production rates largely determine how much waste is recycled.

The second group includes fine-paper manufacturers, operators of basic oxygen steel furnaces, glass container or window glass manufacturers, plastics producers, tire manufacturers, and others. These operations either do not require any salvage materials or only small amounts; they satisfy most of their own salvage materials requirements by internal waste generation and purchase scrap materials only when internal sources are insufficient. Although these industries consume much scrap, especially steel mills and glass plants, a low percentage of their consumption is purchased on the open market.

The distinction between these groups is extremely important, primarily because it explains much about the nature of salvage and recovery in the United States.

Steel scrap, nonferrous metals, glass, and small quantities of newspapers and corrugated are the only secondary materials that are reprocessed into essentially the same products that they were originally. All other materials, including most of the newspapers, leave the industries from which they came and enter other industries. Old corrugated boxes and newspapers become bending board or construction paper. Old tires are converted to material used in tire retreading. Old cottons become wipers. The demand patterns that govern the receiving industries are not necessarily synchronized with the supply patterns of the industries that generated the materials in the first place. Thus, an increase in tire production may in fact mean a decline in purchases of retread tires. Newspaper circulation, advertising linage, and newsprint consumption may grow while construction activity slows and demand for news in construction paper falls.

The quantity of salvage materials consumed by an industry that depends almost exclusively on raw materials is determined by the total production of the industry. Consumption of secondary materials by industries based on virgin materials may be high when production is high and may completely disappear when production is low. When production is low, the industry avoids use of secondary materials and must use its virgin production facilities to the maximum extent possible to maintain economic production levels. In high production periods, virgin materials production facilities are working at peak capacity, and secondary materials can be used to supplement virgin materials.

Predominantly virgin materials producers buy salvage products because: (l) technical factors favor use of secondary materials in some quantities; (2) internal generation of such scrap is too low to permit optimum operation; (3) secondary materials are relatively cheaper than virgin raw materials (inclusive of processing costs).

It is difficult to generalize about the relative value of virgin materials and secondary materials in operations where both are used. Scrap materials are not simple substitutes: they may be required by the process, they may yield special benefits such as prolonged furnace lining life, they may have to be used because they are a process waste material, they may reduce air pollution or water pollution, etc. We shall grapple with these issues elsewhere but wish to point out that, for example, a comparison of published prices, such as those of pig iron selling for $59.99 per ton and heavy melting steel scrap selling for $23.08 per ton, does not tell the whole story about the relative value of each in an integrated steel plant. Complex processing considerations and economics must be taken into account.

Price comparisons, however, are an appropriate tool for understanding the economics of those operations that rely exclusively on secondary materials. To an unintegrated electric furnace operator, a $23 per ton scrap is clearly a more economical raw material than cold pig iron at nearly $60 per ton. Similarly, a combination board mill has little difficulty choosing between old corrugated board at $23 per ton and unbleached kraft pulp selling at $130 per ton, in spite of the fact that the virgin pulp may be a superior material.

This type of scrap consumer buys secondary materials, first because they are cheaper than equivalent quality virgin materials and, second, because the products manufactured do not demand virgin raw materials inputs. The latter condition exists either because the quality of the products need not equal that of products made of virgin materials (as in combination board) or because a product equivalent in quality to those made from virgin materials can be produced (as in electric furnace steel).

Whatever the type of industry, its purchasing agents attempt to buy the best grade of secondary materials available consistent with cost constraints. Low quality scrap materials can be sold only when production rates are high and the normally accessible quantities of high grade scrap are insufficient to meet demand. When virgin materials industries begin to buy larger than usual quantities of secondary materials, secondary materials consumers may begin to buy lower grades of scrap.

Some Trends and Developments. Traditional patterns of secondary materials consumption by industry are being disturbed by the growing awareness of solid waste problems on the part of government administrators and legislators and the resulting publicity and threat of legislation. Recycling of waste materials, which before 1968 or 1969 was viewed by industry as a way of keeping costs down, is beginning to be viewed as one way for industry to avert adverse legislation against the products of an industry.

The threat of legislation is most keenly felt by those industries that consume little or no waste materials obtained from sources external to the industry. Because legislation may seriously affect the very existence of some industries, company officials view the relatively minor cost increases and technical inconveniences associated with increased acceptance of secondary materials as the lesser of two evils. Industry spokesmen who do not wish to challenge the governmental contention that "recycling is the only answer to solid waste problems in the long run" are actively exploring and, in some cases experimenting with, new means of collecting, sorting, and processing wastes for recycling.

While such efforts are to be commended, it remains that new recycling schemes are being brought about by the threat of legislation and are not necessarily based on the companies' best judgments about economics and technical production requirements. Corporate efforts to move against the natural current of technoeconomic tides seem to be based on the assumption that active participation in solid waste management via waste recycling is simply a new operating restriction imposed on industry by government, akin to minimum wage requirements, equal employment opportunity, social security, taxes, and other similar factors that add to costs.

It is too early to say whether or not new programs will entrench themselves well enough to cause significant transformations in salvage buying and waste generation patterns. In the last analysis, materials will be kept out of the waste stream only if consumption of virgin materials is replaced by consumption of wastes. Industry recycling schemes appear to be aimed, at least currently, at curing symptoms. It will be no gain, for instance, if steel cans are recovered from municipal wastes (which would yield much good publicity for the steel industry) only to replace turnings and borings that would be discarded for lack of markets. A step forward would be made only if total scrap consumption would increase.

While recycling is being given another look by virgin materials users, two other trends augur ill for the future of recycling. One is the persistent effort by industry to upgrade or change its products in efforts to stay competitive in essentially affluent times. The other is materials contamination brought on by improved techniques of materials combination, the ability to upgrade product performance and appearance by such methods, and the ability to lower costs or to improve products at the same cost via material composites.

The trend toward upgraded products is visible in many areas, but the significant point is that products based on secondary materials are replaced by products of virgin materials. Examples are the replacement of combination board by bleached sulphate board in packaging, matchbooks, and other similar products; replacement of pulp egg cartons by plastic foam egg cartons; the intrusion of nonwoven paper products and new textiles into the wiping rag field; the use of synthetic fabric modifiers in cotton dresses and shirts, which eliminates ironing for the housewife but also destroys the value of the cotton as a wiping material; displacement of cheap metal fixtures and toys by plastics; elimination of rewoven wool products by virgin wool; and others.

Most of these developments are old and well established and appear to be the result of a combination of factors, including the rise of plastics technology and the low cost of plastics, public demand for convenience products, and a high level of affluence.

The trend toward combining materials is simply a sign of the maturation of a high-level materials technology in which new synthetic materials have come to be used in combination with traditional natural materials and dissimilar metals are combined with each other and with other substances to yield technically and esthetically superior products. Two examples are the steel can with an aluminum top and magazines bound at the back with water resistant adhesives; neither product can be recycled without processing at a cost that is disproportional to the value of the materials.

Contamination of ferrous metals by nonferrous metals is a growing problem in the steel industry, which has a high production waste that must be recycled; contaminants tend to become concentrated in the metallic stream by building up over several recyclings. Synthetic adhesives and coatings plague paper and textile waste consumers. Metallic impurities in glass waste (especially aluminum) and in rubber (tungsten studs) are causing difficulties.

Public Attitudes Toward Salvage

Although affluence and the "throw-away" cultures are everywhere evident, the people of the United States still largely subscribe to the "waste not, want not" adage of the good old days. It is not possible to determine whether this is nostalgic lip service or concrete belief; the evidence points both ways at once, and the picture is muddied by the recent emergence of "ecology" as a household word.

Americans participate in salvage on an almost day-to-day basis. They collect, bundle, and transport nearly 2 million tons of newspapers for recycling in some 80,000 paper drives yearly, without receiving a penny for their efforts.[5] They give away between 1 million and 1.5 million tons of used textiles to social service agencies annually. Many small appliances, furniture, and other usable commodities are also given away to charitable organizations. In millions of garage sales across the Nation, the American sense of thrift and love of a bargain come to full expression: as a result, the life of obsolete or unwanted materials is increased by months and sometimes by years. They still buy half their yearly beverage consumption in returnable containers — and return them.

This picture of frugality, however, must be contrasted with other facts, such as the phenomenal rise in the consumption of one-way beverage containers; the popularity of the paper towel in the kitchen; the rising consumption of disposable cutlery, cups, and plates; the indiscriminate discard of many returnable containers as litter; and hundreds of other similar developments.

The behavior of the public is clearly contradictory. The time and effort involved in segregating and preparing papers and textiles for reclamation, together with whatever transportation costs may be incurred, are gladly expended. On the other hand, some people seem reluctant to spend a few minutes of extra time daily to wash glass cups when disposable paper or plastic cups can be used, or a few minutes a month to return deposit-type beverage containers to the grocery store.

It is difficult to form a conclusion about public attitudes on the basis of the research we conducted (which did not include an attitude survey). However, we will hazard a few observations that appear borne out by the facts.

The American people view salvage under the rubric of "charity," and wherever salvage programs are connected with charitable activities, cooperation can be expected. The appeal is to their better side, and the activity is voluntary. Within this attitudinal framework, the usual and natural desire for convenience disappears.

As soon as the salvage activity becomes official and compulsory, resistance sets in. Perhaps the best example of this in recent times was the segregated steel can collection program in Los Angeles, described in Chapter XI, which failed as a result of fierce public opposition and refusal to cooperate by a segment of the public. A recent example of a successful publicly sponsored voluntary program is the paper recovery venture in Madison, Wisconsin.

Americans, by and large, are too affluent to seek salvage income. If a salvage program offers an incentive, however, they will respond to the appeal with motives in which personal gain, charity, and concern for the environment seem mixed.

[5] Proceeds of paper sales usually go to civic and charitable organizations.

Once accustomed to salvaging or participating in a salvage program, people appear to continue in the activity without the need to be continuously motivated. However, program appeals reach only a small percentage of the people if active participation (for example, delivery of commodities to a collection point) is involved — except where the appeal is personal (made by a child, a church member) as in the case of paper sales or Girl Scout collection of aluminum cans.

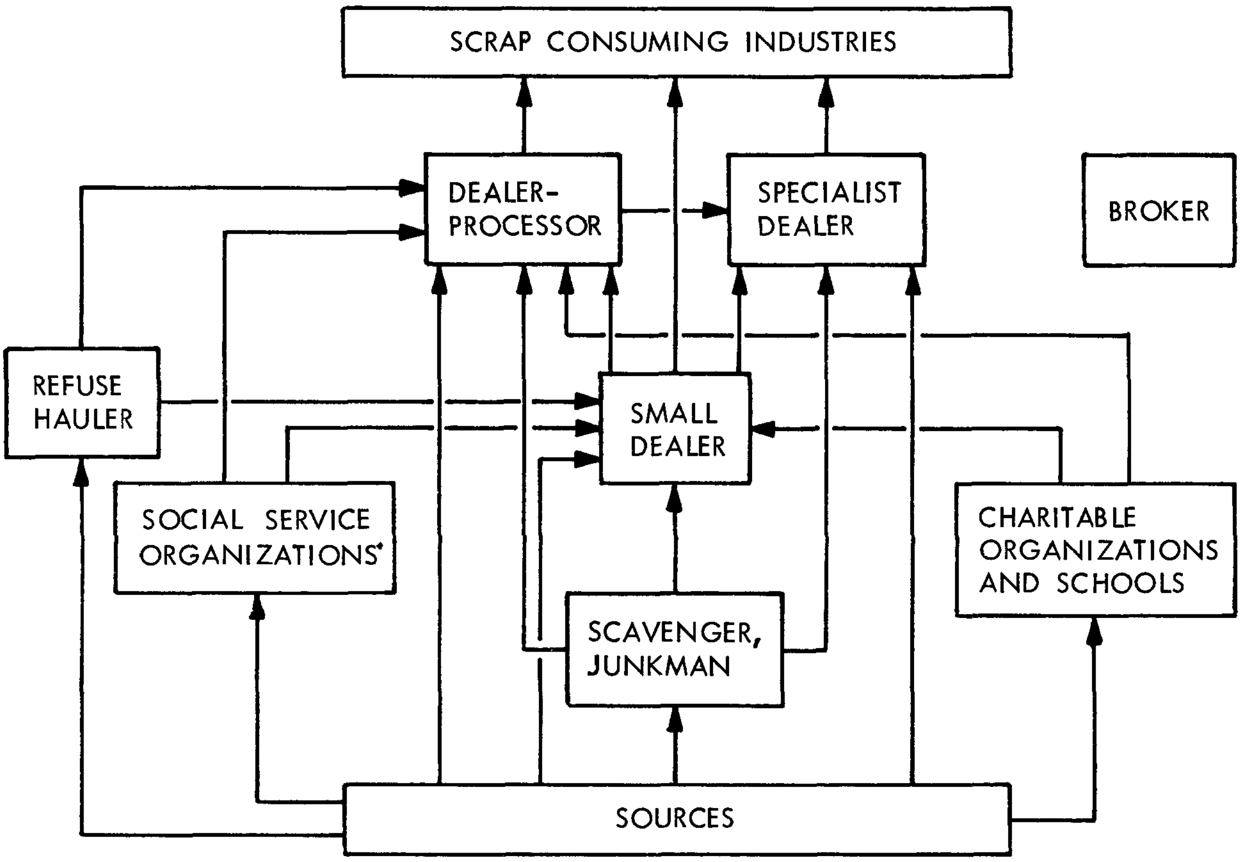

Figure 1. Structure of the salvage industry and flow of commodities.

TABLE 1

*SALVAGE MATERIALS SALES AND TONNAGE SOLD, 1963**

Commodity	Sales in million dollars	% of dollar sales	Sales in 1,000 tons+	% of tons sold
Iron and steel scrap, including alloy steel	1,754	51.19	49,727	69.15
Aluminum scrap	146	4.26	522	0.73
Scrap copper and alloys	365	10.65	648	0.90
Scrap lead	66	1.93	750	1.04
Zinc scrap	30	0.88	273	0.38
Other nonferrous scrap	176	5.14	880‡	1.22
Waste paper	318	9.28	10,474	14.56
Waste textiles, including wiping rags	408	11.91	2,122	2.95
All other wastes, including glass and rubber	163	4.76	6,520§	9.07
Total	3,426	100.00	71,916	100.00

*U.S. Bureau of the Census. 1963 Census of business. v. 4. Wholesale trade--summary statistics and public warehousing. pt. 2. Commodity line sales and miscellaneous subjects. Washington, 1966.

+Tonnage as reported by commodity line which excludes sales by establishments that did not report in this detail. Table 7, p. 8-636.

‡No data available; estimated by Midwest Research Institute (MRI) on the basis of a sales price of $200 per ton for commodity.

§No data available; estimated by MRI on the basis of a sales price of $25 per ton for the category.

TABLE 2

MATERIALS RECOVERED BY THE SALVAGE INDUSTRY,
SOURCES OF MATERIALS, PROCESSING, AND END USES*

Materials category	Principal sources	Principal processing accomplished	Principal end uses
Iron and steel scrap	Industrial wastes, automobile dismantlers, ship and rail wrecking	Sorting, shredding, sizing baling	Steel production
Aluminum scrap	Industrial wastes, demolition	Sorting, sizing, baling	Secondary aluminum smelting
Scrap copper	Industrial wastes, utility demolition	Sorting, sizing	Copper smelting
Scrap lead	Used batteries, utility demolition	Sorting, disassembly, sizing	Lead smelting
Zinc scrap	Industrial wastes	Sorting, sizing	Copper smelting
Waste paper	Converting retail sales residences	Sorting, shredding, baling	Combination board mills, paper mills, construction paper mills
Waste textiles	Industrial wastes residences	Sorting, cutting, washing	Wiping rags, reweaving mills
Glass cullet	Bottling plants	Crushing, washing	Glass container plants
Rubber scrap	Filling stations, tire and rubber products manufacturers	None	Rubber reclaimers
Plastics scrap	Converters	None	Plastics converters

* Compiled by Midwest Research Institute.

TABLE 3

SALES SIZE OF SALVAGE COMPANIES (1958 AND 1963)*

Sales size range	1958 Number of establishments	1958 Total (% of)	1963 Number of establishments	1963 Total (% of)	Increase or decrease in period
Over $2 million	227	2.39	334	4.07	110
$500,000 to $1.9 million	905	9.53	1,084	13.07	179
$200,000 to $499,000	1,319	13.90	1,453	17.53	134
$100,000 to $199,000	1,448	15.25	1,457	17.59	9
Under $100,000	5,418	57.08	3,720	44.88	(1,698)
Not operated entire year	174	1.83	237	2.86	63
Total	9,491	100.00	8,288	100.00	(1,203)

*U.S. Bureau of the Census. 1958 Census of business. v. 3. Wholesale trade-summary statistics and public warehousing. chap. 2. Sales size and employment size; table 2A. Washington, U.S. Government Printing Office, 1961; 1963 Census of Business. v. 4. Wholesale trade--summary statistics, public warehousing. pt. 1. Washington, U.S. Government Printing Office, 1963.

TABLE 4

QUANTITATIVE PARAMETERS OF THE SANITATION ESTABLISHMENT - 1968*

Parameter	Public sector	Private sector	Total
Wastes handled - in million tons			
Household+	73.5	43.1	116.6
Commercial‡	14.3	34.9	49.2
Industrial§	5.3	22.7	28.0
Total	93.1	100.7	193.8
Expenditures - in million dollars	1,700	1,800	3,500
Employment	178,610	158,390	337,000
Compactor trucks used	43,710	49,290	93,000

*Vaughan, R. D. National solid wastes survey; report summary and interpretation. In the national solid wastes survey; an interim report. [Cincinnati], U.S. Department of Health, Education, and Welfare, [1968]. p. 47-53.

+Includes street and alley sweepings.

‡Includes miscellaneous wastes.

§ Includes demolition wastes.

CHAPTER III

SALVAGE OPERATIONS AND OPERATING COSTS

The intent of this chapter is to discuss what must be done to waste materials in order to recover them, to describe the basic technology used in salvage or emerging at this time, to summarize and present in one place whatever data or estimates are available on costs of various operations, and finally to discuss the question of cost allocation practices in municipal waste salvage and related issues.

Salvage Operations

To recover waste commodities, a maximum of five types of operations — acquisition, concentration, purification or separation, shape or size reduction, and preparation for shipment — are required.

Acquisition operations consist of the pickup of a quantity of material and its movement to a processing, storage, or end-use point. If the material is scattered, as at a dump or landfill, retrieval of the commodities is also a necessary part of acquisition.

Concentration operations mean the removal from a quantity of waste those portions or fractions that are not desired, as paper and metal from glass wastes. This is accomplished by some type of sorting, manual or mechanical, or by burning if the unwanted portion is combustible. Concentration may not be necessary if the material to be recovered occurs in a concentrated form.

Purification or separation is another form of concentration, but is usually applied to activities performed on concentrated wastes, such as the sorting of clear glass from brown glass. This operation may consist of sorting, disassembly, breaking, and demolition of joined materials, the removal of one metal from another by melting the fraction with the lower boiling point (sweating), the burning off of contaminants, chemical recovery of a fraction, or simple washing or laundering.

Shape or size reduction is accomplished to make concentration, purification, separation, or shipment easier or to produce a material shaped and sized for a specific end use. Cutting, shredding, breaking, and crushing, either manually or mechanically, are the standard operations used in reduction.

Preparation for shipment consists of processing materials into units that can be easily handled in transportation. This operation usually consists of baling or bundling. Powdered materials may be briquetted.

The relationships among these operations are shown in Figure 2. The operations described are not all necessary, and the sequence in which they are accomplished or whether they are accomplished depends on the material itself and on its source, condition, and end use.

The technology used in the salvage industry is similar to that used in the virgin materials processing industries, with the difference that sorting is usually by hand, unless it consists of the separation of ferrous metals from other wastes by magnetic techniques; even this process is not possible where two metals or a ferrous metal and some other material are mechanically or chemically coupled.

The key operation in salvage is sorting. Sorting is generally manual. It is highest in cost because sorting technology is unavailable and labor costs are high. Sorting is also essential because waste materials are seldom entirely pure. Salvage dealers try to get all of their materials in a presorted form. They have difficulty keeping sorting costs down even on presorted materials, and they cannot afford the costs of sorting municipal wastes.

New technology is under development in the salvage industry, some under government sponsorship. Most innovative efforts are bent toward solving the sorting problem.

Operating Costs

Nature of the Data. Good cost data on salvage operations are scarce. The reason for this is not entirely the poor cost accounting techniques used in the salvage industry, although these do not help. Another reason is that salvage dealers do not like to discuss their operating costs because they fear that their competitors may find out. Yet another reason is that the salvage business is not a continuous processing business; laborers in a scrap yard move from task to task depending on need, and there is neither the time nor inclination in most companies to determine exactly how long each employee spends on each task. Thus, even dealers willing to discuss costs were often unsure and guesstimated their costs rather than looking them up in company records. Considering that most salvage dealers handle a range of products, some requiring extensive processing and some very little, the "ballpark" estimates we were sometimes able to get lack precision.

What applies to costs as a whole also applies to specific operations such as sorting or shredding. We were frequently given "total" processing costs, and attempts to break these down further sometimes failed. Data comparability was poor in that some respondents could give only estimates of labor expended while others included all or most costs. In preparing the data for presentation here, we sometimes combined elements from several interviews, estimated cost elements unknown to our respondents, used wage rates more representative of the industry as a whole to increase costs based on abnormally low wages, and performed other necessary adjustments so that the data would be as useful as possible in general planning.

Costs of Recovering Materials from Mixed Wastes. We would like to cover two instances of recovery: (1) sorting and recovery of mixed refuse as delivered to a salvage plant, (2) retrieval and recovery of wastes from a dump or landfill.

According to a study conducted by the Los Angeles Bureau of Sanitation,[6] the investment cost of a 400 tons per day salvage plant is $577,000; 14 percent of the waste (56 tons) is marketable salvage. From this we infer — using a 252-day work year, a 15-year plant life, and a financing charge of 8 percent yearly — that plant amortization will cost nearly $4.80 per ton of salvage sold.

One man can pick anywhere from 1 to 3.5 tons of materials from a moving belt carrying mixed waste materials (Table 5), depending on the type of material and his efficiency. Assuming an hourly pay of $2.50 plus a 30 percent overhead charge, the cost of sorting can range from $7.43 to $26.00 per ton. Addition of equipment amortization results in an operating cost ranging between $12 and $31 per ton.

These costs exclude some operating costs, fuels, utilities, baling or bundling labor, taxes, supervision, and disposal of unsalvable wastes; no credits are included for landfill space saved. Even without taking such costs into consideration, however, it is clear from estimates that salvage expenses far exceed potential income. Labor costs alone exceed income in four of six cases estimated in Table 5.

If we assume that paper, textiles, metals, and glass occur in the salvable portion of such a hypothetical salvage plant in the same proportion as they appear in waste (Appendix A); and if we further assume that newspapers, corrugated, and mixed papers appear in the same proportions as in consumer products and in commmercial, business, and institutional markets (Figure 13), we can calculate costs and income for a composite ton of salvage (Table 6). Labor costs will be $11.27 per ton for sorting and total cost, including amortization, will be $16.05. Dealers will pay a high of $9.12 per ton for this salvage and a low of $3.37. In order to have an economical operation at the high price, the plant would have to recover 100 percent of inputs (thereby bringing amortization down to 67 ¢) and labor could not be paid more than $1.70 an hour and this only if sorting labor and plant payout are the only expenses.

These cost data show why manual sorting and processing of secondary materials from mixed wastes are not practiced. In the actual experience of compost plant operators, the salable fraction is between 8.5 percent (in Mobile, Alabama) and 6.6 percent (in Gainesville, Florida). The recovered materials are very difficult to sell because of dirt, contaminants, and moisture content.

Paper processing costs at the Gainesville compost plant had been calculated by the Municipal Compost Authority to be $8.64 per ton, including all labor, amortization, incidental expenses, and baling. Textile recovery costs were $8.67 per ton. These costs are lower

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[6] Los Angeles Bureau of Sanitation. Summary of refuse salvage and reclamation study and research program on residential refuse collected by the city of Los Angeles. Unpublished data, Apr. 1963.

than those developed above because salvage does not have to bear all labor and equipment costs.

For costs of dump salvage operations we have only one source — the New York City landfill reclamation program described in Chapter XI. On the basis of data obtained from the salvor and our estimates, it appears that total costs per ton — all the way from retrieval of metals, rubber, and textiles from the landfill to actual sale of processed scrap — are nearly $28 for all materials.[7] Income per ton is just over $30.

Costs of Acquiring Concentrated Wastes. The salvage industry as a whole acquires only secondary materials that are already concentrated, such as newspapers or broken glass. The acquisition cost consists of picking up the material by truck and delivering it to the processing plant. Costs exclude payment for the material to sources.

Acquisition costs range from $3 to $4 per ton for all grades of paper, $3 to $4 for metals, $5 to $6 per ton for glass, $30 to $40 per ton for textiles, and $10 to $15 per ton for rubber. The high costs for textiles are explained by the fact that textiles are collected from residential sources in small quantities. Rubber comes from filling stations and garages, also in small quantities. Newspapers, although derived from residential sources, are first concentrated by the public in a central place (for example, a school) at no cost to the dealer.

Textile collections are part and parcel of social welfare agency collections, which are undertaken principally to obtain resalable products and commodities. Roughly 80 pounds of materials are obtained per call and collection costs are around $3.45 per call or $86 per ton. By weight, usable commodities may be anywhere from 50 to 70 percent of total collections; costs attributable to salvage materials, therefore, can range from $43 to $26 per ton. Textiles are the only material collected in quantity from residential sources by such agencies.

Another way of viewing these costs, however, is to view social service agency collections as taking place exclusively for purposes of usable collection; salvage materials, in that case, ride free. They piggyback on an existing collection system which would proceed even if no salvage were available. This, in essence, is the principle used in Madison, Wisconsin, where paper is collected separately from residences but in the course of waste collections. The city only counts extra expenses connected in the paper recovery, not the costs of operating the trucks. The Madison "extra" is $4.35 per ton of paper collected.

We only spoke to two rubber dealers in the course of our study and neither would detail his costs. We learned, however, that rubber dealers are paid anywhere from 10¢ to 15¢ per tire to remove these from garages and filling stations; this translates to roughly $10 to $15 per ton for rubber acquisition, assuming that dealers make no profit on tire pickup.

Glass is invariably removed from bottling operations by the dealer. The dealer sometimes pays for this glass, especially if the source is a large generator of a desirable grade, like clear glass; more usually, glass is given away. The dealer gets it free for removing it. Sometimes he must provide containers for the glass wastes and maintain these. The acquisition cost used here is one where the glass is free but containers are provided by the dealer.

Paper and metal dealers obtain considerable quantities of materials at the processing plant — they need not physically acquire these in that they are transported by sources or junkmen. The acquisition costs cited are those pertinent to materials the dealer must pick up and transport. Both industries operate on rule-of-thumb type gross profit margins, the margin being the differential between price paid to a source and price received from a consumer. In bulk grades of paper, the margin is usually $10 to $14 per ton; in ferrous metal it is between $14 and $16 per ton, for materials that must be picked up. If the materials are delivered, the margin required by the dealer is lower ($8 to $10 in paper, $11 to $12 in metal), scrap metal dealers operate on a greater margin than paper dealers because metals are sold f.o.b. consuming plant whereas paper is sold f.o.b. dealer's plant.

Processing Costs. Representative processing costs in salvage operations range from a high of $267 per ton for fairly extensive handling required to convert mixed rags into cotton wiping cloth to a low of $6 per ton for processing paper (Table 7).

The costs shown are those required to handle materials received in concentrated form by the dealer. The one exception is steel can recovery from incinerator residue by incinerator operators, where costs include separation of steel cans from incinerator ashes and residues.

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[7] This excludes payment to the city, insurance, maintenance, administrative burden, fuels and supplies, general office overhead, and processing plant lease costs.

With the exception of materials shipped directly from source to consumer through a brokered transaction, some form of processing is required on all secondary materials if processing is used broadly to include all handling. This is the sense in which we use the term "processing."

Processing costs as used here include all costs incurred at the plant — receipt, weighing, in-plant movement, storage and warehousing, as well as processing in the narrow sense, including equipment amortization, energy and utilities, supervision, general overhead, and the loading of materials for shipment. Transportation costs to the consumer, insofar as they are borne by the dealer, are excluded; and profits obtained by the dealer are not reflected in costs shown. The costs pertain to all grades and are calculated across the board; thus, a particular scrap yard may spend $8 per ton on processing all inputs; operations on some grades may cost more or less.

Processing costs are roughly comparable for materials handled in large quantities like paper and ferrous metals. Glass, another bulk commodity, shows higher overall processing costs than paper and metal because all glass cullet must be processed in an intensive manner, whereas the costs for paper and ferrous metals are composite figures for less intensive processing commonly done. High scrap preparation costs in nonferrous metals are attributable to small quantities handled, considerable manual sorting, and some fairly sophisticated processing of some fractions. Textile processing costs are high because of much manual sorting and piece-by-piece preparation of rag stock to make wiping materials.

Steel can recovery is practiced in the United States to satisfy demand for precipitation iron in copper mines. This calls for a clean (free of ash), burned, shredded metal. The largest dealer in this business, Proler, Inc., of Houston, obtains steel cans from incinerator operators, from detinners, and from can manufacturing facilities. The dealer claims to process all steel cans through his operation regardless of source, experiencing a processing cost of $19 to $20 per ton. Some of his input materials come from cities where more or less processing is done — ranging from shredding in Atlanta to simple extraction of metal from residues in Chicago. The best cost data on unit operations come from Atlanta ($10 per ton); the high figure of $14 per ton to recover steel from incinerator residues is taken (and rounded up) from a study conducted on behalf of the Government of the District of Columbia.[8] Steel cans that have been processed through the Atlanta incinerators do not require further processing and are of acceptable quality for copper precipitation. In Louisville, Kentucky, where processing costs must be about the same as in Atlanta (same type of equipment and procedures are used), shredded steel is produced at the incinerator and sold to a steel plant through a dealer.

The cost data on initial sorting of textiles are based on social service organization experience. This is the sorting of textiles collected from residential sources into a resalable portion and a rag portion. In order to make the cost representative, we used a pay rate of $2.50 per hour (rather than the $1.10 to $1.60 usual at such agencies). Furthermore, we included a 30 percent addition to labor to cover overhead expenses. The sorting accomplished includes separation of usable portions into various sales categories — men's coats, ladies' cotton dresses, and the like. By estimate of agency officials, just to sort out rags would cost 10 percent of total cost of $3.90 to $4.00 per ton.

Costs on production of wiping cloth are taken from a 1970 survey (unpublished) conducted by the National Association of Wiping Cloth Manufacturers. These data, together with scrap preparation costs in the nonferrous scrap industry, also obtained by survey, are the most reliable cost data in Table 7.

Discussion. The costs of obtaining and processing secondary materials are high, especially when related to the price they bring in the market place. Operating economics are most unfavorable for those materials that occur in large quantities in waste — mixed paper, metals, and glass. These materials bring the lowest prices in the markets; demand for these low-grade materials is limited, and processing costs are as high as or higher than those for higher grade scrap materials. If the material must be sorted from mixed wastes, costs become prohibitive.

To illustrate, let us take glass for an example. To sort glass from waste manually will cost $13 to $15 per ton; pickup and processing in the traditional fashion will run $14 to $18; delivery costs will add $2 to $3 for a total of $29 to $36 per ton. The glass industry estimates that the benefits of using cullet instead of virgin raw materials are

[8]Day & Zimmermann, Engineers and Architects. Special studies for incinerators; for the government of the District of Columbia, Department of Sanitary Engineering. Public Health Service Publication No. 1748. Washington, U.S. Government Printing Office, 1968. p.78.

worth $2 per ton of cullet. Thus, cullet may cost $2 more *than the furnace charge of sand, soda ash, and* limestone. Virgin materials cost between $15 and $20 per ton; cullet, therefore, is uneconomical at costs above $17 and $22, depending on location and other circumstances.

If an average picking rate of 3 tons per man-day can *be expected in a well-designed salvage plant, the picking* rate at a dump or landfill would probably be at most 1 ton per day. For this glass the scavenger would get $4 to $6 from a dealer and would have to provide transport to the dealer's plant. If engaged full time in this activity, the junkman could earn between $1,000 and $1,500 a year working 5 days a week.

If glass were separately collected by municipal forces in the course of waste pickup, additional costs of refuse removal would be at least $4 per ton of glass, assuming that it would be concentrated at a dump or at an incinerator rather than delivered to the dealer. The dealer could not afford to pay for this glass but could afford to pick it up and process it.

In light of the above, it is not surprising that glass recovery programs must be subsidized if glass from residential sources is to be recovered. This rule generally holds for any recovery scheme, for all materials categories, if the materials must be removed from mixed wastes by presently used techniques that rely heavily on manual labor.

New Technology

Recognition of the adverse economies of manual sorting operations, the difficulties anticipated in recruiting and holding labor for waste sorting, and the widespread belief that residential householders will not cooperate in household segregation schemes have led to developmental work in waste sorting, classification, and preparation.

Two programs are particularly interesting and promising by reason of their advanced state of development: the Bureau of Mines incinerator residue recovery program and the fiber reclamation program of the Black Clawson Company. Other new technology is under development at Stanford Research Institute (air classification of paper), at the Forest Product Laboratories (paper separation), at the Franklin Institute (paper recovery), and the Sortex Company of North America (glass separation). This is not an exhaustive list but is representative of work under way. In addition, the Bureau of Mines is experimenting with processing raw mixed wastes, and private industry has other work under way.

Development of new technology in salvage is perhaps better labeled "technology adaptation." Both the Bureau of Mines and Black Clawson are working with systems developed in industry and are attempting to adapt existing machinery to the processing of wastes. One *radically new concept offered as an ultimate solution to* solid waste management and materials recovery comes from the U.S. Atomic Energy Commission (AEC). Two AEC scientists have suggested that the fusion reaction might be utilized to reduce wastes to elemental particles in ultra-high temperature plasmas.[9] This concept is promising but must await solution of a fundamental technical problem: the continuous confinement of fusion plasmas. All other ideas offered are conventional: the sorting of materials fractions from wastes by some technical process and the utilization of the resulting resources in traditional industrial or agricultural applications.

Bureau of Mines System. The Bureau of Mines has developed and demonstrated a system whereby incinerator residues can be mechanically segregated and recovered, but one manual picking step is necessary. The system uses conventional minerals engineering equipment. According to the Bureau of Mines, "the process, which is comprised simply of a series of shredding, screening, grinding, and magnetic separation procedures, yields metallic iron concentrates, clean nonferrous composites, clean fine glass fractions, and a fine carbonaceous ash tailing."[10]

Technical Aspects. The experimental facility, capable of handling 1,000 pounds per hour, is located in College Park, Maryland, at the Bureau of Mines Metallurgy Research Center. A flowsheet of the process in included (Figure 3). The plant is capable of separating residues into nine materials fractions, including three ferrous and two nonferrous metal fractions, two glass fractions, a sand fraction, and a slime fraction. The nonferrous metals are in mixed form — thus, copper, lead, aluminum, and other nonferrous metals are not sep-

[9] Eastland, B.J., and W. C. Gough. The fusion torch closing the cycle from use to reuse. Washington, Division of Research, U.S. Atomic Energy Commission, May 15, 1969. (WASH-1132.) 25 p.

[10] Spendlove, M. J., P. M. Sullivan, and M. H. Stanczyk. Solid waste research. College Park, Md., U.S. Bureau of Mines, College Park Metallurgy Research Center, 1970. p.1

arated from each other: the nonferrous metal fractions, however, are high in aluminum content. The glass fraction is a fine, granular glass, and is separated into flint glass and colored glass by high intensity magnetism, although color separation is not complete.[11]

The Bureau of Mines System requires some manual sorting. Wire and massive pieces of iron, such as an automotive axle, must be removed manually from a picking belt lest they interfere with subsequent shredding and screening activities. Separation of glass from nonferrous metals requires that the glass be finely ground to be capable of passing through a minus 35 mesh screen.[12] Nonferrous metals, which are not frangible like glass, usually cannot be reduced to so fine a size and are thus separated by screening. The fine, granular glass is not readily salable as glass cullet. For this reason, the Bureau has been experimenting with an optical sorting device to separate clear glass from dark glass and nonferrous metals while the glass is still in 1/2- to 3/4-inch pieces. Preliminary work indicates that a 90 percent purity glass fraction can be achieved using the optical technique; the sorter permits some brown and green glass, some white ceramics, and about 0.1 percent by weight of nonferrous metal to pass into the clear glass fraction.

Theoretically, 82.9 percent by weight of the incoming residue should be salable; it consists of ferrous metals, nonferrous metals, and glass (Table 8). Because brown and green glass cannot be readily separated from nonferrous metals unless ground, and because ground glass cannot be sold readily, we estimate that the salable portion is 62.2 percent; this is the proportion we use in our analysis of cost data developed by the Bureau of Mines.

Process Economics. The Bureau of Mines developed capital investment and operating cost projections for two sizes of incinerator residue plants, a 250 tons-per-day and a 1,000 tons-per-day plant; the first could handle residues from an incinerator burning 1,000 tons of waste daily, the second from an incinerator burning 4,000 tons per day. The Bureau data assume 260 days of operation and a 20-year plant life; depreciation of the capital investment is included but interest on the capital is excluded. Operating data are given in dollars per ton of incinerator residue handled. A summary of the Bureau data is presented in Table 9; accordingly, operating costs are $3.52 per ton at the 250 tons-per-day level and $1.83 per ton at the 1,000 tons-per-day level.

If interest is included at 8 percent a year for the 20-year period, operating costs per ton of residue treated are raised to $4.77 per ton and $3.04 per ton on the small and large plant, respectively. If costs are calculated on the basis of tonnage sold or salable (62.2 percent of inputs), the small plant will have costs of $7.67 per ton of salable residue, the large plant $4.89 per ton.[13]

These projected cost data are promising, especially the lower per ton costs apparently achievable with the larger plant. At a processing cost below $10 per ton, the operation might break even, even if not all materials recovered can be sold. If a credit is claimed for landfill space and landfill operation costs saved, the reclamation program would probably be desirable. At a cost below $5 per ton, the economics, of course, are considerably improved — again assuming a market for the commodities.

Marketing Operations. Preliminary investigations conducted by the Bureau of Mines concluded that the nonferrous metal fraction (2.8 percent of total) could probably be sold in spite of the fact that the metals are a mixture of aluminum, copper, and other metals. Our discussions with nonferrous metal dealers support this conclusion. The large ferrous metals (16.6 percent of the residue) contain all of the steel cans, wire, massive iron parts, and the like. This fraction could conceivably be sold, although the relatively high tin content of steel cans would severely limit marketability. Smaller ferrous metals include mill scale, magnetic slag, and small pieces of iron (bottle caps, nails, etc.); in our opinion this fraction (13.9 percent) would be difficult, if not impossible, to sell. The clear glass fraction (28.9 percent), though probably

[11] There have been reports that the colored glass in the incinerator residue is preferentially absorbing minute traces of iron that cause it to exhibit paramagnetic characteristics. If so, magnetic separation could not be employed for glass in raw unburned refuse. However, the Bureau of Mines disputes this contention.

[12] A particle capable of passing through a minus 35 mesh screen has a maximum diameter of 0.0196 inches, approximately the size of the dot of an i.

[13] The 250 tons per day plant will receive 65,000 tons per year, of which 40,430 tons are assumed salable; total operating cost, including depreciation and interest, will be $310,058. Corresponding data on the 1,000 tons per day plant are inputs of 260,000 ton, salable quantity of 161,720 tons, and costs of $790,072 a year.

salable in some locations, suffers from the fact that glass that has passed through an incinerator is thought undesirable by glass processors, primarily because it contains a proportion of slag high in ferrous metal.

We believe that the Bureau of Mines system — technically workable and apparently economical — is a promising development, but its ultimate success will be contingent on the creation of demand for secondary raw materials that are not as pure as materials obtained by conventional means.

Black Clawson System. The Black Clawson Company has developed a reclamation system at its Middletown, Ohio, research facilities that can accept unsegregated waste from a compactor truck and, by processing, produce a salable paper pulp product, metals, and glass. The system, which has reached the demonstration phase in a facility built at Franklin, Ohio, makes use of paper industry equipment to pulp solid waste and to reject inorganic products like metals and ceramics (the Hydrasposal System), and then to reclaim fibrous materials in a unit employing special filtering and screening devices (the Fibreclaim System) while rejecting unusable organics like plastics and rubber.

According to the company, approximately 30 percent by weight of input tonnage is reclaimable, with the reclaimed portion consisting of two-thirds paper and one-third metal and glass; the metal and glass portion is 63 percent metal, 37 percent glass. Thus, a plant receiving 500 tons per day of raw refuse will yield 100 tons per day of paper pulp (dry basis), 33 tons of metal, and 19 tons of glass. The remaining 348 tons will be composed of organics not reclaimable as fiber; miscellaneous materials like stone, ceramics, and metallic fines; ash; dirt; suspended particles; and moisture (about 20 percent of input tonnage).

Operations. Waste entering the system is introduced into a pulping unit where, in a liquid medium, the waste is chopped, cut, and agitated until a pulpy material results. Heavy materials are removed at the bottom of the pulper; this fraction is rich in metals (69 percent); the pulped wastes are next passed through a cyclone separator where other inorganics are removed; this fraction is rich in glass (79 percent). The inorganic wastes are then passed to a separation unit where glass, ferrous metals, and nonferrous metals can be separated; the pulp is carried to a fiber reclamation system where, in turn, (1) coarse organic materials (rags, plastics, food wastes) are removed by screening; (2) fine dirt (plastics, vegetation) is screened out; (3) fine particles of heavy dirt (glass, ceramics, sand) that passed through the cyclone are centrifuged out and unsightly particles (coffee grounds, leaves, grass) are removed from the pulp; (4) the pulp is partially dewatered using a screw-type thickener; and (5) the pulp is thickened in a high density press.

The company has successfully demonstrated all parts of this system except that portion where inorganic materials — the metals-rich and glass-rich portions are further segregated into ferrous, nonferrous, and glass fractions.

Operating Costs and Revenues. The company has developed detailed cost data for a plant capable of accepting 500 tons per day of waste. The cost data are based on a plant life of 25 years, an interest rate of 6 percent, 260 days per year operations, and an all-inclusive labor cost of $4 to $5 an hour. For comparative purposes the revenues for salable fractions plus the operating costs, including depreciation and interest, for the reclaiming operation have been allocated to the salable commodities, which amount to 39,650 tons per year. Costs of the Hydrasposal (waste pulping) operation have been allocated separately.

All incoming materials, including the salable fractions, pass through the Hydrasposal System at a cost of $4.93 per input ton, which the company uses as the basis for a "disposal fee" for cost comparisons. The recovered fiber accrues a cost of $17.38 through the Fibreclaim System, and the inorganic materials accrue costs of $7.13 per ton in the inorganics processing unit (Table 10). On a composite basis, the costs are $12.30 per recovered ton.

The revenues are based on a sales price of $25 per ton for paper fiber; ferrous metals at $14 to $16 per ton less freight; glass at $18 to $20 per ton, less freight; aluminum at $175 per ton. The composite income for the reclaiming operation is $22 per ton of recovered material, and the net gain is $9.70 per ton, or $2.97 per input ton.

Data on pulping and paper fiber reclamation costs are the most reliable. Inorganic materials separation costs are based on use of moving belts, vibratory belts, and magnetic separation. Equipment to separate glass into clear and colored fractions and a metals shredder to achieve full separation of ferrous and nonferrous metals would be needed to produce materials that can be sold.[14]

The paper fiber available is high in groundwood content[15] and is consequently equivalent to mixed paper or newspaper in the paper market. Although the product of the Black Clawson system is superior to newspapers or mixed papers (it is a pulp, virtually free of contaminants), it may not always bring $25 per ton. Paper dealers and paper companies queried by us concerning this material stated that $15 per ton may be a more realistic selling price for the pulp. Black Clawson Company spokesmen, however, are confident that the pulp could be sold for $25 and the output of the demonstration plant has been sold to a local paper mill at that price.

The company anticipates that the glass and metal fraction will be salable. It appears to us that the clear glass fraction, once segregated, will be salable at an estimated $20 per ton; the dark glass, which will contain opaque particles in the glass fraction, could be used to manufacture secondary products if markets and techniques are developed; otherwise this would be a waste fraction, or could be further color separated and sold at $10 to $15 per ton. The metals may find a market if shredding and separation over and above that now planned are included.

The system appears economically feasible if credit is taken for disposal savings. If disposal credit is $5 per ton, for instance, a facility operator could afford to sell the recovered fractions at 44 percent below the cited figures — pulp at $16.50 per ton for example — and still have a breakeven operation.

Other Developments. Techniques applicable to the sorting and handling of specific portions of the waste are available or under development. A brief capsule of the most significant approaches follows.

Glass Sorting. We have already mentioned optical glass sorting equipment used by the Bureau of Mines. Optical sorting is a well developed technique used widely in the minerals and food processing fields to separate materials of more or less uniform particle sizes but of different colors.

Equipment available from Sortex Company of North America, Inc., operates in the following manner: (1) particles are mechanically lined up sequentially in a narrow furrow on a belt; (2) each particle is propelled from the belt into an optical viewing chamber where it passes in front of an appropriately shaded background slide; (3) while in the chamber, the particle is inspected by a three-lens, wide-angle viewing system; (4) any particle whose color or shade differs from a preset standard excites the photoelectric cells of one or more of the viewers; (5) each signal is evaluated, and if the particle does not match the preset color, an air blast system is activated and blows the particle into a receiving duct. If the particle conforms to standard, it is allowed to pass out of the chamber following a normal trajectory (Figure 4).

The manufacturer states that ideally particle sizes should be between 1/2 and 3/4 inch in diameter for glass sorting. Best separation is achieved at the lowest feed rates, between 10 and 15 tons in a 24-hour operation.

The sorting technique is not 100 percent accurate. With homogeneous materials, fed at a slow rate, composed 50 percent of clear and 50 percent of dark materials, between 2 and 4 percent of the dark particles will end up in the clear portion. In 12 tests conducted by the Bureau of Mines on coarse glass particles, the best results were 3 percent colored glass in the clear portion; worst results were 14.3 percent. As more experience is gained with this or similar equipment, it may be found that multiple sorting may be necessary to process glass from waste sources or that equipment modifications can be introduced to achieve consistent results.

Glass sorting costs have been developed by the manufacturer. Operating costs, excluding equipment amortization, range from $0.95 to $0.18 per ton at feed rates of 0.5 and 2.5 tons per hour, respectively. Investment costs, excluding installation and freight, are about $12,460.

Paper Classification. Experimental work to separate paper from mixed wastes has been conducted by

[14] The addition of a glass sorting operation was proposed for the Black Clawson demonstration plant. This installation would encompass the Sortex optical separator and the Stanford Research Institute zigzag classifier. Economic estimates indicate operating costs of $1.54 per ton and capital costs of $2.62 per ton, or $4.16 total costs, based on a throughput of 3 tons per hour.

[15] A fiber derived mechanically from trees rather than being chemically pulped; newspapers are made of ground wood. See Chapter IV for a full discussion.

Stanford Research Institute (SRI) and the Department of Agriculture's Forest Products Laboratories.

The SRI system makes use of an air classification column wherein shredded materials are separated by being carried up a zig-zag column; heavy materials that cannot be supported by the air stream drop out at the bottom. The system has not been proved to work conclusively, but further research is under way. The key difficulty is that, to be properly separable by the air classification system, particles must conform to characteristics that are not possible to achieve by current shredding equipment. For instance, Stanford scientists specify that paper and corrugated board as delivered from the shredder should have the following characteristics:

> "Particles to be individually separable, to have 4-inch to 5-inch maximum dimension, and to be roughly rectangular with a ratio of length to width of no more than 2:l. Cleanly-cut edges are preferable to torn edges; frayed, mechanically-worked edges are unacceptable."[16]

Once technical difficulties presented by waste preparation prior to classification are overcome, the system is expected to produce mixed paper with little or no Styrofoam packing and sheet plastics and only a small quantity of magazine stock, waxed paper, butter cartons, and the like in the end product. Projected costs are not available on the system.

Forest Products Laboratories at Madison, Wisconsin, has recently begun work on separation of paper products from shredded wastes. This work has not progressed far to date. The objective is to obtain five or more grades of paper stock: newspapers, corrugated, magazines, brown paper, and all other paper. Air classification of milled refuse will be used to effect separation.

One final paper separation technique deserves mention. This method, described under the New York case study in Chapter XI, has been developed to recover corrugated board from commercial and industrial wastes. The system employs a series of belts spaced at distances of 5 inches from each other so that small particles of waste drop down between belts while cardboard bridges the gaps between belts. Heavy particles or objects can force their way between belts and also drop out(e.g., an oil drum, an auto part). This system, with projected operating costs (all-inclusive) of $l0 per input ton or $40 per ton of cardboard recovered, and based on disposal fees and corrugated sales, is nearing commercial start-up in New York City.

Special Economic Considerations Related to Salvage

The economics of salvage are sometimes difficult to understand unless three of its hidden aspects are kept in view. The most significant aspect is that salvage is often an alternative to waste disposal for the generators of the material. Individuals or organizations engaged in recovery of materials do not necessarily compare their operating costs to the price they receive but, instead, compare costs to the alternative of disposing of the materials as waste. A salvage operation costing $l5 per ton and realizing $l0 per ton in income is not, on the face of it, economical. Yet, it may be practiced because disposal costs may be $6 per ton. In effect, the salvage program losing $5 per ton is cheaper than disposal at $6 per ton. A classic instance of this is described in the Atlanta case study (Chapter XI) where the municipality could lose $5.66 per ton on the sale of steel cans from incinerator residue and still realize 1 ¢ per ton profit because the alternative disposal mode would cost $5.67 per ton.

The second aspect of salvage economics is that salvaged materials frequently ride "piggyback" on a system developed for another purpose. In such cases salvage is possible only because an established collection system exists whose costs are borne by another activity. An example is textile collection from residential sources by social welfare agencies. These agencies collect materials from door to door in order to obtain resalable commodities that may translate to income worth several hundred dollars per ton. The high income per ton justifies collection costs of $80 to $90 per ton. Salvage is also picked up. But, since it seldom earns the agency more than $50 to $60 per ton, collecting salvage alone could not be justified. Salvage rides piggyback with more valuable merchandise.

Collection systems that use empty merchandise trucks to carry cardboard from grocery stores to a central warehouse and household collections of secondary materials by garbage truck crews (who have to be there anyway) are other examples of the same principle.

The third aspect is that the recovery of some classes of material is indirectly subsidized by: (l) voluntary con-

[16] Boettcher, R.A. Air classification for reclamation of solid wastes. Compost Science, 11(6):22-29, Nov.-Dec. 1970.

tribution of labor, time, and transportation by the public (as in school-sponsored paper drives); (2) by employment of physically or socially handicapped labor, paid at rates below average (as in social welfare agencies); (3) by people on the margins of economic existence who salvage commodities as an alternative to welfare and who neither pay themselves an average wage nor count all of their real costs (i.e., use of a truck or car); and (4) by some secondary materials dealers and processors who do not account for all costs they incur, especially not for equipment amortization. These hidden subsidies, if eliminated, would make recovery of most textiles, newspaper, and portions of all other recovered materials uneconomical.

The above points should be kept in mind whenever a salvage program is contemplated that would duplicate an existing traditional system in a new mode. Unless the new system enjoys the same subsidies as the traditional system, chances are that it will not be economically feasible.

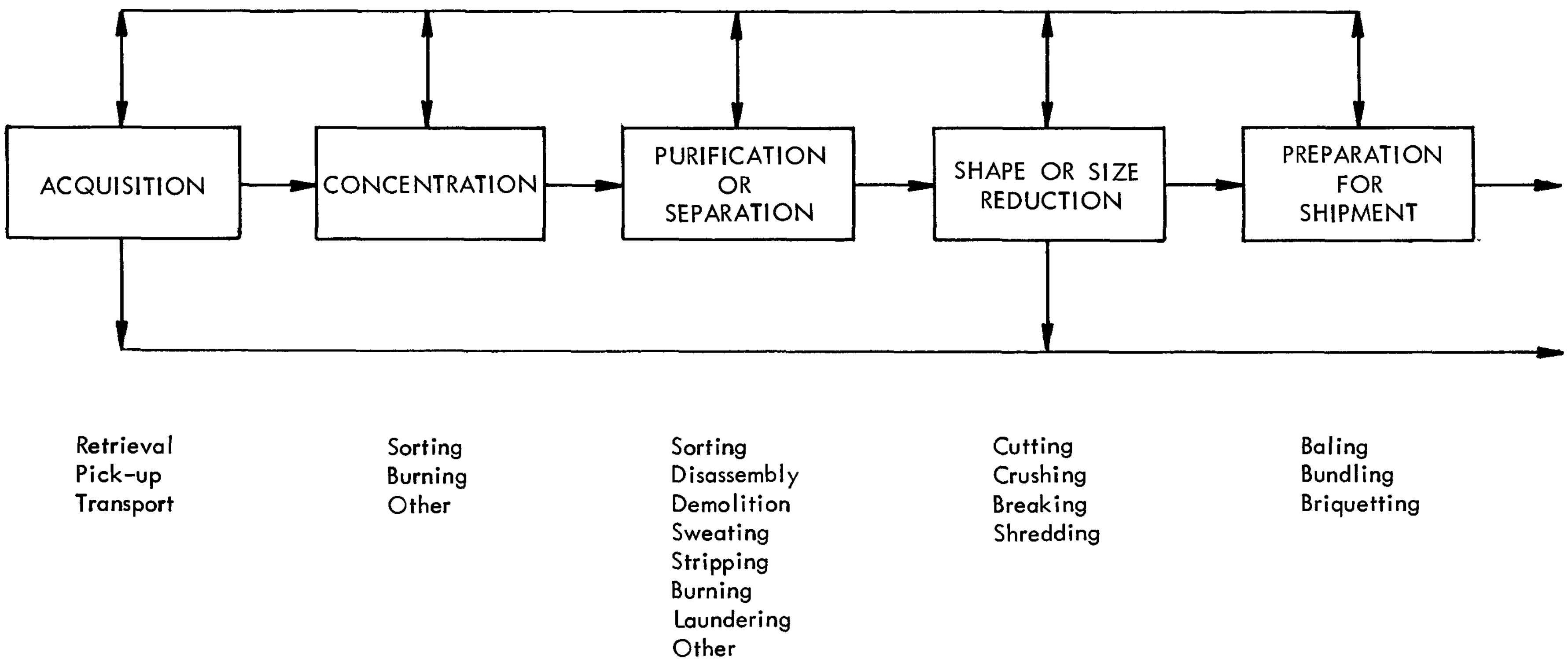

Figure 2. Principal salvage operations.

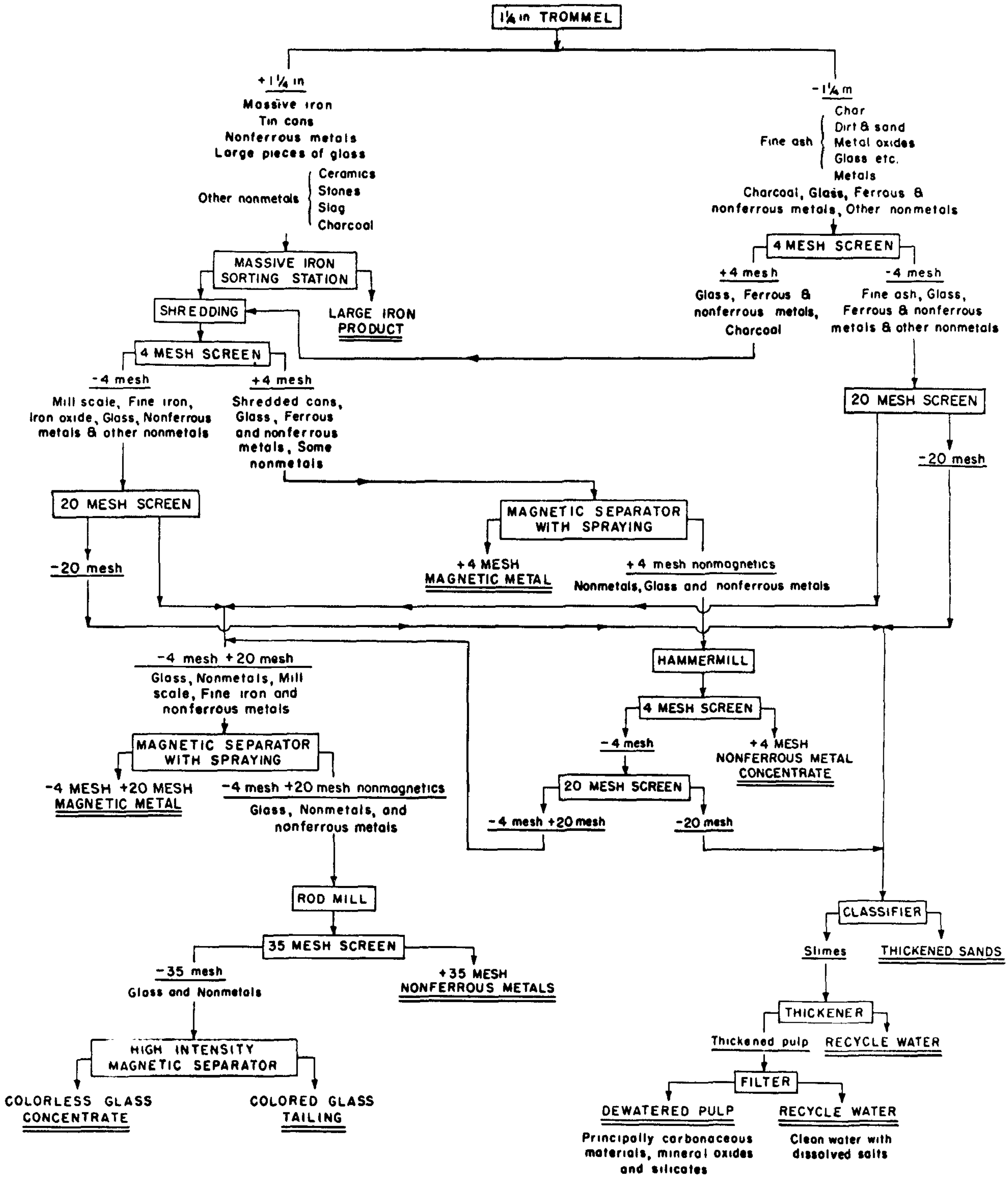

Figure 3. Continuous incinerator residue processing plant flowsheet developed by the Bureau of Mines.

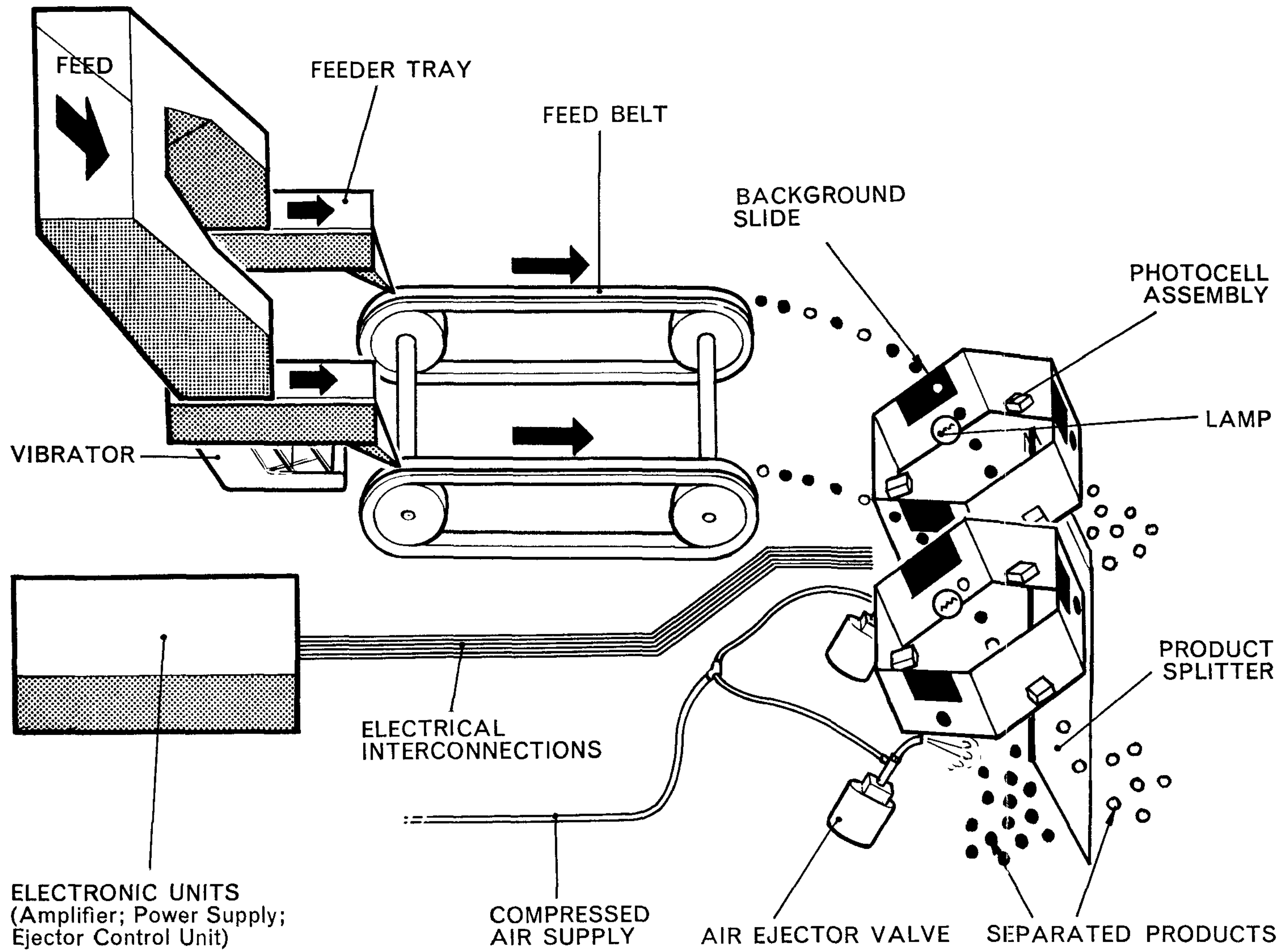

Figure 4. Schematic diagram of glass sorting equipment manufactured by Sortex Company of North America, Inc.

TABLE 5

ESTIMATED QUANTITIES OF MATERIALS THAT CAN BE HAND PICKED FROM MIXED WASTES, LABOR COSTS PER TON, PLANT AMORTIZATION COST PER TON, AND MARKET PRICE OF MATERIALS*

Material	Tons per man-day			Average sorting cost/ton ($26/man-day)	Plant amortization ($/ton)	Partial ‡ processing cost ($/ton)	Price paid by dealer ($/ton)	
	High	Low	Average				High	Low
Newspaper	3.0	1.5	2.25	11.56	4.78	16.34	14	4
Mixed paper	2.5	1.5	2.0	13.00	4.78	17.78	4	0+
Corrugated	3.0	2.0	2.5	10.40	4.78	15.18	15	10
Textiles	2.0	1.0	1.5	17.33	4.78	22.11	60	10
Metals	3.5	2.5	3.0	8.67	4.78	13.45	10	5
Glass	3.5	2.5	3.0	8.67	4.78	13.45	7	5

* Recovery per man-day based on estimates of the Los Angeles Bureau of Sanitation; sorting cost and amortization estimates by Midwest Research Institute; dealer prices are typical prices for the commodity in low and high market periods.

+ Mixed paper cannot be sold in times of low demand.

‡ Excludes all costs except labor and plant amortization.

TABLE 6

ESTIMATED SORTING COSTS OF A COMPOSITE TON OF SALVAGE TAKEN FROM MIXED MUNICIPAL WASTE, INCLUDING PLANT AMORTIZATION AND INCOME RECEIVED*

Material	Salvage (%/ton)	Labor cost to sort fraction ($)	Amortization applicable to fraction ($)	Partial recovery cost ($)	Dealer price paid/fraction ($)	
					High	Low
Newspaper	13	1.50	0.62	2.12	1.82	0.52
Mixed paper	42	5.46	2.00	7.47	1.68	--
Corrugated	19	1.98	0.91	2.88	2.85	1.90
Textiles	1	0.17	0.05	0.22	0.60	0.10
Metals	14	1.21	0.67	1.88	1.40	0.70
Glass	11	0.95	0.53	1.48	0.77	0.55
Per ton	100	11.27	4.78	16.05	9.12	3.77

* From Table 5; percentages of materials calculated by Midwest Research Institute on the basis of data in Appendix A and Figure 13.

TABLE 7

REPRESENTATIVE SALVAGE OPERATION UNIT COSTS BY OPERATION FOR VARIOUS COMMODITIES, IN DOLLARS PER TON*

		Operations performed												
Commodity and activity	Cost per ton ($)	Pick up transport	Manual sorting	Mechanical sorting	Washing	Burning	Sweating	Wire stripping	Briquetting	Crushing	Screening	Shredding/cutting	Bundling/baling	Other costs included
Paper and board														
Physical acquisition of concentrated waste paper (1,2)	4 - 7	x												
Processing of paper (1)	5 - 8		x									x	x	Shrinkage
Total operating costs	9 - 15													
Recovery of paper from mixed municipal waste (3)	9 - 18		x											
Ferrous metals														
Physical acquisition of concentrated steel scrap (1,2)	3 - 4	x												
Scrap preparation (1,2)	7 - 9		x	x		x				x		x	x	Shrinkage
Total operating cost	10 - 13													

* From sources as indicated by Arabic numerals in parentheses.

(1) Dealer estimates obtained by interview.
(2) Midwest Research Institute estimates based on dealer estimate.
(3) Midwest Research Institute estimates based on studies conducted by Los Angeles Bureau of Sanitation.

TABLE 7 (continued)

Commodity and activity	Cost per ton ($)	Operations performed: Pick up transport	Manual sorting	Mechanical sorting	Washing	Burning	Sweating	Wire stripping	Briquetting	Crushing	Screening	Shredding/cutting	Bundling/baling	Other costs included
Steel can recovery from incinerator residues														
By incinerator operator (4,5)	10 - 14		x	x	x							x		
By dealer processor (1)	19 - 20		x	x	x					x	x	x		Shrinkage
Recovery of metals (ferrous and nonferrous) from mixed municipal wastes (3)	14 - 20		x											
<u>Nonferrous metals</u>														
Physical acquisition of concentrated nonferrous scrap (1,2)	3 - 4	x												
Scrap preparation cost (6)	26 - 44		x	x		x	x	x	x	x	x	x	x	Shrinkage
Total operating cost	29 - 48													
<u>Glass</u>														
Physical acquisition of concentrated glass cullet (1,2)	4 - 6	x												
Processing (1,2)	10 - 12		x		x					x	x			Shrinkage
Total cost of operations	14 - 18													

(4) Cost Study (unpublished) by the Atlanta Department of Sanitation (lower cost figure).
(5) Day & Zimmermann, Engineers and Architects. Special studies for incinerators; for the government of the District of Columbia, Department of Sanitary Engineering. Public Health Service Publication No. 1748. Washington, U.S. Government Printing Office, 1968. p.78.
(6) Industrial profile and cost factors in nonferrous scrap processing. New York, National Association of Secondary Material Industries, Inc., [1969]. p. 14.

TABLE 7 (concluded)

Commodity and activity	Cost per ton ($)	Operations performed: Pick up transport	Manual sorting	Mechanical sorting	Washing	Burning	Sweating	Wire stripping	Briquetting	Crushing	Screening	Shredding/cutting	Bundling/baling	Other costs included
Recovery of glass from mixed municipal wastes (3)	13 - 15		x											
Textiles														
Acquisition of textiles from residential sources (7)	20 - 43	x												
Initial sorting of textiles into resaleable and rag portions (8)	39 - 40		x										x	
Acquisition of mixed rag bundles by wiping rag manufacturer (1,2)	3 - 4	x												
Production of wiping rags from mixed rags (9)	267		x		x							x	x	Shrinkage
Total wiping rag production cost	270-271													
Recovery of rags from mixed municipal wastes (3)	9 - 22													
Rubber														
Physical acquisition of rubber tires (2)	10 - 15	x												

(7) Midwest Research Institute estimates and calculations based on information made available by Goodwill Industries, Salvation Army, and Volunteers of America.

(8) Midwest Research Institute calculations based on information provided by Goodwill Industries, Inc., Cincinnati, Ohio.

(9) From 1970 survey conducted by National Association of Wiping Cloth Manufacturers, 1970 (unpublished).

TABLE 8

COMPOSITION OF INCINERATOR RESIDUES PROCESSED THROUGH AN EXPERIMENTAL RECLAMATION SYSTEM*

Item	Weight (%)
Large ferrous metals pieces, wire, steel cans	16.6
Small ferrous metals	13.9
Nonferrous metals	2.8
Clear glass	28.9
Colored glass	20.7
Residue and slime	17.1
Total	100.0

* From Department of the Interior, Bureau of Mines, data obtained during interview.

TABLE 9

INCINERATOR RESIDUE RECLAMATION PLANT OPERATING COST PROJECTIONS*

Cost item	Annual cost 250-TPD plant	Annual cost 1,000-TPD plant	Cost/ton of residue 250-TPD plant	Cost/ton of residue 1,000-TPD plant
Direct costs				
Raw materials	1,100	4,500	0.02	0.02
Utilities	16,300	40,000	0.25	0.16
Direct labor	37,400	117,000	0.58	0.45
Maintenance	40,100	81,500	0.62	0.32
Payroll overhead	15,400	41,500	0.24	0.16
Operating supplies	8,000	16,300	0.12	0.06
Total direct costs	118,300	300,800	1.83	1.17
Indirect cost	15,500	39,700	0.24	0.15
Fixed costs				
Taxes and insurance	15,200	21,500	0.23	0.08
Depreciation	79,000	111,800	1.22	0.43
Total operating cost	228,000	473,800	3.52	1.83

* From Department of the Interior, Bureau of Mines, undated cost summary sheets obtained during interview; data are based on 1969 equipment costs; labor is based on $2.50 per hour rate plus 25 percent supervisory addition.

TABLE 10

OPERATING COSTS OF A 500 TONS PER DAY WASTE RECLAMATION FACILITY, TOTAL ANNUAL COSTS, COSTS PER TON OF RECLAIMED PRODUCT, AND ANTICIPATED INCOME PER TON*

Category	Annual operating cost or income ($)	Materials processed through operation (tons)	(%)	Operating cost or income/ton of reclaimed material ($)	Operating cost or income per input ton ($)
Total Waste Processed	641,000	130,000	100.0		4.93
Reclaiming operation--cost					
Ferrous metal	1,000	8,000	20.0	0.13	0.008
Glass	35,000	5,000	12.5	7.00	0.269
Aluminum	-(+)	650	1.5	0.00(+)	-
Paper pulp	452,000	26,000	66.0	17.38	3.477
Total	488,000	39,650	100.0	12.30	3.754
Reclaimed material--income					
Ferrous metal	64,000	8,000	20.0	8.00	0.492
Glass	50,000	5,000	12.5	10.00	0.385
Aluminum	110,000	650	1.5	175.00	0.846
Paper pulp	650,000	26,000	66.0	25.00	5.000
Total income	874,000	39,650	100.0	22.00	6.723
Net gain	386,000			9.70	2.969

* From W. Herbert, Director of Engineering, Shartle/Pandia Division, Black Clawson Company, personal communication, 2-8-71.

\+ Included with glass.

CHAPTER IV

PAPER

Perspective

Paper is one of the major manufactured materials consumed in the United States and the largest single component of municipal waste.

Paper can be viewed (1) as a commodity of consumption in the Nation's economy; (2) in its role as secondary raw material utilized for recycling; and (3) as an input to the Nation's municipal waste.

Paper Consumption. Paper and paper products penetrate almost every segment of the Nation's economy. Their use is intimately connected with political, economic, social, and cultural activities. Paper is the most important communications medium; the most widely used packaging material; a growing part of personal use "disposable" products; and an important input to construction and industrial products.

In 1969, the Nation consumed 58.5 million tons of paper — more than 12,000 kinds of paper in more than 100,000 end uses. Per capita consumption was 575 pounds in 1969, making paper one of the two or three most important manufactured materials in the United States. By 1980, consumption will be about 85.0 million tons.

Paper is classified in three major categories — paper, paperboard, and construction paper and board. In 1969 consumption of each was: paper, 30.1 million tons (51.5 percent); paperboard, 23.9 million tons (40.8 percent); and construction, 4.5 million tons (7.7 percent). Consumption of paper has increased at a rate of over 4 percent per year in the last decade and appears to be headed at near this rate for the next decade as well.

Paper Salvage. Unlike steel products, which have an average life of 20 years, most paper is used and discarded in the same year it is purchased. Its value is low in comparison to its bulk, and most obsolete paper products enter the solid waste stream. In 1969, paper in the form of recycled waste paper made up about 19.8 percent of fibrous raw materials used in the production of new paper (Table II), and 17.9 percent of total tonnage consumed was recovered for recycling purposes; consumption exceeded production as a result of a net import of 4.73 million tons of paper.

The paper industry does not report on the use of internally generated and consumed scrap (called "broke"). Census data also do not include this material. Where scrap or waste paper is discussed here, it refers only to conversion wastes and obsolete paper (waste paper), that waste recovered far down the manufacturing cycle from the paper mill or after discard of finished products.[17]

Paper products consumed in the United States are derived from wood pulp, waste paper, and other fibers. These raw materials result in the new paper grades that go into finished products. A portion of the raw material is lost in processing; the remainder is either recovered for recycling or is discarded as waste. Scrap created by conversion activities and obsolete wastes from consumers do not commonly go into primary recycling applications.

[17] The paper industry does not recognize the terms "home," "prompt," and "obsolete" scrap as the steel industry does, but has a myriad of scrap grades, each of which is more or less descriptive of the source and quality of the scrap. The term "waste paper" is used commonly in statistical and trade sources but the term "paper stock" is preferred by most dealers and consumers. Paper stock is a term used to describe waste paper that has been recovered from any source and prepared for utilization as a raw material in some paper making process. Dealers are designated "waste paper dealers" but their product is paper stock; paper mills using secondary fibrous materials usually use the term paper stock. Both of these terms of the trade are used interchangeably by us in this Chapter.

Instead, they move into different (and usually cheaper) types of paper products than those that they represented initially. Thus, for the major paper stock consumers, waste paper is a "new" raw material.

The U.S. paper industry places a fairly high reliance on conversion and obsolete scrap and recovers about 22 percent of "available" material. (This excludes that portion of paper retained in use, such as books and records, and that portion used in products not identified as paper in final use, such as paper in shoes.) Nearly all waste paper consumed is purchased — in the sense that it passes through the hands of waste paper dealers.

Paper in Solid Waste. Paper is a high proportion of waste, and at present the recovery of waste paper within the solid waste management framework is negligible. Current recycling of waste paper, however, keeps a substantial quantity of waste out of the waste stream.

The following summary gives an overview of the disposal of of paper (Table 12). In 1967, we consumed 532 pounds of paper per person and discarded to waste 353 pounds per person (420 pounds per person if the diverted category is included).

The magnitude of paper in waste can be judged from two measures of solid waste composition. Based on our analysis of 1967 data, we estimate that paper (in a form that would be identifiable as paper) made up about 41 million tons of solid waste in 1969 in residential and commercial waste; an estimated 2 to 4 million tons probably showed up in building rubble and other products with paper content, including shoes, automobiles, cable, and other manufactured products.

Paper is also about 42 percent by weight (or higher) of typical residential refuse loads in paper trucks. (See Appendix A for waste composition samples.) Additionally, paper in waste usually has over 20 percent moisture by weight, various use-acquired contaminants (food, dirt), and other materials applied in the conversion process (clay, inks, plastics, staples), which add to the quantity usually measured as paper in refuse composition tests.

The Consumption/Disposal Cycle. The cause and effect relationships between paper consumption and discards are straightforward. Virgin raw materials and recycled materials removed from the Nation's materials inventory are converted into manufactured products. The use of the products in final consumption is followed by discard to waste of that portion not subsequently recycled.

Since 1945, total paper consumption has increased dramatically and the recycling rate has decreased. Consequently, discard to waste has been increasing faster than consumption. In the last 10 years, the use of virgin raw materials has grown at about four times the rate of waste paper use (5.2 percent per year versus 1.2 percent per year); thus the burden on solid waste systems has been increasing even faster than the 4.1 percent per year increase in overall raw materials consumption because of the deteriorating position of secondary fiber vis-a-vis total consumption.

The decline of the relative importance of paper stock consumption makes itself doubly felt. First, both absolute and relative exploitation of virgin material increases. Second, in the case of paper, which finds its way into the solid waste stream rapidly, the flow to solid waste disposal systems increases more rapidly than consumption (Tables 13 and 14). Consumption of paper increased from 36.5 million tons in 1956 to 53.0 million tons in 1967, or 45 percent. In the same period, recycling declined from 24.2 percent to 19.4 percent. Paper in solid waste increased by 59 percent, or one-third more than consumption.

Current trends to 1980 appear to be solidly set, with an increase in consumption of 60 percent and of paper in solid waste of 68 percent likely; these projections are based on a 1980 recycling ratio that is expected to be about the same as the actual ratio for the years 1969 and 1970.

Paper Industry Structure and Characteristics

Characteristics of Paper. "Paper" is the general term used to describe a wide variety of matted or felted sheets of fibers (usually of vegetable fiber, such as trees) formed on a fine screen from a water suspension. Somewhat ambiguously, the term "paper" is also used in a more specific sense to distinguish one of the three broad subdivisions of paper from others and also to designate the lighter, thinner, and more flexible types. The second broad subdivision is paperboard, but the distinction between paper and paperboard is somewhat fuzzy. A third designated division is construction paper, which includes both paper and paperboard used in construction products, such as roofing felts.

Paper is characterized by its weight and thickness; strength (tear, burst); fold endurance; optical properties (gloss, color, opacity, porosity); and the type of raw material (mechanical pulp, chemical pulp) from which it is made.

The most important fibrous materials converted to paper and board are the following.

Groundwood Pulp. This is the lowest quality raw material and is produced mechanically by grinding action to separate wood fibers from resinous binders. It is used for newsprint and printing papers.

Sulfite Pulp (or Acid Pulp). This is produced by chemical cooking methods using sufurous acid and a base in the form of a salt. It is used to process low resin woods such as spruce, fir, or hemlock. Sulfite goes into most printing grades of paper, such as business papers, and into tissue; very little is used in paperboard.

Sulfate Pulp (or Kraft Pulp). This material is produced by chemical methods using an alkaline solution of caustic soda and sodium sulfide. Sulfate is the cheapest chemical pulp and produces the strongest fibers. A wide variety of trees can be used, especially those with a high resin content, such as pine and Douglas fir. Yields are low — 40 to 50 percent by weight. Kraft pulps are used principally in paperboard and coarse paper grades; unbleached grades are used in packaging, and bleached grades are used in packaging boards and a number of paper grades, including printing grades and tissue. Sulfate pulp is by far the most important pulp product today.

Semichemical Pulp. This pulp is produced by using a mild chemical treatment on chipped wood followed by mechanical separation of the wood fibers. The pulping process has a relatively high yield, but the fibers are not as strong or flexible as Kraft pulp. The pulp is made from hardwoods and waste paper and is used predominately for the corrugating medium in paperboard boxes.

Waste paper. This is used as a raw material in the same ways as wood pulp. In the case of paper stock, the fibers are separated from the original product by mechanical agitation in a water slurry. Other treatment, such as deinking and contaminant removal, may also take place. Most waste paper goes into paperboard.

Other fibers used in paper making include rag pulp and bagasse. These constitute a minor portion of raw materials for such diverse products as high quality writing papers, wrapping paper, and various types of paperboard.

The quality of virgin pulp produced is eventually reflected in the quality of various waste paper grades used as raw materials. From a technical standpoint, the secondary fiber can be no better than it was as a virgin fiber and must be used in applications that are compatible with the physical characteristics of the original fiber.

The relative importance of various fibrous materials used in paper production can be seen in Table 15. Although raw materials are often used in mixtures and various combinations, in general each paper mill uses a particular type of fiber in great preponderance over the others with which it may be combined.

In the making of chemical pulp from pulpwood trees, high material losses are experienced (Figure 5).[18] If a "composite" pulpwood tree is considered as 100 percent of input weight, 67 percent is lost in making chemical pulp and an additional 4 percent in making paper and converting it to product. Thus, it takes 3.4 tons of tree in the woods to make 1 ton of finished product. Most of the material loss takes place in the production of pulp. However, a high percentage of annual consumption of wood pulp is derived from such sources as sawdust, cuttings, screening, and stumps.

Industry Structure. The paper industry's structure follows its broad end-product markets and types of raw materials used in each segment or subsegment of the industry.

The paper segment, 44.0 percent of output tonnage in 1969, consumes 51.7 percent of wood pulp and 13.4 percent of waste paper used; but waste paper makes up only 6.5 percent of the segment's raw materials consumption.

The paperboard segment, 47.9 percent of output, consumes 43.0 percent of wood pulp and 79.4 percent of waste paper used; waste paper is 33.4 percent of raw materials inputs. Combination board manufacturers account for nearly all of the waste paper consumption in paperboard.

The construction paper segment, 8.1 percent of output, consumes 5.3 percent of wood pulp and 7.2 percent of waste paper; waste paper is 22.4 percent of raw materials used (Table 16 and Figure 6).

The sequence of operations in the industry includes wood pulping in pulp mills as the first step of manufacturing. This is followed by paper mill operations where the various basic paper grades are made. The final manufacturing activity is conversion of paper to finished products.

[18] From data developed by the Forest Products Laboratory, U.S. Forest Service, Department of Agriculture, at its Madison, Wisconsin facility.

Paper converters are manufacturers of paper products such as envelopes, bags, containers, gummed paper and the like. Recycled materials enter at the paper mill level. From conversion, the products go to many kinds of industrial, commercial, and individual consumers. A paper mill operation may or may not include conversion. At the paper mill level the following operating alignments are common.

(1) Integrated paper mill operations where pulp wood is harvested or purchased, wood pulp is produced in pulp mills, the basic grades of paper and paperboard are made, and, if volume warrants, paper may also be converted to a finished form, such as box blanks.

(2) Paper mill operators who do not have pulp mills but produce paper or paperboard from purchased wood pulp and may purchase small quantities of paper stock, and may or may not have converting operations.

(3) Paper mill operators who rely on purchased waste paper for essentially all or a significant proportion of raw materials and who produce various paper or paperboard grades, and may or may not perform converting operations.

There are also a few independent pulp mills that are not integrated forward into paper production; however, these operations are exceptional. Most pulp sold on the open market comes from the excess production of integrated pulp producers.

Nearly all paper and board mills that consume wood pulp use captive virgin raw materials. In 1968, 89.4 percent of all wood pulp consumed in domestic paper mills was captively produced and most of this was consumed in paper or board mills tied directly to pulp mills at the same location.

Conversely, almost all waste paper is consumed in independent mill operations that depend on purchased waste paper for raw materials. This is true even for those organizations with waste paper dealer subsidiaries. In no sense can waste paper sources be captive or "owned" in the way that pulp wood timber and pulp mills are owned and physically controlled. Integrated mill operations consume only a small portion of total waste paper and this is quite often acquired from their own captive converting operations.

In paper manufacturing, there are mills that depend entirely on waste paper (newspaper deinking is an example); some mills use mixtures of pulp and paper stock (tissue is an example); most are based on virgin pulp. In paperboard, the combination board sector of the industry consumes about 90 to 95 percent of the paper stock used in paperboard, and its raw materials are made up of 90 to 95 percent paper stock and 5 to 10 percent wood pulp. Integrated board mills, by contrast, use no more than 5 to 10 percent of the total paper stock consumed in paperboard, most of this going into semichemical board. Construction grades use a high percentage of paper stock as well as wood pulp; the ratios vary according to individual operations and products, but may be virtually 100 percent for either material.

Individual companies can be grouped somewhat according to the integration patterns described above. Some own only operations using virgin wood pulp (the largest companies in the paper industry); some own only operations based on paper stock (the smallest in the paper industry). A number of companies operate both types of mills, but these companies tend to be more heavily oriented to virgin pulp operations and are usually large operations. One major company consumes roughly equal proportions of virgin and secondary materials.

In 1969 there were 366 pulp mills in the United States and 820 paper and paperboard mills, according to the 1970 issue of Lockwoods Directory, a trade publication. Most pulp mills serve one or two paper or board mills. Paper mills based on wood pulp are concentrated in the South, Northeast, North Central, and the West Coast, where commercial timber lands are located. Mills based on paper stock are located predominately in the East, North Central, and Middle Atlantic states — close to population centers where paper stock is generated and mill outputs are consumed. The relative importance of different raw materials on a geographical basis is detailed in Table 17.

Consumption and Production Patterns

Consumption Trends. Consumption of paper has doubled since 1950 — from 29.0 million tons to 58.5 million tons in 1969. Per capita consumption has taken 25 years to double; consumption is growing at three times the population rate. Domestic paper production has also grown dramatically in the last 15 years, reaching 53.8 million tons in 1969, compared to a level of only 26.9 million tons in 1954 (Figures 7, 8, Table 18). The difference between consumption and production is net imports, most of which is newsprint from Canada.

Fibrous raw material consumption has paralleled domestic production, of course, but the history of wood pulp, paper stock, and other fibers are vastly different

(Figures 9, 10). The rapid growth of virgin raw materials consumption has held paper stock consumption growth to a very modest level. Wood pulp consumption in paper doubled between 1954 and 1969; in the same period, paper stock consumption increased only 34 percent, while consumption of other fibrous materials declined slightly. Thus, the use of wood pulp grew at three times the rate of paper stock.

The wood pulp output thus correlates roughly with solid waste generation since most paper products not recycled are discarded. Conversely, the paper stock recovery ratio has declined almost continuously since 1945 (Figure 11) leaving little doubt about the relative importance of scrap in paper manufacturing. In 1969, paper stock recovery was at a level of 17.8 percent of paper consumption, and all indications are that the ratio dropped even lower in 1970.

Why paper stock consumption has declined can be shown by comparing the use of this material in the two main types of paperboard. Combination board is made almost entirely of waste paper. Solid wood pulp board is almost entirely virgin pulp. The American Paper Institute's *Paperboard Group issues statistics on the production of* these board types (Figure 12, Table 19).

Since 1959, total paperboard production increased from 15.97 million tons to 26.38 million tons in 1969, 65 percent in the period. In this decade, solid wood pulp board has increased 112 percent (8.99 to 19.06 million tons). Combination paperboard production increased only 5 percent in a decade (6.98 to 7.32 million tons). Combination board also lost in market share, 43.7 percent in 1959 to 27.8 percent in 1969. Had this not also been a period when combination paperboard mills were increasing their consumption of paper stock (by replacing virgin pulp used in top layers of paperboard with "high grades" of paper stock), the relative decline of paper stock consumption would have been even greater.

End-Use Applications. The end-use applications of paper are also indicative of the relative importance of paper in the economy, especially in transitory use applications (Table 20). Packaging, which accounts for 45.0 percent of the tonnage, and communications papers, which account for 35.7 percent of the tonnage, together absorb 80.7 percent of the paper. The remainder is split between tissue (consumer products), 6.2 percent, and construction grades, 7.7 percent.

Underlying Factors. Several major factors underlie the trends that show up in historical data. Improvements in wood pulping technology have enabled the paper *industry to tap abundant virgin raw materials at costs* low enough and in quantities large enough to meet rising demand for paper; the technology of paper stock utilization has only recently become more competitive with that used for virgin fiber production. Most paper capacity installed since 1945 has been wood pulp based and located close to virgin raw materials, primarily in the South and Far West, rather than close to final markets. In the South the vast forests have been tapped. In the Far West *most of the raw fibrous materials are residues of* lumber mill operations.

The demand for products made of virgin fiber has outpaced demand for products predominantly of secondary fibers in three ways: (1) products made predominantly of paper stock (construction papers, folding cartons) tend to grow at a lower rate than other paper products and are losing markets to competitive materials; (2) wood pulp has taken some markets from paper stock as consumers "up-graded" their products to improve appearance and to achieve higher "purity" where the functional performance requirement did not *change, as in packaging; (3) paper stock has penetrated* only one new market in recent years — newsprint.

The consumption of paper products has grown faster in end uses where the value of paper is in its transitional use followed by discard rather than in long life or *continuous service.* Examples of rapidly growing transitional use products are packaging, communications products, and household "disposables"; all are predominantly wood pulp products.

Paper in Municipal Waste. Most paper is discarded after use. Products found in residential waste are newspapers, magazines, mail, various types of packaging and bags, and "disposable" products such as tissue, towels, and the like. Commercial waste consists largely of business papers or products, mail, and a wide variety of packaging, especially corrugated boxes, plus miscellaneous products. Paper used as part of industrial products is not readily identifiable as paper because it shows up as waste in toys, shoes, appliances, autos, building and construction rubble, and the like. The paper is usually discarded in haphazard mixtures along with the other refuse with which it becomes mixed. At this point, it loses almost all value as a scrap material and is simply disposed of in a conventional manner. Because of its high contamination and low level of concentration by commercial waste grade standards, paper is seldom salvaged from municipal wastes.

Where paper is recovered from solid waste, it is usually one of two types, newspapers or corrugated boxes. In the case of newspapers, the collection from waste is practiced by unauthorized private scavengers who move ahead of residential collection vehicles and pull them out.

Corrugated boxes are sometimes collected in large concentrations by private haulers from commercial accounts (retail stores, warehouses) and delivered directly to a paper dealer. The quantity of paper and board recovered directly from waste is probably not more than 1 to 2 percent of total demand for news and corrugated.

Based on previous work by MRI,[19] the rate of discard of paper products and diversion of paper to unrecoverable uses was estimated for the years 1966 and 1976. This analysis was extended to more detailed census data for 1967 in this study. We found that in 1967, 45.3 million tons of paper were discarded into waste or recycled and 7.9 million tons were either destroyed, lost, or combined with other materials obscuring its identity as paper. The 45.3 million tons disposed of as waste were the maxiumum quantity recoverable for recycling that year; since actual recovery was 10.2 million tons, the recovery ratio was 22.5 percent of all that available, only slightly better than the 19.2 percent recovery using total consumption as a measurement base.

Waste Paper Consumption Patterns

To present an overview of waste paper consumption patterns, we have constructed an input/output table for 1967 as a guide to materials flow from the forest to final disposition of finished product (Figure 13).

Types of Waste Paper. The general types of paper stock grades fall within two groups and five classifications. They are:

(1) Bulk grades — so named because these are grades used in large quantities in paperboard and construction products. There are three classifications:

(a) News consists of old newspapers recovered from residential sources and newspaper publishers.

(b) Corrugated consists of old corrugated boxes recovered from commercial establishments and new clippings from box converting operations.

(c) Mixed covers a wide range of the lowest quality paper stock and consists of unsorted mixed papers obtained from office buildings, printing plants, and other commercial sources.

(2) High grades — so named because they can substitute directly for wood pulp and are high quality fibers. There are two classifications:

(a) Pulp substitutes: clippings and shavings, such as envelopes and bleached board cuttings, and other high quality fibers derived from paper converting plants and data processing centers (tab cards).

(b) Deinking: usually bleached papers that have gone through a printing operation and are collected from printing plants and other convertors.

Uses of Waste Paper. While paper is the principal type of waste recovered, it is used predominantly in paperboard and construction grades. In 1967, the paper industry consumed 10.12 million tons of paper stock (Table 21). Paperboard takes 79 percent of total paper stock consumption, but the only paperboard grades of substantial volume recovered for recycling are old corrugated boxes and box cuttings, which make up about 33 percent of paper stock use. The remainder is various types of waste paper used in paperboard and construction papers. About 6 percent of the recycled paper is reused in the same process from which it came; 94 percent is consumed in processes other than those that generated the original product (Table 22).

Most recycling takes place in mills substantially dependent on paper stock for raw materials: newspaper deinking; other deinking operations; combination board manufacturing; and several construction grades. For these reasons the raw materials competition between wood pulp and paper stock is not severe and the waste paper trade is not heavily influenced by the activities of marginal buyers of paper stock. There are, of course, many marginal buyers (usually of the pulp substitutes) but they operate with limited commitments to paper stock ratios in their products and maintain a flexibility in paper stock consumption to "protect" themselves in rapidly changing paper stock market conditions.

The National Committee for Paper Stock Conservation has established that an additional 1.0 million tons of waste paper is consumed in various grades plus

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[19] Darnay, A., and W. E. Franklin. The role of packaging in solid waste management, 1966 to 1976. Public Health Service Publication No. 1855. Washington, U.S. Government Printing Office, 1969. 205 p. Franklin, W. E., and Darnay, A. The role of nonpackaging paper in solid waste management, 1966 to 1976. Public Health Service Publication No. 2040. Washington, U.S. Government Printing Office, 1971.

construction products that are not defined as paper products (insulation, asphalt, felts, pipe, etc.).[20] This tonnage is made up of the following grades by our estimates: mixed, 782,000 tons; news, 164,000 tons; and corrugated, 109,000 tons.[21]

Some paper producers use waste fibrous materials other than waste paper. In 1969, these materials accounted for 890,000 tons or 1.7 percent of total raw materials consumed by the paper industry (Table II). Of this, an estimated 120,000 tons went into pulp making, 210,000 tons into paper, 520,000 tons into construction products, and 35,000 tons into paperboard. About 220,000 tons of the "other fibers" were cotton fibers or textile wastes which are used in roofing felts, and cotton fiber paper. In fact, in 1970, cotton content paper utilized 57,000 tons of secondary fibers in the form of cotton cuttings and cotton linters equivalent to 44 percent of the raw material input (total fiber consumption for cotton content paper was 130,000 tons).

Sources of Paper Stock. It is very difficult to determine accurately where paper stock is generated. In the absence of data, we have resorted to estimates based on our input/output analysis. Even major paper stock dealers and the Paper Stock Institute,[22] the major industry association, cannot document sources of paper stock accurately. Dealers are most reluctant to divulge their sources of supply. Fortunately, paper stock grades are roughly descriptive of their original source; but even so, our estimates must be classified as "informed judgments."

Paper stock is acquired from residential sources, 1.68 million tons (16.6 percent); commercial sources, 4.41 million tons (43.6 percent); and paper converters, 4.03 million tons (39.8 percent) (Table 23). This means that conversion waste is 40 percent and obsolete is 60 percent of total. Three obvious conclusions are apparent from the data in Table 23: (1) newspapers are collected predominantly from homes; (2) commercial establishments such as stores, warehouses, and offices account for more than half the mixed and old corrugated; and (3) paper converting operations generate most of the high grades as well as respectable quantitites of bulk grade paper scrap.

Of all 45 waste paper grades recognized officially by the Paper Stock Institute, and the numerous additional unofficial grades, only old newspapers have their origin in the home. In fact, newspapers are one of only two materials commonly found in municipal waste still salvaged in quantity from residential sources (the other is textiles). But paper is the only material recycled; textile products are either resold or diverted into secondary uses.

Most paper converters recover their waste paper. Little of it is discarded as waste. The paper is usually baled on site ready for delivery to the mill. Commercial establishments sometimes sell their waste papers and sometimes discard them depending on grade (corrugated can be sold more readily than mixed), on the nature of local markets, and on quantities of paper generated (small quantity generators are less likely to sell than large waste producers). In strong waste paper market areas (Los Angeles, Chicago, most of Ohio, New York City) commercial establishments are likely to do their own baling.

Quality. The most desirable grades of waste paper are those that exhibit the highest quality or purity and accumulate in large quantity. The best grades are pulp substitutes and deinking grades, followed in descending order by corrugated, news, mixed, and finally that portion not recovered but disposed of as waste. In addition, the type of pulp in the paper — groundwood, sulfite, sulfate, or semichemical — is very important because each is not equally useful as a waste material. A final difference is whether the product is of bleached or

[20] Frank Block Associates. Outlook for paper stock consumption-- 1970; prepared for the National Committee for Paper Stock Conservation, American Paper Institute. Unpublished data. This source also carries gypsum liner board under the construction category (780,000 tons) where it logically belongs, but MRI has conformed to the more traditional reporting that shows gypsum liner board under combination paperboard.

[21] It should also be noted that U.S. Census data usually understate actual consumption of paper vis-a-vis American Paper Institute figures (by 824,000 tons of paperboard in 1969, for example) and that it is not possible to determine additional amounts of paper coming into the country as finished products or packaging on non-paper imports. Therefore, while we have not shown this additional 1.0 million tons recycling on our input/output analysis, it is more than covered by consumption that is not recorded. Our input/output analysis was not designed to cover these conditions but remains valid in its present coverage.

[22] One of the major divisions within the National Association of Secondary Materials Industries, Inc.

unbleached fiber content. When all these criteria are taken into account, it is evident that waste paper, by reason of natural admixture of various grades, can best be used in applications where quality requirements are not stringent. The type of pulp in the waste paper usually determines its quality. Thus, paper stock composed predominantly of bleached sulfite pulp has a higher value than groundwood.

Contaminants. A number of materials contaminate paper and destroy its value as a secondary material. Contaminants are sometimes referred to by the delightful British term "pernicious contraries." A few of these bear brief mention.

Clay Coatings. These are found on magazines, which have negligible value in waste paper markets. Clays separate readily from fibers but cause a loading of waste water systems. The principal objection to clay coated paper as a scrap grade is that the weight loss is 30 percent or more, and this raises the cost of the paper fiber obtained.

Asphalt. This is a wet strength agent used principally in boxes. There are efficient systems to remove asphalt during processing of paper stock. These are a part of most mill operations that use old corrugated boxes. Other materials used, such as wax or resins to increase wet strength of the material, may also cause problems in a mill.

Plastic Coatings. These are uneconomical to remove unless there is a separate system to process plastic coated stock; the stock must be accumulated in sufficient quantity to be economical to process. Such systems do exist but are based only on converting scrap such as polyethylene coated milk carton stock. Plastic coated papers in other grades are still a contaminant not removable by conventional mill processing systems.

Adhesives. Hot-melt adhesives and other non-water-soluble adhesives are difficult to remove and will "gum up" paper made from scrap containing them. They are usually avoided. There are solvent systems designed to handle non-water-soluble adhesives, but for the most part the economics are not attractive since these paper grades can be readily avoided. Some efforts are occasionally made by industrial consumers of paper stock to get water-soluble adhesives used instead of nonsoluble, but converters persist in their use.

Laminations. Paper laminated with foil cannot be handled in regular paper mill processing systems for paper stock. These must be eliminated because there is no economical system for processing this type of paper.

Inks. Certain types of ink, especially those used in color printing, cannot be removed readily from paper. Only those inks applicable to existing deinking processes can be handled by consuming paper mills.

Other. Many materials downgrade paper stock needlessly the presence of groundwood, dirt, foam plastics, and the like. Removal of these contaminants by hand is seldom economical. Almost anything added to paper is a contaminant when that paper becomes a paper stock grade. The problem is more one of acquisition of trace amounts in paper rather than large concentrations, because low concentrations of contaminants cannot be removed economically.

The fundamental problems are those of proper accumulation of "pure" grades and of fighting low levels of contamination that essentially destroy the value of waste paper. The progressive contamination of fibrous materials as they work through the converting/consumption cycle has been one of the factors that simply works to the detriment of paper recycling and that has helped push the development of virgin pulp processing — which by contrast is essentially a progressive fiber upgrading process.

Mixed paper in municipal waste — which contains coated papers, laminated papers, printed stocks, and materials containing adhesives — is clearly an undesirable input material to paper and board mills unless it can be upgraded substantially.

Issues in Paper Stock Use

General. From a waste utilization point of view, the paper industry is made up of an integrated segment using wood pulp and an independent segment using paper stock. It is technically feasible to substitute paper stock for wood pulp (within limits) and wood pulp for paper stock. But this is not practiced extensively within the industry except in selected grades such as tissue. The basic technology and economics of both industry segments work to the detriment of substitution. Paperboard provides a good example.

Combination board mills are equipped to handle bulk grades of paper stock and usually produce multilayer products on relatively slow cylinder machines. The cost of pulp is higher than the price such mills receive for their finished products, in part because these mills are dependent on pulp purchased on the open market. Economics defeat use of pulp in this application.

Integrated board mills, located in the South and producing kraft paperboard, are designed as continuous systems starting with pulpwood and ending with finished paperboard. These mills are not equipped to accept purchased paper stock, which must be cleaned and prepared in special equipment. In addition, the remote location of these mills near timber resources introduces a high paper stock freight cost, which, combined with the value of the paper stock at market prices, makes paper stock expensive in comparison with virgin wood pulp. Few mills of this type can justify capital investment to utilize bulk paper stock grades, and unfavorable economics have limited paper stock use.

There is, however, an equivalence of value between various types of wood pulp (kraft, sulfite, etc.) and various grades of paper stock (news, corrugated, pulp substitutes, etc.) based on market value of finished products. For example, pulp substitutes may range in cost from $20 to $40 per ton below the cost of bleached pulp; the differential allows for process losses, cleaning, and waste preparation using specialized equipment to obtain a material equivalent to wood pulp. There is a similar equivalence in the value of other paper stock grades relative to pulp as well, or substitution of one for the other would in fact begin to take place until a new balance was achieved.

The values of wood pulp and paper stock could change vis-a-vis each other. In fact, this is what has taken place since 1945 — the relatively low cost and high quality of virgin wood pulp have hurt paper stock. When values change vis-a-vis each other, the consumption ratios change. But it is difficult to foresee changes in the cost of raw materials that would lead to greater utilization of paper stock in wood pulp mills. To induce the paper industry to idle large increments of standing capital investment in wood pulp production equipment would take a very large decrease in paper stock prices, a high tax on virgin materials, or some equivalent change in the basic cost relationships between virgin pulp and secondary fiber.

Some producers of virgin-based paperboard in the South have begun to use limited quantities of paper stock in recent years, even though a basic shift in the value relations between pulp and paper stock have not taken place. The basis for this relatively new departure is the need for incremental capacity increases.

Some mills have found that incremental expansions in capacity justified by demand increases were not sufficient to install new pulping capacity or could not be achieved because of a local shortage of pulp wood. The incremental capacity, however, could be achieved by installing waste paper pulping equipment and by recycling the company's own generation of corrugated box clippings — a high quality scrap material virtually indistinguishable from virgin kraft pulp. This kind of situation has induced many producers to consume from 5 to 15 percent secondary fiber in the manufacture of virgin liner board.

If a board mill also installs waste cleaning equipment and an asphalt dispersion system, it can also use old corrugated boxes as raw materials, assuming the output capacity of the board mill could be increased to accept the higher throughput.

Such situations are becoming more prevalent at tree-based mills today. But tree-based pulp and paperboard mills have gone about the utilization of secondary fibers with little fanfare and publicity. Apparently they do not wish publicly to "tarnish" the image of board sold as "clean" virgin fiber product. Today many paper industry observers say that there is no such thing as a 100 percent virgin fiber paperboard and that the level of recycled fiber is around 5 percent in virgin kraft paperboard. Most of this recycled fiber, however, is still very high quality conversion scrap (box cuttings), and apparently very few tree-based mills are seeking old corrugated as an input material. To date, therefore, the acceptance of secondary fiber as a raw material in tree-based mills is somewhat tentative and heavily oriented to internally produced conversion scrap.

Technical Constraints. From a technical standpoint the paper industry could accept a much higher quantity of secondary fiber than it does. The technical limits vary from grade to grade but may be estimated for various categories. For example, combination board now uses about 95 percent secondary fiber, with the inner plies of a typical board being 100 percent paper stock bulk grades and the outer ply commonly being pulp substitutes or purchased wood pulp.

Kraft paper producers are only now trying to use secondary fiber, as discussed above, and the secondary fiber consumption rate of these producers is 5 percent of input weight. Technical studies have shown that inputs of secondary fiber of between 30 and 50 percent in kraft in the form of old corrugated boxes are possible — without violating paperboard quality specifications.[23]

Semichemical medium (used for the fluted sections of corrugated boxes) can be made entirely of waste paper; at least one mill now operates on this basis. Many producers probably now use 15 to 20 percent secondary fibers, derived from box cuttings.

Newsprint can be made into newsprint again, using a patented deinking process developed by Garden State Paper Company, Garfield, New Jersey. The process requires only old newspaper for its fibrous input. This company has three mills in operation (Garfield, New Jersey; Alsip, Illinois; Pomona, California) with capacity to produce 320,000 tons per year of newsprint. The newspaper deinking technology has been in commercial application since 1961 and is the most notable new application for waste paper to be developed in many years. Newspaper deinking accounts for nearly 20 percent of waste newspaper consumption today. The deinking mills operate on a continuous basis and rely on traditional collection practices to provide a continuous supply of waste newspapers; this constant demand for news has done much to stabilize waste paper markets in recent years.

Bleached grades of printing paper can be made entirely of waste paper, but the scrap must be high quality deinking grades and pulp substitute grades recovered from converting and printing operations and data processing centers. Bulk grades cannot be used in printing papers at a high rate because the wastes are either high in groundwood content (news) or they are unbleached fibers (corrugated). Various types of tissue also fall into this category. In general, only high quality bleached paper stock grades can be used in paper; however, many producers use paper stock for 15 to 30 percent or more of the input fiber, especially in tissue and some printing papers.

Construction paper and board producers can and do use high proportions of secondary fiber in their inputs. They also commonly use defibrated or exploded pulp, screenings, sawmill waste, and other fibers such as textiles, straw, and bagasse. For many construction paper products, the technical limitations are such that the lowest quality bulk grades of waste paper can be used — mixed paper and news. Although wood pulp accounts for about 50 percent of the wood fiber input into construction paper and board, the ratio could be lowered considerably without affecting the technical performance of the products manufactured.

These observations are based on conditions existing today and do not allow for waste paper consumption potential that might be possible with new approaches to waste paper upgrading or serious research and development expenditures to determine the secondary fiber limits of the predominantly virgin pulp grades in use today. Also virtually unexplored is the whole area of new products (within or outside of the paper industry) that might be made of secondary fibers. The development of new applications for secondary fibers appears to be one way in which sizeable new markets could develop for materials in waste.

Available Supply in Municipal Waste. In theory, municipal waste could provide all the secondary fiber that could be absorbed at present within the technical limitations imposed by product characteristics. Whether or not this also represents an economically viable source of supply is questionable at present.

The paper available in waste can be classed into three categories — newspaper, corrugated, and mixed papers. In 1967 the unrecovered paper discarded totaled 35.2 million tons, of which 6.3 million tons were newspapers, 8.6 million tons were corrugated, and 20.3 million tons were all other. Of this, a total of 20.2 million tons are estimated to have been technically recoverable (Table 24).

The tonnage that could have been recovered is based on our estimates and is lower than tonnage available in waste. We consider 100 percent recovery highly unlikely.

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[23] The figure of 30 percent comes from our conversations with officials of two paper companies who say that this level would be achievable with little technical difficulty, using old corrugated boxes; the figure of 50 percent is based on findings of the Herty Foundation, Savannah, Georgia, in recently completed research for the Paper Stock Institute Division of NASMI. See Reclaimed fibers--50/50 board compares favorably with virgin kraft. Paperboard Packaging, 54(8):23, Aug. 1969.

A portion of the tonnage discarded is lost — in litter, in isolated disposal in fireplaces and in other ways. A portion will occur in remote locations and will never be practically recoverable. A portion would be lost in collection and processing, and a portion would be rejected in processing as unusable for technical reasons. We estimate that, at best, 57 percent of paper going into waste is recoverable (20.2 million of 35.2 million tons) and that the most likely recoverable tonnage would be 10.2 million tons, or 29 percent of discards.

Approximately half of the "additionally recoverable" tonnage in 1967 was made up of newspapers and corrugated board, two grades already recovered in substantial quantities by time-honored methods. This tonnage is theoretically available, and its recovery requires demand for the products so that they will be collected *prior to discard,* by the secondary materials industry and its agents. However, it is very likely that even in the presence of such a demand, economic and logistical problems of recovery would preclude full recovery taking place in traditional ways.

The other half of this tonnage was mixed paper of the sort normally found in mixed refuse. These materials are not now recovered. Their acquisition would require the use of equipment to process them from mixed wastes or a program of voluntary paper segregation by the public followed by processing to remove contaminating inks and coatings.

In order to reduce the quantity of paper entering the solid waste stream, the ratio of paper recycled to total paper consumption must increase. If the recovery ratio experienced in 1969 (17.9 percent) is maintained until 1980, we shall be recovering 15.2 million tons in that year and the discarded portion will be 59.2 million tons, up from 34.5 million tons in 1967 (based on data in Table 13). To keep discards down to 34.5 million tons in 1980, we shall have to recover 39.8 million tons of paper in that year, equivalent to 47 percent of consumption (Table 25). It should be clear from the foregoing discussions that increased waste paper consumption must take place at the expense of virgin fiber.

Waste Paper Dealers

In general, waste paper dealers conform to the general description of secondary materials dealers given in Chapter II. In 1963, the last year for which detailed statistics are available, there were 2,711 paper dealers, most of them concentrated in the New England, Middle Atlantic, and East North Central states (Table 26).

Paper dealers fall into two categories: large dealers with equipment capable of shredding and baling bulk grade paper. These dealers, few in number, are called "packers". The second category is small dealers with more conventional baling equipment or no equipment at all.

There is a trend in waste paper trading toward the entry into this business of private waste haulers. In the far western and southeastern parts of the United States there is already substantial competition between traditional waste paper dealers and private refuse haulers. Refuse haulers are also becoming more important in the collection of waste paper for resale in other parts of the country.

This trend is the result of the fact that commercial accounts are serviced by private waste haulers; the same accounts sell paper to paper dealers. Commercial organizations have found that conventional paper dealers are sometimes uninterested in waste paper because demand is down. At such times waste paper must be hauled away. Commercial organizations are finding it more efficient to deal exclusively with refuse haulers — who, in turn, sell paper when demand for it exists.

Supply, Demand, Prices[24]

The erratic price swings associated with waste paper are more often experienced than understood by the participants in this segment of the paper industry. An aura of mystery is created by the fact that the relationships among prices, demand, and supply are complex and multidimensional, and consequently simplistic answers and misleading explanations are offered in place of tedious exposition of the facts. The relative stability of virgin pulp prices is also frequently explained simplistically. Thus it is not unusual to find paper dealers blaming mills and mills blaming dealers for the volatility of paper stock prices where, in fact, both groups are passive victims or beneficiaries of economic forces.

In general, prices change in response to demand. Demand for paper stock, in turn, is conditioned by demand for combination paperboard, construction activity, paper stock export levels, the supply of pulp

[24] One general reference for this section is Tuchman, S.G. The economics of the waste paper industry. Ph.D. Thesis, New York University, June 1963. 327 p. See especially chapters 6 and 7.

wood, and other factors working independently or together. A series of observations concerning factors that affect supply of, demand for, and prices of paper stock are presented below to explain what causes prices to shift.

Supply. Some fundamental observations about waste paper supply are these.

(1) Waste paper is not consciously produced or intentionally made but is a consequence of manufacturing activities and product consumption and discard patterns. For this reason total waste paper supply is uncontrolled and does not bear a direct relation to demand for paper stock. While consumption of paper stock is regulated (by paper mills) to meet demand, the paper stock supply flows forth in an independent and uncontrolled way — a condition that solid waste management officials know only too well.

(2) Waste paper is generated as the consequence of high rates of production in one segment of the industry, but it is consumed in another segment with lower production rates.

(3) In the short run, total supply is relatively fixed or constant because the waste paper trade taps only those sources necessary to meet mill purchase requirements. It takes time to acquire new sources of supply when a demand increase takes place. It also takes time to cut back supplies once they are established because new source organizations or collectors continue to accumulate scrap.

(4) Waste paper dealers must compete actively to secure those sources of supply with the most favorable waste characteristics. Thus dealers are reluctant to give up sources in "lean" times and have difficulty tapping new sources in "boom" times. Marginal sources are relatively difficult and costly to tap. Most conversion waste generators sell all their wastes, and the total supply of most high grades is not expandable at conversion points. Conversely, bulk grades are in more plentiful supply even in periods of high demand.

Demand. Observations about waste paper demand are as follows:

(1) Demand is determined by the output of those mills that consume paper stock. Mill operators purchase raw materials to meet the demand for their products and determine the level of waste purchasing activity; therefore the adage, "scrap is bought, not sold." However, mills cannot dictate or drive prices down unmercifully in the waste paper market because of their complete dependence on the dealer for their raw materials.

(2) Products containing high proportions of waste paper compete in different markets than products made of virgin fibers. Thus demand for waste paper may be out of phase with supply, with overall supply of the obsolete scrap exceeding demand as a rule. The unneeded portion usually goes directly into waste without being collected by the dealer trade.

(3) Waste paper dealers have no control over demand except as they are able to respond to mill requirements under the constraints of paper stock quality, price, and quantity. There are conditions under which wood pulp and waste paper become substitutes for each other. These conditions are determined by price, availability, and quality of the fiber needed; however, substitution of paper stock takes place because of changes in wood pulp supply and price or new technology that makes paper stock competitive in a new market.

(4) Demand for various grades of paper stock is determined by the level of activity in four general types of paper mills and by their interactions: (a) deinked newsprint *(news)*; (b) business, printing, and tissue papers *(pulp substitutes, deinking grades,* mixed); (c) combination paperboard *(corrugated,* mixed, news); (d) construction *(mixed,* news, corrugated). The dominant waste grade(s) for each type of paper grade is denoted by italics. Markets for combination paperboard and construction are more cyclical than markets for most other grades of paper and board. In some grades, substitution, such as mixed for news, may take place in periods of changing demand.

Prices. Waste paper prices have long been known to fluctuate and to exhibit wide swings. The movements in prices respond to demand changes. Concerning waste paper prices, these general observations may be made.

(1) Waste paper prices and price indexes are a sensitive indicator of changes in demand for waste paper. They are inversely responsive to mill inventory levels as well; these, in turn, are a reflection of demand changes. Prices react to changes in demand levels first and then to changes in marginal cost of supply.

(2) Waste paper prices fluctuate much more widely than consumption for two reasons: (a) the relative rigidity of short run supplies of waste paper that cannot be increased or decreased readily and (b) the marginal costs of acquiring new supplies in boom times and of cutting off other supplies in periods of downswing. In periods of stable markets, no large price swings are experienced.

For example, in recent years the advent of news deinking to produce recycled newsprint has had a stabilizing effect on both demand and prices of news.

(3) A relatively small change in consumption levels in one segment of the industry (for example, combination paperboard or construction) can put the price mechanism into operation "across the board" in several grades, especially in the bulk grades. During price downturns, however, mills may buy some quantities at "normal" prices to protect their dealers and thus their regular sources of supply.

(4) Seldom does excess supply per se set a large price change into motion since this is the chronic condition in the trade. In recent years, the expanding export demand for high grades of paper stock has acted to bring prices up in the face of relatively limited supply of these grades.

(5) New supply is "institutionalized" (assimilated into the established operation of the industry) very slowly because overall demand for waste paper increases only very slowly. Conversely, temporary increases in demand of, say, 5 to 15 percent are not unusual but do not usually last longer than several months; new supplies are not institutionalized within the dealer trade during these brief periods of additional demand and price levels begin to fall as soon as demand does. The institutionalization of new supply leads to price declines and a new level of price and demand, although the general price indexes may in fact stabilize above the previous "normal" level.

Historical Patterns. To provide an illustration of the relationships between demand, prices, and inventories, monthly data (seasonally adjusted) for the period 1950 to mid-1970 were plotted (Figure 14, Table 27). The relatively long-lived changes in waste paper consumption (demand) show up in prices and inventory levels. For example, three periods of interest are 1955-56, 1958-60, and 1966-67.

During 1955-56, demand increased an average of 12.2 percent during a 16-month period beginning March 1955; the price index increased from an average of 88.6 to 133.2, or 46.6 points over a 16-month period beginning May 1955. Inventories declined and did not return to "normal" until consumption did in June 1956.

During the period July 1956 through June 1958, demand was relatively stable and prices stayed in a "normal range" of 80 to 90 with one small rise that appears to be related to rebuilding of an inventory decline that occurred in late 1957. When demand surged in July 1958, prices took off again. This time the consumption cycle lasted until June 1960, during which period demand was up 8.6 percent on the average and the price index up from an average of 81.3 to 125.5 (44.2 percent) until February 1960, when prices started down rapidly.

Following a short decline in consumption and price, demand stabilized at a level of 800,000 tons a month. Prices also stabilized (between 92 and 98) during the period April 1964 to October 1965. The period from October 1965 through July 1966 was another classic example of a consumption increase accompanied by rising prices. The next big price swing, however, seems to have been precipitated by both falling demand and rising inventories. It appears that mills attempted to absorb the tonnage lost by a demand decline by buying waste paper for inventory when prices were generally favorable in 1966-67. Nevertheless, a demand decline back to 800,000 tons per month in early 1967 was accompanied by a price index decline from 113.2 to a low of 74.6. Prices did not return to the 100 range until May 1968, after inventories were worked back down following a demand increase in mid-1967. Average consumption was relatively stable once again into 1970, during which time prices stabilized between 108 and 110. This increased price index level is attributed partly to news prices, which took a temporary surge during a period when new supply was being developed for a news deinking plant near Chicago. The price index for news once again returned to "normal" in 1969.

One cannot escape the conclusion that the law of supply and demand has not been repealed in the case of waste paper consumption. Operating in this market requires some skill because of its uncertain and variable nature, but there is no evidence that waste paper supplies are not available to support increases in demand. Once price levels become generally widespread within the system, prices tend to stabilize as a result of competitive forces within the market due to the incontrovertible fact that products made of paper stock would inevitably disappear if they were not cost competitive with alternative wood pulp products. This does not mean that waste paper purchasing activities by consuming mills are not without difficulties; these are readily apparent especially when a mill is located away from adequate supply quantities.

Wood Pulp Prices. *In contrast with waste paper,* wood pulp is given great credit for its price stability as reflected in published government wholesale price indexes. In fact, pulp price stability is more apparent than real. Most wood pulp operations are integrated and never seek a market as wood pulp; thus, the cost of the pulp is never disclosed. Only 10 percent of wood pulp is market pulp. In addition, long term contracts are used for some market pulp. Wood pulp is sold according to posted prices. In times of excess wood pulp supply, however, there is extensive discounting and unofficial price cutting that never shows up in price indexes. Only when the prices are paid at the quoted level is the index a true measure of price. In 1969, wood pulp came into rather tight supply, and actual prices advanced above previous posted levels, a factor that gave paper stock dealers hope that they might gain new markets at the expense of wood pulp.

Trends in Pulpwood. Some industry observers now say that the forces that led to the rapid expansion of integrated paper mills are not going to be as strong by the 1980's. Low cost, readily available pulpwood lands have all but disappeared. In fact, pulp prices have recently begun to rise quite rapidly. This is attributed to increasingly tight supplies of pulp. By the mid 1980's, the Nation will be consuming more pulpwood than it is growing, and industry experts are talking of the necessity of turning to other fibers, especially waste paper.

To meet the projected demand for wood, various forestry interests are talking of much more intensive forest management practices, utilization of more tree species, and more efficient use of wood residues. Federal lands are also being scrutinized for increasing supplies of pulpwood. Not only does the U.S. Forest Service have a long standing commitment to the exploitation of commercial timber, but a recently completed study[25] may add impetus to the Federal effort. This report recommends (among 137 recommendations): (1) adopting a "dominant use" concept on Federal lands that would open large tracts of commercial timber to the lumber and paper industries; (2) revising Federal cutting specifications to increase the cutting of trees of pulpwood size; and (3) opening more timber areas to commercial cutting by construction of access roads.

Tightening pulpwood supplies appear to indicate that the relative decline of paper stock as a raw material may be halted by the mid-1970's. By the 1980's however, recycling would likely not exceed the ratios of the 1960's unless a major effort is made to expand waste paper usage. History, technology, and basic capital commitments in the paper industry and government are oriented to maintaining a strong virgin raw materials base for the nation. At this junction, we can see only a slow return to paper stock as the "economic accessibility" of pulpwood gradually tightens in the years ahead. Recycled fibers are more likely to be used to fill incremental shortages of wood pulp than to become a major alternative fiber source.

The paper industry, not unaware of pressure to "do something about solid waste," is also looking more seriously at its raw materials balance and the role of secondary fiber in the industry. One major company, for instance, sees two problems in the future that will make waste paper recycling an attractive operation. One is the projected shortage of pulpwood in the 1980's, which will probably raise raw materials costs. The other is intensifying government pressure to clean up air and water pollution occurring as a result of pulp mill operations. Cleanup costs, now around $3 per ton of pulp by the company's estimate, will likely increase to $7.50 per ton or higher in 3 to 5 years, adding to pulp costs. The company is investigating municipal waste processing as a potential new venture, to be a self-supporting service business venture — one of whose side benefits would be the acquisition of secondary fiber.

Conclusions

Our conclusions can be summed up under four headings.

(1) Waste paper consumption relative to total paper consumption has been declining and continues to decline, principally because paper and board grades that are made of secondary fibers are are not holding their own in the market place, and relative demand for waste paper is therefore declining.

(2) A projected shortage of virgin pulp by the 1980's may slow down or arrest the relative decline of paper stock consumption but is unlikely to cause it to grow significantly in ratio of recovery. With the existing industry capacity principally located close to forest sources, this presents substantial logistical and economic constraints to utilization of large quantities of secondary fiber.

(3) Much more waste paper is available (roughly half of it readily available without employment of new technology) than is consumed. Much of this would have

[25] U.S. Public Land Law Review Commission. One third of the nation's land. Washington, U.S. Government Printing Office, June 1970. 342 p. See especially chapter 5.

to be acquired via recovery within the solid waste management establishment. However, that readily available is not necessarily an economic source of supply for fiber consumers. Consumption of this "additionally recoverable" portion is unlikely in the near future without changes in demand brought about by legislative intervention or potential intervention that would bring about changes in the value of paper stock relative to virgin pulp.

(4) The recoverable paper available in solid waste can be acquired, within economic and technical limits, by both source sorting and by the application of new technology to reclaim such fibers from wastes. Some quantities of the bulk grades (mixed, news, corrugated) would be recoverable in traditional ways by separation in homes and businesses. That occurring in mixed form would be partially recoverable, using new technology for separation; mixed paper would also require upgrading to be competitive in existing raw materials markets.

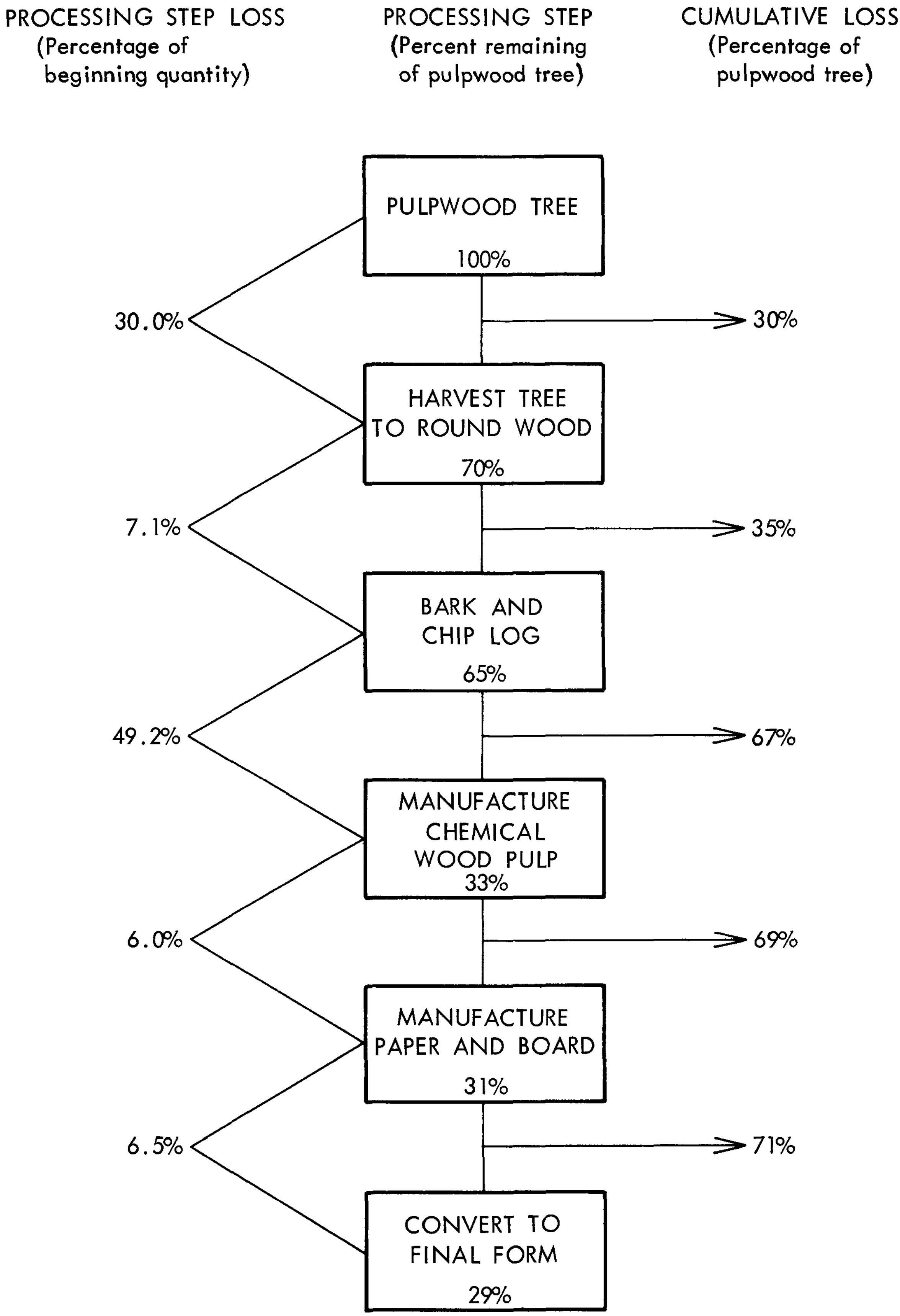
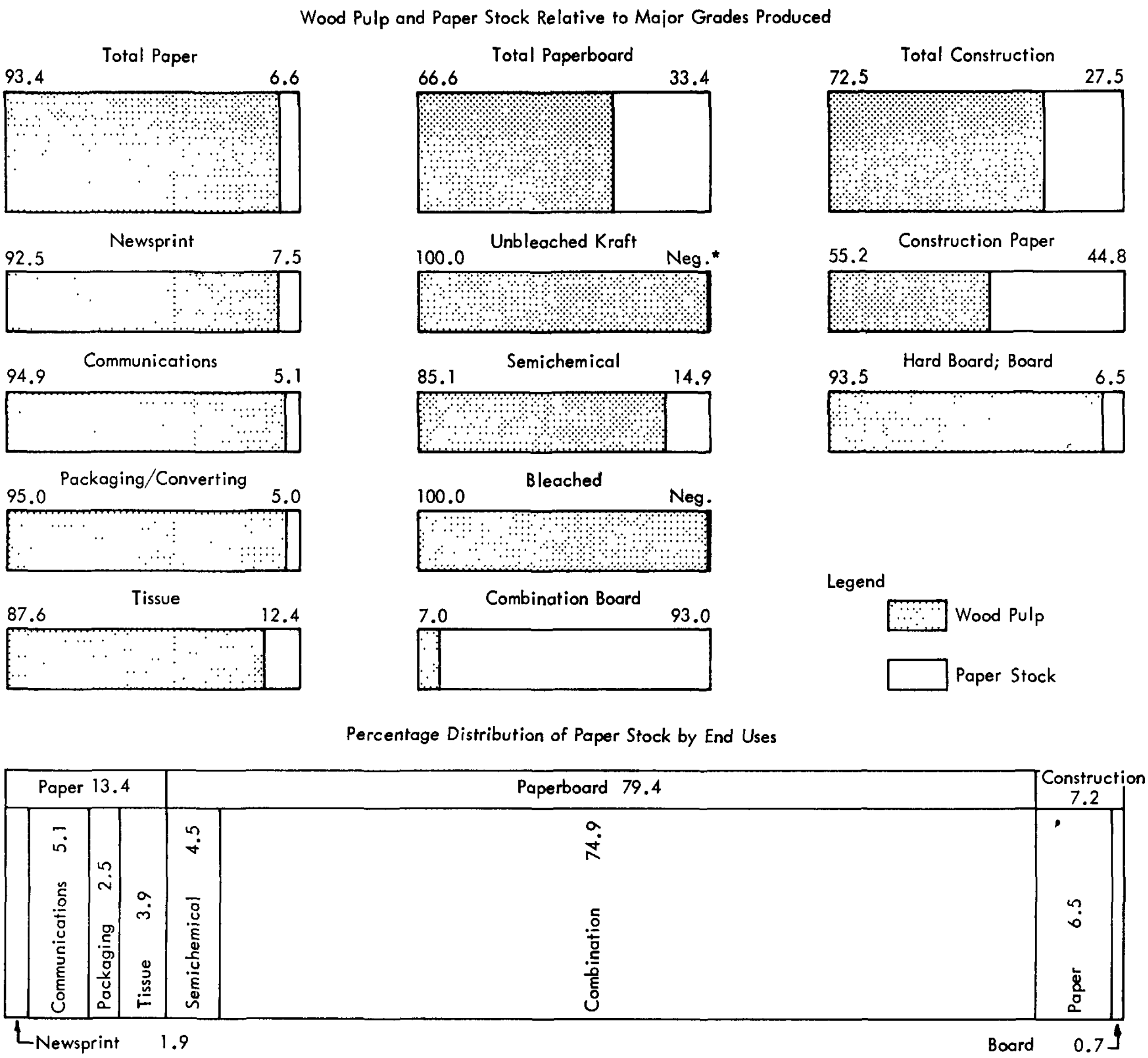


Figure 5. Process losses in paper manufacture (in percent by weight).



Note: Other fibrous materials were excluded; expressed in percent of total wood pulp and paper stock. Based on MRI estimates.

*Small percentage of paper stock used but cannot be verified in statistics.

Figure 6. Relative importance of wood pulp and paper stock in paper, 1967.

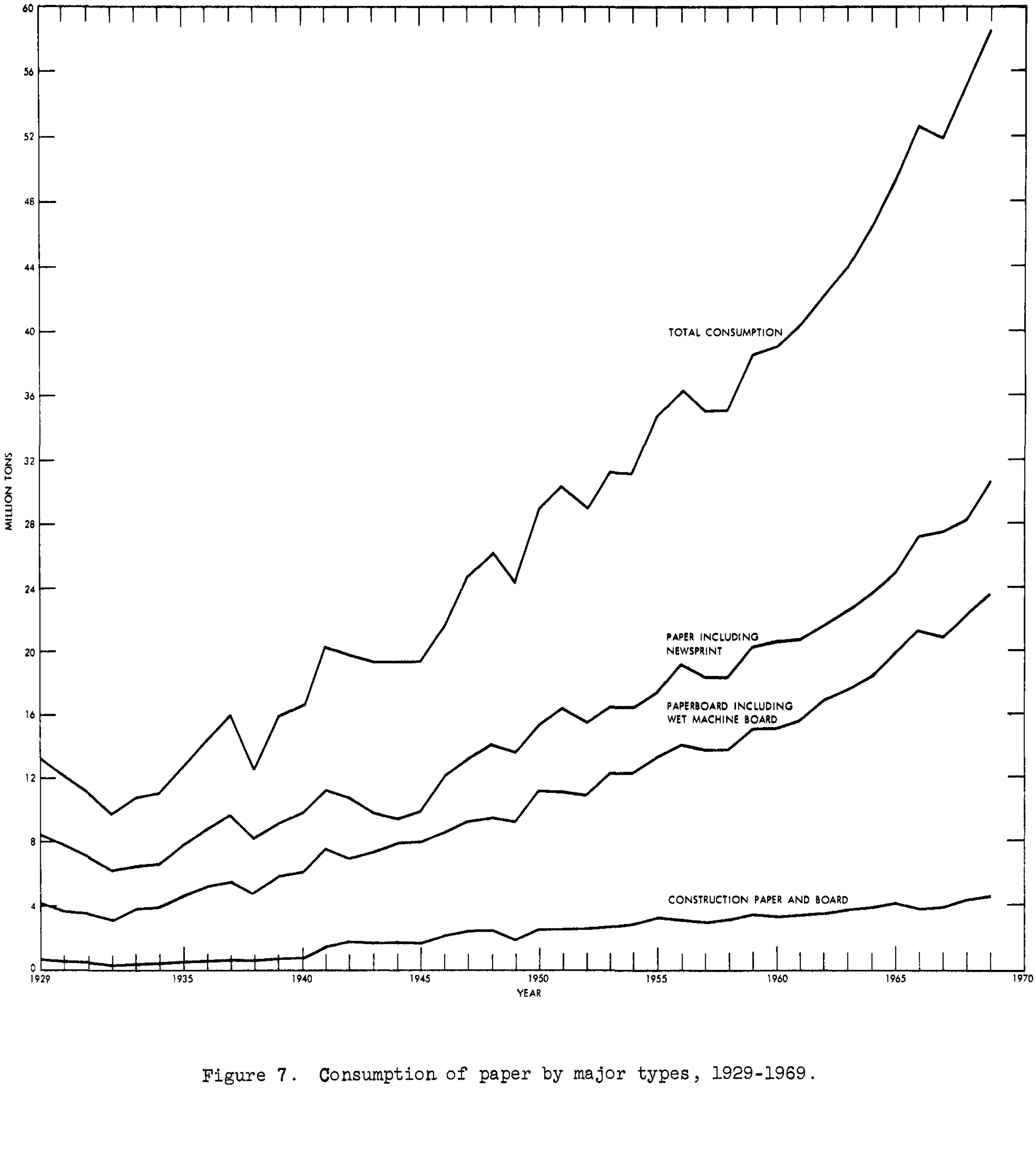


Figure 7. Consumption of paper by major types, 1929-1969.

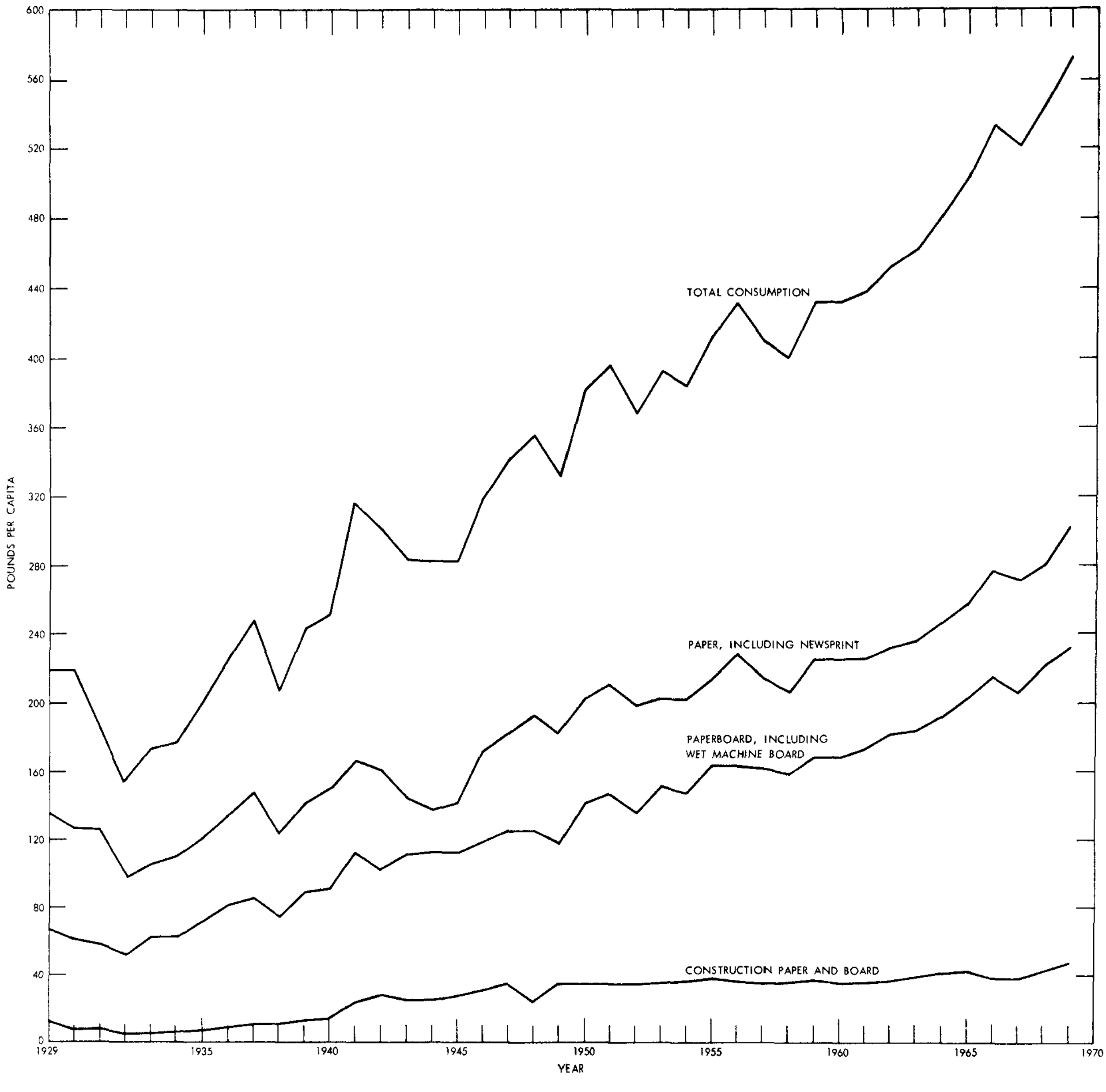


Figure 8. Per capita paper consumption by major types, 1929-1969.

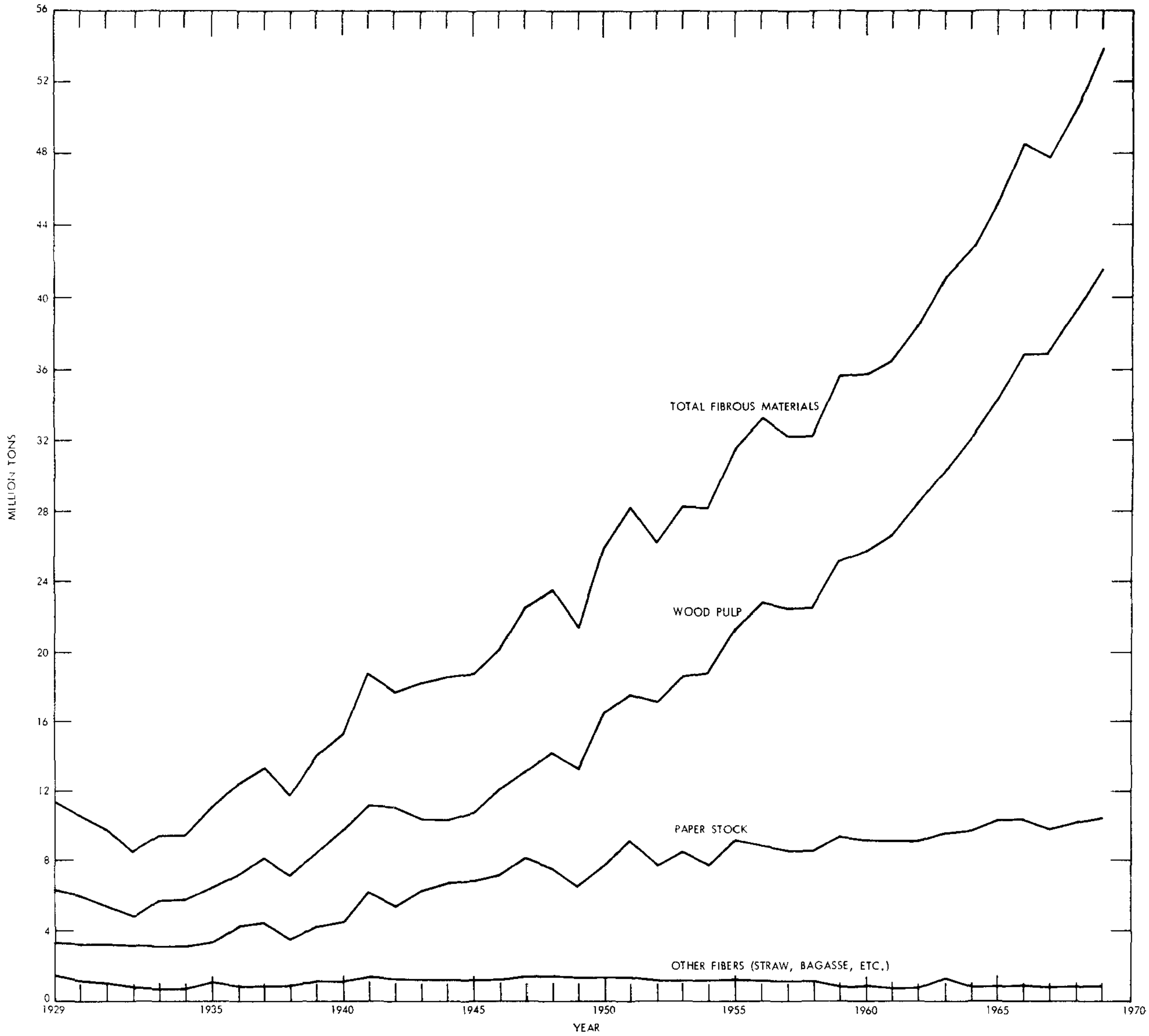


Figure 9. Fibrous raw materials consumed in paper manufacture, 1929-1969.

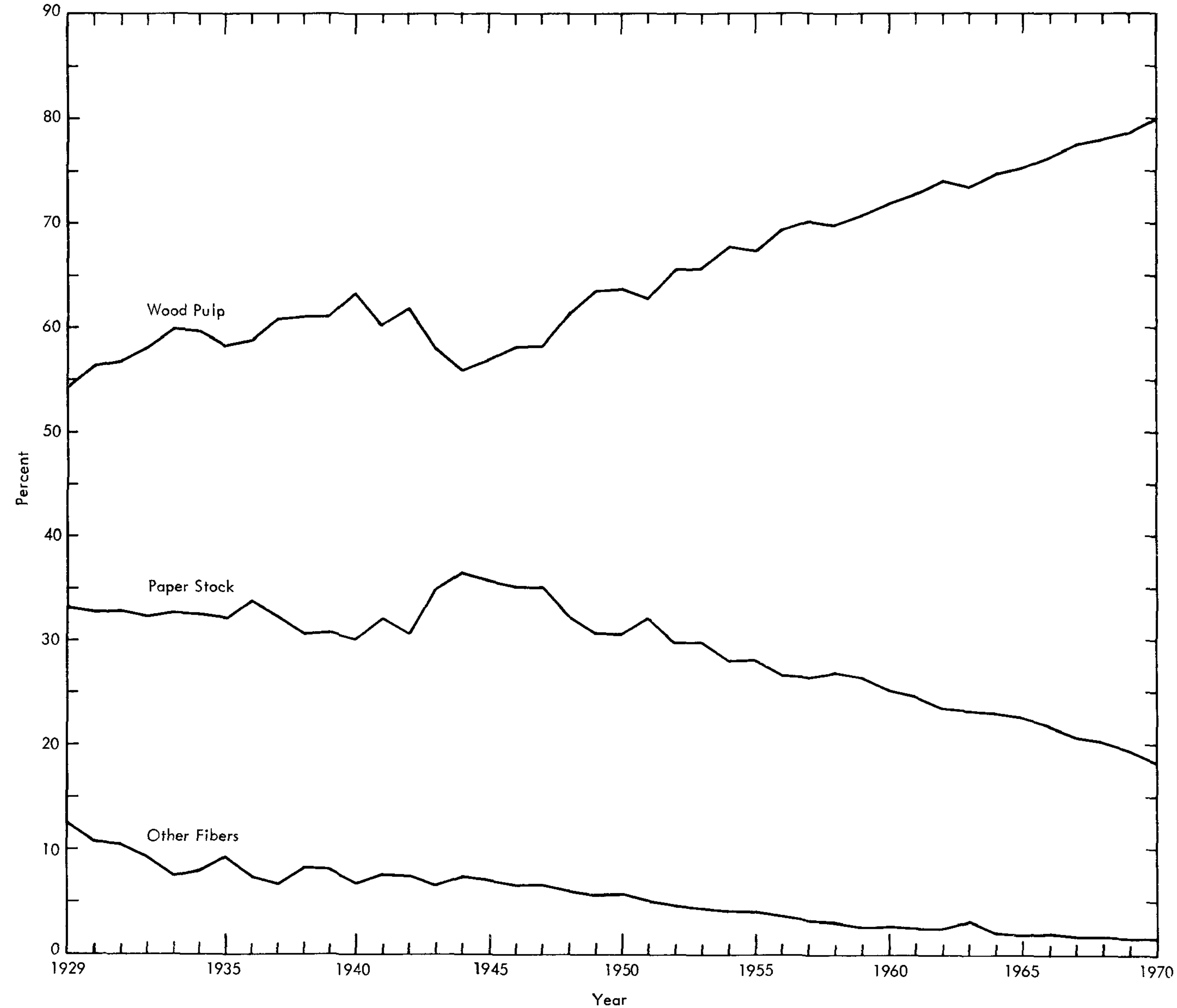


Figure 10. Fibrous raw materials as a percent of total fiber consumption in paper, 1929-1970.

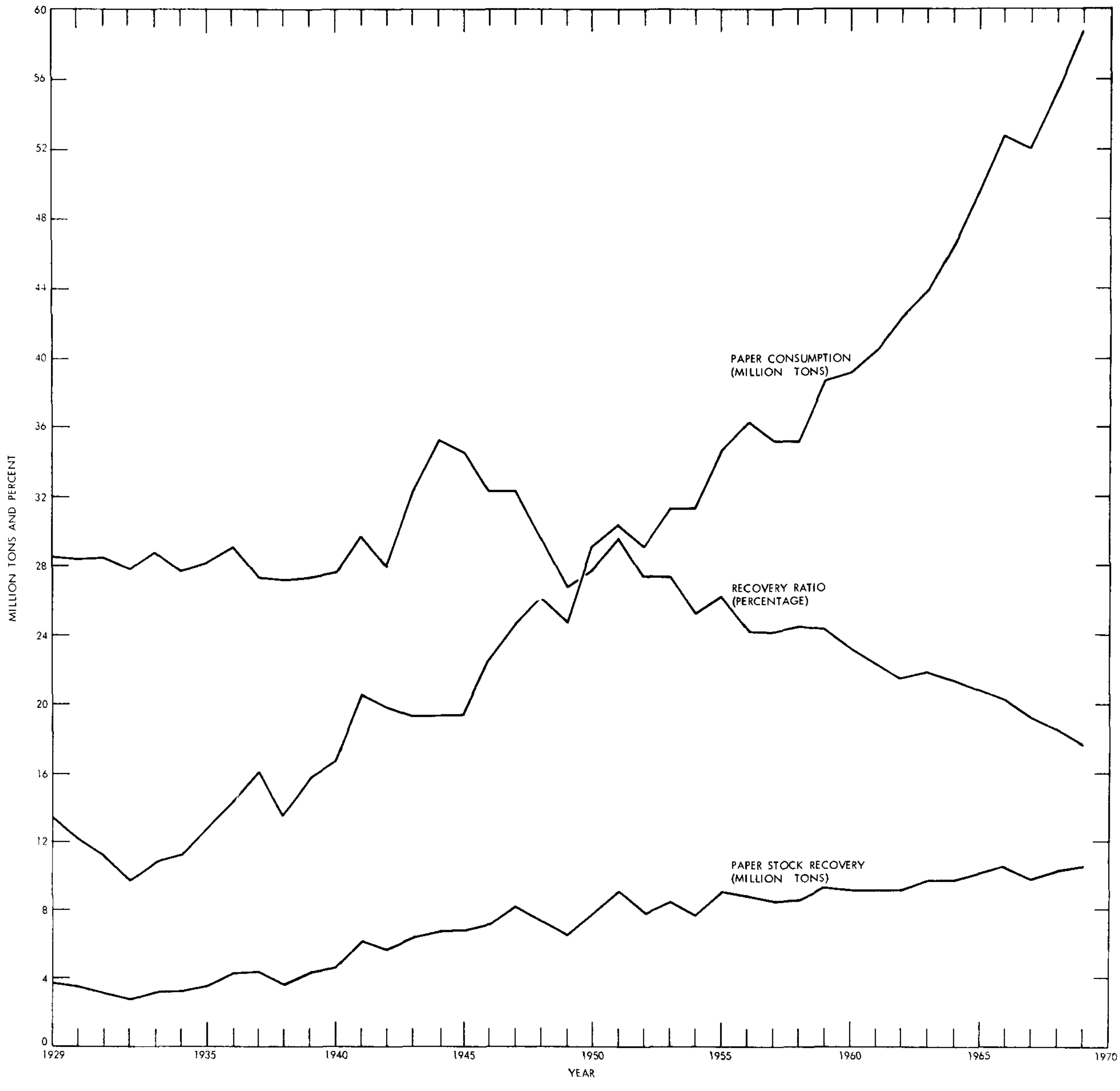


Figure 11. Total paper consumption, paper stock recovery, and recovery ratio.

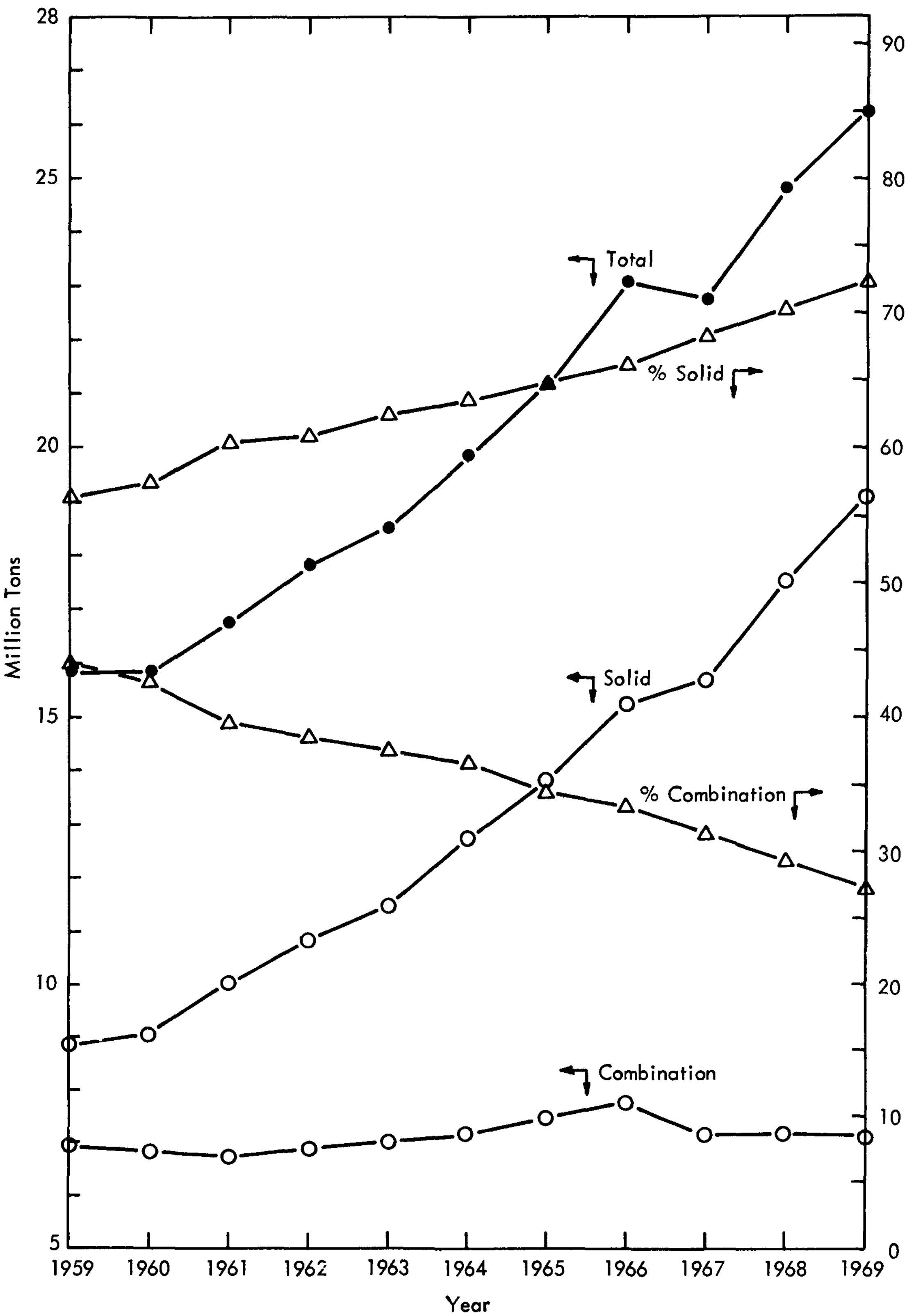


Figure 12. Combination paperboard and solid wood pulp board production, 1959-1969.

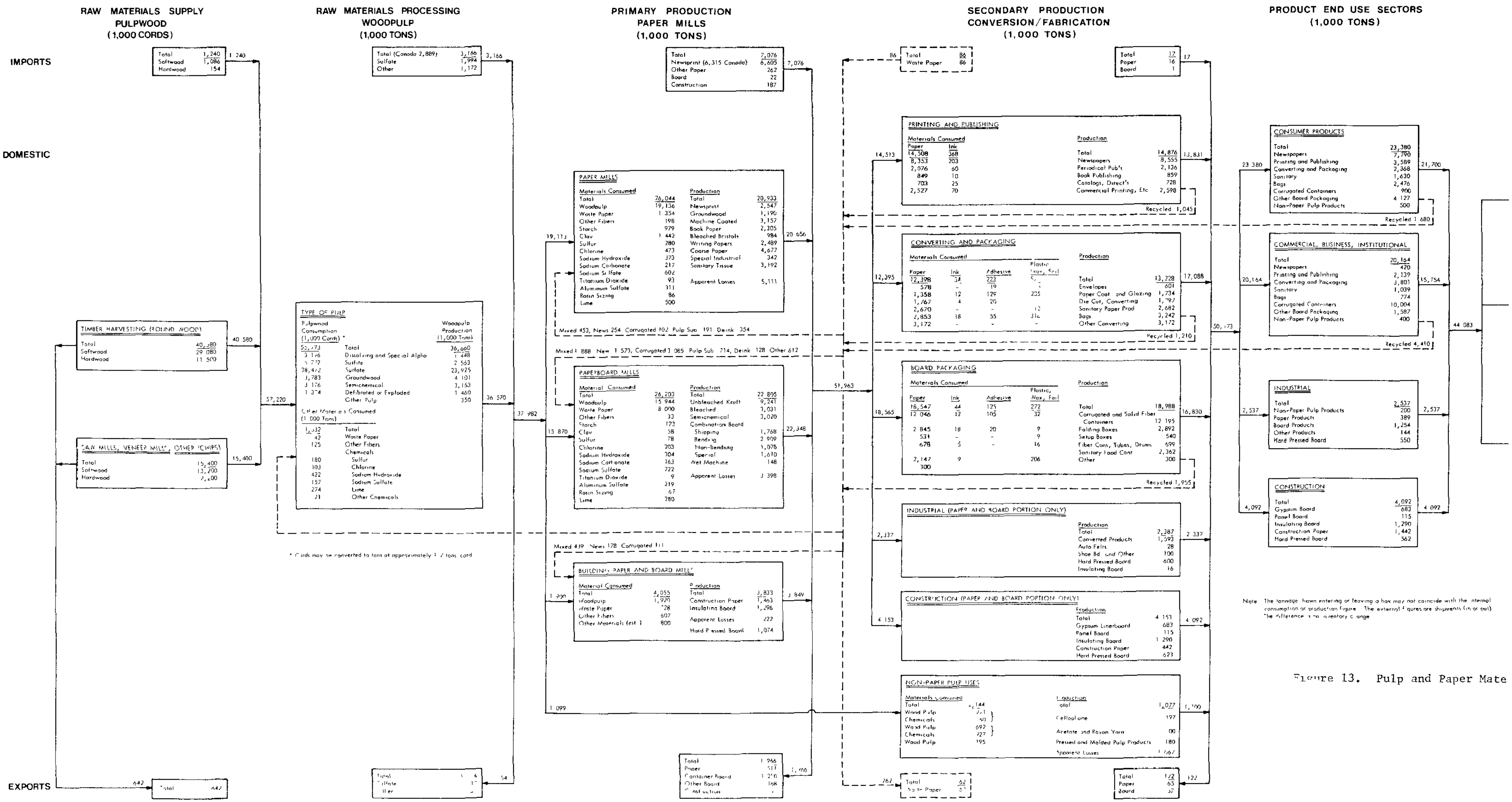
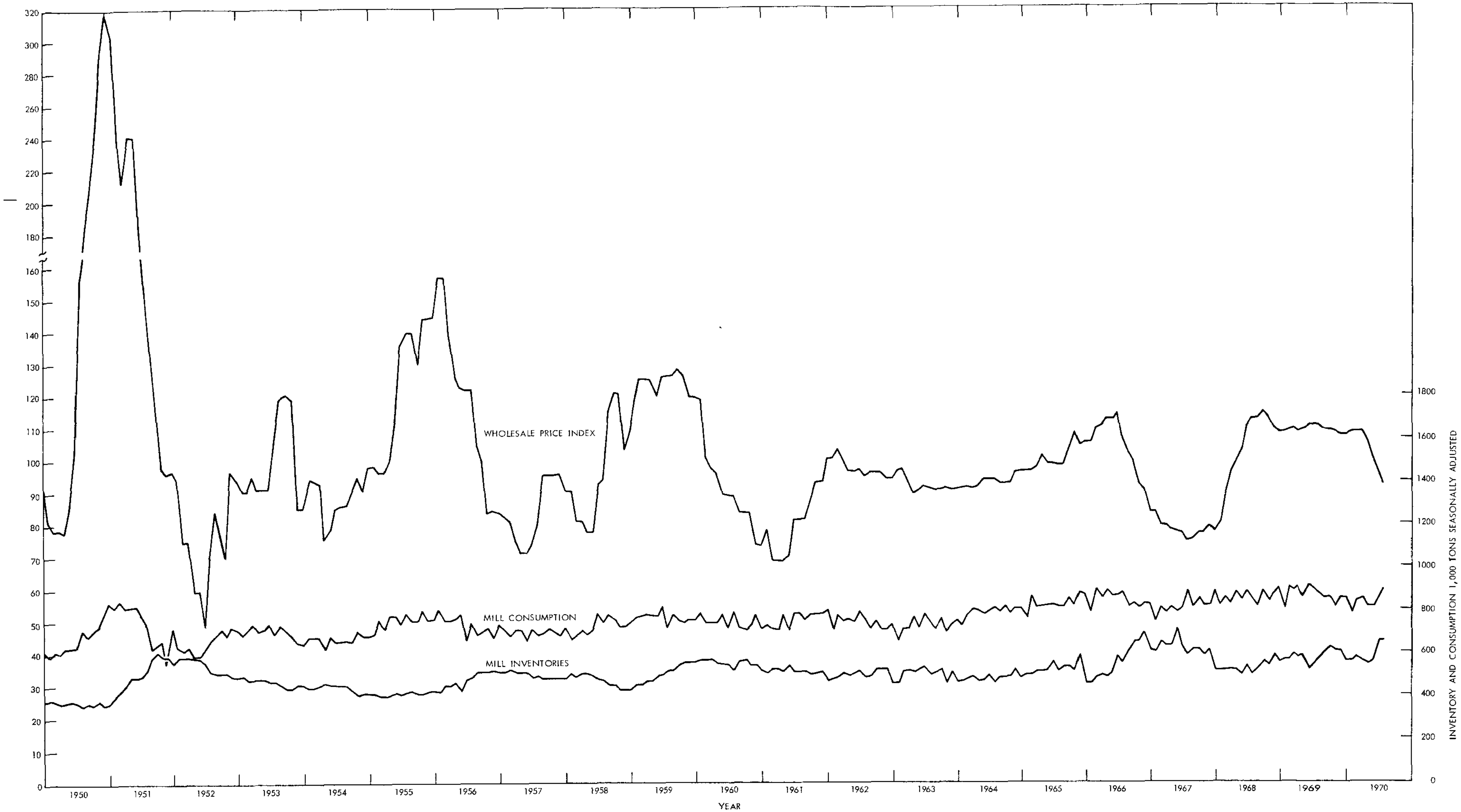


Figure 13. Pulp and Paper Mate



45-10

FIGURE 14 WASTEPAPER PRICES, CONSUMPTION, AND INVENTORIES, 1950-1970 (BY MONTHS)

TABLE 11

FIBROUS RAW MATERIALS CONSUMPTION IN THE PAPER INDUSTRY, 1969, IN MILLION TONS AND PERCENT*

Category	Tons	Percent
Wood pulp	41.6	78.5
Waste paper	10.5	19.8
Other fibers	0.9	1.7
Total	53.0	100.0

*Statistics of paper; 1970 supplement. New York, American Paper Institute. (Based on U.S. Department of Commerce Pulp, paper and board, Current Industrial Reports, Series M26A.)

TABLE 12

DISPOSITION OF PAPER CONSUMPTION, 1967*

Category	Million tons	Percent
Discarded as waste	35.2	66.3
Recovered for recycle	10.1	19.0
Diverted, obscured, and destroyed†	6.6	12.4
Delayed in use (net retention)	1.2	2.3
Total consumption‡	53.1	100.0

*From Midwest Research Institute.

†Includes construction and industrial papers not readily identifiable as paper because they are part of other products; also includes toilet paper.

‡Excludes nonpaper wood pulp products.

TABLE 13

COMPARISON BETWEEN CONSUMPTION AND WASTE DISPOSAL OF PAPER 1956-1980 IN MILLION TONS AND PERCENT*

	1956		1966		1967		1976		1980	
Category	Tons	%	Tons	%	Tons	%	Tons	%	Tons	%
Consumption	36.5	100.0	52.7	100.0	51.9	100.0	74.4	100.0	85.0	100.0
Recycle	8.8	24.2	10.5	19.9	9.9	19.1	13.6	18.3	(15.1)	(17.8)
Waste disposal	(22.2)	(60.8)	34.6	65.7	34.5	66.5	51.1	68.7	(59.2)	(69.6)
Diverted in use or retained	(5.5)	(15.0)	7.6	14.4	7.5	14.4	9.7	13.0	(10.7)	(12.6)

*Consumption and recycle for 1956, 1966, 1967 from Statistics of paper; 1970 supplement. Other data for 1966 and 1976 from Franklin, W. E., and A. Darnay. The role of nonpackaging paper in solid waste management, 1966 to 1976. Public Health Service Publication No. 2040. Washington, U.S. Government Printing Office, 1971. Data for 1967 are from Figure 13 but are adjusted slightly to be consistent with the statistical reporting base of Table 99. Data for 1976 and 1980, Midwest Research Institute, based on historical trends.

TABLE 14

RELATIVE GROWTH OF PAPER CONSUMPTION, DISPOSAL AND RECYCLE, 1956-1980, IN PERCENT AND RATE*

Category	Period	Increase in consumption (%)	Increase in waste disposal (%)	Increase in recycled paper (%)
Percent increase	1956-1967	45	59	15
Percent increase	1967-1980	60	68	50
Growth rate	1956-1967	3.4+	4.3	1.3
Growth rate	1967-1980	3.7	4.1	3.2

* From Midwest Research Institute; Table 13. Data for 1967-1980 based on historical trends.

TABLE 15

FIBROUS RAW MATERIALS USED IN PAPER PRODUCTION, 1969, 1,000 TONS AND PERCENT*

Type of Material		Tonnage	Percent	Pulpwood consumption (cords per ton)
Woodpulp				1.5
Groundwood		4,433	8.4	1.0
Sulfite		2,672	5.0	2.2
Bleached	2,206			
Unbleached	466			
Sulfate		29,130	55.0	1.6
Bleached	11,486			
Semibleached	1,664			
Unbleached	15,980			
Semichemical		3,475	6.6	1.0
Defibrated, screenings, etc.		1,924	3.6	1.2
Total woodpulp		41,634	78.6	
Other fibrous materials				--
Wastepaper		10,431	19.7	
Other, including, straw, rag, etc.		893	1.7	--
Total other fibrous materials		11,324	21.4	
Total, all materials		52,958	100.0	

*The statistics of paper; 1970 supplement.

Note: The export/import balance is relatively unimportant from a tonnage standpoint except for newsprint, which adds an additional 6.66 million net tons of groundwood to the nation's paper consumption.

TABLE 16

DOMESTIC PAPER PRODUCTION AND FIBROUS RAW MATERIALS CONSUMPTION, 1967, IN 1,000 TONS AND PERCENT*

Category	Paper		Paperboard		Construction		Total	
	Tons	%	Tons	%	Tons	%	Tons	%
Paper production	20,933	44.0	22,805	47.9	3,833	8.1	47,571	100.0
Fibrous raw materials								
Wood pulp	19,136	92.5	15,944	66.5	1,920	59.0	37,000	77.2
Wastepaper	1,354	6.5	8,000	33.4	728	22.4	10,082	21.0
Other fibers	198	1.0	33	0.1	605	18.6	836	1.8
Total raw materials	20,688	100.0	23,977	100.0	3,253	100.0	47,918	100.0

*U.S. Bureau of the Census. 1967 Census of manufacturers. Manufacturing and mineral industries. Papermills, except building paper, preliminary report MC67(P)-26A-2; Paperboard mills, preliminary report MC67(P)-26A-3; Building paper and building board mills, preliminary report MC67(P)-26A-4. Washington, [1969]; Current industrial reports. Pulp, paper, and board, 1968. Series M26A(68)-14. Washington. Several data combinations and adjustments have been made by Midwest Research Institute.

TABLE 17

GEOGRAPHIC IMPORTANCE OF DOMESTIC CONSUMPTION/PRODUCTION, 1967
IN PERCENT OF TONNAGE*

Geographic area	Pulp wood consumption %	Wood pulp production %	Wood pulp consumption %	Paper production %	Paperstock and other fiber consumption+ %
Northeast	8.5	10.2	15.3	20.3	34.1
New England	5.7	7.2	8.4	8.7	6.9
Middle Atlantic	2.8	3.0	6.9	11.6	27.2
North Central	9.1	9.3	14.5	20.4	39.4
East North Central	7.2	7.3	12.1	17.4	33.9
West North Central	1.9	2.0	2.4	3.0	5.5
South	59.4	60.4	54.2	45.0	16.2
South Atlantic	35.1	35.0	30.9	24.9	1.7
East South Central	11.9	12.0	11.0	9.7	7.5
West South Central	12.4	13.4	12.3	10.4	7.0
West	22.9	20.1	16.0	14.3	10.3
Mountain	2.2	2.1	2.0	1.5	--
Pacific	20.7	18.0	14.0	12.8	10.3
Total, United States	100.0	100.0	100.0	100.0	100.0

*Current industrial reports. Pulp, paper, and board, 1967. Series M26A(67)-13. Washington, [1968].
+Estimated by Midwest Research Institute using comparative data between wood pulp consumption and total paper production in each region.

TABLE 18

CONSUMPTION OF PAPER AND FIBROUS RAW MATERIALS, 1929-1969
IN MILLION TONS AND POUNDS PER CAPITA*

	Consumption				Consumption of fibers at paper and board mills				Recovery ratio	Consumption pounds per capita			
Year	Total	Paper	Paperboard and wet machined	Construction	Total	Wood pulp	Paperstock	Rags, straw, and others	(Col. 7÷Col. 1) Percent	Total	Paper	Paperboard	Construction paper
1929	13.41	8.46	4.23	0.79	11.57	6.29	3.84	1.44	28.6	220.3	138.9	68.4	12.9
1930	12.31	7.94	3.86	0.57	10.68	6.03	3.49	1.16	28.4	200.7	128.9	62.0	9.2
1931	11.35	7.24	3.66	0.50	9.85	5.60	3.24	1.02	28.5	183.1	128.2	58.4	8.0
1932	9.73	6.23	3.16	0.36	8.40	4.89	2.73	0.79	28.1	155.9	99.7	50.5	5.7
1933	10.91	6.64	3.95	0.35	9.15	5.77	3.16	0.72	29.0	173.8	105.6	62.5	5.6
1934	11.29	6.99	3.94	0.38	9.65	5.73	3.15	0.77	27.9	178.6	110.0	62.0	6.1
1935	12.76	7.74	4.58	0.50	11.06	6.44	3.59	1.03	28.1	200.4	121.5	71.0	7.9
1936	14.65	8.76	5.31	0.63	12.57	7.39	4.25	0.93	29.0	228.8	136.7	82.1	9.9
1937	16.03	9.78	5.63	0.70	13.48	8.21	4.36	0.91	27.2	248.7	151.2	86.6	10.9
1938	13.54	8.01	4.89	0.67	11.95	7.29	3.67	0.99	27.1	208.5	123.3	74.8	10.3
1939	15.95	9.35	5.88	0.76	14.18	8.65	4.37	1.16	27.4	243.7	142.8	89.2	11.5
1940	16.76	9.94	6.00	0.84	15.49	9.78	4.67	1.04	27.9	254.0	150.4	90.5	12.7
1941	20.42	11.22	7.67	1.53	18.86	11.36	6.08	1.42	29.8	306.6	168.3	113.8	23.0
1942	19.78	10.91	6.99	1.88	17.86	11.04	5.49	1.32	27.8	293.7	161.8	102.4	27.8
1943	19.44	9.98	7.68	1.78	18.20	10.64	6.37	1.20	32.8	284.8	146.0	110.5	26.0
1944	19.45	9.64	7.00	1.81	18.75	10.50	6.86	1.39	35.3	281.6	139.3	113.7	26.2
1945	19.67	9.98	7.93	1.76	18.97	10.83	6.80	1.34	34.6	281.8	142.6	111.7	25.1
1946	22.51	12.05	8.46	2.01	20.75	12.09	7.28	1.38	32.3	318.8	170.5	117.7	28.4
1947	24.75	13.17	9.25	2.33	22.76	13.25	8.01	1.49	32.4	343.4	182.7	126.3	32.4
1948	26.08	14.06	9.44	2.58	23.41	14.37	7.58	1.45	29.1	355.9	191.8	126.8	35.2
1949	24.69	13.65	9.07	1.98	21.45	13.64	6.60	1.22	26.7	331.0	182.9	119.9	26.5
1950	29.01	15.33	11.03	2.65	25.90	16.51	7.96	1.44	27.4	381.1	202.2	143.3	34.9
1951	30.56	16.31	11.60	2.65	28.25	17.74	9.07	1.44	29.7	394.6	211.3	148.3	34.4
1952	29.02	15.62	10.79	2.60	26.38	17.29	7.88	1.21	27.2	368.3	198.9	135.7	33.2
1953	31.36	16.23	12.38	2.74	28.47	18.68	8.53	1.25	27.2	391.6	203.4	153.2	34.4
1954	31.38	16.36	12.11	2.91	28.04	18.99	7.86	1.20	25.0	385.0	201.5	147.4	35.9
1955	34.72	17.70	13.76	3.26	31.83	21.45	9.04	1.34	26.0	418.5	214.1	164.4	39.4
1956	36.50	19.31	14.07	3.12	33.09	23.00	8.84	1.25	24.2	432.2	229.5	165.7	37.1
1957	35.27	18.48	13.87	2.93	32.06	22.46	8.49	1.11	24.1	410.1	215.8	160.4	34.2
1958	35.12	18.10	13.91	3.10	32.16	22.48	8.67	1.00	24.7	401.6	208.0	158.5	35.7
1959	38.73	20.12	15.17	3.44	35.55	25.16	9.41	0.98	24.3	435.5	226.3	168.9	38.7
1960	39.14	20.55	15.33	3.27	35.70	25.70	9.03	0.97	23.1	433.2	227.4	167.7	36.2
1961	40.31	20.95	16.05	3.31	36.59	26.68	9.02	0.89	22.4	438.8	228.1	173.0	36.0
1962	42.22	21.77	16.96	3.48	38.64	28.50	9.07	0.96	21.5	452.3	233.3	180.2	37.3
1963	43.71	22.42	17.59	3.70	41.12	30.22	9.61	1.28	22.0	461.6	236.7	184.3	39.1
1964	46.38	23.73	18.68	3.98	42.86	32.09	9.84	0.93	21.2	482.9	247.0	192.8	41.4
1965	49.10	25.15	19.81	4.13	45.12	34.01	10.23	0.88	20.8	504.6	258.5	202.2	42.4
1966	52.68	27.30	21.48	3.89	48.47	36.92	10.56	0.98	20.0	535.1	277.3	216.7	39.5
1967	51.94	27.25	20.78	3.91	47.71	36.99	9.89	0.84	19.4	521.7	273.7	207.3	39.3
1968	55.12	28.20	22.50	4.41	50.54	39.39	10.29	0.87	18.7	548.1	280.4	222.1	43.8
1969	58.53	30.65	23.63	4.55	52.97	41.63	10.44	0.89	17.8	576.0+	301.6	231.2	44.8

*The statistics of paper; 1969 supplement. New York, American Paper Institute; The statistics of paper; 1970 supplement.

+Estimated by American Paper Institute.

TABLE 19

COMBINATION PAPERBOARD AND SOLID WOOD PULP BOARD PRODUCTION, 1959-1969
IN MILLION TONS AND PERCENT*

Year	Total paperboard	Combination paperboard		Solid wood pulp board	
		Tons	Percent	Tons	Percent
1959	15.97	6.98	43.7	8.99	56.3
1960	15.93	6.76	42.4	9.17	57.6
1961	16.73	6.68	39.9	10.05	60.1
1962	17.85	6.91	38.7	10.94	61.3
1963	18.59	7.00	37.6	11.59	62.4
1964	19.95	7.20	36.1	12.75	63.9
1965	21.33	7.53	35.3	13.80	64.7
1966	23.18	7.85	33.9	15.33	66.1
1967	22.82	7.22	31.6	16.60	68.4
1968	24.90	7.34	29.5	17.56	70.5
1969	26.38	7.32	27.7	19.06	72.3

*Paperboard industry statistics, 1969. New York, American Paper Institute, Paperboard Group, May 1970; Paperboard industry statistics, 1966. New York, American Paper Institute, Paperboard Group, May 1967.

Note: This is a different data source than Table 18 and reported paperboard totals are therefore not directly comparable.

TABLE 20

PAPER PRODUCTION AND CONSUMPTION BY MAJOR END USE GRADES, 1969
IN MILLION TONS AND PERCENT*

Category	Production	Net imports	Consumption	Percent
Paper	23.5	6.6	30.1	51.5
Newsprint	3.2	6.6†	9.8	16.7
Communications grades	11.0	0.1	11.1	19.0
Packaging/converting grades	5.7	(0.1)†	5.6	9.6
Tissue grades	3.6	0.0	3.6	6.2
Board	26.0	(2.1)	23.9‡	40.8
Solid wood pulp grades	18.7	(1.9)	16.8	28.7
Combination board grades	7.3	(0.2)	7.1	12.1
Construction grades	4.3	0.2	4.5	7.7
Total, all grades	53.8	4.7	58.5	100.0

*The statistics of paper; 1970 supplement (based principally on Current Industrial Reports; "Pulp, Paper and Board," Series M26A, U.S. Department of Commerce).

†( ) indicates net exports.

‡Packaging grades of board are 20.7 million tons, 35.4 percent; other board grades are 3.2 million tons, 5.42 percent.

TABLE 21

PAPER STOCK CONSUMPTION BY GRADE AND USE, 1967 IN 1,000 TONS*

Paper stock grade	Consumption in					Percent of total
	Paperboard	Paper	Construction	Pulp	Total	
Mixed	1,888	453	439	--	2,780	27.4
News	1,573	254	178	--	2,005	19.8
Corrugated	3,085	102	111	--	3,298	32.6
Pulp substitutes	714	191	--	42	947	
Deinking grades	128	354	--	--	482	20.2
Other grades	612	--	--	--	612	
Total	8,000	1,354	728	42	10,124	100.0
Percent of total	79.0	13.4	7.2	0.4	100.0	

*U.S. Bureau of the Census. 1967 Census of manufacturers. Manufacturing and mineral industries. Papermills, except building paper, preliminary report MC67(P)-26A-2; Paperboard mills, preliminary report MC67(P)-26A-3; Building paper and building board mills, preliminary reports MC67(P)-26A-4.

TABLE 22

PAPER STOCK CONSUMPTION BY RECYCLING MODE, 1967 IN 1,000 TONS*

Category of use	Tonnage	Recycling mode
Paper: In newsprint	192†	Primary
In tissue, fine, printing	1,160	Secondary
Paperboard: In combination board	7,550	Secondary
In other board (semichemical)	450	Primary (as corrugated clippings)
Construction paper and board	730	Secondary
Total	10,082‡	6.4 % primary; 93.6 % secondary

*From MRI estimates.
†By 1969, primary recycling of news had increased to 370,000 tons, or 17 percent of total news recovery.
‡Excludes 42,000 tons consumed in pulp mills.

TABLE 23

WASTEPAPER RECOVERY BY GRADE AND SOURCE, 1967
1,000 TONS *

Grade	Residential	Commercial	Converting	Total
Mixed	70	1,860	850	2,780
News	1,610	50	345	2,005
Corrugated	--	2,300	998	3,298
High grades	--	200	1,841	2,041
Total	1,680	4,410	4,034	10,124
Percent of total	16.6	43.6	39.8	100.0

*From Midwest Research Institute estimates.

Note: Net exports add another 176,000 tons derived from converting operations.

TABLE 24

WASTEPAPER RECOVERY POTENTIAL FROM SOLID WASTE IN 1967
IN MILLION TONS*

Category	Discard to waste	Additional recoverable	Most likely recoverable
Newspapers	6.3	4.5	2.2
Corrugated	8.6	5.7	3.0
All other	20.3	10.0	5.0
Total	35.2	20.2	10.2

*From Midwest Research Institute.

TABLE 25

WASTEPAPER RECOVERY AT VARIOUS LEVELS OF RECYCLING, 1969 AND 1980
IN MILLION TONS*

	1969	1980†
Total paper consumption, including net imports	58.5	85.0
Fiber consumption; in domestic production		
Wood pulp	41.6	65.0
Wastepaper	10.5	15.2
Other fiber	0.9	0.7
Total fibrous materials	53.0	80.9
Recycling compared to paper consumption:		
Wastepaper at 17.9 percent recovery	10.5	15.2
Wastepaper at 30 percent recovery	17.6	25.5
Wastepaper at 40 percent recovery	23.4	34.0
Wastepaper at 50 percent recovery	29.2	42.5

*From Midwest Research Institute.
†Forecast.

TABLE 26

WASTE PAPER DEALER SALES BY GEOGRAPHIC AREA, 1963, IN TONS AND DOLLARS*

Waste paper dealers	Sales of the commodity line 1,000 tons	Sales of the commodity line 1,000 dollars	Number of establishments	All commodity lines $1,000	Waste paper as a % of sales
New England Division	953	26,273	134	38,551	68.2
Middle Atlantic Division	3,420	82,719	483	120,188	68.8
East North Central Division	2,620	60,112	280	88,606	67.8
West North Central Division	3,385	9,375	38	11,992	78.2
South Atlantic Division	922	19,404	93	35,782	54.2
East South Central Division	168	4,372	23	6,466	67.6
West South Central Division	408	9,140	46	14,329	63.8
Mountain Division	137	3,263	13	8,412	38.8
Pacific Division	809	20,096	66	25,435	79.0
United States	9,822	234,754	1,176	349,761	67.1
Waste paper by all waste material dealers†					
New England Division	985	26,938	164	48,697	55.3
Middle Atlantic Division	3,553	85,415	595	147,527	57.9
East North Central Division	3,046	68,567	432	154,074	44.5
West North Central Division	389	9,461	51	16,729	56.6
South Atlantic Division	952	20,044	125	48,362	41.4
East South Central Division	188	4,769	30	14,492	32.9
West South Central Division	411	9,230	55	18,931	48.8
Mountain Division	137	3,263	13	8,412	38.8
Pacific Division	812	20,167	70	26,061	77.4
United States	10,474	247,854	1,535	483,285	51.3

*1963 Census of business. v. 4. Wholesale trade--summary statistics and public warehousing. pt. 2.

†Includes only those scrap dealers handling other materials that also reported waste paper sales.

TABLE 27

WASTE PAPER CONSUMPTION AND INVENTORIES AT MILLS AND PRICE INDEXES, 1950-1970*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
A. Mill consumption, 1,000 tons seasonally adjusted												
1950	606	583	613	605	622	631	632	715	675	712	729	778
1951	849	839	847	823	837	838	777	740	624	640	669	554
1952	722	636	614	639	579	596	622	622	694	717	689	737
1953	715	682	726	747	701	713	741	692	739	717	680	657
1954	645	677	684	666	637	685	659	669	667	653	703	686
1955	675	695	768	724	772	771	744	790	756	752	802	760
1956	769	801	762	754	765	776	664	740	672	710	732	665
1957	741	723	674	718	717	666	719	687	697	732	698	678
1958	721	667	683	703	687	711	783	743	779	754	730	736
1959	742	764	764	776	772	761	821	733	787	751	742	761
1960	752	778	740	742	739	778	725	795	720	706	735	786
1961	714	738	720	704	788	719	792	797	762	778	781	776
1962	799	702	770	742	765	740	782	760	717	756	726	728
1963	736	665	721	722	763	721	771	744	716	760	699	730
1964	759	720	774	802	791	772	798	808	775	821	775	806
1965	808	755	854	812	823	829	838	814	817	857	830	879
1966	868	778	890	851	885	868	868	872	814	837	802	822
1967	827	741	803	770	802	788	809	878	816	851	820	823
1968	880	803	856	839	885	845	886	865	826	886	845	873
1969	903	796	902	882	901	858	922	888	859	866	806	853
1970	858	775	841	852	819	829	856	884				
Seasonal adjustment index basis: 100	97.6	103.8	103.2	102.3	101.5	102.9	85.9	102.3	102.8	104.8	101.5	91.4
B. Mill inventories, 1,000 tons seasonally adjusted												
1950	375	385	376	360	362	363	360	351	357	356	380	362
1951	369	403	421	455	477	476	499	531	576	600	577	586
1952	556	580	587	582	585	572	558	521	513	516	514	492
1953	492	498	482	479	482	479	464	466	452	442	446	452
1954	452	444	448	452	460	459	456	452	450	436	417	422
1955	429	419	402	403	405	414	409	424	425	414	410	421
1956	433	436	450	452	466	434	489	499	511	523	519	523
1957	510	508	523	512	502	503	490	490	486	481	477	488
1958	486	505	499	501	504	496	485	474	456	446	440	439
1959	438	453	454	461	469	495	500	527	526	545	553	552
1960	555	561	562	559	554	547	548	527	554	559	548	547
1961	530	508	521	525	514	543	525	515	513	499	501	508
1962	466	470	484	501	490	500	515	478	487	424	526	528
1963	451	451	515	531	507	515	538	500	506	526	568	512
1964	462	466	475	481	465	473	493	461	485	486	485	521
1965	478	486	499	527	512	524	565	516	532	531	515	587

TABLE 27 (concluded)

1966	458	453	471	491	485	517	571	558	610	646	652	681
1967	613	602	647	637	638	729	639	596	615	603	598	601
1968	511	514	515	523	515	499	544	494	525	569	547	585
1969	550	566	576	591	571	584	532	563	599	632	602	607
1970	562	559	575	569	549	549	657	654				
Seasonal adjustment index basis: 100	106.0	102.3	98.9	98.9	100.5	98.7	98.3	103.1	97.7	96.2	99.3	100.1

C. Waste paper price index (1957-1959 = 100)

1950	92.3	82.0	77.6	77.6	76.8	85.2	102.3	155.8	166.6	182.9	203.9	243.4
1951	277.9	296.5	283.3	238.4	213.3	240.4	214.8	179.4	153.1	118.7	99.0	96.6
1952	96.6	94.2	75.5	75.5	59.5	59.5	47.8	70.9	89.7	76.8	70.9	96.4
1953	93.9	90.4	90.4	95.3	91.7	91.7	91.7	106.3	118.3	121.8	98.0	85.4
1954	85.4	92.5	90.7	89.8	72.5	75.6	85.5	86.3	86.3	90.4	94.4	92.3
1955	97.3	97.3	96.5	96.5	100.0	113.0	135.9	139.3	139.3	129.8	144.5	144.5
1956	144.5	153.9	153.9	137.5	125.6	123.3	121.3	121.0	105.2	99.8	83.4	84.5
1957	83.4	82.4	81.4	74.0	71.3	71.3	73.4	80.6	95.5	95.5	95.5	95.5
1958	90.2	90.2	81.3	81.3	77.5	77.5	92.9	93.9	114.8	120.1	120.1	103.4
1959	109.0	115.6	124.8	124.8	119.2	125.1	125.1	125.1	127.3	124.1	118.5	118.5
1960	116.5	101.0	96.4	95.4	89.8	88.8	88.8	83.5	83.5	83.5	83.5	73.2
1961	73.2	78.1	67.0	67.0	67.0	70.1	82.7	82.7	82.7	108.1	93.8	93.8
1962	100.9	100.1	103.2	98.0	96.2	96.4	96.8	95.1	96.4	96.1	96.0	94.6
1963	94.7	96.1	96.6	92.5	89.8	90.8	91.4	91.2	90.9	90.7	91.0	90.8
1964	91.1	91.1	91.9	90.2	90.8	93.5	93.4	93.3	92.2	92.2	92.5	95.9
1965	96.1	96.0	96.2	97.3	100.3	98.0	98.3	97.5	97.3	104.5	107.0	104.6
1966	105.8	105.5	108.7	110.3	112.0	112.7	113.2	106.7	102.9	98.8	92.7	90.5
1967	83.9	83.2	79.7	79.1	77.5	76.7	76.2	74.6	75.4	76.6	76.5	78.1
1968	76.9	81.8	89.0	96.5	98.2	103.1	110.5	112.8	112.2	114.8	112.8	109.6
1969	107.4	107.8	108.1	109.1	107.1	108.8	111.2	110.3	108.4	107.2	107.2	106.7
1970	107.5	108.2	108.5	108.5	104.2	99.0	95.3	92.6				

*A&B: Current industrial reports. Pulp, paper, and board. Series M26A, 1950; 1951...1970.

Seasonal adjustment factors taken from Tuchman, A. The economics of the waste paper industry. Ph.D. Thesis, New York University, 1963. p. 318.

Actual data for A and B for 1950-1961 taken from Tuchman reference; 1961-1970 data by Midwest Research Institute.

C: Wholesale prices and price indexes. U.S. Bureau of Labor Statistics, 1950; 1951...1970.

CHAPTER V

FERROUS METALS

Perspective

Iron and steel products entering the U.S. economy are derived from two sources: iron ores and obsolete scrap materials. These two commodities supply new ferrous metals that go into products. A portion of the metals processed is irretrievably lost in processing. This quantity of metal must also be replaced each year by new inputs — ores or obsolete scrap.

In addition to new metallic inputs, a large quantity of ferrous metal also "circulates" in the industry; that is, it is consumed every year in the initial production steps (the furnaces), but then it reappears in the final production steps (rolling, fabrication, and conversion) and is once more consumed.

This circulating material is called "home scrap" if it appears within the steel industry itself and "prompt scrap" if it appears in industrial operations outside the steel industry. These types of scrap are contrasted to "obsolete scrap," which means metal derived from products or structures that have completed their useful economic life and are ready for recycling.

Conceptually, home and prompt scrap are in the system and never leave. Ores and obsolete scrap enter the system and leave — either as product or as irretrievable metal losses.

In 1967, the industry sent to final consumers products weighing 95.9 million tons[26] and lost an estimated 11.8 million tons of metals in processing; total metal consumption, therefore, was 107.7 million tons. This was supplied by iron in ores of 86.1 million tons (80 percent), by 21.6 million tons of obsolete scrap (20 percent), and by imported scrap of 229,000 tons. In this period, however, 63.7 million tons of additional scrap circulated in the system and were once more available at the end of the year.

The U.S. iron and steel industry thus has a high reliance on obsolete scrap for new metallic input into its operations. As will be discussed below, between 30 and 40 percent of available obsolete scrap is probably recycled every year.

In addition to the distinctions between home, prompt, and obsolete scrap made above, one also encounters the distinction between "home scrap" and "purchased scrap." "Home" is used to designate scrap for which a consumer does not pay, and "purchased" means all scrap that is the subject of a commercial transaction. This traditional terminology can cause confusion in that the purchased category includes portions of the home scrap (in the sense of "generated internally to the steel industry") as well as most prompt and obsolete scrap. In 1967, purchased scrap of 35.1 million tons was handled, of which 21.4 million tons were obsolete, 11.6 million tons were prompt, and 5.1 million tons were home.

Industry Structure

The iron and steel industry is made up of four segments; (1) integrated steel companies that produce pig iron in blast furnaces, convert pig iron into steel in steel furnaces, and produce intermediate steel products in rolling mills; (2) steel producers who do not have blast furnaces but produce steel from purchased pig iron and scrap, usually in electric furnaces; (3) steel foundries that produce steel castings by melting steel scrap; and (4) iron foundries that purchase pig iron and scrap and produce iron castings.

The products of these industry segments are sold to manufacturers in other industries for further fabrication and conversion into products that are ultimately sold for consumer, commercial, and industrial uses.

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[26] In addition, iron and steel products of 10 million tons were imported.

In 1967, the Iron and Steel Works Directory listed 107 producers of basic steel products, including steel castings, in the United States.[27] Among these were 24 producers operating both blast and steel furnaces; these producers represent the integrated steel industry and they include the industry giants — U.S. Steel, Bethlehem, Republic, Armco, and National Steel. The 4 largest companies produced 50 percent, the 8 largest 69 percent, and the 20 largest 89 percent of all steel products in the United States in 1963.

In addition to these producers, the directory lists 8 that operate only blast furnaces and 75 that operate only steel furnaces. Of these 75 producers, 61 have only electric furnaces, 4 have electric and other furnaces, and 10 have steel furnaces other than electric. These producers are the independent steel producers who rely for their inputs on scrap and purchased pig iron. Though their numbers are large, they represent a small part of total steel production tonnage.

The iron foundry industry consists of around 1,060 companies. In 1963, the 20 largest companies accounted for 51 percent of industry output.

Process Use and Scrap Consumption Trends

The steel industry uses blast furnaces in which ores, coke, and fluxes are converted into pig iron; a small quantity of scrap is usually also charged with these materials.

Blast furnaces are large capacity installations. A total of 225 such facilities supplied 636 open hearth and basic oxygen furnaces with the iron they needed in 1967; each furnace produced an average of 387,000 tons of pig iron (Table 28). It is not unusual to encounter two or three steel furnaces in association with a blast furnace, and in some plants 10 or more steel furnaces may be fed by one blasting installation. In 1967, the ratio of blast furnaces to open hearth and basic oxygen furnaces was nearly 1 to 3.

The construction of a new blast furnace in a steel plant, consequently, requires a considerable expansion of total steel sales by a company or is undertaken at a time when one or more older furnaces need to be replaced. Thus, in the United States the number of blast furnaces shrank from 247 in 1962 to 225 in 1967, while output of pig iron increased from 65.6 million to 87.0 million tons.

The clustering of steel furnaces around a blasting facility is also desirable for technical reasons rather than merely because of size relationships. A steel furnace near a blast furnace can be supplied with hot, molten pig iron ("hot metal"); in this manner, the heat value of the pig iron is used and it is not necessary to reheat cold pig iron.

In the steel furnace, impurities in the pig iron are oxidized or combined with fluxing materials and are removed. Open hearth and basic oxygen furnaces are fed by hot metal, scrap, and small quantities of fluxing agents and ores. The open hearth furnace consumes scrap equivalent to 41.7 percent of metallic inputs; the basic oxygen furnace consumes 29.2 percent scrap on the same basis. Electric furnaces are designed to operate almost entirely on scrap; they are, in essence, scrap melting furnaces. Electric furnaces consume scrap equivalent to 97.9 percent of input metallics.

Basic trends in the industry have been: (1) the decline of the open hearth furnace (down from 87.0 percent of total steel production in 1960 to 50.0 percent in 1968); (2) the rapid rise of basic oxygen furnaces (1960, 3.3 percent; 1968, 37.1 percent); and (3) the moderate growth of electric furnace steel production (1960, 8.4 percent; 1968, 12.7 percent) (Figure 15).

The fundamental advantage of the basic oxygen furnace (BOF) is that it can produce a heat (a batch) of steel in 45 minutes, while the open hearth furnace requires 10 hours for the same production. The resulting savings in labor costs per ton of steel produced justify the use of oxygen as an oxidant in the BOF versus air in the open hearth process. Electric furnaces depend on low cost electricity and cheap scrap for their economic viability.

Because these furnaces have different scrap consumption ratios, shifts in processing equipment mix have led to a decline of scrap in relation to pig iron. In the 1947 to 1953 period, for instance, scrap input was 47.8 percent of total inputs to steel furnaces; in the 1964 to 1968 period, the percentage of scrap had dropped to 43.4 percent as a result of process changes.

It would be erroneous to assume, however, that the ratio of scrap to pig iron will continue to decline indefinitely in steel production. What is more likely to happen is that processing changes will be introduced in the basic oxygen furnace to permit these furnaces to consume more scrap and that more electric furnaces will

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[27] Directory of iron and steel works of the United States and Canada. 31st ed. New York, American Iron and Steel Institute, 1967. p.384-387.

be installed — both moves brought about by a drop in scrap prices as demand for scrap weakens. Scrap consumption in BOF's can be increased by preheating the scrap; this, of course, adds to total steel making costs and is justified only if scrap prices are relatively low in relation to pig iron. In fact, scrap use in BOF's shows signs of increasing: the ratio of scrap to pig iron rose from 27.7 percent in the 1959 to 1963 period to 29.2 percent in the 1964 to 1968 period (Table 29).

Industry Shipments and Scrap Relationships

The steel industry's largest customers are the automobile industry, the construction industry, and steel service centers (wholesale warehousing operations that sell steel mill products to industrial customers and contractors). Together these three consumers account for 56.5 percent of industry shipments, excluding steel and iron castings (Table 30). The major steel products that are most likely to be encountered in municipal waste are containers and appliances (which constitute 11.2 percent of shipments) plus a host of other products from paper clips and coat hangers to toys, hardware, and auto parts. (Auto hulks are a special case not considered in this study.)

All told, the industry shipped 105.9 million tons of product to ultimate consumers in 1967 — including net imports, all steel mill products, and iron and steel castings. Of the total, net imports represented 10.0 million tons and domestic production 95.9 million tons.

How much of the steel consumption tonnage is ultimately recoverable? Estimates range from 65 to 85 percent.[28] Steel has an average life of around 20 years — somewhat longer in underdeveloped countries, somewhat shorter in industrialized countries.[29] During use, steel is lost; it corrodes, it is lost in ship and air disasters at sea, in military operations overseas, and under similar circumstances. Some of the steel is discarded as waste (steel cans, for example); some of it is lost in the form of small objects (nails, staples, pins, paper clips, wire, etc.); some of it becomes encased in concrete and is unrecoverable; and some of it ends up in remote locations from which it cannot be recovered economically. If these losses are equivalent to somewhere between 15 and 35 percent of steel consumption, a total tonnage of 69 to 90 million tons of iron and steel should be available for recovery in 1987 from 1967 consumption.

In 1947, consumption of iron and steel products was an estimated 80 million tons. Accordingly, between 52 and 68 million tons of ferrous scrap materials should have been available for recovery in 1967. In that year, total consumption of obsolete scrap for domestic use was 21.6 million tons — equivalent to between 32 and 42 percent of estimated available obsolete scrap. If exports of scrap are included, recovery was between 43 and 56 percent.

Scrap Consumption

In order to obtain an overview of materials (including scrap) used in the iron and steel industry, we prepared a generalized input/output table for the industry in 1967 using data available from various sources (Table 31).[30] Data in Table 31 are further summarized in Table 32.

According to these data, total scrap demand was 93.0 million tons in 1967. Of this total 7.6 million tons were exported and 85.4 million tons were consumed domestically (of which 0.23 million tons were imported). On a source basis, 52.3 million tons were home scrap, 11.7 million tons were prompt scrap, and 29.0 million tons were obsolete scrap. Domestic demand created 21.4 million tons of obsolete scrap consumption, while exports created 7.6 million tons of obsolete scrap demand.

These data are in general conformity with findings of a Business and Defense Services Administration study on scrap issued in 1966.[31] A summary of BDSA data for the period 1947 to 1964 and updated by us to 1968, is presented as Table 33.

Historical data show that: (1) scrap consumption as a percent of metallics inputs decreased slightly (from 51.5 percent in the 1949 to 1953 period to 49.9 percent in the 1964 to 1968 period); (2) home scrap consumption increased as a percent of total scrap (55.1 percent in the 1949 to 1953 period to 60.0 percent in the 1964 to 1968 period); (3) prompt scrap consumption remained at 16.0 percent; and (4) obsolete scrap consumption decreased

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[28] Pounds, N. J. G. World production and use of steel scrap. Economic Geography, 35(3):249, July 1959.

[29] Pounds, World production and use of steel scrap, p.250.

[30] Use of 1967 data was necessary because information on specific segments of the industry in sufficient detail was not available for later years.

[31] Business & Defense Services Administration. Iron & steel scrap consumption problems. Washington, U.S. Government Printing Office, Mar. 1966. 52 p.

(from 28.9 percent in the 1949 to 1953 period to 24.0 percent in the 1964 to 1968 period).

Data developed by us for 1967 show that home scrap was 61.3 percent, prompt was 13.7 percent, and obsolete was 25.0 percent of total scrap in that year. These data are somewhat divergent from those shown by BDSA; the reason is that the BDSA data understate home scrap consumption by showing a portion of such scrap under the "purchased" category as prompt scrap.

Scrap Use Issues

Scrap is used in both steel furnaces and iron foundries as a relatively inexpensive source of iron. In all instances, scrap competes with pig iron produced in blast furnaces from ores, agglomerates, fluxes, coke, and small quantities of scrap.

Except in electric furnaces, where only scrap is used as an input, scrap does not compete with pig iron on a basis of direct substitutability. For best technical operations, open hearth and basic oxygen furnaces require both hot molten pig iron and scrap. Much of the scrap input is internally generated and must be used in order to avoid severe losses of metallic inputs. Open hearth and basic oxygen furnaces are usually located near blast furnaces and receive molten pig iron, thereby benefiting from the heat in the hot metal. Electric furnaces, however, are generally operated by nonintegrated steel producers who must purchase cold pig iron on the open market if they wish to use it. Pig iron on the open market costs more than scrap and is generally avoided by electric furnace operators. The values of hot metal and scrap to an integrated steel producer, however, are roughly equivalent.

In 1967, for example, the value of input materials to blast furnaces was between $11 and $12 a ton. To obtain 1 ton of pig iron, 2.5 tons of inputs had to be processed. The value of materials consumed per ton of pig iron was between $29 and $30 (Table 34). Estimates developed by Battelle Memorial Institute in 1966 indicate that total costs of hot metal production ranged between $32 and $39 a ton depending on location and size of the producing plants.[32] In 1967, heavy melting steel scrap (the best grade) sold for an average of $24 per ton; and No. 2 bundle steel, a low grade of scrap with a high percentage of impurities, was worth $18 a ton. The differential between scrap and hot metal, then, appears to be between $8 and $21 per ton. Qualitatively, hot metal is the better input material — it is free of impurities and comes in hot, molten form. Scrap requires more careful handling and storage (to keep various grades separated), it is introduced into furnaces at ambient temperatures, and contamination of the steel is always a possibility. If these factors are kept in mind, it is clear that the relative value of the two types of materials is roughly equivalent. No. 1 cupola cast iron, usually consumed by iron foundries, cost $38 per ton in 1967; this type of scrap competed against pig iron purchased on the open market for $57 per ton.

If the values of scrap and pig iron relative to one another change, more of the economically favored material is consumed. There is, however, a limit to the degree of displacement of one material by another.

In addition to the value of materials in pig iron, this material also represents investments in ore mining equipment, sintering and pelletizing plants, coking plants, and blast furnaces — investments that must be amortized. To replace pig iron, scrap would have to be available in very large quantities and at prices low enough to permit the industry to idle its pig iron production plant. Total elimination of pig iron would not be possible even under such circumstances: open hearth furnaces are technically limited to a maximum input of 70 to 80 percent scrap, BOF's to 50 to 60 percent, and the few remaining Bessemer furnaces to 20 percent scrap.[33] In 1967, maximum technically feasible scrap consumption in steel furnaces would have been between 101.3 and 114.5 million tons; actual consumption was 63.0 million tons, or between 55 and 62 percent of maximum (Table 35).

Consumption at maximum technical rates in steel furnaces would create an additional demand for obsolete scrap of between 48.3 and 51.5 million tons (1967 basis), for a total obsolete scrap demand of between 77.3 and 80.5 million tons (29.0 million tons of actual consumption plus additional consumption) (see Tables 32 and 35 for calculation basis).

As indicated above, total obsolete scrap available in any one year is between 65 to 85 percent of the tonnage shipped 20 years earlier. In 1967, the available tonnage was between 52 and 68 million — plus unused scrap accumulations of earlier years. Discounting accumulations (which would soon be consumed if maximum scrap use were instituted), it appears that there is not

[32] Quoted in Iron & steel scrap consumption problems, p.20.

[33] Iron & steel scrap consumption problems, p.14. Electric furnaces already consume 98 percent scrap.

sufficient obsolete scrap available to permit scrap use at maximum technically permissible levels.

Scrap use is also limited by the fact that only a portion of "available" scrap is economically "accessible." Obsolete scrap must occur in fairly large concentrations to be economically recoverable. How much of available obsolete scrap is accessible is a matter of speculation. We suspect that most of such scrap is already being recovered, the exception being automotive hulks, many of them occurring in remote locations in small quantities. Increases in scrap demand tend to be accompanied by price increases. These increases reflect, in part, higher costs occasioned by tapping less desirable, less accessible, sources of scrap.

The necessity to operate blast furnaces to satisfy most of the Nation's metal requirements and the relative availability of scrap at prices comparable to pig iron raw materials values tend to create an equilibrium between pig iron and scrap, so that the use ratios of these materials have not significantly changed in decades (Figure 16).

Any attempt to change the current situation materially would involve the artificial (legislated) increase of pig iron production costs, control of scrap prices so that they do not once more reach equilibrium with pig iron costs, and subsidy of scrap recovery operations so that sufficient supplies of scrap would be obtained and could be sold at controlled prices. The net result would be higher recovery of scrap and displacement of cheap inputs (pig iron raw materials) by more expensive inputs (scrap from "inaccessible" sources).

Sources of Scrap

Home scrap is generated in iron and steel furnace operations and in rolling mill operations. This scrap may be in the form of metallic spills, defective ingots, rolling mill croppings, and the like.

Prompt scrap is generated in metal fabrication and conversion steps and takes the form of defective products; shavings, borings, and punchings; and the like. Fabrication wastes in 1967 are estimated to have been equivalent to 9.9 percent of materials processed by fabricators; conversion wastes to 2.1 percent of materials processed (Table 31).

The origin of obsolete scrap is difficult to determine. The most recent study of the subject was conducted on behalf of the Institute of Scrap Iron and Steel in 1959.[34] According to this study railroads and automobile wreckers account for the bulk of obsolete scrap (14.7 and 13.1 percent, respectively), followed by building demolitions, farms, and shipbreaking. The miscellaneous category accounts for 52.3 percent of total scrap and includes oil field and refinery scrap; incinerator and dump salvage; housing repair and maintenance; and general, unidentified scrap collections (Table 36).

The exact quantity of scrap removed from mixed municipal waste is unknown, but we believe the quantity is extremely small — less than 1 million tons a year, of which a high proportion is diverted to copper mines rather than entering the steel industry.

Scrap Quality

From the steel industry's point of view, the "best" scrap has a known composition, a minimum level of contaminants, and comes from a known source. Steel makers like home scrap best because they know exactly what it contains. The technical characteristics of prompt scrap can also usually be guaranteed (if conscientious segregation is practiced in the fabrication plant) and the nature of the steel processed is known. Equal in desirability is steel derived from building, ship, railcar, refinery, and similar structure demolition. The metal characteristics can be readily ascertained. Shredded automobile steel — with all nonferrous metals and nonmetallics removed — falls into this category. Least desirable is mixed scrap of unknown origin. Bundled automotive bodies (No. 2 bundles) fall into this category. The origin of mixed scrap is usually hard to determine and contaminants are often a high percentage of the materials. Metals derived from municipal wastes belong to this last category.

Grades. Scrap is sold by grades. The grade gives some indication of the origin of the material. Scrap consumption by grade groupings in 1967 is shown in Table 37; this listing combines purchased and home scrap. Principal grades are the following:

(1) Heavy melting steel, which includes much of the home scrap, is scrap no larger than 5 by 2 feet; No. 1 heavy melting grades are at least one-quarter inch thick;

[34] Quoted in McGannon, H. E., ed. The making, shaping, and treating of steel. 8th ed. [Pittsburgh], United States Steel Corporation, 1964. p. 224.

No. 2 heavy melting grades may be as thin as one-eighth of an inch.

(2) No. I busheling is light, loose material, usually from prompt sources, limited to a I foot size in any dimension.

(3) No. I bundles consist of prompt scrap, usually light materials such as sheet clippings, compressed into bundles weighing at least 75 pounds per cubic foot.

(4) No. 2 bundles are usually automotive sheet steel bundled into packages at least 75 pounds per cubic foot. These bundles may not contain tin or lead-coated materials or enamelled stock (such as may be derived from major appliances).

(5) Turnings and borings are the light residues of machining operations in metal fabrication; these materials are sometimes briquetted or bundled to increase their density.

(6) Cast iron comes in a variety of grades and includes broken or obsolete motor block; cast iron borings; cast steel scrap such as broken rail car wheels; hard steel such as automobile rear ends, crankshafts, front axles, springs, and gears; and other cast iron and steel scrap.

All told, 42 grades of iron and steel scrap, 29 grades of alloy steel scrap, and 40 grades of railroad scrap are officially recognized by the Institute of Scrap Iron and Steel; many more are used, being variants of the major grades. Scrap grades include one category known as "incinerator bundles." a grade that is made up of steel can scrap, compressed to bundles weighing 75 pounds per cubic foot. In our survey and investigative work, we did not encounter a single scrap dealer who recognized this grade or had ever handled it. Prices for the most important grades are quoted daily for 16 cities in *American Metal Market*. National average prices, however, are developed only for three grades — heavy melting steel scrap, No. 2 bundles, and cupola cast.

Metallic Impurities. Iron and steel scrap specifications limit the quantity of nonferrous metals in scrap to 0.6 percent maximum, excluding manganese, which may be present at a level of 1.65 percent. The metallic impurities (called residual alloys) expressly mentioned in the Institute of Scrap Iron and Steel specifications are nickel (limited to 0.45 percent), chromium (0.20 percent), molybdenum (0.10 percent), and manganese (1.65 percent).[35] The specifications do not mention tin and copper, but Bureau of Mines investigators have established that tin content of scrap should not exceed 0.06 percent and copper content, 0.10 percent.[36]

Tin Contamination. The recycling of metals occurring in municipal wastes is limited by high tin content resulting from the presence of tin-coated steel cans. How high is the tin content of ferrous metals in municipal waste? In 1968, an estimated 193.7 million tons of waste were collected; of this portion, about 8.0 percent was metal. Bureau of Mines analyses[37] indicate that the ferrous content of the metal is around 93 percent. This results in a ferrous metal proportion in waste of 14.41 million tons. In 1968, steel cans weighing 5.56 million tons and containing 29,190 tons of tin were part of this waste. [38] The tin content of all ferrous metals in municipal waste would thus appear to have been 0.2 percent in 1968. This percentage is in line with physical tests conducted by the Bureau of Mines which placed tin content at between 0.1 and 0.4 percent.[39]

The estimated average tin content of municipal waste metals appears to be three times as great as is acceptable to the steel industry in steel. Tin is undesirable because it readily alloys with steel and cannot be removed by processing. Brittleness and undesirable surface conditions result from the presence of tin; tin causes deterioration of furnace refractories; tin-con-

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[35] Institute of Scrap Iron & Steel. 1968 Yearbook. 29th ed. Washington. p.71.

[36] Cammarota, V.A., Jr. Refining of ferrous metal reclaimed from municipal incinerator residues. In Proceedings; Second Mineral Waste Utilization Symposium, Chicago, Mar. 18-19, 1970. U.S. Bureau of Mines, and Illinois Institute of Technology Research Institute. p.348.

[37] Kenahan, C. B., P. M. Sullivan, J. A. Ruppert, and E. F. Spano. Composition and characteristics of municipal incinerator residues. U.S. Bureau of Mines Report of Investigations No. 7204. [Washington], U.S. Department of the Interior, Dec. 1968. p.9.

[38] U.S. Bureau of Mines. Minerals Yearbook 1967. v. 1-II. Metals, minerals, and fuels. Washington, U.S. Government Printing Office, 1968. p.1123. Tin content of tin plate is shown to be 10.5 pounds per ton of plate, or 0.525 percent in 1967. We assumed no change between 1967 and 1968.

[39] Cammarota, Refining of ferrous metal, p.348.

taining steels cannot be deep-drawn satisfactorily; and the tendency of tin to form hard spots in steel results in difficulties when the metal is processed through rolling mills.[40, 41, 42] Presumably, if tin content is below 0.06 percent of steel, these difficulties are not encountered.

What would be the effect on iron and steel quality of recycling all used tin-containing steel cans? We calculated the impact using a few simplifying assumptions. We assumed:

(1) Using 1967 base data, that iron and steel production would continue unchanged at the 1967 level.

(2) That proportions of ore, home, prompt, and obsolete scrap would remain the same as in 1967.

(3) That all steel cans (5.149 million tons in 1967) would be recycled as part of obsolete scrap (21.650 million tons in 1967).

(4) That iron and steel products shipped in any one year would not become available as obsolete scrap for 20 years, except the portion entering steel cans, which will come back the year following production.

(5) That steel can scrap would be evenly distributed to all steel and iron consuming operations.

Using these assumptions, we find that in the first year of complete can recycling, 27,032 tons of tin would become part of the total metallic input stream of 171 million tons, bringing tin content of all iron and steel to 0.016 percent.

In the second year, tin is introduced as (1) a coating of new cans recovered (27,032 tons), (2) as part of home and prompt scrap returned to furnaces (10,045 tons), and (3) as the residual tin content of the steel made into cans (808 tons). The total input now is 37,885 tons of tin as part of 171 million tons of metal, equivalent to 0.022 percent of the total.[43]

Each subsequent year, the tin content of the total metallic stream is higher, but once the initial buildup is over (the first three years), the growth rate of tin in the metals stream levels out at a rate of 0.3 percent a year. In the 19th year, 46,022 tons of tin are introduced, equivalent to 0.027 percent of total metals, well below the level of undesirability (0.06 percent).

According to our assumptions, in the 20th year that portion of obsolete scrap that does not consist of steel cans (16.249 million tons) will consist of metal manufactured in the first year, and consequently, this scrap will contain tin at the same level as all metal did in the first year: 0.0016 percent. The introduction of this new tin in the 20th and all subsequent years causes tin content to increase in the 20th, 21st, and 22nd years at a fairly rapid rate. Then the growth levels out again, so that in the 32nd year tin content is still only 0.03 percent of total metallics (Table 38, Figure 17).

The very low rate of contamination buildup is explained by the small quantities of tin involved, the large quantity of ferrous metals processed, and the fact that each year about 80 percent of new metallic inputs come from uncontaminated ores.

We conclude, on the basis of the foregoing analysis, that the tin content of steel cans alone would not deter their recycling at high rates — provided that the practical problem of distributing steel can scrap evenly to all metal consuming operations is achievable.

At the current time, when tin-free steel cans are a growing proportion of total cans, the technical feasibility of can recycling is even better than that shown in our analysis. One industrial analyst[44] has estimated that tin content of all steel cans produced will progressively decrease, falling from a level of 0.51 percent in 1968 to a level of 0.44 percent in 1970 and 0.33 percent in 1977. This is attributed to a rise in tin free steel (TFS) and a decline in tinplate cans.

Aluminum. While the tin content of steel cans is decreasing, use of steel cans with aluminum tops in beverage packaging introduces another contaminating

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40 McGannon, H. E. Steel. In Kirk-Othmer Encyclopedia of Chemical Technology. 2d rev. ed. v. 18. [Shale oil to steroids]. New York Interscience Publishers, 1969. p.750, 787.

41 Story, W. S. Problems of the salvage industry as they relate to solid waste disposal. In Proceedings; National Conference on Solid Waste Research, Chicago, Dec. 1963. American Public Works Association, 1964. p.162.

42 The making of steel. New York, American Iron and Steel Institute, 1964. p. 21.

43 Basis: tin content of metallics is 0.016 percent; home and prompt scrap returning are 63,693 million tons, containing tin at a level of 0.016 percent; tin cans returned (5.149 million tons) will contain tin at the level of 0.016 percent in the metal and 27,032 tons as coatings.

44 Gotsch, L. P. Waste from metal packages. In Proceedings; First National Conference on Packaging Wastes, University of California at Davis, Sept. 22-24, 1969. Washington, U.S. Government Printing Office, 1971. p.79.

metal. Aluminum is not a critical contaminant in steel. It improves metal grain and, because of its affinity for oxygen, it is a reliable deoxidizing agent.[45] However, aluminum used as a steel alloy or deoxidant must be introduced under controlled conditions, not as a random input in the form of a scrap contaminant.

Separation of aluminum from steel cans can be accomplished more easily than removal of tin. Cans can be shredded and the ferrous portion separated magnetically; aluminum tends to melt in incineration and thus becomes separated from the ferrous metal.[46] However, the presence of aluminum on a portion of steel cans manufactured requires some form of processing to separate the two metals.

Lead. Another metallic contaminant in municipal waste metals is lead, introduced in the form of a tin-lead alloy as solder in steel cans. The lead content of steel cans is around 0.5 percent by weight, roughly equal to tin content. The quantity of lead in steel cans is declining as a result of the introduction of new seaming practices.[47]

Lead is difficult to alloy with steel, being insoluble in molten steel.[48] The substance is extremely harmful to furnace bottoms and refractories.[49] On the other hand, the presence of lead in steel improves the machineability characteristics of the steel, and for this reason leaded steels are produced in very limited quantities for special applications where much metal is removed in machining. Leaded steels may have between 0.15 and 0.35 percent lead content. However, the lead must be introduced in the form of lead shot by pneumatically operated guns to achieve even dispersion of the additive through the finished steel.[50] We were unable to ascertain whether or not the trace quantities of lead-tin alloy that would be introduced into the metallic stream by recycling of steel cans would cause difficulties.

Steel cans that pass through incinerators are essentially freed of lead.[51] The lead melts and collects in the ash fraction; lead has the lowest melting point (650°F) of all metals normally encountered in municipal wastes. Incineration thus appears to be a simple method for removing lead from tin cans before recycling.

Copper. The presence of copper wire in municipal wastes introduces another metallic contaminant. Copper is a problem primarily where the metallic waste passes through an incinerator. The copper tends to "plate" ferrous metals in the process, making its removal impossible by mechanical means. The maximum acceptable copper level in steel has been estimated as 0.1 percent;[52] copper is undesirable because it weakens the steel.

Copper found adhering to ferrous products in incinerator residues ranges from 0.2 to 0.5 percent according to the Bureau of Mines investigation results. If we assume that all municipal wastes are incinerated and, consequently, all 14.41 million tons of ferrous metals estimated to be in waste would have a copper content of 0.2 percent, recycling of this metal would contaminate the metallic stream with 28,820 tons the first year, a level of 0.017 percent, using the same assumptions (as applicable) as used for calculating tin accumulation above. The rate of accumulation slows down after the third year and reaches 45,863 tons of new copper contamination yearly, a level of contamination of 0.03 percent by the 12th year, well below the critical level.

Not all metal passes through incinerators, of course, and thus the total quantity of copper chemically linked to ferrous municipal wastes must be much lower than that found in incinerator residues. This suggests that copper contamination is not a technical deterrent to recovery of metals from wastes.

White Goods and Frit. The "white goods" (refrigerators, stoves, washers, driers, water heaters, etc.) that appear in bulky municipal wastes have an enamel coating ("frit"), which produces sulfur in the steelmaking process. Sulfur removal is one of the aims in steelmaking, and its introduction in scrap is frowned upon. Thus, for instance, screw making wastes, which have a high sulfur content, are the least desirable grades of prompt scrap.

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45 The making of steel, p.103.

46 Aluminum melts at a temperature of 1220F, iron at 2800F.

47 Gotsch, Waste from metal packages, p. 73.

48 Lyman, T., ed. Metals handbook. 8th ed. v. 1. Properties and selection of metals. Novelty, Ohio, American Society for Metals, 1961 p. 308, 1056.

49 McGannon, Steel, Kirk-Othmer Encyclopedia, p. 750.

50 The making of steel, p.105.

51 See analyses reported by Kenahan, Composition and characteristics of municipal incinerator residues, p.17.

52 Cammarota, Refining of ferrous metal, p.348.

In addition to frit, white goods contain copper or aluminum wiring, glass, plastics, paperboard, and other contaminants. Manual labor can remove motors, wiring, and the like, but it cannot be used (except at inordinate cost) to remove frit. Frit-covered metals, consequently, must be processed through automotive shredders before the metals can be reclaimed. Shredding blasts enamel off the sheet metal, and magnetic separation removes the nonferrous contaminants.

Conclusions. There appear to be no serious technical barriers to the recycling of ferrous metals from municipal wastes — barriers erected by the presence of unremovable impurities. The removal of impurities that respond to processing, however, or the distribution of municipal waste metals evenly to iron and steel producers to insure uniform dilution of unremovable impurities, create economic barriers that prevent the recycling of such metals so long as other sources of scrap can satisfy demand.

Demand, Supply, Prices

The demand for scrap is fixed by three factors: (1) total iron and steel production, which correlates with economic activity as a whole; (2) the ratio of virgin metallics to scrap consumed by the industry, which is largely but not entirely governed by process mix; and (3) export demand for scrap.

In the 1947 to 1968 period, total iron and steel production grew at a rate of 1.9 percent annually, from 99.9 to 148.0 million tons. Domestic scrap consumption in the same period grew at a rate of 1.7 percent yearly (60.9 to 86.8 million tons), showing that scrap is declining as a percent of total metallics consumed. The declining consumption of scrap relative to total inputs has been caused principally by process changes in steelmaking and by improvements in pig iron production as a result of ore upgrading which has kept the costs of pig iron production low.

Scrap exports, in this period, have grown dramatically — from 170,000 tons in 1947 to 6.6 million tons in 1968 — a rate of 19 percent annually. This growth, however, was in large part caused by removal of legislated constraints to scrap exporting. As a result of exports, total scrap consumption grew at a faster rate (2 percent a year) than iron and steel production. But the growth in scrap exports is beginning to level out. In the last 5 years of the period (1964 to 1968), an average of 6.8 million tons were exported compared with 6.7 million tons in the 1959 to 1963 period and 4.6 million tons in the 1954 to 1958 period.

The supply of scrap is also tied to a large extent to iron and steel production — that of home and prompt scrap to current production and that of obsolete scrap to the previous years' production. Because of the relatively slow and stable growth of iron and steel production, consumption of scrap has tended to be the same as scrap generation, *with the exception of automotive scrap.*[53] Scrap generated, of course, does not include all steel products that have become waste or obsolete. Some products are irretrievably lost, others, such as concrete reinforcing bars, are combined with foreign materials in such a manner that their recovery is impractical. Others end up in remote locations and are accumulated in small quantities so that their collection is uneconomical, and yet others become a part of the waste stream and are buried. With the exception of these materials, all other scrap tends to be collected as it is originated, the chief exception being automotive hulks, whose storage on land is frequently more economical for the owner than their sale to scrap dealers.

To put it another way: the supply of scrap in an absolute sense is greater than the demand for scrap; but the readily available scrap is recycled, the only major exception being a portion of obsolete automotive hulks. The large inventory of available obsolete car hulks, which is growing because storage is more economical than recycling, is tapped at times when scrap demand temporarily exceeds supplies of cheaper scrap. These auto hulks represent a pool of metallics that can be drawn upon quickly when economics warrant such action.

Scrap prices appear to be sensitive to demand for scrap rather than supply. High demand drives up scrap prices because it necessitates the collection of scrap from sources that are less economical to tap than those normally used, and dealers must increase the margin between price paid for scrap and price received to cover additional collection and processing costs. Business and Defense Service Administration analysts explain the price-demand relationship as follows:

> "As with any commodity traded in a free market, the price of scrap tends to be determined by its value in its marginal uses; that is, the uses just barely justified at that price. The major marginal use...appears to be in open hearth furnaces of

[53] Iron and steel scrap consumption problems, p.28.

integrated steel producers. Since scrap's principal competitive raw material is hot metal, made by these producers for their own use, purchased scrap tends to be attractive for their open hearths only when scrap prices are lower than the cost of making hot metal."[54]

Thus, when steel industry capacity to produce hot metal is exceeded by increased demand for steel, scrap must be purchased to satisfy the demand for input metallics by furnace operators who buy little or no scrap under ordinary demand conditions. The price of scrap consequently increases. When demand slacks off, these operators avoid scrap, and the prices drop.

In the mid 1960's, a considerable expansion in blast furnace capacity took place, in part as an attempt by the steel industry to free itself of dependence on scrap with its wildly swinging prices. In the 1954 to 1958 period, average tonnage of pig iron produced per year was 264,000 tons per blast furnace; production dropped to 254,000 tons in the 1959 to 1963 period; in the 1964 to 1968 period, however, production rose to 374,000 tons per year.

As a consequence of much higher blast furnace production rates possible in the 1960's, scrap prices did not fluctuate as wildly in the 1960's as they did in the 1950's. At the same time, the ratio of home scrap to purchased scrap used increased, further stabilizing prices (Table 39, Figure 18). In the 1960's, also, the cost of pig iron production appears to have dropped or stabilized as a result of greater efficiency in operations and the growing use of upgraded ore products, which translate to larger yields of pig iron.

The general decline in scrap prices at a time of expanding scrap consumption appears to be sparking an expansion in electric furnace capacity[55] and increased scrap use by basic oxygen furnace operators. In time, scrap prices will rise in response to improved demand, and a new round of adjustments will begin. In fact, scrap prices rose sharply in 1969 in response to such adjustments and record exports, but industry observers believe the price rise is temporary.

Scrap Recovery from Municipal Wastes

It is clear from the foregoing analysis that ferrous metals in municipal wastes are not required to supply the iron and steel industry with metallic inputs. Supplies of more desirable scrap exceed demand — the surplus being in the form of obsolete automotive hulk inventories. For this reason, instances of ferrous metal recovery from municipal wastes are exceptional.

When metals recovery is practiced, it usually takes one of three forms: (1) steel cans are recovered from incinerator residues and sold to copper mines; (2) massive iron pieces and bulky ferrous objects are removed from incinerator residues and sold as scrap; and (3) ferrous metals are retrieved by scavengers from dumps and landfills and sold as scrap.

The quantity of metal recovered in the above manner is very small. Our mail survey of 2,040 cities with 10,000 or more population plus our case studies appear to indicate a recovery of around 50,000 tons a year taking place with the knowledge of municipal officials. At best, total recovery from incinerators and dumps is perhaps double that figure — which would account for cases of illegal salvage and salvage activities where no records are kept. All in all, the tonnage is insignificantly small when seen in light of total scrap consumption. Most of the metal recovered from municipal sources, moreover, is shipped to copper mines rather than back to the steel industry.

Most municipal officials report that there is no market for ferrous metals from waste sources. Dealers indicate that massive iron and steel can be sold, but only if delivered to a dealer's yard. The quantities generated are small, the scrap is of low quality, and therefore dealers cannot afford the high transportation costs involved in picking up such metal. Where automotive shredders are operated, appliances are also accepted, but again only if delivered to the dealer.

Scrap Use in Copper Precipitation

One application where obsolete steel cans are readily accepted is in the copper mining industry. In the United States, approximately 8 percent of the copper consumed

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[54] Iron and steel scrap consumption problems, p.28.

[55] See for instance, Prugh, P. H. Thinking small. More steel users cut costs by purchasing from tiny new mills. Wall Street Journal, 176(83):1, 19, Oct. 26, 1970, which reports on the recent expansion of so-called "mini" mills.

(200,000 tons) is obtained by leaching lean ore deposits or tailings with sulfuric acid to obtain copper sulfate.[56] Production of this so-called "cement" copper grew from a quantity of 8,200 tons in 1921 and is still growing. Copper is precipitated out of the leach solution by substituting iron for copper.[57] This process consumes anywhere from 1.2 to 2.5 tons of iron for each ton of copper produced and consequently represents a specialized market for ferrous scrap.

Shredded tin cans — or any other ferrous metals with a large surface area per unit of weight — are ideally suited for the precipitation process[58] and are extensively used by copper mines. Bureau of Mines estimates that 300,000 tons of old steel cans and can making wastes are consumed yearly.[59]

At present, this is a growth market for shredding tinplate steel because copper extraction by leaching has been growing rapidly. But the market for precipitation iron will top out at 1 million tons a year, according to the Bureau of Mines, three times the 1967-1968 level. This growth will take place over a decade and longer and may not be realized if competing extraction techniques succeed.

Copper mines pay $50 to $60 a ton for precipitation iron at the mine site; thus, ironically, the despised tin-coated steel scrap brings the highest price for metal scrap in the United States. The high price, however, is explained by the fact that consumption points are in Arizona, Utah, Montana, and Nevada, and the shredded metal has a very low bulk density (20 to 25 pounds per cubic foot versus 150 pounds for baled metal) which results in freight penalties.

Freight charges are high (Figure 19) and account for much of the total cost. The most desirable precipitation iron is burned tin cans or tin plate scrap. Processing of this scrap by a dealer with suitable facilities costs $35.60 per ton, including the price paid for the metal (see Chapter XI, Houston). At a selling price of $50 per ton at mine site, the dealer can afford only $14.40 for freight and profit; at $60 per ton, the freight plus profit margin is $24.40. These costs limit the sales of used tinplate cans or scrap to areas within an economic freight distance of the copper mines.

The quantity of precipitation iron derived from municipal wastes is small in our estimation. We found only three cities where can recovery for copper precipitation was practiced on a continuing basis (Chicago, Houston, and Atlanta); these three cities together supplied between 32,000 and 37,000 tons of precipitation iron annually, between 10 and 12 percent of precipitation iron consumption. At the time of our visit to Houston, steel can recovery had been terminated because the incinerator was out of service for repairs.

Most of the precipitation iron comes from can making wastes, either directly from can producers or by way of detinning operations. Detinners handled 866,000 tons of tinplate scrap in 1967, nearly three times the quantity of metal consumed by copper mines. Most of the ferrous metal from these operations is recycled conventionally. Tinplate scrap occurring in cities near copper mines is sold as precipitation iron.

The limited market for precipitation iron — 1 million tons maximum 10 years from now — the availability of large quantities of can making wastes in concentrated form, and the unfavorable transportation situation indicate that recycling of a large percentage of obsolete steel cans to copper mining applications will not be practical.

Detinning

In 1967, 91,473 tons of tin were consumed in the United States, of which 65.5 percent was imported; nearly all the remainder was obtained from secondary sources, including 3,292 tons of tin obtained by detinneries from tinplate scrap and tin can production plant wastes. Tin is a valuable metal; in 1967, at a time of depressed tin prices, tin sold for $1.53 a pound in New York, or $3,060 per ton.

In spite of the high value of tin, detinning of obsolete steel cans is reportedly uneconomical, and the detinning industry accepts only clean tinplate scrap from industrial sources.[60]

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[56] Dean, K. C., R. D. Groves, and S. L. May. Copper cementation using automobile scrap in a rotation drum. U.S. Bureau of Mines Report of Investigation No. 7182. Pittsburgh, [Sept. 1968]. [16 p.]

[57] The reaction $Fe^{+} CuSO_4 \rightleftharpoons Cu\downarrow + FeSO_4$

[58] *Sheffer, H.W., and L. G. Evans. Copper leaching practices in the western United States.* U.S. Bureau of Mines Information Circular 8341. [Washington], U.S. Department of the Interior, [1968]. 57 p.

[59] Dean, Groves, and May, Copper cementation, p.1.

[60] Special studies for incinerators, p.76; Story, Problems of the salvage industry, p.162.

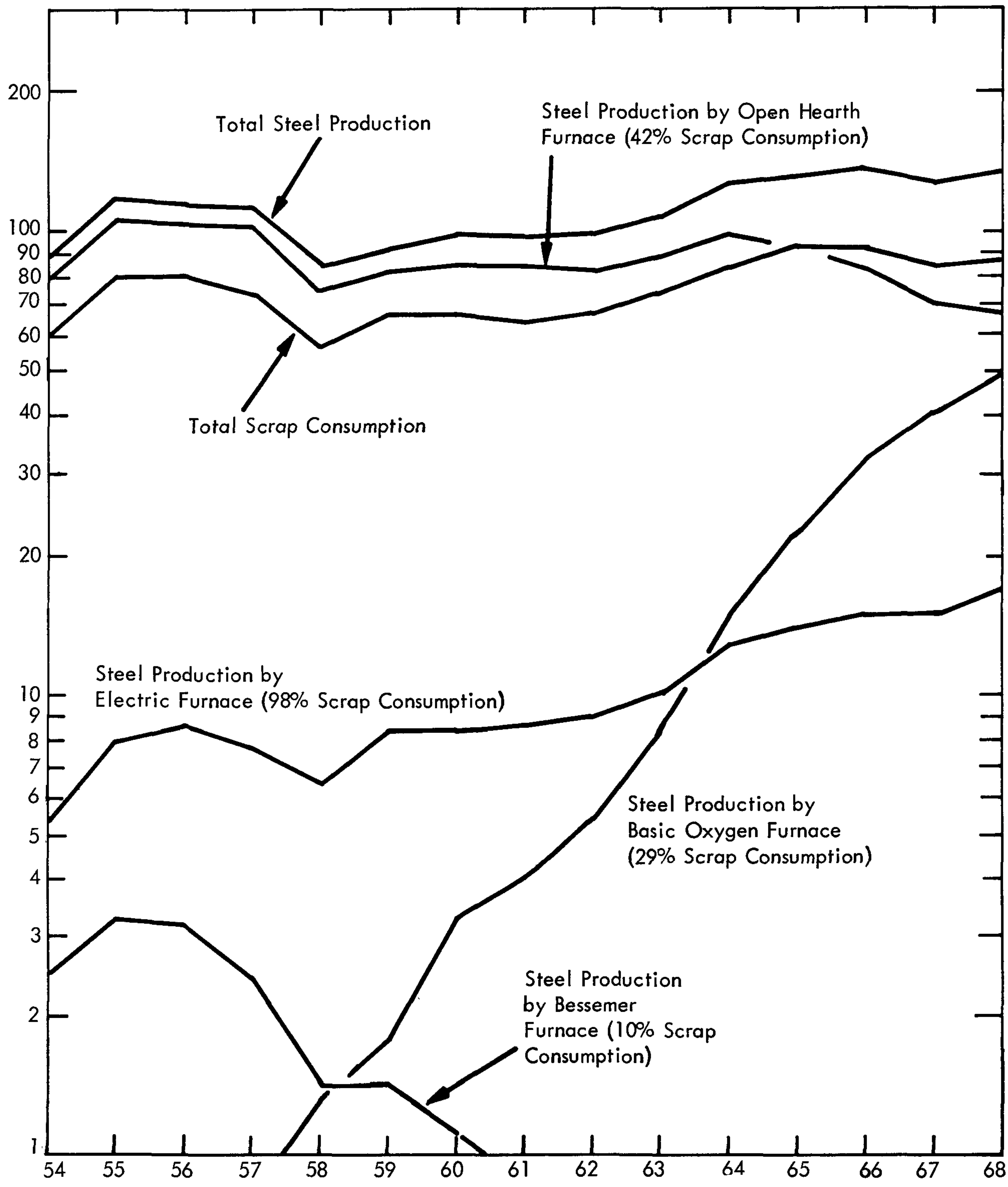
The detinning of obsolete cans appears to be uneconomical only if such recovery has to conform to current patterns of operation in the industry. Although cost data on operations of this industry are not available, one can get an idea of cost relationships by analysis of published data. The industry paid an average of $21.59 per ton for tinplate scrap inputs in 1967. Recovery of tin was at a rate of 0.408 percent of input scrap or, at a price of $3,060 per ton of tin, equivalent to $12.48 per ton of input steel. If we assume that the detinned steel was sold at the price of No. 2 bundles, income from steel scrap was $17.96, for a total value of input materials of $30.44 per ton. This leaves an operating margin of $8.85 per ton of input scrap. This is not a great deal of money when considering that ferrous scrap preparation costs range from $7.00 to $9.00 per ton. Obviously, detinners cannot afford additional handling chores to remove contaminating materials from obsolete cans.

However, the economics of detinning would be much more favorable — and would permit acceptance of obsolete cans — if scrap was made available to the industry at a cost below that now paid for this type of scrap.

Conclusions

Ferrous metals are recycled at a fairly high rate but below the potential supply of ferrous scrap. New metallics consumed by the industry are supplied from ore sources (80 percent) and obsolete scrap (20 percent). Higher consumption of obsolete scrap can be achieved by changing the value of ores relative to the value of scrap. Since the current value relationships are largely determined by free market forces that tend to keep costs minimal, higher scrap consumption rates will be paid for by higher iron and steel prices, either directly reflected in product prices or indirectly in subsidies to scrap collectors and processors.

Recycling of ferrous metals in municipal wastes is not practiced except in unusual cases. The reasons for this are: (1) the absence of sufficient demand to make such metals desirable; (2) the relatively high level of contaminants in municipal waste metals. Our analysis shows that contamination can be circumvented by processing and judicious dilution of municipal scrap with other metallics, but this would take place at a cost and would not solve the problem of absence of demand.



Source: 1968 Annual Statistical Report, American Iron and Steel Institute

Figure 15. Steel production by process, 1954-1968, in millions of net tons.

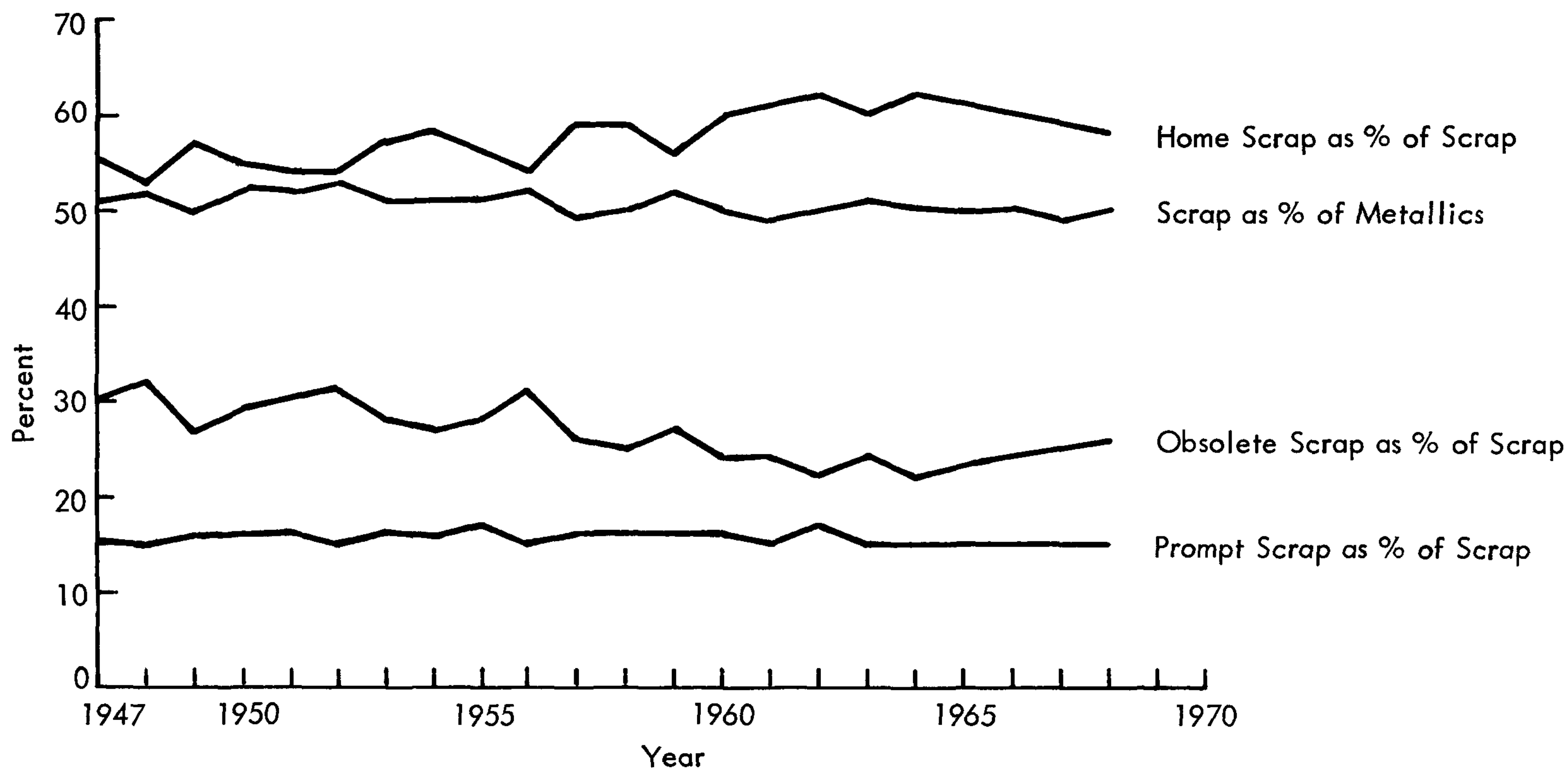


Figure 16. Scrap consumption, 1947-1968, as percent of metallics and type of scrap as percent of total scrap.

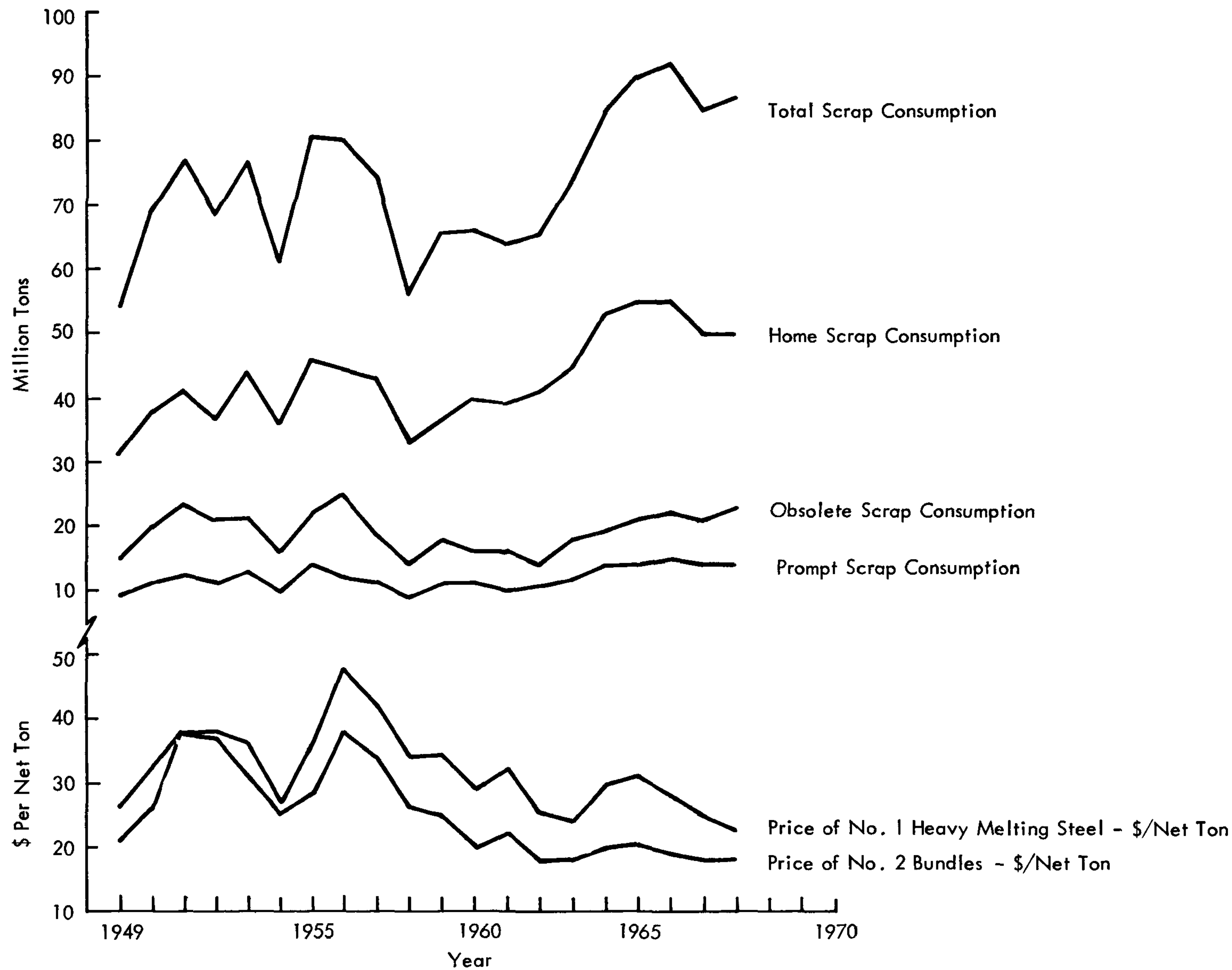


Figure 17. Scrap consumption and scrap price trends, 1949-1968.

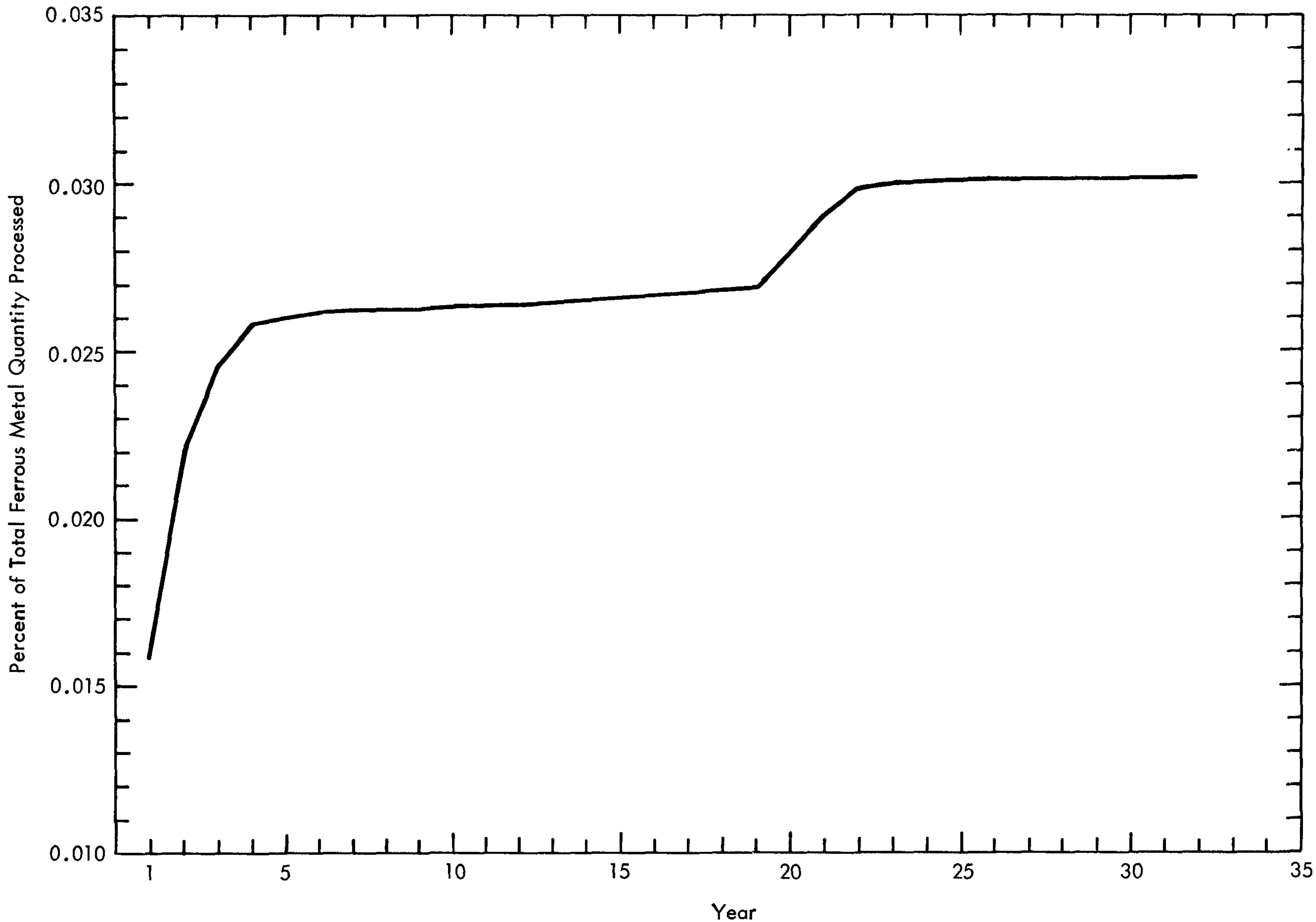


Figure 18. Percent of tin in total ferrous metal stream if all steel cans are recycled, 1967 basis, over time.

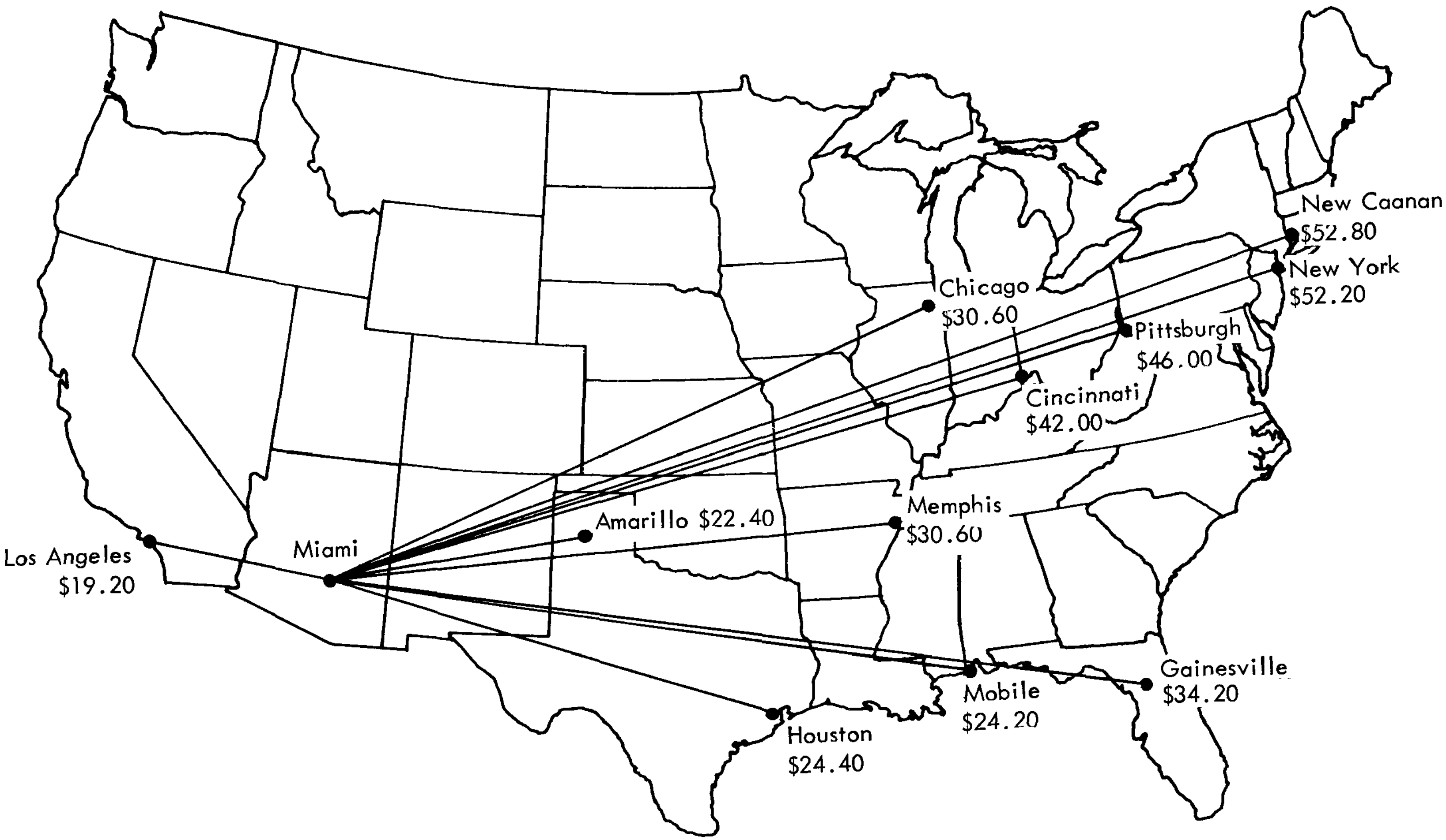


Figure 19. Freight rates to transport 1 ton of shredded tin can scrap from cities shown to Miami, Arizona, by rail, in carload lots of at least 30 tons.

TABLE 28

BLAST FURNACES AND STEEL
FURNACES IN USE IN THE UNITED STATES, 1967*

Type of furnace	Number of installations	Annual production in 1,000 tons†	Average annual production per furnace in 1,000 tons†
Blast furnace	225	86,984	387
Open hearth	591	70,690	120
Basic oxygen	45	41,434	921
Electric	266	15,089	57

*Annual statistical report, 1967. New York, American Iron and Steel Institute, 1968. Directory of iron and steel works, 1967.

†Refers to production of pig iron for blast furnaces and to raw steel production for the three types of steel furnaces.

TABLE 29

SCRAP AS A PERCENT OF METALLICS INPUTS TO STEEL FURNACES, 1947 TO 1968, BY TYPE OF FURNACE*

Type of furnace	Average % for period			
	1947-1953	1954-1958	1959-1963	1964-1968
Open hearth	45.8	43.6	41.5	41.7
Basic oxygen	--	--	27.7	29.2
Electric	98.2	97.4	97.3	97.9
Bessemer	5.2	10.8	10.5	--
Average, all furnaces	47.8	46.9	46.0	43.4

*Business & Defense Services Administration. Iron & steel scrap consumption problems. Washington, U.S. Government Printing Office, Mar. 1966. 52 p. Annual statistical report; 1968. New York, American Iron and Steel Institute, 1969.

TABLE 30

MAJOR STEEL INDUSTRY MARKETS, 1967*

Market area	Shipments in 1,000 tons	% of total
Transportation		
Automobiles	16,488	19.65
Rails	3,225	3.84
Ship and marine	943	1.12
Aircraft	102	0.12
Construction and contractors	15,957	19.02
Steel service centers	14,863	17.72
Industrial applications		
Oil and gas	315	0.37
Mining and lumbering	345	0.43
Machinery	7,802	9.30
Appliances and utensils	2,092	2.49
Containers and packaging	7,255	8.65
Conversion and processing	2,837	3.38
Ordnance	1,622	1.93
Bolts, nuts, rivets, etc.	1,128	1.34
All other	5,456	6.50
Total	83,897	100.00

*Annual statistical report, 1967. New York, American Iron and Steel Institute, 1968; refers only to products fabricated from domestic steel mill shapes; excludes steel castings and iron castings.

SING

PRIMARY PRODUCTION
STEEL FURNACES
(1,000 TONS)

SECONDARY PRODUCTION
ROLLING MILLS/FOUNDRY
(1,000 TONS)

PRODUCT MARKET SECTORS
FABRICATION
(1,000 TONS)

END USES
CONVERSION/CONSUMPTION
(1,000 TONS)

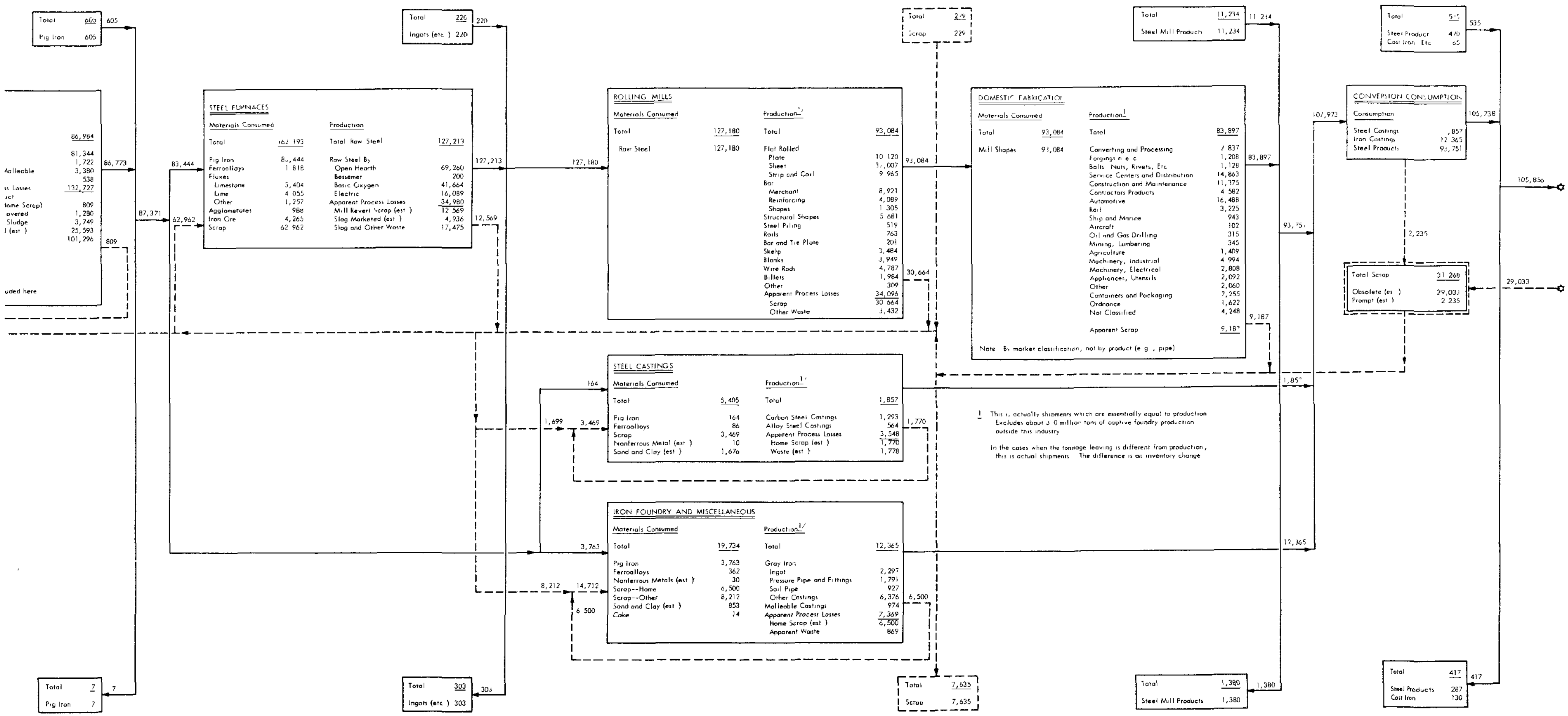


Table 31. Iron and Steel Materials Flow Cycle - 1967

TABLE 32

1967 IRON AND STEEL INDUSTRY MATERIALS BALANCE, IN 1,000 TONS*

Material category	Inputs or consumption		Outputs or production
Ores and scrap - domestic only			
Metal in ore	86,035	Product	95,884
Scrap	85,361	Home and prompt scrap	63,734
		Process loss (derived)	11,778
Total	171,396		171,396
Scrap only - domestic and foreign			
Blast furnaces	4,218		809
Steel furnaces	62,962		12,569
Rolling mills	--		30,664
Steel castings	3,469		1,770
Foundries	14,712		6,500
Fabrication	--		9,187
Conversion	--		2,235
Imports	--		229
Exports	7,635		--
Obsolete scrap (derived)†	--		29,033
Total	92,996		92,996

*From Table 31.

†Obsolete scrap was derived indirectly by working through industry statistics to determine the home and prompt scrap; the residual is the net scrap input to the system or scrap derived from sources external to the industry. The obsolete scrap was estimated from this latter total.

TABLE 33

U.S. IRON AND STEEL SCRAP CONSUMPTION, BY SOURCE, IN THOUSANDS OF SHORT TONS*

	Total scrap consumption		Home scrap †		Purchased scrap					
					Total purchased scrap		Prompt industrial scrap		Obsolete scrap	
Total	Quantity	Scrap as % of total metallics	Quantity ‡	% of total scrap	Quantity ‡	% of total scrap	Quantity §	% of total scrap	Quantity §	% of total scrap
1947	60,864	51.1	33,536	55.1	27,328	44.9	9,048	14.9	18,280	30.0
1948	64,964	52.0	34,430	53.0	30,534	47.0	9,741	15.0	20,793	32.0
1949	54,338	50.4	30.974	57.0	23,364	43.0	8,666	15.9	14,698	27.1
1950	68,901	51.5	37,728	54.8	31,173	45.2	11,267	16.4	19,906	28.8
1951	76,728	51.8	41,266	53.8	35,462	46.2	12,319	16.1	23,143	30.1
1952	69,023	52.9	36,997	53.6	32,026	46.4	10,574	15.3	21,452	31.1
1953	77,130	50.8	43,733	56.7	33,397	43.3	12,609	16.3	20,788	27.0
1954	61,354	51.1	35,585	58.0	25,769	42.0	9,702	15.8	16,067	26.2
1955	81,375	51.3	45,651	56.1	35,724	43.9	13,537	16.6	22,187	27.3
1956	80,315	51.7	43,611	54.3	36,704	45.7	12,167	15.1	24,537	30.6
1957	73,549	49.1	43,100	58.6	30,449	41.4	11,382	15.5	19,067	25.9
1958	56,360	49.6	33,309	59.1	23,051	40.9	8,728	15.5	14,323	25.4
1959	66,062	51.7	37,272	56.4	28,785	43.6	10,839	16.4	17,946	27.2
1960	66,469	49.9	40,074	60.3	26,395	39.7	10,662	16.0	15,733	23.7
1961	64,327	49.4	38,943	60.5	25,384	39.5	9,695	15.1	15,689	24.4
1962	66,160	49.8	40,796	61.7	25,364	38.3	10,903	16.5	14,461	21.8
1963	74,621	50.7	44,939	60.2	29,682	39.8	11,912	16.0	17,770	23.8
1964	84,626	49.5	52,553	62.1	32,073	37.9	13,540	16.0	18,533	21.9
1965	90,359	50.4	55,125	61.0	35,234	39.0	14,457	16.0	20,777	23.0
1966	91,583	50.0	55,162	60.2	36,421	39.8	14,653	16.0	21,768	23.8
1967	85,361	49.4	50,234	58.8	35,127	41.2	13,658	16.0	21,469	25.2
1968	86,766	50.3	49,949	57.6	36,817	42.4	13,818	16.0	22,999	26.4
Annual averages:										
1949-53	69,224	51.5	38,140	55.1	31,084	44.9	11,087	16.0	19,997	28.9
1954-58	70,590	51.0	40,251	57.0	30,339	43.0	11,103	15.7	19,236	27.3
1959-63	67,528	50.3	40,406	59.8	27,122	40.2	10,802	16.0	16,320	24.2
1964-68	87,739	49.9	52,605	60.0	35,134	40.0	14,038	16.0	21,109	24.0

*From sources shown in footnotes for 1947-1964; updated by Midwest Research Institute using comparable data from Institute of Scrap Iron and Steel and Bureau of Mines.

†Home scrap from the sources is defined as recirculating scrap not subject to a commercial transaction; some home scrap has been classified in the prompt category under this definition.

‡Institute of Scrap Iron and Steel and BDSA for 1959-64, BDSA estimates for earlier years, based on Bureau of Mines data, and adjusted by BDSA for comparability.

§Based on estimating techniques developed by Battelle Memorial Institute and revised by BDSA.

TABLE 34

RELATIVE COST RELATIONSHIPS BETWEEN PIG IRON AND SCRAP AS STEEL FURNACE INPUTS, IN 1967, IN 1,000 TONS, PERCENT, AND DOLLARS

Materials	Blast furnace inputs consumed in 1967*	% of total	Value per ton+	Prorated cost per ton of input
Iron ore	42,523	19.35	5.30 - 8.86	1.03 - 1.71
Agglomerates	96,875	44.09	10.95	4.83
Fluxes	14,422	6.57	13.42	0.88
Coke	56,197	25.58	17.42	4.46
Home scrap	809	0.37	--	--
Other scrap	3,409	1.55	23.78	0.37
Mill cinder and scale	5,476	2.49	--	--
	219,711	100.00	--	11.57 - 12.25
Tons of raw materials required per ton of pig iron and output				2.53
Cost of raw materials per ton of pig iron produced				29.27 - 30.99
Cost of heavy melting steel scrap (average, 1967)				23.78
Cost of No. 2 bundles (average, 1967)				18.24
Cost of No. 1 cupola cost (December 1967)				37.95
Value of finished pig iron (average, 1967)				57.20

*From Table 31. U.S. Bureau of Mines. Minerals yearbook 1967. v. 1-11. Metals, minerals, and fuels. Washington, U.S. Government Printing Office, 1968. Ore: low figure is hematite (p. 590); high figure is average value of all U.S. ore at mine (p.677); coke: value at ovens, average for 1967 (p. 401); scrap: composite price of heavy melting scrap 1967 (p. 634).

TABLE 35

MAXIMUM SCRAP CONSUMPTION POSSIBLE
IN STEEL FURNACES IN 1967, IN 1,000 TONS*

Type of furnace	Metallic inputs	Maximum technically feasible scrap consumption in % of metallic inputs	Maximum scrap consumption in year	Actual scrap consumption in year
Open hearth	82,413	70 - 80	57,689 - 65,930	
Bessemer	242	20	48 - 48	
BOF	49,578	50 - 60	24,789 - 29,747	
Electric	19,150	98	18,767 - 18,767	
Total	151,483	67 - 76	101,293 - 114,492	62,962

*From Table 31 and Iron and steel scrap consumption problems, p. 14.

TABLE 36

SOURCES OF OBSOLETE SCRAP,
1959*

Scrap source	% of total obsolete scrap
Railroads	14.7
Auto wreckers	13.1
Demolition projects	6.8
Farms	5.2
Shipwrecking	4.2
Public utilities	2.1
Government agencies	1.6
Miscellaneous--oil fields, refineries, mines, incinerators, dumps, housing repair and maintenance, general collection	52.3
Total	100.0

*McGannon, The making, shaping, and treating of steel, p. 224.

TABLE 37

SCRAP CONSUMPTION IN 1967 BY GRADE GROUPINGS*

Grade	Consumption in 1,000 tons	% of total
Low phosphorous plate and punchings	4,051	4.75
Cut structural plate	1,212	1.44
Steel car wheels	179	0.21
No. 1 heavy melting	28,049	32.86
No. 1 and electric furnace bundles	7,213	8.45
No. 2 and all other bundles	5,354	6.27
Turnings and borings	2,914	3.41
Slag scrap (ferrous content)	2,940	3.44
All other carbon steel scrap	14,659	17.17
Alloy steel, excluding stainless	3,004	3.52
Stainless steel	863	1.01
Cast iron borings	1,595	1.87
All other cast iron scrap	13,320	15.60
Total	85,361	100.00

*Minerals yearbook 1967, p. 631.

TABLE 38

QUANTITY OF TIN IN FERROUS METALS IF ALL STEEL CANS ARE RECYCLED, IN TONS AND PERCENT OVERTIME, 1967 BASIS*

Year	Tons of tin in ferrous metals	Tin as % of total ferrous metals
Start		
Year 1	27,032	0.0158
2	37,885	0.0221
3	42,248	0.0246
4	43,998	0.0257
5	44,705	0.0261
6	44,988	0.0262
7	45,099	0.0263
8	45,145	0.0263
9	45,152	0.0263
10	45,164	0.0264
11	45,174	0.0264
12	45,178	0.0264
19	46,022	0.0269
20	48,086	0.0281
21	49,939	0.0291
22	51,084	0.0298
23	51,725	0.0302
24	52,049	0.0304
25	52,195	0.0305
26	52,271	0.0305
27	52,299	0.0305
28	52,309	0.0305
29	52,338	0.0305
30	52,339	0.0305
31	52,349	0.0305
32	52,353	0.0305

* From Midwest Research Institute calculations.

TABLE 39

PRICES OF TWO GRADES OF SCRAP, ANNUAL AVERAGES, 1949 to 1968, IN DOLLARS PER NET TON*

Year	No. 2 bundles	No. 1 heavy melting steel
1949	20.99	25.55
1950	26.18	31.56
1951	37.83	38.52
1952	38.25	37.41
1953	30.73	35.63
1954	19.89	25.66
1955	27.99	35.50
1956	38.27	47.73
1957	33.60	42.06
1958	25.57	33.76
1959	24.91	33.66
1960	19.78	29.42
1961	22.07	32.40
1962	18.25	25.21
1963	17.73	24.21
1964	20.26	30.07
1965	20.39	30.67
1966	19.47	27.57
1967	18.24	24.66
1968	17.96	23.08

*Institute of Scrap Iron and Steel. 1969 Yearbook. 30th ed. Washington, 1969. Based on composite price at Chicago, Pittsburgh, and Philadelphia, as compiled by American Metal Market. Conversion to dollars per net ton by Midwest Research Institute.

CHAPTER VI

NONFERROUS METALS

Overview Discussion

A convenient classification of nonferrous metals is into: (1) common nonferrous metals, aluminum, copper, zinc, and lead; (2) exotic metals, nickel, cobalt, chromium, titanium, zirconium, molybdenum, tungsten, columbium, tantalum, and beryllium; and (3) precious metals, gold, silver, platinum, palladium, rhodium, and iridium. Magnesium and tin might be considered as common nonferrous metals; however, these substances were consumed in very small quantities, around 90,000 tons yearly versus a million or more for the others.

Our discussion will be restricted to the four major common nonferrous metals, with special emphasis on aluminum, which is consumed in greatest quantity overall and is also the dominant nonferrous metal in waste.

Common nonferrous metals consumed in 1967 weighed 9.8 million tons. In contrast to steel selling for $130 per ton and pig iron selling for $56 per ton, these metals are expensive. Their values range from $277 per ton for zinc to $764 for copper; the composite value of these metals in 1967 was $517 per ton. Scrap consumption rates, measured as a percent of total consumption, range from a high of 49.7 percent for copper to a low of 12.6 percent for zinc; the composite rate for all four metals in 1967 was 30.8 percent; the rates shown above exclude home scrap (Table 40). The comparable recycling rate for iron and steel was only slightly higher — 31.2 percent.[61]

Although the value of these metals is high, they appear in small quantities, often in combination with other metals, and require considerable processing. Thus, the basic observations that apply to other materials also apply to nonferrous metals; namely, that scrap, to be recoverable, must appear in fairly clean form and in fairly large quantities before it can be recycled. The basic difference between nonferrous metals and other recoverable commodities is that their high value permits relatively more processing and the acquisition of relatively small quantities.

Nonferrous metals are about 0.6 percent of municipal wastes, or approximately 1.2 million tons of the 194 million tons total collected in 1968.

Aluminum Recycling

The only nonferrous metal that occurs in significant quantities in municipal waste is aluminum, principally because this metal has become an important container and packaging material, used in cans, foils, trays, and the like. Aluminum appears to be about 0.35 percent of municipal waste, or an estimated 678,000 tons in 1968; all other nonferrous metals are about 0.1 percent, or about 194,000 tons in 1968. This would indicate that roughly 14 percent of aluminum consumed but only 4 percent of all other major nonferrous metals consumed enter municipal wastes.

Industry Characteristics. The aluminum industry is made up of (1) integrated primary aluminum producers and fabricators who convert bauxite into fabricated aluminum products, (2) nonintegrated aluminum producers who rely on scrap and primary and secondary aluminum ingot purchased on the open market, and (3) secondary smelters who convert scrap aluminum into secondary ingot.

The chief consumers of scrap in 1969 were secondary smelters (67 percent), followed by integrated producers (19 percent) and nonintegrated producers (14 percent). Integrated producers generally obtain the scrap they consume from internal source and customer scrap; smelters and nonintegrated producers buy scrap. Nearly

[61] In 1967, steel consumption was 105.9 million tons; obsolete and prompt scrap consumption excluding exports was 33.1 million tons.

90 percent of secondary ingot produced by secondary smelters is consumed by nonintegrated foundries. Thus, there is considerable circular activity in scrap recycling.

The aluminum industry resembles iron and steel in structure. Secondary smelters are analogous to electric furnace operators; integrated producers to steel producers with blast furnace capacity; and nonintegrated producers to the iron and steel foundries.

Scrap Use Patterns. Aluminum scrap is obtained (1) from internal primary aluminum production processes, (2) from fabrication and conversion and (3) from obsolete products. In 1967, an estimated 882,795 tons of purchased aluminum scrap were consumed by the industry; about 60 percent of this tonnage passed through dealer hands on its way back to furnaces. New scrap accounted for 711,399 tons, or 80.6 percent of the total; sweated pig was 63,604 tons, or 7.2 percent of the total (Table 41, Figure 20).[62] In 1967, independent foundries consumed 617,145 tons, or 70 percent; primary aluminum producers consumed 122,987 tons, or 14 percent; and fabricators, foundries, and chemical plants consumed 142,663 tons, or 16 percent.[63]

"New" scrap comes in three forms: borings and turnings that occur in machining operations; clippings, forgings, and other solids; and residues such as dross, skimmings, and slag produced in various melting operations.

"Old" scrap is obtained from junked airplanes, scrap aluminum foil, dismantled automobiles, scrapped power cables, aluminum cans, and discarded household products.

Sweated pig is a special category, usually included with old scrap. This is aluminum removed from iron and steel by heating mixed scrap in sweating ovens until the aluminum melts and runs out.

In the 1950 to 1969 period, consumption of secondary aluminum grew at an annual rate of 8.2 percent, and production of primary aluminum at 9.2 percent. In the last decade, secondary aluminum has begun to grow faster than primary, at 10.0 percent a year in the 1960 to 1969 period versus 7.3 percent for primary aluminum.

Since most secondary aluminum goes into castings, the rapid growth of secondary aluminum is explained by the growth of aluminum castings in the 1960 to 1969 period at a rate of 9.2 percent yearly.

Recovery Economics. Unlike the situation in the steel industry, where scrap and pig iron do not compete on an equal basis for various reasons, scrap aluminum in the form of secondary ingot competes directly with primary ingot in the nonintegrated segment of the industry. Secondary ingot is generally cheaper than primary. For example, a common alloy, No. 380, produced from scrap has sold for an average of $63 per ton lower than the same alloy produced from primary aluminum in the 1960 to 1968 period. The price of the secondary alloy was an average of $470; that of the primary alloy, $533 per ton in the period. Primary aluminum, however, is preferred in all cases where a high level of purity is required.[64]

Economics favor secondary aluminum because the production of primary aluminum requires high investments — $700 to $800 per ton of annual capacity — and the process requires electric power of 15,000 to 16,000 kilowatt hours per ton of aluminum.[65] For this reason, primary producers tend to locate near sources of low-cost electricity. Power costs are usually low in areas remote from industrial centers, and therefore primary aluminum producers have high freight costs, ranging from $5 to $30 per ton. Primary aluminum production costs, including freight to fabricators, range from $306 to $470 per ton.

Secondary smelters can install capacity for $100 to $120 per ton and can locate near scrap sources that are also end-use consumption points. This saves freight costs. Operating costs are also lower because the principal operation is scrap melting instead of electrolytic reduction of alumina to aluminum. Expanding aluminum castings markets, favorable secondary aluminum smelting economics, and ever more abundant scrap resources have contributed to a steady expansion of secondary smelting — from 25 plants in 1941 to more than 90 at present. Secondary smelter total production costs range from $375 to $450 per ton.

Secondary Aluminum Operations. Scrap aluminum is obtained and processed by nonferrous metal dealers and constitutes around 22 percent of such

[62] The 1967 data are based on coverage of about 84 percent of the industry; total scrap consumption for the industry is estimated by the Bureau of Mines at 1,050,000 tons in 1967 and 1,229,000 tons in 1969.

[63] See Table 41 for data sources.

[64] Farin, P., and G.G. Reibsamen. Aluminum, profile of an industry. New York, McGraw-Hill, Inc., 1969. p.35, 41.

[65] Farin, and Reibsamen, Aluminum profile, p.52.

dealers' throughput tonnage. The average scrap preparation cost is $44.40 per ton.[66] Dealers pay anywhere between $155 per ton (for aluminum borings) to $290 per ton (clippings) for the metal to generators and collectors, and they sell the metal to smelters on a delivered basis for $280 per ton (borings) to $355 per ton (single alloy clippings).[67]

Processing of the aluminum scrap depends on the type of scrap. New clippings need only be sorted to remove nonaluminum materials. Borings and turnings must be shredded and dried — the presence of moisture can cause explosion hazards in melting. Residues are milled and nonmetallics and oxides are screened out. Old castings and aluminum sheet are crushed and shredded, passed through magnetic separators to remove iron, and screened to remove pulverized nonmetallics. Aluminum occurring in combination with iron is separated by sweating. Obsolete aluminum cans must be handled like borings and turnings and must pass through magnetic separation units following shredding.

Aluminum Can Reclamation. The largest nonferrous metal component in solid waste is made up of aluminum cans, foils, trays, and the like. Shipments of aluminum containers and packaging in 1969 were 596,500 tons, with metal and composite cans accounting for 333,000 tons.[68]

Aluminum container and packaging shipments grew at a rate of 15.7 percent a year in the 1960 to 1969 period (16.3 percent in 1969 alone); waste generation is growing at a rate of around 4 to 6 percent a year.[69] Thus, the proportion of aluminum in waste is on the increase. This fact, plus the high value of aluminum and the "visibility" of aluminum cans in litter, has led to efforts on the part of aluminum producers and can users to explore the possibility of obsolete aluminum can and sheet recycling.

The most prominent company in obsolete aluminum can recycling has been Reynolds Aluminum; more recently, Coors Brewing Company, Kaiser Aluminum, and Alcoa have become involved.

Reynolds had collected aluminum oil cans from filling stations as far back as 1958, a program that was discontinued as fiber-based oil cans captured this market. Since the early 1960's, the company has agreed to buy back farm roofing and siding materials from buyers for $200 per ton when these materials become obsolete. In 1967, the company launched an experimental can reclamation program in Miami, Florida, in which a chain of gasoline stations acted as collection centers. The stations gave coupons worth one-half cent for each aluminum can brought in; the coupon was redeemable for oil or gas purchases. Next the company expanded the program to include collection points at a chain of grocery stores in unattended Dempster Dumpsters; the proceeds went to a local children's hospital.

A third collection system was tried later that involved Goodwill Industries. The public was asked to deposit cans in Goodwill collection boxes in various shopping centers. Goodwill was paid a fee for collecting and shredding the cans. Total collections ran about 1 ton per month, an insignificant portion of the aluminum cans occurring in Miami. At such a low volume, the costs of collecting relatively small quantities of aluminum were high relative to the proceeds.[70]

A second experiment was begun in Los Angeles in 1969. This time, a single reclamation center was set up, and individuals and organizations were invited to bring in aluminum cans and other aluminum scrap for a cash payment of $200 per ton (10 cents per pound). The operation was calculated to break even if 32 tons were received monthly; this point was reached in October 1969 and has been maintained since (see Chapter XI, Los Angeles case study, for details).

The success of the Los Angeles program has led to a decision by Reynolds to continue the program permanently and to expand it to other cities and states. By mid-1970, the company had operations modeled on the Los Angeles center in Miami, Tampa, and Houston. Centers in New York, San Francisco, and an unspecified

[66] Industrial profile and cost factors in nonferrous scrap processing. New York, National Association of Secondary Material Industries, Inc., [1969]. p.3,14.

[67] Prices based on July 1969 quotations.

[68] Aluminum statistical review, 1969. New York, The Aluminum Association, 1970. 64 p.

[69] Vaughan, R.D. National solid wastes survey; report summary and interpretation. In The national solid wastes survey; an interim report. [Cincinnati], U.S. Department of Health, Education, and Welfare, [1968]. p.47-53.

[70] Testin, R. F. Recycling of used aluminum products. In Proceedings; Third Annual North Eastern Regional Antipollution Conference, Reuse and Recycle of Wastes, University of Rhode Island, July 21-23, 1970. Stamford, Conn., Technomic Publishing Co., Inc. 1971. p.7-9.

location in the Pacific Northwest were planned. In addition, Coors beer distributors in 10 western states were being organized to serve as collection points (as opposed to processing points). Cans collected at these points are sent to Golden, Colorado, to be processed on equipment supplied by Reynolds except in the Los Angeles area where the Coors distributors are satellites of the Reynolds processing center there. Reynolds officials expected that can reclamation centers would be established in 16 states by the end of 1970 — either directly operated by Reynolds or by other companies in cooperation with Reynolds.[71] Aluminum collected by Reynolds is shipped to a Reynolds plant in Sheffield, Alabama, or Richmond, Virginia.

Reclamation economics depend on the delivery of aluminum to the Reynolds centers by individuals and organizations and on a sufficiently high quantity to use the processing equipment at the reclamation plant economically. Data released by Reynolds indicate that aluminum scrap delivered to their smelters costs $480 per ton at current collection quantities (excluding general administrative expense and advertising) while the scrap is valued at $530 per ton.

Reynolds' experience shows that recycling of obsolete aluminum cans is feasible and profitable provided that the material is delivered to a central processing plant for no more than $200 per ton and further that at least 32 tons per month, or 384 tons per year, of aluminum can be obtained.

Because these programs are voluntary, the quantity of aluminum cans ultimately recovered will be between 5 and 30 percent of that reaching the market, according to Reynolds estimates. Recovery trends in the Los Angeles center seem to indicate that in 1971 up to 10 percent of total cans reaching the market place will be recovered, compared to the early 1970 rate of 2 percent.

The Kaiser Aluminum and Chemical Corporation announced the formation of a can reclamation program in San Francisco in early 1970.[72] Cans are accepted at 11 collection sites in the San Francisco area. Only all aluminum cans are accepted. Payment is $200 per ton (10 cents a pound). Coors distributors in the area and the Falstaff Brewing Company are participating in the program.

Alcoa's program was announced in September 1970.[73] The initial program is based in San Diego, California. Cans may be delivered to three Coors beer distributors, six major shopping centers, and a nonferrous metal dealer who also does processing. The 11th Naval District and Coca-Cola of San Diego are also cooperating. Alcoa also pays 10 cents per pound. The metal collected is shipped to Indiana, where the scrap is converted into new aluminum can stock. The San Diego program will be followed by similar efforts in Dallas and Fort Worth, Texas.

Programs started or operated by aluminum producers, brewers, and soft drink producers represent the foundation for a nationwide, voluntary, aluminum packaging recycling system that may well recover 30 percent of aluminum packaging ultimately. There are no technical limitations to recycling aluminum; rather the problem areas of recovery are separation and collection. All of these programs rely on voluntary citizen collection and delivery to a special site; in other words, they involve presegregation and special handling. As yet no company has attempted to tie aluminum packaging and reclamation directly to a municipal waste system, and we found no processing system that sought the aluminum content of mixed refuse in materials.

Other Nonferrous Metals

All other nonferrous metals occur in municipal waste in very small quantities and, consequently, at very low concentrations. Copper makes its appearance in small electrical household appliances in mixed refuse and in major appliances in bulky wastes as copper wire; brass and bronze fixtures also introduce copper into wastes. Zinc appears as an alloy in bronze, brass, and aluminum; as a coating on steel; in some automotive grilles; in toys and small fixtures; in lithograph plates; in addressograph plates; and the like. Lead is introduced as solder in cans, by batteries, as type metals, as ballast in lamps, as an alloy in bronze and brass fixtures, in plumbing fixtures, and in collapsible tubes.

With the exception of lead, virtually none of the nonferrous metals now recovered have ever been in the form of products in consumer markets. They are recovered from industrial wastes, obsolete industrial

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[71] Testin, Recyling of used aluminum products, p.7-9. Personal communication. R.F. Testin, Reynolds Metals Company, to A. J. Darnay, Midwest Research Institute, Dec. 22, 1969.

[72] Kaiser's can-do recycling program. Secondary Raw Materials, 8(6):130-132, June 1970.

[73] Aluminum Company of America. Press release, Sept. 23, 1970.

structures, or governmental wastes (such as cartridge cases) and demolitions.

Copper. Most obsolete copper scrap is wiring and other electrical fixtures obtained from electric utility demolitions (34 percent of obsolete copper scrap). Spent cartridges (4 percent), railroad car dismantling (4 percent), and automotive radiators (9 percent) are other copper grades that reveal their origin. A small quantity of copper wiring and copper-base alloys is obtained from dumps by scavengers and by scrap yards that still accept appliances. Nearly 65 percent of copper consumed is made into electrical wire, and this product, in turn, is used principally in industrial applications, utilities, and motors, where the copper is recovered. Brass mills, which account for nearly 34 percent of consumption, produce industrial products such as boiler condensers, ship propellers, industrial cocks and faucets, artillery cartridge cases, and similar products that are normally salvaged.

Small and large household appliances are the only significant source of copper in municipal wastes. This source is no longer economical unless some of the stripping and collection is subsidized in some way. Thus much of it finds its way into municipal waste systems today despite the high value of copper as scrap.

Zinc. Nearly 80 percent of all zinc recycled is "new" scrap, the major grades being zinc skimmings and ashes derived from zinc galvanizing operations, galvanizers' dross, and chemical residues. "Old" zinc scrap consists of roofing zinc, organ pipes, jar lids, and boiler plates; engravers' plates are a special grade; and diecastings, which include automotive grilles, aircraft forming dies, and other castings, are a third obsolete zinc scrap grade. The relatively low recovery rate for zinc is explained by the manner in which this metal is used — as an alloying agent and coating and as small objects and fixtures. All of these applications make recycling difficult.

Lead. In 1967, lead recovery from new and old scrap was equivalent to 57.6 percent of lead consumption. In actuality, consumption of lead of 1.261 million tons included 247,000 tons of lead used in gasoline additives. If we regard this tonnage as lost for all practical purposes, "solid" lead consumption was 1 million tons, of which 726,000 tons was supplied by scrap, or 71.6 percent of solid lead consumption.

Most recovered lead (86.1 percent) in 1967 was obtained from obsolete materials, 625,000 of 726,000 tons. Most of the obsolete lead (72.6 percent, 454,000 tons) comes from lead battery plates. Recovery of batteries is usually accomplished by specialists. This operation requires facilities for breaking batteries, the collection and neutralization of battery acid prior to discharge into sewers, and equipment to crush battery cases before hauling them to the dump. Specialists have grown in importance as one-piece battery covers replaced multipiece covers. Batteries in one-piece covers cannot be broken by being dropped, and special breaking equipment is necessary.[74] In addition to batteries (which come from auto dismantlers, filling stations, garages, and industrial, farm, railroad, and military demolition), lead is also recovered from obsolete lead-coated cable, a variety of other sources in industrial plants and military installations, and from type metal.

Recovery of lead from obsolete batteries is at a very high rate. In the years 1966 to 1968, lead scrap from batteries was equivalent to 91.4 percent of lead consumption for batteries. Recovery of lead from type metals consistently exceeded consumption of lead in type in the period, reflecting the fact that type lead consumption has stayed relatively stable for more than a decade while scrapping of type metals has increased as lithography has displaced letterpress printing. Lead scrap recovered from cable cover lead has been equivalent to 54.8 percent of consumption for this application in the 1966-1968 period. Unlike batteries and type, however, cable lead has a longer life in use (Table 42).

Scrap Consumption Trends

Nonferrous scrap consumption as a percent of total metals consumption remained relatively unchanging in the 1963-1967 period (Table 43). Scrap as a percent of consumption was 34.8 percent in 1963 and 34.7 percent in 1967; in 1965 it was 31.0 percent.

Consumption of the four major metals grew at a rate of 4.7 percent annually; the scrap consumption growth rate was 4.8 percent. Aluminum and lead scrap consumption grew at faster rates than total consumption of these metals, 8.1 percent for aluminum scrap versus 7.2 percent for all aluminum and 7.3 percent for lead scrap versus 2.1 percent for all lead.

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[74] A study of the secondary lead industry in the United States. New York, National Association of Secondary Material Industries, Inc., [1969]. p.3-4.

Scrap consumption trends in aluminum are already high and are expected to stay high as more aluminum becomes available as scrap. The economics of scrap remelting are favorable over primary production. Aluminum consumption in 1942 was 726,000 tons; in 1967 it was 4.0 million tons, better than a fivefold increase, which means that each year a larger tonnage of aluminum becomes available. The industry is still far from reclaiming all obsolete aluminum scrap that occurs. The metal has an estimated life-in-use of 22 years. In 1945, 943,000 tons were shipped, equal to the tonnage of obsolete aluminum that should have been available in 1967. In 1967, however, only 172,000 tons of obsolete aluminum scrap was recovered, or 18 percent of the tonnage theoretically available. The availability of scrap aluminum and the fact that bauxite is an abundant natural resource indicate that an aluminum shortage is not likely to occur in the foreseeable future.

Copper, zinc, and lead are all materials in short supply worldwide. An estimate published in 1965,[75] put known free-world reserves of these metals at 43 years for copper, 27 years for zinc, and 15 years for lead. The high rate of copper and lead recovery are in part a reflection of this shortage, and we expect recovery of these metals to increase.

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[75] Fangel, H. An expert forecasts future metal needs. Engineering and Mining Journal, 166(3):100,Mar. 1965.

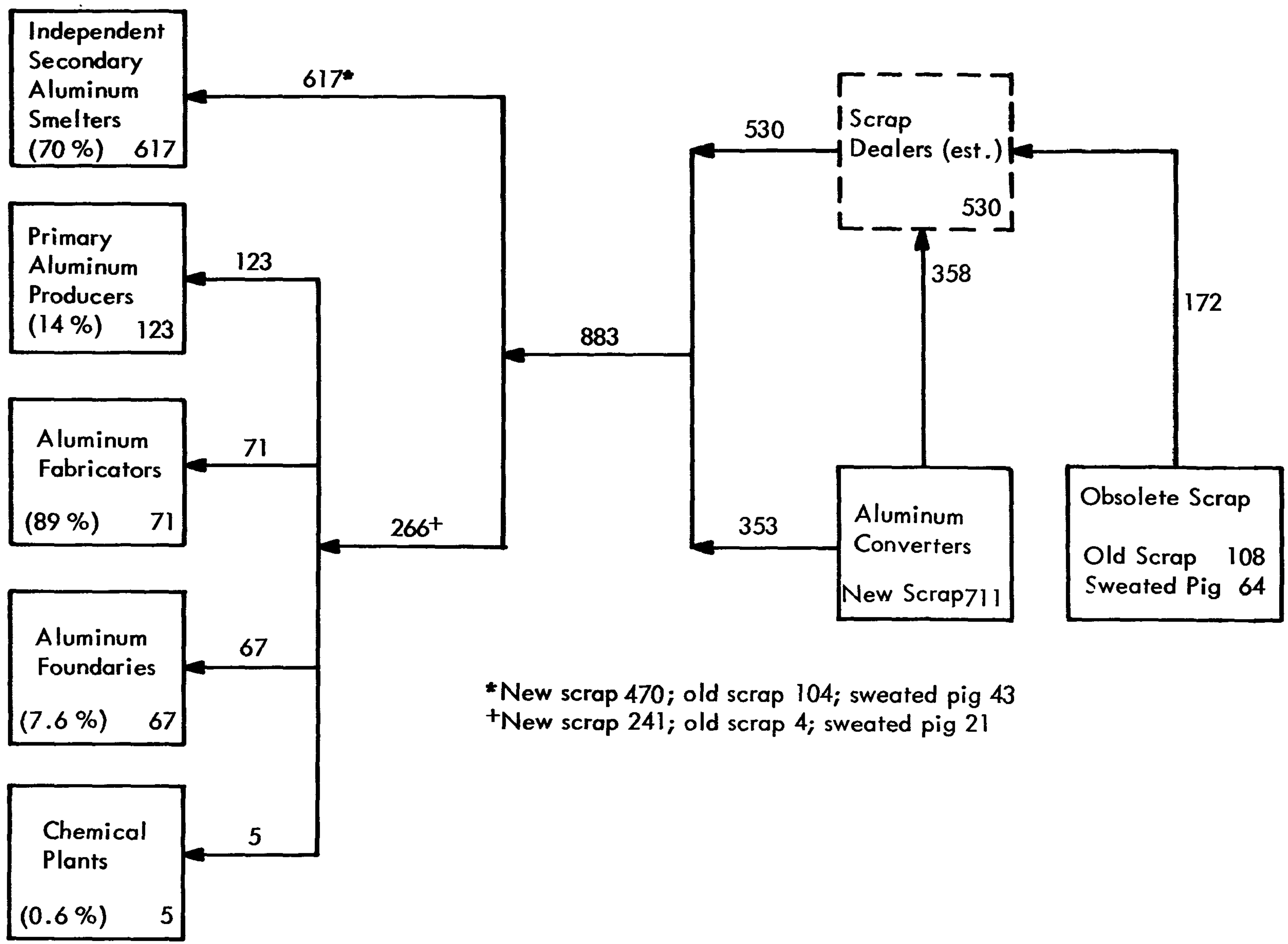

Figure 20. Flow of purchased aluminum base scrap and sweated pig, 1967, in 1,000 tons.

TABLE 40

DATA SUMMARY OF 1967 CONSUMPTION OF SELECTED NONFERROUS METALS, IN 1,000 TONS, DOLLARS, AND PERCENT*

Metal	Consumption	Value in $ per ton	Scrap consumption: New home	Scrap consumption: New other	Scrap consumption: Old	Scrap consumption: Total	Dealer's buying price for scrap $ per ton	Scrap as % of consumption	Scrap as % of consumption, excluding home scrap
Aluminum	4,009	500	150†	561	172	883†	140 - 230	22.0	18.3
Copper	2,913	764	94	785	662	1,541	380 - 920	52.9	49.7
Zinc	1,592	277	43	150	51	244	60 - 120	15.3	12.6
Lead	1,261	300	101	-	625	726	60 - 200	57.6	49.6
Total	9,775	517‡	388	1,496	1,510	3,394		34.7	30.8

*Minerals yearbook 1967.

†Only purchased aluminum scrap is included. Total consumption of aluminum scrap is understated by the tonnage of new home scrap that is recycled within the plant or company and not sold.

‡Weighted average.

TABLE 41

FLOW OF PURCHASED ALUMINUM SCRAP AND SWEATED PIG (1967)*

Scrap consumer	Total consumption		Solids	New Scrap		Total	Old scrap	Sweated pig
	Tonnage	%		Borings and turnings	Foil, dross, and skimmings			
Independent secondary aluminum smelters	617,145	69.9	210,166	150,595	110,170	470,931	103,773	42,441
Total other consumers	265,650	30.1	184,966	15,990	39,512	240,468	4,019	21,163
Primary aluminum producers	122,987	13.9						
Aluminum fabricators	70,505	8.0						
Aluminum foundries	67,053	7.6						
Chemical plants	5,106	0.6						
Grand total	882,795	100.0	395,132	166,585	149,682	711,399	107,792	63,604

*Minerals yearbook 1967; Aluminum statistical review, 1969; Farin, and Reibsamen, Aluminum profile of an industry; and Gordon, Schenck, and Lambo, Preliminary report; the collection of nonferrous scrap.

Note: These data are based on Bureau of Mines reported coverage of approximately 84 percent of the industry. Total scrap consumption for the industry is estimated at 1,050,000 tons for 1967 by the Bureau of Mines. These data include all alloy content of scrap, not recovered aluminum only.

TABLE 42

CONSUMPTION OF LEAD IN SELECTED APPLICATIONS AND RECOVERY OF OBSOLETE LEAD FROM THOSE APPLICATIONS, 1966-1968, IN 1,000 TONS AND PERCENT*

Product	Year			Average for period
	1966	1967	1968	
Batteries				
Consumption	472	467	512	484
Recovery of obsolete batteries	442	454	430	442
Recovery as percent of consumption	93.6	97.2	83.9	91.4
Type metals				
Consumption	30	29	28	29
Recovery from obsolete sources	37	35	33	35
Recovery as percent of consumption	123.3	120.7	117.9	120.7
Cable covering				
Consumption	66	63	54	61
Recovery from obsolete sources	33	34	33	34
Recovery as percent of consumption	50.0	54.0	61.1	55.7

*Minerals yearbook 1967; Annual review. The U.S. lead industry--1968. New York, Lead Industries Association, Inc. 19 p.

TABLE 43

CONSUMPTION AND RECOVERY OF SELECTED NONFERROUS METALS IN THE 1963-1967 PERIOD, IN 1,000 TONS*

Material	1963	1964	1965	1966	1967
Aluminum					
Scrap consumption	648 †	712 †	817 †	896 †	883 †
Aluminum consumption	3,040	3,216	3,734	4,002	4,009
Scrap as percent of total	21.3	22.1	21.9	22.4	22.0
Copper					
Scrap consumption	1,360	1,513	1,735	1,868	1,541
Copper consumption	2,573	2,779	2,921	3,200	2,913
Scrap as percent of total	52.9	54.4	59.4	58.4	52.9
Zinc					
Scrap consumption	202	226	264	263	244
Zinc consumption	1,414	1,536	1,742	1,807	1,592
Scrap as percent of total	14.3	14.7	15.2	14.6	15.3
Lead					
Scrap consumption	641	705	748	741	726
Lead consumption	1,163	1,202	1,241	1,324	1,261
Scrap as percent of total	55.1	58.7	60.3	56.0	57.6
Composite of above					
Scrap consumption	2,851	3,156	3,564	3,768	3,394
Metals consumption	8,190	8,733	9,638	10,333	9,775
Scrap as percent of total	34.8	30.1	31.0	30.5	34.7

*Minerals yearbooks 1963; 1964; 1965; 1966; 1967. Includes home scrap.

†Only purchased aluminum scrap is included. Total consumption of aluminum scrap is understated by the tonnage of new home aluminum scrap that is recycled within the plant or company and not sold.

CHAPTER VII

GLASS

The glass industry has its roots in antiquity. The basic composition of glass has remained essentially the same throughout its history. Glass scrap, called cullet, is a desirable input material; it is usually at least 10 percent of input tonnage and may make up a much higher percentage of certain types of glass products. Since cullet consumption is usually a routine part of in-plant processing, few data on actual cullet consumption have been reported recently in industry statistics.

All forms of glass represent 6 to 8 percent on the average of the materials found in municipal waste. Recovery of glass from waste is very low. Glass is among the lowest in recycling ratios when in-plant scrap is excluded; it is comparable with rubber, plastics, and textiles. In 1967, total glass production was 12.8 million tons and purchased cullet consumption was 0.58 million tons, or 4.7 percent of output. Purchased cullet use varied from 1.1 percent for glass containers to 14.9 percent for pressed and blown glass. The analysis in this chapter focuses on cullet recovery external to the glass manufacturing process and on recent activity of this industry in solid waste recovery.

Industry Characteristics

Structure. The glass industry consists of three segments, containers (bottles and jars), flat glass, and pressed and blown glass. In terms of relative importance, glass containers far outrank the other two on a tonnage basis. Comparing basic raw materials consumption (sand and soda ash) for 1967, containers accounted for 73 percent, pressed and blown for 12 percent, and flat glass for 15 percent of total.

The glass container segment of the industry consists of about 40 companies with 112 plants in 27 states.[76] By contrast, the pressed and blown segment consists of 185 plants and flat glass of 64 plants according to the 1967 Census of Manufacturers data. Glass plants tend to be located close to their customer or consuming markets (food packers); however, the source of basic raw materials (sand) is also a factor in plant location. Glass container plants are concentrated in 10 states: California, Oklahoma, Texas, Illinois, Indiana, Ohio, West Virginia, Pennsylvania, New York, and New Jersey.

Process Characteristics. Glass manufacture is a fully integrated "one step" process in the sense that manufacturers start with the basic raw materials and end with the finished product at the same location. The exception is specialized products accounting for a small part of the total tonnage output of the industry — mirrors, etched and ornamental glassware, and bent and laminated glass.

The principal raw materials of glass are sand, soda ash, and limestone (or dolomite) plus feldspar and other materials used in small quantities. In addition, nearly every type of glass consumes scrap in the form of internally generated cullet (rejected product, trim waste, and intentionally produced cullet).

In the glassmaking process, cullet is a technically and economically functional input material. It aids the melting process and liquefies at a lower temperature than the other raw materials. These properties increase the productivity of batch preparation by reducing fuel requirements, reducing air pollution emissions, extending the life of furnace linings, and producing a "melt" faster than if only virgin raw materials are used. Depending on the ratios used, cullet increases the "stiffness" or viscosity of the molten glass.[77] Cullet utilization varies widely, from 8 percent by weight to 100 percent; the average is

[76] Glass containers 1970. New York, Glass Container Manufacturers Institute, Inc., May 1970. p.11.
[77] Scholes, S. R. Modern glass practice. Chicago, Industrial Publications, Inc., 1941. p.289.

estimated to be 14 to 16 percent for glass containers. Manufacturers strongly favor internally generated cullet because they have no question about the chemical composition and quality of the cullet.

Production and Consumption Patterns

Containers. The packaging sector of the glass industry accounts for the greatest tonnage of glass production and represents glass products intended for transitory one-time use followed by discard to waste. The exception is the returnable bottle used in beer and soft drink packaging.

In the last decade, consumption of glass containers has increased at 5.2 percent per year on a unit basis, from 21.67 billion units in 1959 to 36.15 billion units in 1969. End-use data show important changes taking place in this sector of the industry (Table 44).[78] Beverage containers have now become the dominant type of container, reaching 51 percent of total industry output on a unit basis in 1969 compared to 26 percent in 1959, when the big switch to nonreturnable beer and soft drink containers got under way. The other important end use, food packaging containers, is growing modestly, while drug, cosmetic, and chemical container markets have stagnated or are declining. Other materials (plastics, aluminum, and steel) have been intensive competition for glass in recent years. The glass container industry's future growth appears to be tied directly to its success in nonreturnable beer and soft drink containers. The tremendous growth in beer and soft drink nonreturnable containers is documented in Table 45. Since 1967 returnable glass has declined from 72.8 percent of fillings in soft drinks to 56.1 percent in 1970; in beer the decline has been from 36.5 percent to 28.7 percent. However, glass has had to share this tremendous growth in nonreturnable containers with metal cans.

For all intents and purposes, the entire output of the glass container industry is discarded to municipal waste systems. Even the returnable container output represents replacement of unusable or lost returnable containers. Only a minute portion of glass containers is recovered for cullet use, most of which comes from bottling operations involving liquids (beer, soft drink, water). We estimate that no more than 1 percent, or 100,000 tons, of the waste glass containers are recovered as purchased cullet annually. As will be discussed later, the nature of discard makes most glass unrecoverable for economic and technical reasons.

Pressed and Blown Glass. This sector of the industry accounts for the output of various types of products that are classified in three categories: (1) table, kitchen, art, and novelty, which include tumblers, stemware, tableware, and cookware plus ornamental and decorative products, novelty products, and ashtrays; (2) lighting and electronic glassware of all types such as light bulbs and tubes, television tubes, and the like; and (3) glass fiber for insulation and manufactured products.

Based on materials consumption for 1967, we estimate that output is about 1.7 million tons of products that have highly varying use cycles and lifetimes — from glass tumblers and light bulbs to television tubes, insulation, and sporting goods.

Most of the pressed and blown glass products make their appearance eventually in municipal waste; the principal exception is fiberglas waste. For the most part, pressed and blown glass is indistinguishable from container glass in appearance.

In addition to consuming internally generated cullet, this segment of the glass industry consumed 256,000 tons of purchased cullet in 1967, or an estimated 12 percent of its raw materials input.

Flat Glass. This section of the industry accounts for three general types of product: (1) sheet glass or window glass; (2) plate or float glass used in automobiles, construction (doors), appliances, and other applications; and (3) laminated glass. In 1967 production is estimated to have been 2.1 million tons, and shipments, 1.9 million tons based on raw materials consumption. Plate and float glass is about 72.0 percent; laminated glass, 27.7 percent; and sheet glass, 0.3 percent, based on square feet of glass shipments in 1967. The production of flat glass results in a high generation of cullet, some of which gets into commercial trade and is handled by cullet dealers.

Flat glass is associated predominantly with transportation vehicles (cars, trucks) and construction (offices, factories, homes). When it makes its appearance as waste, it is not normally associated with municipal waste; even when it is, the glass may be a part of another product such as an appliance. Thus, its appearance in waste is generally not recognized in the municipal waste

[78] More detailed coverage of glass containers is provided in Darnay, A., and W. E. Franklin. The role of packaging in solid waste management, 1966 to 1976. Public Health Service Publication No. 1855. Washington, U.S. Government Printing Office, 1969. p.32-43, 130-131. Table 44 updates historical data.

category. The significant exceptions are industrial conversion waste and windows broken by householders.

In addition to consuming internally generated cullet, this segment of the industry consumed 244,000 tons of purchased cullet in 1967, which is about 10 percent of its raw materials input.

Cullet Consumption Patterns

In-Plant Cullet. There is a scarcity of published data about cullet consumption in the glass industry. The internal consumption of cullet takes place routinely and in widely varying percentages depending on a number of factors. In general, glassmakers consume what they produce internally through rejection of "off spec" products and trim scrap. Often, excess production capacity at a plant is devoted to the deliberate production of cullet for recycling back into the glass furnaces. Some companies make interplant transfers of cullet to balance their needs from plant to plant. The consumption of internally generated cullet is strongly motivated by economic and technical considerations. In general it can be said that the glass industry, especially in glass containers, consumes all its internally generated cullet.

Purchased Cullet. Purchased cullet consumption is another matter. Its relative status in the industry can be understood by the terminology applied to purchased cullet — it is referred to as "foreign" or "tramp" cullet.

Trends in the use of foreign cullet by the glass industry have been steadily downward over the years. The glass container segment, which accounts for over 70 percent of the tonnage output, purchases perhaps 1 percent of its raw materials as foreign cullet; this is about 100,000 tons. Most of the purchased cullet is old glass containers obtained from beer and soft drink bottling operations via a cullet dealer. The ratio of overall cullet consumption in glass making, however, has not necessarily declined over the years; rather, glass container plants have simply turned to the use of more and more cullet that is internally generated.

A small amount of purchased cullet still goes into a number of secondary products, for example, the manufacture of glass beads for highway signs, for luminescent paints, and for other end uses.

The flat glass and pressed and blown glass sectors of the industry generate large amounts of cullet in their operations — especially electric lights and electrical products such as tubes and plate glass. Much of this goes back into the production cycle directly or as purchased cullet, which averages about 10 percent of input materials for these two sectors of the glass industry.

An approximate flow of the materials in glass manufacture is shown in Figure 21. Internally generated cullet has been omitted. Glass container manufacturers consume the least amount of purchased cullet on both a percentage and actual tonnage basis. Glass container producers also account for nearly 90 percent of all glass discarded as waste. Purchased cullet consumption compared to production is shown in Table 46, and indicates that consumption is 1.1 percent in containers, 11.3 percent in flat glass, and 14.9 percent in pressed and blown glass.

Cullet Use Factors

The use of purchased cullet in glass container manufacture has declined for many technical, economic, and intangible reasons. Both the cullet consumer — the glass plant — and the cullet broker/dealer face some rather rigid realities.

Glass Plant. As viewed by the glass plant manager or company management, the following factors are relevant to purchased cullet.

(1) The basic raw materials (sand, soda ash, and limestone) are low in cost and readily available. Raw materials costs average \$16 to \$20 per ton for a glass container batch, with sand costing in the range of \$5.20 per ton delivered.[79] Some industry experts say that cullet use saves the plant \$2 to \$3 per ton of input because it produces a faster melt and reduces fuel consumption and furnace deterioration. If so, cullet can sell for \$18 to \$23 per ton and be competitive with virgin materials. A purchased cullet price that violates this basic economic parameter raises the costs of glass production in a highly competitive business. In Chicago and New York, the current prices per ton for cullet are \$22.50 and \$18.00 for flint, \$17.75 and \$17.00 for amber, and \$16.10 for green (in New York). These prices are high by virgin raw material standards yet the dealers lose money on the transaction if all their costs are considered.

(2) Purchased cullet is an "unknown quality" in glass batch formulation and must be compatible with the technical parameters of the glass. This is usually not a "problem" as much as a variable to be dealt with because the manufacturer has no control over the

[79] Values from 1967 Census of Manufacturers data and MRI interviews.

purchased cullet. Specifically, the cullet must be: (a) chemically acceptable, (b) color sorted into flint (clear), amber, or green, with container glass separate from plate glass, (c) clean — free of dirt and organic contaminants — and crushed into l-inch or smaller pieces, (d) free of metallic contaminants, especially iron and aluminum (which are often present as closures on old containers).[80] It is particularly important that flint glass cullet not have significant quantities of colored glass in it or it is not usable for flint glass. These "unknowns" do not crop up in the use of internally generated cullet.

(3) A steady, trusted, and reliable source of cullet is needed to give continuity to the production process and batch mixtures. Physical facilities to handle cullet are not difficult to install nor do they require extensive capital investment.

(4) Purchased cullet is not a necessary raw material substitute and intangible factors sometimes govern its use: risk of batch losses because of contaminants; its low status as a raw material; reliance on single independent suppliers, (cullet dealers whose own sources may be unreliaable or variable). These latter factors have led some companies by policy to avoid foreign cullet altogether. Many companies purchase cullet only to supplement internal cullet when their production rates and "pack to melt"[81] ratio is highly efficient and does not yield sufficient internal cullet. A few companies depend heavily on purchased cullet. For example, MRI documented cases where water bottle manufacturers and ashtray manufacturers use l00 percent cullet.

Cullet Dealers. There are probably fewer than 20 cullet dealers[82] left in the United States. In fact, only 17 can be accounted for by the Glass Container Manufacturer Institute and MRI.[83] Their sad states and gradual demise can be attributed to changes in the economics and conditions of recovery and factors that have been set out above. They face the following rather formidable problems.

(l) The best sources of container cullet have gradually dried up. These are bottling operations for soft drink, beer, water, and milk. There is a relatively large supply of amber and green glass but less flint, the most desirable type. This is because beverage containers are predominantly green or amber while milk bottles have all but disappeared. The best type of glass is the returnable container rejected from a bottle washing operation; however, this source is declining as nonreturnables take over. Containers rejected at the end of a filling cycle may be full of the product and have the closure attached firmly. Plants find it difficult and uneconomical to segregate reject bottles from other waste for dealers. Refuse is not a good source for cullet dealers because most of it is picked up in mixed form and the practice of home separation has declined substantially.

(2) Dealer collection and delivery costs have risen and so have processing costs, principally because these operations are highly labor intensive. Dealers remove cullet and pay the generator, however, if the source is a good one. For other generators, they remove the cullet free of charge which in essence is a free refuse removal service for the bottling plant.

(3) Dealers operate obsolete cullet plants that have not been maintained; the sorting, crushing, washing, and contaminant removal systems are old and inefficient. Sorting by hand is the rule. The plants operate far under capacity and their throughput volume does not justify new capital investment. By contrast, few glass plant managers have been willing to install in-plant washing and crushing systems for processing purchased cullet.

(4) Dealers cannot open up new sources of cullet because of inadequate capital and lack of technology to substitute for labor in processing and because economic supply sources do not exist.

In effect, rising costs and declining sources of good quality cullet supply have worked against the cullet dealer. Most dealers who physically handle cullet have a profitable operation only if they operate with essentially no capital costs, minimum maintenance, and by providing a large increment of the labor themselves. Many years ago when individual scavengers were willing to

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[80] Aluminum creates streaks in the bottles and small black spots that are not acceptable. Ferrous additives are used to make amber glass so ferrous content is unacceptable in flint glass. Flint glass is about 50 percent of the industry's output and many glass container plants produce only flint glass.

[81] An industry term expressed as a ratio of the output of acceptable containers to the molten glass input; at 90 percent "pack," the plant is making 9 good containers for every 10 possible.

[82] See Chapter XI, "Case Studies," for detailed discussion of cullet dealer operations in Chicago, Cincinnati, Los Angeles, New Orleans, and New York.

[83] Private communications with MRI and MRI interviews.

work for "a dollar a day and a bottle of wine," some cullet was reclaimed from municipal disposal sites by hand picking. This practice has virtually disappeared.

Dealers who have a brokerage business may be faring somewhat better. If they can work as the middleman between a glass plant generating and another buying cullet, without handling the cullet, they are able to recover a brokerage fee without incurring the high handling and processing costs.

Technical Criteria. Cullet use in glass of various types can vary from 8 percent to 80 percent, excluding the cases where 100 percent cullet is used. Foreign cullet is considered a raw materials substitute, not a raw material. The actual technical limits are well above current industry practices. For example, container manufacturers use from 8 percent to 20 percent cullet with the industry-wide average probably 15 percent of input tonnage. Industry experts have indicated that the technical limits are far above current practice. In fact, 30 percent cullet use is now a commonly accepted "goal" of the Glass Container Manufacturers Institute. If the glass container industry were using an additional 15 percent purchased cullet, this would mean it would be using about 1.8 million tons annually compared to only 100,000 tons estimated in 1967.

Purchased cullet has no particular attraction per se. If additional cullet were necessary, glass companies might well build a plant just to produce cullet because this would represent a predictable cost and quality material.

Market Factors. The real limits of tapping foreign cullet sources lie in the economic and supply factors. Plant managers are reluctant to seek foreign cullet because of its relatively high cost, low quality, and unavailability in steady volumes. In addition, they have drifted away from reliance on single-source cullet dealer operations that are marginal at best. Single-source arrangements for cullet are not viewed with favor, yet the market will not support a viable competitive dealer system.

Cullet from Municipal Waste

Availability. Glass, especially in the form of containers, is present in quantity in mixed municipal waste. Waste composition tests show that glass appears to range from 3.5 percent to 12.7 percent of municipal refuse by weight. The composite average is about 6 percent. If this percentage is applied to waste collection of 193.7 million tons in 1968, glass in waste was 11.6 million tons that year; applied only to 165.8 million tons of residential and commercial waste, it would have been 9.95 million tons. These lower figures confirm our estimates based on industry output and discard for 1967 of 10.0 million tons (Figure 21). Glass containers occur in wastes in reasonably "pure" form in that they are not physically combined with other materials, as for example are auto glass, construction glass, and light bulbs. However, they often contain contaminating residues of the product they carried to the final consumer.

At present, glass containers are neither economically nor technically accessible because of the nature of their occurrence in waste. They appear mixed in with a good deal of other waste. There is effectively no market for cullet through the traditional dealer system. Experimental technology has been used to sort mixed, crushed glass in municipal refuse by color, but there is no operating system in existence.[84] The interesting prospect is that large quantities of glass could be used in a primary recycling application if such systems were available.

Recent Developments in Cullet Recovery and Utilization. The glass container industry through its association, the Glass Container Manufacturers Institute (GCMI), has been a leader in exploring the solid waste management problems associated with glass. GCMI launched a rather broadly based environmental program aimed at solid wastes in 1967.[85] GCMI's work encompasses research on uses of cullet both inside and outside the glass industry.[86] Most recently, various companies, individually and through GCMI, have adopted a glass collection center concept similar to that initiated by Reynolds Metals for the recycling of aluminum containers.

The glass container industry's sudden flurry of activity in solid waste management and recycling stems from two strong forces. First, the glass industry has faced intensive materials and package configuration competition in its traditional markets. This is particularly evident in

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[84] See the discussions on the Bureau of Mines incinerator residue work and on the Sortex system in Chapter 3.

[85] See Glass makers launch solid waste program. Environmental Science & Technology, 3(1):17-18, Jan. 1969.

[86] Abrahams, J.H. Utilization of waste glass. In Proceedings; Second Mineral Waste Utilization Symposum, Chicago, Mar. 18-19, 1970; U.S. Bureau of Mines, and Illinois Institute of Technology Research Institute. p.363-368; Malisch, W.R. Use of waste glass for urban paving. In Proceedings; Second Mineral Waste Utilization Symposium, p.369-373.

medicinal and health and household and industrial chemicals where plastics have made substantial inroads. "Conquering of a last great frontier"—the nonreturnable beverage container market—has kept the industry from going into decline. This latter market is where the action is. Both steel and aluminum cans have made inroads here so that the glass manufacturers have had to compete strongly to develop the market.

The second factor is that it is the very markets that are "up for grabs"—beverages—upon which the public has focused intensive environmental attention. The glass industry has long received attention and has been active in antilitter activities, and now interest in these containers has spilled over into the solid waste area. Attacks by environmentalists seem to have focused disproportionately on beverage containers as the consumption of "no return" bottles expands by leaps and bounds. Legislative threats at the state and local level abound. It is not surprising, therefore, that glass container manufacturers have responded with positive action steps in the environmental field to protect what has become their major market.

Individual companies have begun to seek sources of foreign cullet from traditional sources[87] as well as focusing attention on citizen action programs in the form of special public collection centers usually located on the property of individual glass plants. Glass plant managers are preparing their plants to handle color-sorted foreign cullet in significant volumes. Time-honored negative views of foreign cullet have been set aside, and the glass container industry has set a goal of using 30 percent cullet in its input materials. More could probably be used; in fact, the upper limit is well above the limits usually cited in public releases.[88]

The collection centers have several features: the public is asked to deliver clean, color-sorted containers free of metallic closures to collection sites. Individuals are paid 1 cent per pound ($20 per ton). In Ann Arbor, Michigan, a remote collection center, (far from a glass plant) pays one-half cent per pound or $10 per ton for glass containers.[89] This center was established by Owens-Illinois in connection with an environmental action group called ENACT.

The collection center concept has several positive and negative features. A center is easy to establish and start up; it seeks voluntary citizen participation; it depends on a "subsidized" and inefficient presegregation, collection, and processing system (delivery of clean, color-sorted containers to a central point); and it is of very limited value as an effective recovery system. Because of a low level of citizen interest, it cannot tap a large percentage of the used containers generated. Even so, at $20 per ton, the industry participants are absorbing costs that could not be justified in a narrow economic sense. One industry spokesman indicated their costs are nearly $50 per ton and must be treated as a "social tax" at present. However, many companies expect to have vastly improved economics of collection, crushing, transporting, and in-plant handling as the collection center concept develops. As yet, no collection center involves participation of a cullet dealer, although a GCMI spokesman reports they are "working with them and keeping them informed." We believe the collection center concept is at best an interim measure not likely to make a significant impact on recovery of glass from waste.

Conclusions

Our analysis of glass as a recyclable material has led to several conclusions.

(1) As opposed to other materials studied, there exists today unfilled demand for cullet because technical and economic problems of cullet supply have not been overcome. Purchased cullet consumption in containers has died away because the use of virgin raw materials and internal cullet has been a much more satifactory source of raw materials supply.

(2) A large quantity of cullet is present in municipal waste. The technical requirements of glass manufacture indicate that 20 to 40 percent of glass now occurring in

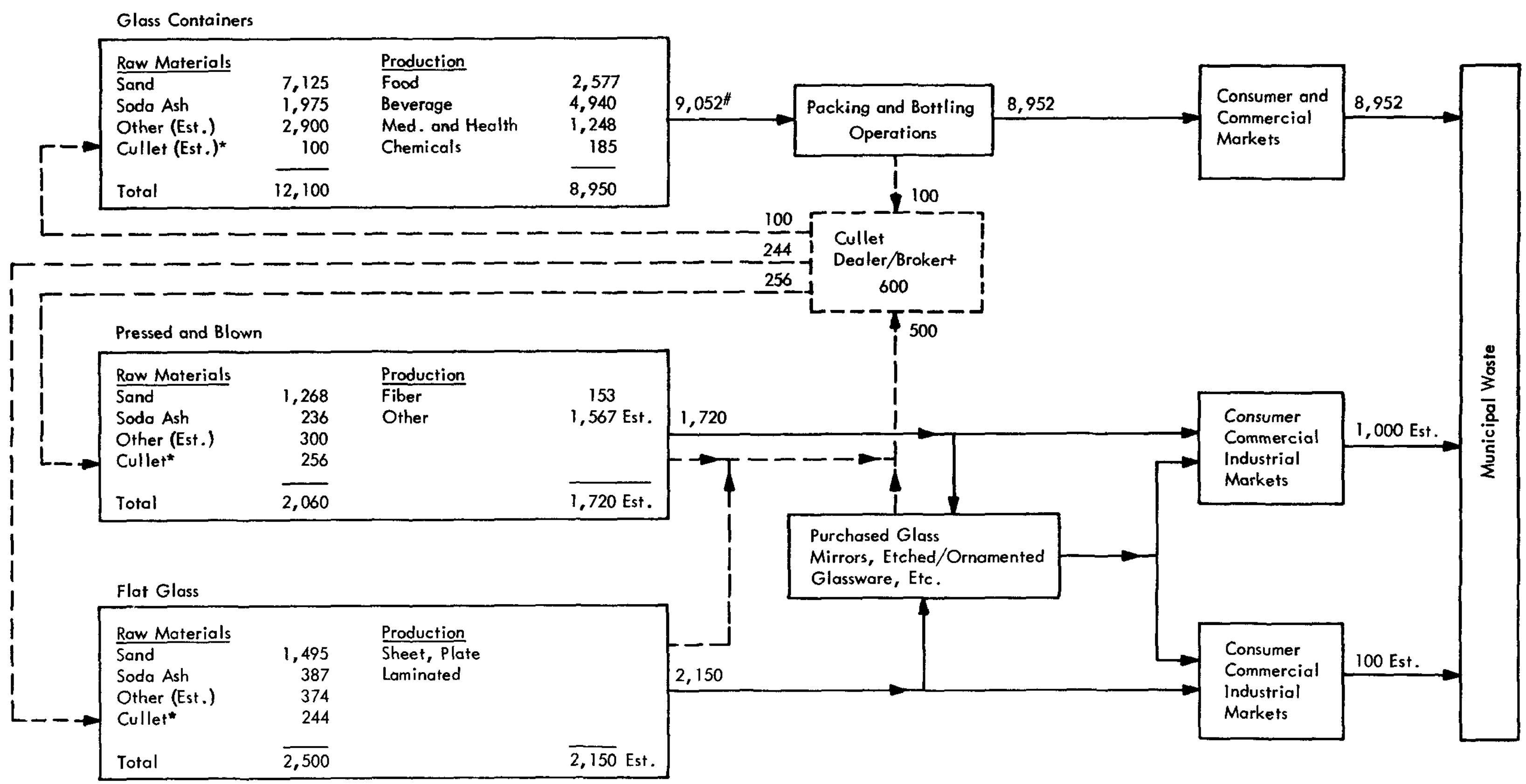
[87] See Chapter XI, "Case studies," New York.

[88] An internal company memo of a glass container manufacturer dated Mar. 20, 1970, given to MRI contains the following statements: "A review of the glass container industry's past production in use of cullet shows that both glass quality and high production can be maintained while using cullet levels from a low of 10 percent per batch to a high of 50 percent." The latter cullet level being used to augment the melting capacity of the furnace. "Based on the above item, glass quality can be maintained regardless of the cullet level so long as the level is held relatively constant so that batch patterns, melting rates, and the thermal history of the glass produced are uniform."

[89] Owens-Illinois. Press release, Aug. 1970. Toledo, Ohio.

municipal waste could be used for recycling in glass containers. The problems of recovery of glass from waste lie in cost, collection, and preparation in competition with readily available low-cost virgin materials, for which no shortage is forseen now.

(3) It is practical to tap this resource only via new technology that produces technically and economically usable cullet in conjunction with a comprehensive waste processing system.



*Excludes internally produced and consumed cullet.
+Only about 1/6 of this is physically handled in dealer processing facilities.
#The difference between production and shipments is an inventory change.

Figure 21. Approximate glass industry materials flow, in 1,000 tons, 1967.

TABLE 44

SHIPMENTS OF GLASS CONTAINERS BY END USE, 1967-1970, IN MILLION UNITS AND PERCENT*

	Units				Percent			
Category	1967	1968†	1969	1970†	1967	1968	1969	1970‡
Food	11,872	11,183	11,901	11,814	36.0	35.0	32.9	31.5
Beverages	14,709	15,411	18,431	20,333	44.7	48.2	51.0	54.1
Liquor	1,980	1,731	2,003	1,784	6.0	5.4	5.6	4.8
Wine	822	829	975	988	2.5	2.6	2.7	2.6
Beer	6,408	6,460	7,356	7,598	19.5	20.2	20.3	20.2
Returnable	624	475	480	350	1.9	1.5	1.3	0.9
Nonreturnable	5,784	5,985	6,876	7,248	17.6	18.7	19.0	19.3
Soft drinks	5,499	6,391	8,097	9,963	16.7	20.0	22.4	26.5
Returnable	1,913	1,747	1,640	1,603	5.8	5.5	4.5	4.3
Nonreturnable	3,586	4,644	6,457	8,360	10.9	14.5	17.9	22.2
Medical and health	3,255	2,887	3,355	3,176	9.9	9.0	9.3	8.5
Toiletries and cosmetics	2,290	1,842	1,817	1,694	6.9	5.8	5.0	4.5
Chemicals	816	624	647	540	2.5	2.0	1.8	1.4
Total	32,942	31,947	36,151	37,557	100.0	100.0	100.0	100.0

*Current industrial reports. Glass containers. Series M32G. 1967; 1968; 1969; 1970.

†Shipments were affected by a 51-day strike.

‡Estimated by MRI on the basis of 8 months data.

TABLE 45

BEER AND SOFT DRINK FILLINGS AND CONTAINER CONSUMPTION, 1967-1970 IN MILLION UNITS*

	1967	1968	1969	1970†
Soft drink:				
Glass closures	32,715	31,046	36,133	35,349
Metal cans	7,290	10,028	11,764	12,856
Glass container shipments:				
Returnable	1,913	1,747	1,640	1,603
Nonreturnable	3,586	4,644	6,457	8,360
Total fillings‡	40,005	41,074	47,897	48,205
Market share %:				
Metal cans	18.2	24.4	24.5	26.6
Returnable bottles §	72.8	64.3	62.0	56.1
Nonreturnable bottles	9.0	11.3	13.5	17.3
Avg. no. trips, returnable bottles¶	16	15	14	n.a.
Beer:				
Glass closures	17,003	16,092	17,834	17,747
Metal cans	13,769	15,342	16,708	18,864
Glass container shipments:				
Returnable bottles	624	475	480	350
Nonreturnable	5,784	5,985	6,876	7,248
Total fillings‡	30,772	31,434	34,542	36,611
Market share %:				
Metal cans	44.7	48.8	48.4	51.5
Returnable bottles §	36.5	32.2	31.7	28.7
Nonreturnable bottles	18.8	19.0	19.9	19.8
Avg. no. trips, returnable bottles¶	19	20	20	n.a.

*Current industrial reports. Glass containers. Series M32G; Metal cans. Series M34D; Closures for containers. Series M34H. 1967; 1968; 1969; 1970. Annual report--metal can shipments--1968. Washington, Can Manufacturers Institute.

†Estimated by MRI on the basis of 8 months data.

‡Total fillings is total crowns and other closures for glass bottles plus total metal cans for the beverage category.

§Calculated as a percent of total fillings, not putput of returnable containers.

¶Estimates by Glass Container Manufacturers Institute in Glass Containers, 1970.

TABLE 46

GLASS PRODUCTION AND PURCHASED CULLET CONSUMPTION, 1967*

Industry segment	Production in 1,000 tons	Purchased cullet consumption in 1,000 tons	Purchased cullet, percent
Containers	8,950	100	1.1
Flat glass	2,150	244	11.3
Pressed and blown	1,720	256	14.9
Total	12,820	600	4.7

*U.S. Bureau of the Census. 1967 Census of manufacturers. Preliminary reports: glass containers, SIC 3221; flat glass, SIC 3211; pressed and blown glass, SIC 3229. Washington, 1969. Production estimate for flat glass and pressed and blown glass is by MRI; external cullet consumption in containers, MRI estimates.

CHAPTER VIII

TEXTILES

Overview

In 1968, 5.7 million tons of textile fibers were consumed in the United States. Synthetic fibers represented the bulk (46 percent), followed by cotton (35 percent), wool (4 percent), and all other (15 percent).

These materials went into clothing (40 percent), home furnishings (30 percent), other consumer products (11 percent), and industrial uses (19 percent).

In making textiles, fiber wastes occur; these are analogous to "home" scrap in the steel industry. When finished textiles are converted to clothing and other products, cuttings and clippings are generated; these are analogous to "prompt" scrap. Used clothing articles represent the chief source of obsolete textiles.

Waste products recovered in the textile industry and from obsolete clothing collections are: (1) consumed in the making of paper and board products; (2) recovered into new textile products; (3) used as stuffings, fillings, backings, and paddings; (4) exported; (5) converted into wiping materials; and (6) resold in secondhand stores to reenter the waste stream at a later date.

In this section, we shall be concerned mainly with the recycling and reuse of finished textiles as opposed to textile wastes generated in the making of textiles. We are thus concerned with fabrication wastes, especially those of the apparel industry, and with the collection and disposition of obsolete clothing articles.

Reliable quantitative information on textile waste generation and consumption is scarce and must be derived by various computations from isolated bits and pieces of data. Very little textile scrap is recycled (put back to use in a new manufactured product). Most textile wastes are either exported (and they may then be recycled), converted to wiping material, or resold for further grading as wools, cottons for paper making, or rags for roofing mills. Used clothing marketing activity is in the hands of social welfare agencies and small commercial shops, and these agencies do not have the detailed record keeping practices that would permit insight into their activities.

Textile Consumption Trends

The best data on textile consumption are published by the Textile Economics Bureau, Inc. (New York) in its *Textile Organon* magazine. This source regularly reports consumption data by weight, although the tonnages given do not necessarily represent weight of finished products delivered to consumers, because the data include conversion losses and exclude weight of such things as buttons and zippers. The *Organon* surveys measure consumption as close to the conversion point as possible and are therefore the best single measure of actual consumption available.

Domestic consumption of textiles rose from a level of 3.9 to 5.7 million tons in the 1960 to 1968 period, a growth rate of 4.2 percent yearly (Table 47). Per capita consumption in this period rose from 43.6 to 57.4 pounds a year. These figures include textiles imported for consumption and exclude textiles exported. However, they do not include imports of clothing nor do they exclude finished clothing exports.

The single most significant change in the 1960 to 1968 period has been the phenomenal growth of synthetic, man-made fibers at the expense of cotton and wool. In 1960, cotton was still King; by 1968, cotton had declined. The share of various fibers in the past 2 years was as follows:

In actual tonnage consumed, cotton barely maintained itself at a no-growth rate; wool consumption declined; man-made fiber consumption nearly tripled; and consumption of other textiles like silk, linen, jute, sisal, and others grew very modestly.

The decline in the share of the market held by wool and cotton has had a significant impact on textile waste recovery, as will be discussed. The advent of synthetic fibers, however, has been significant not only because they captured markets that were in cotton and wool but also because synthetics have reached the market in combination with other fibers, thus contaminating these latter from a recovery viewpoint and making the job of textile sorting more and more difficult.

End Uses

Most textiles, by weight, are consumed in clothing articles, and though men will find this surprising, more textiles are consumed in men's and boys' wear applications than in women's, misses', children's, and infants' wear. The apparel categories together accounted for 39.5 percent of textile consumption in 1968. Home furnishings accounted for 30.3 percent, including such things as bedding, blanketing, towelling, curtains, draperies, upholstery, carpets, and rugs. Textiles in other consumer products accounted for 11.4 percent of textile consumption. This category includes fabrics and yarns that are used to make clothing at home; linings in manufactured clothing,[90] textiles used in shoes, slippers, luggage, handbags, and toys, and medical, surgical, and sanitary textiles. Industrial uses accounted for 18.8 percent of consumption. The single largest industrial category is tire cord textiles, which accounted for 6 percent of total textile consumption; other applications are in reinforced plastics, rope and cordage, bags and bagging, sewing thread, tents, transportation upholstery, belting, and the like (Table 48).

The relative consumption share of end-use markets remained about the same in the 1960 to 1968 period, the only change worth noting being a small increase of textiles consumed in home furnishings.

Textiles in Waste

In 1968, textiles in municipal wastes collected are estimated to have weighed 1.2 million tons, or 0.6 percent of 193.7 million tons. The low rate of apparent textile occurrence in waste relative to total consumption (average for the 1960 to 1968 period being 4.7 million tons a year) cannot be completely explained, but a partial explanation includes the following:

(1) A portion of textiles is lost in laundering.

(2) Waste composition samples are frequently taken from compactor trucks at incinerator pits where carpets and rugs, tires, furniture, draperies, and other bulky materials that contain textiles normally are not present.

(3) A portion of textiles is combined with plastics, leather, and rubber and is probably not recognized as textile in waste analyses or cannot be practically separated from adhering materials.

(4) A portion of textiles (clothing) is diverted from residential sources to social welfare agencies and then into industrial applications such as wiping rags, and may then be disposed of in industrial incinerators.

(5) A portion of old textiles is exported.

These facts suggest that the textile proportion in collected wastes is probably understated or that textiles are retained by owners for long periods following useful life of these products, and such materials appear in waste from time to time in "shock" loads rather than being discarded as they reach obsolescence in a day-to-day manner, as does paper.[91] It appears that both of these explanations are true and account for the relatively low textile content of municipal wastes as measured in composition analyses.

Textile Production Wastes

Textile Mill Wastes. Wastes generated in textile mills, the portion of such wastes utilized, and the portion of that utilized sold have been estimated by survey and projection for 1965.[92] The waste utilized for that year was 462,000 tons; if this tonnage grew at the same rate as textile consumption in the 1965 to 1968 period (3.7 percent a year), the 1968 tonnage was 515,000.

These wastes include a variety of fibrous materials, such as cotton linters, vegetable fibers, jute, man-made fibers, and wool wastes. These materials are used in three ways: (1) they are exported (1968 exports amounted to

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[90] Included here by Textile Organon because use of linings cut across all clothing consumption categories.

[91] If a nonscientific opinion is admissible, it appears that there are few households that lack large accumulations of obsolete textiles, retained either for sentimental reasons (Dad's uniform), as a hedge against hard times, or because disposal is difficult to accomplish (carpets). These accumulations are, of course, eventually disposed of, but disposal may be collected during a spring clean-up drive. Sampling is unlikely to capture such waste loads, and the analyst may even reject the load as unrepresentative.

[92] Combustion Engineering, Inc. Technical economic study of solid waste disposal needs and practices. Public Health Service Publication No. 1886. Washington, U.S. Government Printing Office, 1969 p.98, 99, 116.

104,000 tons); (2) they are consumed in paper, board, and pulp mills (estimated 1968 consumption, 167,000 tons); and (3) they are used in the textile industry itself as felted products, stuffing materials, backings, and the like. Tonnages consumed are not available but are assumed to be equivalent to fiber wastes sold less exports and paper industry consumption, i.e., 244,000 tons in 1968.

Apparel Industry Wastes. One estimate of process wastes sold in 1965 by the apparel industry is 143,000 tons. In 1968, such wastes amounted to an estimated 160,000 tons.[93] These are principally cuttings and clippings but also include some defective products that cannot be salvaged, such as soiled items, ripped clothing, cutting errors, and the like. The apparel industry as here defined includes clothing and other fabricated textiles but excludes industrial textile users. It should be noted that the tonnage shown here is that sold, not necessarily generated wastes.

Apparel industry conversion wastes normally enter the paper industry as rags, are converted to wiping cloth, or are exported. Data on consumption of finished textile wastes, however, do not permit differentiation between conversion wastes and obsolete wastes, and these are therefore treated as a whole later in this chapter.

Textile mill and apparel conversion wastes do not, of course, represent the total "new" scrap produced in textile consumption. These two activities, however, are the only ones where some indication of waste generation and sales is available.

We shall not further concern ourselves with textile mill wastes — essentially the industry's home scrap — but want to note here that these fibrous materials, much like textile wastes, pass through the hands of secondary dealers and represent roughly half the tonnage of materials they handle.

Textile Recycling and Reuse

Textile wastes obtained from industrial sources and from the collection of used clothing by social welfare agencies are channeled through secondary materials dealers with portions going to the paper and board industry, to export, and into wiping rags. The tonnage entering the paper industry is recycled in the usual meaning of the word; that is, it is made into new products. Wiping rag applications are a form of reuse: The textiles are merely delayed on their way to the dump and pick up oils, chemicals, and dirt in the process. However, use of old textiles in wiping applications keeps other, virgin materials out of the waste that would have to be used in their stead. Exported textiles, of course, leave the country; some of these are recycled, the rest are sold as clothing.

In 1968, an estimated 574,000 tons of textiles were sold; the secondary materials industry acquired between 642,000 and 1.1 million tons of textiles in order to satisfy the demand (Table 49) for reasons to be developed below. Obsolete clothing collections by social welfare agencies were between 759,000 and 1.8 million tons to support the secondary textile industry at an output level of 574,000 tons.

Waste Processing Sequence

Textile wastes resulting from conversion operations are collected by secondary materials dealers. Textile wastes from private households are collected by social welfare agencies, which collect textiles in order to obtain resalable clothing articles. The proportion of clothing collected that is actually sold varies from agency to agency. Our best estimate, based on the experience of such agencies in Cincinnati, Houston, and New York, is that 45 percent of collections is sold in secondhand stores and the remainder is sold as mixed rags to secondary textile dealers. Thus, an initial separation of obsolete textiles into "resalable" and "rag" portions takes place within the social service agency.

Mixed rag bundles normally include all clothing articles judged unsalable by social welfare agency sorters. Torn and excessively soiled items, unrepairable items, clothing that is out of style, and items that could not be sold in secondhand stores are all "ragged." Depending on the size and resources of an agency, more or less repair of clothing may be undertaken. Smaller agencies tend to send more of their clothing to rags than larger ones. Rag bundles appear to have roughly the same proportions of the major fibers as new textiles.

Rag bundles may next go to rag sorting organizations where the textiles are manually graded into four basic grades: clothing for export, textiles for wiper stock (pure cottons), pulp substitute rags (small cotton pieces), and roofing rags (low quality rag wastes). Some sorting for woolens may also be accomplished. The rag sorting organization may also be a wiping cloth manufacturer.

The wiping grade cottons are sold to wiping cloth manufacturers who may: (1) further sort into different

[93] Technical-economic study, p.100, 101, 116.

wiping grades (white sheeting, colored cotton slacks, etc.); (2) launder the cottons; (3) remove all buttons, zippers, and other trim and cut open trouser legs, shirt sleeves, and so forth; and (4) bale and package the wipers for shipment to consumers. All other grades obtained from mixed rag bundles may be sold directly to final consumers by the rag sorting organization or may be sold to another dealer, such as an export specialist.

New textile clippings, obtained directly by the dealer, usually come in presegregated form. Cotton clippings are sold to the paper industry. Synthetic fiber clippings are sold to respinners provided these are pure basis materials — dacron, orlon, nylon, etc. If they are blends, they are sold to be used as stuffing and backing materials. Old synthetic textiles are not recycled because the nature of the fiber in such items cannot be adequately identified. A very small quantity of "respinning wool" is also handled for recycling. Respinning wool may be from obsolete clothing articles.

The disposition of waste textiles handled by the secondary materials industry is shown in Figure 22.

The Wiping Cloth Cycle. On the basis of interviews with various participants in the industry, we infer that to obtain 1 ton of wiping materials between 6 and 12 tons of used clothing must be collected from households. The numbers are derived, and the basis for them is as follows.

The source of wiping materials is almost entirely mixed rag bundles obtained by dealers from social welfare agencies. Cottons suitable for conversion into wiping cloths (not all of the cotton in bundles) are believed to be between 15 and 30 percent by weight of mixed rag bundles. Assuming a 30 percent level, 3.3 tons of mixed rags are needed to yield 1 ton of wiping grade cotton. Mixed rags represent 55 percent of social welfare agency collections. Thus, 6 tons of clothing collections will yield the requisite quantity of mixed rags, cottons, and wipers. If the cotton content of mixed rag bundles is 15 percent, the quantitites are twice as great.

Wiping rag consumption in 1969 was estimated to have been 150,000 tons by the National Association of Wiping Cloth Manufacturers (this estimate was obtained in a personal interview). The growth rate of wiping rag consumption is estimated to be 3 percent annually. This would indicate that in 1968, 146,000 tons of textile wipers were used and that this tonnage necessitated the consumption of 482,000 to 978,000 tons of mixed rag bundles and social welfare agency collections of 891,000 to 1.8 million tons. The actual collection rates cannot be established but are believed to be somewhere between the extreme ranges.

These estimates indicate (Table 49) that the secondary textile industry has an excess of intake over output of at least 68,000 tons and possibly as much as 564,000 tons a year — for which it must pay and which it must store or dispose of but which it cannot sell. This raises its costs for the commodities that can be sold.

The partly unsalable materials are man-made fabrics and wool. The three markets for these materials (paper and board, exports, and reprocessors) have no requirements for more than they already consume of these fibers, which is far under the available supply of rags. On the other hand, the textile dealers are forced to accept these additional textiles in order to obtain the cotton materials that they can sell.

This situation has led to the progressive decline in the price paid by dealers for mixed rag bundles, from around $120 to $140 per ton in the mid-1960's to $55 to $65 per ton in 1969 and 1970. In addition to inability to sell all the man-made and wool textiles, two other forces have contributed to depressing prices: (1) the decline in pure cotton content of mixed rag bundles and (2) the steadily rising costs of manufacturing wipers from mixed rags.

The costs of preparing wiping cloth were an average of $267 per ton in 1969, according to an unpublished survey made by the National Association of Wiping Cloth Manufacturers.[94] This cost was up from $242 in 1968. Additionally, raw materials costs were up 14 percent, and freight costs rose by 13 percent between 1968 and 1969. The industry raised prices by 8 percent to compensate for these increases.

The economics of wiper manufacturing can best be illustrated by an example. The dealer buys a mixed rag bundle for $60 a ton.[95] If cotton is 30 percent and assuming that none of the other materials can be sold, his cost per ton of cotton is $199.80. His pick-up cost will be $3.50 per ton of mixed rags, or $11.66 per ton of cotton. His processing cost is $267 per ton of cotton; and his freight cost to the consumer is $35.80 per ton. His total cost thus is $514.26 per ton of wiping rag plus disposal of

[94] The survey excludes initial sorting costs which we added based on interview data obtained from processors. Sorting costs for both years are included at a level of $60 per ton.

[95] Actual price quotations are by the pound.

that portion of other textiles he cannot sell. If he cannot sell any of these materials, he incurs an additional cost per ton of cotton sold of $19.39.[96] Given this extreme case, his total cost is $533.65 per ton of cotton. The average selling price for wipers is $420 per ton.

In order to break even, the dealer must sell a portion of the man-made and woolen textiles and the cotton textiles that cannot be made into wipers. In the export trade, textiles are valued at $240 per ton. To make up the difference between his cotton preparation costs and his wiping rag selling price ($113.65), the dealer must sell 916 pounds of textiles in export, worth $109.92 ($240 per ton); to this is added a saving on disposal cost of $3.81. If he incurs shipping costs to a port or must pay brokerage fees, he must, of course, sell proportionately more than 916 pounds. If the textiles are sold as roofing rags for between $15 and $20 per ton or as pulp substitute grades for between $100 to $200 per ton, the quantities must also be higher to justify wiping rag operations.

If usable cotton is only 15 percent of mixed rag bundles, the dealer's cotton wiper costs will be $776 per ton. His loss will be $356 per ton and he will have to sell 1.4 tons of textiles in export for every ton of wiper cloth he sells to break even.

In 1968, textile dealers sold 268,000 tons of obsolete textiles in addition to wiping rags, equivalent to 1.84 tons per ton of wipers sold. Of this total, 123,000 tons went into the export trade, 144,000 to the domestic consumers. If cotton was 15 percent of mixed rag bundles in 1968, dealers had to sell these nonwiping obsoletes for an average of $186 per ton to break even; if cotton was 30 percent, the break-even sales price had to be $54 per ton. The value of textiles in the export trade was $240 per ton in 1968. Thus, at the 15 percent cotton content level, the average domestic sales price per ton had to be $140 per ton; at the 30 percent cotton content level, dealers could have lost $105 per ton on domestic consumption and still have had a break-even year.[97]

Wiper manufacturers are beginning to feel strong competition from producers of new wiping materials — both textile wipers and paper products. One reaction within the industry is "if you can't fight 'em, join 'em." Wiper dealers are beginning to act as middlemen between new wiper producers and wiping rag consumers. Dealers find that new wipers, which cost more than old rag wipers, are beginning to be competitive in overall cost with old wipers. Old rag wipers are sometimes rejected because nonabsorbent textiles are inadvertently included. For new wipers, handling costs may be cut to the bone because the dealer may have the wipers shipped directly to the customer. In addition, the cost of old wiper production is rising for reasons explained above.

Textile Consumption in Paper and Board. Textile waste, once an important input material to the paper industry, has steadily declined in importance. In 1956, only 0.9 percent of all fibrous materials inputs to the paper industry were rags.[98] After that year, textiles are not separately reported in fiber consumption statistics. Assuming that the ratio of rags to "all other" fibers consumed in the 1952-1956 period has held unchanged, rag consumption in 1968 was 0.4 percent of total fibrous inputs, or 225,000 tons, down from 298,000 tons in 1956. Long-term trends appear to indicate that waste textiles will eventually disappear as paper and board industry inputs.

There are two basic forces at work here: (1) the decline in the use of waste materials in paper, of which rags are one portion; (2) the decline in the availability of textile waste grades acceptable to the paper industry as well as the slow change in demand for rag content paper. Cotton, the vegetable fiber based textile used in large quantities, is in a no-growth situation and is an ever lower proportion of total textiles. Furthermore, more and more of the cotton is used in blends with man-made fibers, which cannot be processed by the paper industry. An additional problem is the use of non-water-soluble adhesive tapes in the fabrication of textile products; such tapes contaminate cotton clipping wastes and make their reuse impossible without prohibitively costly manual sorting.

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[96] Disposal cost is around $5 per 1,200 pound bundle, $8.32 per ton, and $19.39 for 2.33 tons of unsalable textiles.

[97] At the 15 percent level, wiper losses would be $356 × 146,000 tons, or $51.976 million; sales of 268,000 tons of additional textiles will save disposal costs (268,000 × $8.32) of $2.230 million, leaving a net loss of $49.746 million; to cancel this will require a sales price per ton of (268,000 divided by $49.746 million) $185.62. If 123,000 tons are sold for $240 per ton in export ($29.250 million), 144,000 tons need to generate only $140.46 per ton (144,000 divided by $20.226 million). The same logic is used for the 30 percent level; losses at that level are $114 per ton of wipers.

[98] The statistics of paper, 1964. New York, American Paper and Pulp Association. p.21.

Reprocessing of Textiles. A specialized segment of the textile industry engages in the conversion of textile wastes into respun fibers, paddings, backings, and similar products. This industry appears to be declining. The number of establishments dropped from 183 in 1958 to 141 in 1963 and to 138 in 1967. The number of employees dropped from 4,600 in 1958 to 4,300 in 1967. Value of shipments was $93.5 million in 1958, $87.5 million in 1963, and $88.9 million in 1967. Total waste materials consumed by the industry declined from 115,500 tons in 1963 to 71,800 in 1967, a 38 percent decline in the period. The use of textile wastes dropped from 38,800 tons in 1963 to 19,800 tons in 1967, a 49 percent drop in consumption.

Three factors explain the decline in textile reprocessing: (1) the products of this industry are competing against new chemical-based materials — principally foam rubber; (2) wool consumption is dropping, and the proportion of secondary wool that can be consumed (around 4 percent of total consumption) is also declining; (3) acceptable textile waste materials supplies are decreasing in quantity because of "contamination" by chemical blending of fibers. The costs of acceptable materials have risen as a consequence, and reprocessors thus face fading markets and new competition with products that cost more. In 1963, for instance, reprocessors paid $280 per ton for new and used textile wastes; in 1967, they were forced to pay $520 per ton for these input materials.

Export Markets. Confronting declining domestic markets for waste textiles, the secondary materials industry has long viewed the export market as a promising outlet for its commodities. The export picture, however, is not particularly cheerful. Export markets must take up all commodities that cannot be sold domestically, and this largely means those portions of mixed rag bundles that cannot be sold as wiping rags. While wiping rag consumption has grown at a rate of 3 percent annually, exports since 1955 have grown at a rate of 1.8 percent yearly, from 148,100 tons in 1955 to 190,800 tons in 1969 (Table 50).

Not all exports are obsolete textiles. The Bureau of the Census stopped reporting obsolete and new exports separately in 1965, and in earlier periods, only the cotton and wool portions were reported by origin. In 1964, 53 percent of cottons exported and 95 percent of wool exports were obsolete; the two grades combined yield an obsolete ratio of 68 percent. In making our estimates for 1968, we assumed that this ratio was applicable to all grades.

In 1968, 182,300 tons were exported, containing an estimated 123,000 tons of obsolete textiles. Of the obsolete portion, cotton was 42,000 tons; wool, 38,000; man-made fibers, 23,000; and all other textiles, 20,000. If we assume that all the obsolete wool came from mixed rag bundles (which is to be expected) and that the 1968 bundles represent textiles consumed in 1963 (five years earlier) when wool was 6.4 percent of total textile consumption, then the exported wool required the collection of 604,000 tons of mixed rags — roughly in the middle between the low and high estimates presented earlier (Table 49).[99]

Trends in export indicate that export demand for man-made textiles and other textiles is increasing, demand for cotton is stable, and demand for wool is dropping. Textile dealers have experienced this and report that woolen textiles cannot be sold at generation rates.

U.S. waste textiles are consumed in more than 50 countries. The single largest buyers, in descending order of importance, are: Italy, Spain, Canada, France, Nigeria, Phillipines, Iraq, Belgium, England, West Germany, Tunisia, Lebanon, Pakistan, Cameroon, and Japan.

Consumption patterns by commodity type reveal that the largest consumers of cottons are developed nations; of woolens, developing nations; of man-made fibers, industrialized countries; and of "other textiles," developing nations — always excepting Italy, which leads in the consumption of all but one type of textile waste.

Textile dealers point out that the decline in woolen sales (and the slow growth rate of textile exports in general) is explainable by: (1) the development of strong virgin textile industries in southern Europe, especially in Italy; (2) the consequent decline in the demand for used clothing in southern Europe; (3) affluence in Europe leading to the generation of textile wastes there; and (4) the consequent rise in competition for waste textile markets in the Near East and Africa.

These developments have hurt wool exports especially, which go largely to African and Near Eastern countries and Italy. U.S. dealers can least afford to lose their wool markets because woolens are a dis-

[99] It appears from this that mixed rag consumption must have been higher than 604,000 tons in 1968 because nearly all dealers report that they are unable to sell all of their obsolete wool acquisitions.

proportionately large part of mixed rag bundles and because domestic markets for wool are very limited.

Consumption trends, as presently established, do not appear to be responsive to unilateral intervention by the U.S. Government, and dealers can do little to influence the foreign demand.

The Wool Controversy. The textile industry consumes around 10,000 tons of reprocessed wool yearly, equivalent to around 4 percent of total wool consumption. Since woolen articles can be separated and the wool can be rewoven (a process known as garnetting), there is no limit to the quantity of wool that could be recycled. Little is recycled, and dealers blame the 1940 Wool Labelling Act, which requires that manufacturers of woolen articles label garments and other materials to show the percentage of reprocessed wool used.

This has destroyed the reprocessing of wool because consumers, in part conditioned by advertising, have an aversion to reprocessed woolens, preferring "pure" virgin wool.[100]

Textile dealers believe that elimination of the labeling requirement would cause an increased use of reprocessed wool because economics inherently favor reprocessed wool and the quality of products made from waste woolen textiles would not be affected. We are not certain that removal of the labeling requirement would in itself succeed in boosting wool recycling. Sheep growers, already seriously worried by the decline in wool consumption, would undoubtedly exert as much pressure as possible (by trimming costs and by advertising) to maintain wool's image. Sheep growers in Australia, New Zealand, and South Africa launched a scheme as far back as 1956 to give virgin wool an international image. The scheme consists of an international trademark, called "Woolmark." which is granted to manufacturers who make products in which the reprocessed wool fraction is no more than 0.03 percent.[101] "Woolmark" promotion may be used effectively to negate any beneficial effects of a repeal of the Wool Labelling Act.

Conclusions

The large quantities of textiles collected from households by social welfare agencies do not translate into a large recycling rate. Most social welfare textile collections are resold; portions that are sent to dealers are reused and exported, with only a small tonnage being recycled.

In 1968, the recycling rate for textile wastes was 7.5 percent of consumption (428,000 tons of recycling, 5.7 million tons of consumption). This includes exports under the "recycling" category. If exports (some of which are sold as clothing) are excluded, the recycling rate was 4.3 percent of consumption in 1968, or 246,000 tons.

Recycling is declining, in part because textile wastes are used at decreasing rates in paper and board and in part because the most desirable fraction of textile wastes, pure cotton, is decreasing.

Reuse of textiles, although not a direct utilization of these fibers in new products, has a beneficial effect on waste processing nevertheless by keeping wastes down. (For instance, reused textiles doing service as wiping rags could have been thrown away as obsolete textiles and, in addition, the waste stream could have been loaded with new materials in wipers.)

[100] One exasperated industry observer comments: "Most consumers see a virgin product as something esthetically clean. But have you ever seen a sheep?" J. Mighdoll, Executive Director, National Association of Secondary Materials, Inc., quoted in: Turning junk and trash into a resource. Business Week, No. 2145:67, Oct. 10, 1970.

[101] Stansfield, J. R. Textile reclamation in practice. Secondary Raw Materials, 7(10):96, Oct. 1969.

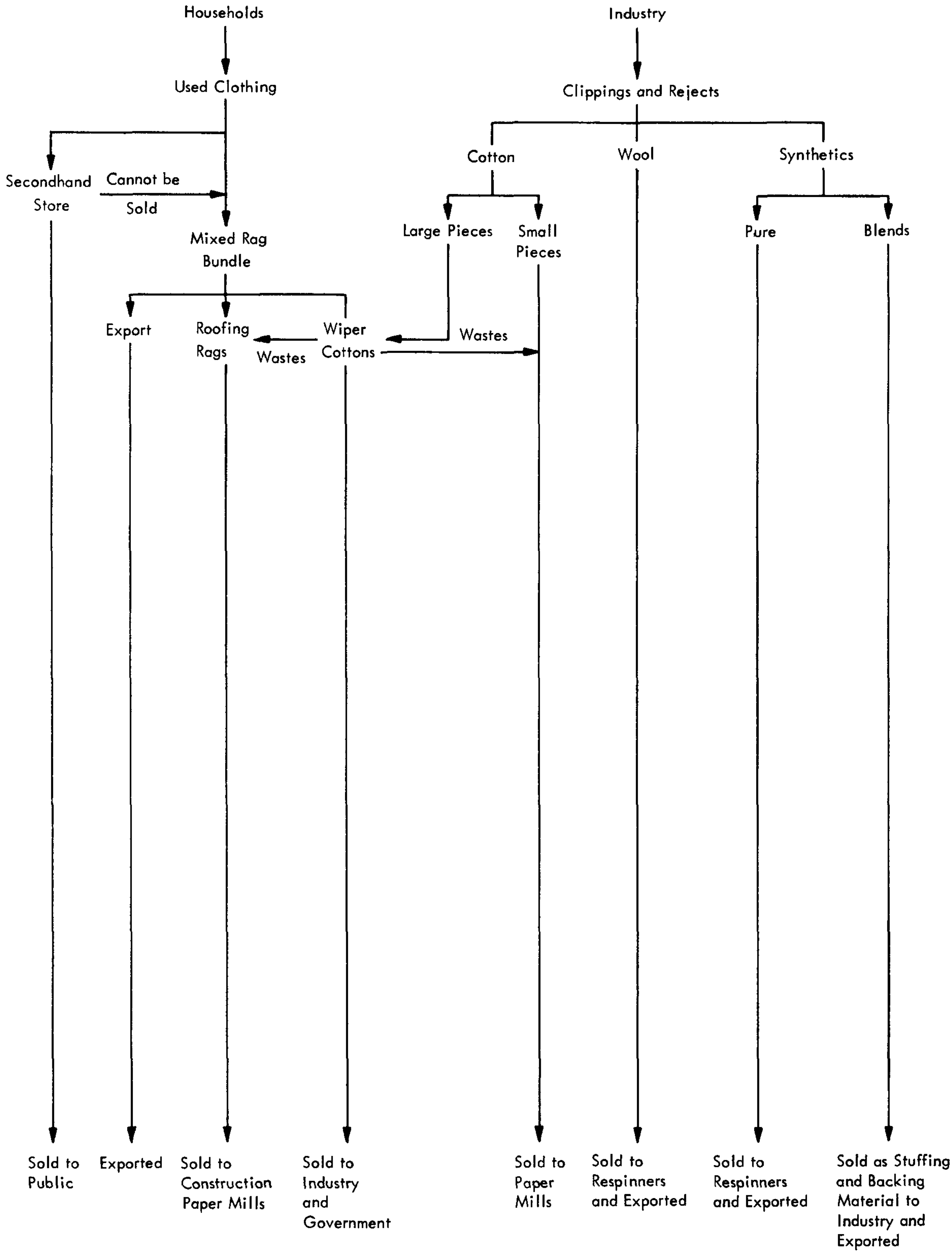

Figure 22. Schematic of commercial disposition of waste textiles.

TABLE 47

CONSUMPTION OF FIBERS FOR DOMESTIC USES
IN THE U. S., 1960-1968, BY TYPE OF FIBER, IN 1,000
TONS AND PERCENT*

Year	Total wt.	Cotton wt.	Cotton %	Wool wt.	Wool %	Man-made wt.	Man-made %	Other† wt.	Other† %
1960	3,895	1,965	50.45	283	7.27	950	24.39	697	17.89
1961	3,974	1,951	49.09	281	7.07	1,041	26.20	701	17.64
1962	4,352	2,015	46.30	282	6.48	1,200	27.57	855	19.65
1963	4,560	2,012	44.12	290	6.36	1,376	30.18	882	19.34
1964	4,738	2,092	44.16	256	5.40	1,557	21.86	833	17.58
1965	5,088	2,144	42.14	270	5.30	1,773	34.85	901	17.71
1966	5,234	2,161	41.29	260	4.97	1,951	37.27	862	16.47
1967	5,182	2,068	39.91	233	4.50	2,100	40.52	781	15.07
1968	5,672	1,994	35.16	239	4.21	2,598	45.80	841	14.83

*Textile fiber end use survey. Textile Organon, 41(1): 1-23, Jan. 1970. Excludes fibers produced for export consumption; excludes imports of finished garments.

†Represents imports of silk, linen, jute, sisal, and other fibers imported for consumption.

TABLE 48

END USE DISTRIBUTION OF 1968 TEXTILE CONSUMPTION, IN 1,000 TONS*

Category	Wt.	% of total
Men's and boys' wear	957	19.80
Women's, misses', children's, and infants' wear	952	19.70
Home furnishings	1,464	30.29
Bedspreads, quilts, blankets, sheeting, etc.	588	12.17
Carpets and rugs	557	11.52
Curtains	32	0.66
Drapery, upholstery, slipcovers	278	5.75
Miscellaneous	9	0.19
Other consumer-type products	553	11.44
Linings, piece goods, fabrics, yarns	330	6.83
Shoes, slippers, luggage, handbags	55	1.14
Toys	12	0.25
Medical, surgical, sanitary	82	1.69
Miscellaneous	74	1.53
Industrial	907	18.77
Transportation upholstery and auto seat covers	46	0.95
Tires	291	6.02
All other	570	11.80
Total	4,833	100.00

*Textile fiber end use survey, Textile Organon, Jan. 1970. Excludes imported silk, linen, jute, sisal, and other fibers that are not allocated by end use in source.

TABLE 49

TEXTILE RECOVERY AND REUSE, 1968, IN 1,000 TONS*

Item	Tonnage
Materials sold	
Wiping rags--largely cotton	146
Paper and board mills--vegetable fiber-based textiles, some synthetics, and wool	225
Exports--all fibers	182
Reprocessors--wool and synthetics	21
Total	574
Materials acquired	
Clippings and other new wastes	160
Mixed rags from social service agencies	482 - 978
Total	642 - 1,138

*Estimated by Midwest Research Institute; see text for explanations of derivations. Quantities on mixed rags from social service agencies are based on two levels of cotton content and are derived from mixed wiping rag sales.

TABLE 50

EXPORTS OF TEXTILE WASTES, 1955-1969, BY TYPE, IN 1,000 TONS AND PERCENT*

	Cotton		Wool		Man-made fibers		All other†		
Year	Tons	%	Tons	%	Tons	%	Tons	%	Total
1955	58.8	39.7	78.3	52.9			11.0	7.4	148.1
1956	60.0	44.6	64.8	48.1			9.8	7.3	134.6
1957	66.5	43.0	79.2	51.2			9.0	5.8	154.7
1958	62.6	46.5	55.4	41.1			16.7	12.4	134.7
1959	68.1	41.4	72.6	44.1			23.8	14.5	164.5
1960	75.4	43.4	72.6	41.8			25.6	14.8	173.6
1961	78.7	46.3	70.3	41.3			21.1	12.4	170.1
1962	88.4	50.0	67.5	38.2			20.9	11.8	176.8
1963	106.4	51.8	74.1	36.0			25.2	12.2	205.6
1964	117.1	55.5	67.5	32.0			26.4	12.5	211.0
1965	90.6	45.7	61.9	31.2	23.5	11.9	22.3	11.2	198.3
1966	91.1	46.5	57.3	29.2	28.3	14.4	19.4	9.9	196.1
1967	83.5	46.0	48.3	26.6	28.9	15.9	21.0	11.5	181.7
1968	79.1	43.4	40.4	22.2	33.8	18.5	29.0	15.9	182.3
1969	70.7	37.0	38.9	20.4	48.4	25.4	32.8	17.2	190.8
Average for period									
1955-1959	63.2	42.9	70.1	47.6			14.1	9.5	147.4
1960-1964	93.2	49.7	70.4	37.6			23.8	12.7	187.4
1965-1969	83.0	43.7	49.4	26.0	32.6	17.2	24.9	13.1	189.9

*U.S. Bureau of the Census. U.S. exports--schedule B commodity and country. Report FT410. Washington, U.S. Government Printing Office, 1974; 1965; 1969.

†Includes man-made fibers, 1953-1964.

CHAPTER IX

OTHER MATERIALS

Rubber

In 1969, the rubber industry[102] consumed 3.2 million tons of rubber, including 279,800 tons of reclaimed rubber. Tires accounted for 67 percent of rubber consumed, the remainder being distributed to a large number of other applications (Table 51). Reclaimed rubber, overall, represented 8.8 percent of consumption. In addition to reclaimed rubber, 752,000 tons of old tires were consumed by retreaders and 7,000 tons by tire splitters,[103] for a total recovery in 1969 of 1.0 million tons (Table 52). Tire splitting is a clear case of reuse, analogous to wiping cloth production from old textiles. Retreading is a more ambiguous case and could be viewed either as recycling or reuse. If retread tires are viewed as recycling, then the weight of retread tires (0.752 million tons) must be added to recycled tonnage and to consumption, in which case total rubber consumption is increased from 3.19 million to 3.94 million tons in 1969. Recycling as a percentage of consumption is increased from 8.8 percent to 26.2 percent in that year.

Rubber Reclaiming. Rubber products are reclaimed in 20 plants across the United States with a capacity of 412,500 tons per year. The reclaiming industry's input products consist of obsolete tires, tire parts (from tire splitters among others), retread buffings (from retreaders), inner tubes, and similar obsolete products (43.7 percent of inputs in 1968), rubber manufacturing scrap (7.5 percent), and other industrial rubber scrap (48.8 percent). Rubber reclaimers used about 71,000 tons of old tires in 1968. The prices paid by reclaimers vary from nothing to $10 per ton for tires delivered to them.

Obsolete and new rubber wastes are reduced to a uniform size by shredding and cracking; metals and fibrous materials are removed; the rubber is mixed with reclaiming oils, softened, and mixed with compounding agents; and after further refining and milling operations, the reclaimed rubber is sold in slabs or bales.

Reclaimed rubber production has averaged 297,000 tons a year in the 1958 to 1968 period. Production data (Table 53) do not show a clearly discernible trend in the direction of growth or decline. Reclaimed rubber as a percentage of total rubber consumption has definitely declined in the period, from 19 percent in 1958 to 9.3 percent in 1968, 8.8 percent in 1969, and a projected 8.5 percent level in 1970.

The no-growth production pattern of reclaimed rubber viewed against the backdrop of an expanding economy and rubber industry suggests that reclaimed rubber is meeting stiff competition from natural and synthetic rubber and other materials. This, in fact, is the case. Some new tire-rubber formulations are incompatible with reclaimed rubber. This has kept reclaim consumption in tires at a plateau. Rubber in a variety of other applications, such as floor mats, hosing, belts, footwear, and the like, has been in competition with plastics. The only application in which reclaimed rubber has exhibited a strong growth pattern is in cements and dispersions; but these materials were only 3.5 percent of total reclaimed rubber in 1969.

Retreading. Automotive and truck tire retreaders are responsible for keeping a significant tonnage of tires out of the waste stream — 734,000 tons in 1968 and 752,000 tons in 1969. The retreader usually buys unsorted

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[102] Pettigrew, R. J., and F. Roninger. Rubber reuse and solid waste management. [Public Health Service Publication No. 2124.] Washington, U.S. Government Printing Office.

[103] Tonnage based on output of these industries rather than input; thus waste produced in retreading and tire splitting is excluded as a by-product sold to rubber reclaimers and new rubber purchased by retreaders.

tires from retailers at a price that brings his cost per usable tire to less than $1.00, probably around $0.75. At times when tires are in short supply, he may pay a tire carcass wholesaler or tire broker from $1.25 to $3.00 a unit. Sorting of tires acquired usually results in the rejection of 50 to 80 percent of the tires collected. After sorting, retreaders remove the remaining tread by buffing and apply a new tread to the tire carcass. The buffings usually become waste, but a small quantity is recycled through reclaimers. Most of the rejected tires must be disposed of by the retreaders at costs of $7 to $10 per ton or higher.

Unlike reclaimed rubber, consumption of retreaded tires has grown in the 1958 to 1969 period at a rate of 2.1 percent yearly. This rate, however, has been slower than new tire consumption, which grew at an annual rate of 6.8 percent. Thus, in 1958, 136.1 million tires were produced, including 37.2 million retreads, or 27.3 percent of total; by 1969, tire production had increased to 251.2 million units; retreads were 46.5 million units, or 18.5 percent (Table 54).

The decreasing use of retreads, relative to total tire consumption, is a reflection of growing affluence, competition from synthetic rubber tires specifically designed and priced to be competitive in the retread market, and technical problems within the retreading industry which have caused costs to increase.

Tire Splitting. The tire splitting industry, consisting of three companies, engages in the production of various industrial products die-cut from obsolete tires. Typical products are gaskets, shims, insulators, doormats, conveyor rollers, belt pieces, and the like. This industry takes in around 29,000 tons of tires, of which around 7,000 tons go out as various products, 18,000 tons are sold to rubber reclaimers, and 4,000 tons go to waste.

Waste Rubber Trading. Rubber wastes, usually in the form of obsolete tires and inner tubes, are handled by secondary materials dealers; some are rubber specialists, but this is a disappearing breed because rubber waste handling is not a very profitable business. Rubber dealers, who once paid waste generators for tires, are converting their operation to a new basis — whereby the generators pay them to remove the tires. Tires bring anywhere from $5 to $14 per ton delivered to a reclaimer's plant. Tire splitters pay $15 per ton. Since tires occur in relatively small concentrations at garages and filling stations, the sales price is usually insufficient to cover a dealer's costs of picking up tires, removal and disposal of unacceptable tires (excessively worn tires, studded snow tires, steel-wire reinforced tires), and delivery or freight to the reclaimer. He must be paid for the removal service in order to stay in business.

Reclaimers, who can best use rubber wastes that are already free of metals and fibers, pay considerably more for such wastes than for tires. Thus retread buffings bring $25 to $35 per ton, natural rubber inner tubes $120 to $160, and butyl rubber inner tubes $100 to $120 per ton.

Conclusions. Conventional recycling and reuse of rubber products is a limited activity at present. Rubber waste recycling and reuse is growing very slowly, and what little growth there is comes as a result of retread tires sales; retreads are of declining importance in the tire industry. The bulk of rubber production reaches the discard state in the form of tires which, though largely rubber, are composites of several materials, including textiles and metals. The reprocessing of this rubber by removal of impurities is less costly than production of virgin rubber, but the cost advantages are not sufficiently great in light of the technical limitations of reclaim, to cause increased use of reprocessed rubber.

Rubber in mixed municipal wastes usually also occurs as a component of products — soles and heels on footwear, rubber backings on textiles, wire coatings, gaskets and insulation in small appliances, etc. Some rubber is pure (water bottles, rubber bands, toys) but this is an insignificant portion of the total. Removal of these materials from mixed wastes for recovery appears impractical.

The most practical use for rubber, particularly old tires, appears to be raw materials recovery by distillation or energy recovery; such technology is unproven in the marketplace today. In addition, a critical cost and logistics problem is the collection of tires to central processing locations.

Plastics

The growth of plastics production continues at impressive rates. In the 1960 to 1970 period, plastics production increased at a rate of 11.8 percent annually, from 3.07 million to 9.35 million tons; forecasts place 1975 consumption at 13.55 million tons and 1980 consumption at 19.0 million tons.[104] The greatest uses for plastics are in construction and packaging (Table 55).

Today plastics are still only a small percentage (1.1 percent) of solid waste — an estimated 2.1 million tons in 193.7 million tons of collected wastes in 1968. For 1970, the total was estimated at 2.55 million tons of plastic waste collected, of which packaging was 1.8 million tons and all other products were 0.75 million tons.[105] Assuming a growth rate for solid waste of 4 percent yearly and for plastics at the rates given above, by 1975 plastics will be 1.5 percent and by 1980, 1.8 percent of collected waste. The proportion may be even higher because consumption of plastics packaging and housewares is growing more rapidly than plastics consumption as a whole.

The term "plastics" is an umbrella term that includes a vast variety of chemical substances. Polyethylene (PE) is the most common plastic, accounting for around 31 percent of total tonnage; polystyrene, 18 percent, and polyvinyl chloride (PVC), 20 percent, are other materials used in large quantities. Most plastics begin with oil refinery byproducts or natural gas purification plant products from which ethylene is produced in a petrochemical plant. Polymerized ethylene yields polyethylene; ethylene and chlorine yield vinyl chloride monomer which is polymerized to PVC; ethylene and benzene are combined to make styrene monomer and, in turn, polystyrene.

Approximately 80 percent of plastics can be remelted again after forming and are labeled "thermoplastics." The remaining 20 percent "set" after forming and are labeled "thermosetting" plastics. This category includes phenolics, polyesters, epoxy, and other materials. Thermoplastics are at least theoretically recyclable; thermosets cannot be recycled with known technology.

Plastics Recovery. There are no data available to indicate the quantities of plastics recycled. Our investigations, conducted predominantly through local interviews and correspondence, revealed that waste production in plastics fabrication is quite high, ranging from 5 to 15 percent for all thermoplastics and from 10 to 30 percent for all thermosets. Thermoset wastes, of course, cannot be remelted and go to disposal. Fabrication waste reuse related to thermoplastic production varies from operation to operation and from company to company. We could discern no pattern. Once plastics leave fabrication points, they are not recovered (there is one exception that we shall discuss), and there is no recovery from obsolete products.

Fabrication wastes, unless they are immediately reused in the plant where they occur or are disposed of, are acquired by plastics scrap processors who specialize in regrinding scrap, color blending, and remelting. These processors frequently operate on a contract basis, returning wastes to the organization that provided them, reformulated into a product that can be reused. These processors also supply manufacturers that use scrap plastics as an input material. We were able to identify 13 such companies in the United States.

Plastic scrap, as prepared by processors, is consumed in the toy industry, in the manufacture of cheap housewares, in the manufacture of plastic pipe, in the production of artificial flowers, and in similar applications where (1) plastics properties and performance are not paramount; (2) relatively noncritical processes are used (compression molding or heavy extrusion); and (3) the cost of plastic resin is a high proportion of total product cost.

We know of only one instance where a plastics product is recycled after doing service in the home. The project involves a San Diego dairy that uses polyethylene milk bottles. Following Earth Day activities in the San Diego area, the dairy worked out an arrangement, with the help of Dow Chemical, producer of polyethylene resins, whereby bottles returned through the milkman or placed into special supermarket bins were ground by the dairy and the material was sold to a manufacturer of drainage tile. Approximately 8 percent of the bottles were returned; consumers were not paid for the plastic.[106]

Plastic fabrication wastes are worth \$10 to \$20 per ton for clear polyethylene, \$40 to \$60 per ton for clear polystyrene, \$90 to \$110 per ton for clear vinyl, and \$120 to \$160 for clear cellulose acetate. These are prices paid by processors. Virgin plastics sell for around \$225 to \$400 per ton for polyethylene, \$310 to \$350 for polystyrene,

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104 Forecast by Society of Plastics Industry, Inc., transmitted in private communication dated Feb. 4, 1971; 1970 production estimated by SPI.

105 Plastics in waste for 1970 estimated by Society of Plastics Industry.

106 Milk bottles to tiles. Chemical & Engineering News, 48(35):11, Aug. 24, 1970.

$240 to $400 per ton for vinyl chloride resins, and $1,240 per ton for cellulose acetate.

Problems of Plastics Recycling. Among the major factors that combine to minimize interest in plastics salvage and to limit severely the extent of recycling are the following.

(1) Techniques for separating plastics from mixed wastes are not available.

(2) Identification of plastics is difficult. Segregation of waste plastics by resin type appears impossible. There are currently over 700 different grades of polyethylene alone.

(3) Degradation of resin properties and performance occurs during the initial fabrication, through aging, and in any reclamation process.

(4) The technology for purification and upgrading of contaminated, degraded, and colored plastics simply does not exist.

(5) Economics of collecting and shipping plastics to points of reuse are generally unfavorable.

(6) Effective market mechanisms for trade in reclaimed plastic materials have not developed.

(7) Standard grades and specifications for reclaimed or salvaged plastics are not established or not widely accepted.

(8) Plastics users distrust the uniformity of reclaimed plastics and are generally unwilling to risk adding another variable to the "inexact science of molding."

A fundamental obstacle to plastics recovery and reuse springs directly from the synthetic origin of the resins. Because resins are created in a relatively pure form, it has not been necessary to develop the technology for purifying and refining plastics.

Unlike the metals production process, which begins with an impure ore which is progressively concentrated, smelted, refined, and freed from impurities to create the desired alloy, plastics processing begins with high purity virgin polymer to which various nonresinous additives, colorants, and reinforcements are added. All plastics processing is downhill from pure and uniform resin to blended, colored, shaped, and partially degraded plastic products.

The recovery of metal scrap is made possible by decades of metallurgical technology designed to upgrade ores and concentrates. Likewise, paper stock recovery is supported by the traditional steps of fiber separation, refining, washing, and bleaching cycle which also converts cut timber into papermaking furnish although it is accomplished in different types of equipment than virgin pulp making. Production processes based upon purification, refining, and upgrading of crude materials are capable of accepting scrap as though it were partially processed ore or charge stock.

No analogous technology for plastics processing has yet developed. Thus plastic scrap is never purified; rather, the regrind is colored darker and used for less critical products. Practical means of removing unwanted contaminants are largely nonexistent.

The general rule governing the reuse of plastic scrap seems to be: "If plastic leaves the machine on which it was formed, it is no longer usable scrap; it's waste!"

The dominant pattern of plastics recycling, for these reasons, is one in which the wastes of a process using high quality resin are either blended back into the process in limited quantities or are resold for use in a less exacting application, sometimes passing through a secondary materials operation where color blending, repelletizing, and similar scrap preparation steps are undertaken.

Value Recovery from Plastics. The rapid growth of plastics and the very major barriers to their recovery suggest that plastics in waste may best be used by recovering their latent energy by incineration followed by heat recovery. Plastics in waste (largely the packaging portion) have a BTU value per pound of 15,770, thus the highest BTU of any material in waste.[107] The BTU value of solid waste as a whole is around 5,500 BTU per pound and rising as the proportion of paper and plastics increases. Insofar as heat recovery will become an accepted means of obtaining value from waste, the presence of plastics in wastes will be beneficial — provided that polyvinyl chloride materials, whose combustion in the presence of moisture results in corrosive hydrochloric acid vapors, can be eliminated or equipment can be shielded from their corrosive effects.

Organics

Organics recovery includes animal and poultry slaughtering waste recovery, food processing waste utilization, reuse of lumber and saw mill wastes, recycling

[107] Kaiser, E. R. Incineration of packaging wastes with minimal air pollution. In Proceedings; First National Conference on Packaging Wastes, University of California at Davis, Sept. 22-24, 1969. Washington, U.S. Government Printing Office, 1971. p.184.

of textile fiber wastes (briefly discussed in Chapter VIII), hog feeding with garbage from commercial and institutional sources, composting of municipal wastes to produce a soil-building material, compost mixed with sewage sludge or synthetic nutrients for some fertilizer value, and manure utilization.

Slaughter Waste Rendering. Rendering is a fairly large waste processing activity that consumed 10.5 million tons of organic wastes in 1969 and converted these to 5.0 million tons of various products.[108]

Rendering industry inputs come from slaughtering plants, breaking plants (where carcasses are cut into retail cuts), food stores, restaurants, and from the collection of dead animals. Industry outputs are grease and tallow (41.5 percent), meat meal (48.6 percent), bone meal (3.4 percent), feather meal (2.2 percent), and other (4.3 percent).

Animal fats sold domestically (approximately two-thirds of total) are made into soap (24.4 percent), fatty acids (23.3 percent), animal and poultry feeds (41.2 percent), lubricants (3.6 percent), and other uses (7.2 percent).

Protein products are used almost exclusively in the domestic animal feed industry. Only feather meal is exported in substantial quantities, but this material is a small percentage of total.

Industry shipments were 5.3 million tons in 1963, 6.5 million tons in 1967 (Table 56), and an estimated 5.0 million tons in 1969.

Using estimates of input materials consumed by renderers and production of end products from inputs provided by the National Renderers Association, it appears that 2 tons of inputs are required per ton of output, the difference being moisture and product loss in rendering. Value of products shipped was an average of $89 per ton in 1967 and the cost of materials to the industry was $54 per ton of shipments, or about $27 per ton of input. Although we could not get confirmation for this, we conclude from the above that prices paid for organic wastes range from $15 to $35 per ton depending on quantities obtainable from a source, distance to rendering plant, and other similar factors.

In 1967, 588 establishments employing 13,800 people comprised the rendering industry. Roughly half these were independently owned, half were affiliated with the meat and poultry industries. The majority were livestock waste rendering operations.

Food Processing. The food processing industry, excluding meat and poultry processors, generates a variety of food wastes, some of which occur in solid form (eggshells, fruit, peelings, bran, and coffee grounds), and some of which are usually viewed as liquid wastes, (whey). With isolated exceptions, food wastes are disposed of since their recovery is uneconomical, impractical, or in violation of sanitation standards.

Some food plant wastes are used in hog feeding operations.[109] Approximately one-third of the 800,000 tons of whey solids produced in dairy operations yearly is sold to formula-feed companies and farmers for animal feeding.[110] California peach canners convert peach stones into charcoal by pyrolysis.[111] Pharmaceuticals are made from citrus fruit wastes,[112] and there are also recovery operations that convert cereal grain processing wastes into animal feeds.

Although there are no data available on the total quantities of food wastes recovered, all indications are that the tonnage is quite small. The chief reasons for this appear to be the following.

(1) Food wastes can best be processed into animal feeds, where high protein or oil content is desired at relatively low cost. Fruit and vegetable wastes are low in protein; high protein animal wastes are already recovered by the rendering industry.

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[108] Based on estimates and observations provided by Personal communication. O. H. M. Wilder, National Renderers Association, Inc., to A. J. Darnay, Midwest Research Institute, Nov. 1969.

[109] Systems analysis for solid waste disposal by incineration. Prepared by FMC Machinery/Systems Group, Engineering Systems Division, FMC Corporation, for the City of San Jose and the County of Santa Clara, Nov. 1, 1968. p.32.

[110] Burch, J. E., E. S. Lipinsky, and J. H. Litchfield. Technical and economic factors in the utilization of waste products. *Food Technology*, 17(10):59, Oct. 1963.

[111] Mercer, W. A. Industrial solid wastes; the problems of the food industry. In Proceedings; National Conference on Solid Waste Research, Chicago, Dec. 1963. American Public Works Association, 1964. p.56.

[112] Sales from scraps. Chemical Week, 95(20):94, Nov. 14, 1964.

(2) The use of pesticides, which tend to show up in vegetable and fruit skins (the waste products) render these wastes undesirable in animal feeds.[113]

(3) Recovery of proteins from food wastes is costly. Ionics, Inc., estimated[114] that the cost per ton of protein produced from organic urban refuse in the form of torula yeast would be between $276 and $356; this compares with $164 to $252 per ton of protein in animal meal. Production of dried press cake, a dewatered byproduct of tomato juicing and canning, was estimated to cost $160 per ton in 1952;[115] this material contains 22.5 percent protein; thus cost per ton of protein was $516.

Waste recovery is beginning to arouse new interest in the food industry — not because profitable new markets for such products beckon but because costs of disposal of both solid and liquid wastes are increasing. One food industry research scientist has proposed conversion of bran into a coarse plastic, recovery of lactose and protein from whey by use of a molecular sieve, conversion of coffee grounds into molded products, and conversion of eggshells into thermosetting insulation materials.[116] Such proposals are still only bandied about. Technical feasibility does not ensure the presence of markets for such converted products.

Agricultural Wastes. Less than 1 percent of crop residues produced in 1952 (200 million tons in that year and an estimated 550 million tons in 1968) were used for various types of building boards, in paper, as soil conditioners, animal feeds, poultry house litter, furfural, in alcohol production, in sugar solutions, in yeast production, as packing material, and as sweeping compounds.[117] Since 1952, the consumption of such residues in at least two applications (building boards and paper) is known to have declined substantially. Most crop residues are left on the field, however, and being degradable they eventually return to the soil and are not a municipal solid waste management problem. Animal manures, produced at an estimated rate of 1.5 billion tons in 1968, occur largely in rural settings where they continue to have some use for fertilizer. There is also some composting of agricultural wastes. In general, the trends to heavily populated animal feed lots and new farm management techniques are tending to accentuate the solid waste disposal problems where they might have been of minor concern in earlier times.

Wood. Wood wastes occur in logging operations and analogous urban tree-trimming and tree-cutting activities, in lumber mills, in lumber conversion, in construction, and similar operations that harvest or convert wood. Discarded wood products in municipal waste is around 2 percent by weight.

Wood wastes are used in essentially four areas: (1) as agricultural mulches, cushioning agents (under fruit trees and on ski slopes) weed control agents (weeds will not grow in an area such as the center strip of a highway covered with wood chips), poultry litter, and similar agricultural and horticultural applications;[118] (2) as inputs to building board mills and paper mills; (3) as a fuel, both by generators of the waste and others, including conversion of wood wastes to charcol, burning of special wood species (hickory, maple, birch, beech, oak, gum, walnut) in meat smoking, in the baking of special foreign pastries, tobacco curing, brooder heating, and in household uses; and (4) in chemical applications such as distilleries, vinegar manufacturing (to provide bacterial aeration), gas purification (sulfur removal by use of iron oxide impregnated hardwood), and tanning.[119] A substantial portion of the paper industry in the Pacific Northwest is based on sawmill wastes for its raw materials.

Data on waste generation and reuse for three wood-using industries (sawmills, wood container man-

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[113] Meller, F. H. Conversion of organic solid wastes into yeast. An economic evaluation. Public Health Service Publication No. 1909. Rockville, Md., U.S. Department of Health, Education, and Welfare, 1969. p.25.

[114] Meller, Conversion of organic solid wastes, p.148.

[115] Burch, Lipinsky, and Litchfield, Technical and economic factors, p.59-60.

[116] Salvaging profit from waste. Chemical Week, 101(12):109, Sept. 16, 1967.

[117] Meller, Conversion of orgānic solid wastes, p.26, citing Dale, A. C. Agricultural residues. In Proceedings; Seventh Industrial Waste Conference, Lafayette, Ind., May 7-9, 1952. Purdue University Engineering Extension Series No. 79. p.12.

[118] Utilization: wood wastes find new uses. American Forests, 72(6):38-40, June 1966.

[119] U.S. Forest Products Laboratory. Uses for slabs, edgings, and trims. U.S. Forest Service Research Note No. FLP-038. Madison, U.S. Department of Agriculture, 1964. p.9-11.

ufacturers, and wood furniture manufacturers) were developed by survey for 1965 by Combustion Engineering, Inc.[120] The same research also resulted in an estimated weight of wood of 8.1 pounds per board foot, a board foot being the standard measure of lumber consumption.[121] Although the weight measure is not strictly applicable to all types of wood, it does provide an approximation of the weight of lumber consumed in 1965170.5 million tons.[122] Waste production in the same year was as follows: sawmills, 9.630 million tons; wood container manufacturers, 2.488 million tons; wood furniture manufacturers, 2.099 million tons, for a total waste production of 14.2 million tons.[123] These three industries reused 66, 51, and 26 percent of their wastes, respectively, or a total of 8.2 million tons, equivalent to 4.8 percent of consumption in 1965. These industries do not represent all the wood-using operations that produce wastes and reuse portions of them. Furthermore, waste reuse here includes burning of wood as fuel, a form of "reuse" not associated with other materials covered in this report. Thus the reuse to consumption ratio used here should not be compared to that of other materials.

Tree-cutting wastes generated in muncipal operations are sometimes chipped and used as mulch in city parks. Lumber wastes are sometimes recovered from dumps and landfills (especially in small towns) and used as fuel or reused in various structures (fencing, repair, etc.). Individuals frequently cart off lumber from incinerator sites where it is accumulated for disposal either by hogging;incineration or by landfill if pieces are too large for the furnaces and no hogger is available. Demolition companies also salvage wood for reuse as lumber or for sale as firewood. Such recovery of "obsolete" wood, while practiced, is an extremely minor activity.

Inorganics

The two major classes of inorganic materials that are significant from a municipal waste management standpoint and have not been discussed to this point are building rubble and ashes. Mine tailings, probably the single largest inorganic waste material category (1968 generation was an estimated 1.1 billion tons), do not occur in municipal wastes.

Building Rubble. Except for portions composed of asphalt, paper, wood, plastics, textiles, and other organic materials, building rubble consists of concrete, bricks, rock, masonry, plaster, clay, glass, nonferrous metals, and steel. These materials occur when buildings and other structures are torn down, roads are taken out, sewer systems are changed, and other constructions are altered.

Combustion Engineering, Inc., in its previously cited report, estimated that in 1966, 19.1 million tons of demolition wastes were generated and that virtually all this material went to disposal without salvage.

Salvage is practiced, of course, but it is losing its importance except in those instances where large quantities of a valuable material can be recovered (steel, from steel frame buildings and nonferrous metal fixtures and installations). The nonmetallic inorganic fraction of demolition wastes is becoming less and less desirable to salvage; the salvable items include brick and stone; concrete (much like thermosetting plastics) is useless except perhaps as fill material. The scarcity of semiskilled labor necessary to justify the considerable hand labor needed for salvage and rising labor costs is probably responsible for the demise of demolition salvage.

Inorganic building rubble is used for landfill in preference to organic wastes. It provides a good substructure for subsequent construction when used in combination with other fill materials.

Ashes. If incinerator ashes are clean inert residue, they can be used as landfill cover by municipalities. This is the most common "use" of incinerator residue. However, most incinerator residue from operating incinerators needs cover because the burn-out is not complete. In Amarillo, Texas, incinerator residues, free of cans, were for a time sold to a railroad, which used the material in road-bed maintenance. Other cities use a portion of this residue for fill material in municipal public works jobs.

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[120] Technical-economic study of solid waste disposal needs and practices, p.116.

[121] Technical-economic study, p.27.

[122] Consumption in 1965 was 42.1 billion board feet; this amount at 8.1 pounds per board foot is 170.5 million tons. Consumption data from U.S. Bureau of the Census. Pocket data book. U. S. A. 1969. Table 304. Lumber. Washington, U.S. Government Printing Office, 1969. p.233.

[123] In addition to wood, these wastes include such things as upholstery wastes, styrofoam, sandpaper, etc., in unknown proportions.

Fly ash, produced by electrical utilities in the combustion of coal, is reused in many types of applications. In 1965, 20 million tons of fly ash were produced in the United States in the combustion of 226 million tons of coal. Fly-ash utilization in the same year was 1.3 million tons, or 6.5 percent of production. In that same year, the utilization rate in England was 39 percent of production, in France 50 percent, and in Germany 27 percent.[124]

Fly ash has four major uses in the United States: (1) in concrete; (2) in road construction as a soil stabilizer and a material to strengthen the road base immediately under the paving; (3) as an asphalt paving filler; and (4) in the production of lightweight aggregate. Its minor uses include its use as an additive to foundry sands, an additive to masonry mortar, use as a blasting compound, use in acoustical blocks, a constituent in heat insulating cement, as a soil conditioner, and as a filler in roofing materials, fertilizers, soap, paper, rubber, asphalt tile, and the like.[125]

Fly ash reuse is increasing in the United States, not only absolutely but also in proportion to total production. In 1963, sales were 739,000 tons;[126] in 1965, 1.30 million tons; and in 1967, 1.56 million tons.[127] During this period, fly-ash production has been just at or below 20 million tons.

The technical advantages of fly ash in construction materials are well known to specialists, but the knowledge is not widespread in the construction industry. Fly ash is useful in concrete because it reacts with calcium chloride at normal temperatures to form products with binding properties, such as calcium silicates. The compactness of concrete is increased and its tendency to shrinkage and breakage is decreased by use of fly ash as a concrete component. In addition to these characteristics of fly ash concrete, it is also easier to pour and mold than ordinary concrete, has an improved resistance to thermal shock and chemical attack, and is generally $1 per cubic yard cheaper than regular concrete.[128]

Acceptance of fly ash as a concrete additive appears to be a slow process in the United States. European countries have also found that penetration of tradition-bound construction markets takes time. Europeans have been more successful in selling fly ash, however, in part because of the need to use all available resources in rebuilding Europe following World War II and the fact that fly ash sales and utilization research is in the hands of large government- operated electrical generation industries that coordinate such efforts for entire countries (England and France).[129] All indications are that U.S. efforts to sell fly ash will succeed in keeping an increasing proportion of this material out of waste. Since the mid-1960's, intensive efforts have been made, especially by the utility and the coal industries, to establish a framework for coordinated buyer education and promotion of fly ash.

In addition to fly ash, utilities also generate bottom ash — heavier ash particles that collect at the bottom of furnaces. Production of this material in 1967 was 9.2 million tons; recovery was 2.3 million tons, or 25 percent.[130] Bottom ash goes into the same markets as fly ash except for aggregates. The largest tonnage of bottom ash is sold as a construction fill material, while fly ash has the most tonnage as a concrete additive (Table 57).

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[124] Brackett, C. E. Availability, quality and present utilization of fly ash. Combustion, 38(11):41, May 1967.

[125] Brackett, Availability, quality and present utilization of fly ash, p.44-45.

[126] Capp, J. P. Fly ash utilization. Combustion, 37(8):36, Feb. 1966.

[127] Meikle, P. G. Fly ash and bottom ash. Mining Engineering, 21(1):61, Jan. 1969.

[128] Bender, R. J. More intensive utilization of flyash. Power, 109(6):94, June 1965; Roman, G. H. You can save money with fly ash, Coal Age, 73(8):62, Aug. 1968.

[129] Bender, R. J. Fly ash utilization makes slow progress. Power, 111(5):116, 118, 120, May 1967. This source also points out that France experienced a serious cement shortage in the early 1960's during which fly ash was used extensively and became "institutionalized."

[130] Meikle, Fly ash and bottom ash, p.61.

TABLE 51

NEW AND RECLAIMED RUBBER CONSUMPTION IN 1969, IN 1,000 TONS, PERCENT, AND BY MAJOR INDUSTRY SEGMENT*

	New rubber		Reclaimed rubber		Total	
Segment	Tons	%	Tons	%	Tons	%
Tires	1,950.3	67.0	188.6	67.4	2,138.9	67.0
Wire-cable	29.1	1.0	--	--	29.1	0.9
Foams	101.9	3.5	--	--	101.9	3.2
Footwear	174.6	6.0	2.8	1.0	177.4	5.6
Mechanical goods	451.2	15.5	16.5	5.9	467.7	14.7
All other	203.8	7.0	71.9	25.7	275.7	8.6
Total	2,910.9	100.0	279.8	100.0	3,190.7	100.0

*1969 review, 1970 preview. Rubber Age, 102(1):47-61, Jan. 1970. Pettigrew, R. J., and F. Roninger. Rubber reuse and solid waste management. [Public Health Service Publication No. 2124.] Washington, U.S. Government Printing Office, 1971. 120 p.

TABLE 52

RUBBER RECOVERY FOR SPECIFIC
USES IN 1968 AND 1969, IN 1,000 TONS*

Type of user	1968	1969
Reclaimers	287.85	279.80
Retreaders	733.80	752.05
Tire Splitters	6.99	7.00
Total	1,028.64	1,038.85

*Pettigrew, and Roninger, Rubber reuse and solid waste management.

TABLE 53

RECLAIMED RUBBER PRODUCTION,
1958-1969, IN 1,000 TONS*

Year	Tonnage
1958	290.8
1959	228.7
1960	328.0
1961	295.5
1962	314.2
1963	315.2
1964	309.4
1965	313.9
1966	310.7
1967	272.9
1968	287.5
1969	280.0

*Pettigrew, and Roninger, Rubber reuse and solid waste management.

TABLE 54

TIRE CONSUMPTION, NEW AND RETREADS, 1958 TO 1969, IN MILLIONS OF UNITS*

	New Tires			Retreads				
Year	Passenger	Bus and truck	Total	Passenger	Bus and truck	Total	Total	Retreads as % of total
1958	85.7	13.2	98.9	29.9	7.3	37.2	136.1	27.3
1959	97.3	15.0	112.3	32.4	7.6	40.0	152.3	26.3
1960	105.7	13.9	119.6	30.6	7.4	38.0	157.6	24.1
1961	104.5	13.9	118.4	31.9	7.6	39.5	157.9	25.0
1962	116.8	15.7	132.5	34.5	7.7	42.2	174.7	24.2
1963	121.9	16.6	138.5	36.3	7.5	43.8	182.3	24.0
1964	132.1	18.3	150.4	36.0	8.0	44.0	194.4	22.6
1965	148.5	20.4	168.9	36.0	7.6	43.6	212.5	20.5
1966	151.0	22.7	173.7	35.3	8.0	43.3	217.0	20.0
1967	151.0	21.8	172.8	34.3	9.3	43.6	216.4	20.1
1968	173.7	25.3	199.0	35.8	9.7	45.5	244.5	18.6
1969	177.3	27.4	204.7	36.5	10.0	46.5	251.2	18.5

*1970 Automobile facts and figures. [Michigan], Automobile Manufacturers Association. 70 p. Pettigrew, and Roninger, Rubber reuse and solid waste management.

TABLE 55

CONSUMPTION OF PLASTICS, 1967 TO 1969, TOTAL AND SELECTED MAJOR END USE MARKETS, IN 1,000 TONS*

End Use Market	1967	1968	1969	Percent 1969
Consumption in selected markets:				
Agriculture	75†	85	95	1.1
Appliances	198	238	234	2.7
Transportation	109	334	536	6.3
Construction	1,070	1,215	1,327	15.5
Electrical	396	452	567	6.6
Furniture	250 †	273	328	3.8
Housewares	313	373	425	5.0
Packaging	1,121 †	1,508	1,729	20.3
Toys	208	243	269	3.2
Total consumption	6,550	7,558	8,535	100.0

*The statistics: 1969. Modern Plastics, 47(1):69-80, Jan. 1970. The plastic industry in 1968. Modern Plastics Pamphlet, Jan. 1969. New York, McGraw-Hill, Inc.

†MRI estimates made to provide comparable data for year; source provided only 1965 data.

Note: This consumption pattern does not include all plastic uses. Construction accounts for about 25 percent of end use applications and packaging about 20 percent. Thus construction is somewhat underreported by these sources.

TABLE 56

RECOVERY OF ANIMAL ORGANICS, 1963 AND
1967, IN 1,000 TONS AND VALUE PER TON*

Organic category	1963 Weight of shipments	1963 Value per ton	1967 Weight of shipments	1967 Value per ton
Grease and tallow	2,353	112.28	2,692	112.82
Protein meals	2,973	82.98	3,797	72.35
Total	5,326	95.91	6,489	89.13

*1967 Census of manufacturers. v. 2. Industry statistics. pt. 1. Major group 20H. Food and kindred products; fats and oils--animal and marine fats and oils. Washington, U.S. Government Printing Office, 1971.

TABLE 57

UTILIZATION OF ASH IN UNITED STATES, 1967,
IN 1,000 TONS AND PERCENT*

Markets	Fly ash		Bottom ash†		Total	
	Tons	%	Tons	%	Tons	%
Road and construction fill	300	19.2	1,150	43.3	1,450	37.5
Concrete additive	600	38.5	200	15.2	800	20.7
Lightweight aggregate	150	9.6	--		150	3.9
Stabilization for road base	120	7.7	50	2.2	170	4.4
Cement manufacture	150	9.6	50	2.2	200	5.2
Asphalt filler	120	7.7	35	1.5	155	4.0
Miscellaneous	120	7.7	820‡	35.6	940	24.3
Total utilized	1,560	100.0	2,305	100.0	3,865	100.0
Total collected	18,500	8.4	9,200	25.1	27,700	14.0

*Meikle, Fly ash and bottom ash, p. 60.
†Includes boiler slag.
‡Includes blasting grit, ice control, agriculture, and roof filler.

CHAPTER X

LEGISLATIVE AND POLICY CONSIDERATIONS

In this chapter we shall outline some of the key issues and problems that need to be considered in the framing of legislation or policy to bring about a proportionally higher rate of secondary materials consumption.

In general, we favor a "global" or "systems" approach to recycling policy in which all pertinent aspects of recycling are given a fair hearing. Thus we do not see recycling solely as a materials conservation activity or only as a solution to solid waste management problems but broadly under the rubric of "resource conservation," with "resource" understood to include both tangible and intangible values.

Today roughly 25 percent of paper, metals, glass, textiles, and rubber are recycled through the market (Table 58), around 48 million tons of materials that need not be handled as solid waste. If other materials are also included, such as plastics, wood, ashes, stone, brick, and the like, the recycled proportion is much lower, of course, but we have no reliable estimates of the quantitites of these latter materials involved.

Why can't we recycle a larger proportion of our wastes and thus unburden our waste management systems? The reason is that demand for scrap materials is limited. These commodities compete with virgin natural resources whose use and processing have become rationalized and institutionalized in large part because in earlier decades wastes were not available in sufficient quantities to satisfy demand for materials while virgin materials were abundantly available. Scrap recovery techniques — in the broad sense of acquisition, upgrading, processing, and distribution — have not changed significantly in the 20th century. In the meantime, the mining or harvesting, purification, upgrading, and processing of virgin materials have made dramatic technological and economic strides forward.

Today scrap use is frequently uneconomical because the productivity of labor associated with acquisition and processing of virgin materials is greater than labor productivity in scrap acquisition and processing. For instance, a steel producer finds it cheaper (l) to mine, beneficiate, and ship ore; (2) to mine and transport fluxing materials; (3) to produce coke from coal (which was also mined and moved); (4) to produce pig iron from these materials; and (5) to produce steel from pig iron (sometimes using oxygen extracted in air liquefaction plants) than to acquire, remelt, and reformulate steel scrap.

In addition to greater labor productivity consequent upon use of advanced materials processing technology, processors of virgin materials also enjoy depletion allowances when extracting virgin materials. Where these processors do not meet air, water, and solid waste standards in manufacturing — or where these standards are leniently set — the processors do not pay the full environmental costs created by pollution and waste generation associated with their virgin materials uses. Many raw materials, also, come principally from foreign sources (like bauxite) and their use contributes to a foreign trade imbalance.

By contrast, secondary materials are not credited with conserving natural resources, get no credits for contributing favorably to our foreign trade balance, get no credit for removing materials from the waste stream, nor credits for providing materials whose processing usually pollutes the environment less than the comparable processing of virgin materials.

When all of the costs of virgin materials use — including those usually disregarded — and all of the benefits of secondary materials are considered, secondary materials would probably turn out to be less uneconomical than they appear to be from an examination of the status quo. As yet, information is not available to establish whether or not this judgment is accurate and, if it is, how it can reorder our economic accounting structures to bring about greater use of secondary materials. Public policy can be directed toward gaining a more comprehensive knowledge of total costs, both tangible and intangible, of various materials processing systems.[131]

Fundamental Legislative/Policy Issues

Why Policy Considerations? Legislation to increase the quantities of waste materials recycled appears justified if the total socioeconomic costs of using virgin raw materials are higher than costs of the alternative use of secondary materials. Given our traditional economic accounting methods, manufacturers experience only a portion of the real or total costs of their materials; some part of total costs occurs externally to industry and externally to the seller-buyer relationship wherein the market value of materials is determined. Any costs that are not incurred directly in a formal financial accounting sense go unrecognized in the commercial system. In this sense, the cost of environmental pollution may be passed along to the population in dirty water, air, and land if the dollar cost of physical control of effluents is not borne by the polluting industry. Thus the market mechanism is not a sufficient guarantor that those materials will be used that have the lowest total cost. It is in these instances where governmental intervention is desirable so that the best use is made of natural resources.[132]

Resource Versus Materials Conservation. In line with this analysis, it appears that public policy aimed at increasing the proportion of secondary materials recycled must be considered within a larger context than that of materials recovery or solid waste management alone. The appropriate context is that of resource conservation, whereby resource is defined broadly to include all substances, energies, manpower, and conditions that we value.

Given a resource conservation context, some products are probably "cheaper" if made from virgin materials; others, cheaper if made from secondary materials. It would clearly be undesirable, for instance, to recycle an abundant material if in so doing two or three times more energy, water, and manpower are expended and pollution is generated than in obtaining the same material from natural deposits. Materials conservation is not necessarily identical with resource conservation.

The concept of resource conservation also permits taking into consideration certain intangible values that are not usually counted in normal cost estimates. For instance, maximum recycling may require an extremely high degree of governmental intervention in industrial decisionmaking. While this may be desirable in order to conserve fossil fuels, scarce materials, and environmental purity, the Nation's commitment to a free-enterprise economic system may be viewed as a value or resource too great to be sacrificed.

The Problem of Comprehensive Economic Accounting. When is it "cheaper" to use secondary materials? The answer would be easy to give if the total costs, tangible and intangible, costs of producing, distributing, using, and disposing of materials were known.

Today, financial accounting practices, industrial reporting practices and census survey practices do not permit the tracing of a material all the way from a mine to the terminal disposal point, showing at each step in the process, the energy consumed and the energy effluents produced, the water consumed and the quality of the liquid effluent, the solid waste generated, the manpower inputs required, and the like — both in production and transportation steps. These are measurable external cost elements but they are not available today.

Such data are not readily available because they were not heretofore needed. Meaningful environmental analysis, however, requires data on the total environmental impact of a product or material.

To compare the solid waste generation associated with a steel can, for instance, versus a glass bottle, it is not enough to know what each one weighs and how much space each occupies. One also needs to know the quantity of mine tailings generated in mining raw

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131 The Resource Recovery Act of 1970 is an example of very recent legislation that moves in this direction. Resource Recovery Act; Public Law 91-512, 91st Congress, H.R. 11833, October 26, 1970. [Washington, U.S. Government Printing Office, 1970.] 9 p.

132 This concept is gaining some currency at present. For example, a trade press article that was concurrent with the writing of this chapter is: Spofford, W. O. Jr., Closing the gap in waste management. Environmental Science & Technology, 4(12):1108-1114, Dec. 1970.

materials, unusable residues generated in raw materials conversion, quantities of unsalable fabrication wastes generated, and the like. Solid waste generation is only one of the many dimensions of external costs.

To develop meaningful public policy to advance recycling, the first step is to acquire such data for at least major material groupings (including secondary materials) and product categories within each. Some of the types of data needed are the following.

(1) Materials compositions of major product classes, including proportions of materials in blends (cotton-synthetic textiles).

(2) Detailed transportation data on materials and products, on a comparable basis for air, water, rail, and truck modes, by type of fuel consumed in each mode, ton-miles of movement, and similar data.

(3) Solid wastes generated in production of materials and products, by type of material, showing portions sold, reused internally, and disposed of.

(4) Fuel consumption, by type of fuel and conversion system, stationary and mobile, in all major mining, harvesting, processing, and fabrications operations.

(5) Gaseous effluents generated in various types of transportation and production operations, related to output tonnage.

(6) Water use in transportation and production operations, related to output tonnage, including data on intake, discharge, and consumption and on water impurities in influent and effluent waters.

(7) More detailed "materials consumed" data by industry classification, in comparable units of measure (pounds or tons, instead of square inches of glass, number of chickens, board feet of lumber, yards of clothing, etc.) with detailed indication of types of waste materials consumed.

(8) Detailed data on processing losses "not accounted for" in gaseous, water, and solid waste effluents.

(9) Detailed cost breakdowns in transportation and production, insofar as these are not available, showing costs of manpower, materials, energy, water, etc. — especially on captive production operations such as primary aluminum smelting, pig iron production, wood pulping, and the like.

Data collection should be by actual survey, should result in national averages and ratios related or relatable to specific materials by weight, and should be comparable for all production sectors, whatever their outputs. Data collection should be continuous and should be institutionalized in the appropriate Federal agencies — Commerce, Interior, and Agriculture. The Environmental Protection Agency and its Solid Wastes Management Office provides a focus and has the need for such data, while the National Materials Policy Act of 1970 provides legislative sanction.

Once such data are available and are analyzed in combination with information on exports and imports of materials, natural resource inventory data, population and production forecasts, national defense materials and energy requirement forecasts, and other measurable factors, an important step has been taken to determine the relative costs of using secondary versus virgin materials.

This still leaves the problem of establishing priorities for different types of values. For instance, what is more desirable, to import fossil fuels at the expense of foreign trade balance and domestic production and employment while conserving the national resource or to maintain a favorable trade balance and domestic production at the expense of depleting the domestic stockpile? These are questions that must necessarily be resolved by the political process.

Cost Allocation Issues. Public policy to increase recycling, framed within the context of resource conservation, will necessarily be based on the assumption or finding that on a national basis, if not on an industry basis, recycling is less costly than use of virgin materials.

Clearly also, new legislation will be necessary only if the higher total costs of virgin materials are not reflected in the market value of materials and therefore a legislative reallocation of costs will be required. Pollution control legislation, requiring manufacturers to clean their gaseous and liquid effluents; changes in import/export regulations and legislation; and a host of other legislative changes whose objective is something other than recycling of wastes may gradually result in a reallocation of costs, which in turn may be reflected in the market value of products and ultimately may increase recycling. Changes in economic factors such as price increases for fuels, virgin raw materials, or transportation brought about by scarcity, technological changes, or increased labor costs may also result in a shift in values favoring secondary materials. Barring such "natural" changes, however, legislated cost reallocation will become necessary to achieve resource conservation desired by the Nation.

In order to bring about the recycling of secondary materials, cost allocation must necessarily work out so that the internal as well as external costs of materials use will be internalized by industry. This means that manufacturers (and in turn final consumers) must pay (directly or indirectly) costs created by their materials use that arise from environmental quality preservation, material and energy conservation, defense posture, social welfare, or other considerations.

Such cost criteria are already recognized by manufacturers; one example is the minimum wage. Legislation requiring recognition of external costs not now borne by industry would thus be the extension of precedents already established. From industry's viewpoint, of course, any such legislation would represent a further constriction of the magic circle within whose boundaries freedom of economic choice is still possible.

Always assuming that total cost of virgin materials use is greater than secondary materials use, legislation will necessarily have the effect of restricting virgin materials use by rendering its use actually more expensive than use of waste commodities. This can be accomplished, in practice, (1) by making the acquisition, processing, and distribution of virgin-based products more expensive in some way while maintaining the costs of secondary raw materials unchanged or (2) by putting on the market secondary materials technically equivalent to virgin materials at a cost sufficiently low so that manufacturers can avoid waste use only at their economic peril.

Raising virgin material prices vis-a-vis secondary material prices can be achieved directly in the form of a tax on any material obtained from natural resources or indirectly by forcing the manufacturers to spend more in the form of pollution control expenditures, transportation charges, environmental maintenance (mine-site landscaping, for example), higher energy cost, longer depreciation schedules, lower depletion allowances, etc.

However achieved, higher virgin materials costs would also require some control over secondary materials costs as well. Otherwise, secondary materials prices might simply rise in proportion to virgin materials prices as a result of increased demand and stabilize at a new and higher level without net changes in the actual consumption ratio of secondary to virgin materials. The net effect would then be higher prices for the consumer. This requirement implies at least some additional governmental control (direct or indirect) over the secondary materials industry — at least during the period of transition between the current situation and one where waste materials are used in a significantly higher proportion.

The other major approach — that of creating a supply of technically acceptable secondary materials at irresistibly low prices relative to virgin materials — can be achieved by fostering the development and use of technology to acquire and process such materials and by achieving an economic relationship on the price of such materials so that they are cheaper than equivalent virgin materials. The amount of subsidy that may legitimately be made available for this purpose should be no more than the difference between market cost of virgin materials and their real or total cost including external cost.[133]

It is clear from this line of reasoning that adequate data on total costs of materials (a "materials policy") is the best way to justify legislative intervention. Lacking such data, the Government is certain to be accused of arbitrary behavior and of artificially raising the cost of materials. Thus the National Materials Policy Act of 1970 is a key piece of legislative authority for working toward a meaningful materials policy.

The Need for Demand Creation

Demand for waste commodities is limited; the low demand is not caused by a lack of supply but by other factors. This is not generally understood. Rather, we frequently encountered the opinion, in the course of this study, that "if only waste commodities were made available, they would be consumed." This opinion is quite natural. People have a "gut feel" that wastes must be cheaper and that consequently they must be preferable to manufacturers.

We found that the supply of waste commodities is not the critical aspect of secondary materials use. Instead, the critical parameter is the demand for waste commodities relative to virgin resources. Unless secondary materials are viewed more favorably as a raw materials supply by industry and unless the relative value relations are

[133] Example: if the market cost of a virgin material is $100 per ton but its total cost including external considerations is $150 per ton, acceptable secondary material supplies can be subsidized at the rate of $50 per ton (less any external costs attributable to the secondary materials). Every time a ton of secondary material is sold to displace a ton of virgin material, $50 in external costs is saved; these savings are used to create resources from waste. If the waste resources can be made available for $40 per ton, then $10 in "resources" has been conserved.

changed to help bring this about, then the demand for waste materials will remain stationary in relation to total consumption (at best) or it will decline.

In such a situation, programs to remove saleable materials from municipal wastes may actually succeed — but they will do so by taking existing markets from the secondary materials industry. This is illustrated by the following hypothetical situations. The situations assume conditions of steady need or demand for 100 units of a given product.[134]

Situation One (Figure 23) represents a hypothetical condition today where total need or demand for a product is 100 units. After the 100 units are discarded, the manufacturing sector recovers 10 units for recycling while 90 units are added to the municipal disposal inventory. Manufacturing withdraws 90 units from the virgin material inventory for manufacture and distribution to customers of 100 new units for use and discard; the cycle repeats.

In Situation Two (Figure 24), the municipal waste sector invests sufficient capital in technology to recover 5 units from its 90 units of waste stream in order to effect "resource recovery" and reduce solid waste disposal quantities. Since demand for recycled units remains at a grand total of 10 units, the traditional secondary materials handling system loses markets for 5 units that can no longer be sold to industry. Thus, the 5 units no longer economically recoverable by industry are instead diverted into the waste stream. The waste system then must really process a total of 95 units (instead of 90) of which it disposes of 90 just as before and recovers 5 units, which it sells to industry. The net result is that the waste system must handle 5 more units of waste and must still dispose of the same quantity as before. The secondary materials industry loses its ability to collect and process 5 units.

The point of Situation Two is that the expenditure of capital and the development of waste processing technology do not necessarily lead to greater recovery of secondary materials and may lead to greater quantities handled by the waste system while the supply of recovered secondary materials remains unchanged in the whole system. Simply making a supply of material available does not assure its consumption. Demand for this material must increase in concert with or in advance of the actual recovery or the system does not change the total waste disposal quantities.

In Situation Three (Figure 25) demand for recycled units is increased to 20 units while total product demand remains at 100 units. A new situation now arises.

In this case, the manufacturing sector has a demand for 20 recycled units. The effects are as profound as in Situation Two. Assume the traditional secondary materials industry sector can recover economically an additional 5 units bringing its recovery to 15 units. The waste system's load is then reduced to 85 units collected instead of 90 units. In addition, assume the waste system invests capital in technology to recover 5 units so that it then disposes of 80 units and can sell 5 units to industry. If the system is to stay in balance, the virgin materials sector of manufacturing gives up 10 units and now supplies 80 units compared to 90 previously.

Obviously, in Situation Three, the burden on solid waste systems is reduced substantially, and both the solid waste and traditional secondary materials sectors recover more materials. The virgin materials producers are penalized because they must give up 10 units of output but the system still supplies the 100 units of demand. The recovered materials consumed for a complete cycle reduce the waste disposal inventory by 10 units over the original condition while 10 virgin material units need not be taken from the virgin material inventory. Both disposal capacity and virgin resources are "conserved" by increasing the number of recycled units.

At present, it appears that far too few people recognize the importance of the demand parameter and far too many place blind faith in technology and capital to increase the supplies of secondary materials not needed or demanded by the materials processing sectors under current economic relationships and industry structures. Recognition of demand as an unforgiving system element in the whole recycling question is simply not present to the degree necessary in the current rush to "recycle resources." What looms then is a potential imbalance of supply and a shift or dislocation of supply of secondary materials from "traditional" systems to waste management systems and an even greater burden on solid waste management systems as a whole. Simplistic assumptions about demand "taking care of

[134] The same results hold true if total demand increases or grows as is the case of the American economy. Only the number of units handled by each sector changes although basic relationships described do not change under the given conditions.

itself" or being simple to change are not realistic. This "supply push" approach is analogous to "pushing on a string" when, in fact, it appears that "demand pull" would more effectively bring about the desired increase of secondary materials consumption.

To bring about a desirable change (Situation Three) requires that virgin material use be displaced. In a situation of increasing consumption, this means that waste recycling must grow faster than virgin materials use. Today the reverse is the case. Since the proportions of waste to primary materials are ultimately determined by the relative cost of each as set in the market, creation of demand necessarily dictates that the cost structure of virgin and secondary materials be changed in relation to each other.

The role of waste processing technology in meeting increased demand depends on the manner in which demand is increased. If virgin resources are made more costly or scarce, by whatever means, manufacturers will seek secondary raw materials and will develop the technology, if needed, for processing and upgrading such wastes to increase the secondary materials supply. If demand is increased by making secondary materials available at a cost below that of virgin materials and of a quality equivalent to that of virgin materials, then the waste commodity sellers and possibly the solid waste management establishment will have to develop and use the processing technology for materials upgrading. In any case, waste processing technology is a vitally important part of increased recycling.

The key point about waste processing technology deployment is that its use will not of and in itself bring about an increase in demand but must be accompanied by actions that will bring about a change in the relative consumption ratios of virgin and secondary materials — in favor of waste commodities.

Other Aspects of Legislation/Policy

The foregoing discussion leaves out of account some aspects of recycling policy that are implicit in the above but that we wish to identify explicitly.

Intermaterials Competition. Legislation to bring about recycling in one material category must take into account the relative competitive position of that material with respect to other materials. Perhaps the most important single trend in materials used today is the penetration of synthetic materials based on hydrocarbons into markets dominated by traditional substances — cotton, wool, paper, wood, glass, steel. Unilateral legislation aimed, for instance, at paper alone may well simply intensify the competition between paper and plastics, making the latter materials, which are not now recycled in any significant quantity, more competitive in paper markets.

The complexity of relationships between materials, especially the substitutability of the amazing plastics for virtually any other material, suggests that recycling legislation must be comprehensive and must be based on a materials policy that can be effectively enforced.

Labor Force Displacement. In a situation where a high percentage of materials consumption is satisfied by secondary materials, the materials "mine" would become the city where a large number of people live in close proximity to each other and thus make waste collection for recycling practical. In today's situation, the labor forces engaged in the mining and harvesting of raw materials are predominantly in rural areas, and such activities are the only economic magnet of many regions. Recycling legislation may well intensify urbanization by shifting labor requirements for mining and harvesting from rural areas to cities.

Commercialization of Sanitation. Unless practical means can be found to induce consumers to separate materials into many different categories at the household level, collection and processing of wastes for recycling will necessarily become the job of sanitation departments and private refuse haulers that now collect the waste in mixed form. Recycling legislation may thus impose on city, township, and county governments a commercial activity that they are not by tradition equipped to handle. Our urban areas are governed by a large number of independent jurisdictions that are only now beginning to learn to plan jointly. Recycling legislation must bring about changes in local government waste management practices if recycling is to succeed. Private sector waste collection practitioners would also be an important factor in any move to bring about further recycling.

Obsolescence. One way to reduce solid waste generation is to use materials for longer periods of time. If a refrigerator is used for 15 years, instead of 10, its continuation in use represents reduction of waste at the source, a form of recycling — without any materials collection, scrap processing, materials reprocessing, fabrication, or redistribution having taken place. Efforts to increase the life-in-use of products would thus result in "resource recovery." The classic example of a long-lived and short-lived product in an identical application is the use of returnable and nonreturnable containers in soft drink and beer packaging. New design criteria for products (such as modular components) that make repair rather than replacement more attractive would have the same effects.

Energy Recovery. Combustible materials need not be recovered as materials; their resource value may be extracted in the form of heat energy. This is a particularly appropriate way to use materials whose recycling in more conventional ways is impractical, such as plastics, wood, and paper products contaminated by laminants, coatings, and adhesives. In this type of recovery, combustible materials would displace fuels — coal, gas, and oil. Because energy demand is large and growing and low-sulfur fuels are in short supply, the impact of energy recovery from waste would have little effect on traditional energy industry alignments; the alternative of recycling such materials as materials would have a far greater impact on present industry structures.

Secondary Recycling. Materials produced by one industry need not necessarily reenter the same industry. Waste rubber and waste glass could be used in road construction, for instance, displacing asphalt and concrete. Organics like rubber can be converted to crude oil by pyrolysis and could displace well oil. Organics can be composted and used to displace a portion of soil conditioners used. The key is that a product is created from waste that competes with or displaces another product used in other applications. To bring about secondary recycling of materials will be equally as difficult as effecting their primary recycling, but such programs are nevertheless a distinct legislative option.

Conclusions

To develop an effective solid waste recycling mechanism it is necessary to view the problem in the broad context of resource conservation in which all costs and benefits are expressed. We, therefore, conclude that the following are relevant to any public policy considerations in this field.

(I) Resource conservation is a concept entirely separate from materials conservation and recycling. To effect true resource conservation a comprehensive systems analysis must be developed in which all the costs and benefits — *tangible and intangible* — are measured in traditional materials consumption practice.

(2) The supply of secondary materials is not now limited by technological inaccessibility but by relative cost constraints. The demand does not exist for large quantities of materials that could be made readily available on a cost competitive basis from municipal waste streams. Institutionalized practices in exploitation of virgin raw materials assign greater value to virgin materials than secondary materials. The basic relations must be changed through the demand mechanism to achieve a significant reversal of recycling trends in force today.

(3) More attention needs to be given to developing demand for secondary materials within the industrial, governmental, and private sectors. Primary recycling is only one option. Other important options are: secondary recycling and reuse applications for waste materials; energy recovery; design criteria to reduce obsolescence and obsoleting of products and to increase their life cycle; and development of new products from waste materials that might substitute for other materials in commercial markets.

(4) The development of technology to recover secondary materials from waste is moving forward under the impetus of Federal and private efforts. The social, political, and economic capabilities of institutional establishments (solid waste management, secondary material suppliers, and industrial consumers) are lagging behind the technological competence to supply secondary materials. These factors need more attention before any substantial new resource recovery can be accomplished.

It is within this broad context that public policy considerations should take place to avoid undesirable displacements and side effects and to develop positive workable resource conservation. This, we believe, is the most important point at which the conclusions of this study can be directed.

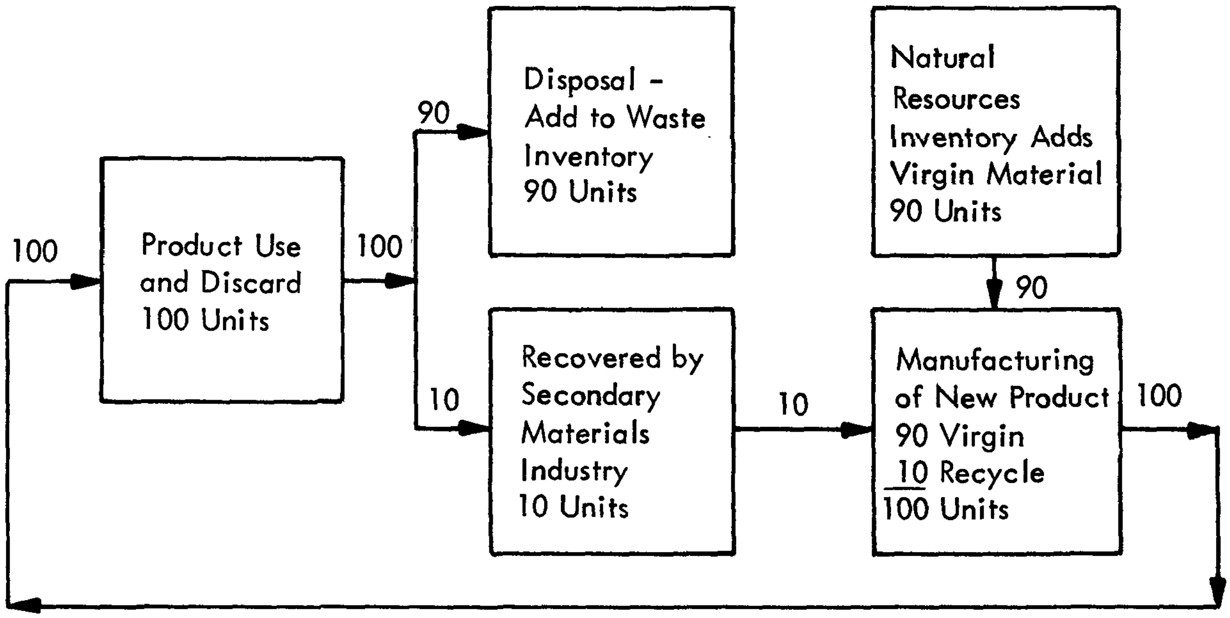

Figure 23. Situation One: Constant demand 100 units; recycle 10 units.

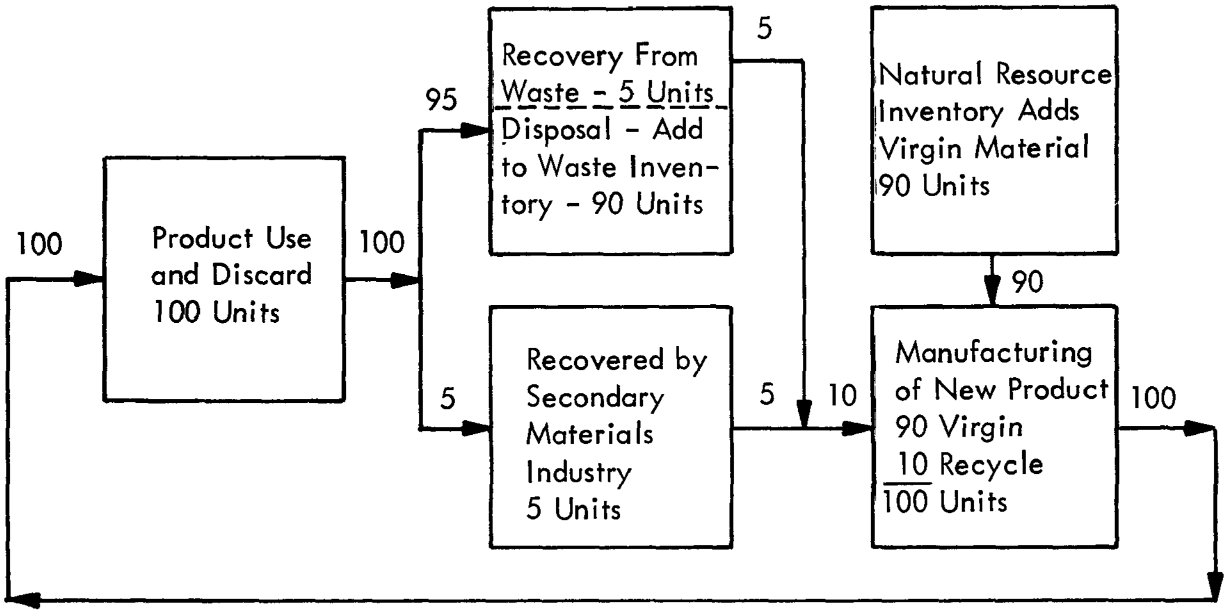

Figure 24. Situation Two: Constant demand 100 units; recycle 10 units.

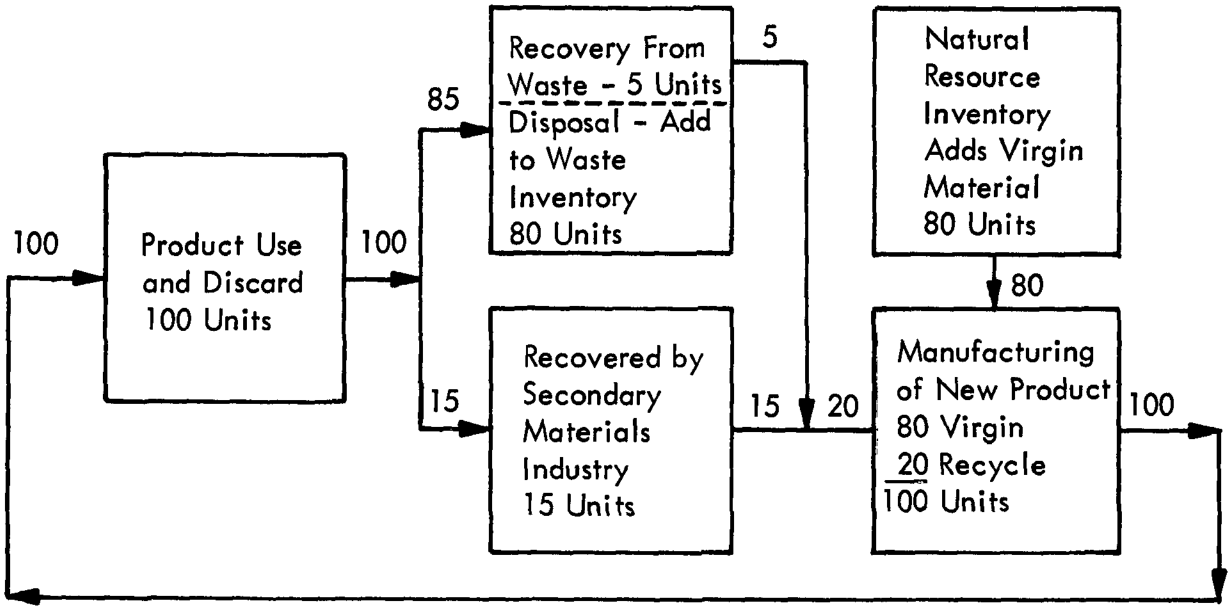

Figure 25. Situation Three: Constant demand 100 units; recycle 20 units.

TABLE 58

DOMESTIC PROMPT AND OBSOLETE SCRAP CONSUMPTION IN SELECTED COMMODITIES, 1967, 1968, OR 1969, IN 1,000 TONS AND PERCENT*

Material	Year	Total material consumption 1,000 tons	Prompt and obsolete scrap consumption for recycling-1,000 tons	Recycling as percent of consumption
Paper and board	1967	53,110	10,124	19.0
Ferrous metals	1967	105,900	33,100	31.2
Nonferrous metals	1967	9,775	3,006	30.8
Glass	1967	12,820	600	4.2
Textiles	1968	5,672	246	4.3
Rubber	1969	3,943	1,032	26.2
Total		191,220	48,108	25.2

*From Midwest Research Institute; for detailed discussion and sources, see various materials chapters. Excludes exports of scrap materials; but in some instances includes imports of scrap for domestic consumption; excludes scrap materials reused (such as textile wastes for wiping rags); nonferrous metals include only aluminum, copper, zinc, and lead; rubber recycling includes tires retreaded for resale as tires.

CHAPTER XI

CASE STUDIES

Introduction and Overview

Case studies of salvage practices were carried out in 14 areas across the United States to discover by actual discussions with public and private agencies the history and current status of recovery and recycling operations.

The surveys consisted of interviews with local public officials, with executives of private refuse removal and secondary materials companies, officials of social welfare agencies, with officers of companies that purchase secondary materials, and with individual scavengers and waste gatherers. Research team members spent between 1 and 3 weeks in each community with the exception of Atlanta, Louisville, New Orleans, and St. Louis; in these last-named cities, we conducted 1 or 2 days of interviewing to get first-hand information on specific projects.

The survey communities were selected on the basis of prior knowledge of their salvage activities, gained by perusal of the literature and examination of the raw data of the 1968 National Survey of Community Solid Waste Practices. We wished to visit only those communities where some form of salvage was known to be practiced. Within that limitation, we attempted to select cities in most important geographical regions of the Nation and to select small, medium, and large communities. These are individual case studies, however, and extrapolation from the data presented here is not advised.

We encountered a number of serious problems in this survey that must be identified to qualify our findings: (1) good documentation on current and past practices was difficult to find; (2) we were refused access to information by some respondents for various reasons; (3) movement of secondary materials was so complex in some instances that we were unable to form a good picture of the total "system"; (4) authoritative price information was withheld in many instances to protect the competitive position of respondents; (5) base data necessary for establishing perspective (total waste processed, number of refuse removal firms) were often not available, especially for that portion of the waste handled by the private sector; (6) individuals with knowledge of events or practices crucial for understanding a situation could sometimes not be located because they were one-man operations, often without office facilities, or because they had moved.

Although the conditions encountered in each city were unique, a number of general observations about salvage activities in the case study communities as a whole can be made here to give an overview of the survey universe.

Reclamation of waste materials and obsolete products is practiced in the following seven major modes.

(1) Retrieval of commodities from mixed refuse deposited at dumps and landfills; this is usually an activity carried out by very poor people, using manual labor sometimes under some sort of contractual arrangement with the city, but usually without a legal basis. Metals and repairable, reusable products are the commodities sought by dump scavengers.

(2) Recovery of metals from incinerator residues; this is accomplished in one of two ways: either the incinerator operator himself recovers metal, usually steel cans, or incinerator residues are delivered to a private corporation that processes residues to obtain metal. In the latter case, the contractor normally pays a standard fee to the city.

(3) Retrieval of commodities from mixed wastes before or during waste collection; this activity is carried on by scavengers who precede collection vehicles on waste collection days and remove newspapers from waste cans set out by householders or by collection crews who separate newspapers and other valuables in the act of collection, storing such items in bins or baskets attached to trucks.

(4) Recovery of commodities — usually only corrugated board — from commercial or industrial wastes; this is practiced by private refuse haulers.

(5) Separate collection of scrap from commercial and industrial sources by secondary materials dealers or junk men. This is the conventional mode of operation of the secondary materials industry.

(6) Separate collection of newspapers by schools and civic groups; this is the traditional "paper drive," which involves delivery of newspapers by householders to a central place or door-to-door collection by youngsters, followed by pick-up of the paper by a dealer.

(7) Separate collection of obsolete commodities from residential sources, followed by resale of a portion of such commodities in second-hand stores and sale of the remaining portion as secondary materials (as a rule only textiles are involved); this activity is carried out by social service agencies.

With the exception of incinerator residue reclamation, these salvage modes can be found in nearly every city or area; they are more or less developed and more or less intensively practiced depending on local demand for secondary materials.

As a rule of thumb, traditional, contractual recovery activities involving municipalities have been terminated in the last few years, or they are being phased out. Dump salvage is discouraged, and supervision over landfill activities is tightening. Salvage by private refuse haulers seems to be on the increase, however; we found several such operations, most of them fairly new; this activity primarily involves cardboard and newspaper recovery.

Paper sales and social welfare agency collections account for the only large-volume recovery of commodities from residential sources, and both of these modes are separate collection modes. The textile recovery business depends almost entirely on social service agency collections and thus, ultimately, on residential sources. A preponderant proportion of newspapers is collected from residential sources.

With the exception of these commodities, little if any waste materials derived from municipal wastes is recovered in quantity. Steel can recovery from incinerator residues was the only fairly widespread example of commodity reclamation from mixed wastes; the tonnages involved, in comparison with total steel recovery, are minimal. The overwhelming percentage of all secondary materials are separately collected from commercial and industrial sources by secondary materials dealers and their agents.

We encountered a scattering of "new-fashioned" salvage operations (aluminum and glass recovery in Los Angeles and newspaper collection in Madison) which are based on voluntary materials segregation by the public and subsidized collection, in the case of aluminum and glass, where the public contributes transportation. We also encountered survivals of very old-fashioned salvage practices that are rapidly disappearing: large scale, uncontrolled dump salvage and recovery of hair and feathers.

Observations about the economics of salvage and salvage operations can be summed up under the following points.

(1) Salvage is severely limited by the absence or disappearance of cheap labor for sorting and collection of commodities. The limit is not declining scrap prices, which have been relatively stable over time, but the proportional increase in wages paid to labor. Sorted materials of homogeneous composition can be sold with some exceptions provided that a buyer is located within an economical transportation radius of the generation point. Sorting is encountered only where one of the following conditions is met: (a) the value of the waste commodity is high (nonferrous metals and IBM cards); (b) cheap labor is available because workers are employed who could not otherwise find jobs (social service agency labor); (c) sorting is accomplished by an entrepreneur (scavenger) who need not pay himself the minimum wage; and (d) the commodity is presorted and only occasional foreign objects need to be removed.

(2) Successful salvage operations depend on a favorable transportation arrangement. For best results, salvage must ride piggyback on a transport system whose economics are independent of salvage income. This criterion is most applicable to salvage commodities that occur in small quantities per stop and loses its force in cases where large quantities of salvage are obtainable with each stop.

(3) Low value commodities, up to $30 per ton, usually cannot be collected and sold economically unless transportation charges to the buyer are at or below $7 to $10 per ton. In practice this means that a bulk commodity will not be collected in an area unless there is a buyer within 300 to 500 miles of the area; usually the buyer is within 100 miles. The exception to this is a case where the generator pays the dealer for removing the waste — a usual instance being rubber tires. As the value of a commodity increases, its ability to absorb transport costs increases, so that pulp substitute grade papers (around

$80 per ton) and metals like aluminum ($200 per ton) are sold to buyers who may be 1,000 miles away.

(4) The same commodity, cardboard, for instance, will bring a higher price when derived from commercial sources than it will fetch if sorted from mixed refuse; in the latter case contamination is virtually unavoidable and this results in a penalty.

(5) Wherever technology is used with a salvage operation, the economics of salvage usually improve. High density baling equipment, for instance, whose operation, including amortization, costs around $2 per ton, can save up to $5 per ton in transport charges on a 500-mile haul of waste paper. A city that operates its own residue reclamation system as part of its incinerator operations can expect to sell steel cans with a modest profit;[135] where the residue is sold unprocessed, the operation seldom survives.

The case studies that follow are presented in alphabetical order by community. In each case study report, a brief summary of the significant findings is given first, followed by discussion of particulars. All statements made refer to the time of the survey itself, indicated in each case by footnotes. An overview of the case studies is presented in Table 59.

Amarillo, Texas[136]

Summary. Amarillo is located near copper mines and could sell all its steel can wastes to mines. An operation to recover cans from incinerator residues had been in existence but was discontinued. Textiles are collected and sold by the Salvation Army. A dump-salvage contract is in force.

Introduction. Amarillo's economy is based on cattle ranching, small-scale agricultural product processing, and fertilizer production. There are no glass, steel, iron, or paper manufacturing facilities in or near Amarillo. No rubber reclaiming is practiced in the vicinity. The city is situated in the center of an industrial desert (the nearest major metropolitan area, Dallas, is 360 miles away), and salvage activity, therefore, is minimal. At the same time, Amarillo is close to several major copper mining operations in Arizona, New Mexico, and Utah. Amarillo enjoys one of the most attractive freight rates for shredded steel cans to copper mining points among the cities in our survey, and consequently it is one of the few communities where the recovery and sale of steel cans could be practiced profitably. The metropolitan area has a population of 193,000, and Amarillo proper; 138,000.

Waste collection and disposal in Amarillo is accomplished by the Amarillo Sanitation Department and three private refuse haulers. The city's forces collect 56,500 tons of waste yearly — nearly all the residential tonnage and about 90 percent of all commercial and institutional wastes. Three private refuse haulers collect an estimated 2,600 tons, mostly commercial wastes with a sprinkling of residential wastes.

The total waste tonnage collected in the city only (just under 60,000 tons) is equivalent to 2.38 pounds per capita per day.

The city incinerates 52,000 tons of waste in an incinerator with a capacity of 350 tons per day. Combustion is at a high temperature (1800° F) and the residues we inspected contained very little unburned organics. The city also delivers 4,500 tons of waste directly to the municipal landfill site and hauls 11,500 tons of incinerator residue to the fill. Private refuse haulers deliver their wastes directly to the landfill. About 2,600 tons of waste are dumped by private haulers. In addition, private citizens deliver wastes to the fill site, but the total quantity is not known.

The landfill is located about 3 miles from the incinerator and consists of a 140 acre site; 8 years of useful life remain in the fill, which will be converted to a golf course. Wastes are deposited into cavities dug in advance and are covered within 20 minutes after discharge from trucks.

Current Salvage Practice. Salvage activity in Amarillo is very limited at present. We identified the four following specific instances of recovery from municipal wastes.

Municipal Salvage Contract with a Private Contractor. This contract became effective December 1969; however, a similar contract had been maintained with another individual previously.

This operation, carried out by one person, consists of retrieving usable or saleable items from wastes dumped at the municipal landfill before they are covered. The contractor has 20 minutes in which to salvage — thereafter the waste is buried.

The contractor keeps no records but claims to remove one load of salvage daily — a pickup truckfull — working 5, more often 6 days a week. We estimate that

[135] Provided, of course, that the city is within economic transport range of the buyer.

[136] Survey concluded in January 1970.

he removes 130 tons of salvage in a year. He concentrates on recovering "usables" (toys, clothing, umbrellas, pots and pans, etc.) in preference to scrap. Aged 57 and with a heart condition, he is unable to handle heavy objects like motor blocks or large pieces of steel. He plans to convert his home to a secondhand store where he will sell usable items he recovers. He stores and accumulates metallics at his home and sells these in batches to the leading scrap merchant in the city.

He has an exclusive right to salvage at the landfill — a privilege he obtained by competitive bidding. He pays the city $237 a month ($2,844 per year) for this right. He estimated that he can gross between $525 and $630 a month from salvage or net, after paying the city, $288 to $393 a month. He supports a wife and four children.

His predecessor, who retired in 1969, had a contract with the city paying $1500 a year for salvage privileges.

Sanitation officials in Amarillo have divergent views on the probable success or failure of this venture. The assistant superintendent holds that the operator will lose money on the contract. The director believes that gross returns will be $15,000 to $20,000 a year. Based on our discussion with the contractor, inspection of his salvage products, and interviews with second-hand product stores in Amarillo, we believe the operator will find it difficult to meet the city payments let alone realize a large profit. His first payment to the city was overdue at the time of our survey.

Unauthorized Salvage at the Landfill. Gatemen at the municipal landfill report that five to eight people, in addition to the authorized contractor, salvage from the landfill in winter; with the onset of warm weather, the number of scavengers increases. Enforcement of the "no-salvage" rule is lax. Apparently gatemen pity the needy scavengers who haunt the landfill to make a living. The salvage contractor stated that this "competition" does not seriously affect him. He considers himself an expert scavenger who learned his business from his father. Others at the landfill site do not possess his discrimination and consequently do not pick up valuable items of scrap; they hunt "usables." In the winter months, he avers, there are few usables in the waste. In the summer, however, usables increase and he plans to complain to the gatemen if he notices unauthorized scavengers leaving with useful commodities.

Salvage by Private Haulers During Collection. Two one-truck private refuse haulers reportedly salvage commodities from waste on their collection routes and then sell usable items to second-hand stores and scrap materials to secondary materials dealers. We were unable to contact these companies for interviews about quantitites and types of wastes recovered. They were under way servicing their routes.

Reuse of Discarded Products and Textiles. In 1969, the Salvation Army facility in Amarillo acquired 300 tons of materials; of this 20 tons were discarded as waste; commodities weighing 186 tons were sold in the Salvation Army Retail Store (clothing, appliances, toys, furniture) and 94 tons of mixed rags were sold to a rag dealer in Dallas, Texas.

Total revenues of the operation (Table 60) were $37,000 ($132.14 per ton of salvage sold); operating expenses were $39,100 ($139.64 per ton), for a net loss of $2,100 ($7.50 per ton). However, the operation must also support a transient hotel. The salvage operation, taken alone, appears to be self-supporting but would not break even on a commercial basis. The wages paid employees average $2,428 per year per employee.

Collection activity extends beyond the borders of Amarillo. In addition to that city, the Salvation Army collects in Vega and Canyon, Texas, west and south of Amarillo, respectively, and accessible by major highway routes. One truck and driver constitute the collection system.

Two sorters separate the loads brought in by the driver, prepare textiles for shipment, and carry on restoration and repair work on other commodities under the supervision, and with the help of, a warehouse foreman. Textiles are not sorted; they are baled as mixed rags and shipped. The facility receives $2.75 per hundredweight ($55 per ton) but must absorb freight charges of $15.95 per ton to Dallas.

Steel Can Recovery. In January 1967 an operation began in Amarillo to recover steel cans from incinerator residues. The operation closed in November 1968, but the debris left behind — physical and organizational — was not cleared up until January 1970. In this period less than 1,000 tons of shredded steel were actually shipped. The details of this operation illustrate the problems that can be encountered in any enterprise to salvage materials from municipal wastes.

History. Late in 1966, the Sanitation Department of Amarillo signed a contract with Apco Metals Company. According to the terms of the contract, Apco Metals would undertake removal of all incinerator residues from the city in exchange for (1) exclusive salvage rights encompassing both the residue and the wastes dumped at the landfill and (2) payment of $0.50 per ton for any material sold. The contract was for 5 years. Apco Metals was required to post a $10,000 performance bond. No arrangements were made for disposal of the unrecoverable incinerator residues.

In January 1967, Apco Metals began hauling the city's residues, using four trucks. The wastes were delivered to a scrap yard north of the incinerator for a brief period. Another site was selected soon thereafter. The can processing plant, a mobile unit, was transferred there. The city undertook to bury the wastes left behind at the original site free of charge.

At this time Apco had a can processing plant designed by the company's president, but it did not have an operational hammermill for shredding the cans. A hammermill of the company's design was on order, but delivery was delayed for 5 months. Consequently, Apco processed the residues through the plant, segregating cans from other materials. The cans were not shredded, however, and were piled up on the lot in the open air.

While awaiting the hammermill, the company salvaged other ferrous and nonferrous metals from the residue and had a team stationed at the landfill to recover salvage. These materials were sold through a scrapyard owned by Apco's president.

Negotiations were conducted for sale of the steel cans during this period with Proler Steel Company (Houston) and copper mines in Miami, Globe, and Winslow, Arizona.

Shredding of steel cans started in June 1967 with the arrival of the hammermill. Apco's former president reports that initially the shredded tin was sold to Proler for $20 per ton. Only a few carloads were sold, however. Next Apco began delivery to copper mines at $55 per ton. This continued for 1 month. The 1967 copper strike began in July of that year, and copper mines refused to take delivery.

During this brief operational period, Apco appears to have shipped between 640 and 960 tons of shredded steel. Apco is now defunct and the memories of various participants are vague about details. The low figure is derived from an audit of Apco's records conducted by the city; according to these data, Apco's sales were $35,000, or 636 tons at $55 per ton. The higher figure is based on an estimate by a company official that 80,000 pounds of metal were processed daily, 6 days a week, for about 4 weeks.

With the conclusion of the copper strike in March 1968, Apco attempted to resume can shipments but could not negotiate any sales. One-time Apco officials did not wish to specify the nature of the arrangements the company had with mines. Apparently the shredded cans delivered by Apco were of poor quality — highly oxidized and fragile; Apco had no firm contracts with the mines but shipped in response to purchase orders; mines could accept or reject shipments upon inspection; following the strike, abundant quantities of high quality shredded metals were available, and Apco could no longer compete.

For another 10 months — March 1968 to January 1969 — Apco hauled incinerator residues from the incinerator to its site. Attempts to market the steel were carried on without success. In February 1969, the operation was sold to a new owner who placed a $5,000 bond with the city; the former owner of Apco was refunded his $10,000 bond. The new owner continued to haul residue until April 1969, when he declared bankruptcy and forfeited his bond. The city resumed residue hauling.

The plant reverted to the former owner of Apco but was not operated; the new owner could not meet his payments. In January 1970, the owner was forced to remove the accumulation of cans and dirt from the plant site to the landfill; the city had concluded that the site was a potential health hazard and planned to let a contract for $30,000 to remove the waste. Rather than being assessed such a charge, the owner elected to undertake the removal job himself.

Financial Basis. The can reclamation operation was a failure for three reasons: (1) the delay in acquisition of the shredding equipment, (2) the onset of the copper strike, and (3) failure to regain the market lost after the copper strike ended. In 2 years of operation, the company lost between $100,000 and $150,000 by our estimates.

Our objective here is not to trace the financial aspects of this venture as it actually unfolded — the detailed data for that are not available — rather, we would like to establish whether or not this operation could have been economically viable if conditions had been more favorable.

This analysis is based in part on data from a city audit of Apco's books, in part on the recollection of company officials, in part on published freight data, and in part on generally accepted industrial overhead and cost factors. Apco's overall operations are difficult to understand. The company, owned by a Lubbock, Texas, investor, consisted of a scrapyard and the salvage plant. It was managed by another individual who had no equity in the business. This manager could not differentiate in detail between the scrapyard and can plant operations in trying to recall specific numbers. The books were kept by a part-time accountant who was employed at the bank that financed Apco's operations; the accountant purchased the scrapyard owned by Apco when the company folded. For these reasons, what follows should be viewed as impressionistic estimates.

In making estimates, we are using reported cost data on the plant but are assuming that: (1) 4,000 tons of shredded steel could have been processed yearly; (2) the plant could have been operating during the entire period; (3) the product of the plant could have been of acceptable quality if it had been processed and shipped immediately; and (4) the company could have been protected from the effects of a copper strike by suitable contract provisions.

Apco's can processing plant was sized to produce around 23 tons of shredded metal in an 8-hour day, or just under 6,000 tons a year operating 260 days. It appears to have had the appropriate capacity for the metal likely to be found in the incinerator residue, with enough additional capacity to permit maintenance and reasonable growth.

Fixed assets of the company related to can reclaiming only were $98,100, or about $4,500 per ton of daily (8-hour basis) capacity. We estimate that total capital-related charges were $21,700 a year ($5.41 per ton of product), operating costs were $60,000 ($15.00 per ton), general overhead was $25,000 ($6.25 per ton), and other expenses (freight and payments to the city) would have been $91,600 ($22.90 per ton). This results in a total cost of production and delivery of $198,300 a year, or $49.56 a ton, yielding a gross, before-taxes profit of $5.43 a ton or $21,700 a year. Cost elements are displayed in Table 61.

These estimates provide only a modest salary for the company president, who had other interests and income; office help consisted of one part-time bookkeeper whose fee is included under capital-related expenses. Miscellaneous expenses include disposal fees for deposition of about 6,000 tons of residue at $1.00 per ton; transport of residues to the dump site is included under operating costs.

In actual practice, Apco also realized income from its scrap operations and from the salvage of metals other than steel cans at the plant site and at the municipal landfill and sold an indeterminable number of carloads of clean residue to the railroad for $200 a carload (about $5.00 per ton). Such income is not reflected in our tabulation because we could not get base data for estimates. It is clear, however, that if the company had been properly operated its profits could have exceeded those in our estimates.

The Secondary Materials Industry. The secondary materials industry in Amarillo consists of five metal scrap processors who collect and process copper, brass, steel, cast iron, and aluminum in the immediate vicinity of Amarillo and sell the metals to users or middlemen in Lubbock, El Paso, Houston, Dallas, and Fort Worth in Texas and in Colorado. There are also three or four part time scrap operators who bid on military and industrial salvage packages and deliver metals directly from the source to users or middlemen.

There is a shortage of metal scrap in the Amarillo area and an oversupply of operators who derive a living from scrap — hence, keen competition between all interests involved in the metal scrap business.

The leading company insures its supplies by posting a standard price list. Prices paid by the company are higher across the board than prices paid by competing yards. The company maintains its buying price regardless of market fluctuations and in this manner attracts materials. The company also usually achieves a higher selling price than its competitors by marketing directly and because it handles a significantly higher quantity of metals than other yards — about 800 tons of metals a month versus 35 to 146 tons handled by others. The company's predominance is also assured by its ability to post large bid bonds on salvage packages, while the financial circumstances of other processors do not permit this.

Two of the five scrap processors derive the bulk of their revenues from the sale of usable items and operate retail outlets. A number of much smaller shops in Amarillo's ghetto area also sell usables derived from municipal wastes. A typical usable product is a kitchen sink, purchased for $1.00 and sold for $1.25 to $2.00.

Scrap processors in Amarillo view metals derived from municipal waste as a nuisance. Such materials are purchased, however, because scrap available from other sources is scarce.

Discussions with numerous individuals revealed an interesting pattern of personnel circulation in the Amarillo scrap business. Apparently the precarious financial condition of smaller yards frequently forces their owners to sell out or to take out bankruptcy. Few of these men take up other lines of work; usually they become brokers, scavengers or, if they have a truck, part-time scrap dealers. As part time dealers or brokers (unencumbered with the cost of facilities and a payroll) they are able to outbid established scrap processors for specific salvage packages. In this manner, they accumulate capital and reemerge again as scrapyard owners. Those who fall hardest engage in the salvage of commodities from the municipal landfill and other dump sites around the area.

In the Amarillo area, there are no dealers in secondary paper, rubber, plastics, organics, and glass. One paper dealer was listed in the telephone book; investigation showed that the company had gone out of business after a short period of operation; none of the individuals concerned with the venture could be located in Amarillo.

Conclusions and Observations. In Amarillo the possibilities exist for the recovery of virtually all steel cans from municipal wastes — at least from the technical and economic point of view. The municipal incinerator can be operated at the desirable temperature to achieve good, clean, burned cans (1200° to 1400° F). The incinerator could be equipped with can reclaiming machinery for $75,000 to $100,000, according to an independent engineering estimate obtained by the city. Freight charges for shredded steel are low. The incinerator is located near a rail line.

Textile salvage is a possibility if segregated collection of textiles were undertaken. This would require a publicity campaign and would call for installation of small hoppers or baskets on municipal collection trucks (see Madison case study). Reclaiming of nonferrous metals would be possible and these could be sold readily to the local scrap processing industry.

The city's experience with metal can salvage has been unfortunate; recent attempts to interest local scrap dealers in can reclaiming have been unsuccessful. Scrap processors view this business as hazardous because of the dominant position of Proler Steel in the market and because the city's approach has been to write a contract for residue removal, which would involve processors in residue separation and can shredding.

The financial situation of the city does not, at present, permit capital investment in can reclaiming equipment at the incinerator site. The technical skills necessary successfully to operate such a system are also absent, in our opinion. Consequently, this resource is not likely to be exploited in the near future.

Even if equipment would be purchased and qualitatively acceptable product could be derived from residues, the city would be in a poor position to sell the shredded steel directly to copper mines, lacking experienced marketing people. The product would have to be sold through a middleman, assuring the city only meager profits on the operation.

Atlanta, Georgia[137]

Summary. In Atlanta recovery of steel cans is practiced at two municipal incinerators; on a 1968 basis, 6,282 tons of tin cans were recovered and sold for $10.27 per ton, or $64,516 total; can reclaiming operating costs, including amortization, were $10.01 per ton, for total net revenues of $1,633 for the reclamation facilities. Steam is also generated at one incinerator and sold to a utility.

Introduction. Atlanta was not one of the scheduled survey cities. City officials were interviewed to obtain facts on Atlanta's can reclamation operation only.

Atlanta had an estimated population of 513,000 in 1969. Wastes are collected by municipal and private forces. Disposal processing of 90 percent of the kitchen refuse (garbage and small residential wastes) is through two incinerators; trash (yard refuse, bulky wastes) is hauled directly to six public and three private landfills. In 1968, 242,000 tons of kitchen refuse were burned in the municipal incinerators.

Salvage Practice. Steel cans are separated magnetically from the residues of the city's two municipal incinerators; the cans are reduced in size by hammermills after washing. The shredded steel is loaded on railroad cars (minimum loading of 50,000 pounds per car) and is shipped to the El Paso facility of Proler Steel Company, buyer of the metal. The steel is ultimately sold to copper mines.

Approximately 2.6 percent by weight of the refuse received at the incinerators is sold — 6,282 net tons in 1968. Given an average national per capita steel can consumption of 52 pounds a year and a population of 513,000, the city appears to be recovering for sale half of the steel cans occurring in the community.

Recovery Economics. The city negotiated a contract with Proler Steel Company in 1966, whereby the city received $15.70 per net ton[138] of shredded steel; the buyer paid transportation costs. In 1968, the buyer

[137] Survey concluded in August 1969.

[138] The city's records are kept on the basis of gross (long) tons; all figures here are shown in net (short) tons for the sake of consistency.

reduced the price to $10.27 per ton, citing product quality deterioration (excessive dirt, rust) as the reason.

It costs the city $10.01 per ton to process salvage metals for shipment, as broken down in Table 62. The city consequently realizes a profit of $0.26 per ton of metal processed or $1,633 profit in 1968. City officials indicate that can recovery would be continued even if the cans would have to be sold at a loss. Discontinuation of metal salvage would necessitate removal of the metal to landfill at a cost of $5.67 per ton, or $35,620 per year; the removal cost includes labor costs and residue truck amortization, but excludes fuel, maintenance, and landfilling costs. In other words, the city could lose $5.66 per ton of metal sold (a selling price of $4.35 per ton) and still expend less on removal of this waste than it would spend by the alternative route of landfilling the metal.

Steam Recovery. At the city's Mayson incinerator, steam is generated and sold to a utility company. The city is required to produce 260,000 pounds of steam every 24 hours, failing which, the city is penalized. In 1968, the city sold 300 million pounds of steam, receiving $0.20 per 1,000 pounds or $60,000. City officials state that this operation loses money; the city's costs to produce the steam are around $0.23 per 1,000 pounds.

Chicago, Illinois[139]

Summary. Chicago, the Nation's second most populous city, operates a large public solid waste collection and disposal system for residential wastes. The private refuse collection and disposal establishment is also sizable. Most of Chicago's waste passes through incinerators. Steel cans and other steel products are recovered at both municipal and private incinerators. Steam is also sold from municipal and private incinerators. One scrap dealer in the area specializes in the disassembly and processing of metallic products normally found in residential wastes — appliances, radios, and the like. The city is an active waste paper market area. A glass cullet dealer operates in Chicago. Textiles are recovered. A waste rubber processor is also active in the area.

Introduction. Chicago, with a population of 3.3 million people, is a major center of industrial and commercial activity in the United States. Sanitation services are handled by the city of Chicago for household refuse of all types and by private refuse haulers who serve the industrial and commercial sectors of Chicago and many of the adjacent suburban communities. These operations depend principally on incineration for volume reduction although there are a number of landfills in operation in Chicago.

The city operates three incinerators, two transfer stations, and one (overfull) landfill. A fourth incinerator was nearing completion at the time of the survey. (Combustible material averages 77 percent of refuse by weight and 90 percent by volume.) In addition, the city has access to privately operated incinerators for disposal. Packer truck tonnage is growing at 2 to 3 percent per year while bulky refuse is increasing at the rate of 5 percent per year.

Refuse collection and disposal in Chicago for 1969 amounted to 1,914,000 tons. Of this amount, the city collected 1,244,000 tons, and private forces collected an estimated 670,000 tons. The waste collected is equivalent to 3.15 pounds per capita per day. Of the waste collected by the city, 14 percent was disposed of at private incinerators and landfills, the remainder in its own facilities. Of the tonnage disposed of by the city, 61 percent was incinerated. The city's sanitation budget was $34 million in 1969, excluding capital improvements, amortization, and equipment maintenance — $27.8 million for collection and $6.5 million for disposal. The city collects residential wastes only; 173 licensed private haulers service industrial and commercial accounts and large private apartment complexes.

Municipal Salvage Operations. The city derives income from three types of salvage activities: (1) the sale of steel cans from incinerator residues; (2) the sale of sheet metal from bulky wastes; and (3) the sale of steam from one of its incinerators.

Incinerator Residue Recovery. In 1963, a scrap dealer approached the city and proposed to build a processing plant to recover steel cans in the city's incinerator residues. The city asked for competitive bids covering the steel cans in its residues. The dealer was the successful bidder, the plant was built, and incinerator residue processing began and continues to this day.

[139] Survey concluded in June 1970.

According to the contract, the city is paid $10.07 per ton of steel cans, based on actual loaded rail-car shipping weights.[140] The city delivers residue to the dealer's plant, which is near the Southwest Incinerator. In addition, the city back-hauls unsalable residue (tailings) separated during processing. The city reserves the right to extract nonferrous metals but makes no attempt to salvage them. In fact, various individuals recover this material as time permits, including one independent scavenger, who spends all his time at the can processor's plant, and city truck drivers, who remove nonferrous metals during their residue runs.

The dealer's intent was to receive screened or magnetically separated residues — in other words, the residues minus ash. This would have minimized double handling of tailings. The city can screen residues at only one of its incinerators, Southwest. Residue from the Medill Incinerator is not received by the dealer because it consists almost entirely (90 percent) of tailings and thus is too expensive for the city to back-haul after can removal. The Calumet Incinerator, which also lacks screening equipment, was delivering residue to the processing plant because the quality of the residue was somewhat better than that of the Medill facility; magnetic separation equipment was planned at the Calumet facility for the fall of 1970.

Only the Southwest Incinerator has consistently delivered residue to the plant. Residues from the Medill facility were refused by the dealer, because of high tailing content, in the second year of the program, and the city readily concurred to save hauling costs. Residues from the Calumet Incinerator were rejected in the period 1967 through 1970, initially because the copper strike destroyed demand for the cans and later because the residues were too "dirty" and excessive processing and back-haul of tailing were needed to obtain an acceptable product.

At the outset of the program, the city's revenues were as high as $160,000 per year. In 1968, 11,297 tons of cans were sold and an income of $113,764 was realized by the city; in 1969, 9,214 tons brought $92,781.

The can processing facility is close to the Southwest Incinerator, which makes residue and tailing haul costs relatively low for the city. The city removes only the reject tailings to the landfill for ultimate disposal. No detailed cost analysis of this operation was available, but it is certain that the city has a profitable operation at the Southwest Incinerator.

At the incinerator itself, one man is stationed at the discharge conveyor to remove bulky metallic objects that would cause problems in the screening operations. A rotating screen is used to separate the ash from larger pieces of residue metallics and nonmetallics. No magnetic separation takes place. City personnel report that only during the copper strike, when much of the stockpiled cans oxidized and had to be hauled back as tailings, did relations between the city and the dealer become somewhat strained. Otherwise, the arrangement has been satisfactory.

By our estimates steel can sales from Southwest Incinerator for 1969 amounted to 3.3 percent of incoming tonnage and 8.7 percent of residue; according to a test made in 1968, incoming waste contained 8 percent metal by weight. Of this, cans may be 6 percent, but this is only an estimate. Based on waste delivery, the metals content was 22,000 tons in 1969, giving a recovery of 41 9 percent of the metals (Table 63). The "loss" is accounted for by nonferrous metals, large ferrous pieces and wire rejects, incineration "fines," oxidation, and other losses prior to shipment.

While the amount of metal actually recovered for sale is not large compared to total waste input or incinerator residue, the city does realize a savings in costly and virtually nonexistent landfill space as well as revenue equivalent to about 14 percent of its disposal budget.

Sheet Metal Recovery. The city collected 381,530 cubic yards (about 47,700 tons) of bulky waste in 1969, of which perhaps 40 percent consisted of metallic items such as appliances. Bulky waste is handled by separate collections on open-body trucks. For about 5 years, portions of the metallics have been sold to local metal dealers. Salvage is done at two transfer stations and the landfill.

This recovery operation depends on hand labor and mechanical loading equipment stationed at the transfer stations and the fill. At the transfer stations this amounts to hand sorting of metals and separate accumulation during periods when transfer trailers are not being loaded. Recovery of the bulk metals is dependent on availability of the loading equipment to move, accumulate, and load.

[140] This price has remained effective since the inception of the program, which is now in its second 5-year contract period. Actual price is $11.28 per long ton, but all data in this report are presented in short tons for the sake of consistency.

Metals are hauled to the dealer's yard by truck, where they are weighed and unloaded. The dealers shred or grind the metal, which then becomes a part of No. 2 bundles sold to the steel industry. The price received by the city is based on the *Iron Age* weekly price quote for No. 2 dealer bundles. The city receives the difference between the *Iron Age* quote and a fixed price bid by the dealers. If, for instance, the dealer's fixed bid is $20 per ton and the Iron Age quote is $22 per ton, the city receives $2 per ton. If the *Iron Age* quote is also $20 per ton, the city receives nothing. At the time of our survey, the city had two contracts with dealers for fixed prices of $17.86 and $14.28 per ton. Revenues to the city have ranged between $2 and $17 per ton, depending on market conditions. Location of the dealer's yard plays an important part in determining the best dealer bid; the city hauls to the yards as close as possible to the accumulation points. The condition of the metal collected is of little consequence to the dealers, although high nonmetallic content is not acceptable. Revenue from sheet metal was $7,166 in 1968 and $16,516 in 1969. The 1969 revenue represented approximately 1,500 tons of metal.

The city will soon start using a special grinder at its Goose Island transfer station to reduce the volume of bulky refuse, but handling of salvable metals will continue to be dependent on hand labor. A magnetic separation unit was planned, but expected revenues do not appear to justify the capital investment of $150,000 required to put it into operation. Four men are employed in salvaging at the Goose Island transfer station. The operation is clearly uneconomical in light of present costs, the low level of mechanization, and revenue realized. The main benefit of the operation is to preserve landfill space. The dealer taking the metal from the Goose Island transfer station estimated he was receiving 20 tons per week and indicated that this was a marginal quantity for his operation.

Steam Sales. Chicago's Southwest Incinerator is equipped to sell waste heat in the form of steam to outside customers. The equipment includes four waste heat boilers with auxiliary fuel burners for standby operations to meet the contract volumes when the calorific value of the waste is too low to provide the steam. At present, the city has a contract to furnish steam to the nearby Central Produce Terminal. (Sales data are in Table 64.)

City officials believe that this is a profitable operation; however, no detailed cost evaluation of the operation has been made. We did not attempt to pursue this item further because of its marginal interest for the salvage study. Two observations raise some questions about the value of heat recovery: (1) the city must frequently supplement its heat load with auxiliary fuel and experiences mechanical problems, and (2) a private refuse incinerator nearby found steam sales to be a constant operating problem and a deficit operation.

Salvage of noncombustible materials is viewed with favor by Sanitation Department officials, not only as a source of revenue but also as a way of preserving scarce landfill space. With the startup of its new incinerator, the city will be nearly fully committed to volume reduction by incineration. Officials believe that a salvage program to recover combustible material could cause severe problems, especially if it involved paper reclamation. Paper is more than 50 percent by weight of the tonnage collected, and the heat value of the paper is important for the proper operation of incinerators.[141]

Steel Can Processing. The steel can processing plant, built in 1963, is located near Chicago's Southwest Incinerator. The plant receives 75 percent of its inputs from the city, the balance from two private incinerators, can manufacturers, and detinners. The processed cans are shipped to the Southwest and the West, where they are used for copper precipitation.

The plant manager reports that cans obtained from the Southwest Incinerator are of excellent quality; they are thoroughly burned, properly screened to remove ash, and the tailings consist largely of nonferrous metals. Cans from the Calumet Incinerator are poor in quality; they are not burnt out properly and are accompanied by tailings equivalent to 75 percent of input weight.

Although the plant manager refused to reveal detailed operating information, the plant appears to be economical: a second can processing line was installed in 1969, bringing total investment cost of the plant to $2 million; the operator is seeking out new sources of cans; residues from the Calumet facility are now accepted after a hiatus of several years, although poor in quality, because the operator needs additional quantities to operate his equipment efficiently.

[141] One waste paper dealer reported that the city had once purchased reject waste paper from his company for use as fuel during a period of very wet weather to overcome incinerator difficulties at one of the municipal incinerators.

The plant manager cites the following major operational problems at the can plant: (1) extreme maintenance problems (50 percent downtime) because iron oxides and residues cut the fittings on the equipment; (2) air pollution arising from burning and shredding of the cans, which has resulted in the levy of fines by the Chicago air pollution control authorities; (3) rail cars are frequently unavailable, especially when operations are at full scale, and the resultant delays cause serious oxidation of stock-piled cans; and (4) wire in the residue hangs up in the equipment and requires elaborate operations for removal.

Operating steps are as follows: (1) materials are loaded by magnetic crane into feed hoppers; (2) material passes through a magnetic separator to eliminate nonferrous metals and ash; (3) four hand pickers pull out deleterious materials such as wire; (4) cans are shredded in a hammermill; (5) shredded materials are magnetically screened a second time; (6) cans are then burned in a rotary kiln at 1800 F to remove coatings, ash, and contaminating residues from mixed refuse incineration; (7) cans are loaded into rail cars or stored; (8) tailings are loaded into city dump trucks for removal to the landfill.

In addition to these operations, considerable scavenging takes place. An independent scavenger collects rejected ferrous and nonferrous metals falling out of the magnetic separation unit and sells these to local scrap dealers, earning between $40 and $60 per week. City truck drivers scavenge for nonferrous metals while loading and unloading operations take place.

Salvage at Private Incinerators. The Chicago area has three large privately owned incinerators used by private refuse haulers. All of them sell steel cans and sheet metal as a part of their normal operations. Operators state that salvage reduces space taken up in landfill and is a profitable or at least break-even proposition financially. These factors must be present to make salvage feasible. Two private incinerator operators were visited.

Incinerator, Inc. This facility is the oldest private contractor-owned incinerator in the United States, dating to 1958; ownership is by 30 private refuse haulers. The incinerator has a rated capacity of 500 tons per day and normally operates at or above this level. The company accepts any refuse delivered and charges a disposal fee based on weight. It receives a wide mixture of residential, commercial, and industrial waste from Chicago and nearby suburban cities. Everything received, including noncombustible bulky items, is processed through the incinerator.

This operation has three salvage systems—steel can, sheet metal, and heat recovery. The facility manager reports that each recovery operation has its problems and that the rewards are entirely dependent upon balancing costs against contractually set or fluctuating revenues. Steel can recovery data are presented in Table 65.

Incinerator, Inc., operates a can processing plant located immediately behind the incinerator building; the plant is owned by St. Louis Carbon Company, purchaser of the cans. Incinerator, Inc., receives a fee for operating the plant. Ultimately, the cans are shipped to Montana copper mines. The equipment is plagued by severe operational and maintenance problems and the operator speculates that it is not a profitable operation for St. Louis Carbon. There are other problems associated with the can reclamation program, namely, obtaining sufficient volume of cans; high cost associated with numerous handling steps (running the cans through the processing step twice to reduce the dirt content); inability to load directly for shipment; rail car shortage; and insufficient product quantities to avoid a freight penalty. Also, the plant location is not advantageous for rail shipment because several rail lines may be involved in a single shipment. Offsetting this is the fact that the plant is adjacent to the incinerator and there are no hauling costs for Incinerator, Inc., to absorb; the haul of residue to landfill is reduced. Financial data were not available beyond those given above. It seems clear, however, that Incinerator, Inc., finds the recovery of cans a satisfactory operation. The company plans to continue this activity after its current contract expires in 1971, although other options will be evaluated at that time.

Bulky sheet metal items are set aside for sale to scrap iron dealers after incineration. The company does not wish to process this scrap for sale. Prices of bulky metals vary according to the market fluctuation for No. 2 dealer bundles, and the company's income varied from $3.57 to $14.28 per ton in the last year. At the low end, it does not recover delivery costs, but at the high end, the operation is profitable. The bulky metal is "dirty" metal and represents a wide variety of products—drums, appliances, engine blocks, sheet steel, etc. Sales in 1969 averaged $0.0092 per ton of waste received and we estimate (recovery of 1,400 to 2,000 tons or about 1 percent of input tonnage; in 1970 the yield had jumped to $0.021

per ton largely because of higher scrap prices in early 1970.

The incinerator residue ash is technically an excellent roadbed base when mixed with lime. However, the company has not been able to commercialize this application, despite one attempt to do so, because traditional materials (gravel and concrete) are so readily available locally. The ash is given away for the asking. Private fills account for what little demand exists; they use the ash as fill cover.

Paper recovery makes no economic sense to the operator in the highly developed Chicago waste paper market. Three barriers exist—contamination and cost of removal; fuel value in incineration; desire of some customers to have financial records or commercial products (outdated encyclopedias) completely destroyed.

Incinerator, Inc., sells 1 million pounds of steam per day to a nearby industrial plant. Until recently, this was an ideal arrangement—both the incinerator and the steam consuming plant operate continuously 7 days a week. Heat recovery, however, proved to be only marginally profitable over 9 years of operation because original design performance and costs were never realized. Steam generation and sale brings pressure on the operator to orient operations toward consistent steam output and therefore incineration practice does not necessarily conform to actual waste flow or its heat content. The $1.25 million steam recovery operation was plagued with fly ash coating of heat exchange tubes that cut efficiency substantially and also required more supplemental fuel than that anticipated; no condensate return line was originally installed, and thus water requirements were large. The operation became more efficient in recent years, but the receiving plant will have internally produced steam available in late 1970. Incinerator, Inc., plans to phase-out the waste heat recovery operation and to sell the heat recovery equipment rather than to seek a new customer.

Van Der Molen Disposal Company. This private incineration operation has a facility with a rated capacity of 700 tons per day and now processes 600 tons per day in its incinerator; another 1,000 tons per day are sent directly to landfills. All types of solid waste are handled—residential, commercial, and industrial—and refuse delivered by cities nearby is also accepted, on a disposal fee basis.

All incoming refuse is incinerated, including bulky metallic items; then a separation of the residue is made. Bulky metallic items are segregated by hand for sale. The balance of the residue is processed through a magnetic separator supplemented by a hand picking operation and a crusher that compacts the steel cans prior to loading into a trailer for delivery to a dealer. A company manager estimates that salvage of the cans reduces the volumes of the residue by 50 percent.

Steel can sales run an average of 225 tons per month, or 2,700 tons per year. This is about 1.2 percent of refuse incinerated. The price paid is $11 per ton based on railroad weight tickets reported from Butte, Montana, apparently the ultimate destination of the cans. The bulk of the cans go to the local dealer servicing the city incinerators. In addition, the company has recently begun dealing with another scrap purchaser whose payments per ton of steel cans delivered are higher.

Sheet metal is sold in volume to a scrap dealer based upon *Iron Age* listings for No. 2 dealer bundles. In general, revenues are about $13.50 per ton under the weekly price listing. Average recovery is 350 to 400 tons per month, 4,200 to 4,800 tons per year, or about 2 percent of refuse incinerated. Sheet metal is separated ahead of the can processing operation by hand. Sheet metal is hauled to the dealer's yard in a trailer truck.

Van Der Molen has one man per shift working on the salvage operation (cans and sheet metal); company officials estimate that one truck driver spends half-time on the hauling operation. We estimate that direct labor costs of $36,000 per year are involved in salvage, excluding equipment maintenance and amortization for which we have no estimates but which would likely equal direct labor costs. Income from cans and sheet metal based on $11 per ton for cans and $12 per ton average for sheet metal would be about $84,000. Thus, the salvage operation is profitable as long as sheet metal prices stay at or above $10 per ton (in fact, they fluctuate between $3.50 and $14.50).

The company also has an arrangement to sell steam to the nearby rail yard of the Chicago and Northwestern Railroad from which it rents its incinerator site. A small profit is realized on the operation.[142]

The company finds its metal salvage operations to be very desirable because of landfill space saved and income realized. In addition, the company has begun to

[142] Three contractor owned and operated incinerators service metropolitan Chicago. Solid Wastes Management/Refuse Removal Journal, 11(5):12, May 1968.

explore ways to salvage old corrugated containers because some of the firm's collections have very high concentrations of old corrugated boxes.

Summary. Based on our Chicago interviews, we estimate that salvage of cans from waste by the city and *by three privately operated incinerators* probably generated in the neighborhood of 20,000 to 25,000 tons per year of cans, all of which are consumed in copper mines; other sources of cans not derived directly from refuse would come from local can manufacturing plants, but this tonnage is probably minor. Of the total can tonnage, well over half is acquired by one dealer.

Other Metal Salvage. Dealers handling a considerable volume of sheet metal from disposal site *salvage operations* were interviewed. Most of the material derived from waste consists of old appliances, water heaters, construction panels, and the like. The large capacity auto body shredders are best suited for processing this type of material because they knock off undesirable enamel and porcelain and produce a clean scrap. Traditional methods of size reduction, such as shearing, followed by bundling produce acceptable scrap despite the fact that appliance sheet steel does not "clean up" completely. Occasionally tin-coated or lead-coated material may be introduced in small volumes. *Apparently the steel companies (the ultimate purchasers)* do not face technical problems if small quantities of contaminants are introduced, but their cost per ton of the purchased scrap may be higher based on ferrous metal *content because the presence of contaminants reduces* the total usable weight.

The scrap derived from waste is usually a small part of a dealer's operation. For example, one dealer who acquires about 1,000 tons of scrap per day receives an average of 3 tons per day from the city; however, many of his other operations are based on obsolete scrap such as auto bodies, engine blocks, mixed iron, and the like. Sheet steel derived from "white goods" is no longer a significant part of the business because collection and freight costs are prohibitive at today's market prices. By *contrast, waste sources of sheet metal,* especially household discards, may be economically feasible to salvage as a part of waste collection for these reasons: (1) the collection cost is a part of refuse removal service; (2) *the delivery distance may be less to a scrap dealer than* to a landfill; (3) mechanized separation may keep segregation costs low (however, those observed by us in Chicago were labor intensive).

Competition among dealers for sheet metal in waste does not appear to be keen. Few dealers are equipped to handle this scrap, and distance from scrap sources appears to favor a few dealers.

One dealer interviewed noted that by far his largest volume was in ferrous metals. The operation specializes in unusual items for the scrap metal trade—motor blocks, other auto components (starters and generators), and many items rich in nonferrous components such as radio and T.V. chassis, aluminum motors, and "copper-bearing scrap." The ferrous metal trade provides high volume *and low profit while the nonferrous metals, at about 1.5* percent of the tonnage, provide the attractive and highly profitable part of the operation. This dealer had developed his own technology for breaking up the scrap *and carefully guards the low cost processing techniques;* almost all of his equipment was adapted from existing commercially sold machinery but featured special low-cost modifications that allowed him to process items other dealers considered worthless. Most of this material was acquired from other dealers over the United States who would sell such "undesirable" products at or barely above their freight costs. The special processing machinery varied from machines with a capability to break up 2,000 engine blocks per day to machines that could be used to disassemble radio chassis.

The dealer contended *that a private scrap dealer* could efficiently operate a large-scale salvage operation based on municipal refuse. To do so, he felt the city should finance the installation and capital equipment *and pay the dealer a fee to operate the plant; the* recovered material could be sold by open bid. This dealer left the distinct impression that consuming industries will knowingly or unknowingly accept and successfully use many low grade and "contaminated" metals; and the technical barriers are not controlling parameters. (Another large dealer, however, contended that municipal refuse is too low quality and expensive to process under any conditions.)

The dealer's operations were very well managed and efficient; the processing sites were neat and well kept. *One operation at his yard illustrates what can be done* with hand labor willing to accept poverty wages. The "fines" or dirt from his processing belts were hauled to one corner of his yard and given to a self-employed scavenger. This *man spent his day recovering and* grading nonferrous pieces of metal less than 1 inch in diameter—mainly brass, copper, and aluminum. The scavenger is paid by the pound and manages to earn $60 to $70 per week. The residue "fines" of this sorting operation are then hauled to a disposal site. The scavenger's entire capital equipment consisted of a 3-foot-by-3-foot house, shovels, and variously sized old steel drums.

Industrial Metal Consumer. Many scrap consuming companies do not hold obsolete scrap in high regard. This is exemplified by one of the largest steel companies in the United States interviewed in Chicago. According to the company, where a company is fully or partly integrated back to raw materials sources, it uses scrap selectively and may avoid obsolete scrap entirely; it must use captively held raw material sources to operate equipment properly—equipment that represents high capital investment and requires high operating rates to keep unit costs low. In the case of the company visited, it buys prompt scrap from three sources: (1) fabrication scrap generated by its own customers; (2) factory bundles, a high quality prompt scrap grade; and (3) prompt scrap from scrap dealers. Thus, while it has a high scrap consumption near Chicago, none comes from obsolete scrap sources. Occasionally it sells mill revert to its competitors to get rid of it. It also sells slag. At one time, the company had tried steel cans derived from city incinerator residue as an input material but found them of unsatisfactory quality because of poor burn-out.

Individuals contacted made it clear that they would seek obsolete scrap only if forced to do so by government edict (or perhaps the prospect of same) because such activity would hurt their established investments in virgin raw materials handling capability. Their size also prevents them from maneuvering efficiently in the highly active and volatile scrap markets, although they influence its volatility by their own normal scrap activities. This policy and attitude toward obsolete scrap varies widely among steel companies, of course, but that described by this Chicago area firm is typical of other companies and other industries heavily committed to captive virgin raw materials supplies.

Paper Recovery. Chicago is one of the key waste paper collection centers in the United States. There is substantial local paper mill demand, but Chicago is a net exporter of paper because of its highly developed dealer collection system and proximity to the waste paper consuming mills of Ohio and Indiana. In all, there are at least 75 waste paper dealers in the city. It is estimated that only about 15 of these have paper mill connections; the remainder channel through the larger dealers and are considered junk dealers. They handle small volumes and many materials. Within a 50-mile radius of Chicago, there are 10 paper mills and 5 board mills; all the board mills are based on waste paper consumption. In addition, two more board mills are located within 75 miles of Chicago.

Illinois produces about 900,000 tons of paper per year from 25 paper and board mills. Virgin pulp consumption is 300,000 tons. Waste paper consumption in Illinois must therefore be 600,000 to 700,000 tons per year. Thus, most mill capacity in Illinois is based on secondary fiber. Of this total, perhaps 400,000 tons are consumed within 75 miles of Chicago. Total waste paper sales in the area exceed 1.5 million tons, based on the 1963 wholesale trade census (sales of $38.5 million worth of waste paper in the Standard Consolidated Area [SCA] of Chicago, and $22 average price per ton. An unknown amount of double counting is involved, however, because dealers sell to each other as well as to mills.) The Chicago SCA accounted for 56 percent of the dollar volume in waste paper in the east North Central region in 1963.

Chicago has two major sources of waste paper: (1) the large paper converting industry—printing and publishing and paper product manufacturers and (2) the commercial and private sector that provides the bulk grades of news, corrugated, and mixed. Almost all the paperstock is collected by the traditional dealer collection system, although a few private refuse haulers have become interested in selling loads of corrugated. The traditional attitude of private refuse haulers is that paper loads are unsaleable if they acquire them. Haulers observe that commercial organizations sell their paper when demand is good and waste quantities diminish at such times. When demand is poor, the paper appears as waste and cannot be sold. They also find that waste paper dealers must dispose of mixed paper and news as refuse at private disposal sites when supply exceeds demand.

Paper converting operations almost always bale and sell their wastes. One large printing operation reported the use of 30 balers in one location and a multitude of grades; their output goes to 28 fine paper mills and they sell paper for $1 to $40 per ton, depending on the grade and volume accumulated. Some of the paper is given away.

The bulk grades come from obsolete products; the mixed from offices and small plants; old corrugated is collected from stores, shopping centers, warehouses, and the like that have sufficient volume to bale their own; newspaper is derived principally from private residences with collection done by social service organizations, Boy Scouts, churches, schools, individuals, and scavengers.

One large dealer reports that his newspaper volume is 110,000 tons per year, of which no more than 15 percent is over-issue news. He operates through smaller dealers and local paper drives for which trailers or collection bins are furnished. The newspaper deinking mill in Alsip, Illinois, has an output capacity of 85,000 tons per year, which means it consumes old news at the rate of about 95,000 tons per year. In fact, the presence of this mill has brought reasonable stability to the Chicago waste news market despite fluctuations in demand by other consumers of waste news, such as the construction product mills. To maintain supplies the dealer responsible for this mill's waste paper supply offers $8 per ton to private groups for unbaled news at collection points, in spite of the fact that selling prices had dropped substantially in recent months and the top price for news was $20 per ton. Most dealers barely break even at a spread of $12 ($20 selling price and $8 buying price).[143]

There are signs in Chicago that waste paper dealers are edging into refuse hauling while refuse haulers are getting interested in waste paper sales. This is a recent development and its magnitude is difficult to judge. Demand for corrugated in Chicago may also increase when selected dealers install expensive ($120,000) high density baling equipment; one such installation is near completion. Such facilities will permit baling of loose corrugated at densities that will make freight rates attractive for long shipping—perhaps even from Chicago to the South. One company is making a study of office building waste to determine if its content and acquisition cost would make it attractive for combination board manufacturers.

Companies contacted see little possibility that Chicago will become a major center for paper salvage based on mixed municipal waste as a source. Waste paper consumption will continue to depend on demand for bulk grade wastes.

Glass Recovery. Chicago has one cullet dealer, a combination processing and brokerage operation. All cullet acquired locally is obtained from bottling operations (beer and soft drink bottlers). No glass is obtained from residential sources or refuse disposal operations. The dealer furnishes to its customers containers that are filled with discarded containers, all of the same color. The glass is picked up free of charge by the dealer and hauled to his plant. Processing, which is through an ancient and deteriorated plant, consists of the following steps: (1) collection drums are dumped into piles by color (flint, amber, green); (2) a front-end loader transfers the glass to a conveyor that moves the glass to the top of a tower; (3) crushing takes place by gravity fall through a grate; (4) the glass is then moved by conveyor belt past picking stations where debris (especially metals) and glass of the wrong color are removed by hand; (5) washing takes place through a spiral classifier and the cullet is dumped on the ground. The dealers must follow this procedure two or three times to obtain a "sound grade." The whole operation uses 14 sorters on 3 lines (6 on flint, 3 on amber, and 5 on green); in addition, there are 7 other employees involved in the operation. The whole processing operation appears very inefficient.

The plant processes about 500 tons of cullet per month. Flint glass brings $22.50 per ton and amber $17.50 per ton. The dealer claims to be just breaking even on the glass that he must handle himself, and based on average wage rates of $2.94 per hour, we can confirm this assumption. Cullet buyers are container manufacturers in the area.

About 95 percent of the dealer's business is in brokerage, which is a profitable operation.[144] The owner places manufacturing cullet (including plate glass cullet) with consumers of cullet without actually handling the material. His task is to locate buyers for cullet. He receives a brokerage fee for this service. Several years ago bead makers purchased cullet (to make highway reflector markers), but they no longer do so; today his only outlet for glass cullet is container manufacturers.

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[143] An interesting comment can be made here involving two cities we surveyed. A low level of concentration activity has created an over-supply of news in Chicago. Yet newspaper obtained in the Madison recovery experiment continues to come into Chicago: It is a "favored source" because of its unique link to solid waste problems and relatively high quality. This tonnage, however, is displacing paper tonnage generated in Chicago. Thus, less newspaper is collected by dealers in Chicago (or more is sent to disposal sites) because the Madison paper recovery operation exists. This means there is solid waste displacement but no net reduction in total waste disposal because total demand for waste paper has not increased.

[144] This is the only glass brokerage operation we encountered in the entire survey.

Since the dealer does not pay for waste glass and only breaks even on the processing, he is in essence reducing disposal costs for his sources and fills local demand for cullet as a service to good brokerage customers. Such conditions suggest that cullet derived from refuse would be uneconomical and impractical to recover without introduction of sophisticated recovery and processing technology at low cost. The dealer expressed no interest in low grade sources of "tramp cullet" because substantial supplies are still untapped from high concentration sources — manufacturing and bottling operations.

We contacted two industrial glass manufacturing plants in the Chicago area. Neither uses outside purchased cullet in its operations. One plant manager reported that his cullet requirements are equvalent to 8 to 12 percent of input tonnage but all this demand is filled by internally generated glass cullet; a typical batch contains 400 pounds of cullet and 1,000 pounds of sand. Output of the plant is 350 tons per day. One reason for the reluctance to use purchased cullet is that it costs $22.50 per ton and virgin materials cost less; however, the company plans to participate actively in the Glass Container Manufacturers Institute's redemption center program when it comes to Chicago. The company's distance from the collection points will restrict its intake; nevertheless, the plant manager anticipated some problems in maintaining product quality using foreign cullet, even in small quantities.

The other plant was a maker of specialty glass products for the pharmaceutical industry. It uses 15 to 50 percent cullet, all of which is generated internally. The plant manager could not recall ever using purchased cullet although other plants in the same company do consume it.

Rubber Reuse. Virtually all scrap rubber consumption in the Chicago area is accounted for by one company. It derives its raw materials from old tires collected primarily from large tire dealers, trucking companies, scavengers, and those factory rejects accumulated by tire manufacturers. The dealer sometimes pays up to 10¢ per tire to obtain raw materials but usually acquires tires free for the pickup, as a no-cost disposal service for the customer. The volume is about 1.5 million tires or approximately 20,000 tons per year, and there is a plentiful supply of tires.

The company's specialty is making rubber products such as dock bumpers, mud flaps, splash shields for agricultural machinery and autos. The process includes debeading, cutting, slitting of the inner sections of tread and walls, and die cutting or stamping of the product.

On a weight percentage basis, old tires are used by this company as follows: manufacture of products, 60 percent; recap tire sales, 12 percent; reusable tire sales, 8 percent; and waste or unusable tires, 20 percent.

Tires processed for products yield 10 percent waste, 40 percent usable fraction, and 50 percent rubber sold to rubber reclaimers outside Chicago. The dealer realizes a $20 per ton price for the fraction sold to rubber reclaimers.

According to the dealer, few, if any, tires came from municipal waste and the supply of tires at outlets that must have them hauled away as waste is plentiful.

Textile Recovery. Our Chicago contacts in textiles were restricted to the National Association of Wiping Cloth Manufacturers. The organizations represented by this association classify themselves outside the salvage trade; they are engaged in making a product from purchased secondary textiles that are their raw materials.

Consumption of old rag cloths is increasing slowly, at rates of 1 to 3 percent per year. In all, 150,000 tons of wiping cloth are used in the United States annually, of which 6,000 tons are purchased by the Federal Government. Old rag wiping cloths are losing some of their share of the market to paper and nonwoven fabrics. Several major problems were cited as the reason for the relative decline of this business in recent years. Among them are the following.

(1) Sources of supply are drying up as mixed rag buyers and sorters go out of business. The percentage of usable textiles is decreasing in mixed rags because man-made fibers and blends are increasing; wools do not sell readily any more because virgin wool is protected by tariffs and labeling laws; the only thing of real value is cotton cloth, which is decreasing in percentage, although some synthetics such as rayons are also usable.

(2) Federal specifications restrict wiping cloths to 100 percent cotton; therefore, blends are not usable. Federal demand is decreasing.

(3) Special fabric coatings and treatments make cotton nonabsorbent, thus destroying the key characteristic that a wiping cloth must have.

(4) Paper and nonwoven products, such as towels and wipers, are displacing cotton wipers; these products are growing at 16 percent a year.

Usually the wiper manufacturer buys from a rag grader who has acquired mixed rags from junk dealers and charitable institutions. A minority of wiper producers purchase mixed rags for grading. Textile mill waste accounts for no more than 10 percent of total volume, while reclaimed household rags, which are items that would otherwise be a part of the municipal waste stream, account for 90 percent.

Chicago had 15 to 20 rag graders in past years; today, perhaps two survive. Wiping cloth grades keep them in business. Chicago is a net importer of wiping cloth material, however, with much of it coming from New York, Baltimore, and the South.

The association represents about 75 percent of the trade by dollar volume but only about one-third of the 500-plus firms in the United States. Many companies are now handling wiping cloths only as a sideline. In Chicago, there are 63 wiping cloth dealers listed in the telephone directory while association membership consists of 10 companies. By contrast there are only 37 waste cotton, wool, and rag dealers listed, many of them junk dealers handling many other materials (these are not rag graders previously mentioned).

Wiping cloth makers have low capital investment requirements, especially in the distribution of their product. The principal processing consists of washing the rags and cutting them into wiping cloths. The principal markets are industrial manufacturers, garages, and filling stations. Operating cost data were not available from wiping cloth makers in Chicago, and we could get no estimate of total consumption in the Chicago area. Cost data are available from association surveys and given in the special section on textiles elsewhere in this report.

Cincinnati, Ohio[145]

Summary. Cincinnati is located in an excellent market area for secondary paper, glass, and metal products. In spite of this, salvage of commodities from municipal waste is not practiced. Acquisition of waste commodities before discard, however, is undertaken by a number of private for-profit and not-for-profit organizations.

Introduction. Cincinnati is a diversified manufacturing city with a population of around 1.4 million in the metropolitan area and 503,000 in the core city. Within 200 miles of the metropolitan area, there are 14 paperboard mills, the principal consumers of secondary paper, especially bulk paper grades. A glass container plant is located at Lawrenceburg, Indiana, 20 miles from the city. Three steel production plants are in or near Cincinnati, and the city is favorably located in relation to other steel scrap consuming centers in Ohio.

In 1968, an estimated 455,000 tons of waste were disposed of in the city by incineration and public and private landfill. Of this total:

98.5 percent originated in the city
73.7 percent was incinerated by the city
26.3 percent went directly to landfill (public and private)
56.0 percent was collected by private forces
44.0 percent was collected by public forces

The total excludes demolition wastes and park wastes. Considering only wastes originating in the city and population of the core city, the disposal rate per capita per day was 4.96 pounds in 1968.

Four incinerators with a combined capacity to handle 1,400 tons per day are operated. The city owns one landfill and uses two private fills.

Current Salvage Practices. Once solid wastes are collected by public or private waste removal forces, little if any of the waste is recovered. At the time of the survey, the city had a contract with a scrap dealer to remove oversized metallics separated from incinerator residues; the dealer was negotiating with the city to cancel the contract because his hauling costs exceeded the price he could get for the metal. At one private dump, which receives only industrial and commercial wastes, paper and metal are recovered intermittently when loads are received that contain salvable materials in high proportions. An estimated 500 tons of materials are recovered annually.

Most of the salvage activity in the city is based on segregated collection of salvable commodities. Glass cullet is collected from bottling operations only; scrap metals are derived from industrial sources; paper is collected both from residential and industrial and commercial sources; textiles are obtained almost exclusively from residential sources.

Paper Recovery. The city's location in an area with numerous paperboard plants has as a result a high level of paper and board collection activity. Boy Scouts and schools are principally involved in the collection of newspapers; the Volunteers of America and the Salvation Army also actively seek newspapers; Goodwill Industries

[145] Survey concluded in February 1970.

accepts (but does not like to handle) news. News collected by these organizations are sold to paper dealers who bale them and deliver them to board mills. Old corrugated boxes are acquired by paper dealers directly or from collectors and are handled in the same manner as news.

Data on total demand and supply in the area could not be assembled as part of this survey. Not only are there numerous sellers and buyers in the area, but paper is both imported into the area (from as far away as Texas) and paperstock is exported (usually to East Coast mills).

The largest processor of paper in the city has a capacity to shred and bale approximately 62,000 tons of bulk grade papers a year. His actual production was not available; however, he processes equal quantities of news and corrugated. If the processor operates at full capacity, he handles 31,000 tons of news. At an average collection rate of 25 tons per school drive, 1,240 school drives would be necessary in the Cincinnati metropolitan area to generate such a tonnage of news.

Costs to transport paper from source points to waste paper processing plants are reported by one respondent to average $4 per ton for all grades. Processing (sorting, shredding, and baling) costs $180 per ton, of which half is labor and half is all other expenses, including equipment amortization. Product shrinkage costs $1 per ton of output. Collectors (schools, scouts, scavengers) are paid $10 per ton for news and corrugated if the paper must be picked up, $14 per ton if the paper is delivered. News is sold for $20, corrugated for $23 to $30 a ton in times of good demand; the buyer pays transportation costs to the mill; these are an average of $3 to $4 per ton.

Another respondent reports a pickup cost of $3 per ton, shredding and baling costs of $2.40 per ton, and sorting costs before shredding and baling of $0.60. This organization is a social welfare agency that issues certificates or receipts to suppliers of the paper in lieu of cash; the company may take a tax credit for a charitable donation based on the "fair market value" of the paper. The social welfare agency does not pay income taxes and, being a sheltered workshop, it pays only half the standard wage rate applicable to the labor category on the open market. If in spite of these advantages, the costs of this organization are comparable to the costs of the first respondent, it is explained by the small tonnage handled by this agency — approximately 1,600 tons a year.

Using national per capita discard figures, more than 252,000 tons of paper are discarded in the Cincinnati metropolitan area yearly. Of this total, 45,000 tons are news and 61,000 tons are corrugated. A fairly high proportion of both these bulk grades appears to be collected and recycled.

Metals Recovery. Metals are sorted from industrial wastes delivered to one private dump in the area, but only if the quantity of metal available justifies the effort. The Salvation Army facility in the city sells between 9 and 12 tons of metals per working day, or 2,250 and 3,120 tons a year; these metals are acquired from the public in the form of appliances and other metal goods. Income from the sale of metals is approximately $18 per ton. With the exception of these two operations, scrap metals are acquired by the secondary materials industry from industrial sources and from automobile dismantlers.

The recent installation in the area of an automotive shredder with a 400 ton per day capacity (8 hour shift) has created demand for automotive hulks; furthermore, appliances that were not acceptable to scrap dealers in the city are now accepted at the shredder facility, if delivered there.

Discussions with secondary materials dealers indicate that transportation expenses are the chief barrier to the recovery of metals from wastes. It is uneconomical to send a truck to pick up a small quantity of metal whose quality is marginal when the same truck can be used to collect uniform prompt scrap from industrial sources. If the metals are delivered to the scrap yard site, they are accepted.

Glass Recovery. One of the Nation's few glass cullet dealers is located in Cincinnati. He acquires 5,900 tons of broken glass a year from three breweries, two soft drink bottlers, and two liquor bottlers. This tonnage shrinks to 4,200 tons in processing and is sold for an average of $19 a ton.

The dealer knows only a few of the processing costs he incurs, these being costs of acquisition, processing, and delivery. These estimates are only approximate and appear to be low. Depending on circumstances, his costs range from $12.25 to $14.70 per ton, broken down as follows: acquisition cost per ton of product sold, $4.25 to $5.70; processing costs, including labor, power, water, and shrinkage, $6.00; delivery cost, $2.00 to $3.00 per ton.

The glass is acquired free. The dealer's cost consists of providing and maintaining suitable containers for the waste glass and collecting and transporting their contents to his plant. The glass acquired contains at least 10 percent by weight of trash — dirty rags, boxes, lunch sacks, and the like. Shrinkage in processing (loss of fines) is 20 percent. Consequently, there is a loss of 30 percent of incoming tonnage.

Glass is processed through a glass grinder and washer followed by magnetic separation of ferrous metal wastes and a screening to remove aluminum in the glass stream. The operation is in an open-air plant that cannot be operated in very cold weather or at night. Three men operate the plant; one man drives the pickup and delivery truck; the owner supervises the operation and carries out the necessary administrative work.

On the face of it, this business appears profitable with a differential between costs and sales price of $4.30 to $6.75 per ton. If all costs were counted, the operation would probably be a financial failure. Equipment depreciation is not charged; the plant is 22 years old and in poor repair. Maintenance is restricted to fixing breakdowns. Inert wastes are deposited on the site; combustible wastes are burned in the open air. Water used in washing cullet is discharged untreated; it carries most of the lost glass in the form of suspended fines.

The owner reports that most of his input glass tonnage is derived from bottling plants that process returnable glass containers; wastes consist of scratched and broken returnables that can no longer be used. With the introduction of one- way glass bottles, waste generation has been declining and he forsees a time when he will be unable to acquire a sufficient tonnage of cullet to stay in business.

The glass is sold to a container producer approximately 20 miles from the cullet plant at Lawrenceburg, Indiana. The nearest other plants are in Zanesville, Ohio, and in Indianapolis, Indiana. Much more glass could be sold, the owner stated, if supplies could be secured. However, salvaging of glass at dumps is no longer practiced. (Cullet dealers have never been involved in acquiring glass at dumps, but they purchased glass picked up by scavengers.)

In Cincinnati, an estimated 57,150 tons of container glass are discarded annually by the population; total annual cullet demand at the Lawrenceburg plant ranges between 14,600 and 18,250 tons; of this total, half is in the form of in-house cullet, half in the form of purchased cullet. Consequently, total demand for obsolete glass is between 7,300 and 9,125 tons a year. Roughly half this demand is already satisfied by bottling plant wastes, leaving very little demand for glass containers discarded after use by the public.

Textile Recovery. Recovery of textiles from residential sources is carried out exclusively by social welfare agencies, such as Goodwill Industries, Salvation Army, and Volunteers of America. These three organizations collected a total of 7,080 tons of textiles in 1969; of this total, 3,860 tons were sold as rags to textile dealers at an average price of $62; the remainder were sold in secondhand outlets as used clothing.

The rag bundles (1,000 pound bales) are sold to textile dealers on the East Coast; freight of $20 per ton is paid by the buyer. The dealer sorts the rags into "wiper." "export," and "roofing rag" components. Wipers are prepared by the dealer in additional sorting, cutting, and laundering operations from cotton fabrics. Exports are usable or repairable clothing items that are shipped out of the country. Roofing rags are unusable textiles and wiper trimmings sold to manufacturers of roofing papers.

The social welfare agencies collect a variety of discarded objects from collection boxes and by operation of door-to-door truck routes. The incoming materials are unloaded at the plant docks and are sorted into general categories (shoes, toys, textiles, etc.); these material streams are then further sorted (into usables and rags, usables into 30 or more categories such as men's overcoats, ladies' cotton dresses, toweling, etc.). Given these integrated operations, the agencies have difficulty isolating costs associated with the collection, sorting, and other processing of specific waste commodities.

One agency estimated that the labor component only of textile sorting, including rag baling, is $13.29 per ton; of this, 10 percent is attributable to rag operations. Most of the sorting effort is expended on separating men's and women's clothing into 34 categories. Sorting labor in this sheltered workshop is paid an average hourly rate of $1.10. The costs cited above do not include overhead or supervision. Another agency, also a sheltered workshop, pays sorters $1.29 per hour; commercial rates are $2.58 per hour.

Prices received for rags by these agencies have been steadily declining — from $120 per ton in 1965 to $76 per ton in mid-1969 to $55 per ton in February 1970; the $55 per ton price was the price received by the agency with the lowest tonnage; the agency with the highest tonnage received $65 per ton, and the agency with the intermediate tonnage achieved a $60 per ton price. All individuals interviewed expected further price declines in the near future.

Reasons for the price decline are twofold: First, the percentage by weight of pure cottons in rag bundles is declining; one source estimated that 15 to 20 percent of rags are cotton now compared with 30 to 35 percent in 1965; another source said that cotton content is 25 to 30 percent today; cottons are the most desirable textiles in rag bundles. Second, the demand for used clothing and rags in foreign countries is declining.

Plastics Salvage. We encountered one curious instance of plastics salvage. A private refuse removal firm serviced a plastics producer delivering wastes to a suburban private dump. The dump operator retrieved semirigid and rigid plastics and sold them to the public. The plastics producer discovered this operation because the dump operator advertised his plastic products in suburban newspapers. The plastics producer thereupon required the waste hauler to deposit plastics waste in another dump and further required a guarantee that the wastes would not be retrieved and sold.

Past Salvage Practices. [146] The operator of the area's largest private dump maintained a major hog feeding operation (1,500 animals) in the early 1950's. Hogs were fed on residential wastes after inedible components were removed by pickers. Wastes were moved past pickers on a moving belt; paper, cardboard, wood, textiles, and metals were removed by hand and sold. The operation was closed afte a few years because health department requirements to boil the garbage before it was fed to hogs made this hog raising operation uneconomical.

During World War II, one company in the area acquired steel cans from dump scavengers, residential sources, and canning operations; the cans were detinned. Cans that had passed through an incinerator could not be detinned; oxides formed during combustion could not be removed. The detinning operation was closed down with the end of the war. The company, however, continued to receive steel cans until 1964. The cans were shredded and sold to a ferroalloy producer. In 1964, the operation became uneconomical; declining scrap prices and abundant supplies of higher quality metals appear to have made steel can scrap unattractive.

Connecticut Area[147]

Summary. In four smaller communities in Connecticut, we encountered only dump salvage operations — scavenging at landfills and dumps. The survey had three points of interest, however: (1) we found one instance of hair and feathers recovery, (2) we visited one hog farm operator, and (3) we interviewed one of the few remaining rubber dealers in the country.

Introduction. In the National Survey of Community Solid Waste Practices, salvage operations at incinerators were reported at Darien, Berlin, and New Canaan, Connecticut, and at a hog farming facility in Marlborough, Connecticut. The combined annual income from salvage at these facilities was reported to be nearly $6,500. For this reason, we decided to conduct one of the case studies in this area of Connecticut. As it turned out, however, the salvage activities were not actually in existence.

The case study was conducted in Darien, Berlin, New Britain, and New Canaan. Interviews were also conducted in Bridgeport, Canton, Glastonbury, and Stamford, Connecticut, with waste collectors and processors. The communities surveyed are small and near each other. Collections are handled exclusively by private forces; most private haulers are small (one- or two-truck operations); open burning is practiced at the dumps. Incinerators are operated by Darien, New Canaan, and New Britain; these range in quality from one fairly sound installation to one incinerator in a state of near collapse. Records on operations are sparse and incomplete. Salvage was practiced legally at two dumps and illegally at two others. Table 66 presents the waste handling profiles of the four communities.

Current Municipal Salvage Practices. Salvage of commodities from municipal wastes is restricted to the removal of metals and usable items from wastes deposited at dumps. The City of Darien has a contract with a scavenger who, for a payment of $500 a year, is permitted to remove materials from the city dump. The scavenger could not be reached for an interview. He reportedly removes bulky items such as refrigerators, stoves, and the like in a small pickup truck, stores materials at his home, and sells metals to a scrap dealer in Stamford. The city is interested in salvage as a means

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[146] Resource recovery from incinerator residue; analysis of factors that affect economic recycling of ferrous metals and other inorganic material contained in municipal incinerator residue. v. 1. Findings and conclusions. APWA-SR-33. Chicago, American Public Works Association Research Foundation, Nov. 1969. p.11, 14-15.

[147] Survey concluded in April 1970.

of conserving dump space; salvage is not viewed as an income-producing activity.

In New Canaan, a city employee at the dump, with additional duties as gateman, retrieves and sorts metal wastes deposited at the city dump. The waste is sold to a scrap dealer in Stamford who pays the city directly. This program results in the recovery of 60 tons of metal yearly and a gross salvage income to the city of $1,200. Less than 1 percent of the waste deposited at the dump is recovered; the dump receives wastes yearly.

New Britain operates disposal facilities for Berlin and Newington as well as for its own population. At present, no salvage is permitted at New Britain's facilities. However, we observed five scavengers working at one of New Britain's two dumps. They recover usables, metals (sold to a scrapyard less than a mile from the dump), wood (about 5 tons per week in winter months), and rubber tires (about 1 ton per week is removed and sold to a tire maker). The gateman at the dump reported he felt sorry for the scavengers and allowed them to work if they did not interfere with dumping operations. We estimate that, at most, 150 to 200 tons are removed annually by scavengers.

Other Salvage Activities. There are a number of secondary materials dealers in the communities, but we were refused interviews by these dealers. Individuals contacted stated on the telephone that the secondary materials business in the area was fiercely competitive and consequently they preferred not to discuss their operations. Interviews with salvage dealers, however, were conducted in Bridgeport and Stamford, Connecticut, from which the following picture emerges.

The secondary materials dealers in the area are fairly small. They handle metals, paper, and rags. The metals are derived from automobile hulks and industrial sources. Paper, in the form of corrugated board, is acquired from commercial sources (stores, warehouses). Newspapers are not handled or are handled by exception only. Rags are obtained from social welfare agencies such as the Salvation Army and Goodwill Industries. Demand for and prices of secondary materials are low. Although we could not obtain data on tonnages handled or prices received, we were left with the impression that the depressed conditions of salvors was the result of the available and abundant cheap supplies of secondary materials in the New York metropolitan area (50 miles away), the distance to the nearest concentrations of the steel industry (western New York and Pennsylvania), and the absence of paperboard mills (there are only two in the State, both located in the New Haven area).

Rubber Salvage. Connecticut is unique in that it is one of nine States in which a rubber reclaiming company has a plant. The plant is at Naugatuck. From the area covered by our case study, approximately 30,000 tires are removed and reclaimed by a scrap rubber dealer every year, equivalent to approximately 300 tons of rubber according to the dealer's estimate.

Tires are acquired from commercial sources such as filling stations, salvage yards, and auto dismantlers. The dealer is paid 15 ¢ a tire ($15 per ton) for removing the tires. In addition, tires are also brought in by individuals in small quantities.

The dealer's total processing cost is at least $10 per ton; he receives $5 per ton for the tires from the rubber reclaimer. Entire loads are frequently rejected by the reclaimer because unacceptable tires are inadvertently shipped (truck tires, steel cord tires, tires with tungsten studs, steel riveted tires, and nylon tires) or because of excessive moisture. Tires are received only at specified times by the reclaimer, and if the dealer's truck arrives too late, it may be sent back. Because of such contingencies, the rubber dealer claims that the used rubber business is not profitable.

Salvage Experience of Goodwill Industries. One Goodwill Industries organization with headquarters in Bridgeport collects discard commodities from residences in Bridgeport and in 10 nearby communities. Materials are brought in on 14 trucks that operate on routes and also service 124 dropoff boxes.

In 1968, the organization collected 1,989 tons of commodities. Of this tonnage, roughly 20 percent was sold in secondhand stores as usable products, 60 percent was sold as salvage, and 20 percent was discarded as waste (Table 67). Average income per ton of usable materials was $1,030, while average income per ton of salvage was $62, and average income per ton of materials collected was $239. The organization tends to lose money on its collections in that operating costs are around $330 per ton of collections. To stay in business, the company must receive donations or other financial support.

The facility employs 157 people whose income ranges between $1,700 a year (workshop employees) to $6,500 a year (administrative personnel); average income per employee is $2,552 a year.

Prices received by the organization for salvage materials (Table 68) are comparable to those received by others elsewhere, ranging from $240 per ton for white cotton wipers to $8 per ton for mixed paper. Salvage materials are sold to secondary materials dealers in processed form — baled or bundled.

Textiles. Approximately 90 percent of all textiles received are sold as rags; a portion passes through the secondhand stores before it is "ragged." The bulk of textiles, however, is sent to rag bundles immediately after receipt. Unlike some social welfare organizations, the Bridgeport Goodwill sorts textile rags into a number of categories rather than selling all textiles as mixed rags; this additional sorting improves income from textile salvage somewhat. The agency achieves $70 per ton for textile salvage, $5 to $10 above that experienced by other organizations we have visited.

Paper. The organization sorts and sells paper only because costs of dumping exceed the costs of sorting the paper. Only newspapers and mixed papers are handled. Although corrugated board sells for $24 per ton in the area (versus news at $20 per ton), the facility does not receive a sufficient quantity of corrugated board to attract dealer interest.

Bedding Materials. At this Goodwill Industries facility we encountered the only instance in our survey of hair and feather recovery — two commodities that, like bones and grease, seem to have disappeared as articles of commerce in the secondary materials business. Hair and feathers are taken from bedding materials — mattresses and pillows. The materials are sold to a dealer who exports them through New York. Mattresses and pillows are split; the hair is classified by type; hair and feathers are bundled for shipment. Cotton materials are sold as textile salvage. These commodities sell at a low price ($18 to $22 per ton); the organization director believes that recovery of hair and feathers is possible at his facility only because of the low wages paid in this sheltered workshop.

Past Salvage Practice. In this area of Connecticut, as elsewhere, more salvage activity has taken place in the past than currently. Tires were recovered from the Darien dump up to 1967; the city paid a salvor 20¢ per tire recovered; the practice was discontinued because retrieving the tires from the dump became uneconomical as used rubber prices declined.

Until March 1969, New Britain had a salvage contract with an individual, which brought the city income of $2,340 yearly. The salvage operation interfered with waste deposition activities because the salvor directed trucks to dump materials in areas most convenient to him rather than for efficient disposal. The contract was not renewed. A private scrapyard offered to remove metals from the dump free of charge, but this offer was withdrawn after one day's trial; the scrap dealer found that his costs were too high in relation to the quantity of metal available.

In Marlborough, Connecticut, garbage obtained in residential waste collections was used as part of the feed for 400 hogs. The farm operator also owned a waste pickup organization. Garbage was separated by householders and was combined with grain (8 parts grain, 2 parts garbage) and fed to hogs. Trash was disposed of adjacent to the hog farm and, later, at municipal dumps. Metals were salvaged from the waste and sold at the rate of approximately 6 tons per year. This operation was dissolved in 1968[148] because the operator had a stroke.

Conclusions. Salvage practice in this area of Connecticut is limited and economically marginal. Rubber salvage is possible because of the proximity of a rubber reclaimer. Even this operation is possible only because generators of waste pay for the removal of the tires. Other salvage activities are pursued by individuals who appear unable to obtain an adequate income any other way.

Gainesville, Florida[149]

Summary. In Gainesville, 49 percent of solid wastes collected and disposed of in the metropolitan area were processed through a compost plant in 1969 where paper and textiles were recovered for sale. Metals were also removed but could not be sold. Adverse economics, including weak markets for salvage, contributed to the shutdown of the plant in 1970. Our case study indicates that salvage of some commodities found in municipal waste is only marginally feasible in Gainesville.

Introduction. Gainesville, home of the University of Florida, is located in the northern part of the State. The university provides more than half of all jobs in the city

[148] The hog farm was started in 1932 when one of the operator's friends caught a greased pig at a fair. The operator bought the pig for $3, penned it in on his property, and began to feed it on garbage picked up from neighbors. One thing led to another.

[149] Survey was concluded in March 1970.

and surrounding communities. The city's industries fall into the light manufacturing category.

Gainesville has a population of 68,000. The surrounding built-up area of Alachua County adds another 28,600 to the population for a total of 96,600 people in the area.

In 1969, 69,380 tons of waste were collected from residential and commercial sources by public and private agencies (Table 69); wastes collected were equivalent to 3.93 pounds per capita per day.

In Gainesville proper, the city collects both residential and commercial wastes with its own forces. The University of Florida has its own collection forces, however, and some private concerns within the city limits transport their own wastes directly to the municipal landfill. In Alachua County, two private refuse haulers remove all wastes under contract with the county. In 1969, wastes were disposed of at the compost plant (49 percent), at the university's landfill (11 percent), and at the municipal landfill (40 percent).

In January 1970, the compost plant was shut down. The Federal Government, which had contributed $145,000 a year in operating funds to the compost plant in the form of demonstration funds, withdrew its support in 1970, thereby reducing operating funds by two-thirds. The compost plant, which had been losing money in spite of Federal support, had to be closed. Salvage activity in the city thereupon came to a halt.

Nature of Gainesville Salvage Markets. Gainesville, like Amarillo, is located in an area where demand for secondary materials is weak. Within a 100-mile radius of Gainesville, there are five paperboard mills and two glass container production plants. The nearest steel furnaces are in Tampa, Florida; Atlanta, Georgia; Montgomery, Alabama; and Birmingham, Alabama. The city is located some distance from areas of industrial concentration where textiles are in demand for making wiper rags. For these reasons, along with others, salvage activity at the Gainesville compost plant has not contributed substantially to the income of the operation.

Salvage Activities at the Compost Plant. In 1969, paper and textiles equivalent to 6.6 percent of incoming waste tonnage were removed from the waste by manual labor and were sold (Table 70). Metals were also removed to insure a desirable compost product, but the city could not find markets for the waste metals.

The paper removed was sold to manufacturers of construction board and felt products in Jacksonville for an average price of $16.50 per ton in 1969, down from $18.28 per ton in 1968. A small quantity of rags (1.37 tons) was also sold to one of the manufacturers of construction products for $18.00 a ton. In all, the city realized an income of $37,393 in 1969 from the sale of 2,255 tons of materials.

The city was able to identify the following costs associated with paper and rag salvage. In 1969, salvage figure includes equipment amortization, labor, and all other incidental expenses. In addition, the city was required to pay the licensor of the compost process one-third of the gross revenues from the sale of products. This amounted to $5.50 per ton of paper sold. The city's total cost, therefore, was $14.14 per ton. Cost of textile sorting and preparation was $8.67 per ton sold; licensor's fee was $5.49 per ton, for a total cost of $14.16 per ton. Thus, the city had costs of $31,936 and sales of $37,393, leaving a profit of $5,457, or $2.42 per ton of salvage commodities sold.

Paper Salvage. According to estimates of the Gainesville Municipal Compost Authority, approximately 24 percent of the paper delivered to the plant (4,240 tons in 1969) was salvageable; most of this paper (2,680 tons) was corrugated board. The authority sold 2,254 tons in 1969, 53 percent of the quantity deemed salvageable by the authority. Poor product quality and weak demand kept sales low. The authority sold paper directly to users without making use of the services of a paper dealer or broker.

The quality of paper and rag products from the compost plant was poor according to buyers. One buyer cited these specific items.

(1) The paper is mixed with garbage and contaminants.

(2) Wet shipments are more common with paper extracted from mixed refuse than with paper obtained from commercial sources; wet loads increase the likelihood of spontaneous combustion and, in turn, can cause increases in insurance rates.

(3) The percentage of hot-melt glues and other water resistant resins is high and causes pulping problems.

(4) Mixed paper from municipal waste sources contains a high proportion of shorter fibers; this reduces the strength of the final product.

Our examination of paper bundles stored at the compost plant substantiated the buyer's claim that the paper contains contaminants. We saw plastics (films and bottles) and glass containers in the paper bundles. The need to pull items off the conveyor belt quickly and the desire to avoid the high costs of a second sorting were responsible for the presence of contaminants. A sorter at the plant, for instance, pulled all corrugated boxes from the waste as it passed by his station at the rate of 20 feet per second. This was the only sorting performed. If the box had some bottles or cans in it, these items became part of the paper bundle.

Because paper products derived from mixed municipal waste sources are low in quality, such commodities can only be used in limited quantities by repulpers. The Gainesville paper was used to make gypsum board liner paper and construction paper — two paper products with low quality requirements. In these applications, the Gainesville paper bundles represented the lowest quality secondary materials inputs.

Construction activity in Gainesville, as elsewhere, was at low tide in 1969; this in turn meant cutbacks in construction materials production. At the time of our visit in early 1970, for example, the gypsum board manufacturer was operating at 80 percent of 1969 production and had terminated all purchases of municipal waste paper. Low grades of secondary paper, especially mixed office paper, were in oversupply. Paper buyers, who depend for their secondary paper shipments on commercial dealers, were reluctant to antagonize these suppliers by buying municipal waste paper direct at a time when higher quality paperstock was in excess supply.

In the Gainesville market area, as elsewhere, used paper buyers repeatedly made the point that they depend on and must work with middlemen. Buying directly from waste generating sources is attractive; savings may be as high as $5 per ton. The buyers cannot acquire more than a small proportion of their supplies by direct purchases (unless, of course, they enter the secondary paper business). For this reason, direct buying is held to a minimum and is done only when demand is high. At the same time, the quality of municipal waste paper derived from mixed refuse is so poor that the buyer can afford to buy it only if it is very cheap. Dealers and brokers, always plagued with an oversupply of low quality paper, are not interested in handling municipal waste paper. Thus, direct buying of such commodities is the only practical alternative.

Textile Salvage. In 1969, more than 900 tons of textiles were processed through the Gainesville compost plant. A manufacturer of construction materials had indicated willingness to purchase all textiles retrieved from the waste. In spite of this, the authority sold only 1.4 tons of textiles. The problem was in sorting out the materials.

Textiles are only 2.7 percent by weight of Gainesville waste (compared with 52.6 percent of paper). The textiles are mingled with other wastes and are difficult to see. The sorting belt moves too rapidly to allow effective textile separation. Slowing down the belt would yield more textile salvage but would also seriously impair the efficiency of the total composting operation.

Other Salvage Operations Considered at the Compost Plant.

Although only paper and textiles were sold from the compost plant, metals were also removed from the waste and attempts to sell these materials were made.

Ferrous Metals. In 1969, 2,300 tons of ferrous metals were removed from the incoming waste. Bulky items were set aside when delivered; smaller ferrous metals were removed ballistically from waste and magnetically from nonferrous metals.

Attempts to sell the metals were made in Jacksonville, Tampa, and St. Petersburg, Florida, and in Birmingham and Emco, Alabama. The metals could only be sold after burning and crushing. Prices offered included the following: (1) $4.00 per ton delivered at Tampa; (2) $4.50 per ton delivered into railroad cars at Gainesville; and (3) $20.00 per ton delivered to Emco, Alabama.

At these prices, sale of the metal was considered uneconomical for the following reasons.

(1) Total cost of removing the metals from waste, burning them, and crushing them was estimated by the authority to be at least $2.56 per ton; this cost excluded air pollution control costs for the metal burning operation.

(2) Additional handling of the metal — from plant site to railroad — was necessary because the compost plant had no rail spur.

(3) Transport cost to Tampa was estimated to be $5 per ton (which we consider too low); and to Emco, Alabama, freight charges were $13.84 per ton (actually quoted as $15.50 per long ton).

(4) One-third of gross revenues were payable to the compost process licensor.

Given these circumstances, the authority would have lost money on all three offers made. We learned of no attempt to compare the magnitude of losses sustained in salvaging with magnitude of costs for the alternative of landfilling metals separated in the composting process.

In the Florida area, there is no market for burned tin cans for use in copper precipitation. The bulk of ferrous metal delivered to the Gainesville compost plant was tin cans (between 80 and 90 percent by weight). The remainder was bulky metallics (stoves, refrigerators), toys, auto parts, household goods, and the like. Consequently, scrap dealers in the region showed little interest in buying the ferrous metals which were contaminated with tin which could only be sold if mixed in small quantities with other scrap.

Nonferrous Metals. No special efforts were made by the authority to market nonferrous metals. Approximately 260 tons of such metals were delivered to the compost plant, in part as components of bulky waste products. Area scrap dealers showed no interest in this resource because excessive sorting and disassembly, such as stripping of electric motors to separate cast iron, aluminum, and copper, would have been necessary to obtain a small quantity of nonferrous metals.

Glass Recovery. Glass container manufacturing plants accessible from Gainesville are located at Jacksonville, Lakeland, and Tampa, Florida; Hapeville, Georgia; and Montgomery, Alabama. Approximately 1,900 tons of glass and ceramics (but mostly glass) were received at the compost plant. The glass plants in the area could absorb such a tonnage as cullet provided the glass was color *sorted and free of metallic impurities.* No attempt was made by the authority to separate glass from incoming waste.

Secondary Materials Industry. Gainesville is located near two large secondary materials centers — Jacksonville and Tampa, Florida. Scrap materials, especially metals and textiles, are exported from these cities. Gainesville secondary commodities must compete againt sources closer to the export shipping points while absorbing freight of $6 to $10 per ton. As a consequence, collection and processing of commercial secondary materials are limited. The city has one secondary materials dealer who concentrates his efforts on ferrous and nonferrous metals and reusable, repairable products. In addition, two or three individuals engage in scavenging activities in the city on a part-time basis.

The city's dealer ships nonferrous metals as far as Philadelphia in the East and Cleveland in the Midwest. The bulk of his collections are exported from the ports of Tampa and Jacksonville. Cast iron is shipped to Birmingham. Approximately 13,000 tons of materials were recovered from the Gainesville area by the dealer in 1969. Junked automobiles and fabrication wastes make up the company's inputs.

Social welfare agencies do not collect discarded products in Gainesville.[150] There is no paper dealer in the city, and area schools consequently do not hold paper drives.

Houston, Texas[151]

Summary. Markets exist for secondary materials in Houston, even for such low quality products as burned, tin-coated steel cans. Paper, rags, steel cans, and other scrap were removed from mixed wastes processed through a compost plant. Steel cans and other scrap metals had been recovered from incinerator residues. Social welfare agencies in the area are active in textile, paper, and scrap collection from residential sources. A rendering operation, which had accepted dead animals from the city, was visited.

Introduction. Houston, with a population of 1.8 million, is a large industrial city on the Gulf of Mexico. The city's largest industrial employers are chemical and hydrocarbon processors, steel manufacturers, mining companies, machinery producers, medical product *manufacturers, and food processors.*

Approximately 1.25 million tons of waste are collected by public and private haulers in the city, equivalent to 3.72 pounds per capita per day. Of this total, 350,000 tons are residential wastes; the remainder is commercial and industrial waste. The city's own forces remove 33 percent of the waste; private agencies handle 67 percent. Wastes are disposed of in two public and one private landfill and in a compost plant. The city has five incinerators; four are permanently closed, and the fifth closed down for extensive repairs. The most recently built unit (1967) had a rated capacity to burn 800 tons of waste per day.

Salvage of steel cans from mixed municipal wastes had been taking place at the city's new incinerator and could presumably be undertaken again when the incinerator is once more operational. At the time of our visit, the facility was down for extensive repair of damage caused by corrosion and slagging.

Paper, textiles, and metals were removed from wastes delivered to the compost plant, owned and operated by

[150] This explains the relatively high textile content of wastes at 2.7 percent by weight compared with that found in the wastes of other cities of a round 0.6 percent.

[151] Survey concluded in February 1970.

a private company. We were denied detailed information about salvage activities at the compost plant on the basis that data were proprietary. At the time of our survey, the future of the compost plant was uncertain. The operation was losing money according to plant officials and had also encountered public opposition.

Houston had a serious solid waste problem in the early part of 1970. Its two public landfills were exhausted; at one, wastes were stockpiled into the vertical dimension. Its incinerators were shut down. The city was in process of finding new arrangements to handle its waste tonnage.

Houston as a Secondary Materials Market. There are, in or near Houston, industrial operations capable of absorbing considerable quantities of secondary materials. There is a large integrated steel operation in the city, including both open hearth and electric furnaces. Other steel centers are located in the State. The largest scrap user in Houston purchases approximately 600,000 tons of scrap yearly. There is a glass container plant in Houston and five other glass container producers are located within a 250 mile radius of the city. One paperboard mill is located in the city; three others are within 150 miles of Houston. In addition, two large manufacturers of building products in the city are also buyers of waste paper. One of these acquires 68,000 tons of waste paper annually, the other, 6,000 tons. The city is located close enough to copper mines in the Southwest to permit economical shipment of steel cans to copper mines for copper precipitation. The presence of a rendering industry in the city permits disposal of dead animals via rendering. Finally, Houston is an exporter of scrap materials through its ports.

The secondary materials industry in Houston consists of 35 salvage yards, most of these being metal processing facilities. Wastes are acquired directly from commercial and industrial sources, from individual scavengers, and from social welfare agencies.

Salvage at the Compost Plant. In 1969, 92,512 tons of mixed refuse were delivered for processing to the city's compost plant, operated by Metropolitan Waste Conversion Corporation, a private firm. The city paid the company $4.03 per ton for the waste delivered. According to samples taken by the Refuse Division, Public Works Department, City of Houston, composition of the waste by input weight was determined (see Table 71).

In the course of our survey, we were able to ascertain only that the metals removed are sold — steel cans for $15 per ton and other metals for $8 per ton. A portion of the paper is removed from the waste as it enters the plant. Experimental bundles of the paper product have been sent out to various consumers of secondary paper in Houston and elsewhere. In the Houston area, we were unable to locate any company that had bought the paper, although companies interviewed had received trial bundles and had decided against buying the paper because of its unacceptably high moisture content (above 6 percent) and foreign materials content (15 percent by weight), approximately 10 percent above maximum specification levels. According to city officials, some paper had been sold (for $10 per ton) as well as some textiles (for $40 per ton).

The metals removed from the waste are loaded directly onto railroad cars and are shipped to a steel can processor who burns, shreds, and tumbles the products and ships the shredded steel to Arizona copper mines.

We learned that attempts to market glass cullet in the Houston area had been unsuccessful — principally because the operator of the local glass container plant prefers to use only cullet generated within the plant.

Steel Salvage at the Incinerator. The city's newest incinerator, which has a design capacity of 800 tons per day, was brought into operation in August 1967, and operated, with one interruption (all of February 1968) until May 1969. In the period from November 1967 to March 1969, steel cans and other metal scrap were removed from the residue and sold to a local scrap processor.

According to city records, during the period of metal salvage 144,021 tons of waste were incinerated and 8,107 tons of steel cans were recovered, equivalent to 5.6 percent of input tonnage (Table 72). Additionally, 80 tons of other metal scrap were recovered (0.06 percent of input).

Terms of the contract between the city and the scrap processor called for a payment of $13 per ton for all steel cans received and $6 per ton for miscellaneous scrap received.

Initially, residues coming from the incinerator furnaces were tumbled to separate ashes and fines from the metal. Later, magnetic separation equipment, put in place at the incinerator by the scrap processor and operated at his expense, was used to separate the metal from other residues. Because wire and other bulky materials were causing difficulties in the operation of the magnetic separator, the city employed, at its own expense, two sorters who removed such items manually before the residue stream reached the magnetic separator.

The scrap processor was required to pay a $50 per month rental for placement of the magnetic separator and was required to pay for energy consumed in operating the separator. Additionally, he was required to post a $10,000 performance bond and to maintain property and accident insurance policies. The processor also supplied containers for the steel products and was responsible for all transportation.

According to the agreement between the city and the processor, the processor was responsible for determining the tonnage of materials received and to submit sworn statements detailing quantities of steel cans and other metals received. This arrangement led to a dispute between the city and the processor, which was unresolved at the time of our survey.

According to the processor, the wastes placed into his containers contained a high percentage of nonmetallic residues, up to 50 percent. Consequently, he has not paid the city for metals removed and allegedly owes a total of $54,670 to the city for the period of metals reclamation. At the time of our survey, the city was contemplating legal action against the processor to obtain payment.

The city's figures appear reasonably accurate, in our opinion. During the period in question, steel cans recovered from residues never exceeded 7.24 percent of the input tonnage in any 1 month, were as low as 4.18 percent of input in 1 month, and averaged 5.63 percent of input tonnage in the period. Analyses of Houston waste delivered to the compost plant showed that steel cans in Houston waste were 7.5 percent of total weight.[152]

A 2-day test conducted by the city in June 1968, indicated that incinerator residues were composed of tin cans (58.8 percent by weight); wire and other metallics (2.9 percent); and ashes, glass, and the like (38.3 percent). Using these figures and assuming that residues were only 20 percent of input tonnage, 28,804 tons of residue would have been produced, of which 16,937 tons would have been steel cans. The city claimed less than half this tonnage as shipments to the processor.

Unfortunately, physical examination of residues actually placed into the processor's containers was not possible because the operation had been terminated at the time of our survey because of incinerator failure.

The steel cans recovered from the incinerator were further processed by the scrap processor. Processing steps, according to the processor, included shredding in a hammermill, magnetic separation, burning at 1000° F in a kiln, shaking (to remove fines), washing, a second magnetic separation, and loading into railcars.

The processor has operations in Houston and El Paso, Texas, and in Chicago, Illinois. He identified costs for all of his steel can operations as follows:

	Cost per ton
Acquisition cost	$16.00 (delivered to plants)
Loss of metal in processing	7.70 (shipped)
Processing cost	12.00 (shipped)
Average freight costs	17.80 (shipped)
Total cost	53.50 (shipped)

We estimate the selling price to be $55 to $60 per ton delivered to the buyer.

Salvage Activity by Social Welfare Agencies.

In Houston, we visited only the Salvation Army facility. Goodwill Industries, Volunteers of America, and the Society of St. Vincent de Paul have operations similar to that of the Salvation Army in Houston.

The Salvation Army in Houston acquires products from residential sources in door-to-door collections using nine trucks. The Salvation Army also obtains products from 124 dropoff boxes placed at appropriate points across the city.

In 1969, the Salvation Army acquired 4,253 tons of commodities. Of this, 1,289 tons were sold as secondary materials in Dallas and Houston; the remainder were sold in the five Salvation Army Thrift Stores around the metropolitan area. Income obtained was $290,380, or $68.28 per ton of material acquired. Income from commodities sold as salvage was $26,380, or $20.46 per ton (Table 73). Expenses were $270,000, or $63.48 per ton of material acquired.

Approximately 56 percent of incoming textiles are judged unsuitable for resale. These items (337 tons in 1969) are sorted out, baled, and sold to a textile dealer in the Dallas, Texas, area for $60 per ton; freight is paid by the dealer.

Paper received (210 tons in 1969) is baled and sold as mixed paper to a paper dealer in Houston; waste paper brings $8 per ton. The paper is a mixture of newspapers, corrugated boxes, and miscellaneous paper found in the incoming loads.

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[152] In 30 waste composition analyses of municipal wastes published in various sources since 1939, the lowest weight percentage for "metals" is 5.2 percent, the highest is 14.5 percent, and most tests are at or above 8 percent.

Metallic scrap sold by the Salvation Army (742 tons in 1969) consists of appliances judged to be beyond repair and assorted metallic products such as toys, furniture or furniture parts, household goods, and the like. The materials bring $6 per ton from a Houston scrap dealer and represent 2 percent of his purchases.

The Salvation Army employs 29 people, including 11 drivers and 4 sorters. The total payroll in 1969 was $156,800, or an average of $5,406 per employee.[153]

Organics Recovery. Three rendering companies in Houston receive and process dead animals, butcher wastes, and other meat wastes into tallow and animal feed supplements. Until the end of 1967, one of these companies had an arrangement with the city according to which it picked up and disposed of dead animals at the city's dog pound and other animals found dead within the city limits. The arrangement had no financial aspect: the city benefited by getting rid of dead animals; the rendering company benefited by acquiring raw materials.

The arrangement was terminated because the costs of picking up dead animals and the value of these animals as organic product achieved equilibrium in 1966 and, in 1967, costs began to exceed value according to the company's president. Quantities of organic wastes picked up were low — a dog or cat at any one time; at the same time special trips were required to pick up these small loads.

The city now disposes of dead animals (some 16,000 yearly) in a small, gas-fired, 120 pounds per hour, pathological waste incinerator.

Concluding Comments. According to estimates made by the city, composition of all municipal waste in Houston is similar to that in other large cities (Table 74). With an annual waste load of 1.25 million tons, the city would appear to generate more than 460,000 tons of paper, 93,000 tons of ferrous and 6,000 tons of nonferrous metals, 18,000 tons of textiles, and 125,000 tons of glass in waste.

Approximately 13 percent of the paper (60,000 tons) would probably be saleable if we assumed that sorting, as practiced in Gainesville, Florida, until recently, is practiced. The local market could absorb this tonnage, but the municipal waste paper would displace other mixed paper grades that are now recycled.

The metals occurring in the waste could be sold, including tin-coated steel cans, without disturbing local salvage practices. In fact, recovery of these metals would be viewed with favor by metal dealers and buyers alike who are experiencing a shortage of scrap in the area. The biggest scrap user in Houston imports scrap from as far away as Mississippi to the east and Oklahoma to the north.

The market for textile wastes is very limited in Houston. Approximately 1,200 tons of roofing grade rags are consumed. Most textiles collected are shipped to Dallas and Fort Worth. It is doubtful that these markets could accept as much as 18,000 tons of waste textiles from Houston.

We estimate that the maximum market for glass cullet in the area (always assuming a clean, color-sorted product free of metallic impurities) is around 15,000 to 20,000 tons, considerably below the available quantity. In order to achieve even the sale of this fraction of total glass waste, local glass producers would have to be convinced to change their cullet use policies, which now exclude use of purchased cullet.

Los Angeles, California[154]

Summary. Los Angeles is the only major metropolitan area where segregated collection of wastes from residential sources has been practiced recently (the mid-1960's) for purposes of recovering waste materials. The city's proximity to copper mines, which consume shredded steel, and the presence of a number of glass container manufacturing plants in the area, made this massive salvage operation possible. Today segregated collection is no longer practiced. Salvage activity is conventional (recovered materials are derived from commercial and industrial sources). A sizeable export market for waste paper and metal scrap exists. A rubber tire reclaimer is located in the city.

Introduction. The Bureau of Sanitation, City of Los Angeles, collected 1.215 million tons of waste in the fiscal year ending June 30, 1969, of which 6,714 tons were commercial wastes.[155] The Bureau serves a population of 2.9 million; waste collections are equivalent to 2.28 pounds per capita per day, up from 2.08 pounds in fiscal year 1959-1960. This tonnage includes all residential waste collected within the city limits, dead animals, and 20

[153] Estimated in part by Midwest Research Institute.

[154] Survey concluded in April 1970.

[155] In Los Angeles, "commercial wastes" includes apartment house wastes.

percent of organic commercial wastes (restaurant garbage).

No reliable information could be obtained on wastes collected by private organizations. The American Public Works Association has estimated that 2.5 million tons of wastes are collected annually in the City of Los Angeles by private forces.[156] This tonnage, combined with the tonnage collected by the city, results in total waste removal rate of 3.715 million tons, or 6.96 pounds per capita per day.

Publicly collected wastes are disposed of in four landfills. Privately collected wastes are transported to any one of 24 privately operated landfills. Wastes are also reduced in on-site incinerators at a few industrial establishments, hospitals, and high-rise apartments.

Los Angeles does not engage in salvage operations. Salvage is prohibited at landfills and the prohibition is strictly enforced. Perhaps 10 percent of private refuse haulers do salvage according to one estimate; this activity usually consists of picking up and delivering commodities already sorted by the waste generator or recovering corrugated board from waste when demand for such materials exists.

Salvage Operations, 1930-1964. As in many other cities of the United States, in Los Angeles salvage and recovery of wastes was an accepted part of waste processing activity in the past. In the period from 1930 to 1957, rubbish (exclusive of garbage) generated by the people was burned in backyard burners. Between 1930 and 1951, the city collected the residues and sold these to a salvage operator; in the period from 1951 to 1957, the company was paid 10 ¢ per yard for disposing of these residues. In this time period, garbage was separately collected by the city.

The salvage company recovered 30 percent by weight of the incoming residue and reduced volume by 80 to 85 percent in so doing. Toward the end of the period, the company recovered approximately 81,000 tons a year from an input tonnage of 270,000 tons. The recovered commodities were the following:

48,000 to 60,000 tons per year of steel cans
2,400 tons of large metallics
1,200 tons of heavy steel scrap
480 to 600 tons of nonferrous metals
18,000 tons of flint (clear) glass
4,800 to 6,000 tons of amber (brown) glass

Using national per capita packaging consumption figures for 1958[157] and 1960 census data for the population of Los Angeles, we calculate that 89,000 tons of packaging metals (mostly steel cans) and 84,000 tons of container glass were generated as waste in Los Angeles during the latter part of the 1930 to 1957 period. Accordingly, between 54 and 67 percent of the packaging metals was recovered even though the recovery operation was for residential refuse only. Between 27 and 29 percent of glass containers was recovered in this operation.

In 1957, open burning was prohibited in Los Angeles and the city began collecting combustible wastes. Separate collection of so-called "hard garbage" (metals and glass) and "soft garbage" (paper, plastics, textiles, food wastes, lawn wastes, etc.) was instituted. Hard garbage was picked up once every 3 weeks, organic wastes more frequently. The inorganic wastes were delivered to the salvage company as burning residues had been delivered earlier.

As of July 1, 1961, the city entered into a 2-year contract with the salvage company according to which the city would collect metals separately and would deliver these to the company. The city would be paid $11.26 per ton for cans delivered. The contract was automatically renewable for an additional year. Glass was eliminated from separation by the city in accordance with an engineering study that showed the least costly collection system was separation of metals only.

Between July 1, 1961, and June 30, 1964, more than 100,000 tons of steel cans were recovered, as follows:

Period	Tons recovered	Income to city
1961-1962	44,348	$499,364
1962-1963	38,548	434,054
1963-1964	23,378	263,231

The rapidly declining rate of can collections and the strong opposition of the mayor to household separation of wastes led to the termination of the contract in mid-1964. Since that time, all wastes have been collected by the city in combined form and disposed of by landfilling.

It appears that the city made money on the salvage operation. In the period from 1968 to 1969 (when all costs can be presumed higher than in the period from 1961 to 1964) the city's cost of collection from residential sources

[156] Resource recovery from incinerator residue, p.3.

[157] Darnay, A., and W. E. Franklin. The role of packaging in solid waste management, 1966 to 1976. Public Health Service Publication No. 1855. Washington, U.S. Government Printing Office, 1969. p.103.

was $11.01 per ton (25 ¢ below receipts for cans in the 1961 to 1964 period); disposal cost was 66 ¢ per ton. In all, then, the city should have realized 91 ¢ per ton of metal recovered.

At least initially the population appeared to cooperate with the salvage project by segregating steel cans. To insure that segregation was accomplished, city inspectors periodically examined garbage cans in selected areas. If cans were found in a refuse container, the container was tagged and city collectors bypassed it. Because containers were only picked up once in 3 weeks, housewives washed the steel cans before these were thrown into trash cans.

For a multitude of reasons that are now difficult to substantiate, can collections declined. The mayor's strong advocacy of mixed refuse collection and opposition to the separate collection scheme are blamed by some observers for the decline. Undoubtedly, however, the convenience of throwing all waste into a single container motivated a large part of the population to disregard the separation requirements.

By the spring of 1963, an estimated one-third of the residents disregarded the city ordinance. A proposal before the city council to impose a $500 fine and 6 months in jail for any violation failed when vociferous opposition to such an ordinance arose (support for such a move was not forthcoming from the community).[158] Enforcement of can segregation was relaxed, and the contract was allowed to terminate.

Until mid-1961, the salvage company separated incoming wastes into several metal fractions, clear and brown glass, and unsaleable residues (ashes, shoes, purses, garden hose, etc.). Glass was sold to cullet dealers and in turn was sold, after crushing and washing, to glass plants in the area. Tin cans were burned, shredded, and shipped to copper mines in Arizona. Other metals were processed and sold to steel companies in the area. For a brief period, steel cans were sold to a steel company, but the operation was terminated because the tin content of the metal reportedly caused difficulties in working the steel produced. Beginning in 1961, the salvage company processed only steel cans for copper precipitation.

Until about 1960, salvage was also practiced by numerous private haulers. One company, whose experience is typical, operated open trucks equipped with barrels. The wastes were segregated immediately upon pickup and were sorted into the barrels. All but 5 percent of the waste picked up was recovered and sold.

In the late 1950's, court rulings forced refuse haulers to pay the minimum wage under the Fair Labor Standards Act.[159] This raised labor costs and, in turn, made compactor trucks more attractive economically as a means to make labor more productive. Larger companies, which were beginning to adopt modern management and planning techniques, also found that the erratic manner in which demand for secondary materials fluctuated made forecasting of salvage income nearly impossible.

Current Salvage Practices. Paper, metals, glass, textiles, and rubber are recovered in the Los Angeles area. Paper, aluminum cans, some of the glass, and textiles are derived in part from residential sources — the paper and textiles in a conventional manner through paper sales and clothing collections by social welfare agencies. The aluminum and glass are collected by new approaches hitherto untried on a national scale.

Paper Recovery. The Los Angeles area has an extensive paper industry consisting of eight paperboard mills and seven paper mills. Paper is also exported from Los Angeles, most of it going to Japan. Demand for waste paper is strong, and a much higher proportion of paper is recovered in Los Angeles County than in the United States as a whole.

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158 California: housewives' revolt. Newsweek, 61(11):36, Mar. 18, 1963.

159 The Fair Labor Standards Act applies to all employees "engaged...in the production of goods for commerce." The language is defined further as follows: "For the purpose of this Act an employee shall be deemed to have been engaged in the production of goods if such employee was employed in producing, manufacturing, mining, handling, transporting, or in any other manner working on such goods, or in any closely related process or occupation directly essential to the production thereof, in any state." Court rulings have held that "employees of an industrial and commercial waste removal service, which derives the major portion of its income from work performed for major interstate producers, are engaged in activities which are 'closely related' and 'directly essential' to the production of goods for commerce." The pertinent arguments and precedents are developed in Appeal from the United States District Court for the Southern District of Alabama. George P. Schultz, Secretary of Labor, Appellant, and Instant Handling Inc., a corporation, and Joseph E. King. Appellees. Apr. 1969.

Annual collection of waste paper is estimated to be 590,000 tons; about 15 percent of this amount is exported. Paper is consumed in Los Angeles and San Francisco board and paper mills and construction paper mills, and is used in miscellaneous applications such as wrapping paper for movers.

The collection of corrugated boxes is well organized. Many chain stores recover their corrugated wastes. Safeway Stores, for instance, uses trucks employed in delivering merchandise from the central warehouse to bring back empty corrugated cartons which are then baled at a central location. This technique, pioneered by Safeway, is being watched by most larger chains in the area, but with depressed prices for corrugated, many chains could discontinue corrugated salvage and move to other methods of solid waste handling. In-store baling is also practiced.

Corrugated boxes are also salvaged directly from commercial waste by private refuse haulers. One organization in the area conducts such salvage on a large scale and in a highly systematic manner. The company makes an empirical determination of the salvageable contents of the waste of a commercial account, and then calculates the relative economic attractiveness of the account from a salvage point of view by correlating data on salvageable contents, proximity of the pickup point to the salvage plant and the nearest landfill, accessibility of waste containers to the pickup crew and truck, and other information. By using a computerized routing system, the company is able to route more or fewer trucks to its salvage plant depending on the demand for paper. This organization is exceptional. Most private haulers who salvage do so intermittently and haphazardly depending on demand for corrugated and time available for the additional chores of pulling out cardboard from other wastes.

Newspapers are obtained by paper sales and from social welfare organizations that pick up paper in the course of normal collections from the population. When demand for paper is high, individual scavengers also engage in recovery of newspaper. Their technique is to follow the routes established for municipal waste collections very early in the morning and to retrieve newspaper bundles, usually placed on top of trashcans set out the night before, before the city collectors arrive.

Some of the newsprint obtained is converted to new uses rather than being repulped. Unprinted news obtained by one processor from the Los Angeles Times is cut to 8.5 by 11 inch size and is sold as school paper; this grade is also sold to moving companies for use as dunnage.

Metals Recovery. A small portion of metals discarded by the population in the form of old refrigerators, driers, washing machines, and the like, appears to be recovered in Los Angeles. The Goodwill Industries facility, for instance, sold 1,850 tons of mixed metals in 1969 for an average price of $6 per ton; the bulk of this tonnage was derived from appliances. It is not known how many other agencies are engaged in similar activities.

The only other recovery of metal from residential sources is the aluminum can reclamation project sponsored by Reynolds Aluminum Company.

Reynolds Aluminum Reclamation Program.[160] The Reynolds Los Angeles Can Reclamation Center (RCRC) is the original and largest of nine reclamation centers operated by this company in the United States. It is centrally located in Commerce, an industrial suburb of Los Angeles. The center consists of a roofed-over, open-sided, 6,000 square-foot area and a small enclosed office. Individuals arriving at the center unload the aluminum into specially designed mobile bins, which resemble over-sized supermarket carts. The bins are maneuvered to a hopper where they are automatically dumped onto a conveyor that has equipment to separate magnetically any ferrous metals from the aluminum and then to weigh and automatically record the actual weight of aluminum received. The individual takes the printed weight receipt to the cashier and receives 10 ¢ per pound (approximately 0.5 ¢ per 12-ounce can) for the aluminum brought in. The average load brought in from the general public ranges between 30 and 50 pounds.

The aluminum cans and other household aluminum packaging material are then conveyed into a hammermill, where the aluminum is shredded and conveyed into storage bins. The material is subsequently loaded into rail cars and shipped to Reynolds' smelting facilities located in Bellwood, Virginia, and Sheffield, Alabama.

The RCRC center also processes the aluminum collected from the public and organizations through some 20 to 25 satellite collection points operated by beer and soft drink company wholesalers and distributors. The satellite locations are located randomly around the

[160] Data in this section have been updated to the end of 1970.

greater Los Angeles area. In this sense, the Los Angeles program follows the mode of operation of Reynolds' other centers throughout the United States.

Based on 1970 year-end data, aluminum received by the RCRC is derived from off-the-street collections (individuals), which amount to about 52 percent; satellite collection points (brewery and soft drink operations), which amount to 45 percent; and other miscellaneous sources, which amount to about 3 percent of the collections. The yield of aluminum per unit weight received averages more than 90 percent, which results in Reynolds paying approximately 11 ¢ per pound for the aluminum received at this location.

In September 1969, the RCRC processed approximately 23 tons of aluminum. This volume has grown progressively to 109 tons in December 1970 (Table 75). Cost data released by the company show that acquisition costs are approximately $220 per ton; processing costs approximately $140 per ton, including labor and overhead for processing, building and equipment depreciation, and miscellaneous expenses. Freight to and handling costs at the smelting plants approximate $120 per ton, including conversion costs, cost of metal loss in conversion, and the like. Total cost for can recovery is around $480 a ton, excluding corporate general administrative expenses and public relations and advertising costs. Since the company values the product shipped from the smelting plant (reclaimed scrap ingot) at approximately $530 per ton, a total operation level profit of approximately $50 per ton is indicated.

The RCRC reached a breakeven tonnage in October 1969 (32.1 tons); receipts dipped down to 25.4 tons in November, but rose again in December, steadily increasing to a volume of 60 tons in June 1970. The higher tonnage achieved in June appears to have been the direct result of the establishment of 10 satellite collection centers under the auspices of beer distributors in the area. Company spokesmen claim that with the establishment of additional satellite centers, other promotional efforts, and increased awareness of the general public, volumes have steadily increased to the current high of 109 tons for December 1970.

If the tonnage achieved in December is sustained, annual recovery will reach 1,300 tons a year, equivalent to 7.5 percent of total aluminum cans that will occur in 1971 in the Los Angeles area (16,500 tons).[161] Reynolds officials estimate a minumum recovery of 5 percent of aluminum occurring and an upper limit of approximately 30 percent for the immediate future.

Expenses associated with public relations and advertising are excluded from the cost data presented above. Reynolds officials indicate that the program appears to be self-sustaining. The company conducted an intensive advertising campaign in Los Angeles in the late summer of 1969 to educate people to bring aluminum to the reclamation center. The campaign came to an end on September 1, 1969. In spite of this, tonnages received continued to increase afterwards.

The experience of Reynolds in Los Angeles in organizing and operating an aluminum reclamation program provides a number of interesting lessons about recycling consumer packaging product waste. Among these are the following:

(1) Most people in Los Angeles appear to be motivated to return materials for reuse by the possibility of financial gain. Reynolds reports that 87 percent of people delivering products to its center do so to realize income; the remainder do so for charitable or other purposes.

(2) Once educated as how to identify an aluminum can and distinguish it from other materials, the public does a good job of segregating the aluminum. In Los Angeles, however, up to 10 percent of the material brought into the center is steel, glass, or some other contaminant.

(3) Despite good cooperation from the general public in segregating material, commercial viability necessitates design and installation of automatic magnetic separation equipment. At the Reynolds center, an initial investment in equipment of just over $50,000 had to be replaced by equipment costing more than $75,000 to achieve proper materials handling.

(4) It appears that convenience of the collection center to the public is one, if not the most, important factor with regard to the success of an essentially voluntary recovery program. Even so, only a relatively small portion of a particular material can be recovered under a voluntary program where the materials must be delivered to a specific site.

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[161] Estimate made by Reynolds. Estimated national per capita consumption of aluminum cans and ends in 1970 was 3.5 pounds; multiplication of this figure by a population of 7,111,400 for the area results in 12,445 tons in the Los Angeles area--an amount lower than the figures used by Reynolds.

(5) The relatively high costs of acquisition, processing, and transport can be justified only if the value of the product to the buyer is higher than the costs. Aluminum scrap has a very high value when compared to other materials occurring in waste in quantity.

Glass Recovery. Glass recovery in the Los Angeles area is difficult to describe because the "system" is in process of transformation. There are eight large manufacturers of glass containers and two manufacturers of glass specialty products in the area. One glass cullet dealer operates in the city, the survivor of five others who had gone out of business through the years because of dwindling sources of cullet that could be obtained, processed, and sold at costs competitive with those of virgin materials. Until the spring of 1970, the glass industry in the area had passed through a protracted period during which sources of external (purchased) cullet were disappearing, cullet dealers were going out of business, and the remaining supplies of cullet could only be obtained at increasing cost. In 1970, a glass recovery program was initiated under the leadership of the Glass Container Manufacturers Institute (GCMI); this program appears to be successful. In what follows, the situation in 1969 and in 1970 will be described separately.

Activities in 1969. In 1969, the city's cullet dealer processed 3,600 tons of cullet, a lesser quantity than in previous years. His plant is capable of handling 40,000 tons per year. In 1969, by the dealer's estimate, 60,000 tons of cullet could have been absorbed by the glass industry (in addition to cullet generated in the glass plants). By our estimates, 190,000 tons of container glass were discarded by the Los Angeles area population in that year. Thus the glass present in waste was more than three times the cullet requirements of the local glass plants.

However, the waste glass was not accessible to industry. The dealer obtained 75 percent of his cullet from a window glass manufacturer in Sacramento, California. The remainder was obtained from bottling plants in Los Angeles. A minute quantity of glass was brought in by scavengers who picked glass from refuse at outlying dumps in the county. Virtually all the glass containers reaching Los Angeles residences were discarded.

The shortage of cullet in the area had several consequences. Most glass plants in the area adjusted to the situation and limited their inputs of purchased cullet to a minumum. Prices of cullet increased to $20 to $23 per ton because the glass had to be obtained from remote locations. All but three glass companies stopped buying cullet except at infrequent intervals when technical reasons demanded that more cullet be used than was available in-plant. Two of the companies that continued to purchase cullet, an ashtray manufacturer and a container producer, used only cullet as input materials. Infrequent buyers of cullet were sometimes forced to import cullet from as far away as Mexico because a local supply was not available.

Glass company officials stated that much more cullet would have been purchased if it had been available free of metals, in appropriate color grades, and at a cost per ton no higher than virgin raw materials plus a $2 per ton differential (the approximate value of fuel and refractory savings obtained with cullet). Raw materials cost between $15 and $17 per ton, indicating a cullet cost of $17 to $19 per ton.

In Los Angeles County, cullet use is required to satisfy air pollution control regulations, and this requirement overrides technical and economic considerations. The Los Angeles County Air Pollution Control District specifies minimum levels of cullet that must be used by each glass manufacturer. The more cullet is used, the lower the emission of sulfurous pollutants. For this reason, minimum cullet use ratios are specified, with the quantity dependent on the chemical characterics of effluent gases produced by a company's raw materials. Some companies need not use cullet at all; most are required to use 15 percent (calculated as a weight percentage of total input charge); some must use as much as 35 percent cullet in the furnace charge.

The situation in 1969, then, can be summed up as follows: Approximately 900 tons of cullet, equivalent to 0.5 percent of total container glass waste occurring, was recovered as bottling plant breakage. Other cullet, weighing 2,700 tons from flat glass sources, was brought in from outside areas. Approximately 60,000 tons of cullet, equivalent to 32 percent of glass occurring, could have been sold under the most favorable circumstances.

Activities in 1970. In April of 1970, eight glass container manufacturers in the area initiated a glass recovery program aimed at the general population. All eight plants organized facilities to receive glass containers from the public. Initially, the companies paid 0.5 ¢ for each container. Many people, some with rather large loads, insisted that the bottles they brought in be counted, and to avoid excessive labor costs, the payment was changed to 1 ¢ per pound, which is roughly the same as 0.5 ¢ per unit but easier to administer.

The program began with radio and newspaper advertisements. News coverage of the program gave the activity additional publicity. Advertising expenditures have been cut back without affecting collections.

In the first week of the program, a record 720 tons of glass (2.9 million containers) were collected. Quantities subsequently dropped but have been increasing steadily since, reaching 175 tons (700,000 containers) per week in July 1970. In July, glass was accepted on Tuesdays, Thursdays, and Saturdays between 9 a.m. and 2 p.m. at eight locations.

Glass Container Manufacturers Institute officials, seconded by glass company officials, believe that the program will ultimately result in the recovery of 30 percent of the glass containers consumed (about 57,000 tons on a 1969 basis) in the area.

Even if the GCMI forecast is not achieved, the program already appears to have eased the cullet shortage situation in Los Angeles. If a collection rate of 175 tons per week is sustained in 1971, the glass industry will recover, as a result of this program alone, 9,100 tons of cullet, more than 10 times the quantity recovered from sources in Los Angeles in 1970. Actual recovery rates should be higher as glass recovery becomes institutionalized, which appears in prospect.

Contrary to GCMI expectations, the majority of individuals bringing bottles for redemption are not youngsters; they are people in their early 40's who cite concern for the environment as the motive for their participation. A few people participate for the income provided. Among institutions, the Girl Scouts have been most active. One group in Orange County set up five collection centers for glass, manned by volunteers, as part of a fund raising drive. Transportation of the glass to the receiving plants was donated. GCMI reports that several communities in the area are contemplating institution of separate collections of glass wastes as a means to supplement sanitation budgets.

The glass recovery program is not economically justified at present. Glass companies pay $20 per ton for the cullet, which is estimated to be $1 more per ton than is justified by process economics. In addition, handling of this cullet is also more costly than the handling of in-house cullet or cullet purchased from a dealer. Initially, much dirty glass was received (half-empty mayonnaise jars, for example) which had to be washed to prevent public health problems. This was overcome by asking the public to bring in clean glass only. The problem of metallic contaminants, especially aluminum rings around bottle necks, remains. Laborers have to be employed in separating aluminum from cullet. This sometimes involves manual breaking of bottles to remove the neck to which aluminum adheres; some glass is lost to waste in this operation.

GCMI officials express the view that recovery economics will improve as increased quantities of glass are obtained and glass plant personnel learn to handle this resource in the most economical way. Modifications of aluminum twist-off closures that leave a ring of metal on the bottle are also being discussed to deal with the aluminum contamination problem.

The glass recovery program in Los Angeles was initiated with the full support and at the express command of glass company chief executives who direct local plant managers to participate in spite of the somewhat adverse economics of the program. Since all the area's large container manufacturers are participating, the additional raw materials costs are experienced by all the plants and the recovery program does not adversely affect the competitive position of any company.

Textile Recovery. In Los Angeles as elsewhere, textiles recovered from residential sources are collected by social welfare agencies such as Goodwill Industries. Our survey data on textile recovery come from interviews with the Goodwill Industries facility serving southern California and with the city's leading wiping materials dealer.

Goodwill Industries of southern California operates in four counties — Kern, Ventura, Los Angeles, and Santa Barbara. Materials are deposited by the population in 829 collection boxes distributed over the area, some of which are emptied daily. A total of 45 truck routes are used for servicing the boxes and to make residential pickups. In 1969, 98,358 residential and 177,226 box pick-ups were made; each box pick-up yielded an average of 18 bags (Table 76).

This collection system brought in 3,542 tons of textiles that were sold as rag bundles, or approximately 2 pounds per residential call or per bag deposited in a box. Although data on total textile collections were not available, on the basis of the experience of other Goodwill agencies, it is safe to assume that rag textiles represent half of all textile pickups.

The agency keeps good records on the number of pickup calls made, costs of pickup, and sales of salvaged and other materials. Unfortunately, the tonnage of materials acquired is not recorded; consequently, it is impossible to calculate what proportion of materials acquisition costs apply to those fractions that cannot be sold in secondhand stores and are therefore either discarded or sold as salvage.

In 1969, the agency's materials acquisition costs were $3.43 per call made (residential and box pickups combined). This cost includes all transportation expenses, including labor, as well as the costs of operating the communications center where residential calls are received and processed. Income from all salvage (paper, metal, and textiles) came to $1.08 per call. Clearly, operation of the routes for purposes of salvage alone would not be economical. Salvage, however, represents only 7 percent of the agency's income; 85 percent is derived from the sale of reusable articles, and 8 percent comes from donations and rehabilitation service fees.

The agency's income per ton of salvage is $53.62. The figures on tonnage of materials sold in secondhand stores were not available, but we infer on the basis of information available from other similar operations that the agency collected nearly 11,000 tons of materials in 1969, realizing an income of around $675 per ton from store sold goods.[162] On the basis of these estimates, it appears that the acquisition cost of all materials is nearly $87 per ton, given an annual collection expenditure of $945,253. This would mean that store sales subsidize the salvage operation. It is impossible to reject nonusables at collection points, which means that collection amounts to everything deposited whether it has value or not.

Prices received by Goodwill for textile rags increased from $70 per ton in 1967 to $75 per ton in 1968 and to $80 per ton in 1969. By mid-1970, prices were beginning to drop steadily, the reported reason being a serious cutback of secondary wool purchases in Italy.

Agencies like Goodwill bundle all textiles judged to be unsaleable; these mixed rag bundles are sold to graders who sort the textiles into cotton wiper and export grades. The wipers are sold to wiper dealers for $160 per ton. The wiper manufacturer inspects and launders the cottons and then prepares them for shipment by removing all buttons, zippers, collars, cuffs, and the like. After processing, the wipers are sold in bundles of varying weight for an average of $420 per ton.

Processing costs run approximately $180 per ton; in addition, costs are incurred in shrinkage of materials (lost in laundering and in wiper trimming), rejection of shipments for inadvertent inclusion of perma-press and drip dry fabrics, and in delivery of the material to the consumer.

The city's leading wiper merchant was pessimistic about the future of wipers derived from residential textiles. Textile treatments used on cottons decrease the absorbency of the wipers. In specialized wiping applications, synthetic resins made part of the cotton fabrics react with chemicals used in manufacturing and cause the cottons to disintegrate. To avoid rejections, such fabrics must be removed, which adds costs at a time of rising labor costs. Raw material costs are also rising because woolen garments used for respinning the wool (garneting) are no longer finding a market in Italy. The Phillipines, which once were an outlet for wearable clothing, are being lost as a market; Japan can deliver new clothing to the Phillipines cheaper than the United States can deliver secondhand clothing. Cottons are decreasing as a percentage of total textiles collected. Dealers who sort mixed rag bundles must, as a consequence of these developments, place a higher proportion of their costs on cottons, which are saleable.

For these reasons, the merchant plans to convert his operation to the distribution of new disposable wipers. Disposables cost more today than wipers obtained from used textiles; the merchant believes, however, that the differential is narrowing and that disposables will in time be more economical than used-textile wipers. With new wipers, the merchant stated, there are no rejections, no labor problems, no processing, no product shrinkage — only purchase and distribution.

This merchant, one of three large operators in Los Angeles, distributes 2,400 tons of wipers yearly. Since these materials are pure cottons and cottons represent 30 percent of mixed rag bundles, the merchant's annual tonnage requires 8,000 tons of mixed rags. Since rag textiles usually represent approximately half the textiles collected by social welfare agencies, total textile collections from residential sources of 16,000 tons are required to create the supply of this merchant. Textile

[162] Quantities collected are estimated on the basis of the experience of the Goodwill agency in Bridgeport, the Salvation Army facility in Houston, and the Volunteers of America agency in New York. Average pickup load weight for these agencies is 79 pounds per call; this weight times 275,584 calls made by the Los Angeles Goodwill in 1969 results in 10,886 tons, of which 5,552 tons are known to have been salvage materials.

consumption in the Los Angeles area is approximately 176,000 tons a year;[163] the activity of this one merchant alone, consequently, partially supports the collection for reuse of 9.1 percent of textiles assumed to be ready for discard by the population. We estimate that total textile collections are probably around 64,000 tons a year in Los Angeles, approximately 36 percent of total new fibers consumed.[164]

Rubber Recovery. Los Angeles is the site of one of the 20 rubber reclaiming plants in the Nation. An interview with the plant's general manager and data on national and regional rubber waste generation yield the following picture.

In the Los Angeles area, 176,700 tons of consumer rubber products are discarded annually by the population; of this tonnage, roughly 109,500 tons are used rubber tires, including truck, bus, and passenger tires. This tonnage translates to 8.36 million tires when we account for the difference in weight between passenger and truck tires and deduct tire wear losses from new tire weights.[165]

The area rubber reclaimer has a capacity to handle 90 tons of waste rubber per day (260 day year basis) but is now operating at 50 percent capacity, receiving 11,700 tons of waste rubber yearly. Only 24.5 percent of reclaimer inputs across the Nation are old tires;[166] the reclaimer, therefore, receives an estimated 2,870 tons of old tires, equivalent to slightly over 220,000 units, or 2.6 percent of tire discards in the Los Angeles metropolitan area. In addition to this tonnage, the reclaimer receives an estimated 2,250 tons of rubber from other reclaiming operations, such as tire retreading, tire splitting, and salvage yards that separate innertubes. The remainder of the input is estimated to be from industrial sources. It appears, then, that this operation results in the reclamation of 3,120 tons of rubber derived from consumer products, or 2.8 percent of total consumer rubber product discards.

Tires received by the reclaimer are concentrated at filling stations; from here they move back to tire manufacturers and in turn to the reclaimer, or the tires are acquired by salvage companies that process them for resale. Two companies in the area specialize in tire collection and are paid $4 per ton by filling station operators for this service according to city officials.[167] The reclaimer declined to discuss acquisition costs, limiting his comment to the statement that prices paid were "nominal"; that is, probably in the $5 to $10 per ton range.

Louisville, Kentucky[168]

Summary. Steel cans and other ferrous metal scrap are recovered from Louisville's incinerator and sold. A private refuse hauling and salvage operation in the city recovers paper and metals from commercial wastes.

Introduction. Louisville was not one of the survey cities. Interviews were scheduled in Louisville to determine the specifics of a municipal steel can recovery operation and to visit a private salvage operation.

Louisville has a population of about 400,000. Residential wastes are collected by city forces. These are processed through one rotary grate incinerator with a daily capacity of 700 tons. Wastes collected by private forces are also accepted at the incinerator. Nearly half the waste incinerated is delivered by private haulers. The city maintains a landfill for receipt of bulky wastes and incinerator residues. One large landfill is operated by a private corporation that concentrates on commercial and industrial waste removal.

In 1968, the city incinerated 258,000 tons of waste, equivalent to 3.53 pounds per capita per day. This does not represent all waste collected and disposed of in the

[163] Basis is 49.5 pounds of new textile consumption per capita (1968) and on area population of 7.1 million people.

[164] Basis for estimate: each of the city's three large merchants handles an equivalent amount; all other dealers handle a quantity equivalent to that of one of the large merchants.

[165] Basis of calculation (using Pettigrew and Roninger, Rubber reuse and solid waste management): (1) rubber waste generation in California is given at 49.7 pounds per capita; tire wastes are 62 percent of total (p.42); (2) new tire weights are shown as 22 pounds for passenger and 75 pounds for truck tires (p.13); (3) total number of tires in 1968, (170 million passenger, 22 million truck) derived from figure on p.15; (4) total new tire weights in 1968, 6.25 billion pounds, came from figure on page 16; (5) annual tread loss in 1968 of 434 million pounds was given on page 43. From these data we derived a composite used tire weight of 26 pounds, 20 pounds for passenger and 70 pounds for truck tires.

[166] Pettigrew and Roninger, Rubber reuse and solid waste management, p.51.

[167] We were unable to confirm this by discussion with the companies involved.

[168] Survey concluded in July 1969.

city, however. Quantities of wastes disposed of by city forces directly at the landfill and quantities disposed of in private facilities were not available.

Recovery of Metals at the Incinerator. The Louisville incinerator is equipped with a materials handling system that separates, cleans, and shreds ferrous metals in the incinerator residue.

The incinerator has two rotary kiln type furnaces that operate at temperatures between 1400° and 1800° F. Organic wastes are completely burned. Glass melts and glass containers are not recognizable in the residue. Residues are quenched and then moved on conveyors past two pickers who remove large metal objects and wire. Next, the residues are tumbled in rotating drums; ashes and fines fall through perforations in the drums, and the material stream leaving the tumblers consists almost entirely of steel cans. These are sprayed with water as they move up a conveyor past two additional pickers who remove wire missed by the first pair. The cans then pass into a hammermill via a magnetic separator. They are shredded and fed by a gravity chute into a rail car. In appearance, the cans are completely burned, shiny black, and clean of ash.

Approximately 4,700 tons of steel cans are recovered and sold yearly, equivalent to 1.8 percent of input tonnage. The cans bring $12.50 per ton. They are sold through a St. Louis, Missouri, broker to an electric furnace operator in North Carolina. Freight is paid by the buyer.

Larger metal pieces separated from the residue are sold to a local scrap dealer for $4 a ton. Around 1,900 tons are sold annually.

Although the city had not undertaken a detailed cost analysis of the metals recovery operation, the superintendent of incineration believed that the operation breaks even. As we observed in Atlanta, however, a break-even operation is probably beneficial to the city when compared to the alternative of removing the metal residues to landfill.

Private Salvage Operations. A private refuse removal company in Louisville has an operation where commercial wastes containing at least 25 percent salvageable materials are sorted and processed. The company recovers paper, primarily corrugated boxes, ferrous metals, and nonferrous metals. The paper is manually sorted on moving belts, is shredded or baled, and is sold to a paper dealer in Columbus, Ohio. Metals are sorted manually and are processed for sale through a scrapyard owned by the company and adjacent to the salvage operation.

The company also receives concentrated loads of used lumber, glass, and Fiberglas. At the time of our visit, the company was seeking markets for shredded wood made by hogging the lumber wastes. Glass could not be sold and was dumped at the company's leased landfill. The organization had a contract study under way to discover uses for Fiberglas which, being worthless, was dumped.

Company officials said that the best sources for salvageable waste loads are large industrial plants and warehouses. Waste loads containing food wastes and mixed commercial wastes such as office building wastes were not considered sufficiently rich in recoverable materials for salvage.

Data on quantities of materials collected and recovered and information on sorting and processing costs and manpower levels were considered proprietary information and could not be obtained.

Madison, Wisconsin[169]

Summary. Madison has little industrialization and the area is essentially a white collar employment region most notably influenced by the University of Wisconsin and the State capital. The secondary materials markets of Madison are of little importance. The city, however, is close enough to Chicago and Milwaukee to support a modest metals trade. Accessibility to paper mills makes paper recovery attractive, although it too is of little importance. The city of Madison, in a special salvage program, recovers and sells a high proportion of residential newspapers discarded. These are voluntarily separated by citizens for pickup with household refuse. Charitable organizations in Madison engage only in processing old clothing, some of which is sold as rags, and usable secondhand merchandise.

Introduction. Madison, Wisconsin, is located in Dane County, Wisconsin, about 150 miles northwest of Chicago. The population of the city in 1969 was about 169,000 persons, making it a relatively small metropolitan area. Dane County has about 273,000 persons, including Madison. It is an area with low industrialization and boasts only a small amount of manufacturing. The University of Wisconsin with 34,670 students is easily the single largest "commercial" activity in Madison.

[169] Survey concluded in March 1970.

Solid waste management in Madison is split between private refuse haulers and city services. The city operates a combined collection system (rubbish and garbage) with weekly pickup. Collection service is offered to private residences, apartments, and commercial buildings. Private haulers take care of large commercial (shopping centers, supermarkets), industrial, and apartment complexes. Refuse trucks are owned and operated by the city, which must confine its activities to the city limits. Bulky items are picked up separately for disposal at the landfill sites; however, no building or demolition material is accepted at city landfills.

Within the city limits, there are four land disposal sites all operated by the city. At present, private refuse haulers may for no charge deposit loads there, which the city handles along with city-collected refuse. One landfill does not accept privately collected refuse and one site is used for burning only brush and trees.

The city, like many other political jurisdictions, is rapidly depleting existing disposal sites and is seeking new locations. To date, it has been unsuccessful in overcoming citizen opposition to various sites, especially those outside the city limits in the township jurisdictions.

Refuse collections for 1968 and 1969 are as follows.

Category	1968 — tons	1969 — tons
City collected	44,200	52,100
Private collected	67,000	74,700
Total	111,200	126,800

This is 4.11 pounds per day per person for 1969 compared to 3.63 pounds per day in 1968.

The city, through its Director of Public Works, has sought to try new approaches and ideas for solid waste disposal. In this regard, Madison has two notable programs under way, both of which have involved private industry working with the city.

One program has been under way since June 1, 1966. It is a pilot demonstration of refuse milling prior to landfill. Participants in the milling program are the Heil Company of Milwaukee (equipment), the University of Wisconsin (engineering evaluation), and the city of Madison. Partial funding was obtained through a demonstration grant of the Bureau of Solid Waste Management together with financial participation of the Heil Company and the City of Madison. The 3-year budget was $555,000. The objective of the program included technical and economic evaluation of waste volume reduction by milling; sanitary parameters of milled refuse; feasibility of depositing milled refuse without earth cover; economic feasibility of salvage; and characterization of physical changes of milled and unmilled wastes in the fill site.

The salvage objective was never pursued actively because of lack of interest of local secondary materials dealers. The milling operation, however, was termed a technical success, and all compactor truck refuse at one disposal site is now being milled before deposit on the landfill. Milling achieves a compacted density of 1,000 pounds per cubic yard versus 800 to 850 pounds per cubic yard for unmilled refuse, and earth cover is not required. Some technical and economic problems of the installation persist, but these were being worked out in late 1970. (Because full and detailed reporting on the project is provided in other Solid Waste Management Office publications, this report makes no attempt to evaluate this project in detail.)

The Forest Products Laboratory (USDA) is using Madison's milled refuse as a starting point in experimental ballistic separation and recovery of various paper grades for recycling.

Newspaper Recovery Program. In Madison, Sanitation Division trucks collect newspapers from residential sources. the paper is separately bundled on a voluntary basis by the public for pickup with refuse, then placed in baskets attached to compactor trucks (with two exceptions of old trucks that cannot be outfitted with baskets); and finally sold to the secondary materials industry for recycling.

This is a well-known project, one usually held up to view as an example of what can be achieved in recovery of wastes. Our analysis indicates that the project has several aspects that demonstrate that care should be taken by any sanitation department contemplating a waste recovery program.

Key points about various aspects of the Madison program are the following:

(1) The city collections provide a steady, predictable, and continuous supply of high-quality waste newspaper that can be used for newspaper deinking processes.

(2) The project has the pledged support of several paper companies, including the Nation's largest waste paper dealer/broker, and is given preferential treatment for its purchase. In other words, the project is partly protected from the full impact of market competition forces (but not from price fluctuations).

(3) In the absence of new demand for paper collected in this type of program or collected in times of incrementally lower demand for waste newspaper, the paper collected preferentially in Madison displaces some

waste paper normally collected in other cities. The result is a shift in the solid waste burden, but no net reduction in solid waste disposal if the total regional market for waste newspaper is considered.

(4) The city has lost money on the project, although a break-even operation appears achievable. In the period January 1969 through July 1970, the city lost a total of $14,585 on the recovery of 1,989 tons of paper, or $7.33 per ton. In the latest period (April through July 1970), the operation has been profitable, bringing the city $1.12 per ton net gain.

This program was initiated by the National Committee for Paper Stock Conservation (NCPSC), a committee of the Paperboard Division of the American Paper Institute. The city of Madison, with advisory support from the NCPSC, operates the program, bears its costs, and receives all the revenue from sales of the old newspapers.

The NCPSC objectives were: to reduce the amount of newspapers being discarded as solid waste, to recover and reuse secondary fiber to conserve trees, and to help assure a continuing supply of secondary fiber as raw material for the paperboard industry. The NCPSC is also interested in determining if residential refuse separation is practical and what the technical and economic parameters and feasibility are for the participants (the sanitation agency, the waste paper dealers, and consuming paper mills). The city's objectives were threefold: to conserve space in rapidly depleting landfills; to reduce nuisance of windblown papers at landfills (and related clean-up costs); and to recycle a marketable portion of the solid wastes collected by the city.

A key question that both parties had was the economic feasibility of such a collection program for both the city and the paper purchasers (mills).[170] This could be answered best by actual experience in the program.

Geographically, the city is separated into an east side and a west side by Lake Mendota and Lake Monona. The two sides are roughly comparable in population and area; the east side is populated predominantly by blue collar and medium income white collar laborers. The west side is predominantly an affluent upper and middle class residential area. The program began on the east side in September 1968, and was extended to the west side in March 1970.

East Side Program. Citizens on the east side were asked to bundle their newspapers voluntarily and to set them at the curb with their weekly waste accumulation. Initially, open body trucks with crews followed the packer trucks and collected paper separately. This method was much too costly to ever hope to be profitable, so all but 2 of the 12 packer trucks operating on the east side were equipped with 1.0 cubic yard baskets, installed at a cost of $170 to $300 each. (The two trucks without baskets are still followed by a dump truck because they have no space on the curb side to accommodate the baskets.)

Baskets are emptied into the dump trucks at the disposal site or earlier if necessary. If baskets fill up before a truck is full, the dump truck is called by radio to meet the packer; transfers are made at mid-day, at a common meeting point.

The paper accumulation is delivered daily to a local paper dealer who sorts and processes the paper; the paper is picked up in baled form by a large Chicago dealer/broker who delivers it to a newspaper deinking mill located in Alsip, Illinois.

According to the original contract with the local waste dealer (which terminated 6 months after the project start-up but whose terms are still in force by verbal agreement), the city receives the market price for No. 1 News (Chicago market price) less $14 per ton; however, the dealer must accept the paper even if the price drops below $14 a ton, a condition that has not occurred throughout the history of the project. In effect, the city absorbs all price fluctuations.

In the period from January 1969 through July 1970, the city was paid an average of $7.90 per ton for east side paper collected and delivered to the dealer. In this period, the city's additional operating costs related directly to paper collection were $21.83 per ton of paper sold, for a loss of $13.93 per ton. By adding $2.25 per ton landfill disposal credit to income received, a total average benefit of $10.15 per ton results, and the net loss

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[170] Wisconsin is a large paper producing state with 3.0 million tons of production in 1968; it consumed 2.2 million tons of pulp and an apparent 0.8 million to 0.9 million tons of waste paper as raw materials. There are 36 paper mills within a 100-mile radius of Madison both to the north and east and 83 paper mills within a 200-mile radius. Both paper and board mills consume waste paper in Wisconsin, although only board mills and construction mills and one newspaper deinking mill near Chicago use waste newspaper.

in the period is $11.68 per ton (Table 77). In this period, 1,483 tons of paper were collected and sold on the east side, an average of 78 tons per month, 936 tons per year. The recovered paper was equivalent to 32.2 percent of newspaper delivered to the east side and 3.8 percent of waste collected on the east side (Table 78).

Citizen participation was obtained by a low-cost advertising program, which consisted of doorknob hanger distribution and essentially free newspaper, radio, and television publicity. Citizen participation was and is excellent, although some participants continue to include magazines and paper sacks with newspapers and to tie bundles with wire, rope, and nylon stockings instead of the recommended string or twine. (Tieing is requested to keep papers from blowing away before pickup and to facilitate rehandling of the bundles.)

The local dealer reports a weight loss of 2.5 to 5.0 percent as a result of non-news inclusions and upgrading to a "super-news" grade, for which a premium of $4 to $5 per ton is paid. Newspapers collected by the city of Madison are reported to be very "clean" by waste paper standards and therefore a desirable material for paper mills consuming secondary fibers of this type. In fact, the principal consumer of the Madison newspaper has been the newspaper deinking mill previously mentioned.

The paper tonnage varies seasonally, as does total waste volume. In the winter, tonnage declines with bad weather and home consumption of paper in fireplaces. The tonnages remained remarkably consistent, however, for comparable months a year after the program began. Newspaper collections average 20 tons per week, or 4 tons a day. Per ton costs vary significantly on the east side; however, since the labor and truck input costs are essentially fixed within the tonnage limits normally experienced, a low tonnage runs cost per ton up rapidly, while the same leverage brings costs down rapidly on high tonnage days.

West Side Program. On March 30, 1970, Madison extended its newspaper collection program to the west side. By a coincidence of timing, the program was aided by Earth Day publicity (April 22). In the 4 months for which we have data (April through July 1970), the city collected 506 tons of news, an average of 126.5 tons per month and 1,518 tons a year (if collections are maintained at this level). Collections were equivalent to 43.7 percent of newspaper occurring on the west side and 5.4 percent of west side waste tonnage (Table 79).

The west side program was also profitable in this period. Revenues were $7.53 per ton plus a $2.25 per ton disposal credit; costs were $4.37 per ton; the net benefit was $5.41 per ton. Differences between the two programs explain the relatively more attractive economics of this operation (Table 80). Differences are the following:

(1) All west side packer trucks are equipped with separate paper baskets, and operation of a dump truck for collection is unnecessary.

(2) Paper is unloaded into trailers at the disposal site; the trailers are provided and picked up by the buyers. Therefore, the city has no delivery costs.

(3) For a very limited time, some paper was sold to a building insulation mill for a price considerably above the average received on the east side.

The city was unable to execute a contract with a local dealer for acceptance of the paper collected on the west side. (The two local dealers closest to the disposal site are not currently handling the paper as originally intended. One dealer has committed his baling capacity to higher value materials, such as aluminum scrap; the other dealer has only limited storage space, which results in extra handling for the city and a delivery cost that makes the haul unattractive.) The Chicago dealer/broker who backed the project agreed to provide a trailer at the disposal site and to service the trailer under a financial arrangement identical to that on the east side. This means that the city had lower handling costs because it did not have to deliver the product to a dealer's yard. The dealer upgraded (processed and baled) the west side paper in his Chicago plant before transferring it to the deinking mill.

In the first 4 months of the program, the city has also been able to sell about 130 tons (1 month's collection) of paper to a manufacturer of insulation for $12 a ton. The manufacturer also provided a trailer at the disposal site. This organization was unable to absorb the city's total west side paper tonnage on a continuous basis because of the relatively low level of housing construction activity at the time.

These factors mean that the west side operation is profitable whereas the east side project is a loss operation. For what period of time the dealer/broker will continue to leave and pick up trailers of loose newspaper for transport to Chicago is not known. If the price is changed in favor of the dealer or if the city has to deliver the paper to a salvage yard, the economics of this operation will also become marginal. The city has no formal written contract with any dealer for sale of its paper and sells under a verbal agreement that has no legal force.

In the 4-month period from April to July 1970, the total paper recovery program (east and west sides) was profitable for the city. On the west side, 506 tons were sold for an average profit of $5.41 a ton, and on the east side, 387 tons were sold at an average loss of $4.50 per ton; a net benefit of $1.12 per ton was realized for the total tonnage (Table 81). In this period, 42 percent of all newspaper occurring in Madison and 4.7 percent of all waste was recovered as a result of this operation (Table 82).

Analysis of the Total Program. Cost data and cost history available on the Madison paper recovery program indicate that the total operation will probably be profitable for the city in the long run. Costs of paper collection on the east side have gone down and could be forced down further by equipping the last two trucks that still operate without baskets with baskets. The 19-month period covered here has been one of eroding paper stock prices. At the time when prices were high, the city experienced excessively high operating costs, which have been brought under control since. As waste paper prices rise, the program will become more profitable, and, over a longer period, the city should realize benefits consistently.

The overall value of the program, however, cannot be established by looking only at its relative costs and benefits for the city of Madison. The paper recovered in Madison has been displacing newspaper that would have been collected elsewhere, although by the more conventional techniques of paper sales and charitable collections. The program was not initiated to fill new demand for the paper stock, although at the time the program was initiated a newspaper deinking mill built near Chicago had recently created an 8,000 ton per month increase in demand. Conversely, the Madison program did prove to be a continuous source of high quality waste newspapers that met the requirements of the Alsip, Illinois, deinking plant better than many conventional collections.[171] Because the program has the support of the NCPSC and specific companies, the paper could be sold at a time when total demand for waste newspaper was below supply from conventional sources, with the consequence that paper sources nearer the Alsip, Illinois, receiving mill were forced from the market and the tonnages recovered in Madison "reappeared" in the wastes of other cities. A key paper dealer in Chicago verified that considerable waste paper collected there was being sent to waste disposal sites. However, the decline in demand has been limited to construction product mills and combination board mills; there has been no comparable decline in demand at the newspaper deinking mill at Alsip, Illinois, for which Madison newspaper is purchased. The high quality of the Madison newspaper helped to sustain the favored treatment of this supply.

The program illustrates a number of positive and negative factors related to municipally operated salvage programs.

Generally positive factors include the following.

(1) Presegregation of waste materials can be made to work; the citizens are voluntarily subsidizing the operation by hand separation of newspapers. Citizens respond to low-cost publicity and appeals.

(2) Low-cost solutions to collection problems can be found. Normal refuse collection costs, however, subsidize secondary materials collection costs. Apparently, solid waste managers can adapt collection and disposal systems to limited salvage without significant operating inefficiency or loss of departmental mission. "Positive" attitudes of public officials are very important to this type activity.

(3) Very good secondary materials quality can be obtained without special processing.

(4) A municipality can realize significant savings in landfill space and nuisance reduction along with the associated costs.

(5) Favorable arrangements with dealers or materials consumers can (and must) be made and can result in a continuous sale of salvaged materials in a fluctuating market. Industry and local governments that do not commonly link in business activity can do so successfully.

Generally negative factors include the following.

(1) Special handling and transfer costs go up very rapidly in the absence of convenient, short distance materials transfer. Costs vary inversely with recovery tonnage because collection costs are not volume-dependent within normal ranges.

(2) Collection equipment manufactured today is not designed or readily adaptable to accommodate volume collection of segregated materials and mixed refuse.

(3) A municipality needs favored treatment (a guaranteed market or outlet) by dealers and industry to

[171] This mill also draws waste newspaper from Detroit, Michigan, and Louisville, Kentucky, as a result of special arrangements for its waste newspaper supply.

cope with waste paper market fluctuations to keep the system in continuing operation. Low market prices received result in economic loss or marginally profitable operations. Capital costs, market vagaries, and basic mission orientation of sanitation discourage acquisition of salvage processing equipment and "competition" in normal secondary materials markets.

(4) Low cost, labor intensive salvage from residential waste is limited to simple materials categories, such as newspapers and magazines; demands subsidized pre-segregation; and cannot be readily expanded to numerous materials. This approach, however, can be very attractive for application under the proper conditions because it taps large municipal waste components.

Private Refuse Haulers. More than 50 percent of Madison refuse is hauled by private organizations. They pick up refuse from commercial, industrial, and apartment house dwellings. The only salvage we discovered by private waste haulers was occasional loads of data processing cards from a Federal military complex at the University of Wisconsin. This material is hauled away free and brings about $24 per ton from a local dealer (data processing cards are perhaps the most desirable waste paper grade commonly sold to paper mills).

Few if any segregated loads of corrugated are recovered; if they are mixed, they are of no value and are dumped at a city landfill. One refuse hauler also reported that supermarkets make an attempt to salvage corrugated. This, however, is often not done and they end up hauling it away anyway, often because a truck driver failed to load it into an empty delivery trailer returning to a central warehouse. A few in-store balers exist in Madison. It appears that commercial salvage is very minor; private refuse haulers have little incentive to salvage as long as loads consist of mixed refuse and disposal fees do not exist in Madison.

Private Salvage Activity. Madison is not a major metropolitan area and has very little manufacturing activity. As a consequence, its secondary materials dealers are relatively small and do not specialize by materials. (They would be termed junk dealers in more populous areas.) All of them, however, concentrate primarily on ferrous and nonferrous metals because these are more profitable and available than lower valued items such as paper and rags. All their recovery in metals is from industrial and commercial sources, with the bulk of it obsolete scrap rather than prompt scrap. They also accept paper, but once again they service only a small number of commercial accounts for corrugated. One dealer specializes in school or Scout paper drives, which yield perhaps 30 tons per month recovery; another handles the city-collected newspapers from the east side. The dealers in turn sell both to consuming mills and to other dealers on a brokerage arrangement.[172]

Social service institutions, such as the Salvation Army and Goodwill Industries, restrict their activities to used items, collected from residences and sold as secondhand merchandise. All these organizations refuse large appliances that are not in operating order and only Goodwill has labor to repair small appliances. All avoid newspapers and other secondary materials per se.

This means that the social service organizations transfer much of the material collected to disposal sites. In fact, they are caught in a squeeze now — people use appliances and other items until they break down completely and their own labor costs prevent economical repair of such items which have a low resale price.

The collection of old clothing means, however, that a significant volume of mixed rags is available. These are baled and sold in Milwaukee through a broker. Goodwill Industries is the only organization with a reasonably large operation in Madison; it carries on a training and rehabilitation program for the handicapped. Even Goodwill does not attempt to grade rags, but it did acquire its own baler about a year ago. Goodwill officials estimate that 250 tons of mixed rags (1,000 pound bales; 40,000-pound carloads) are sold a year for which the organization receives $40 to $50 per ton or $12,500 a year.[173] Rag prices are down from a level of $140 to $160 per ton a few years ago. Goodwill's labor costs are low because it is a sheltered workshop and pays from $0.97 to $1.60 per hour. Since much of the agency's activity is training and rehabilitation, officials consider rag baling profitable, even at current market levels.

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[172] Because of the local dealers' orientation to metals, none are particularly well equipped to handle paper. In fact, the dealer who takes east side paper has an inefficient handling, sorting, and baling procedure using one man full time.

[173] Salvation Army sells possibly another 50 tons of rags a year.

[174] Survey concluded in May 1970.

Mobile, Alabama[174]

Summary. The city of Mobile, Alabama, operates a composting plant intermittently; paper and metals are salvaged from this operation. The market demand for bulk grade waste papers in Mobile exceeds local supplies, an unusual situation not encountered elsewhere. Mobile is an active textile collection and processing center.

Introduction. The city of Mobile has a population of 250,000; it is surrounded by suburban communities with an additional 156,000 inhabitants.

Within the city itself, 174,000 tons of waste were collected in 1969, equivalent to 3.81 pounds per capita per day. Municipal forces collected 98,880 tons; private forces, 75,120 tons. Wastes collected by private forces are derived from commercial and industrial sources; private haulers, however, also remove 1 percent of residential wastes.

In 1969, 164,400 tons of waste were delivered to two landfills for disposal, and 9,600 tons of waste (5.5 percent of that collected) were processed through the compost plant. Of the quantity of materials processed, 837 tons of paper and metal were sold as salvage, 5,593 tons were sold as compost, and 3,170 tons were landfilled as waste at a site adjacent to the compost plant. Excluding the compost, 0.47 percent of the city's collected municipal wastes were recovered.

Historical Salvage Activity in Mobile. In 1965, the city of Mobile stopped salvaging at its Hickory Road municipal dump where, up to that time, as many as 100 people had lived and worked, supporting themselves by salvage and by eating food found in the waste. The unsanitary conditions at the dump and the large rat population it supported in addition to people finally forced closing of the facility. According to poor people who lived at the dumpsite in tents and shacks built from wastes, Mobile's dump was one of the best in the region — there was no harassment from officialdom.[175] Opportunities for making a living existed: the people earned dimes and quarters for unloading wastes from private cars, collected stale bread which they sold to farmers for hog feeding, and salvaged paper, metals, rags, bottles, and usable commodities. At one time, paper recovery at the dump was a well-organized activity operated under the auspices of a paper dealer who had at the site 8 by 5 by 8 feet wire cages that were filled with different grades of paper by the scavengers; filled baskets were transported to the paper dealer's facilities and the contents were baled for shipment to customers.

The city constructed its composting plant to provide an alternative to the Hickory Road landfill, and, in part, to be able to realize salvage income. Attempts were made to rehabilitate the people who were displaced from the dump when it was closed. Since 1965, all salvage activity at the city's two landfills is prohibited and the prohibition is rigidly enforced; for instance, an employee is posted at landfill gates 24 hours a day to prevent nighttime entry to the sites.

Mobile Salvage Markets. Mobile has one boxboard manufacturing plant and two construction paper producers; these companies consume nearly 30,000 tons of bulk grade waste paper yearly; demand for paper, therefore, is good. Steel producers are located in Jackson, Mississippi, and in Montgomery and Birmingham, Alabama, within economical transportation range of Mobile for scrap steel. One container glass producer is located at Gulfport, Mississippi, two are at Jackson, Mississippi, and one is at Montgomery, Alabama. Mobile is also a port from which secondary materials can be shipped to domestic and foreign consuming centers.

Salvage at the Compost Plant. The Mobile compost plant is designed to receive 300 tons of refuse in an 8-hour work day. Since its construction in 1964-1965, the plant has not operated continuously for a variety of reasons, including equipment failure and absence of markets for the plant's compost products. In 1969, the facility was in operation for 4 months; 9,600 tons of waste were processed through the plant. In this period, approximately 80 work days, an average of 120 tons were handled daily, less than half of plant capacity.

In all, 817 tons of materials were removed from the mixed waste for resale (160 tons of paper and 657 tons of steel cans), or 8.5 percent of input tonnage. Sale of these materials brought $5,182 in revenues, $7 per ton of paper and $6 per ton of steel cans (Table 83).

The paper is sold directly to a manufacturer of building products. At the outset of salvage, attempts were made to sell the paper to a dealer; the dealer who handled the product for a few months in 1966 reports that the paper was high in contaminants, ranging from 8 to 12 percent, and excessive resorting labor was required to

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[174] Survey concluded in May 1970.

[175] Connell, M. They "scuffle" for life, and live, on city dump. Mobile Press Register, p.3E, Mar. 3, 1953.

prepare compost plant products for paper buyers. The building products producer, who converts rags, waste paper, and ground wood pulp into roofing felts, can accept a small quantity of low quality paper as inputs.

Steel cans, separated from the waste by magnetic means, are burned, sold to a local scrap dealer, and delivered to a steel mill in Birmingham, Alabama, for $12 a ton. The steel mill can accept small quantities of tin-coated product, which is blended with other scrap as a furnace charge material.

No market was found for the glass that occurs in the waste, although glass is separated from the waste. At the time of our survey, an estimated 200 tons of mixed cullet was stockpiled near the plant. This material is being landfilled.

Estimates of the costs of salvage alone, or of any one unit process within the compost plant, were not available. Paper is sorted manually; cans are separated magnetically. The operation as a whole appears to be losing money. Total plant revenues for 4 months of operation were $36,995. Total 1969 operating budget for the compost plant was $207,447, or $69,143 for a 4-month period, more than twice revenues received. The operating budget excludes amortization of plant and equipment, which is estimated to be $100,000 per year on the basis of a 20-year depreciation cycle.

Paper Salvage. With 406,000 people in the Mobile, Alabama, area, the yearly consumption of paper in all forms is around 110,000 tons. Of this total, roughly 15,000 tons are newspapers, 22,300 tons are corrugated containers, and 8,500 tons are printing and publishing papers.[176] The last three categories, amounting to an estimated 45,800 tons in Mobile, are the sources for bulk grade paperstock.[177]

In the city, 29,060 tons of bulk grade paper stock were consumed in 1969, equivalent to about 63 percent of the bulk grade papers estimated to be available. In spite of this, only 14,035 tons of bulk grade papers were collected in Mobile, and the city's three waste paper consuming plants brought in more than 15,000 tons of paper from other areas to satisfy their needs (Table 84).

The current situation in paper recycling is viewed as transitional by the area's dealers and paper buyers. Before 1965, between 8,000 and 10,000 tons of waste paper were recovered from mixed wastes yearly, primarily from the Hickory Road landfill, handpicked by its scavenger inhabitants. In 1969, only 160 tons of paper came from mixed refuse sources. Since 1965, various schemes have been tried by businesses in the area to increase inputs of obsolete paper, and some of these attempts promise to increase the quantity of paper recovered from Mobile residents and businesses, albeit before rather than after discard of the paper and board.

The area's largest waste paper consumer, a container board manufacturer, has instituted a program whereby individuals and peddlers are paid in S&H Green Stamps or cash for paper. The company advertised its program extensively and, in 1969, it obtained nearly 10 percent of its paper requirements by this program, some 2,100 tons. The Green Stamps proved especially useful in attracting participation by the public.

The city's largest bulk grade paper dealer is in the process of organizing a paper collection system that will involve schools, churches, and civic organizations at the gathering, collection end and a new paper processing facility at the processing end. Although details were not disclosed, the dealer is attempting to overcome the typical problems encountered in using institutional paper collectors, namely the unreliability of the groups in supplying paper at specific intervals, the unpredictability of the quantities and quality of the product, and the fragmented nature of the sources. The dealer hopes to revolutionize waste paper collection in Mobile by his new approach.

On the average, paper dealers in the Mobile area in 1969 paid $12.00 per ton for newsprint, $13.67 for corrugated, and $6.22 for mixed paper. Paperstock buyers on the average paid $20.45 per ton for news, $24.89 for corrugated, and $13.00 for mixed papers. Average price paid for all bulk grade papers by dealers was $12.30 per ton and by final consumers $21.02 per ton. One dealer, who disclosed his financial records to us, realized a profit equivalent to 0.5 percent of sales in 1969. The dealer's cost accounts did not differentiate between bulk grade and high grade papers, but total processing costs, including all expenses except purchase price of the paper, averaged out to $6.59 per ton. Processing costs

[176] The remainder is made up of noncorrugated packaging papers, sanitary paper, industrial paper and boards, and construction papers.

[177] Figures in paragraph based on per capita per year consumption rates as follows: total paper, 0.271 ton; newspaper, 0.038 ton; corrugated containers, 0.055 ton; printing and publishing papers, 0.021 ton.

associated with bulk grade papers are higher than this average.

High grade waste papers, of course, are also collected and sold in Mobile. We could not construct a picture of transactions in this waste paper grade; dealers buy such stocks in distant areas as well as in Mobile and they ship pulp substitute grades as far away as New York; their records, insofar as they were made available to us, did not permit determination of the quantities originating in Mobile. Using national averages for printing and packaging conversion wastes, which are not very reliable when applied to a single community, one can roughly estimate that around 9,000 tons of high grade waste papers occur yearly in the Mobile metropolitan area.

Metals Salvage. At present, the only metals recovered from municipal wastes are steel cans processed from wastes delivered to the compost plant. Based on the plant's 1969 inputs and steel can sales, steel cans account for 6.8 percent of waste tonnage entering the compost plant. If the plant were operating at design capacity of 300 tons per day, 260 days a year, 5,300 tons of cans would be recoverable. According to the present buyer of this metal, such tonnage could also be sold — and at a higher price than the city now obtains ($6.15 per ton). The steel cans, as they emerge from the compost plant, are exceptionally clean and well prepared; they are hammermilled and burned and are virtually free of contaminants. This type of steel could be sold to copper mines for precipitation iron; Mobile is located near enough to copper mines so that freight rates would permit shipment of the cans to mines within economically acceptable limits. The current low price obtained for the cans is the result of the small quantity of such steel available from the compost plant.

Textile Salvage. In Mobile, as elsewhere, textiles are collected by Goodwill Industries and the Salvation Army. Attempts to establish total quantities diverted from wastes were unsuccessful because of the record keeping practices of participating concerns.

One construction paper producer buys 1,200 tons of roofing rags yearly, paying $10 per ton for this product. All other textiles collected in the area are sold as secondhand clothing in area stores, exported, or converted to wiping materials.

In Mobile, we encountered the only instance, in our survey, of a Goodwill Industries facility that converts used clothing into wiping rags, thereby placing itself in competition with wiper manufacturers. The Mobile facility prepares clothing articles that cannot be sold into five rag grades — white rags, soft white, colored mixed, synthetic, and cottons. These are sold directly to users (construction companies, janitorial supply houses, garages, etc.) and to wiper suppliers who simply resell them. Buttons and zippers removed from clothing articles in wiper preparation are packaged and sold in Goodwill's secondhand stores. The facility obtained $10,763 in income from textile salvage sales in 1969. Prices obtained ranged from $45 to $700 per ton depending on grade.

New Orleans, Louisiana[178]

Summary. Two contracts between the city and a salvor had been in effect in the 1948-1968 period. At present there is no organized recovery of municipal wastes. One glass cullet dealer operates in the city.

Introduction. We visited New Orleans as part of our preliminary review for this study in the company of researchers for the American Public Works Association. We were particularly interested in past salvage contracts between the city of New Orleans and a private salvage company.

Based on 1967 data, 711,750 tons of waste were collected in New Orleans by public and private forces. With a population of 675,100, waste pickup rates in New Orleans appeared to be 5.78 pounds per capita per day in 1967. Wastes collected are processed through five municipal incinerators. Residues and wastes that are not burned are deposited at two municipal and one private landfill.

Past Salvage Practice. In the 1948 to 1958 period, the city had a contract with a private salvage company according to which the salvor, for a payment of $16,000 per year, was entitled to recover salvable goods from all municipal disposal sites. Recovery of materials from incinerator residues was included. According to the salvor, the contract was unfavorable to the company from the outset; the metals and paper recovered did not cover total salvage costs; the salvor continued to operate under the contract in spite of adverse economics because one of his partners, engaged in the paper recovery end of the salvage contract, found it politically beneficial to continue. Details of the rationale were not revealed, but obviously considerations that extended beyond the pure profitability of the contract overrode economics.

[178] Visit was made in September 1969.

A second contract, covering the 1958 to 1968 period was signed upon conclusion of the first one. This arrangement was more narrow in focus. In exchange for a payment of $10,000 per year, the city was obligated to deliver all incinerator residues to the salvor's facilities for processing. Apparently the parties encountered difficulties in the fulfillment of this contract also, and the arrangement was terminated in 1963 because it was "to the mutual advantage of all concerned" to do so, according to the salvor.

In the salvor's view, the city (1) failed to deliver all residues to his processing yard; (2) permitted unauthorized salvage of residues; and (3) delivered residues that contained a high percentage of unburned organics so that economical processing of the waste was sometimes impossible.

City officials concede the truth of these allegations, adding that unauthorized salvage was nearly impossible to prevent and that residue hauling costs generally exceeded income from the contract. At the same time, demand for residues by other city agencies for road and parkfill existed.

During the life of these contracts, metals and paper were recovered from New Orleans' municipal wastes. For a brief period, steel cans were shipped to copper mines in Nicaragua for precipitation. The copper company introduced a new process for copper leach solution recovery soon after the salvor began shipping, and the market for shredded steel cans disappeared.[179]

Present Salvage Activity. We gained some insight into current salvage activities (or their absence) in interviews with the city's largest private refuse removal firm, with a glass cullet dealer, and with a glass company. The refuse hauling company president is interested in salvage, but the company does not recover anything now because salvage is viewed as an uneconomical venture. The organization operates a fill facility. At the same time, the company disposes of some potentially salvageable commodities from industrial and commercial concerns.

Metals. The refuse hauler receives very little in the way of metallic wastes from its commercial and industrial accounts. These commodities are received by local scrapyards for sale in the domestic market and overseas, with Japan being the principal buyer. Since metals are a small percentage of total waste tonnage, their recovery appears uneconomical in the opinion of the refuse hauler. The company acquires bulky items such as stoves, refrigerators, and automotive hulks in its waste removal activity. Automotive hulks are given to scrap dealers free of charge. Appliances are landfilled. The only source of concentrated metal wastes is can manufacturers who dispose of a steady stream of reject cans. No attempt is made to recover this waste or to sell it; the aluminum tops on reject beverage containers make the total can manufacturing waste unsalvageable, according to the company.

Paper. There is paper recovery in the city, but demand has not been sufficient to motivate grocery stores and retail warehouses to install paper compaction equipment. The refuse hauler acquires cardboard from many such accounts in sufficiently large quantities so that the company has studied the possibility of paper recycling. At present, however, such a project appears to lack feasibility because of the high investment costs required to process the paper.

Glass. The refuse hauling firm regularly picks up and deposits in its landfill broken glass from bottling operations, charging $2.00 per cubic yard to do so, this in spite of the fact that a cullet dealer operates in the city.

Total demand for purchased cullet in the New Orleans area is estimated to be at most 5,000 tons a year. Approximately 18,000 tons of glass are discarded in New Orleans annually.

The local cullet dealer's operation is small, consisting of the owner and two laborers. The dealer has two sales accounts, a glass producer who buys only flint glass and a producer who buys Georgia green and flint glass. The dealer pays bottling plants to color sort and store broken glass or defective bottles in barrels that are picked up periodically. A small quantity of glass is obtained from peddlers who, in turn, obtain the glass from large restaurants and bars. Glass salvaged at dumps was once the chief source of the dealer's glass supplies. The incoming glass is washed and crushed; metallic impurities are removed; and the glass is then shipped to buyers in trucks. No cost or quantitative information could be obtained on this operation.

An interview with one of the dealer's customers revealed that approximately 16 percent of total input

[179] This company was responsible for building the can recovery facilities at the Louisville municipal incinerator. The system was built to recover cans for the Nicaragua mines; however, the market collasped before the Louisville facility was completed, and Louisville consequently had to find a new outlet for its recovered steel cans.

tonnage to the glass plant is cullet; of this amount, 10 percent is generated in the plant and 6 percent is purchased. The company buys an estimated 2,200 tons of cullet yearly.

Other Materials. During our visit to New Orleans we did not interview processors of textile wastes, organics, and other theoretically salvable materials.

New York, New York[180]

Summary. In New York City and its surrounding areas, considerable salvage activity is taking place: paper, metals, textiles, glass, and rubber are recovered and sold to both domestic and foreign users. We encountered here one of the few large dump salvage operations in the country about which at least some records are kept.

Introduction. To obtain a clear picture of salvage activity in New York City is a well-nigh impossible undertaking thanks to the sheer size of the city (an estimated 8.3 million people in New York and an equal number in adjacent communities); its density (26,000 people per square mile of territory); the unique character of New York as a mercantile, financial, and communications center; and the fact that much salvage material generated elsewhere flows through New York ports to foreign markets. Further, New York is unique in that more than 60 percent of the textile-garment business is located there.

In the fiscal year 1969, New York's Department of Sanitation disposed of more than 6.3 million tons and handled nearly 7.1 million tons of waste.[181] City forces collected approximately 57 percent of the total, private haulers, called "cartmen" in New York, collected most of the remainder. The tonnage disposed of is equivalent to 4.2 pounds per capita per day but does not represent all waste collected in the city: a certain quantity is hauled to private landfills in New Jersey.

In fiscal year 1969, 31 percent of waste received was processed through incinerators; the rest, including incinerator residues, was buried in seven landfills accessible by truck ("truck fills") and two landfills serviced by barge. A certain quantity of construction rubble was ocean-dumped. Throughout this complex system, salvage was practiced at only one location, the Fountain Avenue truck fill in Brooklyn. As a result of this operation, 3,371 tons of waste (0.5 percent of total received) were removed for resale, and the city received $5,200 in income.[182]

Municipal Waste Recovery in Perspective. In the 1950's, salvage was conducted at three 500 ton per day incinerators in New York as well as at several of the city's truck fills. The incinerators were equipped with special pits, moving belt systems, and bins for receiving recovered commodities. The equipment was city owned.

Private concerns were invited to bid once a year for the privilege of operating the salvage facilities. Winning bidders were required to pay a weekly use fee and to maintain salvage equipment in exchange for materials removed. Newspapers, cardboard, metals, glass, and rags were removed manually by contractor employees.

Over the years, annual bids came in at ever lower figures. Equipment was not maintained well by the contractors, and in disputes between the city and the contractors, responsibility for failures could seldom be assigned to the latter. As a result of poor maintenance, salvage equipment at the incinerators broke down in the 1955-1956 period. The city decided that repair or replacement of the facilities was not justified in light of the low contract bids, and the salvage operations at incinerators were consequently terminated.

Salvage activity at the city's truck fills continued thereafter, and, as already mentioned, one such contract was still in force at the time of our survey. Bids for landfill reclamation contracts, however, were also successively lower each year, and the last invitation to bid to which we have access, issued in June 1969, brought in only a single bid for one of the four sites at which reclamation could be practiced. This last bid, for $100 per week, was the lowest ever received by the city.

The decline of private sector interest in salvage, manifested by low bids or complete absence of bids, has led the city to consider nontraditional approaches to salvage. Heat recovery is viewed as a modern approach to value recovery from waste.

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[180] Survey was conducted in July 1969 and in June 1970.

[181] The first figure refers to waste received, the second to waste handled, including rehandling of wastes in the form of incinerator residues.

[182] The city had disposal costs in 1969 of $3.78 per ton; thus total benefit to the city was a disposal savings of $12,743 and an income of $5,200, a total of $17,943, equivalent to 0.07 percent of the city's disposal budget of $23.8 Million. In addition, the city's collection costs were $94.2 million, or $27.28 per ton (excluding that tonnage collected privately).

The Fountain Avenue Salvage Operation. The city's last reclamation contractor operates at the Fountain Avenue landfill in Brooklyn. In consideration of a $100 per week payment, the contractor is allowed to maintain labor and equipment at the disposal site and to remove valuables from the waste before it is buried. His operations may not interfere with disposal operations.

The contractor usually has a crew of seven men at the site, including one of the owners of the company who supervises activities and participates in the work. Two small crane-equipped trucks are used on the site to lift heavy objects. All materials are loaded into a closed-body truck for hauling materials from the fill to the contractor's nearby salvage yard.

Pickers at the site are paid by load or by weight of a particular commodity removed. They earn an average of $15 to $25 a day but tend to work only a few days each week.

Records kept by the city on materials acquired by the scavengers show some categories of materials that are no longer meaningful (Table 85). For instance, the scavenger is said to remove "tin"; upon closer inspection, tin turns out to be enamel-covered sheet steel and complete refrigerators, stoves, dryers, and the like, which include other materials; materials listed under "brass" include not only all copper- containing metals but also nonferrous metals such as zinc, aluminum, lead, silver, and gold. The category of "satinettes" actually means horse and cattle hair products, with the bulk of this category being represented by rug paddings. "Rags" includes all textiles. "Iron" includes all ferrous metals, cast or rolled, except enamelled products.

Because the reporting forms use antique designations and because no great care is exercised to insure that each outgoing load contains only one type of material, data on the composition of wastes removed are not reliable. Data on tonnages are reliable because outgoing loads are weighed on the landfill scales. In addition to materials already identified, the scavenger also extracts, albeit in small quantities, such items as loose copper wire, rubber innertubes, occasional pieces of furniture, mattresses, and a bewildering variety of tools, fixtures, and parts. In addition, much foreign material also adheres to metals removed (for example, plaster or balsa-wood backing to aluminum panelling materials).

Salvage operations at the landfill appear to be orderly and, according to supervisors at the site, do not interfere with disposal work.

Wastes retrieved are trucked to a salvage facility, consisting of a two-story building and an open yard. Here some of the materials are further sorted, separated, graded, cleaned, and prepared for shipment. Iron and steel are sold to a scrap dealer without further processing. Aluminum, textiles, and hair are baled. Virtually all other items are resorted or disassembled. Appliances are taken apart and all components, with the exception of plastics and insulation (if any), are recovered. Thus, for instance, cooling units are sold as aluminum; wiring is stripped to recover copper; motors are separated into cast iron, cast aluminum, and copper fractions; and sheet metal is sold as ferrous scrap.

By our observation, wastes derived from the landfill are separated into at least 100 special grades, most of these being metal scrap grades. These are stored until a sufficiently large quantity of one grade has been accumulated to justify a shipment to a scrap dealer. Disassembly, cleaning, sorting, and related work are done by four men, including the owner. All operations are batch operations, and unit costs as these might pertain to, say, motor stripping, could not be determined. A considerable quantity of waste is generated in the operation, indicating a shrinkage in weight of commodities between extraction at the fill and sale. Wastes are trucked back to the fill and are disposed of free of charge.

For various reasons — poor or misleading records, the nature of sorting and disassembly operations, and the fact that the contractor is also engaged in the processing of marine junk obtained from other sources — the economics of the operation cannot be precisely determined. The owner declined to make his corporate records available for analysis but stated that the operation was only marginally profitable. The owner and his brother have been engaged in this operation during their entire working life and continue in it because no better alternative seems open at present.

Our own analysis, based on data supplied by the owner and augmented by estimates, supports the contention that the operation is only marginally profitable. Assuming landfill or that shrinkage is balanced out by upgrading of low-value salvage into higher value goods by disassembly, the company realizes an income of $30.29 per ton of material removed from the landfill (Table 86).

The company's investment in equipment is $50,700, which results in capital-related expenses of $5,700 a year, assuming 8 percent money and taking the varying life expectancies of items into consideration (Table 87).

If we assume that the two supervisors each earn $800 per month and nine laborers average $100 per week, a total payroll of $85,000 a year results, using a 30 percent payroll burden figure.

These expenses, plus the $5,200 a year payment to the city, yield a total of $95,900 a year or $28.45 per ton. This processing cost excludes insurance, maintenance, administrative burden, fuels and supplies, general office overhead, and property leasing costs. Quite clearly the operation is economically marginal and could not be replicated on a profitable basis if all costs conventionally charged to an industrial operation were applied.

Mixed Waste Reclamation by Private Haulers. With the exception of a few isolated instances (an occasional hauler who sometimes delivered waste loads almost entirely made up of corrugated board to a paper dealer), private refuse haulers did not engage in salvage. We visited one corporation, however, that was building a waste separation and reclamation plant, to be supplied by private haulers servicing commercial and industrial accounts. At the time of our visit, equipment was being installed. The facility was designed to accept 400 tons per day of waste. A 20-hour a day, 7-day a week operation was planned.

Concept. The company will accept waste from private haulers, charging a fee of $2.15 per cubic yard, the amount charged by the city; 25 percent of the fee will be rebated to the Queens County Trade Waste Association, Inc., to be used for research. The association has undertaken to interest its member companies in the venture. The waste will be automatically sorted on a system consisting of belts to separate corrugated paper. Some manual removal of objects will be necessary. Corrugated will be shredded, baled, and sold. The remainder, 75 percent of waste receipts, will be compacted for transport to the city's landfill. Later, a pyrolysis unit will be used to reduce the nonsalvable residues to an inert ash.

Technology. The heart of the operation is a patented system for separating corrugated from mixed wastes. The system was developed by Waste Reclamation Corp., of Los Angeles. The separator consists of a waste receiving station from which wastes run over 13 belts, spaced approximately 5 inches apart, to a salvage receiving station. The belts are set on an inclined plane with the angles of each belt unit slightly different from that of the others. The belt-bearing mechanism is rigged in such a manner that the belts can yield to weight pressure or bulky and heavy objects. A 5-gallon metal can, for instance, can force the belts apart so that it drops below the belted system. Smaller items drop down between the belts and are conveyed to a compactor for baling. The corrugated bridges the gaps between belts and stays on top, moving by conveyor belts to paper shredders and balers. "Foreign" objects carried with the corrugated are thrown out by hand before shredding. Company officials claim that 80 percent of the corrugated in a waste load will stay on the belt system and that 90 percent of the material delivered by the belts will be saleable.

Economics. Company officials estimated that the 400-ton-per-day installation, representing a capital investment of $600,000, will realize an income of $6,000 daily, against which expenses of $4,000 daily will be charged, for a daily profit of $2,000 (Table 88).

We are in no position to comment authoritatively on these economics, not having had access to feasibility analyses. The following observations, however, can be made. The company will receive a net subsidy of $7.50 per ton from refuse haulers, assuming that the waste density of 430 pounds per cubic yard is realistic. In New York, some waste haulers regularly achieve densities of 700 to 1,000 pounds per cubic yard. If densities are higher than those assumed, a likely possibility, subsidy per ton would drop without increasing the income from salvage. Income from the sale of corrugated is estimated at $30 per ton. In New York, mills were paying $23 per ton for this product; dealer buying prices were as high as $15 per ton. The company's total operating cost estimate is $10 per ton of input; if 75 percent of incoming waste must be disposed of (300 tons per day), dump charges alone will run $3.23 per input ton.[183] To this amount would have to be added hauling, sorting, shredding, and baling costs, plus amortization and overhead.

Prospects. This facility will go into operation in the near future according to company spokesmen. According to company estimates, the New York area will support 10 such plants which could handle 50 percent of the commercial and industrial waste in the area. Ultimately, the company plans to acquire its own pulp mill, linear

[183] Basis: $2.15 per cubic yard; 600 cubic yards daily with density of 1,000 pounds per cubic yard; for a total charge of $1,290 per day; this divided by 400 tons of input yields $3.23 per ton.

board plant, and box plants, which would be supplied by reclamation activities. At present, however, all this is still very much dependent on the economic success of the first reclamation plant.

Other Reclamation Proposals. At the time of our survey, a trade association was engaged in the feasibility evaluation of an integrated 500 tons per day waste reclamation plant to be located near New York or Washington, D.C. Early estimates showed a capital investment of $12.81 million, operating costs of $1.99 million a year, and income from the sale of garbage, aluminum, glass, ferrous metal, paper fiber, cellulose, and electricity of $2.36 million a year. Engineering and economic feasibility studies were under way. No likelihood of near-term startup existed.

Reynolds Aluminum Corporation was planning to start an aluminum can recovery system modelled on its Los Angeles Center.

The Glass Container Manufacturers Institute was active in the organization of a glass recovery system in cooperation with a citizen's group.

Social Agency Activities. We interviewed three social welfare agencies in New York: Volunteers of America, Salvation Army, and Goodwill Industries. All three agencies participate in the secondary materials business by collecting textiles from residential sources and selling textiles that cannot be resold in secondhand stores as rags. Volunteers of America and Salvation Army are also active collectors of waste paper from commercial and industrial sources; Goodwill Industries occasionally sells paper wastes accumulated in its operation but does not seek paper from its sources. All three agencies are, of course, primarily dependent on sales of usable soft goods and hard goods in secondhand stores. Salvage activity is not their principal occupation.

Textile Operations. The three agencies sell between 2,500 and 2,700 tons of textiles as rags yearly (Table 89). This represents approximately 60 percent of their textile collections. The remainder is sold in secondhand stores.

Prices received for textiles range from $40 to $65 a ton. Costs of collection and processing of the ragged portion of textiles cannot be isolated with any precision in that these activities are part of operations that service secondhand stores.

Volunteers of America estimates that a truck must bring in at least $30 worth of merchandise to break even. Drivers are paid 1 ¢ per pound for textiles brought in; each of two helpers receives 0.5 ¢ ; total acquisition cost, consequently, is 2 ¢ per pound, or $40 per ton plus expenses connected with operation of the truck and provision of room and board for the three laborers (valued at $17.50 per week). Sorting and baling of textiles costs $10 per ton. Average weekly collection per truck is between 4,000 and 5,000 pounds of textiles. The laborers derive roughly half of their income from their special allowance for textiles collected. Approximately 125 residences contribute the weekly textile tonnage, each providing an average of 36 pounds. Labor, in this sheltered workshop, is paid a minimum of $20 per week but no more than $64 per week.[184] Goodwill Industries reports that cost of operating a pickup truck, including labor expenses, is $38 per day.

Contributors to these agencies may deduct the value of contributions from income taxes. Goodwill Industries, for example, sends out 40,000 tax credit letters a year, allowing anywhere from $20 to $7,000 in tax deductions to contributors. Volunteers of America reports that claims of contributors are sometimes fantastic; one person, for instance, claimed a $300 value for four shirts. A random inspection of the agency's claim files revealed a consistent pattern of over-valuation by contributors.[185]

Textiles sold as rags by the agencies typically pass through the hands of a textile processor who segregates mixed rag bundles and sells woolens, synthetics, and cottons. The processor picks up finished rag bundles at the social welfare agency docks. None of the agencies visited could give an estimate of the materials composition in their rag bundles.

Paper Operations. Among social service agencies, Volunteers of America is prominent in paper collection and sales. Approximately 2,600 tons of paper are acquired by the agency, the bulk being corrugated. Other grades, including newspapers, IBM cards, white ledger, colored ledger, and mixed paper, are also collected. With the exception of newspapers, nearly all

[184] During the first 12 months of employment, labor is paid $0.80 an hour; supervisor, $1.28 an hour; after 12 months, labor is paid $1.60 an hour; in addition, room and board is provided.

[185] It is clear that tax revenues are indirectly used to subsidize social welfare agency activities, assuming that contributions would decline sharply if tax deduction claims were denied or sharply reduced.

the other grades are obtained from commercial and industrial sources.

Companies contributing paper to the Volunteers receive receipts for the paper donated, ranging from $6 per ton for mixed paper to $52.50 for IBM cards (Table 90). The tax credit basis is anywhere from $2 to $16.50 below the price received by the Volunteers; the differentials in favor of the Volunteers are meant to cover pickup and sorting expenses. From the agency's point of view, of course, acquisition cost is equivalent to their pickup costs.

The agency pays its laborers (driver, helpers) a total of $6 per ton of paper collected. Three trucks are continuously engaged in paper collections. A minimum of 2 tons of paper are brought in daily; a single stop may yield anywhere from 500 pounds to 4.5 tons of paper. Paper acquired is sorted and baled in the agency's warehouse and sold to dealers and brokers who arrange for delivery of the merchandise to mills.

By contrast with the Volunteers of America, the Salvation Army paper acquisition activity in New York is quite modest; in all, 106 tons were acquired in the October 1969 to September 1970 period;[186] income from the sale of this paper averaged out to $32 per ton, indicating that high grade papers (IBM cards, ledger) were sold in some quantities as well as bulk grades (news, corrugated, and mixed). The low collections and relatively high income achieved in New York are not representative for the Salvation Army as a whole. In the same period in Newark across the river, the agency collected an estimated 1,813 tons of paper, achieving an income of nearly $19 per ton.

In New York, as elsewhere, social service agencies compete directly with secondary paper dealers for most of the paper they collect, using tax credit certificates in place of cash to make their acquisitions. Their activities are not viewed with favor by dealers. These agencies, however, do in some instances acquire paper from sources too small to be economically serviced by commercial organizations; the agencies can do this because of their low labor costs. At least to sources in this category, the tax credit is a welcome contribution to income (by reducing tax liability), whereas the alternative of hauling the waste paper to dumps is a cost item. Of course if it could be sold by the waste generator, it would be a contribution to net income.

Miscellaneous Comments. The agencies also collect other items that are sometimes sold as salvage, most notably metals. Volunteers of America reports that occasionally appliances are picked up which cannot be sold in the stores; sometimes it is possible to sell such metals as scrap. This agency also sells unrepairable mattresses to an organization that repairs and resells them. During our visit, agency employees were unloading half a truck full of obsolete, wired panels whose original function could not be determined. The warehouse supervisor believed these could be sold somewhere. We also saw a large accumulation of sheet plastic rolls, acquired some years in the past, presumably also with the hope that they would find a buyer. Both Salvation Army and Goodwill Industries report that nearly all the women's shoes acquired by them are discarded as unsaleable and unsalvageable because the typical donors are slender, well-to-do women; the typical buyers are poorer heavyset women who require larger shoes than those contributed. Goodwill Industries reports that collections in the wealthiest areas of Manhattan tend to be meager: domestic servants and employees of apartment houses remove the best items before the agency can pick them up.

Paper Recycling. Within a 40-mile area around New York City there are 17 paperboard mills and 13 papermills and an unknown number of construction board mills, many of which are waste paper consumers. New York consequently is an excellent waste paper market area. Total demand in the area for waste paper is around 1.5 million tons a year. Approximately 100 paper dealers operate in New York City alone.

Two of the largest dealers in New York gave the following picture of paper recovery in the city.

A strong demand for newsprint exists in the area, in large part because of the steadying influence of constant news demand of the Garden State Paper Company, which operates a news deinking plant in Garfield, New Jersey. About 10 percent of news acquired is overissue; the remainder is collected by individual collectors from apartment houses; a small quantity of news is acquired by scavengers who retrieve newspapers from trash cans; and news is also collected by social service agencies. Paper dealers pay around $8 per ton to scavengers and collectors for loose paper. This material is then sorted and baled, usually sold through a broker (brokerage fee: $2 to $3 per ton), and delivered to the mill. The deinking

[186] Extrapolated from data for October 1969 to April 1970.

mill pays about $22 per ton for the grade, plus $3 to $4 per ton in transport costs; this is for well sorted news from which magazines are removed. Other mills may pay less but accept the normal magazine content of collected news.

Corrugated board is acquired from warehouses, department stores, retail stores, and supermarkets. One dealer has initiated a program whereby his company encourages waste haulers to deliver waste loads consisting entirely or nearly entirely of corrugated to the company's plant. Response to this appeal has been good. Haulers receive $14 to $15 per ton for the loose board. The board is baled and sold for $21 to $23 per ton, excluding transportation costs.

Dealers can afford to service only generators of corrugated who store at least a truck trailer load of board. Smaller accounts are serviced by individuals, scavengers, junk shops, or social service organizations — if at all.

The most desirable paper wastes are pulp substitute grade conversion wastes, for instance, cups and envelope clippings, which bring anywhere from $80 to $110 per ton. Least desirable is mixed paper, derived from office buildings. The presence of unacceptable materials, especially carbon paper, plastic, and garbage, makes this grade difficult to move at any time.

Waste paper travels an average of 50 miles to market; some trips as far as 400 miles away are made, but these are unusual.

According to the dealers interviewed, it is impossible to generalize about prices paid to generators of waste paper because the conditions of purchase vary. Elements that determine the price include the following: (1) grade and quality of scrap paper; (2) quantity of paper generated per unit of time; (3) form in which it is available (baled, loose); (4) service required (frequency of pickup, distance, congestion around pickup site, access to paper); (5) demand for the paper at time of purchase; (6) market price of the paper.

In general, published prices are used only to get a "feel" of the market; they do not necessarily reflect what goes on in actual transactions between individual dealers and buying mills.

Metals Recovery. Recovery of metals from municipal wastes or residential sources is virtually nonexistent. The landfill salvage operation earlier described is an exception. In the recent past a corporation approached the city of New York with the proposition to process the city's incinerator residues in order to reclaim the metal. The company wanted to build a recovery operation at the city's Fresh Kill marine landfill in Richmond Borough, which would receive the residues from barges and deliver ash and other unusable components to the fill. The offer was withdrawn when the company realized that costs would exceed projected income.

Recovery of nonferrous metal in the city follows traditional patterns; metals are acquired from the following sources: (1) auto dismantlers; (2) garages and shops (primarily batteries and radiators obtained by small peddlers for resale to dealers); (3) industrial accounts; (4) utilities (especially lead-covered cable and copper wiring); (5) government (all types of metals, usually acquired by dealers by advertised bid).

Glass Recovery. There is no glass container manufacturing plant in New York City, but in neighboring New Jersey there are eight container makers, four of which are supplied with cullet by a cullet dealer located in Jersey City just across the river from New York.

After a relatively lean year in 1969, this dealer found business very good in 1970, in part as a result of attempts by the glass industry to increase quantities of glass recycled. The dealer sold an average of 8,126 tons of cullet in the 1966 to 1969 period, achieving his highest sales in 1967 (11,662 tons) and lowest in 1969 (5,019 tons). He received an average price of $18.46 per ton, lowest in 1966 ($17.35) and highest in 1969 ($20.26) (Table 91).

In 1970, sales of cullet expanded sharply. The dealer estimated that 1970 sales would at least double those of 1969, and might do much better than this. The dealer stated that efforts by the Glass Container Manufacturers Institute to induce higher cullet use rates by their members are directly responsible for the expanded demand.[187]

The dealer obtains plate glass (window glass) from 12 accounts and container glass (flint, green, and amber)

[187] In fact, the actual events leading up to the sudden upsurge in demand were reported to us by another source as follows: the cullet dealer contacted his cullet sources to inform them that he could no longer accept their glass because of low sales. The bottlers, thus facing high waste removal costs by private refuse haulers, turned to the glass manufacturers. With pressure from their customers and increasing public awareness of solid waste problems, the glass container manufacturers began purchasing cullet in increased quantities.

from 35 accounts — breweries, soft-drink bottlers, and food processors. The glass is sold to four container manufacturers in New Jersey[188] and a light-bulb manufacturer.

Some of the glass is acquired free, in compensation for its removal. Large accounts require payment of $7 to $12 per ton for flint and $5 per ton for green and amber. The dealer receives an average of $18 per ton for flint, $16.10 for green, and $17 for amber. Freight, which will run around $2 to $3 per ton, is paid by the buyer. Approximately half of all acquisitions are made in New York, half in New Jersey. All sales are to New Jersey glass plants.

The dealer has never calculated his operating costs. His monthly payroll, including a 30 percent payroll burden, is estimated to be $6,500 for two drivers, eight plant employees, and two supervisors;[189] the investment in plant and equipment is $90,000, which translates to a monthly amortization charge of $1,120 at 8 percent interest and an estimated 10-year life for the equipment packages. Site lease is $295 per month; refuse removal is $160 per month; fuel costs are at least $100 per month; and maintenance, insurance, administrative expense, and property taxes add about $100 per month. This comes to a total of $8,275 per month or, using the average monthly tonnage of 677 (4-year history), $12.22 per ton. To this must be added payments for glass, shrinkage of glass in handling, utilities, and general office overhead.

With demand up, the dealer is rapidly depleting his stockpiles of glass accumulated in past years and faces a glass shortage if demand persists at current levels. The dealer hopes that one of several glass collection schemes discussed in New York that will involve citizen groups, acting as intermediaries between the dealer and residential glass generators, will become reality.

The main technical problem encountered by the dealer is the presence of aluminum rings around bottle necks. A good deal of manual sorting (using rakes) must be done to eliminate this contaminant as well as paper, cans, and other rubbish typically encountered in a load of cullet.

Textile Recovery. We interviewed three organizations engaged in textile recovery (in addition to social welfare agencies) and learned the following.

The starting point for most textile recovery is the social welfare agency that collects textiles from residential sources. Conversion wastes are also obtained from industrial sources, but these wastes play a relatively modest role in the field. Mixed rag bundles are prepared by social welfare agencies and contain all items these organizations cannot resell as used clothing. Mixed rags may be sorted several more times: (1) by mixed rag graders who in turn sell cotton to wiper manufacturers, wool to wool specialists, and synthetics to roofing mills; (2) by a cotton wiper manufacturer into cottons and other textiles (woolens, synthetics); (3) by a wool specialist into various grades of woolens, some for reuse and some for reweaving, and into synthetics; (4) by foreign sorters into various grades of synthetics; these materials are not sorted in the United States; (5) by foreign sorters who receive mixed woolens from the United States.

At the time of our survey, the only commodities selling on the market in any quantity were cotton wipers. The absence of markets for woolens and synthetics was creating a special problem for wiper producers, as can be seen in the following analysis.

Mixed rag bundles contain only about 30 percent cotton. This grade is purchased by the wiper manufacturer for $60 a ton; he must buy 3.33 tons of mixed rags to get 1 ton of cotton. If he cannot sell the 2.33 tons of woolens and synthetics acquired with the cotton, his real outlay for the cotton is $200 per ton (3.33 tons times $60). In addition, he must dump the woolens and synthetics, which costs $5 per 1,200 pound bundle, $8.32 per ton, and $19.39 for 2.33 tons of unusable textiles. The total cost of the cotton, therefore, is $219 per ton. To this must be added sorting, washing, trimming, and baling costs of $240 per ton of cotton (Table 92), plus pickup of mixed rag bundles at $2 per ton, which comes to $6.66 per ton of cotton (3.33 tons times $2). The total price is $466 per ton of cotton, which exceeds the average price received by wiper manufacturers for wipers by some $46. To break even, the manufacturer must sell a ton of woolens or synthetics, for $40 per ton, for every ton of cotton he sells.

The price paid for mixed rag bundles in New York, and elsewhere, has declined from a range of $80 to $120 per ton a few years ago as a direct result of the decline of

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[188] Includes a new account acquired in 1970, a company that has not purchased cullet from this leader in the past 16 years.

[189] Drivers are paid $2.50 an hour; laborers $1.80 an hour; supervisor salaries were conservatively estimated at $800 a month; a third driver is used part time.

wool scrap demand in overseas markets. Ultimately, dealers report, the current problems of the textiles waste industry can be traced back to the 1940 Wool Labelling Act which required the identification of all products made of reprocessed wool. Rewoven products acquired a bad image; domestic reweaving virtually disappeared; and the value of used woolens declined. Foreign markets took up some of the slack, but now foreign markets are fading: virgin wool industries are developing overseas, labor rates are increasing, and obsolete woolens from the United States must compete with European scrap textiles for African markets, where labor is still cheap and local textile industries have not yet developed. Dealers believe that current trends, if they continue, will eventually cause the disappearance of the secondary textile industry.

Wipers, while still moving strong, are also threatened by competing materials whose economics are not dependent on the wool scrap trade, namely mill remnants, paper towels, nonwoven fabrics, and synthetic wipers. These wiper types are generally higher in cost than wipers made from obsolete materials, but the gap is closing as costs of obtaining obsolete materials increase.

One exporter, a firm based in Garden City, Long Island, is introducing another element into the textile scrap business which other dealers eye with anxiety. This company has organized or has a business agreement with a textile sorting and preparation operation in one of the African countries. He is buying mixed rag bundles locally for export and offering prices generally higher than domestic dealers can offer. His African labor cost is $1 a day per man, and he can therefore afford to buy bundles at a higher price, ship overseas, sort and prepare, and even ship back commodities that will sell in the domestic market (wipers). The activity of this single company has resulted, according to local dealers, in a shortage of rag bundles and an upward pressure in price.

We found dealers unanimous in their conviction that textile recovery can be increased (or at least stabilized) only if the Wool Labelling Act is repealed and rewoven wool can once again be sold as new wool.

It was apparent from our interviews and observations that several other problems could plague textile reclamation even if woolens could be sold in quantity. Sorting and grading of textiles is a hand operation accomplished by labor paid the minimum wage or just above minimum. Sorting and grading runs 2 ¢ to 3 ¢ per pound ($40 to $60 per ton). Dealers report that young people cannot be recruited into the business. The proportion of "pure" materials (cotton, wool, and single material synthetics) in textiles is declining. This means on the one hand that readily saleable cotton wipers are a declining percentage of rags and, on the other hand, more sorting and grading of woolens, synthetics, and their blends will be required to move this portion. Collection of textiles is subsidized indirectly by the availability of cheap labor through social service agencies whose role may become less important as social legislation is introduced to put an earning floor under the most needy classes of society.

Rubber Salvage. We interviewed the rubber dealer who buys innertubes, collected at the Fountain Avenue landfill, from the city's reclamation contractor. The dealer characterized rubber reclaiming as a dying business. His own operation has been in the red for several years, and he plans to go out of business.

Tires are picked up from filling stations and garages; the sources must pay for this service; the dealer did not state how much he is paid, but the usual payment is between 10 ¢ and 15 ¢ per tire ($10 to $15 per ton). At one time, he paid 2 ¢ to 3 ¢ per tire, ($2 to $3 per ton) but that was years ago.

Tires are shipped to Connecticut, freight charge being $12 to $13 per ton; the Connecticut reprocessor pays between $6 and $7 per ton, delivered to his plant.

Using these figures, the dealer has between $4 and $10 per ton to collect and sort tires and deliver them for shipment, which means that he breaks even or loses money.

To maintain oneself in this business, according to the dealer, a company must be family owned, with members of the family driving the trucks and doing the work. Union labor rates need not be paid and family members can work as many hours as necessary. If the business is run along conventional lines, however, rubber reclaiming is not profitable.

St. Louis, Missouri[190]

Summary. The purpose of this visit to St. Louis was to inquire about an incinerator residue reclamation program which closed down in March 1969. Tin cans were removed from the residue and sold to copper mines. The operation was closed because of adverse economics.

[190] Survey concluded in October 1969.

Introduction. The city of St. Louis has a population of 680,000. Residential refuse removal is handled by the Refuse Division of the Department of Streets. In 1968, city forces collected 226,000 tons of waste,[191] equivalent to 1.82 pounds per capita per day. The wastes collected exclude all commercial, institutional, and industrial wastes[192] as well as wastes from apartment houses that containerize their wastes and must consequently use private haulers. Wastes are burned in two municipal incinerators; residues are used to fill an empty quarry. Bulky wastes are collected and transferred to a private hauler who conveys them to a private landfill.

Residue Reclamation Program. From April 1968 until March 1969, the city had a contract with a private corporation whereby the city received a standard monthly fee in exchange for which incinerator residues were delivered to the company's facilities; the city was also required to pick up residues at the company plant after these had been processed.

In the period April to December 1968, the city was paid $27,000, at the rate of $1,500 per month per incinerator. In January 1969, the company stopped receiving residues from one of the incinerators; payment dropped to $1,500 a month; in March 1969 the operation closed.

Approximately 12,000 tons of residue were delivered to the salvage contractor monthly in 1968 and 5,200 tons per month in 1969. Of the input materials, an estimated 18% was recovered[193], 7% was lost as moisture or fine, and 75% required disposal in a landfill.

The residues were magnetically sorted into a ferrous metal stream and a stream containing all else. Metals were shredded by hammermilling and loaded on railcars for shipment, presumably to copper mines. Company officials could not be reached to establish final destination of the metal.

The operation was closed down, according to the city, because the contractor could no longer sell the metal extracted for $10 per ton. Their price was reduced to $6 per ton, a price at which the company could not make money.

If 18 percent of the incoming residue was saleable metal, the company obtained 2,160 tons of metal monthly, paying $3,000 for the total amount, or $1.39 per ton. We estimate that operation of the residue plant itself probably cost $7.31 per ton of product (using the experience of the city of Atlanta) and plant amortization cost of $2.70 per ton. This results in a cost of $11.40 per ton of product. The company may have (1) extracted more metal, (2) had lower operating costs, and (3) had lower plant and equipment costs than those used here. It remains fairly certain, however, that the company could not have earned its costs at a $6 per ton selling price.

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[191] Based on 13-month summary.

[192] Exceptions being one hospital and the city market.

[193] Basis is analysis of incinerator residues prepared by Bureau of Mines: Kenahan, Sullivan, Ruppert, and Spano, *Composition and characteristics of municipal incinerator residues*, p.10.

TABLE 59

OVERVIEW OF CASE STUDY COVERAGE

City or area	Materials recovery reported						Sources of material					
										Residential		
	Paper/ board	Metal	Glass	Textiles	Rubber/ plastics	Other	Dump/ fill	Compost plant	Incin- erator	Separate collect.	Social service agency collect.	Commercial
Amarillo		steel cans		mixed		usables	usables, metal		steel cans		textiles	
Atlanta		steel cans				steam			steel, steam			
Chicago	paper, board	steel cans, steel	cullet	mixed	tires	steam	steel		steel, steam			steel, paper, cullet, tires
Cincinnati	paper, board	steel	cullet	mixed	plastics		plastics		steel		paper, metal, textiles	paper, metals, cullet
Connecticut	paper, board	steel, nonferrous		mixed	tires	garbage, hair, feathers, wood	metals, rubber, wood			garbage	textiles, paper, hair, feathers	tires, paper
Gainesville	paper, board	steel, nonferrous		mixed				paper, textiles, metal				
Houston	paper, board	steel cans, steel		mixed		animals		paper, textiles, metal	steel cans, steel		paper, textiles, metal	paper, metal
Louisville	paper, board	steel cans, steel							steel cans, steel			paper, metal
Los Angeles	paper, board	steel, aluminum	cullet	mixed	tires					metal, glass	textiles, paper, metal	tires, paper, glass
Madison	paper	steel, nonferrous		mixed						news- paper	textiles	metal
Mobile	paper, board	steel cans		mixed			all items	metal, paper			textiles	
New Orleans	board	steel cans	cullet				all items		steel cans			glass, metal
New York	paper, board	steel, nonferrous	cullet	mixed	tires		metal, textiles, rubber		metal, textiles, paper	news- paper	textiles, paper	paper, metal tires, glass
St. Louis		steel cans							steel cans			

TABLE 60

REVENUES AND EXPENSES OF AMARILLO'S SALVATION ARMY FACILITY - 1969*

Category	Amount	
Revenues:		
Sale of rags (at $2.75 per hundredweight)	$ 5,145	
Revenue of the retail store	31,855	
Total revenue		$37,000
Expenses:		
Rent	$ 3,530	
Utilities	900	
Wages--7 people	17,000	
Wage-related expenses	2,900	
Food	2,000	
Shop equipment	1,200	
Freight charges on rag shipments	1,500	
Miscellaneous (transport and related waste disposal, repair of salvage, etc.)	10,070	
Total expenses		$39,100
Net loss		($ 2,100)

*From Salvation Army Facility, Amarillo, Texas.

TABLE 61

ESTIMATED INCOME AND EXPENSES OF A STEEL CAN RECLAIMING OPERATION IN AMARILLO, TEXAS*

Category	Cost	Useful life-years	Amortization factor at 8% interest	Annual cost	Cost per tons of product, 4,000 tons per year
Capital-related expenses					
Land	$20,000	-	0.08	$ 1,600	
Warehouse	5,000	20	0.102	510	
Can shredding plant	55,000	10	0.149	8,195	
Trucks	7,600	5	0.250	1,900	
Loader	10,500	5	0.250	2,625	
Subtotal	$98,100			$ 14,830	
Maintenance (4% of investment excluding land)				$ 3,124	
Insurance (1% of investment excluding land)				781	
Administrative and general expenses (1% of total investment)				981	
Property taxes (2% of total investment)				1,962	
Subtotal				$ 6,848	
Total capital-related expenses				$ 21,678	5.41
Operating costs					
Lease of rail siding				$ 12,000	
Payroll, including payroll burdens				44,000	
Fuel and lubricants				4,000	
Total operating expenses				$ 60,000	15.00
General overhead expenses					
Office salaries				$ 12,000	
Utilities				2,000	
Supplies				3,000	
Miscellaneous				8,000	
Total general overhead expenses				$ 25,000	6.25
Other expenses					
Freight on 4,600 tons				$ 89,600	22.40
Payment to the city for 4,600 tons of product				2,000	0.50
Total other expenses				$ 91,600	22.90
Total expenses				$198,278	49.56
Total income				$220,000	55.00
Gross profit				$ 21,722	5.43

* From APCO Metals Company, City of Amarillo, Texas, and Midwest Research Institute estimates.

TABLE 62

COST TO PROCESS ONE NET TON OF SALVAGE METAL FOR SHIPMENT*

Category	Cost per ton
Labor	$ 4.82
Power	.80
Maintenance labor	.81
Parts replacement	.88
Original equipment amortization (20 years)	2.70
Total cost	$10.01
Selling price	$10.27

*From Atlanta Sanitation Department, internal study, February 20, 1969.
Note: Excludes costs of potable water used to wash cans; water costs are treated as a single expenditure item by the city and costs are not allocated down to operating department.

TABLE 63

RESIDUE RECOVERY AT THE CHICAGO SOUTHWEST INCINERATOR, 1969*

Category	Units
Refuse delivered	274,960 tons
Metals average 8.0%	21,997 tons
Residue	208,318 cu. yd.
Residue average 1,500 lb/cu. yd.	156,238 tons
Dry residue (32% quench moisture)	106,241 tons ←—— (38.6% of input)
Sales of cans	9,214 tons ←—— (8.7% of residue)

* From Department of Sanitation, Chicago, and Midwest Research Institute estimates.

TABLE 64

STEAM SALES OF CHICAGO'S SOUTHWEST INCINERATOR*

Year	Steam sold--lb.	Revenue
1968	247,065,810	$167,296
1969	238,344,081	$159,062

* From: Department of Sanitation, Chicago.

TABLE 65

STEEL CAN RECOVERY, INCINERATOR, INC., 1969 AND 1970*

Year	Revenue/input ton	Tons sold	Revenue/ton sold
1969	$0.23	4,870	$7.55†
1970 (5 mo.)	$0.156	N.A.	$5.25

*From Incinerator, Inc., Chicago, Illinois.
†Calculated by MRI based on throughput tonnage reported by company.

TABLE 66

WASTE HANDLING PROFILES
OF FOUR CONNECTICUT COMMUNITIES*

Community	Population	Tons disposed in municipal disposal facilities	Pounds per person per day disposal	Annual salvage income	Salvage income per ton of waste disposed	Period for which reported
Darien	23,000	12,048	2.87	500	0.04	1969
New Canaan	10,000	10,500	5.75	1,200	0.11	1969
New Britain	86,000	66,576	4.24	1,895	0.03	4/68-3/69
Berlin	15,000	7,297	2.67			4/68-3/69

* From sanitation departments of the communities.

Berlin wastes are disposed of in New Britain disposal facilities; salvage income derived from salvage contract at New Britain's dump; salvage was discontinued in early 1969.

TABLE 67

COLLECTION AND REVENUES OF GOODWILL INDUSTRIES, INC., BRIDGEPORT, CONNECTICUT, 1968*

Type of commodity collected	Wt. in net tons	Revenues in dollars	Revenues per ton in dollars
Store usables			
Soft goods	98.5		
Hard goods	289.3		
Total usables	388.8	400,490	1,030.07
Salvage			
Rags, mixed	989.4	69,460	70.20
Cottons	19.2	318	16.56
Special rags	2.4	585	243.75
Hair and feathers	4.3	492	114.41
Paper (news and mixed)	188.6	3,155	16.73
Total salvage	1,202.9	74,010	61.53
Unusable materials dumped	397.5	--	--
Total collections	1,989.2	474,500	238.54

* From Goodwill Industries, Inc., Bridgeport, Connecticut, organizational records.

TABLE 68

PRICES RECEIVED FOR SALVAGE COMMODITIES
BY GOODWILL INDUSTRIES, INC., BRIDGEPORT
CONNECTICUT, 1968*

Type of community	Price per net ton in dollars
Mixed rags	$ 65.00 - $ 70.00
Special rags	130.00
White wipers	240.00
White cottons	100.00
Mixed cottons	45.00
Cattle hair	20.00
Feathers	18.00
Horsehair	20.00
Folded newspapers	20.00
Mixed papers	8.00

* From Goodwill Industries, Inc., Bridgeport, Connecticut, organizational records.

TABLE 69

TONNAGE OF WASTE COLLECTED AND DISPOSED IN GAINESVILLE AREA IN 1969*+

Wastes delivered by	Wastes delivered to			Total disposal
	Compost plant	University landfill	Municipal landfill of Gainesville	
Municipal collection forces from Gainesville (excluding University of Florida)	26,350	--	11,090	37,440
Private contract haulers from Alachua County (excluding Gainesville)	3,030	--	6,320	9,360
University of Florida forces from University of Florida properties	4,680	7,500	--	12,180
Private forces of corporations and individuals	--	--	10,400	10,400
Total	34,080	7,500	27,810	69,380

* From records of the Gainesville Municipal Waste Control Department, the Gainesville Municipal Compost Authority, and estimates made by the owners of Mallard Garbage Service and Mallard Trash Hauling Service, both of Gainesville, Florida.

\+ Includes all residential, commercial, and industrial wastes.

TABLE 70

CHARACTERISTICS OF WASTE ENTERING GAINESVILLE COMPOSTING PLANT IN 1969*

Type of waste	% of weight+	Tons in 1969#	Salvaged and sold in 1969		
			Tons	% of material	% of total input
Paper	52.59	17,923	2,254	12.58	6.61
Ferrous metals	6.75	2,300			
Nonferrous metals	0.77	262			
Textiles	2.69	917	1.37	0.15	0.004
Glass and ceramics	5.59	1,905			
Plastics, leather	4.38	1,493			
Wood	2.70	920			
Garden waste	11.56	3,940			
Food	6.36	2,167			
Ashes	5.24	1,786			
Miscellaneous	1.37	467			
Total	100.00	34,080	2,255	--	6.61

* From unpublished records of Gainesville Metropolitan Waste Conversion Authority.

\+ Based on samples taken on January 24, July 8, and August 21, 1969, and samples taken during the week of September 10-16, 1969; all told, 2,960 pounds of waste were removed for sampling.

\# Breakdown of tonnage calculated by using compositional percentages and applying these to data on total tonnage delivered to the compost plant.

TABLE 71

HOUSTON REFUSE COMPOSITION BY WEIGHT*

Material category	Composition-%	Estimated 1969 tonnage
Paper	44.9	41,538
Textiles	3.2	2,960
Steel cans	7.5	6,938
Other metals	0.6	555
Glass	7.5	6,938
Compostable organics	32.8	30,344
Inert residues	3.5	3,238
Total	100.0	92,512+

* From Public Works Department, City of Houston.

\+ Subtotals fall short of total because of rounding.

TABLE 72

WASTE RECEIVED AND STEEL SCRAP RECOVERED
AT THE HOLMES ROAD INCINERATOR, HOUSTON, TEXAS
NOVEMBER 1967 TO APRIL 1969*

Date	Waste received (tons)	Steel cans recovered (tons)	Steel cans as % of input tonnage	Other metal scrap recovered (tons)
November 1967	7,369	314	4.26	--
December	8,256	576	6.98	--
January 1968	6,627	349	5.26	--
February	--	INCINERATOR CLOSED		--
March	3,354	243	7.24	--
April	11,257	643	5.71	--
May	11,162	745	5.78	--
June	7,169	414	5.77	12
July	10,256	598	5.83	14
August	11,365	650	5.72	13
September	8,513	535	6.28	10
October	6,136	405	6.60	7
November	7,977	405	5.07	12
December	9,537	535	5.61	7
Total, 1968	93,344	5,522	5.91	75
January 1969	12,374	695	5.62	--
February	11,588	639	5.51	5
March	11,081	463	4.18	--
Grand Total	144,201	8,107	5.63	80

* From incineration records of Public Works Department, City of Houston, Texas.

TABLE 73

COLLECTIONS AND SALES OF SALVATION
ARMY FACILITY OF HOUSTON, TEXAS, 1969*

Type of commodity collected	Wt. in tons	Revenues in $	Revenues per ton in $
Store usables			
Clothing	264		
Other	2,700		
Total useables	2,964	264,000	89.07
Salvage			
Textile rags	337	20,246	60.00
Mixed paper	210	1,680	8.00
Mixed metal scrap	742	4,454	6.00
Total salvage	1,289	26,380	20.46
Total usables and salvage	4,253	290,380	68.28

* From: Salvation Army facility headquarters, Houston Texas; tonnages were computed from monthly averages and adjusted to annual income in 1969 sales prices received for salvage goods.

TABLE 74

COMPOSITION OF ALL HOUSTON MUNICIPAL SOLID WASTES IN WEIGHT PERCENT AND ESTIMATED TONNAGE OF MATERIALS IN WASTE IN 1969*

Type of waste	% by wt.	Estimated tons of material in waste in 1969
Paper	37.0	462,500
Ferrous metal	7.5	93,750
Nonferrous metal	0.5	6,250
Textiles	1.5	18,750
Glass	10.0	125,000
All other	43.5	543,750
Total	100.0	1,250,000

*From estimates of Refuse Division, Public Works Department, City of Houston, Texas.

TABLE 75

ALUMINUM RECEIVED BY REYNOLDS
CAN RECLAMATION CENTER IN LOS ANGELES
AUGUST 1969 TO DECEMBER 1970*

Year	Month	Tons of aluminum received
1969	August	22.38
	September	22.86
	October	32.11
	November	25.39
	December	36.23
	Total, 1969	138.97
1970	January	33.02
	February	33.74
	March	32.63
	April	32.45
	May	52.26
	June	80.05
	July	81.13
	August	79.33
	September	90.21
	October	96.40
	November	78.15
	December	108.53
	Total, 1970	807.90

* From Reynolds Metals Company records.

TABLE 76

SUMMARY OF DATA AND ESTIMATES CONCERNING SALVAGE OPERATIONS OF GOODWILL INDUSTRIES, INC. OF SOUTHERN CALIFORNIA. 1967 to 1968*

Item	1967	1968	1969
Collection			
Number of residential pickup calls	94,827	94,716	98,358
Number of booth pickups	154,701	177,463	177,226
Total pickups	248,988	272,278	275,584
Booths on location	759	769	807
Bags collected from booth	3,174,816	3,248,568	3,234,635
Collection expenditures, total			$945,253+
Collection expenditures per pickup			$3.43
Tons of material collected			
Metal scrap	2,500	2,100	1,850
Waste paper	144	151	160
Rag textiles	3,061	3,084	3,542
Total salvage	5,705	5,335	5,552
Tons of other materials collected and sold in stores (est.)	3,130	5,420	5,334
Total collected	8,835	10,755	10,886
Revenues			
Metal scrap	$20,000	$8,400	$11,100
Waste paper	1,728	2,718	3,200
Rag textiles	214,270	231,300	283,360
Total salvage revenues	$235,998	$242,418	$297,660
Store sales (est.)			3,614,440
Donations and services (est.)			340,180
Total			$4,252,280

* From Goodwill Industries, Inc., of Southern California and Midwest Research Institute estimates.

\+ Extrapolated from 5 months of data.

TABLE 77

ECONOMIC ANALYSIS OF MADISON NEWSPAPER RECOVERY PROGRAM, EAST SIDE, JANUARY 1969 to 1970, IN DOLLARS PER TON*

Month	Year	(1) Extra collection costs of credit	(2) Special handling and transport costs	(3) Disposal cost saved	(4) Price paid to Madison	(5) Apparent profit or (loss) to city
January	1969	-0-	58.39	2.25	14.00	(42.14)
February		-0-	44.85	2.25	14.00	(28.60)
March		-0-	34.35	2.25	12.00	(20.10)
April		-0-	26.33	2.25	9.00	(15.08)
May		-0-	23.18	2.25	7.00	(13.93)
June		-0-	23.64	2.25	7.00	(14.39)
July		-0-	21.80	2.25	9.00	(10.55)
August		-0-	19.72	2.25	9.00	(8.47)
September		-0-	19.84	2.25	7.00	(10.59)
October		-0-	17.13	2.25	7.00	(7.88)
November		-0-	17.18	2.25	7.00	(7.93)
December	1969	-0-	23.24	2.25	7.00	(13.99)
January	1970	-0-	21.88	2.25	7.00	(12.63)
February		-0-	15.87	2.25	7.00	(6.62)
March		-0-	13.58	2.25	7.00	(4.33)
April		-0-	11.30	2.25	6.00	(3.05)
May		-0-	12.03	2.25	6.00	(3.78)
June		-0-	13.13	2.25	6.00	(4.88)
July	1970	-0-	14.67	2.25	6.00	(6.42)
Total for period		-0-	21.83	2.25	7.90	(11.68)

* From Sanitation Department, City of Madison; Midwest Research Institute.

Notes: Column (1) - Extra collection costs are not discernible for basket-equipped trucks. Column (2) - These are direct labor and truck costs and exclude supervision, administrative overhead, and amortization. Column (3) - These are direct costs based on 1968 experience. They include salary, fringe benefits, equipment operating costs and amortization, and disposal site costs (roads, fences, etc.). Excluded are administrative overhead, drainage, and land costs.

TABLE 78

MADISON NEWSPAPER RECOVERY PROGRAM, ANALYSIS OF EAST SIDE TONNAGE DATA, JANUARY 1969 to July 1970*

Month	Year	Newspaper circulation - tons	Newspaper recovery by city - tons	Total refuse collected by compactor trucks - tons+	Newsprint recovery % of news	Newsprint recovery % of refuse
January	1969	246.0	65.92	1,898	26.8	3.5
February		224.9	64.78	1,577	28.8	4.1
March		254.4	69.04	1,627	27.1	4.2
April		239.2	85.81	2,254	35.9	3.8
May		246.8	88.65	2,196	35.9	4.0
June		244.9	83.60	2,393	34.1	3.5
July		237.4	79.19	2,310	33.7	3.4
August		243.2	67.21	2,137	27.6	3.1
September		235.1	71.85	2,070	30.6	3.5
October		245.8	81.19	2,104	33.0	3.8
November		248.9	66.56	1,892	26.7	3.5
December	1969	246.3	70.78	1,934	28.7	3.7
Total,	1969	2,912.9	894.58	24,392	30.7	3.7
January	1970	246.3	59.65	1,812	24.2	3.3
February		225.4	62.97	1,537	27.9	4.1
March		225.2	79.05	1,809	31.0	4.4
April		239.8	99.94	2,414	41.7	4.1
May		256.0	95.37	2,436	37.3	3.9
June		253.3	99.72	2,493	42.4	4.2
July	1970	237.7	91.56	2,241	38.5	4.1
Total, 7 months		1,695.1#	588.26	14,742#	34.7	4.0
Total for period		4,608.0	1,482.84	39,134	32.2	3.8

* From Madison Newspapers, Inc.; Sanitation Department, City of Madison; Midwest Research Institute.

\+ Includes newspapers collected and sold by city.

\# Apparent newspaper content of waste is 11.5 percent.

TABLE 79

MADISON NEWSPAPER RECOVERY PROGRAM, ANALYSIS OF WEST SIDE TONNAGE DATA, APRIL 1970 - JULY 1970*

Month	Year	Newspaper circulation - tons	Newspaper collected by city - tons	Total refuse collected by compactor trucks - tons#	Newsprint recovery % of news	Newsprint recovery % of refuse
April	1970	285.3	138.86	2,400	48.7	5.8
May		304.7	125.23	2,427	41.1	5.2
June		282.2	129.78	2,555	46.0	5.1
July	1970	287.4	112.58	2,038	39.2	5.5
Total, 4 months		1,159.6**	506.45	9,400**	43.7	5.4

* From Madison Newspapers, Inc.; Sanitation Department, City of Madison; Midwest Research Institute.

\+ West side collection program initiated along with local publicity.

\# Includes newspapers collected and sold by city.

** Apparent newspaper content of waste is 12.3 percent.

TABLE 80

ECONOMIC ANALYSIS OF MADISON NEWSPAPER RECOVERY PROGRAM, WEST SIDE, APRIL 1970 - JULY 1970, IN DOLLARS PER TON*

Month	Year	(1) Extra collection costs of credit	(2) Special handling and transport costs	(3) Disposal cost saved	(4) Price paid to Madison	(5) Apparent profit or (loss) to city
April	1970	-0-	3.82	2.25	6.00	4.43
May		-0-	4.43	2.25	6.00	3.82
June		-0-	4.94	2.25	12.00	9.31
July	1970	-0-	4.35	2.25	6.00	3.90

* From Sanitation Department, City of Madison; Midwest Research Institute.

Notes: Column (1) - Extra collection costs are not discernible for basket-equipped trucks. Column (2) - These are direct labor and truck costs and exclude supervision, administrative overhead, and amortization. Column (3) - These are direct costs based on 1968 experience. They include salary, fringe benefits, equipment operating costs and amortization, and disposal site costs (roads, fences, etc.). Excluded are administrative overhead, drainage, and land costs. In addition, the refuse milling operation on the West side costs nearly $6.50 per ton (milling and disposal) under conditions existing at the time of this study, but have been excluded here as a credit.

TABLE 81

SUMMARY OF PROFIT AND LOSS OF MADISON NEWSPAPER RECOVERY PROGRAM, JANUARY 1969 TO JULY 1970*

Month	Year	Tons of newspaper sold by city	Profit or (loss) to city $/ton	Total profit or (loss) to city $
January	1969	65.92	$(42.14)	$(2,777.87)
February	1969	64.78	(28.60)	(1,852.71)
March	1969	69.04	(20.10)	(1,387.70)
April	1969	85.81	(15.08)	(1,294.01)
May	1969	88.65	(13.93)	(1,234.89)
June	1969	83.60	(14.39)	(1,203.00)
July	1969	79.19	(10.55)	(835.45)
August	1969	67.21	(8.47)	(569.27)
September	1969	71.85	(10.59)	(760.89)
October	1969	81.19	(7.88)	(639.78)
November	1969	66.56	(7.93)	(527.82)
December	1969	70.78	(13.99)	(990.21)
Total 1969		894.58	$(15.73)	$(14.073.60)
January	1970	59.65	$(12.63)	$(753.38)
February	1970	62.97	(6.62)	(416.86)
March	1970	79.05	(4.33)	(342.29)
April	1970	238.80+	1.30	310.33
May	1970	220.60	0.53	117.88
June	1970	229.50	3.14	721.62
July	1970	204.14	(0.73)	(148.76)
Total, January - July 1970		1,094.71	$(0.47)	$(511.46)
Total, April - July 1970		893.04	$ 1.12	$1,001.07

* From City of Madison Sanitation Department Records; calculations by Midwest Research Institute, from Tables 77, 78, 79, and 80.

\+ Program expanded to city-wide collection.

TABLE 82

MADISON NEWSPAPER RECOVERY PROGRAM, ANALYSIS OF TONNAGE DATA, TOTAL CITY, APRIL TO JULY 1970*

Month	Year	Newspaper circulation - tons	Newspaper collected by city - tons	Total refuse collected by compactor trucks - tons	Newsprint recovery % of news	Newsprint recovery % of refuse
April	1970	525.1	238.80	4,814	45.5	5.0
May		560.7	220.60	4,863	39.3	4.5
June		517.5	229.50	5,048	44.3	4.5
July	1970	525.1	204.14	4,279	38.9	4.8
Total, 4 months		2,128.4	893.04	19,004	42.0	4.7

* From Madison Newspapers, Inc.; Sanitation Department, City of Madison; Midwest Research Institute.

TABLE 83

MOBILE COMPOST PLANT WASTE INPUTS, OUTPUTS, AND REVENUES FOR 1969*

Category	Inputs and outputs, tons	Revenues $
Total waste received	9,600	--
Paper separated and sold	163	1,140
Steel cans separated and sold	674	4,042
Compost produced	5,593	31,813
Residue waste landfilled	3,170	--
Total	9,600	36,995

* From Mobile Compost Plant and Department of Budget and Revenue, City of Mobile.

TABLE 84

BULK GRADE PAPER RECOVERED AND CONSUMED IN MOBILE, ALABAMA, 1969*

Materials and sources		Tons collected	Tons consumed	Apparent imports (tons)
Newsprint dealers		3,810	10,560	6,750
Old corrugated dealers		6,615	13,550	6,935
Mixed paper or grade unknown				
Dealers	1,350			
Compost plant	160			
Direct sales by public and peddlers	2,100			
Total mixed		3,610	4,950	1,340
Total		14,035	29,060	15,025

* From estimates or records of John Gault, H. A. Norden, and Marine Junk (dealers); Stone Container Corporation, National Gypsum, and Rubbermaid Corporation (consumers); and Mobile Municipal composting plant.

TABLE 85

TYPES AND QUANTITIES OF MATERIALS REMOVED BY A RECLAMATION CONTRACTOR FROM THE FOUNTAIN AVENUE LANDFILL, NEW YORK CITY, JULY 1, 1968 TO JUNE 30, 1969*

Type of material	Quantity removed, in tons
Iron	793.6
"Tin"+	1,862.8
"Satinettes"+	229.4
Rags	255.9
"Brass"+	229.2
Total	3,370.9

* From records of Department of Sanitation, City of New York.

\+ See explanatory comments in text.

TABLE 86

PRICES RECEIVED BY RECLAMATION CONTRACTOR
FOR SELECTED COMMODITIES AND ESTIMATED
ANNUAL INCOME FROM THEIR SALE*

Type of commodity	Estimated quantity sold, per year, tons	Price, per ton, $	Estimated annual income realized, $
Iron and steel	793.6	23.00	18,252.80
Enamel-coated steel	1,862.8	8.00	14,602.40
Horse and cattle hair	229.4	32.50	7,455.50
Nonferrous metals	229.2	290.00	66,468.00
Textiles	255.9	60.00	15,334.00
Total	3,370.9	30.29	112,112.70

* From records of Department of Sanitation, City of New York, Votta, Inc., and Midwest Research Institute estimates.

TABLE 87

TYPE, VALUE, AND ESTIMATED USEFUL LIFE OF EQUIPMENT OWNED BY RECLAMATION CONTRACTOR*

Type of equipment	Value, $	Estimated useful life, years	Capital recovery factor at 8% interest	Annual cost, $
Crane trucks (2)	6,000	5	0.250	150
Closed body truck	5,000	5	0.250	125
Crane	17,000	10	0.149	2,533
Shears (2)	7,100	10	0.149	1,058
Baler	6,000	15	0.117	702
Wire stripper	1,300	10	0.149	194
Front-end loaders (2)	8,300	15	0.117	971
Total	50,700			5,733

* From Votta, Inc., New York, New York, June 1970; Midwest Research Institute.

TABLE 88

ESTIMATED DAILY INCOME, EXPENSES, AND PROFIT
OF A 400 TONS PER DAY WASTE PROCESSING FACILITY*

Category	Per day	Per ton of input
Daily income		
Disposal fees at $2.15/cubic yard+	$4,000.00	$10.00
Sales of 100 tons of corrugated at $30/ton	3,000.00	7.50
Total income	$7,000.00	$17.50
Expenses		
Contribution to special research fund of a waste trade association, 25 percent of fees	$1,000.00	$ 2.50
Operating expenses, including amortization	4,000.00	10.00
Total expenses	$5,000.00	$12.50
Profit	$2,000.00	$ 5.00

* From Intergeneral Industries, Inc., Brooklyn, New York, June 1970.

\+ Assumes 430 pounds per cubic yard.

TABLE 89

RAG SALES OF THREE SOCIAL SERVICE AGENCIES IN NEW YORK CITY*

Agency	Time period	Tons sold	Price received per ton
Volunteers of America	Average year	520-720	$65
Salvation Army	10/1969; 9/1970+	777	61
Goodwill Industries	Average year	1,200	40-60

* From Volunteers of America, Queens, New York; Salvation Army, New York, New York; Goodwill Industries, Inc., New York, New York.

\+ Extrapolated from 7-month data, October 1, 1969 to April 30, 1970.

TABLE 90

SALES VALUE RECEIPTS BY VOLUNTEERS OF AMERICA
FOR WASTE PAPER AND PRICES RECEIVED BY THE AGENCY FROM DEALERS*

Type of paper	Sales value per ton - $	Price received per ton - $
IBM cards	$52.50	$69.00
White ledger	30.00	42.00
Colored ledger	20.00	30.00
Corrugated	15.00	18.00
Mixed paper	6.00	8.00
Newspapers	--	24.00

* Volunteers of America, Queens, New York, 1970.

TABLE 91

GLASS CULLET SOLD BY NEW JERSEY
DEALER IN 1966, 1967, 1968, AND 1969, IN TONS AND DOLLARS*

Type of glass sold	Tons sold in 1966	1967	1968	1969
Flint	3,723	2,134	1,605	460
Window glass	872	5,185	3,444	1,035
Green	957	1,060	1,046	758
Amber	1,790	3,283	2,386	2,766
Total	7,342	11,662	8,481	5,019
Dollar sales in year	$127,397	$202,837	$168,178	$101,699
Average price per ton	$17.35	$17.39	$19.83	$20.26

* From records of New Jersey Cullet Supply Corporation, Jersey City, New Jersey.

TABLE 92

REPRESENTATIVE PROCESSING COSTS OF
A WIPING RAG MANUFACTURER IN NEW YORK*

Operation	Cost per pound of cotton sold - in ¢	Cost per ton in $	Comments
Sorting	3¢	$ 60	Includes grading
Washing and drying	5	100	Includes losses
Trimming	3	60	Includes losses of trimmed material
Packaging/baling	1	20	Includes packing materials
Total cost	12¢	$240	

* From Dean Wiping Cloth, Brooklyn, New York, 1970.

CHAPTER XII

MAIL SURVEY RESULTS

As part of this research, and in fulfillment of a contractual requirement to develop a "catalog" of municipal salvage activities, we conducted a mail survey of communities with populations of 10,000 and above to determine how many communities had officially sponsored salvage and recovery programs.

A total of 1,950 questionnaires were mailed;[194] responses were received from 944 communities in time to be tabulated, or 48.4 percent. The responding communities' total population is 53.4 million people — approximately 27 percent of the total United States population and roughly 40 percent of the urban population.

Of the number of communities responding, 890 (94.3 percent) had no salvage program and 54 (5.7 percent) did. On a population basis, negative responses were turned in on behalf of 47.9 million people (89.7 percent) and positive responses on behalf of 5.5 million people (10.3 percent) (Table 93).

The case study cities (Chapter XI) covered by field survey by MRI gave additional information not detailed by answers to the questionnaire. In the 10 case study cities not answering the questionnaire, a total population of 21.1 million people was covered, with waste collection and disposal of 11.2 million tons and salvage recovery of 20,800 tons from municipal waste. Salvage from municipal waste is carried out currently in Chicago, Illinois; three Connecticut communities; Mobile, Alabama; and New York, New York. (Atlanta, Georgia; Houston, Texas; Louisville, Kentucky; and Madison, Wisconsin, were surveyed in the field and also replied to the questionnaire so their responses are included in the tabulated replies in this chapter.)

Thus, in total, this study covers the municipal salvage practices of 956 communities, 74.5 million people, and 57 communities with some type of current municipal salvage, representing 17.5 million people in those communities.

Only 25 of the 54 cities responding positively to the questionnaire gave sufficient information for analysis. In these cities, waste commodities equivalent to 3.68 percent of solid waste disposed of were recovered, chiefly by recovery of materials at landfill sites. Total identifiable tonnage recovered by the 25 cities that gave detailed information was 59,500 tons a year. If we assume that all 54 cities reporting positively recovered at the same rate (on a population basis) as the 25 cities that gave tonnage data, total recovery from all responding communities was 121,200 tons yearly, or 4.5 pounds per capita. This, extrapolated to a population of 200 million, would indicate a total recovery of commodities from municipal waste sources of 450,000 tons a year, or less than 1 percent of total materials recycled.

Municipalities with Recovery Programs

Responses by the 54 communities with recovery programs are displayed in Tables 94 and 95. Table 94 shows the communities that gave a sufficiently complete response to permit comparative analysis (25 cities); Table 95 shows the remainder (29 cities). The discussion below refers only to data given in Table 94.

The 25 communities with programs and a reasonably complete response to all key questions had a population of 2.8 million. These communities collected 1.3 million tons of waste (2.6 pounds per capita per day) and disposed of 1.6 million tons of waste in community operated facilities; the excess of disposed tonnage over collected tonnage is accounted for by privately collected wastes disposed of in municipal facilities.

[194] See Appendix C for a copy of the questionnaire used.

All told, these cities recovered 59,525 tons of commodities from waste, equivalent to 3.68 percent of disposal tonnage. Of the total, 36,225 tons were given by type of material recovered or product in the case of compost. Proportions were:

	Percent
Paper/board	48.75
Iron/steel	28.13
Other metals	1.47
Glass/ceramics	1.88
Plastic/rubber	0.06
Textiles	0.03
Organics, other materials for compost	19.68
Total	100.00

Six cities recovered materials by separate collection only, 14 recovered at landfill sites only, two at incinerators only, one at a compost plant, one by both separate collection and at an incinerator, and one by both separate collection and at a landfill site.

Ten of the 25 cities carried out salvage by contract with salvors; the remainder employed their own forces. Payments to the city ranged from a low of 2¢ per ton salvaged to a high of $9.83 per ton; the average was 84¢ per ton. On a tonnage basis, 37 percent of the total salvage quantity was recovered under contract.

Municipalities Without Recovery Programs

Data on communities responding negatively are summarized in Table 96. These cities represented a total population of 48.6 million people in 833 communities. Of these, 92 cities practiced salvage in the past but dropped the practice because: (1) income did not justify costs; (2) appropriate labor could not be recruited; and (3) salvage products could not be sold. A total of 693 cities had had no past salvage activity; 48 cities failed to respond to the question concerning past activities. Scavenging is permitted in 111 communities and prohibited in 647. No response was received from 75. Where scavenging was permitted, respondents guessed that tonnage removed was minimal and consisted of resaleable or reusable products.

TABLE 93

RESPONSES TO QUESTIONNAIRE*

Community category	Number of responses	Percent of total response	Population	Percent of total population
Communities with no recovery program+	890	94.3	47,901,668	89.7
Communities with recovery program	54	5.7	5,459,129	10.3
Total	944	100.0	53,360,797	100.0

* From Municipal Solid Waste Salvage Practices Survey conducted by Midwest Research Institute.

\+ Also includes 57 communities that gave neither a positive nor negative response.

TABLE 94

CITIES WITH RECOVERY PROGRAM AND COMPLETE RESPONSE

City	Population	Annual tonnage: Collected (000)	Annual tonnage: Disposed (000)	Annual tonnage: Salvaged	Salvage as % of disposal	Salvage by contract	Annual value of contract ($)	Materials salvaged, tons annually: Paper/paperboard	Iron/steel	Other metals	Glass/ceramic	Plastic/rubber	Textiles	Other	Facilities: Incinerator	Land disposal site	Separate collection
Bay Village, Ohio	18,000	8.0	8.0	70	0.88	No	-		70								X
Las Cruces, N. Mex.	45,000	12.0	12.0	24/30	0.2-0.25	Yes	$ 250		24/30							X	
Tulare, Calif.	16,253	2.6	2.6	61	2.3	Yes	30	24	37							X	
Madison, Wisc.	170,000	40.0	120.0	1,000	0.83	No	-	1,000									X
Winston-Salem, N.C.	150,000	80.0	150.0	6,000	4.0	No	-	6,000									X
Merced, Calif.	25,000	29.0	35.0	3,200	9.1	Yes	2,500	1,200	2,000							X	
Cullman, Calif.	12,196	12.0	12.0	20	1.6	No	-		10			10				X	
Albany, Ga.	72,000	48.0	80.0	531	0.66	Yes	1,200	520	10	1						X	
Rock Island, Ill.	51,000	10.0	32.0	290	2.90	Yes	2,500	150	10	10	20	10	10	X*		X	
Orlando, Fla.	100,000	50.4	50.4	11,400	22.6	Yes	250	X*	X*	X*	X*	X*	X*	X*	X		X
Westport, Conn.	32,000	20.0	20.0	550	2.75	No	-	500	50							X	
Sacramento, Calif.	272,000	81.0#	81.0#	272	0.34	Yes	2,674		272							X	
Beacon, N.Y.	75,000	10.4	10.4	600	5.76	No	-		500	100						X	X
Buffalo, N.Y.	480,000	430.0	430.0	2,000	0.46	No	-		2,000							X	
Louisville, Ky.	400,000	281.7#	281.7#	5,000	1.77	Yes	5,000		5,000								
Altoona, Pa.	70,000	9.6	9.6	7,133	74.3	No	-							7,133**	X	X++	
Madera, Calif.	17,000	6.0	6.0	240	4.0	No	-			240						X	
Alexandria, La.	50,000	39.0	65.0	7,000	10.76	No	-	X*		X*						X	
Pekin, Ill.	31,000	52.0	52.0	4,000	7.7	No	-	X*	X*							X	
Atlanta, Ga.	478,000	35.7	35.7	6,250	1.7	No	-	6,250							X		
Claremont, Calif.	24,000	14.0	14.0	1,478+	10.6	No	-	816+		2+	660+						X
Sheridan, Wyo.	11,600	5.0	5.0	100	2.0	Yes	75		100							X	
Corvalles, Oreg.	36,000	15.0	15.0	1,200	8.0	No	-	1,200									X
Weymouth, Mass.	55,000	20.0	30.0	1,000	3.3	Yes	4,000		X*	X*							X
Waltham, Mass.	62,000	-	60.0	100	0.002	No	-		100							X	
Total	2,753,049	1,311.4	1,617.4	59,525				17,660	10,189	533	680	20	10	7,133	3	15	8

* Indicates that type of material is recovered but tonnage is not given.
\+ Extrapolated by MRI from 1 month's data on a new program.
\# Correction of an obvious decimal place displacement error by respondent.
** Compost made from refuse.
++ Compost plant.

TABLE 95

CITIES WITH RECOVERY PROGRAMS AND INCOMPLETE RESPONSE

City	Population	Annual tonnage: Collected (000)	Annual tonnage: Disposed (000)	Annual tonnage: Salvaged	Salvage as % of disposal	Salvage by contract	Annual value of contract ($)	Materials salvaged, tons annually: Paper/ paper-board	Iron/ steel	Other metals	Glass/ ceramic	Plastic/ rubber	Textiles	Other	Facilities: Incinerator	Land disposal site	Separate collection
Hattiesburg, Miss.	38,000	12.0	12.0			Yes	$30,000	X			X	X				X	
Delano, Calif.	15,000	20.0	17.5			No		X	X	X	X	X	X	X		X	
Lake Jackson, Tex.	15,000	30.0	30.0						X	X							
Killeen, Tex.	36,000					No			X							X	
Arlington, Tex.	100,000	130.0	130.0			Yes	2,100		X				X	X		X	
Bridgeport, Conn.	160,000			1,700		No			1,500	200						X	X
So. St. Paul, Minn.	25,000	5.0															
Weston, Mass.	11,046					No			X			X				X	
Waterloo, Iowa	75,000	4.0				Yes	4,000										
San Carlos, Calif.	60,000	20.0		1,500		No		1,500								X	
Newport Beach, Calif.	47,678	39.7	39.7			Yes	$21/ton	X									X
Rapid City, S. Dak.	50,000	15.1				No											
Belmont, Mass.	30,000	20.8		205		No			36	169					X		
Salt Lake City, Utah	189,000	70.0	140.0			Yes	5,000	X								X	
Ferndale, Mich.	30,000	19.2				No											
Athens, Ohio	30,000	0.016*	0.016*			No		X	X	X	X	X	X	X		X	
Richland, Wash.	26,500	11.0	15.4			No										X	
Kaukauna, Wis.	11,356	16.0				No										X	
Greensboro, N.C.	155,000					No		X									
Hartford, Conn.	56,000																
Kennewick, Wash.	16,000	15.0		Operation just beginning		Yes	8,300										
Pendleton, Oreg.	14,000					No										X	
Bradenton, Fla.	22,500	2.0	2.0			Yes	540		X	X							
Houston, Tex.	1,212,000	423.0	997.0			No											
Lexington, Mass.	34,000			500		Yes	$5/ton	500								X	
Yuba City, Calif.	40,000					No		X									
Great Falls, Mont.	60,000	30.0	30.0			Yes	1,000										
Nashua, N.H.	57,000	26.0	26.0			No			X	X					X		
Quincy, Mass.	90,000	100.0	100.0			Yes	1,800		X	X						X	

* *As reported on survey form.*

TABLE 96

CITIES WITH NO RECOVERY PROGRAM

State	Population represented by reply	Communities with no present program	Communities with programs in past: Yes	No	No response	Communities allowing scavenging: Yes	No	No response
Alabama	584,478	8	1	7	-	1	5	2
Alaska	75,000	2	1	1	-	1	1	-
Arizona	932,500	7	1	6	-	1	6	-
Arkansas	330,265	10	-	9	1	5	4	1
California	6,811,263	62	11	47	4	9	46	7
Colorado	737,504	8	1	6	1	1	7	-
Connecticut	554,400	12	1	11	-	3	9	-
Delaware	39,135	2	-	2	-	-	2	-
Florida	1,355,459	29	1	26	2	1	22	6
Georgia	359,500	10	-	10	-	1	9	-
Hawaii	65,000	1	-	1	-	-	1	-
Illinois	1,690,553	50	2	45	3	2	43	5
Idaho	149,460	5	-	5	-	-	5	-
Indiana	1,639,528	19	2	17	-	5	14	-
Iowa	1,056,977	15	5	7	3	1	12	2
Kansas	856,968	21	2	18	1	6	14	1
Kentucky	198,270	9	-	9	-	2	6	1
Louisiana	1,210,450	10	-	10	-	-	6	4
Maine	164,759	5	-	4	1	2	3	-
Maryland	1,981,183	9	1	8	-	2	7	-
Massachusetts	1,283,183	31	2	27	2	5	25	1
Michigan	1,557,157	27	5	22	-	3	23	1
Minnesota	1,308,953	32	1	28	3	1	23	8
Mississippi	65,000	4	-	4	-	1	3	-
Missouri	1,801,822	27	1	25	1	7	18	2
Montana	46,200	3	-	2	1	-	2	1
Nebraska	740,695	11	2	9	-	2	8	1
Nevada	238,112	2	1	1	-	1	1	-
New Hampshire	179,500	5	-	5	-	1	4	-
New Jersey	905,255	31	1	24	6	3	21	7
New Mexico	374,247	7	2	5	-	1	6	-
New York	1,223,273	38	5	31	2	10	27	1
North Carolina	855,709	19	-	17	2	3	14	2
North Dakota	191,090	6	-	6	-	2	4	-
Ohio	4,335,188	54	8	42	4	1	53	-
Oklahoma	441,257	15	3	12	-	1	12	2
Oregon	985,400	6	-	6	-	2	3	1
Pennsylvania	1,401,943	30	2	23	5	4	22	4
Rhode Island	202,900	2	-	2	-	-	2	-
South Carolina	386,700	8	1	7	-	-	8	-
South Dakota	137,506	6	-	6	-	1	5	-
Tennessee	463,251	8	-	8	-	4	4	-
Texas	2,895,316	65	18	45	2	2	59	4
Utah	61,000	4	-	4	-	1	3	-
Vermont	76,000	3	-	3	-	1	2	-
Virginia	683,259	11	2	9	-	-	11	-
Washington	822,664	19	3	15	1	2	11	6
West Virginia	133,500	5	1	3	1	-	4	1
Wisconsin	981,930	29	1	28	-	6	23	-
Wyoming	90,900	2	-	2	-	-	2	-
Unidentified communities*	2,240,106	29	4	23	2	3	22	4
Total	47,901,668	833	92	693	48	111	647	75

* Community was not identified on the questionnaire or by envelope postmark.

APPENDIX A

WASTE COLLECTIONS, COMPOSITIONS, AND MATERIAL CONSUMPTION RELATIONSHIPS

A national survey conducted by the Solid Waste Management Office in 1967-1968 through state solid waste agencies provided, for the first time, some *indication of the total solid waste collected* by public and private forces in 1968 on a national basis. These data indicate a collection rate of 5.32 pounds per capita per day, which extrapolate to 193.7 million tons a year using a population of 199.5 million people (Table 97).

Tonnages of waste collected are difficult to reconcile with data on waste compositions developed by various observers (Table 98) and data on materials consumption available from Bureau of the Census and other industrial sources. The problem can be illustrated by a look at paper.

In 1968, the proportion of paper in municipal waste in various cities ranged from 34.9 percent to 61.8 percent, equivalent to 67.6 to 120.0 million tons, assuming that total collections were 193.7 million tons. In the same year, by our estimates, a minimum of around 36.6 million tons of paper and a maximum of 40.0 million tons went into the waste stream. Even if we assume that the paper contained 30 percent moisture by weight, the resulting tonnages (52.3 to 57.2 million tons) fall below the calculated ranges apparently collected for paper in waste. Moreover, other quantities of paper are not collected because of self disposal, burning, and similar occurrences.

In an attempt to reconcile these divergences, we analyzed composition data for other materials as well and compared the apparent tonnage of these materials in total waste collected with tonnages consumed in those applications that can reasonably be expected to occur in routinely collected wastes soon after consumption (paper, packaging materials) or to appear in roughly the same proportions as consumption (rubber goods, textiles, metallics in appliances and implements). The data are shown in Table 99.

If waste collections are around 194 million tons yearly, then composition analyses appear to overstate the presence of paper and metals if the lowest percentages in waste are used and to overstate the presence of all materials except plastics and rubber if the highest percentages are used. This discrepancy could arise from the fact that most composition analyses are made of packer truck loads delivered to incineration pits from residential or commercial sources; these would not be representative of total municipal waste composition. Thus the methods of orientation of most sampling tests could very well obscure the true material content because of the exclusion from the sampling of industrial and other types of waste not commonly found with household waste loads.

We extended the analysis further by asking: Suppose that the paper percentages are correct but total tonnage collected is significantly lower than the National Survey shows; how then would material tonnages in waste line up in relation to consumption? The results are also shown in Table 99.

We assumed that paper actually discarded in 1968, 36.6 million tons, contained moisture at the 30 percent level and thus weighed 52.3 million tons at time of discard. If this paper was 34.9 percent of waste, total waste collected would be 149.9 million tons, equivalent to 4.10 pounds per capita per day, a rate not unusual in municipal collections.[195] If paper is 44.9 percent of waste, the total collected waste is 116.5 million tons.

At the 149.9 million ton level, the presence of paper in quantities equivalent to consumption (plus moisture) can be justified. At the same time, the quantity of metal, glass, and rubber in waste also looks more proportional to consumption than at the higher waste collection level. Plastics in waste appear to be understated at both the low and high level, and so does the presence of textiles.

Although conclusions on the basis of such data are risky at best, we are inclined to believe that waste collection data are somewhat inflated and that actual waste collection rates (as contrasted to generation rates) are probably closer to 4.0 pounds per capita per day than 5.3 pounds per capita per day. Alternately, the presence of moisture and "moisture rich" materials such as garbage and yard wastes must be much higher than the composition surveys indicate. In either event the presence of manufactured materials is apparently not quantitatively what the average waste composition tests would indicate if applied to total collected tonnage as documented by the National Survey.

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[195] Most of the case study cities covered in this report in Chapter XI are in this range or somewhat lower according to records of sanitation officials (see Chapter XI).

TABLE 97

SOLID WASTE COLLECTION
RATES, PER CAPITA AND TOTAL, 1968 *

Waste source	Pounds per capita per day*	Million tons in 1968, US+
Household	1.14	41.5
Commercial	0.38	13.8
Combined	2.63	95.8
All other	1.17	42.6
Total	5.32	193.7

*Black, R. J., A. J. Muhich, A. J. Klee, H. L. Hickman, Jr., and R. D. Vaughan. The national solid wastes survey; an interim report. [Cincinnati], U.S. Department of Health, and Welfare, [1968]. p.13.

†Extrapolated by Midwest Research Institute using a population figure of 199.5 million for May 1968.

TABLE 98

COMPOSITION OF MUNICIPAL WASTES

Origin and references	Date	Composition - Percent by weight										Type of waste and comments
		Food wastes/garbage	Yard/garden wastes	Paper wastes	Plastics	Rubber and leather	Textiles	Glass/ceramics	Metals	Wood	Ashes, brick, rock, dirt and miscellaneous	
New York City[a]	1939	17.0	3.2	21.9				5.5	6.8	2.6	43.0	Municipal - year's average based on monthly sample
Chandler, Az.[a]	1953	21.8	1.3	42.7	0.4	1.0	1.9	7.5	9.8	2.3	11.3	Residential only
Chicago, Ill.[a]	1957	3.2	19.7	53.3				5.9	9.3		8.6	Municipal - April
	1957	2.3	3.7	59.3				6.5	5.2		23.0	Municipal - November
	1958	1.5	--	63.7				5.8	8.1		20.9	Municipal - April
	1958	0.8	34.4	54.7				3.5	6.2		0.4	Municipal - June
Oceanside, N.Y.[b]	1966	9.6	33.3	32.8	2.4		3.0	9.7	8.0	1.2		Municipal - June
	1966	10.2	19.0	39.8	3.4		3.3	9.5	8.2	6.6		Municipal - June
Cincinnati, Ohio[d]	1966	28.0	6.4	42.0	1.6		1.4	7.5	8.7	2.7		Residential - October
Wayne, N.J.[c]	1966	22.5	--	53.7	2.4		1.7	5.4	7.0	1.7	6.2	Municipal
Passaic, N.J.[c]	1966	21.4	--	44.4	2.3		7.8	5.2	8.7	3.6	8.6	Municipal
Clifton, N.J.[c]	1966	26.8	--	46.8	2.3		2.2	3.7	7.0	3.2		Municipal
Patterson, N.J.[c]	1966	20.2	--	39.8	3.0		5.1	10.0	12.9	3.4	7.0	Municipal
Quad-City, N.J.[c]	1966	21.0	--	46.0	2.0		4.0	7.0	8.0	3.0	8.0	Municipal - regional composite
Oceanside, N.Y.[b]	1967	16.7	0.3	53.3	3.5		2.2	11.9	10.6	1.5		Municipal - February
Flint, Mich.[d]	1967	29.1	26.7	13.0	1.9		0.3	12.7	14.5	1.0		Residential - June
Johnson City, Tenn.[d]	1967	21.1	0.9	59.8	0.9	0.6	1.3	7.0	7.5	0.3	0.6	Residential and commercial - October
Russell H. Susag[e]	1967	25.7	4.1	41.2	0.7			12.8	2.7	12.8		One week's accumulation of a family of six - June
San Diego, Calif.[d]	1967	0.8	21.1	46.1	0.3	4.7	3.5	8.3	7.7	7.5		Residential and commercial
Flint, Mich.[d]	1967	24.0	--	57.0	1.0		1.0	6.0	6.0	2.0	3.0	Commercial - estimate
Berkeley, Calif.[f]	1967	25.1		44.6	1.9	0.3	1.1	11.3	8.7		7.1	Residential and commercial
Raleigh, N.C.[h]	1967	31.8	8.4	38.9				11.9	9.2			Domestic refuse
Santa Clara County, Calif.[i]	1967	2.1	34.5	36.2	1.5	1.1	1.3	10.9	7.4		0.5	Residential
	1967	45.9		28.6	0.4		3.6	5.8		4.2	11.5	Supermarket wastes
Flint, Mich.[d]	1968	36.0	0.3	21.1	2.6		0.8	23.2	14.5	0.8	0.7	Residential - January
Weber County, Utah[d]	1968	8.5	4.2	61.8	2.5		2.0	4.6	8.4	2.2	5.9	Residential and commercial - April
Johnson City, Tenn.[d]	1968	34.6	2.3	34.9	3.4	2.4	2.0	9.0	10.4	0.8	0.2	Municipal - July
New Orleans, La.[g]	1968	18.9	9.2	39.4	1.5		2.6	16.2	12.2			Municipal
Alexandria, Va.[d]	1968	7.5	9.5	55.3	3.1		3.7	7.5	8.2	1.7	3.4	Residential and commercial - May
Atlanta, Ga.[d]	1968	12.3	1.6	58.6	3.0		1.8	10.3	8.6	0.4	3.4	Municipal - December
	1968	17.5	2.8	53.2	2.6		2.0	6.5	8.8	3.2	3.4	Municipal - December
New Orleans, La.[d]	1969	11.0	9.8	44.9	3.5		3.2	9.5	8.1	3.1	6.9	Municipal - February
John Bell[j]	1959-62	12.0	12.0	42.0	0.7	0.9	0.6	6.0	8.0	2.4	15.4	Composite based on several city surveys

a/American Public Works Association. Municipal refuse disposal. 2d ed. Chicago, Public Administration Service, 1966. p. 47, 48, 52.

b/Kaiser, E. R. Composition and combustion of refuse. In Proceedings; MECAR Symposium; Incineration of Solid Wastes, New York, Mar. 21, 1967. Metropolitan Engineers Council on Air Resources, 1967. p. 1-9.

c/Quad-city solid wastes projects; an interim report, June 1, 1966 to May 31, 1967. Cincinnati, U.S. Department of Health, Education, and Welfare, 1968 [181 p.]

d/Bureau of Solid Waste Management. Unpublished data.

e/Susag, R. H. Developing classifications for refuse. Solid Wastes Management/Refuse Removal Journal, 11(3); 20, 37, Mar. 1968.

f/Golueke, C. G., and P. H. McGauhey. Comprehensive studies of solid wastes management; first annual reports. Berkeley, Sanitary Engineering Research Laboratory, School of Public Health, University of California, 1967. p. 34.

g/City of New Orleans. Unpublished data, May 13, 1968.

h/Department of Public Works, City of Raleigh. Evaluating alternatives in refuse disposal; progress report, Jan. 1, 1967-Dec. 31, 1968. Unpublished data.

i/Systems analysis for solid waste disposal by incineration. Prepared by FMC Machinery/Systems Group, Engineering Systems Division, FMC Corporation, for the City of San Jose and the County of Santa Clara, Nov. 1, 1968. 167 p.

j/Bell, J. M. Characteristics of municipal refuse. Presented at National Conference on Solid Waste Research, University of Chicago Center for Continuing Education, Chicago, Dec. 2-4, 1963. American Public Works Association, Special Report No. 29. p.37.

TABLE 99

ANALYSIS OF WASTE COLLECTION, COMPOSITION, AND CONSUMPTION DATA

Material	Reported percent by weight in municipal waste	Millions of tons in waste class if total collection is 193.7 million tons	Quantity to be expected in municipal waste based on consumption, in million tons	Millions of tons in waste class if total collection is 149.9 million tons	Millions of tons in waste class if total collection is [illegible]6.5 million tons
Paper	34.9 - 44.9[a]	67.6 - 87.0	37 - 40[c]	52.3 - 67.3[i]	40.7 - 52.3[i]
Metals	8.1 - 12.2[a]	15.7 - 23.6	10 - 15[d]	12.1 - 18.3	9.4 - 14.2
Glass/Ceramics	6.5 - 16.2[a]	12.6 - 31.4	12 - 14[e]	9.7 - 24.3	7.6 - 18.9
Rubber	0.3 - 2.4[b]	0.6 - 4.6	1 - 3[f]	0.5 - 3.6	0.3 - 2.8
Plastics	0.3 - 3.4[b]	0.6 - 6.6	6 - 8[g]	0.5 - 5.1	0.3 - 4.0
Textiles	1.8 - 3.2[a]	3.5 - 6.2	5 - 6[h]	2.7 - 4.8	2.1 - 3.7

a/ From Table 98, using samples taken in Johnson City, New Orleans (two occasions) and Atlanta (two occasions) in 1968.

b/ From Table 98, using samples taken in Johnson City (two occasions), San Diego, Berkeley, and Santa Clara County in 1967 and 1968; these data include residential and commercial wastes only for low figures and municipal waste for high figures.

c/ Data for 1968; includes tonnage going to waste (lower figure) and tonnage going to waste plus a portion of tonnage diverted and delayed in discard (higher figure). Total consumption was 55.1 million tons for 1968 compared to an indicated minimum discard of 67.6 million tons, based on percentage in column 1, a relationship that indicates more is discarded than is consumed. Even allowing for 30 percent moisture content with adjustments for recycling and "diverted use" application, the minimum figure for discard is too high.

d/ Includes nonferrous metals used in packaging and steel consumed for packaging, appliances, and utensils (lower figure); higher figure is arbitrary; 1967 data.

e/ Includes container glass and pressed/blown glass consumption (lower figure) plus flat glass (higher figure); 1967 data.

f/ Rubber consumption in 1969; lower figure excludes, higher includes tires.

g/ Data for 1968; low figure includes all plastics except that used in agriculture transportation, and construction; higher figure includes total.

h/ Data for 1968; low figure excludes, high figure includes industrial uses of textiles.

i/ Including moisture at 30 percent by weight.

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MAIL SURVEY QUESTIONNAIRE

APPENDIX C

APPENDIX C

MIDWEST RESEARCH INSTITUTE
425 Volker Boulevard
Kansas City, Missouri 64110
Telephone (816) 561-0202

August 19, 1970

Dear Sir:

The possibility of reusing solid waste materials is now in the minds of many people. If municipalities and industry can salvage and sell materials from their wastes, this would not only reduce the quantities of waste requiring disposal but could also provide income to offset some of the costs of waste management.

In order to determine how feasible it is for communities and industry to enter the salvage market, the Bureau of Solid Waste Management of the Department of Health, Education, and Welfare has sponsored an "Economic Study of Salvage Markets for Commodities Entering the Solid Waste Stream" by Midwest Research Institute. The study should show how many U.S. communities now perform or contract for salvage operations and give some indication of how successful it is.

It would be much appreciated, therefore, if you or the appropriate official in your administration would fill in the attached survey form. Even if there has never been any organized salvaging from your community's solid wastes, please return the form with the appropriate notations.

The results of the study should be of interest to you and other municipal officials, and the Bureau will send you a copy of the study if you so indicate on the survey form.

Very truly yours,

Arsen J. Darnay
Project Director

AJD:pa
Enclosures

Budget Bureau No. 85-S-70019
Expiration date: Sept. 30, 1970

MUNICIPAL SOLID WASTE SALVAGE PRACTICES SURVEY

For the purpose of this survey "salvaging" is defined as the controlled recovery and removal of reusable commodities or materials for resale. The object of salvaging is usually that of providing income or, at the least, of offsetting some of the costs of solid waste management.

The uncontrolled picking over or searching of refuse fro usable materials or objects, whether or not permitted by public authority, is called "scavenging" and is not included in the term salvaging.

General

a. Name of municipal agency or department responsible for solid waste management. ______________________________

____

b. Name and title of person completing questionnaire.

____

c. Population of community served by the agency.

____

d. Does your community presently salvage (recover and remove commodities/materials for resale) from solid wastes either directly or by contract? Yes______ No______
If "Yes," go on to Section 2 below.
If "No," complete the questionnaire by answering only those questions in this section.

e. Did your community salvage commodities in the past?
Yes______ No______

f. If "Yes" to e., when was the practice discontinued? Year______

g. Why was the practice discontinued?______________________________

____

____

h. Is scavenging by your employees or others permitted?
Yes______ No______

i. If "Yes" to h., estimate quantity of waste removed per year in tons__________or cubic yards__________.

2. Check here____if you would like a copy of the final report on salvage practices from the U.S. Bureau of Solid Waste Management.

3. Community Solid Waste Practices

   a. Does your community collect and transport wastes____; dispose of wastes collected by own forces and others____; dispose of wastes collected by own forces only____? (Check one or more.)

   b. Does your community handle residential wastes only____; commercial and industrial wastes only____; both____? If both, show approximate percentage of each: residential ____%; commercial/industrial ____%.

   c. Estimate quantity of wastes handled annually in tons or cubic yards. Tons collected ____; tons disposed of ____; or, cubic yards collected ____; cubic yards disposed of ____.

   d. Estimate total annual expenditures on all solid waste management activities. $____________________

4. Specific Salvage Practices

   a. Is salvage practiced by your own community ____; by others under contract with your community ____; both ____? Value of contract in dollars per annum (if applicable). $________________

   b. Are commodities recovered from mixed refuse ____; by separate collection ____; both ____?

   c. Check each type of facility where segregation is accomplished: incinerator ____; land disposal site ____; transfer station ____; compost plant ____; conical (tepee) burner ____; other (Specify):
   ____

   d. Is segregation accomplished manually ____; mechanically ____; combination ____?
   Please describe____
   ____

   c. What processing, other than segregation, is done?
   ____

f. Indicate quantities of materials recovered at each facility or in each operation per year. Quantities given are in tons ____; cubic yards ____; (check one).

Material	Incin-erator	Land Disposal Site	Transfer Station	Compost Plant	Conical (Tepee) Burner	Separate Collec-tion
Paper/Paperboard						
Iron/Steel						
Other Metal						
Glass/Ceramics						
Plastics/Rubber						
Textiles						

Other (Specify)

____

____

____

____

g. Indicate in the following table salvage costs, prices received for salvaged materials and type of buyer for salvaged materials for your community's non-contract salvage operation.

Material	Cost of Salvage[1/] $ Per Ton	Price Received for Salvage $ Per Ton	Type of Buyer[2/]
Paper/Paperboard			
Iron/Steel			
Other Metal			
Glass/Ceramics			
Plastics/Rubber			
Textiles			

Other (Specify)

____

____

____

____

1/ Include total costs of separate collection, processing and other functions related to salvage operation only.

2/ Show whether buyer is dealer, user (e.g., paper plant) or other (specify).

h. For approximately how many years has solid waste been salvaged? _______ years.

i. Do you plan to continue this operation? Yes ___; No ___. Why? ____

____

j. Is scavenging by your employees or others permitted? Yes ____ No ____

PLEASE SEND THIS QUESTIONNAIRE TO MIDWEST RESEARCH INSTITUTE, 425 VOLKER BOULEVARD, KANSAS CITY, MISSOURI 64110, ATTN: A. J. DARNAY.

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