III.

Quantification of Losses From the Materials Cycle

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Quantification of Losses From the Materials Cycle

As a first step in the assessment, a classification of material losses was necessary so that they could be identified and quantified on an orderly basis. A precise accounting of losses would require tracing each material through its production and processing and into its use in the manufacture and consumption of thousands of products. However, since materials availability is the primary concern of this assessment, then it is the major losses (e.g., more than 10 percent of the yearly demand for a material) that are important, since only they would be large enough to affect the availability of materials.

A typical materials cycle is shown in figure 12, which illustrates the various material and product stages. Losses can occur at each step in the cycle and particularly in the utilization stage where ultimately the product must be disposed of either by putting it in storage, recycling it in a variety of ways (metal, components, products), or discarding it. The various types of losses that occur at each stage of the materials cycle are also illustrated in figure 12.

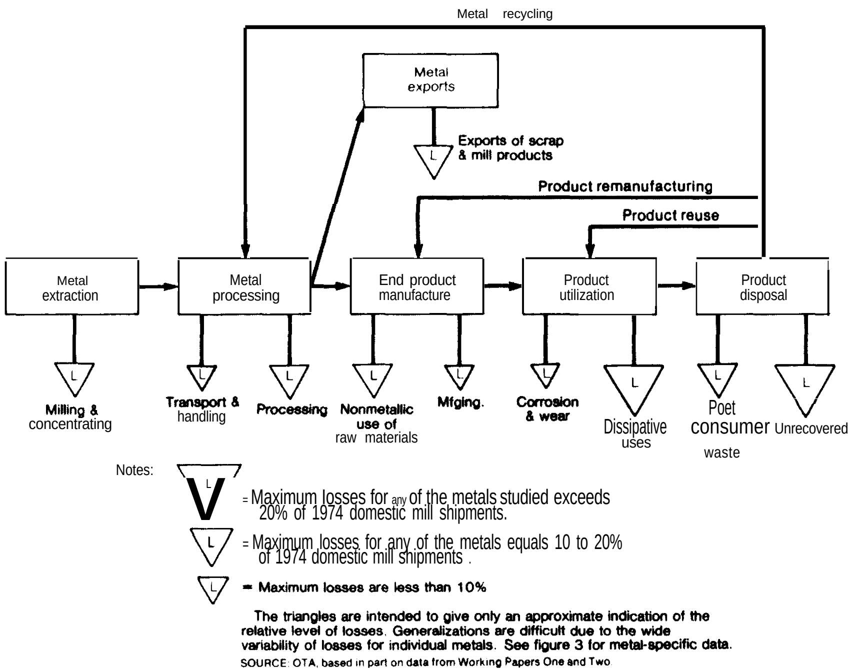
The approach used for quantification of losses was to trace the physical flows for each of the eight selected metals at each stage in the materials cycle. The losses could then be quantified both directly (e.g., from a knowledge of the yields in metal extraction) and indirectly (from a knowledge of the amount of material entering and leaving a given stage) From these data, the major loss categories were identical.

Losses from the 1974 materials cycle were estimated for eight metals: iron and steel, aluminum, copper, platinum-group metals, manganese chromium, nickel, and tungsten. Data on materials flows and losses for 1974 were used. The year 1974 was chosen for several reasons. First, that year represented a high level of economic activity and resource usage. The following year, 1975, was a recession year when resource usage and flows were depressed and possibly distorted. Further, when this assessment was initiated, only fragmentary data were available for 1976.

The estimates presented here are given in summary fashion. Substantially more detail is available in Volume II—Working Papers. In particular. *Working Paper One** (vol. II-A) providesbasic data in support of the estimates of losses from the materials cycle and materials consumption by end use. These data provide the basis for estimating the quantities of wastage.

*A list of the Working Papers is in app. E. The Working Papers are available from the National Technical Information Service (NTIS), Department of Commerce, Springfield, Va. 22161.

Figure 12.—Typical Materials Cycle



SOURCE: OTA based in part on data from Working Papers One and Two

IRON AND STEEL

Domestic iron and steel plants in 1974 shipped about 124 million tons* of iron and steel products to manufacturers and fabricators. In addition, 16 million tons of iron and steel mill products were imported and nearly 6 tons were exported. Of the more than 134 million tons of iron and steel mill products used by end-product manufacturers and fabricators, nearly 111 million tons of iron and steel were embodied in end products in 1974. The remainder was returned to iron and steel plants and foundries in the form of prompt scrap.

Iron and steel mill products represent by far the largest tonnage of basic metal used in the United States. The tonnage of iron and steel used is roughly 20 times that of the next largest metal—aluminum. It is important to consider the conservation options for iron and steel because of the sheer size of the iron and steel industry, the magnitude of its use of energy, and its importance in the manufacture of almost every product.

Estimates of flows in the iron and steel cycle and summary losses from the cycle are given in figure 13. The total losses shown in figure 13 amount to about 79 million tons. This is nearly three-quarters of the total amount of iron and steel embodied in products in 1974.

Estimated amounts of ferrous materials entering useful life in 1974 are given in table 2. Table 2 provides a broad market breakdown of the amount of iron and steel embodied in end products in 1974. By using estimates of the useful life of iron and steel products and data on past production and use of iron and steel, amounts of iron and steel that became obsolete in 1974 were estimated. Table 3 gives a breakdown, by market category, of the estimated 72.5 million tons of iron and steel that became obsolete in 1974. Estimates of the amount of obsolete iron and steel scrap that was recovered and recycled in 1974 are given in table 4, classified by broad category of product from which the scrap was derived. The loss category designated "unrecovered and unknown" (in figure 13) represents the difference between the calculated value of obsolete products (72.5×10^6 tons) and that which is accounted for by recycling, postconsumer solid waste, corrosion and wear, and dissipative uses.

From the preceding data, estimates of the total losses from the domestic iron and steel cycle in 1974 were as follows:

Nature of loss	*Millions of tons*
Milling, concentrating, and handling	23.3
Unrecovered and unknown	19.4
Postconsumer solid waste.	11.0
Scrap exports	7.8
Processing in iron and steel plants	6.8
Disssipative uses	5.4
Corrosion and wear	4.0
Manufacturlng losses	1.1
Total	78.8

*All data are given in short tons (2,000 lbs).

Table 2.–1974 Distribution of Products Manufactured From Iron and Steel
(millions of short tons of iron and steel alloys)

Market category	Quantity
Automotive	17.2
Machinery, including equipment	18.5
Rail transportation	56
All iron and steel castings	12.3
Construction, including maintenance	152
Contractors products	12.0
Electrical machinery	5.0
Shipbuilding and marine.	
Agricultural	3.0
Appliances	3.9
Other domestic equipment	3.8
Containers	9.3
Ordnance and military	1.0
Mining, quarrying, etc.	1.0
Oil and gas drilling	075
Aircraft and aerospace	o.15
Total	1108

SOURCE Working Papers One and Two

Table 3.–Obsolescence of Iron- and Steel-Containing Products in 1974
(millions of short tons in ferrous materials)

Market category	Assumed average useful life (years)	Quantity
Automotive	13	12.3
Machinery, including equipment		9.0
Rail transportation	3.0	6.5
AH iron and steel castings		10.0
Construction, including maint.	30	7.5
Contractors products	27	4.2
Electrical machinery		
Shipbuilding and marine	30	0.8
Agricultural	20	
Appliances	11	2.8
Other domestic equipment	12	
Containers	<1	9.6
Ordnance and military	15	10
Mining, quarrying, etc.		04
Oil and gas drilling	30	
Aircraft and aerospace	20	0.1
Total		725

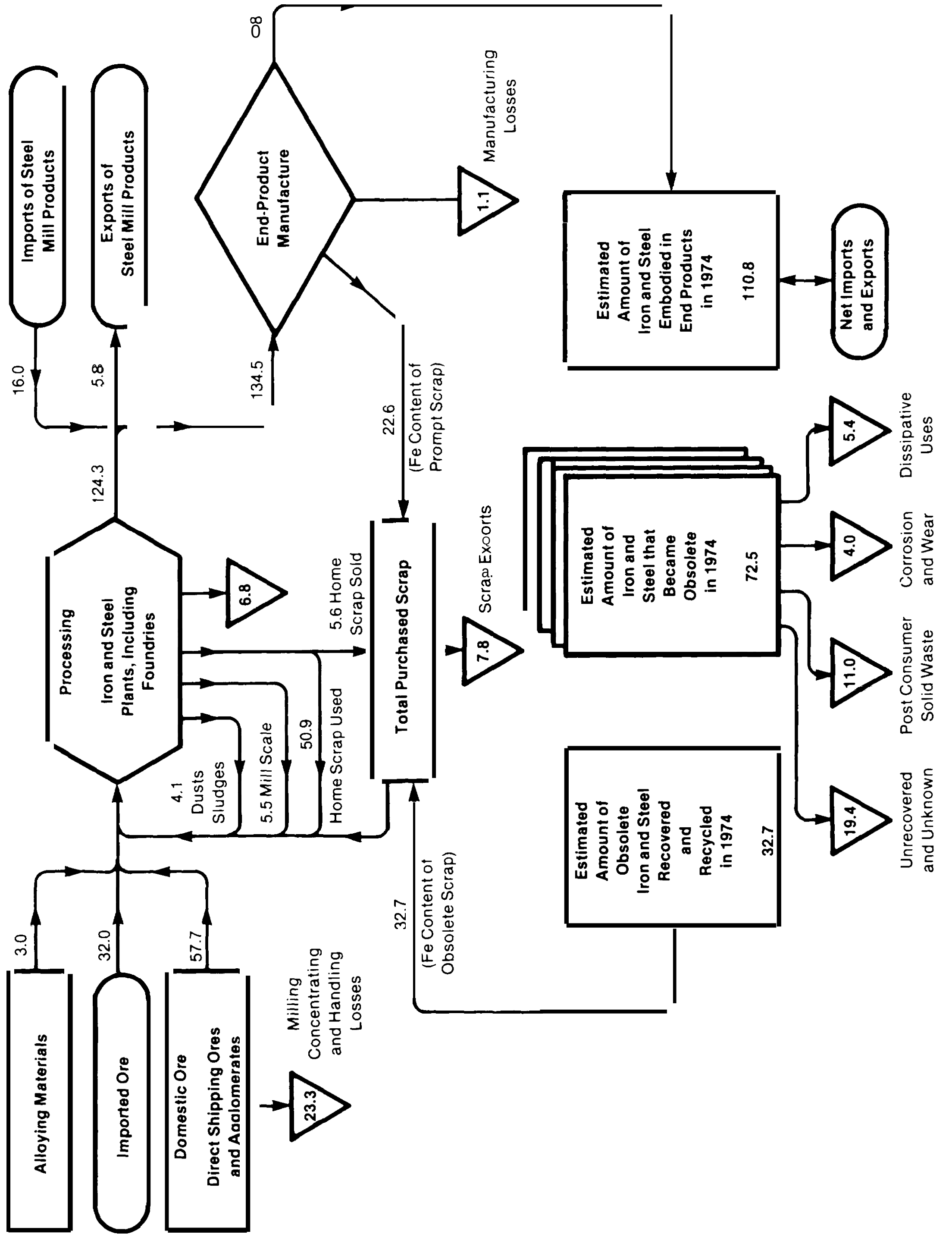
SOURCE Working Papers One and Two

Table 4.–Recycling and Recovery of Iron and Steel in 1974

Market category	Millions of short tons of metal	Percentage recycled
Automotive	10.9	89
Machinery, including equipment	69	
Rail transportation	5.6	86
All iron and steel castings	24	24
Construction, including maint.	22	29
Contractors products	16	38
Electrical machinery	11	42
Shipbuilding and marine	0.6	75
Agricultural	04	25
Appliances	02	7
Other domestic equipment	02	7
Containers.	0.2	
Ordnance and military	02	20
Mining, quarrying, etc	01	25
Oil and gas drilling	01	
Aircraft and aerospace	0 0	_
Total	.32.7	45

SOURCE Working Papers One and Two

Figure 13.—Iron and Steel Cycle: Flows and Losses, 1974 (Millions of short tons of contained ferrous materials)



NOTE: Flows are in millions of short tons of iron and alloying elements.
SOURCE: Working Papers One and Two.

ALUMINUM

In 1974, the aluminum industry produced about 7.2 million tons of aluminum. It exported about 0.5 million tons, placed in stock about 0.4 million tons, and shipped about 6.3 million tons to end-product manufacturers, of which 5 million tons were embodied in end products. Except for minor manufacturing losses, the remainder was returned to primary aluminum plants, secondary smelters, or aluminum foundries in the form of prompt scrap.

Figure 14 presents a summary of the flows of aluminum in the U.S. economy and the losses from the aluminum cycle in 1974. Figure 14 indicates that 5 million tons of aluminum were embodied in end products in 1974. A market breakdown of this figure is given in table 5. Table 6 presents estimates of the amount of aluminum and aluminum alloys contained in products that became obsolete in 1974. The breakdown by market category is based on assumptions of useful life in each of the product categories. Table 7 indicates the amount of obsolete scrap recovered from obsolete products in 1974 classified by market category. A total of about 343,000 tons of aluminum was recovered and recycled.

Losses from the domestic aluminum cycle in 1974, based on data in the foregoing paragraphs are shown to the right.

The total losses from the domestic aluminum cycle in 1974 amounted to over 4 million tons of aluminum content. This loss is sizable, particularly in relation to the 5 million tons of aluminum that were embodied in useful products in 1974.

Nature of losses	*Millions of tons*
Postconsumer solid wastes	1.0
Other uses of alumina	0.5
Exports of ingot and mill products	() 5
Unrecovered and unknown	().4
Losses in bauxite mining and alumina production	0.4
Aluminum processing	0. 4
Dissipative uses of scrap	0.4
Other uses of bauxite	0.3
Dissipative uses.	().2
Losses in end-product manufacture	0.1
Total ., ...,	4.2

Table 5.–Products Manufactured From Aluminum in 1974 (millions of short tons of aluminum alloys)

Market category	Quantity
Buildings and construction . . . ., ...,	1.43
Electrical products . . . ., ...	0.85
Transportation products .	0.80
Containers and packaging.	0.78
Consumer durables	0.44
Machinery and equipment. ., ...	*0.40*
Other	*0.30*
Total..	5.00

SOURCE: Working Papers One and Two

Table 6.–Obsolescence of Aluminum Products in 1974 (millions of short tons of contained aluminum)

Market category	Assumed useful life (years)	Quantity
Building and construction . . .	*30*	0.1
Electrical products	30	0.013
Transportation products, ...	10	0.5
containers and packaging	<1	0.78
Consumer durables .	10	0.3
Machinery and equipment ., . .	20	0.1
Other. ., ...	10	0.1
Total	8	1.893

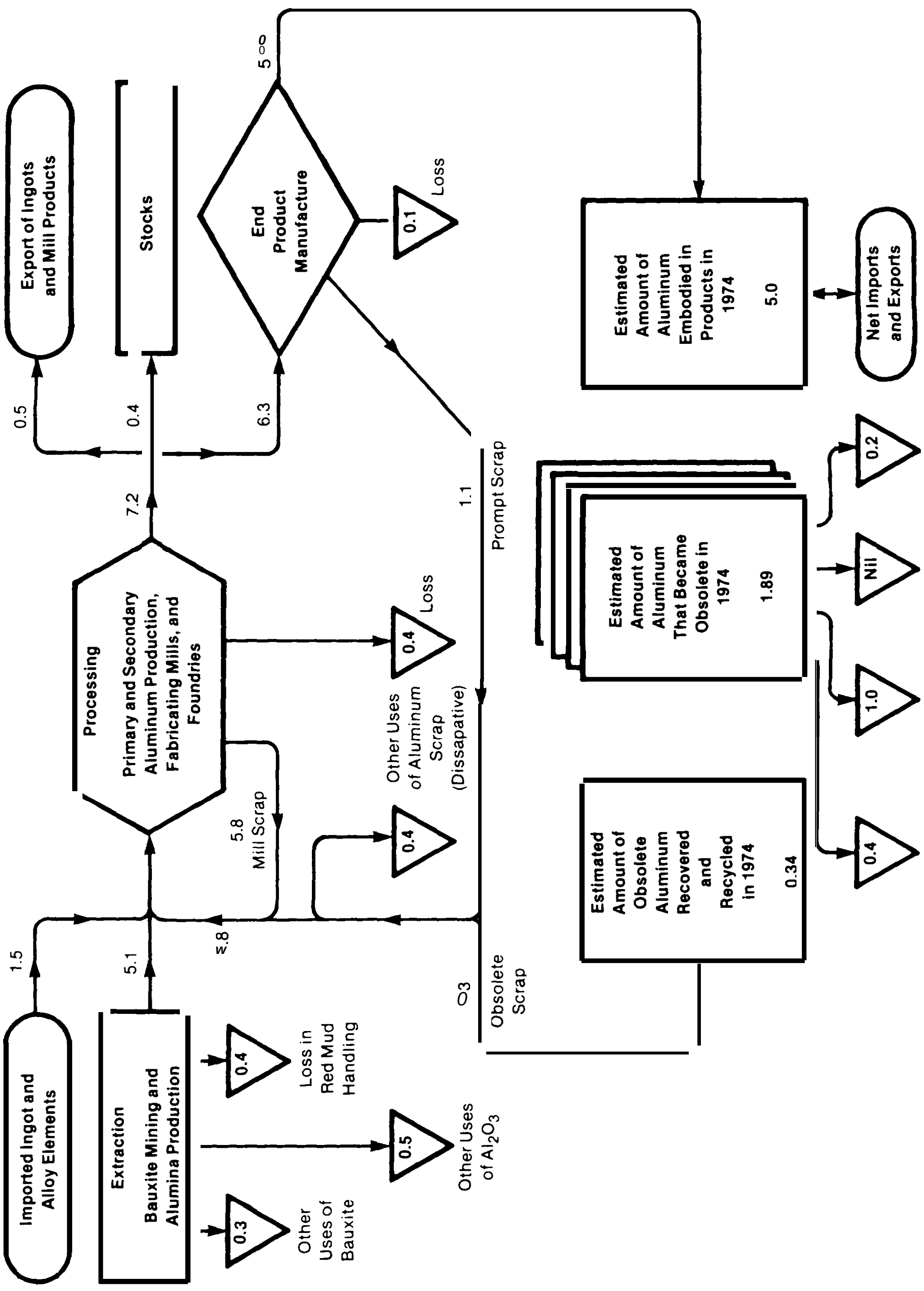
SOURCE: Working Papers One and Two

Table 7.–Recycling and Recovery of Aluminum in 1974 (millions of short tons of aluminum alloys)

Market category	Percent recycle	Quantity recovered
Building and construction.	15	0.015
Electrical products	92	0.012
Transportation products. ...	34	0.169
Containers and packaging ...	7	0.052
Consumer durables. . .	14	0.042
Machinery and equipment	25	0.025
Other.	29	0.028
Total	18	0.343

SOURCE: Workinq Papers One and Two

Figure 14.—Aluminum Cycle: Flows and Losses, 1974
(Millions of short tons of aluminum and alloys)



SOURCE: Working Papers One and Two.

COPPER

The production of copper in 1974 from domestic, primary, and secondary operations amounted to about 2.7 million tons. About 2.2 million tons of copper and copper alloys were embodied in end products in 1974.

The tonnage of copper used in the United States is third largest, after steel and aluminum, of the basic metals consumed. Of the basic primary metals, copper also ranks third in consumption of energy.

Estimates of the flows of copper in the domestic materials cycle are given in figure 15.

An estimate of the copper embodied in end products in 1974 by major end-use category is given in table 8. This end-product distribution has not changed significantly for the past several years. The estimated amounts of copper and copper-base alloys that became obsolete in 1974 are given in table 9. The quantities shown are based on the shipment data available for prior years and on an average estimated useful life for each of the product market categories. Estimates of obsolete copper and copper alloys, which were recovered as scrap in 1974, are given by end-use market category in table 10. The total amount of obsolete scrap recycled in 1974 amounted to about 0.56 million tons.

From the foregoing data and estimates, losses from the domestic materials cycle in 1974 were estimated as follows:

Nature of losses	Millions of tons
Unrecovered and unknown	0.9
Milling .	0.4
Dissipative uses	0.3
Postconsumer solid wastes	0.2
Smelting and reflning	0.065
Brass mills, wire mills, etc	0.009
End-product manufacturing	0.006
Total	1.88

Table 8.–Distribution of Copper End Products to Major Use Categories in 1974
(millions of short tons of copper and copper alloys)

Market category	Quantity
Buildings and construction ...	05
Transportation. ., ..., .,	0.2
Consumer and general .,	0.5
Industrial machinery. ... .,	0.4
Electrical and electronics.	0.6
Total. ... ., ., ...	2.2

SOURCE: Working Papers One and Two

Table 9.–Obsolescence of Copper-Containing Products in 1974
(millions of short tons in ferrous materials)

Market category	Assumed average useful life (years)	Quantity
Buildings and construction.	30	0.2
Transportation . .	12	03
Consumer and general. . . .	10	0.5
Industrial machinery ., ...	20	0.3
Electrical and electronics .	10	0.7
Total		2.0

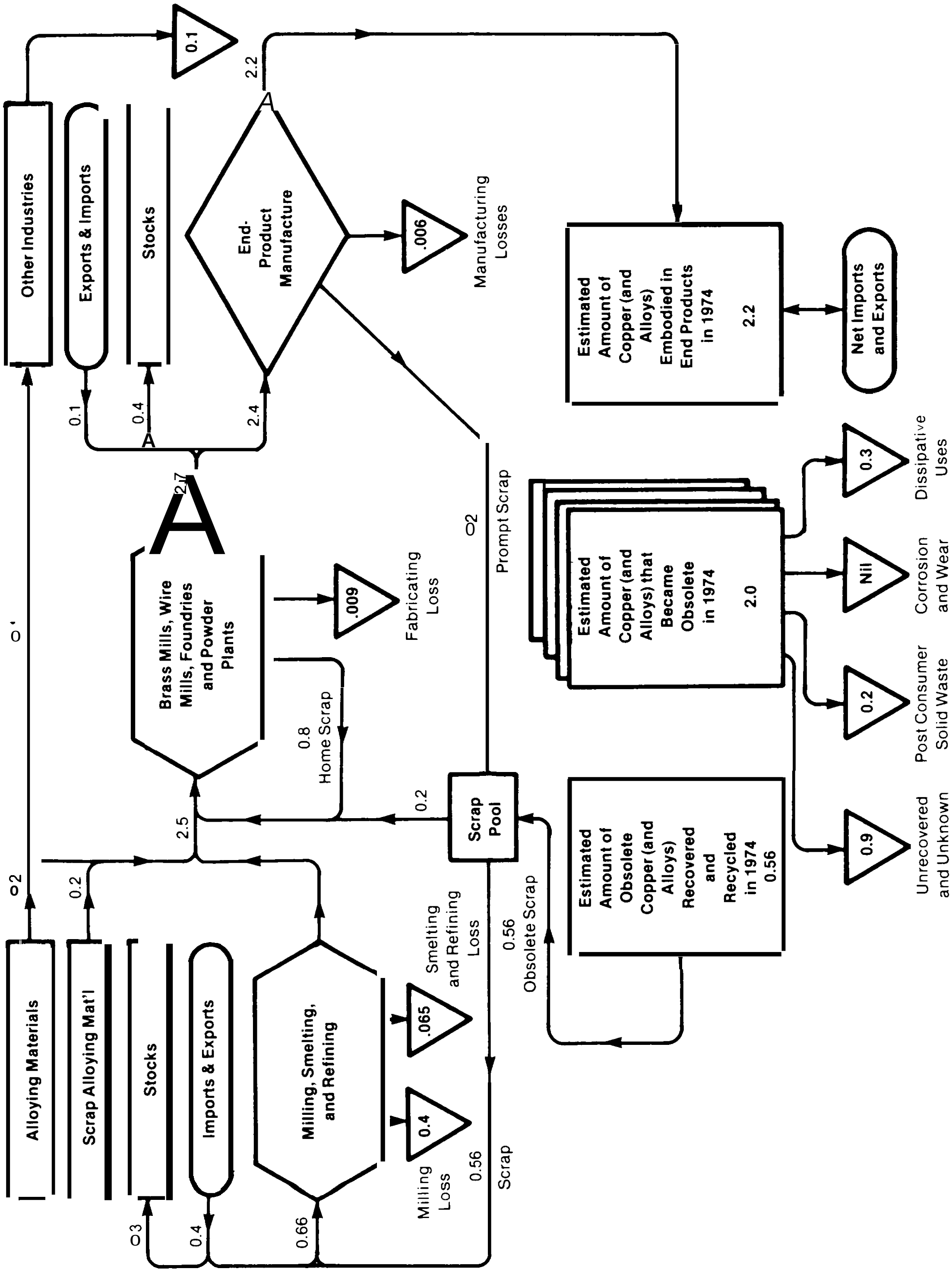
SOURCE Working Papers One and Two

Table 10.–Recycling and Recovery of Copper and Copper Alloys in 1974
(millions of short tons of copper and copper alloys)

Market category	Percent recycle	Quantity
Buildings and construction. . .	25	0.05
Transportation ., ...,	57	0.17
Consumer and general. ...	20	0.10
Industrial machinery .,	13	0.04
Electrical and electronics ... ,	28	0.20
Total ... .,		0.56

SOURCE Working Papers One and Two

Figure 15.—Copper Cycle: Flows and Losses, 1974 (Millions of short tons of copper and copper alloys)



SOURCE: Working Papers One and Two

The six metals included in the platinum group, in order of annual consumption are platinum, palladium, ruthenium, rhodium, iridium, an-d osmium. Prices for all six metals of the group are very high—between $50 and $450 per troy ounce. The platinum group metals are used primarily as catalysts and in electrical and electronic applications. The flows and losses of platinum-group metals are considered to be representative of one class of precious metals.

A simplified flow diagram is given in figure 16 showing the flows of platinum-group metals in the domestic materials cycle and losses for the year 1974. As shown in figure 16, about 3 million troy ounces of platinum-group metals are used by end- product users and fabricators with only a minor manufacturing loss; essentially the same amount was embodied in end products in 1974. Table 11 shows a breakdown by market category of the products manufactured from platinum-group metals in 1974. Most of the usage of platinum-group metals in chemicals and petroleum was in the form of platinum catalysts. The practice of toll refining for these major users of catalysts is very large. Nearly 1 million troy ounces per year are toll-refined. Table 12 gives estimates of the amount of platinum in products that became obsolete in 1974. As with the previous metals, these estimates were based on the assumed average life for each of the categories. About 1.64 million troy ounces of platinum-group metals were recovered from obsolete products in 1974 and recycled. A breakdown by market category of this amount is given in table 13.

From the above, the losses of platinum-group metals from the domestic cycle in 1974 were as follows:

Loss	Millions of troy ounces
Dissipative	(),25
Processing . .	0.015
Unrecovered and unknown	0.014
End-product fabricators and users	0,009
Total ... ., . .	0.288

Table 11 .–Products Manufactured From Platinum-Group Metals in 1974
(millions of troy ounces of platinum-group metals)

Market category	Quantity
Chemicals.	0.58
Petroleum ., ..., ...	0.73
Glass	0.19
Electrical.	0.80
Automotive ... ., ...	0.50
Dental, medical, jewelry, and misc.	0,25
Total. . . . ., .,	3.05

SOURCE Working Papers One and Two

Table 12.–Obsolescence of Platinum-Group Products in 1974
(millions of troy ounces of contained platinum-group metals)

Market category	Assumed average useful life (years)	Quantity
Chemicals	c 1	0.72
Petroleum	<1	0.69
Glass	<1	0.19
Electrical.	20	0.31
Automotive ., ...	6	–
Dental, medical, jewelry, and misc.	20	0.13
Total ., ...		2.04

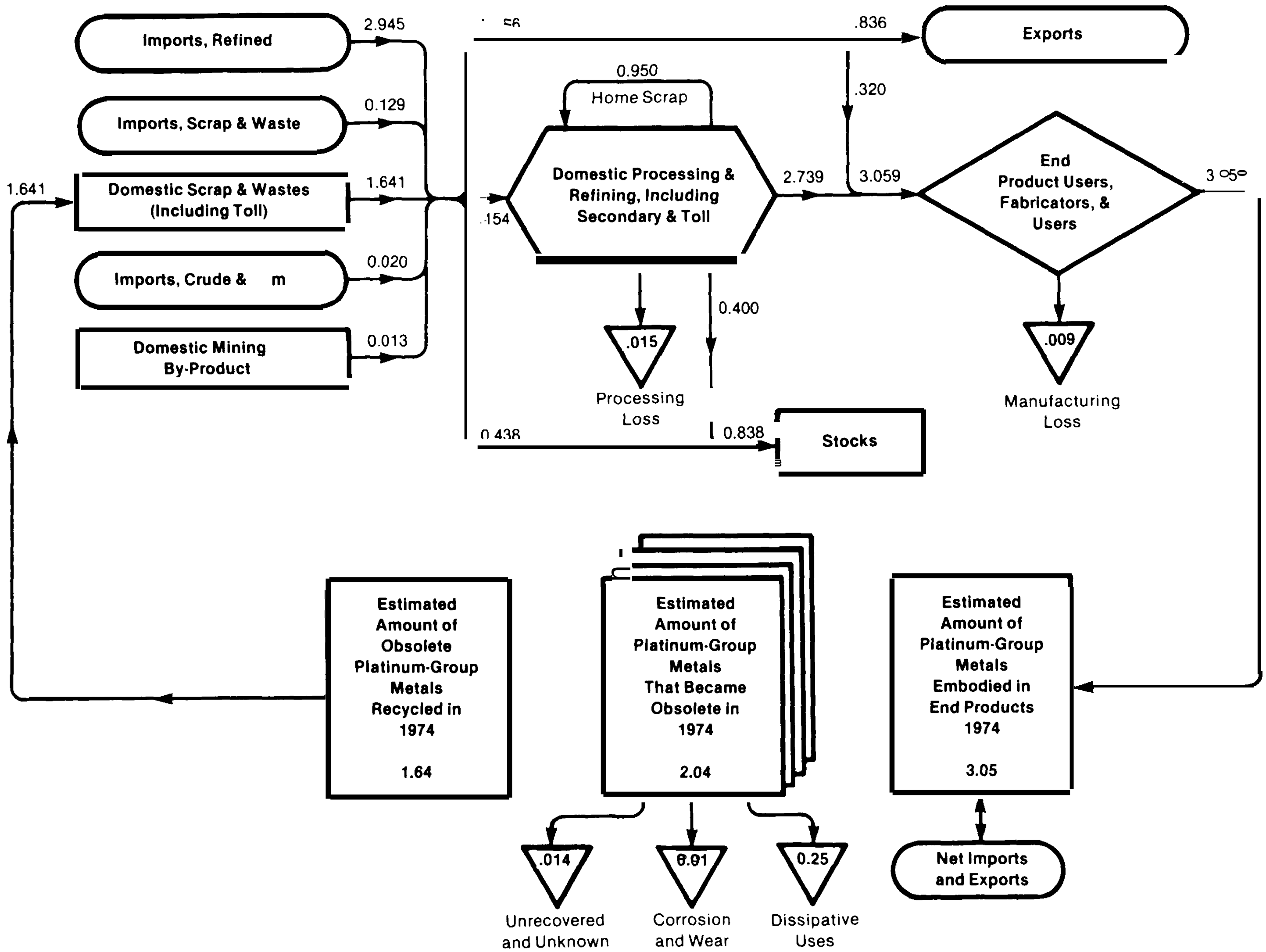
SOURCE Working Papers One and Two

Table 13.–Recycling and Recovery of Platinum-Group Metals in1974
(millions of troy ounces of platinum-group metals)

Market category	Estimated percentage of obsolete platinum-group metals recycled	Quantity
Chemicals	85	0.61
Petroleum ... ., ...	97	0.67
Glass . .	98	0.19
Electrical. . ., ...	45	0.14
Automotive	0	–
Dental, medical, jewelry, and misc. . . . . ,	20	0.03
Total ., ., ...	80	1.64

SOURCE: Working Papers One and Two

Figure 16.—Cycle for Platinum-Group Metals: Flows and Losses (Millions of troy ounces)



SOURCE: Working Papers One and Two.

MANGANESE

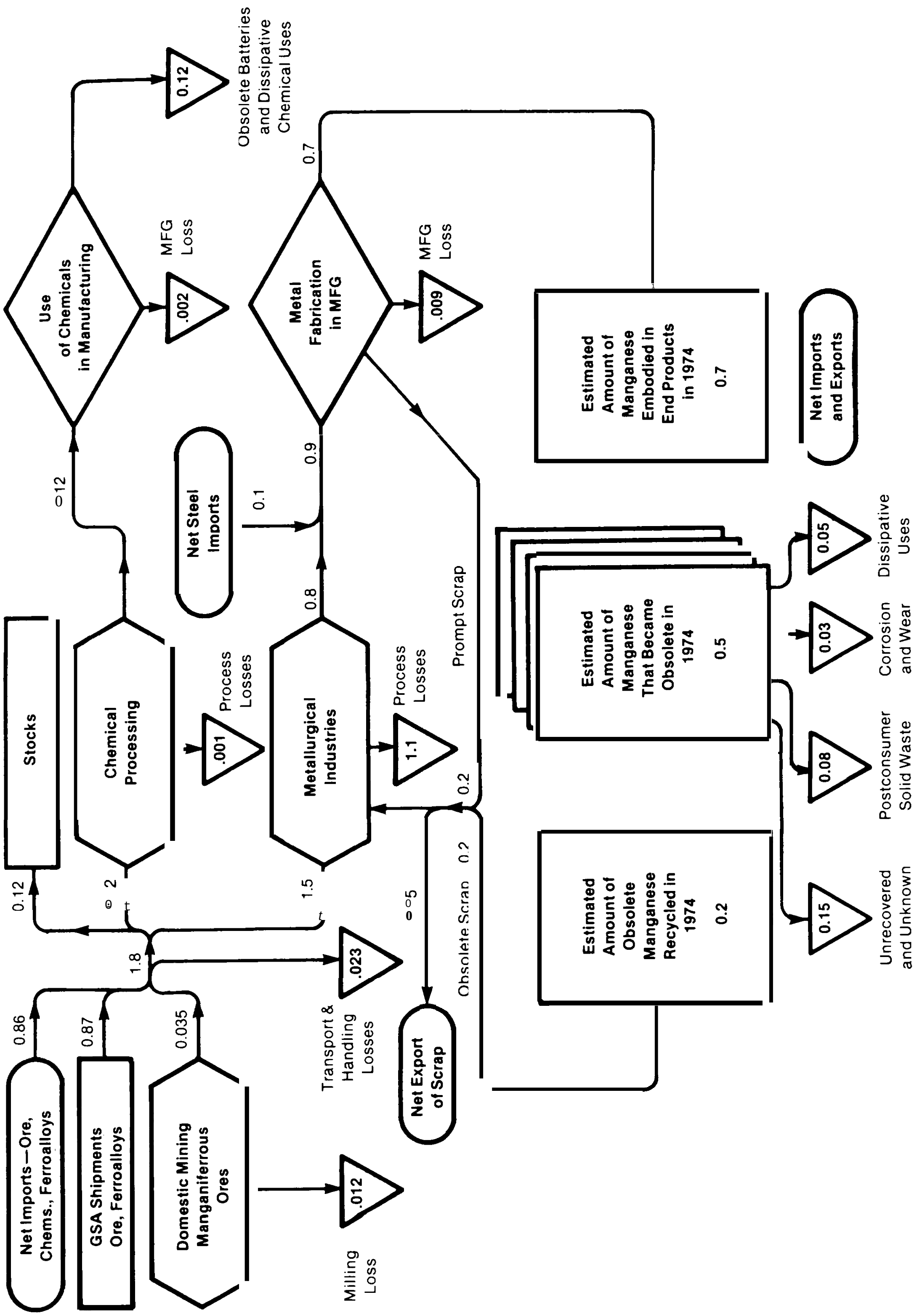
About 90 percent of the domestic usage of manganese is in the production of iron and steel. Although manganese, in amounts usually on the order of one-half to 1 percent, is important to steel properties, the predominant use of manganese is as an inexpensive chemical reagent in the desulfurization (and sulfur control) and deoxidation of steel. The other major domestic use of manganese is primarily as a chemical reagent.

The flow of manganese and losses from the domestic manganese cycle are given in figure 17. About 1.5 million tons of contained manganese were used by the metallurgical industries, while about 0.12 million tons were used in chemical processing. Of the 1.9 million tons of contained manganese entering the metallurgical industries, only 0.8 million tons remain in the metal that is shipped to metal fabricators. The loss of 1.1 million tons occurs in processing (steel). Referring again to figure 17, the net manganese content in end products entering useful life in 1974 was about 0.7 million tons. To a first approximation, the analysis of obsolescence and losses from the consumer cycle for manganese would be similar to that for steel. Estimates of the amounts of manganese that became obsolete in 1974 were based on the end-use pattern of steel, estimates of the amount of iron and steel that became obsolete in 1974, and on the amounts of iron and steel that were recovered and recycled in 1974. On those bases, it was estimated that 0.5 million tons of contained manganese became obsolete in 1974, and of that, 0.2 million tons of obsolete manganese were recycled in 1974.

The pattern of losses from the domestic manganese cycle is different from the patterns of losses from other materials cycles, mainly because of the high processing losses. As has been mentioned, the loss is associated with the use of manganese as an inexpensive chemical reagent in the desulfurization (and sulfur control) and deoxidation of steel. These high processing losses can be reduced technologically by an order of magnitude or more through the use of higher cost reagents and processes. The losses from the domestic manganese cycle in 1974 were estimated to be as follows:

Nature Of losses	Milliosn of *tons*
Process losses	1.1
Unrecovered and unknown	0.15
Postconsumer solid waste	0.08
Dissipative uses	0.05
Corrosion and wear	0.03
Transport and handling	0.023
Milling losses of domestic ores	0.012
Manufacturing and fabricating	0.009
Total	1454

Figure 17.— Manganese Cycle: Flows and Losses, 1974
(Millions of short tons)



SOURCE: Working Papers One and Two.

CHROMIUM

Chromium is used primarily as an alloying element in stainless and heat-resistant steels; in chemicals, including those required for plating; and in refractories. Although chromium is expensive as a metal ($2.60 per lb), it is as low-priced as ferrochrome (30 cents to 45 cents per lb of contained chromium) or as the ore (28 cents per lb of contained chromium). Figure 18 presents the flows and losses in the 1974 domestic chromium cycle. About 840,000 tons of contained chromium in the form of chromite, ferroalloys, and scrap are consumed in materials processing and manufacturing. Figure 18 indicates that of the 724,000 tons of contained chromium used by end-product manufacturers, 639,000 tons were embodied in end products in 1974. Table 14 lists end products manufactured in 1974. Table 15 gives estimates of the amount of chromium contained in the end products that became obsolete in 1974. These estimates of obsolescence were based on assumed values of useful life for each of the product's market categories. Table 16 presents estimates of the amount of obsolete chromium that was recovered and recycled in 1974. Most of the 51,000 tons of contained chromium recycled in 1974 was recovered from transportation equipment and industrial machinery.

Based on the foregoing, losses from the chromium cycle in 1974 were as follows:

Losses	*Thousands of tons*
Dissipated uses	113
Unrecovered and unknown . . .	110
Process losses	83
Manufacturing losses	
Corrosion and wear	Nil
Total ., ...	311

Table 14.–Products Manufactured From Chromium-Containing Materials in 1974 (thousands of short tons of contained chromium)

Market category	Quantity
Construction ., ...	128
Transportation ... ., ...	102
Machinery. ., ...	85
Refractories. ., .,	71
Chemicals and plating. ...	77
Fabricated metal products	77
Other ., ...	99
Total . . . ., .	639

SOURCE Working Papers One and Two

Table 15.–Obsolescence of Chromium-Containing Products in 1974 (thousands of short tons of contained chromium)

Market category	Assumed average useful life (years)	Quantity
Construction .,	30	29
Transportation . .	13	39
Machinery. ., ...,	16	20
Refractories. ., ...	1½	55
Chemicals and plating. .,	10	58
Fabricated metal products ., .,	10	39
Other ., ...,	15	34
Total Uiii . .		274

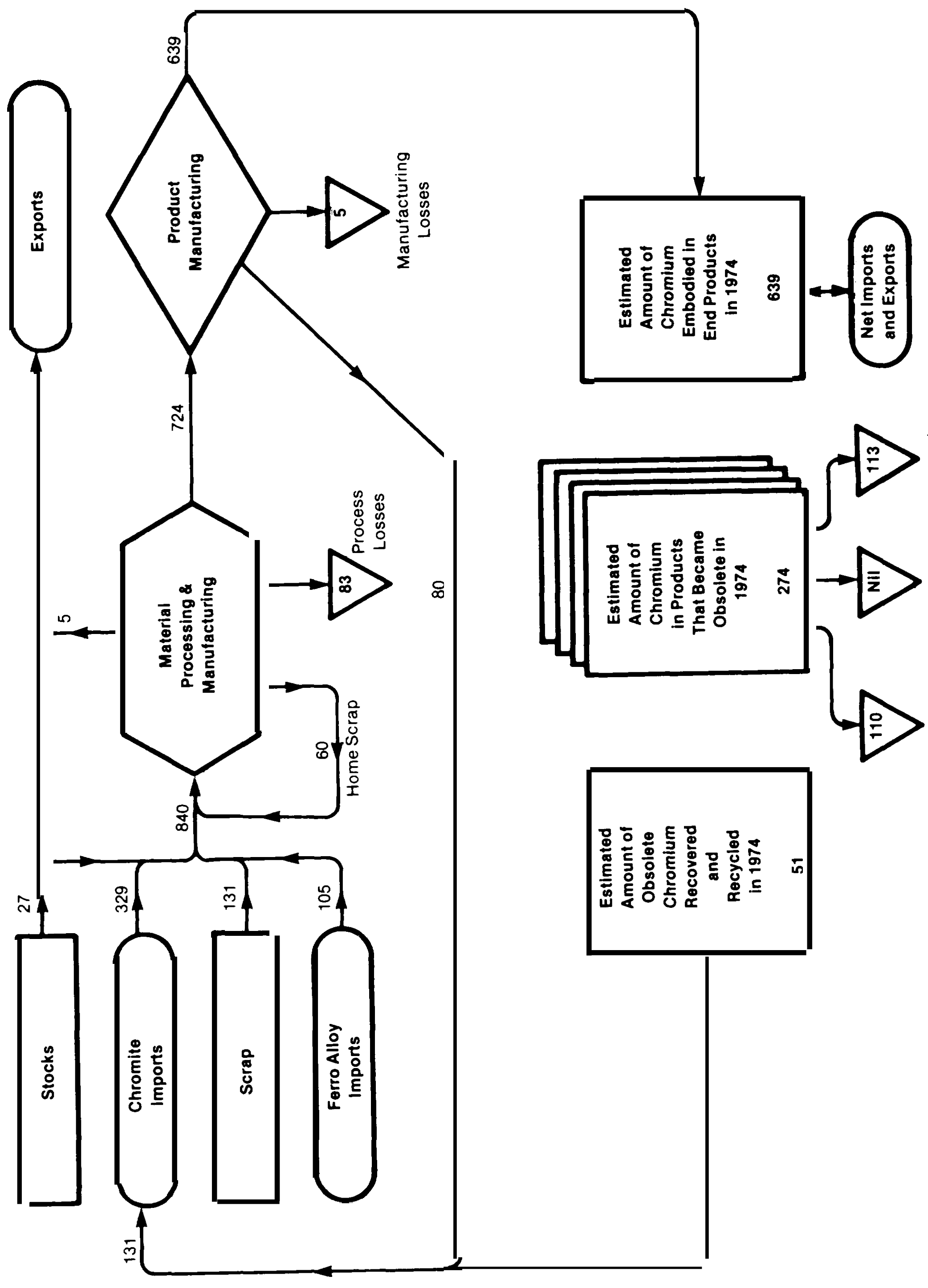
SOURCE Working Papers One and Two

Table 16.–Recycling and Recovery of Chromium in 1974 (thousands of short tons)

Market category	Estimated percentage of obsolete chromium recycled	Quantity
Construction ... ., ...	10	3
Transportation	60	23
Machinery. ., ...	55	11
Refractories. . . . ., ...	–	–
Chemicals and plating. ., ...	–	–
Fabricated metal products	10	4
Other	30	10
Total		51

SOURCE Working Papers One and Two

Figure 18.—Chromium Cycle: Flows and Losses, 1974
(Thousands of short tons of contained chromium)



SOURCE: Working Papers One and Two.

NICKEL

Nickel is a relatively high-priced ($1.74 per lb in 1974), moderate-volume (250,000 tons industrial demand in 1974) specialty metal. About half the annual consumption is by the steel industry in the manufacture of stainless and heat-resisting steels and in alloy steels. One-fourth is consumed in the manufacture of heat- and corrosion-resistant nickel-base alloys and superalloy. About one-eighth is used in electroplating, and the remainder is used as an alloying element in other nonferrous alloys and in various chemical and miscellaneous uses.

Estimates of the flows and losses from the total domestic nickel cycle are given in figure 19. Referring to figure 19, about 252,000 tons of contained nickel were used by end-product manufacturers, of which about 211,000 tons of contained nickel were embodied in end products in 1974.

The estimated amount of nickel embodied in end products in 1974 by product category is given in table 17. From a weighted average of product life for the various broad market categories, the overall "life" of nickel-containing products is probably about 18 years. In the year 1956, an estimated 170,000 tons of nickel in end products entered service. Hence it was estimated that this amount would become obsolete in 1974.

On the basis of fragmentary information, it was estimated that about 25,000 tons of nickel in obsolete products were recycled in 1974. From the foregoing, losses of nickel from the materials cycle in 1974 were estimated as follows:

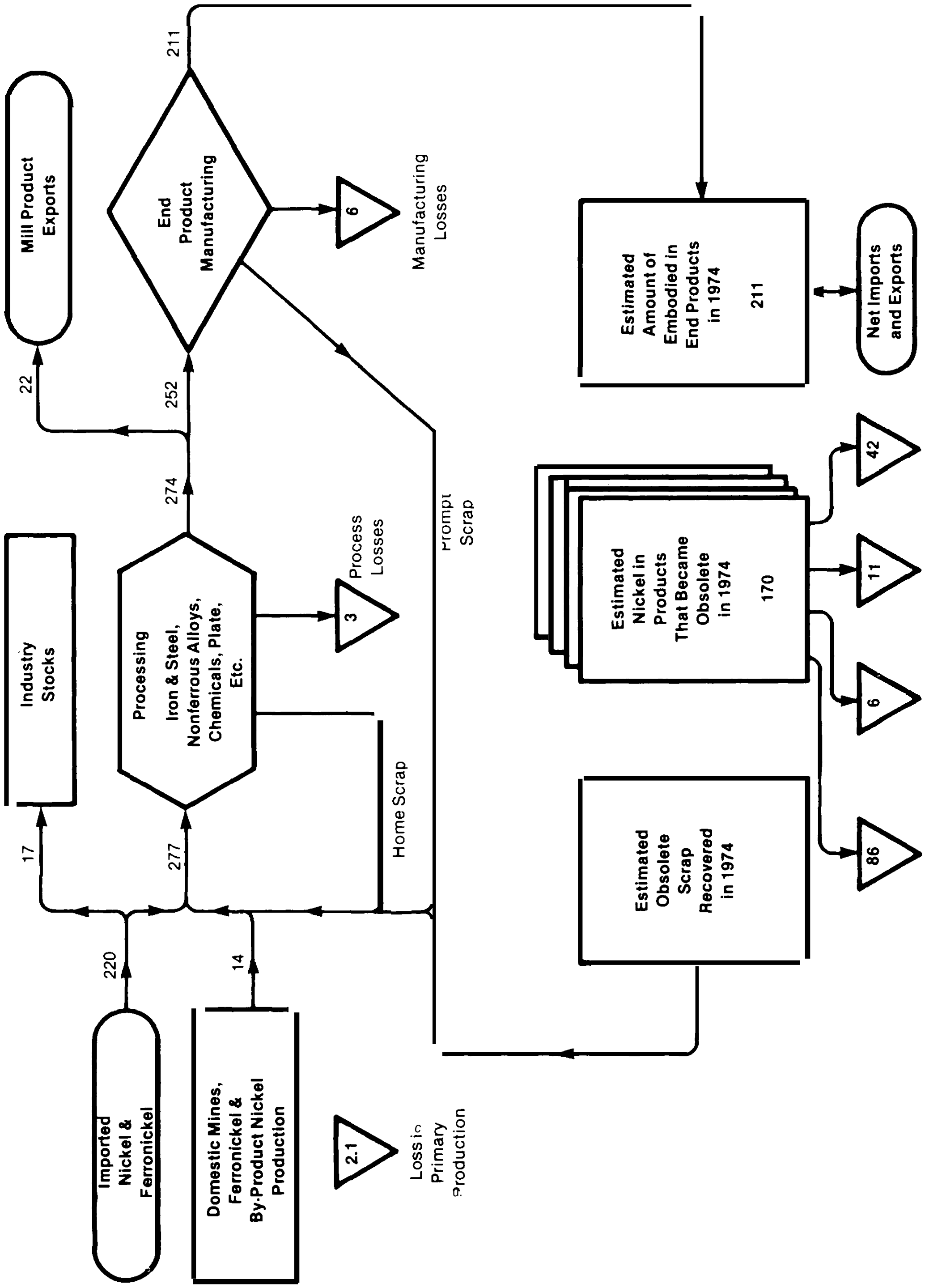
Losses	*Thousands of tons*
Unrecovered and unknown	86
Dissipative	53
Wear and corrosion	6
End-product manufacture.	6
Alloying and mill product manufacturing	3
Domestic ferroalloy manufacturing	2
Total	156

Table 17.–Estimated Nickel Embodied in End Products in 1974
(thousand short tons)

Market category	Quantity
Appliances. . .	13
Other domestic equipment ., ...	9
Ordnance and military	5
Construction ., ...,	7
Contractors products.	16
Automotive	40
Rail transportation	5
Shipbuilding and marine	12
Aircraft ...	18
Oil and gas. .,	10
Mining, quarrying ., ...	5
Agricultural equipment ...	3
Machinery and industrial equipment	49
Electrical machinery ., ...	19
Total	211

SOURCE Working Papers One and Two

Figure 19.—Nickel Cycle: Flows and Losses, 1974 (Thousands of short tons)



SOURCE: Working Papers One and Two.

TUNGSTEN

Tungsten in any form is a valuable commodity. In 1974 its value was nearly $5 per pound, and in the past 3 years the price has nearly tripled. The various sectors for domestic manufacture of tungsten-containing products in 1974 handled 16,000 tons of new and recycled tungsten. In comparison with most other materials, tungsten is regarded as a low-volume, high-priced specialty metal.

Flows and losses from the domestic tungsten cycle are given in figure 20. In 1974, 14,800 tons of contained tungsten were processed from foreign and domestic sources. After accounting for changes in industry stocks and tungsten product exports, 9,100 tons of contained tungsten were used by fabricators and manufacturers. About 8,100 tons of contained tungsten were embodied in end products in 1974. Table 18 provides a breakdown by end-product category of the tungsten embodied in manufactured products in 1974. Table 19 provides estimates of the amounts of tungsten that became obsolete in 1974 and the amounts that were recovered. Table 19 shows that the recovery and recycling of tungsten came primarily from the tools, guides, and dies used in metalworking machinery and cutting tools used in mining and construction.

Based on the foregoing, losses from the domestic tu ıgsten cycle in 1974 were as follows:

Losses	*Thousands of tons*
Unidentified losses	2.5
Exports of tungsten products	2.3
Discard of tungsten carbide inserts	2.1
Dissipative uses	1.9
Tungsten processing and manufacturing	1.0
Domestic milling and concentrating of tungsten areas and byproducts	0.35
Total	C 5

Table 18.—Products Manufactured From Tungsten-Containing Materials in 1974
(thousand short tons of contained tungsten)

End-product category	Estimated amount of tungsten quantity
Metalworking machinery	4.2
Cutting tools	(2.2)
Guides, dies, etc.	(2.0)
Mining and construction	1.5
Cutting tools	(0.9)
Wear resistant surfaces	(0.6)
Transportation	1.0
Lamps and lighting	0.6
Electrical	0.3
Chemical	0.2
Other	0.3
Total	8.

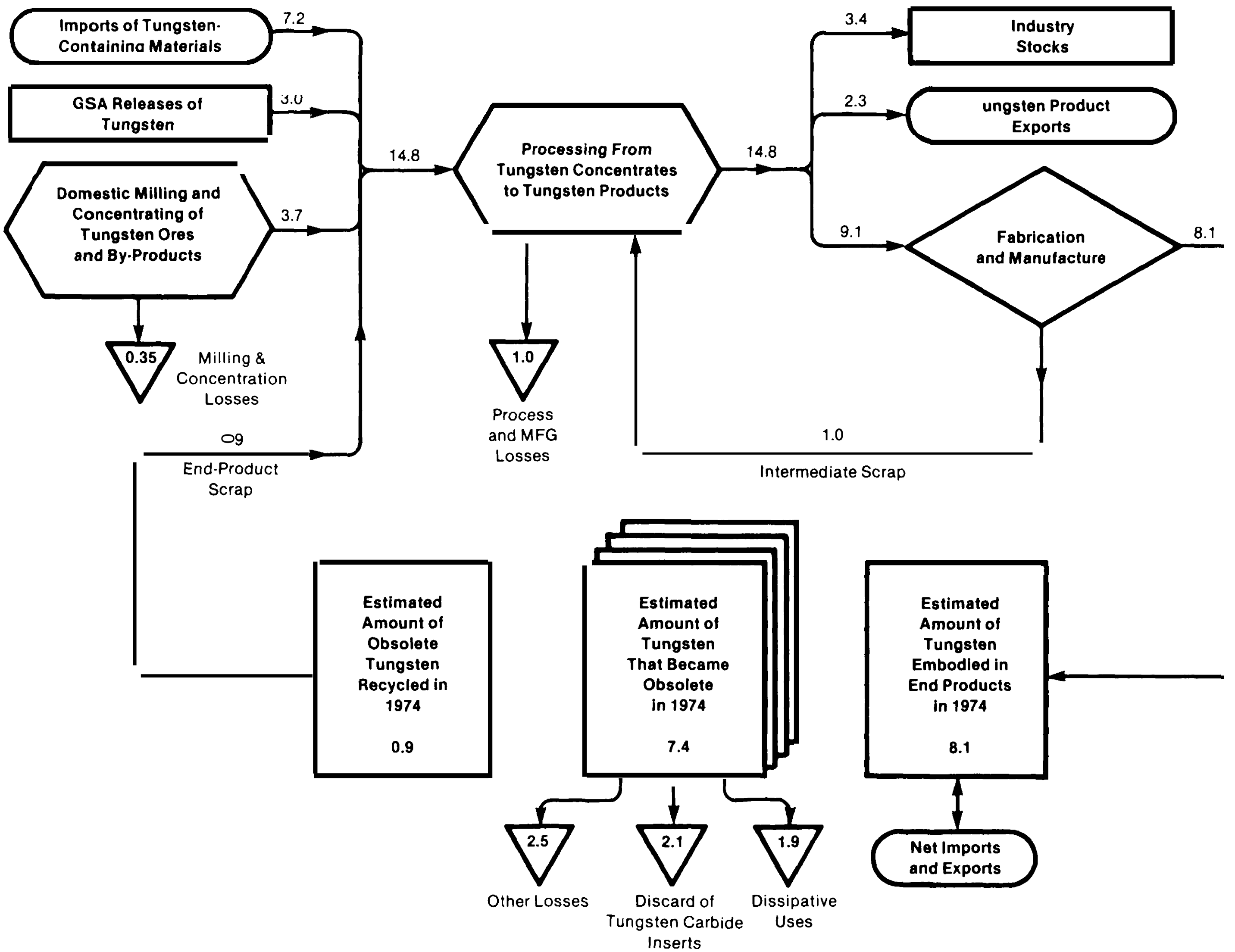
SOURCE: Working Papers One and Two.

able 19.—Estimated Amount of Tungsten That Became Obsolete in 1974 and the Amount Recovered and Recycled
(thousand short tons)

Market category	Estimated age of products (years)	Amount that became obsolete	Obsolete scrap recovery	Percent recycled
Metalworking machinery				
Cutting tools	<1	2.3	○5	22
Guides, dies, etc.	5	1.7	○2	12
Mining and construction				
Cutting tools	<1	0.9	0.2	22
Wear-resistant parts	10	0.4		
Transportation	3	0.9		
Lamps and lighting	3	0.6		
Electrical	' 5	0.2		
Chemical	1	0.2		
Other	, 0	0.2		
Total		7.4	0.9	·2

SOURCE: Working Papers One and Two

Figure 20.—Tungsten Cycle: Flows and Losses, 1974
(Thousands of short tons)



SOURCE: Working Papers One and Two

SUMMARY OF LOSSES FOR SELECTED METALS

A summary of the losses in physical terms is shown in table 20. The losses are listed in the sequence of materials flow—from mining through processing and manufacture and then through usage and recycle. As indicated in table 20, the largest quantities of losses in physical terms are those associated with the high-volume basic materials—iron and steel, aluminum, and copper. Quantities classified as unrecovered and unknown are significant because of their size and because they represent losses that one way or another enter the environment in the form of gaseous, liquid, or solid waste.

In order to develop a better perspective on the various kinds of losses, table 21 gives estimates of losses in percentage terms. In each case, the losses are expressed as a percentage of domestic shipments of mill products of the metal. In other words, these percentages are expressed as a percentage of the amount of metal flowing at one place, arbitrarily selected, in the cycle–shipments of mill products.

As shown in table 21, the most significant losses take place at the end of the materials cycle (unrecovered material, postconsumer waste, dissipative uses). If there are to be substantial reductions in metal losses, techniques must be developed and implemented with emphasis placed on the end of the materials cycle. The end of the material cycle is important for another reason: for each pound of material saved at the end of the cycle, the accumulated losses associated with the production and use of that pound of metal are also saved. For example, referring to the steel flow diagram in figure 13, 110.8 million tons of steel were embodied in production in 1974. Direct losses associated with the production of that amount of steel are 39 million tons of processing losses. Thus for each pound of material in a product, 0.35 lb has been lost in reaching the product stage. This means that 1 lb of metal saved at the end of the cycle translates into a total of 1.35 lbs saved.

Table 20.—Quantities Lost From the Materials Cycle of Selected Metals, 1974

	Quantities lost from cycle							
Nature of loss from cycle	Iron and steel (million short tons)	Aluminum (million short tons)	Copper (million short tons)	Platinum (million troy ounces)	Manganese (million short tons)	Chromium (thousand short tons)	Nickel (thousand short tons)	Tungsten (thousand short tons)
Milling and concentrating	23.3	0.2	0.4	Nil[b]	0.012	0	2.1	0.35
Transportation and handling[a]	(c)	0.2	·	Nil	0.023	Nil	Nit	Nil
Nonmetallic uses of raw materials	Nom[d]	0.8	0.1	Nom	0.12	71	Nom	Nom
Metal processing	6.8	0.4	0.074	0.015	1.1	83	3	1.0
End-product manufacture	1.1	0.1	0.006	0.009	0.009	5	6	Nil
Exports (net)								
Mill products	(10.2)[e]	0.6	(0.1)	(2.1)	(0.1)	0	0	2.3
End products		na	na	na		na	na	na
Scrap	7.8	0	0	0	0.05	0	0	b
Dissipative and quasidissipative uses	5.4	0.6	[illegible]	[illegible]	[illegible]	t13	53	1.9
Corrosion and wear	4.0	Nil	Nil	0.01	0.03	Nil		(9)
Postconsumer waste	11.0	1.0	0.2	(h)	0.08	(h)	(h)	2.1
Uncovered (and unknown)	19.4	0.4	0.9	0.14	0.15	110	86	2.5

[a] These losses from the materials cycle are in nonmetallic form and low in value. Such losses cannot be compared directly with other losses of metallics later in the cycle.
bNil = amount of losses close to zero.
cIncluded in "metal processing losses."
dNom = small but undetermined amount of losses.
e() = net imports.
fna = data not obtained.
gIncluded in "dissipative losses "
hIncluded in 'unrecovered and unknown losses."

SOURCE Working Papers One and Two

Table 21.— Percentage Losses From the Materials Cycles of Selected Metals, 1974

Nature of losses from cycle	Losses as a percentage of 1974 domestic shipments of contained metal[a]							
	Iron and steel	Aluminum	Copper	Platinum	Manganese	Chromium	Nickel	Tungsten
Milling and concentrating	19	3	15	Nil[c]	1	Nil	1	2
Transportation and handling[b].	d	3	—	Nil	3	Nil	Nil	d
Nonmetallic uses of raw materials.	Nom[e]	11	4	Nom	13	11	Nom	Nom
Metal processing	4	5	3	0.5	122f	12	1	7
End-product manufacture.	1	1	1	0.3	1	1	3	Nil
Exports (net)								
Mill products.	(8)[i]	8	(4)	0	11	0	0	15
End products	na[l]	na	na	na	na	na	na	na
Scrap	6	0	0	0	6	0	0	g
Dissipative and quasidissipative uses	4	6	11	9	4	16	23	13
Corrosion and wear	3	0	Nil	0.4	3	Nil	3	h
Postconsumer solid waste	9	14	7	g	9	g	g	14
Unrecovered (and unknown)	16	5	33	5	16	15	37	17

[a]All losses are expressed as a percentage of 1974 domestic mill shipments of mill products containing the metal. For reference purposes, the total 1974 domestic mill shipments for each metal were as follows, in millions of short tons Fe (124 3), Al (7.2), Cu (2 7), Pt (3 9 million troy ounces), Mn (*O* 9), Cr (O 724), Ni (O 274), W (O 0148).

bThese losses from the materials cycle are in nonmetallic form and low in value Such losses cannot be compared directly with other losses of metallics later in the cycle

[c]Nil = amount of losses close to zero

d Included in "metal processing losses"

eNom = small but undetermined amount of losses

fLosses of manganese exceed 100 percent because more manganese is lost as a slag in the Sseelmaklng process than is contained in the steel products actually shipped

gIncluded in "unrecovered and unknown losses"

h Included in "dissipative losses"

1( ) = net Imports

Ina = data not obtained

SOURCE: Workinq Papers One and Two