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PROFILES OF MATERIAL SUPPLIER INDUSTRIES TO THE AUTOMOTIVE MANUFACTURERS

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16. Abstract

This report presents a study of industries supplying materials to the automobile manufacturers. As the automobile industry restructures itself to produce more fuel-efficient vehicles, many of the industries that depend on the automobile will be forced to restructure themselves as well. The industries supplying steel, castings, aluminum, glass, plastics, and paint and their trends toward restructing are covered in this report.

The organization of this report reflects an automotive focus and special attention is paid to the impact of changing automotive requirements. At the same time, an effort has been made to recognize that each industry has its own unique dynamics and that automotive demand is only one factor influencing these dynamics.

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PREFACE

This report presents a Transportation Systems Center study of industries supplying materials to automobile manufacturers. Subsequent reports are planned to deal with parts and components suppliers and capital equipment suppliers.

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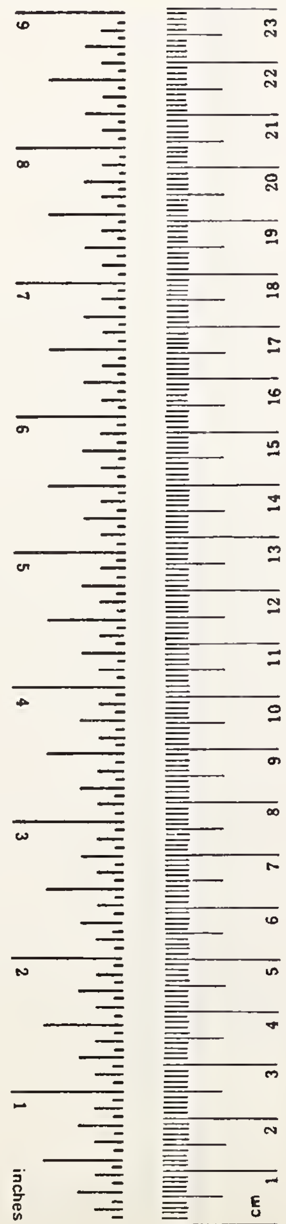
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

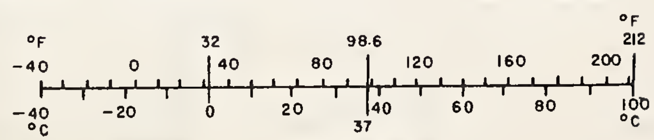
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yerds	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	squere inches	6.5	square centimeters	cm^2
ft^2	squere feet	0.09	square meters	m^2
yd^2	square yerds	0.8	square meters	m^2
mi^2	squere miles	2.6	square kilometers	km^2
	ecres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teespoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	squere centimeters	0.16	square inches	in^2
m^2	squere meters	1.2	square yerds	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	ecres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then edd 32)	Fahrenheit temperature	°F



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1. INTRODUCTION

1.1 GENERAL

The automobile plays the central role in the nation's transportation system, and corresponding to that role, the automobile industry plays a central role in the manufacturing industry. Many other industries are cast in supporting roles, selling automobiles, servicing them, fueling them, and supplying parts and materials. In 1978, the automakers employed nearly 1 million workers, and their suppliers, an even larger number.

The automobile industry is undergoing a period of profound change and stress, and the effects are being felt throughout the economy. As the automobile industry restructures itself to produce more fuel-efficient vehicles, many of the industries that depend on the auto will be forced to restructure themselves as well.

One group of suppliers that will certainly be affected are those industries which supply materials to the automobile industry: steel, aluminum, plastics, tires, castings, paint, and glass. Automobile manufacturing is a major consumer of the products of all of these industries, taking 20 percent of the nation's steel production, 30 percent of its ferrous castings, 26 percent of flat glass, 60 percent of synthetic rubber, 6 percent of plastics, 11 percent of aluminum and 9 percent of paint production.

1.2 PURPOSE, SCOPE, AND ORGANIZATION

This report is intended to serve as a ready source of information on the automobile industry's major materials suppliers. Seven industries are covered: steel, aluminum, plastics, rubber (tires), glass, paint, and castings (aluminum and iron).

The organization of the report reflects an automotive focus and special attention is paid to the impact of changing automotive requirements. At the same time, an effort has been made to recognize that each industry has its own unique dynamics and that automotive demand is only one factor influencing these dynamics.

Special emphasis has been given to the international dimension of these industries. The ongoing "globalization" of the automobile industry makes this imperative. Even an industry which is not exposed directly to international trade in its own products, is subject to international competition in the products of the industries it supplies.

Section 2 discusses changing requirements for automotive materials and presents a brief description of the status of each industry and its relationship to the auto industry. Sections 3 through 9 describe the seven materials supplier industries. The same format is used in characterizing each of the industries. First, world production and trade are described. Then the structure of the domestic industry and market trends are discussed. Technological trends in both product and process technology are presented next. A separate section deals with worldwide changes in the industry and potential impacts on the domestic industry. Finally, Government/industry relationships, primarily regulations, as they affect the industry, are discussed. A bibliography of key references is included for each industry. While an attempt was made to provide similar information for each industry, the level of detail could not be kept consistent throughout the industry descriptions because the availability of data varies greatly by industry.

2. OVERVIEW

2.1 AUTOMOTIVE MATERIALS REQUIREMENTS

In responding to a demand for greater fuel efficiency, the automobile industry is effecting a radical change in the American automobile. A smaller, lighter, front-wheel drive, four-cylinder American car is replacing the large conventional rear-wheel drive, V-8 powered auto of the 1960s and 70s. Part of this change involves the increased use of lightweight materials such as aluminum and plastic. The change also means decreased use of many other materials as the whole car and all its parts are made smaller.

The extent of the change is depicted in Table 2-1 which shows estimates for typical 1975 and 1980 model passenger cars along with a projection for 1985. The small changes in the proportion of these materials are overshadowed in most cases by the overall reduction in vehicle weight. Between 1975 and 1985, the American automobile is projected to shed about three-fourths of a ton of various materials. In a year in which the U.S. auto industry produced 12 million cars, that would translate into roughly 18 billion lbs of various materials no longer needed from other industries.

2.1.1 Steel

Steel continues to be the dominant material used in automobiles, accounting for approximately 60 percent of the vehicle's dry weight. The amount of steel used per vehicle, however, is declining drastically. As shown in Table 2-1, steel use declined by nearly 600 lbs between 1975 and 1980 and a further reduction of nearly 500 lbs is expected by 1985.

Reductions in vehicle size are the primary reason for reduced steel use, but substitution of other materials for steel and increased use of high strength steel are also factors. (The use of high strength steel results in weight reduction because

TABLE 2-1. MATERIALS USAGE IN TYPICAL U.S.-BUILT AUTOMOBILES

MATERIAL	MODEL YEAR 1975		1980		1985	
	%	LBS	%	LBS	%	LBS
Steel	61.0	2422	59.6	1836	56.5	1356
Iron	15.8	627	14.9	459	9.0	216
Aluminum	2.2	87	4.0	123	6.5	156
Copper	.9	36	.8	25	1.0	24
Lead	.7	28	.7	22	1.0	24
Zinc	1.3	52	.6	18	.5	12
Glass	2.4	95	2.6	80	3.0	72
Rubber	4.0	159	4.0	123	4.5	108
Plastics	4.2	167	6.0	185	10.5	252
Other	7.5	298	6.8	209	7.5	180
VEHICLE DRY WEIGHT	3970		3080		2400	

Source: The U.S. Automobile Industry, 1980. Report to the President from the Secretary of Transportation, January 1981, p. 28.

Note: Sources and References used in each section are listed in a bibliography at the end of that section.

the manufacturer can design a "leaner" part using less material but having the same functional strength as one made of conventional steel.)

2.1.2 Aluminum

The use of aluminum in U.S. cars has been increasing, both absolutely and as a proportion of total vehicle weight. This trend is expected to continue.

Aluminum is used in a wide variety of parts involving different manufacturing processes. Aluminum stampings are used to form hoods, deck lids, and a variety of decorative parts; aluminum extrusions are used in bumpers, head rest bars, and a number of smaller items; aluminum castings, which account for the largest portion of aluminum, are used as cylinder heads, transmission cases, intake manifolds, wheels, and a large number of other parts.

The use of aluminum is constrained by its relatively high cost compared to iron or steel. Primary aluminum ingot (used for castings) commonly sells for 76¢ per pound. Aluminum scrap (also used for castings, usually in combination with primary aluminum) goes for 35 to 45¢ per pound. Iron, on the other hand, sells for only about 7¢ per pound. Aluminum sheet (used for stamping) commonly sells for $1.10 per pound compared to 21¢ for sheet steel.

The fuel economy benefit implied by aluminum's weight-saving potential is not, by itself, enough in most cases to make the use of aluminum economical. Other factors, offsetting the material cost, must apply, such as a lower fabrication cost in aluminum or the potential for creating a premium product like a decorative wheel.

Growth in aluminum use in the next 5 years is expected to come primarily in castings. The use of aluminum for the cylinder head on many new engines will be a major factor in the growth of aluminum use. Use of aluminum for engine blocks is expected to be very limited in the period to 1985, but it remains an area with the potential for greatly increasing aluminum use.

2.1.3 Castings

Iron and aluminum are the principal materials used for automotive castings. Three principal types of iron are used: gray iron, which is used in a large variety of engine parts, especially where good wear and lubrication properties are important; malleable iron, which is used in a variety of brackets and other parts where strength is important but heavy wear is not expected; and nodular (or ductile) iron, which is used for crankshafts, brake parts and other parts where great strength is required.

Iron use is declining drastically, both as a result of general vehicle size reduction and the substitution of aluminum for iron in many applications. Aluminum is replacing gray and malleable iron primarily. Nodular iron, which is not threatened by aluminum, has been replacing forged parts in some applications, and as a result, nodular iron use is not declining as rapidly as gray and malleable iron use. The use of aluminum in castings is expected to increase.

2.1.4 Plastics

The use of plastics in U.S. automobiles has been increasing steadily as new plastics have been developed and perfected and new applications identified. Most of the plastics in automobiles today are not reinforced. Half of all applications are for the vehicle interior (e.g., upholstery, carpeting, instrument panels, etc.). The remaining exterior and under-the-hood applications are primarily for the bumper and fascia and a variety of miscellaneous hang-on parts, such as wheel covers and electrical housings.

The development of reinforced plastics opens the possibility of using plastics in structural applications as well. The use of reinforced plastics have been very limited to date and its expanded use depends on developing better information for designers on the properties of the available reinforced plastics and on developing economical, high volume manufacturing techniques. These developments imply long lead times for the extensive use of reinforced plastics.

Reinforced plastics for use in structural and body parts will gradually increase in use through 1985. It is expected these uses will be in vehicles with limited unit production volumes as design and manufacturing engineers gain experience in working with these materials.

Unlike aluminum, iron, and steel, the mechanical properties and manufacturing techniques of reinforced plastics are not well known. The long term potential for the use of reinforced plastics in automotive applications is still uncertain. Experiments and prototype developments being carried out now and during the next few years will provide needed information to better ascertain their potential.

Reinforced plastics and the extent to which they can substitute for other materials is the key to estimating material consumption by the automotive industry in the 1990s. One of the major factors in estimating material consumption in the 1990s is how reinforced plastics will be used and to what extent. If information on reinforced plastics applications can be reasonably obtained, then all other consumption of materials estimates will be more readily derived.

2.1.5 Glass

The development and use of thinner glass for automobiles as well as an overall reduction in vehicle size has resulted in a reduction in the weight of glass used per car. This reduction has been partially offset by a trend toward the use of more glass as a percentage of vehicle-body surface. In the newer models, designers have emphasized the use of glass to increase visibility. As a result, the square-footage of glass per vehicle has not declined in the same proportion as the weight per vehicle.

2.1.6 Rubber

Most of the rubber used in automobiles is in the tires. As cars become smaller and the use of smaller diameter tires increases, the amount of rubber used will decline. A second factor affecting rubber use in tires has been the adoption of special compact spare tires. These tires are designed for use only as temporary emergency replacements and are much smaller than standard tires.

2.1.7 Paint

Approximately 9 percent of U.S. paint production is consumed by the automobile manufacturers. The automotive coatings sector is experiencing a period of radical technological change as the automobile increasingly adopts water-borne and high-solids coatings.

The adoption of high-solids coatings, which have 30 percent greater covering power than conventional, solvent-thinned paint, combined with the adoption by the automobile industry of more efficient application techniques, may result in a secular decline in the quantity of paint demanded by the automobile industry.

2.2 INDUSTRY TRENDS

The impact of changing automotive reuqirements on the supplier industries varies greatly from industry to industry. Each industry has its own unique dynamics, made up of changing trends in domestic competition, market demands, international trade, and technological development.

The industries, facing declining demands, may find other markets growing so rapidly that the decline does not matter or they may find their other problems exacerbated; industries enjoying a rising automotive demand may prosper or they may find that expanding demand just invites increased competition. Some industries may be faced with the complete redesign of manufacturing plants as designs change.

In some industries, the impact may be limited to a few firms or plants specializing in automotive products; in others, the impact may be more diffuse. The industries profiled in this report exemplify the full range of impacts.

The following sections briefly describe the current status of each of the materials supply industries. Table 2-2 presents some summary statistics.

2.2.1 Steel

The U.S. share of world steel production has declined since 1958 from a third of world production to less than a fifth. Currently U.S. industry lacks the capital required to upgrade the industry's technologically obsolete facilities. In 1979 capital expenditures totaled $2.5 billion. A recent Office of Technology Assessment study* estimated that $5.3 billion per year for the next decade is needed to modernize existing mills, expand capacity modestly, and bring profitability up to the level of other domestic manufacturing industries. The industry estimates that $5.5 to $7.0 billion per year are needed. Unless the industry modernizes its facilities, steel imports, currently at 15 percent of U.S. consumption, appear likely to grow.

The automobile industry consumes approximately 20 percent of the domestic steel industry's production. The projected decline in per vehicle steel use will result in a secular decline in automotive demand, although a cyclical increase in vehicle production in the near term may moderate the trend. The impact associated with this decline will depend on the extent to which growth in other steel markets offsets the decline in automotive demand. The largest category of steels used by the automotive industry is hot and cold rolled sheet products. The automotive industry consumes 30 to 40 percent of the domestic output of these steels. Overcapacity already exists to produce these steels and declining demand by the automotive industry is likely to have a major impact on steel mills producing these products.

*Technology and Steel Industry Competitiveness, U.S. Congress Office of Technology Assessment, Washington, DC, Report No. OTA-M-122, June 1980.

TABLE 2-2. CHARACTERISTICS OF MATERIALS SUPPLIERS TO THE AUTO INDUSTRY

Industry	Steel	Aluminum	Plastics	Tires	Glass	Paint	Castings
Number of Plants	193	33 Primary Smelters	424 Resin Mfg. 10,043 Processors	201	62	1576	4279
Employment (000)	451	26.0 Primary 4.3 Secondary 60.0 Mill Products	59.2 Resin Mfg. 460.0 Processors	117	24.5	60.6	450
Shipments to Auto Industry (%)	20	11	6	21[4]	26[5]	9[6]	53 Gray Iron[3] 35 Aluminum
Domestic Production Capacity	110 M Tons	5.4 M Tons Primary 1.8 M Tons Secondary	15.4 M Tons[1]	122 M Units (Radial Tires)	N.A.	N.A.	31 M Tons
Annual Domestic Production	100 M Tons	5.2 M Tons Primary 1.6 M Tons Secondary	18.8 M Tons	145 M Units (All Tires)	3200 M Sq. Ft.	1 B Gallons	14 M Tons
U.S. Exports[2]	$1.7 B	$ .8 B	$2.6 B	$16.1 M	$145 M	$241.6 M	$293 M
U.S. Imports[2]	$6.4 B	$1.0 B	$ .53 B	$32.6 M	$ 54 M	$ 47.8 M	$152 M
Imports as % of Apparent Consumption[2]	14.1%	12%	4%	13.1%	2.7%	.6%	1.2%

[1]Capacity for 6 Major Resins

[2]Source: U.S. Industrial Outlook, 1980, U.S. Department of Commerce

M = Million
B = Billion

[3]1972 Census of Manufacturers

[4]Passenger car and truck replacement market consumes an additional 71% of all tires

[5]Automotive replacement market consumes an additional 7% of flat glass

[6]Of product coatings for manufacturers; 4% of all paint sold

2.2.2 Aluminum

The U.S. aluminum industry is the world's largest producer of primary and secondary ingots and fabricated aluminum mill products. Both U.S. and world demand for aluminum are projected to exceed available supply through the mid-80s. Because the production of primary aluminum is energy-intensive, new facilities must be located near inexpensive and plentiful power supplies. Worldwide capacity expansion is planned for Brazil and Australia where hydroelectric and low cost, coal-fired power sources are available. Further expansion of U.S. capacity is unlikely. As U.S. demand for primary aluminum grows, imports will increase from the present level of about 10 percent of total consumption and prices will rise.

2.2.3 Plastics

The U.S. is the world leader in the production of plastic resins, accounting for a third of worldwide production. The availability of cheap petrochemical feedstocks in the U.S., due to price controls, was a major factor contributing to U.S. dominance in the world market. As price controls are removed, resulting in feedstock cost increases, the U.S. position will erode somewhat. Competition from new facilities in third world oil-producing countries may also threaten U.S. market dominance.

The automotive sector currently demands about 6 percent of domestic resin production. Because the use of plastic parts in automobiles has escalated in recent years, the plastics industry sees the auto industry as a growth market. Thus, even if the volume of new vehicle production does not increase, the plastics industry can expect growth in the automotive market sector. Since the plastics industry is financially healthy and growing rapidly, it should be able to accommodate any level of growth in automotive use of plastics.

2.2.4 Tires

The introduction of radial tires in the U.S. passenger car market has a profound effect on the structure and profitability of the tire industry. Domestic sales of tires have declined in recent years and are now 30 percent lower than the peak years of the past decade. The introduction of the long-wearing radials combined with the reduction in vehicle-miles-traveled, has resulted in a significant decline in replacement tire sales.

Five U.S. tire companies* plus Michelin, a French manufacturer, dominate the U.S. tire market. Michelin, historically a producer of radials, entered the U.S. market when American companies were first developing radial technology. Because Michelin had proven radial manufacturing technology, it was able to penetrate the U.S. market and now has 2.5 percent of the original equipment tire market and 6 percent of total automotive sales, a share which may increase as more radials are demanded.

The U.S. passenger car tire market is divided between sales to the automobile manufacturers for use as original equipment (OE) and sales to consumers for use as replacement tires. Over 90 percent of new cars have radial tires; as a result, some 80 percent of OE tires shipped in 1980, including bias-ply temporary spare tires were radials. The replacement tire market, which took about 75 percent of all tires shipped in 1980, was 54 percent radial.

The U.S. tire industry is estimated to have had a capacity to produce 122 million radials in 1980, compared to total estimated shipments of about 95 million units. Increases in the volume of new vehicle production and in the share of the replacement market taken by radials may cause radial demand to substantially exceed 1980 capacity within the next 5 years. Nevertheless, declining industry profitability and low projected sales revenue growth make the industry reluctant to invest the additional $400 to 500 million to complete the conversion to radial production. The expected undercapacity will probably be made up by a combination of some plant conversions to radial production, by increased multiple shifts and overtime work, and possibly by increased imports.

*Goodyear, Firestone, B.F. Goodrich, General Tire, and Uniroyal.

2.2.5 Glass

About 26 percent of flat glass production is consumed by the auto industry and another 7 percent goes to the automotive replacement market. The principal products purchased are laminated safety glass for windshields and tempered safety glass for rear and side windows. Redesign of autos for fuel economy considerations has not adversely impacted the flat glass industry. Vehicle downsizing left the surface area of glass per vehicle relatively unchanged, but the shift to more expensive, thinner, lighter glass resulted in the continued profitability of sales to the auto industry. While vehicle redesign has not had an adverse impact on the glass industry, the recent drop in auto sales and production has caused some layoffs.

2.2.6 Paint

The paint industry is relatively stable. There are no significant structural or operational changes that are foreseen in the near future. There may be some reduction in the number of paint companies in the U.S. due to normal competition and attrition. The most significant impact taking place in the industry are the changes in automotive coatings. This will affect only a very small percentage of the paint suppliers in the country.

2.2.7 Castings

A number of trends are taking place in the casting industry. The casting industry is becoming more mechanical and less labor-intensive. This is placing a financial burden on many foundries. At the same time Government regulations are also requiring sizeable financial expenditures. It has been estimated that 700 foundries have closed during the last decade because of the financial strain. The majority of these firms were small with employment under 20 workers. This financial burden is not likely to ease in the near future and more closings are expected especially in the smaller foundries.

Another trend is in castings for the automotive industry. The switch from iron to aluminum has caused several large iron casting plants, dedicated to the automotive industry, to close. At the same time aluminum casting plants are being built or expanded to meet the demand of the automotive industry. This trend is likely to continue at least through the middle of this decade.

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3. THE STEEL INDUSTRY

3.1 WORLD PRODUCTION AND INTERNATIONAL TRADE

The world's production of raw steel exceeded 780 million tons in 1978. The largest steel producing nation is the USSR, but its output is mainly consumed within its own boundaries or within the Communist Bloc nations. In the non-Communist world, the United States, Japan, and the European Economic Community (EEC) are the largest steel producing centers; together, they account for over 50 percent of world steel production. The steelmaking countries of the world and their raw steel production are shown in Table 3-1.

The term, raw steel production, is a measure of steel actually made in a given year, and should not be confused with capacity to make steel. Capacity to make steel is a theoretical number seldom achieved, and assumes that there are adequate raw materials available and that the steelmaking equipment runs at optimum output with no major breakdowns. The U.S. raw steel production in 1978 was 137 million tons while its rated capacity was approximately 158 million tons. The world steel industry has been depressed since 1974, and its capacity to make steel is probably considerably larger than the 780 million tons of raw steel that were produced in 1978.

This underutilization of capacity has led many countries to aggressively seek to export steel to other countries in order to keep their own steel mills operating. This has led to heavy price competition and low profit margins for most steel producers. In this environment, many of the less developed countries (LDCs) are expanding their own steelmaking capabilities to become self-sufficient producers or even net exporters of steel. Much of this expansion is motivated by national pride rather than economic considerations. Many of the countries that once exported to the LDCs may someday find they no longer have a market there and that they are competing with the LDCs for other export markets.

TABLE 3-1. WORLD PRODUCTION OF RAW STEEL BY COUNTRIES (THOUSANDS OF NET TONS)

Countries	1979 P	%	1978 R	%	1977	%	1976	%	1975	%
North America										
United States	136,341	16.5	137,031	17.3	125,333	16.9	128,000	17.2	116,642	16.4
Canada	17,723	2.2	16,423	2.1	15,026	2.0	14,649	1.9	14,357	2.0
Total	154,064	18.7	153,454	19.4	140,359	18.9	142,649	19.1	130,999	18.4
Latin America										
Argentina	3,526	.	3,067	...	2,959		2,657	...	2,434	.
Brazil	15,314	..	13,454	...	12,306	..	10,200	...	9,245	..
Chile	708	...	679	...	621	...	554	...	560	...
Colombia	398	...	430	...	359		408	...	430	..
Cuba	331	..	331	...	331		331	...	331	...
Mexico	7,722	..	7,398	...	6,121		5,829	...	5,822	.
Peru	481	..	416	...	418		347	...	474	..
Venezuela	1,660	...	948	..	885		1,032	...	1,172	.
Others	123	...	80	.	87		32		29	.
Total	30,263	3.7	26,803	3.4	24,087	3.2	21,390	2.9	20,497	2.9
Europe										
Western Europe										
EEC										
Belgium-Luxembourg	20,273		19,170		17,178		18,420	...	17,864	
Denmark	886	...	951	...	755		796	...	614	...
France	25,750	...	25,178	...	24,365	.	25,603	...	23,734	...
West Germany	50,750	...	45,474	..	42,972	.	46,752	...	44,547	..
Ireland	79	...	76	...	52		64	...	89	..
Italy	26,731	...	26,767	...	25,722		25,855	...	24,102	.
Netherlands	6,400		6,154	.	5,426		5,708	...	5,310	..
United Kingdom	23,749	...	22,451		22,561		24,761	..	21,868	...
Total EEC	154,618	18.7	146,221	18.5	139,031	18.8	147,959	19.9	138,128	19.4
Other Western Europe										
Austria	5,420	..	4,779		4,777		4,934	...	4,485	
Finland	2,716	.	2,572		2,539		1,818	...	1,781	
Greece	1,102		1,032		1,102		1,224	...	992	
Norway	982	...	879	..	879	..	977	...	982	
Portugal	739		689	...	586		508	...	488	
Spain	13,501	...	12,499	...	12,312		12,106	...	12,238	
Sweden	5,217	...	4,767	...	4,374		5,665	...	6,185	
Switzerland	977	...	864	...	723		595	...	463	
Turkey	2,641	..	2,394	...	2,056		2,174	...	1,877	
Yugoslavia	3,897		3,810		3,508		3,032		3,214	
Total Other W. Europe	37,192	4.5	34,285	4.3	32,856	4.4	33,033	4.4	32,705	4.6
Total Western Europe	191,810	23.2	180,506	22.8	171,887	23.2	180,992	24.3	170,833	24.0

Source: Annual Statistical Report 1979, American Iron and Steel Institute.

TABLE 3-1. WORLD PRODUCTION OF RAW STEEL BY COUNTRIES (CONT.)

Countries	1979 P	%	1978 R	%	1977	%	1976	%	1975	%
Eastern Europe (Red Bloc)										
Bulgaria	2,633	...	2,722	...	2,853	...	2,712	...	2,497	...
Czechoslovakia	16,314	...	16,859	...	16,594	...	16,196	...	15,789	...
East Germany	7,676	...	7,690	...	7,551	...	7,430	...	7,143	...
Hungary	4,299	...	4,274	...	4,104	...	4,026	...	4,047	...
Poland	21,164	...	21,219	...	19,666	...	16,909	...	16,542	...
Rumania	14,230	...	12,984	...	12,629	...	12,092	...	10,526	...
U.S.S.R.	164,244	...	166,929	...	161,659	...	159,614	...	155,784	...
Total Eastern Europe	230,560	28.0	232,677	29.5	225,056	30.3	218,979	29.4	212,328	29.8
Total Europe	422,370	51.2	413,183	52.3	396,943	53.5	399,971	53.7	383,161	53.8
Africa										
Rhodesia	816	...	772	...	551	...	551	...	551	...
Republic of South Africa	9,784	...	8,710	...	8,053	...	7,833	...	7,530	...
Others	992	...	970	...	680	...	637	...	519	...
Total	11,592	1.4	10,452	1.3	9,284	1.2	9,021	1.2	8,600	1.2
Middle East										
Egypt	882	...	661	...	661	...	551	...	551	...
Israel	118	...	104	...	79	...	77	...	66	...
Iran	1,576	...	1,433	...	716	...	661	...	607	...
Other	624	...	201	...	56		17	...	17	...
Total	3,200	0.4	2,399	0.3	1,512	0.2	1,306	0.2	1,241	0.1
Far East										
India	11,162	...	11,132	...	11,033	...	10,322	...	8,809	...
Japan	123,181	...	112,551	...	112,882	...	118,370	...	112,781	...
South Korea	8,389	...	5,477	...	4,677	...	3,875	...	2,198	...
Taiwan	4,685	...	3,783	...	1,951	...	1,795	...	1,113	...
Others	2,114	...	1,817	...	1,179	...	1,334	...	1,072	...
Total	149,531	18.1	134,760	17.1	131,722	17.8	135,696	18.2	125,973	17.7
Far East (Red Bloc)										
China	37,953	...	35,031	...	25,794	...	23,149	...	29,211	...
North Korea	5,842	...	5,600	...	3,472	...	3,307	...	3,197	...
Total	43,795	5.3	40,631	5.1	29,266	4.0	26,456	3.5	32,408	4.6
Oceania										
Australia	8,950	...	8,373	...	8,084	...	8,591	...	8,674	...
New Zealand	252	...	248	...	240	...	236	...	204	...
Philippines	438	...	304	...	331	...	276	...	276	...
Total	9,640	1.2	8,925	1.1	8,655	1.2	9,103	1.2	9,154	1.3
Total Free World	550,100	66.7	517,299	65.4	487,506	65.7	500,157	67.1	467,297	65.6
Total Red Bloc	274,355	33.3	273,308	34.6	254,322	34.3	245,435	32.9	244,736	34.4
TOTAL WORLD	824,455	100.0	790,607	100.0	741,828	100.0	745,592	100.00	712,033	100.0

NOTE: United States data excludes steel shipped by foundries which reported their output to the Bureau of Census, but did not report to American Iron and Steel Institute as follows: 1979—2,029 P; 1978—1,857 P; 1977—1,717; 1976—1,804; 1975—1,937 (in thousands of net tons). Similar data not available prior to 1866.

Source: Annual Statistical Report 1979, American Iron and Steel Institute.

The United States has been a net importer of steel for the last 15 years, as Table 3-2 demonstrates. A certain level of steel imports is beneficial to the U.S. economy. The domestic steel industry does not maintain excess capacity to meet peak demand periods which may happen several times each decade. When peak demand periods occur, such as during 1973 and 1974, imported steel is necessary to keep basic steel-consuming industries from slowing down because of shortages. Many steel-consuming industries maintain ties with foreign steel manufacturers during low and normal demand periods (even though they could probably meet all of their steel requirements from domestic sources) in order to insure that they will receive favorable treatment from the foreign steel producers during periods of tight supply.

Europe and Japan are net exporters of steel. They maintain steelmaking capacities in excess of their own domestic requirements and export steel to offset imports of other goods. During periods of low demand for world steel, the steel companies in these countries compete aggressively for the reduced worldwide steel trade. Many of the European steel firms are government-owned or subsidized and are politically sensitive to layoffs within the steel industry. In Japan where lifetime employment practices are normal, there is a great reluctance to lay off workers. Because labor costs are treated as a fixed expense, companies in these nations try to produce as much steel as possible to spread the labor costs out over a higher production rate. The companies then compete to sell their steel on the world market. Competition usually takes the form of heavy price discounting.

The United States is one of the larger markets in which foreign steel exporters can compete. Table 3-3 shows the last five-year history of imports to the U.S. by country of origin. During 1977 the large amount of foreign steel entering the U.S. at low prices greatly alarmed the domestic steel industry. The domestic industry responded by filing anti-dumping complaints with the Federal government against the foreign manufacturers, charging that they were selling steel in the U.S. below the cost of production

TABLE 3-2. IMPORTS AND DOMESTIC STEEL SHIPMENTS
(Thousands of Net Tons)

Year	Domestic Steel Shipments	Less Exports	Plus Imports	Apparent Steel Supply	Imports as a % of Supply
1979	100,262	3,322	17,518	114,458	15.3
1978	97,935	2,934	21,135	116,136	18.1
1977	91,147	2,003	19,307	108,451	17.8
1976	89,447	2,654	14,285	101,078	14.1
1975	79,957	2,953	12,012	89,016	13.5
1974	109,957	5,833	15,970	119,609	13.4
1973	111,430	4,052	15,150	122,528	12.4
1972	91.805	2,873	17,681	106,613	16.6
1971	87,038	2,837	18,304	102,515	17.9
1970	90,798	7.062	13,364	97,000	13.8
1969	93,877	5,229	14,034	102,682	13.7
1968	91.856	2,170	17,960	107,646	16.7
1967	83,897	1,685	11,455	93,666	12.2
1966	89,995	1,724	10,753	99,024	10.9
1965	92,666	2,496	10,383	100,553	10.3
1964	84,945	3,442	6,440	87,943	7.3
1963	75,555	2,224	5,446	78,777	6.9

Source: Annual Statistical Reports
Years 1972 and 1979
American Iron and Steel Institute.

Note: As steel is converted from raw steel to steel products, there is a loss of 30 percent or more in the form of scrap. This is why Table 3-1 production is higher than Table 3-2 shipments.

TABLE 3-3. IMPORTS OF TOTAL STEEL MILL PRODUCTS BY COUNTRIES OF ORIGIN

(Net Tons)

Countries	1979	% Total	% Apparent Supply **	1978	% Total	% Apparent Supply **	1977	% Total	% Apparent Supply **	1976	% Total	% Apparent Supply **	1975	% Total	% Apparent Supply **
Canada	2,353,883	13.4	2.0	2,363,856	11.2	2.0	1,892,032	9.8	1.7	1,303,680	9.1	1.3	1,009,448	8.4	1.1
Mexico	159,627	0.9	0.1	213,978	1.0	0.2	223,612	1.2	0.2	141,377	1.0	0.1	50,788	0.4	0.1
Brazil	432,238	2.5	0.4	292,683	1.4	0.3	65,290	0.3	0.1	67,409	0.5	0.1	43,226	0.4	—
Argentina	37,579	0.2	—	239,119	1.1	0.2	89,956	0.5	0.1	87,021	0.6	0.1	3,726	—	—
Total Latin America	647,069	3.7	0.6	772,828	3.6	0.7	391,400	2.1	0.4	311,528	2.2	0.3	102,641	0.9	0.1
United Kingdom	433,727	2.5	0.4	671,765	3.2	0.6	818,159	4.2	0.7	533,055	3.7	0.5	572,857	4.8	0.6
Netherlands	499,981	2.8	0.4	685,622	8.2	0.6	607,829	3.1	0.5	388,716	2.7	0.4	448,565	3.7	0.5
Belgium-Luxembourg	956,405	5.5	0.8	1,238,325	5.9	1.1	1,146,688	5.9	1.1	462,621	3.2	0.5	630,213	5.2	0.7
France	1,340,670	7.7	1.2	1,758,832	8.8	1.5	1,586,164	8.2	1.5	730,343	5.1	0.7	753,798	6.3	0.8
West Germany	1,868,076	10.7	1.6	2,294,516	10.9	1.9	2,006,634	10.4	1.9	758,706	5.3	0.8	1,070,400	8.9	1.2
Italy	291,671	1.7	0.3	788,684	3.7	0.7	662,702	3.4	0.6	303,395	2.1	0.3	641,742	5.3	0.7
Total EEC *	5,405,389	30.9	4.7	7,463,394	35.3	6.4	6,832,850	35.4	6.3	3,187,660	22.3	3.2	4,117,575	34.3	4.6
Sweden	194,031	1.1	0.2	227,140	1.1	0.2	125,964	0.7	0.1	106,510	0.7	0.1	81,668	0.7	0.1
Finland	145,985	0.8	0.1	213,844	1.0	0.2	138,939	0.7	0.1	29,599	0.2	—	8,759	0.1	—
Poland	117,121	0.7	0.1	364,066	1.7	0.3	170,391	0.9	0.2	105,805	0.7	0.1	72,331	0.6	0.1
Spain	380,190	2.2	0.3	665,251	3.1	0.6	310,104	1.6	0.3	234,361	1.6	0.2	157,551	1.8	0.2
Romania	38,555	0.2	—	107,058	0.5	0.1	44,444	0.2	—	8,280	0.1	—	12,598	0.1	—
Total Europe	6,392,770	36.5	5.6	9,211,103	43.6	7.9	7,681,040	39.8	7.1	3,739,593	26.2	3.7	4,531,410	37.7	5.1
Japan	6,336,003	36.2	5.5	6,487,166	30.7	5.6	7,820,376	40.5	7.2	7,984,131	55.9	7.9	5,844,005	48.6	6.6
Korea Republic	985,666	5.6	0.9	1,052,122	5.0	0.9	790,039	4.1	0.7	790,458	5.5	0.8	397,187	3.3	0.4
Taiwan	108,515	0.6	0.1	250,369	1.2	0.2	67,234	0.3	0.1	62,485	0.4	0.1	36,075	0.3	—
Republic of So. Africa	485,307	2.8	0.4	694,986	8.3	0.6	463,096	2.4	0.4	21,495	0.2	—	11,033	0.1	—
Total Asia & Africa	7,965,000	45.5	6.9	8,606,107	40.7	7.4	9,237,188	47.8	8.5	8,879,922	62.2	8.8	6,319,374	52.6	7.1
Australia & Oceania	159,413	0.9	0.1	180,688	0.9	0.1	104,952	0.5	0.1	49,882	0.3	—	49,569	0.4	0.1
Total Imports of Steel Mill Products	17,518,135	100.0	15.2	21,134,582	100.0	18.1	19,306,612	100.0	17.8	14,284,605	100.0	14.1	12,012,442	100.0	13.5

* Includes total for Denmark and Ireland.
Country detail may not add to regional total because of omissions of some countries.
** As developed in table 8 of this Report.

Source: Annual Statistical Report 1979, American Iron and Steel Institute.

and that it was causing damage to the domestic industry. The processing of anti-dumping complaints is very time-consuming and sometimes takes over a year before a decision is made.

A special interagency task force was established to determine if a better way could be developed to deal with the steel trade issue. This eventually led to the creation of the Trigger Price Mechanism (TPM), which is covered in detail in section 3.6, Government/Industry Relationships. The TPM essentially set a floor price for steel below which imported steel could not be sold. It stabilized the volatile price fluctuations in the U.S. market as well as afforded some protection to domestic steel producers from unfair competition.

Foreign steel producers, particularly in Europe, who where using the U.S. market to absorb some of their excess steel production, were now faced with the possibility of finding other markets for their products or closing plants. The situation as it presently exists in Europe is discussed in detail in section 3.5, Worldwide Industry Structural Changes and Potential Impacts on U.S. Industry.

3.2 THE STRUCTURE OF THE DOMESTIC STEEL INDUSTRY

In the United States there are over 90 steel companies with an annual capacity to produce 158 million tons of raw steel. The ten largest producers of steel account for approximately 80 percent of the raw steel produced and shipped in the country. The ranking of the top ten companies and their steel output for 1979 are shown in Table 3-4. Most of the remaining companies operate what are commonly referred to as mini-mills. These are firms that operate electric steelmaking furnaces and usually have a capacity of less than 1 million tons per year (TPY).

The large steel producers are all integrated steel manufacturers. These companies usually own and operate their own sources of raw materials (iron ore, coal, and limestone). They convert the raw materials into iron in blast furnaces and the iron is converted to steel in either basic oxygen furnaces or

TABLE 3-4. TEN LARGEST DOMESTIC STEEL COMPANIES

Company	Raw Steel Making Capability*	1979 Raw Steel Production	Finished Steel Shipments**
U.S. Steel	36,100	29,700	21,000
Bethlehem Steel	22,400	19,401	13,436
LTV (Jones & Laughlin)	13,263	11,457	8,538
National Steel	11,500	10,731	8,258
Republic Steel	11,073	10,005	7,374
Inland Steel	8,700	8,221	6,036
Armco Inc.	9,911	8,001	6,004
Wheeling-Pittsburgh	4,400	3,895	2,889
Kaiser***	2,800	2,713	1,904
McLouth	2,000	1,885	1,541
Total of Top Ten Companies	122,147	106,009	76,980
Remainder of Industry†	33,154	29,880	23,282
Total Industry	155,301	135,889	100,262

*Raw steel capability, as defined by the American Iron and Steel Institute, is "the tonnage capability to produce raw steel for a full order book based on the current availability of raw materials, fuels and supplies and of the industry's coke, iron, steelmaking, rolling, and finishing facilities, recognizing current envrionmental and safety requirements."

**Finished steel shipments are always less than raw steel production because there is a loss of metal in the form of scrap when raw steel is converted to sheet, strip, tubes, and wire. The maximum shipping capability of the industry is estimated to be in the order of 110-115,000,000 tons.

***Ford Motor Company manages its own steelmaking facilities with a rated capacity of 3.75 million tons which makes it the eighth largest steel company. Ford does not report its raw steel production or finished steel shipments, although these are included in the total production and shipments for the industry.

†Includes Ford Motor Company.

open hearth furnaces. Steelmaking by this method requires large economies of scale to be profitable. The large steelmakers usually concentrate on producing carbon steel products that are consumed in high tonnage quantities such as sheet and bar products. Because the integrated steel producers consume high tonnages of raw materials, transportation costs become important. For this reason the integrated steel producers locate near their sources of iron ore and coal and preferably on major lakes and rivers where water transportation can be used because of its lower cost.

The large integrated steel companies are the principal producers of flat rolled steel, which make up a large percentage of the steel consumed by the automotive industry. The following firms originate 86 percent of the flat rolled steel products: U.S. Steel, Armco, Republic, Bethlehem, National, Jones and Laughlin, Inland, Wheeling-Pittsburgh, Sharon, and Interlake. If Ford, McLouth, and Kaiser were added to the list, it would increase the percentage well into the 90 percent range.

The major integrated steel producers, their location and flat rolled steel capacity are shown in Table 3-5. In Table 3-6 the steel plants have been arranged by state and Standard Metropolitan Statistical Area (SMSA). Table 3-7 lists those steel plants that have been identified as major suppliers to the automotive industry.

In the mini-mill or electric furnace, steel companies rely on iron and steel scrap as a source of raw materials. Consequently, the companies do not have to be located near iron and coal deposits and their electric mills can be established in any region of the country where there is an assured scrap supply. Capital costs for electric steelmaking furnaces usually are one-half that of an integrated steelmaking facility on a ton for ton basis. The electric steel making companies do not require iron mines, coal mines, sinter plants, coke plants, blast furnaces and all the other support facilities required by the integrated steel mills. In addition this greatly lowers the cost of pollution control equipment needed by the electric steel mills. However, the economies of scale for rolling mill facilities make it impractical

TABLE 3-5. TOP TEN U.S. RAW STEEL PRODUCERS

Company	State	LOCATION County	SMSA	City	Employment	Capacity MNT Sheets H.R.	Capacity MNT Sheets C.R.	Capacity MNT Strip H.R.	Capacity MNT Strip C.R.	% Open Hearth 1973	% Open Hearth 1979	Closings (yr) Employees
U.S. Steel (14)	PA	Bucks	Philadelphia	Fairless Hills	8450			3.1	2.3	9	9	
	PA	Cambria	Johnstown	Johnstown								
	PA	Allegheny	Pittsburgh	Duquesne								Allegheny
	PA	Allegheny	Pittsburgh	Braddock								Co. X
	PA	Allegheny	Pittsburgh	Mikeesport								
	PA	Allegheny	Pittsburgh	Munhall						25		
RAW	OH	Mahoning	Youngst-Warren	Youngstown	1320					15	9	X(80) 3,600
STEEL	OH	Lorain	Lorrain-Ellyria	Lorain	1950							
	IL	Cook	Chicago	S. Chicago						14		
	IN	Lake	E. Chicago	Gary	8000		3.8	7.2	5.1	12		
	AL	Jefferson	Birmingham	Fairfield	300			1.6	1.5	12		X(80) 400 (plate mill)
	TX	Harris	Houston	Baytown								
	UT	Utah	Provo-Oren	Geneva				2.1		10	10	
	CA	Los Angeles	LA Long Beach	Torrance						4	4	X(79)
	PA	Allegheny	Pittsburgh	Oravosburg	3900		2.4	3.1	.8			
	CA	Contra Costa	San Francisco-Oak	Pittsburg					1.5			X(80)
	PA	Allegheny	Pittsburgh	Homestead							11	X(80) (48″ plate mill)
	PA	Westmoreland	Pittsburgh	Vandergrift	925		.02					
	CT			New Haven								X(79)
	PA			Ambridge								X(80)
	PA			Universal								X(80) (Cement Division)
	IN			Buffington								
FABRICATION	PA			Northampton								X(80)
	IL			Chicago								X(80) (Container Plant)
	NJ			Camden								X(80) (Container Plant)
	PA			McKees Rocks								X(81) (Wheel and Axle)
	IL			Waukegan								X(79) (Waukegan & Joliet works closed, except rod div.
	PA			Ellwood City								
	MN			Duluth								X
	IL	Will/Lake		Joliet								X
	PA			Shiffler								Structural Fabrication
	OH	Cuyahoga		Cleveland								
				Irvin								
Bethlehem (8)	PA	Northampton	Allen-Beth-Easton	Bethlehem								
	PA	Northampton	Allen-Beth-Easton	Steelton								
	MD	Baltimore	Baltimore	Sparrows Pt.	18600	5.2	1.9	5.6	N.A.	14	7	
RAW	NY	Erie	Buffalo	Lackawana	19500	2.5	1.7	2.4	1.8	6		Δ 3,500 (77)
STEEL	PA	Cambria	Johnstown	Johnstown	12800					8		Δ 3,800 (77)
	IN	Porter	Gary-Hammond-Vzch	Chesterton	6400							
	WA	King	Seattle	Seattle								
	CA	Los Angeles	LA	Los Angeles								
	IN	Porter	Gary-Hammond	Burns Harbor			1	N.A.*	N.A.			

*Note: N.A. indicates this product originates form this plant, but production figures are not available.

TABLE 3-5. TOP TEN U.S. RAW STEEL PRODUCERS (CONT.)

Company	State	Location: County	Location: SMSA	Location: City	Employment	Capacity MNT Sheets H.R.	Capacity MNT Sheets C.R.	Capacity MNT Strip H.R.	Capacity MNT Strip C.R.	# Open Hearth 1973	# Open Hearth 1979	Closings (yr) Employees
LTV [Jones & Laughlin	J&L PA	Beaver	Pittsburgh	Aliquippa			.7	1.1	.9			
& Youngstown] (9)	J&L PA	Allegheny	Pittsburgh	Pittsburgh		1.3	.6	1.0	1.3	12		
	Y S&T OH	Mahoning	Youngstown-Warren-									
			Brier Hill	Youngstown						23		(80) 5000
	J&L OH	Cuyahoga	Cleveland	Cleveland	4590	3.4	1.2	5.2	1.2			
	J&L MI	Macomb	Detroit	Warren								
	Y S&T OH	Mahoning	Youngstown-Warren	Campbell			1.1					(80) X 1400
												(78) Δ 4200
	Y S&T IN	Lake	Gary-Hammond	E. Chicago								
			E. Chicago	Indiana Harbor	8000		.9	5.0	N.A.		8	
	J&L IL	Putman	(None)	Hennepin	800		1.2		N.A.			
	J&L OH	Stark	Canton	Louisville			.1		N.A.			
Republic Steel Corp.	NY	Erie	Buffalo	Buffalo								
(7)	OH	Mahoning	Youngstown	Youngstown								
	OH	Trumbull	Warren	Warren	5000			1.7	.4			
	OH	Stark	Canton	Canton	6700	.04						
	OH	Cuyahoga	Cleveland	Cleveland	7000			N.A.	1.2	5		
	IL	Cook	Chicago	S. Chicago	5500					4		
	AL	Etowa	Gadsden	Gadsden			.04	.3				
	OH	Trumbull	Youngstown-Warren	Niles					.2			
Inland Steel Co.	IN	Lake	Gary-Hammond									
			E. Chicago	E. Chicago	25000		.6	6.7	3.8	7	7	
	IN											
Armco Inc. (8)	MD	Baltimore	Baltimore	Baltimore								
	PA	Butler	(None)	Butler				.5	5.7			
	OH	Butler	Hamilton	Middletown	7000			2.4	2.1	6	6	
			Middletown									
	KY	Boyd	Ashland	Ashland	4800	N.A.		1.8	N.A.			
			Huntington									
	MO	Jackson	Kansas City	Kansas City								
	OK	Tulsa	Tulsa	Sand Springs								
	TX	Harris	Houston	Houston								
	CA	LA	LA-Long Beach	Torrance								

TABLE 3-5. TOP TEN U.S. RAW STEEL PRODUCERS (CONT.)

Company	State	Location: County	Location: SMSA	Location: City	Employment	Capacity MNT Sheets H.R.	Capacity MNT Sheets C.R.	Capacity MNT Strip H.R.	Capacity MNT Strip C.R.	# Open Hearth 1973	# Open Hearth 1979	Closings (yr) Employees
Wheeling-Pittsburgh Steel Corp. (5)	PA	Westmoreland	Pittsburgh	Monessen						8		
	OH	Jefferson	Steubenville-Weirton	Steubenville				1.2		11		
	PA	Washington	Pittsburgh	Allenport				N.A.	.6			
	WV	Ohio	Wheeling	Wheeling				3.6				
	OH	Jefferson	Steubenville-Weirton	Yorkville					N.A.			
National (4)	WV	Hancock	Steubenville-Weirton	Weirton	12500	2.7		2.40	2.1			
	MI	Wayne	Detroit	Ecorse	10700	.4		3.0	N.A.			
	IL	Madison	St.Louis	Granite City	4500	N.A.	N.A.	1.1	.7			
	IN	Porter	Gary-Hammond E. Chicago	Portuge	1800		2.6		1.3			
Kaiser (1)	CA	San Bernadino	Riverside-San Bernadino Ontario	Fontana				1.8	1.1	8		
McLouth Steel Corp. (1)	MI	Wayne	Detroit	Trenton		2.4	.9	1.7	N.A.			
Ford (1)	MI	Wayne	Detroit	Dearborn			1.7	2.9	2.0			

SOURCES: Raw steel manufacturing plants available from - AISI, 1978.
Hot and cold sheet plant capacity from Directory of Iron and Steel Works of U.S. & Canada.
Hot and cold strip from Steel Industry in Brief: Databook, USA 1979-80.
Open hearth figures: 1973 Steel Plants USA 1960-80 Annual Steelmaking Capacities IISS
1979 Databook, USA 1979-80, IISS.
Employment estimates from Booz-Allen.

TABLE 3-6. LOCATION OF TOP TEN STEEL PRODUCERS' PLANTS

State	U.S. Steel	Bethlehem	J&L	National	Republic	Inland	Armco	Wheeling Pitts	Ford	Kaiser	McLouth	Total # Steel Plants
Pennsylvania												
Pittsburgh	4		2					1				7
Johnstown	1	1										2
Philadelphia	1											1
Allen-Beth-Easton		2										2
(No SMSA) Butler							1					1
Ohio												
Youngstown-Warren	1		2(y)*		2							5
Lorrain Ellyria	1											1
Cleveland			1		1							2
Canton			1		1							2
Hamilton-Middletown							1					1
Illinois												
Chicago	1				1							2
(No SMSA) Hennepin			1									1
St. Louis				1								1
New York												
Buffalo		1			1							2
Indiana												
E. Chicago Gary-Hammond		1	1(y)			1						3
Michigan												
Detroit			1	1					1		1	4
Alabama												
Birmingham	1											1
Gadsden					1							1

*Entries for J&L listed with a "y" are plants still designated as Youngstown Sheet & Tube.

TABLE 3-6. LOCATION OF TOP TEN STEEL PRODUCERS' PLANTS (CONT.)

State	U.S. Steel	Bethlehem	J&L	National	Republic	Inland	Armco	Wheeling Pitts	Ford	Kaiser	McLouth	Total # Steel Plants
California												
Los Angeles	1	1					1					3
San Bernadino												1
Kentucky												
Hamilton-Ashland							1					1
Maryland												
Baltimore		1					1					2
Missouri												
Kansas City							1					1
Oklahoma												
Tulsa							1					1
Texas												
Houston	1						1					2
Utah												
Provo-Oren	1											1
Washington												
Seattle		1										1
West Virginia												
Steubenville-Weirton				1				1				2

TABLE 3-7. STEEL PLANTS LINKED TO AUTO INDUSTRY PRODUCTS

State	SMSA	City	Firm	Estimated Employment	Metropolitan Labor Force
Pennsylvania	Philadelphia	Fairless Hills	U.S. Steel	8,450	2,139,700
	Pittsburgh	Drovosburg	U.S. Steel	3,900 No	1,012,800
	Pittsburgh	Vandergrift	U.S. Steel	925 Raw	
	Johnstown	Johnstown	Bethlehem	12,800 Steel	109,900
	Pittsburgh	Pittsburgh	Jones & Laughlin	5,000	N/A
	Total			19,555	
Ohio	Youngstown-Warren	Youngstown	U.S. Steel	1,320	234,100
	Youngstown-Warren	Warren	Republic	5,000	
	Lorrain-Elyria	Lorrain	U.S. Steel	1,950	NA
	Cleveland	Cleveland	Jones & Laughlin	4,590	914,600
	Cleveland	Cleveland	Republic	7,000	
	Canton	Canton	Republic	6,700	182,400
	Hamilton-Middleton	Middletown	Armco	7,000	NA
	Total			33,560	
Indiana	Gary-Hammond	Gary	U.S. Steel	8,000	
	Gary-Hammond	E. Chicago	Y S&T	8,000	301,000
	Gary-Hammond	E. Chicago	Inland	25,000 No	
	Gary-Hammond	Portage	National	1,800 Raw	
	Gary-Hammond	Chesterton	Bethlehem	6,400 Steel	
	Total			59,200	
Illinois	Chicago	S. Chicago	Republic	5,500	3,370,100
	St. Louis	Granite City	National	4,500	1,084,300
	(None)	Hennepin	Jones & Laughlin	800	NA
	Total			10,800	
Michigan	Detroit	Ecorse	National	10,700	1,983,500
	Detroit	Trenton	McLouth	3,000	
	Total			13,700	
New York	Buffalo	Lackawanna	Bethlehem	19,500	569,900
	Total			19,500	
Kentucky	Huntington-Ashland	Ashland	Armco	4,800	126,600
	Total			4,800	
Maryland	Baltimore	Sparrows Pt	Bethlehem	18,600	1,049,400
	Total			18,600	
Alabama	Birmingham	Fairfield	U.S. Steel	300	378,500
	Total			300	
West Virginia	Weirton-Steubenville	Weirton	National	12,500	NA
	Total			12,500	

Source: Labor force figures taken from Employment and Earnings Department of Labor Statistics.

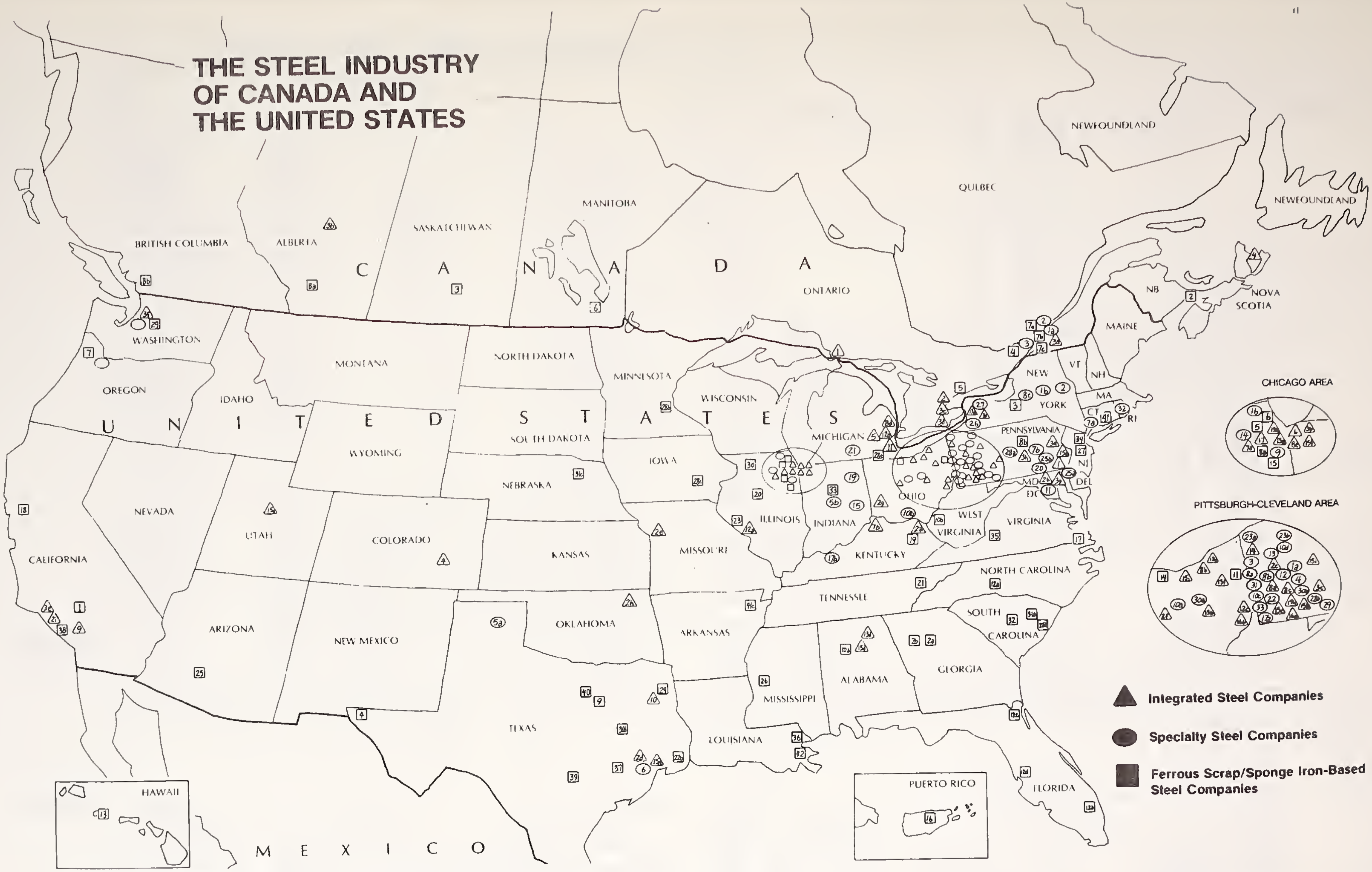
for the smaller mini-mill producers to compete for higher tonnage steel products.

The mini-mill steel producers operate in two sectors of the steel market. Some mini-mill operators produce specialty alloy steels such as stainless, tool and die, heat-resistant, and aerospace steels. These steels are consumed in relatively small quantities in comparison to carbon steels and many of them command premium prices that are many times higher than carbon steel.

The other sector of the mini-mill market is the production of selected carbon steel products for local and regional markets. These products usually consist of items such as concrete reinforcing bars, other bars and light shapes, and pipe. They are competitive with the large integrated steel mills because they serve a regional market and their transportation costs are greatly reduced.

The geographical concentration and plant capacity of the steel industry is graphically shown in Figure 3-1 and Table 3-8. The integrated steel companies demonstrate the highest degree of concentration, operating predominantly in the north central states to be near their sources of raw materials. The specialty steel producers are less concentrated than the integrated producers, although they also tend to concentrate in the industrial north central region primarily to be near their customers. The regional mini-mill steel producers (shown in Figure 3-1 as the ferrous scrap steel companies) are the least concentrated of any of the steel producers. Note that many of the integrated steel producers also operate electric mini-mills and produce specialty steels. Those steel mills that are owned by the integrated steel manufacturers and are smaller than 1 million TPY are probably mini-mills.

Employment within the domestic steel industry has decreased over the last decade, as shown in Table 3-9. Employment levels have recovered from the low point reached in 1977 and 1978, but it is unlikely that the levels will ever recover to the rates reached in 1970. A number of factors are responsible for this. The domestic raw steelmaking capacity has been shrinking



This map was revised by TSC to reflect conditions in the steel industry as of 1980 and also to facilitate photocopying.

Source: Institute for Iron and Steel Studies, 1103 North Washington Avenue, Green Brook NJ 08812

FIGURE 3-1. NORTH AMERICAN STEEL INDUSTRY - PLANT LOCATIONS

TABLE 3-8. NORTH AMERICAN STEEL INDUSTRY - PLANT CAPACITIES

▲ Integrated Steel Companies

CANADA

Map Code	Company and Plant Locations	Raw Steel Capacity Net Tons
1	ALGOMA STEEL CORP LTD	4,000,000
	Sault Ste Marie, Ont	
2	DOMINION FOUNDRIES & STEEL LTD	3,750,000
	Hamilton Ont	
3	STELCO	7 600,000
3a	Contrecoeur, Que	250 000
3b	Edmonton Alta	250 000
3c	Hamilton Ont	5 800,000
3d	Nanticoke Ont	1 300 000
4	SYDNEY STEEL CORP LTD	1 125 000
	Sydney N S	
	Canada Integrated Steelmakers Raw Steel Plant Caoacity Total	16 475 000

UNITED STATES

Map Code	Company and Plant Locations	Raw Steel Capacity Net Tons
1	ALAN WOOD STEEL COMPANY	Inactive
	Conshohocken PA	
2	ARMCO STEEL CORPORATION	10 435 000
2a	Ashland KY	2 200,000
2b	Baltimore MD	100 000
2c	Butler PA	1,000,000
2d	Houston TX	1 600,000
2e	Kansas City MO	1 600,000
2f	Marion OH	200,000
2g	Middletown OH	3 500 000
2h	Sand Sonngs OK	300 000
2i	Torrance CA	35 000
3	BETHLEHEM STEEL CORP	22 170 000
3a	Bethlehem PA	3 380 000
3b	Burns Harbor IN	5,300 000
3c	Johnstown PA	1 200 000
3d	Lackawanna NY	2 800,000
3e	Los Angeles CA	570 000
3f	Seattle WA	520 000
3g	Soarrows Point MO	7 000 000
3h	Steelton PA	1 400 000
4	C F & I STEEL CORPORATION	1 900 000
	Pueblo CO	
5	FORD MOTOR COMPANY	3 750 000
	Dearborn MI	
6	INLAND STEEL COMPANY	9 000 000
	East Chicago IN	
7	INTERLAKE INCORPORATED	1 380 000
7a	Chicago IL	900 000
7b	Wilder KY	480,000
8	JONES & LAUGHLIN STEEL CORP	14 225,000
8a	Aliquiooa PA	3 500 000
8b	Cleveland OH	3 100,000
8c	Pittsburgh PA	1 800 000
8d	Warren MI	325 000
8e	East Chicago IN	5 500,000
9	KAISER STEEL CORPORATION	3 600,000
	Fontana CA	
10	LONE STAR STEEL COMPANY	1 650 000
	Lone Star TX	
11	McLOUTH STEEL CORPORATION	2 400 000
	Trenton MI	
12	NATIONAL STEEL CORP	12 700 000
12a	Granite City Steel Division	2 500 000
	Granite City IL	
12b	Great Lakes Steel Division	6 200 000
	Ecorse MI	
12c	Weirton Steel Division	4 000,000
	Weirton WV	
13	REPUBLIC STEEL CORP	13 100 000
13a	Buffalo NY	1 000,000
13b	Canton OH	1 500 000
	Massillon, OH	
13c	Cleveland OH	4 400 000
13d	Gadsden AL	1,500,000
13e	South Chicago IL	2 000 000
13f	Warren OH	2 700 000
	Youngstown OH	
14	SHARON STEEL CORPORATION	1 560,000
	Farrell PA	
15	UNITED STATES STEEL CORP	38 460,000
15a	Baytown TX	2 000 000
15b	Braddock PA	2 500,000
15c	Duquesne PA	3 000 000
15d	Fairfield AL (closed olate mill	3 500 000
15e	Fairless Hills PA	4 400 000
15f	Gary IN	8 000 000
15g	Geneva UT	2 750,000
15h	Homestead PA (closed olate mill	4 000 000
15i	Johnstown PA	60 000
15j	Lorain OH	3 000 000
15k	South Chicago IL	5 250 000
16	WHEELING-PITTSBURGH STEEL CORPORATION	4 400 000
16a	Monessen PA	1 600 000
16b	Steubenville OH	2 800 000
17	WISCONSIN STEEL COMPANY	Inactive
	South Chicago, IL	
	U S Integrated Steelmakers Raw Steel Plant Caoacity Total	143 410 000

● Specialty Steel Companies

CANADA

Map Code	Company and Plant Locations	Raw Steel Capacity Net Tons
1	ATLAS STEELS CO LTD	395 000
1a	Tracy Que	70 000
1b	Welland Ont	325,000
2	COLT INDUSTRIES CANADA	50 000
	Crucible Steel Division	
	Sorel, Que	
3	HAWKER-SIDDELEY CANADA CANADIAN STEEL WHEEL	200,000
	Montreal Que	
	Canada Specialty Steelmakers Raw Steel Plant Caoacity Total	645,000

UNITED STATES

Map Code	Company and Plant Locations	Raw Steel Capacity Net Tons
1	ALLEGHENY LUDLUM INDUSTRIES	1 080 000
1a	Brackenridge PA	1 040,000
1b	Soecial Metals Sub	40 000
	New Hartford NY	
2	AL-TECH SPECIALTY STEEL CORP	120,000
	Watervliet, NY	
3	BABCOCK & WILCOX COMPANY	650 000
	Beaver Falls PA	
4	BRAEBURN ALLOY STEEL DIV	50 000
	Braeburn Lower Burrell PA	
5	CABOT CORPORATION	52 000
5a	Pamoa TX	27 000
5b	Stellite Division	25,000
	Kokomo IN	
6	CAMERON IRON WORKS	120 000
	Houston TX	
7	CARPENTER TECHNOLOGY GROUP	236 000
7a	Bridgeoort, CT	112 000
7b	Reading, PA	124,000
8	CRUCIBLE INC	1 670 000
8a	Alloy Oivision	1,000,000
	Midland PA	
8b	Stainless Steel Division	600,000
	Midland PA	
8c	Soecialty Metals Division	70 000
	Syracuse NY	
9	COLUMBIA TOOL STEEL CO	20 000
	Chicago Heights IL	
10	CYCLOPS CORPORATION	1 120 000
	Emoire-Detroit Oivision	400 000
10a	Mansfield OH	
10b	Portsmouth, OH	600,000
	Universal Cyclops Oivision	120 000
10c	Bridgeville &	
10d	Titusville PA	
11	EASTERN STAINLESS STEEL CO	180 000
	Baltimore MO	
12	EDGEWATER STEEL CORP	95 000
	Oakmont PA	
13	ELECTRALLOY CORPORATION	70,000
	Oil City PA	
14	A FINKL & SONS INC	100 000
	Chicago IL	
15	INGERSOLL STEEL CO	30,000
	New Castle IN	
16	ITT-HARPER	20 000
	Morton Grove IL	
17	JESSOP STEEL COMPANY	240,000
17a	Washington PA	60 000
17b	Green River Steel Coro	180 000
	Owensboro, KY	
18	EARLE M JORGENSEN CO	80 000
	Seattle WA	
19	JOSLYN STAINLESS STEELS	60,000
	Fort Wayne IN	
20	LUKENS STEEL COMPANY	874 000
	Coatesville PA	
21	MACSTEEL COMPANY DIVISION	180 000
	Jackson, MI	
22	MESTA MACHINE COMPANY	200,000
	West Homestead PA	
23	NATIONAL FORGE COMPANY	225 000
23a	Erie PA	150,000
23b	Irvine PA	75 000
24	OREGON STEEL MILLS INC	350 000
	Portland OR	
25	PHOENIX STEEL CORPORATION	560 000
25a	Claymont, OE	500 000
25b	Phoenixville PA	60,000
26	ROBLIN STEEL COMPANY	170,000
	Ounkirk, NY	
	North Tonawanda NY	
27	SIMONOS STEEL DIVISION	55 000
	Lockoort, NY	
28	STANOARD STEEL DIV TMCA	300 000
28a	Burnham, PA	240,000
28b	Latrobe, PA	60,000
29	TELEDYNE VASCO	30,000
	Latrobe PA	
30	TIMKEN COMPANY	1,265,000
30a	Canton, OH	1,165,000
30b	Latrobe Steel Comoany	100,000
	Latrobe, PA	
31	UNION ELECTRIC STEEL CORP	43,000
	Carnegie, PA	
32	WASHBURN WIRE COMPANY	120,000
	Phillipsdale RI	
33	WASHINGTON STEEL CORP	100,000
	Houston PA	
	U S Soecialty Steelmakers Raw Steel Plant Caoacity Total	10 472 000

■ Ferrous Scrap/Sponge Iron-Based Steel Companies

CANADA

Map Code	Company and Plant Locations	Raw Steel Capacity Net Tons
1	BURLINGTON STEEL CORP	300,000
	Division, Slater Steel, Hamilton Ont	
2	ENHEAT LTD - STEEL DIVISION	25,000
	Amherst, N S	
3	INTERPROVINCIAL STEEL & PIPE	600,000
	Regina Sask	
4	IVACO ROLLING MILLS	300,000
	L'Orignal, Ont	
5	LAKE ONTARIO STEEL LTD	420,000
	Whitby Ont	
6	MANITOBA ROLLING MILLS	200,000
	Selkirk Man	
7	SIDBEC-DOSCO LTD	1 460,000
7a	Contrecoeur Que	1,100 000
7b	Longueuil, Que	200,000
7c	Montreal Que	160,000
8	WESTERN CANADA STEEL LTD	260 000
8a	Calgary Alta	60,000
8b	Richmond, B C	200 000
	Canada Ferrous Scrap/Soonge Iron-based Steelmakers Raw Steel Plant Caoacity, Total	3 565 000

UNITED STATES

Map Code	Company and Plant Locations	Raw Steel Capacity Net Tons
1	AMERON STEEL & WIRE DIV	300,000
	Etiwanda, CA	
2	ATLANTIC STEEL COMPANY	700,000
2a	Atlanta GA	450,000
2b	Cartersville GA	250,000
3	AUBURN STEEL COMPANY	170,000
	Auburn, NY	
4	BOROER STEEL ROLLING MILLS	150,000
	El Paso TX	
5	BW STEEL INC	180,000
	Calumet Steel	
	Chicago Heights IL	
6	CALIFORNIA STEEL COMPANY	120,000
	Chicago IL	
7	CASCADE STEEL ROLLING MILLS	130,000
	McMinnville OR	
8	CECO CORPORATION	390,000
8a	Lemont Manufacturing	220,000
	Lemont, IL	
8b	Milton Manufacturing	170,000
	Milton, PA	
9	CHAPARRAL STEEL COMPANY	475,000
	Midlothian, TX	
10	CONNORS STEEL COMPANY	575,000
10a	Birmingham, AL	275,000
10b	Huntington WV	300,000
11	COPPERWELD STEEL COMPANY	700,000
	Warren, OH	
12	FLORIDA STEEL CORPORATION	980,000
12a	Charlotte NC	210,000
12b	Indiantown FL	218,000
12c	Baldwin FL	300,000
12d	Tamoa FL	252,000
13	HAWAIIAN WESTERN STEEL LTD	100,000
	Ewa HI	
14	HURON STEEL COMPANY INC	250,000
	Sandusky OH (1979)	
15	ILLINOIS BIRMINGHAM BOLT CO	100,000
	Kankakee IL	
16	INOUSTRIAL SIDERURGICA INC	80 000
	Bayamon, PR	
17	INTERCOASTAL STEEL CORP	80,000
	Chesapeake VA	
18	JUDSON STEEL CORPORATION	150,000
	Emeryville CA	
19	KENTUCKY ELECTRIC STEEL CO	180,000
	Coalton KY	
20	KEYSTONE STEEL & WIRE	600,000
	Peoria, IL	
21	KNOXVILLE IRON DIVISION	200,000
	Knoxville TN	
22	KORF INOUSTRIES, INC	1,220 000
22a	Georgetown Steel Sub	620,000
	Georgetown, SC	
22b	Georgetown-Texas Steel	600,000
	Beaumont, TX	
23	LACLEDE STEEL COMPANY	800,000
	Alton, IL	
24	MARATHON-LeTOURNEAU CO	100,000
	Longview, TX	
25	MARATHON STEEL COMPANY	150,000
	Tempe, AZ	
26	MISSISSIPPI STEEL OIVISION	180,000
	Jackson, MS	
27	NEW JERSEY STEEL & STRUCTURAL	250,000
	Sayreville NJ	
28	NORTH STAR STEEL COMPANY	1,050,000
28a	Monroe MI (1980)	400,000
28b	St Paul, MN	400 000
28c	Wilton, IA	250,000
29	NORTHWEST STEEL ROLLING MILLS	200,000
	Seattle, WA	
30	NORTHWESTERN STEEL & WIRE COMPANY	2 300,000
	Sterling, IL	
31	NUCOR CORPORATION	1,400,000
31e	Oarlington, SC	450,000
31b	Jewett, TX	500,000
31c	Norfolk NE	450,000
32	OWEN ELECTRIC STEEL CO	100,000
	Cayce, SC	
33	PENN-OIXIE STEEL CORP	600,000
	Kokomo, IN	
34	RARITAN STEEL COMPANY	500,000
	Raritan, NJ	
35	ROANOKE ELECTRIC STEEL	300,000
	Roanoke VA	
36	ROSS STEEL WORKS, INC	100,000
	Amite, LA	
37	SCHINDLER BROS STEEL CO	60,000
	Sealy TX	
38	SOULE STEEL COMPANY	120,000
	Long Beach CA	
39	STRUCTURAL METALS, INC Sub	180,000
	Seguin, TX	
40	TEXAS STEEL COMPANY	200,000
	Fort Worth TX	
41	YALE STEEL COMPANY	120,000
	Wallingford, CT	
42	BAYOU STEEL COMPANY	500,000
	Laolace, LA	
	U S Ferrous Scrap/Soonge Iron-based Steelmakers Raw Steel Plant Caoacity Total	16 540 000

Source: Institute for Iron and Steel Studies, 1103 North Washington Avenue, Green Brook NJ 08812

TABLE 3-9. STEEL INDUSTRY EMPLOYMENT

Year	Average Number of Wage Employees Adjusted for Turnover	Average Number of Salaried Employees	Average Number of Total Employees
1979	341,939	111,250	453,181
1978	339,155	110,042	449,197
1977	337,396	114,992	452,388
1976	339,021	115,107	454,128
1975	339,945	117,217	457,162
1974	393,212	119,183	512,395
1973	392,851	115,763	508,614
1972	364,074	114,294	478,368
1971	366,982	120,287	487,269
1970	403,115	128,081	531,196

(Covering only those employees engaged in the production and sale of iron and steel products.)

Source: Annual Statistical Report 1979, American Iron and Steel Institute.

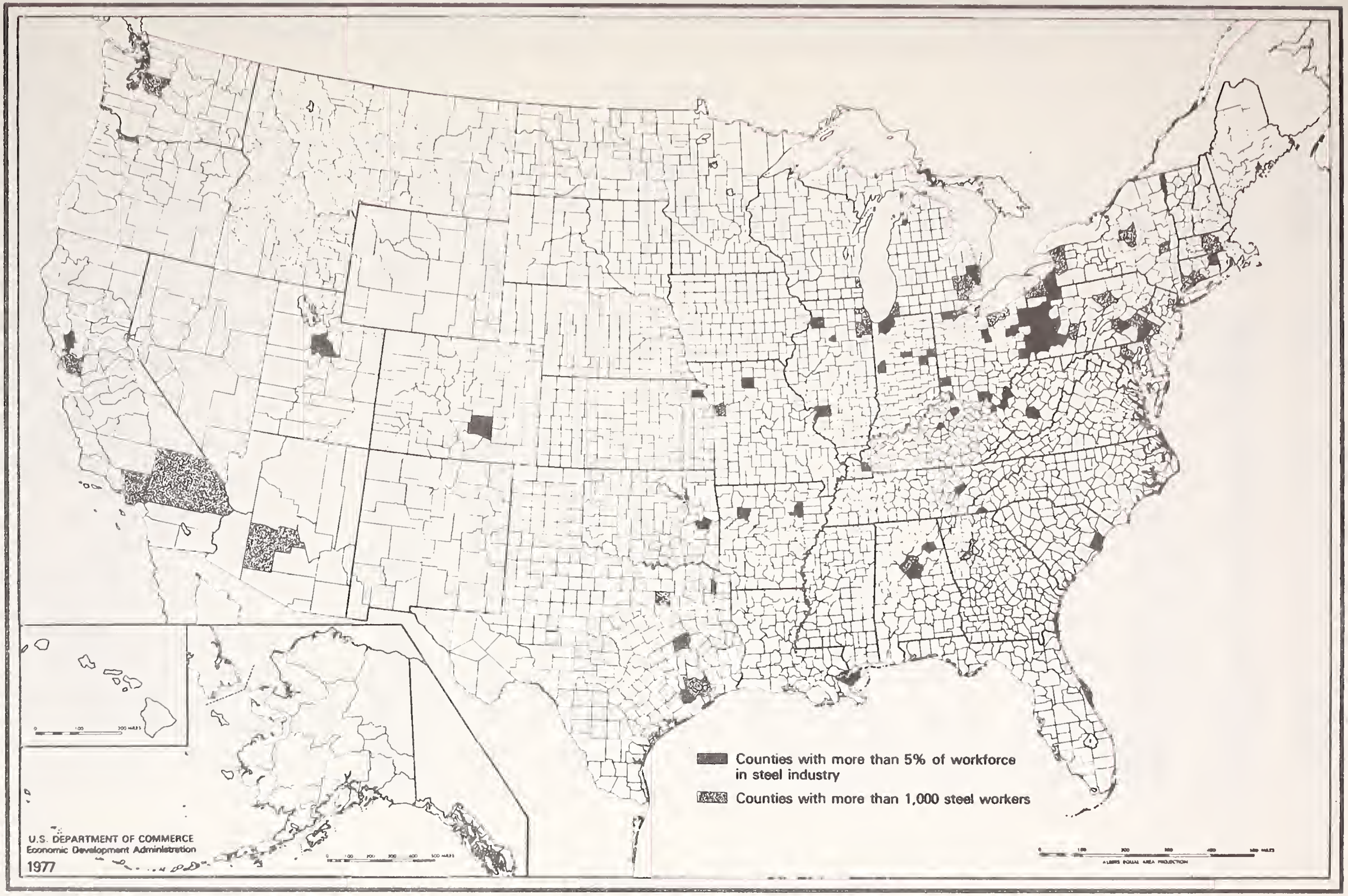
since 1975 with a corresponding loss of jobs. Even if this trend were to be reversed and recover or surpass the steel-making capacity that existed in the mid-1970s, the replacement mills would be much more labor-efficient than their predecessors. Those steel mills that are scheduled to remain open are slowly undergoing modernization programs to improve labor and energy efficiency. In addition to this, some of the steel companies are contracting out some of the jobs once done by steel workers, such as slag removal from the blast furnaces. This will have the effect of reducing the number of steel-related jobs reported to the Bureau of Labor Statistics and increase those reported as service-related jobs, although the net jobs dependent on the steel industry remain the same. As would be expected concentrations of steel employment are closely linked to the locations of the major steel plants, as is demonstrated when Figure 3-2 is compared to Figure 3-1.

3.3 MARKET TRENDS

Each year, The American Iron and Steel Institute compiles data on steel shipments in selected market categories. A ten-year history of these shipments is contained in Table 3-10. The largest market is that of the automotive industry, consuming, on the average, 20 percent of the domestic steel output. The automotive market includes passenger cars, trucks, and buses, with the passenger car portion making up the major share of this sector.

The next largest market is that of the steel service centers that buy in large quantities and sell in small quantities to local manufacturers. Many of the large steel service centers are owned by the major domestic steel manufacturers. The third largest market is the construction industry. These three markets account for approximately 50 percent of all steel shipments.

The pattern of steel shipments to the various markets is also of interest. In Table 3-11 steel shipments by products is compared to market segments. Separating out only the flat rolled steel products as is done in Table 3-12 shows how important these products are to the automotive industry. Out of a total of 18.2



Source: Dun and Bradstreet

FIGURE 3-2. CONCENTRATIONS OF STEEL EMPLOYMENT

TABLE 3-10. NET SHIPMENTS OF STEEL PRODUCTS BY CLASSIFICATION, ALL GRADES (INCLUDING CARBON, ALLOY, AND STAINLESS STEEL)

(Thousands of Net Tons)

Market Classifications	1979 Ship-ments	1979 %	1978 Ship-ments	1978 %	1977 Ship-ments	1977 %	1976 Ship-ments	1976 %	1975 Ship-ments	1975 %
Steel for converting and processing	5,058	5.0	4,612	4.7	3,679	4.0	4,036	4.5	3,255	4.1
Independent forgers (not elsewhere classified)	1,254	1.3	1,192	1.2	998	1.1	952	1.1	1,098	1.4
Industrial fasteners	934	0.9	870	0.9	848	0.9	912	1.0	675	0.8
Steel service centers & distributors	18,246	18.2	17,333	17.7	15,346	16.8	14,615	16.3	12,700	15.9
Construction, including maintenance	9,978	10.0	9,612	9.8	7,553	8.3	7,508	8.4	8,119	10.2
Contractors' products	3,745	3.7	3,480	3.6	4,500	4.9	4,502	5.0	3,927	4.9
Subtotal construction and contractors' products	13,723	13.7	13,092	13.4	12,053	13.2	12,010	13.4	12,046	15.1
Automotive:										
Vehicles, parts, etc	18,099	18.0	20,651	21.1	20,882	22.9	20,667	23.1	14,750	18.4
Independent forgers	522	0.5	602	0.6	608	0.7	684	0.8	464	0.6
Total	18,621	18.5	21,253	21.7	21,490	23.6	21,351	23.9	15,214	19.0
Rail transportation:										
Freight cars, pass. cars & locomotives	2,445	2.4	2,188	2.2	1,709	1.9	1,469	1.6	1,836	2.3
Rails and all other	1,666	1.7	1,361	1.4	1,529	1.7	1,587	1.8	1,316	1.6
Total	4,111	4.1	3,549	3.6	3,238	3.6	3,056	3.4	3,152	3.9
Shipbuilding and marine equipment	924	0.9	845	0.9	869	1.0	969	1.1	1,413	1.8
Aircraft and aerospace	60	0.1	60	0.1	63	0.1	59	0.1	69	0.1
Oil and gas industry	3,739	3.7	4,140	4.3	3,650	4.0	2,653	3.0	4,171	5.2
Mining, quarrying and lumbering	569	0.6	508	0.5	486	0.5	536	0.6	596	0.7
Agricultural:										
Agricultural machinery	1,306	1.3	1,080	1.1	1,017	1.1	1,209	1.4	1,055	1.3
All other	665	0.7	725	0.7	631	0.7	575	0.6	374	0.5
Total	1,971	2.0	1,805	1.8	1,648	1.8	1,784	2.0	1,429	1.8
Machinery, industrial equipment & tools	5,996	6.0	5,992	6.1	5,566	6.1	5,180	5.8	5,173	6.5
Electrical equipment	2,819	2.8	2,811	2.9	2,639	2.9	2,671	3.0	2,173	2.7
Appliances, utensils and cutlery	2,140	2.1	2,094	2.1	2,129	2.3	1,950	2.2	1,653	2.1
Other domestic & commercial equipment	2,073	2.1	1,889	1.9	1,846	2.0	1,813	2.0	1,390	1.7
Containers, packaging & shipping materials:										
Cans and closures	4,994	4.9	4,950	4.9	5,173	5.7	5,301	5.9	4,859	6.0
Barrels, drums and shipping pails	939	1.0	809	0.9	768	0.8	859	1.0	601	0.8
All other	839	0.9	836	0.9	773	0.9	754	0.8	593	0.8
Total	6,772	6.8	6,595	6.7	6,714	7.4	6,914	7.7	6,053	7.6
Ordnance and other military	204	0.2	207	0.2	193	0.2	219	0.2	405	0.5
Export (reporting companies only)	2,007	2.0	1,224	1.3	1,076	1.2	1,839	2.1	1,755	2.2
Nonclassified shipments	9,041	9.0	7,864	8.0	6,616	7.3	5,928	6.6	5,537	6.9
TOTAL SHIPMENTS	100,262	100.0	97,935	100.0	91,147	100.0	89,447	100.0	79,957	100.0

Market Classifications	1974 Ship-ments	1974 %	1973 Ship-ments	1973 %	1972 Ship-ments	1972 %	1971 Ship-ments	1971 %	1970 Ship-ments	1970 %
Steel for converting and processing	4,486	4.1	4,714	4.2	4,199	4.6	3,593	4.1	3,443	3.8
Independent forgers (not elsewhere classified)	1,339	1.2	1,213	1.1	1,007	1.1	1,018	1.2	1,048	1.2
Industrial fasteners	1,331	1.2	1,278	1.1	1,030	1.1	956	1.1	1,005	1.1
Steel service centers & distributors	20,400	18.6	20,383	18.3	16,797	18.3	14,424	16.6	16,025	17.7
Construction, including maintenance	11,360	10.4	10,731	9.6	8,589	9.4	8,666	10.0	8,913	9.8
Contractors' products	6,249	5.7	6,459	5.8	5,055	5.5	4,946	5.6	4,440	4.9
Subtotal construction and contractors' products	17,609	16.1	17,190	15.4	13,644	14.9	13,612	15.6	13,353	14.7
Automotive:										
Vehicles, parts, etc	18,256	16.7	22,468	20.2	17,639	19.2	116,980	19.5	14,011	15.4
Independent forgers	672	0.6	749	0.6	578	0.6	503	0.6	464	0.5
Total	18,928	17.3	23,217	20.8	18,217	19.8	17,483	20.1	14,475	15.9
Rail transportation:										
Freight cars, pass. cars & locomotives	2,132	1.9	1,997	1.8	1,511	1.6	1,855	2.1	2,005	2.3
Rails and all other	1,285	1.2	1,231	1.1	1,219	1.3	1,149	1.3	1,093	1.2
Total	3,417	3.1	3,228	2.9	2,730	2.9	3,004	3.4	3,098	3.5
Shipbuilding and marine equipment	1,339	1.2	1,019	0.9	872	1.0	1,161	1.3	859	0.9
Aircraft and aerospace	79	0.1	69	0.1	63	0.1	53	0.1	56	0.1
Oil and gas industry	4,210	3.9	3,405	3.1	2,789	3.0	2,892	3.3	3,550	3.9
Mining, quarrying and lumbering	644	0.6	534	0.5	502	0.5	478	0.5	497	0.5
Agricultural:										
Agricultural machinery	1,236	1.1	1,155	1.0	962	1.1	788	0.9	809	0.9
All other	623	0.6	617	0.6	477	0.5	342	0.4	317	0.3
Total	1,859	1.7	1,772	1.6	1,429	1.6	1,130	1.3	1,126	1.2
Machinery, industrial equipment & tools	6,440	5.9	6,351	5.7	5,396	5.9	4,903	5.6	5,169	5.6
Electrical equipment	3,242	3.0	3,348	3.0	2,824	3.1	2,593	3.0	2,694	3.0
Appliances, utensils and cutlery	2,412	2.2	2,747	2.5	2,362	2.6	2,148	2.5	2,160	2.4
Other domestic & commercial equipment	1,941	1.8	1,990	1.8	1,816	2.0	1,720	2.0	1,778	2.0
Containers, packaging & shipping materials:										
Cans and closures	6,349	5.8	6,070	5.5	5,128	5.6	5,808	6.7	6,239	6.8
Barrels, drums and shipping pails	1,026	0.9	910	0.8	748	0.8	732	0.8	823	0.9
All other	843	0.8	831	0.7	740	0.8	672	0.8	713	0.8
Total	8,218	7.5	7,811	7.0	6,616	7.2	7,212	8.3	7,775	8.5
Ordnance and other military	654	0.6	'918	0.8	899	0.9	861	1.0	1,222	1.3
Export (reporting companies only)	3,961	3.6	3,138	2.8	2,555	2.8	2,433	2.8	5,985	6.6
Nonclassified shipments	6,963	6.3	7,105	6.4	6,048	6.6	5,364	6.2	5,480	6.1
TOTAL SHIPMENTS	109,472	100.0	111,430	100.0	91,805	100.0	87,038	100.0	90,798	100.0

Similar data not available prior to 1940.

Source: Annual Statistical Report 1979, American Iron and Steel Institute.

TABLE 3-11. 1979 SHIPMENTS OF STEEL PRODUCTS BY MARKET CLASSIFICATION, ALL GRADES (INCLUDING CARBON, ALLOY, AND STAINLESS STEEL)

(Net Tons)

Products	Steel for Converting and Processing: Total Shipments	Steel for Converting and Processing: Less Shipments to Reporting Companies	Steel for Converting and Processing: Net Shipments	Independent Forgings (Not elsewhere classified)	Industrial Fasteners	Steel Service Centers and Distributors	Construction Including Maintenance	Contractors' Products	Automotive	Rail Transportation	Shipbuilding and Marine Equipment
Ingots, blooms, billets, slabs, sheet bars and tube rounds	486,482	242,576	243,906	602,960	385	130,716	155,884	1,706	237,640	14,574	44
Skelp	128,073	94,025	34,048	...	...	93	314	...	...	...	...
Wire rods	1,535,045	300,741	1,234,304	...	270,657	61,620	63,768	100,411	62,056	5	10
Structural shapes (heavy)	4,038	442	3,596	...	...	1,335,310	2,409,608	25,935	62,053	397,521	111,709
Steel piling	...	...	...	...	...	36,728	237,014	...	...	2,121	2,739
Plates	118,097	29,964	88,133	4,077	13,650	1,896,274	1,941,427	138,528	264,930	864,854	712,528
Rails	...	...	...	...	...	49,196	32,274	...	...	1,038,206	930
Rail accessories	155	...	155	...	...	12,653	5,589	...	...	425,281	...
Wheels (rolled and forged)	1	...	1	...	...	2,121	5,266	...	...	163,310	17
Axles	...	...	...	...	...	...	688	...	...	215,373	...
Bars—Hot rolled (including light shapes)	1,503,312	1,242,046	261,266	642,600	336,715	1,316,622	396,469	84,803	2,265,080	308,977	29,229
—Reinforcing	78,540	74,537	4,003	...	...	233,428	2,040,159	9,775	...	...	...
—Cold finished	6,306	1,656	4,650	4,131	42,458	531,926	4,769	27,010	250,987	4,659	3,747
Tool steel	1,321	1,279	42	1,307	74	16,324	746	...	8	4	000
Pipe and tubing —Standard	190,491	114,386	76,105	...	20	1,164,098	139,561	108,610	1,335	3,581	1,139
—Oil country goods	141,160	119,453	21,707	...	...	179,519	17,379	122	...	...	...
—Line	20,490	4,687	15,803	...	...	386,828	50,529	9,359	147	443	10
—Mechanical	35,273	28,567	6,706	...	...	319,944	6,557	31,300	203,927	6,659	112
—Pressure	8,074	7,840	234	...	...	52,718	2,753	1,780	50	90	226
—Structural	4,778	1,810	2,968	...	...	268,776	21,386	8,466	1,836	775	...
—Stainless	2,780	2,218	562	...	...	20,703	877	414	28	...	629
Wire—Drawn	416,679	26,900	389,779	...	166,895	226,825	261,285	153,702	71,463	3,208	72
—Nails and staples	5,526	886	4,640	...	...	205,634	40,749	43	38	180	25
—Other merchant wire products	6,388	1,845	4,543	...	...	187,038	51,849	196	456	573	...
Black plate	43,213	1,427	41,786	...	23	114,415	15,269	58,286	12,444	...	...
Tin plate	20,553	...	20,553	...	...	282,686	488	4,100	90,662	82	...
Tin free steel	1,839	...	1,839	...	...	20,004	8	209	1,608	14	...
Tin mill products-all other	329	...	329	...	...	13,787	20	2,363	45,697	...	...
Sheets—Hot rolled	3,039,802	1,197,823	1,841,979	...	66,632	3,698,615	982,732	596,653	5,723,044	563,897	53,901
—Cold rolled	676,875	65,470	611,405	10	6,980	3,514,887	111,927	951,712	6,910,082	11,951	1,359
Sheets and strip—Galvanized	58,772	3,897	54,875	...	4,528	1,613,742	801,028	1,326,408	1,400,550	37,534	1,887
—All other metallic coated	10,377	1,458	8,919	...	77	118,808	126,682	59,336	510,051	346	1,392
—Electrical	4,969	180	4,789	...	...	69,256	...	...	9,456	4,583	465
Strip—Hot rolled	152,351	125,564	26,787	464	20,476	66,405	51,481	18,228	346,293	40,351	737
—Cold rolled	51,927	4,446	47,481	...	3,997	99,444	1,419	25,994	158,039	1,715	762
TOTAL—ALL GRADES	8,754,016	3,696,123	5,057,893	1,254,549	933,567	18,246,243	9,977,954	3,745,449	18,620,960	4,110,867	923,669
%	...	...	5.0	1.2	0.9	18.2	10.0	3.7	18.6	4.1	0.9

Similar data not available prior to 1940.

Source: Annual Statistical Report 1979, American Iron and Steel Institute.

TABLE 3-11. 1979 SHIPMENTS OF STEEL PRODUCTS BY MARKET CLASSIFICATION, ALL GRADES (INCLUDING CARBON, ALLOY, AND STAINLESS STEEL) (CONT.)

(Net Tons)

Products	Aircraft and Aerospace	Oil and Gas Orilling	Mining, Quarrying and Lumbering	Agricultural	Machinery, Industrial Equipment and Tools	Electrical Equipment	Appliances, Utensils, and Cutlery	Other Oomestic and Commercial Equipment	Containers, Packaging, and 5hipping Materials	Ordnance and Other Military	Export (Reporting Companies Only)	Non-classified 5hipments	Total	%
Ingots, blooms, billets, slabs, sheet bars and tube rounds	15,090	74,713	724	22,779	218,770	395	23	440	29,009	74,735	384,933	391,391	2,599,817	2.6
5kelp	...	...	...	...	58	...	...	...	...	...	59	...	34,572	...
Wire rods	31	42	37	24,965	471,441	5,330	1,190	168,386	1,419	20	31,653	363,944	2,861,289	2.9
5tructural shapes (heavy)	318	48,096	16,255	36,544	223,430	8,065	403	3,395	1,012	1,013	100,831	517,660	5,302,754	5.3
5teel piling	...	378	1,243	...	...	...	...	...	...	...	13,142	...	293,365	0.3
Plates	8,510	202,410	104,673	212,856	1,679,637	193,185	7,723	35,300	8,291	34,169	149,768	474,262	9,035,185	9.0
Rails	...	...	12,889	...	3,760	...	...	...	...	...	23,473	9,500	1,170,228	1.2
Rail accessories	...	...	3,424	...	8	...	...	...	...	66	2,335	8,334	457,845	0.5
Wheels (rolled and forged)	...	...	2,172	...	5,940	...	...	...	...	...	835	...	179,662	0.2
Axles	...	...	629	...	271	...	...	...	...	...	1,251	...	218,212	0.2
Bars—Hot rolled (including light shapes)	13,530	171,573	324,980	315,775	1,035,747	104,255	17,061	64,435	1,375	18,410	96,833	2,161,621	9,958,356	9.9
—Reinforcing	...	46	19,434	25	...	1,981	...	95	...	...	17,919	2,976,356	5,303,221	5.3
—Cold finished	6,698	8,339	7,281	66,060	409,292	27,875	19,739	28,757	7	11,430	8,542	776,908	2,245,265	2.2
Tool steel	193	...	34	...	5,145	...	...	4	23	5	3	70,648	94,560	0.1
Pipe and tubing —5tandard	...	182,704	4,621	10,063	20,446	127,587	1,427	14,906	1,869	...	43,366	51,019	1,952,457	1.9
—Oil country goods	...	1,962,487	...	...	...	...	...	...	2,018	...	270,587	3,815	2,457,634	2.5
—Line	...	856,547	1,235	992	648	3,216	...	602	...	...	123,653	118,561	1,568,573	1.6
—Mechanical	2,111	62,531	4,016	31,915	423,451	5,365	4,764	16,215	620	2,796	25,476	353,245	1,506,810	1.5
—Pressure	11	5,782	1,699	...	56,029	361	...	873	5,321	130	4,337	37,148	169,542	0.2
—5tructural	...	143,261	316	17,503	2,204	24,920	7	1,951	745	...	2,168	48,702	540,984	0.5
—5tainless	145	2,163	29	8	7,733	276	208	620	43	83	475	11,384	46,380	...
Wire—Drawn	108	466	8,031	13,418	123,148	16,765	27,014	229,118	36,327	3,159	7,317	179,072	1,917,172	1.9
—Nails and staples	...	24	70	340	1,569	327	17	134	1,826	...	33	1,640	257,289	0.3
—Other merchant wire products	...	16	491	7,684	4,002	13	...	206	2,636	1	834	13,659	274,197	0.3
Black plate	...	221	5	...	2,764	17,929	18,299	42,610	279,376	...	25,163	...	628,590	0.6
Tin plate	...	69	...	64	5,679	16,920	20,050	32,974	3,866,308	28	263,127	...	4,603,790	4.6
Tin free steel	...	...	...	...	1,137	91	...	174	953,196	...	24,608	...	1,002,888	1.0
Tin mill products—all other	...	...	...	...	1,454	236	2,628	4,262	3,007	46	906	...	74,735	0.1
5heets—Hot rolled	2,527	4,469	38,613	569,177	593,920	273,092	173,034	235,527	389,714	14,172	172,171	1,257	15,995,126	15.9
—Cold rolled	2,849	5,172	1,754	96,664	375,876	1,265,645	1,457,699	956,643	924,776	26,880	49,364	33	17,283,668	17.2
5heets and strip—Galvanized	158	1,131	2,019	431,953	62,996	126,222	269,406	138,934	41,591	3,031	23,746	...	6,341,729	6.3
—All other metallic coated	...	...	2,386	7,200	24,053	12,416	38,023	16,617	5,679	72	43,017	...	975,074	1.0
—Electrical	4	1,132	214	767	13,458	526,038	2,803	3,586	...	...	59,775	579	696,905	0.7
5trip—Hot rolled	5,994	4,404	9,427	81,533	165,503	31,119	10,648	19,419	59,027	2,408	13,005	10,241	983,950	1.0
—Cold rolled	1,666	947	138	22,371	56,899	29,290	67,849	56,586	156,393	11,868	22,784	464,663	1,230,305	1.2
TOTAL—ALL GRAOE5	59,943	3,739,123	568,839	1,970,656	5,996,468	2,818,914	2,140,015	2,072,769	6,771,608	204,512	2,007,489	9,040,642	100,262,129	100.0
%	0.1	3.7	0.6	2.0	6.0	2.8	2.1	2.1	6.8	0.2	2.0	9.0	100.0	...

5imilar data not available prior to 1940.

Source: Annual Statistical Report 1979, American Iron and Steel Institute.

TABLE 3-12. FLAT ROLLED STEEL PRODUCT SHIPMENTS TO THE AUTOMOTIVE INDUSTRY DURING 1979

(Net Tons)

Product	Total Industry Shipments	Shipments to the Automotive Industry	Percent Shipments to the Automotive Industry
Black Plate	628,590	12,444	2.0%
Tin Plate	4,603,790	90,662	2.0
Tin Free Steel	1,002,888	1,608	1.6
Tin Mill Products - All Other	74,735	45,697	61.1
Sheets			
- Hot Rolled	15,995,126	5,723,044	35.8
- Cold Rolled	17,283,668	6,910,082	40.0
Sheet and Strip			
- Galvanized	6,341,729	1,400,550	22.1
- All Other Metal Coated	975,074	510,051	52.3
- Electrical	696,905	9,456	1.4
Strip			
- Hot Rolled	983,950	346,293	35.2
- Cold Rolled	1,230,305	158,039	12.8
Total Flat Rolled Products	49,816,760	15,204,926	30.5
Total All Steel Products	100,262,129	18,213,765	18.2

million tons of steel consumed by the automotive market 15.2 million tons were in the form of flat rolled products. (The remainder is principally bar products.) From the steel industry's point of view, out of the nearly 50 million tons of flat rolled steel products manufactured, the automotive industry consumed 15.2 million tons or over 30 percent of the shipments. This shows that certain sectors of the steel industry (flat steel rolling mills) are more dependent on the automotive industry than total overall shipments of 18 to 20 percent seem to imply.

As recently as a year ago, most steel company executives were estimating that steel shipments to the automotive industry would remain fairly constant through 1985. Their reasoning was based on the assumption that increased production of vehicles would offset the trends of using less steel per vehicle. Since these forecasts were made, certain underlying assumptions have changed. The public has accepted the smaller, downsized vehicles more readily than had been expected. In fact they are in demand, and this has led to a downward trend in steel use per vehicle each time new forecasts are released. Increased foreign competition has also affected the other major assumption in the steel industry's forecasts. It can no longer be assumed that North American production of automobiles will increase at historical levels. In fact, it is possible that there could even be a decline in annual production in the U.S.

A forecast for steel shipments to the automotive industry in 1985 and the mid-1990s has been computed in Tables 3-13 and 3-14, respectively. The net steel content per vehicle was estimated by TSC researchers using the latest automotive company estimates and information from their product plans. Heavy trucks have been included because they are included as part of the automotive market as defined by the American Iron and Steel Institute. To exclude heavy trucks would make any comparison of forecasted shipments to historical shipments invalid.

Three levels of vehicle production were chosen for the forecast: a decline, a no growth, and a growth scenario. Both the decline and no growth scenarios show a marked decrease in steel

TABLE 3-13. 1985 FORECAST OF STEEL SHIPMENTS TO THE AUTOMOTIVE MARKET

HISTORICAL SHIPMENTS TO THE AUTOMOTIVE MARKET				
		North American Vehicle Production (in Millions)		
Yr	Millions of Tons*	Passenger Auto	Light Truck/Van	Medium/Heavy Truck
1977	21.5	10.4	3.1	0.4
1978	21.3	10.3	3.3	0.4
1979	18.6	9.4	2.6	0.4

FORECAST ASSUMPTIONS

			Vehicle Production Range in Millions		
	Est Vehicle Dry Wt	Est Net Steel Content*	A	B	C
PASSENGER	2400	1356	8	10	12
LT TRUCK	3150	1780	2	2.5	3
HEAVY TRUCK	N/A	6000	0.4	0.4	0.4
		*Based on 56.5% steel			

Assuming a 36% difference between gross shipments and net steel usage which accounts for offal and spare part production, the estimated steel shipments for 1985 in millions of tons are:

FORECAST			
	A	B	C
PASSENGER	7.4	9.2	11.1
LT TRUCK	2.4	3.0	3.6
HEAVY	1.6	1.6	1.6
Total	11.4	13.8	16.3
FLAT ROLLED STEEL SHIPMENTS ASSUMING THE 1979 RATIO OF 83.5%	9.5	11.5	13.6

*Shipments to the automotive market as reported by The American Iron and Steel Institute and includes passenger vehicles: light, medium, and heavy trucks, trailers, and spare parts.

TABLE 3-14. AUTOMOTIVE STEEL CONSUMPTION FORECAST FOR MID-1990's

	Vehicle Type	Dry Vehicle Wt (Lbs)	Net Steel* Content (Lbs)	Vehicle Production in Millions		
				A	B	C
W	PA**	2375	1223	8	10	12
	LT***	3150	1622	2	2.5	3
	HT†	N/A	6000	0.4	0.4	0.4
X	PA	2150	1107	SAME		
	LT	2775	1429			
	HT	N/A	6000			
Y	PA	1825	940	SAME		
	LT	2500	1288			
	HT	N/A	6000			
Z	PA	1450	747	SAME		
	LT	2025	1043			
	HT	N/A	6000			

*Based on 51.5% steel.
**Passenger Auto.
***Light Truck.
†Heavy Truck.

		A	B	C
W	PASSENGER	6.7	8.3	10.0
	LIGHT TRUCK	2.2	2.8	3.3
	HEAVY TRUCK	1.6	1.6	1.6
	TOTAL	10.5	12.7	14.9
X	PASSENGER	6.0	7.5	9.0
	LIGHT TRUCK	1.9	2.4	2.9
	HEAVY TRUCK	1.6	1.6	1.6
	TOTAL	9.5	11.5	13.5
Y	PASSENGER	5.1	6.4	7.7
	LIGHT TRUCK	1.8	2.2	2.6
	HEAVY TRUCK	1.6	1.6	1.6
	TOTAL	8.5	10.2	11.9
Z	PASSENGER	4.1	5.1	6.1
	LIGHT TRUCK	1.4	1.8	2.1
	HEAVY TRUCK	1.6	1.6	1.6
	TOTAL	7.1	8.5	9.8

shipments to the automotive market. Even the growth scenario shows an almost 2 million ton decrease in the shipments to the automotive market from the 1979 base. If 1977 or 1978 were used as a base, the decrease would be even larger. Looking only at flat rolled steels, shipments of these products to the automotive industry have a potential of declining from a minimum of 1.1 to a maximum of 5.3 million tons from 1979.

To determine the potential impacts on the steel industry it must be taken into account that other steel-consuming markets are expected to grow and will absorb some of the excess capacity freed up by the automotive sector. Again, looking at only flat rolled products, the other consuming markets are: the steel service centers, construction and construction products, and the container industry. The first two markets show a high sensitivity to general economic conditions and interest rates, whereas the container industry has shown a gradual decline over the last decade, as it has undergone heavy competition from aluminum and plastics.

A number of forecasts have been made of steel shipment growth through the next 10 years.* A series of low forecasts have been made, ranging from 1.5 to 1.9 percent compounded annually to an optimistic high of 3.7 percent. Assuming that a 2.1 percent growth rate represents a compromise between the high and low growth forecasts and that this can be applied to the 34.6 million tons of flat rolled steel products shipped to markets other than automotive, these markets have a potential of increasing by 4.6 million tons. This growth is sufficient to absorb the excess capacity freed up by the automotive industry in both the no growth and growth scenarios using 1979 as a base, but only in the growth scenario using 1977 or 1978 as a base.

Decreasing steel shipments to the automotive industry is already taking its toll on rolling mills. While almost all flat rolled mills are being underutilized, at least one is being closed which may allow the remaining ones to operate with more

*"Technology and Steel Industry Competitiveness," Office of Technology Assessment, June 1980.

efficiency. Jones & Laughlin Steel Corp. has announced that it will close its hot and cold rolled sheet and strip mill at its Pittsburgh Works in 1981. The closing will effect approximately 1000 employees. The reasons given were the age of the mill, which was built in 1937, and a weak demand for its product, which is sold mainly to the automotive market. This hot mill has a rated capacity of 1.3 million tons (small by today's standards), but only operated at an average of 180,000 tons for each of the last 2 years.

Another factor in automotive steel demand is a changing product mix. The automotive manufacturers are beginning to use more galvanized and other coated steels to prevent corrosion. For the steel companies, this means that they are shipping a higher grade and more profitable product to the automotive sector. The other major trend taking place is the trend toward using more high strength steels.

High strength steels have their advantage in weight reduction because they can be used in a thinner gauge to accomplish the same job as the plain carbon steel they replace. The high strength steels also have a cost premium over the plain carbon steels and are more profitable items to make. A switch to high strength steels may also lessen the impact on rolling mills of lower tonnage shipments to the automotive industry. For example, a high strength steel that is 10 percent thinner in gauge than the plain carbon steel it replaced would represent a 10 percent decrease in steel shipments measured in net tons. Yet there would be no change in steel shipments when measured in square footage. Assuming that it takes a rolling mill an equal amount of time to form an equal amount of surface area of high strength steel as it does plain carbon steel, there will be no effect on the operation of the rolling mill even though tonnage output will be reduced.

The term, high strength steels, is a generic term covering a family of steels. The simplest and least costly high strength steels are the renitrogenized/rephosporousized steels, where nitrogen and phosporous are used as strengthening agents. Next come the high strength low alloy steels (HSLA), which obtain their strength by the addition of certain alloys. Following these are the high strength low alloy steels with improved formability; they have the alloys of the normal HSLA steels plus additional ones. Finally come the dual phase steels, which have some of the same alloys as the HSLA improved formability steels but in smaller amounts. These steels derive their strength and greater formability principally from a special heat treating process.

The major classes of high strength steels are shown in Table 3-15. One of the principal points of the table is the relationship between increasing yield strength and decreasing elongation. Elongation is a measure of how well the steel can be formed in a stamping die. The lower the number, the higher the chance that the metal may fracture or break in the die, depending on die design and the degree of deformation required.

In Table 3-15 formability increases in each class of steel, proceeding from top to bottom, when strength is held constant. Material costs also increase in the same relationship, as Figure 3-3 demonstrates.

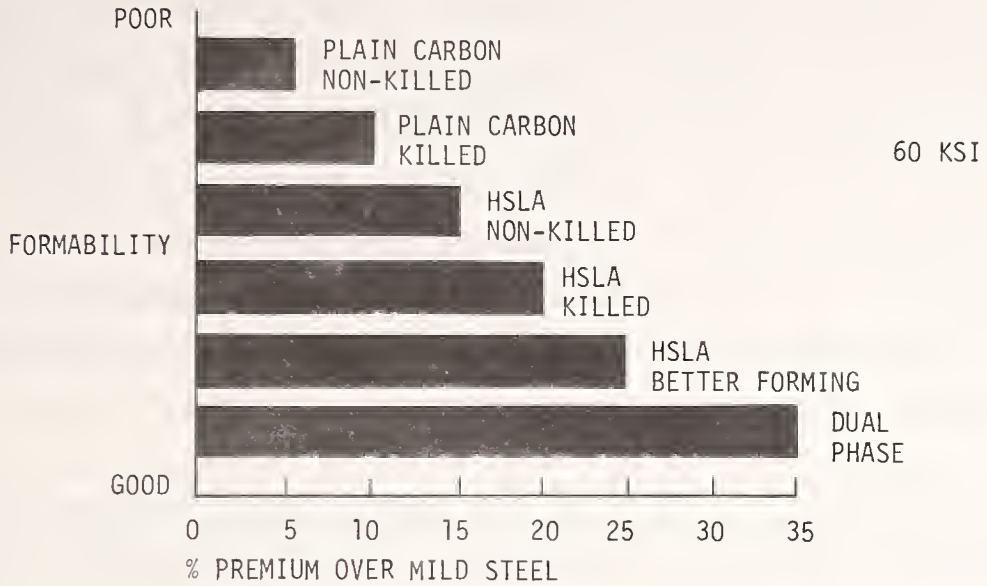
At present dual phase steels have the highest cost premium over plain carbon steels (see Figure 3-3(a)). This relationship may change within the next decade and the dual phase steels may become the most frequently used of the high strength steels in automotive production. As stated earlier, the dual phase steels use a similar alloy content as the HSLA improved formability steels but in smaller amounts, which are therefore less costly. The added cost for the dual phase steels is due to a special heat treating cycle that the steels receive. In the U.S. the dual phase steels receive the special heat treating process on modified, galvanizing steel lines that are run without the galvanizing step activated. This is neither the most cost-effective way of making dual phase steels nor the most efficient use of the galvanizing line. The process is also limited to producing only hot rolled dual phase steels.

TABLE 3-15. HIGH STRENGTH HOT ROLLED SHEET STEEL COMPARISON

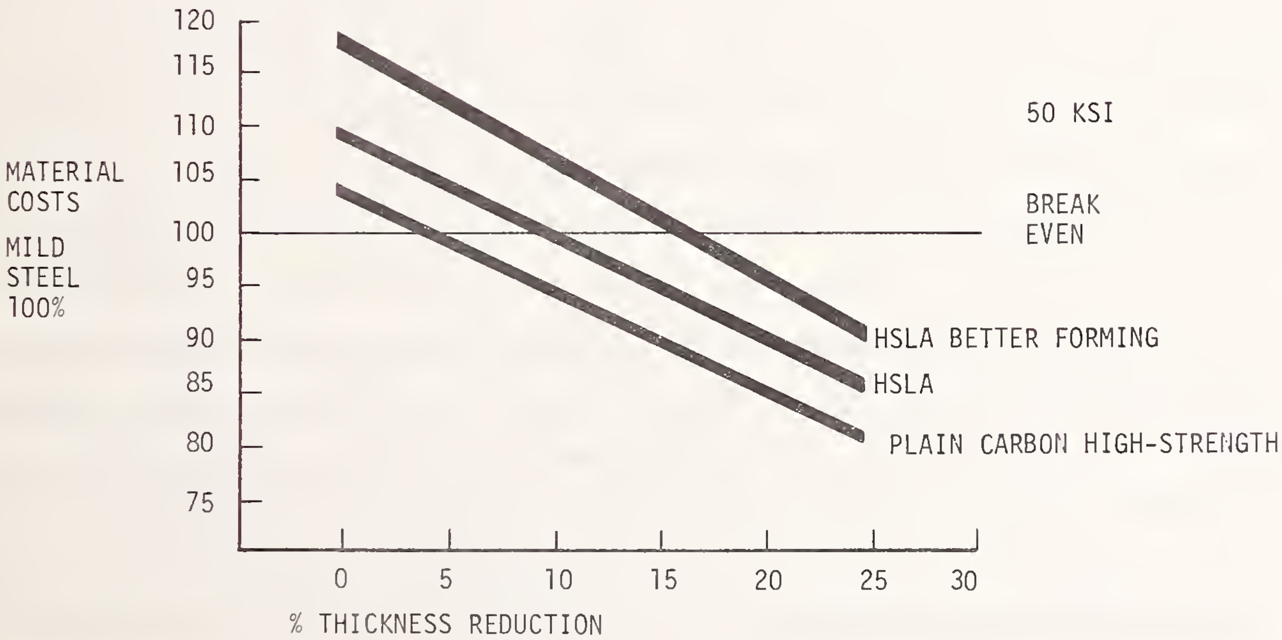
Steel Grade	Alloy Content	Yield Point Ksi (Min)	Tensile Strength Ksi (Min)	Elongation in 2 in., min%
Plain Carbon Mild Steel (base)	C, Mn	30-35 (Typical)	50 (Typical)	34 (Typical)
High Strength Steels				
Renitrogenized and/or Rephospor-ized Plain Carbon Steels	C, Mn P or N	45 50 80	60 65 90	19 17 10
High Strength Low Alloy (HSLA)	C, Mn Cb and/or V	50 60 70	65 75 85	22 18 14
High Strength Low Alloy (HSLA) (Improved form-ability)	C, Mn Plus one or more of Cb, V, Ti, Zr, Si, N, Cu, Mo, Ni	50 60 70 80 100	60 70 80 90 140	24 22 20 18 16
Dual Phase High Strength Low Alloy	C, Mn with Combinations of V, Mo, Cr, Cb, N, P, Si, S	50*	90	27

*Strength as shipped. When dual phase steels are stretched during forming, yield strength will increase to 70-80 Ksi.

(a)
Material cost as a function of formability for 60-KSI strength steels



(b)
Material cost for gauge reduction at 50-KSI strength



Source: High Strength Sheet Steels Booklet 3498, Bethlehem Steel Corp., Aug. 1980.

FIGURE 3-3. COST RELATIONSHIPS

The most efficient way of making dual phase steels is on a continuous annealing line (CA) which costs $100 million. At present there are no CA lines in the U.S. The CA lines can also be used to make plain carbon or any of the HSLA steels, but most of the steel companies have modern batch anneling lines that are adequate for making these products. The CA process can produce these steels at a slightly lower variable cost, but this is not sufficient to offset the initial capital cost of the CA line and the premature write-offs of the batch annealing lines. The CA line can only be justified if its output consists mostly of dual phase steels, and they continue to demand a high premium price even though its variable cost to produce will be below the HSLA better forming steels.

The automotive industry at most could consume the dual phase steel output of only two CA lines. If two companies installed CA lines, this would effectively eliminate the other steel companies from that sector of the market unless they also installed CA lines. If more than two companies installed CA lines, it would lead to overcapacity, heavy price competition, and lower profits per ton and eliminate the justification for installing the CA lines in the first place. This is the major risk faced by the steel industry planners. Presently, at least four domestic steel companies are investigating the possibility of installing CA lines but they are all waiting to see what the others will do. If they wait too long, they may find that the Japanese will claim the whole market for dual phase steels. This should be a strong enough incentive for at least one company to install a CA line, and if one does it, many of the others will probably follow. This is the basis for estimating that the dual phase steel prices will eventually drop over the decade.

3.4 TECHNOLOGICAL TRENDS

The average age of the domestic steelmaking equipment is

17.5 years.* As much as 20 percent of the domestic steelmaking capacity is technologically outmoded and is considered obsolete even though it is still in use.** Capital expenditure within the steel industry during the last decade has been at a rate where each steel mill is upgraded on the average to current technological standards once every 40 years. If this trend continues, the average age of steel plants will gradually shift to a median age of 20 years.

One example of steelmaking equipment that is technically outmoded is the open hearth furnace. The U.S. steel industry still produces approximately 15 percent of its raw steel by these furnaces. These furnaces are much more energy and labor-intensive than either the electric furnaces or basic oxygen furnaces. It is very likely that most of this steelmaking capacity will be replaced with more efficient steelmaking methods in the next 5 years.

A major example of new steelmaking technology that U.S. companies have been slow to adopt is continuous casting. A continuous caster converts raw steel directly into blooms or slabs without pouring the steel into ingot molds, reheating it, and sending it through a roughing mill. The benefits are that less energy and labor is required, and there is less loss of steel in the form of scrap. Table 3-16 shows the relative share of continuous casting capacity of the United States and other steel producing nations.

Continuous casting technology was commercially proven in the late 1960s. Most new mills built after that period incorporated continuous casting, but the older mills were very slow to retrofit the new technology. Recently there have been a number of announcements by steel companies to retrofit their older plants with continuous casters. This is absolutely necessary if the

*The World Steel Industry Data Handbook, Vol. 1, The American Iron and Steel Institute.

**"33 Metal Producing," International Iron and Steel Institute, January 1980, p. 9.

TABLE 3-16. PERCENTAGE OF RAW STEEL CONTINUOUSLY CAST

COUNTRY	YEAR 1969	1975	1977	1978
U.S.	2.9	9.1	11.8	14.2*
JAPAN	4.0	31.1	40.8	50.9**
CANADA	11.8	13.4	14.7	20.2
GERMANY	7.3	24.3	34.0	38.0
FRANCE	0.6	12.8	23.6	27.1
ITALY	3.1	26.9	37.0	41.3
U.K.	1.8	8.4	12.6	15.5

*Assuming that non-integrated plants account for 12% of the U.S. steel industry, their continuous casting usage is approximately 80% and accounts for 54% of the U.S. tonnage continuously cast, while integrated plants have a usage of 7.3%. AISI has reported that for the first half of 1979 the full industry usage rate was 16.1%

**A lower value of 46.2% has been reported by the International Iron and Steel Institute; presumably this figure is for calendar 1978 while the 50.9% figure is for Japanese fiscal 1978 (April 1978-March 1979) and is indicative of the rapidly increasing usage.

Source: "Benefits of Increased Use of Continuous Casting by The U.S. Steel Industry." A technical memorandum October 1979, Office of Technology Assessment.

domestic industry is to remain competitive with the rest of the world. Accelerating the rate at which continuous casters are installed is an attempt to catch up to steelmaking standards used by other steel producing nations.

While continuous casting is one of the most pronounced technological innovations in the last decade, there have been major advances in other steelmaking processes also. These range from improvements in blast furnace designs, larger and more efficient electric and oxygen steelmaking furnaces to improvements in rolling mills and annealing technology. Few of these improvements have been adopted on any significant scale by the domestic steel industry. One of the major restraints preventing the steel industry from using this technology is capital.

Capital requirements for the steel industry to remain competitive total up to billions of dollars. A recent report by the American Iron and Steel Institute (AISI)* stated that the industry will need to spend from $5.5 to $7.0 billion per year for the next 10 years to regenerate itself and remain competitive. Another recent study by the Office of Technology Assessment (OTA) estimated the capital needs at $4.6 billion per year for the next decade.** The main difference between the two studies is that the AISI stresses modernization and expansion at the integrated steel mill level, whereas the OTA emphasizes expansion of the mini-mill sector (where capital costs are lower). OTA also wants to postpone expansion and modernization of the integrated sector until after 1990 when they believe new steel-making technologies will be available. The OTA did not estimate post-1990 capital expenditures for the integrated sector.

The yearly capital expenditures by the industry have been in the order of $2.5 to $3.3 billion historically and under existing market and tax conditions are not likely to increase significantly.

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* Steel at the Crossroads: The American Steel Industry in the 1980s, AISI.

** "Technology and Steel Industry Competitiveness," Office of Technology Assessment, June 1980.

If the present situation continues the steel industry will be unable to fund either program.

3.5 WORLDWIDE INDUSTRY STRUCTURAL CHANGES AND POTENTIAL IMPACTS ON U.S. INDUSTRY

As stated in section 3.4, the steel industry must spend massive amounts of capital in order to remain competitive on a world basis. Not all steel mills in the United States are in poor condition. Many of them are highly efficient, modern, low cost steel mills, while others are marginal at best. In the last 3 years, the domestic steel producers have closed more than 3 million tons of steelmaking capacity, mostly in Pennsylvania and Ohio. The domestic steel industry realized that it was better to close these inefficient plants than to pour money into what would probably turn out to be a marginal operation. They chose to concentrate capital improvements in their more profitable steel mills to make them more efficient.

The end to the closings is probably still not in sight. The recent downturn in the economy has led to partial shutdowns of several steel mills. It is possible that some of these may never be fully reopened. Plants with small, inefficient blast furnaces for making pig iron coupled with open hearth furnaces for making steel are to be closed. In addition to technical obsolescence of steel mills, the decrease in steel demand by the automotive industry will have an impact on steel mills that principally produce flat rolled steel products.

In 1979 the domestic steel industry had approximately 70 million tons of flat rolled steelmaking capacity, produced approximately 50 million tons and shipped 15 million tons to the automotive industry. Already 20 million tons of excess capacity exists in the industry and with the potential of reduced demand by the automotive industry, it is almost inevitable that some mills will have to close. Jones & Laughlin has announced it will close its rolling mill at its Pittsburgh plant which will affect 1000 of the 5000 workers at the plant.

Between the impact of lower steel demand by the automotive industry and the technical obsolesence of steel mills, the integrated sector of the steel industry will continue to undergo a process of retrenchment. This process will be financially difficult for steelmakers, as mills are closed and layoffs take place over the next 5 years, but as marginal plants are eliminated and the supply/demand situation becomes more in balance, the industry should be able to return to a more profitable position.

While the integrated steel sector is contracting, the regional, scrap-based mini-mill sector should expand. This is the most profitable portion of the steel industry and does very well in competing with the major integrated steel producers in selected steel products. In the future they will probably be able to wrest from the major integrated steel companies, the market for certain steel products such as concrete reinforcing bars, light shapes and structural members, and some wire products.

The non-integrated specialty steelmakers are doing well although their future is uncertain. During the 1970s this section of the steel industry was under import protection while it undertook a modernization program to make it competitive in the world market. It emerged with modern, high quality steelmaking plants, but its present concern centers around U.S. industry's belief that foreign steelmakers may dump specialty steels in this country now that import restrictions have been lifted. The reintroduction of the Trigger Price Mechanism on carbon steel products has tended to slow down imported carbon steels and the specialty steelmakers feel that the foreign manufacturers will now switch to the specialty steel market to make up the difference. The specialty steelmakers are now seeking some sort of protection similar to the Trigger Price Mechanism for their sector of the market.

The world overcapacity in steel is causing problems not only in the U.S., but also in Europe. From 1974 through 1979, more than 100,000 jobs were lost in European steel industry, primarily in the United Kingdom, Germany, and France. To bring some order to steel trading within the EEC countries, a special meeting of the EEC Commission was called in early 1977 by EEC Industrial Policy Commissioner, Viscount Etienne Davignon. The meeting led to an agreement that was later to become known as the "Davignon Plan." The plan gave the EEC Steel Directorate the authority to:

- Veto new investment in steel
- Enforce or waive major antitrust laws
- Set minimum prices for steel products
- Set production quotas for each country and suggest production ceilings for each company
- Negotiate voluntary quotas for imports of steel by Japan, Eastern Europe, and Third World nations
- Make projections of planned capacity set against likely demand for every category of steel
- Provide supplemental funds to deal with displaced workers
- Veto all government subsidies to steel. (However, the Steel Directorate cannot force a company to close a facility.)

This alliance threatened to dissolve at the end of 1980 when the EEC Steel Directorate declared there should be a 13 to 18 percent reduction in steel production during the next 9 months. The West German steel industry felt they were being hit the hardest. They have the newest mills and the lowest costs to produce steel in Europe. They are also not government subsidized or owned, as are many mills in other parts of Europe, and the West German steel companies have already undergone the difficult task of closing inefficient mills. The Germans wanted the older, inefficient producers who are heavily subsidized in other nations to take the brunt of the reduction in production. Approximately 40,000 workers will be laid off throughout Europe because of the production cuts. German steel manufacturers finally agreed that they would share equally in the reductions for the nine-month duration, but, if it is to be extended beyond that point, they may pull out of the agreement.

Recently the West German government stated that it may take steps to protect its own steel market from cheaper subsidized steel imports. The protection under discussion is a "subsidy equalization tax" of 100 marks on each ton of imported steel. If the tax is imposed, it could send severe repercussions through the EEC.

Maintaining excess steelmaking capacity has been very costly to the governments that subsidize the industry. Italy, Belgium, Britain, and France are expected to spend at least $13.5 billion between 1976 and 1983 in subsidies to their steel industries. British Steel Corp., the largest steelmaker in Europe and also one of the most heavily subsidized, has lost a total of $3 billion for the last 5 consecutive years. All total subsidies to the steel industry in Europe has amounted to $28.8 billion since 1975.

It now seems that some of these countries are beginning to reevaluate their support to the steel industry. Both Britain and France have decided it is better to close old inefficient plants than to try and keep them alive with subsidies. France has cut its steel workforce by 20,000 in the last 2 years and plans to reduce it by another 10,000 by the end of 1981. British Steel has laid off over 50,000 employees within the last 2 years. During the last few years there has been a net reduction of approximately 20 million tons of steelmaking capacity throughout the EEC nations. Britain, France, and West Germany have led in the closures. The other EEC countries may follow if the world over-capacity continues for the next few years.

Japan also has a problem of excess steelmaking capacity. Capacity utilization rates were below 70 percent from the 1975 to 1978 time period for the Japanese steel industry as a whole.

Japan maintains capacity in excess of its own needs and depends heavily on exports to use much of this excess capacity. With a worldwide steel slump and various types of trade restrictions, they have been unable to fully utilize their modern, efficient mills. Despite these problems, the steel companies in Japan are still profitable. The lower wage rates and the energy- and labor-efficient mills still allow the Japanese steel companies to produce the lowest cost steel in the world, even though the operating rates are low. In the event of a steel shortage and the full capacity can be utilized, the Japanese cost of producing steel should decrease even further. Also during a world steel shortage, as in 1973, Japanese steel, unrestrained by price controls, commands a premium price, and profits for the industry soar, which are then reinvested in more efficient steelmaking equipment.

Japan's two largest export markets for its steel are the U.S. and Europe, but it also derives a substantial portion of its sales from Third World and Developing Countries. Sales to the first two markets are presently being limited by the Trigger Price Mechanism in the U.S. and voluntary quotas in Europe. Sales to the Third World and Developing Countries are also gradually being limited by these nations. Many of these nations are trying to become self-sufficient in their steel requirements while others are adding extra capacity with the intent of becoming net exporters of steel. The irony of the situation is that the Japanese, with their lead in steelmaking technology, have been cooperating with developing nations, both financially and technically, to build up their steelmaking industry. The Japanese now see these developing nations with the most modern steelmaking equipment and lower wage rates, not only locking them out of the countries' home markets, but aggressively competing in other Asian markets that have traditionally belonged to the Japanese. One South Korean steel company, assisted by Japanese steel companies, is now in a position to export steel to Japan and sell it at a lower price than the Japanese can. The major Japanese steel companies are now undergoing a review of their policy of exporting steel technology.

In the short run they have made good profits from the engineering contracts with developing nations, but in the long run it may damage the profitability of their own steelmaking operations.

The present situation in world steel trade stems from a prolonged period of worldwide overcapacity. Talks of trade restrictions, worldwide restructuring of the steel industry, and government subsidies would quickly give way to the need to expand steel capacity and unconscionable profits in the event of a world steel shortage. This is a situation that could quickly develop when the world economy comes out of its present slump. When the operating rate exceeds 90 percent of the effective capacity, steel companies start to place their customers on allocations and ordering times become longer. Discounting disappears and price increases become more frequent. Some analysts believe that a world steel shortage could happen in the very near future while others predict that it could not happen until the late 1980s or early 1990s. Regardless of the time, the Japanese will be in the best possible position to take advantage of the situation. Their profits will rise faster relative to other steel producing nations and because all of their plants are modern and well planned, they should be able to make incremental expansions faster and at less expense than could be done at older mills.

3.6 GOVERNMENT/INDUSTRY RELATIONSHIPS

Historically, the relationship between the U.S. Government and the domestic steel industry has been viewed as an adversarial one. This has manifested itself in the form of price controls and environmental and safety regulations, which have had a significant impact on the steel industry.

During the 1960s, price increases in the steel industry were singled out as a potential cause of inflation. Through Presidential pressure, which has become known as "jawboning" planned price increases by the steel industry were rolled back or reduced to very moderate levels. Beginning in the 1970s, "jawboning" gave way to formal and informal wage and price controls. Because steel price increases have such a major, direct, and indirect influence on both the wholesale and consumer price indexes, the steel industry came under very strong pressure to moderate or delay price increases that were justified by cost increases. As a result, cost increases outpaced price increases and net income as measured in relation to sales and to stockholders' equity fell far below the average of all manufacturing. What may have been an effective national strategy for controlling inflation did not necessarily contribute to the long term health of the steel industry.

In the areas of environment and safety, the steel industry also feels that it was singled out for special scrutiny. Although OSHA regulations have been burdensome to the steel industry, the Federal and state environmental laws have had the most costly impact on the steel companies.

Environmental regulations required controlling pollutants with the best available technology, resulting in large economic impacts. The steel industry is a large, capital-intensive industry. Most of its steelmaking facilities were built prior to the time of great environmental concerns. Also, they are major sources of water and air pollutants. Environmental regulations required the steel industry to spend large amounts for environmental control systems.

The steel industry responded to the regulations by filing lawsuits every time they were required to install pollution equipment. In most instances they were able to delay making expenditures of their limited capital resources on what the industry considered non-productive investments. Because many plants were old and required expensive retrofitting, some were closed earlier than they might have been under other circumstances. Other plants underwent modernization, installing more efficient and cleaner steelmaking equipment. Opponents and proponents of environmental regulations point out the extremes of the impacts of justifying their arguments. One side holds environmental regulations responsible for the reduction in steelmaking capacity while the other argues that it has been a major incentive to modernize with more efficient equipment.

Relationships are gradually improving between the Government and the steel industry. In 1977 foreign steel imports reached a point that greatly alarmed the domestic steel industry. The domestic steel industry responded by filing anti-dumping complaints with the Federal government against the foreign steel producers. The large number of dumping complaints led the Federal government to set up an interagency task force to determine how to handle the steel trade issue. In December 1977 the President accepted the recommendations of the Task Force with the main point being the establishment of a Trigger Price Mechanism (TPM). The TPM essentially set the minimum floor price at which foreign steel could be sold in the U.S. The prices were based on Japanese production costs (the lowest in the world) plus handling and shipping charges to the U.S. with a 6 percent profit added on. The TPM was designed to create some order to the chaotic discounting of steel prices in the U.S. and to act as a brake on the ever-increasing steel imports.

The TPM did have some flaws. It allowed European steel producers, whose pretax steel production costs are higher than both the Japanese and domestic producers, to sell steel in the U.S., as if their costs were the same as Japan. This upset the domestic steel producers who felt that even though the European steel producers were observing the Trigger Prices, they were still dumping steel in this country because their home steel prices were higher than the prices in this country.

On March 21, 1980 U.S. Steel Corp. filed a number of anti-dumping complaints with the Federal government. The dumping complaints covered five major categories of steel produced by 16 steel companies in seven European countries. The complaints charged that steel was sold in this country at prices below those charged by the steel companies in their home market. On the same day the Department of Commerce suspended the TPM, stating that they did not have the staff to both process the complaints and monitor the TPM.

The dumping complaints posed a complex problem for the U.S. Government. If the complaints were processed and it was determined that many of the European steel companies were dumping steel in this country, it may have triggered an international trade war. European countries could have placed restrictions on imports of U.S. produced petrochemicals and plastics because of alleged subsidies to their manufacturers by the U.S. Government in the form of price controls on petroleum feedstocks. Other trade items may also have been involved if European manufacturers were restricted from exporting steel to the U.S.

To prevent an international trade war, the Government held extensive meetings with representatives from U.S. Steel Corp. to determine if a compromise could be reached, whereby U.S. Steel would withdraw its complaints before they could be processed. In late September 1980, it was announced that an agreement had been reached. Some of the major points of the agreement were:

1. The Trigger Price Mechanism was restored at an average of 12.1 percent higher than when it was terminated. This is approximately where it would have been if the TPM had not been suspended.

2. The Department of Commerce promised that there would be "significant improvements" in its monitoring of the TPM. The Department had earlier in the year been criticized by the General Accounting Office for its management of the TPM.

3. A special anti-surge section was added to the TPM. When imports are above 15.2 percent of apparent domestic consumption, the U.S. industry is operating at a rate below 87 percent of capacity, and there "appears to be a surge" in specific steel products from specific countries, the Department of Commerce will automatically undertake an investigation of that country to determine if dumping is taking place.

4. A new depreciation schedule was proposed that will allow write-offs at a rate 40 percent greater than is permitted under current law. In addition an extra 10 percent tax credit (with the existing 10 percent tax credit) for capital investments of up to $10 billion will provide job opportunities in depressed areas.

5. New initiatives were proposed to encourage research and development of new steelmaking technologies.

6. A modification of the Clean Air Act was proposed to allow delays in compliance with some environmental requirements.

7. A renewed commitment to address the problems of the steel industry through the Tripartite committee which is composed of Government, labor, and industry.

Some of the points of the agreement require changes in Federal law and may be modified before they are passed. The Trigger Price Mechanism is scheduled to last a maximum of 5 years. This period is to afford the industry a certain amount of protection while it undergoes reorganization. At the end of 5 years, it is expected that the steel industry should be competitive in the world market.

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4. THE ALUMINUM INDUSTRY

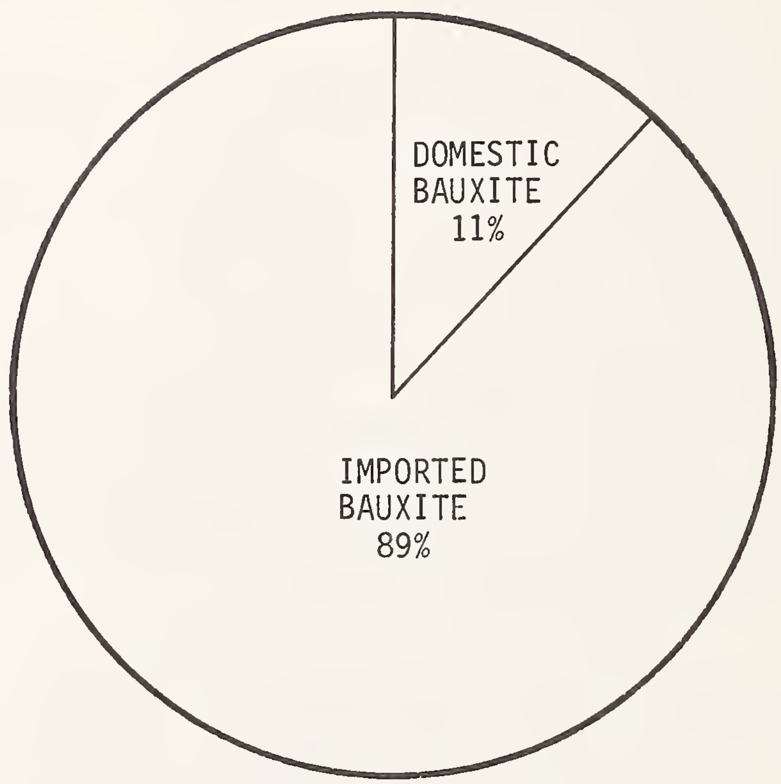
4.1 WORLD PRODUCTION AND INTERNATIONAL TRADE

Aluminum is one of the lightest and most abundant metals in the earth's crust. Approximately 8 percent of the earth's crust is composed of the element aluminum. Only oxygen and silicon exceed aluminum in abundance. In comparison iron makes up only 5 percent of the earth's crust.

Aluminum is never found naturally in its elemental state. It is always combined with oxygen or some other element to form an ore. Because aluminum has an exceptionally high affinity for combining with other elements, large amounts of energy are required to break this bond. The amount of energy needed to separate iron from the elements it combines with is substantially less than with aluminum. The manufacturing of iron is easier and less costly in terms of energy input than that of aluminum. This is the reason iron dominates the market for structural metals than the more abundant aluminum.

Aluminum is found in large concentrations in ores such as anorthosite, alumite, clays, and bauxite. Even fly-ash from smoke stacks contains large amounts of aluminum. Although there are many aluminum-bearing ores, the one that has proven to be the most economical for conversion to aluminum is bauxite. The U.S. has limited reserves of this ore and depends heavily on imports to fulfill its needs. Imports of bauxite or alumina (bauxite is first converted to alumina before it is smelted to aluminum) makes up nearly 90 percent of the domestic requirements, as is shown in Figure 4-1.

Traditionally the U.S. has obtained its bauxite requirements from the Caribbean and South American nations of Jamaica, Surinam, Guyana, Haiti, and the Dominican Republic. Many nations produce bauxite, but because of their proximity to the U.S. and hence lower transportation costs, these nations have been the principal sources of bauxite to the U.S.



Source: Energy and the Aluminum Industry, The Aluminum Association, Inc., 818 Connecticut Ave., NW, Washington, DC 20006, April 1980, p. 4.

FIGURE 4-1. U.S. ALUMINUM INDUSTRY BAUXITE IMPORT RELIANCE 1979

In 1974, following on the heels of the success of the oil producing nations forming OPEC, the major bauxite producers, led by Jamaica, formed the International Bauxite Association (IBA). The main purpose of this cartel is to maximize profits for the countries supplying bauxite. This was done by indexing the price of bauxite to a percentage of the market price of primary aluminum. Revenues to the countries increased every time the price of aluminum increased and if this didn't seem to be enough, they would raise the index percentage. As they essentially had a captive market, this strategy was very successful and succeeded in raising the revenue for bauxite sales by the member nations several fold. The flaw in the system was that although Australia was a member of the IBA, it refused to go along with the price indexing system, and Brazil with large reserves of bauxite refused to join the IBA. In the short run, the IBA members were able to charge very high prices for their bauxite. In the long run, they see their market share of world bauxite production erode, as the major bauxite consumers shift their bauxite sourcing to non-IBA members and Australia. Although the IBA members still supply a large percentage of the world's bauxite, they are rapidly losing their power to control prices. The world bauxite-producing nations are shown in Table 4-1.

In contrast to the bauxite producing nations, the primary aluminum producing nations are the industrialized nations. The U.S., Canada, the Western European nations, Japan, and the USSR account for most of the world production of aluminum, as shown in Table 4-2. Primary aluminum is energy-intensive, requiring large amounts of electrical power. Because the industrialized nations have traditionally produced the majority of the world's electrical power, aluminum companies have tended to be located near the source of power.

Aluminum production is also extremely capital-intensive. A 200,000 ton per year smelter can cost over $400 million. Construction costs in the industrialized nations are usually lower than in less developed nations. Specialized engineering personnel do not have to be brought into the country at premium

TABLE 4-1. WORLD PRODUCTION OF BAUXITE

(Short Tons)

	1975	1976	1977	1978	1979
United States (a)	1,984,600	2,193,600	2,218,900	1,839,800	1,931,200
Haiti	575,500	631,600	755,100	760,100	553,211
Jamaica (b)	12,460,059	10,307,744	11,239,598	11,557,600	12,709,803
Dominican Republic	865,410	568,800	573,200	568,099	524,142
Brazil	1,068,100	1,100,500	1,490,400	1,350,100	1,344,800
Guyana	4,220,990	3,425,576	3,686,411	3,321,668	3,133,248
Surinam	5,237,027	5,057,352	5,352,530	5,534,946	5,255,742
Total America	**26,411,686**	**23,285,172**	**25,316,139**	**24,932,313**	**25,452,146**
France	2,825,100	2,568,500	2,269,400	2,180,100	2,171,000
Greece	3,313,107	2,812,100	3,176,900	2,899,000	3,083,200
Italy	34,455	26,500	38,100	-	-
Spain	9,400	14,900	10,600	11,000	11,000
Yugoslavia	2,541,900	2,241,000	2,253,100	2,828,500	3,257,300
Total Europe	**8,723,962**	**7,663,000**	**7,748,100**	**7,918,600**	**8,522,500**
Republic Of Guinea	8,432,300	11,351,400	11,949,800	13,298,800	13,293,700
Ghana	358,500	299,346	305,510	381,480	363,800
Mozambique	5,700	5,500	2,200	-	-
Sierra Leone	789,200	727,500	821,200	789,200	789,200
Total Africa	**9,585,700**	**12,383,746**	**13,078,710**	**14,469,480**	**14,446,700**
India	1,404,806	1,597,190	1,674,046	1,832,694	2,132,329
Indonesia	1,094,094	1,036,459	1,434,551	1,110,838	1,166,129
Malaysia	775,535	727,780	689,200	677,981	426,061
Pakistan	440	197	100	1,692	1,301
Total Asia	**3,274,875**	**3,361,626**	**3,797,897**	**3,623,205**	**3,725,820**
Australia	**23,152,200**	**26,547,200**	**28,755,000**	**26,786,400**	**29,994,700**
Sub Total	**71,148,423**	**73,240,744**	**78,695,846**	**77,729,998**	**82,141,866**
U.S.S.R. (c)	7,275,200	7,385,400	7,385,400	7,385,400	7,385,400
Hungary	3,185,100	3,216,300	3,250,900	3,195,300	3,280,200
Rumania	858,700	981,000	992,100	992,100	992,100
China (c)	992,100	1,102,300	1,102,300	1,212,500	1,212,500
Sub Total	**12,311,100**	**12,685,000**	**12,730,700**	**12,785,300**	**12,870,200**
Total	**83,459,523**	**85,925,744**	**91,426,546**	**90,515,298**	**95,012,066**

(a) Dried equivalent of crude ore.
(b) Estimated dry tons.
(c) Estimated.

Sources: Nonferrous Metal Data, American Bureau of Metal Statistics, Inc., 1979, U.S. Bureau of Mines, World Bureau of Metal Statistics and other sources.

TABLE 4-2. WORLD PRODUCTION OF ALUMINUM
(Short Tons)

	1975	1976	1977	1978	1979
United States	3,879,000	4,251,000	4,539,000	4,804,000	5,023,000
Canada	967,891	692,306	1,072,666	1,155,739	948,303
Mexico	43,996	46,691	47,091	47,500	47,614
Brazil	133,800	153,400	184,200	205,500	264,000
Surinam (a)	29,134	51,183	63,609	61,458	68,983
Venezuela	54,800	51,300	47,800	78,400	230,000
Total America	**5,108,621**	**5,245,880**	**5,954,366**	**6,352,597**	**6,581,900**
Austria	97,937	96,378	101,208	100,723	102,077
France	421,777	424,452	439,641	431,400	435,500
Germany, F.R.	746,900	768,400	817,700	815,300	817,800
Greece	149,035	147,689	142,925	158,600	154,700
Iceland	68,100	72,000	77,983	81,060	78,315
Italy	209,887	234,773	266,719	299,503	297,825
Netherlands	287,500	281,600	265,900	287,900	285,400
Norway	655,679	680,757	686,435	703,884	727,317
Spain	231,907	230,400	233,500	233,900	270,900
Sweden (b)	85,310	90,958	90,627	90,410	89,800
Switzerland	87,100	86,200	88,000	87,600	91,500
United Kingdom	339,870	368,758	385,502	381,600	396,100
Yugoslavia	183,300	201,300	194,600	198,400	209,100
Total Europe	**3,564,302**	**3,683,665**	**3,810,740**	**3,870,280**	**3,956,334**
Bahrain	128,200	134,600	133,800	135,400	138,900
India	184,571	233,500	202,700	226,303	233,424
Iran	56,200	33,700	23,300	28,100	13,200
Japan	1,116,915	1,013,482	1,309,750	1,165,914	1,113,800
Republic Of Korea	19,400	19,400	19,100	19,500	19,600
Taiwan	30,986	28,100	54,800	55,000	60,700
Turkey	18,200	39,100	56,500	36,400	25,200
Total Asia	**1,554,472**	**1,501,882**	**1,799,950**	**1,666,617**	**1,604,824**
Cameroon	57,225	53,661	50,922	45,500	47,600
Egypt	2,200	65,000	99,200	110,700	110,100
Ghana	157,873	166,574	169,893	125,070	185,990
Republic Of South Africa	83,700	86,400	86,000	89,400	94,900
Total Africa	**300,998**	**371,635**	**406,015**	**370,670**	**438,590**
Australia	**235,800**	**256,047**	**272,904**	**290,303**	**297,153**
New Zealand	**120,699**	**154,103**	**159,927**	**166,568**	**171,400**
Sub Total	**10,884,892**	**11,213,212**	**12,403,902**	**12,717,035**	**13,050,201**
U.S.S.R. (c)	2,369,900	2,425,100	2,425,100	2,535,300	2,535,400
Czechoslovakia	47,700	44,100	40,200	44,100	44,000
Germany, D.R. (c)	66,100	66,100	71,600	71,600	73,600
Hungary	77,400	77,700	78,600	78,700	79,200
Poland	113,400	113,500	114,600	110,500	110,100
Rumania	225,100	223,800	230,400	234,800	235,200
China and Other Asia (c)	209,400	209,400	242,500	275,600	264,600
Sub Total (c)	**3,109,000**	**3,159,700**	**3,203,000**	**3,350,600**	**3,342,100**
Total	**13,993,892**	**14,372,912**	**15,606,902**	**16,067,635**	**16,392,301**

(a) Exports.
(b) Includes alloys.
(c) Estimated.

Sources: Nonferrous Metal Data, American Bureau of Metal Statistics, Inc., 1979, U.S. Bureau of Mines, World Bureau of Metal Statistics and other sources.

wage rates, and secondary support systems such as highways and housing, already in place in industrialized countries, have to be developed at added cost in the less developed countries.

A number of the less developed countries also tend to have less stable governments then the industrialized nations. One of the problems facing an aluminum producer is investing over half a billion dollars or more in a country only to see the government change radically and the investment nationalized.

World aluminum production is dominated by six companies, which together own or have equity interest in about one-half of the world's primary aluminum capacity. These companies are ALCOA, Reynolds, and Kaiser from the United States, ALCAN from Canada, and Alusuisse and Pechiney from Europe. Their dominance has slowly decreased from year to year as smaller private companies and state-owned nationalized companies increase their market share.

World consumption of aluminum, like production, is concentrated in the industrialized nations. Table 4-3 shows the major aluminum consuming nations in the world. The United States is by far the largest single consumer of aluminum with over 30 percent of the world's total. Consumption figures in Table 4-3 are slightly higher than production figures in Table 4-2 because of the inclusion of secondary or recycled metal usage.

4.2 THE STRUCTURE OF THE DOMESTIC ALUMINUM INDUSTRY

The aluminum industry in the United States is composed of 12 companies operating 33 primary aluminum smelters. The three largest companies, ALCOA, Reynolds, and Kaiser, dominate the industry with about 63 percent of the almost 5.4 million tons per year production capacity. In addition the secondary aluminum industry recycles an additional 1.8 million tons of aluminum per year, using new and used scrap. The amount of metal produced by the secondary aluminum industry is more a function of the availability of scrap metal than melting capacity, which can be added in a very short period of time.

TABLE 4-3. WORLD CONSUMPTION OF ALUMINUM
(Short Tons)

	1975	1976	1977	1978	1979
United States	3,599,000	4,949,900	5,242,500	5,484,900	5,712,100
Canada	323,300	355,200	366,400	372,300	329,400
Mexico	56,100	61,600	58,300	83,600	79,400
Argentina	80,000	74,300	54,800	46,200	44,100
Brazil	230,600	240,200	275,500	272,000	264,600
Other America	76,600	79,100	97,000	88,200	88,200
Total America	**4,365,600**	**5,760,300**	**6,094,500**	**6,347,200**	**6,517,800**
Austria	92,300	117,500	110,100	118,900	120,900
Belgium	196,400	269,200	259,400	282,900	242,000
France	440,000	543,000	588,400	587,200	656,900
Germany, F.R.	775,700	1,052,000	1,005,600	1,049,700	1,207,200
Italy	297,600	402,300	421,100	445,300	434,300
Netherlands	96,500	131,500	118,300	114,600	111,600
Norway	102,200	102,600	105,900	117,100	115,700
Spain	239,000	245,300	276,500	259,700	253,900
Sweden	125,800	111,900	102,300	108,000	103,200
Switzerland	93,000	115,400	121,000	115,700	122,400
United Kingdom	432,900	490,000	460,900	443,300	460,300
Yugoslavia	140,800	149,400	169,600	179,564	227,500
Other Europe	77,500	105,400	118,200	136,800	134,600
Total Europe	**3,109,700**	**3,835,500**	**3,857,300**	**3,958,764**	**4,190,500**
India	162,000	219,000	211,000	247,000	291,000
Japan	1,375,900	1,831,600	1,661,000	1,875,700	1,989,900
Taiwan	50,400	61,500	75,300	109,100	111,600
Turkey	66,200	75,100	86,000	49,600	50,700
Other Asia	187,700	199,200	296,200	335,200	352,700
Total Asia	**1,842,200**	**2,386,400**	**2,329,500**	**2,616,600**	**2,795,900**
Cameroon	28,900	30,400	25,600	33,100	33,100
Egypt	16,500	22,000	33,100	35,300	40,000
Ghana	6,400	6,600	6,600	6,600	6,600
Republic Of South Africa	57,500	51,600	57,900	50,600	55,000
Other Africa	12,600	15,000	15,400	22,000	22,000
Total Africa	**121,900**	**125,600**	**138,600**	**147,600**	**156,700**
Australia	**146,800**	**175,100**	**193,300**	**204,100**	**214,300**
New Zealand	**22,100**	**30,500**	**25,700**	**24,400**	**21,400**
Sub Total	**9,608,300**	**12,313,400**	**12,638,900**	**13,298,664**	**13,896,600**
U.S.S.R. (a)	1,741,600	1,862,900	1,940,000	2,017,200	2,028,200
Bulgaria	41,900	44,100	49,600	51,800	52,900
Cuba	1,100	1,100	1,100	1,100	900
Czechoslavia (a)	154,300	136,700	137,800	143,300	143,300
Germany, D.R. (a)	220,500	231,500	237,000	248,000	246,900
Hungary	183,000	187,800	186,000	193,600	194,000
Poland	152,100	159,800	164,200	176,400	176,400
Rumania	132,300	143,300	165,300	165,300	165,300
China (a)	352,700	385,800	407,900	463,000	463,000
Other Asia (a)	22,000	24,300	34,400	40,200	39,700
Sub Total (a)	**3,001,500**	**3,177,300**	**3,323,300**	**3,499,900**	**3,510,600**
Total	**12,609,800**	**15,490,700**	**15,962,200**	**16,798,564**	**17,407,200**

(a) Estimated.

Sources: Nonferrous Metal Data, American Bureau of Metal Statistics, Inc., 1979, U.S. Bureau of Mines, World Bureau of Metal Statistics and other sources.

The location, capacity, and planned additions to the primary aluminum plants are shown in Table 4-4. The Canadian plants have also been shown because of their large contribution to the amount of aluminum which the U.S. imports. Figure 4-2 shows the locations of the primary and secondary aluminum plants. Approximately 26,000 workers are employed in the production of primary aluminum and another 4300 in secondary aluminum. Employment concentrations correspond closely to the locations on the map. Another 50 to 60,000 are employed in the manufacturing of mill products such as sheet, foil, and extensions. Employment for these workers are principally concentrated in the northern states, east of the Mississippi.

Aluminum companies usually operate on an international scale, owning and operating raw material, smelting and fabricating facilities in many countries throughout the world. For example ALCOA ownes bauxite mines in six countries and has interest in 15 smelters, of which only eight are in this country. Because of their high costs aluminum smelters often are built as joint ventures. Table 4-5 shows the ownership relations for the domestic aluminum companies. Alusiusse and Pechiney are the two largest aluminum producers based in Europe. Mitsui & Co. is one of the large Japanese trading firms. Many of the new smelters being built overseas may have as many as four or five corporate investors from a wide range of countries.

4.3 MAJOR ALUMINUM CONSUMING MARKETS

The major markets for aluminum products are the building and construction industry, the transportation industry, and the container and packaging industry, which together account for about 69 percent of the aluminum shipments. Aluminum usage by market category is shown in Figure 4-3.

The transportation market includes all modes of transportation--aerospace, rail, ship, truck, bus, and passenger car. The passenger car segment of this market is by far the largest single portion with approximately 50 percent of the shipments to the

TABLE 4-4. ALUMINUM INGOT CAPACITY
(As of January 1, 1980)

Company	Present Capacity	Sched'd Additions or New Plants	Total
Aluminum Co. of America			
ALCOA TN	270,000	-	270,000
Anderson County TX	30,000	-	30,000
Badin NC	120,000	-	120,000
Evansville IN	280,000	-	280,000
Massena NY	205,000	-	205,000
PT. Comfort TX	180,000	-	180,000
Rockdale TX	295,000	-	295,000
Vancouver WA	115,000	-	115,000
Wenatchee WA	195,000	-	195,000
Total ALCOA	1,690,000	-	1,690,000
Reynolds Metals Co.			
Arkadelphia AR	68,000	-	68,000
Jones Mills AR	125,000	-	125,000
Listerhill AL	202,000	-	202,000
Longview WA	210,000	-	210,000
Massena NY	126,000	-	126,000
Corpus Christi TX	114,000	-	114,000
Troutdale OR	130,000	-	130,000
Total Reynolds	975,000	-	975,000
Kaiser Aluminum and Chemical Corp.			
Chalmette LA	260,000	-	260,000
Mead WA	220,000	-	220,000
Ravenswood WV	163,000	-	163,000
Tacoma WA	81,000	-	81,000
Total Kaiser	724,000	-	724,000
Anaconda Aluminum Co.			
Sebree KY	180,000	-	180,000
Columbia Falls MT	180,000	-	180,000
Total Anaconda	360,000	-	360,000
Consolidated Aluminum Corp.			
New Johnsonville TN	145,000	-	145,000
Lake Charles WA	36,000	-	36,000
Total Consolidated	181,000	-	181,000

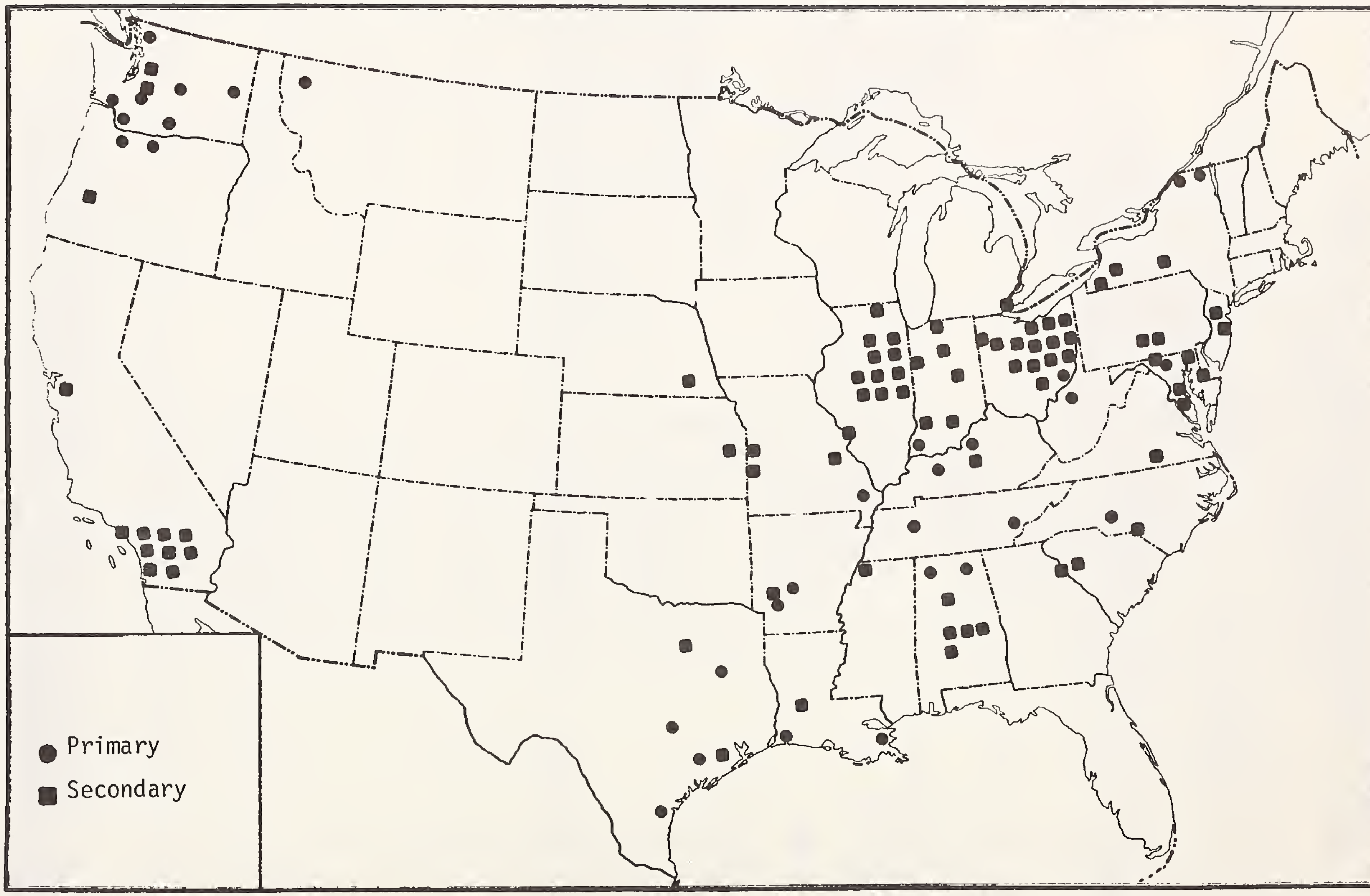
TABLE 4-4. ALUMINUM INGOT CAPACITY (CONT.)
(As of January 1, 1980)

Company	Present Capacity	Sched'd Additions or New Plants	Total
Martin Marietta Aluminum			
The Dalles OR	90,000	-	90,000
Goldendale WA	110,000	-	110,000
Total Martin	200,000	-	200,000
Others			
Revere Copper & Brass Scottsboro AL	112,000	-	112,000
Ormet Corp.			
Hannibal OH	263,000	-	263,000
National-Southwire Aluminum Co.			
Hawesville KY	180,000	-	180,000
Noranda Aluminum Co.			
New Madrid MO	140,000	-	140,000
Alumax Inc.			
Berkley City SC	197,000	-	197,000
Eastalco			
Frederick MO	176,000	-	176,000
Intalco			
Ferndale WA	265,000	-	265,000
Total Other	1,333,000	-	1,333,000
Total U.S.	5,463,000	-	5,463,000

TABLE 4-4. ALUMINUM INGOT CAPACITY (CONT.)
(As of January 1, 1980)

Company	Present Capacity	Sched'd Additions or New Plants	Total
	CANADA		
ALCAN Aluminum Ltd.			
Arvida PQ	465,000	-	465,000
Isle MaLiqne PQ	83,000	-	83,000
Shawinigan Falls PQ	91,000	-	91,000
Grande Baie PQ	-	189,000	189,000
Beauharnois PQ	51,000	-	51,000
Kitimat BC	295,000	-	295,000
Total ALCAN	985,000	189,000	1,174,000
Canadian Reynolds Metal Co.			
Baie Comeau PQ	175,000	-	175,000
Total Canada	1,160,000	189,000	1,349,000
Total North America	6,623,000	189,000	6,812,000

Source: Metal Statistics of 1980: The Purchasing Guide of the Metal Industries. 73 edition, American Metal Market and Company Annual Report.



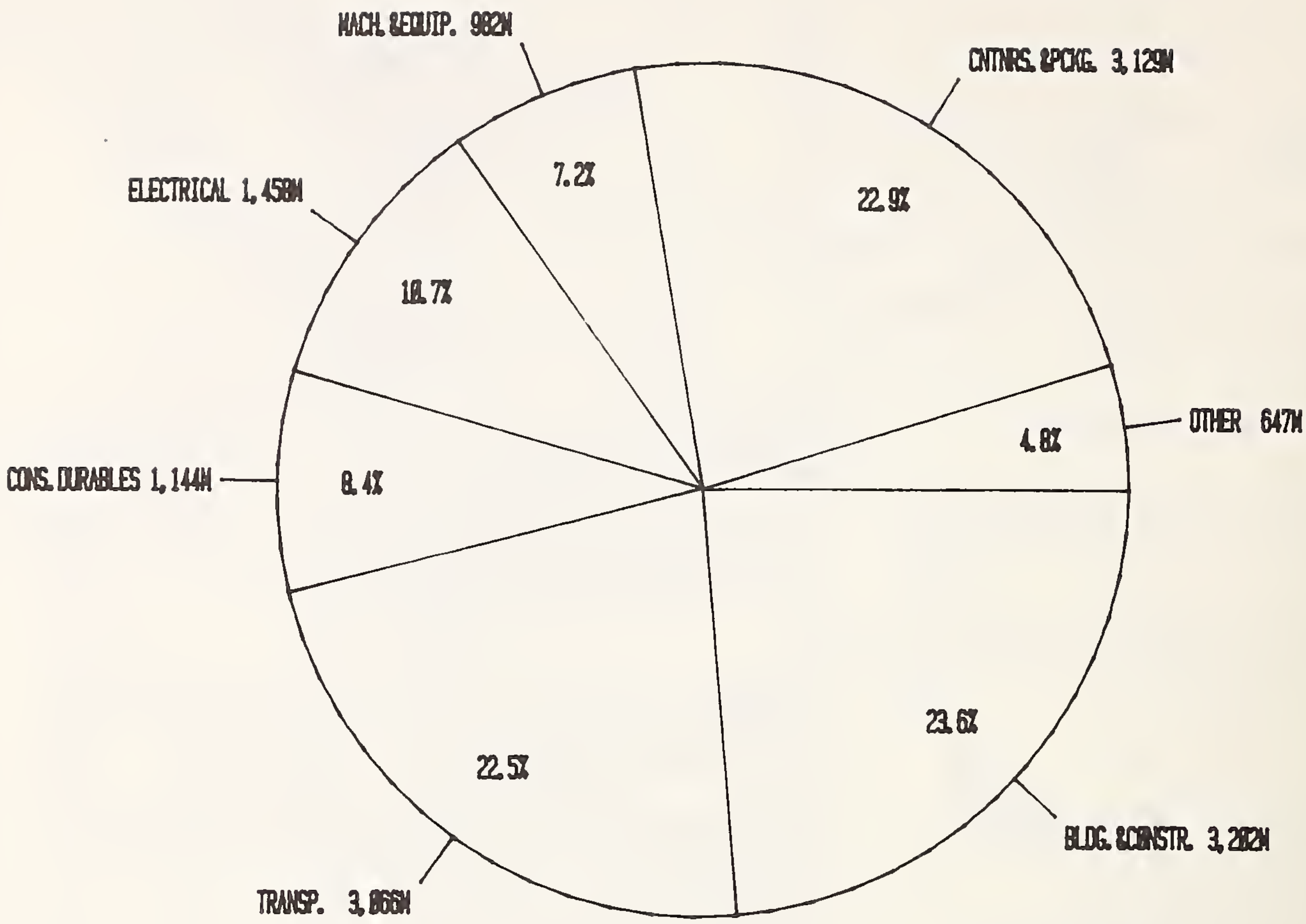
Source: Aluminum Statistical Review 1978
The Aluminum Association Inc.

FIGURE 4-2. LOCATION OF THE PRIMARY AND SECONDARY ALUMINUM PRODUCERS

TABLE 4-5. OWNERSHIP OF PRIMARY ALUMINUM PLANTS

	OWNERSHIP
Aluminum Company of America (ALCOA)	100% Self
Reynolds Metals Co.	100% Self
Kaiser Aluminum & Chemical Corp.	100% Self
Anaconda Aluminum Co.	Subsidiary of Anaconda Corp. which is 100% owned by Atlantic Richfield Co.
Consolidated Aluminum Corp.	60% Swiss Aluminum Ltd. [Alusiusse]; and 40% Phelps Dodge Corp.
Revere Copper & Brass Co.	100% Self
Ormet Corp.	66% Consolidated Aluminum Co. and 34% Revere Copper & Brass Co.
National - Southwire Aluminum Co.	50% National Steel Co. and 50% Southwire Aluminum Co.
Noranda Aluminum Co.	100% Noranda Mines Ltd.
Alumax Inc.	50% AMAX; 45% Mitsui & Co., 5% Nippon Steel
Eastalco	50% Alumax; 50% Howmet [Pechiney]
Italco	50% Alumax; 50% Howmet
Martin Marietta	100% self

DOMESTIC SHIPMENTS



	% DISTRIBUTION	AMOUNT
TOTAL DOMESTIC	94.7	13,628
EXPORTS	5.3	762
TOTAL INDUSTRY	100.0	14,390

Source: Aluminum Statistical Review 1978
The Aluminum Association Inc.

FIGURE 4-3. 1978 ALUMINUM NET SHIPMENTS BY MAJOR MARKET
(In Millions of Pounds)

transportation market. Table 4-6 shows the historical consumption of aluminum by the passenger car market. The table divides aluminum usage for this market into two major categories, ingot and mill products, and then subdivides mill products into specific types.

The category "aluminum ingot" is the aluminum product used most commonly by the passenger car market. This form of aluminum is used to make castings. Ingot is a generic term for metal as it comes from the primary or secondary smelter and before it is processed into mill products. Physically, ingots come in three forms: powder, solid shapes, and molten metal. Solid shapes can range from the size of a nugget to the size of a bathtub.

The automotive industry is the largest single purchaser of ingots in the molten metal form. Substantial energy savings can be realized by buying molten metal that can be used to make castings rather than purchasing metal in a solid form and remelting it. Because of the advantage of using molten metal, automotive casting plants are usually located in close proximity to primary and secondary aluminum smelters.

Aluminum competes with iron when used in castings. Aluminum's advantage in this context is weight, which is approximately one-third that of iron. The principal disadvantage is material cost. Raw material cost for iron is approximately 7¢ per pound. Primary aluminum unalloyed is 76¢ per pound and some primary aluminum alloys are as high as 90¢ per pound. Scrap metal, which probably accounts for over 50 percent of the metal charge for the casting, currently sells for 35 to 45¢ per pound, although the price fluctuates rapidly as demand changes. When the prices of aluminum and iron are adjusted on a volume basis to account for the different material densities, aluminum is still more expensive than iron.

Aluminum does have a slight advantage in manufacturing costs over iron. Iron castings can be made only by the sand casting method while aluminum castings, depending on the shape of the part,

TABLE 4-6. SHIPMENTS OF ALUMINUM TO THE PASSENGER CAR MARKET BY TYPE OF PRODUCT (Millions of Pounds)

	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1968
Ingot	961	952r	856r	644	763	998	795	699	569	685	703
Total mill products	568	527	386	215	261	321	247	190	146	172	163
Sheet	392	378	264	124	154	204	164	138	96	123	124
Plate	2	-	1	-	-	-	-	-	-	-	-
Foil	41	35	22	14	12	17	15	10	9	7	6
Rolled & continuous cast rod & bar	11	11	12	9	12	16	10	2	2	3	2
Extruded rod & bar	- (1)	- (1)	- (1)	- (1)	- (1)	- (1)	- (1)	1	1	1	1
Extruded shapes	77	58	51	42	54	43	24	13	19	23	15
Extruded pipe & tube	14	14	11	7	9	12	10	6	4	2	2
Drawn tube	13	13	10	6	7	15	15	13	8	6	6
Bare wire	1	1	1	1	2	2	2	2	2	2	2
Forgings	14	14	9	8	7	6	2	1	1	1	1
Impacts	3	3	5	4	4	6	5	4	4	4	4
Passenger cars total(2)	1,529	1,479r	1,242r	859	1,024	1,319	1,042	889	715	859	866
Mill Products as a % of Total	37.1	35.6	31.0	25.0	25.5	24.3	23.7	21.4	20.4	20.1	18.8

r - revised

(1) Extruded rod and bar combined with rolled and continuous cast rod and bar from 1972 to present.

(2) Shipments to "Passenger Cars" cover new domestic automobile production, spare parts, accessories and aftermarket parts. Shipments for light trucks and vans are included in Trucks and Buses.

Source: Estimated by the Statistical and Marketing Research Committee of the Aluminum Association, Inc. Aluminum Statistical Review 1978, pgs. 24,25, The Aluminum Assoc., Inc.

can be made by die casting or the permanent mold process as well as sand casting. Aluminum is also softer than iron and an aluminum casting can be machined faster with less tool wear than a similar iron casting.

Die casting is capital-intensive and is used only for high volume parts. Its advantage is that it can produce castings to close tolerances that may require little or no machining, at a high rate of production, and with limited labor input. The finished die cast part is very cost competitive with a sand cast iron part that has to be machined. This is one of the reasons that die cast automatic transmission cases were made out of aluminum long before weight reduction became a factor.

The permanent mold and sand casting methods produce aluminum castings at a premium cost over a similar iron casting. Although there is an incremental cost associated with these castings, there is a number of automotive castings made by these methods. It appears that the added costs are considered acceptable by the automotive industry when it is compared to the amount of weight saved. (For a more detailed description of the casting process used see section 9, The Casting Industry).

Aluminum, when used in mill product applications, such as bumpers, wheels, and deck lids, faces a different set of circumstances than when it is used in casting. In the case of castings the only other suitable material that could be used in place of aluminum and iron is magnesium. Magnesium presently has a higher cost per volume than aluminum and it also has a very limited production base. Magnesium smelting capacity would have to be increased several fold before the volume reached a level where it could seriously be considered as a substitute for aluminum. Aluminum mill products have a much wider range of competitors, ranging from plain carbon steels, high strength steels, and many types of reinforced and unreinforced plastics.

On the basis of incremental cost per pound saved, aluminum in mill products has a disadvantage compared to aluminum in castings. In general the aluminum in mill products must be a slightly thicker gauge than the steel it is replacing. While aluminum can be substituted in a ratio of 1 lb to 3 lbs of iron in casting, it can only be substituted in a ratio of 1 lb to roughly 2.5 lbs of steel in mill product applications. This tends to make aluminum mill products a more expensive option for weight reduction than aluminum castings.

Shipments of aluminum to the passenger car market are given in Table 4-6. The table breaks down the type of aluminum products used by the automotive industry. Mill products as a percentage of the total shows a steady increase over an eleven-year span (1968-1978). The percentage may overstate the amount of mill products actually used in a finished vehicle because the manufacturing of components made from mill products produces scrap, which is usually made into castings. Aluminum use per average car is given in Table 4-7. In 1981 aluminum usage per vehicle seems to have leveled off, at least temporarily.

It is believed that the automotive manufacturers are undergoing a critical examination of their future use of aluminum. A number of factors are involved in this assessment. Consumer acceptance of downsized vehicles has been better than anticipated. Downsizing is one of the least costly methods of undergoing weight reduction. Second, the automotive manufacturers have rapidly increased their knowledge and experience with high strength steels and reinforced plastics, which are now in contention for applications where a few years ago aluminum was the only material under consideration. Third, many forecasters are predicting aluminum demand could exceed supply before 1985. The automotive companies are reluctant to become dependent on a material that soon could be in short supply. Finally, the price of aluminum has risen sharply over the past few years. The price increases reflect both higher energy costs and the need for additional capital for expansion plans. The automotive companies seem to see this as a

TABLE 4-7. ALUMINUM USAGE IN U.S. AUTOMOBILES

YEAR	ALUMINUM APPLICATION (Pounds per Car)
1946	12
1953	18
1960	54
1961	63
1962	67
1963	70
1964	72
1965	71
1966	73
1967	71
1968	72
1969	74
1970	78
1971	77
1972	78
1973	81
1974	83
1975	84
1976	87
1977	100
1978	114
1979	120
1980	130 Est.
1981	130 Est.

Sources: 1946 figure from "Automotive Industries," July 1, 1976, p. 37; 1953 figure from "Automotive Industries," Dec 1, 1972, p. 37; 1960-1978 figures from Automotive News 1977 Market Data Book Issue, p. 20; 1979 figure from "American Metal Market," May 21, 1979, p. 27; 1980 figure from Ward's Automotive Yearbook 1980; 1981 figure from Ward's Automotive Reports, Jan. 26, 1981, p. 26.

trend and are looking for alternate materials where the potential price increases may not be so great.

As recently as 4 years ago, industry analysts estimated aluminum usage could reach 300 to 400 lbs per vehicle by 1985. A 1979 estimate by General Motors forecasted only 175 to 235 lbs by 1985. In 1980 General Motors revised the estimate to 145 to 200 lbs. A Ford forecast in late 1980 estimated only 160 lbs by 1985. As 1985 approaches, the automotive manufacturers are devising less expensive ways to improve fuel economy without having to resort to using larger amounts of aluminum and their forecasts are being reduced accordingly.

Aluminum is versatile and has been used in many automotive applications as Table 4-8 demonstrates. Most of the applications are on selected car models, and few extend across all manufacturers or even all model lines of a single manufacturer. Many of the present applications of aluminum are used to adjust a vehicle's weight to a targeted EPA weight class. Significant weight reductions can be gained in existing model lines by using aluminum in hang-on parts with minimal component redesigning or assembly operations changes. As new car models are developed and new assembly lines are built, designers will have the flexibility to use a material to its full potential and in its most cost-effective application. The designers will not be limited to adapting a material's use to an existing design. Many of the current applications of aluminum may not be used in the future and new applications may be developed.

The new Ford Escort/Lynx automobiles can probably be considered representative of the typical 1985 vehicle. They are front-wheel drive vehicles with 28 to 30 mpg fuel economy in the urban cycle. Aluminum usage ranges from approximately 120 lbs on the model with no options and manual transmission to over 216 lbs with all options including air conditioning, automatic transmission, and aluminum wheels. Table 4-9 lists the aluminum applications on the Escort/Lynx in addition to the weight of each part.

TABLE 4-8. ALUMINUM PARTS ON 1980 CARS

PART	MAKE AND MODEL
BUMPER SYSTEMS	
Bumper, Face Bars, Extruded, Anodized	Buick Skylark, Oldsmobile Omega, Pontiac Sunbird, Ford Fairmont, LTD Station Wagon (S/W) (rear), Pinto, Mercury Bobcat, Zephyr, Dodge Omni, Plymoth Horizon, AMC Concord, Spirit, Eagle, Volkswagen Rabbit
Bumper, Face Bars, Extruded, Chrome Plated	Mercury Marquis S/W (rear)
Bumper, Face Bars, Sheet, Chrome Plated	Lincoln Continental, Mark VI, Chrysler Newport (front), New Yorker, Cordoba, Dodge St. Regis (front), Mirada (rear), Plymouth Gran Fury (front), AMC Jeep Cherokee, Jeep Wagoneer
Bumper Reinforcements, Extruded	Chevrolet Monza 2+2
Bumper Reinforcements and Brackets, Sheet	Buick Century, Electra, LeSabre, Cadillac DeVille, Eldorado, Fleetwood, Chevrolet Caprice, Impala, Malibu, Monte Carlo, Pontiac - Most Models, Oldsmobile 88, 98, Cutlass, Ford - Most Models, Lincoln - Most Models, Mercury - Most Models, Chrysler Newport (brackets), New Yorker (brackets), Dodge Omni (2-door), St. Regis (brackets), Plymouth Horizon (2-door)
WHEELS	
Wheels, Forged	Buick Skyhawk, Chevrolet Pick Up/Van, Pontiac - All Models, Ford Mustang, Pinto, Pick Up/Van, Lincoln Versailles, Mercury Capri, Bobcat, Chrysler Cordoba, LeBaron, Dodge Diplomat, Mirada, St. Regis, AMC Spirit, Concord, Jeep, Pacer
Wheels, Cast	Virtually all models offer cast wheels as an option.

Source: Compiled by The Aluminum Association, 818 Connecticut Avenue, NW, Washington, DC 20006.

TABLE 4-8. ALUMINUM PARTS ON 1980 CARS (CONT.)

PART	MAKE AND MODEL
WHEEL ACCESSORIES	
Hub Caps, Sheet, Anodized	Most Cars
Trim Rings, Sheet, Anodized	Chevrolet Monza, Chevette, Pontiac Sunbird, S/W, Chrysler - Some Models, Dodge - Some Models, Plymouth - Some Models
Wheel Cylinder Piston	Ford - All Models, Lincoln - All Models, Mercury - All Models
Opening Mouldings, Sheet, Anodized	Most Cars
Wheel Cover, Sheet, Anodized	Buick - Some Models, Cadillac - Some Models, Chevrolet - Some Models, Oldsmobile - Some Models, Pontiac - Some Models, Chrysler - Some Models
Proportioning Valve, Extrusion	Ford - All Models, Mercury - All Models
Splash Shield, Sheet	Ford LTD, Mercury Marquis, Dodge Omni, Plymouth Horizon
Power Brake Booster Plate, Sheet	Ford Fairmont, Mercury Zephyr
Brake Drums, Permanent Mold Casting	Buick Regal, Cadillac - Some Models, Chevrolet Monte Carlo, Oldsmobile Cutlass, Pontiac - Some Models, Ford LTD, Mustang, Mercury Capri
Master Cylinder, Cast	Buick Skylark, Century, Chevrolet Malibu, Citation, Oldsmobile Cutlass, Omega, Pontiac LeMans, Grand Am, Phoenix, Ford LTD, Mustang, Thunderbird, Lincoln Continental, Mark VI, Mercury Capri, Marquis, Chrysler - All Models, Dodge - All Models
Brake Silencer Pad, Casting	Dodge Omni, Plymouth Horizon
TRIM MOULDINGS	
Sheet Anodized (Body, Roof, Window, Windshield, Fender, Door, Dashboard, Some Lights, Some Grilles, Some Rocker Panels)	Buick - All Models, Cadillac - All Models, Chevrolet - All Models, Oldsmobile - All Models, Pontiac - All Models, Ford - All Models, Lincoln - All Models, Mercury - All Models, Chrysler - All Models, Dodge - All Models, Plymouth - All Models, AMC - Some Models, Volkswagen Rabbit

Source: Compiled by The Aluminum Association, 818 Connecticut Avenue, NW, Washington, DC 20006.

TABLE 4-8. ALUMINUM PARTS ON 1980 CARS (CONT.)

PART	MAKE AND MODEL
Door Belt Trim Support, Sheet	Buick Century, LeSabre, Riviera, Cadillac Eldorado, Chevrolet Malibu, Impala, Caprice, Oldsmobile Cutlass, Delta 88, Torondo, Pontiac LeMans, Grand Am, Grand Prix, Catalina, Bonneville, Ford LTD, Mercury Marquis, Chrysler LeBaron, Newport, New Yorker, Dodge Aspen, Diplomat, Omni, St. Regis, Volare (limited), Plymouth Horizon, Volkswagen Rabbit
BODY APPLICATIONS	
Deck Lid, Inner and Outer Sheet, Painted	Pontiac Bonneville
Deck Lid Guards, Sheet	Buick Riviera, Cadillac Eldorado, Oldsmobile 88, 98
Hood, Inner and Outer, Sheet, Painted	Buick Electra, Some Regals, Cadillac DeVille, Oldsmobile 88, 98, Cutlass, Some Toronados, Pontiac Bonneville, Grand Prix, Lincoln Continental, Mark VI, Versailles
Hood, Hinges, Sheet	Buick Electra, Cadillac DeVille, Oldsmobile - Some Models
Hood Latch Reinforcements, Sheet	Buick Electra, Cadillac DeVille, Lincoln Continental, Mark VI, Versailles
Rear Hinge Reinforcement, Sheet	Lincoln Continental, Mark VI, Versailles
Head Rest Bar, Extrusion	Buick - All Models, Cadillac - All Models, Chevrolet - All Models, Oldsmobile - All Models, Pontiac - All Models, Ford - Some Models, Mercury - Some Models
Seat Backs, Sheet	Many Station Wagons, Cadillac DeVille, Ford Thunderbird, Mercury Cougar
Seat Frames, Extrusion	Ford Mustang, Mercury Capri
Seat Power Adjustments, Assembly, Forging, Sheet	Cadillac - All Models, Buick Riviera, Electra, LeSabre, Oldsmobile - Most Models, Chevrolet Caprice, Pontiac Bonneville, Chrysler - Some Models

Source: Compiled by The Aluminum Association, 818 Connecticut Avenue, NW, Washington, DC 20006.

TABLE 4-8. ALUMINUM PARTS ON 1980 CARS (CONT.)

PART	MAKE AND MODEL
Arm Rest Frame, Sheet	Buick - Some Models, Cadillac - Some Models, Chevrolet - Some Models, Oldsmobile - Some Models, Pontiac - Some Models
Tulip Panel, Sheet	Buick Skylark, Chevrolet Monte Carlo, Oldsmobile Omega, Pontiac Grand Prix
Sun Roof Hatch Frame and Panel, Sheet	GMC - Some Models, Ford - Some Models, Chrysler - Some Models, AMC - Some Models, Volkswagen - Some Models
Carpet Scuff Plate, Sheet	GMC - All Models, Ford - All Models, Chrysler - All Models, AMC - Some Models, Volkswagen Rabbit
Door Guards, Sheet, S.S. Clad	Bucik Riviera, Cadillac Eldorado, Oldsmobile Toronado
Instrument Panel Tie Bar, Sheet	Chevrolet Malibu
Dash Panel Insert, Sheet	Cadillac
Luggage Rack and Air Deflector, Sheet, Extrusion	Buick Century, LeSabre, Regal, Chevrolet Malibu, Monte Carlo, Impala, Caprice, Oldsmobile Cutlass, Delta 88, Pontiac LeMans, Catalina, Ford LTD S/W, Mercury Marquis SW, AMC - Some Models, Volkswagen Rabbit
Load Floor, Sheet	Buick S/W, Chevrolet Chevette, Monza S/W, Oldsmobile S/W, Pontiac Sunbird S/W, Ford LTD S/W, Mustang, Mercury Caprice, Marquis S/W
License Plate Bracket, Front, Sheet	Pontiac Grand Prix
Steering Wheel	Ford Mustang, Pick Up, Mercury Capri
ENGINE - POWER TRAIN	
Steering Column Support Bracket	Ford Pick Up
Steering Column Gear Housing	Chevrolet Chevette, Ford Fairmont, Mustang, Mercury Zephyr, Capri, Chrysler - Some Models, Dodge - Some Models, Plymouth - Some Models
Flipper Panel	Ford Mustang, Capri, Fairmont, Mercury, Zephyr, GMC Corporate "B" Wagon
Cylinder Head	Dodge Omni, Plymouth Horizon, AMC - 4-cylinder, Volkswagen Rabbit

Source: Compiled by The Aluminum Association, 818 Connecticut Avenue, NW, Washington, DC 20006.

TABLE 4-8. ALUMINUM PARTS ON 1980 CARS (CONT.)

PART	MAKE AND MODEL
Alternator Bracket	Buick Skylark, Chevrolet Citation, Oldsmobile Omega, Pontiac Phoenix, Ford - Some Models, Lincoln - Some Models, Mercury - Some Models
Cam Gear	GMC - Some Models, Chrysler - Some Models
Cam Shaft Housing	Buick - Some Models, Cadillac - Some Models, Chevrolet - Some Models, Oldsmobile - Some Models, Pontiac - Some Models
Carburetor, Various Parts	GMC - Some Models, Ford - Some Models, Chrysler - Some Models
Carburetor, Air Horn	Ford, Lincoln, Mercury - Some Models
Engine Rear Cover Plate and Alternator Bracket, Sheet	Ford (RCP) - Most Engines, Mercury Marquis, Montego
Radiator, Tube and Sheet	Chevrolet S/W (large), Volkswagen Rabbit
Radiator Shroud, Sheet	Buick - All Models, AMC - Jeep Wagoneer, Volkswagen Rabbit
Radiator Support Assembly, Sheet	Buick Century, Pontiac LeMans
Oil Filter Cap, Sheet	Ford - Most Engines, Volkswagen Rabbit
Oil Filter Base, Sheet	Dodge Omni, Plymouth Horizon, AMC - Some Models
Pump Mounting Bracket, Sheet	Ford Mustang, Mercury Capri
Fuel Pump Body	Ford - Some Models, Chrysler - Some Models
Rear Cover Plate, Sheet	Ford - Most Engines
Air Cleaner Housing, Sheet	Ford, Lincoln, Mercury - Most Models
Heat Shields Catalytic Converter, Sheet	Chevrolet Chevette, Chrysler, Dodge, Plymouth - All Models
Fuel Filler Tube, Drawn	Dodge Omni, Plymouth Horizon, AMC - Some Models, Volkswagen Rabbit
Rack and Pinion Housing	Buick Skylark, Chevrolet Citation, Chevette, Oldsmobile Omega, Pontiac Phoenix, Ford Fairmont, Pinto, Mercury Zephyr, Bobcat, Dodge Omni, Plymouth Horizon
Starter Cover Housing	Buick, Chevrolet, Oldsmobile, Pontiac, Ford - Some Models

Source: Compiled by The Aluminum Association, 818 Connecticut Avenue, NW, Washington, DC 20006.

TABLE 4-8. ALUMINUM PARTS ON 1980 CARS (CONT.)

PART	MAKE AND MODEL
Starter Motor Housing	Ford, Lincoln, Mercury, Chrysler, Dodge, Plymouth, Pontiac - Some Models
Ignition Module	All Manufacturers - Some Models
Power Steering Pump Housing	Ford - Some Models, Mercury - Some Models
Water Pump Housing Body	GMC - Some Models, Ford - Some Models, Mercury - Some Models, Dodge Omni, Plymouth Horizon
Transmission Housing (Automatic)	All Manufacturers - All Models
Transmission Components	All Manufacturers - Most Models
Fan Blades, Sheet	Buick - Some Models, Cadillac - Some Models, Chevrolet - Some Models, Pontiac - Some Models, Ford - Some Models, Lincoln - Some Models, Mercury - Some Models
Air Conditioning (Also, Evaporators - #8 or #12 Brazing Sheet; Condensor Coils - Finned Tube; Also various Accessories such as Line Tubing, Muffler (Sheet), Suction Control Valve, Skived Fin Condensor, Compression Piston)	Many Manufacturers
Air Conditioning Compressor Housing	All Manufacturers - All Models
Miscellaneous Engine Components (Fan Spacer, Alternator Housing, Oil Pump, Fuel Injectors, Front Wiring Harness, Engine Temperature Sensors, Air Pump Housing, Pistons, Timing Chain Covers)	Many Manufacturers

Source: Compiled by The Aluminum Association, 818 Connecticut Avenue, NW, Washington, DC 20006.

TABLE 4-8. ALUMINUM PARTS ON 1980 CARS (CONT.)

PART	MAKE AND MODEL
Miscellaneous Fasteners - Screw Machine/Upset Parts (Drive Pinion Gear for Power Door Lock, Seat Belt Actuator Pins, Distributor Cap Insert, Windshield Wiper Bolt, Ignition Coil Insert; Headlamp Adjusting Screws, Various Brake Valve Parts, Ashtray Rivets, Stator Rivets)	Many Manufacturers
Intake Manifold, Cast	Buick - Some Models, Cadillac - Some Models, Chevrolet - Some Models, Oldsmobile - Some Models, Pontiac - Some Models, Ford - Most Models, Lincoln - Most Models, Mercury - Most Models, Chrysler - Most Models, Dodge - Most Models, Plymouth - Most Models, AMC - Some Models, Volkswagen Rabbit

Source: Compiled by the Aluminum Association, 818 Connecticut Avenue, NW, Washington, DC 20006.

TABLE 4-9. 1981 ESCORT/LYNX ALUMINUM USAGE

WROUGHT ITEMS		
Aluminum bumpers front and rear	24.0	
Aluminum air cleaners	2.0	
Aluminum rear engine cover plate	.37	
Aluminum "A" roof pillar	.5	
Heat shields	3.0	
Standard air conditioning components	12.5	
Aluminum extruded brake proportioning valve	.5	
Various trim	8.6	
Seat belt restrainer bracket	0.5	
Alternator bracket (Hi mount A/C only)	1.0	
Engine mount brackets	5.0	
	58.0	
CAST ITEMS		
ENGINE COMPONENTS		
Cylinder head	24.1	
Intake manifold	4.9	
Oil pump body	1.6	
Water pump housing	0.9	
Rear crank seal retainer	0.5	
Water Outlet	1.0	
Distributor housing	0.7	
Pistons	3.3	
Ignition module	1.0	
Air pump bracket (Hi mount A/C only)	0.6	
Air pump housing (Hi Mount A/C only)	1.0	
A/C bracket	3.5	
	43.1	
MISCELLANEOUS		
Master brake housing and rack & pinion steering gear housing	11.3	
Air conditioner compressor housing/head/piston	6.7	
Aluminum wheels	57.6	
AUTOMATIC TRANSMISSION COMPONENTS		
Transmission case	31.40	
Intermediate band servo cover	1.29	
Upper valve control body	4.00	
Converter assembly	1.00	
Valve throttle	.24	
Reverse clutch piston	.72	
Forward clutch piston	.40	
Direct clutch piston	.38	
	39.43	
MANUAL TRANSMISSION COMPONENTS		
Transaxle clutch case	15.1	
Transaxle trans case	8.2	
Speedometer drive retainer	0.2	
	23.5	
Total Aluminum Components (with A/C) Manual transmission		142.55 lbs.
(with A/C) Auto transmission		158.6 lbs.
(with A/C) Auto transmission and optional wheels		216.2 lbs.

Source: Automotive and Truck Committee, The Aluminum Association, Inc

Ford has traditionally been the largest user of cast aluminum applications, and this trend has continued on the Escort/Lynx. Many of the applications are under 1 lb each but combined add up to a sizeable amount of aluminum used in castings applications. As stated before, castings appear to be one of the most cost-effective uses of aluminum and this application is also not subject to further substitutions by reinforced plastics as many wrought applications are.

Aluminum components usually carry a cost penalty over the steel or iron parts they replace. The aluminum industry realizes this is one of the barriers to the use of aluminum in vehicles. They counter this deterrent to using aluminum by arguing that the consumer will actually benefit because the added cost of the aluminum will more than be offset by the savings in reduced fuel consumption over the life of the vehicle. The concept of lifetime energy consumption compares energy use in production of a specific component plus fuel required to transport the part in a vehicle over the life of the vehicle for alternative materials. The aluminum industry claims that aluminum has a lower lifetime energy consumption in relation to other materials.

The steel and plastic industries have also issued their own reports on lifetime energy consumption that reach different conclusions than those of the aluminum industry. The concept of lifetime energy consumption is relatively new and does not yet appear to be widely accepted. It does seem to have some merit and is likely to be given more consideration in the future.

4.4 TECHNOLOGICAL TRENDS

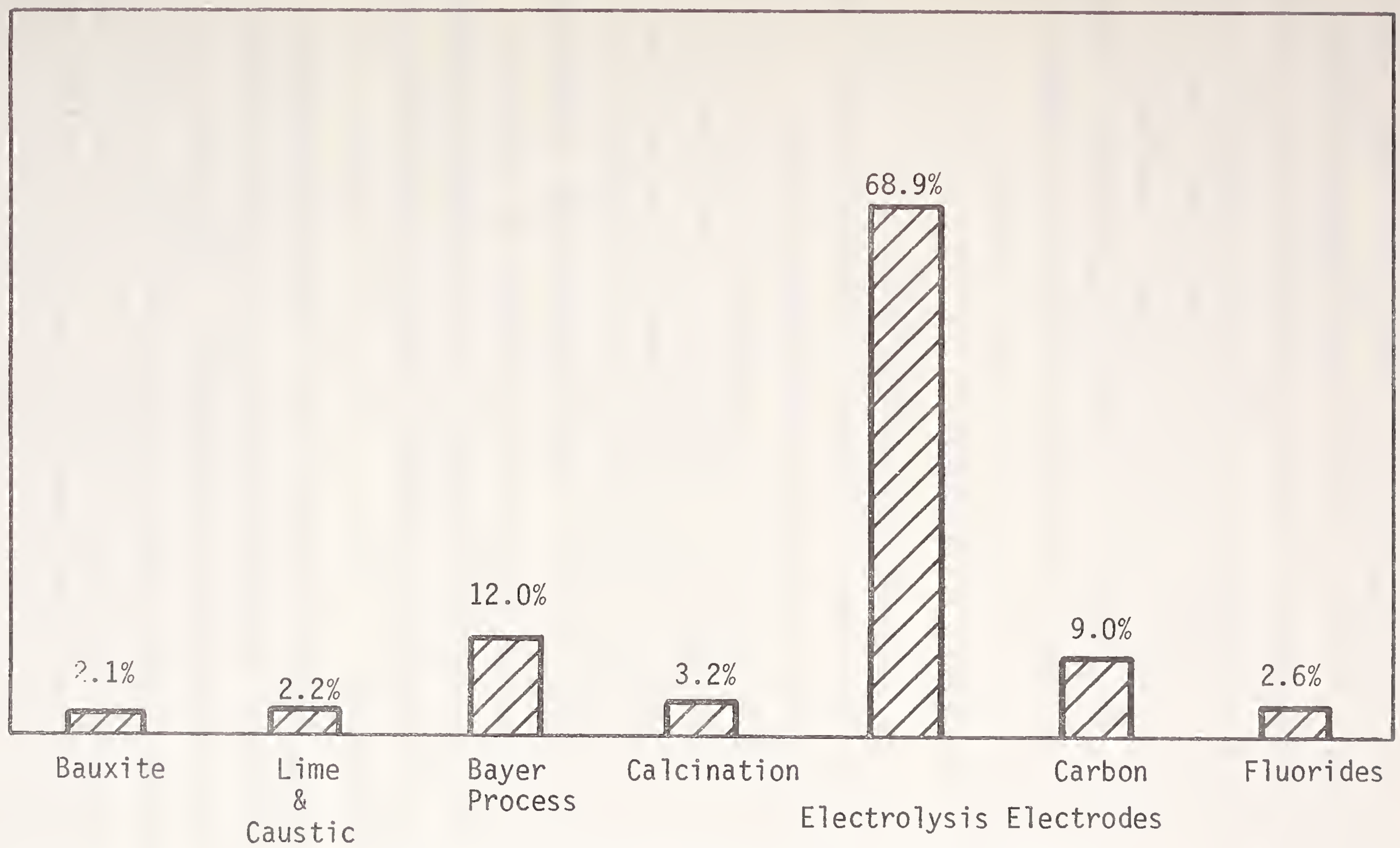
The energy cost in producing primary aluminum constitutes a major factor in the selling price of the metal. If the energy content could be substantially reduced, prices could be adjusted to make aluminum more competitive with other materials. For this reason both industry and Government have a major research effort underway to explore ways to reduce the amount of energy required to make aluminum.

The percentage of energy consumed at each step of the production process is shown in Figure 4-4. The electrolysis step where aluminum is smelted down to primary metal is by far the largest energy consumption step in the process, requiring an average of 7.5 kwh/lb. The energy in this step is consumed in the form of electricity. The theoretical minimum for producing a pound of aluminum is 2.89 kwh/lb but rarely are theoretical limits ever reached even in a laboratory.

A recently developed modification to the aluminum smelting pots has allowed electrical consumption to be decreased by about 15 percent. It acts by lowering the distance between the anode and the cathode in the smelting pots and it is easily adaptable to current smelters in operation. Additional reductions in electricity consumption cannot be achieved in existing plants.

The average age of the aluminum smelters in the United States is 20.5 years. They were built when energy costs were not as significant a factor as they are today. In Western Europe the average age of the smelters is only 13.5 years. Because European energy costs have historically been higher, the Europeans chose to increase their capital investments per plant in order to increase the energy efficiency. The European average is about 6.6 kwh per pound.

The newest and most modern plant in the world is the Mt. Holly SC plant owned by Alumax. It has an energy consumption rate of 6.2 kwh per pound and uses the latest technology for energy saving. The plant is conventional in that it still uses the



(Total Energy Consumption = 244×10^6 BTU/Ton)

S.K. Das <u>Extractive Metallurgy of Aluminum: The Past - The Present - The Future</u> Report No. 6-79-54 Aluminum Company of America.

FIGURE 4-4. THE PERCENTAGE OF ENERGY CONSUMPTION BY VARIOUS STEPS IN THE ALUMINUM PRODUCTION

Hall-Héroult smelting process that has dominated the industry for over 90 years. Further major reductions in energy consumption may have to come through the development of a new smelting process.

One new process presently undergoing testing has been named the ALCOA Smelting Process. This process uses aluminum chloride instead of aluminum oxide which is used in the Hall-Héroult process. The ALCOA Smelting Process requires only 4.5 kwh to produce a pound of aluminum. ALCOA presently has a 30,000 ton per year test facility operating in Palestine TX to test the economic feasibility of this process. Apparently ALCOA has not reached a decision on this process since it has announced plans to expand its domestic aluminum making capacity as well as build a new smelter in Australia using the Hall-Héroult process.

Another more radical method of producing aluminum is also being investigated by ALCOA. In this process aluminum ores, clay, and coke are used to produce aluminum-silicon alloys by a carbothermic reaction much as iron ores are reduced to pig iron in a blast furnace. The significant advantage of this process is that the energy required to make alloys comes from coke and not electricity. The aluminum-silicon alloys are adequate for many types of castings, particularly those used by the automotive industry, but the metal would have to be purified in order to make mill products which are the mainstay of the aluminum industry. Research efforts are also being conducted to purify aluminum-silicon alloys economically.

ALCOA and the Department of Energy are jointly funding research on the carbothermic reduction process. The process apparently works in small laboratory situations. The next step would be to construct a large scale prototype facility possibly by modifying an obsolete iron blast furnace. This step will cost many millions of dollars and the chance of success is still considered risky. Industry sources indicate that this process is still 10 to 15 years away from a determination on economic feasibility.

Technological improvements are usually incremental changes to existing manufacturing processes. Seldom are they significant enough to render all previous production methods obsolete. Although the best available technology can produce aluminum at a slightly lower energy input than the current average, the difference is not significant enough to warrant the estimated $16 billion the industry says would be needed to replace the older smelters. However, the carbothermic reaction process, which is still in the early stages of development and represents a radical departure from the existing Hall-Héroult process, could have a major impact on the structure and performance of the aluminum industry.

4.5 WORLDWIDE INDUSTRY STRUCTURAL CHANGES AND POTENTIAL IMPACTS ON THE U.S. INDUSTRY

In the early 1900s the world capacity for aluminum production was highly concentrated in only a few companies. ALCOA and its wholly owned Canadian subsidiary, Northern Aluminum Co., were the only producers of aluminum in the western hemisphere. Together with a few European producers, these companies formed a cartel to restrict price competition and to prevent intrusions into markets dominated by other cartel members.

A series of antitrust actions forced ALCOA to divest itself from Northern Aluminum Co. and required the controlling stockholders to choose between the two companies. Northern Aluminum Co. later changed its name to ALCAN.

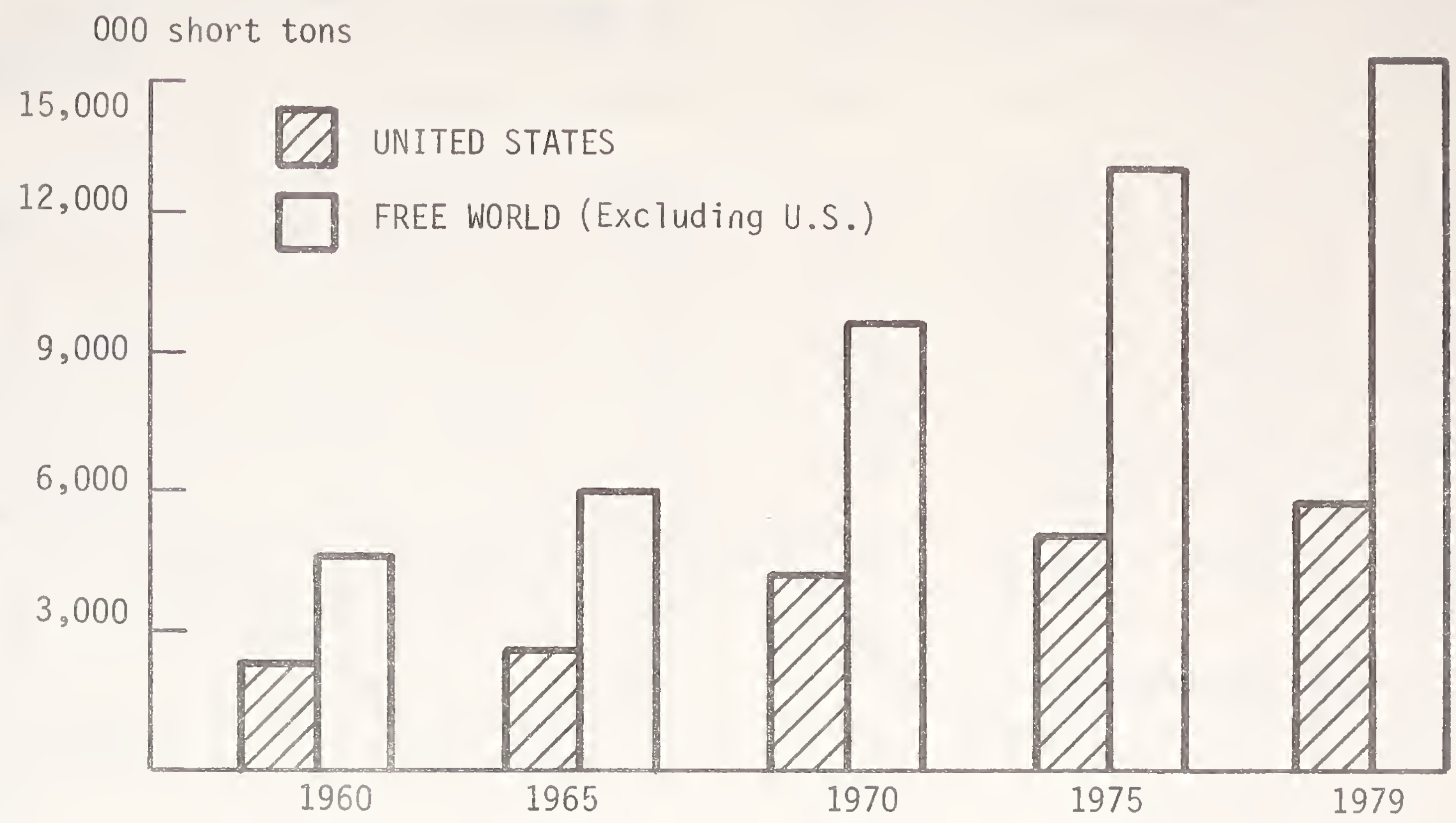
During World War II and again during the Korean War, defense requirements for aluminum necessitated that the Government either build its own aluminum smelters (which were sold at the end of the war) or offer Government loans to encourage private industry to build smelters. This is how Reynolds, Kaiser, Anaconda, Harvery (Martin Marietta), Ormet (Revere and Conaleo) were able to enter the aluminum industry. During the 1960s and early 1970s the remaining producers opened production plants in the U.S., sometimes with the technical assistance and as subsidiaries of the major European producers.

As the United States was expanding its capacity, so too was the rest of the world. From 1960 to 1979 the world's primary aluminum capacity increased 235 percent, an annual average growth rate of 6.6 percent. During the same period U.S. capacity increased by 113.9 percent or at an annual growth rate of 4.1 percent. Figure 4-5 shows the relative changes in U.S. capacity in comparison to world capacity.

This growth rate has tended to keep the demand and supply relationships nearly in balance although, except for 1970 and 1980, the U.S. has been a net importer of primary metal during the last 10 years. In 1980 a relatively weaker demand for aluminum in the U.S. and a stronger demand in Europe and Japan caused the import/export relationship to change. This is expected to again reverse itself when demand in the U.S. begins to firm up.

Future aluminum demand in the U.S. is expected to outpace primary metal production and secondary metal recovery. This will level to a higher dependence on imported aluminum. Traditionally imported aluminum has made up only a small component of the total aluminum supply as seen in Figure 4-6. The current forecasts now predict that imports of metal will become more important as construction of primary smelters in the U.S. lags behind expected demand. Table 4-10 shows a forecast of domestic metal consumption through 1985. What is important in this forecast is the trend. Actual metal demand in individual years may not match the forecast, but the trend in imported metal to meet domestic demand clearly shows an increase.

The primary reason given for not increasing domestic smelting capacity in line with demand is the unavailability of suitable location sites for a smelter. To be economically feasible, an aluminum smelter needs assurances that it will have access to a long term electrical power supply at moderate prices. The power needs of a typical 200,000 ton per year smelter are equivalent to that consumed by a city of 90 to 100,000 in population. Many electrical power companies cannot guarantee long-term price or availability of power and are unwilling to take on such a large customer.



Source: *Energy and the Aluminum Industry*, The Aluminum Association, Inc., 818 Connecticut Ave., N.W., Washington, DC 20006, April 1980, p. 6.

FIGURE 4-5. DISTRIBUTION OF WORLD PRIMARY ALUMINUM CAPACITY

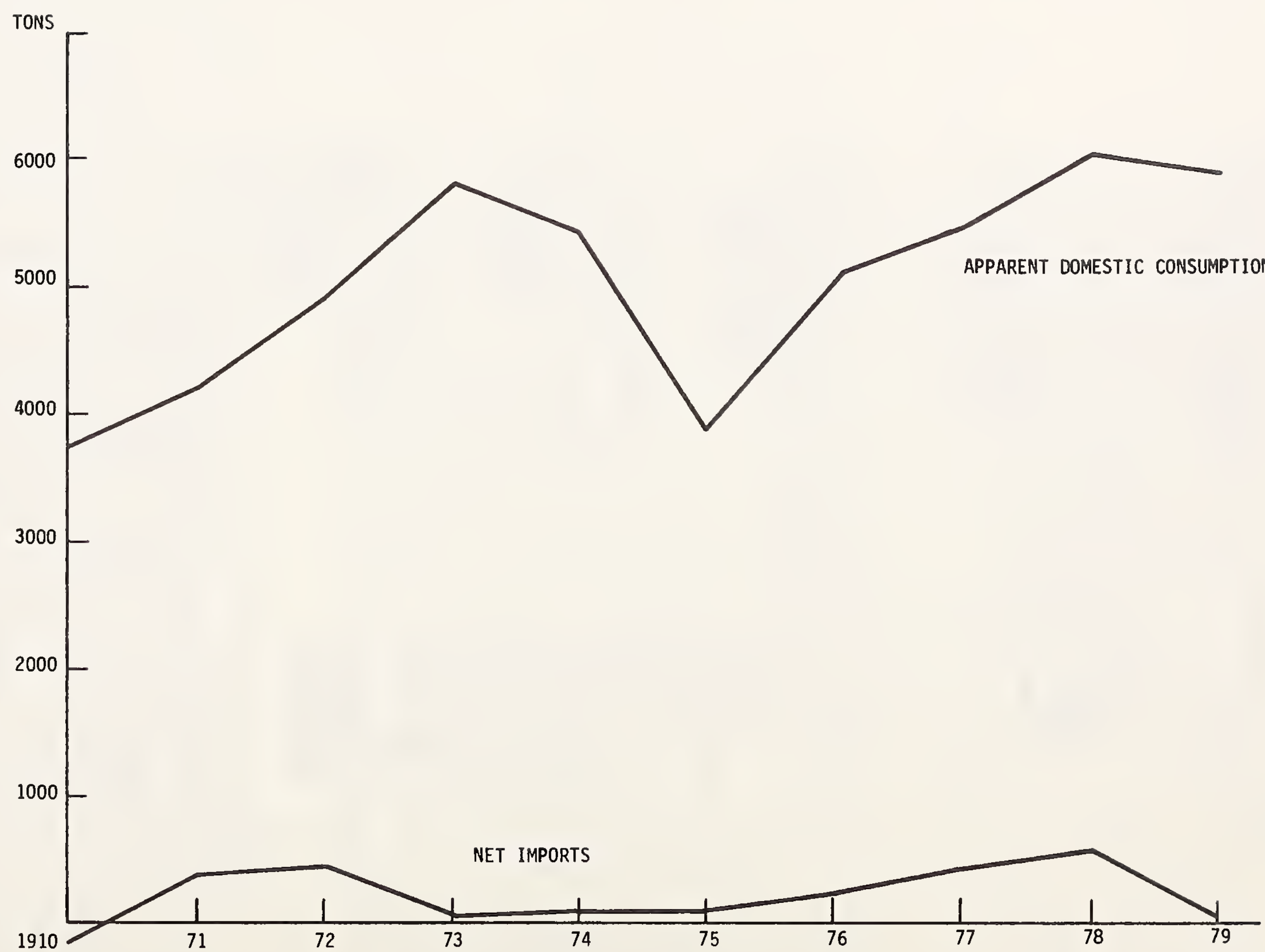


FIGURE 4-6. NET IMPORTS IN COMPARISON TO DOMESTIC CONSUMPTION (THOUSANDS OF SHORT TONS)

TABLE 4-10. DOMESTIC ALUMINUM INDUSTRY SUPPLY/DEMAND OUTLOOK
(Millions of Pounds)

	Act.			Forecast			
	1979	1980	1981	1982	1983	1984	1985
U.S. Economy							
(% Change - Real GNP)	2.3%	(1.2%)	0.4%	4.4%	4.4%	1.4%	1.6%
Total Aluminum Shipments...........	14,600	13,700	14,600	15,500	16,500	16,100	16,700
(% Change in Shipments)............	1.5%	(6.3%)	6.6%	5.7%	6.8%	(2.5%)	3.5%
Aluminum Demand....................	12,600	11,500	12,300	13,400	14,000	14,300	14,700
Aluminum Supply							
Primary Production...............	10,000	10,000	10,500	10,900	11,000	11,100	11,100
Primary Capacity.................	10,600	10,900	11,200	11,400	11,600	11,700	11,700
Operating Rate*	95%	92%	94%	95%	95%	95%	95%
Old Scrap and Alloys Added.........	1,900	1,900	2,000	2,100	2,100	2,100	2,200
Imports Less Exports...............	100	(900)	(100)	800	1,200	1,300	1,300
Inventory Charges..................	600	500	(100)	(600)	(500)	(200)	--
Shortfall..........................	-	-	-	200	600	-	100
Total Supply	12,600	11,500	12,300	13,400	14,400	14,300	14,700

*Based on unrounded values

Source: Aluminum Co. of America, reported in American Metal Market, Nov. 12, 1980, p.8.

The Alumax smelter in North Carolina may have been the last new primary aluminum smelter to be built in the U.S. Alumax had also planned to build a new smelter in Oregon. This was held up pending a resolution of how electrical power was to be shared between industrial and municipal users in the Pacific Northwest area serviced by the Bonneville Power Administration (BPA). Because of low water reserves in the area during the last few years, hydroelectric power had to be reduced. This required the purchasing of more expensive thermal and nuclear power to service the demand. The municipal users sued the BPA, stating that they had first claim to the hydroelectric power and that the industrial users would have to switch to other sources. Switching to more expensive sources would have made some of the aluminum smelters uneconomical to operate. Possibly 25 percent of the aluminum smelting capacity in the area may have had to shut down if they were forced to switch.

Congress resolved the issue by passing the Northwest Power Act at the end of the Ninety-Sixth Congress. Under the act the aluminum companies are to give up their old contracts for low cost power. In return they are to get new 20-year contracts at twice the cost (it will still be significantly lower than anywhere else in the country) and also better assurances of continuous power, although it could still be curtailed during low water conditions as it has in the past. Alumax will be allowed to build its smelter if the BPA builds sufficient generating power to service the smelter and other users. The BPA is presently facing a power generating deficit during the early 1980s. Alumax does not know if they will ever be able to build the smelter. Alumax is also facing another challenge from the Oregon legislature. Presently there is a bill in the legislature to prohibit the building of any more aluminum smelters in the state.

Two other aluminum smelters have also been proposed for construction in the U.S. Coastal & Offshore Plant Systems Inc. has plans to build primary aluminum smelters in South Carolina and North Carolina. Coastal is a new entrant to the aluminum industry and little is known of its capabilities. It presently has permits to construct the South Carolina plant but it is believed there are still some issues to be resolved such as power availability and cost as well as financing that may scuttle the project. If construction were started now, aluminum production could start by mid-1983. The North Carolina plant is in an earlier stage of planning and no start-up date has been announced. Until construction actually begins, these plants should be considered speculative. For example, the Eastalco plant in Maryland, partly owned by Alumax, proceeded two months into an expansion of its capacity before it was notified by the local power company that it could not guarantee power if the plant expanded. Financial and environmental consideration had delayed the power company's ability to expand. Expansion plans for the Eastalco plant are now considered inactive. A similar situation could face Coastal.

Power availability and cost affect not only new plant construction but also existing plants. In the Pacific Northwest, which holds approximately one-third of the domestic aluminum smelting capacity, electrical power can be rationed during periods of low water supply. Aluminum smelters must partially or fully terminate operations because low stream flow reduces the amount of hydroelectric power that BPA can generate. During these conditions residential and municipal customers have first claim on available power and direct service industries, such as the aluminum industry, get any remaining power. Fortunately power reduction to the aluminum industry has not coincided with peak aluminum demand in the recent past. The remaining operating smelters have been able to supply most of the U.S. demand without resorting to substantial increases in imports. This may not always be the case. The projected imports of 1.3 billion pounds of aluminum in 1984 and 1985 could be substantially understated if there were a prolonged drought in the Pacific Northwest.

Existing plants can also be affected by electrical cost. The most sensitive plants in the country appear to be Reynolds Metal Company's Corpus Christi TX plant and ALCOA Point Comfort TX plant. Both plants rely on thermal electric power produced from natural gas. When the plants were first constructed, intrastate gas was considered cheap. Now that it is unregulated, it is substantially more expensive than other forms of energy such as coal and hydropower. These two plants are usually the first to reduce production during a slowdown in aluminum demand and the last to be restored to full production when demand picks up. If aluminum plants ever close because of the high cost of electrical power, these two plants will probably be affected first.

Since the possibility of constructing new smelters in the U.S. appears to be limited, the aluminum companies are looking to other countries that have adequate supplies of low cost electrical power or have the potential of developing it. In Canada there are plans to build at least three new smelters as well as plans to expand existing plants. Canada still has a large potential for developing hydroelectric power. British Columbia alone has the potential of supporting an aluminum smelting base as large as that in the Pacific Northwest of the U.S. Environmental restraints could delay or prohibit the full development of the hydroelectric power in the region. As Canada is already self-sufficient in aluminum production and exports more than half of it, it is reasonable that most of the new capacity will be available for export also. Canada presently supplies half of the U.S. imports of aluminum, and it is also reasonable to assume this trend will continue or even increase in the future. The three new smelters would be able to supply almost all of the projected U.S. requirements for imports in 1985.

Australia is another country that is destined to become a major aluminum-producing nation. At least six new smelters have been planned or are presently under construction in the country. Australia has the unique combination of political stability, vast reserves of bauxite, and relatively inexpensive energy in the form of coal. The coal is close to the surface and can be easily strip mined. Power generating facilities are then built adjacent to the mine to power the aluminum smelters.

Another country with large reserves of bauxite and low cost power is Brazil. Brazil has a large potential of developing its river systems to produce low cost hydroelectric power. Presently there are four firms investigating the possibility of locating smelters in that country.

In addition to Canada, Australia, and Brazil, there are at least 14 Third World nations presently considering the construction of aluminum smelters. Many analysts feel that there could be a world supply shortage of aluminum during the early 1980s, but that this could rapidly turn into an oversupply situation if all the smelters presently under consideration were built.

4.6 GOVERNMENT/INDUSTRY RELATIONSHIPS

A number of Federal, state, and municipal government agencies appear to have a closer working relationship with the aluminum industry than with other industrial sectors of the economy. The aluminum industry has spent a considerable amount of effort in fostering goodwill with Federal, state, and local government agencies. In an effort to understand the objectives of these agencies, the aluminum industry works at reaching acceptable compromises that will benefit industry and government.

The aluminum industry also has an advantage in that it has not had to face many of the problems that have plagued other industries. This has lessened the number of potential conflicts between industry and government. For example, pollution problems in the aluminum industry are relatively less than in other heavy industries. The industry has had to spend substantial sums on pollution abatement equipment but not to the extent of other industries. The additional costs of the equipment and its operation has not driven up total operating expenses of aluminum plants to a point where they have become uneconomical and had to close. When this occurs in other industrial sectors, plant closings and layoffs are likely and tensions between industry and government run high.

Unlike the steel industry, the aluminum industry has not had to face heavy import competition. Consequently, the aluminum industry has not had to appeal for Federal relief funds, a practice which has provoked conflict within the Government and between it and industry. So far the aluminum industry has avoided being drawn into this form of conflict.

However, some conflict is inevitable, and the aluminum industry has come in conflict with local governments in the Pacific Northwest over the issue of sharing a limited electrical power supply. It appears that most of these issues have been resolved by the passage of the Pacific Northwest Electric Power Planning and Conservation Bill. The bill represents a good compromise among the various parties involved. The fact that a difficult situation could be resolved to the satisfaction of opposing special interest groups proves that the aluminum industry will try to resolve a conflict through negotiation and compromise rather than a more antagonistic course through the court systems.

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5. THE PLASTICS INDUSTRY

5.1 WORLD PRODUCTION AND INTERNATIONAL TRADE

In 1976 world production of plastics exceeded 37 million metric tons. Tables 5-1 through 5-5 give a statistical overview of the world production, trade, and usage of plastics. Plastics production is concentrated in the industrialized Western European nations, Japan, and the United States. The U.S. is by far the largest producer of plastics, accounting for a third of world production, but it ranks only fourth in per capita consumption. West Germany and Japan are the second and third largest producers, each producing at about half the U.S. level. In terms of exports, West Germany ranks first, and the Netherlands and the U.S. are a close second and third, respectively, with about half of West Germany's volume. This has led to a large, net positive balance of payments with foreign countries for the U.S. and has helped to offset the negative balance of payments in petroleum products, cars, and steel.

For the past 5 years, the U.S. share of the world export plastics market has remained fairly steady. However, it has declined since 1966, when the U.S. accounted for nearly a quarter of world exports. While the U.S. market share has declined, the volume of exports has increased.

TABLE 5-1. PER CAPITA CONSUMPTION OF PLASTICS
(Kg per person)

COUNTRY	1973 PER CAPITA	1973 RANK	1974 PER CAPITA	1974 RANK	1975 PER CAPITA	1975 RANK	1976 PER CAPITA	1976 RANK
	Kg		Kg		Kg		Kg	
Australia	35.5	11	35.3	11	32.5	12	33.8	12
Belgium	40.6	8	41.6	7	36.7	7	41.6	9
Canada	41.1	7	38.5	10	34.8	8	41.5	10
France	48.6	6	46.2	6	41.6	3	47.5	5
West Germany	81.1	1	76.6	2	67.1	2	90.0	1
Italy	39.9	9	40.8	8	32.6	11	43.4	7
Japan	50.9	5	55.0	4	36.8	6	41.7	8
Netherlands	37.3	10	39.9	9	34.4	10	40.0	11
Spain	27.7	13	29.7	13	23.6	13	30.2	13
Sweden	72.0	2	82.0	1	70.0	1	83.0	2
Switzerland	58.2	3	56.8	3	40.1	5	52.6	3
United Kingdom	33.4	12	35.0	12	34.7	9	44.5	6
United States	56.2	4	52.9	5	40.4	4	52.3	4

Source: International Plastics Resins Statistics: Selected Countries, 1973-1977, The Society of the Plastics Industry, Inc.

TABLE 5-2. PLASTICS PRODUCTION
(1,000 Metric Tons)

	1973		1974		1975		1976	
COUNTRY	QUANTITY	RANK	QUANTITY	RANK	QUANTITY	RANK	QUANTITY	RANK
Australia	339	12	403	12	436	11	381	12
Belgium	773	8	835	8	678	9	832	9
Canada	433	11	479	11	433	12	706	10
France	2,532	4	2,639	4	2,016	5	2,562	5
West Germany	6,414	2	6,249	3	4,730	3	6,023	2
Italy	2,508	5	2,600	5	2,100	4	2,650	4
Japan	6,392	3	6,801	2	5,254	2	5,803	3
Netherlands	1,315	7	1,683	7	1,376	7	1,705	7
Spain	728	9	830	9	723	8	959	8
Sweden	514	10	535	10	450	10	553	11
Switzerland	104	13	105	13	75	13	102	13
United Kingdom	2,457	6	2,108	6	1,806	6	2,228	6
United States	13,185	1	13,357	1	11,351	1	12,483	1

Source: International Plastics Resins Statistics: Selected Countries 1973-1977, The Society of the Plastics Industry, Inc.

TABLE 5-3. IMPORTS OF PLASTICS
($ million)

	1973		1974		1975		1976	
COUNTRY	VALUE	RANK	VALUE	RANK	VALUE	RANK	VALUE	RANK
Australia	124.0	12	176.0	13	173.0	12	244.1	11
Belgium	362.1	6	556.2	6	503.9	6	670.1	6
Canada	322.0	7	537.6	7	411.6	7	503.6	7
France	733.4	2	968.0	2	985.9	2	1,275.8	2
West Germany	975.0	1	1,272.0	1	1,253.0	1	1,667.3	1
Italy	498.6	4	724.4	4	582.0	3	856.1	3
Japan	233.9	9	323.9	11	150.5	13	225.5	13
Netherlands	420.7	5	607.5	5	525.8	5	700.7	5
Spain	186.0	11	305.7	12	190.5	11	234.3	12
Sweden	31.4	13	416.2	8	401.8	8	468.7	8
Switzerland	257.5	8	380.9	9	260.6	9	414.9	9
United Kingdom	502.4	3	845.0	3	581.4	4	830.4	4
United States	208.1	10	331.3	10	230.6	10	321.3	10

Source: International Plastics Resins Statistics: Selected Countries, 1973-1977, The Society of the Plastics Industry, Inc.

TABLE 5-4. EXPORTS OF PLASTICS
($ million)

	1973		1974		1975		1976	
COUNTRY	VALUE	RANK	VALUE	RANK	VALUE	RANK	VALUE	RANK
Australia	13.0	13	24.0	13	33.4	12	33.8	13
Belgium	592.4	6	914.2	7	832.2	6	1,086.0	6
Canada	53.5	11	57.7	11	54.5	11	70.6	11
France	672.2	4	987.3	6	877.4	5	1,170.1	4
West Germany	2,045.9	1	3,202.1	1	2,520.9	1	3,227.2	1
Italy	556.7	7	1,055.0	5	763.3	8	953.0	8
Japan	646.1	5	1,154.0	4	996.7	4	1,099.7	5
Netherlands	994.9	3	1,549.2	3	1,327.6	2	1,732.8	2
Spain	21.5	12	40.0	12	33.2	13	48.6	12
Sweden	252.7	9	264.1	9	245.7	9	300.2	9
Switzerland	125.5	10	178.5	10	162.3	10	269.2	10
United Kingdom	552.3	8	858.4	8	785.9	7	953.5	7
United States	1,027.9	2	1,617.6	2	1,173.4	3	1,672.3	3

Source: International Plastics Resins Statistics: Selected Countries, 1973-1977, The Society of the Plastics Industry, Inc.

TABLE 5-5. 1977 MAJOR MARKET CONSUMPTION (%) OF PLASTIC RESINS

MAJOR MARKET	AUSTRALIA	BELGIUM	CANADA	FRANCE	WEST GERMANY	ITALY	JAPAN	NETHERLANDS	SPAIN	SWEDEN	SWITZERLAND	UNITED KINGDOM	U.S.A.
Packaging	20	28	37	–	21	29	29	23	20	20	25	31	27
Building and construction	19	15[a]	19	–	25	10	7	29	9[a]	30	27	18	17
Electrical & electronics	15	32	5	–	14	10	11	3	16	12	12	8	9
Transportation	7	–	7	–	6	5	8	6	6	25	3	6	7
Housewares	6	18[b]	3	–	3[b]	5	10[c]	5	9	10	5	5	–
Furniture & furnishings	9	–	9	–	5	6	3	1	–	3	4	6	6
Agriculture	6	–	4	–	4	4	3	4	–	–	5	3	–
Consumer & institutional	–	7	–	–	–	–	–	–	26	–	–	–	10
Industrial	4	–	–	–	6	–	–	–	–	–	7	–	1
Adhesives, inks & coatings	–	–	–	–	–	15	17	–	–	–	–	–	6
Other	14	–	16	–	16	16	12	29	14	–	12	23	17

[a] Including furniture

[b] Including sporting goods, toys

[c] Including toys

Source: International Plastics Resins Statistics: Selected Countries, 1973-1977, The Society of the Plastics Industry, Inc.

5.2 THE STRUCTURE OF THE U.S. PLASTICS INDUSTRY

The U.S. plastics industry has the capacity to produce over 38 million pounds of various types of plastic resins. The industry, which consists of both resin manufacturers and plastic processors, employed (in 1977) more than 500,000 persons in more than 10,000 establishments. One-third of industry employment was located in California, Ohio, Illinois, and New Jersey. The portion of the industry which supplies the automotive market is more concentrated in the north central region due to the number of prime (automaker) plastic plants.

In order to identify that portion of the industry which supplies the automotive market, a study of the major plastic producers was conducted.* Figure 5-1 shows the location of the major domestic plastic producers' plants identified as automotive-related. Also included are 23 automaker facilities, shown in Figure 5-1 and in the accompanying list in Table 5-6. Further information on these plants is provided in Table 5-7, including location (city, state), number of employees, and type of plastics produced.

Due to the close link with the automakers, these areas are expected to show impacts of the auto industry market fluctuations. The current downturn in automotive production has not resulted in plant closings or sizeable layoffs from these major producers. The resilience of this supplier group is due to the small percentage of total sales devoted to the auto market, diversity of items produced at each plant, and general growth of demand for plastics. Between 1972 and 1977, value of products shipped increased over 100 percent and employment rose over 30 percent.

*The Booz-Allen and Hamilton Company study under contract to the Transportation Systems Center, U.S. Department of Transportation.

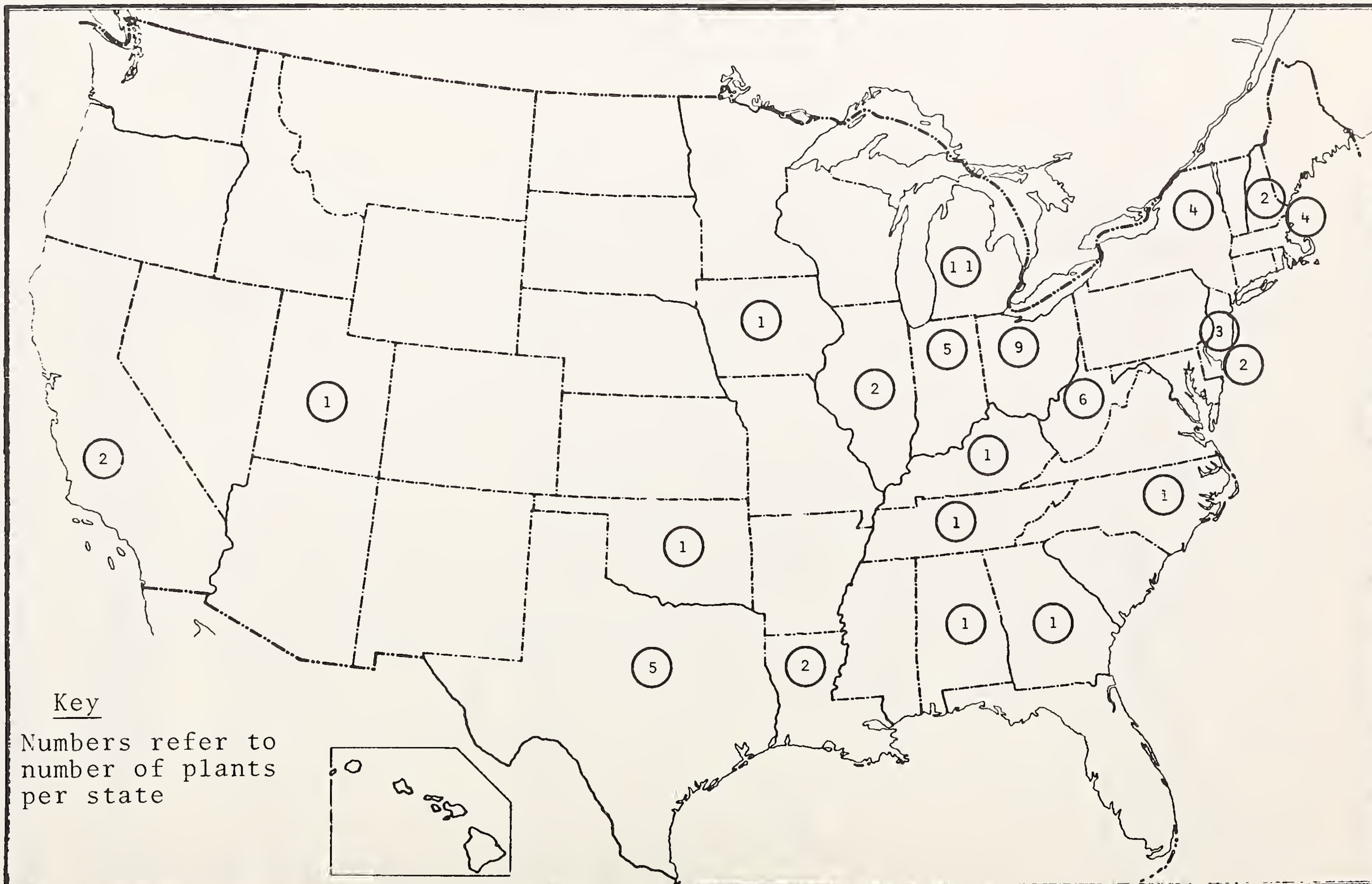


FIGURE 5-1. MAJOR DOMESTIC AUTO-RELATED PLASTIC PLANTS (INCLUDING CAPTIVE PLANTS)

TABLE 5-6. AUTO-RELATED PLASTICS PLANTS IN THE UNITED STATES (NUMBER OF PLANTS PER STATE)

Alabama	1	Michigan	11
California	2	New Hampshire	2
Delaware	2	New Jersey	3
Florida	1	New York	4
Georgia	1	North Carolina	1
Illinois	2	Ohio	9
Indiana	5	Oklahoma	1
Iowa	1	Tennessee	1
Kentucky	1	Texas	5
Louisiana	2	Utah	1
Massachusetts	4	West Virginia	6
Total 66			

Note: There are also three Canadian plants that supply plastics to the automotive market.

TABLE 5-7. MAJOR DOMESTIC AUTO-RELATED PLASTICS PLANTS

COMPANY	LOCATION	EMPLOYMENT	PRODUCTS
Monsanto	Addyston OH	950	Polystyrene, ABS, San, Phenolics, Styrene, Formaldehyde, and Foamed Polystyrene Board.
	Anaheim CA	600	Vydyne and Engineering Thermoplastics
	Muscatine IA	550	Lustran ABS, Lustran San
	Pensacola FL	4,150	Vydyne Nylon Thermoplastic
	Springfield MA	2,000	Lustran ABS, Lustran San, Polystyrene, Polyvinyl Butyl
	Trenton MI	900	Vydyne Nylon Thermoplastic
Borg-Warner	Washington WV	650	Cycolac ABS
	Ottawa IL	900	ABS
Mobay	New Martinsville WV	1,150	TDI, MDI, Merlon Polycarbonate
	Baytown TX	400	TDI, MDI
B.F. Goodrich	Long Beach CA	200-300	Polyvinyl Chloride Resin
	Henry IL	500	PVC
	Louisville KY	1,100-1,200	Synthetic Rubber Latex
	Pedricktown NJ	300	PVC
	Avon Lake OH	725	PVC, Polyurethane
	Plaquemine LA	120	PVC

TABLE 5-7. MAJOR DOMESTIC AUTO-RELATED PLASTICS PLANTS (CONT.)

COMPANY	LOCATION	EMPLOYMENT	PRODUCTS
Hercules	Pasadena TX	200	Propylene, Polypropylene
	Lake Charles LA	600	Propylene, Polypropylene, Copolymer and Upgraded Items
	Magna UT	2,000	Graphite Fiber
Amoco	New Castle DE	260	Polypropylene
	Alvin TX	900	Polypropylene
DuPont	Yerkes NY	975	Tedlor (for Woodgrain Trim)
	Fayetteville NC	1,100	Butacite
	Memphis TN	1,200	Lucite
	Newport DE	700	Lucite SAR
	Orange TX	2,500	Zytel (Nylon), Teflon, Butacite, Delrin, Minlon, Croton, Lucite, Rynite
General Electric	Mt. Vernon IN	1,000	Polycarbonate, Polybutylene
	Selkirk NY	400	Noryl
	Pittfield MA	250	Genal (Phenolic Molding Compound)
Davidson*	Dover NH	800	Armrests, Headrests, Exterior Side-Rails
	Farmington NH	1,200	Polyurethane Soft Bumpers, Padded Dashboard
	Americus GA	1,000	Polyurethane Soft Bumpers, Flexible Fascias
	Fort Hope ONT	350	Polyurethane Arm Rests, Flexible Fascias, Padded Instrument Panels

*These plants fabricate plastic automotive components with plastic resins supplied from other sources.

TABLE 5-7. MAJOR DOMESTIC AUTO-RELATED PLASTICS PLANTS (CONT.)

COMPANY	LOCATION	EMPLOYMENT	PRODUCTS
General Tire*	Ionia MI	1,500	Truck and Body Parts, Fascias, Front Body Parts, Fiberglass Reinforced Parts
	Marion IN	1,000	Fiberglass Reinforced Parts Exterior Body Panels
	Toledo OH	800	Vinyl Seat Covers, Door Panels, Carpet Bindings
	Lawrence MA	300	Vinyl Fabrics
	Reading MA	N.A.	Vinyl-Coated Fabrics
	Ada OK	250	EDPM, Fascia Front-End Parts, Polyurethane Front-End Parts
Union Carbide	S. Charleston WV	2,000	Urethane Intermediates
	Charleston WV	2,000	Urethane Intermediates
	Sisterville WV	600	Silicone for Urethane Foam
	Port Laxaca TX	1,400	Urethane Intermediates, Polyethylene
	Piscataway NJ	1,400	Phenolic Resins
	Marietta OH	125	Phenolics

*These plants fabricate plastic automotive components with plastic resins supplied from other sources.

TABLE 5-7. MAJOR DOMESTIC AUTO-RELATED PLASTICS PLANTS (CONT.)

CAPTIVES

COMPANY	LOCATION	EMPLOYMENT	PRODUCTS
Ford*	Saline MI	6,100	ABS, Polyvinyl Chloride for Grilles, Panels, Gauges, and Tails Lenses.
	Milan MI	3,600	Polyester, Polypropylene for Grilles, Fender Aprons, and extensions
	Mt. Clemens MI	2,300	Polyvinyl Chloride, Polyurethane for Seat Cushions and Backs, Vinyl Roofs
General Motors*	Delco Remy, Anderson IN	17,000	Acrylic Polypropylene for Molded Parts for use in Alternators, Generators and Starters
	Packard Elec., Warren OH	10,000	Polystyrene, Polypropylene for Wiring Harness Assemblies and Cables
	Saginaw S.G., Saginaw MI	8,700	Polystyrene, Polypolylene for Component Parts for Steering Systems
	Fisher Body, Elyria OH	2,500	Polystyrene, ABS for Trim Parts
	Guide Div., Anderson IN	6,500	Acrylic and Vinyl Molded Parts
	Chev. Div., Adrian MI	175	Polypropylene for Exterior Front End Parts
	Fisher Body, Flint MI	4,100	Polypropylene, Polyvinyl Chloride for Trim, Seat Belts and Headliners

*These plants fabricate plastic automotive components with plastic resins supplied from other sources.

Except for 1975, the industry has enjoyed 27 years of growth, averaging 11 percent annually. (See Table 5-8.) In the past the industry overbuilt capacity in a particular time frame. The overcapacity did not remain very long before demand caught up. This happened in 1975. The industry added a considerable amount of capacity in the early 1970s in anticipation of increasing sales. The recession of 1975 led to low plant utilization rates, stiff price competition, and low profit margins. But this situation lasted only a short time, and now the industry is in a position to consider expansion. This is in sharp contrast to slow growth industries like steel, where it has taken many years for demand to catch up with supply.

The major producers of plastics are companies involved in either the chemical industry or the petroleum industry. Because the production of polymers requires a large capital investment, the industry is relatively concentrated. Nearly 200 firms produce commercial resins, with the top four firms accounting for 27 percent of shipments. In contrast, there are roughly 7000 plastics processors, with the top four firms accounting for only 8 percent of shipments.

Today, there are approximately 40 different generic plastic resins available. However, four resins account for roughly 70 percent (by weight) of all resin sales. These resins are polyethylene, polypropylene, polystyrene, and polyvinyl chloride. (See Table 5-9.) No one company produces all types of plastic resins but there are usually at least several manufacturers for any one of the most common plastics. For example, B.F. Goodrich Co. is the largest producer of polyvinyl chloride but does not produce any ABS, while Borg-Warner Inc. is the largest producer of ABS and does not produce polyvinyl chloride. The plastic resin manufacturing industry might be considered as consisting of many sub-industries, each producing a different resin. Table 5-10 lists the major suppliers of five different plastic resins to the automotive industry.

TABLE 5-8. TOTAL U.S. PRODUCTION AND SALES AND CAPTIVE USE OF PLASTIC RESINS
(in millions of pounds)

YEAR	PRODUCTION (Excluding Polyurethane)	POLYURETHANE PRODUCTION[d]	PRODUCTION (Including Polyurethane)	SALES & CAPTIVE USE (Excluding Polyurethane)
[a]1953	2,752	---	2,752	2,306
1954	2,812	---	2,812	2,435
1955	3,750	1	3,751	3,160
1956	3,991	8	3,999	3,406
1957	4,385	17	4,402	3,740
1958	4,578	33	4,611	4,003
1959	5,925	67	5,992	5,097
1960	6,226	95	6,321	5,277
1961	6,780	150	6,930	5,905
1962	7,977	220	8,197	6,952
[b]1963	9,084	280	9,364	7,380
1964	10,230	295	10,525	8,581
1965	11,829	390	12,219	10,684
1966	13,719	480	14,199	11,294
1967	13,923	550	14,473	11,789
1968	16,581	650	17,231	14,811
1969	18,935	785	19,720	15,788
1970	19,226	830	20,056	16,747
[c]1971	20,201	960	21,161	18,949
1972	25,285	1,190	26,475	24,433
1973	27,783	1,430	29,213	27,432
1974	27,944	1,330	29,274	26,693
1975	21,588	1,240	22,828	21,162
1976	27,646	1,550	29,196	26,984
1977	32,098	1,850	33,948	31,106
1978	35,655	1,950	37,605	35,063

[a] U.S. Tariff Commission data used for 1953-1970. May exclude some captive use.
[b] Cellulosics not included through 1962. Included beginning in 1963.
[c] SPI data used for 1971-1978
[d] *Chemical Economics Handbook*, SRI International, Menlo Park, Cal.

Compound Growth Rate

	Total Production	Sales & Captive Use
1953-1978	11.0%	11.5%
1963-1978	9.7%	10.9%
1968-1978	8.1%	9.0%
1973-1978	5.2%	5.0%
1977-1978	10.8%	12.7%

Source: Facts & Figures of the Plastics Industry 1979 Ed. The Society of the Plastics Industry, Inc.

TABLE 5-9. DOMESTIC PLASTIC RESINS MERCHANT SALES
($ Millions and Lb Millions)

Resin	1978		1977	
	Net Dollar Value	Quantity	Net Dollar Value	Quantity
Low Density Polyethylene	$1,492	5,491	$1,434	5,164
Polyvinyl Chloride	1,195	4,725	1,052	4,223
Polystyrene	978	3,461	866	3,165
High Density Polyethylene	828	3,265	771	2,890
Polypropylene	612	2,235	569	2,016
Polyester	482	1,130	410	993
ABS	475	1,075	433	1,010
Phenolic	452	1,259	446	1,131
Other Styrenes	345	796	275	622
Nylon	275	238	245	217
Epoxy	251	285	201	243
Urea	187	1,086	157	935
Other Vinyls	113	109	107	112
Melamine	87	145	83	145
Polyvinyl Alcohol	74	115	71	111
SAN	41	99	38	95
All other (excluding polyvinyl acetate and polyurethane)	2,179	2,917	1,469	1,769
Total	$10,066	28,431	$8,627	24,841

Domestic merchant sales are quantities of sales excluding interplant transfers, captive consumption and exports.

Net dollar value represents the actual selling price after deductions for cash discounts, quantity discounts, returned goods and allowances, federal excise taxes, local taxes, and outgoing transportation (prepaid or otherwise) to warehouses or customers.

Source: Facts and Figures of the Plastics Industry 1979 Ed. The Society of the Plastics Industry, Inc.

TABLE 5-10. MAJOR SUPPLIERS OF AUTOMOTIVE PLASTIC RESINS

Plastic Resin	Suppliers
Polyurethane	Union Carbide Dow Chemical Mobay Olin Upjohn ARCO
Polyester	Reichhold W.R. Grace Ashland PPG Owens-Corning
Polypropylene	Hercules Amoco Shell Exxon
Polyvinyl Chloride	B.F. Goodrich Tenneco Diamond Shamrock Conoco
ABS	Borg-Warner Monsanto Dow Chemical USS Chemicals

The raw materials used in the manufacture of plastic resins are called intermediates or monomers and are derived from natural gas, natural gas liquids, crude oil, or petroleum products. The major intermediates are ethylene, benzene, and propylene. The production of plastic resins currently accounts for 1.5 percent of the total domestic demand for oil and natural gas.

In the basic process of making plastics, called polymerization, simple monomers are joined together in large chains called polymers. Modifiers, chemicals, and additives are introduced into the plastic such as pigments for coloring, plasticizers to increase flexibility, stabilizers to make the product more resistant to heat and light, or fiber reinforcements to make the material stronger. This process is called compounding. A variety of processing techniques is used to convert the resins into finished plastic products. These include compression molding, injection molding, extrusion, and filament winding, among others.

Because natural gas and petroleum were held at artificially low prices in comparison to world prices, the U.S. was able to become a dominant force in world plastics production. In addition, U.S. plants on the average have a larger capacity than those elsewhere in the world. This gives an economy of scale benefit to the domestic manufacturers. The domestic industry is also operating with some of the world's most modern and efficient plants, giving the U.S. another cost advantage. The recent rise in petroleum-based products to more closely reflect world prices has caused plastics prices to increase, but, at least for the next few years, the domestic industry should be able to remain competitive both domestically and internationally because of its other cost advantages.

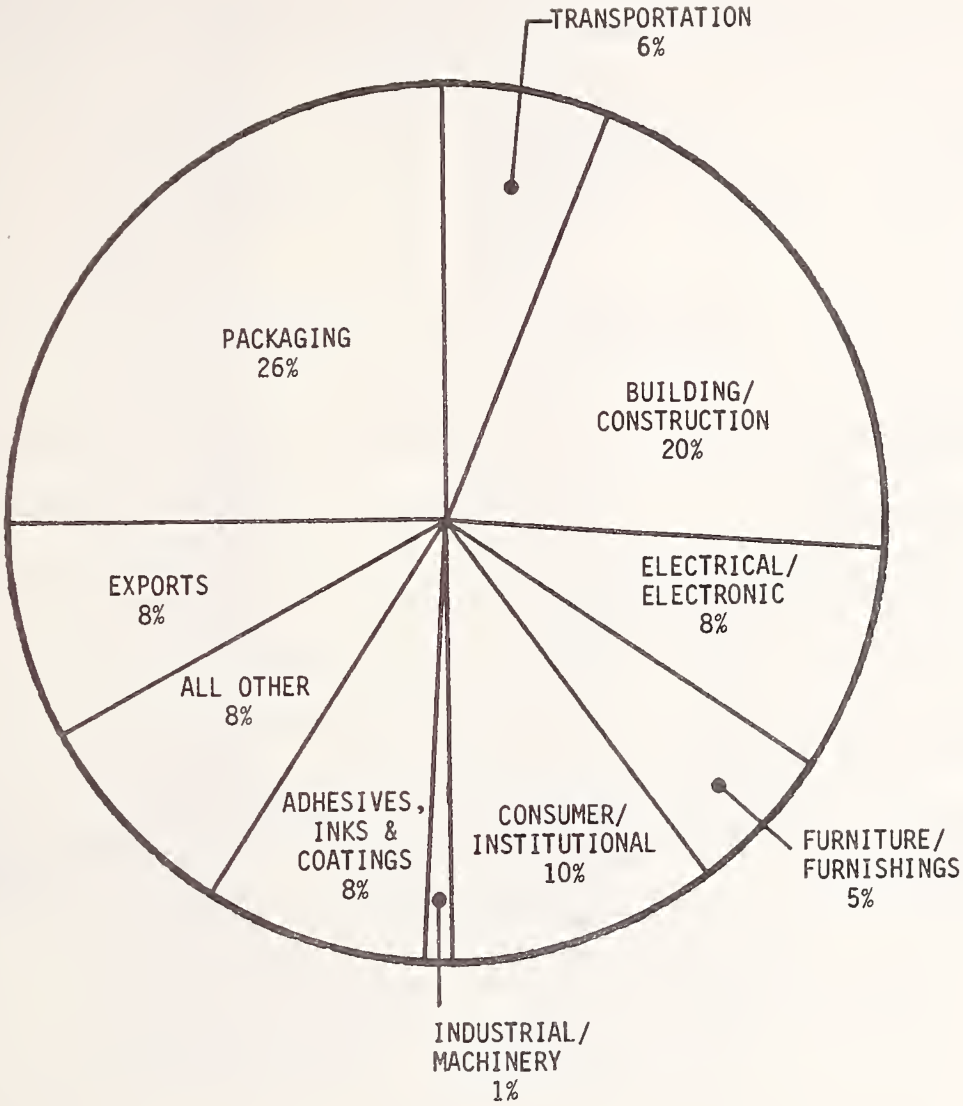
5.3 MARKET TRENDS

The plastics industry has ten major market segments for the consumption of plastics. The packaging industry and the building and construction industry together account for approximately 45 percent of plastics sales. The remaining eight markets individually account for 10 percent or less of plastics consumption. The pie chart in Figure 5-2 shows the distribution of sales to the major markets. This is a total of all plastics. Each type of plastic has its own separate market structure, and sales for each plastic type can differ radically from the average. For example, only 2 percent of ABS plastic goes to the packaging industry, 3 percent to exports, and 13 percent to the transportation industry.

The transportation market includes passenger cars, trucks, buses, rail cars, and aircraft. Approximately 90 percent of this market goes to the passenger car sector. The use of plastics in automobiles has grown from 20 pounds per vehicle in 1960 to 200 pounds in 1980. Plastics consumption in the passenger car sector b type of plastic is shown in Table 5-11. Some of the applications of plastics in automotive production are shown in Table 5-12.

Plastics were first introduced into the automotive market as materials for vehicle interiors because of their attractive appearance. Fire safety standards regulating occupant crash protection further expanded plastics usage within the passenger compartment. In recent years the need for weight savings, brought on by fuel economy goals, created the demand for increased plastics usage in interior functional parts. Under-the-hood applications represent the smallest use of plastics in a car. Higher temperature and chemical resistance requirements limit the application of plastics within the engine compartment.

In the next 5 years, increased use of plastic on auto interiors will be found primarily in seat frames and more extensive use of padding. New exterior applications will involve bumper systems and body parts such as hoods, trunk lids, doors, and fenders. New under-the-hood applications will involve the introduction of plastic structural members and some increase in plastic functional components. Table 5-13 contains a representative industry forecast for 1985 plastics usage in the typical automobile.



Source: Facts and Figures of the Plastics Industry, 1979 Ed. The Society of the Plastics Industry, Inc.

FIGURE 5-2. DISTRIBUTION OF 1978 SALES AND CAPTIVE USE BY MAJOR MARKET

TABLE 5-11. 1979 U.S. AUTOMOTIVE PLASTICS CONSUMPTION*

	Average Formulated Plastics Per Car (Lbs)*	Total Resin Usage (Lbs Millions)***
ABS	20	200
Acrylic	4	40
Cellulosic	1	10
Nylon	6	60
Phenolic	4	40
Polyethylene	11	110
Polypropylene	44	440
Polyurethane	46	460
Polyvinyl chloride	27	270
Unsaturated polyester	20	200
Other **	11	110
Total	194	1,940

* Excludes acrylic paints, elastomeric absorbers, seals, tires, sealants, and polyvinyl butyral glass interlayer.

** Includes acetal, polycarbonate, polyphenylene oxide, polysulfone, and thermoplastic polyesters.

***Based on 10 million unit production.

Source: Facts and Figures of the Plastics Industry, 1979 Ed. The Society of the Plastics Industry, Inc.

TABLE 5-12. MAJOR PLASTICS APPLICATIONS IN 1979 AUTOMOBILES*

Area	Application	Material	Pounds Per Car
Interior	Crash pad	Urethane, ABS, PVC	5
	Headrest pad	Urethane, PVC	4
	Trim, glove box	Polypropylene, PVC, ABS	18
	Seating foam	Urethane	24
	Seat belts	Nylon	3
	Upholstery	PVC, nylon, polyester	18
	Instrument panels	ABS SAN, urethane	8
	Headliners	Styrene, PVC	6
	Carpeting	Nylon	9
	Package shelf	ABS	3
Exterior	"Soft" bumpers	Urethane	20
	Fascia panels	Urethane	22
	Fascia retainers	G.R. polypropylene	7
	Fender liners	Polypropylene	12
	Front end panels	G.R polyester, G.R. polycarbonate	14
	Wheels covers	Polyphenylene oxide	8
	Fender extension	G.R. polyester, nylon	3
	Grille	ABS	4
	Lamp housing (rear)	Polypropylene, ABS	4
	Styled roof	PVC	6
	Bumper sight shield	EPDM-rubber, urethane	12
	Window louvers	Polybutylene terephthalate	2
Under-the-hood	Ducts	Polypropylene	4
	Battery case	Polypropylene	2
	Fan shroud	Polypropylene	3
	Heater and air cond.	Polyester, polypropylene	9
	Electrical housing & wrg.	Phenolic, PVC, silicone	11
	Electronic ignition comp.	Polybutylene terephthalate, phenolic	1
	Master brake reservoir	Nylon, HDPE	1
	Battery trays	G.R. polypropylene	1

*Other than soft interior components, many applications are not on every car; weights given are averages for fully formulated filled plastic parts and includes the weight of the resin, fillers, and reinforcements.

Source: Facts and Figures of the Plastics Industry 1979 Ed. The Society of the Plastics Industry, Inc.

TABLE 5-13. PROJECTED AUTOMOTIVE PLASTICS CONSUMPTION IN 1985

	Pounds Per Car	Total Resin Usage* (millions of pounds)
ABS	42	500
Acrylic	8	100
Nylon	17	200
Cellulosic	2	20
Phenolic	3	40
Polyethylene	14	170
Polypropylene	53	630
Polyurethane	48	580
Polyvinyl chloride	38	460
Unsaturated polyesters	50	600
Other **	25	300
Total	300	3,600

*Based on 12,000,000 automotive units built.
**Includes thermoplastic olefin elastomers, acetals, polypheneylene oxide, polycarbonate, thermoplastic polyesters, etc.

Source: <u>Facts and Figures of the Plastics Industry</u>, 1979 Ed. The Society of the Plastics Industry Inc.

The proliferation of product liability lawsuits in the past few years has made auto manufacturers reluctant to use plastic in structural parts. Before introducing plastic into parts which are critical to the safe operation of an automobile (e.g., wheels, springs, etc.), manufacturers must be assured of the structural integrity of these parts over the operational life of an automobile. Unpredicted failures can cause accidents with potentially catastrophic consequences. The purchaser of an automobile may also be reluctant to buy a car with plastic structural parts which could be perceived as safety risks.

Technological improvements are needed before many potential applications for plastic are cost-effective in automotive production. While plastics fabricators are working to decrease the cost of producing plastic parts, the steel and aluminum industries are doing the same.

5.4 TECHNOLOGICAL TRENDS

The domestic plastics industry, both those companies that produce plastic resins and also the manufacturers who convert the resins into finished products, is operating at or near the state-of-the-art, given consideration for normal plant replacement and modernization requirements. The industry is highly competitive and those companies that do not maintain technological competence will quickly become noncompetitive.

Technological changes in the plastics industry are shifting from the development of new resins to the improvement of existing ones. In the 1970s, only three new resin compositions were introduced commercially. The slowdown in the rate of introduction of new polymer compositions compared to past decades indicates that an adequate variety of basic resin compositions is now available to meet existing and potential market needs. The resin industry is focusing its technical efforts on modifying existing polymer materials to improve their properties for specific uses and to decrease the cost of both resin manufacture and fabrication into final products. In addition coal is being investigated as a possible feedstock source. For automotive applications improving manufacturing technology by reducing cycle time and improving the finish quality are some of the key areas of research. As mentioned in section 5.3, many automotive applications of plastics are waiting for technological improvements to make them competitive with existing metal usage in terms of quality, quantity, and cost.

Expanding the plastic resin capacity of the U.S. takes from $400 to $1000 or more per annual ton of capacity. The cost variation is dependent on the size of the plant to be constructed and the type of resin to be produced. In general the larger the plant constructed, the lower the capital cost per ton, as shown in Table 5-14. The table shows costs for several high volume plastic resins, and where market conditions exist there is a definite cost advantage of building plants with a 150 to 200,000 or more ton capacity. But economies of scale differ for each plastic type. For a small volume plastic where consumption may be only 50,000 tons per year, it would be impractical to add more than 5 to 10,000 tons capacity at any one time because of the long lead time before demand exceeds supply.

5.5 WORLDWIDE INDUSTRY STRUCTURAL CHANGES AND POTENTIAL IMPACTS ON U.S. INDUSTRY

The domestic plastics industry is a growth industry, well financed and very likely the most efficient in the world. It does not suffer from heavy import competition as does the steel industry, and it is not restricted to location because of a reliance on high volume, low cost electrical power as is the aluminum industry.

The plastics industry relies on petroleum-based feedstocks and currently is responsible for 1.5 percent of the nation's consumption of these scarce resources. As prices of these feed-

TABLE 5-14. CAPITAL INVESTMENT FOR VARIOUS POLYMER MANUFACTURING PLANTS

	Nominal Plant Capacity 10^3 Metric Tons/Yr	Capital Investment $/Annual Ton
Polyethylene, LD (from Ethylene)	60	760
	100	600
	150	500
Polyethylene, HD (from Ethylene)	40	1000
	80	700
	150	450
Polypropylene (from Propylene)	30	1100
	60	800
	100	600
Polystyrene (from Benzene & Ethylene)	60	970
	100	810
	200	610
PVC (from Ethylene & Chlorine)	40	750
	100	640
	200	360

Source: "Automotive Manufacturers' Cost/Revenue, Financial and Risk Analysis: Projected Impact of Automobile Manufacturing on the Plastics Industry" Report No. DOT-TSC-NHTSA-79-21.

stocks rose worldwide in recent years, U.S. price controls on oil and gas kept feedstock costs to U.S. companies below the costs paid by European and Japanese manufacturers, giving U.S. manufacturers a competitive advantage over their foreign counterparts. In the coming years, this feedstock cost advantage will disappear as U.S. prices are deregulated. In the meantime, this feedstock advantage could be as troublesome as it is beneficial. The European Economic Community (EEC) refers to U.S. oil price controls as an "unfair subsidy" and wants countervailing duties put on imported plastics and other chemicals.

The U.S. position in the world market is likely to weaken by the end of the decade. The loss of the feedstock cost advantage will erode the U.S. competitive position. In addition government-owned companies abroad are a potential source of competition. Pricing decisions by these nationalized companies are often driven by considerations other than profits. Also, Middle Eastern oil-producing companies have recently begun to integrate forward into the production of resins.

The U.S. plastics industry has reached the state of maturity where it is no longer considered a rapid growth industry. The phenomenal expansion which the industry experienced in the 1960s and 1970s will taper off in the 1980s amidst increasing competition in the world market.

The rate of growth of the chemical industry, of which plastics is a part, is projected to grow somewhat faster than the rate of growth of the Gross National Product. The increased use of plastics in automobiles will contribute to the continuing growth of the plastics industry. Uncertainty regarding the availability and price of petroleum and natural gas makes it difficult for the industry to make long-term plans. Price increases are not expected to fully offset added costs for raw materials and energy. Sales are expected to increase, however industry profits are not expected to rise at the same rate because of increasing maturity.

5.6 GOVERNMENT/INDUSTRY RELATIONSHIPS

Implementation of the Toxic Substances Control ACT (TSCA) will have a major impact on the future operations of the entire chemical industry. The Act provides for premanufacture notification, more extensive product testing and evaluation, disclosure of confidential technical and business information to Federal agencies, and labeling requirements. These regulations will significantly restrict the introduction of products with limited sales potential because of higher development costs. Smaller firms with limited resources might not be able to survive with the added burdens imposed by TSCA. The Act may also prove to be a deterrent to foreign manufacturers contemplating marketing in the U.S.

For several years the plastics industry has been subject to the Occupational Safety and Health Administration (OSHA) regulations concerning worker exposure to potentially carcinogenic substances. On occasion the industry has criticized the regulations as being arbitrary. A recent Supreme Court decision, applauded by the industry, will require OSHA to take a more balanced approach toward the relative costs and benefits of its worker safety regulations.

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6. THE TIRE INDUSTRY

6.1 WORLD PRODUCTION AND INTERNATIONAL TRADE

The U.S. tire industry is the major consumer of both natural and synthetic rubber in this country. In order to address world production and international trade in the tire industry, it is both necessary and useful to briefly examine some facts about these raw materials, and their effects on this industry.

6.1.1 Raw Materials

Over the years, the amount of natural rubber consumed by the tire and tire products market has remained at or near 77 percent of total natural rubber consumption, whereas the amount of total synthetic rubber consumed by the tire and tire products market has decreased by nearly 10 percent since 1977 (See Table 6-1). According to the Bureau of the Census, 62 percent of total synthetic rubber consumption had been used in tire and tire products in 1977. As can be seen from Table 6-1, the 1977 figure is closer to 52 percent.

Since production of synthetic rubber has remained relatively constant at about 2.5 million tons per year over the past few years,* and the amount of synthetic rubber consumed has decreased by nearly 9 percent since 1977, the trend indicates that the absolute amount of rubber consumed by the tire industry has decreased.

6.1.1.1 Synthetic Rubber -- Synthetic rubber is made from derivatives of petroleum and natural gas. Escalating costs of crude oil and the diversion of some petroleum feedstocks for energy use have resulted in rapidly increasing petrochemical prices and hence, synthetic rubber costs.**

*Current Statistics, Standard and Poor's Statistical Service, May 1979 and Oct 1980.

**U.S. Industrial Outlook 1980, U.S. Department of Commerce, January 1980, p. 160.

TABLE 6-1. RUBBER CONSUMPTION BY U.S. TIRE INDUSTRY 1977-1979

YEAR	RUBBER	TOTAL CONSUMPTION	TIRE INDUSTRY CONSUMPTION	PERCENTAGE OF CONSUMPTION BY TIRE INDUSTRY
1977	Natural	789,539	612,950	77.6%
	Synthetic	2,432,772	1,440,887	59.2*
1978	Natural	759,363	581,276	76.5
	Synthetic	2,453,008	1,355,898	55.3
1979	Natural	740,449	577,917	78.0
	Synthetic	2,501,086	1,324,272	52.9

*This figure was revised in the 1980 issue of the U.S. Industrial Outlook to 62 percent.

Source: Current Industrial Reports - Rubber, 1979 and 1978 issues, Bureau of the Census, U.S. Department of Commerce.

The high cost of synthetic rubber, coupled with the decline in domestic new car production and the growing market for radial tires, indicates a strong negative impact on the synthetic rubber industry.

U.S. foreign trade in synthetic rubber has been significant for many years. In the past few years, exports have represented 10 to 12 percent of U.S. production while imports approached 7 percent of U.S. consumption. In the international context, the U.S. share of world synthetic rubber production has been declining.*

A ten-year industry forecast for synthetic rubber consumption in the U.S. and Canada recently released by the International Institute of Synthetic Rubber Producers, Inc.,** predicts an increase in North American synthetic rubber consumption of more than 20 percent through this decade. This figure, however, does not include any change in the percentage of total synthetic rubber used by the tire segment of the rubber industry. If the projected reduction in the use of synthetic rubber in tires is factored in, the total consumption of this material will, in fact, constitute a decline of 1.5 percent between 1979 and 1990.

6.1.1.2 Natural Rubber -- Natural rubber is primarily imported into the U.S. from the major producing countries of Malaysia, Indonesia, and Thailand. Other producers include Brazil, Guatemala, and the Philippines. Domestically, the experimental plant, guayule, may offer an alternative to tree rubber. However, the financial viability and commercial processing capability of this development are under investigation, with a decade forecasted as the earliest possible time table for commercial production.

*U.S. Industrial Outlook 1980, U.S. Department of Commerce, January 1980, p. 160

**Headquarters in Houston TX

As previously mentioned, natural rubber is predominantly used for tires and tire products as is true of synthetic rubber. Unlike synthetic rubber, however, natural rubber is not affected by rising costs of crude oil. Consequently, world production of natural rubber is increasing in response to expected increases in demand into the 1990s. Presently, the return on investment in natural rubber plantation expansion is financially advantageous.

Four major U.S. tire companies, Goodyear, Firestone, Uniroyal, and Goodrich, grow their own rubber and have recently expanded acreage not only in the Far East, but also in Brazil, Guatemala, and the Philippines. Similarly, programs to aid producers or growers of natural rubber in increasing their future outputs have been initiated by both the Malaysian and the Brazilian governments.

6.1.2 World Production in the Tire Industry

The U.S. share of total world tire production is decreasing while imports to the U.S. are increasing. Worldwide, the U.S. still produces more than twice as many tires as any other country, accounting for more than one-third of world production. This share has slipped from about one-half in 1968.

By contrast, Japan's production has doubled since 1968 and during the last 6 years has steadily increased by 5 million tires per year. Its total production is now the second largest worldwide at about one-half the U.S. figure. Another example of rapid growth is provided by Brazil, which in the last 10 years has tripled its production and has become a significant world market contributor. The Western European countries on the other hand, although still accounting for a substantial world share, have not increased their production significantly since 1972.

Table 6-2 shows that more than 15 million passenger tires were imported in 1979, or about 8 percent* of the total number sold in the United States. Canada was the largest exporter of

*Current Statistics, Standard and Poor's Statistical Service, October 1980

TABLE 6-2. U.S. PASSENGER TIRE IMPORTS*
(In Thousands)

COUNTRY	1979	1978
Canada	3,645	3,145
France	3,037	2,674
West Germany	1,758	1,301
Italy	1,595	1,113
Spain	1,467	1,073
Japan	1,157	1,070
United Kingdom	696	479
Brazil	406	443
Ireland	297	363
Republic of South Korea	246	146
Israel	192	330
Yugoslavia	162	---
Mexico	126	210
Netherlands	---	172
Others	377	406
Total	15,161	12,925

*Excludes original equipment on imported cars.

Source: Bureau of the Census, U.S. Department of Commerce passenger car tires (more than 3.6 million units or 24 percent of the total), followed by France with over 3 million units or a 20 percent share of the total. French exports amount to only 6 percent of that country's total production. Germany, Italy, Spain, and Japan had between 8 and 12 percent each and all other countries less than 5 percent each. Total imports increased by 17 percent or 2.2 million tires from 1978 to 1979, while U.S. production fell by 5.5 percent or 11.7 million tires (Table 6-3). The major exporters shared about equally in the increase.

6.2 STRUCTURE OF THE DOMESTIC TIRE INDUSTRY

Dominating the domestic tire market are five U.S. tire companies and one French manufacturer. They are Goodyear, Firestone, Goodrich, Uniroyal, General Tire, and Michelin, respectively. Each of the five domestic tire companies have a substantial share of the market but are, to varying degrees, diversifying as the industry outlook for tire and related fabrications becomes less profitable. Michelin, a producer of radials years before U.S. tire companies, has a 5 percent share of the U.S. tire market.*

The introduction of the radial tire has had a significant effect on the tire industry structure and its profitability. The increased demand for radials coincided with the period of substantial reductions in car and tire sales to OEM and replacement markets. In addition, the combined effects of radials' significantly longer life, declining driving mileage, reduced speed limits and tire wear, and the strong trend to smaller size tires have all contributed to an unprecedented decrease in sales of the major and minor tire manufacturers. These difficulties have been further compounded by the high costs of plant conversions from bias-ply to radial production, a survival necessity at a time of capital scarcity, high interest rates, and negative cash flows.

Unlike the major manufacturers who did diversify into other areas within and outside the rubber industry, minor manufacturers

*"Modern Tire Dealer," January 1981

TABLE 6-3. WORLD TIRE PRODUCTION - MAJOR PRODUCING COUNTRIES
(Passenger Cars and Commercial Vehicles)
(In Thousands)

COUNTRY	1968	1970	1972	1974	1976	1978*	1979*
Brazil	6,237	7,847	10,246	15,321	14,466	20,460	21,387
Canada	16,204	19,109	20,882	N/A	N/A	N/A	N/A
France	29,300	39,415	45,055	45,405	43,995	46,416	47,772
West Germany	29,442	37,548	41,242	34,607	37,699	37,524	38,568
Italy	18,099	22,383	29,020	27,715	28,692	52,944	53,643
Japan	51,761	66,556	78,080	70,778	80,456	90,900	100,020
Spain	5,892	8,909	12,767	15,231	10,455	N/A	N/A
United Kingdom	29,384	30,545	30,337	27,499	29,870	N/A	N/A
U.S.	203,060	190,251	229,288	211,390	187,956	223,680	212,013
U.S.S.R.	20,894	22,351	25,980	32,117	37,394	58,800**	60,000**

*Annualized from monthly data.

**Estimate - including tires for off-the-road vehicles.

Source: U.N. Statistical Yearbook (1978 and Monthly Updates Through April 1980).

such as Armstrong Rubber, Cooper Tire, and Mohawk Rubber, do not have the potential to do this. As a result, they may either drop out of the tire business completely because of shrinking tire markets, costly idle capacity, and severe price competition, or, if they intend to remain in tire making, they may be inclined to become more specialized. Thus, manufacturers may eliminate passenger car tire production and focus on the specialty tire markets: truck tires, racing tires, aircraft tires, industrial tires, and specialized farm tires. Sales to private brand dealers, are also a viable specialty area. In the future the private brand tire dealer will have to purchase from several specialty producers to get a full line of tires, or find a major, full line tiremaker from which to buy.*

With tire manufacturers either cutting production, converting to radial production, entering into specialty markets, diversifying, or dropping out of the market completely, it is inevitable that various plants across the nation are either closing down or laying off workers resulting in significant employment level reductions (See Tables 6-4 and 6-5). While new radial tire plants, which have been built in the past 10 years, have created approximately 10,000 jobs, these hardly compensate for the 20,000 jobs lost through layoffs and plant closings over the same time period.** Since there exists a trend toward better quality and longer lasting radials and the demand for tires is expected to grow only 1 to 2 percent a year through the 1980s, it is safe to assume that the outlook for employment in the tire industry is far from promising.***

*"Rubber and Plastics News," Sept. 17, 1979, p. 9.

**Estimate provided by the United Rubber Workers Research Department (June 12, 1980), and lists jobs affected at date of plant closing. Several plants cut back in stages, so that jobs lost at closing underestimate total jobs lost.

***Firestone 10-K Statement 1978, p. 7.

TABLE 6-4. PASSENGER TIRE PRODUCTION PLANT EMPLOYMENT, 1970-1980

PASSENGER TIRE PLANTS		EMPLOYMENT LEVEL	1975	1976	1977	1978	1979	1980
Firestone:	Akron OH	1,762				Closed		
	Albany GA	1,387						
	Decatur IL	1,709						
	Des Moines IA	2,400						
	Los Angeles CA	1,022						Closed
	Memphis TN	2,774						
	Pottstown PA	2,400						Closed
	Salinas CA	1,152						Closed
	Wilson NC (Opened 1974)	1,200						
	Dayton OH	1,308						Closed
	Oklahoma City OK	1,200						
	Barberton OH	925						Closed
General:	Charlotte NC	720						
	Mayfield KY	1,486						
	Waco TX	1,311						
	Mt. Vernon IL (Opened 1974)	700						
Goodrich:	Akron OH	2,360		Closed				
	Ft. Wayne IN	1,567						
	Los Angeles CA	732	Closed					
	Miami OK	1,965						
	Oaks PA	1,310						
	Tuscaloosa AL	1,775						
Goodyear:	Akron OH	2,500						
	Gadsden AL	2,800				Closed*		
	Jackson MI	1,477						
	Lawton OK	400-1400					Opened	
	Los Angeles CA	1,050					Closed	

*Two phases 1975, 1978.

TABLE 6-4. PASSENGER TIRE PRODUCTION PLANT EMPLOYMENT, 1970-1980 (CONT.)

PASSENGER TIRE PLANTS		EMPLOYMENT LEVEL	1975	1976	1977	1978	1979	1980	1982
Goodyear: (Cont.)	Topeka KS	2,910							
	Union City TN	2,050							
	Cumberland MD	1,800							
	Freeport IL	1,137							
	Tyler TX	1,175							
	Fayetteville NC	2,300							
Michelin:	Greenville SC	2,000	Opened						
	Spartanburg SC	1,200				Opened			
	Dothan AL								
	Nova Scotia (3 Plants)						Opened		
	Lubbock TX								To Open
	Lexington SC								To Open
Uniroyal	Chicopee Falls MA	1,300						Closed	
	Detroit MI	1,600						Closed	
	Eau Claire WI	1,987							
	Los Angeles CA	500				Closed			
	Opelika AL	1,356							
	Ardmore OK (Opened 1970)	1,400							
Armstrong:	Des Moines IA	893							
	Hanford CA	554							
	Natchez MS	889							
	West Haven CT	700						Closed	
	Nashville TN*	570	1973 Acquired						
Lee:	Conshohoken PA	850						Closed	

*This plant was sold by Gates in 1973 when Gates left the tire manufacturing business.

TABLE 6-4. PASSENGER TIRE PRODUCTION PLANT EMPLOYMENT, 1970-1980 (CONT.)

PASSENGER TIRE PLANTS		EMPLOYMENT LEVEL	1973	1974	1975	1976	1977	1978	1979	1980
IRI:	Lousiville KY	300							Closed	
Mansfield:	Mansfield OH	750						Closed		
	Tupelo MS	700							Closed	
McCreary:	Baltimore MD	85			Closed					
Mohawk:	Akron, OH	300						Closed		
	West Helena AK	470							Closed	
	Salem VA	515								
Gates:	Denver CO	800	Closed							
	Nashville TN	Sold								
Cooper:	Findley OH	812								
	Texarkana AR	986								
Denman:	Warren OH	337								
Dunlop:	Buffalo NY	1,085								
	Huntsville AL	985								

Total jobs lost through closings, 19,742 (URW Estimate). Total jobs in new plants, 10,000 (URW).

Source: URW Estimates for production workforce.

TABLE 6-5. TIRE AND INNER TUBE PRODUCTION, WORKERS' ANNUAL AVERAGE EMPLOYMENT*

1970	79,300
1971	84,700
1972	87,600
1973	96,100
1974	100,900
1975	89,900
1976	71,100
1977	95,300
1978	91,700
April 1979	95,400
April 1980	76,200

*Employment and Earnings in the U.S. 1909-78 (SIC Code 301).

Similarly the outlook is not promising for U.S.-based companies concerning their position in the world market. U.S.-based companies at one time represented the top four tire producers in the world; by 1979 the foreign companies had gained rapidly (see Figure 6-1). There are several reasons for this. First, the home markets of foreign companies have been growing much more rapidly than the home markets of the American companies. Secondly, in two of the foreign countries, Japan and France, the governments have pursued policies which facilitate the growth and expansion of their national companies. Thirdly, it would appear that the tire operations of some foreign companies have been more succesful than some of the American companies. Four of the American companies have made major retrenchments and have withdrawn from some of their operations in Europe. The elimination of foreign operations also reduces the opportunity to export tires. When sales organizations in foreign countries are dismantled it becomes more difficult to maintain distribution abroad.

Although two major producers (Goodyear and Michelin, shown in Figure 6-1) are expanding their investments in the United States, the other American producers are following various strategies for consolidating and shrinking their U.S. tire operation. The balance of power in the world tire market is shifting to foreign-based companies.

Foreign operations of leading U.S. producers, however, remain uncertain in 1980 due to keen price competition and year-to-year changes in foreign currency exchange rates. The profitability of these operations varied widely in 1978-79, with most producers reporting operating losses, foreign exchange translation losses, and plant closings.

In order to better their position in the world market, the domestic tire industry must modernize their outdated facilities or build completely new plants. To do this, capital investment is required.

Source: TSC Industry Workshop, "The U.S. Industry: Problems and Prospects," Cleveland OH, Aug. 12, 1980.

FIGURE 6-1. 1979 SALES VOLUME WORLDWIDE OF LEADING TIRE AND RUBBER COMPANIES

Tire industry officials estimate that the domestic tire industry will require $1.5 billion in the next 5 years. The money will be used to complete conversion to radial tire production for cars and trucks and to pay for normal capital costs for replacement of worn equipment and other modernization.*

Automobile tires for original equipment, including temporary spares, are currently (1980) over 80 percent radial. Replacement tires are only about 50 percent radial. Taking the two markets together, radial tires constitute about two-thirds of total domestic usage.

In contrast, both light and heavy truck tires have a considerable way to go toward conversion to radials. The small truck tires in 1980 for original equipment (OE) and replacement, are only about 15 percent radial. The potential for medium truck radials is also substantial. It has been estimated that in the next 5 years there will be a doubling of demand and production capacity for radial truck tires.

It has been estimated that the cost of a new radial tire plant is $14 million for each 1000 tires per day capacity. Thus, a typical plant with a capacity of 20,000 tires per day would require a capital investment of $280,000,000. Conversion of a plant from bias to radial tires is more economical, costing an estimated $4 million for 1000 tires per day capacity. The decision to convert depends on whether the plant is in a favorable overall cost location and whether the remainder of the plant is sufficiently modern to yield low cost production after conversion.

Another issue that must be faced is quality control. A new highly automated plant tends to be a better quality producer, due mainly to mechanization of processes which are performed by hand in older plants.

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*Statement from the Workshop, "The U.S. Tire Industry: Problems and Prospects," Cleveland OH, Aug. 12, 1980.

The tire industry is currently confronted with considerable difficulty in utilizing any of the normal sources of capital. The declining profitability of the industry makes it unattractive to equity investors, decreases the flow of internally generated funds, and makes long term borrowing more costly.

6.3 MARKET TRENDS

The two principal market areas within the tire industry are the OE market and the replacement market. "Modern Tire Dealer" (January 1981) estimates that approximately 92 percent or 190 million units of all U.S. tire shipments are passenger car and truck units. (See Table 6-6). Of this figure, approximately 23 percent went to the OE market and approximately 77 percent went to the replacement market.

Through 1978, combined tire shipments to the OE and replacement markets have been rising relatively slowly. (See Table 6-6.) This historical pattern led analysts to assume that no major year-to-year variations in OE tire shipments could be expected. Recent plant layoffs and factory closings, however, have somewhat altered the analysts' original assumptions.

In 1979, total tire shipments fell by nearly 11 percent in the OE market and nearly 7 percent in the replacement market. (See Table 6-7.) Data for 1980 reveals a more drastic decline in total shipments of passenger car and truck tires, amounting to a reduction of 16.7 percent from the 1979 level. Shipments to the OE market were down by 29.7 percent and shipments to the replacement market declined by 11.9 percent.

Similarly, annual domestic tire production figures indicate a drastic decline from 1979 to 1980. (See Tables 6-8 and 6-9.) Total 1980 domestic tire production (passenger, truck, and bus) for the seven-month period, January to July 1980, is down by 29.3 percent from a comparable period in 1979.

Regarding specific companies and the OE market, Goodyear has been the largest supplier of OE tires with nearly 30 percent of

TABLE 6-6. TOTAL U.S. TIRE SHIPMENTS - 1980
(Million Units)

TIRES	OE	REPLACEMENT	TOTAL
Farm	1.6	2.7	4.3 (2%)
Truck	6.0	27.0	33.0 (16%)
Passenger	37.0	120.0	157.0 (76%)
Subtotal	44.6	149.7	194.3
Other	N.A	N.A	12.0 (6%)
Total			206.3 (100%)

Source: "Modern Tire Dealer," Janaury 1981.

TABLE 6-7. THE TREND IN TIRE SHIPMENTS

PASSENGER TIRE SHIPMENTS (Million Units)	1980	1979	1978	1977	1976	1975
REPLACEMENT*	120 (-11.1)**	135 (-8.2)	147 (5.8)	139 (1.5)	137 (6.2)	129
OE*	37 (-27.4)	51 (-9.7)	56.5 (-2.6)	58 (16.0)	50 (25.0)	40
TOTAL	157 (-15.6)	186 (-8.6)	203.5 (3.3)	197 (5.3)	187 (10.7)	169
TRUCK TIRE SHIPMENTS (Million Units)	**1980**	**1979**	**1978**	**1977**	**1976**	**1975**
REPLACEMENT*	27.0 (-15.1)	31.8 (0)	32 (12.3)	28.5 (21.8)	23.4 (9.3)	21.4
OE*	6.0 (-41.2)	10.2 (-15.0)	12 (7.1)	11.2 (21.7)	9.2 (10.8)	8.3
TOTAL	33.0 (-21.4)	42.0 (-4.5)	44 (10.8)	39.7 (21.8)	32.6 (21.8)	29.7
TOTAL TIRE SHIPMENTS FOR PASSENGER AND TRUCK (Million Units)	**1980**	**1979**	**1978**	**1977**	**1976**	**1975**
REPLACEMENT*	147.0 (-11.9)	166.8 (-6.8)	179 (6.9)	167.5 (4.4)	160.4 (6.6)	150.4
OE*	43.0 (-29.7)	61.2 (-10.7)	68.5 (-1.0)	69.2 (16.9)	59.2 (22.6)	48.3
TOTAL	190.0 (-16.7)	228.0 (-7.9)	247.5 (4.6)	236.7 (7.8)	219.6 (10.5)	198.7

*Includes both captive and non-captive imports.
**Figures in parentheses indicate percentage change from previous year.

Source: "Modern Tire Dealer," Jan 28, 1980.

TABLE 6-8. ANNUAL DOMESTIC TIRE PRODUCTION
(Million Casings)

YEAR	PRODUCTION VOLUME	% CHANGE OVER PRIOR YEAR
1979	196.7	(-12.0)
1978	223.7	(-3.0)
1977*	231.6	(+23.2)
1976	188.0	(0.5)
1975	186.7	(-11.7)
1974	211.4	(-5.4)
1973	223.4	(-2.7)
1972	229.6	(+6.0)
1971	216.4	(+13.7)
1970	190.4	

*Production levels in 1977 were unusually high as manufacturers rebuilt inventories, following a lengthy strike in 1976. ("Modern Tire Dealer," Jan 24, 1979).

Source: Basic Statistics -- Transportation, Standard and Poor's Corp., March 1980 p. 252.

TABLE 6-9. ANNUAL DOMESTIC TIRE PRODUCTION
(Million Casings)

YEAR	PASSENGER		TRUCK & BUS		TOTAL	
1980*	74.43	(-28.9)**	16.85	(-31.2)	91.28	(-29.3)
1979*	104.67		24.49		129.16	

*Figures for Total Production, Jan to July.

**Figures in Parentheses indicates percent change over previous year.

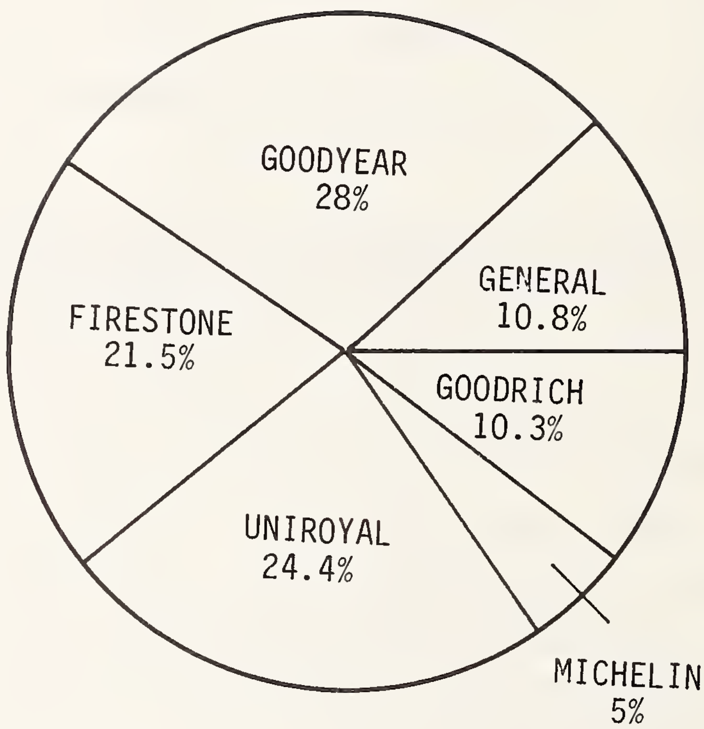
Source: Current Statistics - Standard and Poor's Statistical Service, Oct. 1980, p. 23.

the market. Goodyear supplies tires to all four U.S. automakers. Firestone, with nearly a quarter of the OE market, is the largest single supplier to Ford and is estimated to account for the needs of 15 to 20 percent of other automakers. Uniroyal accounts for another quarter of the OE market, supplying General Motors and Ford. General Tire has a 10.8 percent share of the market. Goodrich had a 10 percent share, but according to the "Wall Street Journal" (Jan 9, 1981), they now have dropped out of the OE market completely. Michelin completes this list with a 5 percent market share. (See Figures 6-2, 6-3, and Table 6-10.)

The aftermarket (or the replacement market) is the other major segment of the automobile tire market. As the radial tire has taken over an increasing proportion of the OE market, the market demand for replacement tires has fallen off. (See Table 6-11.) Because of the durability and longevity of the radial, the fewer annual miles driven, etc., the long term outlook for growth in replacement demand is relatively uninspiring.

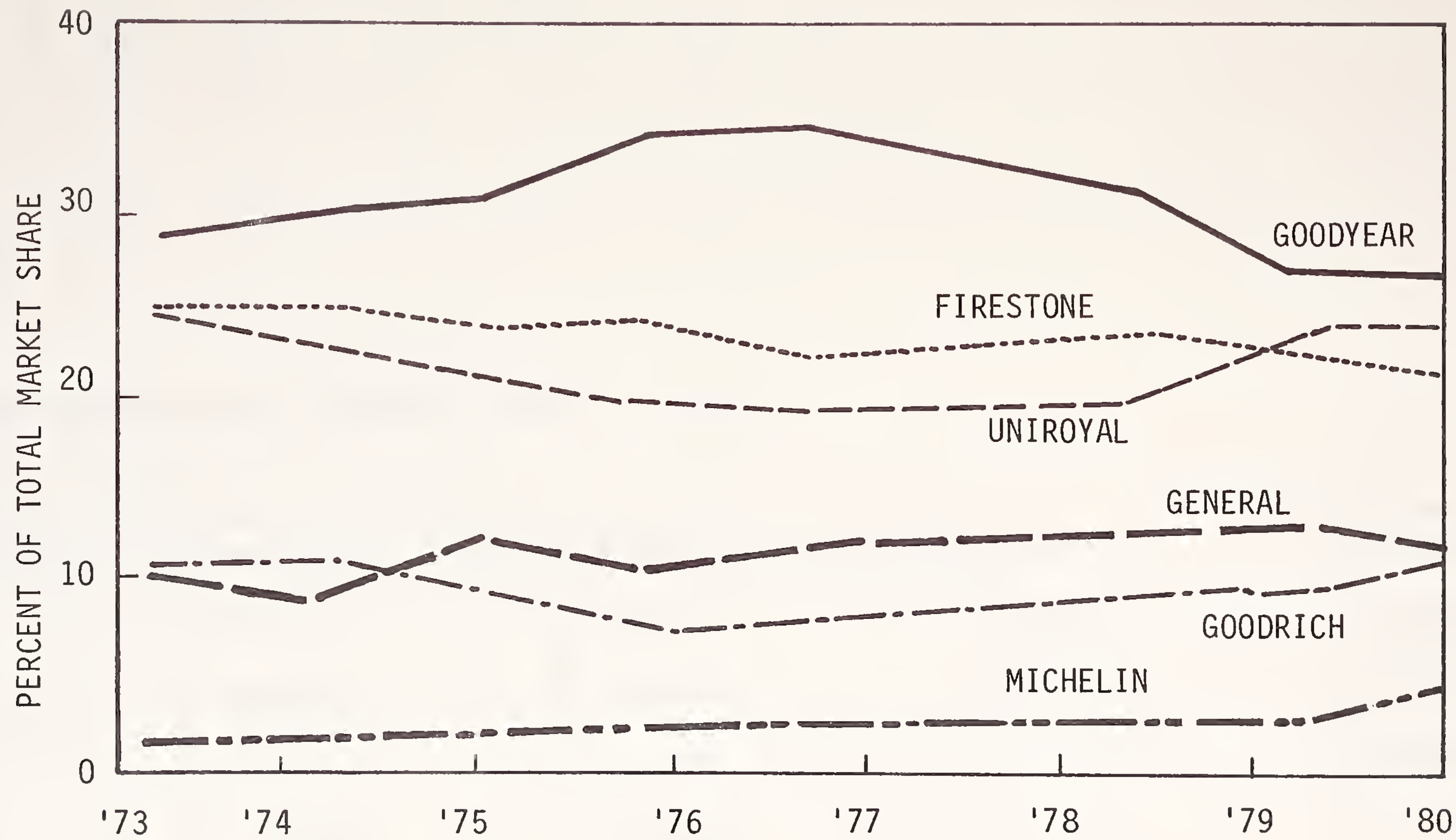
From 1975 to 1980, the trend toward radial tires has been steadily increasing. (See Table 6-11). In 1980, over 80 percent of OE tires, including temporary spares, were radials. The replacement tire market, which constituted 73 percent of sales in 1979, is currently 50 percent radial and is estimated to be 75 percent radial by 1985.

According to data and projections by B.F. Goodrich, sales of tires to the original equipment market will grow with the rate of new car sales. The replacement market, at 112 million units per year at mid-1980, is expected to reach 125 million units per year in 1981-82 period, and is expected to grow at 1 to 2 percent per year. The replacement market is expected to be 75 percent radial by 1985. Estimated current (1980) industry capacity to produce radials is 122 million units. Declining industry profitability and low projected sales growth make the industry reluctant to invest the additional $400 to 500 million required to complete



Source: "Modern Tire Dealer," January 1981.

FIGURE 6-2. 1980 DOMESTIC OE TIRE MARKET SHARES



Source: Modern Tire Dealer," January 1981.

FIGURE 6-3. ESTIMATED TOTAL DOMESTIC OE MARKET SHARES

TABLE 6-10. ESTIMATED 1980 BRAND SHARES — DOMESTIC OE MARKET

GENERAL MOTORS	FORD	CHRYSLER	AMERICAN MOTORS	VW OF AMERICA
Goodyear....... 21%	Goodyear..... 24%	Goodyear....... 61%	Goodyear..... 100%	Goodyear..... 40%
Firestone...... 18	Firestone.... 34	Firestone...... 26	Firestone........	Firestone.......
Uniroyal....... 36	Uniroyal...... 7	Uniroyal..........	Uniroyal.........	Uniroyal..... 10
Goodrich..... 12.5	Goodrich..... 11	Goodrich..........	Goodrich.........	Goodrich........
General...... 12.5	General....... 8	General...... 12.5	General..........	General.........
Michelin..........	Michelin..... 16	Michelin...... 0.5	Michelin.........	Michelin..... 50

Source: "Modern Tire Dealer," January 1981.

TABLE 6-11. DISTRIBUTION PERCENTAGE OF TIRE CONSTRUCTION TYPES BY FUNCTIONAL CATEGORY

	1975		1976		1977		1978		1979		1980	
	OE	REP	OE	REP	OE	REP	OE	REP	OE	REP	OE	REP
BIAS	15%	36%	13%	39%	11%	36%	13%	35%	15%	33%	18%	28%
BIAS BELTED	19	35	22	31	22	26	18	23	9	19	1	18
RADIAL	66	29	65	30	67	38	69	42	76	48	81	54

OE -- Original Equipment

REP -- Replacement Market

Source: "Modern Tire Dealer," Jan 24, 1979 and Jan 1981.

the conversion to radial production in spite of projections that radial capacity will fall short of demand. TSC estimates that radial tire demand will exceed capacity by 19 to 39 million units in 1985, depending upon the level of new vehicle production. Undercapacity is expected to be made up by some conversions to radials, by increased multiple shifts and overtime work, and possibly increases in imports.

Several tire companies have forecasted a period of sales stability - Goodyear has predicted a yearly growth rate of only 1.5 percent in aftermarket sales over a five-year period, while Firestone has forecasted sales in 1984 as being only 6 percent above 1978 levels.*

For the tire producers, the greater earnings on sales came from the aftermarket, and so the current trend of decreasing unit volume sales and increasing price competition has resulted in both U.S. firms and the French Michelin Company vying for the replacement tire market share. In 1978, Goodyear and Firestone led the replacement market with market shares of 27 to 29 percent and 25 percent respectively. All other manufacturers lagged well behind these two companies.**

The differential between the price of an OE market tire and an identical tire in the replacement market tends to widen during periods when profits in the auto industry are declining, since the automakers are more likely to negotiate greater price concessions from the tire makers under these circumstances. During most periods of economic recession, the relatively greater profitability of the replacement tire has enabled the tire manufacturers to maintain their earning performance.

*Standard and Poor's Industrial Survey -- Rubber Fabricating, March 20, 1980, p. R 199-201.

**Standard and Poor's Industrial Survey -- Rubber Fabricating, March 20, 1980, p. R 202.

6.4 TECHNOLOGICAL TRENDS

Most of the technological innovations in the tire industry appear to be in reinforcing materials and basic improvements to the radial tire. Since the main technical objective of the major auto companies is to improve fuel economy and to meet the federally mandated fleet average of 27.5 mpg by 1985, improvements of the radial tire are necessary and forthcoming. High-pressure radials are a relatively recent development that will become increasingly more common. They require inflation pressures 6 to 8 lbs higher than conventional radials but deliver significantly better fuel economy because their reduced flexing cuts rolling resistance.*

In 1978, Goodyear introduced an elliptic radial tire which was available on some 1979 cars and on many 1980 cars. In tests at 50 mph, cars with these tires got 7.5 percent more mpg than those with standard radials. The elliptic shape of the tire allowed it to be inflated to a pressure approximately 50 percent higher than that of a standard radial, thus cutting rolling resistance.** High tire pressure usually means a rough ride, but with the new tire the elliptical shape compensates for the higher pressure in terms of ride quality.

The other major tire companies also introduced new tire designs. Firestone introduced a new tire during 1978 which operates on the same principal of higher pressure but fits on a standard rim and, like the Goodyear tire, is designed to save fuel.

In January 1979, Goodrich introduced a new tire that is a modification of a steel-belted radial. It is made with a special tread compound and gets 9 percent more fuel savings than the standard radials for passenger cars.***

In early 1980 Uniroyal introduced a new tire containing puncture sealant. The company claims this development will extend the life of a tire to 9 to 10 years, thus eliminating the use of

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*"Popular Science," Oct. 1980, p. 100.
**"Popular Science," Oct. 1980, p. 103.
***Phone communication: B.F. Goodrich (Ken Alexander) and Nancy Fava, TSC, Jan. 7, 1981.

spare tires in cars, reducing vehicle weight, and increasing gas mileage. The sealant will be in the tire tread and will protect against flats caused by objects of up to 3/16 of an inch in diameter. However, the sealant will do nothing for a sidewall puncture.*

The perfected puncture-proof tire will put pressure on all concerned to eliminate the spare tire altogether. Such developments will be highly desirable as a means to save weight, trunk space, fuel, and initial vehicle costs. However, it would reduce OE tire sales by 20 percent and will also affect some sales in the replacement market.

As cars become smaller in size, the elimination of the spare tire becomes very important. Presently spare tires come in two types, the mini and the collapsible. The mini spare is a thin tire mounted on a special rim. It occupies less trunk space than a conventional spare and is intended to be used on an emergency basis only. The collapsible spare is also a thin tire mounted on a special rim, but it is stored uninflated in the trunk and occupies even less space than the mini. It, too, is intended for emergency use only. Before use, it must be inflated from an aerosol bottle. Also, it must be deflated before storing it in its well. Both types of spares have a life expectancy of about 2000 miles and should not be driven at speeds over 60 mph. They do reduce the weight of a car as compared to full-size spare tires and subsequently fuel economy is improved.

One last development that has been underway for about 20 years is the cast (plastic) tire. No outstanding progress has been made with this development, however, since the tire is not usable at speeds above 25 mph. No other major technological innovation is expected in the next 5 to 10 years.**

*"Rubber and Plastics News II," March 10, 1980, p. 8.

**Statement from the Workshop on "The U.S. Tire Industry: Problems and Prospects," Cleveland OH, Aug 13, 1980.

6.5 WORLDWIDE INDUSTRY STRUCTURAL CHANGES AND POTENTIAL IMPACTS ON U.S. INDUSTRY

At present, the U.S. tire industry is experiencing one of the severest slumps in sales, production, employment, and earnings in its history. The tire industry is currently operating at 65 to 75 percent capacity and projected demand is declining.* Auto tire production is down 30 percent from its 1973 peak. Truck tire production has declined by 37 percent from its 1978 peak. The number of production workers is down 20,000. Tire industry officials predict that total earnings of tire companies in 1980 will be down 75 percent from 1973.**

Several factors have contributed to the current decline in the domestic tire market. First, there are the long-term declines in tire demand due to longer wearing tires, diminished driving per car, and slower driving speeds. Second, imports have claimed an increasing share of the U.S. tire market. In 1980, 16.0 million tires were imported, more than double the 7.4 million tires imported in 1975.***

The change from the use of bias and bias-belted to radial tires† has also contributed to the present decline of the tire industry. The industry found itself with excess capacity for bias and bias-belted tire production and insufficient radial tire capacity. The decline in the demand for bias and bias-belted tires necessitated the closing of some of the older facilities, while others have been converted to radial production. As pointed out in section 6.2, the expense of plant conversion is much lower than the cost of a new facility.

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*"1980 U.S. Industrial Outlook for 200 Industries with Projections for 1984," U.S. Department of Commerce, Industry and Trade Administration, p. 161.

**Statement from the Workshop on "The U.S. Tire Industry: Problems and Prospects," Cleveland OH, Aug 12, 1971.

***"Modern Tire Dealer," January 1976, p. 67, January 1981, p. 32.

†See Section 6.3, Table 6-11.

The closing of plants inevitably results in unemployment. Since 1970, 22 plants, employing approximately 10,000 workers have closed.* During the first 5 months of 1980, the major tire manufacturers closed several tire plants, which resulted in the indefinite layoff of 10,000 more tire workers. These layoffs have occurred in both the newer radial tire plants as well as the older bias tire plants, as keyed on the map of Figure 6-4. Since the demand for tires is projected to grow only 1 to 2 percent a year in the 1980s, the net loss of 20,000 jobs represents a permanent loss in this manufacturing sector.**

While the market for tires has been shrinking, tire manufacturers' costs have been increasing. A new union contract signed in July 1979 had a significant effect on the tire industry. This industry already had one of the highest wage levels in the U.S., with only the steel and auto industry surpassing it. (See Figure 6-5.) This contract is expected to push labor costs up by as much as 40 percent over the next few years.*** Tire companies have been unable to absorb the level of wage and benefit increases for which the unions have negotiated. Two of the largest tire companies are earning little if any profit on domestic tire operations. Escalating prices of synthetic rubber and other petroleum-based products have boosted the bill for raw materials by 20 to 25 percent in 1980. With rubber and other prices soaring, tire companies are forced to pass their cost increases on to consumers.

The response of the major companies to these trends of low growth and low profitability have been varied. Generally, they include an intensified struggle for market share, moves toward diversification outside of the automotive market, and plant closings to reduce excess bias-ply capacity and cut losses.

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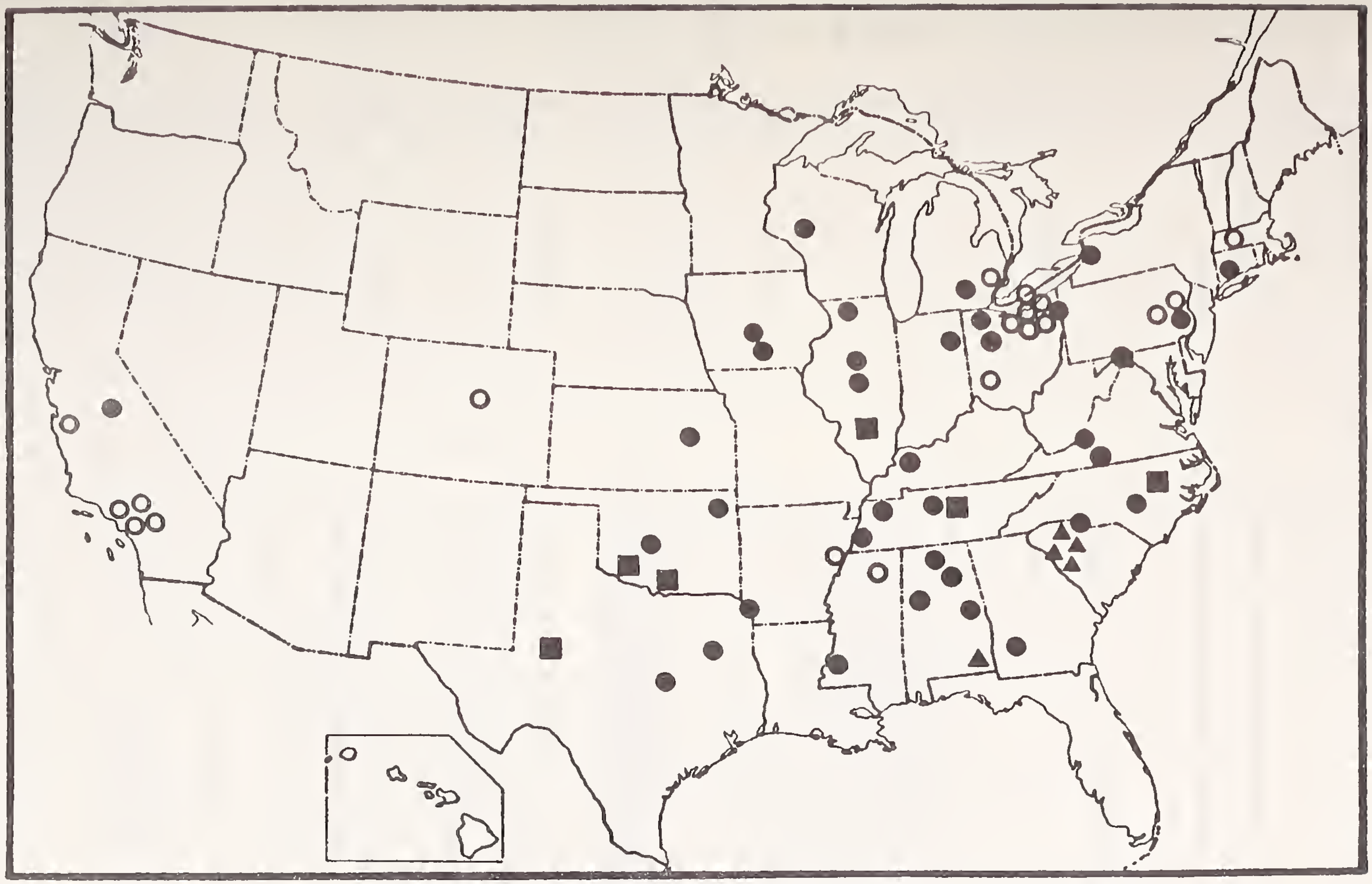
*"Employment and Earnings," Bureau of Labor Statistics, U.S. Department of Labor, June 1980, Table E-1.
**Firestone 10-K Statement 1978, p. 7.
***"Time" magazine, Feb 11, 1980, p. 59-60.



● 1970 Tire Manufacturing Plants/Continuing to Operate (35).

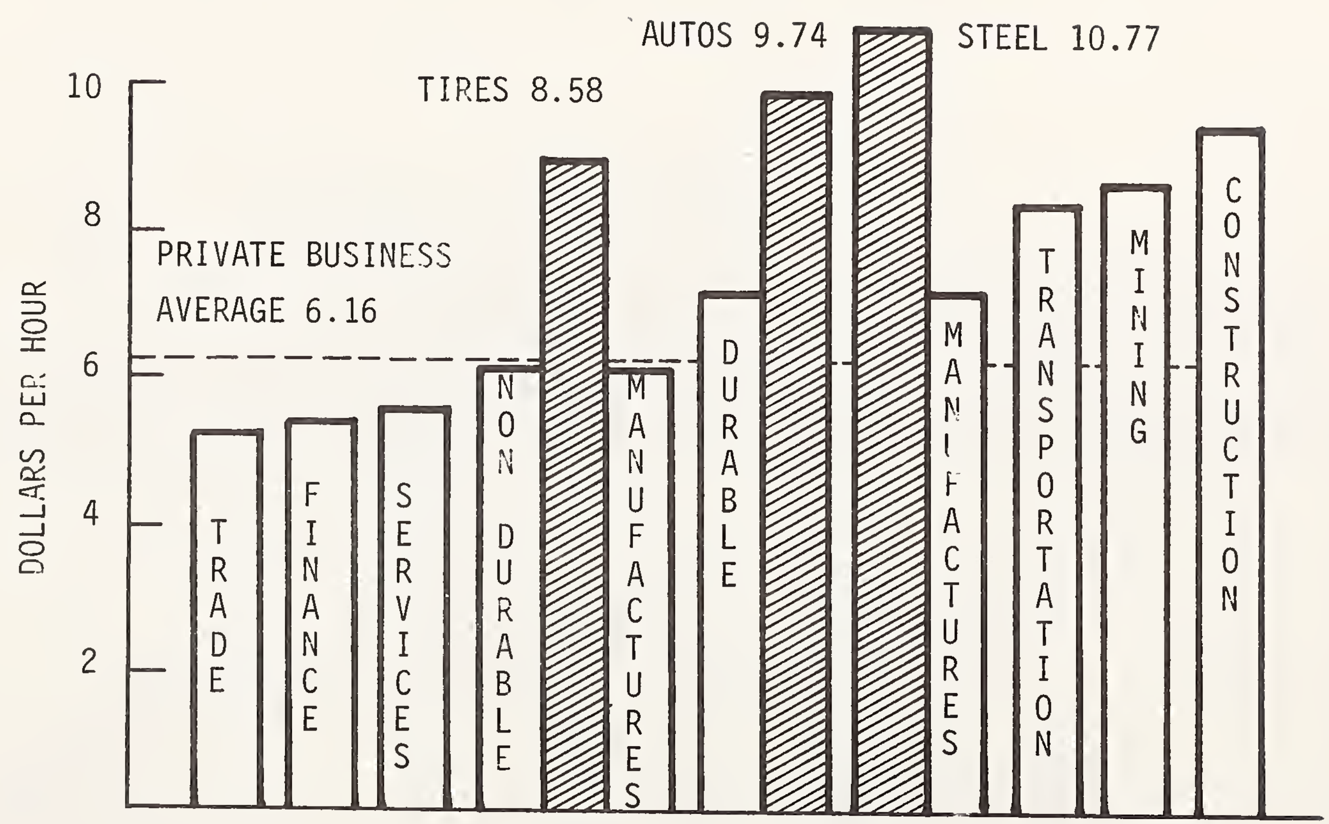
○ Tire Manufacturing Plants Closed or Announced to Close Since 1970 (19).

New Tire Manufacturing Plants Opened or Announced to Open Since 1970 (11).

■ Domestic Tire Manufacturers (6).

▲ Foreign Tire Manufacturers (5).

FIGURE 6-4. U.S. TIRE MANUFACTURING CHANGES, 1970-1980



Source: Edwin H. Sonnecken, Retired Vice-President of Goodyear, at the Workshop, "U.S. Tire Industry: Problems and Prospects," Cleveland OH, August 12, 1980.

FIGURE 6-5. 1979 U.S. AVERAGE HOURLY WAGES (EXCLUDING BENEFITS)

Goodyear, widely regarded as the strongest of the major domestic tire companies, is expanding while its domestic rivals are cutting back or diversifying. Because of its strength and expansion capabilities, however, Goodyear is finding itself in stiff competition with a non-domestic rival, Michelin.

Michelin, a French manufacturer, currently has 5 percent of all U.S. tire sales.* It had pioneered the radial tire, and its production experience gave Michelin an advantage in the U.S. market. While U.S. competitors worked out production and quality control problems with their own radial tire, Michelin had almost total control over the radial tire market through the 1970s. Michelin's original marketing strategy was to create a high quality image for their product and they priced it accordingly. Today, however, both auto tire and truck tire original equipment customers agree that the quality gap between Michelin and U.S. competitors has nearly closed.

Since competition has been tough and Michelin's desire to increase market share in the U.S. has been strong, some radical changes have taken place in their marketing strategies, none of which seem to show profit as an objective. Michelin has recently:

- Slashed prices for replacement tires. At retail, tires that once sold at 30 percent premium relative to the market now sell at prices comparable to competing brands.
- Won a major OE supply contract from Ford Motor Co. for the new Escort and Lynx models but at prices so low that industry sources say profits will be slim or nonexistent.
- Given consideration for the first time to using new tire materials, which suggests a possible expansion of Michelin's product line into other than steel-belted radials.

*"Modern Tire Dealer," January 1981, p. 35.

- Expanded its dealer network rapidly, while vying with its own dealers for national accounts. This is causing a near-rebellion among some of these retailers.*

Michelin has gained one percentage point per year in the tire market share since 1977 and would like to continue that rapid growth. However, some analysts believe that Michelin's growth has peaked. A Goodyear offical, Charles J. Pilliod Jr., feels that "the radial was invented by Dunlop, introduced by Michelin and is going to be popularized by Goodyear."*

Other companies have also cut back. B.F. Goodrich has elected to stay only in the most profitable tire lines and has not sought to add to its overall U.S. share. As mentioned in section 6.3, Goodrich has also decided not to compete in the domestic OE market. Officials feel that as some of the U.S. producers decline, foreign companies will take up the slack in U.S. market share.

6.6 GOVERNMENT/INDUSTRY RELATIONSHIPS

Tire manufacturers do not view themselves as being in the best of economic conditions and thus feel they are severely impacted by the costs of Government regulations. The National Highway Traffic Safety Administration (NHTSA) sets standards for tire manufacturers, and often these standards or regulations prove costly. An example of this is the considerable expense involved in implementing the current tire grading and labeling requirements. This system of tire grading and labeling was developed to aid the consumer in selecting a safe and economical tire.

Other factors affecting the domestic tire industry are regulations set by Congress, such as the 55 mph speed limit, Environmental Protection Agency (EPA) requirements, Occupational Safety

*Michelin: Spinning its Wheels in the Competitive U.S. Market, "Business Week," Dec. 1, 1980, p. 119.

and Health Administration (OSHA) requirements, and most importantly, product liability costs. Firestone was hit heavily by product liability costs in 1978-79 resulting from a recall of Firestone 500 steel-belted radials. These tires had safety related defects and thousands of failures had been reported during the year. The tires' rate of failure was two to four times greater than that of any other domestically manufactured steel-belted radials. Eventually NHTSA and Firestone reached an agreement which led to the recall of the Firestone 500 steel-belted radial.*

Recently there has been much discussion between NHTSA and the tire industry regarding the proposed Federal requirements to register individual tire ownership at the time of purchase. Since this would entail more paperwork and administrative costs for the tire dealers, the industry would like to have each buyer register by mail. The matter has not been resolved as of this writing.

Tariffs and trade barriers are yet other factors impacting the tire industry. According to tire industry officials, the 4 percent tire tariffs in the United States are the lowest of any country.** Although domestic radial tires are now equal in quality to, or, in some aspects, better than imports, foreign competition is still adversely affecting the U.S. tire industry. Low tariffs, compounded by the fact that large increases in exports of passenger car tires are highly unlikely indicates that some positive action must be taken to help get the U.S. tire industry back on its feet.

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*"Automotive News," Aug 14, 1978, p. 35.

**Workshop on "U.S. Tire Industry: Problems and Prospects," Cleveland OH, Aug 12, 1980.

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7. THE GLASS INDUSTRY

7.1 WORLD PRODUCTION AND INTERNATIONAL TRADE

The glass industry is composed of two segments: flat glass, used in mirrors and windows, and glass containers. Table 7-1 illustrates the relative sales levels of the two glass markets for the domestic glass industry. Fiberglass, a related product in that it uses the same raw materials as flat glass, is used as insulation and reinforcement for some plastic products. This report concentrates on the flat glass industry.

International trade has historically been a relatively minor segment of the industry, with exports accounting for approximately 7.2 percent of U.S. product shipments and imports accounting for 2.7 percent of consumption. Because glass is expensive to ship, very fragile, and subject to non-tariff trade barriers, manufacturing facilities tend to be located near the regions of use.

U.S. imports of flat glass increased in 1979 to $54 million, after falling sharply between 1972 and 1975. (See Table 7-2) The recent increase in imports was due to both heavy domestic demand and the spread of new float glass production technology to foreign producers, resulting in reduced prices for imported flat glass. The U.S. still had a trade balance surplus of $91 million in 1979.

The major suppliers of flat glass to the U.S. are Canada, West Germany, Japan, and Roumania, while the U.S. exports flat glass primarily to Canada, West Germany, Venezuela, and Australia.

7.2 STRUCTURE OF THE DOMESTIC GLASS INDUSTRY

The U.S. flat glass manufacturing industry is a moderately concentrated one, consisting of 11 companies, with three accounting for 81 percent of production. Table 7-3 illustrates the changes in the market share that have occurred between 1971 and

TABLE 7-1. FLAT GLASS INDUSTRY PROFILE

SIC CODE: 3211

Value of Shipments (Million $)............	1,740
Value Added (Million $)...................	1,023
Total Employment (000)....................	24.5
Number of Establishments, Total (1977).....	62
Number of Establishments with 20 Employees or more (1977)................	32
Exports as a Percent of Product Shipments..	7.2
Imports as a Percent of Apparent Consumption*...........................	2.7
Compound Annual Rate of Change, 1974-79:	
Value of Product Shipments**..........	9.7
Value of Exports**....................	16.4
Value of Imports**....................	-2.1
Total Employment......................	2.6
Major Producing States: Ohio, Tennessee, Illinois, and Pennsylvania	

*Imports divided by product shipments plus imports minus exports.

**Rates of change based on current dollars.

Source: <u>1980 U.S. Industrial Outlook</u>, U.S. Department of Commerce.

TABLE 7-2. FLAT GLASS IMPORT/EXPORT TRENDS 1974-1979
(In Millions of Dollars)

	1974	1975	1976	1977	1978	1979
Value of Exports	68	65	106	121	119	145
Value of Imports	60	48	64	72	57	54
Trade Balance	+ 8	+17	+42	+49	+61	+91

Source: 1980 U.S. Industrial Outlook, U.S. Department of Commerce.

TABLE 7-3. FLAT GLASS MARKET SHARES
(Percentage Based on Capacity)

COMPANY	1971	1973	1975	1977	1979E
PPG INDUSTRIES	41%	38%	36%	34%	34%
LIBBEY-OWENS-FORD	30	29	28	28	28
FORD	13	14	18	19	19
GUARDIAN INDUSTRIES	3	5	6	7	9
ASG INDUSTRIES*	8	8	6	6	5
C-E GLASS	1	3	3	3	3
FOURCO**	4	3	3	3	3***
TOTAL	100%	100%	100%	100%	100%

*Now AFG Industries.
**Fourco is now a wholly owned subsidiary of AFG Industries.
***Includes operations sold in 1977.

Source: U.S. Glass, Metal and Glazing, January 1978.

1979. The changes can be attributed to the speed with which each corporation was able to implement technological breakthroughs in the production process, the most significant of which being the transition to the float glass method.

In 1979, the domestic flat glass industry registered $1.74 billion in total sales. The industry employs 24,500 persons, with facilities concentrated in the Midwest (primarily Ohio and Illinois) Pennsylvania, and Tennessee. Figure 7-1 shows the location of glass production and fabricating plants, whose output is used mainly by the automotive sector.

The three major types of flat glass are float, tempered, and laminated glass. The latter two are variants of float glass that have received additional processing to achieve necessary safety-oriented properties. Laminated glass, used in automotive windshields, fractures on impact but does not fragment, while tempered glass fragments into small pieces. Table 7-4 lists the automotive glass plants in the U.S. and their principal products. According to Table 7-5, the OEM automotive sector accounts for 26.5 percent of total domestic flat glass consumption, with replacement automotive glass accounting for another 6.6 percent

Ford Motor Company, besides being the second largest car manufacturer in the U.S., is also the third largest flat glass producer, supplying its own glass needs from within the corporation. Chrysler buys flat glass and then processes it further into windshields, side windows, etc. General Motors purchases all its glass needs from Libbey-Owens-Ford (LOF) (72 percent) and PPG (28 percent). Due to its heavy dependence on the automotive industry, LOF is particularly vulnerable to the uncertainties of the automotive market. In fact, during 1980, LOF was forced to temporarily shutdown several plants in Illinois and Ohio due to the automotive industry downturn.

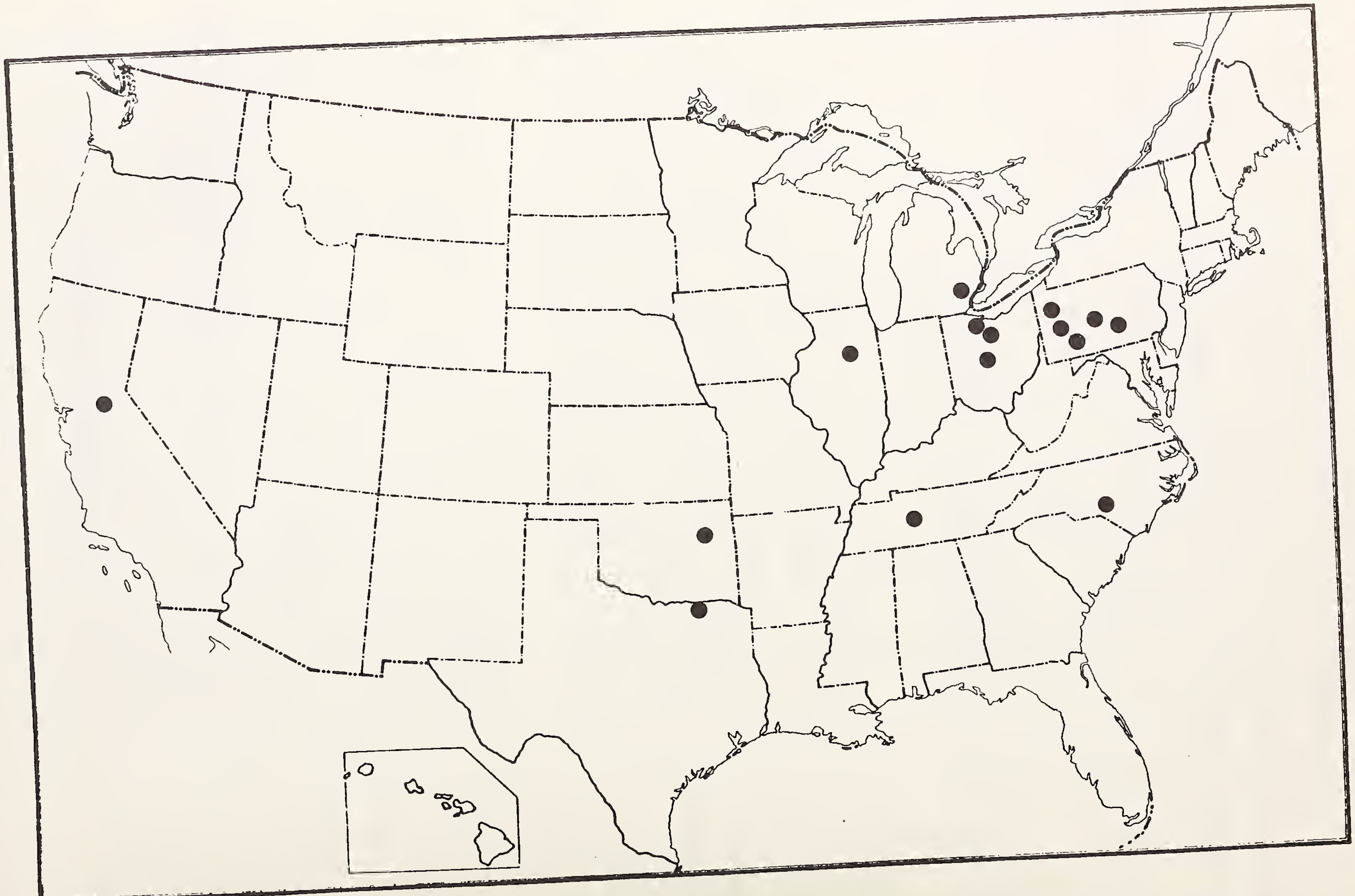

FIGURE 7-1. AUTOMOTIVE-RELATED GLASS PRODUCTION AND FABRICATING PLANTS

TABLE 7-4. GLASS PRODUCTION INFORMATION FOR THE AUTO-RELATED PLANTS OF MAJOR U.S. GLASS PRODUCERS

COMPANY	LOCATION	EMPLOYMENT	PRODUCTS FOR THE AUTOMOTIVE INDUSTRY
LIBBEY-OWENS-FORD	ROSSFORD, OH	2,000	FLOAT GLASS, TEMPERED AND FILMED GLASS
	TOLEDO, OH	2,000	FLOAT GLASS, TEMPERED, LAMINATED AND SPECIALITY GLASS FOR WINDSHIELDS, AUTO WINDOWS.
	LATHROP, CA	600	FLOAT GLASS, TEMPERED AND LAMINATED GLASS
	OTTAWA, IL	1,500	FLOAT GLASS, AUTO WINDSHIELDS AND SIDE GLASS
	COLLINGSWOOD, ONT	230	FABRICATES LAMINATED AND TEMPERED GLASS
	SHERMAN, TX	270	FABRICATES LAMINATED WINDSHIELDS, TEMPERED SIDELIGHTS AND BACKLIGHTS
	LAURINBURG, NC	970	FLOAT GLASS, FABRICATED TEMPERED GLASS
PPG	CREIGTON, PA	2,500	SUPPLIES OEM MOSTLY, FLAT GLASS, FABRICATED AUTO GLASS
	TIPTON, PA	700	N.A.
	CRESTLINE, OH	950	75% TO OEM AND AFTERMARKET (ALSO SUPPLIES VW) AUTO GLASS
	GREENSBURG, PA	600	OEM AND AFTERMARKET (ALSO VW)
	CARLISLE, PA	1,100	FLAT GLASS USED AT GREENSBURG AND CRESTLINE
FORD	NASHVILLE, TN	6,050	FLOAT GLASS, WINDSHIELDS, BACKLIGHTS, SIDELIGHTS
	DEARBORN, MI	800	RESIDENTIAL SAFETY GLASS, WINDSHIELDS
	TULSA, OK	3,150	AUTO GLASS, CONSTRUCTION GLASS
	NIAGARA FALLS, ON	500	GLASS FOR AUTO AND CONSTRUCTION (FABRICATION ONLY)

TABLE 7-5. ESTIMATED FLAT GLASS CONSUMPTION BY MARKET* (ESTIMATED FOR 1979)

MARKET	MILLIONS OF SQUARE FEET	PERCENT OF TOTAL
CARS	640	20.0
TRUCKS	210	6.5
TOTAL AUTOMOTIVE	850	26.5
AUTOMOTIVE REPLACEMENT	210	6.6
RESIDENTIAL CONSTRUCTION	1,250	39.1
NONRESIDENTIAL CONSTRUCTION	410	12.8
OTHER**	480	15.0
TOTAL	3,200	100.0

*Excludes imports.

**Includes mirrors, industrial, export, manufactured inventories, etc.

Source: U.S. Glass, Metal and Glazing, January 1978.

7.3 MARKET TRENDS

Flat glass is primarily a cyclical industry, dependent on its two largest users, the automotive and construction industries. These sectors of the economy have been operating at a high level during the past decade and have been the primary cause of the recent high production level in the flat glass industry. However, recent downturns in both automobile sales and construction activity have been a cause for concern for flat glass manufacturers. In the automotive industry, emphasis is presently on the fuel-efficient small car in which lighter glass is used on a smaller surface area. For the flat glass manufacturer, this translates into a lower demand for glass to the automotive industry.

There is cause for optimism, however, since the industry expects increases in demand for nonresidential construction, storm windows, and insulated glass window units. The latter two products are direct results of recent Federal energy reduction incentives. The industry can also anticipate an increased demand for reflective glass to reduce summer cooling costs. Therefore, as reported by the U.S. Department of Commerce, even with a continued drop in consumption of glass by the automotive and construction industries, the outlook for flat glass appears to be favorable over the next few years.

Table 7-6, derived from Department of Commerce data, presents annual flat glass shipments and the constant-dollar values of those shipments. As is evident, both volume of production and price (base year 1967) have remained stable for the past 3 years.

The three major companies - PPG, LOF, and Ford - operate 16 plants, six of which are located in the Midwest, with plans for expansion in the South. A steady shift from plate to float glass manufacturing processes and an exceptional ability to adapt to new requirements from the automotive and construction industries have maintained growth while increasing operational efficiency.

7.4 TECHNOLOGICAL TRENDS

Glass is basically the result of fusing together, under intense heat, silica sand, soda ash, limestone, salt coke, and other ingredients. The manufacturing of glass products requires three basic steps:

- mining raw materials
- processing the raw materials into the primary product
- fabricating the primary product into the various finished configurations.

In the last two of these basic steps, changes have occurred that have impacted the industry.

Major technological advances have been made in primary production methods. The transition from the sheet glass roller process to the more efficient and flexible float glass method has rearranged the market shares within both the domestic and foreign markets.

At the present time, the most significant changes related to the flat glass industry are not within the industry itself but are a function of the types of products being demanded by consumers of flat glass products. These changes in demand have forced the flat glass industry to make alterations in the third basic production step, the fabrication of finished configurations.

The most notable of these changes in demand come from the automotive industry. The upgrading of glass parts designed for use primarily in automobiles has been significant during the past years. A few examples of product changes are:

- the transition from mostly clear, relatively simple glass to more sophisticated products that utilize heat-absorbing glass, curved for greater visibility
- rear window defogging capability

TABLE 7-6. SUMMARY OF FLAT GLASS PRODUCTION, 1977-1979

YEAR	TOTAL PRODUCTION (1000 SQ. FT)	VALUE OF SHIPMENTS - CONSTANT $*	CONSTANT $ COST/SQ.FT.	% CHANGES FROM PREVIOUS YEAR
1979	3,783,395	468,483	$0.1238	+3.0
1978	3,990,522	478,731	$0.1202	-3.7
1977	3,683,360	459,728	$0.1248	

*The data was adjusted using the Producer Price Index for the flat glass as published by the Bureau of Labor Statistics. The base year is 1967.

Source: Derived from data in Current Industrial Reports, U.S. Department of Commerce, Fourth Quarter, 1979.

- built-in radio antenna
- improved windshield safety characteristics made possible by improved interlayer materials
- thinner glass that is up to 17 percent lighter in weight.

The most important of these product changes has been the development of a thinner and lighter glass. Windshield weight and thickness have been reduced substantially in recent years and similar reductions also have been made in side and rear windows. These weight reductions are important to the automotive industry in meeting weight reduction requirements. In addition, there is a trend towards a higher ratio of glass to body metal, adding style and a streamlined look to new cars.

As might not initially be expected, the manufacturing cost of thinner flat glass has not been less than that of thicker glass. There are a number of reasons for this. First, the process throughput rates for the new, thinner glass must be reduced, resulting in less output per unit of time. Second, optical quality is more difficult and timely to achieve. Finally, the strength of raw glass decreases with the inverse square of its thickness. Therefore, the rate of breakage of thinner glass is greater throughout the entire manufacturing process, increasing the amount of wasted material, production time, and resources. Definite incentives exist for the flat glass industry to develop more cost-effective methods for producing thinner glass. There is no doubt that the demand for this lighter product will continue, and the trend of the future will be toward an even thinner and lighter flat glass product.

One note of concern to the flat glass industry is a recent development by Dow-Corning and General Electric of a hard, clear coating for plastic, which renders it suitable material for automobile windows. This plastic window's protective surface is applied in a very thin layer. It provides the lightweight, impact-resistant plastic windows with almost glass-like properties and performance, while allowing the material to flex with the windows. Coated plastic windows are now in use in transit buses, and its producers are hoping to enter the automobile glass market soon. Traditionally, plastic has been considered to be a good lightweight substitute for glass except for the fact that it scratches easily. Dow-Corning claims to have solved this problem. The new coatings are now being studied by automakers for weight-saving applications in opera windows, rear quarter windows, and various light truck and van window applications. Presently, glass windows in automobiles are a significant area of study for further weight reduction.

The difficulty in meeting capital requirements in the flat glass industry is representative of all U.S. industry. Inflation is continually consuming business capital, causing spiraling increases in cash requirements. The replacement cost of worn-out, obsolete production facilities is two to four times the original capital investment. It has become a formidable task for most flat glass businesses just to sustain their position.

7.5 WORLDWIDE INDUSTRY STRUCTURAL CHANGES AND POTENTIAL IMPACTS ON U.S. INDUSTRY

The future health of the domestic flat glass industry depends on the ability of the producers to deal with certain structural changes or realities inherent to the industry. The industry is currently required to cope with four particular structural issues that have potentially large impacts on flat glass production. These four structural issues are:

- the continued downsizing of the U.S. autos and the resultant decrease in glass per car
- the cyclical nature of the automotive, housing, and construction industries
- the impact of the energy crisis on production and markets
- the growing shortage of basic raw materials.

The downsizing trend in the automotive industry has had ambiguous effects on the flat glass industry. The popular small cars require less glass per car than the traditional mid-size and full-size vehicles. However the smaller cars also require a lighter weight glass product that meets all other performance requirements. The new lightweight glass requiring additional fabricating and finishing, yields greater profits from the value-added effort prior to shipping. If the current problems in the automotive industry worsen in the future, it could mean severe implications for flat glass producers. In such an event, the glass manufacturers can only hope that auto designers will utilize more glass per car to differentiate among the smaller vehicles. For the flat glass industry more stylized glass products equals more profits per foot of glass and hopefully continued prosperity.

The cyclical nature of the housing, construction, and automotive industries represents a structural problem that flat glass manufacturers have traditionally encountered. Most glass companies have attempted to diversify their manufacturing base to carry them through the slow periods of the year. An example of the negative aspects of dependence on a cyclical industry is the relationship between the flat glass industry and the automobile manufacturers. By agreement, glass companies negotiate automotive glass production contracts before the model year begins. If automobile sales should prove to be poor that year, the glass companies have no capability of improving their share of the automotive market. Their unused capacity is then shifted to other markets, at times creating a significant surplus of supply and resultant decline in prices in these other markets.

The impact of the energy crisis on the flat glass industry also has had contradictory implications. The increasing cost of energy has been acutely felt by glass manufacturers and is a cause for continuing concern. The energy crisis has been the impetus for the institution of energy conservation measures and dual fuel capabilities in glass production facilities. On the other hand, escalating fuel costs have created an increasing demand for new flat glass products (e.g., storm windows, insulated glass window units, reflective glass).

Glass production costs have risen sharply, as gas, oil, and electric fuel costs have doubled or tripled over the past 5 years. Many proposals to help eradicate the nation's energy problems create difficulties for the flat glass industry. For example, plans to shut down manufacturing plants during periods of national gas shortages have caused many glass companies to rely on alternative fuels. Some companies have even purchased or developed their own gas reserves. However, restrictions on the shipping of gas through interstate pipelines might be applied in the future. In addition, incremental pricing of natural gas gives some plants a cost advantage over others depending on whether their supply is either "old" or "new" gas. These problems of energy supply are expected to worsen in the future.

The flat glass industry has been reasonably prudent in planning to meet anticipated energy and raw materials requirements. According to the U.S. Department of Commerce, the general materials situation in the glass industry is favorable. In addition, the flat glass products manufactured are competitive with other industries facing similar difficulties, especially in terms of energy.

The obvious solution to a number of structural problems encountered by the flat glass industry would be the diversification of the manufacturing base. Some glass manufacturers have followed this route, but one, PPG, has been guided by a different strategy. With both automobile production and construction activity declining, PPG has chosen not to retreat from these markets. Instead, they have implemented a plan of aggressive marketing and capital investment maintaining their dependence on automobiles and construction by focusing on the healthy areas. For example, PPG was an early entrant into the conservation glass market, quickly learning the economic fact that more specialized products return higher pretax margins. Whether this becomes a strategy for other flat glass producers to follow remains to be seen.

7.6 GOVERNMENT/INDUSTRY RELATIONSHIPS

The relationship between the flat glass industry and the Government has been considered by many to be an adverse one. Burdensome regulation and/or reporting requirements by agencies such as OSHA, EPA, IRS, and DOE have been widely criticized by industry in general, and the glass industry in particular, as being an expensive hindrance to production.

The glass industry is also restricted by trade barriers, largely non-tariff, set by foreign governments, who set production standards on the region's prevailing manufacturing methods. The U.S. glass producers would prefer a policy of aggressive bargaining with foreign governments to relax barriers of entry into foreign markets. Automotive glass, only exported as original equipment on new cars, is not impacted as heavily as other glass products.

The flat glass industry is presently facing two areas in which innovation is necessary for continued prosperity. First, the automotive producers require lighter and thinner glass for the newer model cars. Second, the increasing cost and short supply of both energy and raw materials underline the importance of developing more efficient production methods. The current economic climate is not conducive to large R&D expenditures by any one firm, and cooperative research among firms would violate anti-trust laws.

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8. THE PAINT INDUSTRY

8.1 WORLD PRODUCTION AND INTERNATIONAL TRADE

Free world production of surface coatings (paints) in 1975 (latest world information available) is estimated at 35 billion lbs (See Table 8-1). The manufacturing of most paint products does not require large capital investments or a highly skilled labor force. Few barriers exist to entering the paint manufacturing industry and it is one of the first industries set up in developing countries.

Profit margins are usually low because of high competition. Paint manufacturing plants are built near their major markets to reduce shipping charges. Extensive shipping costs can make the difference between adequate profits and no profits. Shipping costs are and will continue to be a major barrier to international trade. International trade in paint measured in pounds represented only 5 percent of the free world's production in 1975.

8.2 STRUCTURE OF THE DOMESTIC PAINT INDUSTRY

There are an estimated 1,100 paint companies in the United States, but the four largest producers, Sherwin-Williams, DuPont, PPG Industries, and SCM Corporation (through its Glidden-Durkee division) account for about 30 percent of the total market. Sherwin-Williams, the largest producer, concentrates on the trade sector, although its sales of industrial finishes are significant. Table 8-2 ranks the domestic producers by sales.

A small number of companies supply paint to the automobile industry. General Motors uses DuPont, Inmont, and Glidden as suppliers of paint for passenger cars. DuPont, Cook, and Celanese supply coatings for GM trucks. Ford makes its own paints. Chrysler uses PPG, Celanese, Cook, DuPont, and Inmont. Volkswagen of America purchases its paint from DuPont, Inmont, and Cook and is currently working on primers with PPG and Celanese.

TABLE 8-1. WORLD PRODUCTION OF PAINTS BY SELECTED COUNTRIES, 1975

	Million Pounds
NORTH AMERICA	
United States	8,820
Canada	840
Total	9,660
WESTERN EUROPE	
West Germany	2,664
United Kingdom	1,854
Italy	1,722
France	1,693
Sweden	452
Netherlands	412
Belgium	258
Austria	230
Denmark	216
Norway	163
Switzerland	150
Finland	150
Portugal	84
Total	10,048
EASTERN EUROPE	
Soviet Union	6,650
Poland	979
East Germany	701
Czechoslavakia	452
Roumania	287
Hungary	234
Bulgaria	146
Total	9,449
OTHER COUNTRIES	
Japan	2,519
Cuba	558
Australia	400
Other	2,366
Total	5,843
GRAND TOTAL	35,000

Source: Kline Guide to the Paint Industry, 5th Edition, Charles H. Kline and Company, Inc. Fairfield NJ 07006.

TABLE 8-2. SALES OF U.S. COATINGS PRODUCERS

COMPANY	TYPE OF PAINT*	1977 SALES**	1977 % of CORP. TOTAL	1979 SALES**	1979 % of CORP. TOTAL
Sherwin-Williams	arch., ind.	$425	45%	$540	45%
OuPont Company	arch., ind.	415	4	500	3
PPG Industries, Inc	arch., ind.	375	15	460	17
Glidden (SCM)	arch., ind.	250	17	426	26
Mobil Corporation	arch., ind.	230	+	237	+
Inmont (United Technologies)	ind.	180	14	190	14
Grow Group, Inc	arch., ind.	135	87	202	85
Oesoto, Inc	arch., ind.	191	36	223	68
Benjamin Moore	arch., ind.	110	100	175	100
Insilco Corporation	arch.	105	29	140	24
Ford Motor Company	ind.	100	+	85	+
Reliance Universal, Inc	ind.	100	72	148	73
Dutch Boy	arch., ind.	80	60	95	55
Cook Paint[1]	arch., ind.	75	50	66	100
Valspar	arch., ind.	75	88	110	92
O'Brien	arch., ind.	70	95	115	95
Pratt & Lambert, Inc	arch., ind.	65	79	77	76
Lilly Industrial Coatings	arch., ind.	55	100	81	100
RPM, Inc	arch., ind.	55	100	75	90
Standard Brands	arch.	50	39	50	32
Oexter Corporation	ind.	50	16	80	18
Conchemco[2]	arch., ind.	45	42	--	--
Carboline Company[3]	ind.	40	100	56	100
Celanese Corporation	ind.	40	2	45	2
Kelly-Moore Paint	arch.	40	65	80	80
Koppers Company	ind.	40	3	40	2
Porter Paint Company	arch., ind.	51	100	66	100
Whittaker Corporation	ind.	40	6	85	8
General Paint (Div., Cotter)	arch.	40	5	52	70
Olympic Stain (Comerco)	ind.	35	63	50	72
M.A. Bruder & Sons	arch.	30	100	35	100
Guardsman Chemicals	ind.	30	65	38	68
International Paint	ind.	30	100	40	100
Wyandotte Paing	ind.	30	100	32	100
Cook Industrial	ind.	--	--	30	100

*Arch: architectural coatings. ind: industrial coatings.

**In millions of dollars, excludes manufacturing outside U.S.

+Less than 1 percent.

[1]Cook's industrial coatings operations became Cook Industrial Coatings in 1979, jointly owned with BASF.

[2]Conchemco sold remaining coatings operations to Valspar in 1978.

[3]Carboline is now part of Sun Oil.

Source: "Chemical Marketing Reporter," Oct. 27, 1980, p. 29.

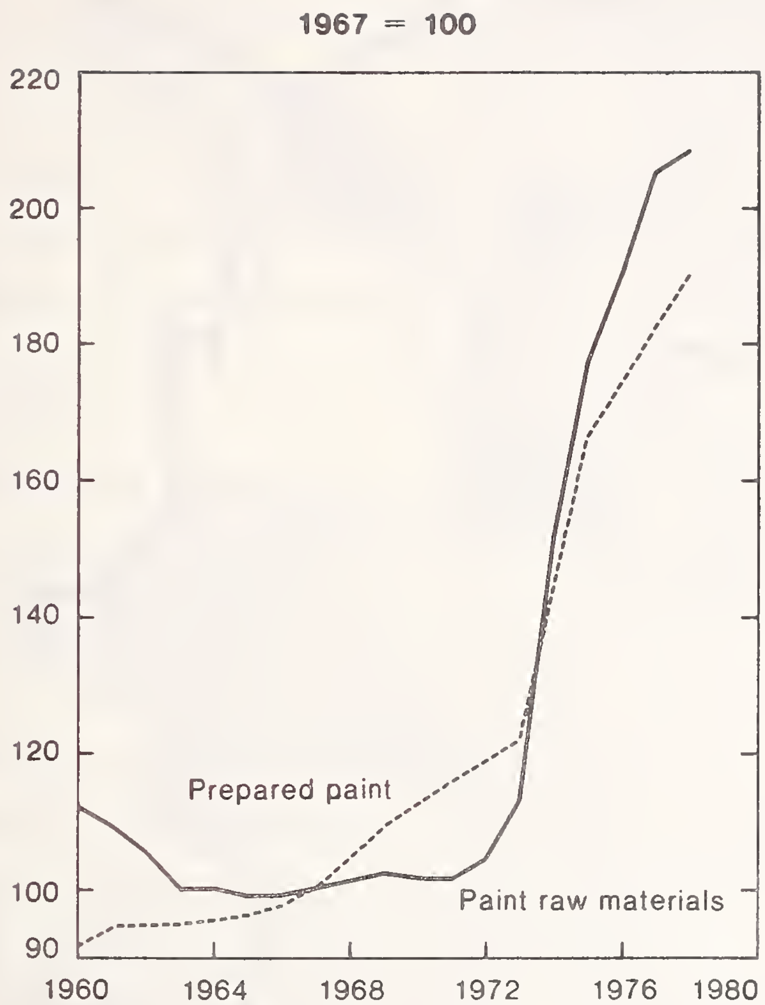
The paint industry is one of the few remaining industries supporting many small companies. Although a few large firms account for a large part of the industry's output, to minimize shipping costs and to lower prices, paint manufacturing plants are located throughout the United States. Small producers can compete with larger firms in regional markets.

The profitability of the paint industry is difficult to determine. Almost all of the larger paint companies are part of diversified operations whose coatings operations are only a small part of total corporate activities. Their profitability on paint sales is not made public. The industry also has a large number of private firms which do not publish financial data.

The paint industry is characterized by a relatively low level of capital investment. In an inflationary period, labor and raw material costs tend to rise rapidly, and in order to maintain profits, these increased costs must be offset by higher selling prices or increased productivity. The limited data available on the paint industry shows that since 1961 profit margins for paint have been consistently lower than the average for all manufacturing. In 1979 the Producers Price Index (PPI) for paint manufacturing averaged 192.3, while the average for paint raw materials came to 212.7. (See Figure 8-1.)

Because the paint industry is highly competitive, price increases are difficult to achieve. Productivity increases are also difficult to achieve because the industry's technology and equipment have long been highly developed, offering little opportunity for radical improvements in manufacturing processes. Productivity gains are for the most part accomplished only through improving the efficiency of established techniques.

Because paint is expensive to ship, its manufacture is concentrated in the geographic regions of highest use. According to data from the 1972 Census of Manufactures, the heaviest concentration remains in the industrial areas of the Northeast. (See Figure 8-2.)



Note: Prices for 1978 based on first six months.
Source: Bureau of Labor Statistics.

FIGURE 8-1. PRICE INDEXES OF PREPARED PAINT AND PAINT RAW MATERIALS, 1960-1978

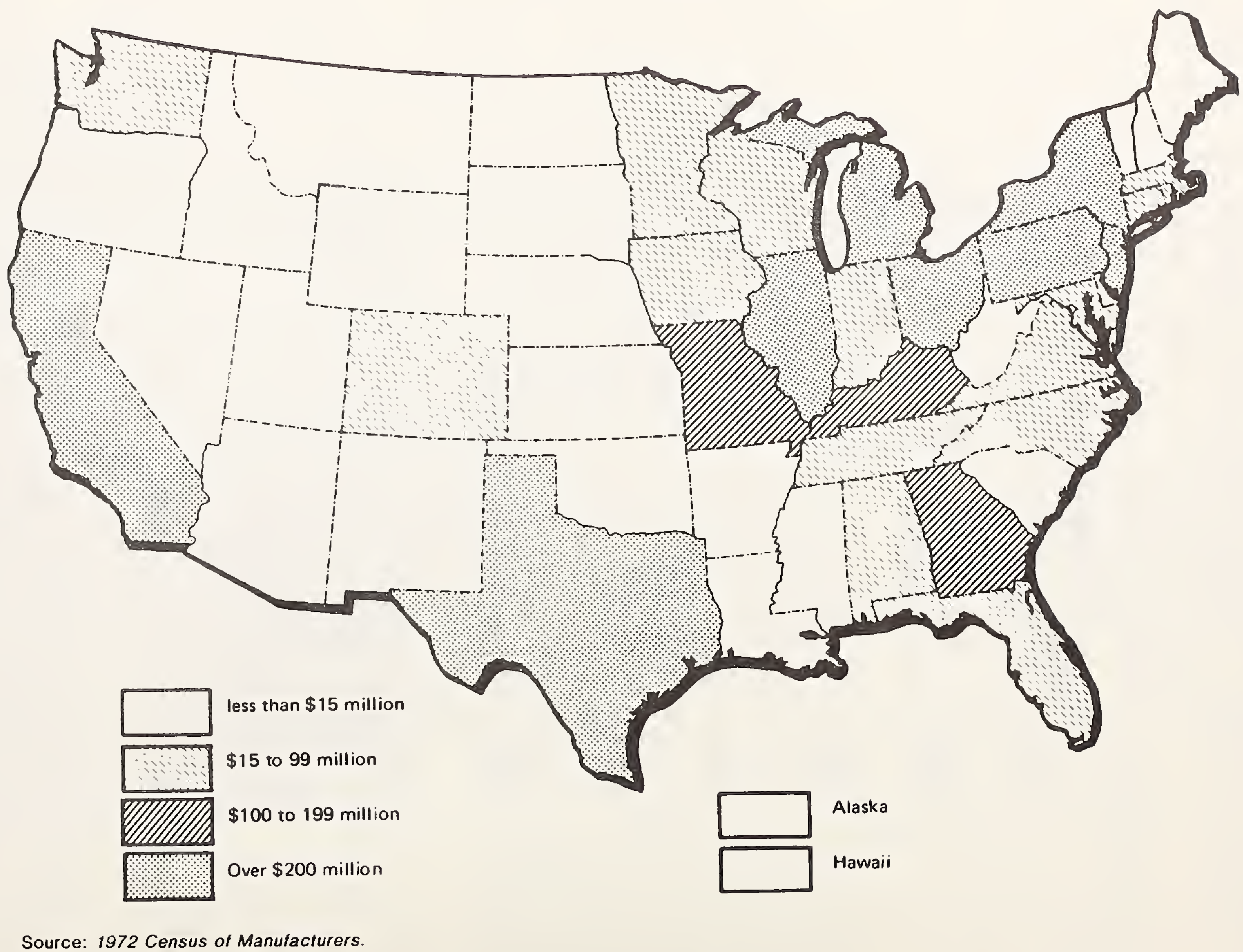


FIGURE 8-2. U.S. SHIPMENTS OF PAINTS AND ALLIED PRODUCTS BY STATE - 1972

Total employment in the coatings industry was 60,600 in 1979, a decline of 1 percent since 1978. Since 1972, the number of production workers has dropped by 9 percent, primarily due to production efficiencies within the industry. Since paint manufacture is not concentrated in one region, the impacts of reduced employment trends will be less than in other more regionally concentrated industries.

During the last decade there has been a gradual decline in the number of paint manufacturing plants from about 1,500 to 1,100. This is not an unexpected behavior in an industry where many firms produce a similar product and price competition is high. Mergers and closures by less efficient firms will tend to reduce the number of firms operating in the industry.

8.3 MARKET TRENDS

The paint market in the past has been divided into two major areas, trade sales and industrial finishes. Trade sales or "shelf goods" included products sold directly to consumers, contractors, and professional painters. Industrial finishes include numerous products for use by manufacturers in the factory or for industrial maintenance and production. Principal industrial customers include manufacturers of furniture, appliances, transportation equipment (autos, ships, and trucks), construction components, farm implements, and the graphics art industry.

Recently, products of the industry were reclassified for statistical purposes. The three classifications are architectural coatings, product coatings OEM (original equipment manufacturers), and special purpose coatings.

Architectural coatings are defined as stock type or shelf goods normally distributed through wholesale and retail channels and purchased by the general public, painters, building contractors, and others. These coatings totalling 415 million gallons in 1977, account for about 4.2 percent of all shipments. Housing and construction activity directly concerns producers of architectural coatings.

Product coatings or finishes account for 40 percent of total shipments. They are formulated specific requirements and are applied to products such as appliances and autos as part of the manufacturing process. Table 8-3 shows a breakdown of product finishes by end use. In 1977, 385 million gallons of product coatings were shipped in the U.S. The automobile industry consumed 50 million gallons or 13 percent of the total. Overall coating sales for passenger cars are expected to be off 30 percent because of the recession and rising imports.*

Special purpose coatings are formulated for special applications and conditions such as industrial maintenance paints, traffic paints, and automotive and machinery refinish coatings. About 18 percent of total shipments fall within this category. Manufacturing activity of most sectors of the U.S. economy affects production and sales of this special purpose group. In 1977, 170 million gallons of special purpose coatings were shipped in the U.S., of which 40 million gallons, or 24 percent, went for automotive refinishes. (See Table 8-4). The balance of total shipments are made up of putty, fillers, aerosols, thinners, and other miscellaneous products.

Overall, the auto industry accounts for 9 percent of paint industry shipments, 5 percent in product coatings, and 4 percent in special purpose coatings.

8.4 TECHNOLOGICAL TRENDS

8.4.1 Overall Paint Industry

In formulating coatings, the paint manufacturer must combine a large number of different raw materials to satisfy many basic requirements such as appearance and performance. The paint industry is perhaps unequaled in the variety and specialization of its finished products. This is especially true of industrial

*"Chemical Marketing Reporter," Oct. 27, 1980, p. 30.

TABLE 8-3. U.S. SHIPMENTS OF PRODUCT FINISHES BY END USE, 1977

PRODUCT	MILLION GALLONS	$ MILLION
Metal Finishes		
Decorating	50	$ 240
Prefinished Stock	30	180
Furniture and Fixtures	25	125
General	20	100
Total, Metal Finishes	125	645
Wood Finishes		
Furniture and Fixtures	55	175
Prefinished Stock	30	135
Total, Wood Finishes	85	310
Transportation Equipment		
Automobiles	50	310
Trucks and Buses	15	95
Railroad, Marine and Other	30	180
Total, Transportation	95	585
Machinery and Equipment	30	160
Appliances	20	130
Packaging	10	50
Miscellaneous	20	100
TOTAL	385	$1,980

Source: Kline Guide to the Paint Industry, 5th Edition, Charles H. Kline and Company, Inc. Fairfield NJ, 1978, p. 42.

TABLE 8-4. U.S. SHIPMENTS OF SPECIAL PURPOSE COATINGS BY END USE, 1977

PRODUCT	MILLION GALLONS	$ MILLION
Industrial Maintenance	65	$ 350
Automotive Refinishes	40	350
Traffic Paints	40	150
Miscellaneous	25	120
TOTAL	170	$ 970

Source: Kline Guide to the Paint Industry, 5th Edition Charles H. Kline and Company, Inc., Fairfield NJ, 1978, p. 45.

and special purpose paints where most products are custom-formulated to do a specific job for a specific customer. The number of formulations of an average plant which makes industrial coatings can easily run into the thousands. One paint plant can require hundreds of different raw materials.*

Techniques for the manufacture of coatings have remained basically the same for years. Coatings are composed of three basic components: (1) the film-forming binder consisting of resins or drying oils; (2) a dispersion medium of volatile solvents or water which maintains fluidity; and (3) a pigment system containing coloring or opacifying materials and various extenders. The binder and the solvent together are often referred to as the vehicle. When a coating is applied to a substrate, the volatile solvent evaporates, leaving the binder and pigment to form a continuous, adherent film.**

All surface coatings orginally used drying oils and natural resins as their film-forming component. Oils and natural resins are still occasionally used alone in architectural paints. However, they are often combined with synthetic resins to impart flexibility and other desirable properties to the coating.

There are many different types of solvents. Terpene solvents are the oldest in use and are obtained from pine trees. They have been largely replaced by aliphatic hydrocarbon solvents. Petroleum and coal-tar hydrocarbon solvents are used because of their good solvent power for oils and resins. Oxygenated solvents (alcohols, esters, ketones, ether alcohols) are used extensively.

There are three basic types of pigments: (1) prime white pigments that contribute whiteness and brightness as well as opacity and hiding power; (2) extender pigments that are used to

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* Kline Guide to the Paint Industry, 5th Edition, Charles H. Kline and Company, Inc., Fairfield NJ 1978, p. 28.

** Kline Guide to the Paint Industry, 5th Edition, Charles H. Kline and Company, Inc., Fairfield NJ, 1978, p. 28.

add solids while reducing costs and to contribute such properties as viscosity, chemical and water resistance, color retention, flow, and package stability, (3) color pigments (natural and synthetic), some of which provide anticorrosion and durability properties.

Although methods of paint manufacture can differ slightly, basically all paints are made in the same way. Pigments are usually added to the vehicle (solvent-binder mixture) by blending the ingredients in large paste mixers. The pigment-vehicle paste consists of imperfectly dispersed aggregates of pigment distributed throughout the vehicle. The material is then put through a roller mill which wets the individual pigment particles and distributes them evenly throughout the vehicle.

Film-forming or curing is accomplished by one or a combination of three general methods: evaporation, oxidation, and polymerization. In evaporation, a solvent can simply volatilize under normal temperature conditions or the process can be accelerated by heating in an oven. In the oxidation process a coating dries by the absorption of oxygen from the air. Polymerization may occur during oxidation when two or more oils combine in a more complex structure.*

Most equipment used by the paint industry is common to many industries and does not require special adaptation for paints. This includes storage tanks, reaction kettles, pumps and motors, filters and strainers, filling and capping equipment, and packaging equipment. The special equipment used by the paint industry is for mixing, dispersing, and grinding. This includes such high speed dispersion mixers as dissolvers, sand mills, colloid mills, rotary batch mixers and blenders, rollers, and grinding equipment. The industry also utilizes many instruments which include electronic devices for color measurement, reflectometers, glossmeters, hazemeters, viscosimeters, thickness guages and testers for hardness, impact, and adhesion.**

*Encyclopedia Britannica, William Benton Publishing, 1966.
**"Automotive News," Jan. 28, 1980, p. 26.

During the 1970s, significant changes took place in the paint industry. Government pollution, safety and consumer protection regulations required changes in paint formulations as well as application systems. Solvent emissions released in the atmosphere (mainly from paint application) and worker exposure to the solvents used prompted the development of water-based, high-solids, urethane, and powder (low-solvent) paints. The use of these new paints required new application systems. Industries that are large users of industrial coatings such as the appliance and the automotive industry had to undergo major conversions of their painting systems to use the new paints and comply with Government regulations.

The paint industry receives a great deal of technical service from its suppliers. They provide technical information on the use of their products, suggested paint formulation, application data, test results, and data on outdoor exposure. Equipment manufacturers and industrial users of coatings account for new developments in application technology.*

Paint companies are cautious in adopting new raw materials. Generally, a new material must offer superiority in an important property to be considered for use over existing materials. Paint technology groups will not consider unknown products whose utility has not been demonstrated. Testing of new materials can take 18 months to 5 years. Accepted materials in established formulations are not generally replaced because of the high cost of reformulating and testing the coating. However, in such coatings as automotive paints, formulations change fairly often as the industry changes styling options and stresses efficiency improvement in applying coatings.

A major advance in paint formulation and manufacture is the growing use of electronic control devices. Such equipment is replacing trained tinters and reducing color matching to two or

*"Automotive News," Jan. 28, 1980, p. 26.

three operations at a considerable saving in cost and time.* Computers are increasingly being used for materials allocation and calculating formulations after the interrelationships of various ingredients have been determined.

The continual improvement of paint products is a long-term consideration that will affect the growth of the paint industry. Thinner coatings with high durability have been developed to meet competition, to offer high performance, and to meet pollution standards. The industry has helped to develop more efficient application methods, such as electrodeposition and electrostatic spraying, which reduce waste and thus paint purchases. Although these factors tend to slow the growth of the gallons of paint sold, on balance the trend is healthy.

Capital requirments for the industry are relatively small. (See Table 8-5.) For the years 1966 to 1976, capital expenditure was a small percentage of sales, averaging about 2 percent. The paint industry is not a large investor in research and development. According to the National Paint and Coatings Association, research and development expenditures for new products were 2.2 percent of sales in 1977. This is below the rate of R&D expenditures for the total chemical and allied products industry, which spends about 2.8 percent of sales on research and development.

8.4.2 Automotive Coatings

The automotive coatings sector is experiencing a period of technological change and will continue to do so. The industry is responding to issues relating to pollution, corrosion, appearance quality, and constant cost pressures. As stated before, solvent emissions from paint application must be reduced. Environmental regulations have been the cause of recent technological change, as noted in section 8.4.1.**

*Kline Guide to the Paint Industry, 5th Edition, Charles H. Kline and Company, Inc., Fairfield NJ 07006, 1978, p. 38.

**"Chemical Marketing Reporter," Oct. 27, 1980, p. 32.

TABLE 8-5. PAINT AND ALLIED PRODUCTS INDUSTRY CAPITAL EXPENDITURES, 1966-1976

(In $Million)

YEAR	NEW BUILDINGS AND STRUCTURES	NEW MACHINERY AND EQUIPMENT	TOTAL	% OF SALES
1966	$24.5	$38.6	$ 63.1	2.1%
1967	28.8	41.9	70.7	2.4
1968	19.5	48.6	68.1	2.2
1969	24.7	44.9	69.6	2.2
1970	31.7	84.8	116.5	3.4
1971	21.7	44.8	66.2	1.8
1972	26.5	55.0	81.5	2.1
1973	21.2	51.4	72.5	1.7
1974	39.8	79.3	119.1	2.4
1975	46.1	75.5	121.6	2.4
1976	42.1	80.3	122.5	2.1
AVERAGE ANNUAL GROWTH RATE 1966-1976	5.6%	7.6%	6.9%	-

Note: Excludes expenditures for used plant and equipment.

Source: Annual Survey of Manufactures, U.S. Department of Commerce.

Water-borne coatings are the only types of paint that have made significant improvements over the conventional types of both primers and topcoats. Water-based formulations are popular because they meet anti-pollution requirements and have excellent performance and application properties.

The single, biggest deterrent to the conversion of plants to water-borne systems is the need for expensive, large-scale, air conditioning equipment to permit their satisfactory application under conditions of high humidity. An additional problem is the energy-intensiveness of the system.

Cathodic electrodeposition, a water-based process, is rapidly emerging as one of the most widely utilized priming systems of the auto industry. General Motors currently uses this method to apply the initial coat on 56 percent of its cars while Ford employs the process on 70 percent of its vehicles.

PPG developed cathodic electrodeposition. In this system car bodies to be coated are submerged completely in an electrodeposition bath filled with corrosion-inhibiting paint particles suspended in a water solution. The metal car body serves as a negative terminal, while electrodes along the wall of the electrodeposition tank act as the anodes or positive terminals. When electric current is applied, the positively charged paint particles are drawn to the negatively charged car body as if it were a magnet. The paint film builds until it insulates the metal and electrodeposition is essentially complete.

The paint systems used for topcoats are regular, solvent-thinned formulations and water-borne enamels. However, industry experts say that conventional auto finishes will be virtually obsolete by the mid-1980s, due to increasingly stringent demands for better surface quality finishes and cost pressures inherent in water-based coatings. The most promising low emission, energy-efficient products of the future are high-solid paints.*

*"Chemical Marketing Reporter," Oct. 27, 1980, p. 34.

High-solids technology involves greatly reducing the solvent content of paint formulations while increasing the amount of pigments and resins or solids. By lowering the amount of solvents in every gallon of paint, the amount of hydrocarbons released into the air is reduced. At the same time, high-solids still have the diverse capabilities of solvents.

The manager of paint production for one of the domestic automotive companies contends that high-solids are superior to water-based coatings in two areas. While water-borne coatings have low-solvent content, the probability of obtaining high transfer efficiencies is less than with high-solids coatings. In addition, a water-borne system is very energy-intensive because of the rather expensive equipment required to control temperature and humidity. Another advantage of high-solids over other systems is that major changes in application methods are unnecessary.

The use of high-solids coatings reduces the amount of paint needed per car. Jeep Corporation, a subsidiary of American Motors Corporation, is one of the first automotive manufacturing operations in the U.S. to begin a complete conversion to high-solids topcoat technology. From a sprayer's standpoint, the high-solid paints are easier to apply because a better, faster film build is obtained. Currently, Jeep finishes most of its vehicles with conventional air spray guns, though the corporation has been testing electrostatic spray equipment to improve transfer efficiency.*

In the electrostatic spray system, an electrostatic charge draws the atomized paint particles to the grounded part until baking fuses them together and to the metal. This method has the capacity to curb solvent emissions by 60 percent. It also should reduce the amount of paint needed per unit by 30 to 40 percent. Using less paint during application also contributes to reduced solvent emissions, and greater coating efficiency results in less waste and pollutants.

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*"Chemical Marketing Reporter," Oct. 27, 1980, p.34.

Automotive coating research is not limited to the major, metal body parts. The increased use of flexible plastic and rubber components on many front and rear end assemblies brought about the need for a new low-solvent, elastomeric coating. PPG has met this need with a paint that is the initial entry of water-borne technology into the automotive elastomeric coatings market.*

Paint prices could go up as much as 60 to 80 percent over the next 5 years, as paint producers try to recover both the cost of the higher concentration of material and the cost of the new technology. In the long run, market forces will ultimately determine the price structure.

8.5 WORLDWIDE INDUSTRY STRUCTURAL CHANGES AND POTENTIAL IMPACTS ON U.S. INDUSTRY

No significant changes in the structure of the paint industry are contemplated for the next decade.

Although the number of firms will continue to decline because small companies are being squeezed out by the cost of the required sophisticated technology, this trend will not materially affect the industry in the future. Recently, raw material suppliers have cut back on some of their technical service to paint companies. The smaller companies have relied on this service to compete effectively with the larger companies. On their own, they cannot afford the large expenditures required for product development. However, proximity to local markets will sustain many smaller paint dealers in competition with larger companies, none of which holds a significant share of a single, local market. Large paint manufacturers thrive primarily by having small pieces of many markets.

The large corporations such as DuPont, PPG Industries, SCM, and Mobil produce paint only as a minor part of their total business. Changes in consumption of paints will not have a major effect on these companies.

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*"Chemical Marketing Reporter," Oct. 27, 1980, p. 34.

The industry should maintain a rate of growth slightly below its long-term average in the future. Paints face competition from such materials as stainless steel, plastics, stone, glass, wall coverings, and porcelain enamel, but competition from these sources has existed for a number of years and paint has already proven that it cannot be substantially replaced. It is the most flexible material for decorating, allowing frequent color changes at reasonable costs and providing a wide range of choices. Also many of the competing materials either require or are improved by the use of paint. For example, plastic furniture and exterior automotive parts are almost always painted. Coatings provide not only decoration, but also the necessary corrosion and environmental protection unavailable from other materials.

8.6 GOVERNMENT/INDUSTRY RELATIONSHIPS

As with other chemical producers, paint manufacturers are facing increased controls through Government regulations. Standards have been established for all aspects of paint manufacture, from the use of specific raw materials to the transportation and application of coatings products.*

A major issue confronting the coatings industry is the EPA's efforts to control the emission of volatile organic compounds in order to comply with the Clean Air Act Amendment of 1977. Under this amendment, the emission of solvents and other organic compounds from surface coating operations must be reduced to meet Federal standards. Evaporating paint solvents are the major violators of Ambient Air Quality Standards. (Ambient standards limit total air pollution from all sources in an area.**)

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*Kline Guide to the Paint Industry, 5th Edition, Charles H. Kline and Company, Inc., Fairfield NJ 07006, 1978, p. 24.

**"Automotive News," Jan. 28, 1980, p. 26.

Water pollution regulations also affect the paint industry. Under the Federal Water Pollution Control Act, the EPA was required to establish effluent guidelines for 28 groups of industrial polluters. These guidelines govern the amount and the chemical, physical, and biological characteristics of effluents that may be dumped into the waterways.

The EPA is also in the process of developing a second level of water pollution control for a number of industries including the paint and ink formulation industries. The agency is attempting to establish a "zero discharge" level for both direct and indirect discharges.

The regulation of toxic substances indirectly affects the paint industry. The Toxic Substances Control Act (TSCA), passed in 1976, gives the EPA responsibility for establishing standards on the use of toxic chemicals. The act is intended to prevent unreasonable risks of injury to health or the environment, associated with the manufacture, processing, or distribution in commerce, use, or disposal of chemical substances. Since most paint products are considered to be mixtures, it is the ingredient suppliers to the industry that are affected.* Polychlorinated biphenols (PCBs) are the only materials regulated under TSCA that affect the industry. Under this act, the EPA has set a standard of 50 parts per million PCBs in pigments. The industry responded by developing new processes that conform to this standard.

Under the Resource Conservation and Recovery Act, effective in November 1980, the coatings industry is forced to comply with numerous regulations, governing the generation, transportation, treatment, packaging, labeling, storage, and disposal of hazardous wastes.

A number of other acts and regulations affect the coatings industry, such as the National Education and Disease Prevention Act. This act established the levels of lead and mercury in

*Kline Guide to the Paint Industry, 5th Edition, Charles H. Kline and Company, Inc., Fairfield NJ 07006, 1978, p. 26.

paints. The Occupational Safety and Health Act of 1970 grants to the Occupational Safety and Health Administration (OSHA), the authority to set workplace standards relating to dust particle exposure, noise levels, and the handling and storage of hazardous materials. The Consumer Product Safety Commission protects the industry's customers by regulating what can be bought and sold. The Hazardous Materials Control Act of 1970 regulates the transportation of flammable chemicals and other dangerous materials. Regulations are primarily concerned with the type and construction of containers used in shipping with specifications for flash points, pressures, viscosities, and weights.*

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STANDARD AND POOR'S INDUSTRY SURVEYS. Standard Poor's Corporation, 345 Hudson Street, New York NY 10014. Weekly.

KLINE GUIDE TO THE PAINT INDUSTRY. Charles H. Kline And Company, Inc., 330 Passaic Avenue, Fairfield NJ 07006. Triennial.

U.S. INDUSTRIAL OUTLOOK, 1980. U.S. Department of Commerce, Bureau of the Census, Washington DC 20402.

*Kline Guide to the Paint Industry, 5th Edition, Charles H. Kline and Company, Inc., Fairfield NJ 07006, 1978, p. 27.

9. THE CASTING INDUSTRY

9.1 WORLD PRODUCTION AND INTERNATIONAL TRADE

The capacity of the metal casting industry in the U.S. is estimated to be 31 million tons* while current production has fluctuated between 21.9 (1973)**, and 14 million tons (1980)***. World production in 1978 and 1979 was approximately 100 million tons, 90 percent of which were ferrous castings.† The U.S. produces about one-fifth of total world casting supply. The U.S. ranks among the top five producers of ferrous castings and leads in production of aluminum castings. The other major producers are the Soviet Union, Japan, China, and West Germany. These countries produce 70 percent of the world's ferrous castings and 60 percent of the world's aluminum castings.

World capacity figures are not available. Due to the lack of data on world casting capacity, worldwide shifts in casting capacity cannot be determined. Production figures can be used, however, as an approximation of capacity. As shown above, the five major producers dominate world production of castings. Because of the concentration of production in the top five countries, year to year shifts in production worldwide are minor.

Import and export of castings account for less than 5 percent of U.S. production. Although this is a small portion of the market, there are noteworthy trends. The U.S. enjoys a trade surplus in total ferrous castings, but in 1979 trade shifts occurred for ferrous castings not classified as a part of machinery. Prior to 1979, these U.S. ferrous exports exceeded imports. In 1979 imports rose 20 percent while exports declined 70 percent. The total balance of trade did not change, but trading countries changed. The trade changes occurred among the U.S. , Canada, and India. In

*Metal Casting Industry Census Guide 1979, Penton Publications Foundry M&T, p. 47.
**Metal Casting Industry Census Guide, 1979, p. 3.
***"Modern Casting," January 1981, p. 44.
†"Modern Casting," December 1980, p. 25.

1979 U.S. casting exports to Canada dropped by half and India became a significant source of castings for the U.S. Even with these changes, Canada remains our major casting trade partner.* Similar trading information for world markets is unavailable.

U.S. casting production is currently running well below capacity and is projected to remain below capacity in 1981. Constraints on production may arise, however, from material shortages. Due to the projected aluminum shortfall of 1 to 1.5 million tons, conversion from iron casting to aluminum casting may be slowed.**

An industrywide constraint on production could occur if scrap prices rise to the March 1979 high of $130 a ton or if export levels approach that of 1974 when the Department of Commerce restricted scrap exports.*** Since the current U.S. production level is 30 percent below the 1979 level, the supply of scrap is expected to more than adequately meet demand. Although data on worldwide supply and demand for castings is unavailable, the observations concerning the U.S. production constraints also apply to the world casting market.

9.2 STRUCTURE OF THE DOMESTIC INDUSTRY

There are approximately 3,800 companies producing castings in the U.S. The largest 100 companies employ 45 percent of the foundry workers† in the U.S. and 16 percent of all workers are employed by the top ten companies. Table 9-1 lists the largest employers in the casting industry. General Motors Corp. and Ford Motor Co. lead the list followed by Textron Inc., International Harvester, and NL Industries Inc. Of the top five employers, all

*U.S. Industrial Outlook 1980, U.S. Department of Commerce, p. 174-176.

**"Modern Casting," January, 1981, p. 43.

***U.S. Industrial Outlook 1980, U.S. Department of Commerce, p. 175.

†Employment figures include employees engaged in the production of castings but exclude administrative personnel or other company employees working in other product divisions. Employment figures include captive foundries not classified by the census as such. Because TSC includes captive foundries, TSC estimates are larger than U.S. census figures for foundries and employment

TABLE 9-1. TOP TEN EMPLOYERS IN THE U.S. CASTING INDUSTRY

COMPANY	EMPLOYEES (Percentage)
General Motors Corp.	6%
Ford Motor Co.	2
Textron Inc.	1
International Harvester Co.	1
NL Industries Inc.	1
Outboard Marine Corp.	1
Midland-Ross Corp.	1
Rockwell International Corp.	1
National Steel Corp.	1
Abex Corp.	1
Total Percentage of U.S. Foundry Employees	16

Source: TSC Data Base.

except International Harvester provide castings to the passenger car market. Textron Inc. includes CWC-Castings Division, and NL Industries is the parent company of Doehler-Jarvis. Both companies supply automotive castings.

In 1980, there were 4,279 foundries in the U.S. The majority of these foundries employ less than 50 workers. Table 9-2 shows the distribution of foundries by number of employees. Only 14 foundries in the U.S. employ more than 2,500 employees. Of the largest foundries, eight are General Motors facilities,* two are Ford plants, and one is a Textron casting plant. Clearly, automotive foundries dominate the industry. The remaining three foundries are listed as American Cast Iron Pipe Co., National Steel Corp., and Caterpillar Tractor Co.

Even though foundries are located in every state, they are concentrated in the North Central region. Figure 9-1 shows the states in which 70 percent of U.S. foundries are located. Table 9-3 lists the number of foundries per state. Similarly, casting employment concentrates in the North Central region. Figure 9-2 displays the eight states where two-thirds of the casting employees are located. Table 9-4 lists the states in Figure 9-2 in descending order of percentage of U.S. employment. Total U.S. casting employment is approximately 450,000.** This figure includes captive and jobbing casting workers. Jobbing foundries produce castings for an outside customer while captive foundries produce castings for internal use.

The casting industry is divided by type of metal cast and casting process. The major division is by type of metal, ferrous or nonferrous. Ferrous includes: gray, malleable, ductile, and steel. Nonferrous includes: aluminum, copper-based, zinc, magnesium, and all other metals. Of the 4,279 foundries in the U.S., 1701 cast ferrous metals primarily, while 2,578 foundries cast nonferrous metals. Although the ferrous foundries are only one-

*TSC Data Base.
**Metal Casting Industry Census Guide 1979, p. 9.

TABLE 9-2. FOUNDRIES IN THE U.S. BY EMPLOYMENT SIZE

NUMBER OF EMPLOYEES	NUMBER OF FOUNDRIES	PERCENTAGE OF TOTAL	CUMULATIVE PERCENTAGE
(1-9)	1,047	24.5%	24.5%
(10-19)	689	16.1	40.6
(20-49)	993	23.2	63.8
(50-99)	656	15.3	79.1
(100-249)	563	13.2	92.3
(250-499)	212	5.0	97.3
(500-999)	70	1.6	98.9
(1000-2499)	35	0.8	99.7
(2500+)	14	0.3	100.0
Total Foundries	4,279		

Source: TSC Data Base.

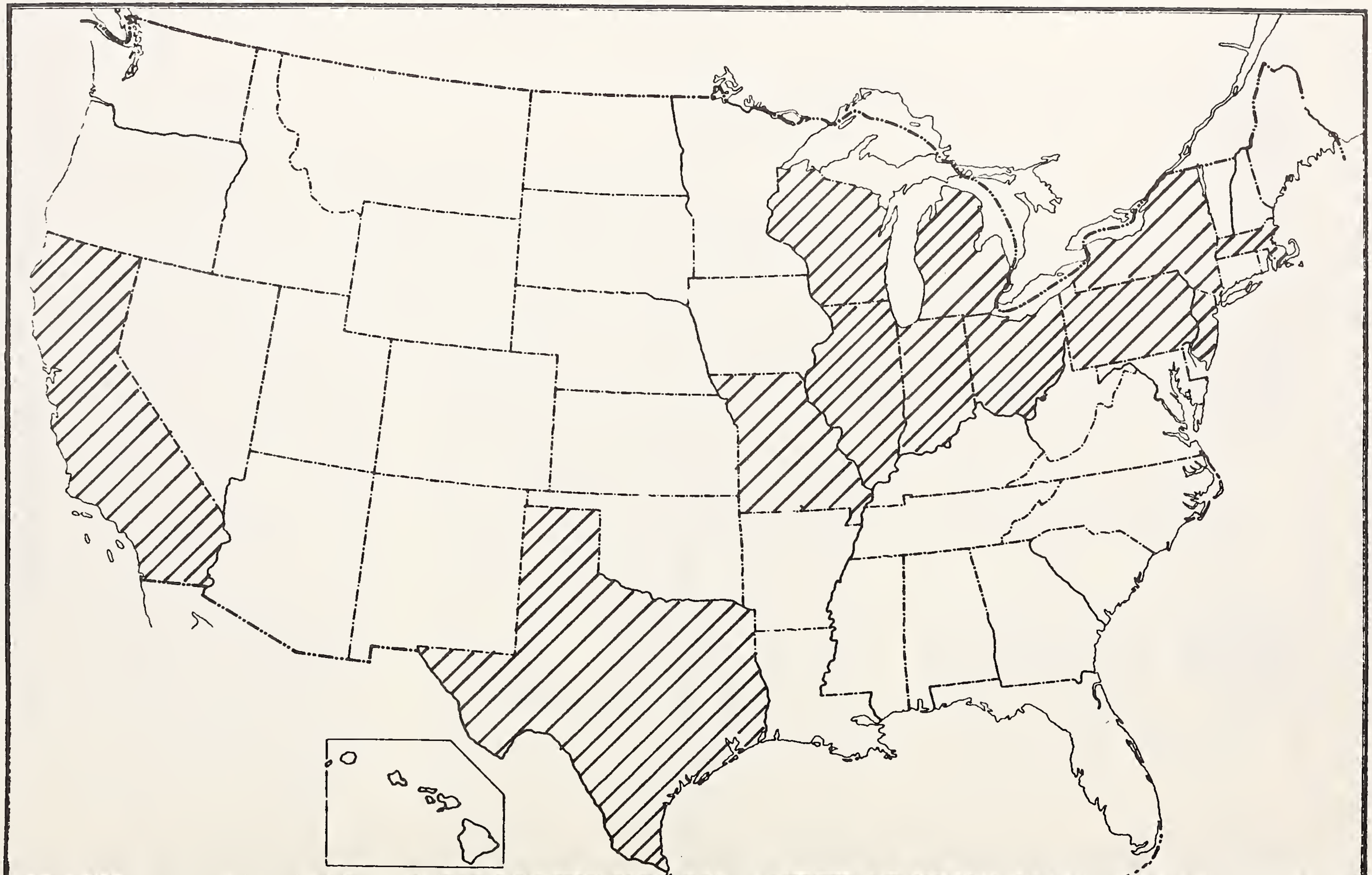

FIGURE 9-1. STATES WITH 70 PERCENT OF ALL DOMESTIC FOUNDRIES

TABLE 9-3. STATES WITH 70 PERCENT OF ALL DOMESTIC FOUNDRIES

STATE	NUMBER OF FOUNDRIES
Ohio	443
California	413
Pennsylvania	362
Michigan	334
Illinois	301
New York	252
Wisconsin	192
Texas	185
Indiana	185
Massachusetts	135
New Jersey	122
Missouri	111
Total 12 States	3035
Total U.S.	4279

Source: TSC Data Base.

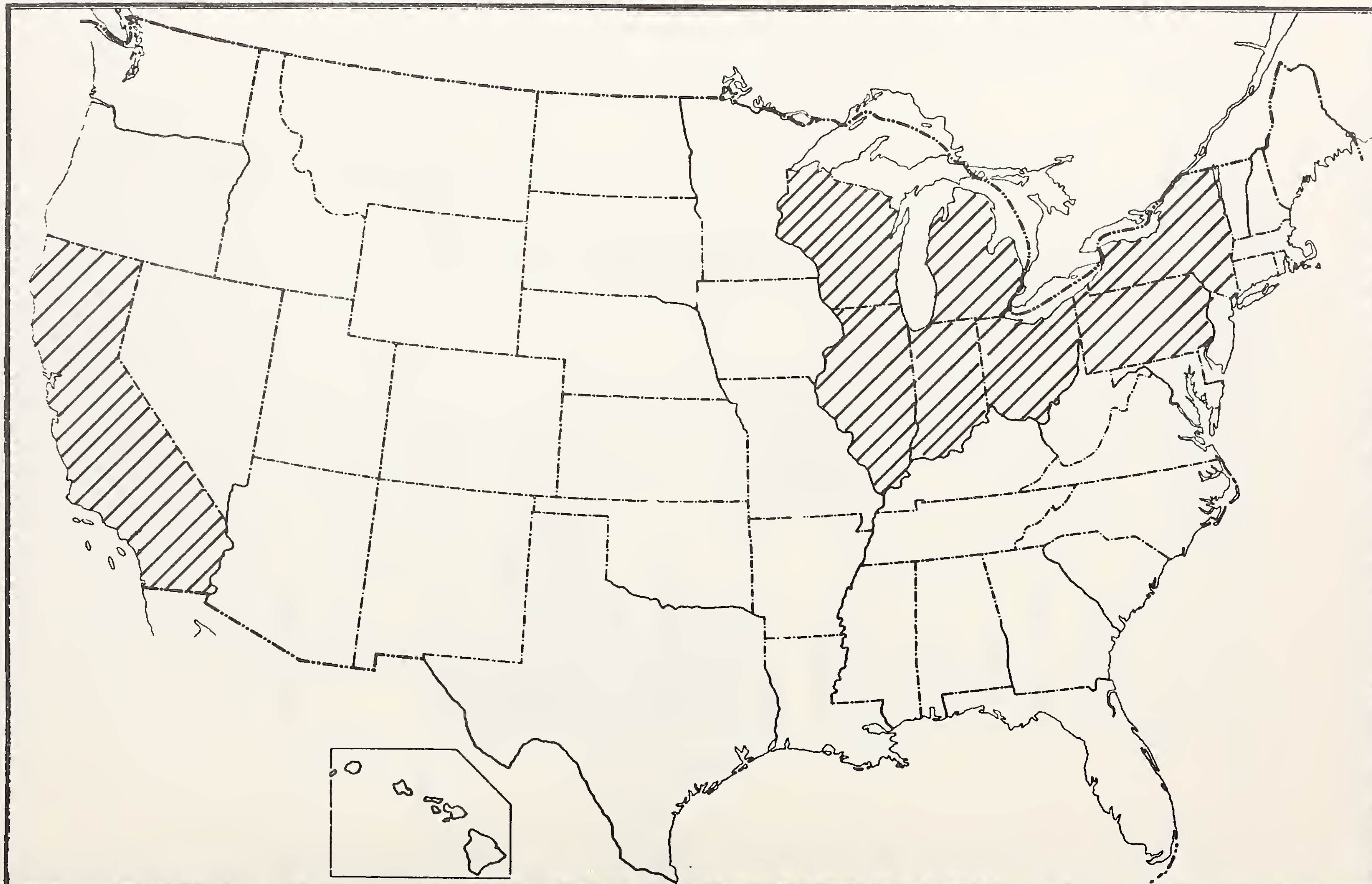

FIGURE 9-2. STATES WITH 67 PERCENT OF DOMESTIC FOUNDRY EMPLOYMENT

TABLE 9-4. CASTING EMPLOYMENT BY STATE

STATE	PERCENTAGE OF U.S. CASTING EMPLOYMENT
Michigan	14
Ohio	13
Pennsylvania	9
Illinois	8
Wisconsin	7
Indiana	6
New York	5
California	5
Total Percentage of U.S. Casting Employment	67

Source: TSC Data Base.

third of the total U.S. foundries, they employ two-thirds of all casting workers. The nonferrous foundries, which comprise two-thirds of U.S. foundries, employ only one-third of casting workers. Ferrous and nonferrous foundries are geographically concentrated in the eight states shown in Figure 9-2. In Table 9-5, the ferrous and nonferrous foundries are ranked by number of foundries per state in descending order. Ohio ranks first for ferrous foundries and California leads the nonferrous list.

Thus far, the casting industry has been discussed in terms of its distribution of foundries and employment in the U.S. In order to understand the significance of the casting industry to the U.S. economy, it is necessary to examine the industry in relation to other domestic manufacturers.

Metal casting is ranked fifth among industries in value added by manufacture.* The casting industry has been growing in production and product value. The current production peak occurred in 1973. Table 9-6 shows casting value doubling over the decade while shipments rose by a few thousand tons. The large rise in casting value is due to price changes and the fact that casting size is decreasing.

Production shipments consist predominantly of ferrous castings. Shipments for 1979 by type of metal cast appear in Table 9-7. Ferrous castings amount to 90 percent of casting shipments in 1979, with gray castings alone accounting for over 60 percent of shipments. The dominance of ferrous castings can be seen in Table 9-8 which shows casting production by metal from 1953 to 1977. A review of Table 9-8 also reveals the growth of aluminum casting production which now accounts for 5 percent of all castings.

The captive auto casting plants contain 15 percent of the U.S. casting capacity. General Motors' combined casting capacity for 24 foundries is estimated to be 3.1 million tons per year.** The six

*1975 Annual Survey of Manufacturers, U.S. Department of Commerce.
**Metal Casting Industry Census Guide 1979, p. 5.

TABLE 9-5. FERROUS AND NONFERROUS FOUNDRIES IN THE U.S.

STATE	FERROUS FOUNDRIES		U.S. FERROUS EMPLOYMENT (Percentage)
Ohio	183		13%
Pennsylvania	180		10
Michigan	141		15
California	104		3
Wisconsin	103		8
Illinois	92		8
Indiana	80		6
New York	71		5
Total Eight States	954	56%	68
Total U.S. Ferrous	1701		
STATE	**NONFERROUS FOUNDRIES**		**U.S. NONFERROUS EMPLOYMENT (Percentage)**
California	309		10%
Ohio	260		12
Illinois	209		8
Michigan	193		9
Pennsylvania	182		7
New York	181		7
Indiana	105		6
Wisconsin	88		7
Total Eight States	1527	59%	66
Total U.S.	2578		

Source: TSC Data Base.

TABLE 9-6. METAL CASTING GROWTH

YEAR	CASTING PRODUCTION (Millions of Tons)	CASTING VALUE (Billions of Dollars)
1961	13.8	$ 6.0
1962	15.2	7.3
1963	16.7	7.7
1964	18.7	8.6
1965	20.5	9.6
1966	20.8	9.9
1967	18.9	10.5
1968	19.5	11.2
1969	20.8	12.3
1970	18.0	11.3
1971	17.8	11.6
1972	19.6	13.8
1973	21.9	17.0
1974	20.2	17.8
1975	16.4	16.4
1976	18.4	20.2
1977	19.4	22.1
1978	19.6	23.0

Source: Metal Casting Industry Census Guide, 1979, Penton Publications, p. 3.

TABLE 9-7. U.S. CASTING SHIPMENTS

FERROUS CASTINGS	SHORT TONS	TOTAL SHIPMENTS (Percentage)
1979		
Gray Iron	11,797,000	63%
Ductile Iron	2,690,000	14
Malleable	720,000	4
Steel	2,033,000	11
Total Ferrous	17,240,000	92
NONFERROUS CASTINGS		
1979		
Copper	296,266	2
Aluminum	992,032	5
Zinc	258,526	1
Magnesium	16,366	-
Lead	12,670	-
Total Nonferrous	1,575,860	8
Total Castings	18,815,860	100

Source: Current Industrial Reports, U.S. Department of Commerce.

TABLE 9-8. CASTING PRODUCTION IN THE U.S.

(Thousands Of Tons)

Year	Gray Iron	Ductile Iron	Malleable	Steel	Copper-Base Alloys
1977	12.683	2,734	832	1,721	290
1976	11,923	2,245	848	1,804	274
1975	10,622	1,824	731	1,938	256
1974	13,459	2,203	914	2.090	332
1973	14,801	2,246	1,031	1,894	390
1972	13,493	1,835	961	1,596	381
1971	11,728	2,111	884	1,583	352
1970	12.338	1,607	852	1,724	375
1969	14,679	1,254	1,172	1,897	426
1968	14.097	1,033	1,007	1,730	396
1967	13,466	863	1,041	1,857	483
1966	14,931	785	1,131	2,156	503
1965	15,128	585	1,136	1,961	445
1964	13,838	478	1,001	1,835	446
1963	12,391	373	933	1,504	426
1962	11,321	232	868	1,423	403
1961	10,649	175	723	1,217	365
1960	11,424	170	821	1,392	380
1959	12,135	173	916	1,413	436
1958	10,253	118	661	1,121	381
1957	12,665	n.a.	863	1,766	437
1956	13.861	n.a.	952	1,932	483
1955	14.838	n.a.	1,105	1,531	504
1954	11,532	n.a.	882	1,184	418
1953	13,708	n.a.	971	1,834	495

Year	Aluminum	Magnesium	Zinc	All Other Metals	GRAND TOTAL
1977	1,008	24	308	15	19,615
1976	921	19	347	16	18,397
1975	688	16	286	18	16,379
1974	880	24	347	19	20,268
1973	1.013	23	454	20	21,872
1972	928	21	399	23	19,637
1971	787	22	368	22	17,857
1970	753	17	348	23	18,037
1969	849	21	439	23	20,760
1968	794	21	426	23	19,527
1967	767	20	419	14	18,930
1966	820	22	487	15	20,850
1965	704	16	532	21	20,528
1964	627	16	458	15	18,714
1963	604	17	402	15	16,665
1962	583	16	393	14	15,253
1961	381	12	301	8	13,831
1960	387	12	311	10	14,907
1959	393	14	316	11	15,807
1958	321	14	250	10	13,129
1957	376	15	335	12	16,469
1956	397	18	347	11	18,001
1955	413	14	389	11	18,805
1954	312	13	260	9	14,550
1953	329	17	261	10	17,625

NOTE: Nonferrous casting production data beginning 1962 is derived from different census sampling base and according to Bureau of the Census is not directly comparable with figures from previous years.

n.a = not available

Source: Metal Casting Industry Census Guide 1979, Penton Publications, p. 60.

Ford foundries have an estimated capacity of 1.8 million tons and Chrysler's five foundries combined capacity is .6 million tons. Combined, these captives could produce 5.5 million tons of the total 31 million ton U.S. casting capacity.*

In addition to the captive casting supply, the major automakers source castings from an estimated 500 to 600 companies. The volume of automotive casting demand is estimated to be 4 million tons (see section 9.3, Table 9-11). Of the 4 million tons, one-fourth of this is estimated to be provided by jobbing foundries and the remainder is produced by captive foundries.** Information disclosing which companies are the major suppliers to the automaking industry is not available. A partial list of large foundries, some known to be dependent on sales to the automotive market, is presented in Table 9-9.

For some U.S. companies, capacity information and product destinations are available. Table 9-10 lists companies which have a combined casting capacity of almost 10 million tons per year (one-third of U.S. capacity). Such information is not available for all U.S. casting foundries.

Since company information concerning current operations is sketchy, it is difficult to predict how the U.S. companies are adjusting to future market trends.

The market trends for ferrous and nonferrous casting are quite different. The ferrous casting industry is projected to grow 3 to 3.5 percent between 1981 and 1985.*** Aluminum castings grew 9 percent between 1978 and 1979† and is generally projected to be a growing portion of casting production. An indication of what these market changes mean in terms of casting foundry opera-

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*Metal Casting Industry Census Guide 1979, p. 47.

**Potential Impacts on Iron Foundries from Substituting Castings in the Automotive Industry, Arthur D. Little, August 1980, p. 22.

***U.S. Industrial Outlook 1980, U.S. Department of Commerce, p. 177.

†U.S. Industrial Outlook 1980, U.S. Department of Commerce, p. 191.

TABLE 9-9. MAJOR FOUNDRIES

COMPANY	MONTHLY IRON CASTING PRODUCTION UNITS	TYPE OF FOUNDRY	PERCENT TO AUTO INDUSTRY
General Motors Central Foundry	100,000	Captive	
Lynchburg Foundry	25,000		50
Deer & Company	22,000	Captive	
Wheland	20,000		90
CWC-Textron	17,000		25
Hayes-Albion	16,000		75
International Harvester	15,000	Captive	
Caterpillar Tractor	12,000	Captive	
Waupaca	12,000		
Dayton Malleable	11,000		30
Brillion	8,800		
Neenah	8,500		
East Jordan Iron Works	6,600		
Eaton Corporation	6,500		
Auto Specialties	5,400		
Columbus	5,000		50

Source: Iron, Steel and Aluminum Suppliers to the Automotive Industry, Booz, Allen and Hamilton, July 1979, p. 6.

TABLE 9-10. ANNUAL CAPACITY OF MAJOR CASTING COMPANIES

COMPANY	STANDARD INDUSTRIAL CODE	PRODUCT DESCRIPTION	NUMBER OF FOUNDRIES	ANNUAL CASTING CAPACITY (TONS)
Abex Corp.	356	General Industrial Machinery	19	180,600
Bendix Corp.	3714	Motor Vehicle Parts and Accessories	3	36,300
Bethelehem Steel Corp.	331	Blast Furnaces and Steel Mills	4	47,000
Caterpillar Tractor Co.	3523	Farm Equipment and Machinery	1	180,000
Chrysler Corp.	371	Motor Vehicles and Equipment	5	603,600
Crane Company	343	Heating and Plumbing Fixtures	6	69,600
Deere and Co.	352	Farm and Garden Machinery	5	397,900
Dresser Industries	353	Construction, Mining & Material Handling Equip.	6	134,400
Eaton Corp.	3714	Motor Vehicle Parts and Accessories	5	7,500
	342	Tools & Hardware		
FMC Corp.	353	Construction, Mining, & Material Handling Equip.	5	22,000
	356	General Industrial Machinery		
	3551	Food Products Machinery		
Ford Motor Company	371	Motor Vehicles & Equipment	6	1,800,000
General Electric Co.	362	Electrical Industrial Apparatus	17	66,700
General Motors Corp.	371	Motor Vehicles & Equipment	24	3,113,300

Source: Metal Casting Industry Census Guide 1979, Penton Publications, p. 5.

TABLE 9-10. ANNUAL CAPACITY OF MAJOR CASTING COMPANIES (CONT.)

COMPANY	STANDARD INDUSTRIAL CODE	PRODUCT DESCRIPTION	NUMBER OF FOUNDRIES	ANNUAL CASTING CAPACITY (TONS)
General Signal Corp.	374 366	Railroad Equipment Communication Equip.	6	48,000
International Harvester Co.	352	Farm & Garden Machinery	4	276,000
Midland Ross Corp.	355 3714	Industrial Machinery Motor Vehicle Parts	8	278,400
Outboard Marine Corp.	373 351	Ship & Boat Building Engines & Turbines	3	45,800
Rockwell International	382 343	Measuring & Controlling Instruments Heating & Plumbing Fixtures	9	177,300
TRW Inc.	3714 372	Motor Vehicles Parts & Accessories Aircraft & Parts	6	71,600
United States Steel Corp.	331	Blast Furnaces & Steel Mills	9	500,000
Total			151	8,056,000

Source: Metal Casting Industry Census Guide 1979, Penton Publications, p. 5.

tions and capital investment plans can be found by reviewing current changes at General Motors foundries.

General Motors has closed the Buick Division, Flint MI foundry to reduce iron casting production and is expanding the aluminum casting facilities in Bedford IN and Massena NY by 144,000 sq.ft. and 179,500 sq.ft., respectively.* Iron casting capacity has also been reduced by Ford with the closing of its Windsor and Dearborn foundries, and Chrysler with the closing of the Huber Ave. foundry in Detroit MI.

Similar capacity adjustments have been reported at Dayton-Malleable, which ships about one-third of its products to the automotive market. Dayton-Malleable closed its iron casting facility in Columbus OH and expects to complete construction of an aluminum casting plant in Springdale AR in 1981. The new plant will produce steering, air conditioning, and brake parts for passenger cars.**

Capital expenditures in the foundry industry, as in any industry, are based on the expectation of a good return on capital derived from a strong market demand. The current market demand for casting has weakened as evidenced by the drop in production. During 1980, casting production fell 30 percent below 1979 levels and casting foundries operated at 70 to 80 percent of capacity.*** Orders for new equipment in 1980 declined 4 percent from the 1979 level.† Given the current recessionary climate, aluminum casting industry expansion plans may be delayed until the casting industry recovers to higher capacity utilization levels.

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*"Ward's," General Motors Foundry, Oct. 13, 1980.

**Dayton Plans Aluminum Foundry in '81 from "American Metal Market," June 9, 1980, p. 24.

***Foundrymen Cautiously Optimistic, "Modern Casting," January 1981, p. 44.

†Foundrymen Cautiously Optimistic, "Modern Casting," January 1981, p. 45.

9.3 MARKET TRENDS

As discussed in section 9.2, the casting market is divided by type of metal cast. Just as most ferrous castings are gray castings, most nonferrous castings are aluminum. The other nonferrous metals are produced in negligible quantities. Table 9-11 shows the top five markets for gray and malleable steel, and aluminum castings. Motor vehicle parts consumed 53 percent of all gray castings and 35 percent of aluminum castings shipped to manufacturers in 1972.

Automotive dominates the gray and aluminum market while construction machinery and railroad equipment consume about 40 percent of steel castings. Updated information for the manufacturer casting markets will not be available until the Bureau of the Census releases the 1977 series of Selected Materials Consumed.

Current market data is available from industry publications and studies which indicate permanent shifts occurring in the automotive market. A TSC projection of this shift appears in Table 9-12. The automotive requirements for iron castings is estimated to decline by as much as 1.2 million tons and for aluminum castings to increase by as much as 300 thousand tons. A drop of 1 to 2 million tons in the automotive market for ferrous castings has been predicted in the literature.

Several studies have estimated the extent of the conversion from iron to aluminum castings. Projections of the substitution per car appear in Table 9-13. A review of Table 9-13 confirms that the weight of iron castings per car is generally projected to drop from about 600 to 300 lbs by 1985 and the weight of aluminum castings per car is projected to increase from 50 to 120 lbs by 1985.

Although the various estimates do not agree concerning actual pounds material/car, a major shift away from iron castings is indicated in Table 9-12 and 9-13. This shift was projected to be absorbed in 1978 by the market growth for iron castings as shown in Table 9-14. Current production figures, however, show a downturn in ferrous markets.

TABLE 9-11. TYPES OF CASTINGS BY CONSUMING INDUSTRY

GRAY AND MALLEABLE CASTINGS			
SIC	CONSUMING INDUSTRY	TONS (000)	%
3714	Motor Vehicle Parts and Accessories	3,870.0	53
3519	Internal Combustion Engines N.E.C.	425.2	6
3523	Farm Machinery and Equipment	327.4	4
3585	Refrigeration and Heating Equipment	237.4	3
3531	Construction Machinery	229.2	3
Total of Top Five Markets		5,089.2	69
Total Consumption by Manufacturing Sector		7,301.4	

STEEL CASTINGS			
SIC	CONSUMING INDUSTRY	TONS (000)	%
3531	Construction Machinery	182.2	19
3743	Railroad Equipment	179.0	19
3714	Motor Vehicle Parts and Accessories	88.6	9
3794	Valves and Pipe Fittings	58.3	6
3559	Special Industry Machinery	37.5	4
Total of Top Five Markets		545.6	57
Total Consumption by Manufacturing Sector		962.4	

ALUMINUM CASTINGS			
SIC	CONSUMING INDUSTRY	Million Lbs	%
3714	Motor Vehicle Parts and Accessories	562.9	35
3579	Office Machines N.E.C.	184.2	11
3519	Internal Combustion Engines N.E.C.	119.0	7
3711	Motor Vehicles and Car Bodies	82.3	5
3546	Power Driven Hand Tools	42.4	3
Total of Top Five Markets		990.8	61
Total Consumption by Manufacturing Sector		1,625.5	

Source: 1972 Census of Manufactures.

TABLE 9-12. PASSENGER CAR IRON AND ALUMINUM CONSUMPTION

	1975	1980	1985		
Cars Produced (millions)	7.8[a]	7.3[a]	8[p]	12[p]	12[p]
Iron/Car (lbs)	626[b]	458[b]	216[b]		
Aluminum/Car (lbs)	86[e]	124[e]	156[p]		
Cast Aluminum/Car (lbs)	64[e]	74[e]	94[p]		
Finished Aluminum Castings (thousand tons)	250	270	376	470	564
Ingot Consumption (thousand tons)	322[a]	350[e]	490[p]	615[p]	735[p]
Total Aluminum Consumption (thousand tons)	430[a]	490[e]	810[p]	1015[p]	1220[p]
Finished Iron Casting (thousand tons)	2441	1672	864	1080	1296

a - actual
e - estimated by TSC
p - projection by TSC
b - "The U.S. Automobile Industry, 1980," Report to the President from the Secretary DOT, p. 28.

Note: Total aluminum consumption and aluminum ingot consumption figures for 1975 are taken from Aluminum Statistical Review 1978.

TABLE 9-13. ALUMINUM AND IRON CONSUMPTION IN THE U.S. AUTOMOBILES (1975 TO 1991)

	1975	1976	1977	1978	1979	1980	1981	1984	1985	1936	1987	1990	1991
Iron Castings (lb/car)		600[1] 665[2]	620[11] 640[5] 620[23] 665[2]	615[7] 530[24] 673[20]	585[9] 585[21]	590[2]	430[5] 410[23]		370[20] 400[5] 320[7] 200[1] 305[2] 150[19] 310[21]		300[9]	360[5] 80-280[22] 225[23] 250[24]	175[1]
Aluminum Castings Only (lb/car)	59[4]	50[2]	65[4] 110[11] 64[12] 50[2]	80[24]		75[2] 94[12]			120[2] 150[12]			150[24]	
Total Aluminum (lb/car)	85[4] 84[17] 120[11] 80[14] 89-84[16]	85[17] 90[11] 84-37[16]	95-100[14] 100[4] 100[5] 100[12] 100[15] 100[16] 96-100[16]	110-120[3] 118[15] 100-115[16]		150[4] 175[12] 150-200[16] 180-200[17]	180[5] 200[13]	330[16]	325[12] >200[4] 220[15] 236[8]	400[13]			215[1]
Average Car Weight (lb)	4400[12]	4000[1]	3900[23]	2000-3700[22]		3200[18] 3300[24]	3300[23]		2800[1] 2700[18] 2900[24] 3000[23] 2000-3400[22]			2800[23] 2500[24] 1840-3200[22]	2500[1]

*1982, 1983, 1988 and 1989 excluded because no data reported in published documents surveyed.

1. American Metal Market, July 2, 1979.
2. Modern Casting, November 1978.
3. Arthur D. Little, Inc. – Average Ford Car.
4. University of Michigan Study, May 1979.
5. Iron Age, April 9, 1979.
6. Iron Age, March 26, 1979.
7. Ford Car – Arthur D. Little, Inc.
8. American Metal Market, July 2, 1979.
9. American Metal Market, March 5, 1979.
10. American Metal Market, September 24, 1979.
11. Light Metals Age, February 1978 – Average Ford Car.
12. Aluminum Association, 1979.
13. Private Communications.
14. University of Michigan Study – Average GM Car.
15. University of Michigan Study – Average Ford Car.
16. Aluminum Industry Estimates.
17. U.S. Bureau of Mines.
18. American Metal Market, June 2, 1980 – Composite GM Car.
19. American Metal Market, March 5, 1979.
20. Plastics World, November 1978.
21. American Metal Market, December 17, 1979 – Average GM Car.
22. Arthur D. Little Inc. – Various Car Sizes.
23. Arthur D. Little Inc. – Average U.S. Car.
24. American Metal Market, December 24, 1979.

Source: Potential Impacts on Iron Foundries from Substituting Aluminum Castings in the Automotive Industry, Arthur D. Little, August 1980, p. 6.

TABLE 9-14. FERROUS CASTING MARKET PROJECTIONS

GRAY AND DUCTILE IRON FORECAST

	ESTIMATED ANNUAL GROWTH	1980 TONNAGE (000)	1985 TONNAGE (000)
Automotive	(-8.6%)	2,802	1,647
Transportation (Non-Automotive)	4.0%	1,380	1,679
Machinery and Equipment	4.6%	2,570	3,220
Fabricated Metals	3.2%	303	380
Electrical Equipment	3.9%	327	410
Other	3.2%	96	120
Total		7,383	7,348
1976 Actual Total	6,769		

Source: "Modern Casting," January 1978, p. 63.

The various 1985 estimates are based on assumptions of auto production levels, casting parts to be converted, and schedules for part conversions. Although there is some difference of opinion about which parts can be successfully converted to aluminum, information from industry sources indicates that conversions will occur to parts listed in Table 9-15. Greater uncertainty surrounds the time frame for casting conversion. Table 9-16 outlines the time frame projected in "Modern Casting" in 1978 and Table 9-17 shows the updated 1980 projection.

By comparing these estimates, it is apparent that the change-over is substantially underway. The 1980 projection shows accelerated conversion periods for: master cylinders, brake drums, water pumps, transmission (cases, housings, extensions), timing chain covers, and alternator housings.

There are other market factors which are expected to contribute to the shift in market share away from ferrous to aluminum castings. These influences will affect market share, although their actual effect is not known. In the ferrous market, the steel industry's conversion to continuously-cast steel will eliminate some demand for ingot molds. A short-term offsetting factor in the ferrous market is the current boom in machine tool demand created by changes in product such as automotive downsizing. In the aluminum market, growth pressures will originate from computing and accounting machinery and office equipment. Table 9-18 and Figure 9-3 display the projections of market growth from a 1979 industry survey. Total aluminum shipments was estimated to increase by 77 percent to a total of 1,871,000 tons.

In 1980, casting production dropped to about 14 million tons, a drop of almost 30 percent from the 19 million tons shipped in 1979. The sharp drop in the 1980 metal casting market conflicts with industry projections of growth. The market slump is due to the slowdown in the U.S. economy. The casting industry is tied closely to the economy since castings are intermediate products.

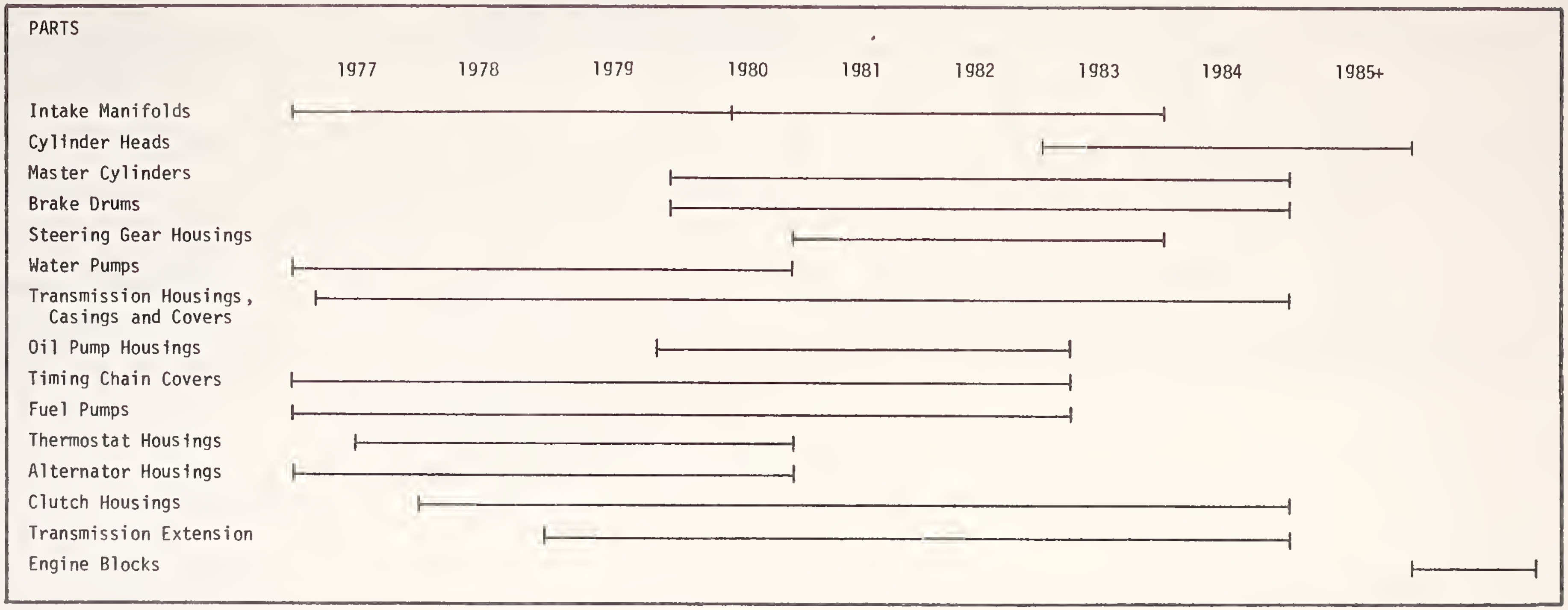
TABLE 9-15. PRESENT AND POTENTIAL ALUMINUM CAST PARTS

PARTS	STATUS*	ESTIMATED WEIGHT RANGES IN POUNDS IRON	ALUMINUM
Intake Manifolds	C	8-40	4-20
Engine Blocks	N	180-260	30-70
Cylinder Heads	N	40-60	15-25
Master Cylinders	N	3-5	1-2
Brake Drums	N	12-20	4-8
Steering Gear Housings	N	8-10	3-4
Water Pumps	C	4-12	1½-5
Transmission Housings and Casings	C	30-50	11-18
Oil Pump Housings	N	3-5	1-2
Timing Chain Covers	C	7-15	3-6
Pistons	C		1-1½
Thermostat Housings	N	1-2	4-7
Alternator Housings	C		2-3
Distributor Adapters	C	2-3	1-2
Clutch Housings	N	9-12	3-4
Transmission Extensions		17-20	6-7½
Air Conditioner Parts	C		
- Body	C	N.A.	3½
- Head	C	N.A.	N.A.
- Cover	C	N.A.	N.A.

*C - converted (on some or all) U.S. Models.
N - Nonconverted on any U.S. models.
N.A. - Not Available.

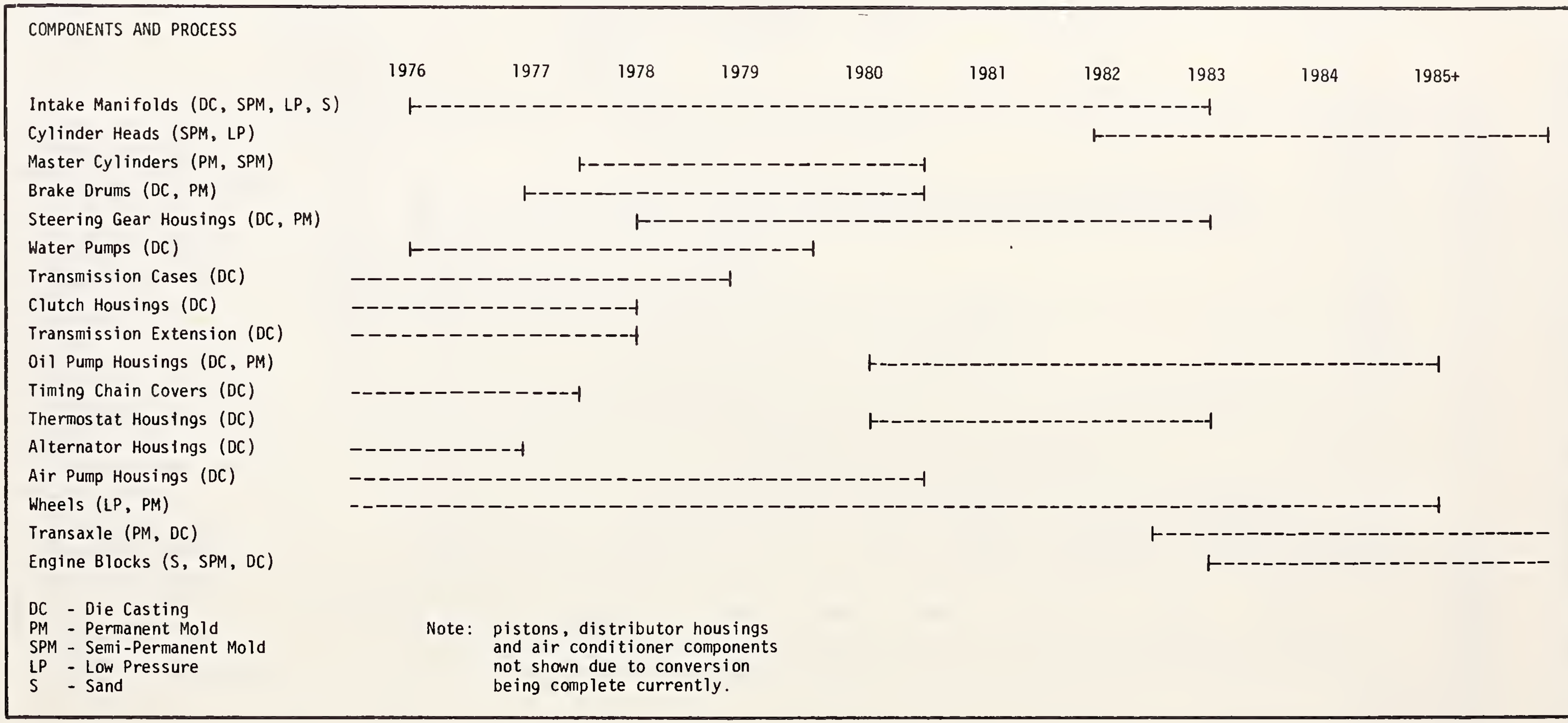
Source: "Modern Casting," January 1978, p. 62.

TABLE 9-16. IMPLEMENTATION SCHEDULE FOR CONVERSION OF ALUMINUM CAST PARTS



Source: "Modern Casting," January 1978, p. 62.

TABLE 9-17. IMPLEMENTATION SCHEDULE FOR ALUMINUM CASTINGS

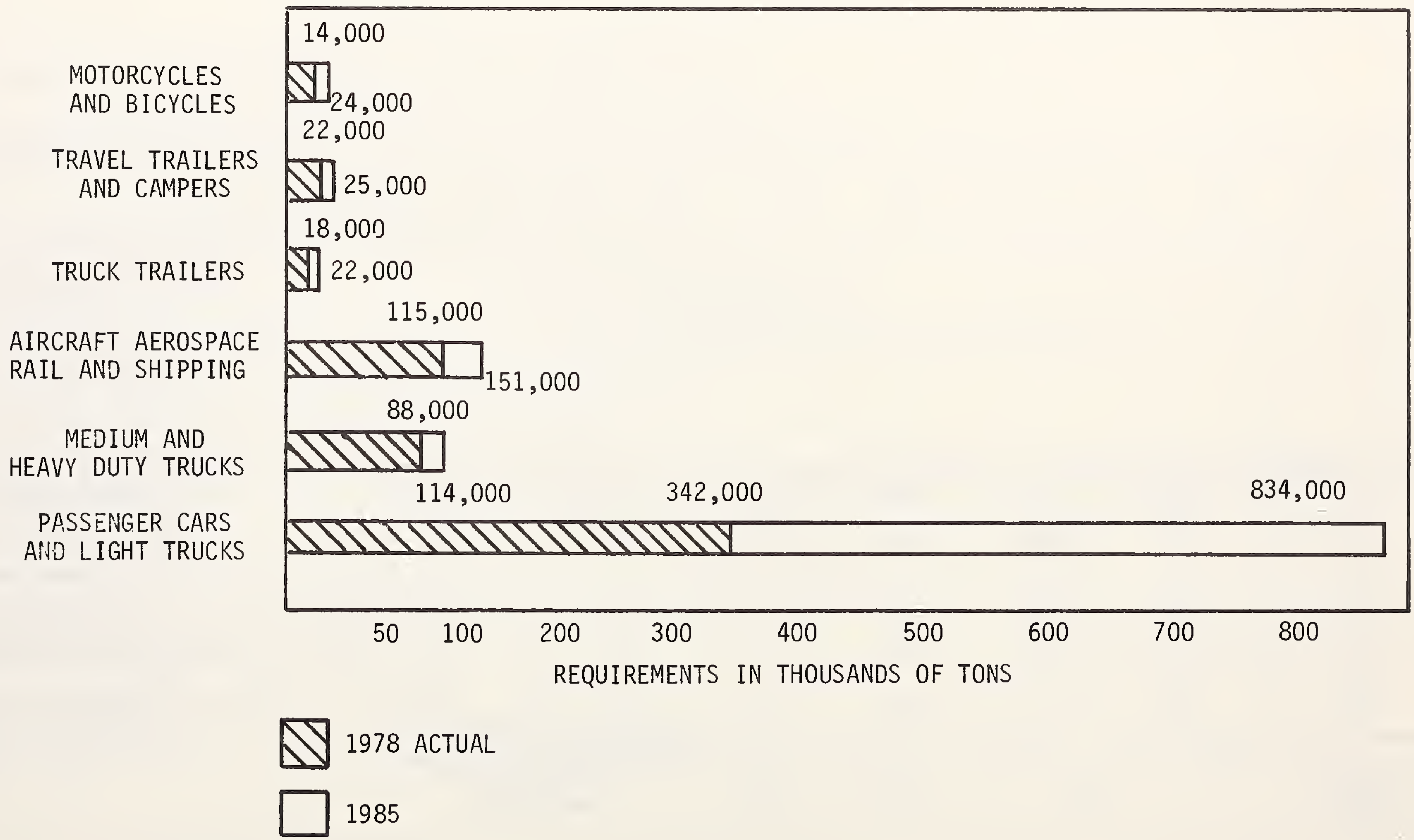


Source: "Modern Casting," January 1980, p. 60.

TABLE 9-18. TOTAL ALUMINUM CASTING MARKET PROJECTIONS (WEIGHTS IN 000 TONS)

MARKET	1978 ACTUAL WEIGHT	1978 ACTUAL % OF TOTAL	1980 WEIGHT	1983 WEIGHT	1985 WEIGHT	1985 % OF TOTAL	% TOTAL GROWTH 1980-1985
Transportation (SIC 37)	610	57.6	779	993	1170	62.5	92%
Machines & Equipment (SIC 35)	146	13.8	167	201	230	12.3	58
Electrical Equipment (SIC 36)	130	12.2	145	174	195	10.4	50
Other Metal Products (SIC 34)	64	6.0	77	100	121	6.5	89
All Other Markets	110	10.4	121	140	155	8.3	41
Total Industry	1060	100.0	1289	1608	1871	100.0	77

Source: "Modern Casting," January 1980, p. 61.



Source "Modern Casting," January 1980, p. 61.

FIGURE 9-3. TOTAL ALUMINUM CASTING MARKET PROJECTION - TRANSPORTATION

Fluctuations in the final product demand translate directly to fluctuations in the demand for castings.

High interest rates have slowed the purchase of capital goods and automobiles, both significant markets for castings. Total casting production is projected to rise along with the recovery in the general economy.

The 1985 projections for market growth cited earlier, assumed the economy was stable and that auto sales grew slightly throughout the 1978-85 period. Current projections indicate that castings will rebound 9 percent* in 1981 which will result in a production level of 30 percent below the 1973 peak. Production levels for the 1961-1980 period are shown in Table 9-19.

9.4 TECHNOLOGICAL TRENDS

The processes employed in casting have evolved over the centuries to the highly automated metal casting operations available today. The casting processes currently used for automotive applications include: green sand, shell mold, permanent and semi-permanent mold, and die casting. Before discussing the trends in casting processes, each process will be described, highlighting the distinguishing characteristics.**

Some terms are common to all forms of castings. The following definitions will be useful for an understanding of casting processes.

Metal Casting - The final metal product formed from molten metal poured into a mold.

Mold - The receptacle which forms molten metal into the solidified casting.

*"Foundry M&T," January 1981, p. 30.
**Industry process information in this section is drawn from the contract report: "Casting and Forging Processes in Motor Vehicle Manufacturing," Booz Allen and Hamilton, August 1979.

TABLE 9-19. METAL CASTING PRODUCTION

YEAR	MILLIONS OF TONS
1961	13.8
1962	15.2
1963	16.7
1964	18.7
1965	20.5
1966	20.8
1967	18.9
1968	19.5
1969	20.8
1970	18.0
1971	17.8
1972	19.6
1973	21.9
1974	20.2
1975	16.4
1976	18.4
1977	19.4
1978	19.6
1979	18.8
1980	14.0 (Estimate)

Sources: U.S. Bureau of the Census, Department of Commerce
Metal Casting Industry Census Guide, p. 3.

Cope - Upper half of the mold.

Drag - Lower half of the mold.

Pattern - A wood or metal form which is the shape of the finished casting.

Core - Part of the mold which creates hollow chambers inside the casting.

Metal casting refers to the several processes used to form molten metal into a finished part. The common elements in these processes include: heating raw materials to a molten state, channeling the metal into a mold, removing the part from the mold. Casting processes differ in the type of mold and the pressure applied to the molten metal. The major processes for casting automotive parts are described below.

Green sand - The mold in green sand casting can be constructed from wooden or metal patterns. Green sand refers to the fact that the mold sand contains moisture in contrast to dry sand molds which are baked dry. The sand is combined with clay and compacted around the pattern to form the mold. The molten metal is poured into the mold by gravity force and cools into solid state in the mold. Some castings require hollow chambers within the casting. To achieve these chambers, cores of sand and clay are constructed and inserted into the mold. When the casting solidifies, the mold is destroyed and the sand residue is cleaned from the casting.

Shell Mold - Shell molds must be constructed from metal patterns. The mold is composed of sand and resins packed to a thickness of a few millimeters. Molten metal is poured into the shell under gravity pressure. After the casting solidifies, the mold is broken away.

Permanent and Semi-Permanent Mold - Permanent and semi-permanent mold casting are basically the same process. Permanent mold uses metal molds and cores while semi-permanent uses metal molds and sand cores. Metal cores must be extracted from the finished casting while sand cores can be cleaned from the casting chamber. Metal cores consequently, restrict the mold design while sand cores allow for more complex castings. The term "permanent" refers to the fact that molds are reused for thousands of castings. The molten metal is poured into the mold under gravity pressure. After the metal solidifies, the mold divides into two halves and the casting is removed.

Die Casting - This process forces molten metal into metal molds at pressures between 3,000 and 15,000 lbs per square inch. There are two variations of the process, hot chamber and cold chamber. Hot chamber requires machinery which combines mold pouring and furnace equipment. A plunger forces molten metal from a furnace reservoir into a die (mold). Once the metal has set, the die ejects the casting and the process starts again. This process is limited to low melting point metals; ferrous metals cannot be die cast. High melting point metals react with the equipment. Cold chamber die casting transfers the molten metal to an injection chamber. The metal is poured by gravity into the chamber which slows the casting process and results in cold chamber production rates lower than hot chamber rates. Cold chamber castings are injected into the die by a plunger system which maintains pressures until the cast solidifies. As with hot chamber casting, the casting is ejected from the die and the cycle repeats.

Table 9-20 lists the processes just described and compares their characteristics. The following paragraphs summarize the information in Table 9-20.

The most versatile metal casting process in terms of range of metals cast is sand casting. Green sand casting also has the advantages of high production rates and low cost. The cost is low relative to other methods because sand is recycled and wooden patterns can be used to form molds. The process can achieve complex casting forms because sand cores are not extracted from the casting; they are destroyed inside the casting and the sand residue is cleaned away. The limitations of the process include the size of the casting and casting wall thickness. Sand casting tolerances deteriorate as the casting size increases. Production sand casting

TABLE 9-20. METAL CASTING PROCESSES

CASTING PROCESS	TYPE OF MOLD AND CORE	METALS SUITABLE FOR PROCESS	ADVANTAGES	DISADVANTAGES	CURRENT AUTOMOTIVE APPLICATIONS	FUTURE AUTOMOTIVE APPLICATIONS
Green Sand Casting	Mold and Core-- Compacted Moist Sand and Clay Mold Destroyed	Iron, Steel Aluminum Copper, Brass, Bronze	Used for parts requiring complex cores, Usually least expensive process. Higher production rate than permanent mold.	Not suitable for castings over 100 lbs unless pit molding is used, cannot produce thin wall castings, tolerances not as good as permanent mold.	(90% iron casting, sand cast) Engine blocks, cylinder heads brake drums, calipers, Rotors, power steering housings.	Fewer iron castings slated for use in the automobile due to substitution of cast aluminum parts, hence sand-casting will be reduced.
Shell Mold Casting	Mold and Core-- Sand and Clay Resin (mold destroyed)	Most Ferrous and Nonferrous Metals	Faster than sand casting, produces better dimensional accuracy than green sand which reduces machining.	Mold production more expensive, process requires more control equipment than sand casting.	Cams, crankshafts, exhaust valves, transmission parts.	Shell mold application now 8% of automotive iron casting, expected to decline.
Permanent Mold and Semi-Permanent Mold (Same process)	Metal Mold and Core Metal Mold and Sand Core	Ferrous and Nonferrous (with lower melting point) Metals preferred	Fine tolerances, finish superior to sand casting, can be highly automated.	Expensive due to high cost of molds, mold design less flexible than sand casting, cores must be designed for removal from finished casting.	Wheel cylinders, valves, fan hub, air conditioning compressor bodies cylinder heads (aluminum)	Improvements in sandcasting automation technique could challenge permanent mold applications and automotive redesign may favor diecasting.
Die Casting	Metal Mold and Metal Core	Nonferrous Metals (Aluminum, zinc, Magnesium)	Excellent tolerances, little machining required, good surface finish, high production rate, intricate parts can be cast, good for "near net shape" process.	Parts under 50 lbs. only, expensive process cannot die cast ferrous metals, air entrapped in metal is the most common casting defect.	Carburetor body, fuel pump body, engine block, transmission housing, timing chair cover, pistons, water pump housing.	Applications in aluminum increasing due to automakers plans for fuel efficiency through weight reduction.

Source: "Casting and Forging Processes in Motor Vehicle Manufacturing," Booz Allen and Hamilton, August 1979.

is limited to parts under 100 lbs; parts over 100 lbs are cast in sand pits. Sandcasting cannot achieve thin wall construction, as with die casting.

Most automotive parts are sand cast. About 90 percent of all automotive castings are iron and 90 percent of these are sand cast. The proportion of sand cast automotive parts will decline in the future. The drop is a secondary effect due to the substitution of aluminum castings for iron castings. The predominant aluminum metal casting process is die casting and consequently, as the changeover occurs, the sand cast process will be less common in automotive applications. This shift will affect many foundries in the U.S. Of 4,279 foundries, 70 percent have sand casting capability.* See Figure 9-1 for states with major concentrations of foundries.

About 8 percent of cast parts are produced by the shell mold process. Thirty of the 504 shell mold foundries use only the shell mold casting process. Industry sources indicate that fewer parts will be shell mold cast. Since this process contributes a small share to the automotive market and because almost all foundries using this process have other casting capabilities, the reduction in shell mold parts is expected to have minimal impact on the foundries.

Permanent and semi-permanent mold castings represent a small portion of automotive parts. Both aluminum and iron are cast by this process. The increase in aluminum permanent mold parts is expected to exceed the loss of permanent mold iron parts. Whether the permanent mold process will continue to be used for aluminum automotive applications depends on its continued competitive edge versus other processes. Permanent mold production lags behind that of sand casting, however, tolerances and surface finish are superior to sand casting. Sand casting can challenge permanent mold casting because it is cheaper and the sand molds are more versatile for casting design than permanent molds. Over 600 foundries cast metals by the permanent mold process and 20 percent of these cast by this process solely.

*See Table 9-21 which gives foundries by process.

TABLE 9-21. U.S. FOUNDRIES BY TYPES OF CASTING PROCESSES

PROCESS	FOUNDRIES WITH CAPABILITY	FOUNDRIES CASTING THIS PROCESS ONLY
Sand	2,994	1,376
Shell	502	30
Permanent Mold	638	138
Die Casting	670	509

Source: TSC Data Base.

Die cast foundries currently amount to 16 percent of U.S. foundries. Of the 670 foundries equipped for die casting, 509 cast this process exclusively. Only nonferrous metals can be die cast. The increasing aluminum applications will likely benefit die casters. This process offers excellent tolerances, good surface finish, thin wall construction, and higher production rates. The cast part achieves a near net shape which requires little machining. Some automotive parts cannot be die cast. Parts under 50 lbs which can be designed with metal cores are candidates for die casting.

Since aluminum is cast by processes which are not suited to ferrous metals (permanent mold and die casting), the companies supplying the automotive market as well as the captives have been exploring the expansion or adoption of these processes. Table 9-22 compares the metals used in automotive parts and identifies the parts cast in each metal and the processes suitable for each metal.

In an effort to adopt the best in die casting technology, U.S. firms have been borrowing from the more advanced European automotive die casters. General Motors and Ford have purchased die casting equipment from Voisin, a subsidiary of Teksid (which is owned by Fiat).*

Advances incorporated into this equipment include:

- Carousels of casting units fed by one molten metal source.
- A cylinder head production rate of 1,200 a day on triple shift compared to a conventional line with 420 a day.
- Entirely automated metal pouring controlled by robots.

Hayes-Albion entered into a joint venture with Honsel-Werke A.G. of Germany to benefit from the expertise developed by Honsel-Werke in the low-pressure permanent mold cast process.** Honsel-Werke designs and builds low-pressure permanent mold machines and

*Alloy Heads Boost Efficiency, from "Automotive Industries," July 1980, p. 49-51.

**Aluminum Casting Today, from "Modern Casting," May 1978, p. 48-49.

TABLE 9-22. METAL CHARACTERISTICS AND CASTING PROCESSES

METAL AND PREDOMINANT CASTING PROCESS	ADVANTAGES	DISADVANTAGES	AUTOMOTIVE APPLICATIONS
Gray Iron Sand Casting, Shell Mold Casting, Permanent Mold	Holds lubrication, readily machinable, extremely wear resistant, high thermal conductivity, high vibration absorption, low shrinkage resulting in few defects, lowest cost cast metal, lowest ferrous melting temperature.	Weight, cast iron parts are being replaced by aluminum which weigh 60 percent less, most common casting defect is cracking, metal is relatively brittle.	Master cylinder, cylinder head, manifolds, water pump housing, cylinder block, brake drum, wheel cylinder, proportioning valves, fan hub, air compressor bodies.
Malleable Iron Sand Casting, Shell Mold Casting, Permanent Mold	Good ductility, good machinability, withstands stress without breaking.	Shrinks 5% which results in defects.	Brake calipers, universal joints, yokes, automatic transmission parts, suspension parts.
Ductile Iron Sand Casting, Shell Mold Casting, Permanent Mold	High ductility, high degree of elasticity, high strength.	More expensive than gray iron,. poorer heat transfer than gray iron, most common casting defect is carbon nodule segregation, requires complex metallurgy and close process control.	Disc brake parts, steering gear housings, crank shafts, differential carriers, cases, front knuckle castings.
Aluminum Die Casting, 70%, Permanent Mold 20%, Sand Casting 10%	Lightweight, can be cast in thin walls, good finish appearance, good thermal conductivity, corrosion resistance suitable for most applications.	Must be alloyed to strengthen the metal, aluminum cost rising, availability of metal may be a problem, production rate lower than zinc die casting, requires heat treatment to improve wear resistance.	Intake manifolds, cylinder heads, engine block, brake drum, oil pump housing, carburetor bodies, clutch housing, alternator housing, thermostat housing fuel pumps, transmission housings, water pump bodies.
Magnesium Die Casting	Lightweight; is 1/4 weight of zinc and 2/3 weight of aluminum, strength suitable for some structural uses.	Not appropriate for applications requiring extreme wear resistance.	Distributor diaphragm housing, manual transmission case, steering column lock housing, mirror control cover plate.
Zinc Die Casting	Low cost per casting, ease of casting and finishing, high production rate, highest strength of all die cast metals except copper alloys.	Not appropriate for applications requiring extreme wear resistance.	License plate frame, windshield wiper housings, grille, fender extensions, parking lamp housing, head lamp bezel, hood ornaments, door and window handles, rear view mirror, exterior moldings, side turning markers, wheel trim parts.

Sources: "Casting and Forging Processes in Motor Vehicle Manufacturing," Booz Allen and Hamilton, August 1979.

produces wheels by this process in Germany. Hayes-Albion is producing aluminum cylinder heads in the Tiffin OH plant which is dedicated to this joint venture.

The search for optimum technology has led to experimentation with new production casting processes. General Motor's Central Foundry in 1982 will produce aluminum cylinder heads by the lost-foam process.* The process sets a styrofoam duplicate of the casting in a sand packing. Molten metal is poured onto the styrofoam which dissipates and is replaced by the cooling metal casting. Although the process has been available for several years, it has never been tried on a production level. The experimentation stage for new and improved processes is expected to last for several years. Gradually, a preferred process will emerge which offers the best in quality, production, and cost.

The expansion programs are being financed through internal and borrowed capital. Larger foundries expect to cover about 50 percent of their capital needs from earnings and depreciation while smaller foundries estimate that about 30 percent of their capital will originate from internal sources.** Total capital estimated to be required for foundry capital spending programs through 1981, exceeded known sources by 18 percent. This projected shortfall, prompted the Cast Metal Federation to propose legislation liberalizing depreciation laws and providing write-offs for mandatory pollution equipment. There are no reliable estimates of the total cost of foundry plant adjustments. Spiraling interest rates raise the cost of borrowing while foundry capital outlays for pollution abatement compliance accounts for as much as 35 percent of all capital outlays.*** Industry representatives agree that the casting industry requires depreciation laws that are more favorable to capital investment if the U.S. casting industry is to remain competitive with countries that allow rapid recovery of capital costs.

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*Ward's, "GM Central Doundry Div...", Oct. 13, 1980.

**Capital Shortage Threatens Foundry Growth, from "Foundry M&T" Sept. 1977.

***"Foundry Industry Legislative Position Paper," Cast Metals Federation, 1980, p. 6.

9.5 WORLDWIDE INDUSTRY STRUCTURAL CHANGES AND POTENTIAL IMPACTS ON U.S. INDUSTRY

As mentioned in section 9.1, trade in castings between the U.S. and other nations amounts to less than 5 percent of U.S. production. The major international impact on the U.S. casting industry is the technological improvements made in foreign industry which are being adopted in the U.S. In Table 9-23, the trend of foundry equipment imports and exports for 1974-80 is listed. In 1979, imports rose 60 percent, while exports rose only 3 percent. The U.S. has increased its import of equipment with advanced casting technology such as the Voisin machinery described in section 9.4. The automotive requirements for worldwide competitive technology in aluminum casting has contributed to the surge in orders for overseas equipment.

The aluminum market has grown at the expense of the automotive iron casting market. The downturn in automotive orders has resulted in 19 plant closings as listed in Table 9-24. The plant closings removed 1 million tons of iron casting capacity in the U.S. Between 5,000 and 11,000 foundry employees have been affected by these closings. Further plant closings may occur since estimates indicate that the automotive iron casting demand may decline by an additional one-half million tons.

9.6 GOVERNMENT/INDUSTRY RELATIONSHIPS

The foundry industry agrees with the legislative goals of a clean environment and safe working conditions but objects to the way Federal agencies enforce regulations. They also question the objectivity of the regulating agencies. The foundry industry associations support the Cast Metals Federation which represents their interests in Washington DC. The following paragraphs summarize the position of the foundry industry as stated by the Federation.*

*"Foundry Industry Legislative Position Paper," Cast Metals Federation, February 1980.

TABLE 9-23. FOUNDRY EQUIPMENT: TRENDS AND PROJECTIONS, 1974-1980
(in millions of dollars except as noted)

ITEM	1974	1975	1976	1977	1978*	1979*	PERCENT CHANGE 1978-79*	1980**	PERCENT CHANGE 1979-80**
Product (SIC 35592)									
Value of Shipments***	214	267	242	328	344	406	+18	504	24
Trade									
Value of exports	55	98	103	63	58	60	+ 3	65	+ 8
Value of imports	16	18	15	18	25	40	+60	50	+25

*Estimated except for hourly earnings, price indexes, and 1979 trade data.
**Forecast.
***Value (quantity) of shipments of foundry equipment produced by all industries.

Source: <u>1980 U.S. Industrial Outlook</u>, U.S. Department of Commerce, p. 227.

TABLE 9-24. 1980 IRON FOUNDRY PLANT CLOSINGS

FIRMS	TONS/YR CAPACITY	PLANT LOCATION	EMPLOYMENT RANGE (MINIMUM)	(MAXIMUM)
Chrysler Corp.	290,000	Detroit MI	100	249
Chrysler Corp.	100,000	Fostoria OH	NA	NA
Ford Motor Co.	150,000	Dearborn MI	500	999
Ford Motor Co.	120,000	Windsor ONT	1000	2,499
General Motors Co.	192,000	Flint MI	1000	2,499
Dayton Malleable	50,000	Columbus OH	500	999
General Electric	24,000	Louisville KY	100	249
General Electric	12,000	Elmira NY	100	249
International Harvester Co.	25,000	Memphis TN	500	999
Ausco	20,000	Benton Harbor MI	250	499
Dana Corp.	20,000	Havana IL	100	249
Frank Foundries Corp.	9,600	Davenport IL	100	249
Stedman Foundry and Machine Co.	6,000	Aurora IN	100	249
Koppers Co.	5,000	York PN	20	49
Ingersoll-Rand	4,800	Kutztown PN	100	249
Lewisburg Casting Co.	3,600	Lewisburg TN	100	249
Crompton and Knowles	3,500	Worcester MA	50	99
Autocrat Corp.	2,500	New Athens IL	50	99
LFE Corp.	1,250	Columbus OH	50	99
Total	1,039,250		4,720	10,832

Source: TSC Data Base and information from industry contacts.

The most vital concern of the industry is the adoption of an accelerated depreciation rate for plant and equipment. The Federation has worked since 1978 for the passage of a Capital Cost Recovery Act providing for 10 years depreciation for plant, 5 years for machinery and 3 years for vehicles. A 10-5-3 bill is expected to raise the rate of investment in the foundry industry which will improve productivity and the competitive position of the industry. The decline in investment is due in part to the capital requirements to comply with Environmental Protection Agency (EPA) and Occupational Safety and Health Administration (OSHA) regulations. The Federation estimates that 35 percent of industry capital is consumed in EPA and OSHA projects.

The EPA legislation affecting the foundry industry includes the Clean Air Act, Clean Water Act, and the Resource Conservation and Recovery Act. The cost to comply with air pollution is estimated to exceed 229 billion for expenditures from 1977 to 1986. The industry is now controlling 95 percent of foundry pollution emissions. Further control of pollution will require expenditures the industry considers exorbitant compared to the benefits attained.

The Federation contends that EPA studies are not objective and that cost/benefit analysis should be conducted by outside agencies. The industry supports innovative approaches to pollution compliance such as the "bubble" concept where a plant manager can comply with EPA requirements using a variety of solutions.

The industry has challenged OSHA regulations in court and in the case of lead standards, won a stay of regulations. Objections to OSHA regulations are similar to those cited against EPA. Flexibility in regulatory solutions is desired. The Federation proposes that both EPA and OSHA regulations should allow for a variety of methods for the industry to comply with regulatory standards. One example of this is to allow workers to wear protective gear rather than protecting workers by installing safety or environmental equipment.

The Federation charges that the cost of complying with Government regulation has contributed to the closing of over 700 foundries in the past decade. The decline of foundries is shown in Table 9-25. The greatest loss has occurred in the foundries employing less than 20 employees. These small firms have less internal capital to meet extraordinary expenditures than the larger firms. As discussed in section 9.4, capital requirements for retooling also fall hardest on small foundries, and the industry's capital needs are expected to exceed known sources by 18 percent.

The U.S. foundry industry considers the relationship with the Government to be more adversarial than the industry/government relationship in other countries. Due to the support foreign governments provide to their domestic casting industries, foreign producers can offer products at advantageous prices in U.S. markets. The Federation support of a 10-5-3 bill is motivated then, by the goal of protecting the domestic industry from foreign subsidized export products as well as providing the industry with adequate capital to modernize their facilities and cover the expense of meeting regulatory requirements.

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FOUNDRY EQUIPMENT MANUFACTURERS ASSOCIATION, 1000 Vermont Avenue, Northwest, Washington DC 20005.

IRON CASTINGS SOCIETY. Cast Metals Federation Building, 20611 Center Ridge Road, Rocky River OH 44116.

NATIONAL FOUNDRY ASSOCIATION, 9838 Roosevelt Road, Post Office Box 128, Westchester IL 60153.

TABLE 9-25. PLANTS IN THE U.S. AND CANADA BY SIZE OF WORK FORCE

SIZE OF WORK FORCE	1980	1975	1969	1965	1965-1980 NET CHANGE
over 1000	52	61	47	37	+15
500 to 999	72	83	83	82	-10
250 to 499	229	232	224	191	+38
100 to 249	610	628	610	547	+63
50 to 99	716	721	749	701	+15
20 to 49	1087	1109	1181	1195	-108
Under 20	1884	2104	2472	2729	-845
Total	4650	4938	5366	5482	-832

Source: TSC Data Base and Metal Casting Industry Census Guide 1979, p. 2.

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