Magnesium

By E. Chin [1]

Production and shipments of magnesium metal by The Dow Chemical Company were 120,823 short tons and 111,185 short tons, respectively, in 1972. Disposal of magnesium from the Government stockpile throughout the year totaled 7,737 tons.

Currently, domestic capacity to produce primary magnesium metal represents 58% of the total world production capacity. With the entry of a fourth U.S. producer of magnesium metal, total domestic production capacity will be 235,000 short tons per year by 1975.

Legislation and Government Programs.—In 1970, the Office of Emergency Preparedness removed magnesium metal from the list of strategic and critical materials, and the stockpile objective for magnesium was abolished. Under authority of Public Laws 90–604, 91–321, and 92–113, the General Services Administration (GSA) continued the disposal of all the magnesium remaining in the national stockpile.

In 1970, GSA sold 14,572 short tons of metal from the Government stockpile, compared with 710 tons in 1971. A total of 7,737 short tons of magnesium was sold during 1972, leaving 89,926 short tons in the stockpile at yearend.

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Table 1.—Salient magnesium statistics

(Short tons)

	1968	1969	1970	1971	1972
United States:					
Production:					
Primary magnesium	98,375	99,887	112,006	123,485	120,823
Secondary magnesium	15,525	13,470	12,042	14,703	15,662
Shipments: Primary	103,671	117,695	118,693	120,217	111,185
Exports	19,457	27,372	35,732	24,311	17,556
Imports for consumption	4,808	4,316	3,295	3,671	4,479
Consumption	86,427	95,132	93,495	90,458	99,455
Price per pound—cents	35.25	35.25	35.25	36.25	37.25
World: Primary production	212,305	221,469	242,253	255,753	255,995

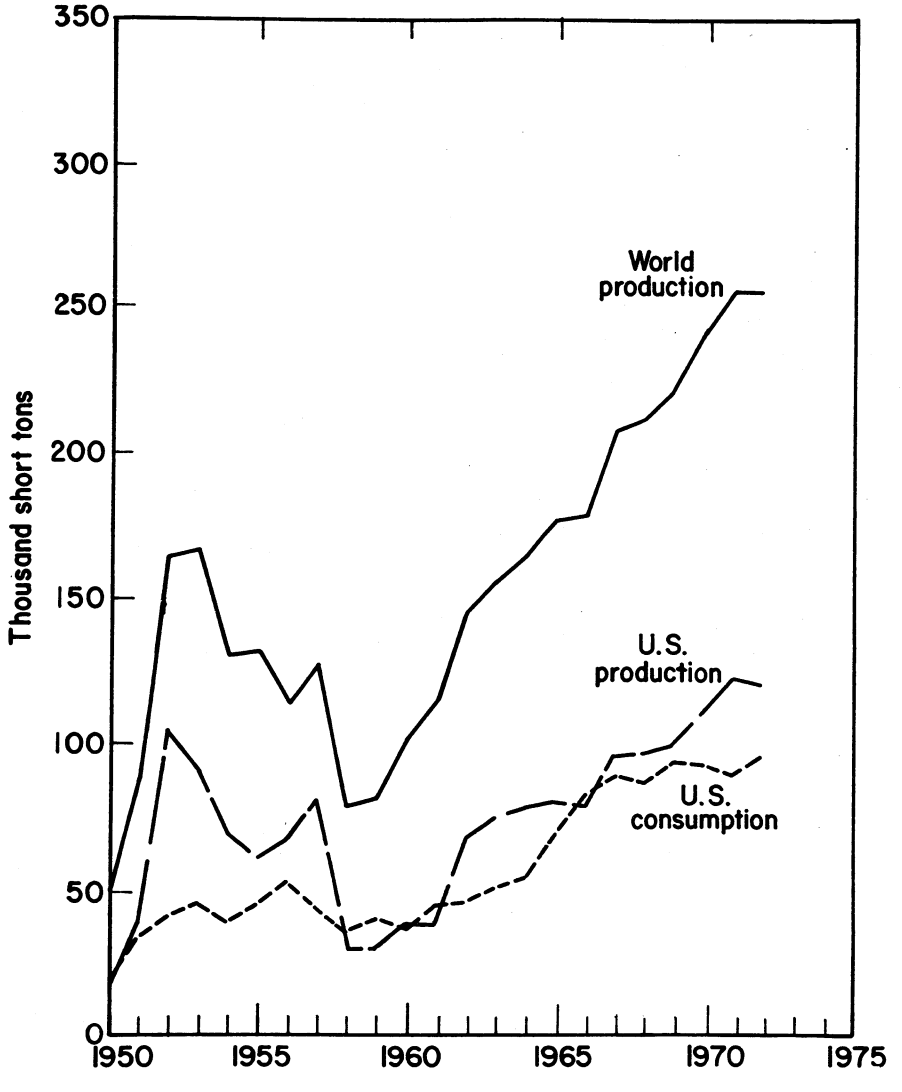

Figure 1.—U.S. and world production and U.S. consumption of primary magnesium.

DOMESTIC PRODUCTION

Production of primary magnesium metal by The Dow Chemical Co. at Freeport, Tex., was 120,823 short tons in 1972. American Magnesium Co. (American Magnesium) at Snyder, Tex., and NL Industries, Inc. (NL), at Rowley, Utah, also produced some metal.

In compliance with an order of the Texas Air Control Board, American Magnesium halted production in mid-1971 to

effect improvements in the effluent control systems at its plant. In 1972, American Magnesium was granted a license to use a U.S.S.R.-designed electrolytic cell. Soviet technicians visited the electrolytic plant at Snyder, Tex., to assist American Magnesium's personnel with the operation of the cell, which is reportedly the largest in the Western World. Late in the year, the reduction plant was operated intermittently and some magnesium metal was produced.

Late in 1972, NL initiated operational startup of its magnesium reduction plant, located on the southwestern shore of the Great Salt Lake, near Rowley and Grantsville, Tooele County, Utah. NL's electrolytic plant has a rated annual capacity of 45,000 tons per year of magnesium metal and 70,000 tons of chlorine. Electrical power for NL's project was supplied by the Utah Power and Light Co.

NL's process uses a modified electrolytic cell of the I.G. Farben design and a closed metal circulation system. Raw material source is the brine from the Great Salt Lake which contains approximately 0.7% magnesium, about five times more than sea water. The lake brines are pumped into precipitation ponds where solar evaporation increases the concentration of the magnesium chloride from 2.5% to 30%. From there it is pumped into holding tanks for storage as raw material feed. The storage tanks hold more than a 1-year supply of magnesium chloride for cell feed.

Early in 1972, Great Salt Lake Minerals and Chemicals Corp. (GSL) received $2.975 million from Dow in cancellation payments for the $3 million magnesium chloride facility GSL built at Ogden, Utah. The facility was to supply magnesium chloride for Dow's proposed magnesium plant at Dallesport, Oreg. In 1971, Dow indefinitely delayed the construction of the Dallesport magnesium chloride reduction facility.

The Aluminum Company of America (Alcoa) acquired a license from France's Péchiney Ugine Kuhlmann to use the Magnetherm process for the production of magnesium metal. The magnesium plant, to be situated at Addy, Wash., will use dolomitic limestone deposits in the area for the metal production. The Magnetherm process involves the reduction of calcined dolomite by ferrosilicon at temperatures in excess of 1,500° C. Northwest Alloys, Inc., a newly formed Alcoa subsidiary, will begin construction of the facility in April 1973 with startup targeted for March 1975. Initial capacity will be 24,000 tons per year of magnesium and an ultimate capacity of 40,000 tons per year. The $50 million facility will have a work force of 200 to 250 persons, and will be increased to 300 to 400 persons as capacity is brought up to 40,000 tons per year. The Bonneville Power Administration will supply electricity beginning in October 1974 to the 240-acre Addy site located 50 miles northwest of Spokane. The magnesium and byproduct silicon, two important alloying agents for aluminum, will be used internally by Alcoa.

Table 2.—Magnesium recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1968	1969	1970	1971 r	1972 p
Kind of scrap:					
New scrap:					
Magnesium-base	7,006	4,767	4,564	6,722	6,816
Aluminum-base	5,050	5,712	4,698	4,838	5,646
Total	12,056	10,479	9,262	11,560	12,462
Old scrap:					
Magnesium-base	2,113	1,700	1,518	1,719	1,656
Aluminum-base	1,356	1,291	1,262	1,424	1,544
Total	3,469	2,991	2,780	3,143	3,200
Grand total	15,525	13,470	12,042	14,703	15,662
Form of recovery:					
Magnesium alloy ingot [1]	2,502	3,231	2,006	3,905	3,612
Magnesium alloy castings (gross weight)	15	11	13	14	9
Magnesium alloy shapes	82	149	189	500	275
Aluminum alloys	9,900	8,378	7,088	7,423	8,790
Zinc and other alloys	18	13	24	17	16
Chemical and other dissipative uses	64	65	80	478	581
Cathodic protection	2,944	1,623	2,642	2,366	2,379
Total	15,525	13,470	12,042	14,703	15,662

r Revised. p Preliminary.
[1] Figures include secondary magnesium content of both secondary and primary magnesium alloy ingot.

CONSUMPTION AND USES

Consumption of magnesium in the United States reversed the 1971 decline and rose to almost 100,000 short tons. Magnesium metal is consumed in two broad categories: Structural products such as castings and wrought products, and distributive or sacrificial applications where advantage is taken of the metal's chemical properties. At present, about one-third of consumption is for structural applications while sacrificial uses account for the remaining two-thirds of magnesium consumption.

A wide-ranging series of applications for magnesium were noted in 1972. Archery bow handles, baseball bats, bowling pins, pack frames, snowmobile parts, and staple nailers were among the promising new uses for magnesium die castings. A yttrium-zinc-magnesium base alloy, developed by the Frankford Arsenal, was being used and tested for various helicopter parts. An aluminum-magnesium-steel shield will cap the Centaur booster and Viking spacecraft scheduled to be launched for Mars in 1976.

The use of magnesium and aluminum in U.S. automobiles is expected to increase sharply in the next 5 years, due to the necessity of minimizing the weight of cars. The target for weight reduction per car is about 300 pounds, approximately the weight of mandatory safety and emission control equipment. Some new car models to be introduced in the fall of 1973 will feature magnesium fender extensions as well as decorative items.

The Melmag racing car wheel, designed by Magnesium Elektron, Ltd., won the 1972 Design Award of the International Magnesium Association. The one-piece, magnesium die-cast deck of the Satellite lawnmower, produced for the Parkton Corp. by Paramount Die Casting, Inc. was awarded first prize in the current production category in the First International Magnesium Die Casting Competition.

In sacrificial applications, the area of magnesium growth was expected to be in such uses as the desulfurization of steel and in anodes for the cathodic protection of buried pipelines and storage tanks. Magnesium dry cell batteries for walkie-talkies are a new application for wrought metal, and magnesium continued to be used in water-activated and sea water-activated reserve cell batteries. Retail sales of dry-cell batteries, excluding those for mili-

tary applications, were expected to reach $400 million in 1973, and the market was estimated to be growing at more than 10% per year. The alkaline-magnesium cell market, the fastest growing segment, was expected to reach $60 million.

Table 3.—Consumption of primary magnesium in the United States, by use
(Short tons)

	1968	1969	1970	1971 r	1972 p
For structural products:					
Castings:					
Die	7,337	7,484	9,002	7,477	8,600
Permanent mold	607	404	260	779	955
Sand	3,740	2,562	1,735	1,143	768
Wrought products:					
Extrusions	11,280	13,110	12,250	5,481	8,045
Sheet and plate	(1)	(1)	(1)	4,447	5,992
Other (includes forgings)	(1)	(1)	(1)	2,782	1,377
Total	22,964	23,560	23,247	22,109	25,737
For distributive or sacrificial purposes:					
Alloys:					
Aluminum	34,484	37,375	36,543	37,335	40,568
Copper	(2)	(2)	(2)	1,576	1,563
Zinc	52	54	35	26	28
Other	(2)	(2)	(2)	175	983
Cathodic protection (anodes)	5,714	6,087	5,778	7,050	6,428
Chemical	(2)	(2)	8,385	8,960	9,732
Nodular iron	2,480	2,374	4,720	4,135	4,684
Powder	(2)	(2)	5,646	3,410	(2)
Scavenger and deoxidizer	(2)	(2)	(2)	68	327
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium	6,209	7,363	6,300	5,587	6,089
Other	14,524	18,319	2,841	27	3,316
Total	63,463	71,572	70,248	68,349	73,718
Grand total	86,427	95,132	93,495	90,458	99,455

r Revised. p Preliminary.
1 Included with "Extrusions."
2 Included with "Other."

PRICES

During 1972, the quoted base price for primary magnesium pig and ingot in 10,000-pound lots, 99.8% magnesium, f.o.b. plant, was 37.25 and 38.00 cents per pound, respectively. This compares with corresponding prices of 36.25 and 37.00 cents per pound, respectively, during 1971.

Depending upon the state of preservation of the metal available from the national stockpile, GSA accepted bids for primary magnesium ranging from 28.25 to 34.75 cents per pound, f.o.b. storage locations. The average price of metal sold by GSA during the year was 32.45 cents per pound.

STOCKS

Producer and consumer stocks of primary magnesium totaled 22,011 tons as of December 31, 1972. Yearend stocks of primary magnesium alloy ingot were 986 short tons. Stocks a year earlier were 13,021 short tons of primary metal and 1,727 short tons of alloy ingot.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1972

(Short tons)

Item	Stocks Jan. 1 [r]	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Cast scrap	153	1,899	644	1,197	1,841	211
Solid wrought scrap [1]	736	4,969	4,588	--	4,588	1,117
Total	889	6,868	5,232	1,197	6,429	1,328

[r] Revised.
[1] Includes borings, turnings, drosses, etc.

FOREIGN TRADE

As in prior years, the United States continued to be a net exporter of magnesium metal in 1972. However, U.S. exports of magnesium metal in all forms, declined from 24,311 short tons, valued at $15.7 million in 1971, to 17,556 tons, valued at $11.7 million in 1972. For the past decade, West Germany was the largest single export destination for U.S. metal. However, in 1972 U.S. exports to West Germany declined sharply, totaling only 859 tons.

Imports by Brazil, Canada, and Japan accounted for 31, 20, and 7%, respectively, of the total U.S. magnesium metal exported. Shipments to France, Italy, Mexico, Switzerland, the United Kingdom, and West Germany collectively totaled 4,157 tons or 24% of total exports. The remaining 3,113 tons were exported to some 20 countries.

Total U.S. imports for consumption of magnesium were 4,479 short tons, valued at $2.6 million in 1972, compared to 3,671 tons, valued at $2.3 million in 1971. Canada, the largest of U.S. sources in 1972, contributed 1,618 tons of the total metal imported. Receipts from West Germany and the Netherlands were, respectively, 1,101 and 513 tons. The remainder of U.S. imports, 1,247 tons, was contributed by 15 other nations.

The duty on unwrought magnesium, other than alloys was 20% ad valorem, and on unwrought magnesium alloy (magnesium content) was 8 cents per pound plus 4% ad valorem. The duty on wrought magnesium metal was 6.5 cents per pound plus 3.5% ad valorem.

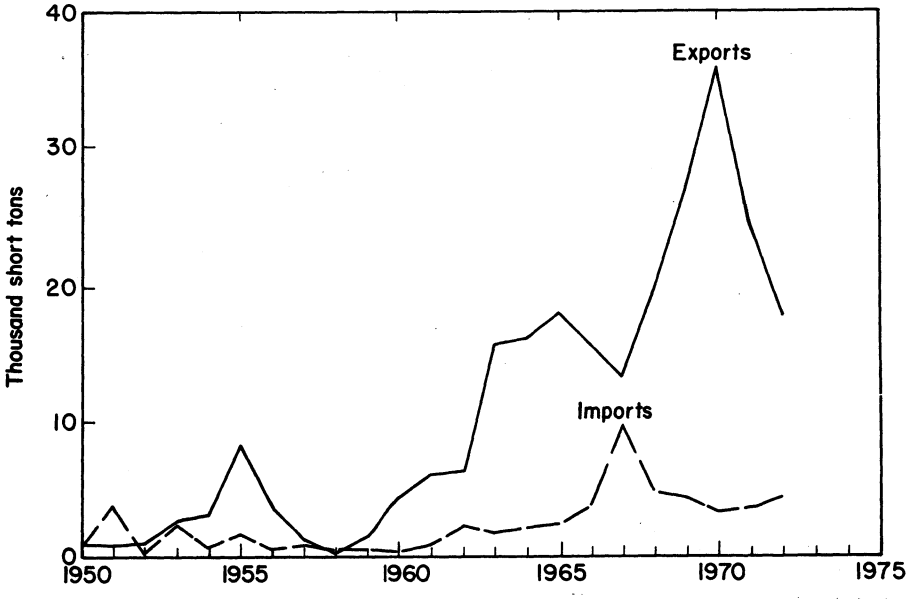

Figure 2.—U.S. imports and exports of magnesium.

Tables 5.—U.S. exports of magnesium, by class and country

Destination	1971						1972					
	Waste and scrap		Primary metals, alloys		Semifabricated forms, n.e.c., including powder		Waste and scrap		Primary metals, alloys		Semifabricated forms, n.e.c., including powder	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Angola	--	--	--	--	60	$77	--	--	2	$2	--	--
Argentina	--	--	502	$374	1	6	--	--	313	232	--	--
Australia	--	--	455	294	46	106	--	--	312	168	45	$74
Austria	--	--	48	29	--	--	--	--	22	12	5	10
Belgium-Luxembourg	--	--	225	135	3	9	33	$11	135	78	1	6
Brazil	--	--	6,692	3,787	2	6	--	--	5,439	3,360	3	10
Canada	22	$94	2,002	1,225	207	291	27	80	3,253	1,907	289	397
Colombia	--	--	12	9	5	12	--	--	8	7	2	4
Egypt	--	--	7	4	--	--	--	--	34	24	--	--
France	--	--	36	25	17	38	--	--	432	247	17	48
Germany, West	--	--	9,857	5,742	137	317	--	--	801	506	58	154
Ghana	--	--	1	1	2	2	--	--	225	148	1	1
India	1	1	8	7	--	--	--	--	283	169	--	--
Indonesia	--	--	--	--	--	--	--	--	7	8	--	--
Israel	--	--	6	4	35	54	--	--	21	15	40	57
Italy	1	1	673	411	51	43	--	--	425	258	16	37
Japan	17	11	213	119	243	435	21	7	1,000	591	254	480
Malaysia	--	--	--	--	--	--	--	--	25	14	--	--
Mexico	--	--	910	705	32	41	11	15	938	609	5	10
Netherlands	--	--	282	155	34	104	--	--	385	228	21	36
New Zealand	--	--	15	9	--	--	--	--	45	26	--	--
Norway	--	--	106	60	1	1	--	--	95	56	--	--
Pakistan	--	--	--	--	--	--	--	--	24	15	--	--
South Africa, Republic of	--	--	112	63	2	1	--	--	190	113	1	1
Spain	--	--	457	256	4	6	--	--	386	219	2	3
Sweden	--	--	--	--	33	93	--	--	--	--	17	27
Switzerland	--	--	65	48	1	1	--	--	721	444	6	10
Taiwan	--	--	66	43	--	--	--	--	129	70	(1)	1
United Kingdom	--	--	350	195	17	46	--	--	711	410	16	36
Venezuela	--	--	148	113	32	33	2	3	189	126	13	15
Other	--	--	50	35	7	15	(1)	(1)	92	70	8	37
Total	41	107	23,298	13,848	972	1,737	94	116	16,642	10,132	820	1,454

[1] Less than ½ unit.

Table 6.—U.S. exports and imports for consumption of magnesium

Year	Exports					
	Waste and scrap		Metals and alloys in crude form		Semifabricated forms, n.e.c.	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1970	42	$30	34,143	$20,090	1,547	$2,422
1971	41	107	23,298	13,848	972	1,737
1972	94	116	16,642	10,132	820	1,454

Year	Imports							
	Waste and scrap		Metal		Alloys (magnesium content)		Powder, sheets, tubing, ribbons, wire and other forms (magnesium content)	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1970	1,632	$651	1,316	$915	122	$300	225	$637
1971	2,142	713	1,300	920	99	286	130	397
1972	3,042	1,040	1,256	950	168	464	13	103

WORLD REVIEW

World production of magnesium metal in 1972, excluding two U.S. producers, was 255,995 short tons, an increase of 242 tons over world production in 1971. The United States produced 47% of the world magnesium output, followed by the U.S.S.R. 23%, and Norway 16%. The remaining 14% was by Canada, People's Republic of China, France, Italy, and Japan.

World producers of magnesium with annual capacities, processes, and plant locations are as follows:

Country	Company	Capacity (short tons)	Process	Plant location
Canada	Chromasco Corporation Limited	12,000	Silicothermic	Haley, Ontario.
China, People's Republic of	NA	5,000	do	Ying-kou, Liaoning.
France	Société Générale du Magnésium Péchiney Ugine Kuhlmann S.A. (70 percent). Société des Produits Azotés (SPA) (30 percent).	9,000	do	Marignac.
Italy	Società Italiana per il Magnesio e Leghe di Magnesio.	7,700	do	Bolzano.
Japan	Furukawa Magnesium Company	7,700	do	Koyama.
	UBE Industries, Ltd	6,600	do	Yamaguchi.
Norway	Heroya Electrokemiske Fabrikker A/S subsidiary of Norsk Hydro-Elektrisk A/S	47,000	I. G. Farbenindustrie	Heroya.
U.S.S.R.	NA	50,000	Electrolytic	NA.
United States	American Magnesium Co	30,000	do	Snyder, Tex.
	The Dow Chemical Co	120,000	Dow cells	Freeport, Tex.
	NL Industries, Inc	45,000	Electrolytic	Rowley, Utah.

NA Not available.

Australia.—A research group at the University of Tasmania was investigating the feasibility of constructing a sea water magnesium facility in Australia. The main purpose of the study was to determine if all of Australia's magnesium requirements could be satisfied by a sea water magnesium plant.

India.—The Central Electrochemical Research Institute at Karaikudi started production from its magnesium pilot plant rated at 550 pounds of metal per day. A 10,000-ampere cell with a monthly capacity of 1.7 short tons was commissioned. The project was jointly sponsored by the Council of Scientific and Industrial Research and the Tamil Nadu Government. A larger scale plant with an annual capacity of 660 short tons employing the same process was scheduled for construction. The cost of production was estimated to be approximately equivalent to the price of imported magnesium.

The large reserves of magnesite at Salem and the considerable tonnages of sea bitterns to be produced at Tuticorin encouraged the Tamil Nadu Government to finance the project. The Research Institute developed a spray drier with a rated capacity to produce 155 pounds per hour

Table 7.—Magnesium: World production by country

(Short tons)

Country [1]	1970	1971	1972 [p]
Canada	10,353	7,234	5,844
China, People's Republic of [e]	1,100	1,100	1,100
France	5,083	7,954	[e] 7,700
Italy	8,356	8,496	[e] 8,300
Japan	11,395	10,685	12,004
Norway	38,959	39,799	40,224
U.S.S.R. [e]	55,000	57,000	60,000
United States	112,007	123,485	[2] 120,823
Total	[r] 242,253	255,753	255,995

[e] Estimate. [p] Preliminary. [r] Revised.

[1] The United Kingdom, listed among producers in previous editions, has been deleted because it was determined that the material credited to the United Kingdom subsequent to 1966 is entirely remelt alloy.

[2] Excludes two U.S. producers.

of partially anhydrous magnesium chloride from magnesium chloride solution. The metal production process involves the electrolysis of anhydrous magnesium chloride in a fused salt bath at 700° C.

Japan.—Mitsubishi Chemical Industries Co., Ltd., abandoned its plans to build a small electrolytic magnesium plant in Japan. The original plans had called for an electrolytic plant with an initial capacity of 5,000 tons per year of magnesium.

Netherlands.—Shell Minerals Netherlands NV (Shell) announced that it decided to postpone indefinitely its magnesium chloride project in the Friesland province of the country. Shell stated that it had suitable processing technology for magnesium, but that it was still too costly. Also, world prices for light metals, especially for aluminum, were depressed and that there was no prospect of a recovery in the near future.

The Netherlands Economics Ministry in The Hague said that Shell would not be given the production license it applied for 1½ years ago in view of the company's decision to shelve the project. The award had been delayed a number of times due to local opposition on environment-protection and pollution grounds.

The Economics Ministry added that, in view of the importance of the project for the economic development of the northern provinces of the Netherlands, it intended to set up an independent group to study other possibilities for exploiting the magnesium in the short term. Shell agreed to place the necessary technical information at the group's disposal.

Norway.—The Magnesium Division of Norsk Hydro A/S created a special 20-man technical staff to engage in technical marketing and to develop new applications for magnesium. The technical staff reported potential in the fields of alloying, electroplating, pressure die casting magnesium, and organic synthesis.

U.S.S.R.—The estimated production of magnesium metal in 1972 was 60,000 short tons, a 3,000-ton increase over 1971 production. According to the Soviet weekly ECOTASS, Russian magnesium exports reached 19,900 tons in 1972, a 34% increase compared with the 14,800 tons shipped in 1971.

TECHNOLOGY

The research laboratories of Alcoa developed a process whereby the magnesium content of aluminum scrap is reduced from about 0.5% to 0.1%.[2] Conventional methods to reduce the magnesium content of scrap produced chloride fumes. Alcoa's Fumeless Demagging Process, a pollution-free process, reportedly lowers operating costs and produces 99% pure magnesium chloride, a salable byproduct. The process involves the reaction of magnesium and chlorine by multiple-stage gas-liquid contacting in a closed reactor-settler tank, eliminating wet or dry scrubbers and dust filters. The operating costs are approximately one-third of those for chlorine fluxing and scrubbing systems. The capital cost is estimated at $75,000 for a system to remove magnesium from 24 million pounds per year of alloy scrap. The process is currently being installed at Alcoa's Davenport, Iowa, smelter where it will be used for in-plant wrought alloy scrap.

To prevent molten magnesium from oxidizing on contact with air, the molten metal is presently covered with a mixture of fine potassium and magnesium chloride powder. The Magnesium Research Center at Battelle Memorial Institute announced a $160,000 research program on the fluxless melting of magnesium which may possibly reduce the cost of casting magnesium by 4 cents per pound. Data from laboratory experiments as well as from commercial operations indicate that sulfur hexafluoride (SF_6) was a practical oxidation inhibitor for molten magnesium.[3] The optimum concentration of SF_6 in air for most efficient protection of molten magnesium is 1/10% or less.

Research by Bureau of Mines investigators showed that yields of vanadium in excess of 98% can be achieved by reducing

[2] Chemical Week. New Process That Solves Aluminum Can Recycling Problems. V. 111, No. 8, Aug. 23, 1972, p. 24.

[3] Hanawalt, J. D. Practical Protective Atmospheres for Molten Magnesium. Metals Engineering Quarterly, November 1972.

vanadium dichloride with magnesium.[4] The resultant vanadium metal product has a purity greater than 99.8%. The high efficiencies in the individual process steps indicated that vanadium produced with magnesium as the reductant has an excellent potential from an economic standpoint.

Other investigations by the Bureau of Mines demonstrated that nitrogen was an effective medium for quenching magnesium vapor produced in the carbothermic process.[5] Contrary to prior belief, the formation of magnesium nitride was not a major problem. For the carbothermic process to be cost competitive with the electrolytic process, large volumes of the quenching agent must be available at low cost. Nitrogen is available in abundant supply, and as a byproduct of oxygen production in steel and other metallurgical plants, should be relatively inexpensive.

According to the American Cast Iron Pipe Company (Acipco), Birmingham, Ala., magnesium-impregnated coke (Mag-Coke) is an effective desulfurizing agent for steel.[6] Acipco estimated that 1 pound of Mag-Coke would remove 0.018% of sulfur per ton of iron; the removal of 0.01% of sulfur per ton of iron would cost 25 to 30 cents. Spokesmen for several steel producers confirmed experimenting with Mag-Coke. Republic Steel Corp. reported that the use of Mag-Coke was beyond the research stage and was being used in regular iron production at its Warren, Ohio, and Gadsden, Ala., facilities.

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[4] Campbell, T. T., J. L. Schaller, and F. E. Block. Preparation of High-Purity Vanadium by Magnesium Reduction of Vanadium Dichloride. Metallurgical Trans., v. 4, No. 1, January 1973, pp. 237–241.

[5] Dean, K. C., V. E. Edlund, and A. G. Lawrence. Quenching Carbothermic Magnesium With Nitrogen. Light Metal Age, v. 30, Nos. 5–6, June 1972, pp. 21–23.

[6] American Metal Market. Steelmakers Confirm Magnesium Used as Sulfur Removing Agent. V. 79, No. 113, June 16, 1972, p. 4.