

Helium

By Russell J. Foster¹

Sales of high purity helium (minimum 99.995% purity) in the United States by the Bureau of Mines and private industry reached 811 million cubic feet in 1978, and were estimated at 817 million cubic feet in 1979.² High purity helium exports, all by private producers, increased to 190 million cubic feet in 1978, and an estimated 245 million cubic feet in 1979. The Bureau of Mines f.o.b. plant price for high purity helium remained at \$35 per thousand cubic feet, unchanged since 1961. High purity helium sold by private producers averaged approximately \$22.50 per thousand cubic feet.

Legislation and Government Programs.—A Congressionally ordered inter-

agency helium study was completed in February 1978. The report concluded that the demand for helium is likely to increase, and the long-term rate of growth will be greatly affected by energy-related technologies. The study deemed unsound the purchase of helium for storage by the Federal Government in the short term, but recommended that policies be implemented to promote economic utilization and avoid waste, and stated that the private sector should be encouraged to extract helium from natural gas to eliminate venting helium into the atmosphere. Areas identified for further study were examined in a supplementary report issued in August 1978.

DOMESTIC PRODUCTION

Nine plants with the capacity to extract helium were operational in 1979. Seven of the plants were owned by private industry and the other two were owned by the U.S. Government and operated by the Bureau of Mines. Six extraction plants were located in Kansas, two in Texas, and one in Oklahoma.

Union Carbide Corp. began operating the world's largest helium purification and liquefaction plant at Bushton, Kans., in 1979. The \$7 million facility has the capacity to liquefy 300 million cubic feet of high purity helium per year. Northern Helix Co. is providing crude helium to the plant under a long-term contract.³

Cities Service Helix, Inc., completed an expansion program in 1979, which has increased production capacity of high purity helium by 35% at its Ulysses, Kans., plant.⁴ Western Helium Co. closed its high purity helium plant at Shiprock, N. Mex., in October 1978.

The Bureau of Mines awarded a contract in July 1979 for a pressure swing adsorption

helium purification unit. This noncryogenic system has a capacity of 1 million cubic feet per day, and will be installed at the Exell, Tex., plant. High purity helium production was resumed at the Exell, Tex., plant in June 1978 to meet increased demand for helium sales and redeliveries. Installation of another helium liquefier was completed at the Bureau's Amarillo, Tex., helium plant, raising capacity to about 100 liters per hour. The unit was purchased in 1977 from Kerr-McGee Corp.'s closed Navajo, Ariz., plant.

Nondepleting helium reserves contained in natural gas of low fuel value, unusual composition, or poor location have become more attractive to natural gas producers as the price of natural gas has increased. In 1978, Mobil Oil Co. began drilling operations for potential gas production at the Tip Top field in Wyoming, the largest of the Government-owned nondepleting helium reserves. Should production capability be proven, Northwest Pipeline Corp. will purchase and upgrade the gas. Both companies

have expressed a desire to cooperate with the Bureau in the possible recovery of helium. The first nondepleting reserve to be

put into production was Wyoming's Table Rock field in December 1977 by Colorado Interstate Gas Co.

Table 1.—Helium extracted from natural gas in the United States
(Thousand cubic feet)

	1975	1976	1977	1978	1979 ^P
Crude helium:¹					
Extracted at Bureau of Mines plants -----	183,725	195,758	^r 118,760	77,301	108,946
Extracted at private industry plants -----	149,794	391,553	419,228	471,226	501,648
Total -----	333,519	587,311	^r537,988	548,527	610,594
High purity helium:²					
Extracted at Bureau of Mines plants -----	184,524	177,677	219,495	221,101	235,597
Extracted at private industry plants ³ -----	560,899	^r 630,805	^r 727,558	779,434	826,722
Total -----	745,423	^r808,482	^r947,053	1,000,535	1,062,319
Grand total -----	1,078,942	^r1,395,793	^r1,485,041	1,549,062	1,672,913

^PPreliminary. ^rRevised.

¹Excludes crude helium purified after interplant transfer.

²Includes only those quantities produced for sale; quantities entering conservation storage system after purification are included under crude helium.

³Includes helium purified at the Bureau of Mines Keyes plant for the accounts of others, as follows, in thousand cubic feet: ^r1975—39,396; 1976—130,356; 1977—204,948; 1978—229,512; and 1979—222,320.

Table 2.—Ownership and location of helium extraction plants in the United States, 1978-79

Category and owner or operator	Location	Product purity
Government owned:		
Bureau of Mines -----	Exell, Tex -----	Crude and high purity helium.
Do -----	Keyes, Okla -----	Do.
Private industry:		
Alamo Chemical Co.-Gardner Cryogenics Corp -----	Elkhart, Kans -----	High purity helium.
Cities Service Cryogenics, Inc -----	Scott City, Kans -----	Crude helium. ¹
Cities Service Helex, Inc -----	Ulysses, Kans -----	Crude and high purity helium.
Kansas Refined Helium Co -----	Otis, Kans -----	High purity helium.
Northern Helex Co -----	Bushton, Kans -----	Crude helium.
Phillips Petroleum Co -----	Hansford County, Tex -----	Do.
Union Carbide Corp., Linde Div -----	Bushton, Kans -----	High purity helium.
Western Helium Co. ² -----	Shiprock, N. Mex -----	Do.

¹Output is piped to Cities Service Helex, Inc., plant at Ulysses, Kans., for purification.

²Plant closed in 1978.

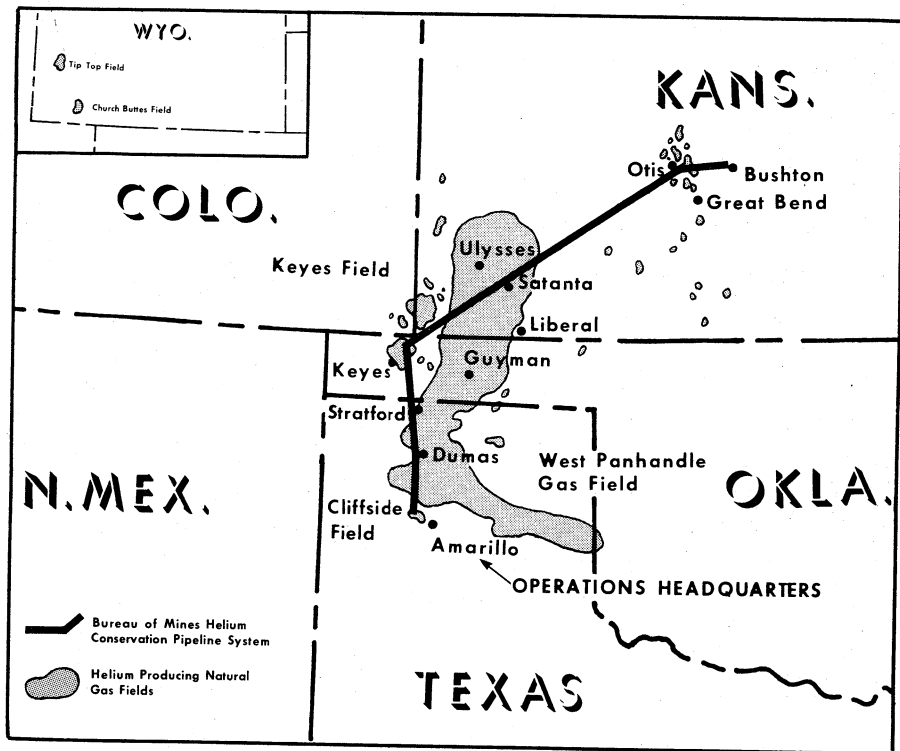


Figure 1.—Major U.S. helium-producing gasfields.

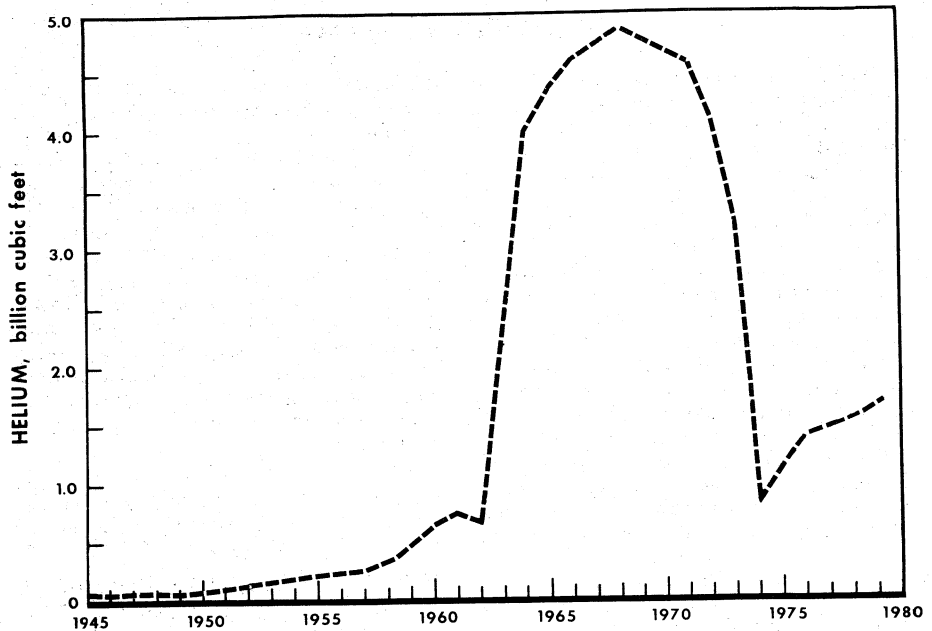


Figure 2.—Helium production in the United States, 1945-79.

Table 3.—Summary of Bureau of Mines helium plant operations
(Thousand cubic feet)

	1977	1978	1979
Supply:			
Inventory at beginning of period ¹ -----	8,881	5,721	18,066
Helium extracted:²			
Excell plant:			
Crude -----	r 9,807	8,801	-103,876
High purity -----	r -1,074	32,336	69,907
Total Excell plant -----	8,733	41,137	-33,969
Keyes plant:			
Crude -----	108,953	68,500	108,946
High purity ³ -----	218,876	195,101	165,832
Total Keyes plant -----	327,829	263,601	274,778
Total extracted -----	336,562	304,738	240,809
Helium returned in containers (net) -----	-5,671	4,981	-2,894
Total supply -----	339,272	315,440	255,981
Disposal:			
Sales of high purity helium -----	219,495	221,101	235,597
Net deliveries to helium conservation system ⁴ -----	114,056	76,273	4,058
Inventory at end of period ¹ -----	5,721	18,066	16,326
Total disposal -----	339,272	315,440	255,981

¹Revised.

²At Excell and Keyes plants and at Amarillo shipping terminal.

³Excludes conservation helium produced from native gas withdrawal wells at Cliffside field that have been invaded by stored helium.

⁴Excludes 204,948,000 cubic feet purified for others in 1977, 229,512,000 cubic feet in 1978, and 222,320,000 cubic feet in 1979.

⁵Excludes return of conservation helium produced as indicated in footnote 2 to conservation storage system.

CONSUMPTION AND USES

Domestic end uses of helium in 1978 and 1979 were primarily cryogenics, welding, and purging and pressurizing. Other uses included synthetic breathing mixtures, chromatography, leak detection, lifting gas, heat transfer, and controlled atmospheres. The Pacific and Gulf Coast States were the principal centers of demand.

Federal agency purchases in the form of direct sales from the Bureau of Mines constituted most of the Bureau's total high purity helium sales. Almost all of the remaining sales of high purity helium by the Bureau were to Federal agencies through General Services Administration contracts with private distributors. Federal agencies are required by law to purchase from the Bureau. These contracts make relatively small quantities of helium readily available to Federal installations at reduced freight charges.

The Bureau of Mines f.o.b. plant price of high purity helium in 1978 and 1979 was \$35 per thousand cubic feet, unchanged since 1961, and maintained for the purpose of financing the Government's helium conservation program. Except in special circumstances, this was not competitive with

the private producer average price of approximately \$22.50 per thousand cubic feet, f.o.b. plant.

All high purity helium sold by the Bureau of Mines was shipped in gaseous form in cylinders, railroad tank cars, highway tanker trailers, or in liquid form in containerized dewars from the Amarillo helium plant. Private industry distributors shipped helium in both gaseous and liquid forms. Much of the helium transported in liquid form was delivered by semitrailer and/or containerized dewars to distribution centers where it was regasified and compressed into trailers and small cylinders for delivery to the end user.

Table 4.—Total sales of high purity helium in the United States

(Million cubic feet)	
Year	Quantity
1975	601
1976	7634
1977	7779
1978	811
1979	817

^aEstimate. ^rRevised.

Table 5.—Bureau of Mines sales of high purity helium, by recipient

(Thousand cubic feet)			
	1977	1978	1979
Federal agencies:			
Department of Energy	22,297	23,382	23,634
Department of Defense	114,690	119,627	114,050
National Aeronautics and Space Administration	24,694	15,464	27,555
National Weather Service	1,682	1,850	1,483
Other ¹	8,868	14,378	27,833
Total Federal agencies	172,231	174,701	194,555
Private helium distributor sales ²	45,023	44,169	38,478
Commercial sales	2,241	2,231	2,564
Total	219,495	221,101	235,597

¹Includes quantities used by the Bureau of Mines.

²Most of this was purchased by commercial firms which sold equivalent quantities to Federal installations under contract agreements with the General Services Administration.

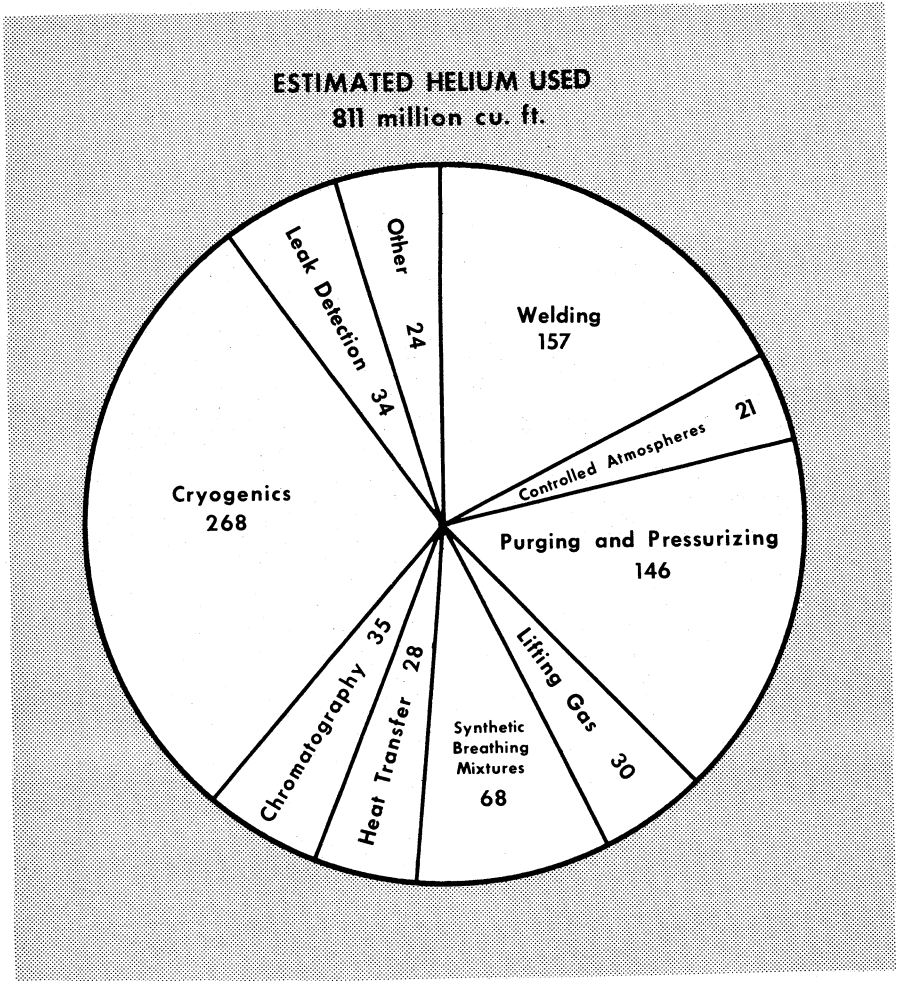


Figure 3.—Helium consumption, by end use, in the United States, 1978.

CONSERVATION

Helium held in the Bureau of Mines conservation storage system, which includes the conservation pipeline network and the Cliffside gasfield near Amarillo, Tex., totaled over 40 billion cubic feet at yearend 1979. The conservation storage system contains crude helium purchased by the Bureau of Mines under contracts entered into with four companies in 1961, and

crude helium accepted between April 4 and November 12, 1973, under a court order obtained during 1973 by three of the companies. The Bureau of Mines presently stores in the conservation system helium produced in excess of sales, and private producers store helium under contract with the Bureau.

Table 6.—Summary of Bureau of Mines helium conservation system¹ operations
(Thousand cubic feet)

	1977	1978	1979
Helium in conservation storage system at beginning of period:			
Stored under Bureau of Mines conservation program ² -----	37,666,363	37,780,419	37,856,692
Stored under contract for private producers' own accounts -----	1,424,931	1,695,010	2,031,570
Total -----	39,091,294	39,475,429	39,888,262
Input to system:			
Net deliveries from Bureau of Mines plants ³ -----	114,056	76,273	4,058
Stored under contract for private producers' own accounts -----	582,935	723,788	787,125
Total -----	696,991	800,061	791,183
Redelivery of helium stored under contract for private producers' own accounts -----	-312,856	-387,228	-403,160
Net addition to system -----	384,135	412,833	388,023
Helium in conservation storage system at end of period:			
Stored under Bureau of Mines conservation program ² -----	37,780,419	37,856,692	37,860,750
Stored under contract for private producers' own accounts -----	1,695,010	2,031,570	2,415,535
Total -----	39,475,429	39,888,262	40,276,285

¹Includes conservation pipeline system and Cliffside field.

²Includes helium accepted after Apr. 4, 1973, under court order.

³Excludes return to system of conservation helium produced from native gas withdrawal wells at Cliffside field which have been invaded by stored helium.

Table 7.—Deliveries and withdrawals of crude helium stored for private companies' own accounts in the Bureau of Mines conservation storage system
(Thousand cubic feet)

Owner	1978			1979		
	Delivered	Withdrawn	Net	Delivered	Withdrawn	Net
Cities Service Helix, Inc. -----	6,247	5,423	824	20,527	18,844	1,683
Northern Helix Co -----	274,096	---	274,096	302,188	---	302,188
Phillips Petroleum Co -----	211,823	65,547	146,276	226,976	72,615	154,361
Jack B. Kelley Co -----	---	---	---	---	1,132	-1,132
Kansas Refined Helium Co -----	215,025	168,353	46,672	215,025	174,623	40,402
Union Carbide Corp., Linde Div -----	---	63,724	-63,724	---	62,008	-62,008
Airco, Inc -----	---	70,940	-70,940	---	54,544	-54,544
Liquid Carbonic Corp -----	16,598	13,240	3,358	22,407	19,393	3,014
Total ¹ -----	723,788	387,228	336,560	787,125	403,160	383,965

¹Data may not add to totals shown because of independent rounding.

RESOURCES

As of January 1, 1979, domestic measured and indicated helium resources were estimated at 348 billion cubic feet. The resources included measured and indicated reserves estimated at 86 and 55 billion cubic feet, respectively, in natural gas with a minimum helium content of 0.3%. The remaining resources included 40 billion cubic feet stored in the Bureau's conservation storage system, 65 billion cubic feet of helium in measured natural gas reserves with a helium content of less than 0.3%, and 102 billion cubic feet of indicated helium in natural gas with a helium content of less than 0.3%. Of this 102 billion cubic feet, 7 billion cubic feet has been identified by individual field evaluations and is defined as indicated helium in natural gas with a helium content of 0.1% to 0.3%. The re-

mainder is based on natural gas resource estimates provided by the Potential Gas Committee and is included here for the first time as undefined indicated resources in natural gas with a helium content of less than 0.3%. Approximately 29% of the domestic helium resources are under Federal ownership or control. Included are the Tip Top and Church Buttes fields in Wyoming, the Keyes field in Oklahoma, and the Cliffside field in Texas.

The majority of domestic helium resources are located in the midcontinent and Rocky Mountain regions of the United States. A total of 75 gasfields in 10 States contain measured and indicated helium reserves. About 83% of these reserves are located in the Hugoton field in Kansas, Oklahoma, and Texas, the Keyes field in

Oklahoma, the Panhandle and Cliffside fields in Texas, and the Tip Top field in Wyoming. Approximately 48% of the measured and indicated reserves (0.3% or greater helium content) at yearend 1978 were in currently producing gasfields. In 1978, about 22% of the helium-rich natural gas (0.3% or greater helium content) produced was processed for helium extraction. Helium in the remaining helium-rich natural

gas output was dissipated incident to the consumption of the gas.

The Bureau examined a total of 369 gas samples from 16 States and 1 foreign country during 1978 in connection with its efforts to survey and identify possible new sources of helium supply. None of the samples collected and analyzed indicated the presence of major new deposits of helium.

FOREIGN TRADE

Exports of high purity helium, all by private industry, increased 13% in 1978 to 190 million cubic feet. Nearly 69% of exported helium was shipped to Europe, primarily the United Kingdom (42%), Belgium-Luxembourg (16%), and France (8%). The remaining exports were distributed as follows: North America, 11%; Asia, 10%; South America, 5%; Oceania, 3%; and Africa, 2%. Exports in 1979 were estimated at 245 million cubic feet. Continued shipments of large quantities of helium to Western Europe during 1978 and 1979 were attributed mainly to its use in the explor-

ation for and development of oil and gas deposits, especially in the North Sea area.

Table 8.—Exports of high purity helium from the United States

(Million cubic feet)

Year	Quantity
1975	144
1976	174
1977	168
1978	190
1979	*245

*Estimate.

Source: U.S. Bureau of the Census.

WORLD REVIEW

World production of helium, excluding the United States, was estimated at 149 million cubic feet in 1978 and 181 million cubic feet in 1979. Production from a plant near Paris, France, was approximately 11 million cubic feet. The U.S.S.R. and the central economy countries of Europe produced an estimated 138 million cubic

feet in 1978 and 170 million cubic feet in 1979.

In December 1979, an explosion damaged the natural gas upgrading facility, including the helium extraction plant, at Odolanow, Poland, halting production of helium. The plant will remain closed for an indefinite period.

TECHNOLOGY

A key component of an experimental superconducting generator capable of producing several times more electric power than similar models was successfully tested in 1979 by General Electric Co. Superconducting generators are more compact than conventional generators of the same capacity. Helium is required to attain temperatures near absolute zero, thus reducing the electrical resistance of certain metals, which are then subjected to a magnetic field.⁵

A prototype helium liquefier that is smaller, more efficient, and more shock resistant

than existing units of the same capacity has been developed at the U.S. Naval Research Laboratory to provide a cryogenic environment for potential shipboard use of superconducting devices.⁶

The Montana Research and Development Institute is constructing a magnetohydrodynamics powerplant near Butte, Mont. After initial tests using oil, pulverized coal will be used as fuel to produce the high temperature plasma that is passed through a helium-cooled magnetic field to create an electric current.⁷ The University of Tennessee received a 5-year contract from the

Department of Energy (DOE) to continue development and testing of a coal-fired flow concept for a magnetohydrodynamics system and to operate a test facility.⁸

Oak Ridge National Laboratory was named as the site of an Engineering Test Facility Design Center for fusion energy. Researchers will determine the type of fusion reactor to be designed and establish technical requirements for the components of a prototype.⁹ Six helium-cooled magnets are being built for Oak Ridge's fusion program.¹⁰ The United States and Japan initiated a joint fusion energy research program to bring a tokamak unit, operated for DOE by General Atomic Corp. at La Jolla, Calif., up to its full operating parameters, and to study its predicted advantages.¹¹

Recent tests conducted over known uranium deposits by the Electric Power Research Institute have shown that measuring helium in soil and ground water can be helpful

in uranium exploration. Helium is a decay product of uranium and thus can mark deep-lying ore deposits.¹²

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²All helium statistics in this chapter are in terms of contained helium measured at 14.7 pounds per square inch absolute at 70°F.

³Chemical Week. High on Helium. V. 122, No. 18, May 3, 1978, p. 15.

⁴Chemical Marketing Reporter. Helium Liquefaction Unit Is to Expand for Cities. V. 214, No. 23, Dec. 4, 1978, pp. 5, 45.

⁵Chemical & Engineering News. Superconducting Generator Closer to Reality. V. 57, No. 46, Nov. 12, 1979, p. 24.

⁶—, Helium Liquefier for Shipboard Use. V. 57, No. 8, Feb. 19, 1979, p. 8.

⁷Mining Journal. Coal-Fired MHD Power Project. V. 293, No. 7509, July 20, 1979, p. 47.

⁸Chemical & Engineering News. DOE Contract Aids Tennessee's MHD Design. V. 57, No. 34, Aug. 20, 1979, p. 16.

⁹—, Oak Ridge Gets Fusion Energy Design Center. V. 57, No. 6, Feb. 5, 1979, p. 17.

¹⁰—, Superconducting Magnets for Fusion Work. V. 57, No. 31, July 30, 1979, p. 18.

¹¹—, U.S. Japan Begin Joint Fusion Research. V. 57, No. 37, Sept. 10, 1979, p. 7.

¹²—, Helium a Guide to Uranium Deposits. V. 57, No. 9, Feb. 26, 1979, p. 26.

