CHAPTER 6

Western Energy Equipment and Technology Trade With the U.S.S.R.

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CHAPTER 6

Western Energy Equipment and Technology Trade With the U.S.S.R.

The previous four chapters have discussed the impact of Western energy technology and equipment on Soviet energy production in qualitative terms. This chapter examines the nature and extent of Soviet energy-related purchases from the West. Using available trade data, it seeks t. ascertain the magnitude and sources of this trade, to analyze identifiable patterns and trends, and to illuminate the role of the United States in providing material assistance to Soviet energy industries. In the latter context, the chapter addresses the issue of "foreign availability," i.e., the extent to which the United States is the sole or preferred supplier of energy equipment and technologies that the Soviet Union has purchased in the last 5 years or is likely to seek during the present decade.

The methodology employed in this chapter is as follows: OTA used the surveys of the Soviet oil, gas, coal, nuclear, and electricity transmission industries which appear in chapters 2 through 5, together with information on common Western practice, to compile a broad list of important energy technologies, items of equipment, and services.[1] This list was refined by using trade statistics to identify those areas in which the U.S.S.R. has made purchases from the West in the past 5 years. Major items were then subjected to a foreign availability analysis in which OTA attempted to ascertain which West European and Japanese firms manufacture similar equipment or possess expertise comparable to those companies that actually supplied the U.S.S.R.

[1]No attempt has been made here to distinguish between "technology" and "products" or "equipment". For a discussion of this subject, see OTA, *Technology and East-West Trade* (Washington, D. C.: U.S. Government Printing Office, 1979), ch. VI.

Foreign availability is a highly subjective concept. As chapter 13 discusses in detail, there is no universal agreement on the parameters that define the degree of equivalency necessary to constitute foreign availability, on how the parameters should be weighted, or indeed on how equivalency itself can and should be measured. Given the limitations of this study, no attempt was made to conduct an exhaustive worldwide search for all alternative sources for each item; in most cases identification of two or three suppliers was deemed sufficient.

Nor did OTA construct a rigorous framework for defining and measuring foreign availability. Information on energy technologies and equipment was collected from industry sources in a number of countries and evaluated by independent technicians. These evaluations were supplemented by interviews with representatives from energy-related companies in the United States and with members of the intelligence community. The criteria of comparability were quality, price, and technical capabilities (i.e., speed, capacity, precision). OTA did not investigate the potential manufacturing capacity of alternative suppliers or evaluate the willingness of firms to sell to the U.S.S.R. The latter are both issues that would have to be taken into account in an exhaustive foreign availability analysis.

Although the results of the analysis carried out here are limited, they can be used to indicate those areas in which the United States enjoys a significant technological edge over other Western nations in an energy-related process, system, or piece of equipment important to the oil, gas, coal, nuclear, or electric power industries of the U.S.S.R.

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A variety of statistical systems were examined in the course of this study, no one of which provided an ideal data base. OTA has dealt elsewhere with the problems associated with measuring and reporting trade,[2] but a brief review of the data sources employed here can provide a sense of the limitations of the analysis that follows and of the strength of the generalizations that may legitimately be drawn from it.

This chapter relies most heavily on the United Nations' Standard International Trade Classification (SITC). This scheme summarizes trade information for thousands of different items by organizing them into commodity groupings of up to seven digits, The SITC system is the only readily available statistical source that reports data for all of the Western countries examined during the course of this assessment. The disadvantage of SITC lies in the fact that it is highly aggregative, i.e., its codes encompass items that are not specifically energy related. Consequently, many of the values shown are inflated, and should be understood to represent relative orders of magnitude rather than precise amounts of energy-related exports. OTA has collected data for those SITC codes believed to consist largely, albeit not exclusively, of energy-related items. These codes are shown in table 40. The data are best used for comparative purposes—to identify the relative importance of suppliers of particular items to the U. S. S. R., for example.

In some cases a more discrete analysis than that possible from SITC data seemed warranted. Here three other data bases were employed: Schedules B and E from the U.S. Department of Commerce,[3] and the European Economic Community (EEC)'s Nomenclature of Goods for the External Trade Statistics of the Community and Statistics of Trade Between Member States

[2]Ibid.

[3]DOC's Schedule B is based on the U.N. SITC and also employs seven digits. It was replaced in 1978 with Schedule E, a system designed to reflect greater precision in the codes. DOC data are, therefore, Schedule B through 1977 and Schedule E thereafter.

Table 40.—UN SITC Energy-Related Equipment Codes

SITC code	Description
571 1	Propellent powders and other prepared explosives
571.2, 571.2	Safety and detonating fuses, percussion and detonating caps, igniters, etc.
6294	Transmission, conveyor or elevator belts of vulcanized rubber
642.93	Gummed or adhesive paper in strips or rolls
655.92	Transmission, conveyor or elevator belts of textiled material
678, 672.9	Tubes, pipes and fittings of iron and steel
695.24	Rock drilling bits; tools and bits for assorted hand tools
711.1	Steam and other vapor generating boilers and parts, n.e.s.
711.2	Auxiliary plant for use with steam and other vapor generating boilers
711.7	Nuclear reactors and parts thereof n.e.s.
714.3	Automatic data processing machines and units thereof; magnetic and optical readers and machines for processing data
714.92	Parts, n es. of and accessories for ADP and other calculating machines
718.42	Self-propelled shovels and excavators, self and nonself propelled levelling, tamping, boring, etc., machinery and parts thereof
718.51	Machinery for sorting, screening, separating, washing, crushing, etc., for earth, stone, ores and other minerals
719.21	Pumps for liquids and parts thereof
719.22	Air and vacuum pumps and air or gas compressors and parts thereof
719.23, 712.31	Filtering and purifying machinery and apparatus for liquids and gases
719.31	Other lifting, handling, loading and unloading machinery, n.e.s.
722.1	Rotating electric plant and parts thereof; transformers, converters, rectifiers, Inductors and parts.
722.2	Electrical apparatus for making or breaking electrical circuits
723.1	Insulated electric wire, cable, bars, strip and the like
723.21	Electrical Insulators of other materials
729.52	Electrical measuring, checking, analysing or controlling Instruments, n.e.s.
729.92	Electric welding, brazing, soldering and cutting machines and apparatus and parts thereof, n e s.
732.4	Special purpose motor lorries, vans, crane lorries, etc.
735.92	Light vessels, floating cranes and other special purpose vessels, floating docks
735.93	Floating structures other than vessels
861.81, 729.51	Gas, liquid, and electricity supply or production meters.
861.91	Surveying, hydrographic, etc., and geophysical Instruments (nonelectrical)
86199	Parts, n.e.s., of meters and counters; nonelectrical and electrical measuring, checking, etc., instruments of SITC 729.52, 861.8 and 861 97

SOURCE Off Ice of Technology Assessment

(NIMEXE). The former were useful in providing a clearer sense of the role of energy-related items in U.S. exports; the latter fulfilled the same role for West European countries. Cross-checking Western export with Soviet import data proved impossible. This phenomenon is not unique to the energy sector; it reflects different classification systems and data reporting criteria.

It must be noted that U.S. export statistics do not include the value of Western technology and equipment sales that originate from U.S. subsidiaries or licensees abroad; nor will the category of U.S. exports to the U.S.S.R. include items that are first destined for third countries. Corporations that export energy technology and equipment are often multinationals or at least have international corporate affiliations in other countries. Some sense of the international nature of this industry can be gleaned from appendix A, which shows a partial list of energy corporation affiliations worldwide. The complexity of these relationships makes it extremely difficult, if not impossible, to always attribute technology sales to the true country of origin. The data collected here, therefore, very likely understate the contribution of American technology to the U.S.S.R.

Finally, export statistics are ill-suited to identifying such technology transfers as the sale of licenses or turnkey plants. For this reason, OTA supplemented its statistical data bases with a comprehensive search of *Soviet Business and Trade,* a biweekly publication that reports major trade deals between the U.S.S.R. and the West.[4] Tables B-1 and B-2 in appendix B summarize energy-related transactions reported in this publication between 1975 and 1980.

[4] *Soviet Business and Trade* is published in Washington, D.C. by Welt Publishing Co.

EAST-WEST TRADE IN ENERGY TECHNOLOGY AND EQUIPMENT

Although Soviet trade with the West has grown markedly in the past decade, it has remained a relatively small part of world trade as a whole. Except for sales of agricultural commodities (i.e., grain), the United States has captured relatively small market shares of this trade compared to other nations in the Industrial West (IW, defined here as Canada, France, Italy, Japan, Netherlands, Norway, Sweden, Switzerland, the United Kingdom, the United States, and West Germany).[5] Table 41, which shows total Soviet imports from the IW, demonstrates that when agricultural commodities are excluded, in 1979 the United States lagged behind West Germany, Japan, and France in industrial exports to the U.S.S.R.

Table 42 shows the value of Soviet imports of items in the energy-related SITC codes listed in table 40. From these data, OTA estimates that energy-related items constituted about 25 percent of total Soviet imports from the IW in 1975, and about 22 percent in 1979. When total imports are adjusted to omit agricultural commodities, the relative importance of energy-related trade increases slightly. In 1979, about 28 percent of Soviet nonagricultural imports from the West consisted of energy equipment and technology.

It is clear from table 42 that the vast preponderance of the U.S.S.R.'s energy-related imports are destined for its oil and gas industries, a fact that is demonstrated graphically in figure 11. The oil and gas sector in 1979 took up 77 percent of such imports. Assuming that a similar proportion of multiarea items—i.e., those that could be employed in more than one energy industry—were destined for the oil and gas industries, approximately 81 percent of all Soviet purchases of energy equipment and

[5] See OTA, op cit., ch. 111.

Table 41 .—industrial West Exports to the U. S. S. R., Selected Countries[a] 1975-1979 (million U.S. dollars)

Year	Total Industrial West[a]	United States	Japan	France	West Germany	Italy	United Kingdom	Other
1979	$15,255	$3,604	$2,461.0	$2,007	$3,619	$1,220	$694	$1650.4
Industrial.	12,151	1,319	2,461	1,791	3551	1,191	655	1,183,1
Agricultural	3,104	2,285	0.2	216	68	29	39	467,3
1978	12,419	2,249	2,502	1,455	3,141	1,133	665	1,274
Industrial.	10,485	804	2,501	1,408	3,128	1,084	615	945
Agricultural	1,934	1,445	1	47	13	49	50	329
1977	10,788	1,624	1,934	1,496	2,789	1,228	607	1,110,1
Industrial.	9,411	747	1,934	1,369	2,765	1,218	602	776
Agricultural	1,377	877	0	127	24	10	5	334
1976	11,051	2,306	2,252	1,118	2,685	981	432	1,277
Industrial, ...	9,005	946	2,252	977	2,659	974	427	770
Agricultural	2,047	1,360	0	141	26	8	5	507
1975	10,092	1,834	1,625	1,147	2,824	1,020	464	1,178
Industrial.	8,469	720	1,625	1,059	2,816	996	459	794
Agricultural	$1,623	$1,114	$ 0	$ 88	$ 8	$ 24	$ 5	$384

a Industrialized Western nations include Canada France Italy Japan the Netherlands Norway Sweden Switzerland the United Kingdom the United Stales and West Germany

SOURCE: OECD, *Stastitics of Foreign Trade Series* B Paris (Annual).

Table 42.—Soviet Energy-Related Imports From Selected Western Countries[a]
(million U.S. dollars)

Year	Oil/qas	Coal	Nuclear	Electric power	Multiarea commodities	Total
1979	$2,652.5	$255.9	$84.1	$279,3	$155.1	$3,427
1978 ..., ...	2,321,0	237.0	70.4	3319	134.8	3,095
1977	1,991.7	174.4	98.8	252.6	103.4	2,621
1976 ......, ...	2,250,0	202.8	70.2	157.0	86,5	2,767
1975 ......, ...	$1,989.5	$212.5	$90.5	$117,6	$90.3	$2,500

a Includes Canada France Italy Japan, the Netherlands Norway Sweden, Switzerland the United Kingdom the United States and West Germany

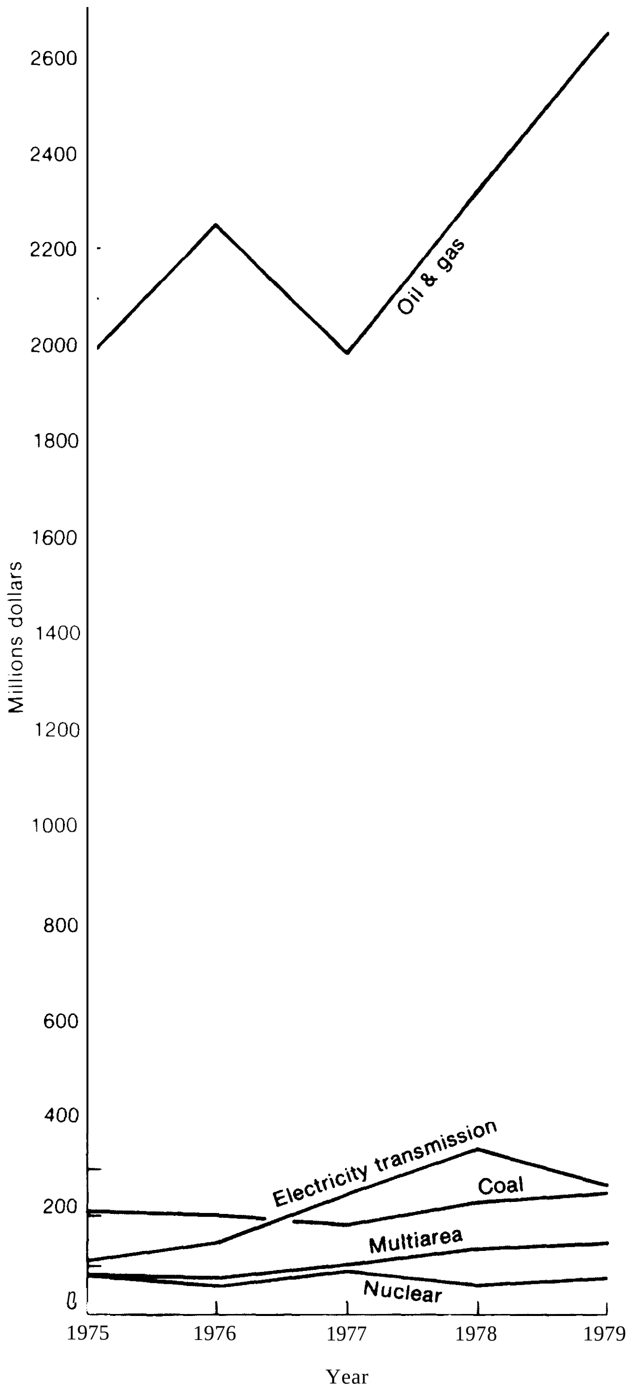
NOTE Data here IS for the SITC codes listed in table 40

SOURCE United Nations SITC data

technology were used to find, produce, and deliver oil and gas. The share of the nuclear power sector was less than 3 percent; that of coal 7 percent; electric power, 8 percent; and other multiarea items, 1 percent.

The role of the United States in this energy-related trade has been small, both in terms of its share in U.S.-Soviet trade as a whole, and in comparison to the relative shares of energy-related equipment and technology in the Soviet trade of America's allies. As table 43 displays, the value of U.S. exports to the U.S.S.R. in energy-related SITC codes for 1979 was $237.6 million. This constituted some 6.6 percent of America's total and about 18 percent of its industrial exports to the Soviet Union in that year. Table 43 also shows that in 1979, the value of U.S. energy-related exports to the

Figure 11 .—Soviet Imports of Western Energy Equipment and Technology, by Industry



SOURCE Table 42

U.S.S.R. was lower than those of Japan, West Germany, France, and Italy. Japan was by far the largest energy equipment supplier to the U. S. S. R., its exports totalling about one-third of all Soviet purchases in this area. West Germany was a close second. France and Italy both recorded exports about double those of the United States. In 1979, the United States accounted for under 7 percent of energy-related exports to the U.S.S.R. of the Western countries examined. Moreover, given the fact that the SITC data on which this analysis is based seriously inflates the export figures by including items not destined for the Soviet energy sector, this percentage may actually be even smaller. U.S. trade statistics as of this writing are available only through October 1980, but these suggest that U.S. energy-related exports plummeted in 1980, the result of the post-Afghanistan technology embargo.

The composition of the Soviet Union's purchases from the United States reflects the same pattern as its energy-related imports from the West as a whole, i.e., they are largely composed of items destined for the oil and gas industries. This pattern is shown in figure 12. But although U.S. sales have not been high in dollar amounts, or particularly impressive as a percentage of total Soviet energy-related imports, it has been contended that their importance to the U.S.S.R. is greatly magnified by the fact that they have been composed of critical items, some of which are unavailable elsewhere in the world. The remainder of this chapter will investigate this assertion, examining sector by sector the composition and magnitude of Soviet imports in each of the five energy industries under consideration, and identifying the sources of these imports. Where U.S. firms have been active traders, an attempt has been made to ascertain whether or not comparable items are available elsewhere in the West.

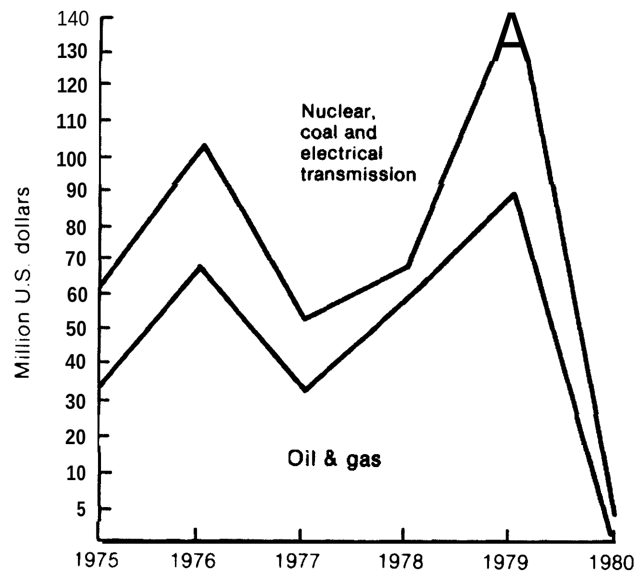
Table 43.—Energy-Related Exports to the U.S.S.R. by Selected Countries[a] (million U.S. dollars)

Year	United States	Japan	France	West Germany	Italy	United Kingdom	Other	Total energy exports
1979	$2376	$1,0971	$474.4	$906.1	$408,2	$90.5	$213.1	$3,427
1978	1598	1,0675	391.4	8393	390.6	113.8	133.0	3,095
1977	211.7	5999	418.6	7454	447,5	49,7	148.2	2,621
1976	2847	9044	3083	627.8	4384	46.3	156.7	2,700
1975	$2183	$4795	$3344	$854.8	$4338	$38.4	$140,3	$2,500

[a] includes Canada, France, Italy, Japan, Netherlands, Norway, Sweden, Switzerland, United Kingdom, United States, and West Germany

SOURCE: United Nations SITC Data

Figure 12.—U.S. Energy Related Exports to the U. S. S. R., by Industry



SOURCE U S Department of Commerce

NUCLEAR

WESTERN EXPORTS

Two SITC codes relate particularly to the nuclear industry:

711.7 Nuclear reactors and parts thereof.

729.92 Electric welding, brazing soldering and cutting machines and apparatus and parts thereof.

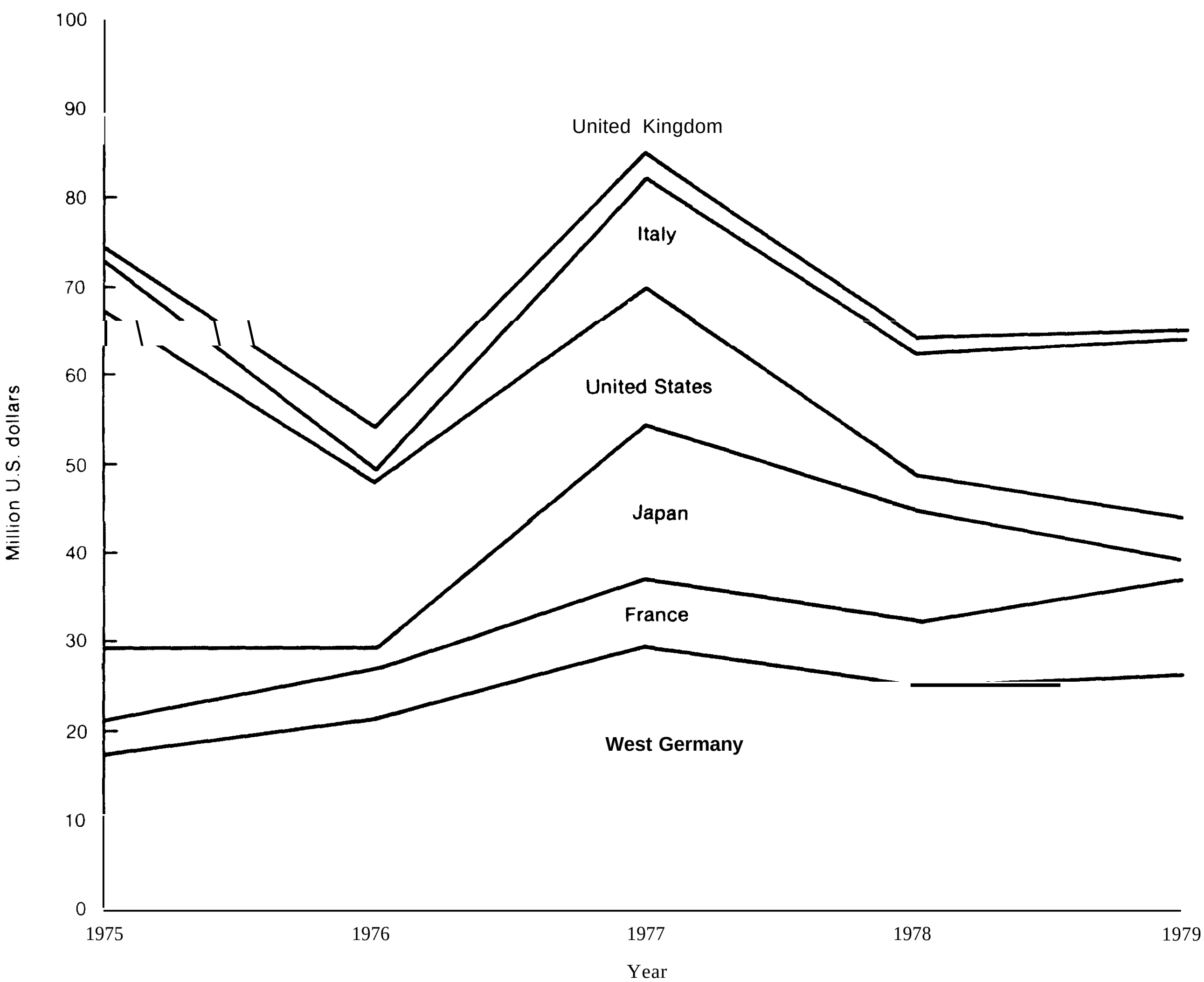
The latter code clearly incorporates a broad range of equipment that can also be utilized by other industries.

Little Soviet trade in nuclear reactors and parts has been recorded—exports of $448,700 from the United States in 1978 and $329,000 from West Germany in 1976. OTA has been unable to find any unclassified accounts that provide further information on either of these figures. There have been report that the U.S.S.R. may be considering the purchase of reactors from Italy, but as yet no such deal has been completed. (It must be noted that the U.S.S.R. has also exported nuclear reactors to the West.) However, the limitations of using and difficulties in interpreting trade statistics may be illustrated by the fact that a $47 million contract purportedly signed with the Italian firm Breda Termomeccanica in 1976 for the design and building of reactor manufacturing facilities at Atommash and Izhora does not appear in this SITC code.[6] It is possible that this deal was not consummated or that it is reflected elsewhere in the trade data,

SITC code 729.92 covers electric welding, brazing, soldering, and cutting machines and apparatus and parts. IW trade in this area amounted to over $90 million in 1975 and over $84 million in 1979, but as figure 13 indicates, U.S. shares have been falling since

[6] Soviet Business and Trade, Nov. 24, 1976, p. 4.

Figure 13.— Western Energy Trade With U.S.S.R.—Welding Equipment (SITC 729.92)



SOURCE United Nations SITC Data

1975. In 1979, less than 10 percent of the welding equipment supplied to the U.S.S.R. by the IW came from the United States, while West Germany and Italy together supplied nearly half.

In addition to the items contained in these two codes, several purchases that may have been destined for the nuclear industry have been noted in *Soviet Business and Trade.* These include a hydraulic press purchased from Japan;[7] pumps from a United Kingdom firm,[8] and various valves, shutters, and plugs from West Germany and Canada.[9] Velan Engineering Co. of Canada is a major supplier of valves for the Soviet oil, gas, chemical, and nuclear industries.

FOREIGN AVAILABILITY OF NUCLEAR EQUIPMENT AND TECHNOLOGY

Aside from complete reactors, chapter 4 has identified some areas in which, should they decide to step up their nuclear-related purchases, the Soviets might usefully turn to the West to supplement their own manufacturing capabilities. These areas include nuclear grade tubing and pipes, welding and brazing equipment, steam generators, pumps and casings (to circulate coolant through the reactor), nuclear valves, and computers, software, and automatic control. It must be stressed that at present the U.S.S.R. imports very little, if any, such equipment. Indeed, analysis of the trade data has confirmed chapter 4's generalization that the Soviet nuclear power industry has been virtually self-sufficient. Assuming for purposes of argument that the U.S.S.R. might reverse its policy, OTA sought to determine in which, if any, of these areas the United States might be considered a sole or preferred supplier to the U.S.S.R.

OTA's "foreign availability analysis" for the nuclear industry was based on information from industrial trade journals and interviews with representatives of U.S. firms (Westinghouse, Rollmet, Ransome), Oak Ridge National Laboratories, the Nuclear Regulatory Commission, and the U.S. Department of Energy. The results of this analysis are reported in tables C-1 through C-7 of appendix C. It can be seen from these tables that firms in a variety of countries could potentially supply the U.S.S.R. with the kind of nuclear equipment and technology it is most likely to seek.

There is one area in which the United States could be a strongly preferred supplier. The United States is the acknowledged world leader in many areas of computer technology. Computers are normally used at nuclear power stations for rather mundane tasks—data acquisition and simple process control—and the U.S.S.R. presently relies heavily on domestically produced computers at its nuclear stations. If greater power station automation is planned, however, more sophisticated systems might be necessary.

The United States is also a world leader in developing and mass-producing exotic, high-strength materials (zircalloy, and high nickel content stainless steel). These are useful in the nuclear industry, particularly for advanced breeder reactors. Such technology has been fairly widely diffused. Indeed, the means by which nuclear technology is spread throughout the world may be illustrated by several examples: The U.S.-based Westinghouse Electric Co. exports nuclear grade tubing to Mitsubishi in Japan, Framatone in France, and ENSA in Spain, and each of these companies constructs nuclear reactors under a Westinghouse license. Toshiba and Hitachi of Japan are General Electric licensees.[10] The reactor in the state-owned plant at

[7] *Soviet Business and Trade,* Nov. 24, 1976. This, together with Italian large boring and milling machines, German machine tools, and U.S. welding and X-ray equipment, was destined for Atommash. See also ***Nucleonics** Week, Nov. 8, 1979,* p. 12.

[8] Hayward Taylor & Co., Ltd. *Soviet Business and Trade,* Feb. 17, 1975.

[9] *Soviet Business and Trade,* Feb. 17, 1975; Apr. 28, 1975; and Dec. 6, 1978.

[10] Mans Lonnroth and William Walker, T'he Viabilit J' of the Civil Nuclear Industry, " International Consultative Group on Nuclear Energy (The Rockefeller Foundation, 1979).

Krsko, Yugoslavia, was purchased from Westinghouse.

SUMMARY AND CONCLUSIONS

The U.S.S.R. is presently self-sufficient in the design, manufacture, and operation of its nuclear plants. Should it reverse its policy and begin seeking Western imports in this area, it would find numerous potential suppliers in several nations.

COAL

WESTERN EXPORTS

The U.N. SITC codes that contain equipment applicable to coal mining are as follows:[11]

571.1	Propellent powers and other prepared explosives.
571.2	Safety and detonating fuses, percussion, and detonating caps, igniters, etc.
629.4	Transmission, conveyor and elevator belts of vulcanized rubber.
655.92	Transmission, conveyor and elevator belts of textile materials.
695.24	Rock drilling bits: tools and bits for assorted hand tools.
718.42	Self-propelled shovels and excavators, self and non-self-propelled leveling, tamping, boring, etc., machinery and parts thereof.
718.51	Machinery for sorting, screening, separating, washing, crushing, etc., for earth, stone, ores, and other minerals.

Figure 14 summarizes trade in each of these categories for the period 1975-79. It shows that the U.S.S.R. has purchased no fuses or explosives from any IW nation (SITC 571.1 and 571.2) since 1977. During 1975 and 1976, U.S. exports in these categories were very small ($5,000 to $28,000). Japan and West Germany led the sale of transmission, conveyor, and elevator belts of vulcanized rubber (SITC 629.4) to the U.S.S.R. in 1975-79; Soviet purchases from the United States were a weak third or fourth (behind Italy). These sales totaled about $48.7 million for all countries during the entire period. Sales in the category 655.92 were negligible.

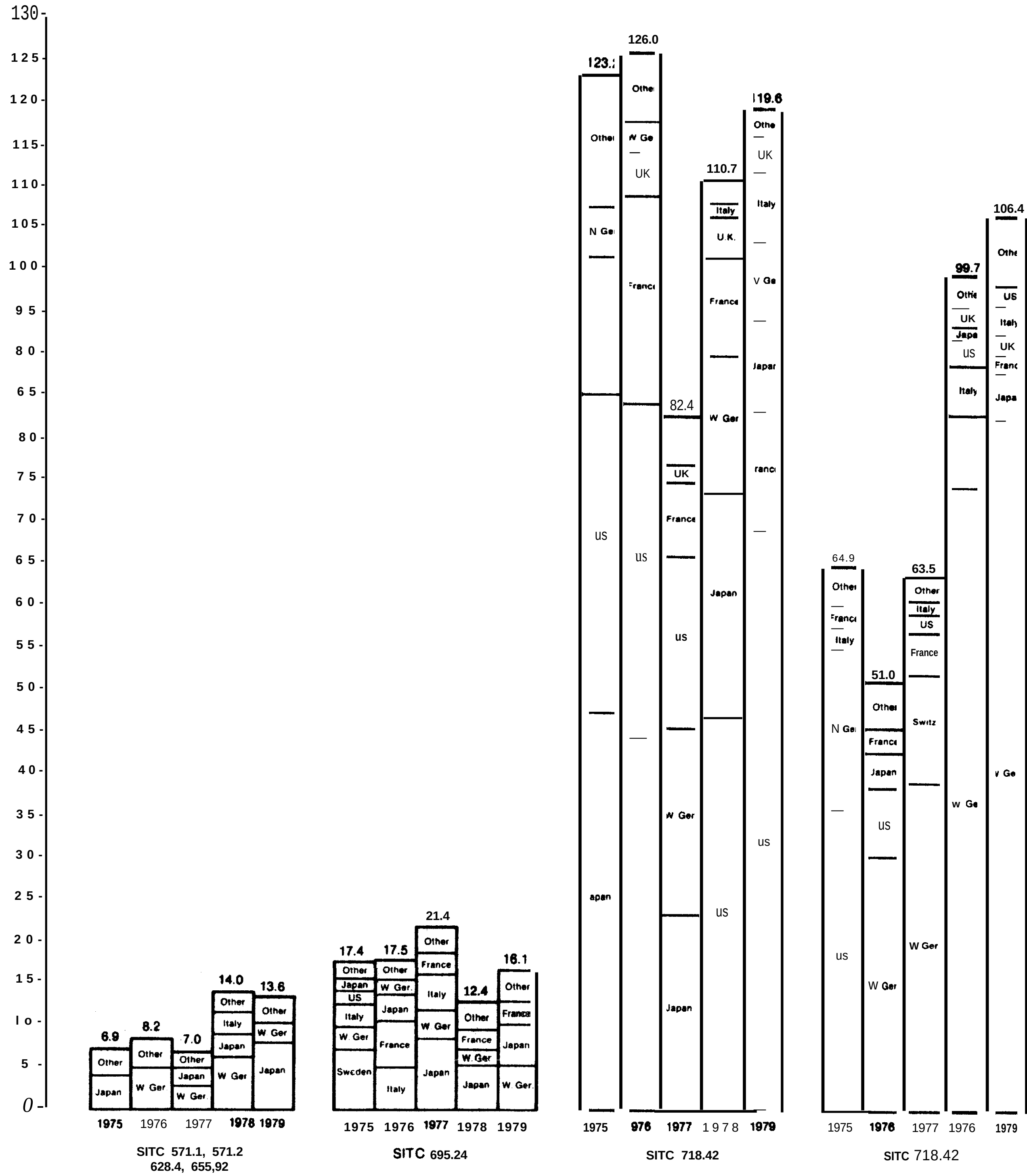
In sales of rock drilling bits and tools, and bits for assorted hand tools (SITC 695.24) to the U. S. S. R., the United States lagged West Germany, Japan, France, Italy, and the United Kingdom. Indeed, the U.S. market share here has fallen precipitously since 1975 when sales of $1.3 million were recorded—in 1979 only $13,000 of such goods were purchased from the United States. Because this equipment might equally well be destined for the oil and gas sector, it is discussed in more detail below.

The Soviet Union buys considerable amounts of self-propelled shovels and excavators, leveling, tamping, and boring machinery (SITC 718.42). However, the finer breakdowns available from U.S. Scheduled B and E and NIMEXE data reveal that most of the purchases here are for items probably destined for the oil and gas industries. Coal-relevant subcategories from Schedule B and Schedule E include draglines, dragline buckets, coal cutting machines, continuous mining machines, longwall mining machines, and excavating machines (including attachments). No exports from the United States to the U.S.S.R. whatsoever have been reported in any of these subcategories.

In 1979, the U.S.S.R. bought $81.8 million worth of machinery for sorting, screening,

[11] SITC 719.31 (other lifting, handling, loading, and unloading machinery) proved on further examination using DOC and NIMEXE data to consist mostly of items relating to oil and gas.

Figure 14.—Coal-Related Equipment Exports to U.S.S.R. (million U.S. dollars)



SOURCE United Nations, SITC data

separating, washing, and crushing (SITC 718.51) from West Germany. Imports from the United States in the same category came to less than $2.4 million, mostly for crushing, pulverizing, and grinding machines and parts. West Germany has carried most of this market since 1976.

In sum, it would appear that Soviet purchases from the West for its coal industry have been relatively modest and that between 1975 and 1979 little of these came from American firms. Soviet import statistics corroborate this broad conclusion. Although the Soviet method of reporting commodity trade differs from that employed in the West—in commodity groupings, valuation, coverage, and the method used for identifying trade partners—data from the U.S.S.R. reflect the same patterns as Western export statistics.

Table 44 shows official Soviet import data on items that may have an impact on coal-related activities, These data indicate that in recent years, Soviet purchases from West Germany and Japan have been much larger than those from the United States. For example, in 1978, the figures show imports of $115.4 million of sorting machinery from West Germany, but only $6 million from the United States. West Germany ($30.4 million) also led the United States ($4.2 million) in exports of mechanical shovels and excavators. Although the only Soviet imports of ships, derricks, and cranes reported in 1977 and 1978 come from the United States, the dollar amounts ($891 ,000 and $5.7 million) are relatively small. The U.S.S.R. purchased $58.6 million and $92.4 million worth of these goods from Japan in 1976 and 1975, respectively.

A search of *Soviet Business and Trade* for transactions that might not have appeared in the SITC codes indicates that the most important category of U.S. exports likely destined for the Soviet coal industry was transportation. Approximately 100 trucks (ranging in size from 100 to 200 tons) purchased from the Unit Rig & Equipment Co. of Tulsa, Okla., for about $70 million were for use in coal-related activities.[12] Other American deals have included $14 million worth of slurry pumps from Ingersoll-Rand between 1974 and 1976;[13] and front-end loaders contracted for $1 million from the Clark Equipment Co. in 1978, and for $2.9 million from Dart Division of Paccar, inc. in 1979.[14]

Between 1974 and 1980 Japanese firms involved in the South Yakutian Development Corp. were responsible for sales totaling approximately $450 million,[15] most of which consisted of shovels and other surface mining equipment. In addition, in 1976 and 1975, respectively, the U.S.S.R. reportedly contracted for $500,000 worth of equipment for excavation in underground mines from

Table 44.—Soviet Imports From Selected Western Nations[a]

	1978	1977	1976	1975
U.S.S.R. imports of ***machinery for sorting***				
United States . .	6,096	26,287	32,900	24,110
West Germany	115,423	30,780	7,573	4,555
	1978	**1977**	**1976**	**1975**
U.S.S.R. ***Imports of mechancial shovels and excavators***				
United States . .	4,169	917	9,692	10,923
West Germany .	30,444	11,799	9,262	28,516
France	2,790	1,157	13,299	5,522
	1978	**1977**	**1976**	**1975**
U.S.S.R. ***imports of ships, derricks*** and ***cranes***				
United States . .	5,677	891	266	10,424
Italy	—	—	3,693	16,068
United Kingdom	110	037	2,758	3,700
Japan	—	—	58,646	92,403

[a]OTA collected Soviet data for France, Italy, Japan, the United Kingdom, United States West Germany and West Berlin. Only those areas that showed trade in a given category are presented here

SOURCE CIA based on Soviet trade data

[12]*Soviet Business and Trade*, Mar. 1, 1978, p. 3.
[13]*Soviet Business and Trade*, Aug. 1, 1975, pp. 1-2.
[14]*Soviet Business and Trade*, June 6, 1979, p. 7.
[15]*Soviet Business and Trade*, June 6, 1979; Nov. 22, 1978; May 26, 1976.

the United Kingdom, and a similar amount in front tunneling machines and loaders from West Germany.[16]

FOREIGN AVAILABILITY OF COAL TECHNOLOGY AND EQUIPMENT

As chapter 3 has indicated, the U.S.S.R. is well able to design, test, and manufacture its own coal mining equipment. Soviet equipment is heavier and somewhat less sophisticated than U.S. equipment, but it is adequate. A common Soviet practice has been to buy items applicable to a specific phase of coal mining and reproduce them. Soviet-made continuous miners, for example, are copies of West German, English, and French models. Drill bits that were formerly purchased from Western Europe are now domestically produced. Equipment for Siberian surface mining was originally purchased from Marion in Japan.

In short, like the nuclear industry, the Soviet coal mining industry has been essentially self-sufficient. In an attempt to ascertain whether a reversal of past Soviet practice with respect to coal-industry equipment imports would focus on items in which the United States is a sole or preferred supplier, OTA assembled a list of essential equipment for coal mining operations, and attempted to locate suppliers of this equipment in Western Europe and Japan. The results may be found in tables C-8 and C-9 of appendix C. Outside of the few deals discussed above, there is no evidence that any of the companies listed here have actually supplied or intend to supply equipment to the U.S.S.R. Nevertheless, it is clear from table C-9 that there exist many European and Japanese suppliers of coal mining equipment.

Comparison of the items available from these companies and those produced in the United States reveals substantial differences between underground and surface mining capabilities. The majority of Soviet underground mining utilizes longwall techniques not widely employed in the United States. Longwall mining was invented in the 1950's in West Germany; in fact, the United States is heavily dependent on Britain and West Germany for longwall research and development, and it also imports substantial amounts of European longwall equipment. (The U.S.S.R. has attempted to export its own longwall systems to the United States.) Much of the underground coal mining equipment manufactured in large quantities in the United States is therefore of little or no use to the U.S.S.R. Undercutter are available only from the United States, but these are not necessary for longwall mining operations. There are also differences in geologic formations that render much U.S. equipment inapplicable in the U.S.S.R.; e.g., the narrow seams in many Soviet mines do not easily lend themselves to mechanization.

A different situation pertains with respect to surface mining, which, as chapter 3 has pointed out, will become increasingly crucial to Soviet coal production as the decade progresses. The United States is a world leader in surface mining equipment and technology, and produces items that could be of great use to the U.S.S.R. One example is the dragline. This is the only piece of surface mining equipment in continuous operation, and coal output is heavily affected by its speed in removing overburden. U.S. draglines and excavators have the largest capacities currently available. Increased excavation capacity would allow Soviet surface mining to become more productive, and bigger draglines would facilitate deeper surface mining. U.S. firms also produce trucks, power shovels, and excavators with capacities much larger than any available from Western Europe or Japan. These items, though not vital to the ability to mine coal, could help to increase output.

SUMMARY AND CONCLUSIONS

Both Soviet and Western trade data show that the U.S.S.R. has purchased relatively little coal mining equipment and technology

[16] *Soviet Business and Trade,* Nov., 22, 1978; June 6, 1979.

from the West, perhaps less than 10 percent of its total equipment needs. With the possible exception of transport vehicles, American market shares in this trade are smaller than those of other Western countries, especially West Germany and Japan. The only coal mining technology that OTA could establish as unique to the United States is undercutter, but these are not used in the U.S.S.R. American underground mining technology is unlikely to be particularly attractive to the Soviet Union.

While no surface mining technologies seem to be unique to the United States, U.S. firms do produce the largest capacity trucks, draglines, and excavators in the world. Chapter 3 has maintained that the future of Soviet coal production rests on expanding its surface mining operations. Should the U.S.S.R. depart from past practice and begin to import large quantities of Western surface mining equipment, the United States would—all other things being equal—be the preferred supplier.

ELECTRIC POWER

WESTERN EXPORTS

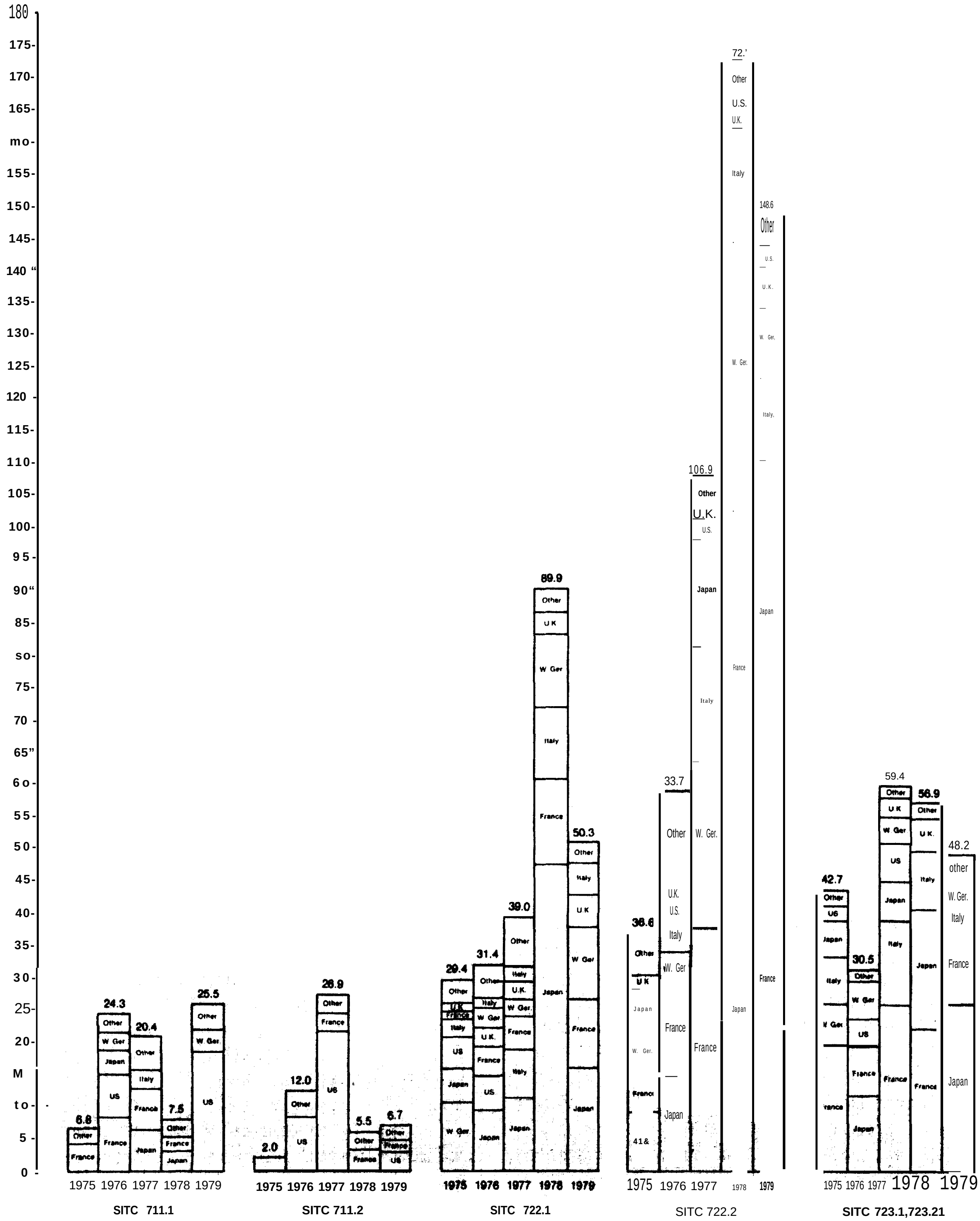
Figure 15 shows export statistics for the following SITC codes containing equipment used for the generation and transmission of electric power:

- 711.1 Steam generating boilers.
- 711.2 Auxiliary plant for use with steam and other vapor generating boilers.
- 722.1 Rotating electric plant and parts thereof; transformers, converters, rectifiers, inductors and parts.
- 722.2 Electrical apparatus for making or breaking electric circuits.
- 723.1 Insulated electric wire, cable, bars, strip and the like.
- 723.21 Electrical insulators and other materials.

1979 statistics for SITC 722.1 indicate that Japanese, French, and West German firms supplied the U.S.S.R. with $15.2 million, $11.9 million, and $11.1 million worth of transformers, converters, rectifiers, inductors, and parts thereof, respectively. Purchases from the United States in this category amounted to only $1.35 million. Much the same situation has prevailed since 1977. Similar patterns hold for electrical apparatus used in making or breaking electrical circuits (SITC 722.2). From 1975 to 1979, Soviet imports from the United States ($3 million) have been dwarfed by imports from France ($59.2 million), Japan ($51.7 million), West German ($11.3 million), and Italy ($13.6 million). The Soviet Union does not purchase many electrical insulators (SITC 723.21). Most of its 1979 purchases came from the United States, but these amounted to only $666,000. Even this was an anomaly. Between 1975 and 1979, no Soviet purchases from any country exceeded $48,000.

A similar aberration can be seen in the data for SITC 711.1, steam generating boilers. The $19 million recorded in this category for U.S. exports in 1979, although not a large amount in absolute terms, represented a departure from Soviet practice over the past 5 years in two ways. The United States had not before been the largest Western supplier of this equipment, and the amount was significantly greater than any recorded previously for a single country in a single year. OTA has been unable to discover any details of the transaction or transactions that accounted for these exports. SITC 711.2 contains auxiliary plant for such boilers. Except for large U.S. sales in 1976 and 1977 ($9.4 and $22.7 million), for which OTA has been unable to obtain more information, Soviet purchases in this category have come almost exclusively from France in amounts ranging between about $.2 and $5 million per year.

Figure 15.—Electric Power Equipment Exports to the U.S.S.R. (million U.S. dollars)



SOURCE United Nat Ions, SITC data

It was not possible to determine the proportion of the equipment in these codes that was actually destined for the Soviet electric power industry. *Soviet Business and Trade* noted only one relevant deal over the past 5 years, a Soviet purchase of cable for the Siberian power grid from Siemans AG of India and West Germany.[17]

FOREIGN AVAILABILITY OF ELECTRIC POWER EQUIPMENT AND TECHNOLOGY

The U.S.S.R. does not purchase very large amounts of electric generation or transmission equipment from the West. As in the coal and nuclear sectors, however, Soviet policy could change. OTA, therefore, attempted to determine whether competing firms in Europe and Japan could supply the U.S.S.R. with electrical transmission technology.

American industry representatives have maintained that technology for the production of most of the necessary equipment for electricity generation and transmission is widespread and available in the open literature. Interviews with General Electric (GE), Westinghouse, the Electric Power Research Institute (EPRI), and the Bonneville Power Administration produced a consensus view that European-produced equipment typically costs less than American equipment, and that the quality and capacity of the equipment produced by West European and Japanese companies compare favorably with U.S. items. A representative from GE claimed that the West Europeans were at least on par with, and possibly ahead of, the United States in high voltage transmission, and a representative from the Bonneville Power Administration told OTA that West Germany, Sweden, and Japan equal the United States in producing high capacity underground cable technology and equipment,

West European and Japanese firms that produce electric generation and transmission equipment are listed in tables C-3 and C-10 of appendix C. Licensing agreements between Mitsubishi and Siemens exist for many of the items used in transmission, Moreover, the U.S.S.R. itself produces some transmission components for export. The Soviet trading organization, Energomash, has sales agents in Australia, Austria, Argentina, Belgium, Brazil, Canada, West Germany, and the United States. Among the products it markets are coupling capacitors for high voltage transmission lines, three-phase power transformers, and circuit breakers for use in substations.

SUMMARY AND CONCLUSIONS

While the Soviets buy some electrical equipment from the West, these purchases are relatively modest and no corroborating evidence is available to link them to electric transmission. The sole exception is purchases of cable (from Siemens of West Germany). International sales representatives for General Electric and Westinghouse, and electric transmission experts who have visited the U.S.S.R. agree that the Soviets design and produce virtually all their own transmission equipment.

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"L5'{)({Pt *Business and Trade*, Sept. 29, 1976.

OIL AND GAS

WESTERN EXPORTS

Figure 16 shows United Nations data for the most important oil and gas related SITC codes:

Exploration

714.3 Automatic data processing (ADP) machines and units thereof; magnetic and optical readers and machines for processing data.

714.92 Parts and accessories for ADP and other calculating machines.

861.91 Surveying, hydrographic, etc., and geophysical instruments (nonelectric).

861.99 Parts of meters and counters; nonelectric and electrical measuring, checking, etc., instruments.

Drilling

695.24 Rock drilling bits; tools and bits for assorted hand tools.

732.4 Special purpose motor lorries, vans, crane lorries, etc. (includes rigs).

Production/completion/transportation

678, 679.2 Tube-s, pipes, and-fittings of iron and steel.

642.93 Gummed or adhesive paper in strips or rolls (for pipe insulation).

719.21 Pumps for liquids and parts thereof.

719.22 Air and vacuum pumps and air or gas compressors and parts thereof.

719.23, 712.31 Filtering and purifying machinery and apparatus for liquids and gases.

719.31 Ships, derricks, cranes and mobile lifting cranes and parts; other lifting, handling, and loading and unloading machinery.

Offshore

735.92 Light vessels, floating cranes and other special purpose vessels, floating docks.

735.93 Floating structures other than vessels.

Multiarea

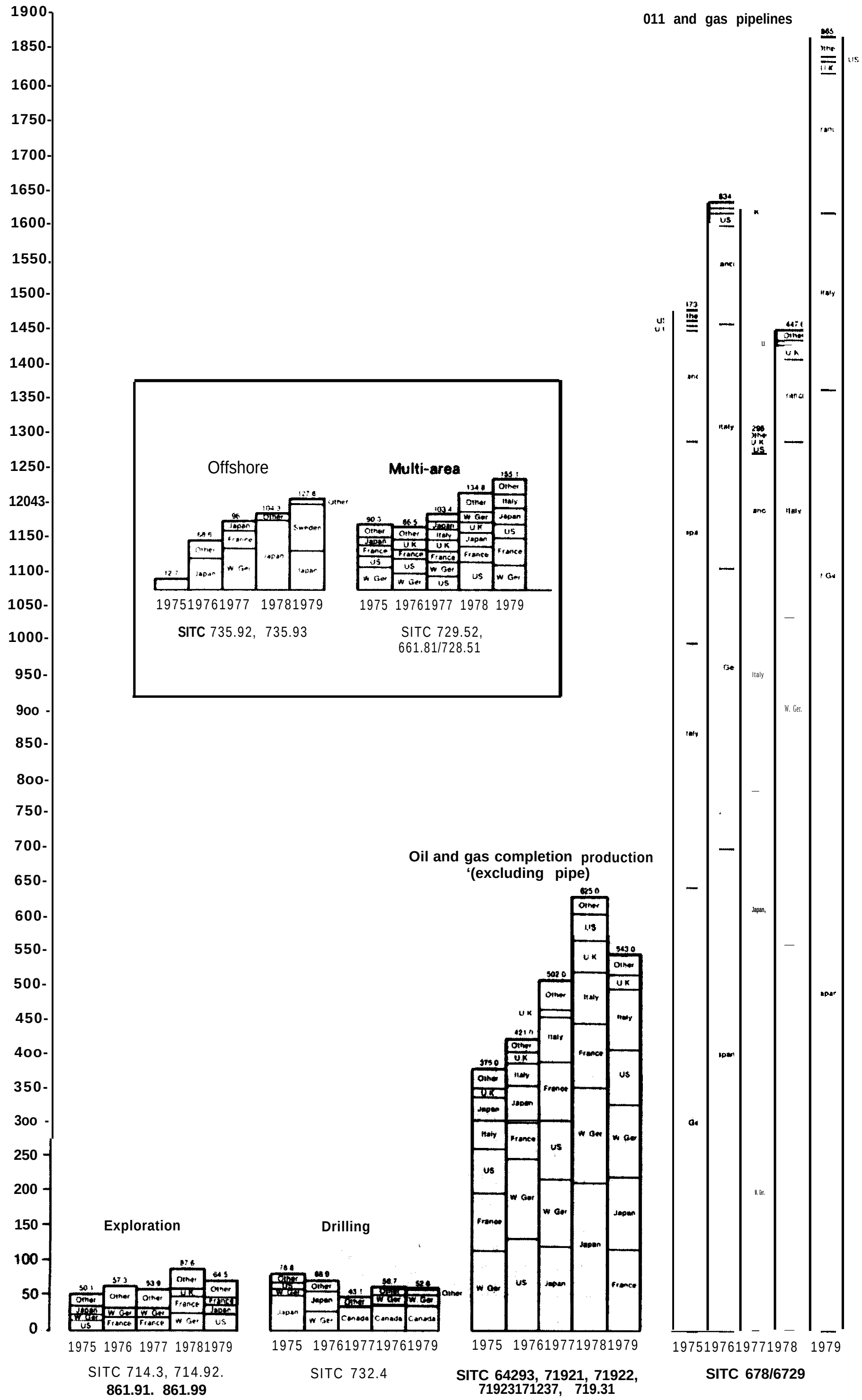
729.52 Electrical measuring, checking, analyzing, or controlling instruments.

861.81, 729.51 Gas, liquid, and electricity supply or production meters.

The codes presented here are clearly unsuitable for any precise analysis of Soviet oil and gas industry imports. They include many items that may have been destined for other energy sectors or for another part of the Soviet economy altogether, and they fail to reflect known important transactions—the U.S. sale by Dresser Industries of a drill bit plant, for instance. For this reason, OTA has supplemented the SITC data with Department of Commerce Schedules B and E statistics—which provide detailed information about U.S. exports–the EEC NIMEXE system, and information about specific transactions gleaned from *Soviet Business and Trade*. These sources have allowed a rather more detailed, albeit sometimes qualitative, discussion of the nature, extent, and source of Western exports in the Soviet oil and gas industry.

The Department of Commerce data shown in table 45 indicate that U.S. oil and gas equipment trade with the U.S.S.R. nearly tripled between 1975 and 1979, from about $31 million to about $90 million. This growth has been largely due to increases in the value of computers and parts, drill rigs and parts, and pumps. The data also show that while the share of Soviet purchases of exploration equipment has declined slightly, that of drilling-related equipment has grown enormously, largely at the expense of well completion and production items. This may partly reflect a shift in Soviet emphasis away from

Figure 16.— U.S.S.R. Imports of Oil and Gas Equipment (million U.S. dollars)



SOURCE United Nations SITC data

84-389 O - 81 - 13

Table 45.—U.S. Oil and Gas Equipment Trade With U.S.S.R. Relative Percentage of Each Technology Area (thousand U.S. dollars)

	1975	1976	1977	1978	1979
Total	30,818.0	68,418.8	33,882.8	59,652.7	89,741.0
Exploration					
Geophysical	2,282.0	983.1	480.7	862.5	2,022,6
Computers & pts	8,282.0	16,215.0	3,643.4	17,578.3	22,311.0
Total exploration	10,569.8	17,198.1	4,124.1	18,440.8	24,333.6
Percent of total	34%	25%	12.2%	31%	27%
Pipe	—	2,821.0	1.9	404.7	579.2
Bits	219,9	—	147.2	—	—
Rigs and pts	1,477.0	6,513.0	8,272.0	33,247.9	37,235.3
Total drilling	1,696.9	9,334.0	8,421.1	33,652.6	37,814.5
Percent of total	5%	13.6%	24.8%	56.4%	42%
Well completion/ production					
Pumps	11,657.4	22,220.1	3,674.3	1,241.9	9,979.7
Pump parts	5,928.8	8,235.6	11,743,9	242.9	17,613.2
Gas compressors	765.3	10,445.6	5,432.3	5,937.8	—
Oil and gas sep.	199.8	685.4	487.1	136.7	—
Total comp/prod	18,551.3	41,886.7	21,337.6	7,559.3	27,592,9
Percent of total	60%	61%	63%	12.7%	30,7%

SOURCE Department of Commerce

the use of U.S. electric submersible pumps in favor of gaslift techniques that are available from non-U.S. sources (see below).

According to these data, the United States captured only 3.3 percent of the 1979 estimated Western sales in the oil and gas sector reported in table 42 above. It must be noted, however, that the Department of Commerce statistics underrepresent the full value of the U.S. equipment and technology purchased by the U.S.S.R. For instance, neither SITC nor DOC trade statistics show any U.S. contributions in the area of offshore equipment. Yet, a recent survey of Soviet offshore rigs revealed drilling equipment of U.S. origin.” This apparent contradiction may be attributed to the fact that although the U.S.S.R. has purchased its rigs from other nations, these suppliers themselves have imported U.S. drilling equipment for installation on the rigs. The U.S. sale will appear as an export to the third country.[19] Similarly, although U.S. statistics show no sales in the area of refining, U.S. firms are known to have supplied engineering and technical services to West European and Japanese companies engaged in the con-

[18] 1980-81 Directory of Marine Drilling Rigs, pp. 19-172.
“American technology reexported from third countries is still subject to U.S. export control laws.

struction of petroleum refineries in the U.S.S.R.[20] These transfers of know-how–like the sale of the Dresser drill bit plant–are not recorded in Schedule B/E data and are thus not reflected in table 45 or figure 17.

These data problems limit the precision of any conclusions that can be drawn from Western export statistics. Nonetheless, some generalizations about Western exports to the U.S.S.R. in a number of oil and gas industry sectors are possible.

Exploration

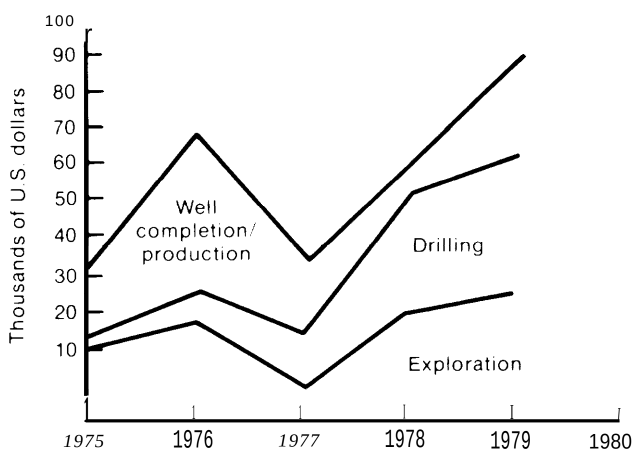
Most of the exploration equipment exported to the U.S.S.R. has consisted of computers and geophysical equipment. Figure 18, for instance, illustrates Soviet purchases of automated data processing equipment from selected Western countries. This figure shows that the primary exporters of this exploration-related computer equipment were the United States, France, and West Germany. Through 1978, the United States tended to supply the majority of the hardware and the French to specialize in software.[21] The post-1978 decline in such exports may be due to tighter multilateral export controls on computers, or to improvements in the Soviet hardware base.

The Control Data Corp. (CDC) has been by far the leading exporter of American computers capable of processing the large quantities of data associated with seismic surveying. In recent years, CDC has sold three Cyber 172s and a Cyber 73 to various Soviet ministries engaged in seismic exploration. IBM has also sold two S/370-148 computers for geophysical applications. Another American firm, Geosource, Inc. of Houston, had by 1979 sold 13 Command II field processing systems that are used to preprocess seismic data in the field.[22] This sale alone, valued at $6 million, accounted for nearly 30 percent of total U.S. sales of computers and computer parts in 1979. The French firms Ferney-Voltaire and CIE Generale Geophysique (CGG) have provided the majority of the specialized software used with the CDC computers.[23]

The United States and France are also the U.S.S.R.'s leading Western suppliers of geophysical equipment. NIMEXE and DOC data show that between 1975 and 1979 French sales in this area have increased, while those from the United States have been erratic, ranging from as high as $2.2 million to as low as $480,000. CGG was a major supplier of geophysical equipment, in 1976 alone selling to the U.S.S.R. $14 million worth of digital seismographic recorders, magnetometers, gravity meters, and hydrophones. The equipment was used to equip two geophysical ships that were built for the Soviet Union by Mitsubishi of Japan.[24]

Geosource is the largest American supplier of geophysical equipment, and it sold approximately $30 million worth of equipment to the U.S.S.R. between 1975 and

Figure 17.—U.S. Oil and Gas Equipment Trade With U.S.S.R. by Technology Area

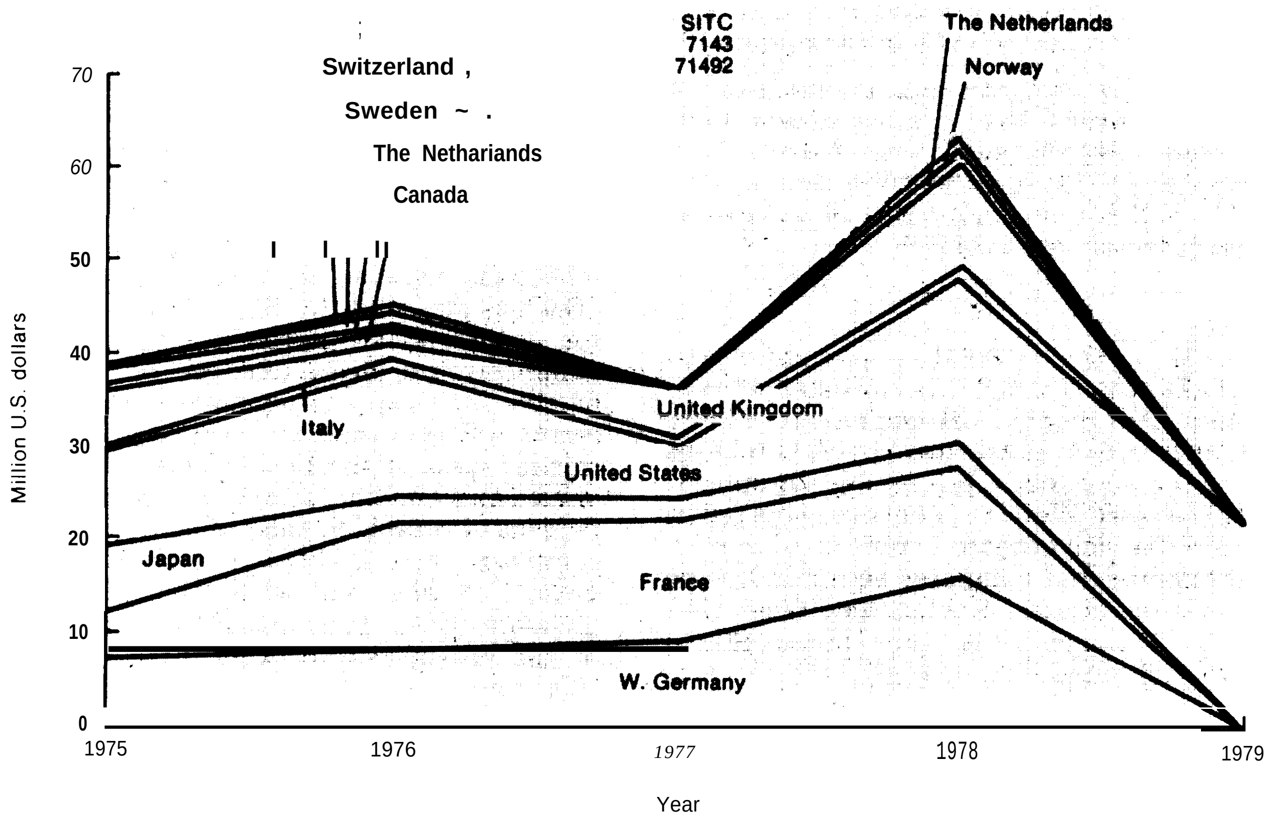


SOURCE Table 45

[20] Soviet Business and Trade, Jan. 1, 1979

[21] Soviet Business and Trade, Apr. 11, 1979.
[22] Ibid,
[23] Ibid., and Mar. 18, 1979.
[24] Soviet Business and Trade, Sept. 29, 1976.

Figure 18.—Western Energy Trade With U.S.S.R. Automated Data Processing Equipment



SOURCE United Nations SITC Data

1979.[25] Geosource has supplied the U.S.S.R. with a wide array of geophysical prospecting equipment, including 13 photodot automated digital display systems that are used in conjunction with the Command I I system.

Drilling

The major Soviet imports in this area have been drill pipe and casing. Soviet imports of drill pipe and casing have come predominantly from Japan, West Germany, France, and Italy. Within these countries, important suppliers have been Mannesmann (West Germany); Vallourec (France); and Finsider (Italy). The U.S.S.R. has also sporadically purchased packers, mud additives, power tongs, and heavy drilling equipment from the West. The Soviets have purchased a number of packers from both Technip in France and Lynes International in the United States.[26]

U.S. exports of drill pipe and casing to the U.S.S.R. totaled less than $1 million over the last 3 years. These relatively low levels are at least partially due to a rapid increase in U.S. drilling activity, which caused U.S. demand for drill pipe and casing to exceed domestic supply. The American shortfall has largely been made up with pipe and casing imported from Japan. The majority of U.S. drilling-related exports to the U.S.S.R. are drilling rigs and parts for drilling rigs. While the

[25] *Soviet Business and Trade,* Feb. 14, 1979.

[26] *Soviet Business and Trade,* Jan. 2, 1980.

United States has not been a major supplier of complete rigs–-approximately 12 U.S. rigs have been sold to the Soviet Union over the last 10 years–the Soviets are purchasing U.S. drilling rig parts in significant dollar values.

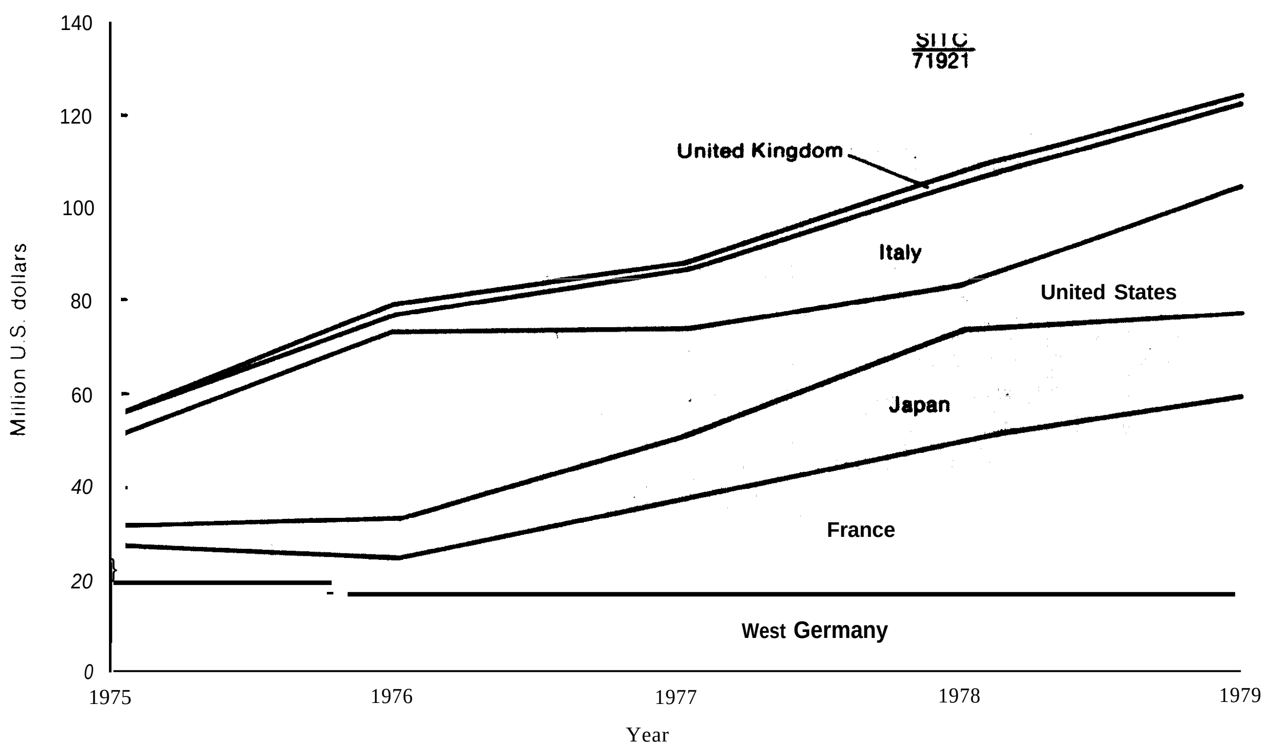
U.S. firms account for most of the non-Communist world's production of drill bits, and U.S. bits are of significantly higher quality than Soviet counterparts. The Soviets, however, have purchased fewer than 100 U.S. drill bits over the last 5 years. Instead they have opted to purchase the design and equipment for a drill bit plant from Dresser Industries. Nor have drill bit imports from Western Europe been large. The NIMEXE system classifies drill bits into both bits made of base metal and metal carbide. EEC exports of both types have been inconsequential.

Well Completion/Production

Figure 19 shows a steady growth in Soviet imports of pumps for liquids. The leading exporters of these items have been France, West Germany, and the United States. While it is not clear that West German and French pumps are used in the production of oil and gas, Schedule B/E data show that almost all of the U.S. trade is in oil well and oilfield pumps. This is confirmed by articles in *Soviet Business and Trade* that indicate that U.S. companies such as TRW-Reda, Centrilift, and Oil Dynamics have been major exporters of electric submersible pumps for Soviet oilfields.

Finally, Western trade activity in pipe handlers and gas lift equipment was not ascertainable from the trade data due to problems of aggregation. It was apparent from

Figure 19.—Western Energy Trade With U.S.S.R. Pumps for Liquids



SOURCE United Nat Ions SITC Data

articles in *Soviet Business and Trade*, however, that these items have been exported to the Soviets by the United States, Japan, and France: gas lift equipment predominantly by the French, and pipelayers primarily by the United States and Japan. Technip of France has sold gas lift equipment for over 2,000 wells. Pipelayers have been sold to the U.S.S.R. by Caterpillar and International Harvester in the United States and Komatsu in Japan.

The Soviet Union has made sporadic purchases of enhanced recovery equipment and technology. Among the transactions that have appeared in *Soviet Business and Trade* have been the sale of two carbon dioxide (CO_2) plants by Borsig of West Germany, two surfactant plants by Pressindustria of Italy, a surfactant plant as well as chemicals from Sanyo Chemical Industries of Japan, and an alpha-olefin plant from Davy International in Great Britain.[27]

Transportation

The most important commodities in this sector have been large diameter pipe and gas pipeline compressor stations. SITC codes 678 and 672.9 contain a number of subcategories and cover a wide variety of tubes and pipes. Figure 16 shows that in each category, Japan, West Germany, and France are the major Soviet suppliers, and the United States is by far the smallest. In the category of tubes, pipes, and fittings of iron and steel, for instance, 1979 Japanese exports were worth approximately $0.75 billion and West Germany's over $0.5 billion, while U.S. sales amounted to a little over $1 million. Some of this pipe may have been used in the nuclear industry, but it is probably safe to assume that a large portion of it went to the oil and gas sector. The principal companies supplying the pipe are Sumitomo (Japan), Mannesmann (West Germany), Vallourec (France), and Finsider (Italy). The United States does not produce the 56-inch diameter pipe that the Soviets use to construct gas pipelines.[28]

Compressor stations for gas pipelines are another active commodity. The largest exporters of compressor stations to the U.S.S.R. have been Italy, West Germany, and the United States, with Nuovo Pignone of Italy and GE of the United States the major suppliers.[29]

Refining

The U.S.S.R. has purchased refineries and refinery equipment from Japan, Italy, and France, the tendency being to import entire refineries rather than component parts. The primary contribution of the United States in this area has been through Fluor Corp., which provided design and engineering services to Italian and Japanese construction firms.[30]

Offshore

Trade in this area has consisted primarily of sales of offshore drilling rigs and auxiliary vessels and equipment, and the principal suppliers have been Japan and the Netherlands.[31] Rauma-Repola Oy of Finland was recently granted a contract to build three dynamically positioned drill ships for the Soviet Union, to be delivered in 1981 and 1982. The United States has supplied auxiliary equipment for rigs sold to the Soviets, but Soviet purchases in this area have been both moderate and sporadic.[32]

Conclusions

Examination of trade data reveals that the U.S.S.R. has been very selective in the kinds of Western equipment and technology it has purchased to supplement its domestic

[27] *Soviet Business and Trade*, Aug. 15, 1979.

[28] Interview with J. Brougher, Bureau of East-West Affairs, Department of Commerce.

[29] *Soviet Business and Trade*, Nov. 10, 1976.

[30] *Soviet Business and Trade*, Jan. 31, 1979.

[31] *Soviet Business and Trade*, July 15, 1980; May 21, 1980.

[32] 1980-81 Directory of Marine Drilling Rigs, pp. 19-172.

oil and gas equipment. Indeed, the relatively modest imports of may items lead one to suspect that the U.S.S.R. has been supplementing domestic equipment stocks at times of peak demand and/or purchasing the best available product for particularly difficult application. It is equally probable that some items have been procured for laboratory examination and duplication, or to serve as guides to correct specific problems.[33] The most prominent exception here is Soviet imports of Japanese and West European large diameter pipe, which have been consistently large and which seem to be required because of insufficient domestic production capacity.

Interestingly, the U.S.S.R. has not purchased many items basic to the petroleum industry. These include magnetometers, gravimeters, mud-pumps, drilling mud, casing cement, engines, pipe insulation, separation equipment, and offshore floating production platforms. These omissions or gaps in trade with Western countries can be interpreted in a number of ways: that the U.S.S.R. and its CMEA partners have an adequate industrial base to supply their needs, even if the result is inefficient by Western standards; that insufficient hard currency has forced priority-setting among Western imports; or that the U.S.S.R. has made a policy decision to be as independent as possible of supplies from the Western countries in certain critical segments of the oil and gas industries. It is most likely that a combination of such factors is at work.

Be that as it may, the following generalizations seem warranted by the data:

- In value terms, by far the largest Soviet purchases from the West have been in the area of iron or steel seamless pipes and tubes (including the large diameter pipe used in Soviet oil and gas lines). Purchases in this area from the United States have been negligible. By far the largest suppliers have been Japan and West Germany.
- The U.S.S.R. has also purchased substantial amounts of various pumps and gas compression equipment. Here, the United States has had larger market shares. The U.S.S.R. has made only a few large purchases in the area of light vessels, floating docks, etc., which includes offshore drilling rigs. None of the vessels themselves have come from the United States. In 1979, Japan and Sweden were the only large exporters in this category.
- The U.S.S.R. has purchased very few drill bits from the West, apparently preferring to acquire its own additional manufacturing capacity in the form of an entire plant.

FOREIGN AVAILABILITY OF OIL AND GAS INDUSTRY EQUIPMENT AND TECHNOLOGY[34]

Much oil and gas technology originated in the United States, but that technology has lost its American identity over the years through licensed production, wholly owned subsidiaries overseas, and employment of U.S. commodities and expertise worldwide. Other sophisticated technology was developed elsewhere. For example, Schlumberger of France first developed electric well log-

[33] There is substantial evidence of duplication. 1 n an interview with OTA, a Vice President of TRW-Reda Pump, Inc., asserted that when one of his technicians toured a Soviet pump plant in 1979, he saw 20-year-old Reda models being produced.

[34] This section is based on trade journals, industry catalogues, *Soviet Business and Trade, The Composite Catalogue of Oil Field Equipmcnt and Services* (Houston, Tex.: Gulf Publishing Co., 1980), and interviews with representatives of the following firms: Gulf Oil Exploration & Production CO., Geosource, Inc., Dresser Industries, BWT World Trade, Cameron Iron Works, Inc., Hughes Tool Co., TRW-Reda Pump, Inc., Brown & Root, Inc., and Williams Bros. Engineering Co. Representatives of these firms provided candid, forthright observations of their past dealings with the U. S. S. R., insight gained during country visits and an appraisal of their foreign competitors. These visits, coupled with the other reported U.S.S.R./Western trade deals, provided a basis on which to judge the availability of Western oil and gas technology. While these sources could not provide complete identification of all possible suppliers, OTA believes that it was acquainted with the most significant suppliers and the strongest competitors to U.S. firms.

ging equipment that is recognized today as the world's standard. Likewise, the steel industries in Western Europe and Japan generally produce products that are as good as, if not better than, those available from the United States–and at lower prices. Technological leads are perishable with time. Licensed manufacturers frequently improve upon designs or manufacturing processes based on local conditions and equipment. Wherever the original development work and design may have been done, ideas soon become general knowledge. The following sections discuss the foreign availability of energy technology that would be useful to the U.S.S.R. in the various phases of oil and gas production and delivery.

Exploration

As noted above, the American firm Geosource has been very active in Soviet trade. Sercel of France has been a strong competitor to Geosource for sales of field data collection and preprocessing centers. Table 46 compares basic parameters of Geosource, Texas Instruments (another U.S. firm), and Sercel products used in seismic work. The table shows that the equipment, although not identical, is similar.

Table 47 identifies the major items of seismic surveying equipment and suppliers around the world. Most items are produced by firms in Western Europe and Japan, and many are available in the Eastern Bloc, although the quality of the latter is questionable and Western equipment tends to be more advanced. The United States may lead technically in one or two items, but the general consensus is that products from Sercel, for example, are capable of performing similar functions. On the other hand, only the United States is able to supply the full range of equipment.

Table 46.—Comparison of U.S. and French Seismic Equipment

	Geosource MDS-10			Texas Instruments DFSV			Sercel 338 B
	Data channels	Sample Interval (MS)	Packing density	Data channels	Auxiliary channels	Sample rates	
	24	½	1,600	SEG-B			24 Channels @ 1, 2, 4 ms
Data	24	1	800 or 1,600[a]	To 24	4	1, 2 or 4 ms	
	24	2	800 or 1,600[a]	28	2	1, 2 or 4 ms	
	24	4	800				
Channels	48	1	1,600	48	4	1[b], 2 or 4 ms	48 Channels @ 2, 4 ms
	48	2	800 or 1,600[a]	60	2	2 or 4 ms	
	48	4	800 or 1,600[a]	96	4	2 or 4 ms	
	96	2	1,600	120	4	2 or 4 ms	96 Channels @ 4 ms
	96	4	800 or 1,600[a]	240	4	4 ms	
	Solid state stacking available at all sample rates			Packing density 800 or 1,600 bpi except (1) 1,600 bpi only.			
Packing density maximum BPI	1,600			1,600			1,600 6,250 for 338IR (IBM recorder)
Number of bits	14 bits plus sign bit 4 bit gain word			14 bits plus sign bit 3 bit gain word			14 bits plus sign bit
Frequency response	2 to 1,000 Hz			3 to 256 Hz			Unknown
Distortion	0.1 0/0 maximum @ 0.53V RMS input			0.050/0			Less than 0.1 °/o @ .05V input
Tape speed range	Unknown			10 to 120 ips			20 to 92 ips

[a]800 BPI NRZI optional
[b]1 ms at extra cost to 56 channels

SOURCE Office of Technology Assessment

Table 47.—Manufacture of Seismic Equipment by Country

	U.S.A.	France	W. Ger.	Japan	Holland	Canada	Brazil	U.S.S.R.	Bulgaria	E. Ger.	Hungary	Poland	China	U.K.	Israel
Vibrator	X		X												
Vibrator control	X														
Shooter explosive	X														
Recorder field	X	X		X		X		X			X				
Tape transport	X	X						X			X				
Camera CRT	X			X							X				
Cables	X	X	X		X	X	X	X				X			
Connector	X	X			X	X		X							
Geophone	X			X	X			X				X	X		
Airgun (marine)	X														
Marine streamer	X	X	X											X	
Marine positioning	X	X												X	
Seismic computer	X	X	X			X		X	X	X	X				
Array transform processor	X	X													
Plotter	X	X	X								X				X

NOTE No Inferences as to quality or comparability can be made from this table which merely shows the existence of commercial manufacturers

SOURCE Off Ice of Technology Assessment

Seismic survey data must ultimately be processed by large mainframe, third generation computers with floating point and array processors. The United States has approved the sale of six large computers, with somewhat restricted array processors, for use in the major hydrocarbon producing regions in the U.S.S.R. Two French firms, Ferney - Voltaire and CGG, are known to have supplied sophisticated geophysical software (*computer* programs) used on the U.S. machines to analyze seismic survey results. An IBM sale included American software.

In sum, the equipment to perform seismic surveys and record seismic data are generally available worldwide. U.S. firms are unique, however, in being able to provide systems displaying the full range of equipment and know-how. U.S. firms also lead in the accuracy of some equipment; and the United States has a substantial lead in computers that process the seismic data. Soviet capabilities in this area are generally 5 to 15 years behind the West and purchases of such equipment would certainly enhance the U.S.S.R.'s seismic work. The degree to which this would necessarily lead to increased oil production in the present decade is unclear, however.

Drilling

The U.S.S.R. has purchased 15 portable drilling rigs from Tamrock Oy of Finland. Canadian sales of $12 million to $32 million each year between 1975 and 1979 were probably also portable rigs, which are known to be produced by the Canadian firm Foremost. Mobile equipment capable of drilling to 20,000 ft is also available from Romania, although it may not perform to advertised specifications.

The U.S.S.R. has imported drill pipe almost entirely from firms in Western Europe and Japan. Prominent suppliers have been Vallourec and Creusôt-Loire of France; Mannesmann of West Germany; Italsider and EFIM of Italy; and Mitsubishi, Mitsui, Sumitomo, Japan Steel Works, and Nippon Kokan of Japan. Japanese pipe is generally considered to be equal to, if not better than, U.S. pipe and is available at a significantly lower price. It is manufactured by the latest methods including inertial welding of the tool joints on the ends of the pipe, and U.S. drillers are buying Japanese pipe to supplement U.S. production capacity.

The United States is the predominant producer of drill bits in the West, with the American firms Hughes, Dresser, Smith, and Reed supplying the vast majority of bits used outside the Communist world. These firms produce the greatest diversity of high-quality bit types for varying underground rock strata. A few diamond bits and core bits are produced by Diament-Boart of Belgium and Tsukimoto Seiki in France, but these cannot substitute directly for rock drill bits. While Tsukimoto produces both diamond and metal bits, its total annual production is very small, approximately 5,000 bits. European bits have a more limited operating capability than their U.S. counterparts and their quality does not match U.S. standards. Creusôt-Loire, SMF Division of France, has recently been purchased by Hughes Tool Co. and the drill bit plant is being modernized to U.S. standards.

The Soviet Union is itself a prodigous producer of drill bits, and it has not purchased Western bits in large quantities. A great deal of publicity has accompanied the sale by Dresser Industries of a tungsen carbide journal bearing drill bit plant to the U. S. S. R., the capabilities of which are discussed in chapter 2. The export license for this plant was recently revoked, but all the technology relating to production machinery, manufacturing processes and metallurgical specifications has already been transferred. The revocation mainly prohibits Dresser from providing onsite training of Soviet technicians once the manufacturing plant is completed. The U.S.S.R. will therefore be forced to resort to trial and error to duplicate Dresser-achieved quality. In sum, the United States enjoys a significant lead in both quality and quantity of rock drill bits. But the U.S.S.R. does not purchase significant quantities of such bits and the sale of the American advantage—if the plant achieves its rated capacity of high-quality bits.

Most of the well-logging equipment currently employed in the U.S.S.R. is copied from U.S. Halliburton "Jeep" single conductor logging tools acquired as part of lend-lease equipment after World War II. The current technology in the West employs multiple conductors (up to seven) to obtain all the desired information on a single pass in the borehole. These multiple conductors significantly expedite complete logging operations. The Soviets have purchased well-logging tools from several U.S. firms (Halliburton, Dresser, Gearhart-Owens) but have not allowed experienced Western firms to enter the U.S.S.R. to provide logging service. The world's leading logging firm, Schlumberger, has a policy of selling only services, not equipment, and it performs 80 percent of the logging services outside the Communist world. Other logging services exist in France, United Kingdom, and West Germany. These firms are generally small, however, without Schlumberger's reputation for quality of service. In sum, the U.S.S.R. substantially lags in logging equipment, but the technology is available outside the United States.

Well Completion/Production

The process of completing a well entails the installation of equipment necessary to isolate the producing zones in the well, extract, and contain the crude oil or gas–well head assemblies (christmas trees, chokes, valves), downhole packers (for both single and multiple zone completion in a single well), and artificial lift equipment (sucker rod pumps, electrical submersible pumps, and gas lift equipment).

The literature reveals few exports of well completion equipment to the U.S.S.R. Sales of well head assemblies have been made by Hübner-Vamag AG in Austria; FMC Europe (Luceat), Cameron de France and Creusôt-Loire of France; EFIM of Italy; producers in Romania; and BWT World Trade, CAMCO, Otis Engineering, Cameron Iron Works, FMC Petroleum Equipment Co., and Baker Oil Tools, Inc. of the United States. U.S. industrial representatives generally agree that equipment available overseas provides satisfactory service except under severe conditions, i.e., high pressure and corrosive atmospheres. These problems are usually best served by U.S.-supplied equipment. But such conditions are found infrequently in the major Soviet oil and gas producing regions—less than 5 percent of the time and then principally only in the North Caucasus, the Caspian, and Sakhalin.

Artificial lift equipment is less generally available outside the United States than wellhead equipment. The Soviets are known to produce their own sucker rod pumps and electric submersible pumps. U.S. technicians who have seen Soviet submersible pumps report that they appear to be exact copies of pumps produced by Reda in the United States shortly after World War II. None of the pumps observed were estimated at greater than 200 horsepower (hp). This may be compared to the up to 1,000 hp pumps available in the United States. Soviet pumps also have a considerably shorter life in the well than their U.S. counterparts. Within the U. S. S. R., Soviet pumps reportedly operate 30 to 90 days in the hole while pumps imported from the United States last 120 to 360 days. (American pumps routinely operate in excess of 1 year in U.S. wells before they require service.) U.S. pumps that fail in the U.S.S.R. are often not returned to service. The Soviet Union has consistency refused to allow American service technicians into the field, and the Soviets themselves have insufficient trained personnel and supplies of replacement parts. In the West, a specific pump is "fine tuned" by the manufacturer at the site to optimize usage. Since this has been made impossible in the U. S. S. R., the pumps probably operate inefficiently.

Excluding the U. S. S. R., the world supply of submersible pumps is provided by four U.S. firms. They are TRW-Reda, Hughes-Centrilift (formerly Borg-Warner/Byron-Jackson), Baker-Kobe (formerly FMC), and Oil Dynamics, Inc. Prices of U.S. pumps range from approximately $10,000 for those with small diameters and low power, to $200,000 for the largest and most powerful. Soviet purchases have averaged approximately $100,000 per unit, suggesting that they are supplementing their own production with the larger units available only in the United States. The U.S.S.R. purchased about 1,500 pumps from the United States between 1974 and 1978, but none have been imported since. This suggests that the Soviets are now supplying their own needs or using other techniques to remove fluid from wells.

One such technique is gas lift, which the U.S.S.R. has in fact used to augment its submersible pumps. The Soviets made a major purchase of gas lift equipment–enough to equip almost 2,400 wells—in 1978 from Technip of France. They have also purchased gas compressors from Dresser Industries and gas lift equipment from CAMCO in the United States. Gas lift is more expensive than pumps per unit volume of oil produced because it requires complicated compression equipment to handle the large volumes of gas it employs. The gas distribution valves and their proper sequencing are the most critical technology required in this technique. These are generally available outside the United States.

Sucker rod pumps, such as those seen dotting the Midwestern and Western United States, are also used to lift oil. Until about 15 years ago, Soviet-made models were commonly beset with bearing failures and cracking of the rods. Through improved metallurgy, the U.S.S.R. seems to have solved these problems and it does not import in this area.

Transportation

The expansion of Soviet pipelines for both oil and gas has benefitted *extensively* from imports from the West. The Soviets have purchased a seamless pipe manufacturing plant with a capacity of 170,000 metric tons per year from Creusót-Loire in France and a West German group composed of Mannes-mann-Demag-Meev. The plant uses the French Vallourec process. The U.S.S.R. has also purchased extensive quantities of finished pipe from Mannesmann and Kloeckner of West Germany; Cie de St. Gobain-Point-a-Mousson in France; Finsider in Italy; and Mitsui, Sumitomo, Nippon, Seiko, Nippon Kokan, Kawasaki, and Itoh of Japan. Japanese steel plate is also used for rolling into pipe in the U.S.S.R. The Soviet Union has purchased pipeline valves from Hubner-Vamag in Austria; Honeywell Gmbh, Borsig Gmbh, and Klaus Union in West Germany; Petrovalves, WAGI SpA, and Grove Italia in Italy; and Kobe Steel and Japan Steel Works in Japan. Clearly this technology is available worldwide.

Pipeline booster pumping stations for oil and gas compressor stations and their related components have been supplied to the U.S.S.R. by Honeywell-Austria Gmbh in Austria; AEG-Kanis Turbinenfabrik, Klaus Union, Cooper Vulkan Compressor Gmbh in West Germany; Kongsberg Turbinfabrik in Norway; Nuovo Pignone and Worthington SpA of Italy; Sumitomo and Hitachi of Japan; Thomassen of the Netherlands; and John Brown Engineering of Scotland. Several U.S. firms, including Ingersoll-Rand, Dresser, GE, Cooper Industries, and International Harvester, have also exported compression and pumping equipment. GE was selected as a major supplier of compression equipment for the Orenberg gas pipeline, but 75 percent of GE Orenberg order was filled by firms outside the United States under subcontract to GE. Compression equipment is manufactured worldwide. Some of the more modern designs are derivatives of jet aircraft engines, but the technology is not advanced and is available in Western Europe and Japan.

The U.S.S.R. has also purchased pipeline laying equipment from the West. This usually consists of a crawler tractor with side-mounted support to lower the pipe into a prepared trench. Fiat-Allis Construction Machinery, Inc., of Finland has supplied spare parts for both bulldozers and pipe-

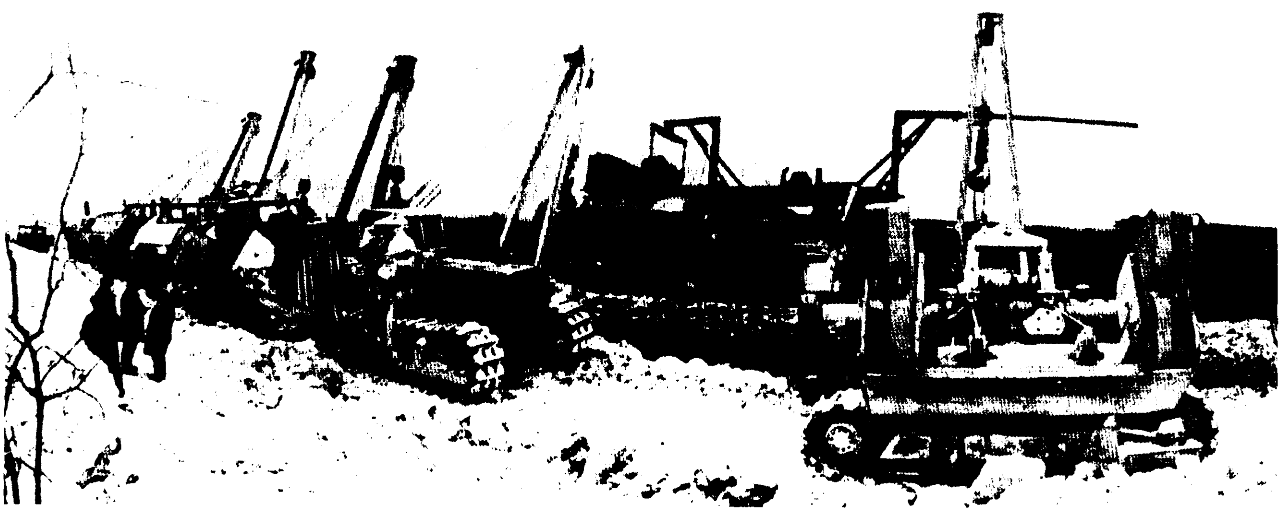


Photo credit Oil and Gas Journal

Equipment for work on large diameter pipelines layers, Caterpillar-Mitsubishi and Komatsu of Japan have also exported pipelayers, as has Bunsar in Poland (an International Harvester licensee). International Harvester and Caterpillar have been the major U.S. suppliers of similar equipment. Foremost of Canada has also supplied heavy pipe carrying vehicles. The technology requirements for these vehicles are not advanced and are generally available outside the United States. Although American firms may produce the largest machines and American models may be better suited to work in cold climates, alternative models, especially from Japan, could fulfill Soviet requirements. No information was collected on production capacities in any country. The Soviets seem to be buying these commodities due to shortfalls in their own production.

U.S. firms, namely CRC International and Perry Equipment Corp., have won contracts to supply the U.S.S.R. with pipeline inspection robots, or "pigs," but competitive bidding to supply this type equipment for the Orenberg gas pipeline included Mannesmann and Prenatechnik of West Germany; Primaberg and OeMV of Austria; General Descaling of the United Kingdom; Nippon Kokan of Japan; and Aveary Lawrence of Singapore. Both Prenatechnik and General Descaling have previously sold pipeline inspection pigs to the U.S.S.R. OTA's assessment of the general capabilities of these pigs indicated that foreign equipment is comparable to U.S. models.

In sum, well completion/production equipment, blowout preventers and wellhead assemblies (Christmas trees) designed for very high pressure and/or highly corrosive conditions are available only from U.S. firms. But these types of equipment would be required for only a small percentage of the wells drilled in the U.S.S.R. The United States does maintain a monopoly on quality electric submersible pumps, but the U.S.S.R. has not purchased these for the past 2 years. It is purchasing large quanities of pipe and pipeline equipment–which are available in Western Europe and Japan.

Secondary/Tertiary Recovery

The Soviets have been experimenting with several enhanced recovery techniques. As noted above, the U.S.S.R. has purchased two CO_2 recuperation/liquefaction plants with a combined capacity of 400,000 tons/year from Borsig Gmbh, a subsidiary of Deutsche Babcock AG, and a chemical surfactant plant (alkyl phenol) with a 100,000-ton/yr capacity from Fried Uhde Gmbh, both of West Germany. A plant capable of producing 250,000 tons of surfactant per year was obtained from Pressindustria in Italy, and other deals have been broached with firms in Japan and England. It is not clear when these facilities will be brought online. In any event, the contribution to overall production will be negligible. The benefits of tertiary recovery techniques are still being explored through testing and experimentation in the West as well as in the U.S.S.R.

More enhanced recovery experience resides in the major oil and service companies operating in the United States than anywhere else in the world. U.S. firms could probably aid the U. S. S. R., if it would allow foreigners to provide technical services. There has as yet been no sign of Soviet interest in such services.

Offshore

After the initiation of the Soviet-Japanese cooperative project on Sakhalin Island (see ch. 11), the U.S.S.R. approached the Gulf Corp. regarding the use of its highly sophisticated survey ship, the *Hollis Hedberg.* The Soviet Union, however, prohibited the use of an American crew in Soviet waters, and Gulf declined to participate. Instead, the U.S.S.R. leased a French survey ship with crew from CGG for 6 months during the summer of 1976. The Soviets also procured from CGG sufficient geophysical equipment to completely outfit two geophysical ships. In the same year, they purchased two ships from Mitsubishi of Japan, and another completely equipped geophysical survey ship has reportedly been bought from Serete Engineering of France. GECO of Norway was hired in 1978 to conduct an offshore survey using 48-channel equipment in the Baltic Sea off the East German-Polish coast. A similar ship, ordered from GECO in 1977, performed surveys during the summer of 1978 in the Barents Sea. These transactions suggest that the U.S.S.R. has been able to acquire substantial Western expertise to develop its offshore fields, with little to no direct participation from the United States.

The United States has, however, provided a third-generation main frame computer, a CDC-Cyber 172, suitable for seismic analysis. This is installed in a computer center on Sakhalin Island. The software for the CDC computer, and for another installed elsewhere in the U. S. S. R., was purchased from the French firms CGG and Ferney-Voltaire. The Sakhalin Island computer facility is used to analyze the marine seismic data acquired by at least two of the Soviet geophysical ships equipped with CGG instrumentation and equipment.

Offshore exploratory drilling in the Sakhalin region was initially performed in 1977 with a semisubmersible rig leased from a Norwegian firm, Fred Olsen & Co. This was subsequently replaced by a Mitsubishi-built semi, the *Hakuryu II.* Additionally, the Japanese consortium has provided several jackup rigs for exploratory drilling off Sakhalin. The drilling rigs are operated by Japanese-trained Soviets, and a Japanese drilling supervisor remains with each rig.

The U.S.S.R. obtained its first mobile offshore rig in 1966 from IHC in the Netherlands. This rig, which was for use in the Caspian Sea, has become the prototype for Soviet domestically produced rigs. Equipment used on Soviet domestically produced offshore rigs is also reported to be of Soviet origin.

In 1976, Armco Steel (U. S.) was granted an export license to provide Rauma-Repola Oy of Finland the necessary technical data to produce three semisubmersible drilling rigs that were to be sold to the U.S.S.R. and assembled at the Astrakhan shipyards on the Caspian Sea. The first semi, the *Kaspmorneft,* was completed for sea trials in August 1979, but is not yet operational. The second, the *Shelf-1,* was ready for sea trials in 1980. The third semi is being modified at the yard based on experience with *Kaspmorneft.* The Soviets have now ordered three dynamically positioned drill ships, also from Rauma-Repola Oy, for exploratory drilling in the Barents and Kara Seas. The dynamic positioning systems are being provided by Kongsberg Vaapenfabriken of Norway. Other competitors included Simrad A/S of Norway and Honeywell of the United States.

The drill ships, as well as many of the other assembled offshore rigs supplied to the U. S. S. R., are largely outfitted with drawworks, prime power, rotary tables, subsea blowout preventors, mud pumps, and cranes made by U.S. firms and their overseas subsidiaries and licensees. Dominant U.S. suppliers are National Supply, Ideco, Continental Emsco, Oilwell, and Gardner-Denver. The main structural platforms for these rigs are made in many shipyards around the world, but U.S. firms produce the majority of the mobile offshore designs. Major U.S. firms here are Bethlehem Steel, Marathon LaTourneau, Livingston, Avondale, Todd, McDermott, and Ingalls. Significant quantities of rigs are also produced in the Netherlands by Verolme, IHC, Rhine-Schelde-Veroime; in Canada by Davie, Halifax and Scott-Lithgow; in Finland by Rauma-Repola Oy; in Japan by Mitsubishi, Mitsui, Hitachi, Sumitomo, IHI, and Nippon Kokan; in Norway by Aker, Nylands, Trosvik and Normarig; and in France by CFEM. Lesser suppliers may be found in Taiwan, Italy, United Kingdom, West Germany, Venezuela, Scotland, Hong Kong, Singapore, Australia, Sweden, Korea, and Spain. In the Communist world, rigs have been constructed by the People's Republic of China, Romania, and the U.S.S.R. These are usually copies of Western rigs.

The prime power used on the rigs is usually diesel-electric, and the suppliers include all the world's major diesel manufacturers:

General Electric/EMD, Caterpillar, Fairbanks-Morse, Detroit Diesel Allison, SACM and Alsthom-Atlantique/SEMT Pielstick (France), and Paxman and MTU (West Germany). Dynamic positioning control systems have been supplied to the U.S.S.R. by Honeywell and Delco in the United States, Simrad A/S and Kongsberg Vaapenfabriken in Norway and CIT Alcatel in France. Mechanical anchoring systems and cranes have been provided by U. S., Japanese, West German, Norwegian, and French firms. Diving equipment on the rigs has been most frequently provided by COMEX in France, but Ocean Systems (U. S.) has also exported in this area. Subsea blowout preventers appear to be available only from U.S. suppliers, including Cameron Iron Works, Hydril, and NL Industries. These firms are also the sole suppliers of subsea well completion stacks. A leading U.S. supplier indicated that his firm had provided subsea blowout preventors for all Soviet offshore rigs and ships.

The offshore oil and gas industry is a classic example of the worldwide nature of this technology. While the earliest offshore activities were concentrated off the Gulf and California coasts of the United States, the industry is now active in other parts of the Caribbean, off Brazil, West Africa, the North Sea, Asia, and the North Slope of Alaska and Canada, The most stringent requirements for offshore technology are represented by North Sea and North Slope activities, and both U.S. and European firms are benefiting from this experience. In sum, while the U.S.S.R. sorely needs offshore equipment, with the exception of drawworks, rotary tables, mud pumps, subsea blowout preventers, and well completion stacks—the narrow range of items in which the United States still maintains a monopoly or lead—it can acquire quality items in Western Europe and Japan.

Engineering firms are perhaps the most critical element in successful offshore operations. U.S. firms clearly have the greatest breadth of experience in this area, but numerous foreign companies can supply most individual aspects of the know-how. Table 48 lists major foreign offshore engineering firms that are able to perform all or part of the engineering design required in defining and establishing a new offshore producing field and providing associated equipment.

Teamed together, the firms listed in table 48 could provide the same capability that is resident in U.S. firms like Brown & Root, Inc., and J. Ray McDermott. In fact, there has been substantial teaming for the North Sea and the Beau fort Sea.

Refining

Although current capacity seems to supply current needs, improved refining technology and equipment may well be required in the U.S.S.R. during this decade. Increased natural gas production will require processing of vast amounts of natural gas. Gas processing complexes have been sold to the U.S.S.R. by Technip and Construction Metalliques de Provence in France and the Japan Steel Works, Nichiman Jitsugyo & Co., Ltd., and Mitsubishi in Japan. The Fluor Corp. of the United States has pro-

Table 48.—Non-U.S. Offshore Engineering Firms

Norway:
- Aker, Kvaener

Netherlands:
- Herrema

United Kingdom
- Worley
- Adkins
- Halgrove-Eubank
- Matthew-Hall
- Davey Powergas
- Willey
- Lawrence & Allison

France:
- E.T.P.M.
- U.I. E.
- Serete

Italy:
- Technomare
- Saipem
- Snamergetti

Mexico:
- Protectors

Spain:
- Initel

SOURCE Brown and Root, Inc.

vialed engineering services and technical assistance on at least two Japanese sales.

Mitsubishi has sold an oil refinery to the U.S.S.R. Competitors for that sale were reported to be Linde AG in West Germany and C-E Lummus in the United States. Other Soviet imports of oil refining equipment during the period 1975-78 have included deals worth over 190 million rubles from Japan, 165 million rubles from East Germany, 76 million rubles from France, 43 million rubles from Czechoslovakia, 1.5 million rubles from Italy, and 1 million rubles from the United Kingdom. The U.S.S.R. will probably continue to seek assistance in this area, but the technology to produce and operate an adequate refinery is not advanced and is available on a worldwide basis. (This includes the use of hydro and catalytic cracking to break up the heavy hydrocarbon molecules to form the lighter molecules in motor fuels and aviation gasoline.) Modern U.S. and Western European refineries now have sophisticated computer controls, which the Soviets lack. These controls improve efficiency but are not generally integral to the basic technology. In short, the technology required for refining crude oil is available in several Western countries, and the U.S.S.R. is certainly not dependent on the United States for refining technology to meet its near-term needs.

TECHNOLOGY TRANSFER AND "FOREIGN AVAILABILITY"

Until recently, the United States had been the sole source of "state-of-the-art" technology in virtually all technological areas.

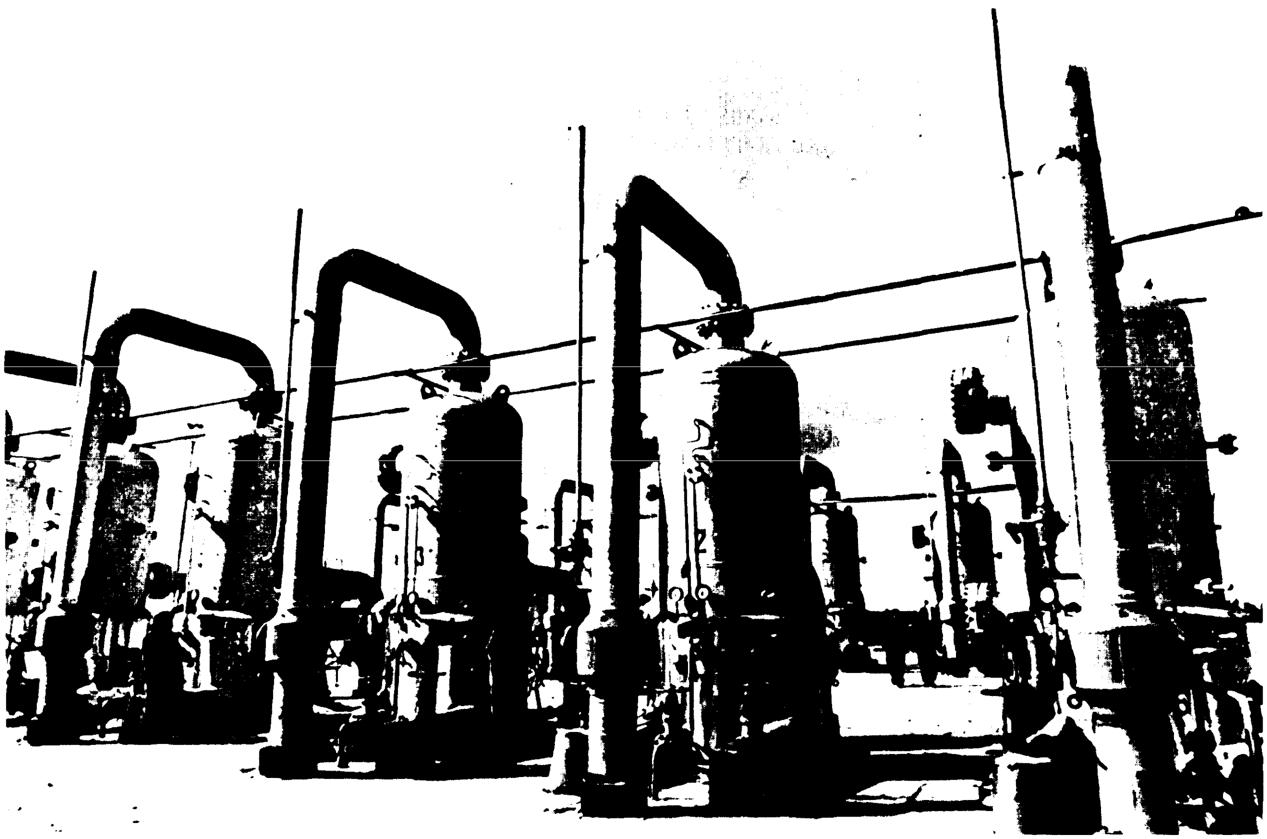


Photo credit TASS from SOVFOTO

Separation installations at a West Siberian gas compression station

America's technological lead was largely attributable to two factors: it outspent most other countries in research and development and the wealth of technological "know-how;" and equipment produced by U.S. R&D had remained resident in U.S. corporations. The rise of the multinational corporations during the 1960's altered this state of affairs.

In their quest for expanded markets and higher profit margins, the multinationals have transferred significant quantities of advanced technological know-how and equipment. This process is nowhere more evident than in the oil industry, where the first true multinationals emerged. The international nature of oil and gas exploration and production provided a natural incentive for oil industries to adopt a global approach to the dispersion of know-how and equipment. As far back as the 1940's, oil companies perceived a need for local sources of equipment and technology. Transfers of technology between U.S. firms and other Western concerns have taken place in nearly all of the key technological areas of the oil and gas industry. The data also show several transfers of American technological know-how directly to the Soviets; i.e., the Dresser drill bit plant and the Armco licensing of offshore rigs. The result of these transfers has been to significantly reduce the number of areas in which the United States is a sole source of supply.

The three principal vehicles for transfer of technology are wholly owned subsidiaries, affiliates, and licensing of production processes and know-how. Parent corporations have availed themselves of all three methods. Each provides varying levels of technology transfer, and differing amounts of control which the parent organization retains over the end use of technology.

Transfers of technology have affected the position of the United States as sole source in two ways. An initial technology transfer spreads U.S. know-how throughout the world. Once a foreign concern acquires a technological base, it can expand upon this base and develop similar product lines on its own. One example of this process in the case of GE licensing of compressor technology to Nuovo Pignone of Italy. Shortly after acquiring the technology, Nuovo Pignone was producing its own gas pipeline compressor stations in competition with GE line. In 1976 Nuovo Pignone won a large Soviet contract for pipeline compressors over a competing bid from GE. Nuovo Pignone is now an important supplier of this type of equipment.

The United States still leads in some areas, however. These are discussed in the following sections.

Exploration

In exploration, the United States holds a unique position in that it is able to provide the complete set of equipment, computers, and software needed to model subsurface structures and locate oil and gas. The lead of American firms in this area may be attributed to the fact that their international subsidiaries, affiliates, and licensees do the vast majority of exploration in the West. Many of the components of these systems are available elsewhere, especially from the Japanese, but the most advanced expertise resides in the United States. The United States also has a slight edge in hydrophore and geophone accuracy.

Although other sources exist for the latest technology in integrated circuits, the United States currently is the only source of minicomputers used to rapidly process and initially analyze seismic data in the field. This capability allows up to 24-hour turnaround for initial seismic results (v. a more normal 90-day turnaround of complete results from a central data processing center) to alert the field crew to particularly promising locations or to inadequate data that should be repeated. This is "state-of-the-art" technology, however, and is still used by only a small number of firms, even in the United States.

Several U.S. firms manufacture advanced geophones and hydrophores that exhibit

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small, incremental advances over items available in the United Kingdom, France, or Germany. The foreign models, however, can certainly perform the necessary tasks.

Computers

In the United States, computers have become an integral part of the business of finding, extracting, processing, and delivering energy. Computers do not play as pervasive a role in the U.S.S.R. both because their value was recognized later and because of systemic problems in organizing and realizing the production of hardware and software. Soviet energy industries have relied extensively on indirect transfers, although a number of direct transfers have played an appreciable role in selected areas, most notably in geophysical processing.

OTA has isolated a number of key areas where the Soviets lag behind the United States in computing. These are summarized in figure 20. The first is hardware. Although other Western nations, notably Japan, can supply equivalents, the United States still leads in supplying integrated systems for these applications. The United States also holds a commanding lead in software and software development techniques, although the French have supplied the U.S.S.R. with some geophysical software. It is in the development of integrated systems and software that Soviet systemic problems have had the greatest impact.[35] Because of the improving Soviet hardware base, there will be less overt pressure to buy from the West, but indirect Soviet reliance on Western, and in particular, American developments will very likely continue.

Other Oil and Gas Equipment

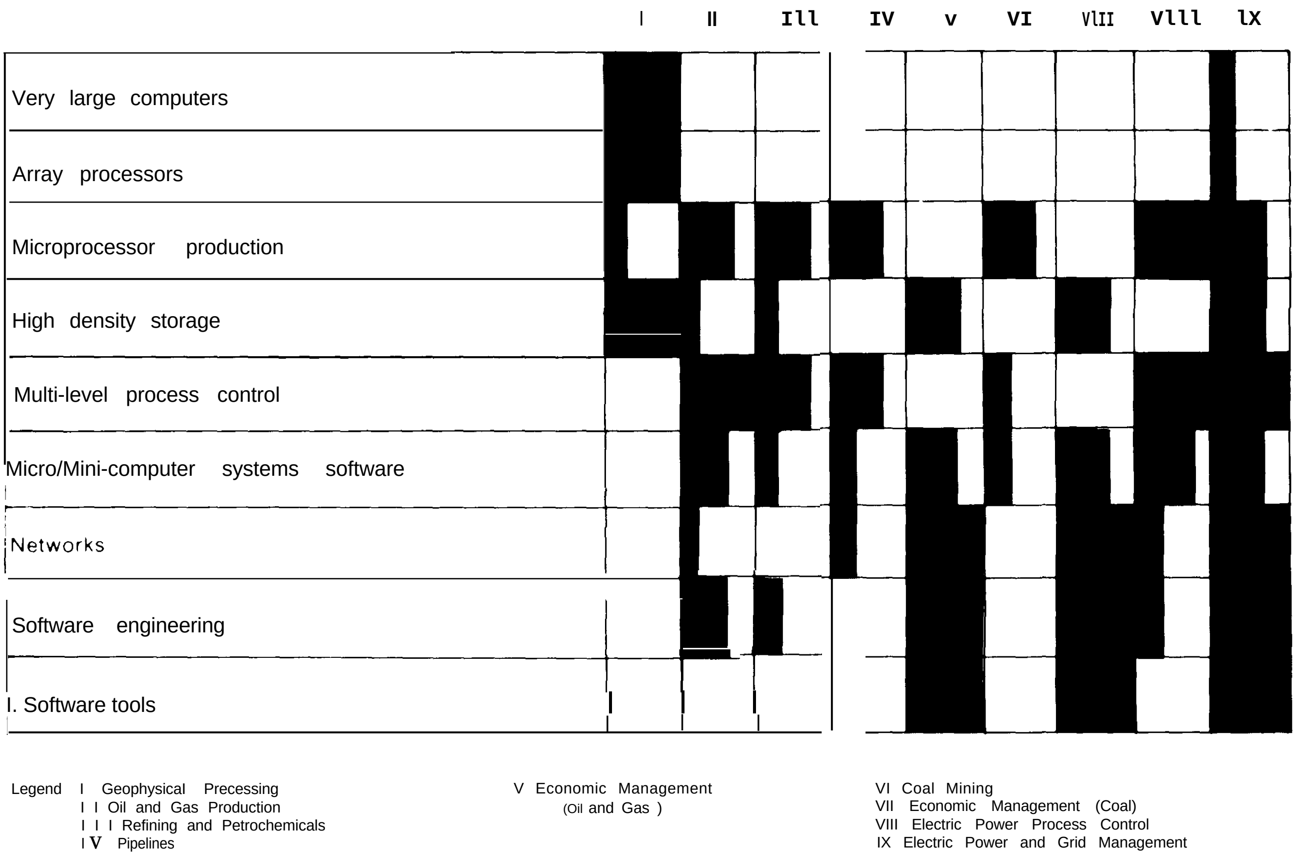
U.S. drill bit manufacturers have the most extensive variety of bits in the world and a near monopoly on bit sales outside the Communist countries. Only a few small bit suppliers exist outside the United States, Most of these specialize in diamond-coated bits that have a relatively narrow range of application. In any case, the experience base of U.S. firms and the proven quality and durability of their products clearly establish them as world leaders. Even with the sale of a U.S. bit manufacturing plant to the U. S. S. R., it is doubtful that the Soviets can produce comparable quality bits without extensive one-on-one training by U.S. technicians in the manufacturing steps and quality assurance provisions. Sustaining high-quality metallurgical raw materials will also be necessary to achieve a capability equal to that of the United States. The required knowledge and experience can be gained through trial and error, but several years may be required to achieve the capability that a few months of onsite training might provide.

The world's major purveyor of well logging services is Schlumberger, a French firm, and logging equipment was first developed in France. Nevertheless, U.S. firms do excel in the electronic technology and interpretation experience necessary to obtain high-quality well-logging survey results, and improvements made in the United States, with U.S. technology and based on the extensive U.S. drilling and logging experience, have been important.

In well completion and production, several items appear to be unique to the United States: blowout preventers and wellhead assemblies designed for either very high--pressure service (above 10,000 psi) or for use in highly corrosive hydrogen sulfide environments, and electric submersible pumps. Although firms outside the United States can provide less capable units, oil field specialists everywhere recognize U.S. blowout preventors and Christmas trees as the ultimate in quality. The electric submersible pumps needed to produce high volume wells are exclusively available in the United States. U.S. pumps have proven down-hole longevity when properly tailored to the well and served with reliable power. The size range of 25 to 1,000 horsepower exceeds by a

[35] S. E. Goodman, "Soviet Software: Progress and Problems" Advances in Computers, vol. 18, 1979,

Figure 20.— Relative Importance to Soviet Energy Industries of Computer-Related Technologies in Which the U.S.S.R. Lags the United States



wide margin the range of pumps produced in the U.S.S.R.

The area of enhanced recovery equipment and know-how is difficult to evaluate. The Soviet Union has purchased entire plants to produce chemical surfactants and CO, to aid in the extraction of heavy oil or oil tightly bound in rock. Soviet literature has also reported experimentation with hot water and steam injection, fire flooding, and even under-ground nuclear explosions to achieve improved recovery of oil from a reservoir. These techniques are still not in widespread commercial use even in the United States. Nevertheless, the United States has had more experience with technical approaches to achieve improved recovery of crude oil than any other nation. It is reasonable to conclude, therefore, that the United States is the sole source of substantial experience in tertiary recovery methods-if the U.S.S.R. were to seek that type of service. Thus far, it has not.

The final area where the United States is a sole source supplier is in subsea blowout preventers, marine draw-works, mud pumps, rotary tables, and wellhead completion assemblies used in offshore operations. Any such items with significant capacity ratings are available only from U.S. manufacturers. But the current proliferation of licensees for the manufacture of platform drilling equipment; i.e., draw-works, mud pumps, rotary tables, etc., may soon effectively remove those items from the sole source list.

In sum, of the thousands of pieces of equipment used to find, extract, and produce oil and gas, only a handful are unique to the United States. This finding reflects the dispersal of technology that occurs with multinational companies and the worldwide nature of the petroleum business.

SUMMARY AND CONCLUSIONS

In 1979, the Soviet Union devoted some $3.4 billion, approximately 22 percent of its trade with its major Western trading partners, to energy-related technology and equipment. The vast majority of its purchases—worth about $2.7 billion—was destined for the Soviet oil and gas industries. These imports clearly have played important roles in compensating for production shortfalls and poor quality of Soviet domestically produced equipment. With the exceptions of sophisticated computers and software, and some aspects of offshore development, however, there is little reason to believe that the U.S.S.R. uses these imports to acquire technologies hitherto beyond its own capabilities.

The Soviet coal, nuclear, and electric power sectors have been largely self-sufficient. It is the oil and gas industries that have been most characterized over the years by the involvement of the West, and there is no doubt that the industry would benefit substantially from Western imports on a massive scale. Whether from lack of hard currency, a deliberate policy of self-reliance, the reluctance or inability of Western firms to sell, or all three, Soviet purchases have generally remained relatively modest and strategically targeted. An important exception is large diameter pipe, an item that will be crucial to energy development in the present decade. Here, the U.S.S.R. is quite dependent on firms in Japan and West Germany. The United States does not produce pipe in the diameter required by the U.S.S.R.

Indeed, the United States is not the predominant supplier of most energy-related items recently imported by the Soviet Union. The foreign availability sections of this chapter have identified numerous foreign firms supplying oil and gas equipment to the U. S. S. R., reinforcing the theme of the international nature of the major oil and gas companies. Newly developed technology has generally been diffused throughout the world through an extensive network of subsidiaries, affiliates, and licensees.

There are a few items of oil and gas equipment which are either solely available from the United States or for which the United States is generally considered a preferred supplier: integrated computer systems and software; rock drill bits; electric well logging equipment; blowout preventers; and wellhead completion assemblies for high pressure, corrosive or subsea applications; marine draw-works; mud pumps; rotary tables; electric submersible pumps; and a substantial experience base in tertiary recovery techniques. With the exception of computers, however, the U.S.S.R. is either not purchasing these items, is on its way to acquiring the capacity to produce them domestically, or has demonstrated that they are not essential to oil and gas production.

This study reinforces the international extent of the oil and gas industry. The spread of technology that was originally developed in the United States has been enhanced through the growth of multinational companies that supply equipment to all users. This results in relatively few items that remain exclusively available from U.S. sources. The United States continues to represent the ultimate in quality or capability in some equipment, but the extent of that lead is diminishing. The United States still leads in exploration, drilling, offshore, well completion, enhanced recovery, and operations in extreme geologic conditions. But the item most badly needed by the U.S.S.R.—large diameter pipe–is available from Japan, West Germany, France, and Italy. The United States retains the best reputation as the supplier of pipeline pumping and compressor stations, and, in particular, for the turbine drive units that power them. But the Soviet Union can and does obtain most of what it needs for continued development of its oil and gas resources from sources outside the United States. In short, U.S. industry could assist the U. S. S. R., but to make a significant impact the assistance would have to be massive—and unprecedented.

Appendix A. – Energy Corporation Affiliations

Parent company	Country	Products	Divisions	Subsidiaries	Licenses
ITT	United States	Oil seal equipment		Gallino (Italy)	
Texas International	United States	Oil seal equipment, High speed presses		Rockwell Machine Tool Ltd. (Britain) Matrix Engineering Ltd. (Scotland)	
Marion Power Shovel Co	United States	Crawler cranes, pile drivers, Mining shovels, large diameter pipes, steel piping, compressor equipment			Sumitomo (Japan)
Deutsche Babcock & Wilcox	West Germany	Ball valves for pipelines	Borsig GmbH		
Studebaker-Worthington, Inc	United States	Booster pumps, concrete pumps, high pressure pumps	Worthington SpA (Italy) Division of Worthington Pump Inc. (U. S.)		
Int'1 Systems & Controls Corp.	United States	Natural gas filtration equipment	Black, Syvallo and Bryson		
George Kent Group	United Kingdom	Turbine meters, readout instruments		Kent France S.A.	
Harnischfeger	United States	Crawler cranes, pile drivers			Kobe Steel (Japan)
Bucyrus-Erie		Crawler cranes, pile drivers			Komatsu (Japan)
Baker Trading Corp.	United States	Wellhead equipment, testing equipment for wildcat well heads, workover rigs, drilling test equipment	Baker Division	Lynes Inc.	
TRW	United States	Submersible pumping units, pumps, cable	TRW-Reda Pump Inc.		
			TRW Crescent Wire and Cable Division		
Creusôt-Loire S.A.	France	Seamless pipe plant		Creusôt-Loire Enterprises (Licensee of SMF International Member)	
Joy Manufacturing Co.	United States	Powertongs	Hillman-Kelly		
ASEA	Sweden	Welding line (automatic)		ESAB	

Parent company	Country	Products	Divisions	Subsidiaries	Licenses
J. Ray McDermott & Co.	United States	Propane coolers, pipeline coolers		Hudson Products Corp. Licensee of Creusôt-Loire (France), Hudson Italiana SpA (Italy)	
Cooper-Besemer Co.	United States			Chiyoda Co. Ltd. (Japan)	
Finmeccanica SpA	Italy	Valves		WAG I International SpA (Italy)	
Borg-Warner Corp.	United States	Submersible pumps		Centrilift Inc.	
W-K-M Valve Group	United States	Gate valves, wellheads			Hubner-Vamag AG & Co. (Austria)
Dresser Industries	United States	Mining shovels and blast hole drills; compressors for pipe line	Marion Power Shovel, Clark Division		Sumitomo Heavy Industries
Grove Valve & Regulator Co	United States	Gate and ball valves			Japan Steel Works
Armco Steel	United States	Machine for semisubmersible offshore drilling rigs, semisubmersible rigs		National Supply	U.S.S.R. Ministry of Shipbuilding
U.S. Steel	United States	Oilwell cementing	Western Rock Bit and Oilwell Supply		
International Harvester Co.	United States	Standby power generating equipment turbines	Solar		
VOP Inc.	United States	Large dry gas scrubbers		VOP Ltd., U.K.	
Perry Equipment Co.	United States	Pig launching/receiving station			Sirtech (Italy)
Rockwell International	United States	Pipeline metering stations		Robsa (Neth.)	
Westinghouse Elec. Co.	United States	Compressor stations			Mitsubishi
Big Three Industries of Houston	United States	Welding positioners	Ransome Co.		
Stewart & Stevenson	United States	Blow-out prevention controls	Koomey Division		
Cameron Iron Works	United States	Christmas trees, stainless steel wellhead equipment	Cameron DeFrance		
FMC Corp.	United States	Christmas trees, stainless steel wellhead equipment	FMC Europe (Luceat)		
Schenck GmbH	West Germany	Screens for coal washing plant			Japan Kurimoto Iron Works Co.
McNally-Pittsburgh Manuf. Corp.	United States	Flo-driers			Sumitomo Heavy Industry

Parent company	Country	Products	Divisions	Subsidiaries	Licenses
General Electric	United States	Compressors, gas pipeline, turbines, automation equipment, compressor stations	General Electric of Britain		Nuovo Pignone (Italy) Mitsubishi Heavy Ind. AEG-Kanis (FRG) John Brown Engineering Ltd. (Scotland) Thomassen Holland (Neth.) AEG-Telefunken (FRG) Mannesmann (FRG) Hitachi (Japan) All these associates have worked with G.E. on gas turbines. Under the agreement, G.E. supplied rotating parts and the associates supplied stationary parts and compressor to G.E. specs. Mannesmann supplied engineering and design, procurement, Installation and training services
Smith Int'l Inc.	United States	Vertical drill	Caldwell Division		
Kendavis Industries Int'l, Inc.	United States	Triple-joining plants for wide-diameter pipe mining dump trucks M-200s	Mid-Continental Equipment Co. Unit Rig and Equipment Co.		
Cooper Industries Inc.	United States	Centrifugal compressors	Cooper Energy Services	Cooper-Vulkan Compressor GmbH (W. Germany Joint Venture)	Creus8t-Loire (France) Kawasaki Heavy Industries, Ltd. (Japan)
Crutcher Resources Corp.	United States	Spare parts - large diameter pipeline and welding equipment leases welding systems	CRC Crose CRC Automatic Welding CRC Int'l		
Honeywell-Bull, Inc.	United States	Control and measuring devices	Honeywell Austria GmbH (Austria)		
Fiat Group	Italy	Flexible hose, flexible hose expansion joints			Gilardini SpA (Member)
Geosource Inc.	United States	Digital display system seismic field recorder photo dot digital plotting system	ET L/Mandrel I Products Division Petty Ray Geophysical		

Parent company	Country	Products	Divisions	Subsidiaries	Licenses
Grove Valve & Regulator co.	United States	Flex-flo valves		Italian Affiliate	
Caterpillar Tractor Co.	United States	Spare parts - bulldozers and pipelayers	Fiat-Allis Construct ion Machinery, Inc, (Witractor) (Finland)		

Appendix B. – Trade by Company

The following table presents a sampling of the dealings of various Western companies involved in the export of energy-related equipment to the U.S.S.R. The data was obtained from a search of the bimonthly publication Soviet Business and Trade (SB&T) for the period 1975-80.

SB&T draws on a variety of sources, including the Soviet News Agency TASS, to gather information on Soviet trade. The staff ensures the accuracy of the reported deals through a system of cross-checking sources and phone verification with U.S. companies.

According to its publisher, fully one-half of the subscribers of SB&T are found in countries outside the United States, especially Western Europe and the Soviet Union. The subscribers provide feedback as to the accuracy of the reporting. A concerted effort is made by the editorial staff to provide a representative sample of Soviet purchases across the spectrum of both technological areas and supplying countries.

U.S. Government agencies, such as the Department of Commerce, the Central Intelligence Agency, and the Department of Energy, also subscribe to SB&T. U.S. industry representatives have indicated that information about their firms' activities is generally accurate, and they are usually contacted in advance of publication regarding the accuracy of a reported item.

No attempt has been made to validate total authenticity or completeness of the trade data contained in SB&T. OTA is confident that the major trade deals from SB&T referred to in the course of this study are factual and accurately represent the availability of energy technology and commodities from sources outside the United States. It is possible, however, that transactions recorded here may not have been consummated, or that their terms may have changed.

Table B-1 .—Trade by Company—Oil and Gas

Equipment area Exploration

Suppliers	Country	Product	Year	Value
Foremost Industries	Canada	73 tracked geophysical survey vehicles [under subcontract to Geosource (U.S.)]	1979	
Potter Test	Canada	Portable production testing equipment		
Serete Engineering	France	1 geological survey ship	1980	$113 million
Ferneg - Voltaire	France	Geophysical software to be used on CDCs Cyber 172s	1979	
CIE Generale Geophysique	France	Special geophysical software used on the CDC Cyber 172s	1979	
CIE Generale Geophysique	France	6 month lease of a complete geophysical ship and crew	1976	
CIE Generale Geophysique	France	Digital seismographic recorders, magnetometers, gravity meters, cables and hydrophores for 2 geophysical ships	1976	$14 million
Stere	France	Underwater prospecting equipment	1975	
Comex	France	Deep sea diving equipment		
Mitsubishi Corp.	Japan	2 geophysical ships (using the geophysical equipment bought from CIE above)	1976	$2.5 million
Geosource Inc.	United States	Command II field processing systems	1979	$6 million
Control Data Corp.	United States	2 Cyber 172-4 computers	1979	$12.1 million
Control Data Corp.	United States	1 Cyber 73; 1 Cyber 172 computer		

Table B-1.–Trade by Company–Oil and Gas (Continued)

Equipment area **Exploration**

Suppliers	Country	Product	Year	Value
Geosource Inc.	United States	13 photodot automated digital display	1979	$7 million
Gearhart-Owen, Inc.	United States	Cooperative agreement on the production of direct digital well logging equipment	1978	
Magnavox Labs	United States	5 navigation systems for satellite pinpointing of geological teams	1975	
Geosource Inc.	United States	Seismic field recorder (manufactured by Geosource, Inc., ETL/Mandrell Products Division)	1975	$370,000
Petty Ray Geophysical Division of Geosource	United States	Photodot digital plotting system	1975	$300,000
Geospace Corp.	United States	Seismic plotting system with geophones	1975	$250,000
Lynes Inc.	United States	Testing equipment for wildcat wellheads	1975	$2.5 million
Mertz Inc.	United States	24 servo-hydraulic vibrator systems		$6 million
IBM Trade Development S.A. with Western Geophysical	United States France	IBM 370-148 and an array processor	1979	
Schlumberger S.A. Halliburton Services Inc. Dresser Industries	France United States	Help locate hydrocarbon reserves	1978	
Drilling				
Maschinenfabrik Heid	Austria	Machine tools for making couplings and adapters for oilwell casing and drill pipe	1979	Sch 150 million
Tamrock Oy	Finland	15 crawler mounted drilling rigs	1978	
Airan	Finland	Drilling equipment	1975	$100,000
SMF International	France	400 kellies	1978	
Vallourec Export	France	Well head casing	1975	
Wotan Werke	West Germany	Heavy drilling equipment	1980	R4 million
Japanese Consortium	Japan	200,000 tons of seamless pipe for oil wells; to be delivered between October 1980 and March 1981	1980	
Sodeco	Japan	Casing, drill pipe, bits and clay	1976	$2 million
Baker Trading Co,	United States	Drilling test equipment	1979	$1.6 million
Farr International	United States	10 power tongs and a diesel/hydraulic power system for each	1979	$1 million
Halliburton Services	United States	Cementing systems	1978	$3 million
Joy Manufacturing	United States	Power tongs	1978	
Ekel Manufacturing Co.	United States	20 power tongs competitors: Farr International (U. S.) Joy Manufacturing Co. (U. S.)	1978	

Table B-1 –Trade by Company—Oil and Gas (Continued)

Equipment area ***Drilling***

Suppliers	Country	Product	Year	Value
Dresser Industries Inc.	United States	Equip a new addition to an existing rock drill bit plant	1978	$147 million
Hercules Inc.	United States	Mud additives	1978	
Stewart & Stevenson's Koomey Division	United States	6 blow-out prevention controls	1975	
Drilco	United States	Degasser and pipe inspector	1975	
Well Com~ietion/Production				
Hübner-Vamag AG	Austria	130 complete oil well head assemblies	1979	$14.5 million
Hübner-Vamag AG	Austria	*155* natural gas drill hole plugs and production vanes	1979	$11.5 million
Hübner-Vamag AG	Austria	1,000 single slab gate valves for pipelines and well heads	1978	Sch 100 million
Hübner-Vamag AG	Austria	*80* well heads	1978	
Hübner-Vamag AG	Austria	702.5 meter diameter ball valves for duty down to -55° C	1976	
Hübner-Vamag	Austria	Ball cock and tilt check valves for gas pipelines	1976	$5.2 million
Honeywell Austria GmbH	Austria	129 units of control and measuring devices for Orenberg line equipment built by British Sereck Controls Ltd.; UK)	1976	$9 million
Dresser Industries Ltd.	Canada	***42*** compressor units 21 - used for gas lift 21 - used in fire flooding	1978	$30 million
Foremost Industrles Ltd.	Canada	30 metric ton payload husky 8 vehicles (pipe carriers)	1976	***$4*** million
Flat-Allis Construction Machinery, Inc. (Witractor)	Finland	Spare parts for bulldozers and pipelayers	1978	R241,000
Vallourec	France	152,000 tons of large diameter pipe in 1980	1980	
Entrepose S.A.	France	Line pipe (actually supplied by Vallourec Export S. A.)	1978	
CIE Francaise d'Etudes de Constructions (Technip)	France	Gas lift equipment for 2,371 wells	1978	Fr 835 million
Cie de St. Gobain-Point-a-Mousson & Vallourec Export S.A.	France	Steel line pipe	1977	$70 million
FMC Europe (Luceat) and Cameron de France	France	Christmas trees and stainless steel wellhead equipment	1975	$6 million
Honeywell GmbH	West Germany	Large diameter pipeline valves	1980	
Borsig GmbH	West Germany	Large diameter pipeline valves	1980	
Klaus Union	West Germany	Pipeline fittings and ball valves	1979	DM 1.3 million
AEG-Kanis Turbinenfabrik	West Germany	***17*** gas compressor stations	1978	

Table 6-1 —Trade by Company –Oil and Gas (Continued)

Equipment area ***Well Completion/Production***

Suppiers	Country	Product	Year	Value
Klaus Union	West Germany	20 multipurpose pumps	1977	$200,000
Borsig GmbH	West Germany	200 ball valves for pipelines	1976	$8.8 million
Mannesmann Rohrwerke AG	West Germany	3.5 million tons of wide diameter steel pipe	1976	
Cooper-Vulkan Compressor GmbH	West Germany	15, RF2BB-30 centrifugal compressors (a joint venture with Bremer Vulkan Schiffbau und Maschinenfabrik)	1976	
Gebr Windhosst	West Germany	Fire prevention gear for Orenberg line 123 units	1976	$3.2 million
Kloeckner	West Germany	32,000 tons of large diameter pipe	n.a.	
Hudson Italiana SpA	Italy	32 propane coolers for severe climatic conditions	1978	
Nuovo Pignone	Italy	1. Automation equipment; gas compression plant 2. Remote control equipment for gas gathering and transmission system 3. 5 compressor stations	1978 1978 1978	 $1.5 million $150 million
Petrovalves SpA	Italy	400 check valves for oil and gas pipelines, with diameters from 1,000 to 700 MM	1978	$6 million
WAGI SpA	Italy	Pipeline valves	1978	
Worthington SpA	Italy	20 booster pumps for pipeline	1976	
Nuovo Pignone	Italy	35 compressors for Orenberg line	1976	
Finsider	Italy	2,5 million tons of large diameter pipe	1975	
Finsider	Italy	Large diameter pipe	1974	$1.5 billion
Grove Italia	Italy	Ball valves for oil and gas pipelines	1979	
Mitsui & Co,	Japan	200,000 tons of 70 kg/mm^2 grade steel plates for production of wide diameter pipe	1979	Y20 billion
Kobe Steel, Ltd.	Japan	230 large diameter ball valves for gas pipelines	1979	$6.8 million
Sumitomo Corp.	Japan	Steel piping, pumping and compressor equipment, large diameter pipe	1978	$130 million
Sumitomo Metal Industries Nippon Seiko Nippon Kokorn Kawasaki Steel	Japan	500,000 tons 1,400 mm steel pipe for pipelines	1976	
C. Itoh & Co., Ltd.	Japan	Wide diameter steel pipe	1976	
Yamamoto Suiatsu Kogyosho, Ltd.	Japan	Pipe binding equipment	1976	$4.3 million
Hitachi Ltd.	Japan	Five 10,000 kW gas turbine compressor units	1976	
Japan Steel Works	Japan	56" valves for Orenberg line (subcontract to Perry)	1976	$9 million
Caterpillar-Mitsubishi	Japan	193 D-6 bulldozers/pipelayers	1975	$16 million
Sumitomo Corp.	Japan	400,000 metric tons of pipes, both large diameter and seamless	1980	

Table B-1 —Trade by Company—Oil and Gas (Continued)

Equipment area Well ***Completion/Production***

Suppliers	Country	Product	Year	Value
Robsa	Netherlands	Pipeline metering stations, using Perry (U. S.) flow measuring equipment (Robsa is a subsidiary of Rockwell International; U. S.)	1976	$5 million
Thomassen	Netherlands	10 turbines for Orenberg (under subcontract to GE.)	1975	$10 million
Kongsberg Turbinfabrik	Norway	Standby turbine generators for Orenberg line (a subcontract for Nuovo Pignone - Italy)	1976	
Bunsar	Poland	34 pipe layers (International Harvester Co. supplied dimensions, metallurgical specs, tooling and machinery techniques, quality control and assembly methods. International Harvester receives a royalty on each vehicle sold to a third party)	1976	
John Brown Engineering	Scotland	33 gas turbine compressor units for Orenberg line (J.B.E. as a manufacturing associate of G.E.)	1976	$47 million
TRW-Reda Pump, Inc.	United States	90 submersible pumps	1979	$10.5 million
Ingersoll-Rand Co.	United States	Gas pipeline compressors	1979	
Baker World Trade	United States	Down-hole completion equipment, including wire-line, packers, safety valves and primary cementing equipment for 31 gas wells. About half are designed for extreme cold weather operations (-65°) for large diameter, large volume production.	1979	$2,5 million
Cameo	United States	2,216 gas lift and completion units and 80 wire line units	1979	$36.1 million
Otis Engineering	United States	Down-hole completion and wire line equipment for 101 gas wells	1979	$7 million
ODI Inc.	United States	Submersible oil pumps	1978	$2 million
TRW-Reda Pump, Inc. and Borg Warner	United States	Submersible oil pumps	1978	$33.5 million
011 Dynamics	United States	20 submersible pumps	1978	$2 million
TRW-Reda Pump, Inc.	United States	90 submersible pumps	1978	$10.5 million
Centrilift Inc.	United States	188 submersible pumps (built in the firm's Toronto plant). Note: This sale brought total number of centrilift pumps in the U.S. S, R. to 600	1978	$23 million
Occidental Int'l Eng. Co.	United States	Design and construction of a pipeline	1978	$300 million
CRC International	United States	internal line-up clamps, clean and wrap machines, pipe benders; pigs	1978	
Otis Engineering	United States	Completion equipment	1978	$3 million
Cameron Iron Works	United States	40 well heads	1978	

Table B-1 .—Trade by Company—Oil and Gas (Continued)

Equipment area ***Well Completion/Product/in***

Suppliers	Country	Product	Year	Value
FMC Petroleum Equipment Division & Cameron Iron Works	United States	Christmas trees	1978	
TRW-Reda Pump, Inc.	United States	350 pumps	*1976*	$64 million
International Harvester	United States	500 TD-25C bulldozers and pipelayers	1976	
General Electric	United States	Hot gas rotating components of the compressors for the Orenberg line	1976	
Crutcher Resources Corp.	United States	Spare parts for large diameter pipeline welding equipment	1976	$200,000
Roscoe Brown Sales Co. Inc.	United States	Pipeline augers	1976	$250,000
Cooper Industries	United States	73 RF2BB-30 centrifugal compressors	1976	
International Harvester	United States	Standby turbine generators for Orenberg line	1976	
Grove Valve & Regulator Co.	United States	The smaller valves for Orenberg line (a subcontractor for Perry)	1976	
F. H Maloney Co,	United States	Pig signalers (subcontract to Perry)	1976	$250,000
Health Consultants Inc.	United States	Pig locaters (subcontract to Perry)	1976	$250,000
E. H Wachs Co.	United States	Pipe cutters	1976	$300,000
Perry Equipment Corp.	United States	Entire complement of pig launching/receiving stations for Orenberg pipeline Competitors: Mannesmann - FRG Prenatechnik - FRG* Primaberg - Austria OeMV - Austria General Descaling - U.K. • N,K,K. - Japan Avery Lawrence - Singapore ● Have sold pigs to U.S.S.R. before.	1976	$27,650,000 $9 million from Perry
Baker Oil Tools Inc.	United States	*20* sets of gas well completion equipment, 2 wire line units, and inflatable packers	*1976*	
Mertick Engineering	United States	Equipment for welding 12 to 25mm diameter pipe	1975	$700,000
CRC Automatic Welding	United States	Lease of its proprietary automatic welding system to Hungary and Poland for Orenberg line	1975	
Mid-Continent Pipeline Equipment Co,	United States	2 triple jointing plants for 42, 48, and 56 inch pipe; mandrills, clamps, cleaning, lining and coating equipment	1975	*$5* million
Ransome Co.	United States	*9* welding positioners	1975	$200,000
Deuma	United States	4 welding positioners	1975	

Table B-1 .—Trade by Company –Oil and Gas (Continued)

Equipment area **Well Completion/Production**

Suppliers	Country	Product	Year	Value
International Harvester	United States	Bulldozers and pipe layers	1975	
General Electric Co.	United States	Gas turbines for pipelines	1975	
TRW-Reda Pump, Inc.	United States	137 electrodynamics submersible pumping units	1975	$17 million
TRW-Reda Pump, Inc.	United States	Submersible pumps	1975	$20 million
Borg-Warner	United States	120 submersible pumps	1975	
Mission Manufacturing	United States	Submersible pumps	1975	
General Electric	United States	65 MS3002, two-shaft turbines rated at 14,500 hp (all are being built under GE license in 6 different countries)	1974	$250 million
C-E Lummus & Co.	United States	Pipeline coolers	1978	
FMC Petroleum	United States	Stainless steel wellhead equipment	1978	$1 million
Creusôt-Loire Enterprises with Mannesmann-Demag-Meev Group	France West Germany	A seamless pipe plant using the Vallourec process with a capability of 170,000 metric tons per annum	1979	$230 million
Creusôt-Loire Hudson Italiana SpA	France Italy	Pipeline coolers Pipeline coolers	1978	
Caterpillar Tractor Co. and Caterpillar-Mitsubishi	United States Japan	50 Caterpillar pipelayers and 2 years of spare parts	1976	
Secondary/Tertiary Recovery				
Fried Uhde GmbH	West Germany	100,000 ton per year alkyl phenol plant (used as a surfactant)	1978	DM 50 million
Borslg GmbH	West Germany	CO_2 recuperation plant	1979	
Offshore				
Rauma-Repola Oy	Finland	Build the hull for the semi below	1976	$15 million
UIE & ETPM	France	An offshore oil platform fabrication yard at Baku	1980	
Serete	France	Floating drilling platforms	1975	
Blohm & Voss	West Germany	Self-propelled crane to position offshore rigs	1976	$40 million
Blohm & Voss AG	West Germany	Rebuild a shipyard at Astrakhan for assembling jackups and semi-submersible rigs	1979	
Modec	Japan	Class III 3-legged jackup rig; design by Levlngston Shipbuilding (U.S.); drilling equipment by National Supply (U.S.); blowout preventor stacks and controls from N.L. Petroleum (U.S.)	1979	$35 million

Table B-l —Trade by Company —Oil and Gas (Continued)

Equipment area ***Offshore***

Suppliers	Country	Product	Year	Value
Sanwa Kizai Co. Ltd.	Japan	14 augers used for pile driving	1976	
IHC	Netherlands	Seagoing pipe layer	1971	
IHC	Netherlands	Jackup rig	1967	
Ulstein Hatlo A/S	Norway	3 ships to tow exploration and production drilling platforms	1976	
Kongsberg Vaapen Fabrikk A/S	Norway	3 dynamic positioning systems for the 3-drill ships built by Rauma-Repola Oy Competitors: Simrad A/S (Norway) Honeywell (U. S.)	1979	
Simrad A/S	Norway	Dynamic positioning system for the Armco semi built for U.S.S.R.	1979	
Armco, Inc.	United States	Equipment for a jackup being built by Mitsui Ocean Development & Engineering Co. Ltd.	1978	
Lynes International Inc.	United States	11 strings of drill stem testing equipment for offshore facilities	1979	$3.8 million
Armco, Inc.	United States	License for semisubmersible rigs built by Rauma-Repola Oy for Soviets	1978	
National Supply	United States	Provide most of the machinery for a semisubmerisble rig being built by Rauma-Repola Oy	1976	$25 million
Armco, Inc.	United States	License for production of semi's in U.S.S.R.	1976	
Refining				
Tech nip	France	15,000 cubic meter per annum natural gas	1975	$230 million
Constructions Metalliques de Provence	France	28 natural gas purification stations	1975	
Walworth Aloyco Grove International	Italy	1,580 ball valves for oil refineries	1975	
Japan Steel Works	Japan	Manufacturing for the above plant	1979	
Nichimen Jitsugyo	Japan	3 plant gas processing complex	1976	$250 million
Mitsubishi Corp.	Japan	Primary oil refining equipment Competitors: Linde AG - FRG C-E Lummus - U.S.	1978	
Fluor Corp.	United States	Designs, engineering, procurement, and field technical advisory services for plants to convert natural gas into ethane, methane, pentane, liquid propane, gasoline and other products	1979	
Fluor Corp.	United States	Provide engineering and technology assistance for the three plants above	1976	
Mitsubishi Heavy Industries	Japan United States	Gas processing complex	1978	
Japan Steel Works & Fluor Corp.	Japan United States	Gas processing complex	1978	$250 million

Table B-2.—Trade by Company—Coal

Equipment area ***Exploration***

Suppliers	Country	Product	Year	Value
Plategods Co	Norway	Rock drilling equipment	1975	$25 million
Preparation				
South Yakutian Coal Development Corp.	Japan	Coal preparation equipment	1978	
Marubeni Corp.	Japan	33 large screens for coal washing plant Note built by Kurimoto Iron Works Co under a license from Schenck GmbH (FRG)	1978	Y1.2 billion
Sumitomo Heavy Industrles	Japan	Four 600 ton/hour flo-driers (under license from McNally Pittsburgh Manufacturing Corp. (United States)	1978	
Transportation *from Mine*				
Komatsu Ltd.	Japan	***30 120*** ton capacity heavy mining trucks	1979	$30 million
Unit Rig & Equipment Co	United States	30 M-200 vehicles for use in coal fields	1976	$40 million
Unit Rig & Equipment Co.	United States	Heavy duty dump trucks	1975	$13 million
Ingersoll-Rand	United States	Slurry pumps powered by a 3,000 HP engine	1975	$14 million
Ingersoll-Rand	United States	Slurry pumps	1974	
Unit Rig & Equipment Co.	United States	***54 M-200s*** Note To be built by the Canadian Division	1979	
Surface Mining Excavation				
Kent France S A	France	10 electric mining shovels	1975	
Orensteim und Koppel	West Germany	3 large and 1 small excavator for open cast lignite mines	1980	DM 220 million
Sumitomo Heavy Industries	Japan	20 cubic meter bucket, hydraulic mining dhovels	1978	
Sumitomo Corp.	Japan	10 self-propelled 20 cubic meter bucket, mining Shovels	1976	
Sumitomo Heavy Industries	Japan	10 “Super Front” mining shovels used in strip mining	1975	
South Yakutian Coal Development Corp.	Japan	Coal development equipment	1974	$450 million
Sumitomo Heavy Industries	Japan	10 crawler-mounted blast hole drills Note Built under a Marion Power Shovel license		
Sumitomo Heavy Industries	Japan	5 “Super Front” mining shovels Note Built under license from Marion Power Shovel, Division of Dresser Industries		
Paccar Inc.	United States	7 Dart D-600 15 cubic yard front-end loaders	1979	$286 million
Clark Equipment Co	United States	3 Model 475 B front-end loaders	1978	$1 million

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Table B-2.–Trade by Company—Coal (Continued)

Equipment area Transportation at ***Underground Mine Site***

Suppliers	Country	Product	Year	Value
Ohlemann GmbH	West Germany	36 underground mining vehicles	1979	
Komatsu Ltd.	Japan	30 120-ton capacity heavy mining trucks	1979	$30 million
Linden Alimak	Sweden	Mine shaft hoists	1979	SKr 5 million

Appendix C. – Suppliers of Essential Equipment

Table C-1.—Suppliers of Nuclear Grade Pipes and Tubes Outside the United States

Austria	Austriatom
	Vereinigte Edelstahlwerke Voest-Alpine
Canada	Chase Nuclear
	Dominion Bridge Co
	Finnan Engineered Products
	Noranda Metal Industries
	Rio Algorn (Atlas Alloys Div.)
France	Creusôt-Loire
	Delattre-Levivier
	Metaux Inoxydables Ouvres
	Vallourec
Great Britain	Cabot Alloys Europe
	Cameron Iron Works
	Fine Tubes
	Pipework Engineering Developments
	RGB Pipelines
	Tioga Pipe Supply International
Italy	Dalmine
	Tecnitub Italiana SpA
Japan	IHI
	Japan Steel Works
	Kawasaki Steel Corp.
	Kobe Steel
	Kubota
Netherlands	Ameron BV
	Kawecki-Billiton Metaalindustrie
	Trent Tube
	Van Mullekom
	Van Wijk & Boerma
Sweden	Avesta Jernverks
	Nyby Uddeholm
	Sandvik
Switzerland	Zschokke Wartmann AG
West Germany	Klockner-Werke
	Mannesmannroehren-Werke AG
	Schmoele, R.&G. Metallwere GmbH

SOURCE: *Nuclear Engineering International* (NEI) International Buyers' Guide 1980

Table C-2.—Suppliers of Welding Equipment Outside the United States

Canada	Bata Engineerlng
France	Polysoude
	Sciaky S. A.
Great Britain	Cunnington & Cooper
	NEI Clarke Chapman Power Engineering
	Sciaky Electric Welding Machines
	Tioga Pipe Supply International
	Vickers Shipbuilding Group
Italy	Breda Termomeccania
	Corradi, Franco
Japan	IHI
	Kawasaki Heavy industries
	Kobe Steel

SOURCE: NEI International Buyers' Guide 1980

Table C-3.—Suppliers of Steam Generators Outside the United States

Austria	Austriatom Simmering-Graz- Paaker Voest-Alpine
Canada	Babcock & WIlcox Canada Davie Shipbuilding Noranda Metal Industries
France	Creusôt-Loire Framatome Stein Industrie Sulzer
Great Britain	Babcock Power NEI Clark Chapman Power Engineering NEI International Combustion RNC Nuclear
Italy	Breda Termomeccanica Construzioni Meccaniche Franco Tosi NIRA
Japan	IHI Kawasaki Heavy Industries Kobe Steel Mitsubishi Heavy Industries Toshiba
Netherlands	Neratoom Royal Scheide RSV-A
Spain	Babcock & WIlcox Espanola Equipos Nucleares
Sweden	Uddcomb Sweden
Switzerland	Sulzer Brothers
West Germany	Babcock-Brown Boveri Reaktor Deutsche Babcock GHH Sterkade Klockner-Werke

SOURCE NEI International Buyers Guilde, 1980

Table C-4.—Suppliers of Pumps Outside the United States

Austria	Andritz Austriatom
Canada	Finnan Engineered Products Hayward Gordon
France	Creusôt-Lotre Dresser Europe Framatome Pompes Guinard
Great Britain	GEC Reactor Equipment Haskel Hayward Tyler & Co Holden & Brooke Weir Pumps
Italy	Fiat TTG Franco Tosi
Japan	IHI Kawasaki Heavy Industries Torishima Pump Manufacturing Co Toshiba
Netherlands	Borg-Warner Corp. Delaval-Stork
Sweden	Karlstads Mekaniska Werkstad
Switzerland	Eschler Urania K. Rutschi, Ltd. Sulzer Brothers
West Germany	Interatom Klein, Schanzlin & Becker Orlita

SOURCE NEI International Buyers Guilde, 1980

Table C-5.—Suppliers of Valves Outside the "United States

Canada	Canadian Worcester Controls Curran Valve Supply EPG Energy Products Group Fisher Controls Co of Canada Velan Engineering
France	Alsthom-Atlantique Neyrpic Pont-a-Mousson Trouvay & Cauvin
Great Britain	Adams, Gebruder GEC-Elliott Control Valves Hattersley Heaton Hindle Valves Hopkinsons
Italy	Fiat TTG
Japan	Japan Steel Works Okano Valve Mfg. Co. Utsie Valve Co.
Netherlands	Borg-Warner G. Dikkers & Co,
Sweden	Karlstads Mekaniska Werkstad
Switzerland	Alfred Battig Sulzer Brothers
West Germany	Gebruder Adams ARF Armaturen-Vetrieb Deutsche Babcock Stahl-Armaturen Persta

SOURCE: NEI International Buyers Guide, 1980

Table C-6.—Suppliers of Containment Structures Outside the United States

Austria	RFB Veost-Alpine
Canada	Can atom Davie Shipbuilding
France	Bignier Schmid-Laurent Creusôt-Loire Neypic Spie-Batignolles S.A.
Great Britain	Babcock Power Fairey Engineering GEC Reactor Equipment Sir Robert McAlpine & Sons, Ltd.
Italy	Bosco Industrie Mecca niche Fochi
Japan	I HI Kawasaki Heavy Industries Kobe Steel Shimizu Construct Ion Co
Switzerland	Bureau BBR Buss Sulzer Brothers Woolley Zschokke Wartmann
West Germany	Krupp Fried Maschinenfabrik Augsburg-Nurnberg AG L. & C. Steinmuller

SOURCE: NEI International Buyers Guide, 1980

Table C-7.—Suppliers of Control Systems Outside the United States

Canada	Automatec Canadian General Electric Enercorp Instruments Fischer & Porter Thermo Electric
France	CGEE Alsthom Fichet-Bauche Leanord SODETEG Spie Batignolles
Great Britain	Ferranti Computer Systems Foxboro-Yoxall Honeywell Kent Process Control R.P. Automation
Italy	ELSAG Marelli, Ercole & Co. Montedel
Japan	FUJI Electric Co Kawasaki Steel Corp. Sukegawa Electric Co. Toshiba
Sweden	A SEA Tekniska Rontgencentralen
Switzerland	Bachofen Brown Boveri & Cie High Energy & Nuclear Equiprnent Sulzer Borthers
West Germany	Brown Boveri & Cie Karftwerk Union Nuclear Data Siemens

SOUR CE NEI International Buyers Guide, 1980

Table C-8. —Essential Equipment for Coal Mining

Preparation

1 Agitators, Conditioners, Mixers
2 Crushers
3 Flotation Machines and Reagents
4 Grinders
5 Pulverizers
6 Separators
7 Washers
8 Cleaning Breakers
9 Blending Machines
10 Electrostatic Precipitators

Surface Mining Excavation

11 Draglines
12 Drills
13 Power Shovels
14 Bulldozers
15 Front-end Loaders
16 Scrapers

Transportation *at Surface Mine Site*

17. Coal Haulers (100 ton)

Underground Mine Excavation

18 Continuous Miners
19 Loading Machines
20 Longwall Equipment
21 Bulldozers
22 Coal Cutters
23 Heading Machines
24 Undercutter

SOURCE C. Simeons, Coal Its Role in Tomorrow's *Technology (New* York Pergamon Press 1978I

Table C-9.—West European and Japanese Suppliers of Essential Coal Mining Equipment

1. ***Agitators, Conditioner and Mixers***

France
- Fives-Call Babcock

England
- APV-Mitchell (Dryers), Ltd.
- GEC Mechanical Handling, Ltd.
- Johnson-Progress, Ltd.
- Joy Manufacturing Co.

Japan
- Kawasaki Heavy Industries, Ltd.

2. ***Crushers***

England
- Aveling-Beuford, Ltd.
- British Jeffrey Diamond
- Magco, Ltd.
- Newell Dunford Eng., Ltd.
- Pegson, Ltd.
- Underground Mining Machinery, Ltd.

West Germany
- Buckan-Wolf Maschinenfabrik AG
- Buhler-Miag
- Esch-Werke AG
- Hazemag GmbH & Co
- IBAG International Baumaschinenfabrik AG
- Krupp GmbH

France
- Alsthom Atlantique
- Dragon SA Appareils
- Fives-Call Babcock
- Joy SA
- Stephanoise de Constr

Japan
- Ishikawajima-Harima Heavy Industries
- Kawasaki Heavy Industries, Ltd.
- Kurimoto Iron Works, Ltd.

3. ***Flotation Machines and Reagents***

England
- Machines
  - Joy Manufacturing Co
- Reagents
  - Century Oils, Ltd.

West Germany
- Machines
  - KHD Industrianlagen AG
  - Krupp GmbH, Fried, Krupp Industriel
  - Lurgi Gesellschaften

Japan
- Machines
  - Kawasaki Heavy Industries, Ltd.
- Reagents
  - Sanyo Chemical Industries, Ltd.

4. ***Grinders***

England
- Beryllium Smelting Co, Ltd.
- Chapman, Ltd.
- GEC Mechanical Handling, Ltd.
- Head Wrightson & Co, Ltd.
- Helipeds, Ltd.
- Joy Manufacturing Co
- Newell Dunford Eng., Ltd.
- Pegson, Ltd.
- Simon-Warman
- Wilkinson Process Linatex Rubber Co, Ltd.

France
- Alsthom Atlantique
- Dragon SA Appareils
- Fives-Call Babcock
- Stein Industrie

West Germany
- Buhler-Miag
- Esch-Werke AG
- IBAG International Baumaschinenfabrik AG
- KHD Industrianlagen AG
- Krupp GmbH, Fried, Krupp Industrie
- Kulenkampff Gebruder
- O&K Orenstein & Koppel AG
- Polysius Werke

Japan
- Ishikawajima-Harima Heavy Industries
- Kawasaki Heavy Industries, Ltd.
- Kabe Steel, Ltd.
- Kurimoto Iron Works, Ltd.
- Mitsubishi Steel Mfg. Co. Ltd.

5. ***Pulverizers***

England
- British Jeffrey Diamond

West Germany
- KHD Industrianlagen AG
- Krupp GmbH, Fried, Krupp Industrie

Japan
- Ishikawajima-Harima Heavy Industries

6. ***Separators***

England
- Boxmag-Rapid, Ltd.
- GEC Mechanical Handling, Ltd.

France
- Fives-Cail Babcock
- Saulas & Cil
- Stein Industrie

West Germany
- Bavaria Maschinenfabrik GmbH & Co
- KHD Industrianlagen AG
- Krupp GmbH, Fried, Krupp Industrie
- Polysius Werke

Table C-9.–West European and Japanese Suppliers of Essential Coal Mining Equipment (Continued)

Japan
- Ishikawajima-Harima Heavy Industries
- Kawasaki Heavy Industries. Ltd.
- Kobe Steel Ltd.
- Kurimoto Iron Works Ltd.

7. ***Washers***

England
- Aveling Barford Ltd.
- GEC Mechanical Handling, Ltd.

France
- Alsthom Atlantique
- Dragon SA Appareils

West Germany
- Bavaria Maschinenfabrik GmbH & Co
- Esch-Werke AG
- IRAQ International Baumascninenfabrik AG
- KHD Industrianlagen AG

Japan
- Kurirnoto Iron Works Ltd.

8. ***Cleaning Breakers***

England
- British Jeffrey Diamond
- Compair Construction & Mining Ltd.
- GEC Mechanical Handling, Ltd.
- Gullick Dobson, Ltd.
- Mining Supplies, Ltd.
- Padley & Venables
- Underground Mining Machinery, Ltd.

France
- Fives-Ca[l Babcock
- Stephanoise de Constr. Mecaniques. Soc.

West Germany
- Deutsche Montabert GmbH
- KHD Industrianlagen AG
- Orenstein & Koppel AG
- Westfalia Lunen

Japan
- Furukawa Rock Drill Sales Co Ltd.
- Ishikawajima-Harima Heavy Industries

9. ***Blending Machines***

England
- Babcock-Moxey. Ltd.
- Babcock & WIlcox, Ltd.

France
- Fives-Call Babcock
- Realization Equipments Industriels

West Germany
- Buckau-Wolf Maschinenfabrik AG
- Demag Lauchammer Masch & Stahlbau GmbH

Japan
- Ishikawajima-Harima Heavy Industries

10. **Electrostatic Precipitators**

England
- Head Wrightson & Co Ltd.

West Germany
- KHD Industrianlagen AG
- Lurgi Gesellschaften

Japan
- Ishikawajima-Harlam Heavy industries
- Kawasaki Heavy Industries Ltd.

11. ***Draglines***

England
- Ransomes & Rapier Ltd.
- Ruston-Bucyrus Ltd.

France
- Poclain
- Realization Equiprnents Industriels

West Germany
- Aumund-Forderbau GmbH
- Demag AG. ABT Bergwerksmachinen
- Demag Lauchhammer Masch & Stahlbau GmbH
- Demag Verdichtertechnik GmbH
- Krupp GmbH, Fried, Drupp Industril Una Stahlbau
- Liebherr Hydraulikbagger GmbH
- Maschinenfabrik Augsburg-Nurnberg AG
- Orenstein & Koppel AG

Japan
- Hitachi Construction Machine Co. Ltd.
- Ishikawajima-Harima Heavy Industries
- Kawasaki Heavy Industries
- Kobe Steel Ltd.

12. ***Drills***

England
- Boart, Ltd.
- Compair Construction & Mining. Ltd.
- Eimco, Ltd.
- English Drilling Equipment Co., Ltd.
- Euro-Drill Equipment, Ltd.
- Hydraulic Drilling Equipment. Ltd.
- Mining Dev., Ltd.
- Underground Mining Machinery, Ltd.

13. ***Power Shovels***

See Draglines

14. ***Bulldozers***

See Draglines

France
- Maco-Meudon

West Germany
- Demag AG, ABT Bergwerksmachinen
- Demag Drucklufttechnik GmbH
- Demag Verdichtertechnik GmbH
- Deutsche Montabert GmbH
- Flottman-Werke GmbH
- Werth & Co

Japan
- Furukawa Rock Drill Sales Co
- Koken Boring Machine Company
- Mitsubishi Steel Mfg. Co Ltd.
- Mitsui Shipbuilding & Eng. Co, Ltd.

Table C-9.—West European and Japanese Suppliers of Essential Coal Mining Equipment (Continued)

15. ***Front-end Loaders***

England
- Aveling-Barford, Ltd.
- Eimco, Ltd.
- Matbro, Ltd.
- Mining Dev., Ltd.

France
- France Loader
- Realization Equipment Industriels

West Germany
- Aumund-Fordererbau GmbH
- Deilmann-Hanill GmbH
- Eickhoff Maschinf bk-U Eisengiesserei Mb
- Gutehoffnungshuttl Sterkrade AG
- Orenstein & Koppel AG
- Salzgitter Maschinen AG
- Westfalia Lunen

Japan
- Furukawa Rock Drill Sales Co
- Hiltachi Construction Machine Co., Ltd.
- Kawasaki Heavy Industries, Ltd.
- Kobe Steel, Ltd.
- Komatsu, Ltd.
- Mitsuboshi Belting, Ltd.
- Shinko Electric Co, Ltd.

16. ***Scrapers***
See Draglines

17. **Coal *Hauler***
See Draglines

18. ***Continuous Miner***

England
- Babcock & WIlcox, Ltd.
- Dasco Overseas Eng., Ltd.

West Germany
- Demag AG, ABT Bergwerksmachinen
- Demag Verdichtertechnik GmbH

19. ***Loading Machine***
See Front-end Loaders

20. ***Longwall Equipment***

England
- British Jeffrey Diamond
- Underground Mining Machinery, Ltd.

France
- Minex Mine-Expert

West Germany
- Eilckhoff Maschinf bk-U Eisengiesserei Mb
- Westfalia Lunen

21. ***Bulldozer***
See Draglines

22. **Coal *Cutters***

England
- Babcock & Wilcox, Ltd.
- Bntish Jeffrey Diamond
- Dosco Overseas Eng., Ltd.
- Mining Supplies, Ltd.
- Underground Mining Machinery, Ltd.

France
- Minex Mine-Expert
- Stephanoise de Constr. Mecaniques

West Germany
- Eickhoff Maschinf bk-U Eisengiesserei Mb
- Thyssen Industrie AG
- Titanit Bergbau Technik
- Westfalia Lunen

23. ***Heading Machines***

England
- Eimco, Ltd.
- Gullick Dobson, Ltd.
- Mining Dev., Ltd.
- Thymark Thyssen Group

West Germany
- Becorit Grubenausbau GmbH
- Salzgitter Maschinen AG
- Westfalia Lunen

24. ***Undercutter***
See Draglines

SOURCE C Simeons *Coal Its Role In Tomorrow s Technology (New* York Pergamon Press, 1978)

Table C-10.—West European and Japanese Producers of Electric Transmission Equipment

Country	Company	Country	Company
West Germany	Siemens AEG	Sweden	ASEA (High Voltage Transformers and DC Equipment)
England	English Electric GEC	Switzerland	Brown- Boveri
France	Thomson-Brandt Alstom-Atlantique DEL (High Voltage Circuit Breakers)	Japan	Mitsubishi
		Netherlands	Philips

SOURCE Off Ice of Technology Assessment