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TECHNOLOGY EXCHANGE

IMPORT POSSIBILITIES FROM THE U.S.S.R.

RAND CORPORATION

PREPARED FOR

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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Technology Exchange: Import Possibilities from the U.S.S.R.

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A Report prepared for

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Rand
SANTA MONICA, CA. 90406

PREFACE

This report is part of Rand's work on technology exchange for the Defense Advanced Research Projects Agency and the Council on International Economic Policy. It discusses what forms of technological information from the Soviet Union may be useful to the United States for saving our own resources, paying in kind for U.S. technology, or negotiating for transfer of our technology to the Soviet Union.

Other reports of this project dealing either with the broader political and economic aspects of the problem or with other specialized subjects are:

R. E. Klitgaard, *National Security and Export Controls*, The Rand Corporation, R-1432-ARPA/CIEP (forthcoming).

N. Leites, *The New Economic Togetherness: American and Soviet Reactions*, The Rand Corporation, R-1369-ARPA (forthcoming).

J. P. Stein, *Estimating the Market for Computers in the Soviet Union and Eastern Europe*, The Rand Corporation, R-1406-CIEP/ARPA (forthcoming).

An overview report is also planned.

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SUMMARY

This report analyzes matters related to possible increased technological exchange between the Soviet Bloc and the United States. Emphasis is on the transfer of technology from the Soviet Union to the United States. Is there a significant amount of technology in the Soviet Bloc that the United States can use? In what areas of technology are they most likely to have information from which we can learn and save R&D or other resources?

A wide range of objects and individuals might be imported from the Soviet Bloc in exchange for technology or other products they desire from us. This range of technological information is characterized by varying costs we might have to pay to derive the contained know-how. Political and legal differences between the United States and the Soviet Bloc are so great with respect to government-industrial relations that enormous effort and ingenuity will be required to create an appropriate environment for each technological exchange.

Unfamiliarity with the Russian language in the United States is another barrier to exchange, as is the psychological carryover from the cold war environment. Wide differences in standards and insufficient interface between U.S. industry and the newly organized U.S.-USSR Joint Commission on Scientific and Technical Cooperation present other barriers to technology exchange.

The various components of the research and development process do not vary greatly in kind between the Soviet Union and the United States. There is likely to be a significant amount of technical information in the area of applied research that is not readily available for exchange through present operating institutions. A proposal is made to fill this gap by extending into the Soviet Union the activities of U.S. research institutes now operating in a technical-information exchange role in Western Europe and elsewhere. One way such organizations might operate for this purpose includes the use of a deductive technique for searching out Soviet technology that may be of interest to the United States. Promising possibilities from the

use of this technique lie in such fields as electric power production and distribution, ferrous and nonferrous production methods, permafrost science and engineering, high-yield crops for cold climates, and specialized machinery.

ACKNOWLEDGMENTS

The author wishes to acknowledge the useful comments and suggestions received in connection with this study from his colleagues at Rand, H. Campbell, A. R. Johnson, R. E. Klitgaard, J. E. Koehler, N. Leites, A. E. Nimitz, J. P. Stein, and C. Wolf, Jr.; and T. Schelling of Harvard University. Any remaining errors of fact or interpretation are the sole responsibility of the author.

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CONTENTS

I. INTRODUCTION

Numerous agencies in the government (and in private industry) have a keen interest in the export of the U.S. technology--whether furthering it or opposing it--but no government agency has an organizational interest in the import of technology from the Soviet Union (and Eastern Europe) for domestic use. However limited such import possibilities may be, there should be some Eastern Bloc technology from which we might benefit in return for what we export. Knowledge about such potentially useful foreign technology would put the United States, and in particular the DOD, in a stronger position when we are considering Soviet requests for exports.

This report looks briefly and qualitatively at the nature and the costs and benefits of different types of technical information. Various barriers to technological exchange between the Soviet Union and the United States are examined including those that are inherent in the Joint Commission on Scientific and Technical Cooperation. Types of organizations and methods of operation are outlined that might reduce some of the exchange barriers.

Exchange implies that the Soviet Union must be persuaded to take altered courses of action with respect to their technology in response to U.S. initiatives, or that both countries must arrive at new positions as the result of bargaining. If we are looking for things we may want to persuade the Soviet Union to supply us in *exchange* for our technology, we need to look for knowledge in their possession that is not readily available unless they cooperate in delivering it, not merely information lying dormant and unused in Russian language publications.

II. STRUCTURE OF TECHNOLOGY

ACTIVITIES, RELATIONS, AND OUTPUT FROM TECHNICAL CATEGORIES

Table 1 was constructed in an attempt to organize and define typical activities, interrelations, and outputs of the three usual categories--basic research, applied research, and technology development--plus a fourth category, included for completeness, management technology. There is, of course, specialization within each category. A single individual rarely carries out all of the activities listed. In basic research, for example, some people are best at observation, some in making deductions, some in experimenting. The overall basic research activity in a subject area need not have occurred in the same institution, the same country, or the same decade. There is less dispersion of this type in applied research because of the specific nature of the activities. Even there, however, basic and applied results from other times and other countries can be extremely useful inputs for current purposes.

Management technology was added to emphasize that the best designed technology can fail badly if its operation is not managed skillfully. This technology is probably the least scientific or quantitative of all. Perhaps for this reason it is most difficult to exchange without the involvement of key individuals.

The column labeled Outputs in Table 1 indicates some of the types of items that are typically available from the activities of the various science and technology categories.* Some of these outputs are professional papers, books, and monographs that are conventionally published in countries where these activities take place. Whatever the transfer costs in terms of current availability and language barriers, the information they contain may usually be obtained through currently operating flow channels. However, many

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*Although the institutional distribution of these activities and their organizations may vary in different countries and between industries, the outputs listed are characteristic of the several activities and are more or less independent of their specific organization.

Table 1

TYPICAL ACTIVITIES AND OUTPUTS OF BASIC RESEARCH, APPLIED RESEARCH, TECHNOLOGY DEVELOPMENT, AND MANAGEMENT TECHNOLOGY

Category	Activities	Outputs
I. Basic research	1. Observe nature.[a]	1. Compendiums of facts.
	2. Deduce hypotheses.	2. Hypotheses about nature.
	3. Develop and build models.	3. Models of natural phenomena.
	4. Test hypotheses using models and experimentation	4. Designs for useful apparatus and techniques.
	5. Formulate quantitative natural laws.	5. Lists of patentable ideas or results of obvious practical usefulness.
	6. Publish results.	6. Derivations of quantitatively predictive laws of natural behavior.
		7. Papers, books, monographs.
II. Applied research	1. Observe technological problems or potential demands.	1. Knowledge of technological problems and potentially useful products.
	2. Formulate possible solutions.	2. Knowledge of possible solutions to technological problems.
	3. Search outputs of previous basic and applied research for suggested approaches to solutions.	3. Annotated literature bibliographies by subject area.
	4. Design experiments, equipment, and computer models to evaluate the possible problem solving approaches.	4. Designs for useful apparatus, instrumentation, and experimental techniques; computer programs.
	5. Develop quantitative data and evaluate.	5. Technical handbooks.
	6. Apply for patents where appropriate.	6. Trade secrets and other know-how.
	7. Communicate results to appropriate technologist users.	7. Patents.
	8. Publish results of a basic or other nonproprietary nature.	8. Patentable ideas.
		9. Professional papers.
		10. Technical reports.
		11. Books and monographs.
III. Technology development	1. Observe production or product problems.	1. Engineering reports on process or product improvements, mostly proprietary.
	2. Remain aware of improved production and product possibilities by communication with applied researchers, observation of competition, and product market research.	2. Engineering drawings and specifications for production units and products
	3. Design, construct, and operate pilot scale equipment necessary for final evaluation of process or product improvement and the design of factory units and market products.	3. Patents.
	4. Reduce patentable ideas to practice and apply for patents.	4. Technical publications of a nonproprietary nature, e.g., generalized relations between size, cost and output; solutions of measurement and health, safety, and environmental problems.
	5. Design full-scale equipment, plant, or product and prepare necessary drawings and other appropriate specifications.	5. Production and product know-how, including trade secrets.
	6. Operate full-scale prototype production line or experimental factory.	6. Empirical recipes and formulas for products and processes.
	7. Become aware of associated problems of industrial health, safety, environmental pollution, and product safety in use. Provide proper safeguards.	7. Feedback to applied research.
IV. Management technology	1. Control production facilities and inputs with the purpose of meeting output objectives of firm.	1. Appropriate mix of products meeting quality standards at low cost.
	2. Provide motivation and discipline of workers.	2. Publications on management techniques for quality control, scheduling, and worker interactions.
	3. Monitor operations including product quality and environmental health and safety.	3. Production and product know-how.
	4. Schedule and inspect raw materials, internal operations, warehousing, and shipping to minimize costs while meeting product objectives.	4. Feedback to technology development.
	5. Provide cost inputs to corporate cost system and adjust behavior according to outputs from cost system.	

[a]Basic researchers often direct their attention to specific areas of nature where there are problems that confront applied researchers and technologists. This has sometimes been designated as directed basic research. A classic example is the fundamental research by Irving Langmuir at General Electric on surface adsorption, a field of great practical importance in the manufacture of light bulbs.

others of these items are not published but are held within organizations or have limited circulation. The proportion of this limited information increases from the more basic to the more practical regions of this spectrum. From Table 1, the following items are likely to be limited in distribution and therefore subject to negotiation for exchange:

Basic Research

- Useful apparatus and techniques
- Patentable ideas

Applied Research

- Annotated bibliographies by subject
- Useful apparatus, instrumentation, experimental techniques, computer programs
- Knowledge of technological problems and potentially useful products
- Technical reports
- Patentable ideas
- Trade secrets and other know-how

Technology Development

- Engineering reports
- Engineering drawings and specifications
- Patentable ideas
- Production and product know-how, including trade secrets
- Empirical recipes and formulas for products and processes

Management Technology

- Production and product know-how

In a later section of this report, institutional means and techniques are suggested by which at least some of this information of limited circulation might be collected and obtained in exchange for U.S. technology export.

THE NATURE OF TECHNICAL INFORMATION

Technical knowledge that might be exchanged is represented by a wide variety of objects and key persons. There is not just a certain class of technology that embodies "know-how" and another class that does not. Rather, certain kinds of technological objects contain information that is easy and cheap to extract and apply, whereas extracting useful information from other forms may require extensive laboratory detective work and independent development programs. The latter type of technological knowledge may still be well worth obtaining if other forms are unavailable or costly.

Some specific examples will make these points clearer. Possibly the object containing the ultimate amount of specific technological information is a production plant constructed in a foreign country on a turnkey basis, guaranteed to operate at certain production levels and produce goods of a specified quality. The vendor trains the workers and furnishes machines and spares, and supplies material specifications.* Such a plant might produce, for example, steel-belted radial tires in large numbers over a long time without further association with the vendor agency. If only the tires were sold to the foreign country, a lengthy series of investigations and costly pilot development would have to be supported to "read" the information contained in the tires and use it to construct a successful production plant. The importing country would remain dependent on the producing country unless it chose to invest large sums in developing independent production means. With the turnkey plant, the receiving country obtains the means to become self-sufficient in the manufacture of this type of tire.

Just the knowledge that a product exists or is technologically feasible to produce is extremely useful information in itself. Not

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*There are many variants of this turnkey foreign plant investment, often motivated by political, social, and economic factors removed from technological considerations. These variants may have quite different potentials for technology transfer. If Mideast oil-producing countries were to invest in and own refineries constructed and operated in the United States, they would learn far less refinery technology than if the refineries were constructed in their own countries for their operations on a turnkey basis. Sometimes the key managerial talent and skilled workers are imported to operate the plant. Recognizing the limitations on knowledge exchange imposed by these conditions, some countries (e.g., Canada and Mexico) require that a certain fraction of managerial and other key employees be nationals.

too many years ago, most tire experts would have derided the suggestion that steel-belted radial tires could be a mass-produced, extremely valuable product.

Microminiature circuits are another example. Their extreme value for certain purposes may be obvious, but developing production techniques is a very costly procedure. The availability of sample circuits can somewhat reduce these development costs because scientific detective work on the samples can delimit the experimental alternatives that must be explored to create a production process. The availability of applied technical literature (including patents) describing aspects of original production methods can further reduce development costs, and having the services of key individuals involved in the original production yields an additional cost advantage. The value of key individuals is attested to by the "pirating" of technical personnel among competitive firms and by the rush after World War II by both the United States and the Soviet Union to obtain the services of German scientists and engineers in selected fields.

For specific objectives such as producing tires or microminiature circuits, the range of costs for obtaining technical information from the various modes mentioned might be as follows:

> turnkey plant < key individuals < license for product or process < patent literature < other technical literature < scientific literature < sample product < rumor of product or process feasibility.

The price of obtaining technical information probably decreases in the order listed above, analogous to the way prices of mineral ores increase with increasing mineral concentration while the costs of producing the pure mineral decrease with increasing ore richness. If an item rich in technological information (for example, a license) is priced much more than it would cost to develop the technology from a cheaper source, then the potential buyer will be motivated to obtain the cheaper source (for example, a sample product) and apply his own efforts (scientific deduction and intelligence gathering) to developing the technology.

Frequently, a combination of several or all of these exchange modes is involved in exchange agreements:*

> Exchange of scientific and technical services between Bechtel Corporation and the Soviet Union will take place as a result of a protocol agreement signed by the parties. Specifically aimed at engineering and construction in the chemical, petrochemical, mining and metallurgical industries, the pact calls for exchange of scientific and technical information; documentation and product samples; delegations of specialists and trainees; lectures and symposiums; joint research and development, and listing of processes and methods.

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*Chemical and Engineering News, July 16, 1973, p. 11.

III. TECHNOLOGY AVAILABLE IN EXCHANGE FROM THE SOVIET UNION

Evidence is presented in this section to support the proposition that there is a large stock of technical information in the Soviet Union that is not at present readily available for exchange. This stock occurs in the types of objects listed primarily under Applied Research in Table 1. The stock exists because this category has received large resource inputs yet there have been internal bottlenecks limiting its application to specific products or processes. Also, technical information of this nature tends not to lose value over time.

QUANTITY OF INPUTS

The Russian government showed early support for research when Peter the Great founded the renowned Imperial Academy of Sciences in 1725. The Soviet phase of the now USSR Academy of Sciences is characterized by the progressively accelerated expansion of the Academy's facilities and personnel since 1927, when the Academy was given a new statute and reorganized to bring it closer to the state structure of the Soviet Union.* The title of academician carries greater prestige than any other professional title in the Soviet Union.†

The number of individuals engaged in the overall research and development activities in the Soviet Union is large. The exact magnitude of the numbers of personnel given below, especially in comparisons with the United States, should not be given undue weight because of possible discrepancies in definitions and counting of research workers. In fact, missing data probably cause an understatement rather than an overstatement of the Soviet numbers. In any event, these

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*A. G. Koral, *Soviet Research and Development*, The M.I.T. Press, Cambridge, Massachusetts, 1965.

†L. Graham, "Reorganization of the USSR Academy of Sciences," in P. Juviler and H. Morton (eds.), *Soviet Policy Making*, Praeger, New York, 1967, p. 67.

numbers indicate dedication on the part of the Soviet Union in providing major manpower inputs to their research and development activities.[*]

Even as early as 1935, the total manpower of the Soviet industrial research laboratories more than matched the employment of the U.S. industrial research laboratories, and a larger proportion of national income was being spent on R&D.[†] By 1962, the comparison by manpower engaged in R&D in the two countries was estimated to be as follows:

	Scientists and Engineers Engaged in R&D	Total Personnel Engaged in R&D
United States	435,600	1,159,500
Soviet Union	416,000 to 487,000	1,039,000 to 1,472,000

The range in estimates of Soviet manpower results from the assumptions used as to the fractions of persons working in design organizations who are engaged in development work.[‡]

By 1965 an estimate of the R&D scientists and engineers in the two countries appeared as follows:

Scientific and Technical
Personnel in R&D--1965

United States	Soviet Union
498,000	599,000 to 682,000

[*] An attempt to compare total expenditures for research and development by the two countries involves not only the uncertainties mentioned but additional problems with the conversion of research rubles to dollars.

[†] R. A. Lewis, "Research and Development Effort of the Soviet Union, 1924-35," *Science Studies*, 2, April 1972, pp. 143-179.

[‡] C. Freeman and A. Young, *The Research and Development Effort in Western Europe, North America and the Soviet Union*, Organization for Economic Cooperation and Development, Paris, 1965.

Distribution*

(Percent)

	United States	Soviet Union
Basic	15	10
Applied	22	47
Development	63	43

Nolting† confirms that the activities and outputs of applied research in the Soviet Union are of the nature given in Table 1. He also estimates that expenditures in this category in 1968 were 60.3 percent of the total expenditures for research and development.

The range in the estimates of numbers of Soviet personnel results from including or omitting professionals engaged in contract research at higher educational institutions, and in R&D performed at industrial enterprises. No subsequent events have occurred that would indicate a degradation in the favorable numbers position in the Soviet Union. For example, D. M. Gvishiani, Deputy Chairman of the State Committee on Science and Technology of the USSR Council of Ministers, states in an interview in *Der Spiegel* that by the beginning of 1972 the Soviet Union had a total of about 936,000 scientific workers, which, plus assistants, gives a total of approximately four million scientific personnel.‡ In the same *Der Spiegel* interview, Gvishiani comments with respect to Soviet-West German trade that: "We can achieve extraordinary results if we combine *our great scientific potential* . . . with your engineering expertise."** V. A. Trapeznikov, first Deputy Chairman of the same State Committee states:

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*Nancy Nimitz, Personal Communication, The Rand Corporation, September 1973. Also, L. M. Gatovskii, *Ekonomicheskie problemy nauchnotekhnicheskogo progressa*, Nauka, Moscow, 1971, p. 130.

†L. E. Nolting, *Sources of Financing the Stages of the Research, Development, and Innovation Cycle in the U.S.S.R.*, Bureau of Economic Analysis, U.S. Department of Commerce, Washington, D.C., September 1973.

‡*Der Spiegel*, No. 19, May 1, 1972, pp. 69-73.

**Emphasis added.

> Our country's scientific potential is extremely high and science in the Soviet Union is taking rapid strides forward. The total number of scientific establishments . . . exceeds 5,000, and more than one million workers work in them, including about 200,000 candidates and doctors of sciences. More than half the total number of scientific workers work in the applied science sphere.*

About 55 percent of these total scientific workers were in research institutes, 37 percent in higher education institutions (both research and pedagogical staff), and 8 percent in industry.† As for continuing expansion of these activities, V. Glushkov, Vice President of the Ukranian Academy of Sciences, remarked:

> In the future, the role of pure science will be constantly growing. As long as we had the task of catching up with the technological development of the capitalist West, we could afford to devote less attention to long-range research, making wide use of the scientific and technological experience accumulated abroad. But, those who are marching ahead have no one to learn from.‡

PRODUCTIVITY AND BOTTLENECKS LIMITING INTERNAL USE OF RESEARCH RESULTS

The references above pertain to inputs and say nothing of the relative productivities of basic and applied research and technology development. In the early days after World War I, productivity in the Soviet Union was undoubtedly less than in those countries having longer-established industrial-research facilities. The rapid build-up in the Soviet Union resulted in a mix of very young, unseasoned researchers and a lack of suitable instruments, research materials (such as reagents), and so on. More recently the personnel has certainly become older and more experienced, although there are still reports of shortages of equipment and other limitations on productivity in certain fields.

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* *Ekonomicheskaya Gazeta*, No. 38, September 17, 1973, p. 21.

† Discussions of D. Z. Beckler, T. J. Mills, and J. L. Tech of the United States with M. Grishayev, Head, Finance Department, USSR State Committee on Technology at Moscow, October 9-13, 1972.

‡ Graham, op. cit., p. 150.

Conventional measures of research productivity--for example, number of papers and patents--must be viewed with reservations as the Soviet researcher has different motivations and opportunities to publish, and, until recently, patents were not commonly obtained in the USSR. By an international measure such as the Nobel Prizes in sciences (including economics), the United States greatly outscores the Soviet Union by 94 to 6, through 1972. Such measures are, however, greatly influenced by the isolation of Soviet science and scientists who are not personally acquainted with foreign scientists and do not often engage with them in informal seminars or in other personal exchanges.* One must rely, therefore, on reported subjective observations that there is a substantial amount of good and some outstanding research in the Soviet Union. For example, after completing an extensive study of Soviet research and development, A. G. Korol reports: "the Soviet potential to develop and engineer impressive projects of national efforts may be shifted from the military toward civilian objectives, important achievements in the field of applied science can be expected in many areas which may be neglected in other economies."†

"The USSR is the largest source of advanced technology in the world," is a more effusive statement on the subject attributed by a Russian source‡ to Mr. G. Shur, President of Patent Management, Inc., a Washington-based firm specializing in technology licensing.

Amann et al. make the following statements regarding productivity in research:

> The shortage of scientific equipment relative to scientific manpower can be seen as a special case of the general phenomenon that Soviet industry as a whole is at a less advanced

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*V. V. Nalimov and Z. M. Mul'chenko, "Sciometry: The Problems of Scientific Information," from the book *Sciometry*, Nauka, Moscow, 1969, translated by Nancy Nimitz and appearing in W. B. Holland (ed.), *Soviet Cybernetics Review*, 3, The Rand Corporation, Santa Monica, October 1969.

†A. G. Korol, op. cit., p. 234.

‡L. Yeliseyev, "USSR-United States: Relations are Developing," *Mezhdunarodnaya Zhizn*, No. 6, 1973, pp. 86-90, Moscow. Mr. Shur did not respond to the author's direct query on this subject.

> level than the United States. . . . It would nevertheless be unwise to draw firm conclusions about the productivity of Soviet research personnel on the basis of this evidence. Some Soviet research projects--it is not known what proportion they constitute of the whole--are extremely well-equipped. . . . Moreover, the intellectual and scientific environment of the scientist and his motivation, are always crucial to his productivity; . . . and in some branches of knowledge, physical facilities are not a major influence on the quality and speed of research.*

Amann et al. note that iron and steel research is one field in which visiting Western specialists obtained a favorable impression of both equipment for research and lack of duplication. Sager suggests that Soviet technology probably comes nearest to that of the West in machinery, electronics, and metallurgy.† Coal-mining and industries based on timber, textile, and food are especially backward, while chemicals, petroleum, electricity, and construction appear to be at an intermediate stage. One must be cautious, however, in extrapolating poor technology in industry to equally poor performance in related applied research. For example, Kuebler, a Westerner who worked in a Soviet institute of wood research reports:‡

> There was . . . no shortage of any essential research equipment. Modern instruments of measurement were just as plentiful as they are in Western scientific institutes. The lean years of the past have taught the Russians the art of improvisation and they continue to practice it. . . . The libraries were well equipped. They stocked not only the relevant publications of the Eastern bloc but also all the important scientific books and journals of the Western world.
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> In the field of wood research, the achievements of the Soviet research workers appeared to me to be generally good but not altogether satisfactory considering the large

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*R. Amann, M. J. Berry, and R. W. Davis, "Science and Industry in the USSR," in E. Zaleski et al. (eds.), *Science Policy in the USSR*, OECD Publications, Paris, 1969.

†Peter Sager, *The Technological Gap Between the Superpowers*, Swiss Eastern Institute Press, Berne, 1971.

‡Hans Kuebler, "Exchange Scientist in Leningrad," *Survey*, No. 52, July 1964, pp. 61-68.

number of people engaged. This does not mean that Soviet research is bad; it reflects the low technology level of the Soviet timber industry.

Within the Soviet Union widespread dissatisfaction is expressed with the inefficiencies demonstrated by their industrial enterprises in innovating to develop new and improved processes and products through the application of knowledge derived from basic and applied research.* This lack of "productivity" in innovation is attributed by both Soviet and foreign students of the system to the following reasons among others:

- o Reluctance of enterprises to introduce new products because their production often reduces centrally dictated performance indicators that determine bonuses. There is thus a weak "demand pull" for development.
- o Centrally dictated policy for pricing new products discourages their introduction by enterprises.
- o There is a shortage of pilot plant development facilities.
- o Salary levels and other benefits to personnel associated with industrial, technology-development laboratories are

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*A typical statement, for example, is "However, together with the great accomplishments achieved in accelerating the pace of scientific and technical progress, broadening its range and intensifying its influence on all economic sectors in the country, substantial shortcomings and difficulties exist. We still have many enterprises and scientific research organizations which are not carrying out their assignments on the development and utilization of new types of goods and technologies." K. Yefimov, "Scientific and Technical Progress: Organization and Management," *Kommunist*, No. 10, July 1973, pp. 90-101, *JPRS*, 59,918, August 29, 1973.

Or, "The December 1972 CPSU Central Committee plenum noted that the advantages of socialism in terms of accelerating scientific and technical progress are still not being fully used in our country; the latest scientific and technical achievements are being slowly applied in a number of production sectors." Anonymous, "Improving Management and Upgrading the Effectiveness of Industrial Output," *Kommunist*, No. 11, July 1973, pp. 25-34, *JPRS*, 60002, September 11, 1973.

+These inefficiencies appear to be greatly decreased in priority areas such as production of military hardware and space activities.

maintained below levels of Academy institutes, creating personnel shortages, dissatisfaction, and lower levels of competence in industrial development.

- Most of the applied research and preliminary development is performed in independent, specialized research and development organizations that are geographically and otherwise isolated from enterprises. This creates barriers to effective communication between basic and applied research and production.*

On the other hand, basic and applied research not only receive large resource inputs from the state but are least penalized in their activities by separation from production and by the disinclination of enterprises to innovate. Some of this research output, which may be available for import from the Soviet Union, undoubtedly duplicates that already known and accomplished in the United States. This overlap is, however, likely to be less than between the United States and other countries with which U.S. scientists have had closer contacts.† In addition, research showing negative technical results can have positive economic value in that those areas need not be explored again. Also, research of a routine nature can have a significant economic value. For example, the availability of long-time corrosion exposure test results can save expensive facilities and operating costs. Basic and applied research results do not "spoil" or become out-of-date with time as does much product development effort. The whole stock of past Soviet research may be a source of useful technological exchange material.

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*An excellent discussion of these and other relations of Soviet research and product innovation is contained in R. Amann et al., op. cit. Also see *The Economist*, "The Technological Gap--In Russia," February 8, 1969, pp. 64-65.

†This is a value judgment based on the tendencies in science to emulate successful research. Duplication or near similarity of research through such emulation is judged to be more probable than is the accidental duplication that may result through poor communication between isolated scientific societies.

Presenting any extensive analysis of useful, specific outputs from the applied research area of the Soviet Union is beyond the scope of this report. However, it is unlikely that there are many earth-shaking new ideas or developments unknown in the United States that represent major technological breakthroughs with respect to the U.S. state of the art. Information about major new items such as lasers, microminiature circuits, and boron filaments tend to leak through communication barriers because of their inherent interest and great potentials for application. The majority of the useful uncovered technical information is likely to represent potentials for moderate improvement in products and processes. This does not mean that such improvements are unimportant *in toto*. In large segments of mass-production industry (e.g., the steel industry), mark-up on sales is often low, 2 to 3 percent. Thus, a modest improvement that results in a 1/4 percent reduction in unit cost could yield a 25 percent increase in profit on sales. More important, such an increase in profit on sales could mean a much larger percentage and absolute increase in return on investment, thereby greatly improving the viability of the U.S. industry and its ability to survive and compete in world markets. Unquestionably, considerations of this sort are present when U.S. firms license Soviet continuous casting processes for steel ingots or aluminum production techniques. Through this leverage, a number of moderate improvements can have great value to both large and small U.S. firms.

A second point is that each interesting Soviet product or process represents only a small amount of the associated and potentially useful technical information of the types listed in Table 1. For example, the availability of Soviet construction machinery specially designed for operating on permafrost means that there very probably is a large store of basic and applied knowledge about all aspects of the complexities of permafrost.*

These comments about the potential value of applied research outputs are not meant to imply that there are not some areas of highly developed nonmilitary Soviet technology and specific products that we

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*Having made a literature survey of the subject some years ago, the author can affirm the extent of Soviet technical information on permafrost.

may wish to search out and transfer to the United States on a favorable basis. Methodologies for accomplishing this search and evaluation will be described in a later section. These methodologies can also help in evaluating and aiding in the transfer to us of the most pertinent basic and applied research output.

IMPLICATIONS

The preceding observations confirm that the Soviets have devoted large resources to research and development. In particular, applied research has received a significantly greater fraction of input than has the comparable area in the United States. However, there is strong evidence that bottlenecks in the Soviet Union limit the application of this research. The result of the great input plus low application of the output is a large stock of unused applied research.

Practical developments are taking place in the exchange of technical information that buttress the conclusions derived above. Exchanges of scientists working at a basic level are occurring through the activities of the Academies of Sciences in the Soviet Union (and of Eastern European countries) and in the United States. The recently instituted U.S.-USSR Joint Commission on Scientific and Technical Cooperation has also begun exchange operations, again with emphasis on basic information. In the realm of technology development and production know-how, U.S. industrial firms are dealing with Soviet agencies; and private U.S. licensing firms are arranging for exchanges of patents and other technological information.

Problems still associated with these modes of technical information exchange may limit their productivity. In the next sections, these problems are described and measures are suggested to alleviate these barriers to exchange. Such measures are later combined to suggest policy instruments as they might be formulated and usefully applied.

The one area in which there may not yet be satisfactory institutions and techniques to promote exchange is in applied research. The types of useful outputs of this class were outlined earlier in Table 1. U.S. research institutes might fulfill an exchange function in this area, operating as they have in the past in other countries.

IV. PROBLEMS IN TRANSFER OF TECHNICAL INFORMATION

TRANSFER THROUGH LITERATURE AND PERSONAL CONTACT

The value of applied technical literature (for example, trade journals) in reducing the costs for technological transfer was mentioned earlier. Familiarity with this literature, as well as with the more basic scientific literature, also helps determine what foreign technological information may be worth considering for exchange. Although the value of basic (and applied) knowledge transfer through literature and personal contact for these purposes is widely quoted, one gains the impression that technology transfer through these mechanisms is limited, except for such areas of direct military interest as nuclear energy, electronics, and weaponry. Where there is such transfer of basic and applied research results, except for direct military areas, the exchange appears to be more from the United States to the Soviet Union. There are probably several reasons for this. First, an overwhelmingly larger fraction of scientists and engineers in the Soviet Union read and speak English than their counterparts in the United States read and speak Russian. Second, there is a wider variety of U.S. than of Soviet publications, and they are apparently more readily available to Soviet scientists than theirs are to us.* Third, Soviet personal contacts (missions, meetings, and the like) appear to be better briefed and organized for obtaining technical information than do ours. Of course, they may have been more greatly motivated in this activity in the past by the relative technical richness of the United States.

Perhaps subvention of some type may be required to lower the transfer costs for American technologists to obtain this Soviet

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*This directionality of exchange is attested in the author's personal experience in several research areas. The Soviet literature would show references to a large fraction of U.S. papers and articles on a subject, whereas U.S. papers on the same subject would be devoid of any Soviet references although worthy research existed on the subject in the Soviet Union. Nalimov and Mul'chenko (op. cit.) also note this imbalance in literature citation. In addition, they complain of difficulties in obtaining foreign periodicals in the Soviet Union.

knowledge. In military technical intelligence organizations, specialists work full time analyzing foreign literature selected for its possible pertinence to direct military interests. One gains the impression that information from these organizations that is of pertinence for nonmilitary activities, or information of interest for both military and nonmilitary purposes, is not very effectively transferred to the domestic area. This resistance to flow probably stems from the lack of motivation on the part of the military, from security barriers, from the lack of appropriate communication media, and from absence of knowledge about the existence of such information as well as the lack of acceptor and synthesizing functions in domestic government agencies and in industrial organizations.

Given the wider-spread illiteracy of American scientists and technologists in the Russian language (and in the languages of the Eastern European countries) some kind of translation services must be supplied in addition to encouraging wider knowledge of Russian. The results of any such attempt to motivate increased learning of an unconventional* language are, however, likely to be slow in bearing fruit. Knowledgeable individuals, familiar with both the technical field in question and with the Russian language, must be rewarded for helping to select and translate pertinent articles and reports. Organizational means for this are described later.

The literature is by no means devoid of technical information from the Soviet Bloc in the English language. Many of the papers of Eastern European countries appear in their original journals in English (or in German) rather than in their native tongues. Technical abstracting services and organizations in a number of fields provide English abstracts of many Soviet and Eastern European journal articles.† A number of these journals are translated in their entirety under the aegis of scientific societies or by private publishing firms. The

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*Unconventional in the sense that Russian is not frequently a required foreign language for undergraduate or graduate curricula in science and engineering.

†These are professionally oriented abstracting services: *Chemical Abstracts*, *Engineering Abstracts*, *Bioresearch Index*, and others.

World Index of Scientific Translations is published quarterly in the Netherlands and contains information about western language translations of specific papers. Translation journals, some published by the Soviet Union, also contain scientific and engineering information. These include *ABSEES*, abstracts of books, newspapers, and journals; *Bibliography and Index*, the U.S. Joint Publications Research Service translations; *Current Digest of the Soviet Press; Digest of the Soviet Press; Digest of the Soviet Ukrainian Press; Foreign Broadcast Information Service (FBIS); Soviet Review*, quarterly journal of translations with emphasis on social and political sciences but some technology; *Foreign Trade; Moscow News*, and *Soviet Life*. And there are others.

The U.S.-USSR Joint Commission on Scientific and Technical Co-operation was organized as the result of an agreement between the two countries signed in Moscow on May 24, 1972. In selected fields, the operations of the Commission and the several Joint Working Groups are already accomplishing interactions between certain Soviet and United States scientists and technologists.* Explicitly directed at information exchange, the Joint Commission approved the plans of the U.S. National Science Foundation and the USSR All-Union Research Institute for Scientific and Technical Information to conduct a symposium on scientific and technical information.

A reading of the records of the actions and recommendations of the Joint Commission and of the Joint Working Groups illuminates what may be a flaw in the ability of these agreements to accomplish their objective of technological information transfer to those U.S. agencies that can use the information most advantageously--namely, U.S. industrial firms.

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*The active Joint Working Groups and their fields are Energy Research and Development; Applications of Computers to Management; Agricultural Research; Water Resources; Chemical Catalysts; and Production of Substances Employing Microbiological Means. Additional Joint Working Groups were suggested for: Forestry Research and Technology; Standards and Standardization; Oceanographic Research; Transportation; Special Topics in Physics; and Electrometallurgy. In general these subjects are ones in which U.S. government agencies have significant direct interest and in-house capabilities rather than those having direct appeal to U.S. industry.

BARRIERS TO TRANSFER OF TECHNICAL INFORMATION BETWEEN U.S. GOVERNMENT AGENCIES AND INDUSTRY

The U.S.-USSR Joint Commission on Scientific and Technical Cooperation and the Joint Working Groups are overwhelmingly manned by employees of U.S. government agencies.* The exceptions are usually from universities rather than from industry. Although the report of the Joint Commission notes the differences in the relations between firms and their governments in the two countries, no recorded actions appear to be directed at ameliorating the communications difficulties that are likely to occur just between U.S. government agencies and U.S. firms.

Our government stays mostly out of the economic realm: while U.S. firms maximize, our government's traditional role is to watch.† The USSR does otherwise. Its firms have few maximizing incentives, but its government does. The Soviet government has entered into informational and marketing sides of the economy to a far greater extent than has the U.S. government. We wish to examine aspects of this U.S. government-industry relationship insofar as it affects technological information transferred from the Soviet Union to U.S. firms.

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*The Soviet representatives by the nature of things are all state employees. One gains the impression that, with some exceptions, the Soviet representatives are not only higher in their government's bureaucracy but are also more eminent in the specific technical fields than are the U.S. representatives.

†The role of the U.S. government in trade is described by P. G. Peterson, then Secretary of Commerce, as follows: "For our part, we believe that economic decisions are made best when individual firms decide for themselves what is in their interests and commit their resources accordingly. The role of our government is not to make these decisions but rather to provide an environment in which our private sector is treated fairly with respect to such matters as office and communication facilities made available to it abroad, matters such as fair compensation for the transfer of property--whether that property be physical as in the case of goods, or intangible as in the case of patents and copyrights--and matters such as the arbitration of disputes in a manner that prevents the escalation of minor commercial matters into major political confrontations.

"We must always remember that we are an enterprise economy and that the role of the government...is to facilitate and stimulate private business transactions. It is certainly not to supplement the private sector." P. G. Peterson, *U.S.-Soviet Commercial Relationships in a New Era*, Department of Commerce, Washington, D.C., August 1972, pp. 14-15, 20.

There are some indications in the United States that give the appearance that important "blockages" exist for transfer between government and industry of domestic science and technology. Two major programs are being initiated, aimed largely at devising and experimenting with ways to overcome alleged blockages that slow down or prevent the application of science and technology in industry and government. The closest to implementation of the two programs is that under the National Science Foundation, the Experimental Research and Development Incentives Program. A similar program has been funded in the Department of Commerce, the Experimental Improvement Program. The results obtained from these programs should be followed closely because findings that pertain to domestic technology transfer should be equally applicable to transfer of information derived originally from the Soviet Union.

Technology-transfer blockage is not necessarily indicated if there are advanced technical developments that seem applicable but are not used for domestic production or products. From many such situations, the use of the advanced technology is just not warranted on criteria of marginal cost and marginal revenue. However, use of the advanced technology may be justified for, say, analogous military or space applications on the basis of extra-financial considerations. Also, the use of advanced technology by some industries and not by others for similar purposes is not indicative of lagging technology transfer. The using industry may be subject to government price control so that it operates inefficiently and thus uses advanced technology where its use might not be indicated in a more competitive industry.*

If there are blockages to the transfer of technology from government to industry within the United States, such blockages are hard to justify on the basis of ignorance of the existence or usefulness of the available advanced technology on the part of industry. Such blockage to transfer, if it exists, seems more likely to result from legal,

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*L. O. Johnson and H. Averch, "Behavior of the Firm Under Regulatory Constraint," *Am. Econ. Rev.*, 52, 1962, pp. 1052-1169. H. Leibenstein, "Allocative Efficiency vs. X-Efficiency," *Am. Econ. Rev.*, 56, 1966, pp. 392-415.

institutional, or psychological factors. If U.S. government agencies deal with individual firms, favoritism may be charged.* If firms combine to deal with the government as an industry, the Department of Justice may descend in wrath with charges of monopolistic practices. Traditionally, U.S. firms deal with their government in an arm's-length, adversary role and are not conditioned to deal with the government on a routine commercial basis. This attitude will extend to dealing with the Soviet government agencies that "front" for Russian firms. This attitude of U.S. firms in dealing with the Soviet government has been additionally conditioned during the past 25 years by "containment," the "iron curtain," and other cold war political manifestations.

If U.S. firms face legal barriers in dealing with their own government on commercial matters, they face even more formidable ones in dealing with agencies of the Soviet government. Charges of restraint of trade and monopolistic practices against the domestic firm by the U.S. government are still a threat in their dealings with foreign firms and governments. Such charges are not infrequently brought against U.S. firms, particularly in the case of joint ventures.† The socialist concepts of the ownership and management of the firm are so different from those in the United States that certain types of cooperative ventures, especially involving equity or U.S. management, become extremely difficult, if not impossible, to consummate. Mutual exchanges that can be covered by contract are more feasible. These most easily involve purchase or license of patents, exchange of raw material, finished goods, and so on.‡

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*This difficulty might be overcome if proprietary rights to government-acquired technology were sold at public auction as are land and other government-held resources.

†W. Friedmann (ed.), *Joint Business Ventures of Yugoslav Enterprises and Foreign Firms*, International Colloquium, Belgrade, June 12-14, 1967, Belgrade, 1968.

‡In the Soviet Union, the All-Union Association Licensintorg offers licenses for inventions in diverse fields. They also offer to undertake development work for others on inventions (*Foreign Trade*). The USSR Chamber of Commerce and Industry acts as agent for foreigners in obtaining patents in the USSR and obtain Soviet patents abroad in addition to its other commercial functions. The Committee on

STANDARDS AS EXCHANGE BARRIERS

The hindrance to technology transfer from the USSR through our unfamiliarity with the Russian language has already been mentioned. An analogous barrier is the physical, mechanical, and other such standards of all kinds that differ between the two countries. These differences can be costly to overcome in realizing importation and use in the United States of a wide variety of products and processes. These standards differences are not just straightforward dissimilarities in units of measure between, say, metric and English units. Rather, they involve such matters as alloy compositions and specifications, screw-thread contours and dimensions, taper-fit specifications, surface characteristics, and shaft-seal design, among others. These can be especially burdensome in cases where U.S. firms may purchase rights to manufacture Soviet equipment or products in the United States. Our tools, dies, and so on are not designed to produce to these standards. Either extensive redesign of the products must be undertaken to conform to U.S. standards or parts and production equipment must be imported from the USSR. An outstanding example of the difficulties that can arise in attempting to transfer the manufacture of products from one country to another, even under favorable transfer circumstances, was the effort in producing the Rolls Royce aircraft engine in the United States during World War II. Here, all know-how, blueprints, English specifications, and consultants were freely available; but a lengthy, costly, trouble-ridden development program was required before the American manufacturers could produce a satisfactory Rolls engine. The difficulties were primarily caused by the types of differences in standards described above.

A related set of standards problems pertains to reliability and other performance qualities for foreign products either purchased directly or manufactured according to foreign license and specifications. A recent example is the Wankel Engine. Rights to manufacture this foreign-developed engine have been purchased by several U.S. automobile

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Inventions and Discoveries under the USSR Council of Ministers supervises and administers much of the patent, search, evaluations, planning, and screening for export.

manufacturers. The trade literature recounts the expensive efforts being undertaken to develop in this engine the reliability expected by the American manufacturers and their customers. The Soviet Bloc literature indicates that the Soviets are less than satisfied with their consistency in maintaining such quality standards and are making efforts to improve. At their first meeting, as indicated earlier, the U.S.-USSR Joint Commission on Scientific and Technical Cooperation recommended the establishment of a Joint Working Group on Standards and Standardization.

V. POSSIBLE MEANS FOR OVERCOMING DIFFICULTIES IN TECHNICAL INFORMATION EXCHANGE

A wide range of objects and individuals might be imported from the USSR in exchange for products they desire from us. This range of technical information is characterized by increasing cost for deriving the contained know-how. The relative investments of the two countries in activities represented at the extremes by research and by production indicates that, with some exceptions to be noted, the United States might seek to import more basic and applied ideas and inventions, while the USSR might seek to import finished products and production facilities. The political and legal differences between the United States and the Soviet Bloc are so great with respect to government-industrial relations that enormous effort and ingenuity will be required to create a commercial environment in which mutually desirable transactions can readily occur.

Unfamiliarity with the Russian language is a barrier to U.S. assimilation of Soviet technology as are the psychological effects of the long cold-war environment. The usefulness of the newly activated U.S.-USSR Joint Commission on Scientific and Technical Cooperation can be greatly hindered by barriers to communication between the Commission, the U.S. government, and U.S. industry. Wide differences in standards of all types among the several countries can make exchange costly.

CURRENT AND PLANNED ORGANIZATIONS AND ACTIVITIES

Some organizations and activities are already planned or in existence whose initiation and expansion can help minimize hindrances to technology exchange. The Summit Agreement of May 1972 between the United States and the Soviet Union also provides for the creation of a U.S. Commercial Office in Moscow and a similar Soviet Trade Representation in Washington. Organization of these agencies depends upon acceptance of most-favored-nation tariff treatment for the USSR. If and when agreement on this matter is reached, and the respective trade organizations are established, the USSR will probably gain the net advantage. True, the United States will gain a new information source in the Soviet Union, but the transfer of information to and from American firms and this new government agency will be subject to the same restraints as may exist between the Joint Commission and U.S. industry. The Soviet government agency will tend to be more aggressive and entrepreneurial.* It is quite possible, therefore, that U.S. firms will gain more knowledge about technology and products of use to them through the Soviet representatives in Washington than through the U.S. agency in Moscow.

During the summit meeting, a joint U.S.-USSR Commercial Commission was set up. This is co-chaired by the Minister of Foreign Trade of the USSR and the U.S. Secretary of Commerce. Its terms of reference cover the whole complex of trade and economic matters between the two countries. As the result of a more recent protocol, a U.S.-Soviet Chamber of Commerce was established.

Before the cold-war era and again recently since the thaw in East-West relations, individual U.S. firms negotiated various trading agreements directly with agencies of the Soviet government. These have been mostly very large firms having other international ties in the form of European subsidiaries and self-derived understandings of Soviet capabilities and demands. General Electric Corporation and Occidental Petroleum are two firms that recently entered into extensive exchange agreements with the Soviet Union.

There are private organizations that (among their possible other activities) deal in foreign patents, including those from the Soviet Bloc countries. Two of these mentioned in the literature are National Patent Development Co. and Patent Management, Inc., of Washington, D.C.

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*This does not imply that the Soviet government is particularly adept at introducing new technology piecemeal into their industry. Quite the contrary, diffusion of new technology appears to be difficult in the USSR because of the lack of motivation on the part of individual firms as well as normal resistance to change. Recognizing this, the Soviet mission will be aggressively searching for U.S. technology that bypasses this difficulty--for example, finished products or unit production processes.

These organizations appear to operate by having knowledge of Soviet Bloc inventions and American industrial interests. Agreements are arranged with Licensintorg (or similar agencies in other countries) for rights to Soviet inventions. Licenses to use these inventions are then negotiated with American firms.

One of the largest and best known of the licensing firms is Dr. Dvorkovitz and Associates, Ormond Beach, Florida, which maintains a large, computerized file of patents and other know-how that firms and U.S. and foreign government agencies submit to them for distribution to their clients. These latter also include Soviet Bloc countries and other foreign governments. Surprisingly, the main flow of technology through their system* during the past decade has been from the Soviet Bloc to the United States. Imports to the Soviet Bloc have been mostly very large items, such as turnkey installations not involving the Dvorkovitz system, but, rather, negotiations among large U.S. firms, the U.S. State Department, and Bloc government bureaus.† This smaller relative flow to the Soviet Union of more detailed technology through their system may also reflect its insulation from Soviet-firm managers and the previously mentioned lack of motivation to innovate on the part of these managers.

The Dvorkovitz organization recognizes the large stock of technical information existing in the Soviet Union in the more basic and applied research outputs such as are listed in Table 1, but has not devised a means to collect or handle this information within their system. (Their transmittal to clients constitutes publication and nullifies future patent possibilities.)

Informed, honest licensing services of this nature can be useful in expediting technology transfer from the USSR to U.S. firms. Probably the most that is required of the U.S. government to encourage this private activity constructively is to continue to provide the legal framework (including those controls necessary to minimize dishonest practices) so this commerce can proceed effectively.

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*The Dvorkovitz system emphasizes technology in the pharmaceutical, chemical, and process industries.

†Personal Communication, Mr. Ralph Miller, Western Representative, Dr. Dvorkovitz and Associates, August 21, 1973.

Other legal aspects of the commercial environment, particularly with respect to contractual relations of all sorts, should be followed closely to determine where future barriers to useful imports may arise. Particularly if import possibilities exist for the United States in the more basic and applied Soviet areas, legal aspects of publication, translation, and royalties become important. Both countries are now members of the 1952 World Copyright Convention, the USSR as of May 27, 1973. For the Soviet Union the Convention is not retroactive.* Neither country is a member of the more protective Berne Convention, although the United States enjoys certain "backdoor" privileges with Berne member nations. Because the Berne Convention imposes conditions in addition to the home country's own laws on copyrighted material, the Soviet Union is unlikely to become a member.† The United States has bilateral agreements with a number of countries, and experience may indicate that such a bilateral agreement with the USSR will be productive.

A ROLE FOR U.S. RESEARCH INSTITUTES

There may be a useful place for another, more analytical type of private organization to define and promote technological exchange with the Soviet Bloc by eliminating or reducing many of the barriers described in Sec. IV. Indeed, because the types of organizations to be described perform some general consumption services, the U.S. government might partly subsidize its activities.

The nature of the proposed organization is suggested by the structure and activities of several nonprofit research institutions in developing inventions and other technological ideas within the United States, in Europe, and in other parts of the noncommunist world, particularly since the end of World War II. Such organizations as Battelle Memorial Institute, Stanford Research Institute,‡ Research

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*M. Boguslavskiy, "The Universal Copyright Convention," *Translations on USSR Political and Sociological Affairs*, No. 421, *JPRS*, 59826, 1973.

†Ibid.

‡Since this was written, Stanford Research Institute has announced an agreement on scientific and technical cooperation between SRI and the State Committee of the Council of Ministers of the USSR, September 18, 1973.

Corporation, A. D. Little,* and others have become proficient in searching out useful technological ideas in the United States and in other countries, developing the inventions where necessary and arranging for their exploitation by native or foreign firms. A lot of operational know-how has been accumulated by such organizations over the years in accomplishing technological exchange and *use*, by industry--the latter being a possible weakness of present U.S. government activities.

Advantages of organizations of this type in expediting the exchange of technology from the USSR to the United States are:

- o Experience in dealing with foreign governments and firms with regard to contractual and other business arrangements.
- o Provision of a method by which a single U.S. firm, or a group of U.S. firms with common technological interests, can spread costs of search, purchase, and development of technology.
- o Experience in knowing where and how to search for new technology.
- o Knowledge of the specific technological interests of U.S. firms.
- o Experience with creating and maintaining foreign technology information and translation centers.
- o Providing a legal *modus operandi* by which U.S. firms can cooperate on R&D interests, including standardization, without accusations of collusion. (Joint research by U.S. firms of this nature for other purposes is permitted by the Justice Department.)
- o Preference of U.S. firms for working through such institutes rather than through government agencies.
- o Provision of centralized organizations for interaction with concerned U.S. government agencies as well as supplying the pathways by which socially desirable activities in this context of exchange can be subsidized by the U.S. government (translations, services to small business, and so on).

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*A. D. Little is a profit corporation.

The means by which these research institutes have organized similar activities in other foreign countries have varied widely, depending upon the nature and state of development of the country* and the character of the mother U.S. institute. In highly developed foreign countries, large R&D laboratories may be established, primarily staffed and led by native research and development people. In such situations, most of the functions listed above are accomplished at the foreign laboratory site with mostly the finished technology product moving back to the United States. In smaller countries, branch offices may be maintained that interact either with a daughter laboratory of a neighboring foreign country or with the mother institution in the United States where most information processing is done. Usually each mother research institute is competent in particular areas of technology and their daughter foreign branches will reflect these specifications.

The advantages for technological exchange inherent in such organizations and operations suggest that the possibilities for initiating several prototype activities of this nature in one or more Soviet Bloc countries be actively explored.

INDUCTIVE, DEDUCTIVE, AND OTHER METHODS FOR LOCATING USEFUL TECHNOLOGICAL INFORMATION FOR EXCHANGE

The entrepreneurial motives of the government of the Soviet Union suggest that they may have developed knowledge about our potential demand for their technology and that we should ask the Russians what of their technology might be most useful for us. Even if such knowledge exists among the Soviet bureaucracy, and there is no desire to withhold it,† to whom should such questions be addressed and would the Soviets be willing to collect useful answers? Perhaps the proposed

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*In this discussion, the function of transferring technology from the foreign country to the United States is emphasized. Such organizations have also served to transfer U.S. technology to foreign countries. The direction of the net flow to or from the United States can vary greatly as, say, between such countries as West Germany or Switzerland on the one hand and South Korea on the other.

†As, for example, for national security reasons.

Soviet Trade Representation in Washington would be a useful contact in this connection as well as Licensintorg. It seems unlikely, however, because of the complexities involved, that answers will flow freely from the Soviets. Rather, U.S. agencies and firms will probably have to expend considerable effort in properly formulating the questions and in searching for Soviet agencies with the answers.

This latter activity is a usual function of the daughter, private, research institute organizations described above, which, in addition, maintain close surveillance over technical developments in their area of competence and may operate computerized information storage and retrieval systems containing useful information about developments, investigators, and laboratories. They may regularly publish annotated bibliographies in selected technical areas, and upon special order may prepare a critique of the state of the art in a field using an inductive process and all of the above types and sources of information.

Another technique, infrequently used but capable of yielding information in cases where data are scarce or where for some reason they are difficult to locate, involves a deductive process. This technique actually is analogous to applying the scientific method to the problem of defining and locating useful technical information. Having a particular nation as the focus of attention, a first step is to observe and organize a wide variety of facts about the nation. The facts should concern the detailed geographic, demographic, social, economic, and political attributes of the nation, both inherent and man-made. If our concern is to discover technological information that may be further advanced and of a different nature in the foreign nation than in the United States, facts should be emphasized about this foreign nation that are most divergent from similar facts about the United States. To aid in developing hypotheses, the factual attributes may be set by category against listed segments of U.S. economic and social activities in a tabular form that is sometimes called a contextual map.* Technological knowledge and judgment is then applied to the various combinations of foreign factual attributes and U.S. activities to

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*J. L. Kennedy, "A Display Technique for Planning," The Rand Corporation, P-965, October 1956.

generate hypotheses of possibly useful and available technology. The generated hypotheses are used as the bases for selective searches of the foreign technology. This process, if used intelligently, can narrow the areas of search for potential items for exchange. It can allow for the interaction and systematized contributions of individuals with different talents and provides for improving predictions as the result of experience. To improve interactive capabilities and flexibility, the developing contextual map may be programmed for computer use with remote consoles having visual display devices.

Suppose the country of focus is the Soviet Union and we are interested first in only the grossest initial screening of possible interesting technical areas. We know the Soviet Union land mass lies much further north than that of the United States and that this area is subjected to the continental arctic and subarctic climate with long, cold, windy winters and short, cool, summer growing seasons. Without attempting to be all-inclusive one may deduce that the Soviet Union has probably placed more effort than the United States in developments in the following fields:

- Engineering for construction and other activities on permafrost and tundra (useful to the United States for Alaska).
- Crops having short development times and high yields under the above conditions.
- Special vehicles for overland (and ice/water) use under difficult conditions.
- Medical treatments for disease types that occur most frequently in cold climates.
- Clothing adapted to cold climates.
- Games, sleds, skis, and other articles for recreational use.
- Construction materials, metals, plastics, mastics, lubricants, coolants, and hydraulic fluids designed for use under extremes of temperature.
- Communication and transportation components and systems adapted to strenuous treatment.

If one bears in mind the Soviets' relative scarcity of skilled workers, their long-time emphasis on capital (including hydro-power) rather than consumer goods yields the following quick deductions:

- In steel technology look for promising advances in the production and fabrication of heavy castings, forgings, plate, and weldments. There is probably little of interest in light sheet production or processing.
- Hydro- and steam-turbine designs may be of interest.
- Concrete technology for large structures such as dams is probably advanced, especially for use in difficult climates.
- Long-distance power transmission technology is probably advanced.
- Medical services may have something to teach us in economical use and training of skilled personnel.
- There are possibly interesting developments in nonferrous alloys for electrical conductors, switching gear, and so on.
- There may be technology for protecting high-voltage lines, switching stations, etc., against lightning damage and so on.

The fact that the General Electric Company is one of the first U.S. firms to negotiate exchange arrangements with the USSR lends credence to some of these quick deductions. If such a process were to be seriously applied, systematic procedures such as the previously mentioned contextual maps will need to be developed to insure minimum productivity. An abbreviated illustrative contextual map showing the derivations of the technical possibilities listed above is shown in Table 2.

The previous list contains mostly end products that might be deduced from Table 2 by technologists and engineers. Basic or applied researchers viewing the same set of attributes would probably derive a set of hypotheses consistent with their interests and experiences.

Table 2

AN ILLUSTRATIVE CONTEXTUAL MAP FOR GENERATING HYPOTHESES
TO NARROW TECHNOLOGY SEARCH

USSR Attributes	Hypotheses About Technology Applicable for the United States in: Transportation	Other Industry	Agriculture	Education	Medical	Recreation	Government
Geographical, A 1. Land mass lies mostly north of U.S. 2. Subarctic, continental climate 3. Short growing season 4. Extensive Permafrost and tundra 5. Characteristic soil types 6. Concentration of population in European section	I. A1+A2+A3 → Special rail and roadway construction techniques II. A2+A4+A6 → Special vehicles for difficult transportation demands	I. A1+A2 → Clothing designed for activity in the cold II. A1+A2 → Construction materials, lubricants, etc., designed for extreme temperature use	I. A3+A2+A5 → Special crops having high yield under harsh conditions	I. A6+C1+C3 → Flexible educational system	I. A1+A2 → Advanced treatments for diseases of cold climates	I. A1+A2 → Winter sports products	I. A6+D1 → Innovative solutions to urban management problems
Demographic, B 1. Women greatly outnumber men in age range of 48-80 2. Low population fraction, both sexes in ages 32-40 3. Shortage of skilled workers **Social, C** 1. Universal literacy 2. Limited personal freedom 3. Large number of minority ethnic groups		III. B3+D2 → Advanced techniques in heavy steel products IV. D2+D3 → Interesting hydro- and steam-turbine designs V. A2+A4+D3 → Advanced concrete technology VI. A6+D2+D3 → Good long-distance power transmission techniques					
Political-Economic, D 1. Government management of economic activity 2. Emphasis on investment in heavy industry vs consumer goods 3. Large investments in electric power	III. A6+D3 → Advanced electrical-powered vehicles	VII. A2+A6+D3 → Advanced lightning protection technology	II. A5+B1+B2+B3 → Soil and crop cultivation techniques requiring low skills	II. A6+C1+C3 → Some solutions to multilingual problems in education and communication	II. B1+B2+B3+C1 → Economical use and training of medical personnel	II. A2+B1+C2 → Artifacts from cottage industry	II. D1+D2 → Developed governmental methods of entrepreneurship

NOTE: The alphanumeric symbols in this table denote the combination of attributes used to deduce the listed hypotheses.

This set would tend to the more basic end of the technical information spectrum and might include the following:

- Physics of high-voltage electrical discharges
- Physiology of diseases of cold climates
- Physical chemistry of soils
- Rheology of lubricants

and so on.

VI. CONCLUSIONS AND POLICY IMPLICATIONS

Indications are that significant amounts of useful technical information are available from the Soviet Union that might be obtained in exchange for technology transferred from the United States. Agreements are in effect and both U.S. government and private organizations are operating in a manner that can assist in locating and obtaining this information. However, some barriers may limit the amount of technical information that reaches U.S. industry, a major customer for this product, including language differences and translation costs; gaps in communication between the U.S. government and U.S. industry; and differences in technical and quality standards between the Soviet Union and the United States.

To improve technology exchange to the United States through present public and private means, U.S. policies with respect to legal and commercial aspects of all types of international contractual relations should be examined to determine if any inhibit exchanges of patents, licenses, publication rights, and grants. The effectiveness of technology exchange to U.S. industry through the U.S.-USSR Joint Commission on Scientific and Technical Cooperation might be improved by increasing the representation of private industry on this Commission and by expanding the technical subjects for cooperation to include more of direct interest to private industry.

Soviet applied research is an area for which there may not be institutions and techniques to promote transfer to the United States, or they may be relatively ineffectual. Technology outputs of considerable magnitude and value probably exist in the Soviet Union in this field. To help fill this gap, U.S. research institutes might fulfill an exchange function, operating as they have in the past in other countries in promoting exchange in both directions, perhaps in cooperation with Soviet research institutes. Practical difficulties to such operations, among them the national security research conducted by such institutes in both countries and the problem of obtaining suitable facilities in the Soviet Union, must be overcome if this proposal is to succeed.