AN ANALYSIS OF TRANSFER MECHANISMS FOR FEDERALLY FUNDED RESEARCH AND DEVELOPMENT

by

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ABSTRACT

The United States government's emphasis on transferring technologies from labs into commercialization has escalated over the last decade due to a growing fear that U.S. firms have lost their competitive edge in the global marketplace. A number of pieces of legislation have been enacted in the eighties that stress the importance of this "technology transfer" of Federally funded research and development.

However, little has been done to analyze the effectiveness of those methods used to transfer this technology, or what this thesis calls "technology transfer mechanisms." Further, studies on the relationships among these mechanisms and other attributes of technologies, such as their stage of development, have likewise been neglected.

The purpose of this thesis is to understand exactly what technology transfer mechanisms are more effective than others when transferring Federally funded research and development projects in various stages of development. This thesis also "characterizes" these mechanisms with respect to transfer objectives, recipients, forms, and the U.S. Department of Energy program offices that funded the projects.

The analysis is carried out for 116 technology transfer case studies based on survey data compiled through the USDOE program offices. The results show, among other things, that offering financial incentives and creating supportive advisory groups are highly successful ways to transfer technology. Also, active forms of communication are important in the technology transfer process. Lastly, the analysis suggests the existence of major defects in the licensing processes of the U.S. government.

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CHAPTER ONE:
AN INTRODUCTION TO TECHNOLOGY TRANSFER

1.0 What is Technology Transfer?

For this thesis I will use a definition of technology transfer that is employed by the U.S. Department of Energy program offices in their evaluations of technology transfer projects; that is, technology transfer is:

> "the process by which technology, knowledge, and/or information developed in one organization, one area, or for one purpose is applied and utilized in another organization, in another area, or for another purpose."[1]

Other definitions are often found in the technology transfer literature; however, since the data for this thesis is derived from a survey emanating out of the U.S. Department of Energy, the above definition seems highly appropriate.[2]

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1 This definition has been adapted from "Guide to Technology Transfer," Report to U.S. Senate, October 4, 1988, p.3.

2 It should be noted that the definitions for technology transfer capture the breadth of a spectrum ranging from the transfer of ideas among research scientists to the transfer of marketable products among commercial entities. As technologies are transferred up this mountain of development, they at one point reach the pinnacle, that is commercialization or widespread utilization. As will be seen in Chapter Two, the U.S. government is beginning to involve itself in these "later stage" processes. P. Jervis and T.C. Sinclair illustrate the technology transfer spectrum when they define technology transfer as a "matter of either the unplanned percolation, or the planned transmission, of ideas, technical routines, or information from research/scientific [entities] to manufacturing industry and so into commercial exploitation and eventual use." (From Jervis and Sinclair, "Conditions for Successful Technology and Innovation in the U.K.," Technology Transfer, p.149). R. Cole supports this spectral concept by recognizing technology transfer "on the middle of a spectrum that ranges from the development of the technology in the first instance through

The broadness of this definition can lead one to underestimate the intricately complex nature of technology transfer. The definition lacks any description about <u>how</u> the technology is transferred; that is, what mechanisms, or modes of transfer, are used to create the necessary linkages between where the technology is "developed" and where it is "applied and utilized." For the policy maker, it is imperative to understand these mechanisms in order to provide efficient and successful technology transfer planning. Fulfilling this essential requisite is the underlying purpose of this thesis.

1.1 The Importance of Improving Technology Transfer Processes

To justify efforts towards improving the technology transfer process, we must first realize the importance that technological innovation and the transfer of those innovations have on economic growth and improved standards of living. This relationship may seem obvious. In fact, there is common agreement in the academic, scientific, political, and industrial arenas acknowledging that economic growth is derived from the commercialization of new technical know-how,

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technology transfer to the marketing of an established technology for established uses," (From R. Cole, "Theories of Technology Transfer," EPRI Proceedings on Technology Transfer, p.A-25).

i.e. through innovation. Innovation and the transfer of this innovation is, therefore, of prime importance to economic progress, both at the national level and at the level of the individual industries.[3] In fact, technology development has accounted for over 80% of U.S. growth in the Post-Depression era.[4] The value, then, of technology transfer is that it enhances the innovation process, leading to a greater commercialization of new products or processes, or the improvement of existing technologies or techniques, and hence, to economic growth.[5]

Particularly in the U.S. government, the concern for effective technology transfer in order to enhance economic growth has been inspired by the fact that U.S. dominance in world markets is not what it used to be. Once the leader in almost all high-tech industries, the U.S. has met increased global and domestic competition from firms in Western Europe and East Asia. Indeed, the U.S. experienced its first high-

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[3] Dr. Roy Rothwell, "From Invention to the Marketplace -- Successfully!," in Technology Transfer, Davidson, Cetron, and Goldhar, p.113.

[4] Washington, D.C., Council on Competitiveness, John A. Young, Chairperson, "Picking Up the Pace: The Commercial Challenge to American Innovation," September 1988.

[5] U.S. Senate, "Commercialization of Federally Funded R&D: a Guide to Technology Transfer From Federal Laboratories," Report for the Committee on Commerce, Science, and Transportation, October 4, 1988.

tech trade deficit in the late eighties, as it watched its once overwhelming share of the U.S. domestic market for consumer electronics drop from 100% in 1970 to less that 5% today. Furthermore, although major technological innovations are conceived in the U.S., more and more foreign firms are acquiring U.S. patents; in fact, 46.6% of U.S. patents were received by foreign firms in 1987.[6] Table 1-1 represents the decline of U.S. companies' shares in their own domestic markets for some high-tech products that were pioneered by U.S. firms. As this awareness of technological declinism grows, the technology transfer issue is slowly becoming a top national priority.

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[6] Both of the above statistics are from Washington, D.C., Council on Competitiveness, John A. Young, Chairperson, "Picking Up the Pace: The Commercial Challenge to American Innovation," September 1988.

TABLE 1-1[7]

A look at the declining dominance of the U.S. domestic market by U.S. firms in high-tech products.

Technology	Pioneered by	U.S. Companies' Share of Domestic Market (%) 1970	1975	1980	1987
Phonographs	U.S.	90	40	30	1
Color Televisions	U.S.	90	80	60	10
Audio Tape Recorders	U.S.	40	10	10	1
Telephone Sets	U.S.	99	95	88	25
Video Cassette Recorders	U.S.	10	10	1	1
Semiconductors	U.S.	99	71	65	64
Machining Centers	U.S.	100	97	79	35

1.2 Some Theories of Technology Transfer

There are many theories of technology transfer, each attempting to characterize the process and exploiting those characteristics that appear more important than others. These theories can be categorized into one of three broad groups: (1) supply theories, (2) demand theories, and (3) linker

[7] Table derived from, U.S. Senate, "Technology Administration Authorization Act of 1989," Report of the Senate Committee on Commerce, Science, and Transportation, October 3, 1989, p.4.

theories.[8]

In supply theories it is the characterization of the technology being transferred that takes precedence in determining what planned process(es) should be used for effective transfer. Here, it is important to identify the traits inherent to a particular technology. These traits can be of a wide variety, ranging anywhere from the stage of development of the technology to the complexity of the technology.

Demand theories require observations of the potential users of the technology, or "technology recipients." Here, investigators are concerned with the traits of a particular recipient. These can include factors such as the sectoral nature of the recipient (e.g., whether the recipient is private or public), its size, its decision making structure, or its organizational structure.

In the linker theories, characteristics are identified that relate to the technology transfer "agent," or the mechanism by which the transfer process is carried out.[9] The

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[8] Cole, "Theories of Technology Transfer," EPRI Proceedings on Technology Transfer, p.A-30).

[9] It should be noted that the technology transfer "agent" does not necessarily have to be a person, although much of the literature assumes that this is the case. Indeed it can be a process, a paper, or chance happening that

mechanistic traits can include such items as the level of communication between the supplier and the recipient, the level of information flow, or the existence of financial incentives.

It is the interactive relationships among these three technology transfer "participants" that should be understood in any technology transfer strategy. Much of the technology transfer literature emphasizes the human aspects of these relationships. In fact, person-to-person communication is usually identified as the most effective mechanism for technology transfer; that is, in the technology transfer process people are the most important movers of technology, and that active and efficient communication is necessary among people for technology transfer success. The literature is in wide agreement of this notion:

> "...personal experience and contacts are the principle sources of information for successful innovation."[10]

> "...the human being is the most effective source of information in spite of all that has been done to

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carries out the transfer process. However, because of the human nature of the supplier and the recipient, the "agent" does need to have a human counterpart in either organization to initiate (from the supplier's perspective) or terminate (from the recipient's perspective) the transfer process.

[10] Rothwell and Robertson, "The Role of communications in Technological Innovation," Research Policy, 2, 1973, p.204-225.

automated information transfer."[11]

"The most elementary and essential ingredient in any exercise of technology transfer seems to be a person-to-person element. People of different professions, fields, or orientations frequently enhance transfer when they bring their individual skills and perceptions to bear on the problem."[12]

"people exchange is the best way to transfer technology."[13]

"People are still the best transfer mechanism for complex concepts, scientific knowledge, and engineering know-how."[14]

Although it is agreed that people have a large role to play in the technology transfer process, there are certain mechanisms that facilitate the way in which people communicate and work together. As stated above, some mechanisms may work more effectively than others given the conditions of the

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[11] S. Epton, "Ten Years of R&D Management," R&D Management, 11, 1981, p. 165.

[12] U.S. House of Representatives, Committee on Science, Space, and Technology, "Technology Policy and its Effect on the National Economy," October 19, 1988, p.48.

[13] U.S. House of Representatives, hearing before the Subcommittee of Energy Research and Development of the Committee on Science, Space, and Technology, testimony of Dr. Edwin B. Stear, executive director of the Washington Technology Center, October 12, 1987.

[14] U.S. House of Representatives, Committee on Science, Space, and Technology, and U.S. Senate, Subcommittee on Energy Research and Development of the Committee on Energy and Natural Resources, joint hearing on technology transfer, testimony of Erich Bloch, Director of the National Science Foundation, September 4, 1986.

technology supplier and recipient. It is the effectiveness of these mechanisms, particularly in transferring technologies supported by the public sector, that this thesis will now explore.

CHAPTER TWO: TECHNOLOGY TRANSFER AND THE ROLE OF GOVERNMENT

2.0 The Legislative History of Technology Transfer

As seen in Chapter One, the decline of American dominance in the global marketplace has caused some concern over the past decade. In response to this decline, the U.S. government has passed legislation in the eighties that attempts to more closely link the U.S. private sector and the government, in terms of technological innovation.

The incredible scientific and technical resources of the government, once used solely for public sector purposes, are now seen as potential assets for U.S. companies. The argument for increased government and industry cooperation is as follows: (1) U.S. industry's position in the global marketplace is closely associated with the growth of the U.S. economy and, hence, the U.S. consumers' welfare and standard of living; (2) therefore, any technical assistance or cooperation between the government and industry, within reason, is actually a return on investment to the U.S. public as a whole (that original investment being Federal taxes). From this philosophical base, a new role for government is emerging -- that of facilitating the transfer of technologies from government labs or projects to U.S. industry.

Legislation has been passed supporting this role and addressing the need for mutually beneficial government-industry cooperation. Here are a few brief excerpts from the major pieces of legislation passed in the 1980's that helped technology transfer evolve from a scientific/business notion to a major government responsibility.

* **The 1980 Stevenson-Wydler Act**[15] outlined the purpose and goals for increasing government-industry cooperation, particularly through technology transfer. Section 2 of this act stated that:

> "Cooperation among academia, Federal laboratories, labor, and industry, in such forms as technology transfer, personnel exchange, joint research projects, and others, should be renewed, expanded, and strengthened...There is a need for a...national policy supporting domestic technology transfer and utilization of the science and technology resources of the Federal Government."(15 USC 3701)

In section 3 of the act, Congress pointed out that one of the five purposes of the Act was to

> "improve the economic, environmental, and social well-being of the United States by...stimulating improved utilization of federally funded technology developments by State and local governments and the

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[15] P.L.96-480, October 21, 1980.

private sector [and] encouraging the exchange of scientific and technical personnel among academia, industry, and Federal laboratories."(15 USC 3702)

Further, in Section 11, Congress stated that,

"It is the continuing responsibility of the Federal Government to ensure the full use of the results of the Nation's Federal investment in research and development. To this end the Federal Government shall strive where appropriate to transfer federally owned or originated technology to State and local governments and to the private sector."

* **The 1980 Bayh-Dole Act** (amended in 1984) allowed universities and small businesses to receive the patent and royalty rights on inventions made by them with federal money.[16]

* **The Federal Technology Transfer Act (FTTA) of 1986,**[17] which amended the Stevenson-Wydler Act of 1980, sought as its purpose to promote technology transfer by allowing Government-operated laboratories to enter into cooperative research and development agreements with industry and by establishing a Federal Laboratory Consortium for Technology. In section four of the FTTA, the expansion of technology transfer into the

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[16] United States Department of Commerce, "The Federal Technology Transfer Act: The First Two Years," July 1989, p.4.

[17] Public Law 99-502, October 20, 1986.

traditional laboratory missions[18] was made formal:

> "Technology transfer, consistent with mission responsibilities, is a responsibility of each laboratory science and engineering professional...Each laboratory director shall ensure that efforts to transfer technology are considered positively in laboratory job descriptions, employee promotion policies, and evaluation of the job performance of scientists and engineers in the laboratory."

This Act also created Offices of Research and Technology Application (ORTAs) for individual Federal labs, whose responsibility is to identify and assess "technologies and ideas originating within the facility which have potential for application in other environments."[19]

* **The 1987 Executive Order 12591**, entitled "Facilitating Access to Science and Technology," gave the technology transfer mission official support from the executive branch. This order outlined a number of steps designed to "promote cooperation between the Federal Government, State and local governments, industry and academia in cooperative research and

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18 "Traditional laboratory missions" refers to the period after WWII until only recently, when labs were structured to carry out basic scientific research, with no emphasis placed on the later stages of development of product technologies, nor the transfer of these technologies to the private sector.

19 United States Senate, "Guide to Tech Transfer," p.6.

the commercialization of research."[20]

* **The Omnibus Trade and Competitiveness Act of 1988**[21] established the National Institute of Standards and Technology and "Regional Centers for the Transfer of Manufacturing Technology," two groups now promoting technology transfer. The Institute was enabled to assist private sector initiatives and cooperative efforts with government labs in order to accelerate the development of commercializable technologies.[22] Similarly, the Manufacturing Centers were developed to "enhance productivity and technological performance in U.S. manufacturing" by transferring manufacturing technology, disseminating information, and working with cooperating industries.[23]

* **The 1989 National Competitiveness Technology Transfer Act**

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[20] Office of the Press Secretary, "Facilitating Access to Science and Technology," White House Fact Sheet, April 10, 1987.

[21] P.L. 100-418, August, 23, 1988.

[22] Omnibus Trade and Competitiveness Act, Subtitle B, Part I, Subpart A, sec. 5111 (1(b)).

[23] Ibid., Subtitle B, Part I, Subpart B sec 5121, 25(a)).

(NCTTA)[24] which amended the Stevenson-Wydler Act of 1980 stated that,

> "There is a need to enhance United States competitiveness in both domestic and international markets; and the Federal laboratories and other facilities have outstanding capabilities in a variety of advanced technologies and skilled scientists, engineers, and technicians who could contribute substantially to the posture of United States industry in international competition..."[25]

2.1 Why All the Concern?

Why has this novel relationship between government and industry only recently been considered in such a mission-oriented fashion? One of the reasons is the growing fear that the U.S. is losing its competitive edge globally (see Table 1-1), and that increasing the U.S.'s competitive advantage could depend on the link between industry and the Federal labs.[26] Even the public record suggests that the transfer of federally funded technologies to the private sector for the benefit of the US economy should be increased, primarily by increasing

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[24] P.L. 101-189, Nov. 29, 1989.

[25] Findings and Purposes, Part C of the DOE National Security Authorizations and Other Authorizations, in the National Defense Authorization Act For Fiscal Years 1990 and 1991, Public Law 101-189, Nov. 29, 1989.

[26] United States Department of Commerce, "The Federal Technology Transfer Act of 1986: The First Two Years, July 1989, p.1.

industry-government participation and cooperation.[27]

Further, in an extensive study released recently by the M.I.T. Commission on Productivity, it was acknowledged that cooperation between the U.S. government and all sectors of the economy is needed for the U.S. to sustain economic vitality, and that more could be done with respect to the federal role in technology development and the U.S. private sector. The following passage sums up the Commission's findings:

> "The nation is paying heavily for [its] unwillingness to recognize the potential importance of collaboration among the federal government, business, labor, universities, states, and localities in creating the conditions required for economic growth....[Partnerships] can and should include collaborative efforts with government to promote the development of technologies for productive performance..."[28]

Specifically, with regards to technology transfer, this study noted that the federal government's support of research and development should be extended to include a greater emphasis on policies that "encourage the downstream phases of product and process engineering and to clear any current obstacles to innovation."[29]

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[27] Cherri Langenfeld, Director, Office of Technology Policy, U.S. Department of Energy, personal communication.

[28] M.I.T. Commission on Industrial Productivity, <u>Made in America: Regaining the Productive Edge</u>, p.131-140.

[29] Ibid., p.151.

Another study, released by Washington's Council on Competitiveness, placed the movement of ideas from Federal labs to private industry and the commercialization of these ideas as a "top national priority." This report also emphasized the need for government to widen its research focus and broaden its cooperative relationships with private industry, and state and local governments.[30]

2.2 The Role of the DOE as a Technology Transfer Agent

The above relationship seem to be ideal, given the government's ability to carry out large R&D projects and the private sector's ability to commercialize the results of such projects.

> "The Federal laboratory system has extensive science and technology resources developed as a consequence of meeting the mission requirements of the Federal departments and agencies...However, the Federal Government does not have the authority or capability to develop, refine, adapt, and market the results of this research and development beyond legitimate Government mission objectives. Thus the expanding interest in transferring technology to the private sector which has the resources to undertake commercialization activities."[31]

One of the major contributors in the government to this

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30 Washington, D.C., Council on Competitiveness, "Picking Up the Pace: The Commercial Challenge to American Innovation," John A. Young, Chairperson, preface.

31 United States Senate, "Guide To Technology Transfer," p.3.

R&D pool is the U.S. Department of Energy (DOE), which alone accounts for over 30 research and development labs,[32] employs over 26,000 scientists and engineers and expends over five billion dollars for research and development each year.[33] Because of this incredible scientific resource base the DOE feels that it can "enhance U.S. competitiveness by increasing the transfer of Federally funded technologies and knowledge to the private sector for commercial application."[34]

Given these conclusions about the direction in which federal R&D should be headed, along with its emerging, collaboration-oriented mission, it is natural for the DOE (and all Federal agencies involved in R&D for that matter) to investigate its "technology transfer relationship" with industry. Studies such as this thesis, have begun to evaluate in depth this process called "technology transfer" and the necessary role government must play in it.

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[32] The DOE conducts most of its research in these national labs, owned by the government, but often operated by private firms or universities. The largest of the labs, or the multi-program labs, account for almost 90% of the DOE's R&D and include Argonne, Berkeley, Livermore, Brookhaven, and Oak Ridge. From Congressional Budget Office, "Using Federal R&D to Promote Commercial Innovation," April 1988.

[33] Cherri Langenfeld, Director, Office of Technology Policy, U.S. Department of Energy, personal communication.

[34] Ibid., personal communication.

CHAPTER THREE:
THE SURVEY

3.0 The Survey

The survey which provides the data for this thesis was performed in the Fall of 1989 by Pacific Northwest Laboratory (operated by the Battelle Memorial Institute) in an effort to characterize the technology transfer projects of the DOE. It includes 172 detailed case studies completed by staff members of the DOE's program offices. These offices provide Federal funding for research and development projects. For my data pool I used 116 of the 172 cases, removing those cases in which no success ratings were provided or the technology was identified as being in more than one stage of development. The original survey is provided in Appendix A.

When PNL staff carried out the survey, they worked with the DOE's program offices, helping them choose from hundreds of technology transfer projects those which represented both successful and unsuccessful transfers, and which "characterized [a] full spectrum of technology transfer activities."[35] The questionnaires were completed by DOE staff

[35] Pacific Northwest Laboratory (PNL), "U.S. Department of Energy Program Office Technology Transfer Survey," June 1990.

members familiar with the technologies, and workshops were held in which questions pertaining to the survey were discussed and answered. These workshop sessions ensured that all respondents has a common understanding of the survey material.

The survey involved a number of DOE Assistant Secretary Offices, including the following: Conservation and Renewable Energy, Fossil Energy, Nuclear Energy, Energy Research, Defense Programs, and Civilian Radioactive Waste Management. The technologies chosen were of many different types, ranging from product technology to complex process technology, from standards and practices to simple information transfer. As shown in Appendix A, the survey asked for a short description of the technology transferred, a funding history, the objective of the initial transfer mission, the stage of development of the technology when it was transferred, the attributes of the technology, the transfer's recipient, the effectiveness of the transfer process, the identification of a technology "champion," the mechanisms used to transfer the technology, and a ranking of these mechanisms. For my analysis, I was primarily concerned with only several of these responses. They are: the stage of development of the technology at the time of transfer, the success rating of the transfer process, and the mechanisms used to transfer the technology.

3.1 The Variables

The variables that existed in light of my analysis are illuminated in questions #8, #13, and #19.

Question #8: Stage of Development

Question #8 asks the respondent what stage of development the technology was at when it was transferred. The choices from the original survey are:[36]

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[36] Note: The basis of breaking up stages of development in this way is somewhat arbitrary, however, these are the generally accepted definitions used in several program offices at DOE, particularly Conservation and Renewable Energy, whose office made up a large portion of the case studies. Also, much of the literature on technology transfer defines the stages of development similarly. For example, Tushman and Katz identify four "task categories" for R&D management as follows:

"1. Basic Research: Work of a general nature intended to apply to a broad range of applications or to the development of new knowledge about an area;
2. Applied Research: Work involving basic knowledge for the solution of a particular problem. The creation and evaluation of new concepts or components but not development for operational use;
3. Development: The combination of existing feasible concepts, perhaps with new knowledge, to provide a distinctly new product or process. The application of known facts and theory to solve a particular problem through exploratory study, design, and testing of new components or systems; and,
4. Technical Service: Cost/performance improvement to existing products, processes or systems. Recombination, modification and testing of systems using existing knowledge. Opening new markets for existing products."

From Michael Tushman and Ralph Katz, "External Communication and Project Performance," Management Science, 26, 1980, p.1076.

- Basic stage; that is, when new knowledge is discovered and general research must be conducted for further, basic understanding;
- Exploratory R&D; that is, when R&D is performed to uncover unknown applications of a technology.
- Applied and Information based R&D; that is, when research is performed to apply basic knowledge in order to solve a particular problem.
- Technology Development; that is, when the R&D is "hardware" oriented and the application of the research is already well thought out and possibly designed.
- Market Penetration; that is, when effort is put into finding particular market uses for a technology.

For my analysis, I combined the first two stages, basic and exploratory, into one category. This was done for two reasons. First, and most importantly, both stages represent the very beginning of a technology development, and making the distinction between them was a difficult task for most respondents; that is, it can be very difficult to distinguish when a new idea is discovered and the initial exploratory research is performed, since often times these processes go hand-in-hand. Secondly, the low number of case counts involving technology transfer at the survey's defined "basic" stage (in fact, zero) leads one to believe that although such a category appears in theory, it is indeed almost impossible to identify. For these reasons the first two categories were combined into a "Basic/Exploratory" stage.

Question #13: Success of the Technology Transfer

Question #13 asked the respondents to rate the technology transfer process with respect to how effectively it met its "technology transfer objective." The ratings were based on a scale of one to five, "1" being "Very Effective," and "5" being "Not Very Effective." As will be noted later, an inversion of these numbers was performed to ease the analysis (particularly with regards to correlations) and so those projects rated as "Very Effective" I rated as "5's;" likewise, those rated as "Not Very Effective" I rated as "1's."

Question #19: Mechanisms of Technology Transfer

Question #19 asked the respondents to identify the mechanisms used in the technology transfer process and to rank those mechanisms "from most important to least important in meeting the technology transfer objectives for this technology." The mechanisms are listed in Table 4-1 and are described in detail in the "Characterization of Mechanisms" section of this thesis.

Because several mechanisms tended to share some common traits, I found the analysis to be more logical and meaningful when I grouped the mechanisms according to these common characteristics, thus reducing the group of 25 mechanisms to only seven. The groupings I used are different from those used by others who have analyzed technology transfer mechanisms for DOE in the past.[37]

The seven groups I used are as follows:

- Advisory Groups (End User Review, Technical Review);
- Collaboration With Cost Sharing (Industrial Consortia, Demonstration Projects, Cooperative R&D, User Facilities);
- Collaboration Without Cost Sharing (Contracting R&D);
- Personnel Exchange (Work For Others, Staff Consulting, Guest Staff, Staff Transfer);
- Licensing/Spin-off Companies;
- Active Dissemination of Information (Brokers, Workshops, Information Dissemination Centers, Education); and,
- Passive Dissemination of Information (Mailings, Technical Reports, News Releases, Journals and Magazines, Fact Sheets, Video Tapes, Decision Tools, Electronic Bulletin Boards).

The remainder of this thesis explores the characteristics of each of these groups of mechanisms and their relationship with other variables of the survey.

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[37] The "past" groupings I am now referring to are those that were used by both Los Alamos National Laboratory in a technology transfer study they carried out in 1989, and by PNL in the characterization of this survey. Both used the following eight groups of mechanisms: Advisory Groups, Collaboration, Staff Exchanges, Technical Assistance, Licensing, Spinoffs, Information Dissemination, and Education.

Although I abandoned these categories, I confirmed my rationale for grouping the mechanisms as shown above in discussions with Pete Wilfert of the Battelle Memorial Institute (PNL), who initially carried out the survey for PNL.

CHAPTER FOUR:
A CHARACTERIZATION OF TRANSFER MECHANISMS

4.0 Technology Transfer Mechanisms

Technology transfer mechanisms are those operations that transport a given technology from supplier to recipient. In general, they can be financial, technological, or human processes.[38] More specifically, they consist of a wide variety of procedures ranging from active, one-on-one communication, such as consulting by research staff, to passive, one-way information transfer, such as the reading of a technical journal by the recipient.

The mechanisms used in the survey are listed in Table 4-1. As stated in chapter three, these mechanisms are divided into seven categories. The categories are: Advisory Groups (ADVIS), Collaboration With Cost-Sharing (CWCS); Collaboration Without Cost-Sharing (CNCS); Personnel Exchanges (PERS); Licensing and Spinoffs (L/S); Active Dissemination of Information (I/A); and, Passive Dissemination of Information (I/P).

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[38] Electric Power Research Institute, "Proceedings: Technology Transfer Workshop," August 1982.

Table 4-1

TECHNOLOGY TRANSFER MECHANISMS

ADVISORY GROUPS
- End User Review Groups
- Technical Review Groups

COLLABORATION WITH COST-SHARING (CWCS)
- Industry Consortia
- Cooperative R&D
- Demonstration Projects
- User Facilities

COLLABORATION, WITHOUT COST-SHARING (CNCS)
- Contracting R&D

PERSONNEL EXCHANGES
- Work For Others
- Staff Consulting
- Guest Staff
- Staff Transfers

LICENSING/SPINOFFS (L/S)
- Licensing
- Spinoff Companies

ACTIVE DISSEMINATION OF INFORMATION (I/A)
- Broker Organizations
- Workshops, Seminars or Conferences
- Information Centers
- Education

PASSIVE DISSEMINATION OF INFORMATION (I/P)
- Mailings
- Technical Reports
- News Releases
- Journal and Magazine Articles
- Fact Sheets
- Video Tapes
- Decision Tools
- Electronic Bulletin Boards

The following pages define these groups, describe the specific mechanisms within each group,[39] and finally characterize each group with respect to other survey variables.

4.1 Characterization of Mechanisms

The graphs that follow give frequencies of occurrence for each mechanism, with respect to the form of the transfer, the objective of the transfer, the program of sponsorship, the recipient of the transfer, the stage of development of the technology, and the success rating.[40] The definitions for each of the variable names used in these graphs are given in Appendix B.

The following list of graphs briefly reveal what will be encountered in this section. The first set (Set One: Graphs 4-1 to 4-3) represents occurrence frequencies for all the

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[39] Much of the description for each specific mechanism is adapted from "The Technology Transfer Process: Background for the U.S. National Energy Strategy," report PNL-SA-17482 prepared for the U.S. Department of Energy by Pacific Northwest Laboratory (PNL), January, 1990. I would also like to thank Pete Wilfert of the Battelle Memorial Institute for his help in defining the individual mechanisms and their appropriate categories.

[40] Recall again that the success ratings used in the analysis are the reverse of those used in the survey; that is, in the analysis "5" represents a "most successful" project and "1" represents "least successful," while in the survey "5" represented "least successful" and "1" represented "most successful." This was done to make the analysis less abstract conceptually when drawing correlations between this variable and others.

mechanisms with respect to one another. The second set (Set Two: Graphs A-1 to H-6) is a cross-cut of each of the mechanisms with the variables mentioned above. Graphs A-1 to A-6 depict the overall (mechanism independent) frequencies of each variable, and comparisons between these and the mechanism dependent graphs (Graph B-1 to H-6) are made to identify particular traits or tendencies of a given mechanism. It should be noted that the number above each bar in the bar graphs represents the absolute number of cases that involved a given variable. Further, respondents to the questionnaire were able to mark more than one response for several variables, and so counts will add up to more than the total case count for these variables.

Set One:

Percent of Total by Mechanism Used (bar graph, Graph 4-1) -- this represents the percentage of cases that used a particular mechanism. For example, the Passive Dissemination of Information (I/P) was used most often -- in about 90% of the total number of cases.

Percent of Total by Top 3 Used Mechanism (bar graph, Graph 4-2) -- this represents the percentage of cases that used a particular mechanism as one of its "top three." For example, Collaboration With Cost Sharing (CWCS) was used as a "Top 3" mechanism in about 47% of all the cases.

Percent Mechanism Used as a Top 3 Mechanism (Graph 4-3) -- this shows the frequency in which a used mechanism was also one of the "top three." For example, about 75% of the time that Collaboration With Cost Sharing was used, it was a "Top 3" mechanism. This is also the case with Collaboration Without Cost Sharing.

Set Two:

Percent of "XXX" by Form (Graphs "X"-1) -- this represents the percentage of cases using mechanism "XXX" that transferred the technology in a particular form (given as X-axis). For example, in Graph A-1 the transfer of technology in the form of "information" was by far the most common, involved in over 80% of the total cases.

Percent of "XXX" by Objective (Graphs "X"-2) -- same as above except cross-cut with the "objective of the transfer." For example, in Graph A-2 the "introduction of a new technology to the end user" and the "acceleration of user acceptance" were the two most frequently cited objectives of the technology transfer, constituting about 55% of all the cases.

Percent of "XXX" by Program (Graphs "X"-3) -- same as above except cross-cut with "program of sponsorship." For example, Graph A-3 shows that about 30% of the cases had Conservation (CE) as their sponsor, more than any other program offices.

Percent of "XXX" by Recipient (Graphs "X"-4) -- same as above except cross-cut with "recipient of transfer." For example, in Graph A-4 the overwhelming majority of the cases (over 70%) had "manufacturing business" as the recipient of the technology transfer.

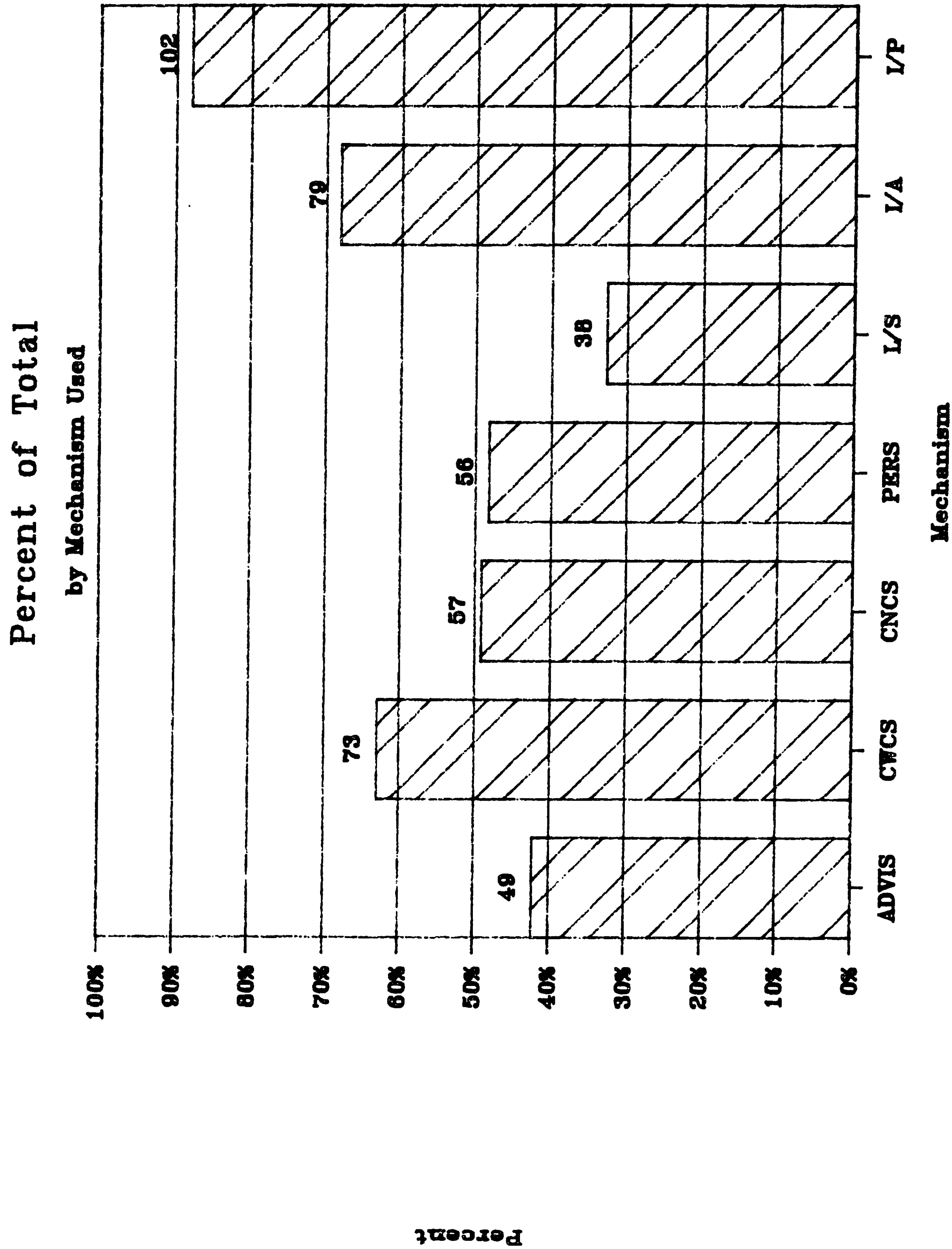
Percent of "XXX" by Stage of Development (Graphs "X"-5) -- same as above except cross-cut with the "stage of development" of the technology. For example, Graph A-5 show that "technology development" constituted almost 38% of all the cases' stage of development.

Percent of "XXX" by Success Rating (Graphs "X"-6) -- same as above except cross-cut with the "success rating." For example, in Graph A-6 the success rating "5" or "most successful" was given in 53% of the total number of cases.

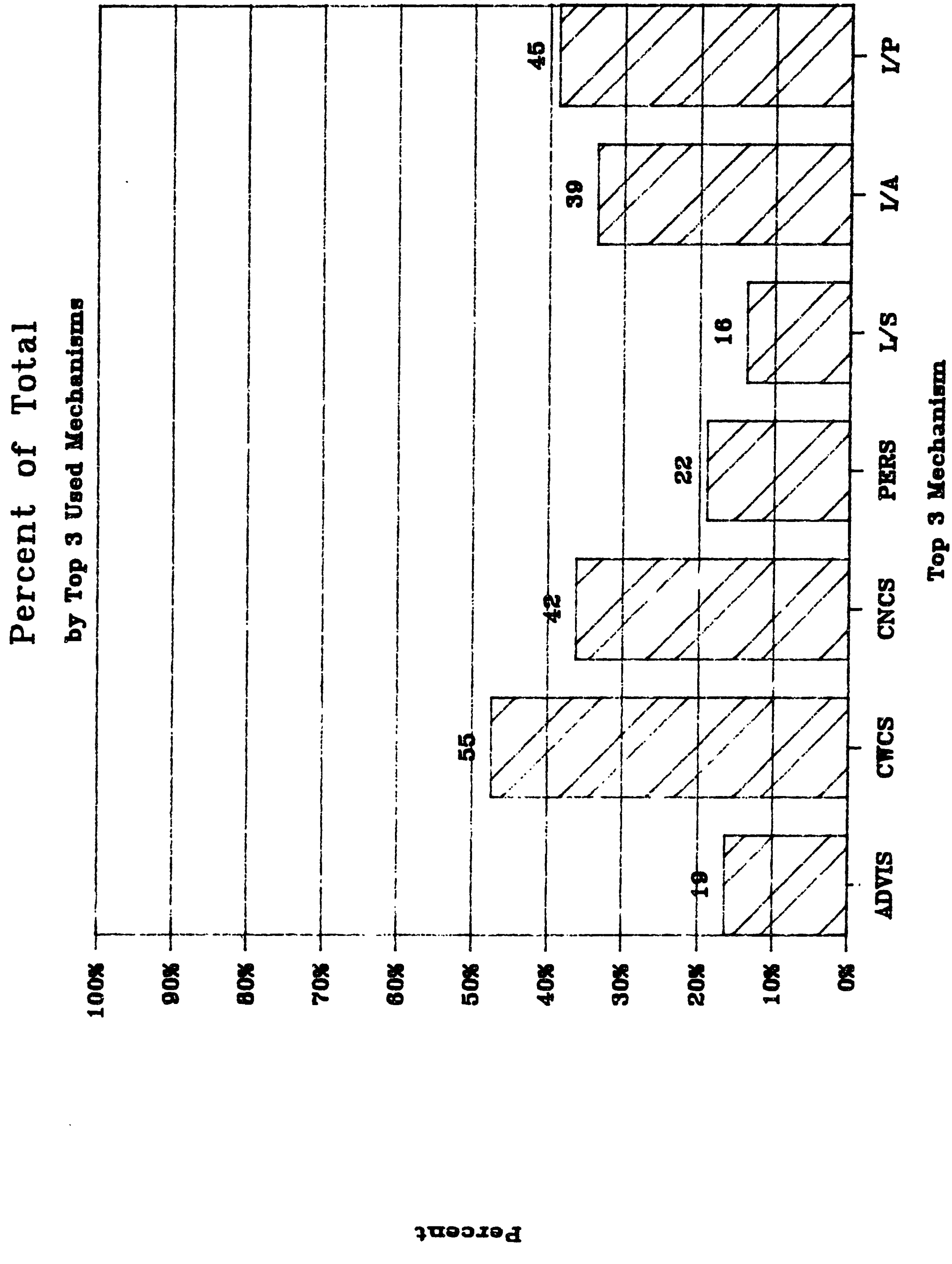
This thesis does not statistically analyze all these relationships, but only presents them here. The "analysis" of this thesis arrives in Chapter Five, where, among other things, the relationship between a mechanism's use and the success of the transfer is evaluated for each stage of development.

SET ONE

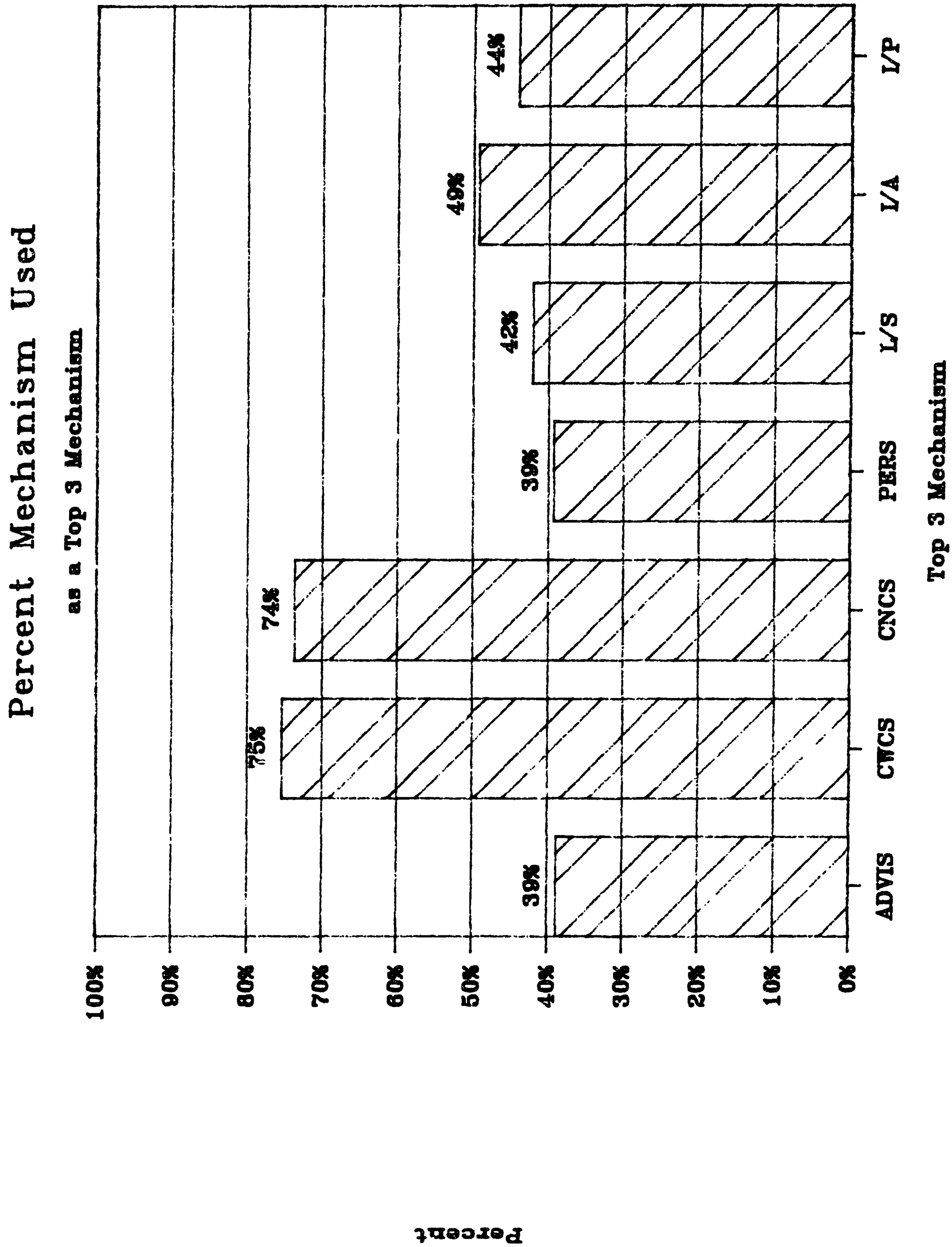
Graph 4-1:


Percent of Total
by Mechanism Used
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent
49
73
57
56
38
79
102
ADVIS
CWCS
CNCS
PERS
L/S
I/A
I/P
Mechanism

Graph 4-2:


Percent of Total
by Top 3 Used Mechanisms
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent
19
55
42
22
16
39
45
ADVIS
CWCS
CNCS
PERS
L/S
I/A
I/P
Top 3 Mechanism

Graph 4-3:



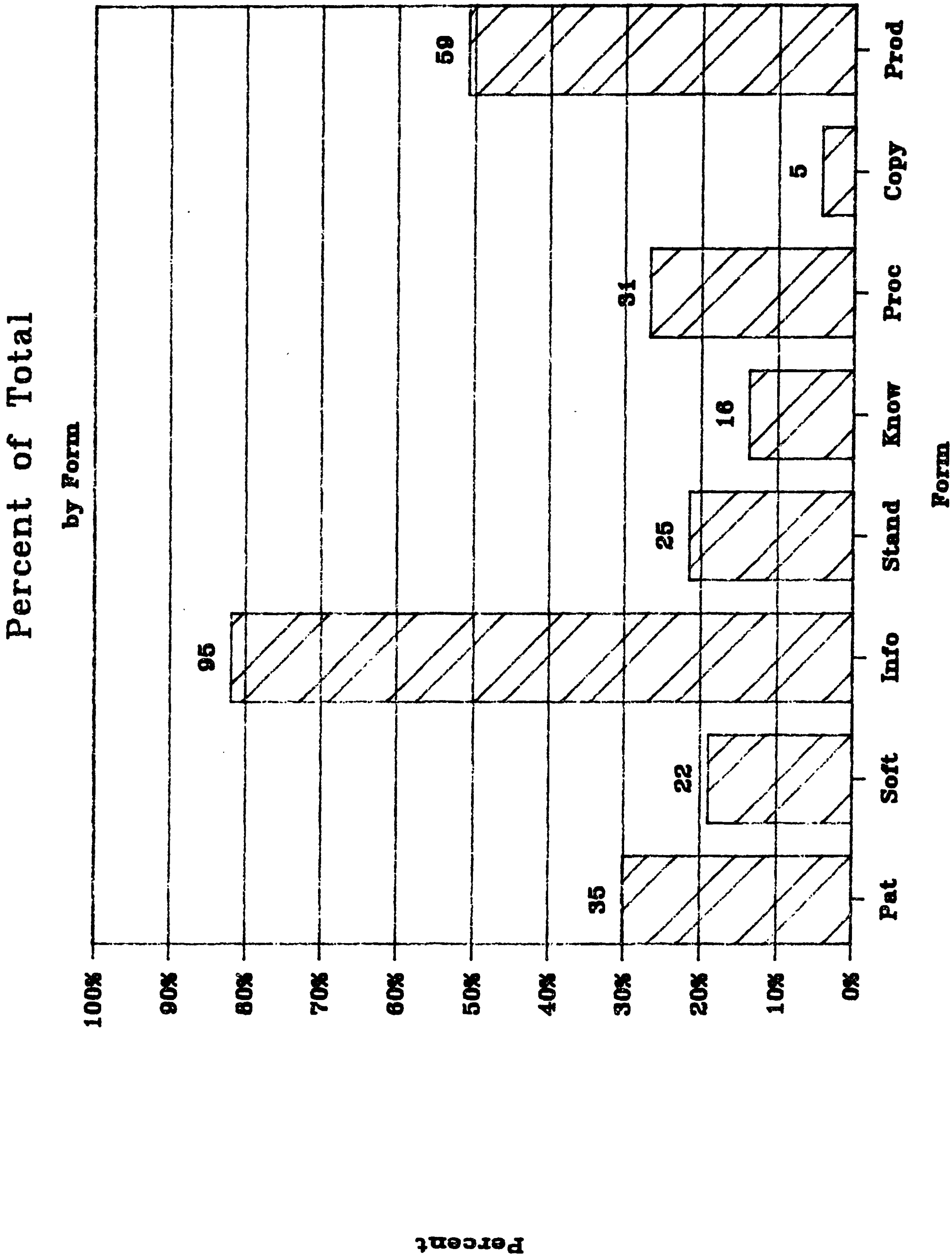
Percent Mechanism Used
as a Top 3 Mechanism
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent
39%
75%
74%
39%
42%
49%
44%
ADVIS
CWCS
CNCS
PERS
L/S
I/A
I/P
Top 3 Mechanism

SET TWO

4.1.1 Total Cases (Mechanism Independent)

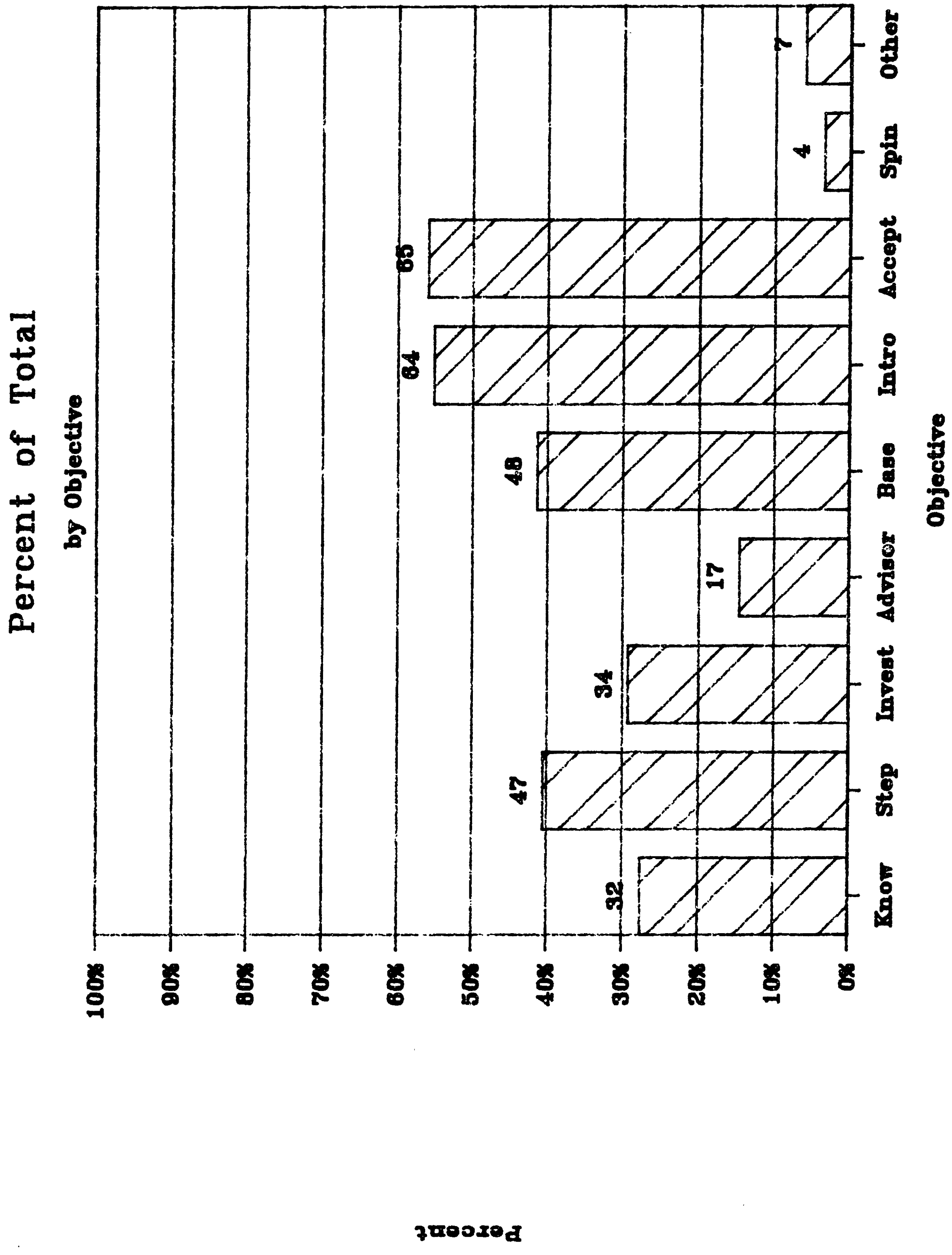
Graphs A-1 to A-6 represent the frequencies of a number of variables in the survey. The highlights of these graphs are pointed out above in the descriptions of the graphs presented in Set Two. The reader is again referred to Appendix B for definitions of each of the variable names.

Graph A-1:



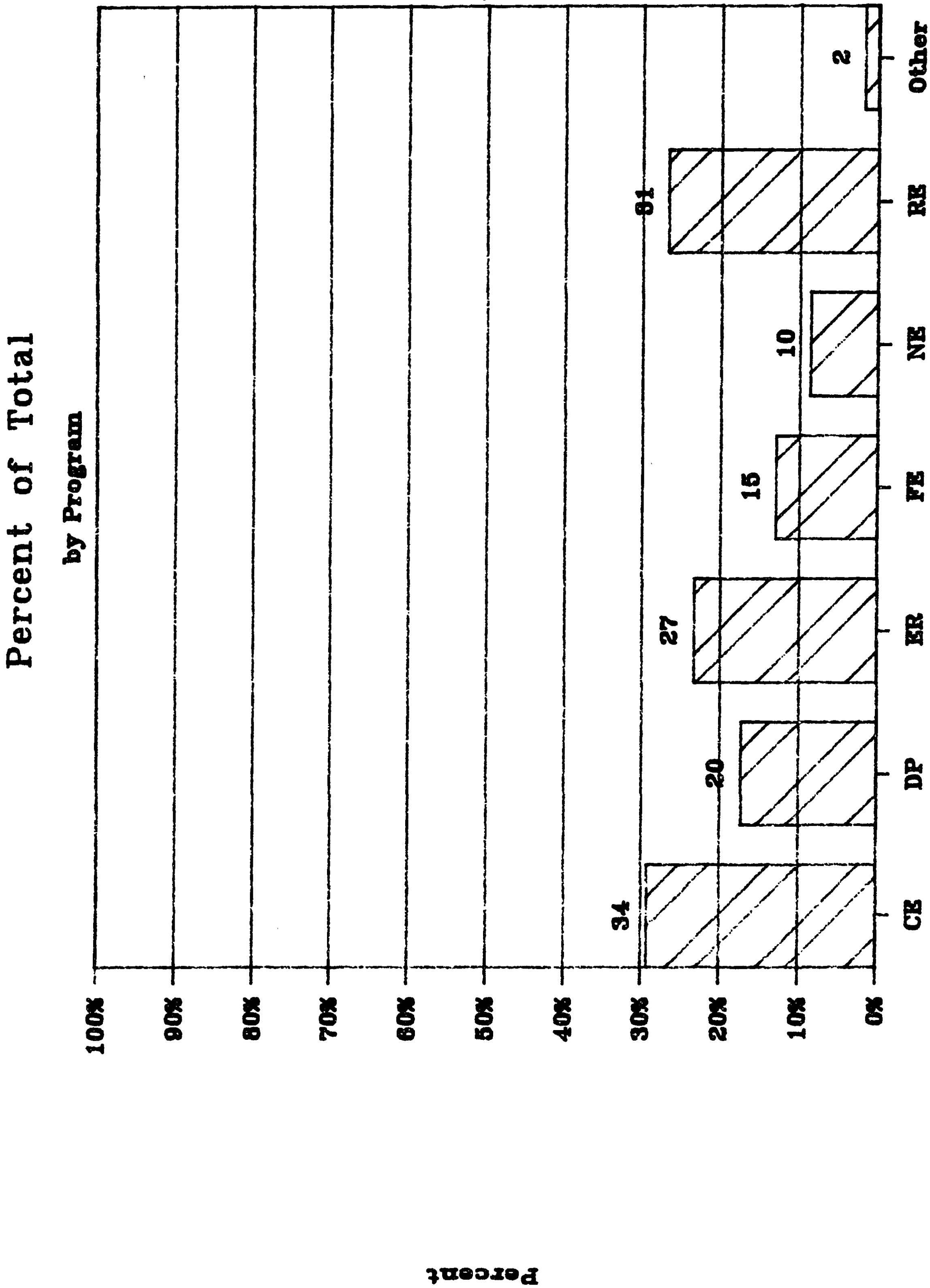
Percent of Total
by Form
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
35
22
95
25
16
31
5
59
Pat
Soft
Info
Stand
Know
Proc
Copy
Prod
Form
Percent

Graph A-2:



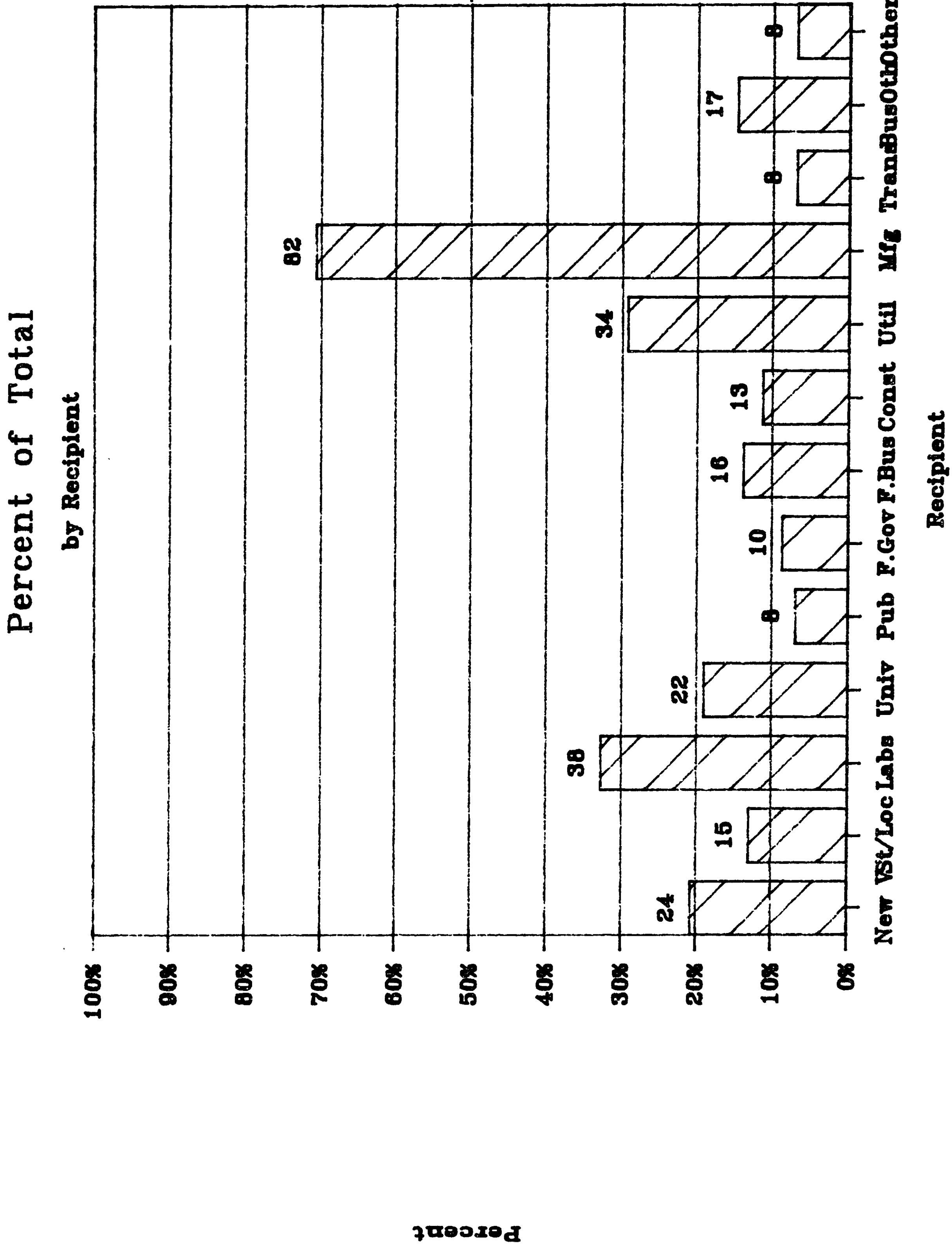
Percent of Total
by Objective
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent
32
47
34
17
48
54
55
4
7
Know
Step
Invest
Advisor
Base
Intro
Accept
Spin
Other
Objective

Graph A-3:



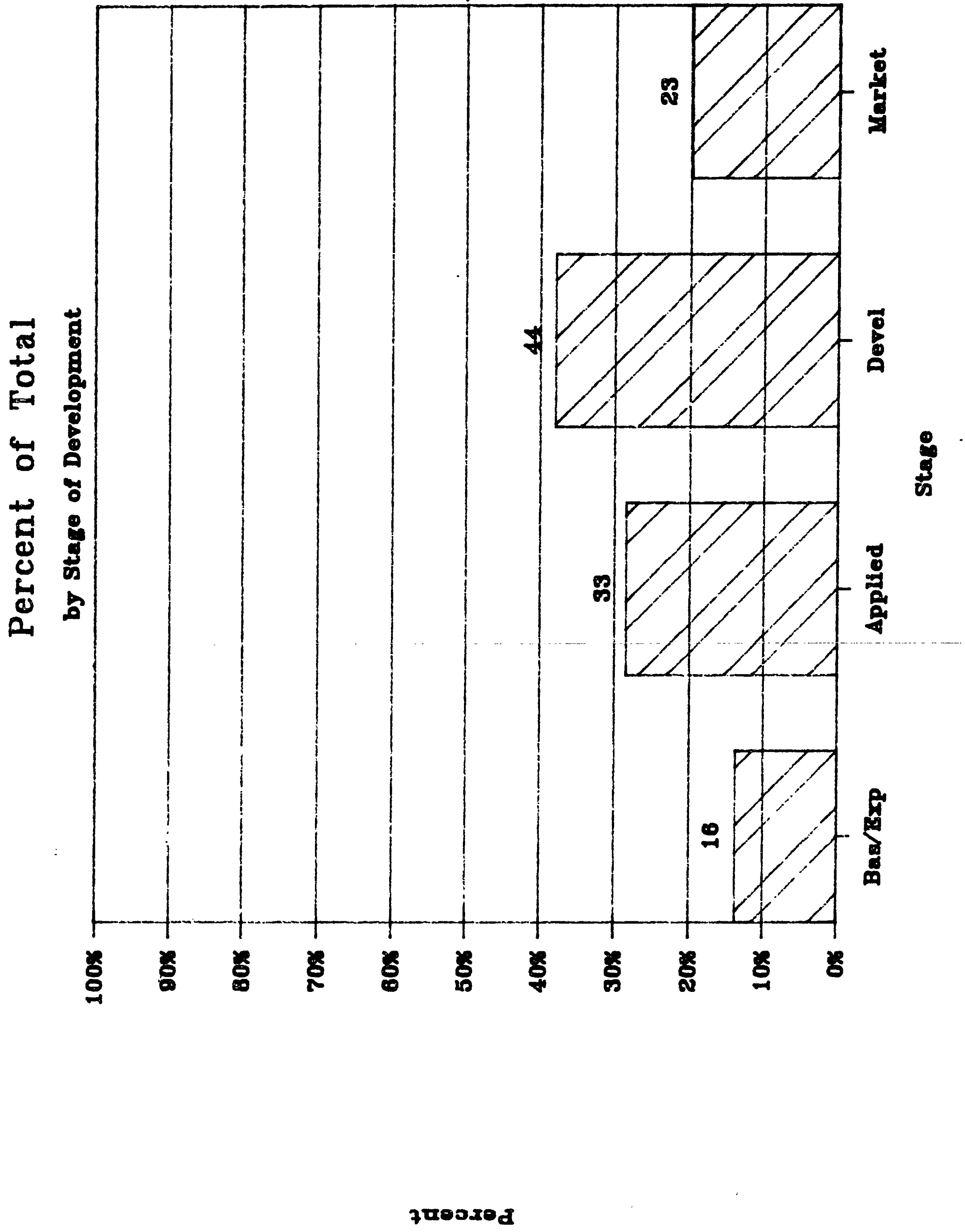
Percent of Total
by Program
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
34
20
27
15
10
31
2
CE
DP
ER
FE
NE
RE
Other
Program
Percent

Graph A-4:

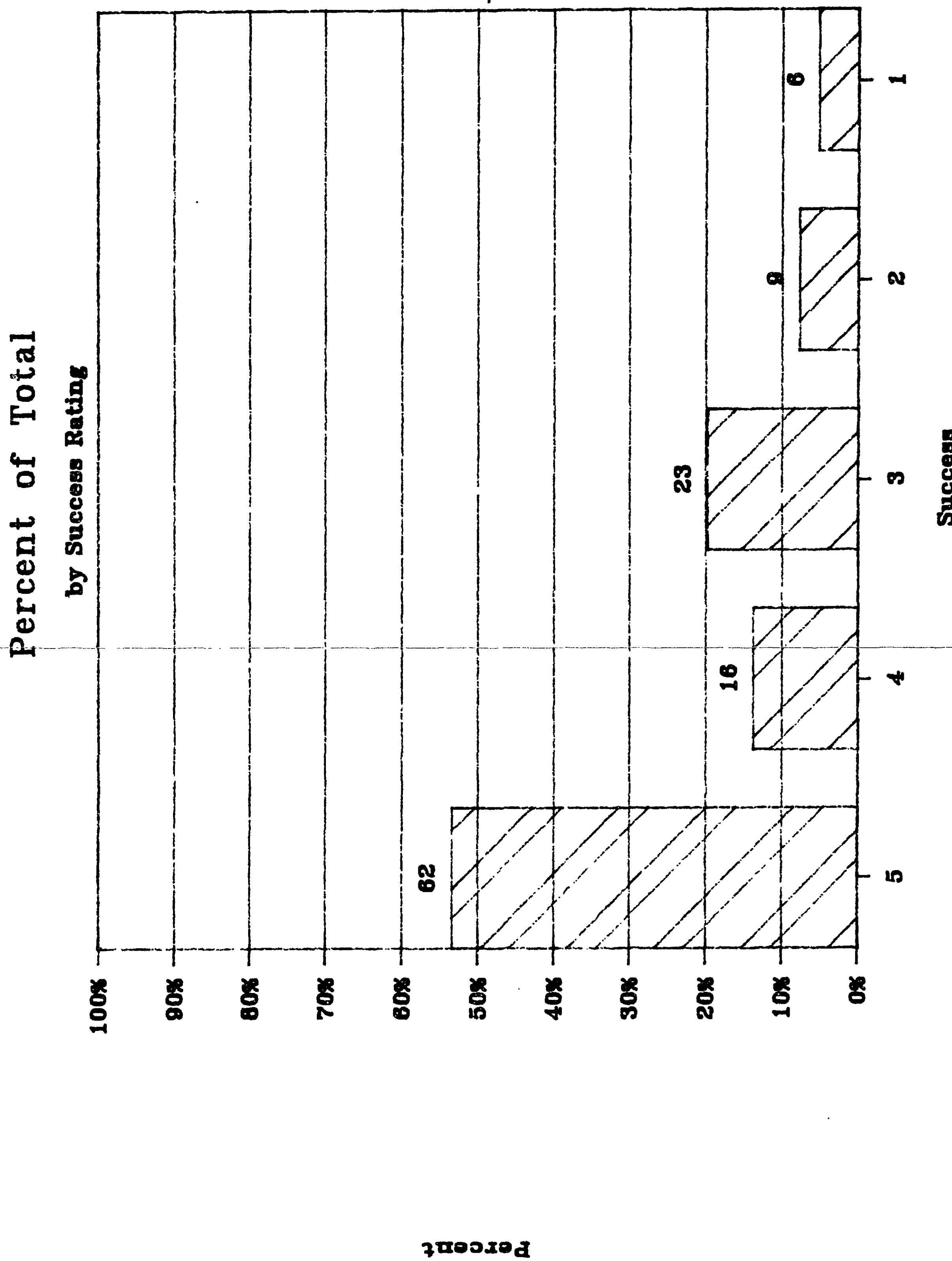


Percent of Total
by Recipient
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
24
15
38
22
8
10
16
13
34
82
8
17
8
New
VSt/Loc
Labs
Univ
Pub
F.Gov
F.Bus
Const
Util
Mfg
Trans
BusOth
Other
Recipient
Percent

Graph A-5:


Percent of Total
by Stage of Development
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
16
33
44
23
Bas/Exp
Applied
Devel
Market
Stage
Percent

Graph A-6:


Percent of Total
by Success Rating
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
62
16
23
9
6
5
4
3
2
1
Success
Percent

4.1.2 Advisory Groups

"Advisory Groups" represent those mechanisms whereby some industrial or technical board of experts, not directly involved in the research itself, helps define and direct research and development programs. The two types examined here are "end user review" groups and "technical review" groups. These groups have a high degree of personal interaction and can provide regular assessments of an on-going project from the perspective of both unbiased scientists and also users familiar with market conditions.

End User Review

End user review boards can provide necessary market inputs in R&D projects that help define or propose the commercial possibilities of a technology.

Technical Review

Technical review boards are similar to end user review boards, but are made up of technical experts that can provide unbiased technical support or focus for a research and development project.

Discussion of Graphs:

Graphs B-1 to B-6 show the cross-cut of cases that used Advisory Groups as a mechanism with other variables of the survey. Notable differences between cases that used Advisory Groups and the total cases are as follows:

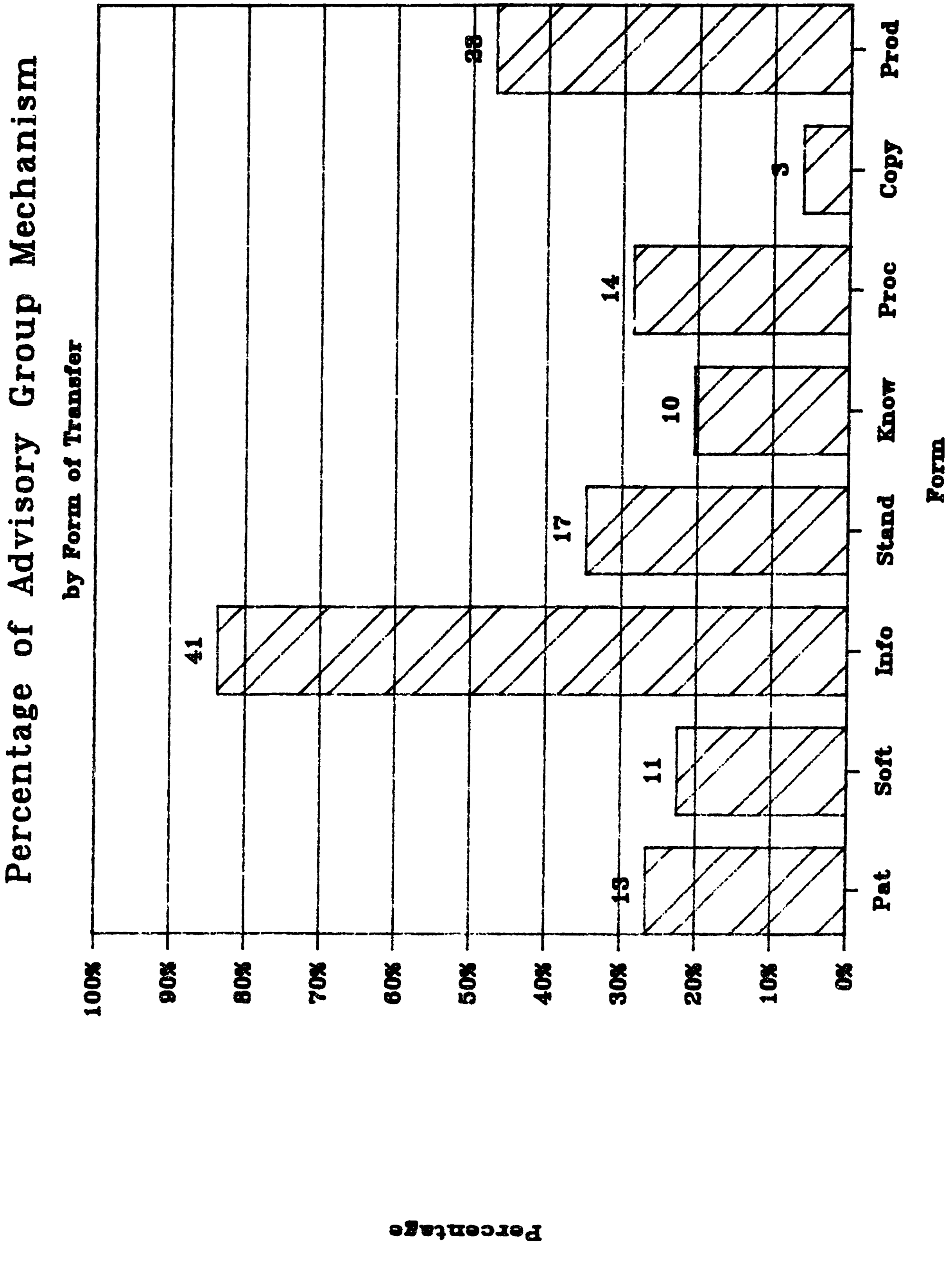
* Whereas "Standards/Practices/Training" was the form of transfer for about 22% of the total number of cases, more than 35% of the cases using Advisory Boards used this form of transfer.

* Whereas "To transfer scientific knowledge" was the objective of about 26% of the total number of transfers, almost 40% of the transfers using Advisory Boards had this as an objective.

* Whereas Defense Programs were involved in sponsoring over 17% of the total number of cases, there were no cases sponsored by DP that used Advisory Groups as a mechanism.

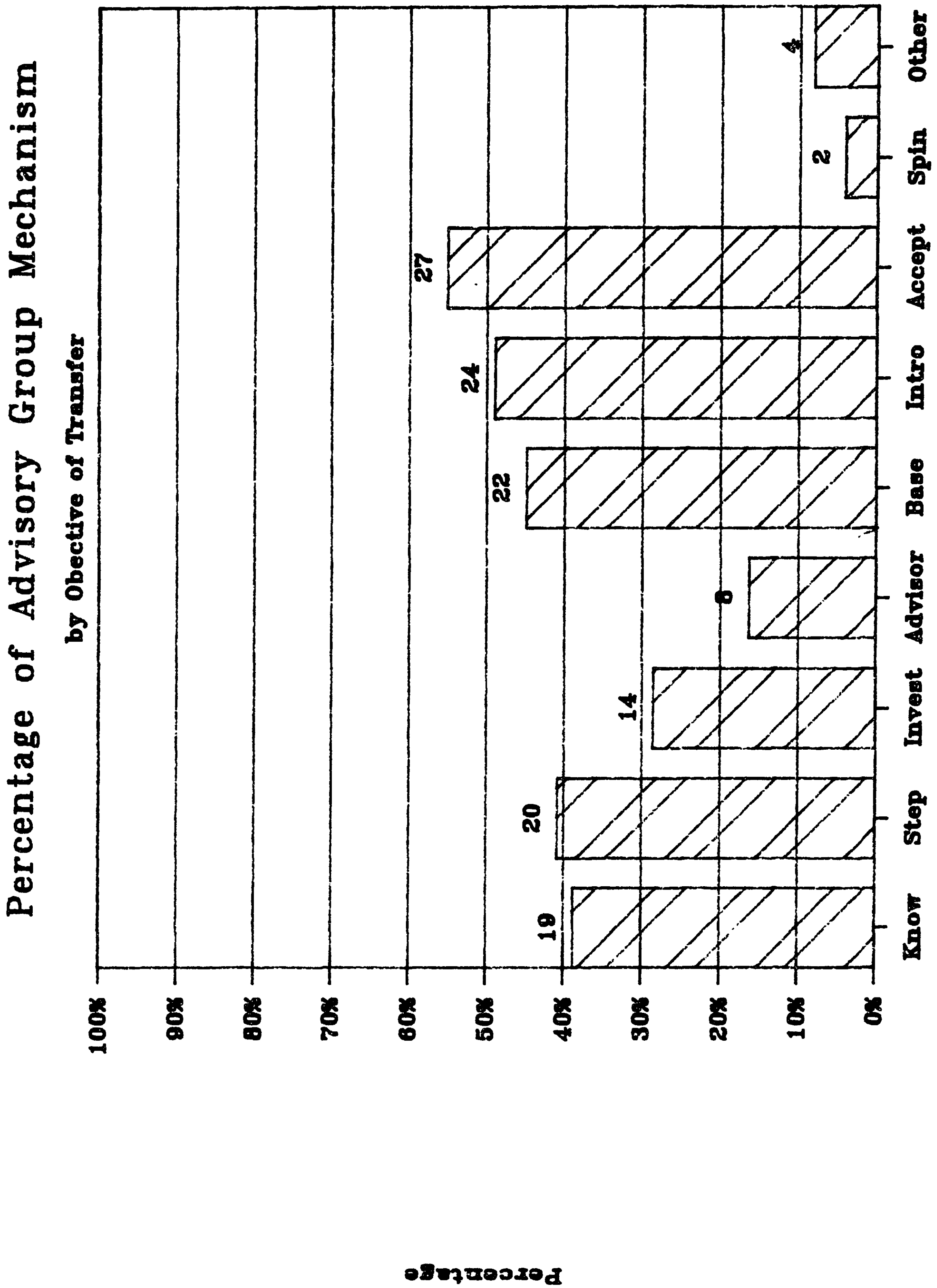
* Whereas the "Utility Sector" received almost 30% of the total number of transfers, almost 40% of the transfers using Advisory Boards went to this recipient.

Graph B-1:

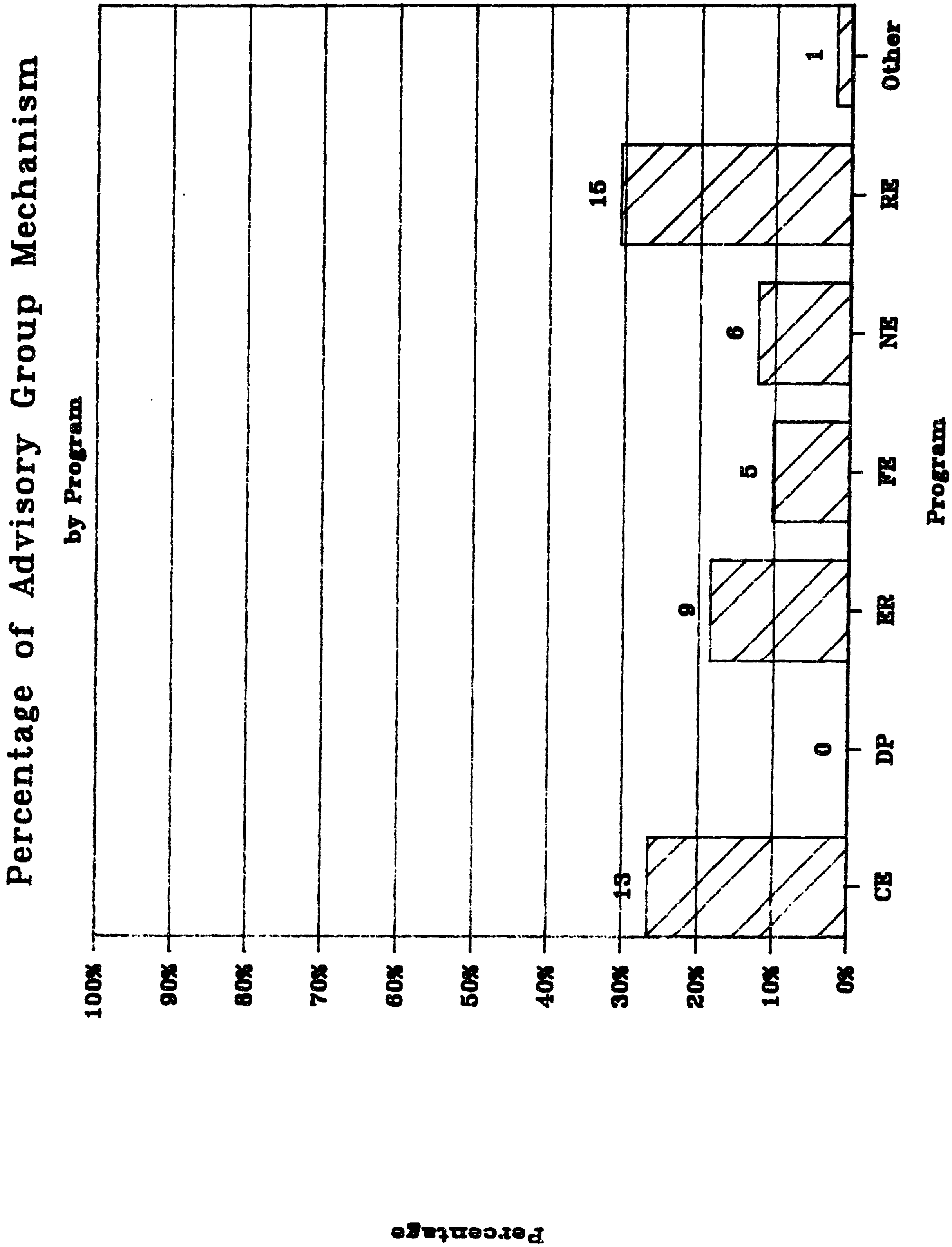


Percentage of Advisory Group Mechanism
by Form of Transfer
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
13
11
41
17
10
14
3
38
Pat
Soft
Info
Stand
Know
Proc
Copy
Prod
Form
Percentage

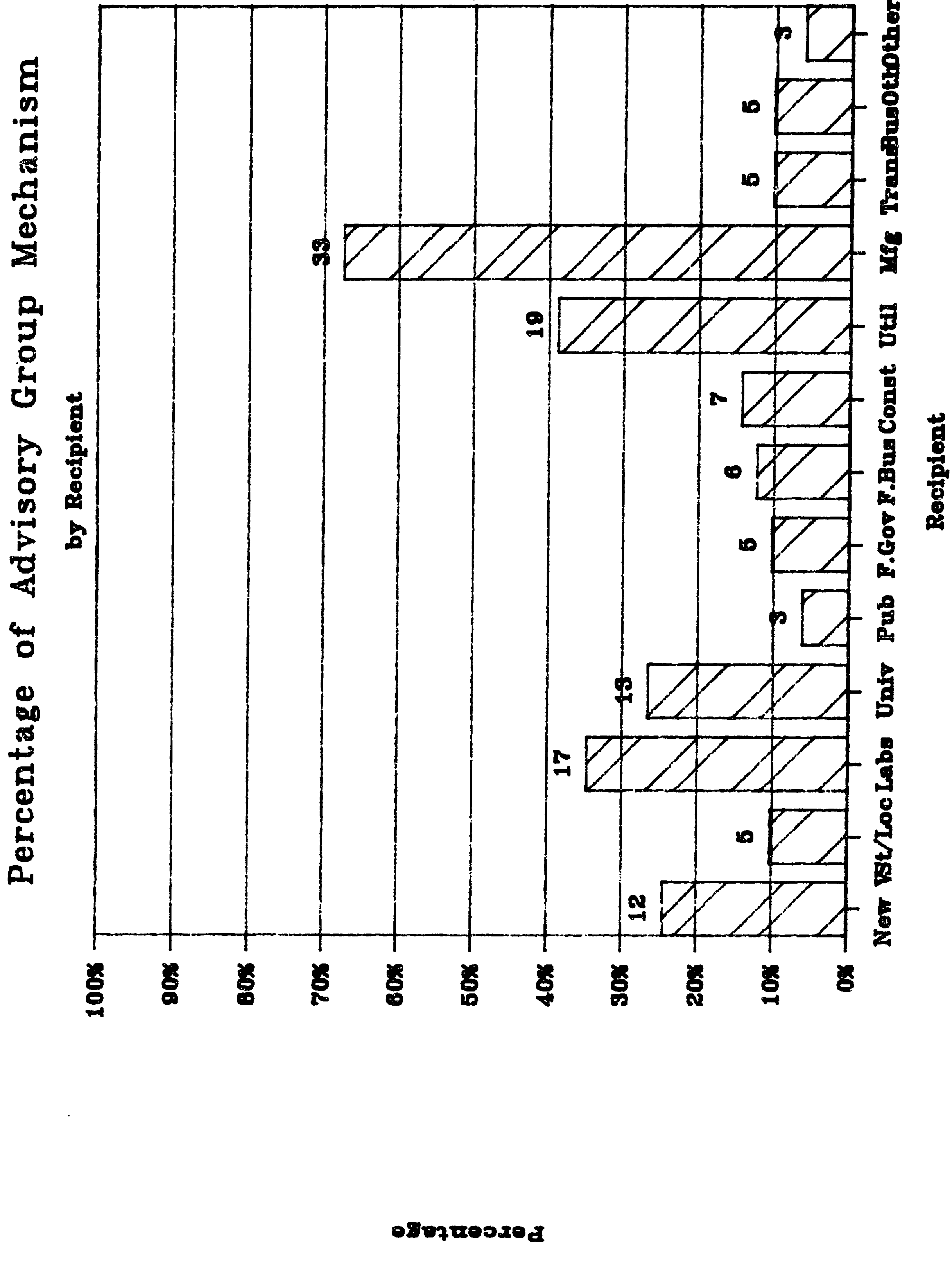
Graph B-2:


Percentage of Advisory Group Mechanism
by Obective of Transfer
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
19
20
14
8
22
24
27
2
4
Know
Step
Invest
Advisor
Base
Intro
Accept
Spin
Other
Objective
Percentage

Graph B-3:

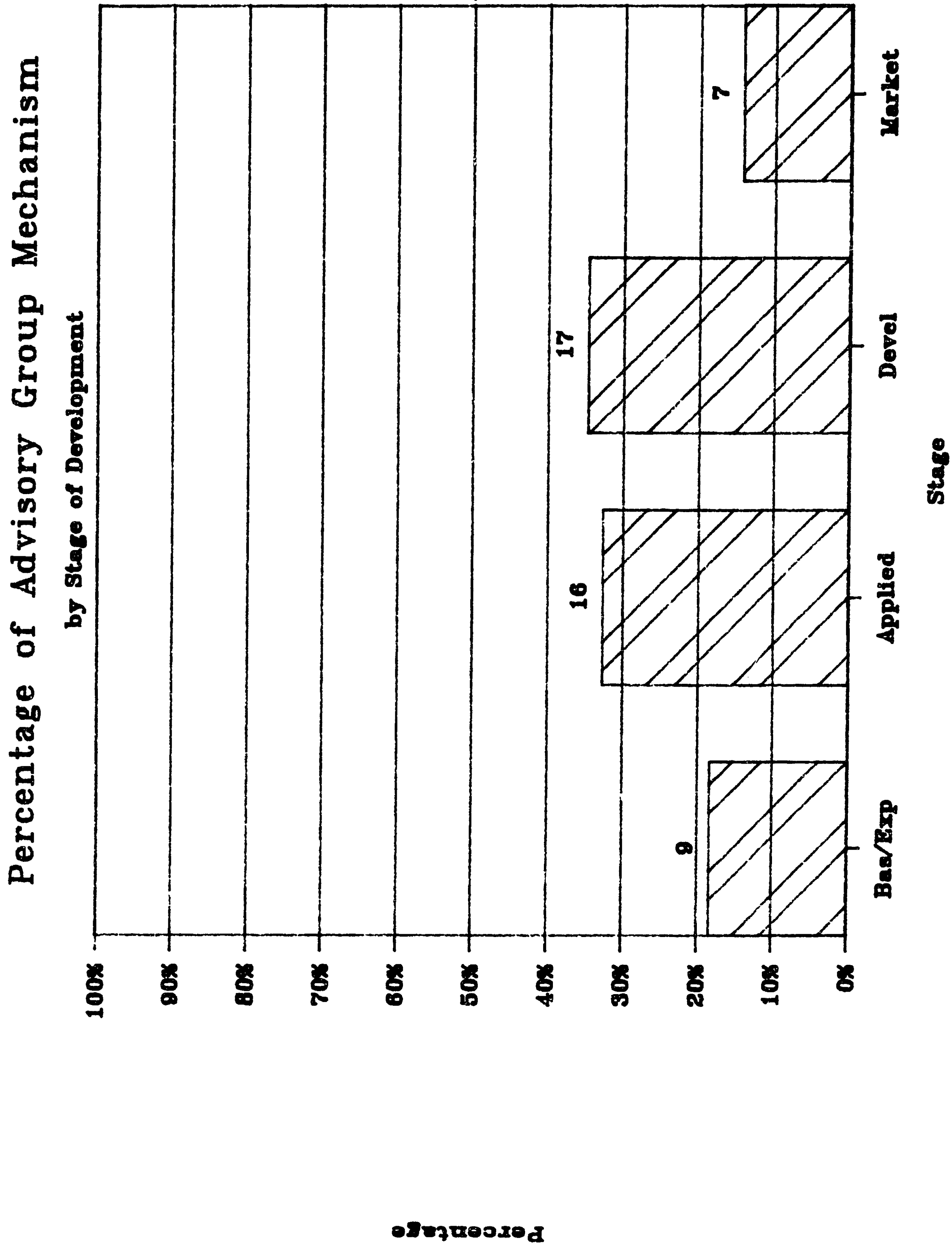

Percentage of Advisory Group Mechanism
by Program
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
13
0
9
5
6
15
1
CE
DP
ER
FE
NE
RE
Other
Program
Percentage

Graph B-4:

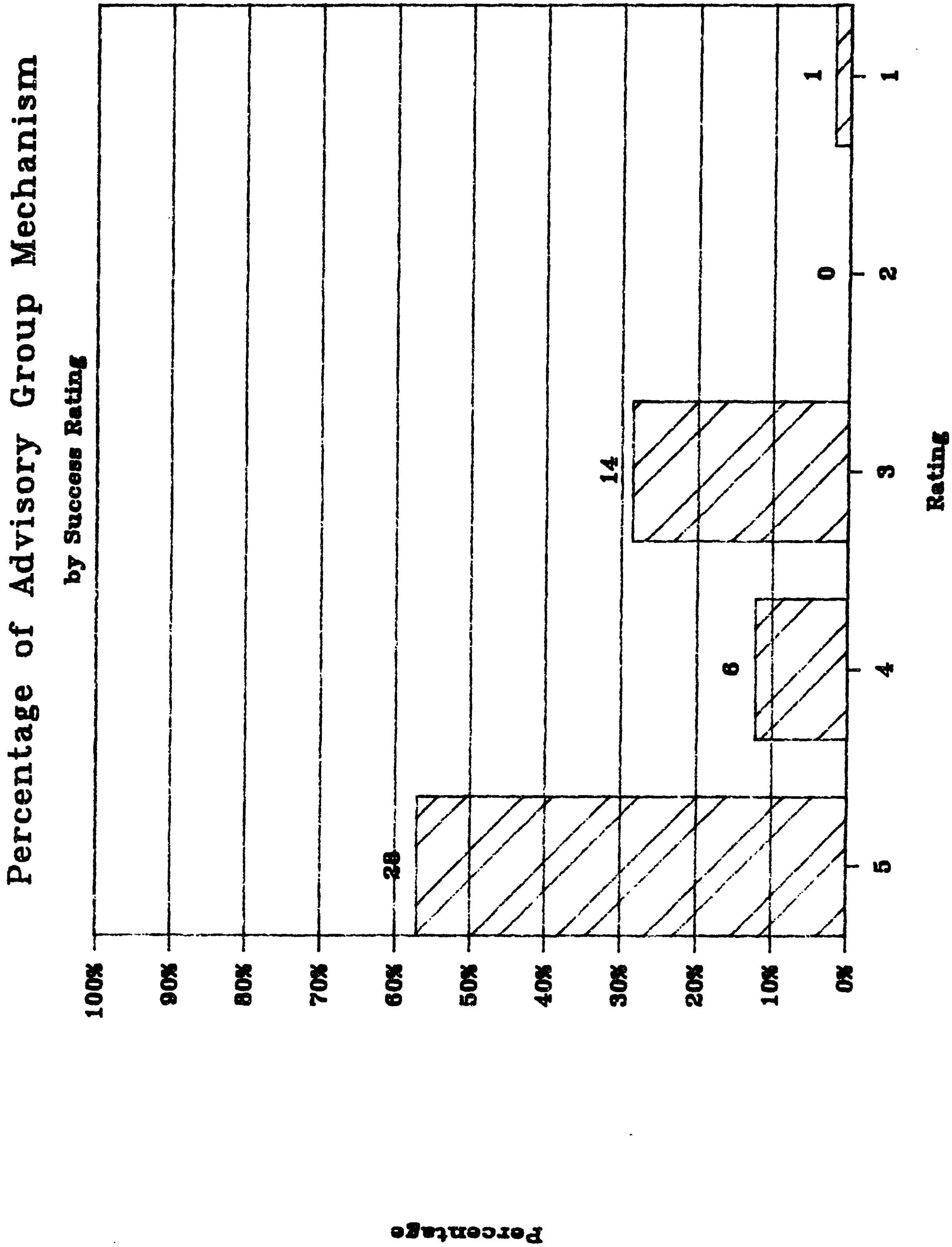


Percentage of Advisory Group Mechanism
by Recipient
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
12
5
17
13
3
5
6
7
19
33
5
5
3
New
VSt/Loc
Labs
Univ
Pub
F.Gov
F.Bus
Const
Util
Mfg
Trans
Bus
Oth
Other
Recipient
Percentage

Graph B-5:


Percentage of Advisory Group Mechanism
by Stage of Development
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
9
16
17
7
Bas/Exp
Applied
Devel
Market
Stage
Percentage

Graph B-6:


Percentage of Advisory Group Mechanism
by Success Rating
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
28
6
14
0
1
5
4
3
2
1
Rating

4.1.3 Collaboration With Cost Sharing

"Collaboration With Cost Sharing" represents those mechanisms where there is cooperation and sharing of the input resources by the parties involved and, hence, a shared stake in the project's results. These mechanisms include industrial consortia, cooperative R&D, demonstration projects, and user facilities. The role of cost-sharing is an important one; it reduces the risks of carrying out R&D for all parties, and therefore can bring together groups that would normally not work together. Further, cost-sharing enhances resources, whether they are capital, equipment, or experience, and thus enhances the scope and scale of research projects. Technology transfer takes place between the groups involved in the R&D, which usually requires the interaction of a number of engineers, scientists, and even managers from a variety, and sometimes large number of areas.

Industrial Consortia

Working with industrial consortia is a mechanism whereby the government cooperates with a number of industrial firms, trade associations, universities, or others in order to carry out a particular R&D venture. Because industry is involved, there is usually a large focus on market needs, which leads to more transferrable products.

Cooperative Research Projects

Cooperative research projects are working partnerships established between parties (usually government and an industrial partner) to carry out a common research project.

Demonstration Projects

A demonstration project is a mechanism that uses government equipment, technical expertise, installation expenses and/or other resources to "demonstrate" the capabilities of a technology to one or more cost-sharing partners.

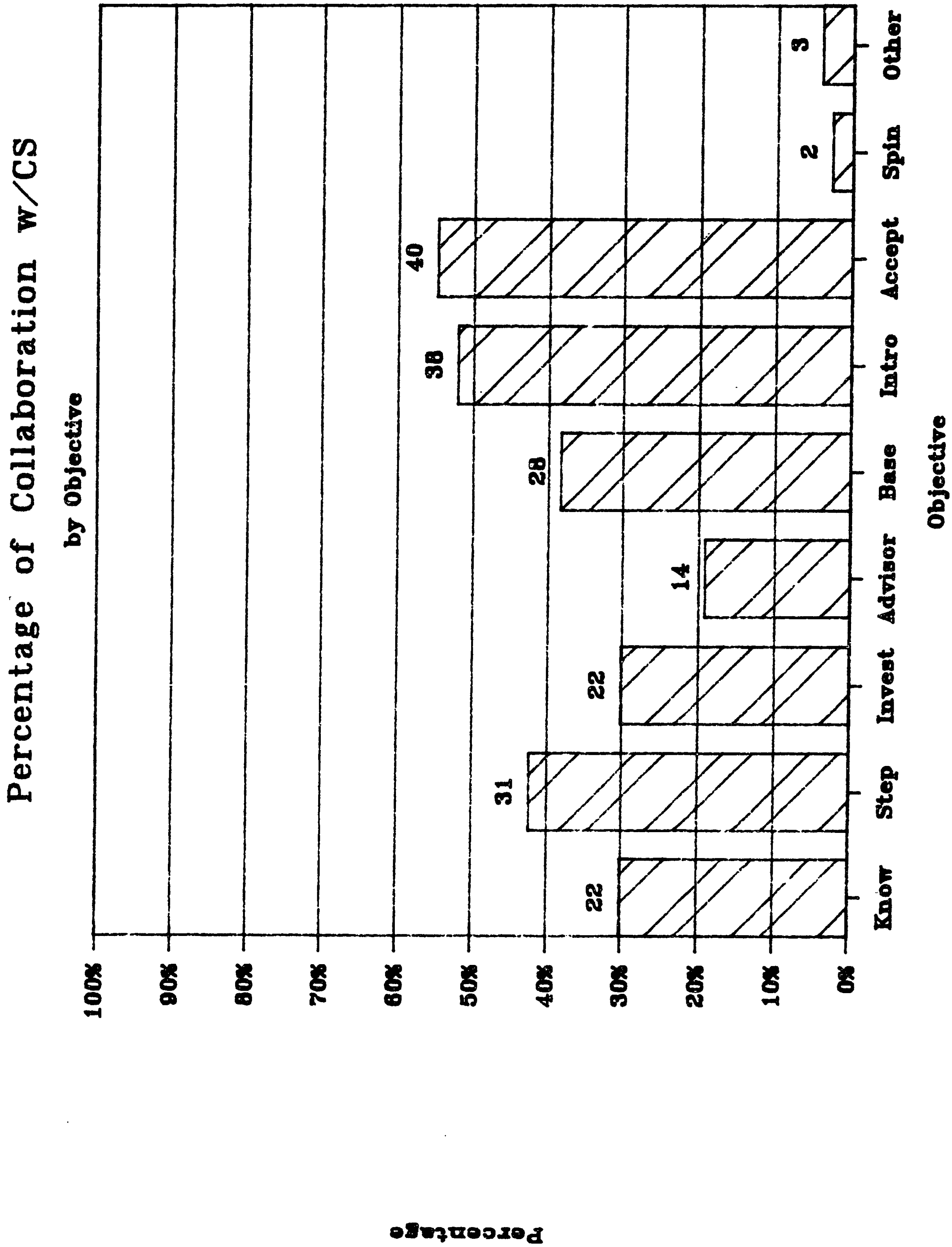
User Facilities

User facilities are government facilities designed to accommodate other collaborating parties. Hence, R&D can be carried out without needing to make huge investments in equipment or testing instrumentation, for example.

Discussion of Graphs:

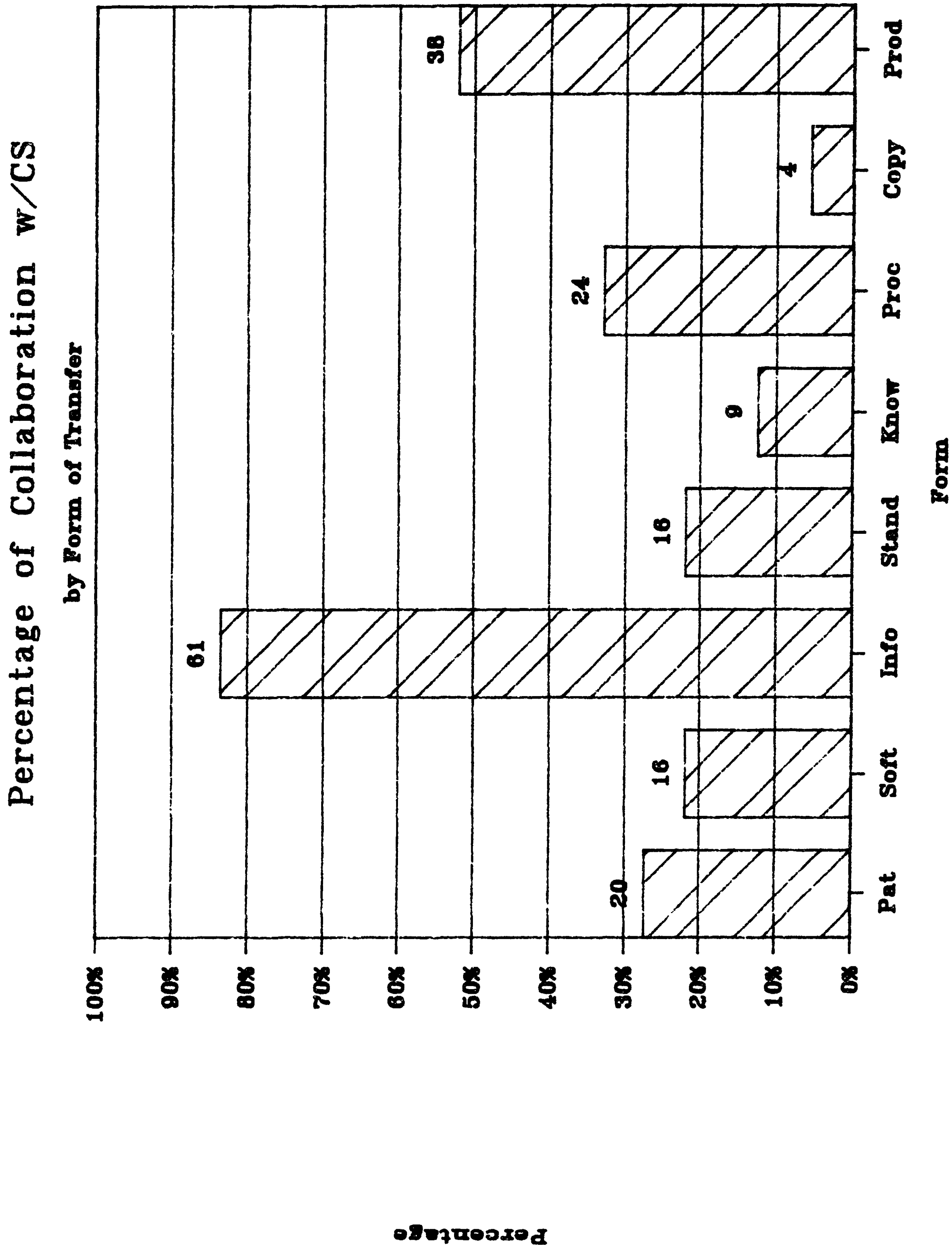
Graphs C-1 to C-6 show the cross-cut of cases that used Collaboration With Cost Sharing as a mechanism with other variables of the survey. There are no notable differences between cases that used Collaboration With Cost Sharing and the total cases.

Graph C-1:

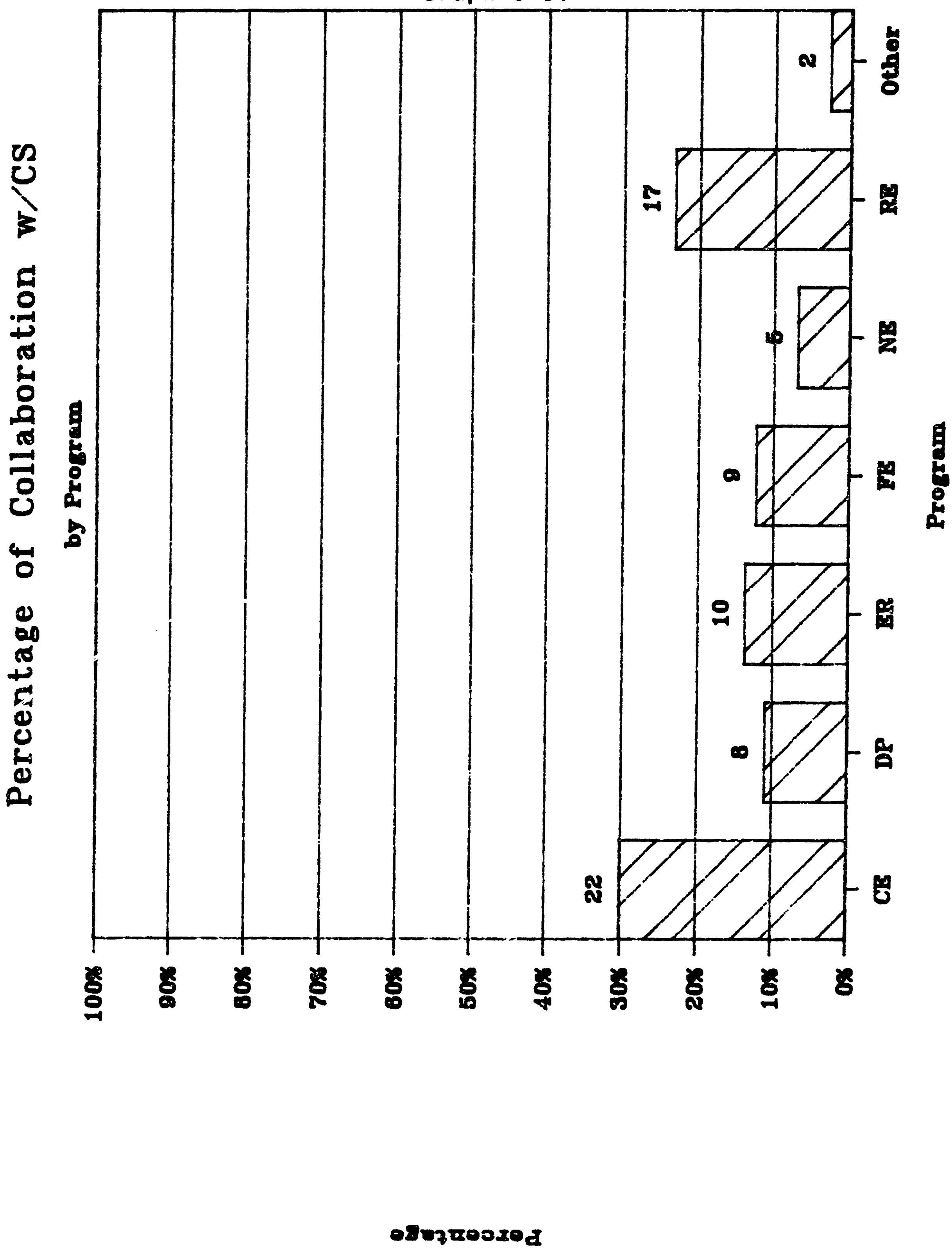


Percentage of Collaboration w/CS
by Objective
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
22
31
22
14
28
38
40
2
3
Know
Step
Invest
Advisor
Base
Intro
Accept
Spin
Other
Objective

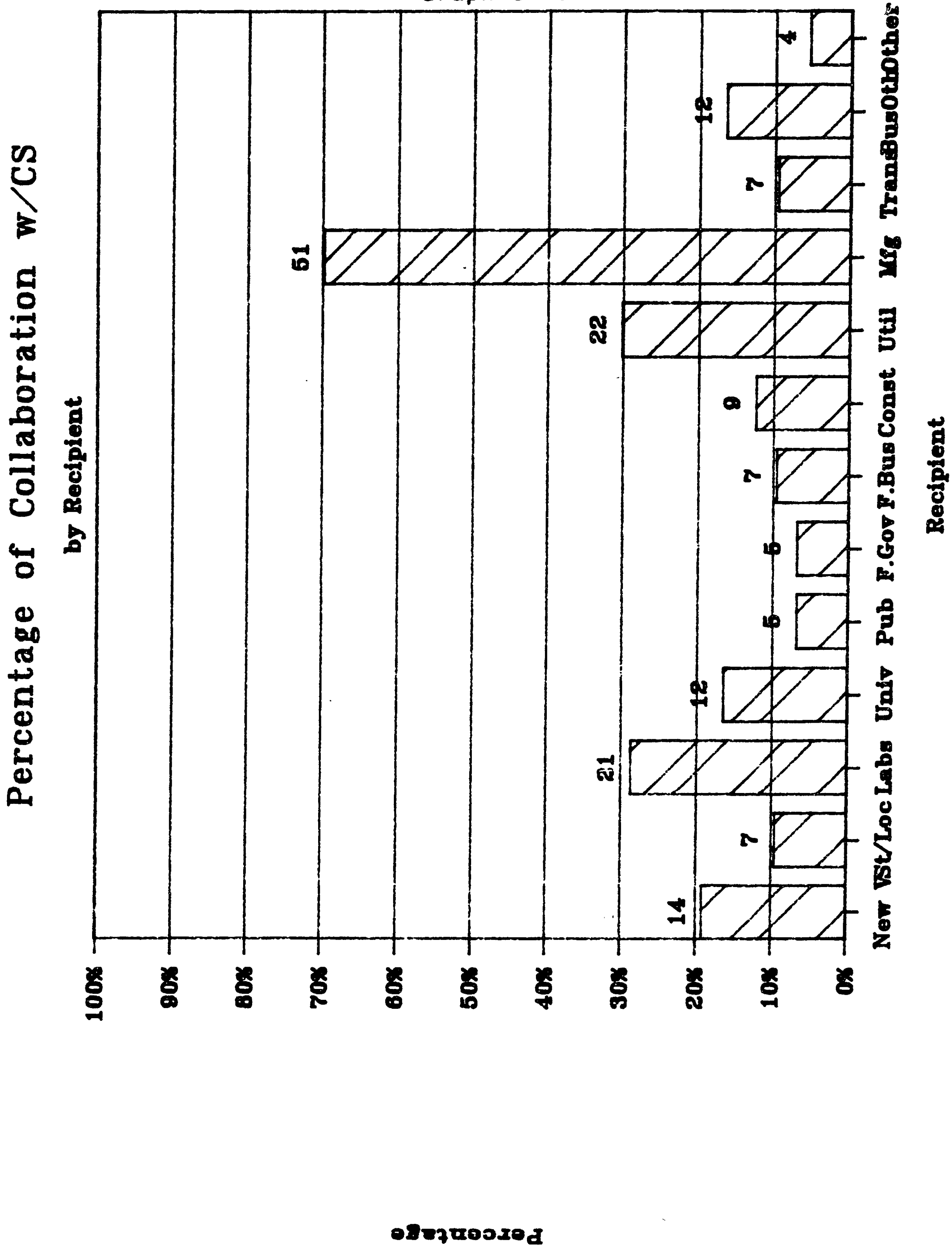
Graph C-2:


Percentage of Collaboration w/CS
by Form of Transfer
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
20
16
61
16
9
24
4
38
Pat
Soft
Info
Stand
Know
Proc
Copy
Prod
Form
Percentage

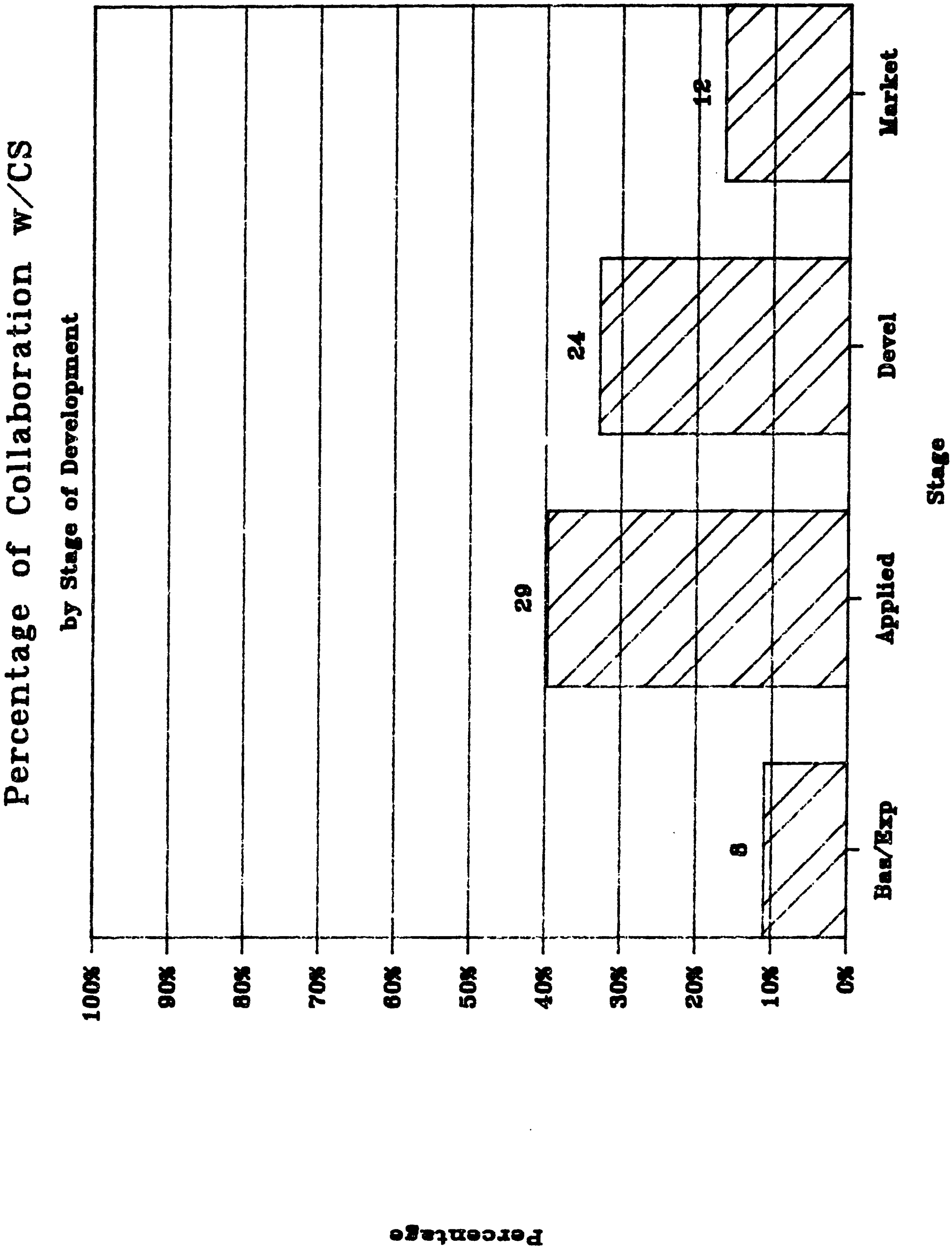
Graph C-3:


Percentage of Collaboration w/CS
by Program
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
22
8
10
9
5
17
2
CE
DP
ER
FE
NE
RE
Other
Program
Percentage

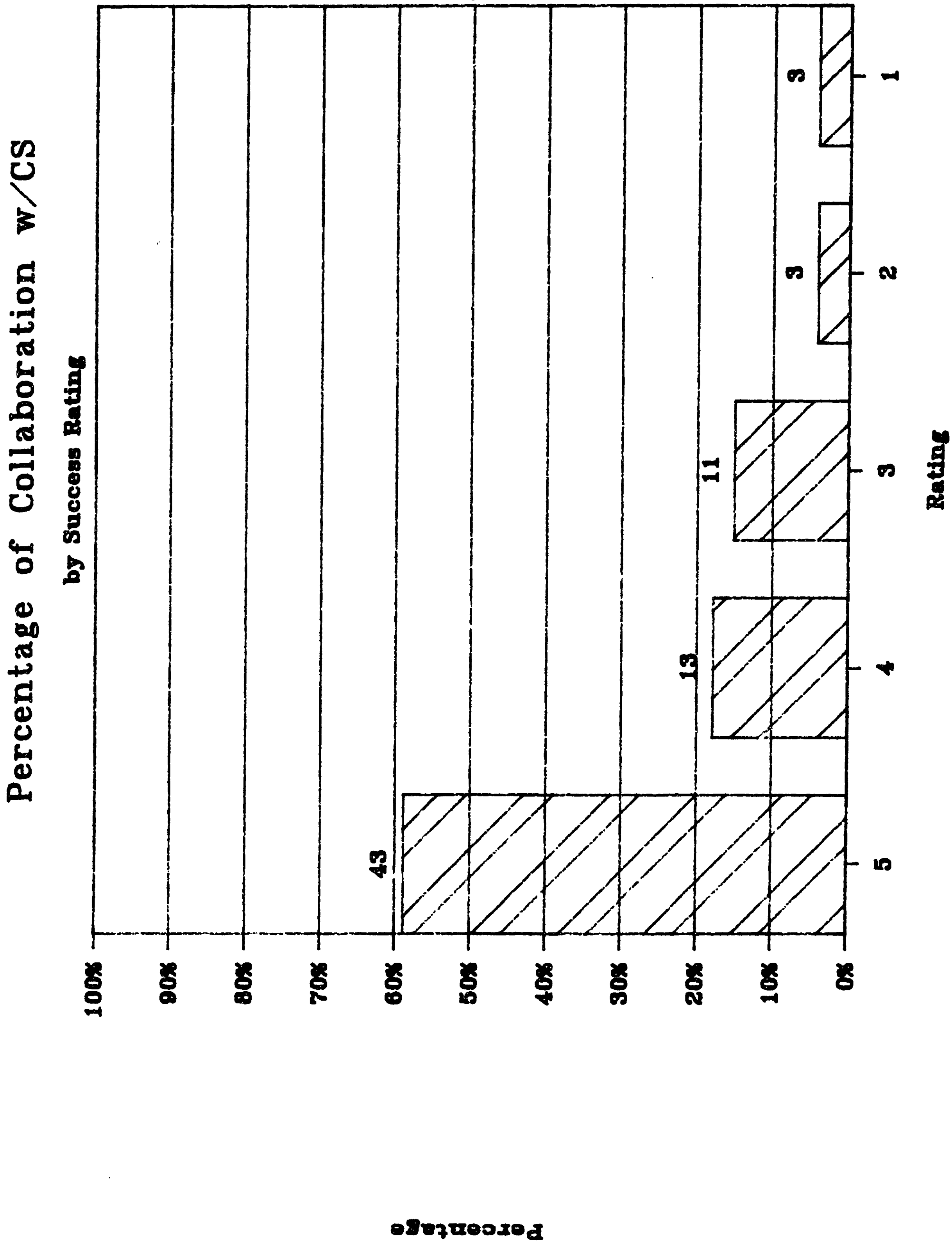
Graph C-4:


Percentage of Collaboration w/CS
by Recipient
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
14
7
21
12
5
5
7
9
22
51
7
12
4
New
VSt/Loc
Labs
Univ
Pub
F.Gov
F.Bus
Const
Util
Mfg
Trans
BusOth
Other
Recipient
Percentage

Graph C-5:


Percentage of Collaboration w/CS
by Stage of Development
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
8
29
24
12
Bas/Exp
Applied
Devel
Market
Stage

Graph C-6:



Percentage of Collaboration w/CS
by Success Rating
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
43
13
11
3
3
5
4
3
2
1
Rating

4.1.4 Collaboration Without Cost Sharing

"Collaboration Without Cost-Sharing is cooperation among parties where there is no sharing of costs; that is, one party pays for all the resources needed in a project. The only mechanism that falls into this category is "Contracting R&D," whereby one party is paid (contracted) to carry out research for another.

Discussion of Graphs:

Graphs D-1 to D-6 show the cross-cut of cases that used Collaboration Without Cost Sharing as a mechanism with other variables of the survey. Notable differences between cases that used Collaboration Without Cost Sharing and the total cases are as follows:

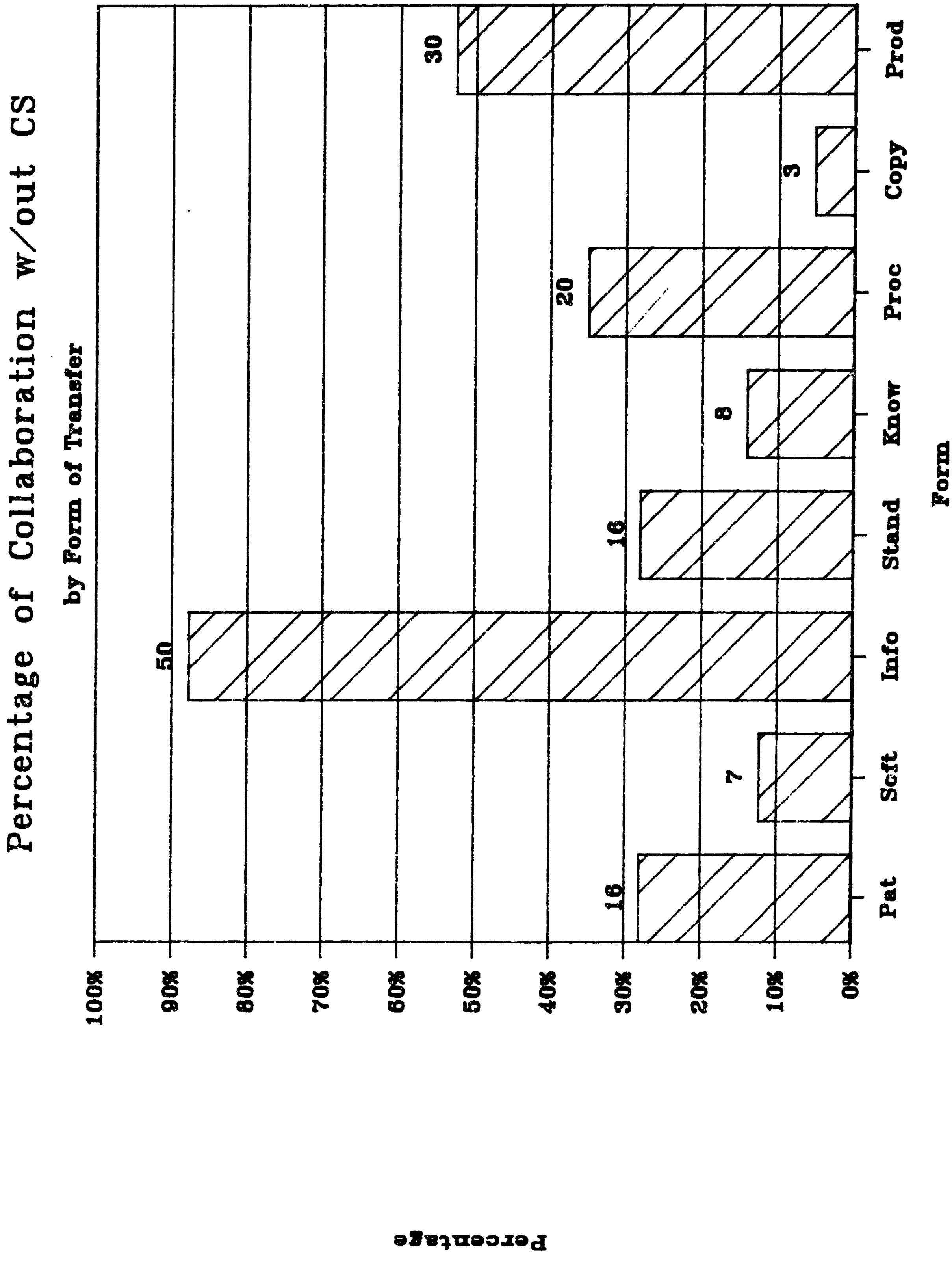
* Whereas "Software" and "Standards-Practices-Training" were the form of transfer for 19% and 21% of the total number of cases, respectively, they represented 12% and 28% of the cases using Collaboration Without Cost Sharing as a mechanism.

* Whereas "To introduce a new technology" was the objective of transfer in about 55% of the total case studies, only 43% of cases using Collaboration Without Cost Sharing had this as an objective.

* Whereas Energy Research (ER) and Defense Programs (DP) were the sponsors of 24% and 17% of the total case studies, these programs sponsored only 10% and 3% of those cases using Collaboration Without Cost Sharing.

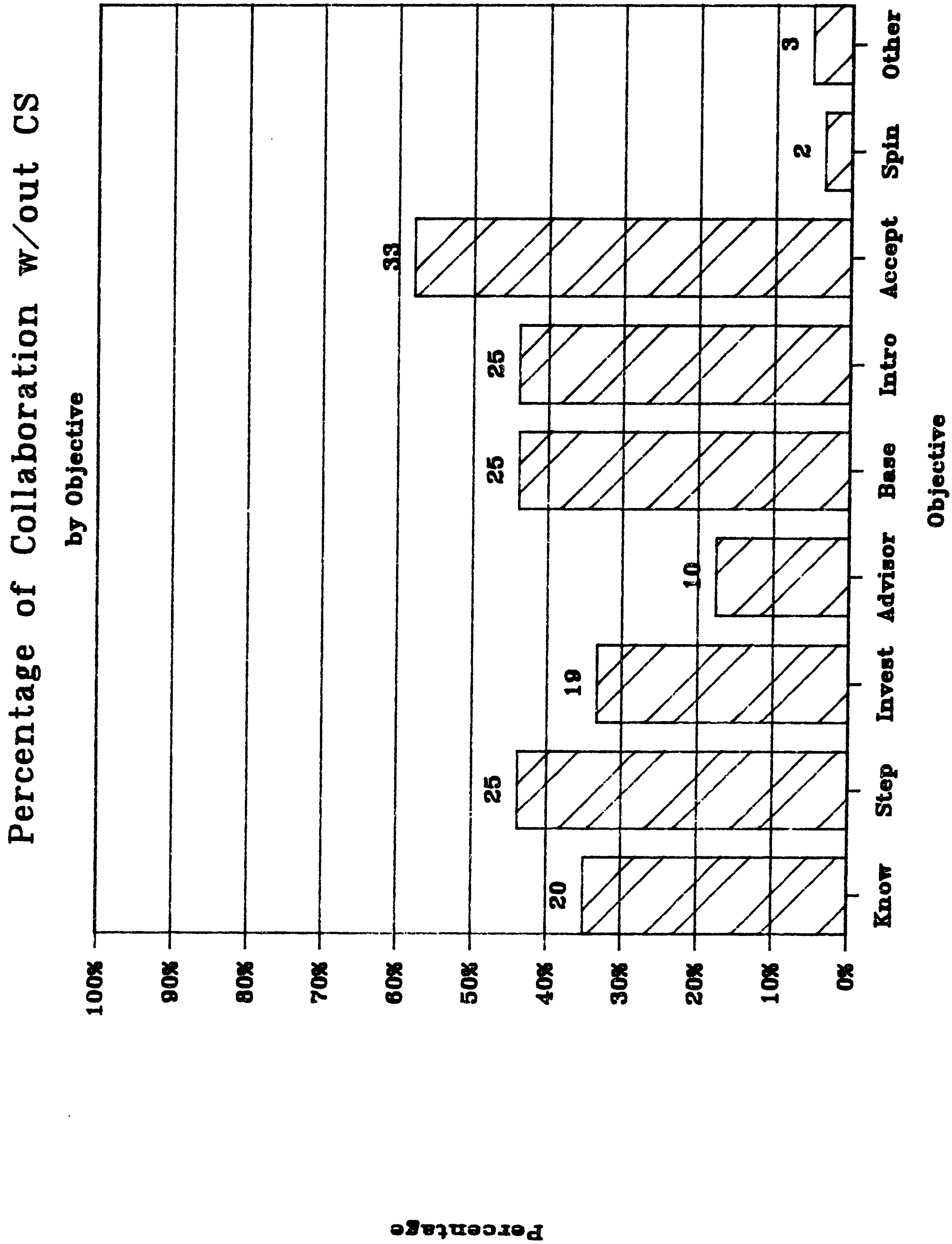
* Whereas "Market Penetration" was the stage of development for about 20% of the total number of cases, only 9% of the cases using Collaboration Without Cost Sharing had technologies in this stage of development.

Graph D-1:

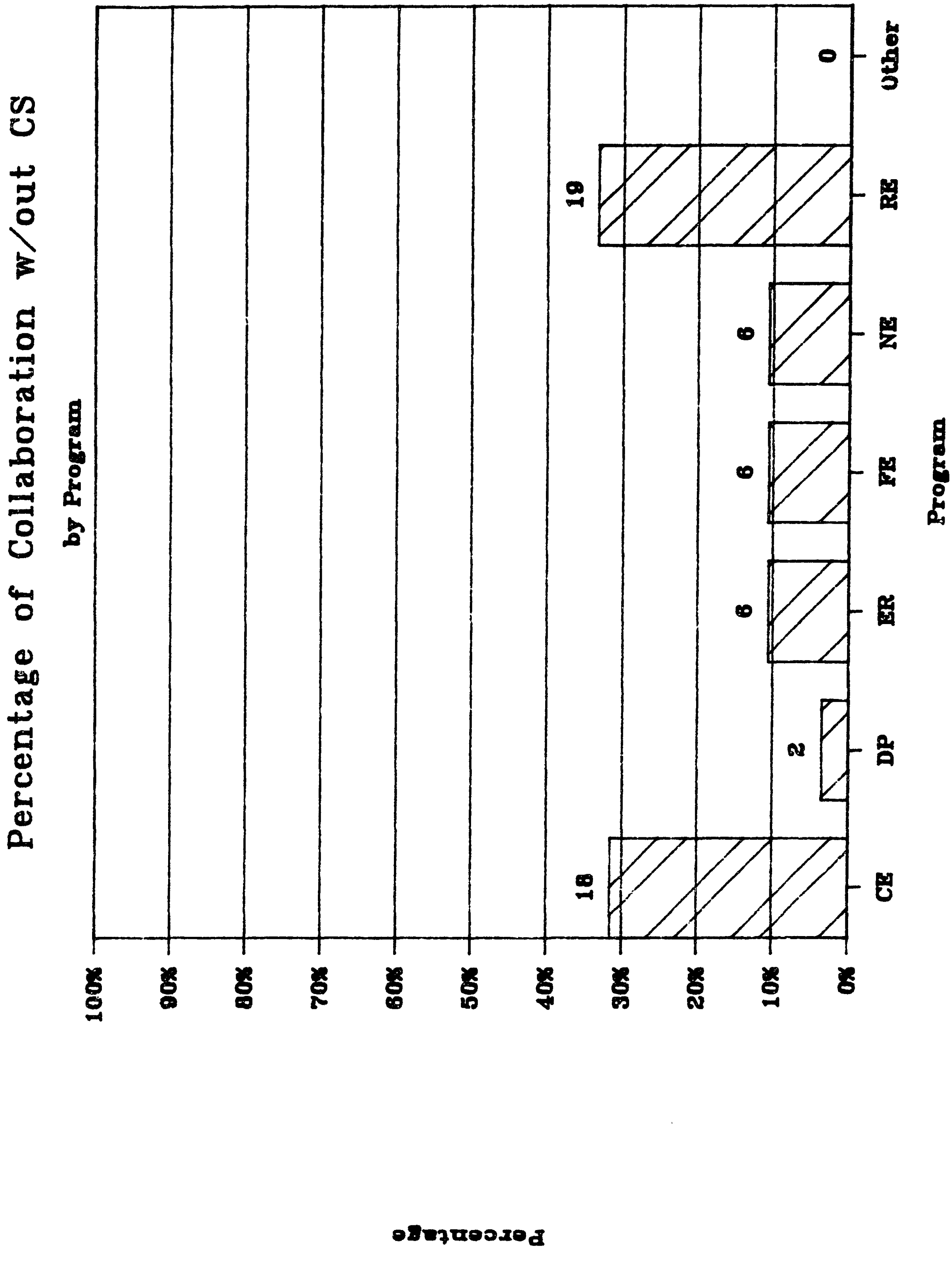


Percentage of Collaboration w/out CS
by Form of Transfer
Percentage
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
16
7
50
16
8
20
3
30
Pat
Scft
Info
Stand
Know
Proc
Copy
Prod
Form

Graph D-2:

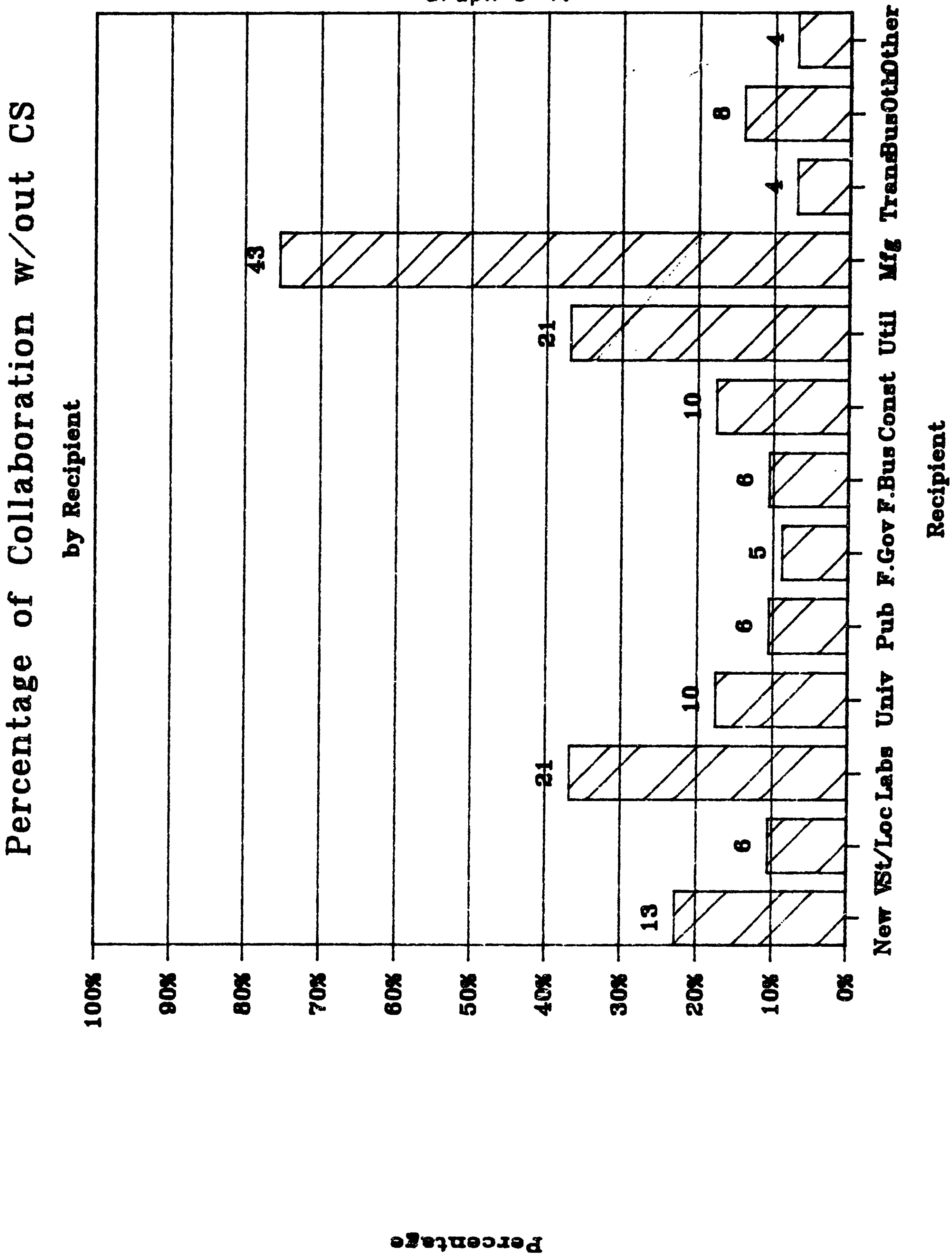

Percentage of Collaboration w/out CS
by Objective
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
20
25
19
10
25
25
33
2
3
Know
Step
Invest
Advisor
Base
Intro
Accept
Spin
Other
Objective

Graph D-3:



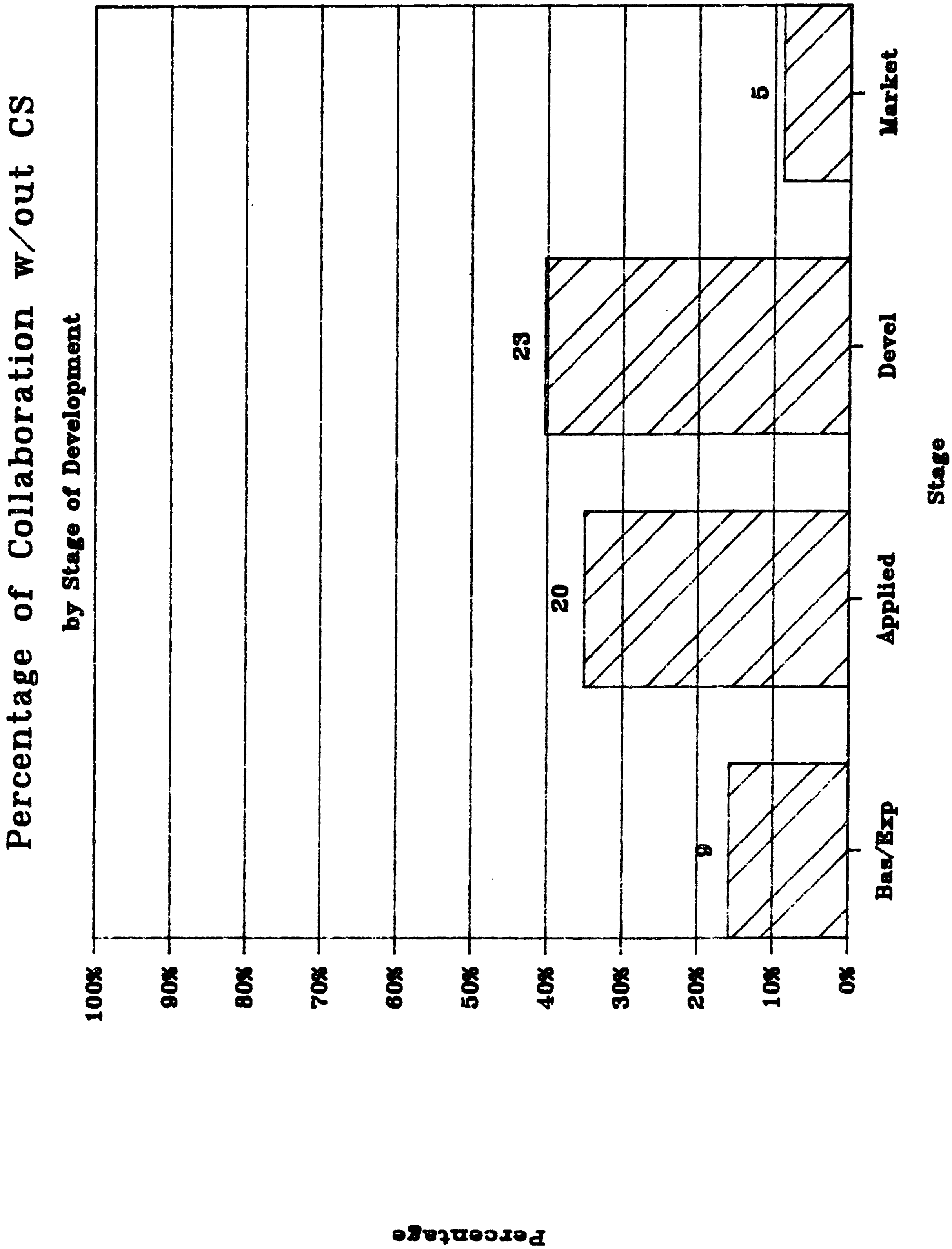
Percentage of Collaboration w/out CS
by Program
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
18
2
6
6
6
19
0
CE
DP
ER
FE
NE
RE
Other
Program
Percentage

Graph D-4:



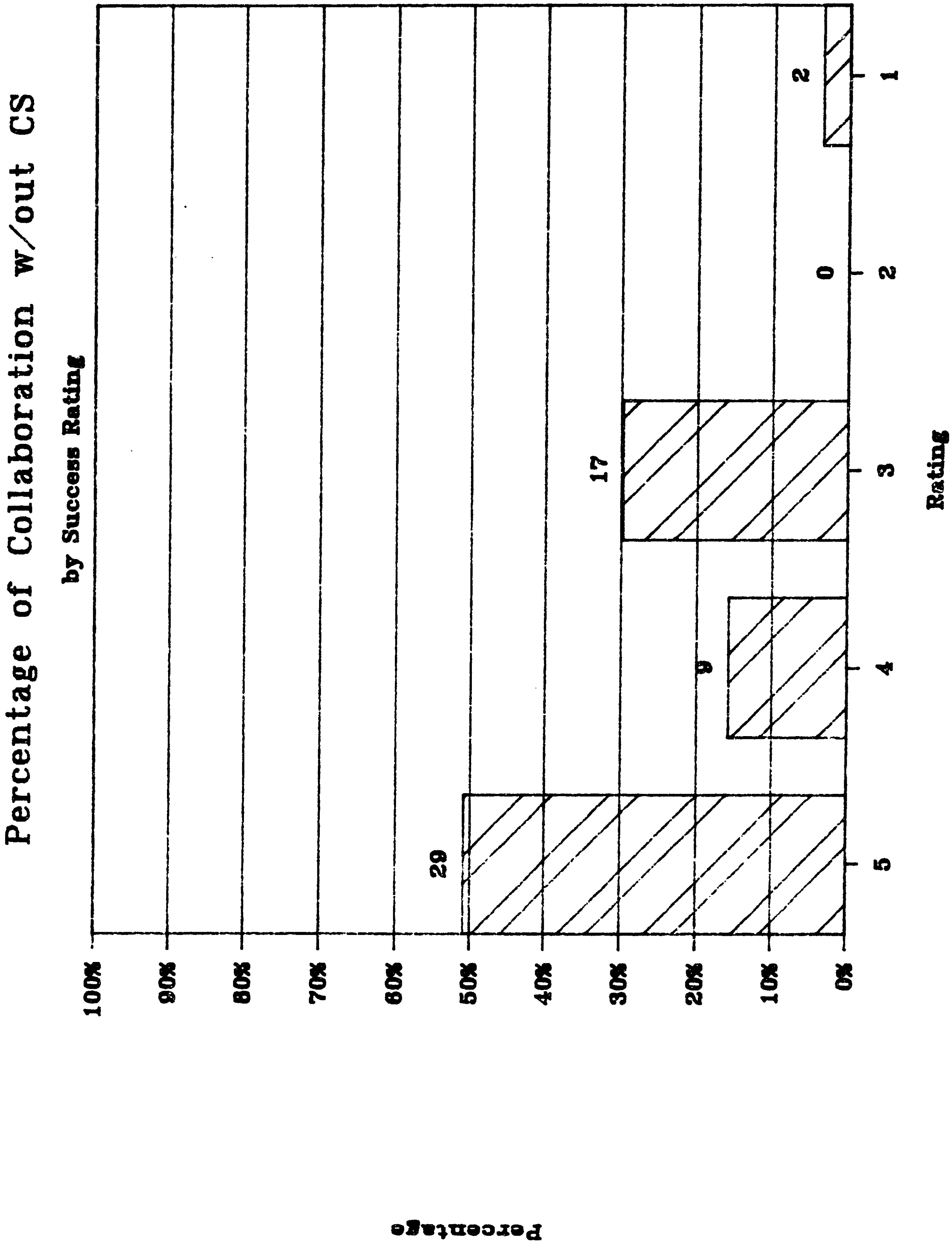
Percentage of Collaboration w/out CS
by Recipient
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
13
6
21
10
6
5
6
10
21
43
4
8
4
New
St/Loc
Labs
Univ
Pub
F.Gov
F.Bus
Const
Util
Mfg
Trans
BusOth
Other
Recipient
Percentage

Graph D-5:



Percentage of Collaboration w/out CS
by Stage of Development
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
9
20
23
5
Bas/Exp
Applied
Devel
Market
Stage

Graph D-6:



Percentage of Collaboration w/out CS
by Success Rating
29
9
17
0
2
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
5
4
3
2
1
Rating
Percentage

4.1.5 Personnel Exchanges

"Personnel Exchanges" are those mechanisms where actual staff members of one party consult or work for another party to assist in a research project. The technology transfer occurs with the knowledge and experience that the staff member brings along with him/her. The mechanisms that fall into this category are "Work For Others," "Staff Consulting," "Guest Staff," and "Staff Transfers." These personnel exchanges allow one-on-one information exchange and also involve teaching in a highly communicative fashion.

Work For Others

"Work for others" is a mechanism whereby a knowledgeable and experienced staff member(s) of one party does work for/with another party.

Guest Staff

The mechanism "guest staff" refers the temporary reassignment of a staff of one party to another. Staff members that are reassigned become part of the new organization's research project team.

Technical Staff Transfer

"Technical staff transfer" includes the transfer of staff from one organization to another. It usually is for longer, if not permanent, periods of time than "guest staff." The staff member transferred becomes more integrated into the second organization as a whole, and not just the R&D project.

Staff Consulting

"Staff consulting" is a mechanisms whereby a staff member contributes his/her knowledge and experience by consulting. Consulting can be done in person or by phone, depending on the project.

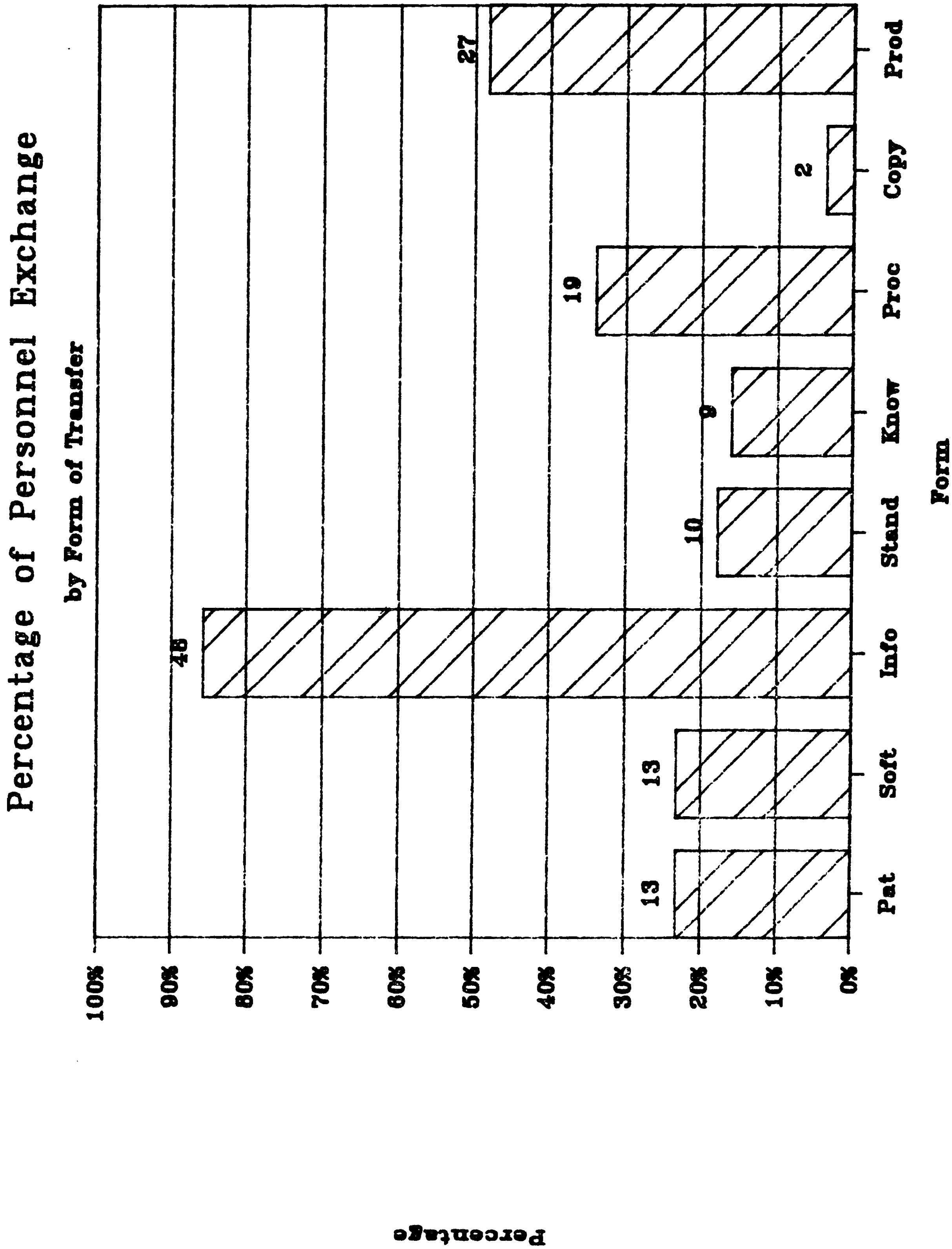
Discussion of Graphs:

Graphs E-1 to E-6 show the cross-cut of cases that used Personnel Exchange as a mechanism with other variables of the survey. Notable differences between cases that used Personnel Exchange and the total cases are as follows:

* Whereas "To move a technology into the next step" was an objective of the transfer in 40% of the total cases, only 30% of the cases using Personnel Exchange had this as an objective.

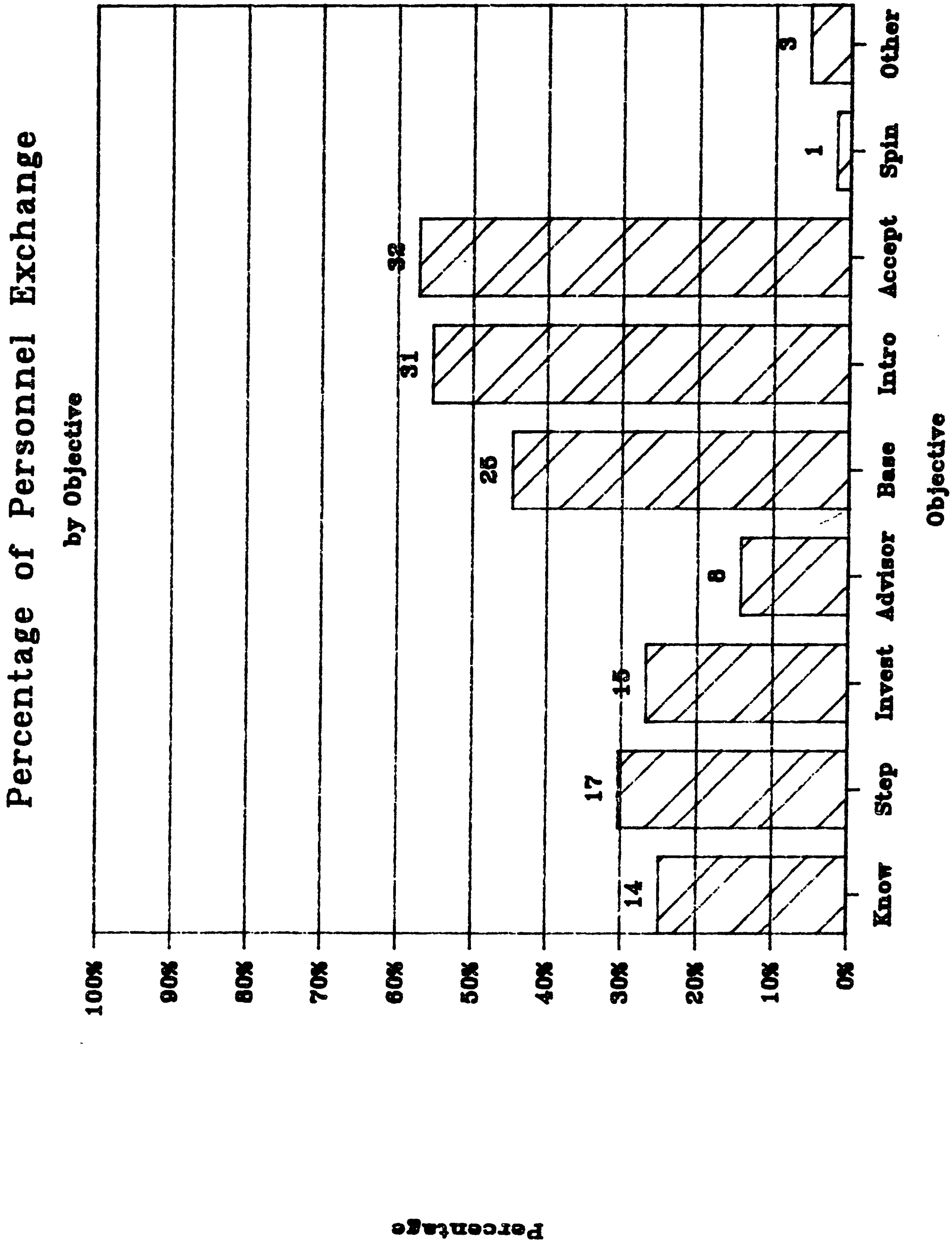
* Whereas Conservation (CE) and Nuclear Energy (NE) programs sponsored about 30% and 9% of the total cases, respectively, they only sponsored 14% and 2% of the cases using Personnel Exchange as a mechanism.

Graph E-1:

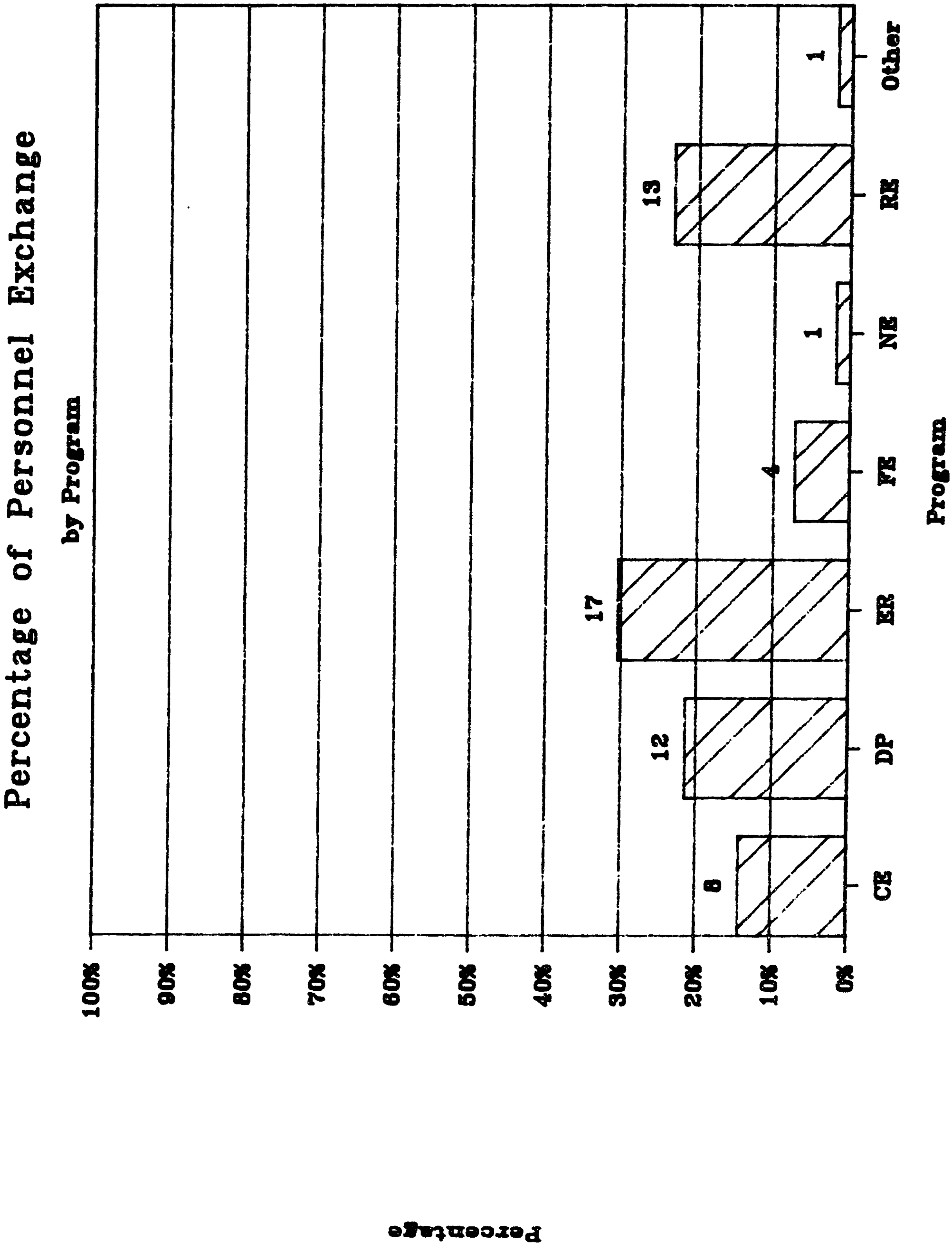


Percentage of Personnel Exchange
by Form of Transfer
13
13
48
10
9
19
2
27
Pat
Soft
Info
Stand
Know
Proc
Copy
Prod
Form
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage

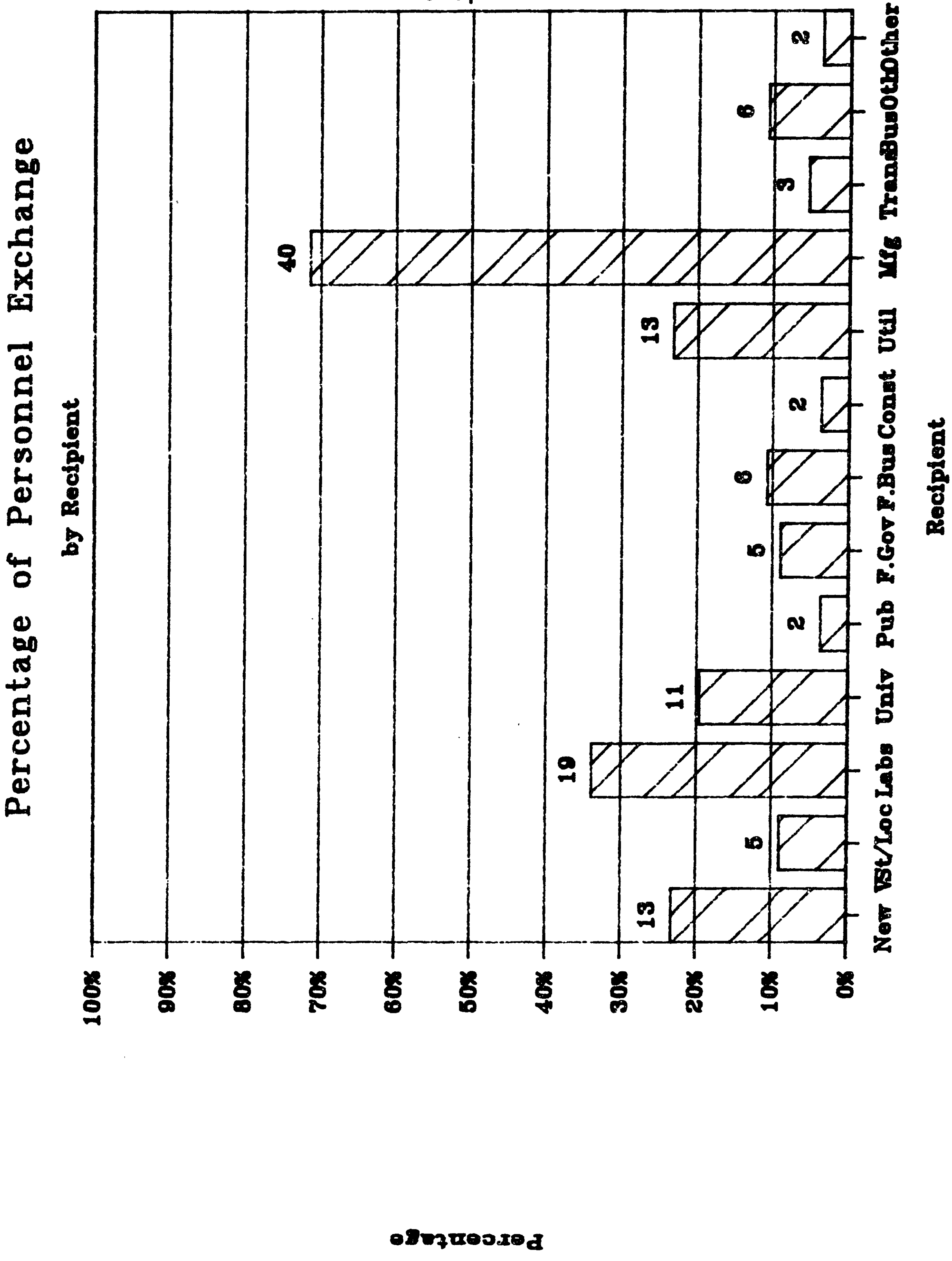
Graph E-2:


Percentage of Personnel Exchange
by Objective
Percentage
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
14
17
15
8
25
31
32
1
3
Know
Step
Invest
Advisor
Base
Intro
Accept
Spin
Other
Objective

Graph E-3:

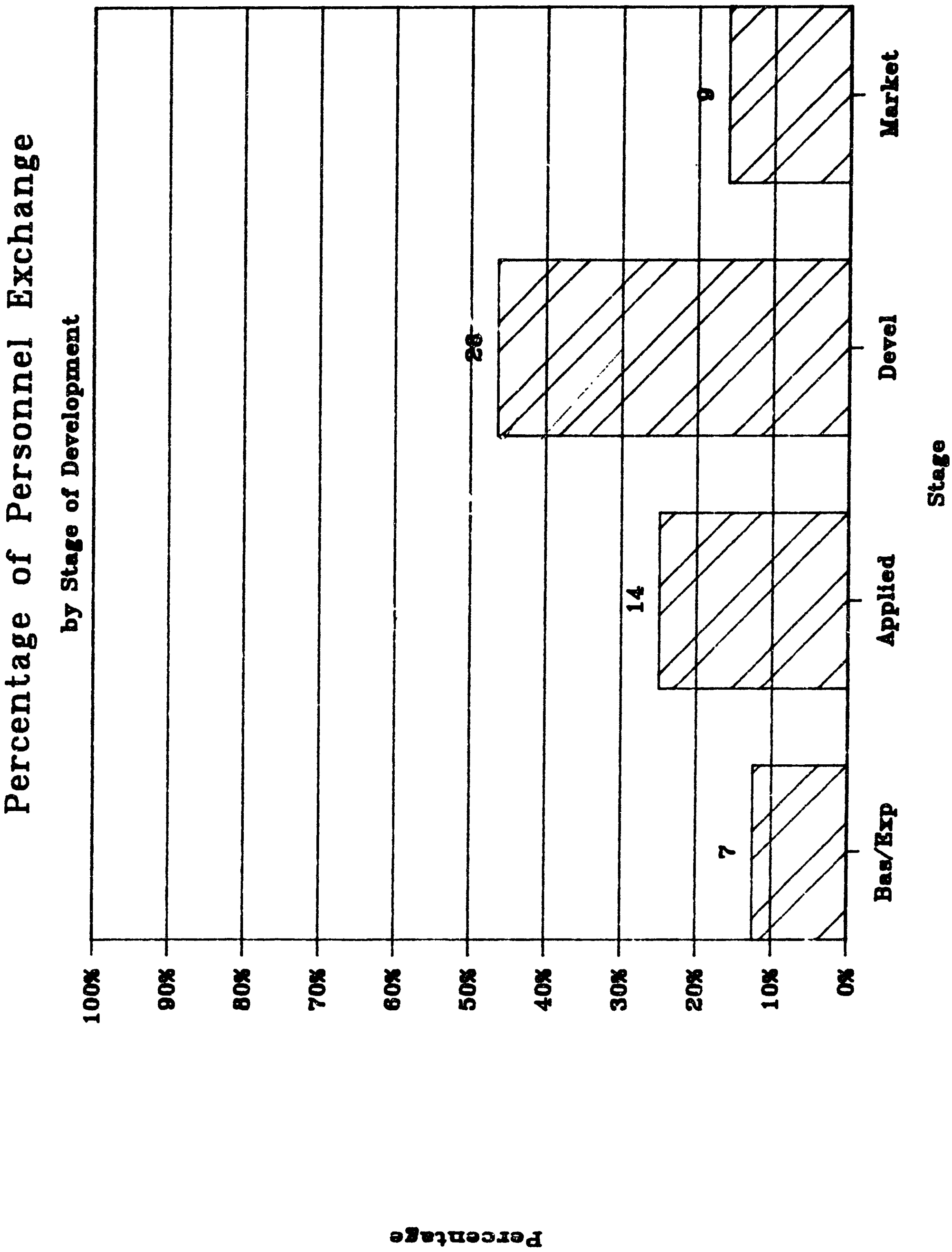

Percentage of Personnel Exchange
by Program
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
8
12
17
4
1
13
1
CE
DP
ER
FE
NE
RE
Other
Program
Percentage

Graph E-4:

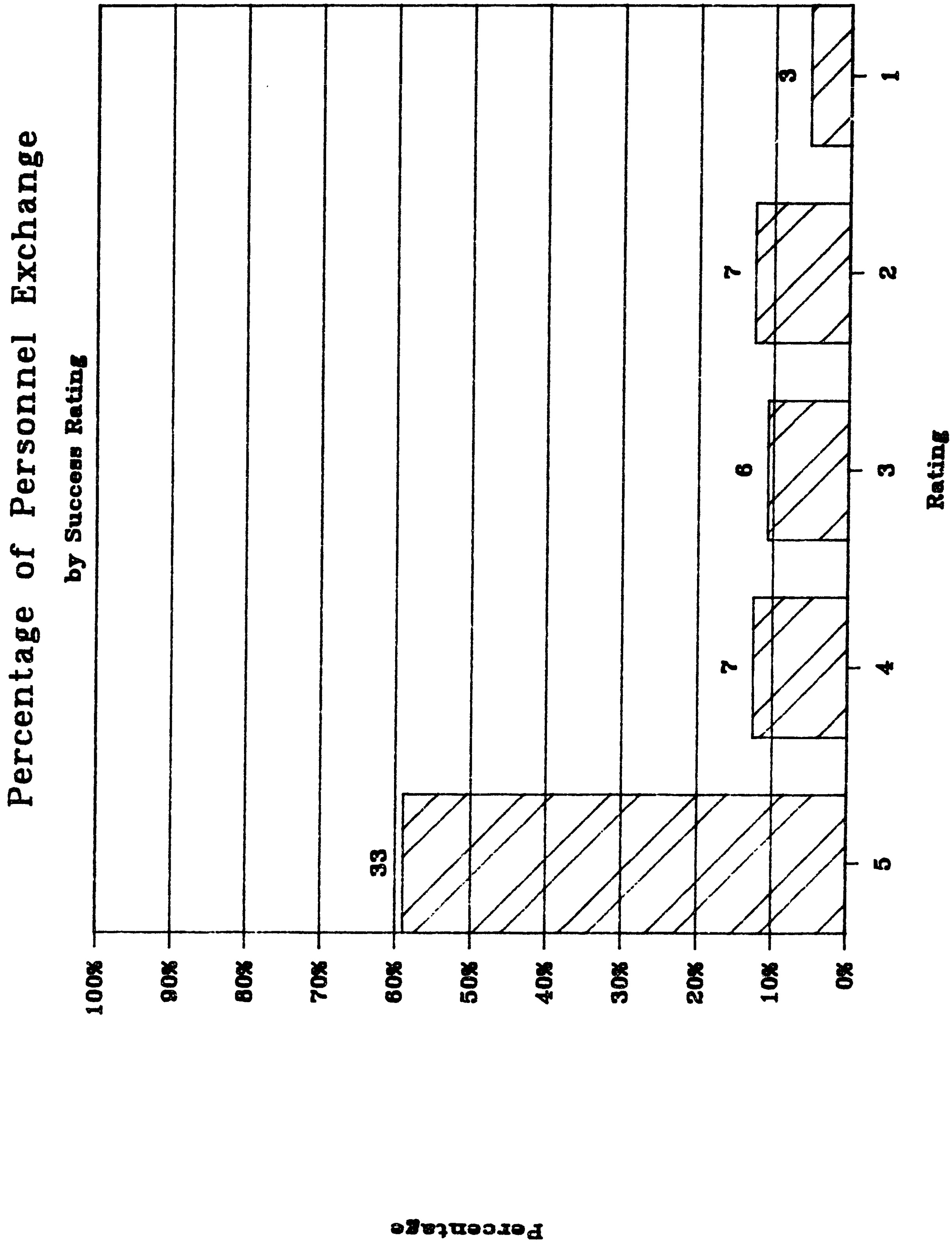


Percentage of Personnel Exchange
by Recipient
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
13
5
19
11
2
5
6
2
13
40
3
6
2
New
VSt/Loc
Labs
Univ
Pub
F.Gov
F.Bus
Const
Util
Mfg
Trans
BusOth
Other
Recipient
Percentage

Graph E-5:


Percentage of Personnel Exchange
by Stage of Development
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
7
14
28
9
Bas/Exp
Applied
Devel
Market
Stage

Graph E-6:


Percentage of Personnel Exchange
by Success Rating
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
33
7
6
7
3
5
4
3
2
1
Rating

4.1.6 Licensing/Spinoffs

The "Licensing/Spinoff" group consists of the two mechanisms, "Licensing" and "Spinoff Companies." Both represent the exercise of one party obtaining rights to continue the development of a technology conceived by another party.

Licensing

"Licensing" involves the issuance of either an exclusive or non-exclusive permit to one organization to further develop or manufacture a product that has been originally conceived at another organization.

Spinoff Companies

The generation of "spinoff companies" is a mechanism whereby a new company is created to commercially exploit a given technology, headed by personnel involved in the technology's original development.

Discussion of Graphs:

Graphs F-1 to F-6 show the cross-cut of cases that used Licensing/Spinoffs as a mechanism with other variables of the survey. Notable differences between cases that used Licensing/Spinoffs and the total cases are as follows:

* Whereas "Patent/License" was the form of transfer for 30% of the total cases, over 70% of those cases using Licensing/Spinoffs used this as a form of transfer.

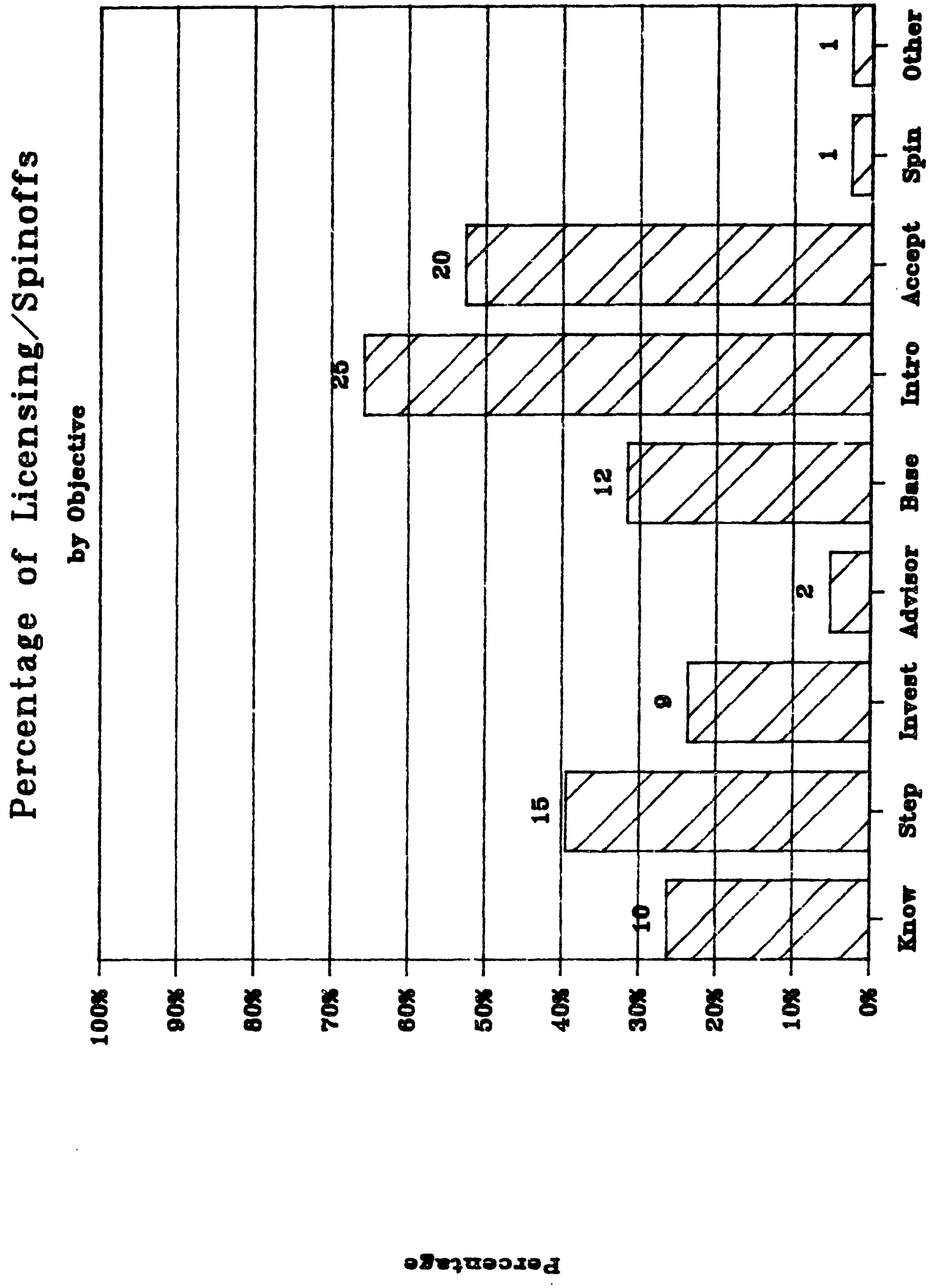
* Whereas "To obtain feedback from users" was an objective in 15% of the total cases, only 6% of the cases using Licensing/Spinoffs cited this as an objective. Also, while "To introduce a new technology to the end user" was an objective in 55% of the total transfers, almost 67% of those cases using Licensing/Spinoffs cited this as an objective.

* Whereas Defense Programs, Energy Research, and Renewable Energy sponsored 17%, 23%, and 28% of the total case studies respectively, 8%, 37%, and 16% of the case studies that used Licensing/Spinoffs were sponsored by DP, ER, and RE, respectively.

* Whereas "New Ventures" and "Utilities" received 21% and 29% of the total technology transfers, respectively, almost 38% and only 18% of the cases using Licensing/Spinoffs included these recipients, respectively.

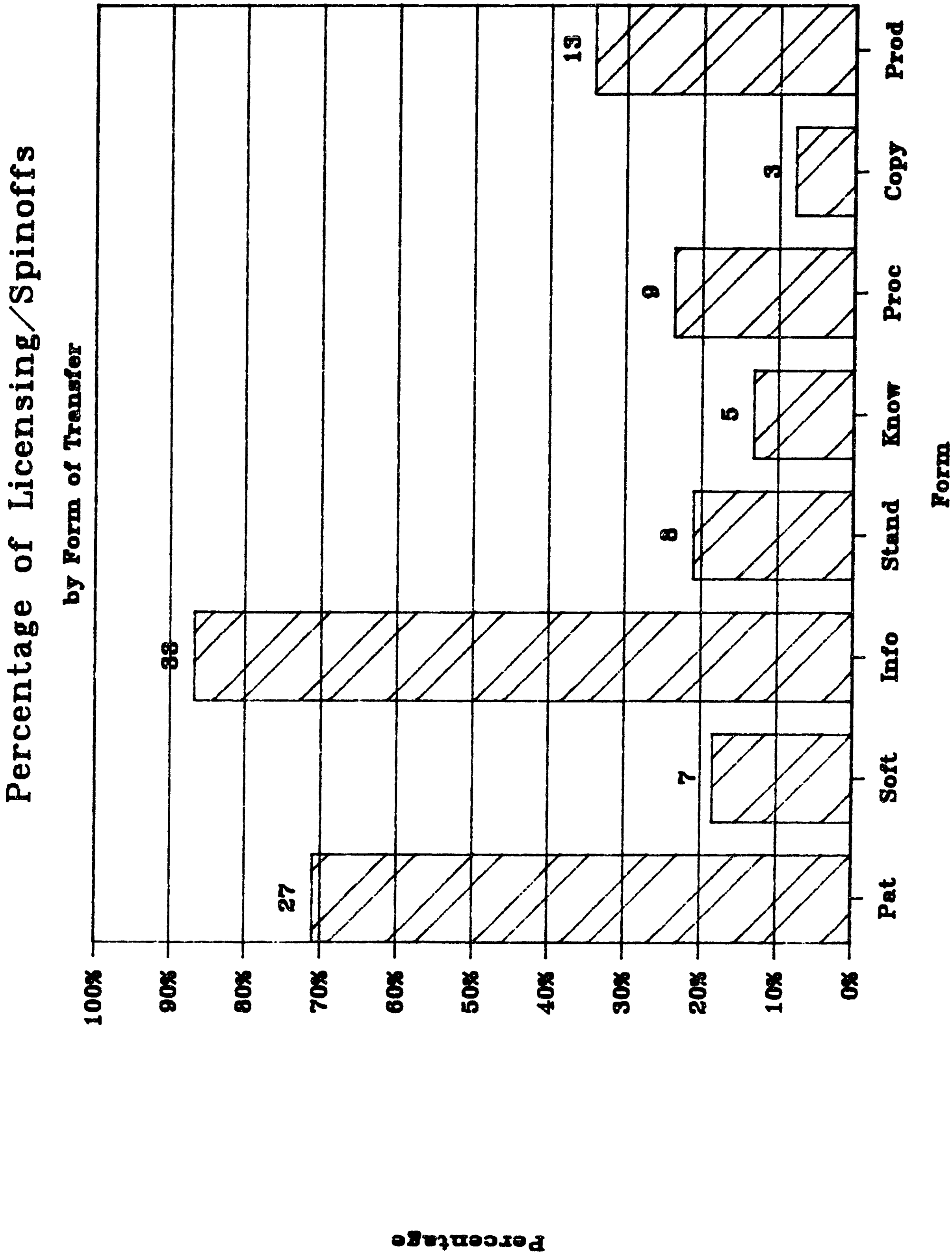
* Whereas 14% of the total cases were in the "Bas/Exp" stage of development, almost 32% of the cases using Licensing/Spinoffs were in this stage. On the other hand, although 38% of the total cases were in the "Technology Development" stage, only 21% of the cases using Licensing/Spinoffs were in this stage.

Graph F-1:

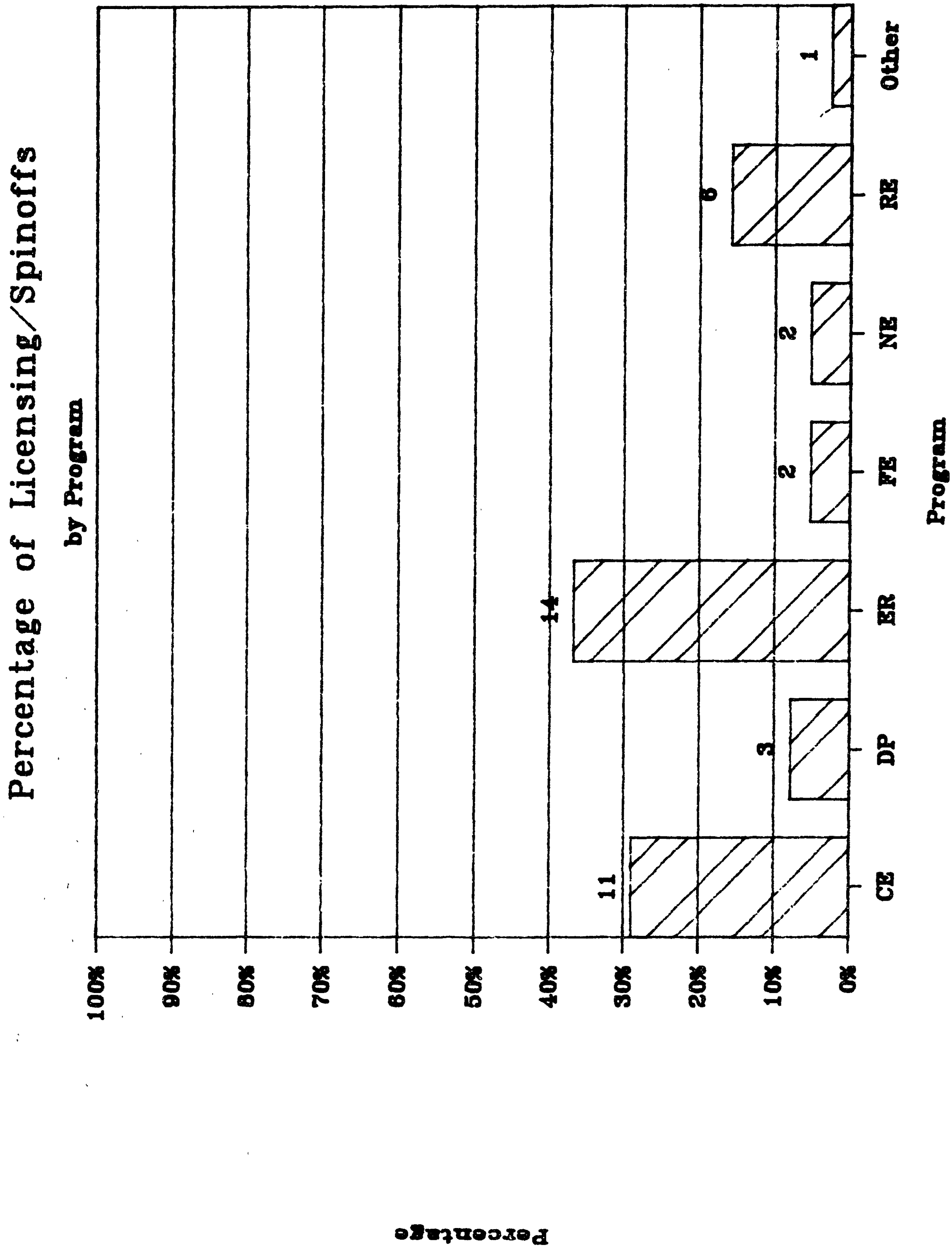


Percentage of Licensing/Spinoffs
by Objective
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
10
15
9
2
12
25
20
1
1
Know
Step
Invest
Advisor
Base
Intro
Accept
Spin
Other
Objective

Graph F-2:

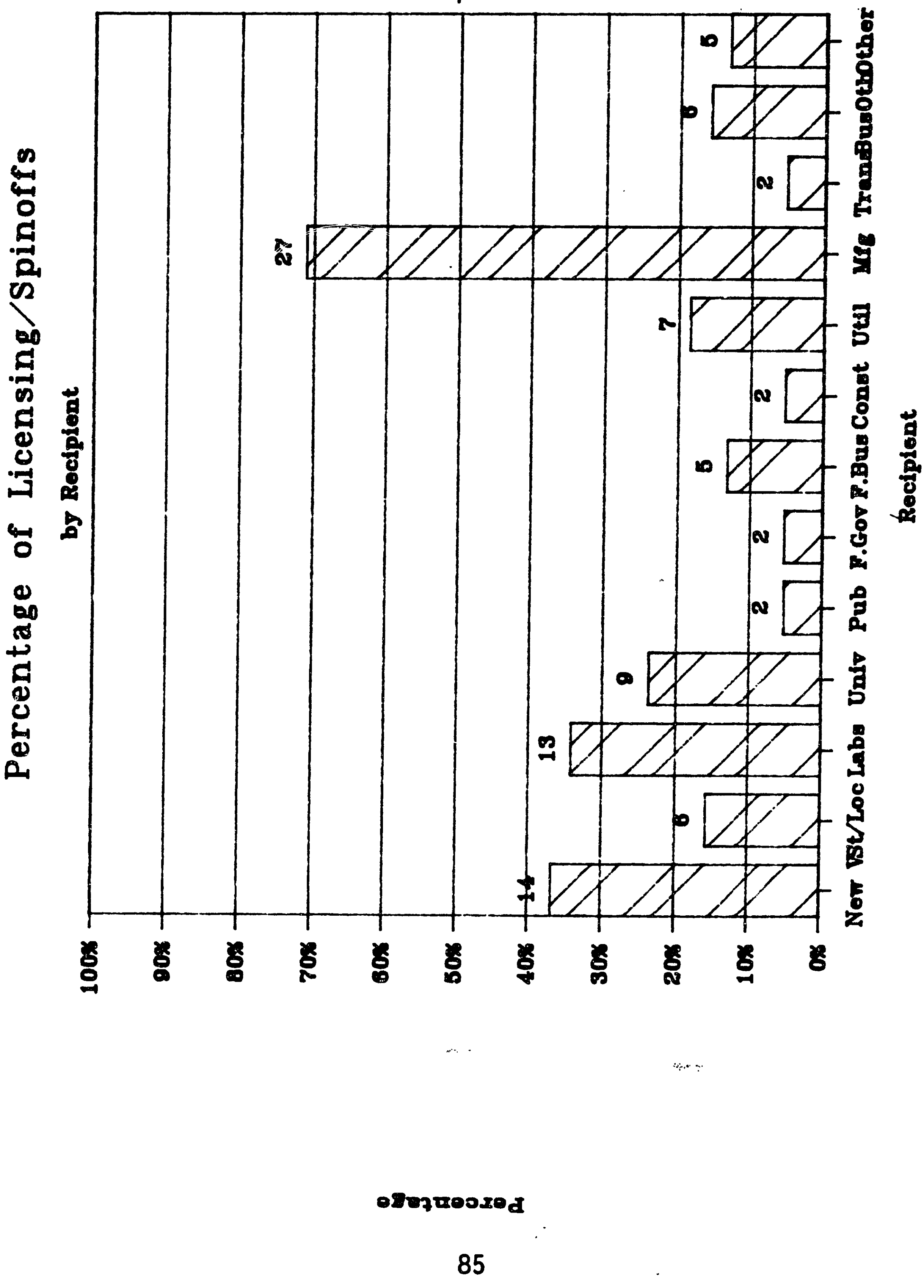

Percentage of Licensing/Spinoffs
by Form of Transfer
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
27
7
33
8
5
9
3
13
Pat
Soft
Info
Stand
Know
Proc
Copy
Prod
Form
Percentage

Graph F-3:



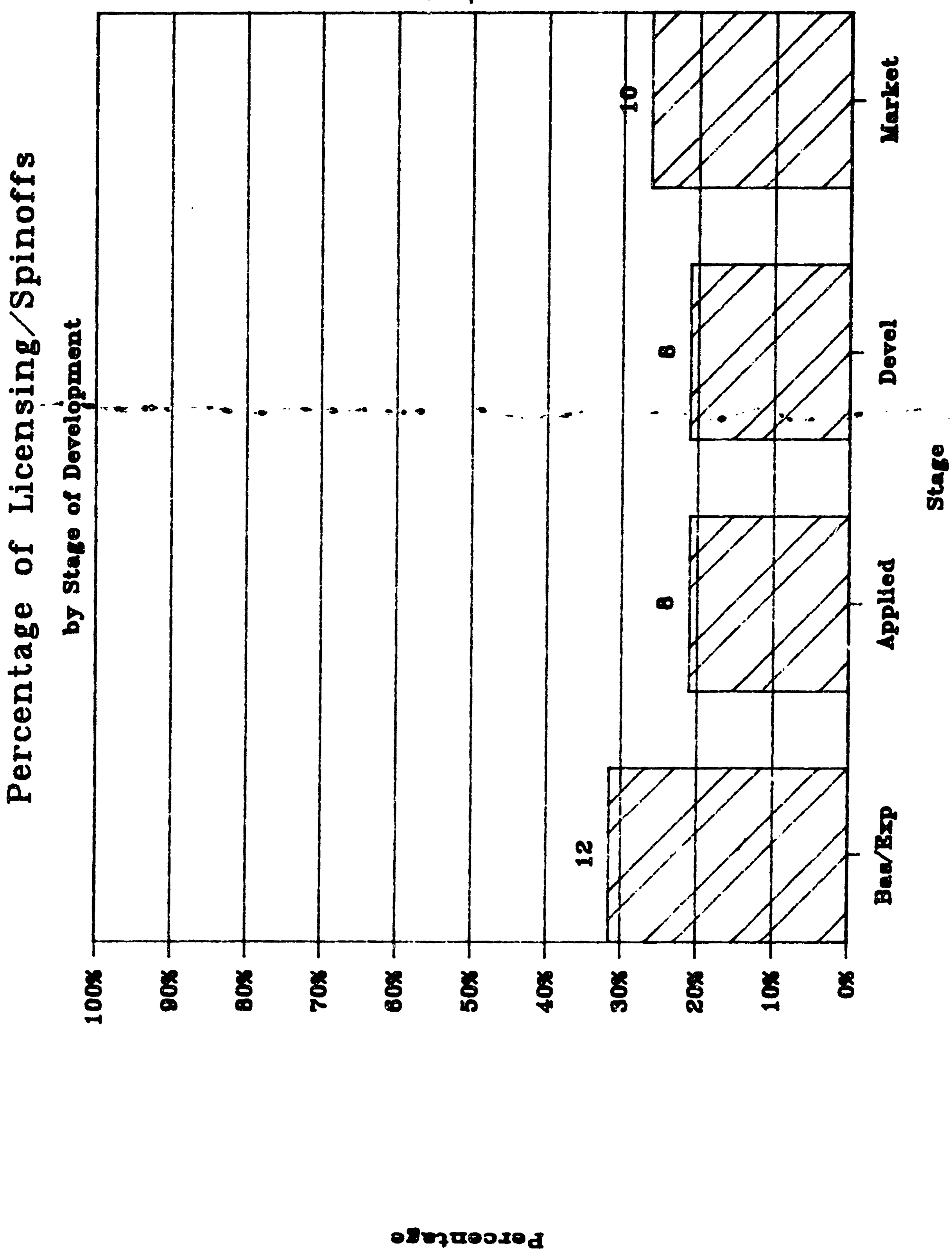
Percentage of Licensing/Spinoffs
by Program
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
11
3
14
2
2
6
1
CE
DP
ER
FE
NE
RE
Other
Program
Percentage

Graph F-4:

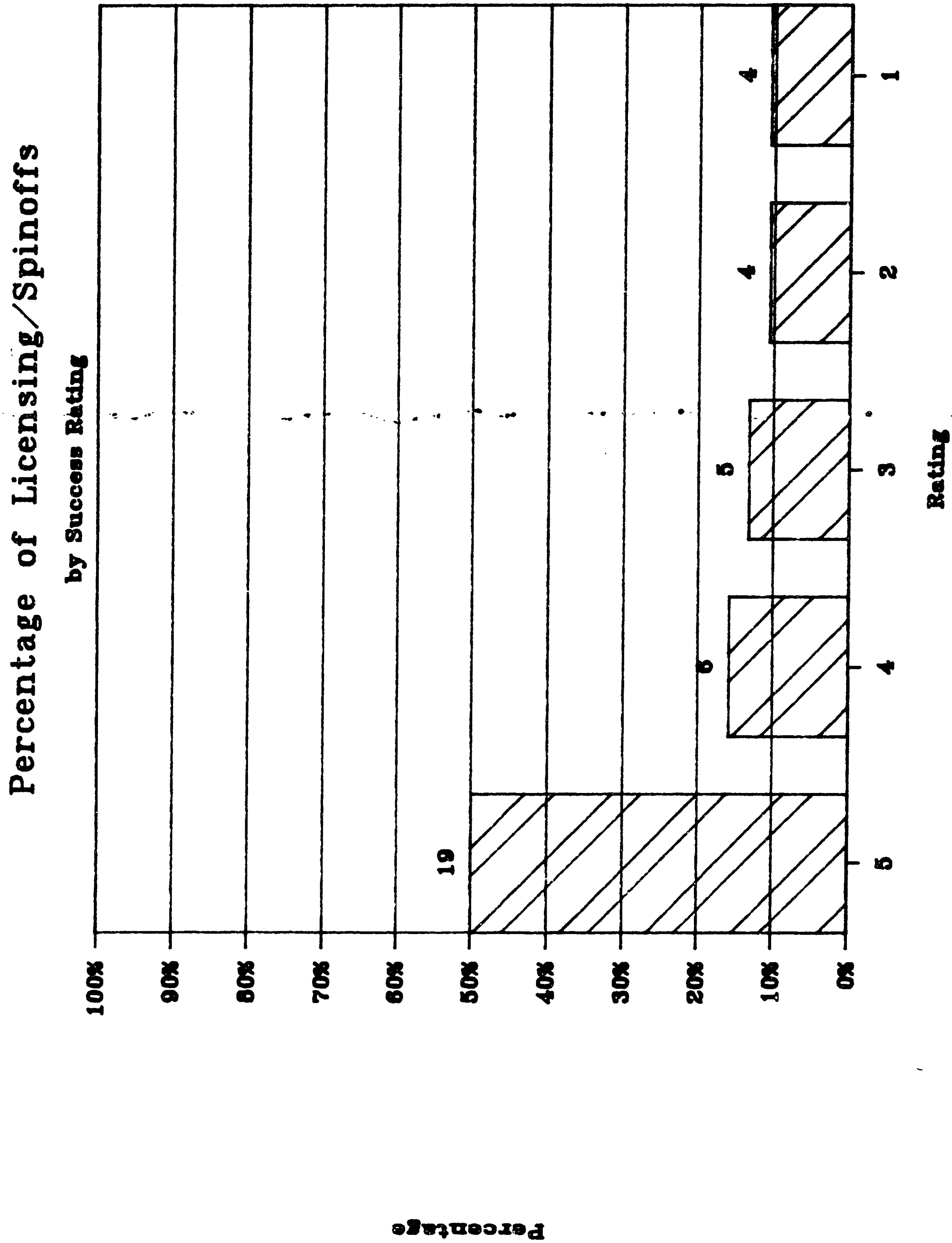


Percentage of Licensing/Spinoffs
by Recipient
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
14
6
13
9
2
2
5
2
7
27
2
6
5
New
VSt/Loc
Labs
Univ
Pub
F.Gov
F.Bus
Const
Util
Mfg
Trans
BusOth
Other
Recipient
Percentage

Graph F-5:


Percentage of Licensing/Spinoffs
by Stage of Development
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
12
8
8
10
Bas/Exp
Applied
Devel
Market
Stage

Graph F-6:


Percentage of Licensing/Spinoffs
by Success Rating
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
19
6
5
4
4
5
4
3
2
1
Rating
Percentage

4.1.7 Active Dissemination of Information

The dissemination of information, be it technical or otherwise, is an important aspect of technology transfer. The group of mechanisms defined as "Active Dissemination of Information" consists of information dissemination in ways that facilitate the active dialogue between the informer and the recipient. This can be one-on-one communication, or communication with organizations. However, to be in this group the communication mechanisms must have some sort of dialogue component, so that questions can be asked and answered, preferably on a personal level. The specific mechanisms which fall into this category are: "Broker Organizations," "Workshops, Seminars, or Conferences," "Information Dissemination Centers," and "Education." Because these are "active," specific technical questions can be asked and answered in two-way streams of information. Important here is the capabilities of the people interacting, their communication skills, and their desire to carry out the process.

Broker Organizations

Broker organizations are organizations whose primary function is to link the suppliers of technology with the recipients by acting as a network for open dialogue between the two groups.

Workshops, Seminars, or Conferences

These mechanisms entail meetings of varying degrees of formality and format to convey technical information. Usually at these functions time is set aside so that the technology "players" can interact and discuss particular problems, markets, developments, etc., relevant to their projects. The social aspect of these mechanisms should also not be ignored, as players can familiarize themselves with each other for future reference, interaction or communication.

Information Dissemination Centers

"Information dissemination centers" are centralized organizations that offer a variety of technical information resources and networking capabilities. These centers are often helpful in providing definitive answers to questions about relating to particular R&D problems. They also provide general information about the progress and developments in a particular field.

Education

"Education" refers to those mechanisms that are designed to teach those interested about new technologies and R&D

projects. This teaching takes place in many different types of educational surroundings: from public hearings to highly technical, university programs or classes.

Discussion of Graphs:

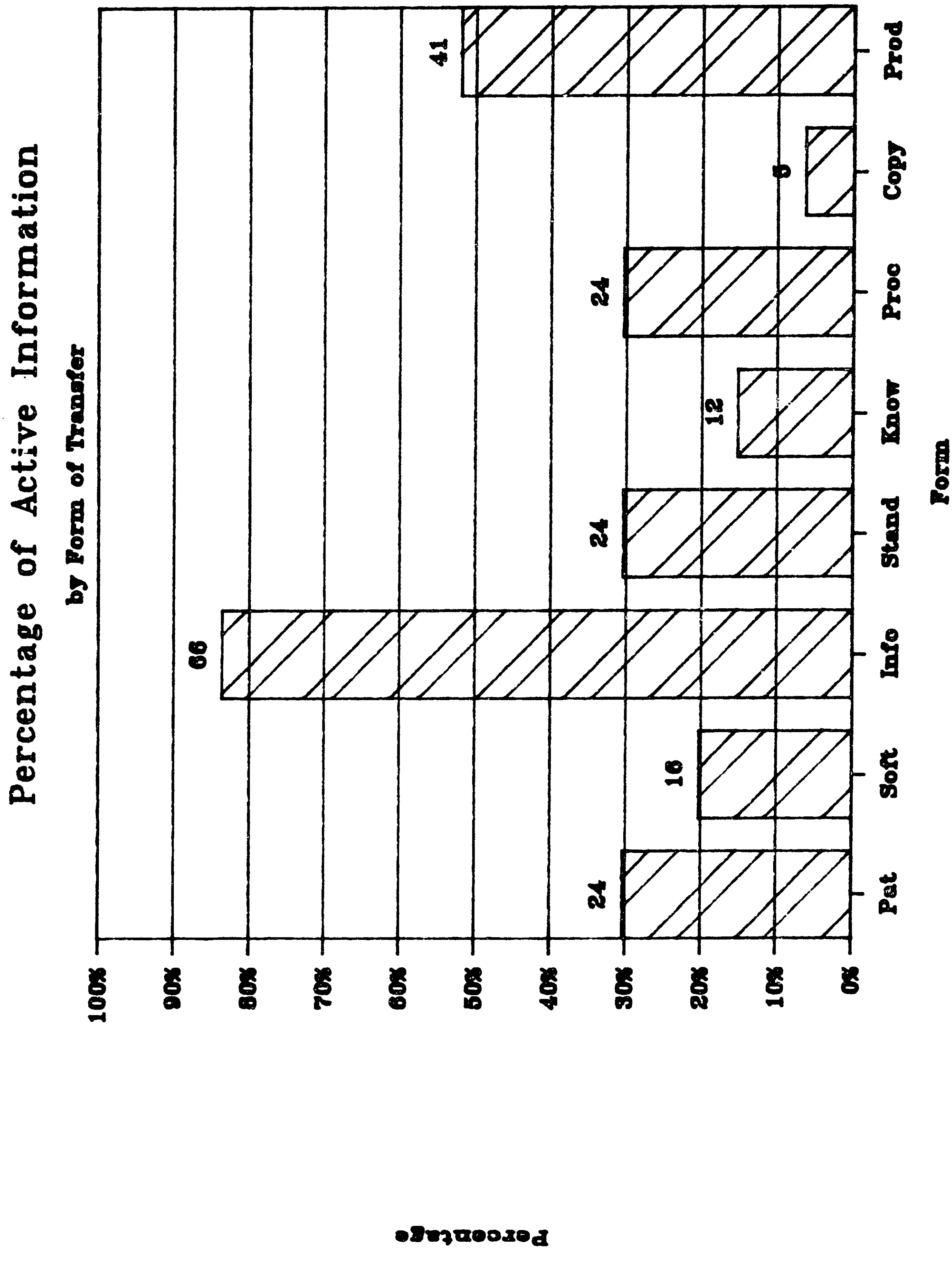
Graphs G-1 to G-6 show the cross-cut of cases that used Active Dissemination of Information as a mechanism with other variables of the survey. Notable differences between cases that used Active Dissemination of Information and the total cases are as follows:

* Whereas "Standards/Practices/Training" was the form of transfer for about 22% of the total cases, over 30% of those cases using the Active Dissemination of Information (I/A) had this as a form of technology transfer.

* Whereas "To introduce a new technology to the end user" was the objective of over 55% of the total number of cases, only 42% of the cases using I/A had this as an objective.

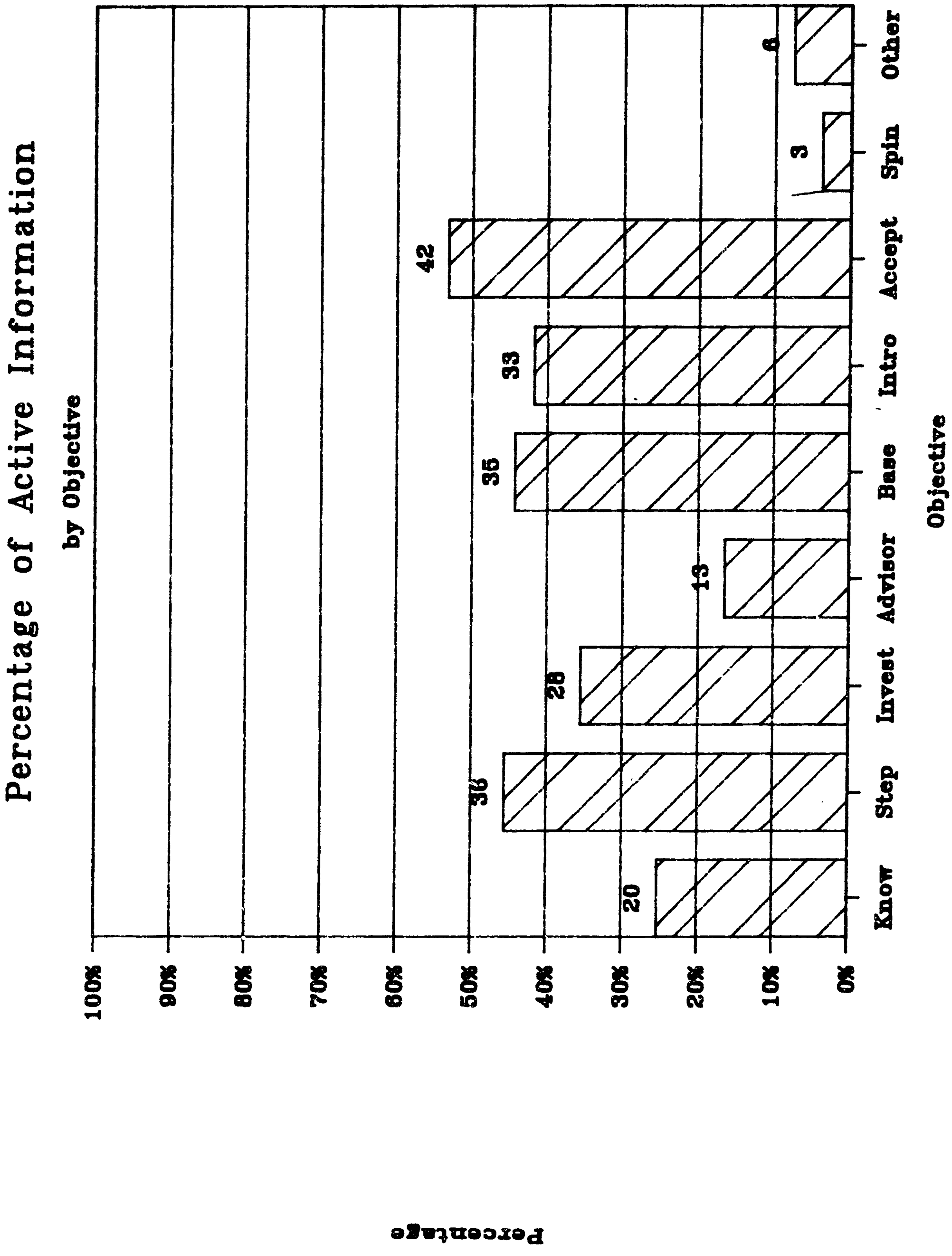
* Whereas Defense Programs sponsored 17% of the total number of case studies, only 8% of the cases using I/A were sponsored by DP.

Graph G-1:

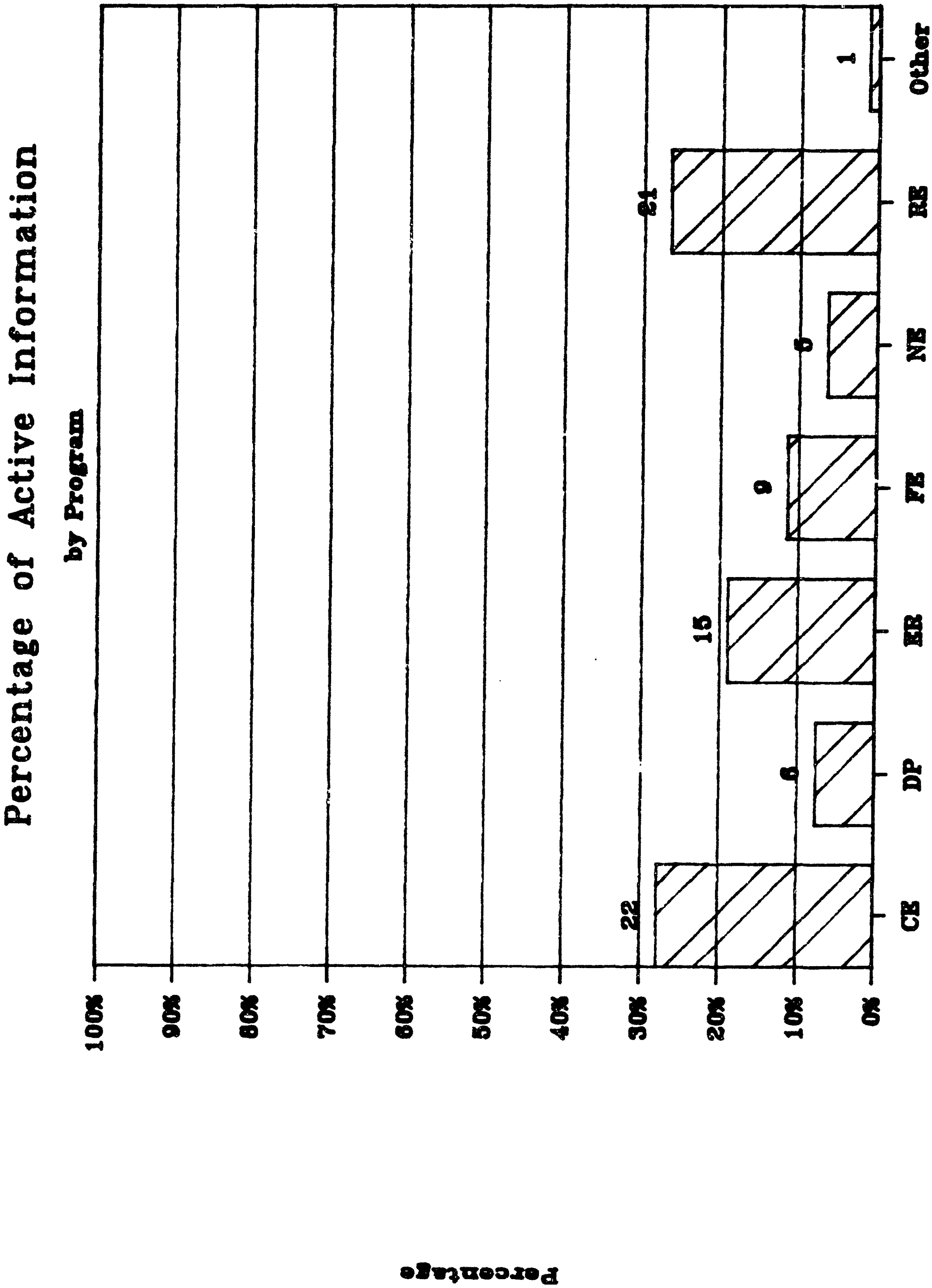


Percentage of Active Information
by Form of Transfer
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
24
16
66
24
12
24
5
41
Pat
Soft
Info
Stand
Know
Proc
Copy
Prod
Form
Percentage

Graph G-2:

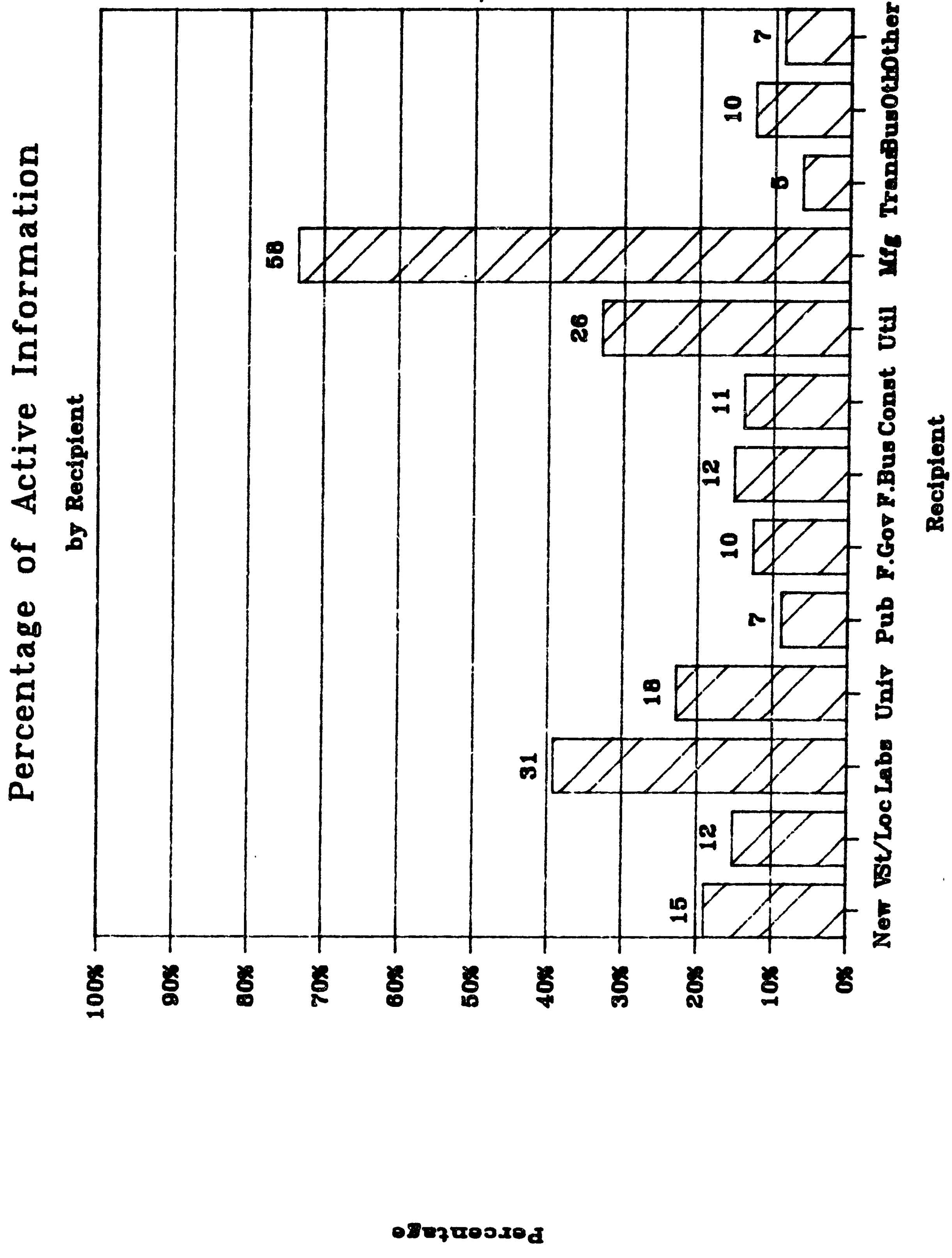

Percentage of Active Information
by Objective
20
36
28
13
35
33
42
3
6
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Know
Step
Invest
Advisor
Base
Intro
Accept
Spin
Other
Objective
Percentage

Graph G-3:



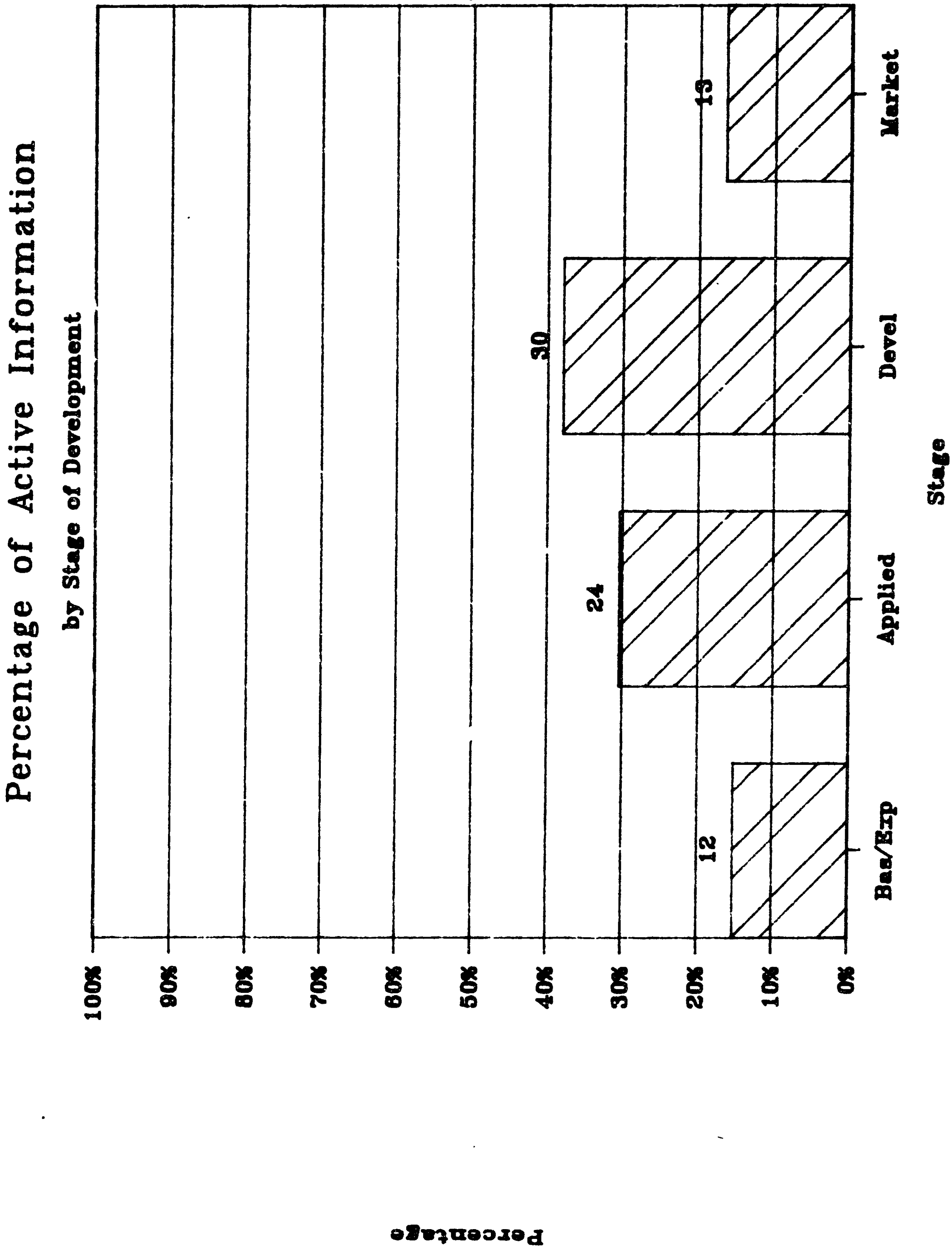
Percentage of Active Information
by Program
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
22
6
15
9
5
21
1
CE
DP
EE
FE
NE
RE
Other
Program

Graph G-4:



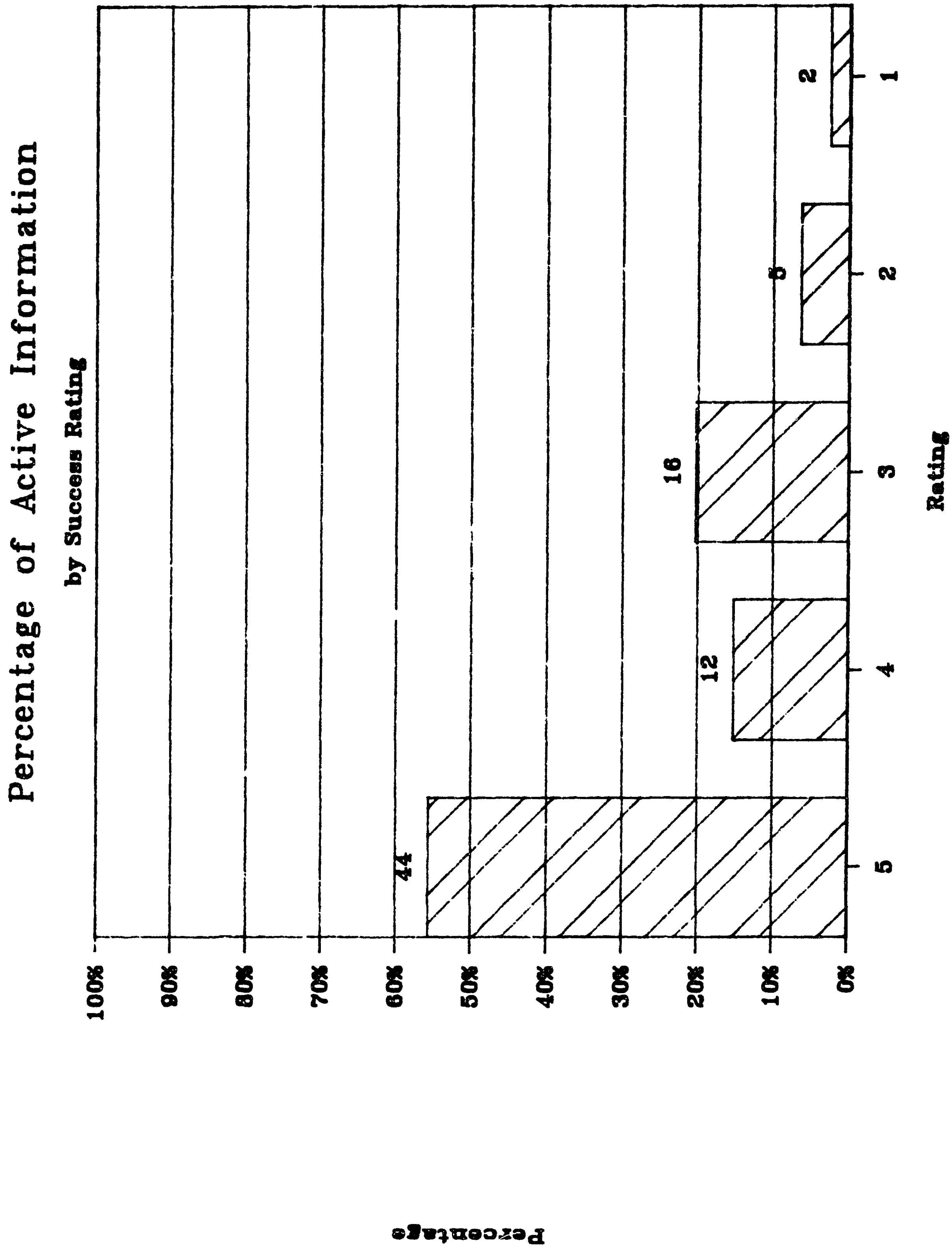
Percentage of Active Information
by Recipient
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
15
12
31
18
7
10
12
11
26
58
5
10
7
New
VSt/Loc
Labs
Univ
Pub
F.Gov
F.Bus
Const
Util
Mfg
Trans
BusOth
Other
Recipient
Percentage

Graph G-5:



Percentage of Active Information
by Stage of Development
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
12
24
30
13
Bas/Exp
Applied
Devel
Market
Stage

Graph G-6:


Percentage of Active Information
by Success Rating
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
44
12
16
5
2
5
4
3
2
1
Rating
Percentage

4.1.8 Passive Dissemination of Information

"Passive Dissemination of Information," as alluded to above, entails those mechanisms that provide information about a technology or its developments with communication that is, more or less, "one-way." Information disseminated through "Mailings," "Technical Reports," "News Releases," "Journals and Magazines," "Fact Sheets," "Video Tapes," "Decision Tool Programs," or "Electronic Bulletin Boards" all fall into this category.[41]

Mailings

"Mailings" consist of the widespread or selected dissemination of information, research results, or technological opportunities through the mail.

Technical Reports

"Technical reports" are formal reports that document the progress of a given R&D program or project. These are usually required by many programs where sponsors need to ensure that their contracted is progressing. These provide comprehensive technical information.

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[41] Although there may be some type of interaction between members on an electronic bulletin board system, this is not considered an "active" approach for this thesis because it does not bring with it the necessary human interactions that make active dissemination dynamic, spontaneous, and immediately responsive.

News Releases

"News releases" include nontechnical summaries of research and development projects that are widely disseminated through public, mainstream media.

Articles in Journals and Magazines

"Articles in journals and magazines" are articles published in journals or magazines describing any R&D projects or results that may be attained by the researching group.

Fact Sheets

"Fact sheets" are brief summaries of research developments, accomplishments or products, including information on applications, relevant data, etc. This versatile group is often used as handouts, mailing pieces, background for news releases, or responses to inquiries.

Video tapes

"Video tapes" consist of formal, scripted video programs or informal enactments of experiments, tests or procedures, to explain a process or development to the recipient. Because of the visual aspect of this mechanism, recipients can actually see particular processes or experiments being carried out.

Decision Tools

Decision tools are computer programs employing logical reasoning to help the user make choices among certain decision options; They are particularly useful for training, design studies, or diagnostic routines.

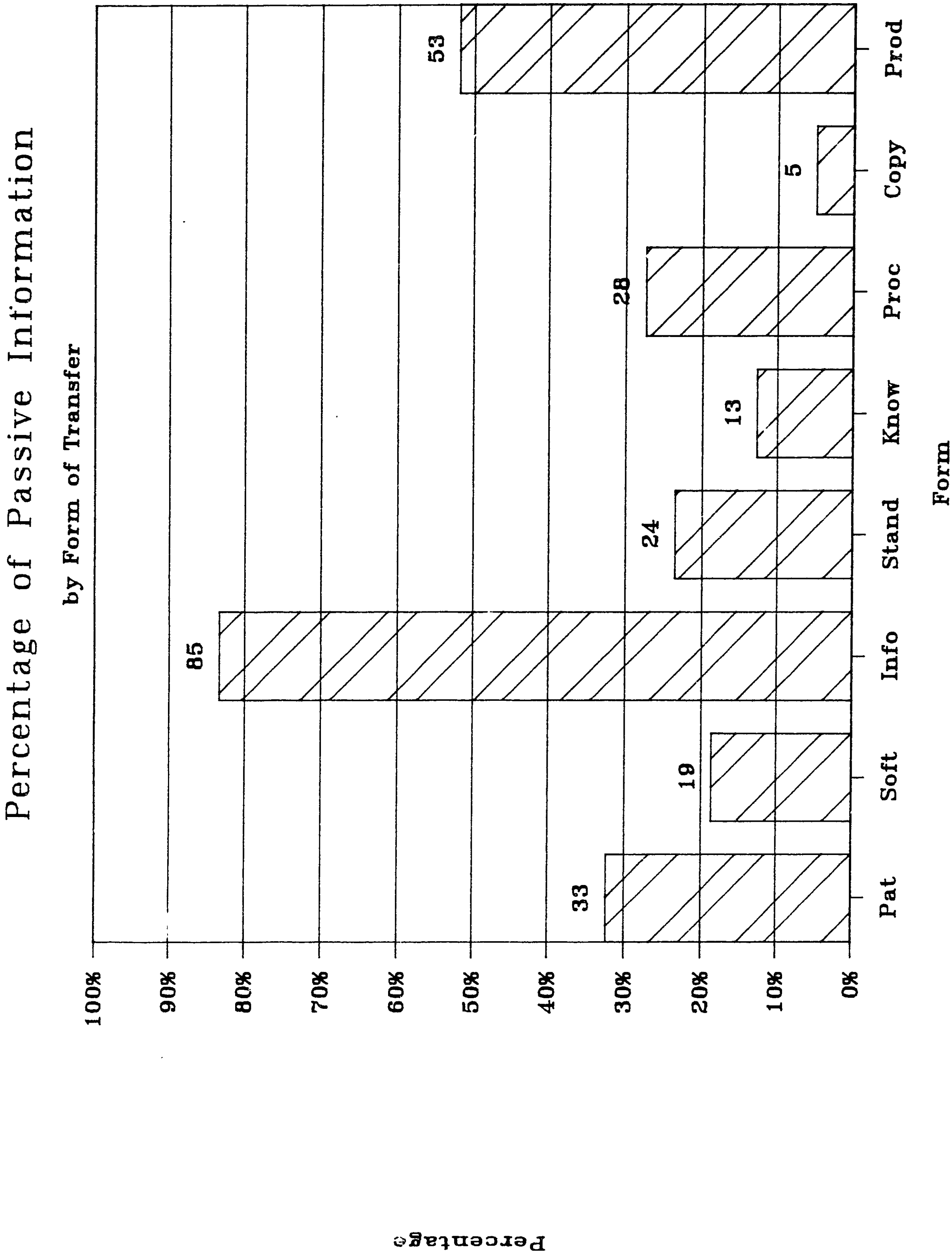
Electronic Bulletin Boards

This mechanism consists of the transfer of information through electronic computer network systems, and can include anything from the posting of a calendar of events, to the electronic sending of much more complex technical data.

Discussion of Graphs:

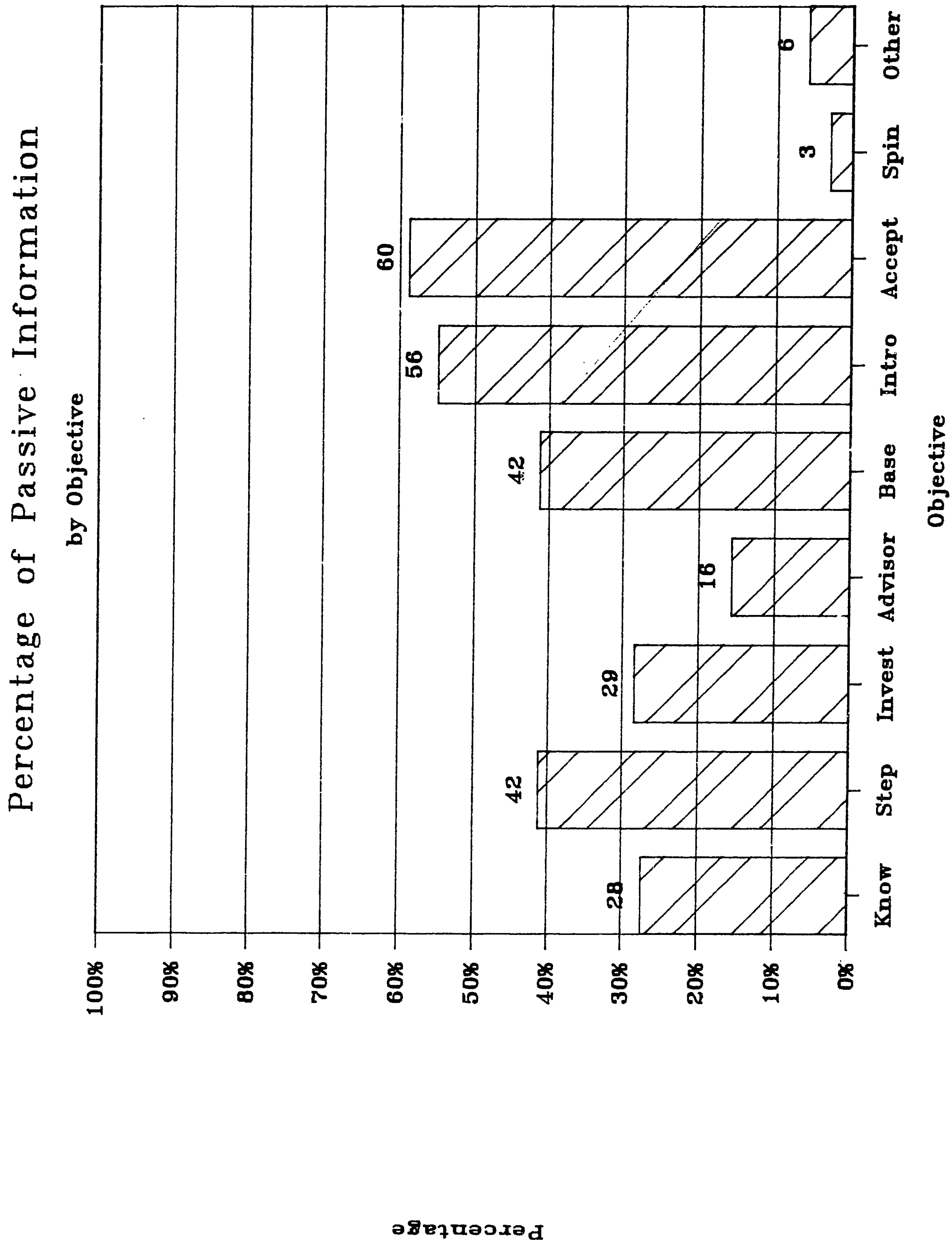
Graphs H-1 to H-6 show the cross-cut of cases that used Passive Dissemination of Information as a mechanism with other variables of the survey. There are no notable differences between cases that used Passive Dissemination of Information and the total cases.

Graph H-1:



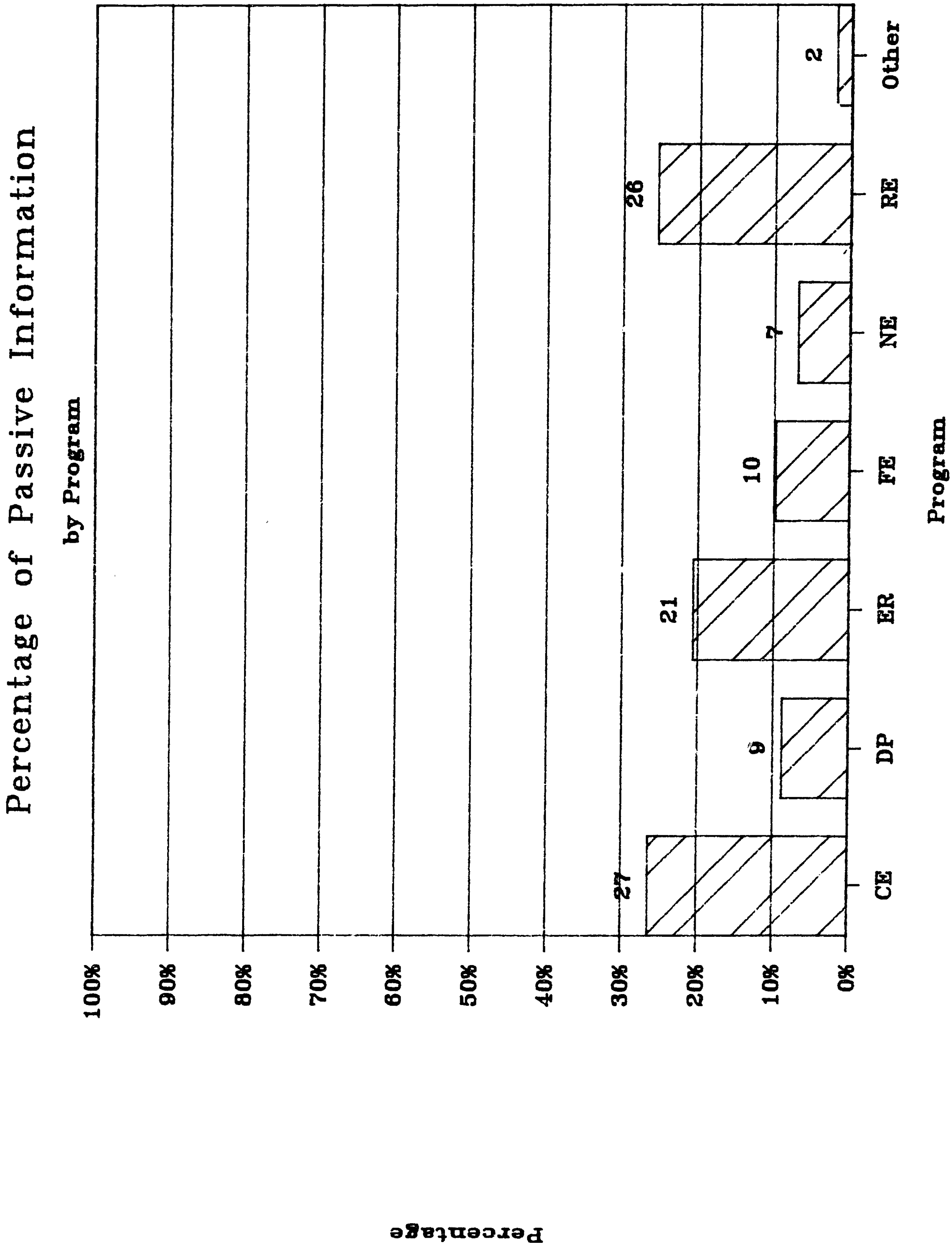
Percentage of Passive Information
by Form of Transfer
Percentage
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
33
19
85
24
13
28
5
53
Pat
Soft
Info
Stand
Know
Proc
Copy
Prod
Form

Graph H-2:

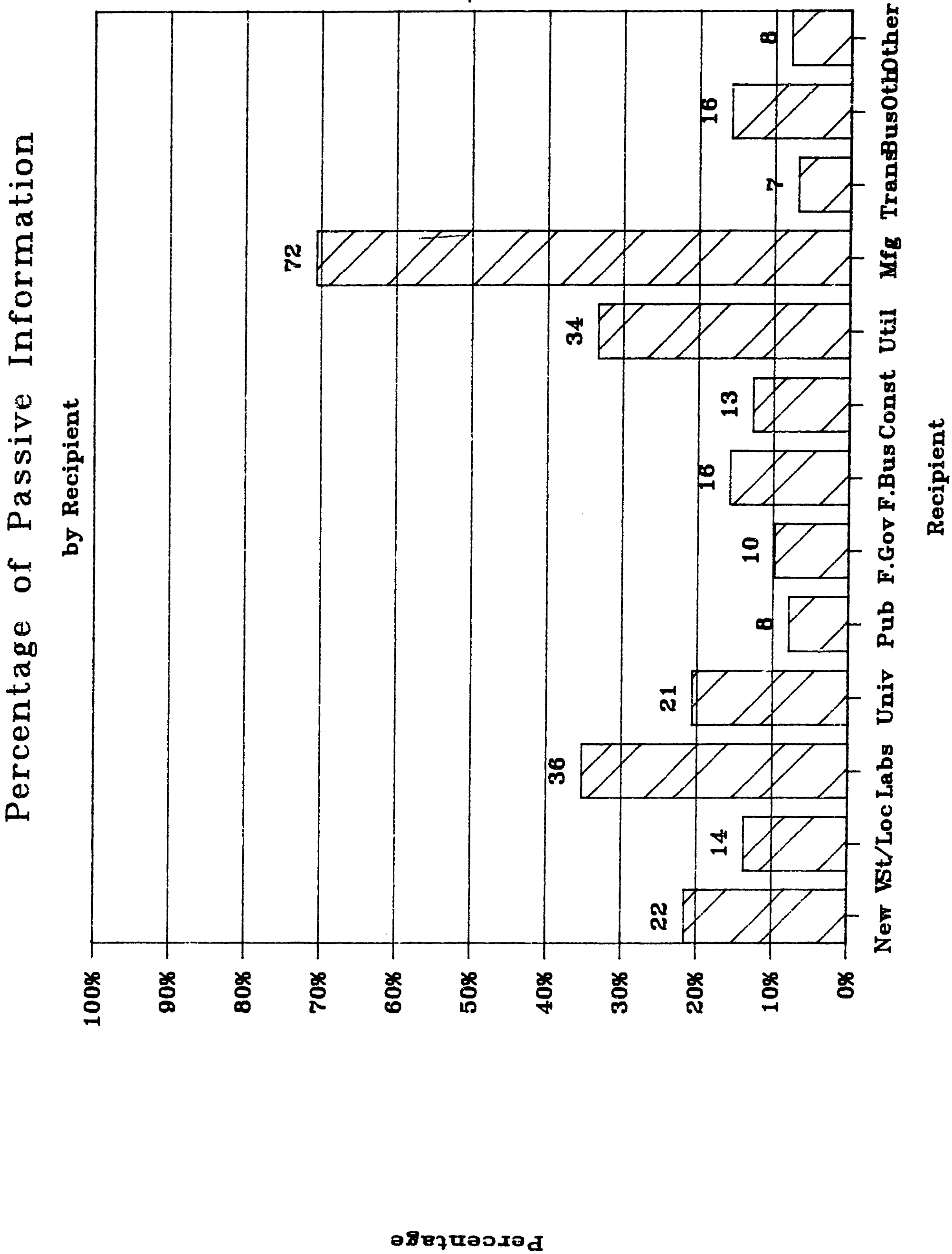


Percentage of Passive Information
by Objective
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
Objective
Know
Step
Invest
Advisor
Base
Intro
Accept
Spin
Other
28
42
29
16
42
56
60
3
6

Graph H-3:

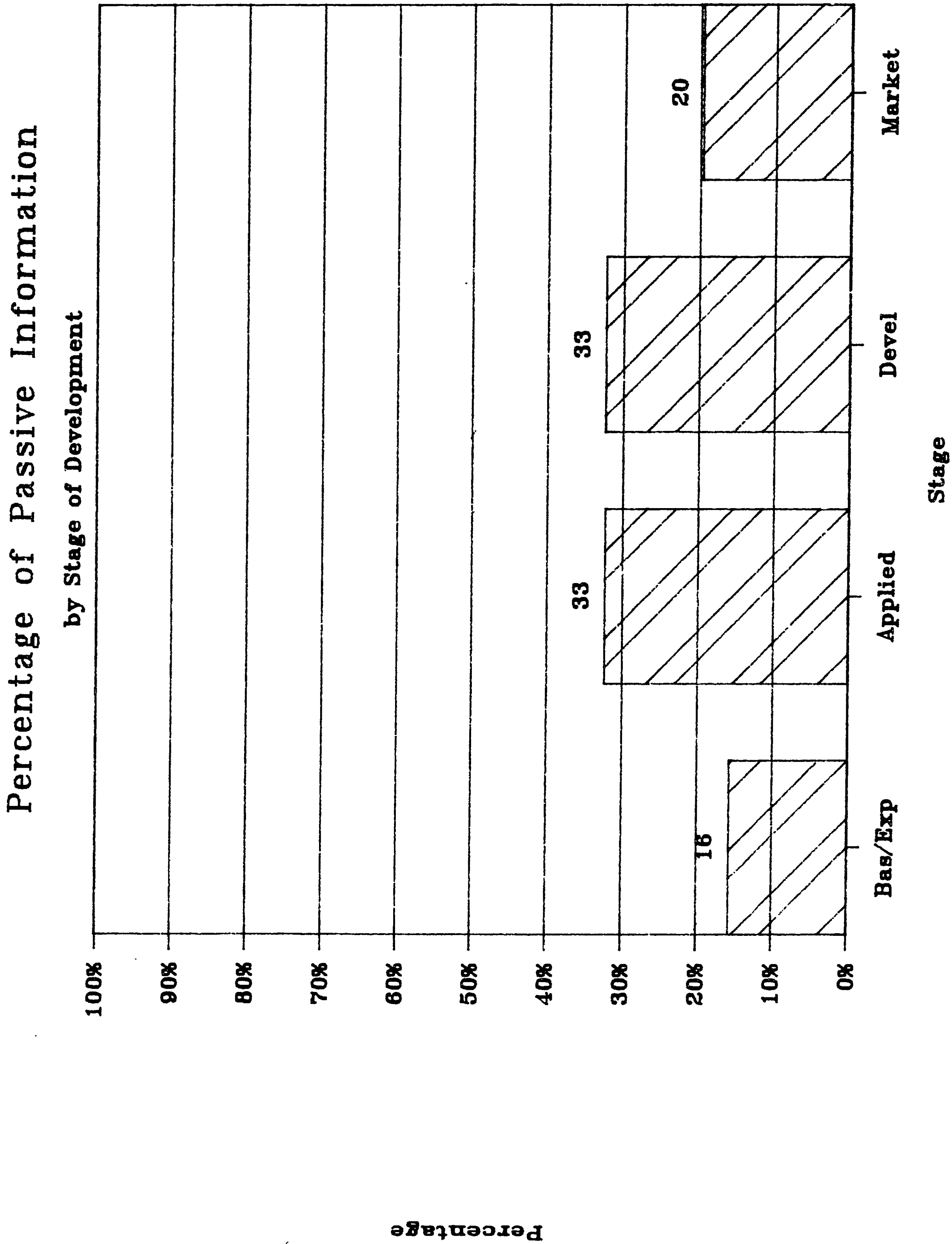

Percentage of Passive Information
by Program
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage
27
9
21
10
7
26
2
CE
DP
ER
FE
NE
RE
Other
Program

Graph H-4:

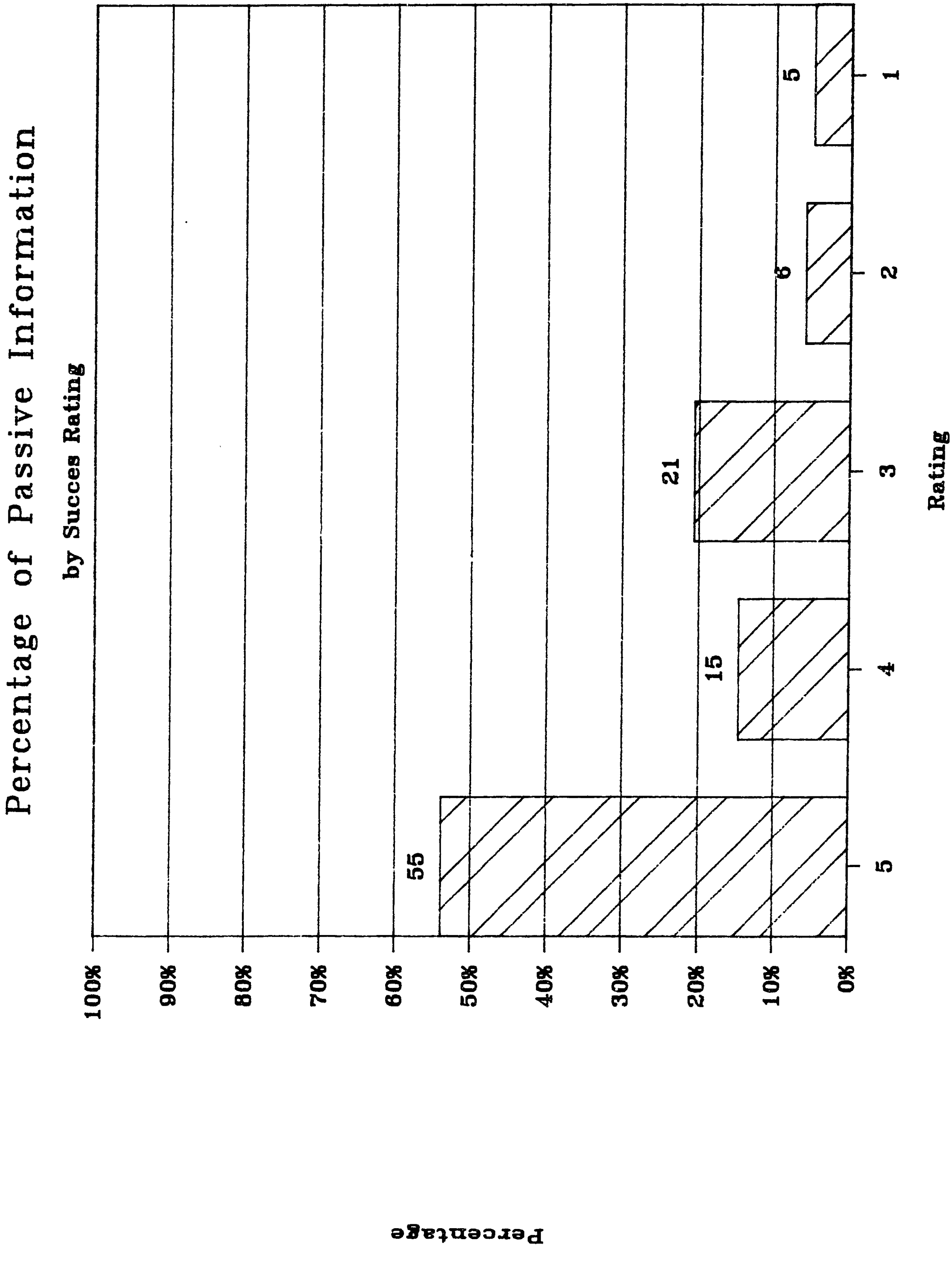


Percentage of Passive Information
by Recipient
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
22
14
36
21
8
10
16
13
34
72
7
16
8
New
VSt/Loc
Labs
Univ
Pub
F.Gov
F.Bus
Const
Util
Mfg
Trans
BusOth
Other
Recipient
Percentage

Graph H-5:


Percentage of Passive Information
by Stage of Development
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
16
33
33
20
Bas/Exp
Applied
Devel
Market
Stage
Percentage

Graph H-6:


Percentage of Passive Information
by Succes Rating
55
15
21
6
5
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
5
4
3
2
1
Rating
Percentage

CHAPTER FIVE:
METHODOLOGY, RESULTS AND ANALYSIS

5.0 Methodology

The analysis of the survey data is in two parts. In the first part, the characteristics of each group of mechanisms are considered. This section is provided in Chapter Four and only examines frequencies of occurrence -- that is, the number of times a mechanism is used in conjunction with other survey variables.

Part two of the analysis, provided here, explores the relationships among a technology's stage of development, the mechanisms used for its transfer, and its success rating. Student T-Tests are used to describe statistically the difference in the means between scenarios that use a specific mechanism and ones that do not.[42] The relatively simple question is asked: What is the difference of the success ratings (mean score) between cases where a given mechanism is used and those cases where that same mechanism is not used. This statistical analysis can determine the importance of a mechanism's inclusion in a technology transfer strategy for each stage of development.

---

[42] Student T-Tests, or Difference of the Means tests, have been used for studies similar to this. See Tushman and Katz for an example of such a use.

5.1 Results and Analysis

The relationship among success, stage of development, and mechanisms used was explored using Student T-Tests (sometimes called "Difference of the Means" tests). As stated above, the Student T-Tests examine the mean success rating for case studies that used a given mechanism against those that did not for each stage of development. The results are presented in tabular form and discussion of each mechanism follow the respective table. One (*), two (**), or three (***) asterisks follow those results that are statistically significant to the 95%, 85%, and 75% certainty levels, respectively; that is, $p(*) < .05$, $p(**) < .15$, and $p(***) < .25$. Table 5-1 gives the breakdown of all the cases with respect to their mean success rating and the technology's stage of development. Tables 5-2 to 5-8 represent the T-Tests for each of the respective groups of mechanisms, and Table 5-9 provides a look at a combination of the two most successful mechanisms. Graphs 5-1 to 5-8 present these results graphically.

TABLE 5-1
Breakdown of Total Cases

Stage	N	Mean	Std.Dev.
Total	116	4.026	1.233
Basic/ Exploratory	16	3.813	1.328
Applied	33	4.121	1.023
Technology Development	44	3.864	1.374
Market Penetration	23	4.348	1.152

5.1.1 Significant Findings

The following is a composite of the significant findings from this analysis:

* When an **Advisory Group** is used as a technology transfer mechanism, it makes a statistically significant positive contribution to transfer success in general ($p<.15$) and in the Technology Development stage of development ($p<.05$) in particular (see Table 5-2 and discussion).
* When **Collaboration With Cost-Sharing** is used as a technology transfer mechanism, it makes a statistically significant positive contribution to transfer success in general ($p<.05$), in the Market Penetration stage of

development ($p<.05$), and in the Technology Development stage of development ($p<.25$) (see Table 5-3 and discussion).

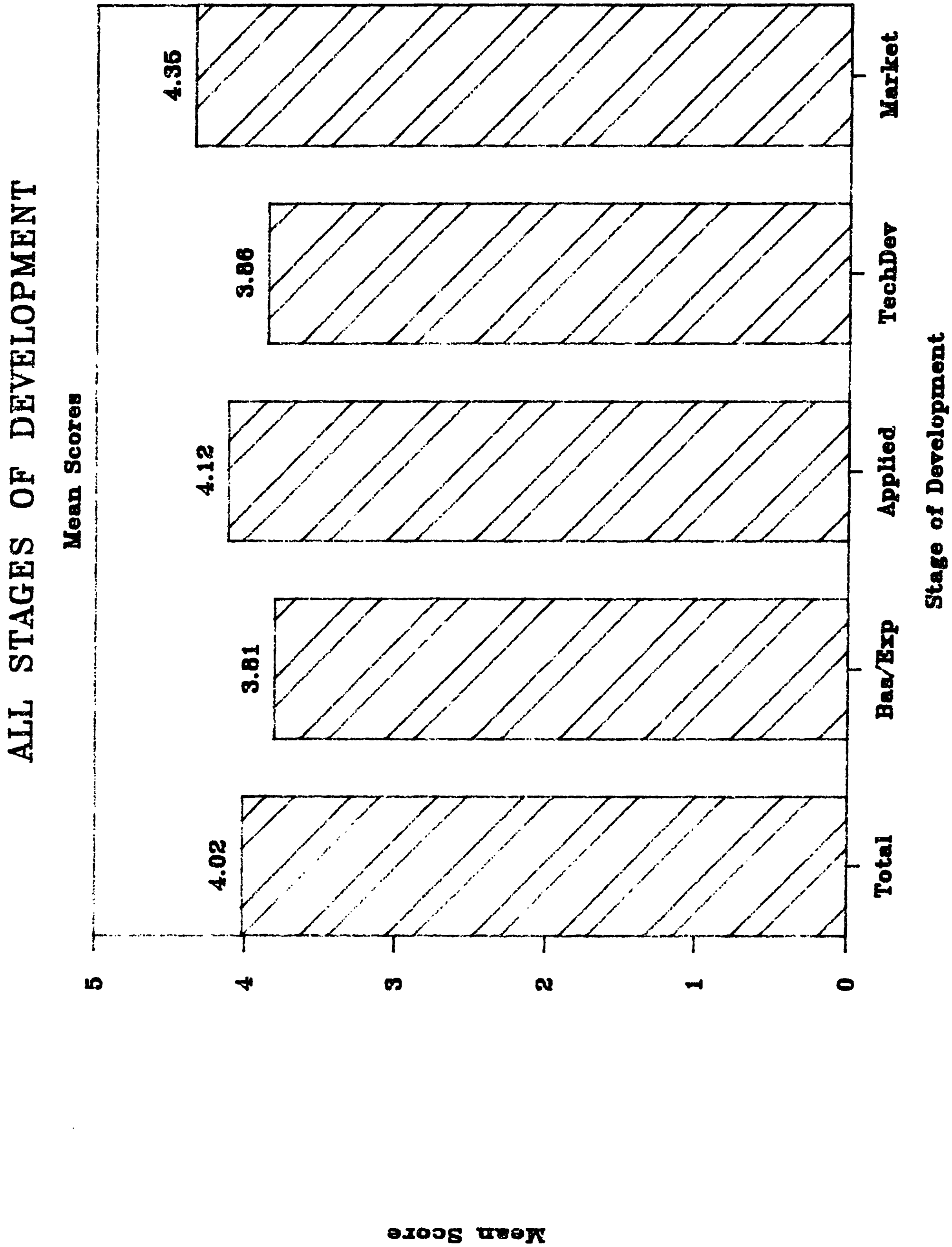
* When **Collaboration Without Cost-Sharing** is used as a technology transfer mechanism, it makes a statistically significant positive contribution to transfer success in the Technology Development stage of development ($p<.15$). However, when this mechanism is used in the Market Penetration stage of development there is a significant negative contribution to transfer success ($p<.25$) (see Table 5-4 and discussion).
* When **Personnel Exchange** is used as a technology transfer mechanism, it makes no statistically significant contributions, positive or negative, to transfer success (see Table 5-5 and discussion).
* When **Licensing/Spinoffs** are used as technology transfer mechanisms, they make a statistically significant negative contribution to transfer success in the Basic/Exploratory ($p<.25$) and Market Penetration ($p<.25$) stages of development (see Table 5-6 and discussion).
* When the **Active Dissemination of Information** is used as a technology transfer mechanism, it makes a statistically

significant positive contribution to transfer success in general (p<.15), in the Basic/Exploratory stage of development (p<.25), in the Technology Development stage of development (p<.15), and in the Market Penetration stage of development (p<.25) (see Table 5-7 and discussion).

* When the **Passive Dissemination of Information** is used as a technology transfer mechanism, it makes no statistically significant contributions, positive or negative, to transfer success (see Table 5-8 and discussion).

* In general, cases using **Advisory Groups** and **Collaboration With Cost Sharing** have much higher mean success scores than the total average. Cases using **Collaboration Without Cost Sharing** and **Active Dissemination of Information** have mean scores only somewhat higher than the total average, and those using **Passive Dissemination of Information** to an even lesser degree. Cases using **Licensing/Spinoffs** actually have mean success scores lower than the total average (see Table 5-9 and discussion).

GRAPH 5-1:


ALL STAGES OF DEVELOPMENT
Mean Scores
4.02
3.81
4.12
3.86
4.35
Total
Bas/Exp
Applied
TechDev
Market
Stage of Development
0
1
2
3
4
5
Mean Score

5.1.2 Advisory Groups

TABLE 5-2
Student T-Tests for Cases With or Without Given Mechanism as a Function of Total and Stage of Development

MECHANISM: **Advisory Groups**

Stage of Development	Mean Without	Mean With	T-Value	2-Tail Prob.
Total	3.88 (N=67)	4.22 (N=49)	-1.491	.1387 **
Basic/Exploratory	3.57 (N= 7)	4.00 (N= 9)	-0.627	.5404
Applied	4.12 (N=17)	4.13 (N=16)	-0.020	.9839
Technology Development	3.52 (N=27)	4.41 (N=17)	-2.190	.0341 *
Market Penetration	4.38 (N=16)	4.29 (N= 7)	0.167	.8689

Discussion of Table 5-2:

As seen in the table, when an Advisory Group is used as a technology transfer mechanism, it makes a statistically significant positive contribution to transfer success in general ($p<.15$) and in the Technology Development stage of development ($p<.05$) in particular.

The positive contribution of Advisory Groups is what one would expect, given the interactive and "technically personalized" nature of these types of mechanisms. Indeed, one study of the technology transfer process at Federal labs identified that two of the major barriers of technology transfer are that the expectations of one party are not always shared by the other party, and that there often exists a lack of awareness of the value of the technology being transferred.[43] Advisory Groups would seem to solve both of these problems by giving a consensual direction or focus to the research and development process. The Technology Development stage of development also seems like the appropriate stage of development for this contribution to stand out, since it is in this stage that specific questions arise that need to be addressed by a diverse and often market oriented group of experts. These conclusions are supported by another study, called Project SAPPHO (Scientific Activity Predictor from Patterns with Heuristic Origins), which showed that pre requisites for successful innovations include an understanding of user needs, attention to marketing and publicity, and using of outside technology and scientific advice.[44]

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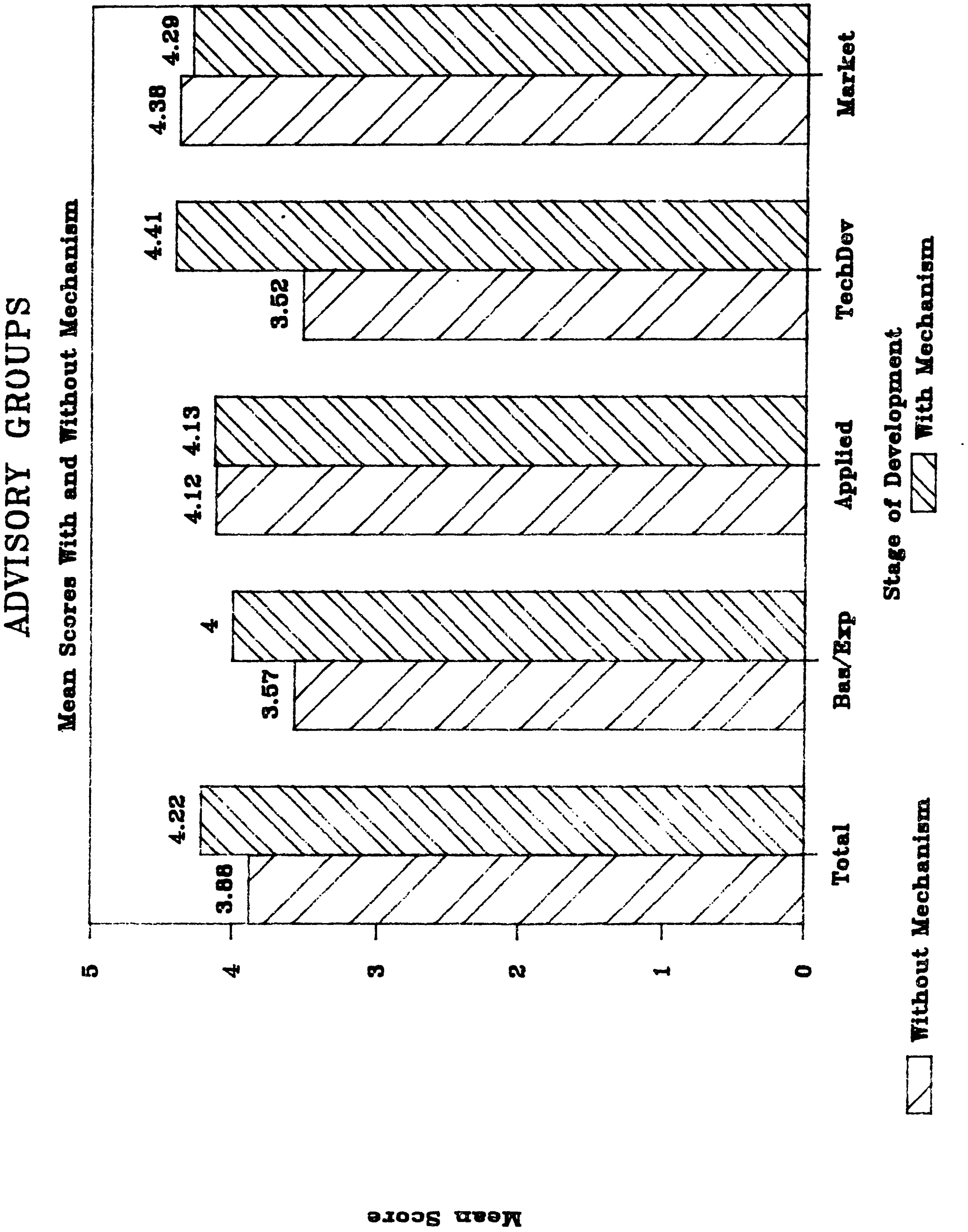
[43] DeBruin and Corey, "Technology Transfer: Transferring Federal R&D Results For Domestic Commercial Utilization," report SAND88-1716, for the United States Department of Energy, August, 1988, p.62.

[44] Rothwell, p.125.

Graph 5-2:


ADVISORY GROUPS
Mean Scores With and Without Mechanism
Mean Score
5
4
3
2
1
0
3.88
4.22
3.57
4
4.12
4.13
3.52
4.41
4.38
4.29
Total
Bas/Exp
Applied
TechDev
Market
Stage of Development
Without Mechanism
With Mechanism

5.1.3 Collaboration With Cost Sharing

TABLE 5-3
Student T-Tests for Cases With or Without Given Mechanism as a Function of Total and Stage of Development

MECHANISM: **Collaboration With Cost Sharing**

Stage of Development	Mean Without	Mean With	T-Value	2-Tail Prob.
Total	3.67 (N=43)	4.23 (N=73)	-2.404	.0178 *
Basic/Exploratory	3.50 (N= 8)	4.13 (N= 8)	-0.937	.3643
Applied	4.00 (N= 4)	4.14 (N=29)	-0.249	.8050
Technology Development	3.60 (N=20)	4.08 (N=24)	-1.167	.2499 ***
Market Penetration	3.82 (N=11)	4.83 (N=12)	-2.308	.0312 *

Discussion of Table 5-3:

As seen in the table, when Collaboration With Cost Sharing is used as a technology transfer mechanism, it makes a highly positive contribution to transfer success in general ($p<.05$), and in the Market Penetration stage of development ($p<.05$). There is also a significant positive contribution, though not as strong in the Technology Development stage of development ($p<.25$). A weak positive contribution exists in the Basic or Exploratory R&D stage of development.

The fact that financial incentives (through cost sharing) are quite effective at breeding successful technology transfers is confirmed by the data in this table. Several explanations for this phenomenon are possible: (1) cost sharing (and the potential financial losses associated with it) forces recipients to look more carefully at a project before entering a collaborative agreement, and only those projects showing high success potential are chosen; (2) cost sharing may attract recipients with money already invested in the technology elsewhere or in some other form, and these recipients bring with them the experience that successful transfers need; (3) cost sharing promises that certain intellectual property rights or licenses remain protected,[45] and hence, the potential profit incentive of these projects remains,[46] or, (4) cost sharing breeds a commitment by both

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[45] Studies have shown that the confidentiality of company data and research results are normally among the first issues of business concern when these businesses begin exploring opportunities of collaborative research and development. From "Technology Transfer: Constraints Perceived by Federal Laboratory and Agency Officials," Briefing report to the Committee on Science, Space and Technology, House of Representatives, by U.S. General Accounting Office, GAO/RCED-88-116BR, March 1988, p.16.

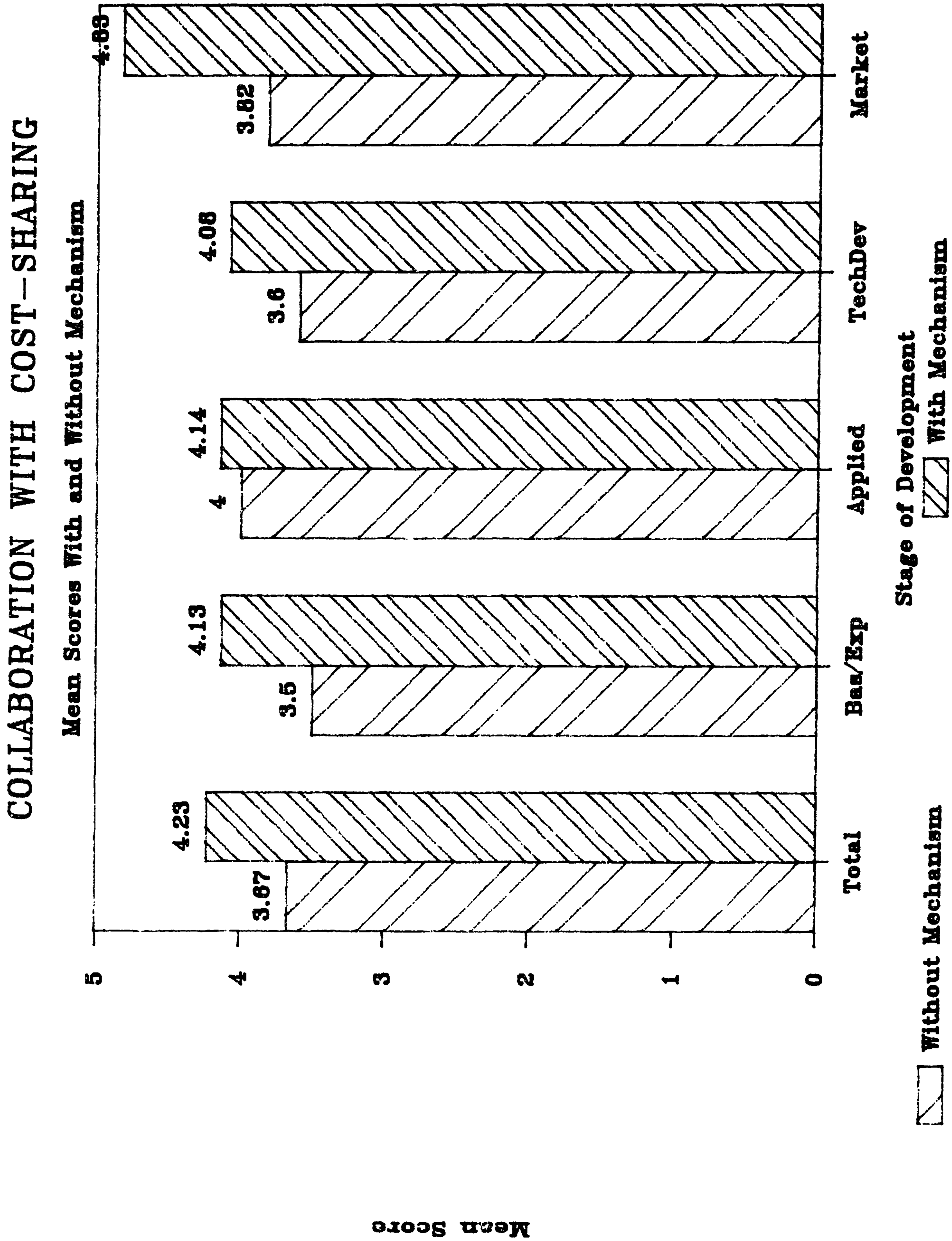
[46] Another observation I made when analyzing the survey data also supports the hypothesis that financial incentives promote successful technology transfer. The observation stems from a Student T-Test performed with two distinct sets of cases: (1) those with only private sector recipients (N=64); and (2) those with only public sector recipients (N=5). The results showed that cases with only private sector recipients had a mean success score of 4.06 with a standard deviation of 1.258, while those cases

parties to make a project work because only successful projects bring returns to the investor.

---

with only public sector recipients had a mean success score of 3.00 with a standard deviation of 1.581. The T-value for the difference of these means is 2.0248, which gives $p<.05$ and hence the result is statistically significant to the 95% certainty level.

Graph 5-3:



COLLABORATION WITH COST-SHARING
Mean Scores With and Without Mechanism
Mean Score
5
4
3
2
1
0
3.67
4.23
3.5
4.13
4
4.14
3.6
4.08
3.82
4.83
Total
Bas/Exp
Applied
TechDev
Market
Stage of Development
Without Mechanism
With Mechanism

5.1.4 Collaboration Without Cost Sharing

TABLE 5-4
Student T-Tests for Cases With or Without Given Mechanism
as a Function of Total and Stage of Development

MECHANISM: **Collaboration Without Cost Sharing**

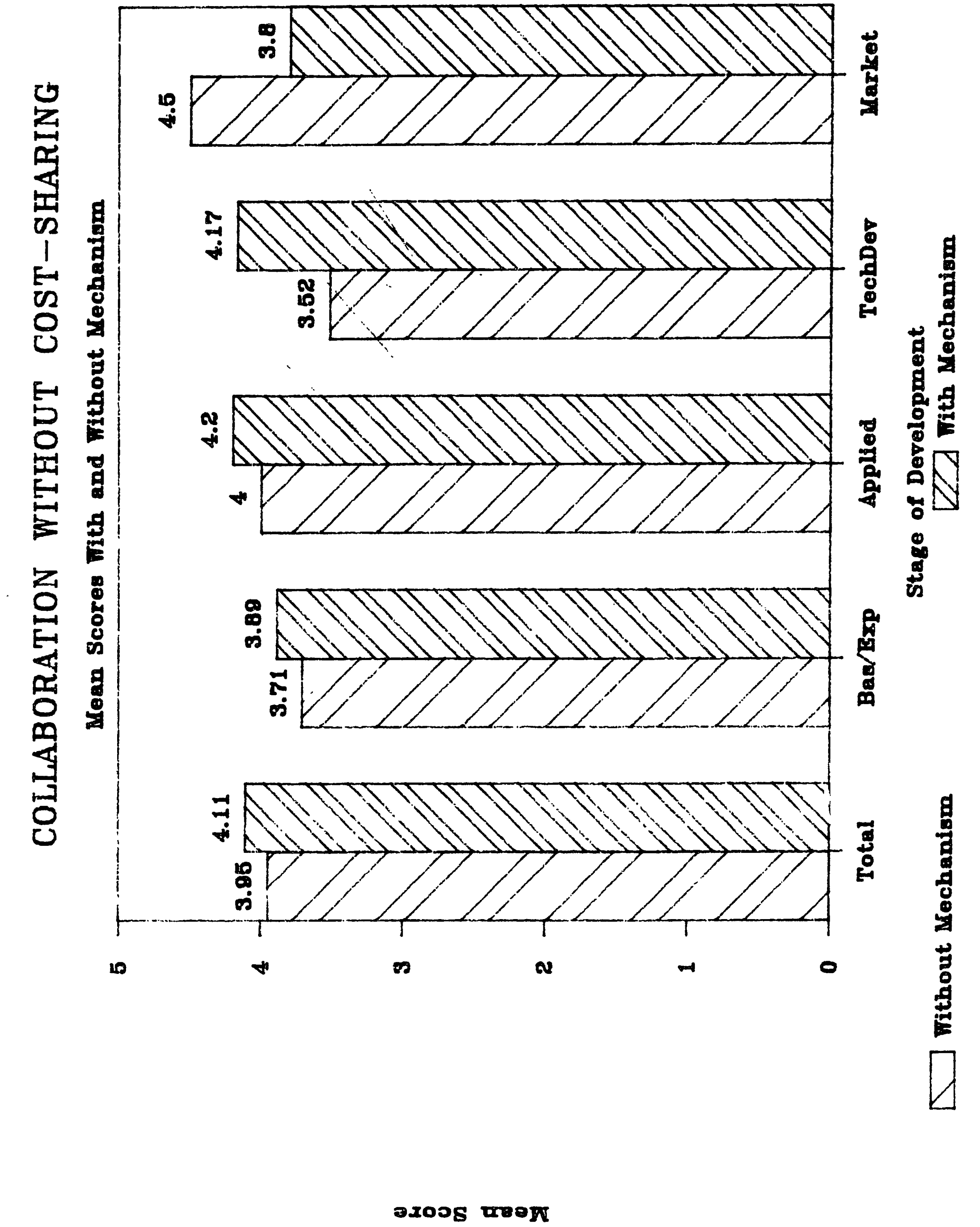
Stage of Development	Mean Without	Mean With	T-Value	2-Tail Prob.
Total	3.95 (N=59)	4.11 (N=57)	-0.680	.4979
Basic/Exploratory	3.71 (N= 7)	3.89 (N= 9)	-0.253	.8042
Applied	4.00 (N=13)	4.20 (N=20)	-0.542	.5914
Technology Development	3.52 (N=21)	4.17 (N=23)	-1.600	.1181 **
Market Penetration	4.50 (N=18)	3.80 (N= 5)	1.214	.2381 ***

Discussion of Table 5-4:

As seen in the table, when Collaboration Without Cost-Sharing is used as a technology transfer mechanism, it makes a positive contribution to transfer success in the Technology Development stage of development ($p<.15$). However, when this mechanism is used in the Market Penetration stage of development there is a significant negative contribution to transfer success ($p<.25$).

Collaboration, because of its highly communicative and personal nature would seem to naturally be associated with transfer success, as seen in the Technology Development stage, where "hands-on" work and communication are important. However, without the financial incentives of cost-sharing (both positive in terms profits, and negative in terms of losses -- see Collaboration With Cost Sharing), collaborators may involve themselves in projects that are riskier or offer less incentives to perform than projects where they would be expected to share costs. Furthermore, because these collaborators must share any intellectual property arising through their research, they may be hesitant to disseminate their results (transfer the technology) as widely as possible. This can be accounted for by the negative contribution made by Collaboration Without Cost Sharing in the Market Penetration stage of development, where intellectual property rights (including trade secrets and market analyses) may be vulnerable to the public domain.

Graph 5-4:


COLLABORATION WITHOUT COST-SHARING
Mean Scores With and Without Mechanism
Mean Score
Stage of Development
Total
Bas/Exp
Applied
TechDev
Market
3.95
4.11
3.71
3.89
4
4.2
3.52
4.17
4.5
3.8
0
1
2
3
4
5
Without Mechanism
With Mechanism

5.1.5 Personnel Exchange

TABLE 5-5
Student T-Tests for Cases With or Without Given Mechanism as a Function of Total and Stage of Development

MECHANISM: **Personnel Exchange**

Stage of Development	Mean Without	Mean With	T-Value	2-Tail Prob.
Total	3.98 (N=60)	4.07 (N=56)	-0.383	.7024
Basic/Exploratory	4.11 (N= 9)	3.43 (N= 7)	1.021	.3243
Applied	4.05 (N=19)	4.21 (N=14)	-0.443	.6610
Technology Development	3.72 (N=18)	3.96 (N=26)	-0.564	.5761
Market Penetration	4.14 (N=14)	4.67 (N= 9)	-1.067	.2980

Discussion of Table 5-5:

Although there are no statistically significant relationships in this table as I have defined them, it is interesting to note the weak but existing negative contribution that Personnel Exchange makes when technologies are in the Basic or Exploratory R&D stage of development. A somewhat stronger positive correlation holds for this same mechanism when the technology is in the Market Penetration stage of development.

The positive relationship in the Market Penetration stage may be attributable to the person-to-person communications necessary in finding particular market uses for a technology, including market knowledge and experience often only found outside of the research center. The weak negative relationship in the Basic/Exploratory stage of development may be due to the nature of basic science and exploratory research; that is, one of abstract concepts coupled with the search for a broad range of applications, where individual exchanges may lead to confusion rather than assistance. Also other intangible and psychological problems can exist whenever personnel are exchanging work environments. Some studies point out that there is often a lack of incentives for personnel to work for others on a part time basis or having to move to a new location.[47] These situations may create attitudes, such as indifference, that can be detrimental to the technology transfer process.

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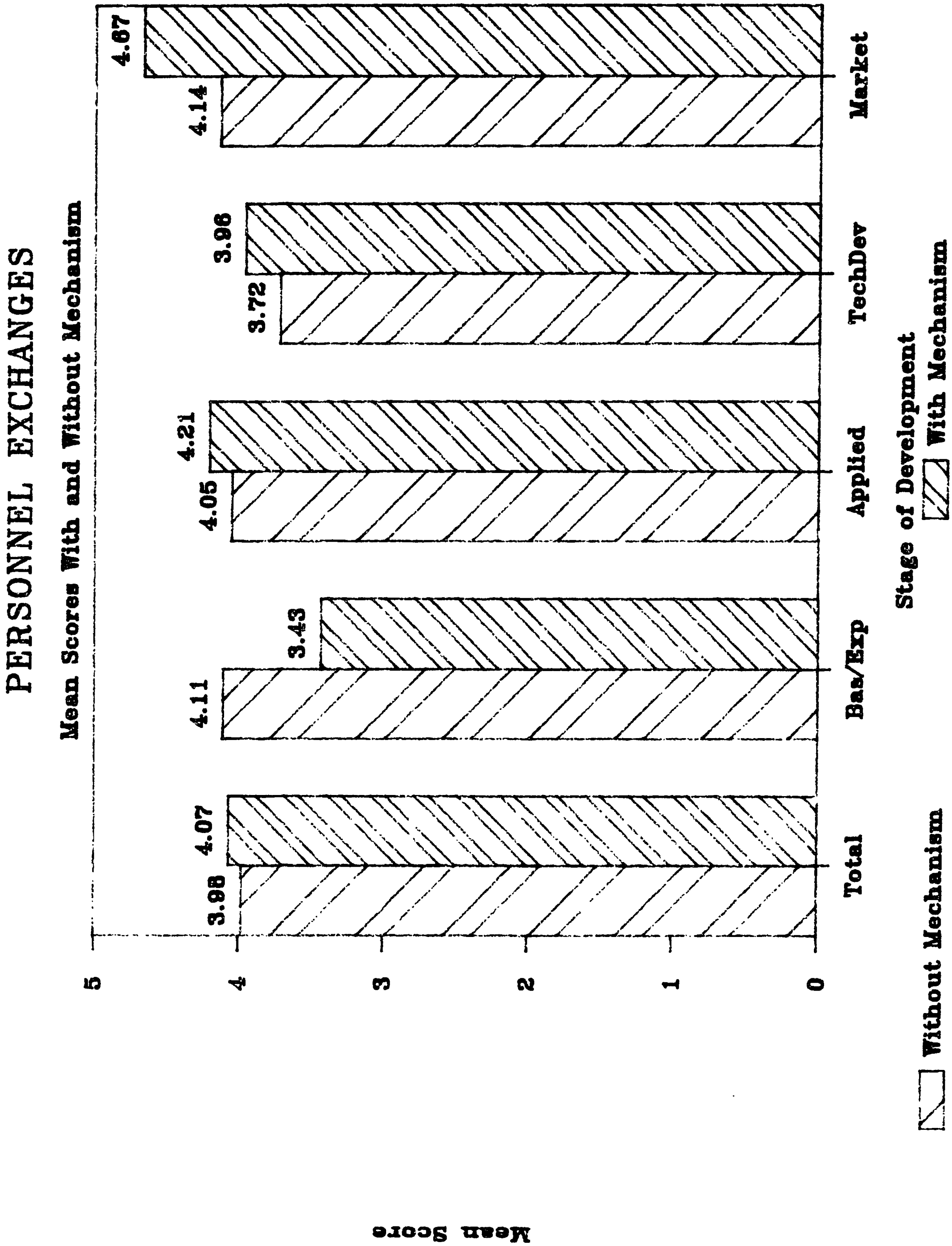
[47] See, for example, Dorf and Worthington, "A Study of Technology Transfer Arrangements for National Laboratories," report UCRL-15967 for Lawrence Livermore National Laboratories, August 25, 1987, p.21, or Goldberg, et al., "Mobility and its alternatives in a national R&D system," R&D Management, 11, p.117.

Graph 5-5:


PERSONNEL EXCHANGES
Mean Scores With and Without Mechanism
Mean Score
5
4
3
2
1
0
3.98
4.07
4.11
3.43
4.05
4.21
3.72
3.96
4.14
4.67
Total
Bas/Exp
Applied
TechDev
Market
Stage of Development
Without Mechanism
With Mechanism

5.1.6 Licensing/Spinoffs

TABLE 5-6
Student T-Tests for Cases With or Without Given Mechanism as a Function of Total and Stage of Development

MECHANISM: Licensing/Spinoffs

Stage of Development	Mean Without	Mean With	T-Value	2-Tail Prob.
Total	4.12 (N=78)	3.84 (N=38)	1.121	.2645
Basic/Exploratory	4.50 (N= 4)	3.58 (N=12)	1.215	.2446 ***
Applied	4.16 (N=25)	4.00 (N= 8)	0.380	.7068
Technology Development	3.86 (N=36)	3.88 (N= 8)	-0.026	.9797
Market Penetration	4.62 (N=13)	4.00 (N=10)	1.288	.2116 ***

Discussion of Table 5-6:

As seen in the table, there is a significant negative contribution to transfer success when Licensing/Spinoffs are used as a technology transfer mechanism, particularly in the Basic/Exploratory ($p<.25$) and Market Penetration ($p<.25$) stages of development. A weaker correlation exists in general.

The overall negative contribution that licensing/spinoff mechanisms have on transfer success at first seems counter-intuitive until one considers the licensing policies of government sponsored research. More often than not licenses distributed by the government are non-exclusive and thus are available for any firm that desires them -- at relatively low costs. In fact, to obtain an exclusive license, firms must show that: (1) the interests of the public are better served than in the non-exclusive case, (2) the commercialization will not occur under a nonexclusive license, and (3) financial investment for further development will not occur under a non-exclusive license.[48] Therefore, using non-exclusive licensing or spinoff companies to transfer technology may be anti-productive for some companies because there is no protection from their competitors, and in fact, by acquiring the license, these companies send a message to their competitors about their future marketing plans.[49] Further a "Not-Invented-Here" attitude may persist at companies that acquire licenses and will then not use them.[50]

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[48] Jacques D. Bagur and Ann S. Guissinger, "Technology Transfer Legislation: An Overview," Journal of Technology Transfer, 12(1), 1987, p.57.

[49] As noted in a recent government report, the development of technologies acquired through non-exclusive licenses or other openly available means, such as publications or government reports, is too risky a venture for most firms to make. (From Dorf and Worthington, "A Study of Technology Transfer Arrangements for National Laboratories," p.28).

[50] U.S. House of Representatives, hearing before the Subcommittee on Energy, Research and Development of the Committee on Science, Space, and Technology, testimony of Dr. M. K. Korenko, Manager, Advanced Reactor Development of Westinghouse, October 12, 1987, p.53.

Speedy negotiations for licensing are also important. The negotiations with government agencies can often take many months to several years, due to bureaucratic slowness and government reluctance to grant exclusive rights. Presently, to obtain a license, a firm must:

- submit a development or marketing plan for the licensed technology;
- carry out development or marketing plan in a specified time;
- report periodically on efforts to commercialize the technology;
- observe adequate U.S. preference positions;
- not reassign the license without the approval of the original granting entity; and,
- licenses can be terminated if development schedules are not met, or appropriate steps towards commercialization are not taken.[51]

These requirements, and the fact that companies must fit their innovations into their product development schedules while holding on to earmarked funding, can create delays that make the innovation obsolete, as the firm's strategic situation

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[51] Bagur and Guissinger, p.56-57.

changes or originally involved people move on (here, spinoff companies are especially vulnerable).[52]

Lastly, because the actual cost of R&D compared to the total costs of product development is usually one to ten percent,[53] a company that acquires a license may not have the capital necessary to proceed with development and production; they instead "shelf the license."

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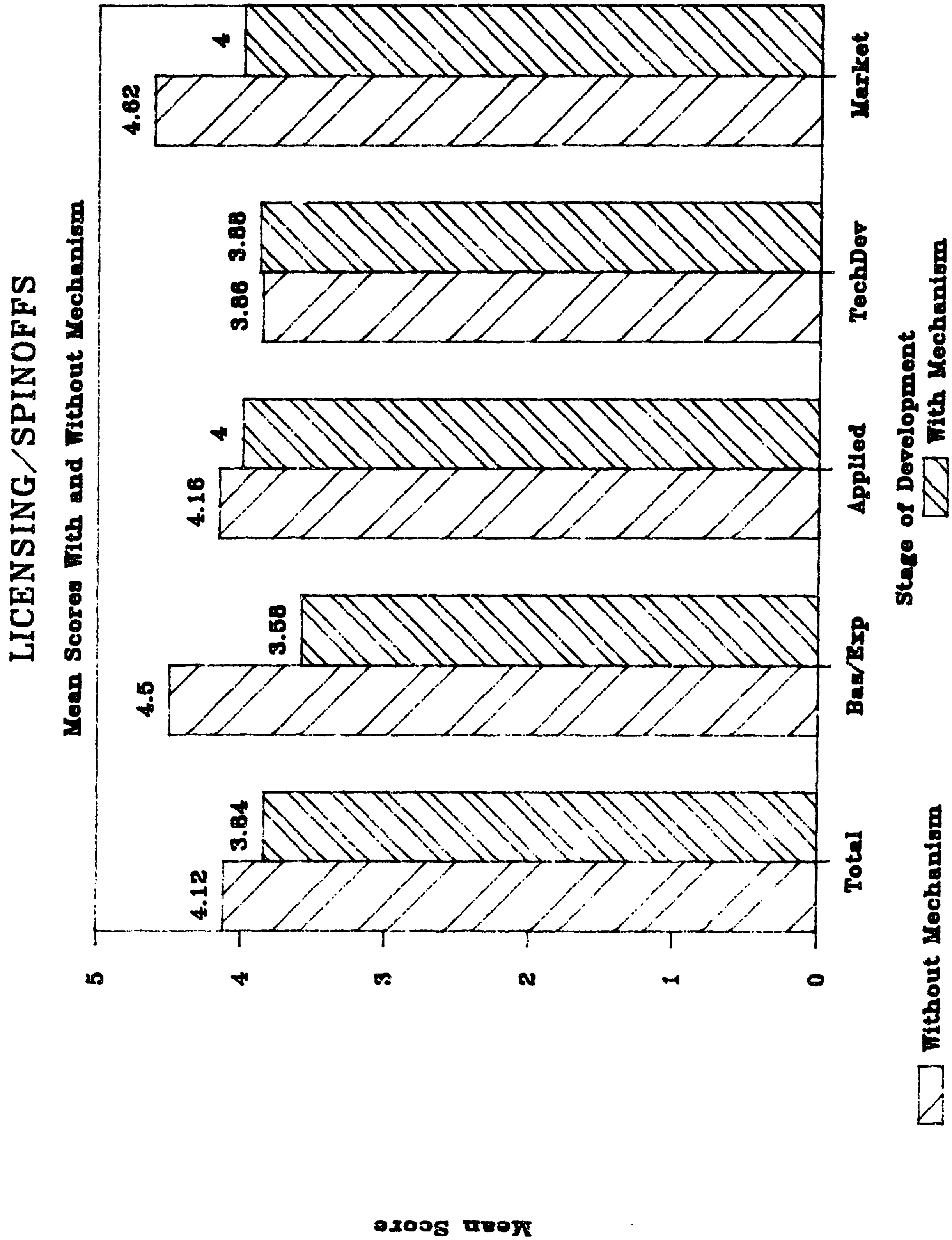
[52] Congressional Office of Technology Assessment, "Making Things Better, Competing in Manufacturing," report OTA-ITE-443, February, 1990, p.192. Time delays in the licensing process were also noted as a major barrier to the transfer of technology in United States General Accounting Office, "Technology Transfer: Constraints Perceived by Federal Laboratory and Agency Officials," p.18.

[53] Patrick Kelly, "Technology Transfer: Some Dimensions of a Conceptual Framework," in "Proceedings: U.S. DOE Technology Transfer Workshop, Washington, DC May 30, 31, and June 1, 1984," prepared by Meridian Corporation, December 1984, p.65.

Graph 5--6:


LICENSING/SPINOFFS
Mean Scores With and Without Mechanism
Mean Score
0
1
2
3
4
5
4.12
3.84
4.5
3.58
4.16
4
3.86
3.88
4.62
4
Total
Bas/Exp
Applied
TechDev
Market
Stage of Development
Without Mechanism
With Mechanism

5.1.7 Active Dissemination of Information

TABLE 5-7
Student T-Tests for Cases With or Without Given Mechanism as a Function of Total and Stage of Development

MECHANISM: **Active Dissemination of Information**

Stage of Development	Mean Without	Mean With	T-Value	2-Tail Prob.
Total	3.76 (N=37)	4.15 (N=79)	-1.620	.1081 **
Basic/Exploratory	3.00 (N= 4)	4.08 (N=12)	-1.467	.1646 ***
Applied	4.33 (N= 9)	4.04 (N=24)	0.724	.4747
Technology Development	3.43 (N=14)	4.07 (N=30)	-1.453	.1536 **
Market Penetration	4.00 (N=10)	4.62 (N=13)	-1.288	.2116 ***

Discussion of Table 5-7:

As seen in the table, when the Active Dissemination of Information is used as a technology transfer mechanism, it make a significant positive contribution to transfer success in general ($p<.15$), in the Basic/Exploratory stage of development ($p<.25$), in the Technology Development stage of development ($p<.15$), and in the Market Penetration stage of development ($p<.25$).

This relationship points out two important aspects of technology transfer: (1) the necessary dissemination of information to wide audiences; and, (2) the active nature of that dissemination. It is interesting to note the large difference in mean scores between cases in the Basic/Exploratory stage of development -- where the communication of information is extremely important. The active dissemination of information also overcomes an information barrier identified by many R&D managers who believe that technical information in documents is often too technical for the user to understand.[54] With active, two-way communication, receivers of technology have an opportunity to have any difficult concepts clarified or explained.

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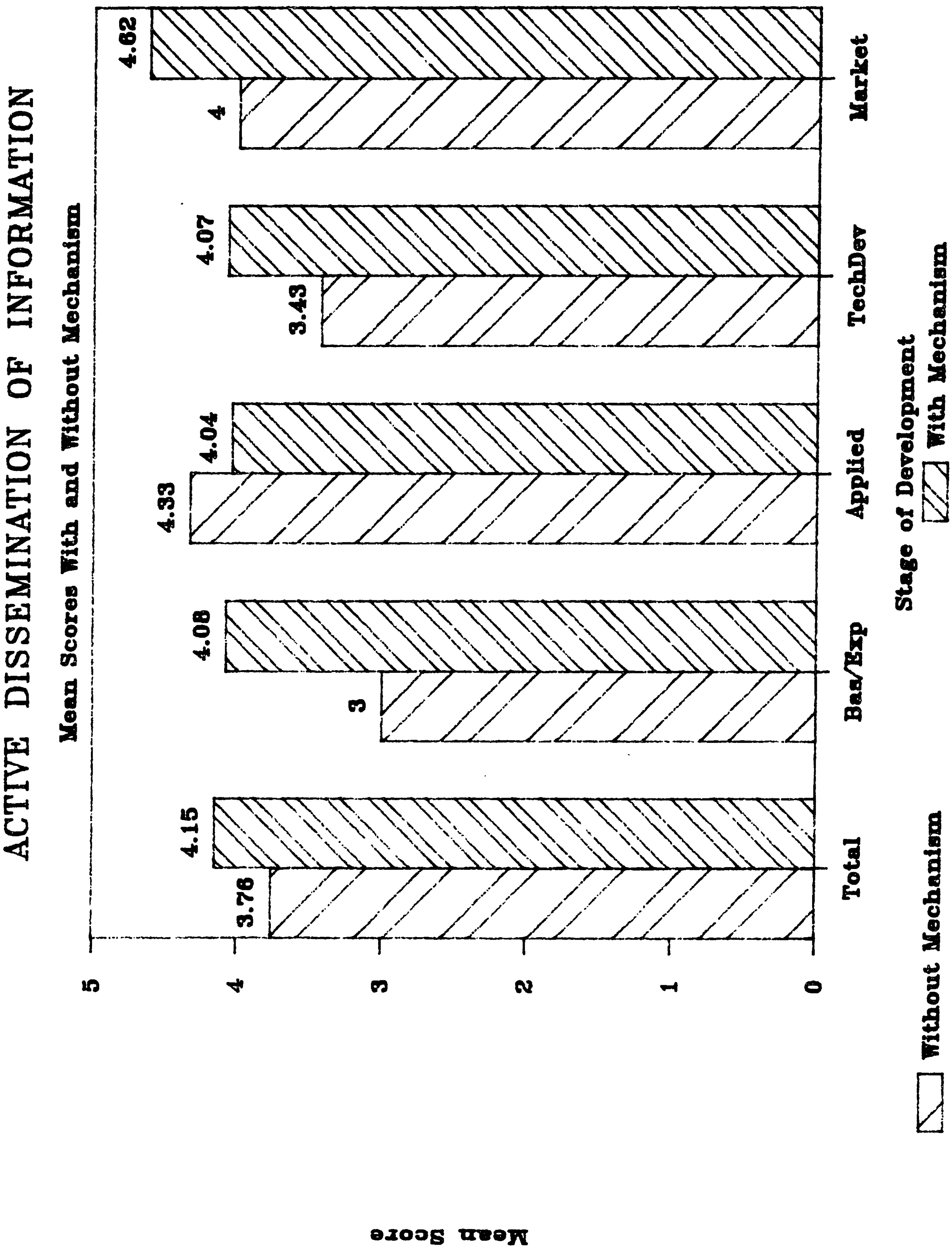
[54] DeBruin and Corey, p.62.

Graph 5-7:



ACTIVE DISSEMINATION OF INFORMATION
Mean Scores With and Without Mechanism
Mean Score
5
4
3
2
1
0
3.76
4.15
3
4.08
4.33
4.04
3.43
4.07
4
4.62
Total
Bas/Exp
Applied
TechDev
Market
Stage of Development
Without Mechanism
With Mechanism

5.1.8 Passive Dissemination of Information

TABLE 5-8
Student T-Tests for Cases With or Without Given Mechanism
as a Function of Total and Stage of Development

MECHANISM: Passive Dissemination of Information

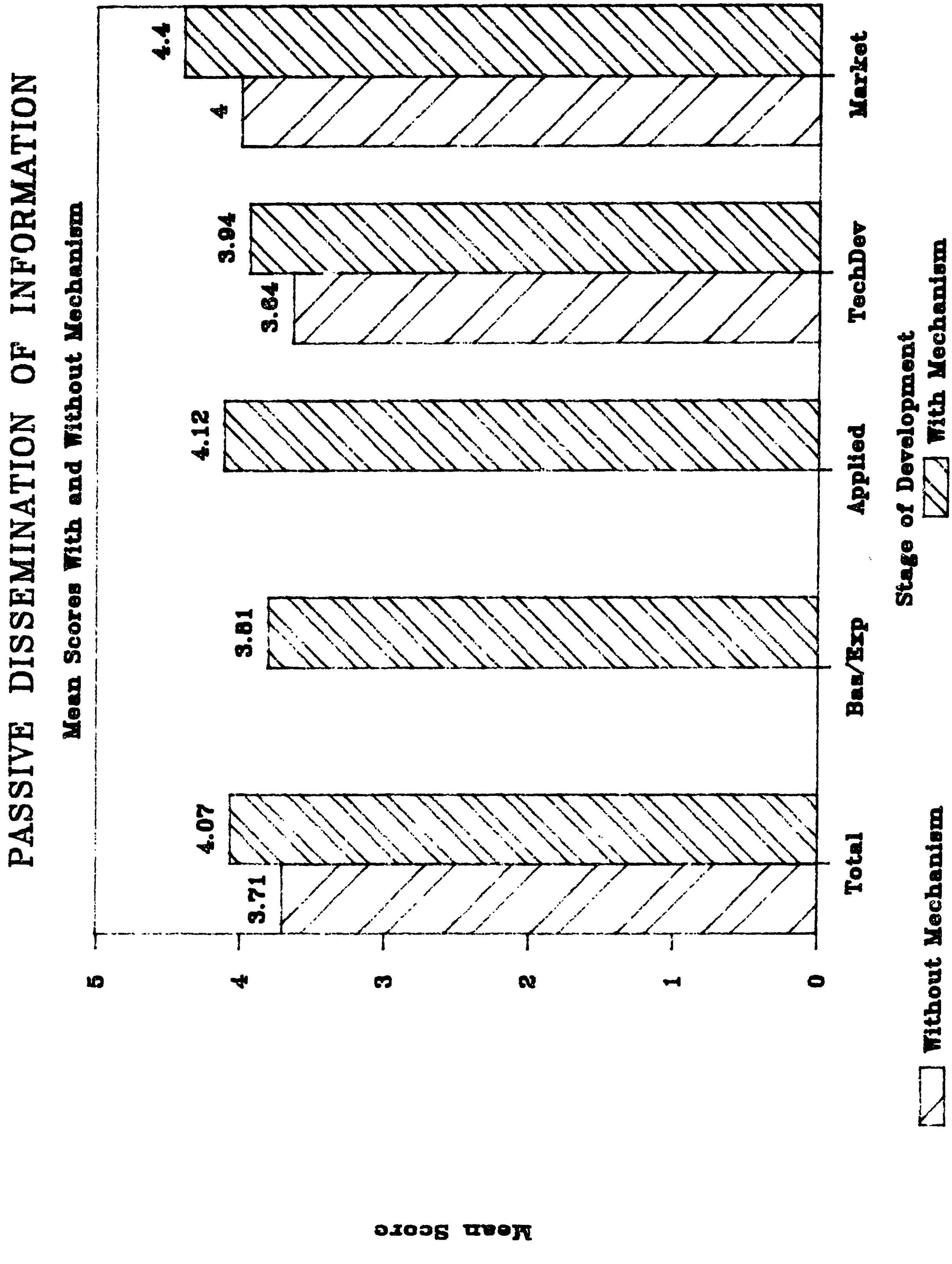
Stage of Development	Mean Without	Mean With	T-Value	2-Tail Prob.
Total	3.71 (N=14)	4.07 (N=102)	-1.008	.3155
Basic/Exploratory	(N= 0)	3.81 (N=16)	-----	-----
Applied	(N= 0)	4.12 (N=33)	-----	-----
Technology Development	3.64 (N=11)	3.94 (N=33)	-0.629	.5328
Market Penetration	4.00 (N= 3)	4.40 (N=20)	-0.552	.5870

Discussion of Table 5-8:

Although there are no statistically significant correlations here, as I have defined them, it should be noted that there is a weak positive contribution to transfer success in general for cases that used this mechanism. Because of zero case counts for transfers not using this mechanism in conjunction with the Basic/Exploratory or Applied stage of development, there are no statistical inferences made of these situations.

The Passive Dissemination of Information (particularly through technical reports) is often a pre requisite for any research entity accepting government funds (hence, the large number of cases using this mechanism). This "one-way" flow of information is valuable, but not as significant as "two-way" flows provided by the Active methods described above.

Graph 5-8:


PASSIVE DISSEMINATION OF INFORMATION
Mean Scores With and Without Mechanism
Mean Score
5
4
3
2
1
0
3.71
4.07
3.81
4.12
3.64
3.94
4
4.4
Total
Bas/Exp
Applied
TechDev
Market
Stage of Development
Without Mechanism
With Mechanism

5.1.9 A Combination of the Best

TABLE 5-9
Student T-Tests for Cases With or Without Given Mechanism as a Function of Total and Stage of Development

MECHANISM: **Advisory Groups and Collaboration With Cost Sharing**

Stage of Development	Mean Without	Mean With	T-Value	2-Tail Prob.
Total	3.62 (N=29)	4.40 (N=35)	-2.478	.0159 *
Basic/Exploratory	2.67 (N= 3)	4.00 (N= 4)	-1.019	.3548
Applied	5.00 (N= 1)	4.23 (N=13)	-----	-----
Technology Development	3.50 (N=16)	4.54 (N=13)	-2.198	.0367 *
Market Penetration	4.00 (N= 9)	4.80 (N= 5)	-1.089	.2974

Discussion of Table 5-9:

This table takes the two apparently "best" mechanisms (the two with the highest total mean score) and examines cases that either used both of them or did not use either of them. As seen in the table, when the combination of Advisory Groups and Collaboration With Cost Sharing is used, mean scores are significantly higher in general ($p<.05$), and in the Technology Development stage of development ($p<.05$). Also notice the almost perfect score in the Market Penetration stage of development. The effect that combinations of mechanisms have on technology transfer success is not studied in detail in this thesis.

The next chapter discusses how the above findings can be applied in formulating technology transfer policy.

CHAPTER SIX:
POLICY IMPLICATIONS

6.0 Policy Goals

The results presented in Chapter Five must now be translated into implementable policy. As stated in Chapter Two, the goal of U.S. technology transfer policy is to use the scientific resource base of the Federal government to "enhance U.S. competitiveness by increasing the transfer of Federally funded technologies and knowledge to the private sector for commercial application." With this technology transfer mission in mind, and given the information derived from the survey, what specific policy recommendations can be made to strengthen the technology transfer process?

6.1 The Survey Results Restated

From the survey data previously analyzed, Table 6-1 can be constructed to offer a clearer picture of the importance of specific mechanisms in the technology transfer process. The table shows the significance of Advisory Groups and Collaboration With Cost Sharing, both contributing to high mean success scores when used. Collaboration Without Cost Sharing and Active Dissemination of Information also contribute to a mean somewhat higher that the total mean score (however, Collaboration Without Cost Sharing has a negative impact in the Market Penetration stage of development). Personnel Exchange and the Passive Dissemination of Information have neither a positive nor negative impact on transfer success. Lastly, Licensing/Spinoffs actually have a negative impact on the technology transfer process. This table provides the foundation for the policy options, recommendations and implementation issues that follow. Also included in this chapter is a discussion of the role of the established Offices of Research and Technology Applications (ORTAs) with regards to technology transfer, which is followed by final remarks and recommendations for further study.

TABLE 6-1
Mean Values for Cases With and Without Given Mechanism

Mechanism	Stage of Development	Mean Without	Mean With
Total	Total	----	4.03
	Bas/Exp	----	3.81
	Applied	----	4.12
	TechDev	----	3.86
	Market	----	4.35
Advisory Groups	Total	3.88	4.22
	Bas/Exp	3.57	4.00
	Applied	4.12	4.13
	TechDev	3.52	4.41
	Market	4.38	4.29
Collaboration With Cost Sharing	Total	3.67	4.23
	Bas/Exp	3.50	4.13
	Applied	4.00	4.14
	TechDev	3.60	4.08
	Market	3.82	4.83
Collaboration Without Cost Sharing	Total	3.95	4.11
	Bas/Exp	3.71	3.89
	Applied	4.00	4.20
	TechDev	3.52	4.17
	Market	4.50	3.80
Personnel Exchange	Total	3.98	4.07
	Bas/Exp	4.11	3.43
	Applied	4.05	4.21
	TechDev	3.72	3.96
	Market	4.14	4.67
Licensing/Spinoffs	Total	4.12	3.84
	Bas/Exp	4.50	3.58
	Applied	4.16	4.00
	TechDev	3.86	3.88
	Market	4.62	4.00
Active Dissemination of Information	Total	3.76	4.15
	Bas/Exp	3.00	4.08
	Applied	4.33	4.04
	TechDev	3.43	4.07
	Market	4.00	4.62
Passive Dissemination of Information	Total	3.71	4.07
	Bas/Exp	----	3.81
	Applied	----	4.12
	TechDev	3.64	3.94
	Market	4.00	4.40

6.2 Policies Regarding Collaboration With and Without Cost Sharing

6.2.1 Policy Options

The survey analysis shows that collaboration as a whole is a relatively successful mechanism for technology transfer. However, the added financial incentives of cost-sharing significantly increase the success of a project. This is particularly the case in the Market Penetration stage of development, where the absence of cost-sharing negatively contributes to the transfer process. The apparent reasons for these impacts are discussed in Chapter Five. Building from these results, a likely policy objective would be:

* To increase the level of R&D collaboration between the public and private sectors, and to create cost-sharing incentives to enhance project success.

6.2.2 Policy Recommendations

Given the above objective, the following recommendations should be implemented. Issues involved in this implementation are discussed in the next section.

* The government should emphasize the importance of collaborative R&D with private industry and where possible require costs to be shared by collaborating

partners, particularly in the later stages of a technology's development. For entities that are unable to share costs, other mechanisms, such as recoupment or loan schemes, should be built into the research agreements and financial incentives should be offered to successful collaborators.

* Exclusive licenses should be granted to all cost-sharers, but licenses should have mandatory conditions of time, scope, geographic location, or monetary payment. The extent of these conditions should be proportional to the extent of the cost sharing.

* The provisions in the Amendments to the Patent and Trademark Act of 1980,[55] the Trademark Clarification Act of 1984,[56] the Federal Technology Transfer Act of 1986, the National Competitiveness Technology Transfer Act of 1989, and the Steel and Aluminum Energy Conservation and Technology Competitiveness Act of 1988,[57] which allow

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[55] P.L. 96-517.

[56] P.L. 98-620.

[57] P.L. 100-680.

government owned labs to collaborate with the private sector and offer patent rights, exclusive licenses, and Freedom of Information Act exemptions to firms, should be more widely "advertised" to industry through the Offices of Research and Technology Applications, in order to attain a broad and representative group of firms willing to collaborate.

* Specific legislation should be enacted that specifically gives cost-sharing entities confidence that their intellectual property rights will not be violated when entering collaborative agreements.[58]

* Formal cooperative research and cost sharing programs, such as Clean Coal Technology, Small Business Innovation Research, Energy Conservation Utilization Technology, and High-Temperature Super Conductivity Pilot Center programs should be further studied and evaluated, and improved programs resulting from lessons learned should be initiated.

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[58] Legislation to date is abstract enough that firms are hesitant and unsure about the extent of their intellectual property rights when they enter collaborative agreements. (See Dorf and Worthington, DeBruin and Corey, Bagur and Guissinger).

6.2.3 Policy Implementation Issues

The key issues that arise when trying to implement government-industry collaboration policies, particularly in terms of cost sharing, are: (1) fairness (of partner selection and of licensing), and (2) communication barriers.

First a note about fairness of partner selection. If the government chooses to give all private firms equal access to R&D collaboration ventures and cost sharing is required, the government must consider special provisions for entities such as small businesses with little access to capital. Further, in its duty to serve the American public, the government must also consider collaboration with foreign firms that may use technical information gained at the public sector's expense to develop products that compete with U.S. companies and negatively impact the U.S. balance of trade. Methods of financing cooperative firms (e.g., guaranteed loans) and choosing collaborative partners (e.g., contract agreements that require substantial returns to the American public) could be carefully developed by government agencies to address these issues.

Secondly, licenses (discussed in more depth in section 6.3), must also be fairly distributed, which has traditionally meant non-exclusivity; however, non-exclusive licenses do not attract private sector firms to collaborative, cost-shared research. Although the protection of a collaborating firm's intellectual property rights is necessary, too much protection may prevent public access to research results that it, in fact, has funded. Flexible licensing negotiation procedures are necessary so exclusive licenses could be distributed, but with stipulations that encourage commercialization and promise fairness to the American public.

Lastly, open and active communication channels among researchers, government officials and industry are necessary for successful, cost-shared collaboration. This is for two reasons. First, if the government wants to solicit the best and most appropriate partners for a project, it will need to effectively communicate with and solicit a wide representation of firms in a particular industry. Second, because cost-sharing calls for a capital input from a firm, that firm's managers would obviously wish to know as much as possible about the project (including its commercial possibilities) before it gets underway. In both cases communication among government officials, researchers and industry is imperative. However, because oftentimes each of these groups "speaks its own vocabulary," (for example, scientists speaking of publishing while managers are speaking of profits) commercialization opportunities are missed. This "communication barrier" must be overcome -- possibly through agents in each facility's ORTA that act as a communication bridge between research and commercialization (see section 6.5.3 for further discussion of this role).

6.3 Policies Regarding Licensing/Spinoffs

6.3.1 Policy Options

Table 6-1 clearly shows that there is something faulty with the licensing and spinoff mechanisms intended to transfer Federally funded R&D. The roots of these defects were discussed in Chapter Five and include bureaucratically motivated time delays, capital deficiencies, and the low-incentive nature of non-exclusive licenses that eventually end up "shelved." The options available for improving these mechanisms are:

* To revise the licensing process in order to eliminate unnecessary delays, and to promote the use of exclusive or partially exclusive licensing in order to encourage the commercialization of technologies by the private

sector.

6.3.2 Policy Recommendations

Given the above objective, the following policy recommendations should be implemented. Implementation issues are discussed in the next section.

* Licensing decisions should become more decentralized in all national labs, both government- and contractor-operated, in order to speed up the process and add flexibility to negotiations. Giving labs more control over licensing decisions will do this. However standards and methods of accountability should be devised by each agency to filter out those difficult decisions which upper level management or the central agency needs to consider (usually with regards to exclusive licensing).

* Exclusive licenses should be considered more often when efforts are focussed on technology commercialization. These licenses, however, should include conditions of time (e.g. granting exclusivity for a certain number of years), scope (e.g., granting exclusivity for only certain uses of a technology), geographic location (e.g.

granting exclusivity for commercialization in specific regions only), or monetary payment (e.g., requiring licensed firms to pay royalty fees).

* Spinoff companies that would use Federally funded R&D as their technology base, should receive financial incentives, such as tax breaks or accelerated depreciation schedules, to assist them in the further development and commercialization of the given technology.

6.3.3 Policy Implementation Issues

The most important licensing/spinoff implementation issues involve (1) exclusivity and (2) process. First, as stated above, granting exclusive licenses to firms is contrary to the traditional role of government licensing and is still a relatively new concept.[59] Because public funds are used for government research, granting exclusive rights to companies so they can monopolize a technology may be construed as unfair. A tradeoff arises -- the public sacrifices its non-exclusive

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[59] 1980 marked the first time that Congress realized the importance of exclusive licensing -- see the Bayh-Dole Act of 1980.

rights for the benefits that commercialization may offer, given exclusive protection. Whether this tradeoff is acceptable or not depends on the technology being licensed and the surrounding circumstances or potential benefits of commercialization. Negotiating licensing conditions can help in some ways to balance this tradeoff and provide more flexibility in handling these situations.

A second issue is the government's licensing procedures -- arguably slow and bureaucratic. A licensing system that works faster and responds more flexibly to firms' needs should be devised. However, another tradeoff occurs here because although the process must work faster (therefore implying less centralized bureaucracy), the government must maintain enough control so that it remains responsive to the public's needs; that is, when decentralizing decision-making procedures, care must be taken to ensure that difficult licensing decisions that can adversely affect the American public are overseen by upper level management. A decentralized decision-making process could be developed that filters out potential licensing agreements that may be controversial in order for central agencies to evaluate the agreements more closely. The legislation mentioned above that allows government owned labs to license their technologies with minimal central agency oversight is a step towards this decentralized process; however, whether the process has led to an reduction in licensing time delays has not yet been shown.

6.4 Policies Regarding Advisory Groups and the Active Dissemination of Information

6.4.1 Policy Options

Advisory Groups and the Active Dissemination of Information have been shown to contribute considerably to the technology transfer process for reasons discussed in Chapter Five. Knowing this, a policy objective would be:

* To increase the diversity and availability of Advisory Groups, and to increase the opportunities for researchers to participate in two-way, active communication.

6.4.2 Policy Recommendations

Given the potential contributions that could be made by using Advisory Groups and Active Dissemination of Information, the following recommendations are proposed. Implementation issues regarding these recommendations are discussed in the next section.

* Technical and industrial advisory groups, such as those

found in the High-Temperature Superconductivity Pilot Centers should be encouraged throughout the research and development process, and incentives should be offered for firms to participate. Regional groups made up of technical and industry experts should be organized by the labs ORTAs for continuous reference, with frequent meetings or workshops to review ongoing technical developments. Researchers using Federal funds should be required to work with such groups when appropriate. Conflicts of interest could be monitored by the ORTAs.

* Active forms of information transfer should be required for each project receiving Federal funds, particularly in the very early and very late stages of research and development. These can be organized by the labs' ORTAs, and special funding should be set aside for this purpose. At least one person from each project should also be held responsible and should be offered incentives for initiating active forms of information dissemination.

6.4.3 Policy Implementation Issues

The key implementation issues here are (1) determining who participates on advisory groups, and (2) whether participation can raise conflicts of interest. For example, an industrial advisory group member who has financial interests in a project that the group is advising, may not be appropriate for that group. Because participation on such groups can bring such benefits as information access and directional influence, conflicts of interest may naturally arise. When creating these groups, then, care has to be taken to assure that these conflicts are identified and avoided.

6.5 Policies Regarding Personnel Exchanges and the Passive Dissemination of Information

6.5.1 Policy Options

The Stevenson-Wydler Act and amendments, the 1987 Executive Order 12591, and the Federal Technology Transfer Act of 1986 all specifically order national labs to use their personnel to assist private firms in developing commercial uses for lab developed technologies. However, from the data presented here, transfer success has proven to be "indifferent" with regards to this mechanism. This is also the case with the Passive Dissemination of Information.

6.5.2 Policy Recommendations

Given this "indifference," the following recommendations are made regarding Personnel Exchange and the Passive Dissemination of Information:

* Formal personnel exchanges should still be encouraged, but not to the extent previously thought necessary. Attempts should be made instead to integrate market oriented personnel with technically oriented personnel (and vice versa) more informally or in situations where interaction would occur anyway (e.g., workshops or conferences).[60]

* Parties carrying out research funded by the government should be required and given incentives to disseminate as much information as possible, including publishing reports that are helpful not only to technicians, but also corporate managers.[61]

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[60] In industry, informal channels of technology transfer, primarily through personal contact, have often proven to be far more effective than more formal mechanisms. (See Dorf and Worthington, and Thomas J. Allen, Managing the Flow of Technology, 1977, p.31).

[61] It was the concern of many lab managers that the passive information disseminating from the labs was too technical for most corporate managers to understand. (See DeBruin and Corey).

6.5.3 Policy Implementation Issues

The issues involved in implementing personnel exchanges rise mainly from conflicts of interest and the protection of intellectual property. Because personnel exchange should be de-emphasized (or even "un-implemented") these will not be discussed.

On the other hand, the Passive Dissemination of Information that is to continue, particularly in producing information that gives an industrial perspective, requires the involvement of people knowledgeable of both technology and business. These people are not necessarily found at research labs, where scientists have different priorities and concerns than those of the corporate manager. Projects will need to have information disseminators that are aware of all aspects of a technology, including its commercialability. ORTAs seem to be the most appropriate place to house such personnel, however all agencies should employ people in their central offices who have these dual skills.

6.6 Policy Regarding ORTAs

6.6.1 Policy Options

The implementation of the above recommendations can be assisted (if not solely carried out) by the already existing Offices of Research and Technology Applications (ORTAs). ORTAs were established in the Stevenson-Wydler Act (See Chapter Two), in which more than 700 national labs were required to create these offices. The ORTAs were directed to identify technologies that offered commercialization opportunities to private industry and to act as information disseminators.[62] Although elevated to a managerial level, it is not clear that ORTAs have received the respect or the funding that is necessary for them to make noticeable impacts on technology transfer. A reasonable policy objective, therefore, would be:

* To enhance the capabilities of national ORTAs by enhancing their status and funding in order to carry out the above recommendations.

6.6.2 Policy Recommendations

Given the above objective, the following recommendations are made with respect to ORTAs. Implementation issues are discussed in the next section.

* Legislation should be enacted to heighten the level of

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[62] Bagur and Guissinger, p.61.

ORTA funding and responsibilities to include those functions necessary in carrying out the policy recommendations prescribed above.

* Financial incentive structures should be instituted by each agency, similar to the royalty schemes now established for researchers, that reward ORTAs for transferring lab technologies into the private sector. ORTAs should also be held accountable by agency groups for successes and failures. Lastly, ORTAs should be required to keep a detailed record of technology transfer expenses and develop a "technology tracking system" that "tracks" the lab released technologies into the private sector and monitors the technologies' effects in industry and the marketplace.

* Multi-program agencies, such as the DOE, should order each program to install an "ORTA liaison" (person or committee) responsible for monitoring ORTA operations and expressing the needs and goals of the program.

* Technology transfer assessments should be made regularly

by public-private entities in cooperation with the ORTAs, using standard, but flexible measures of success.

6.6.3 Policy Implementation Issues

The above recommendations assume, as Congress did when establishing ORTAs, that ORTAs are the proper vehicles for assisting in technology transfer projects. Whether this is true has not yet been shown. Therefore, two co-dependent issues that must be studied further are: (1) whether ORTAs are the most effective structures for performing technology transfer, and if so, (2) whether ORTAs have been performing this job adequately in their few years of existence. These are pertinent issues; if ORTAs prove ineffectual, other "transfer agents", whether institutionalized or not, need to be considered.

6.7 What Else Is Needed?

Although surveys such as the one carried out by PNL and analyzed here are necessary in understanding the technology transfer process itself, research pertaining to a number of other technology transfer issues needs to be performed. For example, little is known about the costs and benefits of using these technology transfer mechanisms. Cost data are unavailable -- even for the formal mechanisms discussed here -- and the benefits of technology transfer depend on whether the technology is fully commercialized and what that commercialization brings to the American public.

There is also a need for a better understanding of informal technology transfer processes, mentioned above, that exist between government and industry. Inter- and intra-corporate studies on this subject have been carried out, but government-industry informal mechanisms have not been so thoroughly examined.

More work also needs to be done on identifying those particular attributes of the technology and the recipient, if any, that tend to make transfers successful (see Note 46 for an example). This thesis has concentrated on the effectiveness of the mechanisms used for technology transfer (with respect to the technology's stage of development) but there are a number of other related variables associated with technology transfer, such as its objectives, its source and its recipients that needs to be analyzed.

Lastly, studies on the effectiveness of ORTAs and an assessment of other methods of lab-industry interaction need to be undertaken. Whether ORTAs should have the task of transferring technology and whether they have accomplished this task are two issues that must be addressed. Currently we may have a situation where we know what mechanisms enhance transfer success, but we are unsure about what institutions can apply these mechanisms most competently.

APPENDIX A:
The original PNL survey.

Technology Transfer Process for Selected Projects

Questionnaire

Program Office: ____________________ Respondent: ____________________

Date: ________________ Telephone: ______________________

Project Title: ____

Description of the Base Technology:

____
____
____
____

I. FUNDING HISTORY

1. Total number of years the project has been funded (including FY90).

   _________ Years Start Date: _________ End Date: _________

2. Total funding for the project (including FY90).

   $_________

3. Total funding for the technology transfer component of the project (including FY90).

   Base Technology $_________

   Spin-Off Technologies $_________

II. TECHNOLOGY TRANSFER HISTORY

1. Was technology transfer planned as part of the project's mission?

   _______ Yes _______ No

2. From the following list, select the three most important (primary) objectives of the technology transfer process for this project?

- _____ To transfer scientific knowledge
- _____ To move a technology into the next step/stage
- _____ To encourage private sector investment or redirection of private sector research programs
- _____ To obtain feedback from users (demonstration projects, advisory panels, user facilities)
- _____ To improve the nation's technology base
- _____ To introduce a new technology to the end user
- _____ To enhance/accelerate user acceptance and use
- _____ To expand alternative technology applications (spin-offs)
- _____ Other ______________________________

3. Did/Does the technology offer to displace a significant number of barrels of imported oil fuel?

- _____ No
- _____ Yes

4. Did/Does the technology offer to significantly reduce the life cycle costs to end users? If yes did, please estimate the percent of life cycle costs to be saved, by end users, over the technology it would replace.

- _____ No
- _____ Yes _______% of life cycle costs to be saved over the technology to be replaced.

5. Aside from energy savings and reduced end user costs, what other attributes may have helped or will help facilitate the transfer of this technology? Please check the three (3) most important.

_____ Technology leadership
_____ Industrial competitiveness
_____ National security
_____ System reliability
_____ Environmental quality
_____ Public health
_____ Employment
_____ Potential profits or earnings
_____ Other ______________________________

6. Please provide any quantitative data you may have that documents how the attributes listed in Q5 helped or will help you to facilitate the transfer of this technology.

____
____
____

7. Please indicate any barriers you may have encountered, or foresee encountering, while attempting to transfer the technology.

_____ Difficult to do business with the government (bureaucratic red tape)
_____ Information not available about new technology developments
_____ Technology write ups not accessible and understandable
_____ Chaotic storage of materials describing technology development
_____ Private sector did not develop the technology
_____ Financial risk associated with the technology
_____ Technological risk associated with the technology
_____ Technology not "market ready"
_____ Market conditions changed between the time of program initiation and completion
_____ Other ______________________________

8. At what stage of development was the technology when it was transferred?

_____ The technology has not been transferred.

_____ Basic. When a new idea is discovered.

_____ Exploratory R&D. When R&D is exploratory in nature (no one firm can conduct the research on its own and ultimate applications are uncertain and possibly widespread).

_____ Applied and Information-Based R&D. Where the R&D is applied and information-based.

_____ Technology Development. Where the R&D is applied and "hardware" oriented.

_____ Market Penetration. Where efforts are directed toward market entry.

9. If the technology has not been transferred, what is the current stage of development?

_____ Basic
_____ Exploratory R&D
_____ Applied
_____ Technology Development
_____ Market Penetration

10. At the time of transferring the technology, how valuable was it perceived by the marketplace/end user on a scale of 1 - 5, where 1 = very valuable and 5 = not very valuable?

_____ Not applicable

_____ (1) Very valuable
_____ (2)
_____ (3) Somewhat valuable
_____ (4)
_____ (5) Not very valuable

11. To whom was the technology transferred? If the technology has not been transferred, who do you plan to target for transfer? Please check all that apply to this project.

_____ New Venture/Spin-Off Company
_____ State/Local Government
_____ Other Federal researchers/labs/agencies
_____ Universities
_____ General Public
_____ Foreign Government
_____ Foreign Business/University
_____ Business - Construction Sector
_____ Business - Utility Sector
_____ Business - Manufacturing Sector
_____ Business - Transportation
_____ Business - Other
_____ Other ________________________________

12. In what form was the technology transferred? If the technology has not been transferred, in what form do you plan to transfer the technology? Please check the three (3) most important.

_____ Patent/License
_____ Software
_____ Information (Technical reports, Brochures)
_____ Standards/Practices/Training
_____ Knowledge of transferred staff
_____ Process specifications
_____ Copyright
_____ Product design/specifications
_____ Other ________________________________

13. How effective was the technology transfer process in meeting the primary technology transfer objective on a scale of 1 - 5, where 1 = very effective and 5 = not very effective?

_____ Not applicable

_____ (1) Very Effective
_____ (2)
_____ (3) Somewhat Effective
_____ (4)
_____ (5) Not Very Effective

Please provide any quantitative data you may have that documents the effectiveness of the technology transfer process.

____
____
____

14. What, if anything, would you now do differently for the technology transfer process used on this project?

_____ Not applicable

____
____
____

15. How long did the technology transfer process take, from initiation to the point where the technology was transferred or a decision to stop the transfer process was made?

_____ Not applicable

_____ Years _____ Continuous

16. Was/is there an identifiable "Champion" associated with the technology development? What type of organization was the "Champion" from?

_____ No Champion
_____ Champion from University
_____ Champion from Laboratory
_____ Champion from DOE program office
_____ Champion from Industry
_____ Champion from Other ____________________________

17. Were any of the following special end user feedback processes important in the technology transfer process?

_____ Market survey using primary sources
_____ Market survey using secondary sources
_____ Public hearings
_____ End user focus groups
_____ End user associations/societies

18. Please provide any other information which might be useful in understanding the technology transfer process and its outcome for this project.

19. The purpose of the chart on the next page is to collect information about the technology transfer mechanisms used in the technology transfer process for this technology. The following steps should be followed when completing the chart.

Step 1. Please check each mechanism that was used or you plan to use in the technology transfer process for this technology.

Step 2. Indicate at what time(s) during each stage of development the mechanism was used (Beginning, Middle, End). Place a check (x) at the time periods during each stage of development that each mechanism was used. If the technology has not been transferred, indicate at what time(s) you plan to use specific mechanisms.

Step 3. Rank order the mechanisms from most important (1) to least important in meeting the technology transfer objectives for this technology. If the technology has not been transferred, what do you expect to be the most important mechanism (1)?

Step 4. List the percent of total technology transfer budget that was allocated to each mechanism used for this technology transfer process. If the technology has not been transferred, list the percent of total technology transfer budget that you plan to allocate to each mechanism.

BASE TECHNOLOGY

Mechanisms Used in the Technology Transfer Process	Stages of Development: Basic			Exploratory R&D			Applied			Technology Development			Market Penetration			Ranking of Importance	Percent of Technology Transfer Budget
	B	M	E	B	M	E	B	M	E	B	M	E	B	M	E		
ADVISORY GROUPS																	
End User Review																	
Technical Review																	
COLLABORATION																	
Contracting R&D																	
Industry Consorita																	
Cooperative																	
Demonstration																	
User Facilities																	
Work for Others																	
Staff Consulting																	
Broker Groups																	
STAFF EXCHANGE																	
Guest Staff																	
TECHNICAL ASSIST																	
Staff Transfers																	
LICENSING																	
SPIN OFFS																	
INFORMATION																	
Workshops																	
Information Centers																	
Mailings																	
Technical Reports																	
News Releases																	
Journals and Magazines																	
Fact Sheet																	
Video Tapes																	
Decision Tools																	
Electronic Boards																	
EDUCATION																	

Key: B = Beginning, M = Middle, E = End.

20. Please list each spin-off technology that occurred as a result of this technology development. Also check (x) at what stage of development each spin-off occurred.

_____ There were/are no spin-off technologies.

Stage of Development

Spin-Off Technology	Basic	Exploratory R&D	Applied	Technology Devlopment	Market Penetration
1) ____________	_____	_____	_____	_____	_____
2) ____________	_____	_____	_____	_____	_____
3) ____________	_____	_____	_____	_____	_____
4) ____________	_____	_____	_____	_____	_____
5) ____________	_____	_____	_____	_____	_____

Question 21 only pertains to spin-off technologies that occurred during the base technology development. Please ignore if there were no spin-off technologies.

21. The purpose of the chart on the next page is to collect information about the technology transfer mechanisms that were used for spin-off technologies. If the technology transfer process is generally the same for all spin-offs then the chart should be filled out to represent the strategy you generally use. When the strategy used for an individual spin-off deviates from the general technology transfer strategy for spin-offs, indicate the difference by inserting the number of the spin-off technology, as listed in Q17, rather than a check (x) mark.

Step 1. Please check each mechanism that is generally used in the technology transfer process for spin-off technologies.

Step 2. Indicate at what time(s) during each stage of development the mechanism is generally used (Beginning, Middle, End). Place a check (x) at the time periods during each stage of development that the mechanisms are generally used.

Step 3. Rank order the mechanisms from most important (1) to least important in meeting the technology transfer objectives for spin-off technologies in general.

Step 4. List the percent of total technology transfer spin-off budget that is generally allocated to each mechanism for spin-off technologies.

SPIN-OFF TECHNOLOGIES

Mechanisms Used in the Spin-Off Technology Transfer Process	Stages of Development: Basic			Exploratory R&D			Applied			Technology Development			Market Penetration			Ranking of Importance	Percent of Spin-Off Technology Transfer Budget
	B	M	E	B	M	E	B	M	E	B	M	E	B	M	E		
ADVISORY GROUPS																	
End User Review DS																	
Technical Review DK																	
COLLABORATION																	
Contracting R&D DL																	
Industry Consortia DM																	
Cooperative DN																	
Demonstration DO																	
User Facilities DP																	
Work for Others DQ																	
Staff Consulting DR																	
Broker Groups D[illegible]																	
STAFF EXCHANGE																	
Guest Staff DT																	
TECHNICAL ASSIST																	
Staff Transfers DU																	
LICENSING DV																	
SPIN OFFS DW																	
INFORMATION																	
Workshops DX																	
Information Centers DY																	
Mailings DZ																	
Technical Reports EA																	
News Releases EB																	
Journals and Magazines EC																	
Fact Sheet ED																	
Video Tapes EE																	
Decision Tools EF																	
Electronic Boards EG																	
EDUCATION EH																	

Key: B = Beginning, M = Middle, E = End.

APPENDIX B:
A list of graph variables and their definitions.

The following list provides the reader with definitions for the variables used throughout this thesis.

With respect to the FORM of transfer:

- Pat -- Patent/License
- Soft -- Software
- Info -- Information (Technical reports, Brochures)
- Stand -- Standards/Practices/Training
- Know -- Knowledge of transferred staff
- Proc -- Process specifications
- Copy -- Copyright
- Prod -- Product design/specifications

With respect to the OBJECTIVE of transfer:

- Know -- To transfer scientific knowledge
- Step -- To move a technology into the next step/stage
- Invest -- To encourage private sector investment or redirection of private sector research programs
- Advisor-- To obtain feedback from users
- Base -- To improve nation's technology base
- Intro -- To introduce a new technology to the end user
- Accept -- To enhance/accelerate user acceptance and use
- Spin -- To expand alternative technology applications (spinoffs)

With respect to the PROGRAM sponsoring the transfer:

- CE -- Conservation Programs
- DP -- Defense Programs
- ER -- Energy Research Programs
- FE -- Fossil Energy Programs
- NE -- Nuclear Energy Programs
- RE -- Renewable Energy Programs

With respect to the RECIPIENT of the transfer:

- NewV -- New Venture/Spinoff Company
- St/Loc -- State/Local Government
- Labs -- Other Federal researchers/labs/agencies
- Univ -- Universities
- Pub -- General Public
- F.Gov -- Foreign Government
- F.Bus -- Foreign Business
- Const -- Business - Construction Sector
- Util -- Business - Utility Sector
- Mfg -- Business - Manufacturing Sector
- Trans -- Business - Transportation Sector
- BusOth -- Business - Other

With respect to the STAGE OF DEVELOPMENT of the technology:

- Bas/Exp -- Basic or Exploratory R&D
- Applied -- Applied R&D
- Devel -- Technology development
- Market -- Market Penetration

REFERENCES USED

Allen, Thomas J., Managing the Flow of Technolgy. The MIT Press: Massachusetts, 1977.

Allen, T.J., et al., "Technology Transfer as a Function of Position in the Spectrum From Research Through Development To Technical Services," Academy of Management Journal, 22, 1979.

Bagur, Jacques D., and Ann S. Guissinger, "Technology Transfer Legislation: An Overview," Journal of Technology Transfer, 12(1), 1987.

DeBruin, Jeffrey P., and James D. Corey, "Technology Transfer: Transferring Federal R&D Results For Domestic Commercial Utilization," report SAND88-1716 for the U.S. Department of Energy, August 1988.

Dorf, Richard C., and Kirby K. F. Worthington, "A Study of Technology Transfer Arrangements for National Laboratories," report UCRL-15967 for Lawrence Livermore National Laboratories, August 25, 1987.

Electric Power Research Institute, "Proceedings: Technology Transfer Workshop," prepared by the Battelle Memorial Institute (PNL), August 1982.

Epton, S., "Ten Years of R&D Management," R&D Management, 11, 1981.

Goldberg, J., et al., "Mobility and Its Alternatives in a National R&D System," R&D Management, 11.

Jervis, P. and T.C. Sinclair, "Conditions for Successful Transfer and Innovation in the U.K.," in NATO Advanced Study on Technology Transfer, Technology Transfer. Leiden: Noordhoff International Publishing Co., 1977.

Levi, Bob, ed., "Internation Symposium Proceedings, 1983", Technology Transfer Society: Los Angeles, 1983.

Manning, G.K., ed., Technology Transfer: Successes and Failures. San Francisco Press, Inc.: San Francisco, 1974.

Marshall, Ken, Package Deals: A Study of Technology Innovation and Transfer. Intermediate Technology Publications: London, 1983.

McNamara, Margaret M., and Leslie M. Strazza, ed., "Technology Transfer Society International Symposium Proceedings, Boston, June 1984," Technology Transfer Society: Los Angeles, 1984.

Meridian Corporation, "Proceedings: U.S. Department of Energy Technology Transfer Workshop, Washington, DC May 30, 31, and June 1, 1984," Government Printing Office: Washington, DC, December 1984.

M.I.T. Commission on Industrial Productivity, Made in America: Regaining the Productive Edge. The M.I.T. Press: Cambridge, 1989.

Office of the Press Secretary, "Facilitating Access to Science and Technology," White House Fact Sheet, April 10, 1987.

Pacific Northwest Laboratory, "The Technology Transfer Process: Background to the NES," report PNL-SA-17482 for the U.S. Department of Energy, January 1990.

Persson, Olle, "Notes and Critical Comments on the Gatekeeper Concept in Science and Technology," R&D Management, 11.

Ray, George, The Diffusion of Mature Technologies. Cambridge University Press: New York, 1984.

Richardson, Jacques, ed., Integrated Technology Transfer. Lomond Books: Maryland, 1979.

Rothwell, Roy, "From Invention to the Marketplace -- Successfully!," in NATO Advanced Study Institute on Technology Transfer Technology Transfer. Leiden: Noordhoff International Publishing, Co., 1977.

Rothwell, R. and D. Robertson, "The Role of Communications in Technological Innovation," Research Policy, 2, 1973.

Seurat, Silvere, Technology Transfer: A Realistic Approach. Gulf Publishing Co.: Houston, 1979.

Taylor, R., "The Technological Gatekeeper," R&D Management, 5, 1975.

Tushman, Michael and Ralph Katz, "External Communication and Project Performance," Management Science, 26, 1980.

United States Congressionsal Budget Office, "Using Federal R&D to Promote Commercial Innovation," U.S. Government Printing Office: Washington DC, April 1988.

United States Congressional Office of Technology Assessment, "Making Things Better: Competing in Manufacturing," report OTA-ITE-443, U.S. Government Printing Office: Washington, DC, February 1990.

United States Department of Commerce, "Federal Technology Transfer Forum, Ames Research Center, Summary Report," report PB88-234968 for the Economic Development Administration, Washington, DC, September 11, 1987.

United States Department of Commerce, "The Federal Technology Transfer Act of 1986: The First Two Years," Government Printing Office: Washington, DC, July 1989.

United States Department of Energy, "Development of a Strategic Technology Transfer Plan for DOE's Active Heating and Cooling Division," report DO/SF/11972--T1, Washington, DC., 1984

United States General Accounting Office, "Technology Transfer: Constraints Perceived by Federal Laboratory and Agency Officials," report GAO/RCED-88-116BR, March 1988.

United States House of Representatives, Committee on Science, Space, and Technology, "Technology Policy and its Effect on the National Economy," October 19, 1988.

United States House of Representatives, Subcommittee of Energy Research and Development of the Committee on Science, Space, and Technology, hearing October 12, 1987.

United States House of Representatives, Committee on Science, Space, and Technology, and United States Senate, Subcommittee on Energy Research and Development of the Committee on Energy and Natural Resources, joint hearing September 4, 1986.

United States Senate, "Commercialization of Federally Funded R&D: a Guide to Technology Transfer From Federal Laboratories," report for the Committee on Commerce, Science, and Transportation, October 4, 1988.

United States Senate, Committee on Commerce, Science, and Transportation, "Technology Administration Authorization Act of 1989," October 3, 1989.

von Hipple, Eric, "Cooperation between rivals: Inforfmal Know-How Trading," Research Policy, 16.

Washington, DC, Council on Competitiveness, "Picking Up the Pace: The Commercial Challenge to Americal Innovation," U.S. Government Printing Office: Washington, DC, September 1988.

United States House of Representatives, Subcommittee of Energy Research and Development of the Committee on Science, Space, and Technology, hearing October 12, 1987.

United States House of Representatives, Committee on Science, Space, and Technology, and United States Senate, Subcommittee on Energy Research and Development of the Committee on Energy and Natural Resources, joint hearing September 4, 1986.

United States Senate, "Commercialization of Federally Funded R&D: a Guide to Technology Transfer From Federal Laboratories," report for the Committee on Commerce, Science, and Transportation, October 4, 1988.

United States Senate, Committee on Commerce, Science, and Transportation, "Technology Administration Authorization Act of 1989," October 3, 1989.

von Hipple, Eric, "Cooperation between rivals: Inforfmal Know-How Trading," Research Policy, 16.

Washington, DC, Council on Competitiveness, "Picking Up the Pace: The Commercial Challenge to Americal Innovation," U.S. Government Printing Office: Washington, DC, September 1988.