PATENTS FROM GOVERNMENT-FINANCED RESEARCH AND DEVELOPMENT[1]

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SUMMARY

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This is a report on the numbers of patents arising in the postwar period from government-financed research and development. The many previous studies and investigations of federal patent policies never yielded more than incomplete and often inconsistent data. The total number of patents, owned by or licensed to the federal government, has grown rapidly. The total, however, is quite small when compared with the total of all patents issued or assigned in the postwar period to residents of the United States and to U.S. corporations. The numbers of patents from government-financed R & D have grown and fluctuated in step with applied research, but with a lag whose average length is estimated to be at least five and one-half years.

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Data are presented on the numbers of titles and licenses by major federal agencies. The title-policy agencies hold many licenses, and the license-policy agencies administer large portfolios of titles. The government acquires titles and licenses from its own employees and from R & D contractors. Employees account for about one-third of all of the patents. They are heavily concentrated in a few technologies and in a few industries.[2]

This is the first of a series of studies of the patent activities of the federal government, of its employees, and of its contractors.

This article presents for the first time, so far as we know, the complete data on the numbers, the sources, and the kinds of patented inventions flowing from research and development financed by the federal government. The disposition of patent rights from R & D conducted by private organizations and paid for by the federal government is of course the question of federal patent policies, a question much controverted for many years. So too is the disposition of the rights to the inventions of government employees. There is no need for us to review the controversies

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[2]This article presents only part of the data we have collected. Our complete data, contained in about 50 separate tables, consist of the numbers of titles and licenses by years from 1945 to 1962, by agency and by sources (employees and contractors); the titles and licenses are also classified by Patent Office Classes and according to the Standard Industrial Classification.

here or to take a stand on which patent policy best fosters the public interest. Our task now is the modest one of setting forth the simple facts about the patents in which the federal government has an interest.

On October 10, 1963, President John F. Kennedy addressed a Memorandum on government patent policy to the heads of the executive departments and agencies. The Memorandum points to the importance of the patent practices of the several departments and agencies engaged in research and development. The Memorandum contains a statement of guidelines for policy on the disposition of rights to inventions made under contracts with outside organizations. To "monitor, record, and evaluate the practices of the agencies," as well as to carry out other duties, a Patent Advisory Panel was to be established under the Federal Council for Science and Technology.

The creation of the Patent Advisory Panel testifies to the continued importance attached to the patent policies of the federal agencies. The Panel has been hampered until now by the lack of comprehensive and accurate factual knowledge on just what has been happening under the different practices of the federal agencies.

The data we report here have still another significance. Patented inventions are one, but just one, kind of output from the resources devoted to research and development. Much is known about R & D inputs; the National Science Foundation has published a wealth of detailed material on R & D activity, both federal and private. In contrast, little is known about the output of

federal R & D. To be sure, there is much awareness of the major accomplishments of federally financed R & D--the new weapons and devices, the advances in space technology, and the host of other technical improvements. When we say that little is known about R & D output, we mean the lack of knowledge of the specific, comprehensive, quantitative data on output, and in particular, of specific input-output relations. The outputs of federally financed R & D are inventions, information, and improvements in technology. To measure these outputs is not easy; but we believe that some kinds of meaningful indexes can be constructed. To pursue this line of thought, however, is to go beyond the bounds of this article. It deals solely with the patented inventions from federally financed R & D.

PREVIOUS STUDIES

In the large literature on federal patent policies there are some studies that contain more than fragmentary statistical materials on the operation of patent policies.[3] The first major

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[3]This discussion excludes studies about the thousands of patents seized by the Alien Property Custodian during World War II. The Custodian kept complete records on the numbers of seized patents, their sources, and the numbers of licenses granted on them. The data were published in the annual reports of the Custodian.

The National Patent Planning Commission, established in December, 1941, was authorized by President Franklin D. Roosevelt

study in the postwar period was the Attorney General's Report of 1947.[4] This massive report, with its 19 monographs, does not of course contain any data later than for the year 1946. Despite the wealth of detail scattered about in the three volumes, the report offers no panoramic view of the total of the patented inventions flowing from the research and development activities of the federal government in the years before 1947. The 1956 Report of the Attorney General[5] also deals with patent policies and their possible effects. Most of the data in this report, however, are on federal research and development expenditures and their concentration in large companies.

More information on patents from federally financed research and development became public in the late 1950's. The Atomic

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to make a comprehensive study of the American patent system. The Commission began to study the government's own patent practices by sending questionnaires to government agencies. Because the Attorney General was assigned a similar task in February, 1943, the Commission did little or nothing with the data it had collected.

[4]U.S. Department of Justice, Investigations of Government Patent Practices and Policies: Report and Recommendations of the Attorney General to the President. 3 vols. (Washington, D.C.: U. S. Government Printing Office, no date).

[5]Report of the Attorney General Pursuant to Section 708(e) of the Defense Production Act of 1950, as Amended. November 9, 1956. Mimeographed.

Energy Commission furnished the Joint Committee on Atomic Energy fairly complete data on AEC's invention disclosures, patent applications, and patents issued from 1943 to 1958.[6] Other committees of Congress also got small amounts of information from the executive agencies.[7]

Another source of knowledge about the patents from federal R & D is the series of studies published after 1958 by the Subcommittee on Patents, Trademarks, and Copyrights of the Senate Committee on the Judiciary. Among the studies are reports on the patent practices of each of the federal agencies. These reports contain much information and statistical data on the patents assigned to and licensed to federal agencies. But the data are incomplete,

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[6] U. S. Congress, Joint Committee on Atomic Energy, Selected Materials on Atomic Energy Patents, 2 vols., 86th Cong.,1st Sess., 1959; U. S. Congress, Subcommittee on Legislation of the Joint Committee on Atomic Energy, Hearings, Atomic Energy Patents, 86th Cong., 1st Sess., 1959.

[7] The lack of comprehensive factual knowledge about patents and federal R & D, which lack never stood in the way of firm opinions on the wisdom of opposing patent policies, is well illustrated in the experience of "Study Group 14." This committee of the patent attorneys of executive agencies was set up in 1957 to study the matter of the division of patent rights between contractors and the government and to make recommendations for possible changes in patent policies. The committee was unable, however, to gather together a body of data to serve as a foundation for analysis.

and from them no full and consistent picture of the patents emerging from the total R & D program of the federal government can be drawn.

The most important single report on the patent practices of an agency is that for the Department of Defense. This report[8] was issued on September 1, 1961. The data on patents "obtained" and assigned to the Departments of the Army, Navy, and Air Force were supplied by patent counsel in each of the military departments. The data show the numbers of patents acquired between 1938 and 1960 by contractors and by the government. For government-owned patents, the report gives sources, i.e., whether they originated from the work of government employees or from contractors. There is also a list of firms licensed to use government-owned patented inventions.

The same report includes the results of two surveys--one of defense R & D contractors and one of firms licensed to use government-owned patented inventions. In 1960 the Subcommittee sent to 120 contractors a questionnaire on their research and development expenditures and their patent activities. A different

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[8]Patent Practices of the Department of Defense. Preliminary Report of the Subcommittee on Patents, Trademarks, and Copyrights of the Committee on the Judiciary, United States Senate. 87th Cong., 1st Sess. Pursuant to S. Res. 55. Report No. 1481. (Washington, D.C.: U. S. Government Printing Office, 1961).

questionnaire, directed toward determining rates of commercial use, was sent to 89 companies licensed to use government-owned patented inventions. As in most surveys of this kind, the data returned are incomplete because only 78 of the contractors and 49 of the licensed companies supplied the information requested. Not all of these furnished complete responses.

In 1959, the Operations Research Office (now the Research Analysis Corporation) published a study on defense spending and the U. S. economy.[9] Appendix F of that study covers patent matters in military research and development activities. To highlight the inadequate and confused state of data about government R & D patents, the ORO Group presented two sets of numbers on patents assigned to the Departments of Army, Navy, and Air Force during 1956. These numbers are for the year 1956 only. The researchers counted the numbers of patents assigned to each of the military departments that were listed in the Index of Patents, published annually by the U. S. Patent Office. They also counted the numbers of patents recorded by the Assignment Branch of the U. S. Patent Office. The margin of disagreement between the two totals ranged from 4 per cent for the Department of the Navy to 26 per cent for the Department of the Air Force.

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[9]Leon Karadbil, Richard Sherman, and Herbert Striner, Defense Spending and the U. S. Economy (ORO-SP-57) 2 vols. (Bethesda, Maryland: Operations Research Office of The Johns Hopkins University, 1959).

Several patent attorneys have studied government R & D patent matters.[10] These investigations were made at the time the Government Patents Board maintained its index of patents assigned to and those licensed to the government.[11] Most of the data used in these

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[10]Marcus B. Finnegan and Richard W. Pogue, "Federal Employee Invention Rights--Time to Legislate," Michigan Law Review 55 (May, 1957), pp. 903-966; and Howard I. Forman, Patents, Their Ownership and Administration by the United States Government (New York: Central Book Company, 1957).

[11]In compliance with an Executive Order (No. 10096, January 23, 1950), the Government Patents Board maintained records of all patents in which the government had an interest. The only data published by the Board were lists of government-owned patented inventions available for free use to the public. (The Patent Abstract Series). Most of the work of the Board was concerned with determinations of the property rights of the government and of government employees in inventions made by employees.

Because of reduced Congressional appropriations, the Government Patents Board eliminated the Index Section. After a short period of being maintained by the Commissioner of Patents, the Index on the numbers of titles and licenses was transferred to the Office of Technical Services, U. S. Department of Commerce. Since the transfer, OTS has kept a file, by Standard Industrial Classifications, of government-owned patents. That office never maintained the records on license-policy patents.

studies came from the Government Patents Board.

Under a contract with the National Aeronautics and Space Administration, Dr. Archie M. Palmer studied the administration of government-owned patents.[12] The Palmer Report includes information on the numbers of patents owned by the government and the sources of these inventions for the period 1935 to 1955. The data were collected while Dr. Palmer was chairman of the Government Patents Board.

In earlier investigations the authors of this article gathered information about government R & D patents.[13] Data about patents arising from R & D sponsored by the Department of Defense and owned by government contractors was the main concern of Watson.

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[12]Archie M. Palmer, Administration and Utilization of Government-Owned Patent Property, NASA Contract NASw-177 (December, 1960). A reprint of the report appears in U .S. Congress., House, Special Subcommittee on Patents and Scientific Inventions of the Committee on Science and Astronautics, Hearings, Patent Policies Relating to Aeronautical and Space Research, Part 2. 87th Cong., 1st Sess., 1961, pp. 65-138.

[13]Donald S. Watson, Harold F. Bright, and Arthur E. Burns, "Federal Patent Policies in Contracts for Research and Development," The Patent, Trademark, and Copyright Journal of Research and Education, 4 (Winter, 1960), pp. 295-428.

The information collected by Holman concentrated on government-owned patents. Holman made the first complete count of these patents.[14]

THE DATA

The information in this article on the numbers of patents assigned to and licensed[15] to the government comes from records maintained by the Assignment Branch of the United States Patent Office. We believe that these records are the only complete and are the most reliable source of data on the numbers of patents arising from government-financed R & D in the postwar period. These records are a valuable source hitherto unexploited.

In compliance with an Executive Order,[16] government agencies are required to forward to the Assignment Branch complete information about all patents assigned to or licensed to the government.

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[14]Mary A. Holman, "The Utilization of Government-Owned Patented Inventions," The Patent, Trademark, and Copyright Journal of Research and Education, 7 (Summer, 1963 and Fall, 1963), pp. 140 ff.

[15]We are aware of the fact that almost all of the licenses to the government are irrevocable, nonexclusive, and royalty-free.

[16]On February 22, 1944, President Roosevelt issued an Executive Order (No. 9424) providing for the establishment of a register of all patents in which the government has an interest. The Commissioner of Patents assigned the chore of administering this register to the Assignment Branch of the Patent Office.

Although this requirement has been in effect since 1944, the Assignment Branch proceeded to gather data about government-interest patents issuing before 1944. Being part of the Patent Office, the Assignment Branch can collect information about patents that does not necessarily flow to the government agencies financing the R & D from which the patents originate. This is true particularly when patent applications are filed by government contractors. They do not always inform government agencies of the existence of license-policy patents.

The Assignment Branch maintains three different card indexes, each open to inspection by the public. The first contains all government-interest patents (titles and licenses), arranged by date of issue. The second index lists, by agency, all patents licensed to the government. The third index lists, also by agency, all patents assigned to the government.

The card indexes contain much information about government-interest patents, such as the names of inventors, the names of companies employing the inventors, dates of patent applications, dates of patent issues, and divisions of ownership rights.

Personnel in the Assignment Branch do not prepare reports on the numbers of patents acquired by the government each year. Members of our research staff counted each card in the license and in the assignment index. Our data are as accurate and as complete as possible. The tedium of counting the cards opens the way to clerical error, which, however, is certainly less than one per cent. There are three other possibilities of small errors.

First, government agencies might not send information about every patent to the Assignment Branch. Secondly, clerks in the Assignment Branch can make many different kinds of mistakes. Finally, people using the indexes can misplace the cards because they are loose.

Information about the patents can be obtained from other sources. However, there is no other single source that will give a complete picture of all patents assigned to and licensed to the government. The Index of Patents, published annually by the Patent Office, lists all government-owned patents, by agency. That publication, however, has no information about patents licensed to the government. In addition, it does not show changes in the numbers of government-owned patents that result from changes in ownership after patents issue. In 1962, the Office of Technical Services began to keep records of the patents assigned to the government, but not of those licensed to the government.

Some government agencies keep complete records on both license-policy and title-policy patents. Others keep records only on the title-policy patents. The records of some agencies are incomplete and scattered because of reorganizations and changes in filing systems. One government agency sent much of its information about government R & D patents to a warehouse for storage because of a shortage of space.

The Role of Secrecy Orders

Rescinding secrecy orders on groups of patents affects the annual rates of acquisition of patents assigned to and licensed to the government. Under current patent law, the Patent Security

Division, in cooperation with officials in defense-oriented government agencies, can place inventions covering security-classified technology under secrecy orders. Such orders preclude the issue of patents, and hence the disclosure of new technology deemed vital to the national defense, until after the orders are rescinded. In the late 1940's and the early 1950's, the Department of Defense rescinded secrecy orders on many inventions made during World War II. The Atomic Energy Commission did the same thing in the mid-1950's. The main impetus to the action of the Commission was a Tripartite Agreement between the United States, Canada, and the United Kingdom on September 24, 1956. The Agreement provided for the exchange of patent rights in the technology of atomic energy. Since the late 1950's, only a few inventions arising from the research and development sponsored by the Atomic Energy Commission and by the National Aeronautics and Space Administration have been classified for security reasons.

Secrecy orders tend to lengthen the time lag between patent applications and patent issues. The average lag between application and issue of patents assigned to the government is 56 months. There is an average lag of 48 months for patents licensed to the government and of 42 months for all U. S. patents. These differences in time lags suggest that more patents assigned to the government are placed under secrecy orders than those licensed to the government. The government does not, of course, grant licenses to use government-owned inventions or disseminate information about them until secrecy orders are rescinded.

THE NUMBERS OF PATENTS

The numbers of patents acquired by the government and licensed to the government are shown in Table 1.[17] The patents are one of the results of the research and development financed by the federal government. Strictly speaking, however, not every patent included in Table 1 is a product of federally financed R & D. A few dozen of the patents were donated in the early postwar period to the federal government. Another small number resulted from research conducted by government employees using only their own private resources.

It is clear from Table 1 that for each patent it owns, the federal government holds licenses to two others. The Table also shows that the numbers of titles have grown faster than the numbers of licenses. Since 1954, however, the proportion of titles to licenses has remained fairly steady. The effect of the extension of the title policy in legislation since 1958 has been offset by the steadily higher proportion of contract to total research and development. Although contract research results in both titles and licenses, the proportion of licenses is much higher.

Relevance of the Data

What is the larger meaning of the numbers in Table 1? The

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[17]The Table covers an 18-year period. For some purposes, it is preferable to present such data for a 17-year period. We chose 18 years so as to give a complete description for the postwar period.

TABLE 1

TOTAL PATENTS FROM GOVERNMENT-FINANCED R & D

1945 - 1962

Calendar Years	Numbers of Patents			Percentages	
	Owned by Government	Licensed to Government	Total	Owned by Government	Licensed to Government
1945	87	850	937	9.3	90.7
1946	150	1,383	1,533	9.8	90.2
1947	157	1,364	1,521	10.3	89.7
1948	374	1,416	1,790	20.9	79.1
1949	498	1,719	2,217	22.5	77.5
1950	637	1,710	2,347	27.1	72.9
1951	675	1,498	2,173	31.1	68.9
1952	712	1,281	1,993	35.7	64.3
1953	678	1,198	1,876	36.1	63.9
1954	624	912	1,536	40.6	59.4
1955	701	1,070	1,771	39.6	60.4
1956	939	1,553	2,492	37.7	62.3
1957	980	1,475	2,455	39.9	60.1
1958	1,193	1,779	2,972	40.1	59.9
1959	1,434	1,836	3,270	43.9	56.1
1960	1,170	1,957	3,127	37.4	62.6
1961	1,443	2,022	3,465	41.6	58.4
1962	1,219	1,870	3,089	39.5	60.5
Totals	13,671	26,893	40,564	33.7	66.3

Source: Compiled from data in the Assignment Branch, U.S. Patent Office.

Memorandum of October 10, 1963 from the President of the United States to the heads of executive agencies mentions "a considerable number of inventions and discoveries" resulting from the conduct of research and development paid for by the federal government. Table 1 gives the actual number. Then the Memorandum goes on to say that the inventions resulting from work performed under government contracts "constitute a valuable national resource." If they do, then so do also the inventions resulting from the intramural research performed by federal agencies. The men who drafted the Memorandum could hardly have intended to slight the inventions coming out of government laboratories. Nevertheless, they did, because throughout the Memorandum they refer to inventions made under contract.[18]

It is not easily possible, in fact, to present exact data that distinguish the patented inventions coming from the government's laboratories and other installations from those coming from private organizations with government contracts or grants. The titles shown in Table 1 come from both sources; so do the licenses. Later in this article we present data on government employees and government contractors as sources of patented inventions. The employees account for about one-third of all inventions. It seems to be a coincidence that one-third of all patents from government-financed R & D are owned by the government. Quite

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[18]Perhaps they thought that inventions from intramural R & D are covered by Executive Order 10096 of 1950.

apart from the coincidence, however, we estimate that in all probability the one-third ratio also applies to the numbers of patents (both titles and licenses) from the government's intramural R & D as a fraction of the total of all of the patents. We base this estimate on the ratio of intramural to total R & D in the postwar period.

The Government's "Portfolio"

The patents owned by the federal government appear in another light when the numbers of these patents are arranged as portfolios of unexpired patents. Table 2 displays the federal government's patent portfolio at the end of each calendar year from 1947 to 1962. Two sets of data had to be spliced to obtain the figures in Table 2. One set are unpublished data compiled by Dr. Archie Palmer when he was chairman of the Government Patents Board; these data are the patent acquisitions for each of the years from 1931 to 1944. The other data are for 1945 to 1962, from the Assignments Branch of the Patent Office. Because Palmer's data go back no farther than 1931, the portfolio of unexpired patents has to begin in 1947.

A portfolio of patents is to be watched over and managed. Otherwise the word "portfolio" has little meaning. The only meaning the word can have for the federal government is the mere statistical meaning -- the numbers in Table 2. Until Holman published her research on government-owned patents, no one ever knew how many there are. And there is still no mechanism for

TABLE 2

THE PATENT PORTFOLIO OF THE GOVERNMENT

1947 - 1962

Calendar Year	Number Acquired	Total Portfolio	Index(1947=100)
1947	157	1,035	100.0
1948	374	1,381	133.4
1949	498	1,842	177.9
1950	637	2,428	234.5
1951	675	3,074	296.9
1952	712	3,764	363.6
1953	678	4,409	425.9
1954	624	5,000	483.0
1955	701	5,642	545.0
1956	939	6,531	630.9
1957	980	7,471	721.7
1958	1,193	8,621	832.8
1959	1,434	9,993	965.3
1960	1,170	11,115	1,073.7
1961	1,443	12,452	1,202.9
1962	1,219	13,584	1,312.2

Source: Figures obtained from an unpublished table compiled by Dr. Archie Palmer at the time he was chairman of the Government Patents Board and from data in the Assignments Branch of the U.S. Patent Office.

unified management of the portfolio.

The p tents from federally financed R & D in the period 1945-1962 are less than 6 per cent of the total of United States patents issued in that period. According to the U. S. Patent Office, 703,950 patents were issued from the beginning of 1945 to the end of 1962. The government acquired a total of 40,564 titles and licenses. (Table 1). The ratio is 5.76 per cent. When the total number of patents is reduced to allow for patents issued to residents of foreign countries and assigned to foreign corporations, the ratio is still small -- it becomes 6.89 per cent.[19]

RELATION TO RESEARCH AND DEVELOPMENT

Nearly all of the patents owned by and licensed to the federal government are one of the outcomes of the research and development performed by the government and by its contractors and grantees. We have already mentioned the inventions donated

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19To obtain this figure, certain adjustments had to be made. The Patent Office has not published at time of writing (June, 1964) the post-1957 data on patents issued to individuals, to residents of foreign countries, and assigned to U.S. and to foreign corporations. These data are available only up to 1957. On the assumption that the patents going to foreign persons and firms are in the same ratio to the total for 1945-1962 as they were for 1945-1957, the numbers of patents issued to U.S. residents and assigned to U.S. corporations can be estimated for 1958-1962.

to the government. Beside these, some titles have been bought by the government, and others have been acquired under international agreements. Other patents not from R & D are licenses bought by the government and some of the patents issued to government employees. The handful--a few dozen out of the forty thousand--of inventions donated to the federal government belong to the early postwar period. Most of them, it seems, were applied for during World War II and the Korean War; many were given to the government for patriotic motives. The employee inventions licensed to the government are ostensibly the fruit of the time and of the other resources of the employees themselves. Some of these inventions should be attributed to federal R & D programs as at least indirect results, arising in the new environment created by federal R & D. Although we do not know their number, other employee inventions must be the products of purely private research endeavors lying outside the mainstream of federal R & D programs. We plan to make a study of the inventions made by government employees.

A great difference between federally financed R & D, whether intramural or extramural, and the company-financed R & D conducted by private corporations is that patented inventions are not an intended or planned output of federal R & D. Clearly, not all private R & D is aimed at the production of patented inventions. But much, if not most, of it does indeed have this goal. In any event, the fact that patented inventions are unplanned byproducts of federally financed R & D is probably a major cause

of their small numbers alongside the numbers of inventions assigned to private corporations.

So far we have made only preliminary examinations of the relation between the flow of federally financed R & D and the ensuing flow of patents assigned and licensed to the government. For one thing, there is a long lag between the conduct of R & D and the issue of a patent. Exploration of its length, by comparison of the time series of R & D and of patents, suggests that the lag averages 5 1/2 years, with much variation about this probable average.

But examination of the patenting process suggests a somewhat longer time lag -- about 6 3/4 years. As previously mentioned, the average time lags between the date of a patent application and the issue of a patent are 56 months for patents assigned to the government and 48 months for patents licensed to the government. An unweighted average of lags for all inventions arising from government-financed R & D is about 52 months. Analysis of almost 1,000 invention disclosure cases in the files of the Assistant General Counsel for Patent Matters in the National Aeronautics and Space Administration shows that the time lag between the letting of an R & D contract and the conception of an invention averages 8 months.[20] Government contractors are

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As might be expected, a small number of inventions disclosed to NASA by government contractors were conceived before contracts were let. For these inventions, the lead time before contract

neither more nor less expenditure than officials in government installations in reporting inventions to NASA. Invention disclosure cases show that both contractors and government employees disclose inventions to NASA about 8 months after conceiving the inventions. Upon receiving invention disclosures, technical experts and patent counsel evaluate the technical merits and patentability of the inventions. For inventions warranting patent prosecution, NASA's average time lag between disclosure and patent application is about 12 months. In summary, the average period for conception, reduction to practice, evaluation, and preparation of a NASA patent application is about 28 months; the average period in the Patent Office is another 52 months.

Data on federally financed R & D are collected and published by the National Science Foundation. These data need two adjustments to obtain the flow that can meaningfully be related to the flow of inventions. One adjustment is to separate applied research from the lump sum total of all research and development. Clearly, pure or basic research must be taken out of the R & D total.

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awards is short -- between 3 and 7 months. It seems that contractors sometimes begin inventive work in anticipation of contract awards, or after informal agreements have been made, or in order to have substantive ideas for contract proposals. The files of NASA have no information on the time lag between intramural R & D expenditures and the conceptions of inventions.

By its very definition, basic research results, when it pays off, in new ideas or theories. They of course are not patentable. Applied research, which is research conducted toward specific practical objectives is therefore the relevant, the meaningful, R & D component for present purposes. The development part of total R & D must also be cut out. Development consists of technical activities such as the design and operation of pilot plants, nonroutine testing, the design and construction of preproduction prototypes, etc.[21]

At the time of writing, the National Science Foundation had published only fragmentary data on the separate amounts of basic research, applied research, and development for each year since 1940. (With a 5 1/2 year lag, the patented inventions of the calendar year 1945 were the result of applied research in the fiscal year 1940.) A rough rule of thumb, based on study of the bits and pieces of NSF data, is to assign 10 per cent of total R & D to basic research, 15 per cent to applied research, and 75 per cent to development.

The second adjustment is to get rid of the distorting influence of postwar inflation and to transform the expenditure data for applied research into constant dollars. To do this an appropriate

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[21]These definitions are adaptations of those published in various places by the National Science Foundation.

index of deflation is needed. We have made provisional calculations, using the implicit price deflators belonging to the national income and product accounts. The result is "adjusted applied research," i.e., 15 per cent of R & D expenditures corrected for inflation.

Preliminary examination of the relation between the annual patent data nad adjusted applied research lagged 5 1/2 years shows that the two series have grown and fluctuated together. This finding, we must admit, should hardly occasion surprise. Anyway, the two patterns of growth are similar. The decline in the numbers of patents in each calendar year from 1950 to 1954 is matched by the decline in adjusted applied research in each fiscal year from 1945 to 1948. The steady increase in adjusted applied research from 1948 on was accompanied by a growth in the numbers of the patents from 1954 to 1959. From 1959 to 1962 the annual average number of patents remained at a fairly stable level. So did the data for adjusted applied research.[22]

We can conjecture that the continued increase in the resources devoted to applied research will result in ever larger numbers of patents owned by and licensed to the government. It is probable, however, that the growth in the numbers of patents will be smaller,

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[22]We have postponed closer analysis of the relation of R & D to patents until more refined data on R & D and its components are available.

proportionately, than the growth in most applied research. This estimate follows from observation of the behavior of the two variables in the 1940's and 1950's. Real applied research was more volatile, both upward and downward, than the numbers of patents.[23]

THE AGENCIES

The federal agencies with substantial patent activities are customarily labled as either "title-policy" or "license-policy" agencies. Table 3 shows the titles and licenses acquired by the major federal agencies in the period 1945-1962. The Table indicates immediately that the title-policy agencies administer more titles than they do licenses, whereas the license-policy agencies have acquired more licenses than titles. And yet, the Department of the Army and of the Navy each have acquired more titles than the Atomic Energy Commission. In turn, AEC's licenses are more numerous than Agriculture's titles.

The many titles held by the Department of Defense reflect, not so much an aggressive policy of invention retrieval, as acquisition by default. Many of these inventions are turned over by contractors who do not want them themselves. Patent attorneys in the Department of Defense believe that licenses offer the

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[23]In other words, the elasticity of the numbers of patents with respect to the dollar volume of applied research (adjusted or unadjusted) is well less than unity.

TABLE 3

TITLES AND LICENSES BY MAJOR AGENCIES,

FOR THE PERIOD 1945-1962

Agency	Numbers of Patents		Percentages	
	Titles	Licenses	Titles	Licenses
Agriculture	1,297	115	91.9	8.1
Atomic Energy Commission	3,050	1,460	67.6	32.4
Department of Defense	8,667	24,916	25.8	74.2
Army	3,529	8,159	30.2	69.8
Navy	4,234	10,067	29.6	70.4
Air Force	904	6,690	11.9	88.1
All Other Agencies[a]	657	402	62.0	38.0
Total	13,671	26,893	33.7	66.3

[a]The other agencies with small, though significant, patent activities are Commerce, Interior, and National Aeronautics and Space Administration.

Source: Compiled from data in the Assignment Branch, U.S. Patent Office.

government as much protection as is needed against possible infringement suite.

For the Department of Defense, the amounts of intramural and contract research and development have as much, if not more, to do with the proportions of titles and licenses as does patent policy. Most of the R & D sponsored by the Department of the Air Force has been contract R & D. Among the three military departments, the Department of the Army has the smallest proportion of contract research; the Department of the Navy is between the Air Force and the Army. As the Table shows, the three military departments have the same ranking in the proportions of titles and licenses — Air Force, Navy, and Army.

The Department of Agriculture has the highest percentage of titles because it staunchly follows the title policy and because it sponsors very little contract R & D. Agriculture is required by the Bankhead-Jones Research Act of 1935 to use federal and state research facilities as much as possible. Agriculture has made one modification of its title policy: Under provision in special appropriations acts, the Rural Electrification Administration permits contractors to retain titles to patents originating under contract R & D. Because its R & D program is so small, the REA has not been an important source for licenses administered by the Department of Agriculture.

The Atomic Energy Commission, whose devotion to a strong title policy can hardly be denied, has one license for every two titles. Most of these patents licensed to the Atomic Energy

Commission belong, however, to the war and the early postwar years.

Although the National Aeronautics and Space Administration held interest in relatively few patented inventions at the end of 1962, the holdings of that agency will certainly rise substantially in the future. In the period from 1958 to 1963, NASA jumped to a place second only to the Department of Defense in its research and development budget. Of the patents NASA currently has an interest in, about 70 per cent are owned by the government. Most of the patents licensed to NASA arose from R & D activities of a predecessor agency, the National Advisory Committee for Aeronautics.

THE KINDS OF PATENTS

The patents coming out of the research and development financed by the federal government in the postwar period could be grouped or classified in several ways. How this should be done depends on the purposes of inquiry. When attention focuses on the spillover or fall-out effects of federal R & D, inventions can be put into two groups -- those not yet commercially used and those actually being so used. These last, in turn, can be further subdivided into the more and into the less valuable. Another way of classifying the patents is to separate them according to source, i.e., whether they come from government employees or from government contractors. We discuss the sources later in this article. In another study we plan to analyze the sources of the patents in the R & D activities of the largest

government contractors.

Patent Office Classes

Here we first classify the patents by their fields of technology. The system of classification is that of the Patent Office. With over 300 "Main Classes" and over 57,000 "Subclasses" in 1964, that system is designed to facilitate the search of prior art. For this reason and because it is exclusively technical, the Patent Office's system is not well adapted to answer questions such as ours: What fields of technology have the most inventions from government-financed R & D? For example, inventions that we should like to group under "aviation" are scattered over many Main Classes of the system of classification of the Patent Office. Inventions coming within the Patent Office Class 244 -- Aeronautics -- are limited to machines and structures adapted to be sustained by air or to be propelled through the air. Propulsion systems and electronic guidance devices are other kinds of inventions made by the aircraft and missiles industry; they fall into other Patent Office Classes. The Patent Office looks upon firearms and paper napkin holders with the same view, because both are devices for dispensing materials.

Despite the difficulties of using the Patent Office Classification system for purposes other than the one it was designed for, grouping of government R & D patents by this system does show that most of the inventions are defense-oriented. Table 4 shows the percentage distribution of titles and licenses falling into the four main Patent Exmaining Operation Divisions. These Divisions form the

TABLE 4

PERCENTAGES OF PATENTS FROM FEDERALLY FINANCED R & D IN PATENT OFFICE EXAMINING OPERATION DIVISIONS

Title of Examining Operation Division	Percentage of Titles[a]	Percentage of Licenses[b]
Chemical	30.9	7.9
Electrical	39.7	50.1
Mechanical Engineering	20.1	22.5
General Engineering and Industrial Arts	9.3	19.5
Total	100.0	100.0

[a]The percentage distribution includes the first 20 most important classes, by numbers of patents, of all patents assigned to the government between 1955 and 1962. The format of the Index of Patents precludes classification before 1955.

[b]The percentage distribution includes the first 20 most important classes, by numbers of patents, of groups of randomly sampled patents that were licensed to the government between 1946 and 1962. The sizes of the samples are: the Atomic Energy Commission, 233 patents; the Department of the Army, 268 patents; the Department of the Navy, 270 patents; and the Department of the Air Force, 267 patents. The Index of Patents lists patents by assignee but does not separate those licensed to the government from others.

Source: Compiled from data in the Assignment Branch of the U.S. Patent Office, the Index of Patents of the U.S. Patent Office, and the Official Gazette of the U.S. Patent Office.

broadest technical classification. There are thirty-two Examining Groups under the four Examining Operation Divisions. The 300 Main Classes, with their 57,000 Subclasses, come under the thirty-two Examining Groups.

One of the thirty-two Examining Groups deserves particular attention. That is Group 220 -- "Security." About one-third of all titles and licenses are in this group, which comes under the general supervision of the Electrical Examining Operation Division. Almost all patent applications covering security-classified inventions are reviewed by Patent Office officials assigned to Group 220. The inventions can cover chemical, electrical, or mechanical technologies. The Patent Office established the Security Group to facilitate the handling and examination of security-classified inventions. In Table 4, however, the main patent classes comprising the 220 Security Group were put into their original groups.[24] Therefore, the Electrical Examining Group appearing in Table 4 does not include the 220 Security Group as such.

As the Table shows, the largest proportion of patents arising from government-financed R & D embody electrical technology. Of these, the majority of inventions fall within the Radiation and Instrument Group (Number 260). Other sizable blocks of patents

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[24]Mr. Richard A. Wahl, Director, Mechanical Engineering Exmaining Operation, kindly helped us with patent classification matters, particularly those associated with the 220 Security Group.

are in the Information Transmission Group (Number 230), the Electric Component Systems and Devices Group (Number 250), and the Power Group (Number 210).

Within the Mechanical Engineering Examination Operation Division, the Material or Article Handling and Dispensing Group (Number 310) and the Manufacturing and Assembling Articles Group (Number 330) have the most government R & D patents. After reclassification of the 220 Security Group, ordnance, ammunition, and explosive devices are in Groups 310 and 330. In the Chemical Exmaining Operation Division, most inventions flowing from R & D sponsored by the Department of Defense and the Atomic Energy Commission fall within the General Chemistry Group (Number 110), and the High Polymer Chemistry Group (Number 140). The many government R & D patents covering technology on Nuclear Reactions and Systems are in the General Chemistry Group. The majority of food and beverage inventions flowing out of the R & D sponsored by the Department of Agriculture come within the Specialized Chemical Arts and Industries Group (Number 170). The Physics Group (Number 430) has the greatest number of government R & D patents coming under the control of the Engineering and Industrial Arts Examining Division.

Classification by Industry

Another way to classify the patents from government-financed R & D is by industry, using the definitions of the Standard

Industrial Classification.[25] Designed mainly for the Census of Manufacturers, that classification makes it possible to compare patents as outputs with the inputs of federal spending on industry. Unfortunately, the industry expenditure data reported by the National Science Foundation are available only since 1956.

Table 5 gives the industrial classification of patents owned by and licensed to the government from 1946 to 1962. Notice that the first year in Table 5 is 1946, rather than 1945. The total number of titles for 1946-1962 can be looked upon as the government portfolio at the end of 1962 (See Table 2). In 1963, the Office of Technical Services of the Department of Commerce published a list of government-owned patents unexpired on December 31, 1961, arranged according to the Standard Industrial Classification.[26] Because some patents fall into more than one class, the total number of patents classified by OTS exceeds the total number of patents actually owned by the government at the end of 1961. The classification appearing in Table 5 is based on the same percentage distribution of patents in each industry as that obtained from the list published by OTS.

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[25] The Standard Industrial Classification Manual is published by the Technical Committee on Industrial Classification, Office of Statistical Standards, Bureau of the Budget.

[26] U.S. Department of Commerce, Index to the Patent Abstract Series: Government-Owned Inventions Available for License through December, 1961 (Washington, D.C., U.S. Government Printing Office, 1963).

TABLE 5

STANDARD INDUSTRIAL CLASSIFICATION OF PATENTS FROM GOVERNMENT-FINANCED R & D

PERIOD 1946 TO 1962

Industry	Numbers			Percentages		
	Titles	Licenses	Total	Titles	Licenses	Total
Food and Kindred Products	418	a	418	3.1	a	1.1
Paper and Allied Products	60	a	60	0.4	a	0.2
Chemicals and Allied Products	2,574	1,834	4,408	18.9	7.2	11.2
Petroleum Refining and Extraction	79	285	364	0.6	1.1	0.9
Rubber Products	50	70	120	0.4	0.3	0.3
Primary Metals	365	243	608	2.7	1.0	1.6
Fabricated Metal Products	979	1,900	2,879	7.2	7.4	7.3
Machinery	1,134	3,952	5,086	8.3	15.5	13.0
Electrical and Communication Equipment	2,456	9,731	12,187	18.1	38.0	31.1
Motor Vehicles and Other Transportation Equipment	132	403	535	1.0	1.6	1.4
Aircraft and Missiles	789	2,082	2,871	5.8	8.1	7.3
Professional and Scientific Instruments	2,088	2,641	4,729	15.4	10.3	12.1
Ordnance and Accessories	2,038	1,806	3,844	15.0	7.1	9.8
Total Above	13,162	24,947	38,109	96.9	97.6	97.3
Other	422	625	1,047	3.1	2.4	2.7
TOTAL	13,584	25,572[b]	39,156	100.0	100.0	100.0

[a]Less than 0.1 per cent of all patents licensed to the Atomic Energy Commission and the Department of Defense.

[b]The total number of licenses shown above is less than that in Table 1. The total above includes only patents licensed to the Atomic Energy Commission and the Department of Defense.

Source: Compiled from data in the Assignment Branch of the U.S. Patent Office; the Official Gazette of the U.S. Patent Office; the Office of Technical Services, U.S. Department of Commerce; and the Standard Industrial Classification Manual, U.S. Bureau of the Budget.

The classification of patents licensed to the government follows the description of inventions given in the Official Gazette of the U. S. Patent Office. The Office of Technical Services does not maintain records on patents licensed to the government. The classifications shown in the Table are inflated random samples of all patents licensed to the Atomic Energy Commission and to the Department of Defense between 1946 and 1962.[27] Because so few patents were licensed to other government agencies during that period, they were not classified and are not included in the totals.

It is not surprising that the largest proportion of total patents (31 per cent) belong to the electrical equipment and communication equipment industry. The electrical and communication equipment industry performs about one-fourth of all the federally financed R & D performed by industry. Compared with the proportion of federal R & D funds, about 50 per cent in recent years, the proportion of patents belonging to the aircraft and missiles industry is low (8 per cent). In part, this can be explained by lags between the time R & D is undertaken and the time when patents issue. Federally financed R & D in the aircraft and missiles industry has increased rapidly since the first Sputnik and the inception of NASA. The small proportion can also be

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[27] The sizes of the samples are: the Atomic Energy Commission, 233 patents; the Department of the Army, 268 patents; the Department of the Navy, 270 patents; and the Department of the Air Force, 267 patents.

explained by the fact that the development portion of R & D is high in this industry.

In contrast, the proportion of patents in the chemical and professional and scientific instruments industries is large compared with the proportion of federal funds going into these industries. Evidence from preliminary investigations suggests that the ratio of the numbers of patent applications to invention disclosures is higher in the field of chemistry than in other technologies.

Table 5 also shows some difference between the kinds of patents owned by the government and those licensed to it. The titles are more defense-oriented than the licenses. For example, 15 per cent of the titles are in the ordnance group, in contrast to 7 per cent of the licenses. Many of the chemical patents -- 19 per cent of the titles and 7 per cent of the licenses -- are new developments in chemical warfare. Very few license-policy patents cover technology used by the food industry. Almost all of the patents employed in that industry arise from R & D sponsored by the Department of Agriculture. One of the most important exceptions to this are the inventions leading to the development and widespread use of TV dinners. These inventions came from R & D sponsored by the Department of the Army.

SOURCES

Patents on the inventions from federally financed research

and development are issued to their inventors, who are either government employees[28] or employees of organizations receiving contracts or grants from the federal government. The government employees either assign title to the government or else retain title themselves, giving the government the usual irrevocable, nonexclusive, royalty-free, license. So far as we know, employees of business corporations, of universities, and of other research organizations always assign title to their employers or to the government. We do not know if this happens invariably. It seems possible that there must have been a few inventions of no interest or apparent value either to the contractors or to the government whose titles were allowed to remain with the employee-inventors. However this might be, we now group all of the patents as having two sources, government employees and contractors.

Table 6 presents the data. The footnote to the Table explains the sources of the few patents included in the column for contractors.

One-third of all of the patented inventions from government-financed research and development were made by government employees. This proportion, however, has not been constant in the postwar period. In some years in the late 1940's, employees accounted for 40-50 percent of all inventions. During the 1950's, the

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[28] An exception to this rule is the issue of certain patents from NASA's research to Mr. James E. Webb, the Administrator of NASA.

TABLE 6

EMPLOYEES AND CONTRACTORS AS SOURCES OF PATENTS FROM GOVERNMENT-FINANCED R & D

1945 - 1962

Calendar Year	Numbers of Patents (Titles and Licenses)		Percentages	
	Employees	Contractors[a]	Employees	Contractors[a]
1945	477	460	50.9	49.1
1946	511	1,022	33.3	66.7
1947	521	1,000	34.2	65.8
1948	737	1,053	41.2	58.8
1949	999	1,218	45.1	54.9
1950	975	1,372	41.5	58.5
1951	835	1,338	38.4	61.6
1952	773	1,220	38.8	61.2
1953	608	1,268	32.4	67.6
1954	436	1,100	28.4	71.6
1955	567	1,204	32.0	68.0
1956	749	1,743	30.0	70.0
1957	726	1,729	29.6	70.4
1958	939	2,033	31.6	68.4
1959	935	2,335	28.6	71.4
1960	903	2,224	28.9	71.1
1961	967	2,498	27.9	72.1
1962	960	2,129	31.1	68.9
TOTAL	13,618	26,946	33.6	66.4

[a]Nearly all of the patents in this column are from contractors. A few are from grantees, from donors, from purchases (of patents or of licenses) by the government, and from international agreements.

Source: Compiled from data in the Assignment Branch, U.S. Patent Office.

employees' share of the total declined from about 41 per cent to about 29 per cent.

These changes are roughly consistent with one of the major alterations in the pattern of federally financed R & D, namely, the increasing reliance on contract research. According to the National Science Foundation,[29] federal obligations for "intramural performance" in the fiscal year 1955 were 37 per cent of thetotal obligations for R & D. The fiscal year 1955 is the first for which such data are available. By the early 1960's, this percentage had fallen to about 20. Even so, the R & D activities performed in government-operated installations continued to grow rapidly--in fiscal 1963 they were about 2 1/2 times larger, in dollar amount, than they were in fiscal 1955.[30]

Table 7 shows the sources of government-owned patents by major agencies for the period 1945-1962. Table 8 gives the data for the patents licensed to the government. The variations from one agency to another reflect the two influences--the patent practices of the agencies and the proportions of intramural and contract research.

CONCLUSION

We have sketched the picture of the functioning of the title and the license policies in the conduct of research and development

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[29] Federal Funds for Science XI, 1963, p. 12.

[30] Ibid.

TABLE 7

SOURCES OF GOVERNMENT-OWNED R & D PATENTS,

BY AGENCY, FOR THE PERIOD 1945-1962

Agency	Numbers of Patents		Percentages	
	Employees	Contractors[a]	Employees	Contractors
Agriculture	1,263	34	97.4	2.6
Atomic Energy Commission	28	3,022	0.9	99.1
Department of Defense	3,509	5,158	39.7	60.3
Army	1,820	1,709	51.6	48.4
Navy	1,347	2,887	31.8	68.2
Air Force	342	562	37.8	62.2
All Other Agencies[b]	489	168	74.4	25.6
Total	5,289	8,382	32.7	67.3

[a]Nearly all of the patents in this column are from contractors. A few are from grantees, from donors, from purchases (of patents and licenses) by the government, and from international agreements.

[b]The other agencies with small, though significant patent activities are Commerce, Interior, and National Aeronautics and Space Administration.

Source: Compiled from data in the Assignment Branch, U.S. Patent Office.

TABLE 8

SOURCES OF PATENTS LICENSED TO THE GOVERNMENT,

BY MAJOR AGENCIES, FOR THE PERIOD 1945-1962

Agency	Numbers of Patents		Percentages	
	Employees	Contractors[a]	Employees	Contractors
Agriculture	109	6	94.8	5.2
Atomic Energy Commission	40	1,420	2.7	97.3
Department of Defense	7,991	16,925	32.1	67.9
Army	2,994	5,165	36.7	63.3
Navy	4,257	5,810	42.3	57.7
Air Force	740	5,950	11.1	88.9
All Other Agencies[b]	189	213	47.0	53.0
Total	8,329	18,564	31.0	69.0

[a]Nearly all of the patents in this column are from contractors. A few are from grantees, from donors, from purchases (of patents and licenses) by the government, and from international agreements.

[b]The other agencies with small, though significant, patent activities are Commerce, Interior, and National Aeronautics and Space Administration.

Source: Compiled from data in the Assignment Branch, U.S. Patent Office.

financed by the federal government to the end of 1962. The strokes of our brush are broad, but they are also, we are certain, accurate. What remains is to fill in detail.

This article is a report on part of a continuing study of the inventions flowing from government-financed research and development. Except for the data we present, little is now known about the more than 8,000 patents owned by government employees. Do they still own all of them? Or have some been assigned to business corporations? What is the rate of use of these inventions? How does this rate compare with the rates of utilization of the government-owned inventions and of the industry-owned license-policy inventions? What amounts of government-financed R & D went into the creation of the employee-owned inventions? In research still to be undertaken, we hope to give answers to these and to related questions.

Continued examination of the functioning of the title policy will center on the activities of the large patent departments of the federal government. We have already learned that all but one of these departments file patent applications on only a part of the inventions disclosed to them. We intend to probe into this matter and gain insight into the inventive activity stimulated by the federal government. The President's Memorandum of October 10, 1963 speaks of the (contract) patented inventions as "a valuable national resource." What of the many thousands of inventions that are not patented? Not all of these, we tentatively believe, are unpatentable. Are they too a resource?

We do not now know.

Deeper investigation of the operation of the license policy can bring to light the numbers of patents acquired in the postwar period by the largest R & D contractors--patents both from company-financed and from government-financed R & D. Still another line of inquiry is into the facts, rather than into the opinions about, of the concentration of patent holdings in large corporations in the postwar period.