and this was recognized by plaintiff's expert, the patentee was not entitled to claim all structures which exercised the desired function, but only those which he himself invented, and a device which produces the same result through translation of force operates in a substantially different manner than one in which force is directly applied. This is not infringement, Westinghouse v. Boyden Power Brake Co., 170 U. S. 537, 568, especially where the patent is not a generic one and the patentee is entitled to but a narrow range of equivalents. See Directoplate Corp. v. Donaldson Lith. Co., 51 Fed. (2d) 199 (C. C. A. 6). There are two tests of equivalency (1) identity of function, and (2) substantial identity of way of performing that function. Walker on Patents, 6th Ed. 511. Primary as well as secondary patents are infringed by no substitutions that do not fully respond to these tests. Even if identity of function were present, the patent not being a primary one, the requirement of substantial identity of way should not be considered so elastic [illegible] important difference in manner of operation.

There is no infringement, and the decree below is affirmed.

Supreme Court of the United States

UNITED STATES OF AMERICA v. DUBILIER CONDENSER CORPORATION

Nos. 316, 317, 318 Decided Apr. 10, 1933

Patents—Patents—

Patent is not, accurately speaking, a monopoly, for it is not created by executive authority at expense of and to prejudice of all community except grantee of patent; inventor deprives public of nothing which it enjoyed before his discovery but gives something of value to community by adding to sum of human knowledge; he may keep invention secret and reap its fruits indefinitely; in consideration of its disclosure and consequent benefit to community, patent is granted.

Patents—Specification—Sufficiency of disclosure—

Law requires such disclosure to be made in application for patent that others skilled in art may understand invention and how to put it to use.

Patents—Title—Employer and employee—

Patent is property and title can pass only by assignment; if not yet issued, agreement to assign when issued, if valid as contract, will be specifically enforced; respective rights and obligations of employer and employee, touching invention conceived by latter, spring from contract of employment; one employed to make invention who succeeds during term of service in accomplishing that task is bound to assign to employer patent obtained; on other hand if employment be general, albeit it covers field of labor and effort in performance of which employee conceived the invention for what he obtained patent, contract is not so broadly construed as to require assignment of patent.

Patents—Patentability—Invention—

Invention consists neither in finding out laws of nature nor in fruitful research as to operation of natural laws but in discovering how those laws may be utilized or applied for beneficial purpose by a process, a device or a machine; it is result of inventive act, birth of an idea, and its reduction to practice; product of original thought; concept demonstrated to be true by practical application or embodiment in tangible form; embodiment is not the invention and is not subject of a patent.

Patents—Title—Employer and employee—

Employment merely to design or construct or devise methods of manufacture is not same as employment to invent; shop right is that, where servant during hours of employment working with master's materials and appliances conceives and perfects invention for which he obtains patent, he must accord master non-exclusive right to practice invention; but employer has no equity to demand conveyance of invention; this remains property of him who conceived it together with right conferred by patent to exclude all others than employer from accruing benefits.

Patents—Title—

Title of the patentee is subject to no superior right of Government; grant is not, as in England, a matter of grace or favor so that conditions may be annexed at

pleasure of executive; laws passed by Congress alone may be looked to for guidance as to extent of limitations of respective rights of inventor and public; Constitution evinces no public policy which requires holder of patent to cede use or benefit of invention to United States.

Patents—Applicants—

No servant of United States has by statute been disqualified for applying for and receiving patent for his invention save officers and employees of Patent Office during period for which they hold their appointments.

Patents—Title—Government employees—

Supreme Court has applied rules enforced as between private employers and servants to relation between Government and its officers and employees; United States is entitled, in same way and to same extent as private employer, to shop rights, that is, free and non-exclusive use of patent which results from efforts of those employed in their working hours and with material belonging to Government; statutes, decisions and administrative practice negate existence of duty binding one in service of Government different from obligation of one in private employment; United States like any other employer, if it desires assignment of employee's rights, must prove contractual obligation on part of employee to assign patents to Government; employees of Bureau of Standards who did not agree to exercise inventive faculties in their work and who made invention not within its scope need not assign patents to Government; written evidence of employment does not mention research, much less invention; never was word said to employees prior to discoveries concerning invention or patents or duties or obligations respecting these matters; other employees of Bureau of Standards and other departments had, while so employed, received numerous patents and enjoyed exclusive rights against all private persons without let or hindrance from Government;* no act of Congress authorizes United States to take patent or to hold one by assignment; no statutory authority exists for transfer of patents to any department or officer of Government or for administration of patents or issuance of licenses on behalf of the United States; inventors do not hold patents in trust for Government.

Patents—Title—Government employee—

Act of 1883 and as amended in 1928 provides patent without fee for Government employee who in course of employ conceives invention; he should afford Government free use thereof but should be protected in right to exclude all others; similar right accrues to Government employee paying fees for patent.

Patents—Jurisdiction of courts—

Until 1910 Court of Claims was without jurisdiction to award compensation to owner of patent for unauthorized use by United States or its agents; power extended only to trial of claims based upon express or implied contracts for such use; in 1910 Congress enlarged jurisdiction to embrace former class of claims, but imposing restriction that it should not extend to owners of patents obtained by employees of Government while in service.

Patents—Title—Government employees—

Congress has refrained from imposing upon Government servants contract obligation to assign to Government patent for invention discovered or developed during period of Government service and incidental to line of official duties, and court will not assume such contract obligations.

Patents—Radio Receiving Apparatus title transfer refused—

1455141, Lowell & Dunmore, Radio Receiving Apparatus, title transfer refused.
1606212, Dunmore & Lowell, Power Amplifier, title transfer refused.
1635117, Dunmore, Signal Receiving System, title transfer refused.

On writs of certiorari to the United States Circuit Court of Appeals for the Third Circuit.

THOMAS D. THACHER, Solicitor General (CHARLES B. RUGG, Assistant Attorney General, ALEXANDER HOLTZOFF, PAUL D. MILLER and H. BRIAN HOLLAND with him on the brief) for petitioner; JAMES H. HUGHES, JR. (E. ENNALLS BERL, JOHN B. BRADY and WARD & GRAY with him on the brief) for respondent.

Mr. Justice ROBERTS delivered the opinion of the Court.—Three suits were

*The remaining portion of the syllabus was based upon a paragraph deleted from the opinion by order of the court. (See Note, p. 161.)

brought in the District Court for Delaware against the respondent as exclusive licensee under three separate patents issued to Francis W. Dunmore and Percival D. Lowell. The bills recite that the inventions were made while the patentees were employed in the radio laboratories of the Bureau of Standards, and are therefore, in equity, the property of the United States. The prayers are for a declaration that the respondent is a trustee for the Government, and, as such, required to assign to the United States all its right, title and interest in the patents, for an accounting of all moneys received as licensee, and for general relief. The District Court consolidated the cases for trial, and after a hearing dismissed the bills.[1] The Court of Appeals for the Third Circuit affirmed the decree.[2]

The courts below concurred in findings which are not challenged and, in summary, are:

The Bureau of Standards is a subdivision of the Department of Commerce.[3] Its functions consist in the custody of standards; the comparison of standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with those adopted or recognized by the Government; the construction of standards, their multiple or subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connection with standards; and the physical properties of materials. In 1915 the Bureau was also charged by Congress with the duty of investigation and standardization of methods and instruments employed in radio communication, for which special appropriations were made.[4] In recent years it has been engaged in research and testing work of various kinds for the benefit of private industries, other departments of the Government, and the general public.[5]

The Bureau is composed of divisions, each charged with a specified field of activity, one of which is the electrical division. These are further subdivided into sections. One section of the electrical division is the radio section. In 1921 and 1922 the employees in the laboratory of this section numbered approximately twenty men doing technical work and some draftsmen and mechanics. The twenty were engaged in testing radio apparatus and methods and in radio research work. They were subdivided into ten groups, each group having a chief. The work of each group was defined in outlines by the chief or alternate chief of the section.

Dunmore and Lowell were employed in the radio section and engaged in research and testing in the laboratory. In the outlines of laboratory work the subject of "airplane radio" was assigned to the group of which Dunmore was chief and Lowell a member. The subject of "radio receiving sets" was assigned to a group of which J. L. Preston was chief, but to which neither Lowell nor Dunmore belonged.

In May, 1921, the Air Corps of the Army and the Bureau of Standards entered into an arrangement whereby the latter undertook the prosecution of forty-four research projects for the benefit of the Air Corps. To pay the cost of such work, the Corps transferred and allocated to the Bureau the sum of $267,500. Projects Nos. 37 to 42, inclusive, relating to the use of radio in connection with aircraft, were assigned to the radio section and $25,000 was allocated to pay the cost of the work. Project No. 38 was styled "visual indicator for radio signals," and suggested the construction of a modification of what was known as an "Eckhart recorder." Project No. 42 was styled "airship bomb control and marine torpedo control." Both were problems of design merely.

In the summer of 1921 Dunmore, as chief of the group to which "airplane radio" problems had been assigned, without further instructions from his superiors, picked out for himself one of these navy problems, that of operating a relay for remote control of bombs on airships and topedoes in the sea, "as one of particular interest and having perhaps a rather easy solution, and worked on it." In September he solved it,

In the midst of aircraft investigations and numerous routine problems of the section, Dunmore was wrestling in his own mind, impelled thereto solely by his own scientific curiosity, with the subject of substittuing house-lighting alternating current for direct battery current in radio apparatus. He obtained a relay for operating a telegraph instrument which was in no way related to the remote control relay devised for aircraft use. The conception of the application of alternating current concerned partic-

[1] 49 F. (2d) 806 [9 U. S. Pat. Q. 181].

[2] 59 F. (2d) 881 [18 U. S. Pat. Q. 887].

[3] See Act of March 3, 1901, 31 Stat. 1449; Act of February 14, 1903, Sec. 4, 32 Stat. 826.

[4] Act of March 4, 1915, 38 Stat. 1044; Act of May 29, 1920, 41 Stat. 684; Act of March 3, 1921, 41 Stat. 1303.

[5] The fees charged cover merely the cost of the service rendered, as provided in the Act of June 30, 1932, Sec. 312, 47 Stat. 410.

ularly broadcast reception. This idea was conceived by Dunmore August 3, 1921, and he reduced the invention to practice December 16, 1921. Early in 1922 he advised his superior of his invention and spent additional time in perfecting the details. February 27, 1922, he filed an application for a patent.

In the fall of 1921 both Dunmore and Lowell were considering the problem of applying alternating current to broadcast receiving sets. This project was not involved in or suggested by the problems with which the radio section was then dealing and was not assigned by any superior as a task to be solved by either of these employees. It was independent of their work and voluntarily assumed.

While performing their regular tasks they experimented at the laboratory in devising apparatus for operating a radio receiving set by alternating current with the hum incident thereto eliminated. The invention was completed on December 10, 1921. Before its completion no instructions were received from and no conversations relative to the invention were held by these employees with the head of the radio section, or with any superior.

They also conceived the idea of energizing a dynamic type of loud speaker from an alternating current house-lighting circuit and reduced the invention to practice on January 25, 1922. March 21, 1922, they filed an application for a "power amplifier." The conception embodied in this patent was devised by the patentees without suggestion, instruction, or assignment from any superior.

Dunmore and Lowell were permitted by their chief, after the discoveries had been brought to his attention, to pursue their work in the laboratory and to perfect the devices embodying their inventions. No one advised them prior to the filing of applications for patents that they would be expected to assign the patents to the United States or to grant the Government exclusive rights thereunder.

The respondent concedes that the United States may practice the inventions without payment of royalty, but asserts that all others are excluded, during the life of the patents, from using them without the respondent's consent. The petitioner insists that the circumstances require a declaration either that the Government has sole and exclusive property in the inventions or that they have been dedicated to the public so that anyone may use them.

First. By Article I, Section 8, clause 8 of the Constitution, Congress is given power to promote the progress of science and the useful arts by securing for limited times to inventors the exclusive rights to their respective discoveries. R. S. 4886 as amended (U. S. Code, Title 35, § 31) is the last of a series of statutes which since 1793 have implemented the constitutional provision.

Though often so characterized a patent is not, accurately speaking, a monopoly, for it is not created by the executive authority at the expense and to the prejudice of all the community except the grantee of the patent. Seymour v. Osborne, 11 Wall. 516, 533. The term monopoly connotes the giving of an exclusive privilege for buying, selling, working or using a thing which the public freely enjoyed prior to the grant.[6] Thus a monopoly takes something from the people. An inventor deprives the public of nothing which it enjoyed before his discovery, but gives something of value to the community by adding to the sum of human knowledge. United States v. Bell Telephone Co., 167 U. S. 224, 239; Paper Bag Patent Case, 210 U. S. 405, 424; Brooks v. Jenkins, 3 McLean 432, 437; Parker v. Haworth, 4 McLean 370, 372; Allen v. Hunter, 6 McLean 303, 305-306; Attorney General v. Rumford Chemical Works, 2 Bann. & Ard. 298, 302. He may keep his invention secret and reap its fruits indefinitely. In consideration of its disclosure and the consequent benefit to the community, the patent is granted. An exclusive enjoyment is guaranteed him for seventeen years, but upon the expiration of that period, the knowledge of the invention enures to the people, who are thus enabled without restriction to practice it and profit by its use. Kendall v. Winsor, 21 How. 322, 327; United States v. Bell Telephone Co., *supra*, p. 239. To this end the law requires such disclosure to be made in the application for patent that others skilled in the art may understand the invention and how to put it to use.[7]

A patent is property and title to it can pass only by assignment. If not yet issued an agreement to assign when issued, if valid as a contract, will be specifically enforced. The respective rights and obligations of employer and employee, touching an invention conceived by the latter, spring from the contract of employment.

[6] Webster's New International Dictionary: "Monopoly."

[7] U. S. Code, Tit. 35, § 33.

One employed to make an invention, who succeeds, during his term of service, in accomplishing that task, is bound to assign to his employer any patent obtained. The reason is that he has only produced that which he was employed to invent. His invention is the precise subject of the contract of employment. A term of the agreement necessarily is that what he is paid to produce belongs to his paymaster. Standard Parts Company v. Peck, 264 U. S. 52. On the other hand, if the employment be general, albeit it covers a field of labor and effort in the performance of which the employee conceived the invention for which he obtained a patent, the contract is not so broadly construed as to require an assignment of the patent. Hapgood v. Hewitt, 119 U. S. 226; Dalzell v. Dueber Watch Case Mfg. Co., 149 U. S. 315. In the latter case it was said:

"But a manufacturing corporation, which has employed a skilled workman, for a stated compensation, to take charge of its works, and to devote his time and services to devising and making improvements in articles there manufactured, is not entitled to a conveyance of patents obtained for inventions made by him while so employed, in the absence of express agreement to that effect."

The reluctance of courts to imply or infer an agreement by the employee to assign his patent is due to a recognition of the peculiar nature of the act of invention, which consists neither in finding out the laws of nature, nor in fruitful research as to the operation of natural laws, but in discovering how those laws may be utilized or applied for some beneficial purpose, by a process, a device or a machine. It is the result of an inventive act, the birth of an idea and its reduction to practice; the product of original thought; a concept demonstrated to be true by practical application or embodiment in tangible form. Clark Tread Co. v. Willimantic Linen Co., 140 U. S. 481, 489; Symington Co. v. National Castings Co., 250 U. S. 383, 386; Pyrene Mfg. Co. v. Boyce, 292 Fed. 480, 481.

Though the mental concept is embodied or realized in a mechanism or a physical or chemical aggregate, the embodiment is not the invention and is not the subject of a patent. This distinction between the idea and its application in practice is the basis of the rule that employment merely to design or to construct or to devise methods of manufacture is not the same as employment to invent. Recognition of the nature of the act of invention also defines the limits of the so-called shop right, which shortly stated, is that where a servant, during his hours of employment, working with his master's materials and appliances, conceives and perfects an invention for which he obtains a patent, he must accord his master a non-exclusive right to practice the invention. McClurg v. Kingsland, 1 How. 202; Solomons v. United States, 137 U. S. 342; Lane & Bodley Co. v. Locke, 150 U. S. 193. This is an application of equitable principles. Since the servant uses his master's time, facilities and materials to attain a concrete result, the latter is in equity entitled to use that which embodies his own property and to duplicate it as often as he may find occasion to employ similar appliances in his business. But the employer in such a case has no equity to demand a conveyance of the invention, which is the original conception of the employee alone, in which the employer had no part. This remains the property of him who conceived it, together with the right conferred by the patent, to exclude all others than the employer from the accruing benefits. These principles are settled as respects private employment.

Second. Does the character of the service call for different rules as to the relative rights of the United States and its employees?

The title of a patentee is subject to no superior right of the Government. The grant of letters patent is not, as in England, a matter of grace or favor, so that conditions may be annexed at the pleasure of the executive. To the laws passed by the Congress, and to them alone, may we look for guidance as to the extent and the limitations of the respective rights of the inventor and the public. Attorney General v. Rumford Chemical Works, *supra*, at pp. 303-4. And this court has held that the Constitution evinces no public policy which requires the holder of a patent to cede the use or benefit of the invention to the United States, even though the discovery concerns matters which can properly be used only by the Government; as, for example, munitions of war. James v. Campbell, 104 U. S. 356, 358. Hollister v. Benedict Mfg. Co., 113 U. S. 59, 67.

No servant of the United States has by statute been disqualified from applying for and receiving a patent for his invention, save officers and employees of the Patent Office during the period for which they hold their appointments.[8]

[8] R. S. 480; U. S. Code, Tit. 35, § 4.

This being so, this court has applied the rules enforced as between private employers and their servants to the relation between the Government and its officers and employees.

United States v. Burns, 12 Wall. 246, was a suit in the Court of Claims by an army officer as assignee of a patent obtained by another such officer for a military tent, to recover royalty under a contract made by the Secretary of War for the use of the tents. The court said, in affirming a judgment for the plaintiff:

"If an officer in the military service, not specially employed to make experiments with a view to suggest improvements, devises a new and valuable improvement in arms, tents, or any other kind of war material, he is entitled to the benefit of it, and to letters-patent for the improvement from the United States, equally with any other citizen not engaged in such service; and the government cannot, after the patent is issued, make use of the improvement any more than a private individual, without license of the inventor or making compensation to him."

In United States v. Palmer, 128 U. S. 262, Palmer, a lieutenant in the army, patented certain improvements in infantry accoutrements. An army board recommended their use and the Secretary of War confirmed the recommendation. The United States manufactured and purchased a large number of the articles. Palmer brought suit in the Court of Claims for a sum alleged to be a fair and reasonable royalty. From a judgment for the plaintiff the United States appealed. This court, in affirming, said:

"It was at one time somewhat doubted whether the government might not be entitled to the use and benefit of every patented invention, by analogy to the English law which reserves this right to the crown. But that notion no longer exists. It was ignored in the case of Burns."

These principles were recognized in later cases involving the relative rights of the Government and its employees in instances where the subject-matter of the patent was useful to the public generally. While these did not involve a claim to an assignment of the patent, the court reiterated the views earlier announced.

In Solomons v. United States, 137 U. S. 342, 346, it was said:

"The government has no more power to appropriate a man's property invested in a patent than it has to take his property invested in real estate; nor does the mere fact that an inventor is at the time of his invention in the employ of the government transfer to it any title to, or interest in it. An employe, performing all the duties assigned to him in his department of service, may exercise his inventive faculties in any direction he chooses, with the assurance that whatever invention he may thus conceive and perfect is his individual property. There is no difference between the government and any other employer in this respect."

And in Gill v. United States, 160 U. S. 426, 435:

"There is no doubt whatever of the proposition laid down in Solomons case, that the mere fact that a person is in the employ of the government does not preclude him from making improvements in the machines with which he is connected, and obtaining patents therefor, as his individual property, and that in such case the government would have no more right to seize upon and appropriate such property, than any other proprietor would have. * * *"

The distinction between an employment to make an invention and a general employment in the course of which the servant conceives an invention has been recognized by the executive department of the Government. A lieutenant in the navy patented an anchor while he was on duty in the Bureau of Equipment and Recruiting, which was charged with the duty of furnishing anchors for the navy; he was not while attached to the bureau specially employed to make experiments with a view to suggesting improvements to anchors or assigned the duty of making or improving. The Attorney General advised that as the invention did not relate to a matter as to which the lieutenant was specially directed to experiment with a view to suggesting improvements he was entitled to compensation from the Government for the use of his invention in addition to his salary or pay as a navy officer.[9]

A similar ruling was made with respect to an ensign who obtained a patent for improvements in "B. L. R. ordnance" and who offered to sell the improvements, or the right to use them, to the Government. It was held that the navy might properly make a contract with him to this end.[10]

[9] 19 Opinions Attorney-General, 407.

[10] 20 Opinions Attorney-General, 329. And compare Report Judge Advocate General of the Navy, 1901, p. 6; Digest, Opinions Judge Advocate General of the Army, 1912-1930, p. 287; Opinions, Judge Advocate General of the Army, 1918, Vol. 2, pp. 529, 988, 1066.

The United States is entitled, in the same way and to the same extent as a private employer, to shop-rights, that is, the free and non-exclusive use of a patent which results from efforts of its employee in his working hours and with material belonging to the Government. Solomons v. United States, *supra*, pp. 346-7; McAleer v. United States, 150 U. S. 424; Gill v. United States, *supra*.

The statutes, decisions and administrative practice negate the existence of a duty binding one in the service of the Government different from the obligation of one in private employment.

Third. When the United States filed its bills it recognized the law as heretofore declared; realized that it must like any other employer, if it desired an assignment of the respondent's rights, prove a contractual obligation on the part of Lowell and Dunmore to assign the patents to the Government. The averments clearly disclose this. The bill in No. 316 is typical. After reciting that the employees were laboratory apprentice and associate physicist and laboratory assistant and associate physicist respectively and that one of their duties was "to carry on investigation research and experimentation in such problems relating to radio and wireless as might be assigned to them by their superiors," it is charged "in the course of his employment as aforesaid, there was assigned to said Lowell by his superiors in said radio section, for investigation and research, the problem of developing a radio receiving set capable of operation by alternating current. * * *"

Thus the Government understood that respondent could be deprived of rights under the patents only by proof that Dunmore and Lowell were employed to devise the inventions. The findings of the courts below show how far the proofs fell short of sustaining these averments.

The Government is consequently driven to the contention that though the employees were not specifically assigned the task of making the inventions (as in Standard Parts Co. v. Peck, *supra*) still, as the discoveries were "within the general field of their research and inventive work" the United States is entitled to an assignment of the patents. The courts below expressly found that Dunmore and Lowell did not agree to exercise their inventive faculties in their work and that invention was not within its scope. In this connection it is to be remembered that the written evidence of their employment does not mention research, much less invention; that never was there a word said to either of them, prior to their discoveries, concerning invention or patents or their duties or obligations respecting these matters; that as shown by the records of the patent office, employees of the Bureau of Standards and other departments had while so employed received numerous patents and enjoyed the exclusive rights obtained as against all private persons without let or hindrance from the Government.[11]

---

[11] No exhaustive examination of the official records has been attempted. It is sufficient, however, for present purposes, to call attention to the following instances.

Dr. Frederick A. Kolster was employed in the radio section, Bureau of Standards, from December, 1912, until about March 1, 1921. He applied for the following patents: No. 1,609,866, for radio apparatus, application dated November 26, 1920. No. 1,447,165, for radio method and apparatus, application dated January 30, 1919. No. 1,311,654, for radio method and apparatus, application dated March 25, 1916. No. 1,394,560, for apparatus for transmitting radiant energy, application dated November 24, 1916. The Patent Office records show assignments of these patents to Federal Telegraph Company, San Francisco, Cal., of which Dr. Kolster is now president. He testified that these are all subject to a non-exclusive license in the United States to use and practice the same.

Burten McCollum was an employee of the Bureau of Standards between 1911 and 1924. On the dates mentioned he filed the following applications for patents, which were issued to him. No. 1,085,878, alternating current induction motor, March 11, 1912. No. 1,156,364, induction motor, February 25, 1915. No. 1,226,091, alternating current induction motor, August 2, 1915. No. 1,724,495, method and apparatus for determining the slope of subsurface rock boundaries, October 24, 1923. No. 1,724,720, method and apparatus for studying subsurface contours, October 12, 1925. The last two inventions were assigned to McCollum Geological Explorations, Inc., a Delaware corporation.

Herbert B. Brooks, while an employee of the Bureau between 1912 and 1930, filed November 1, 1919, an application on which patent No. 1,357,197, for an electric transformer, was issued.

William W. Coblentz, an employee of the Bureau of Standards from 1918, and still such at the date of the trial, on the dates mentioned, filed applications on which patents issued as follows: No. 1,418,862, for electrical resistance, September 22, 1920. No. 1,458,165, system of electrical control, September 22, 1920. No. 1,450,061, optical method for producing pulsating electric current, August 6, 1920. No. 1,563,557, optical means for rectifying alternating currents, September 18, 1923. The Patent Office records show that all of these stand in the name of Coblentz, but are subject to a license to the United States of America.

August Hund, who was an employee of the Bureau from 1922 to 1927, on the dates mentioned filed applications on which letters patent issued, No. 1,649,828, method of preparing Piezo-electric plates, September 30, 1925. No. 1,688,713, Piezo-electric-crystal oscillator system, May 10, 1927. No. 1,688,714, Piezo-electric-crystal apparatus, May 12, 1927. No. 1,648,689, condenser transmitter, April 10, 1926. All of these patents are shown of record to have been assigned to Wired Radio Inc., a corporation.

Paul R. Heyl and Lyman J. Briggs, while employees of the Bureau, filed an application January 11, 1922, for patent No. 1,660,751, on inductor compass, and assigned the same to the

In no proper sense may it be said that the contract of employment contemplated invention; everything that Dunmore and Lowell knew negatived the theory that they were employed to invent; they knew, on the contrary, that the past and then present practice was that the employees of the Bureau were alowed to take patents on their inventions and have the benenfits thereby conferred save as to use by the United States. The circumstances preclude the implication of any agreement to assign their inventions or patents.

*Moreover no court could, however clear the proof of such a contract, order the execution of an assignment. No Act of Congress has been called to our attention authorizing the United States to take a patent or to hold one by assignment. No statutory authority exists for the transfer of a patent to any department or officer of the Government, or for the administration of patents, or the issuance of licenses on behalf of the United States. In these circumstances no public policy requires us to deprive the inventor of his exclusive rights as respects the general public and to lodge them in a dead hand incapable of turning the patent to account for the benefit of the public.

The record affords even less basis for inferring a contract on the part of the inventors to refrain from patenting their discoveries than for finding an agreement to assign them.

The bills aver that the inventions and patents are held in trust for the United States, and that the court should so declare. It is claimed that as the work of the Bureau, including all that Dunmore and Lowell did, was in the public interest, these public servants had dedicated the offspring of their brains to the public, and so held their patents in trust for the common weal, represented here in a corporate capacity by the United States. The patentees, we are told, should surrender the patents for cancellation, and the respondent must also give up its rights under the patents.

The trust cannot be express. Every fact in the case negatives the existence of one. Nor can it arise *ex maleficio*. The employees' conduct was not fraudulent in any respect. They promptly disclosed their inventions. Their superiors encouraged them to proceed in perfecting and applying the discoveries. Their note books and reports disclosed the work they were doing, and there is not a syllable to suggest their use of time or material was clandestine or improper. No word was spoken regarding any claim of title by the Government until after applications for patents were filed. And, as we have seen, no such trust has been spelled out of the relation of master and servant, even in the cases where the employee has perfected his invention by the use of his employer's time and materials. The cases recognizing the doctrine of shop rights may be said to fix a trust upon the employee in favor of his master as respects the use of the invention by the latter, but they do not affect the title to the patent and the exclusive rights conferred by it against the public.

The Government's position in reality is, and must be, that a public policy, to be declared by a court, forbids one employed by the United States, for scientific research, to obtain a patent for what he invents, though neither the Constitution nor any satute so declares.

Where shall the courts set the limit of the doctrine? For confessedly, it must be limited. The field of research is as broad as that of science itself. If the petitioner is entitled to a cancellation of the patents in this case, would it be so entitled, if the employees had done their work at home, in their own time and with their own appliances and materials? What is to be said of an invention evolved as the result of the solution of a problem in a realm apart from that to which the employee is assigned by his official superiors? We have seen that the Bureau has numerous divisions. It is entirely possible that an employee in one division may make an invention falling within the work of some other division. Indeed this case presents that exact situation, for the inventions in question had to do with radio reception, a matter assigned to a group of which Dunmore and Lowell were not members. Did the mere fact of their employment by the Bureau require these employees

Aeronautical Instrument Company of Pittsburgh, Pennsylvania.

C. W. Burrows was an employee of the Bureau of Standards between 1912 and 1919. While such employee he filed applications on the dates mentioned for patents which were issued, No. 1,322,405, October 4, 1917, method and apparatus for testing magnetizable objects by magnetic leakage; assigned to Magnetic Analysis Corporation, Long Island City, N. Y. No. 1,329,578, relay, March 13, 1918; exclusive license issued to make, use and sell for the field of railway signaling and train control, to Union Switch & Signal Company, Swissvale, Pa. No. 1,459,970, method of and apparatus for testing magnetizable objects, July 25, 1917; assigned to Magnetic Analysis Corporation, Long Island City, N. Y.

John A. Willoughby, an employee of the Bureau of Standards between 1918 and 1922, while so employed, on June 26, 1919, applied for and was granted a patent, No. 1,555,345, for a loop antenna.

*This paragraph was deleted from the opinion by order of May 8, 1933.

to cede to the public every device they might conceive?

Is the doctrine to be applied only where the employment is in a bureau devoted to scientific investigation *pro bono publico?* Unless it is to be so circumscribed the statements of this court in Burns v. United States, *supra*, Solomons v. United States, *supra*, and Gill v. United States, *supra*, must be held for naught.

Again, what are to be defined as bureaus devoted entirely to scientific research? It is common knowledge that many in the Department of Agriculture conduct researches and investigations, that divisions of the War and Navy Departments do the like, and doubtless there are many other bureaus and sections in various departments of government where employees are set the task of solving problems all of which involve more or less of science. Shall the field of the scientist be distinguished from the art of as killed mechanic? Is it conceivable that one working on a formula for a drug or an antiseptic in the Department of Agriculture stands in a different class from a machinist in an arsenal? Is the distinction to be that where the government department is, so to speak, a business department operating a business activity of the government, the employee has the same rights as one in private employment, whereas if his work be for a bureau interested more particularly in what may be termed scientific research he is upon notice that whatever he invents in the field of activity of the bureau, broadly defined, belongs to the public and is unpatentable? Illustrations of the difficulties which would attend an attempt to define the policy for which the Government contends might be multiplied indefinitely.

The courts ought not to declare any such policy; its formulation belongs solely to the Congress. Will permission to an employee to enjoy patent rights as against all others than the Government tend to the improvement of the public service by attracting a higher class of employees? Is there in fact greater benefit to the people in a dedication to the public of inventions conceived by officers of government, than in their exploitation under patents by private industry? Should certain classes of invention be treated in one way and other classes differently? These are not legal questions, which courts are competent to answer. They are practical questions, and the decision as to what will accomplish the greatest good for the inventor, the Government and the public rests with the Congress. We should not read into the patent laws limitations and conditions which the legislature has not expressed.

Fourth. Moreover, we are of opinion Congress has approved a policy at variance with the petitioner's contentions. This is demonstrated by examination of two statutes, with their legislative history, and the hearings and debates respecting proposed legislation which failed of passage.

Since 1883 there has been in force an act [12] which provides:

"The Secretary of the Interior [now the Secretary of Commerce, act of February 14, 1903, c. 552, Sec. 12, 32 Stat. 830] and the Commissioner of Patents are authorized to grant any officer of the government, except officers and employees of the Patent Office, a patent for any invention of the classes mentioned in section forty-eight hundred and eighty-six of the Revised Statutes, when such invention is used or to be used in the public service, without the payment of any fee: Provided, That the applicant in his application shall state that the invention described therein, if patented, may be used by the government or any of its officers or employees in the prosecution of work for the government, or by any other person in the United States, without the payment to him of any royalty thereon, which stipulation shall be included in the patent."

This law was evidently intended to encourage government employees to obtain patents, by relieving them of the payment of the usual fees. The condition upon which the privilege was accorded is stated as the grant of free use by the government, "its officers or employees in the prosecution of work for the government, *or by any other person in the United States.*" For some time the effect of the italicized phrase was a matter of doubt.

In 1910 the Judge Advocate General of the Army rendered an opinion to the effect that one taking a patent pursuant to the act threw his invention "open to public and private use in the United States." [13] It was later realized that this view made such a patent a contradiction in terms, for it secured no exclusive right to anyone. In 1918 the Judge Advocate General gave a well-reasoned opinion [14] holding that if the statute were construed to involve a dedication to the public, the so-called patent would at most amount to

[12] Act of March 3, 1883, c. 143, 22 Stat. 625.

[13] See Squier v. American T. & T. Co., 21 F. (2d) 747, 748.

[14] November 30, 1918; Opinions of Judge Advocate General, 1918, Vol. 2, p. 1029.

a publication or prior reference. He concluded that the intent of the act was that the free use of the invention extended only to the Government or those doing work for it. A similar construction was adopted in an opinion of the Attorney General.[15] Several federal courts referred to the statute and in *dicta* indicated disagreement with the views expressed in these later opinions.[16]

The departments of government were anxious to have the situation cleared and repeatedly requested that the act be amended. Pursuant to the recommendations of the War Department an amendment was enacted April 30, 1928.[17] The proviso was changed to read:

"Provided, That the applicant in his application shall state that the invention described therein, if patented, may be manufactured or used by or for the Government for governmental purposes without the payment to him of any royalty thereon, which stipulation shall be included in the patent."

The legislative history of the amendment clearly discloses the purpose to save to the employee his right to exclude the public.[18] In the report of the Senate Committee on Patents submitted with the amendment, the object of the bill was said to be the protection of the interests of the Government, primarily by securing patents on inventions made by officers and employees, presently useful in the interest of the national defense or those which may prove useful in the interest of national defense in the future; and secondarily, to encourage the patenting of inventions by officers and employees of the Government with the view to further protection of the Government against suits for infringement of patents. The Committee stated that the bill had the approval of the Commissioner of Patents and was introduced at the request of the Secretary of War. Appended to the report is a copy of a letter of the Secretary of War addressed to the committees of both Houses stating that the language of the legislation then existing was susceptible of two interpretations contrary to each other. The letter quoted the proviso of the section as it then stood, and continued:

"It is clear that a literal construction of this proviso would work a dedication to the public of every patent taken out under the act. If the proviso must be construed literally we would have a situation wherein all the patents taken out under the act would be nullified by the very terms of the act under which they were granted, for the reason that a patent which does not carry with it the limited monopoly referred to in the Constitution is in reality not a patent at all. The only value that a patent has is the right that it extends to the patentee to exclude all others from making, using, or selling the invention for a certain period of years. A patent that is dedicated to the public is virtually the same as a patent that has expired."

After referring to the interpretation of the Judge Advocate General and the Attorney General and mentioning that no satisfactory adjudication of the question has been afforded by the courts, the letter went on to state:

"Because of the ambiguity referred to and the unsettled condition that has arisen therefrom, it has become the policy of the War Department to advise all its personnel who desire to file applications for letters patent, to do so under the general law and pay the required patent-office fee in each case."

And added:

"If the proposed legislation is enacted into law, Government officers and employees may unhesitatingly avail themselves of the benefits of the act with full assurance that in so doing their patent is not dedicated to the public by operation of law. The War Department has been favoring legislation along the lines of the proposed bill for the past five or six years."

When the bill came up for passage in the House a colloquy occurred which clearly disclosed the purpose of the amendment.[20] The intent was that a gov-

[15] 32 Opinions Attorney General, 145.

[16] See Squier v. American Tel. & Tel. Co., 7 F. (2d) 831, 21 F. (2d) 747; Hazeltine Corporation v. Electric Service Engineering Corp., 18 F. (2d) 662; Hazeltine Corporation v. A. W. Grebe & Co., 21 F. (2d) 648; Selden Co. v. National Aniline & Chemical Co., 48 F. (2d) 270.

[17] 45 Stat. 467, 468.

[18] Report No. 871, 70th Cong., 1st Sess., House of Representatives, to accompany H. R. 6108; Report No. 765, 70th Cong., 1st Sess., Senate, to accompany H. R. 6108; Cong. Rec., House of Representatives, March 19, 1928, 70th Cong., 1st Sess., p. 5018; Cong. Rec., Senate, April 24, 1928, 70th Cong., 1st Sess., p. 7066.

[20] Cong. Rec., 70th Cong., 1st Sess., Vol. 69, Part 5, p. 5018:

"Mr. LaGuardia. Mr. Speaker, reserving the right to object, is not the proviso too broad? Suppose an employee of the Government invents some improvement which is very valuable, is he compelled to give the Government free use of it?

"Mr. Vestal [who reported the bill for the Committee and was in charge of it]. If he is employed by the Government and the invention is made while working in his capacity as an agent of the Government. If the head of the bureau certifies this invention will be used by the Government, then the Government, of course, gets it without the payment of any royalty.

"Mr. LaGuardia. The same as a factory rule?

"Mr. Vestal. Yes; but the man who takes out the patent has his commercial rights outside.

"Mr. LaGuardia. Outside of the Government?

"Mr. Vestal. Yes.

"Mr. LaGuardia. But the custom is, and with-

ernment employee who in the course of his employment conceives an invention should afford the government free use thereof, but should be protected in his right to exclude all others. If Dunmore and Lowell, who tendered the Government a non-exclusive license without royalty, and always understood that the Government might use their inventions freely, had proceeded under the act of 1883, they would have retained their rights as against all but the United States. This is clear from the executive interpretation of the act. But for greater security they pursued the very course then advised by the law officers of the Government. It would be surprising if they thus lost all rights as patentees; especially so, since Congress has now confirmed the soundness of the views held by the law officers of the Government.

Until the year 1910 the Court of Claims was without jurisdiction to award compensation to the owner of a patent for unauthorized use by the United States or its agents. Its power extended only to the trial of claims based upon an express or implied contract for such use.[20] In that year Congress enlarged the jurisdiction to embrace the former class of claims.[21] In giving consent to be sued, the restriction was imposed that it should not extend to owners of patents obtained by employees of the Government while in the service. From this it is inferred that Congress recognized no right in such patentees to exclude the public from practicing the invention. But an examination of the legislative record completely refutes the contention.

The House Committee in reporting the bill, after referring to the law as laid down in the Solomons case, said: "The United States in such a case has an implied license to use the patent without compensation, for the reason that the inventor used the time or the money or the material of the United States in perfecting his invention. The use by the United States of such a patented invention without any authority from the owner thereof is a lawful use under existing law, and we have inserted the words 'or lawful right to use the same' in order to make it plain that we do not intend to make any change in existing law in this respect, and do not intend to give the owner of such a patent any claim against the United States for its use."[22] From this it is clear that Congress had no purpose to declare a policy at variance with the decisions of this court.

The executive departments have advocated legislation regulating the taking of patents by government employees and the administration by government agencies of the patents so obtained. In 1919 and 1920 a bill sponsored by the Interior Department was introduced. It provided for the voluntary assignment or license by any government employee, to the Federal Trade Commission, of a patent applied for by him, and the licensing of manufacturers by the Commission, the license fees to be paid into the Treasury and such part of them as the President might deem equitable to be turned over to the patentee.[23] In the hearings and reports upon this measure

---

out this bill, the Government has the right to the use of the improvement without payment if it is invented in Government time and in Government work.

"Mr. Vestal. That is correct; and then on top of that, may I say that a number of instances have occurred where an employee of the Government, instead of taking out a patent had some one else take out the patent and the Government has been involved in a number of suits. There is now $600,000,000 worth of such claims in the Court of Claims."

It will be noted from the last statement of the gentleman in charge of the bill that Congress was concerned with questions of policy in the adoption of the amendment. These, as stated above, are questions of business policy and business judgment—what is to the best advantage of the Government and the public. They are not questions as to which the courts ought to invade the province of the Congress.

[20] See Belknap v. Schild, 161 U. S. 10, 16; Eager v. United States, 35 C. Cls. 556.

[21] Act of June 25, 1910, 36 Stat. 851: (See Crozier v. Krupp, 224 U. S. 290.)

"That whenever an invention described in and covered by a patent of the United States shall hereafter be used by the United States without license of he owner thereof or lawful to use the same, such owner may recover reasonable compensation for such use by suit in the Court of Claims: Provided, however, That said Court of Claims shall not entertain a suit or reward compensation under the provisions of this Act where the claim for compensation is based on the use by the United States of any article heretofore owned, leased, used by, or in the possession of the United States: Provided further, That in any such suit the United States may avail itself of any and all defenses, general or special, which might be pleaded by a defendant in an action for infringement, as set forth in Title Sixty of the Revised Statutes, or otherwise: And provided further, That the benefits of this Act shall not inure to any patentee, who, when he makes such claim is in the employment or service of the Government of the United States; or the assignee of any such patentee; nor shall this Act apply to any device discovered or invented by such employee during the time of his employment or service."

The Act was amended in resepcts immaterial to the present question, July 1, 1918, 40 Stat. 705. See William Cramp & Sons Co. v. Curtis Turbine Co., 246 U. S. 28; Richmond Screw Anchor Co. v. United States, 275 U. S. 331, 343. As amended it appears in U. S. C., Tit. 35, § 68.

[22] House Report 1288, 61st Cong., 2d Sess.

[23] S. 5265, 65th Cong., 3d Sess.; S. 3223, 66th Cong., 2d Sess.; H. R. 9932, 66th Cong., 2d Sess.; H. R. 11984, 66th Cong., 3d Sess.

stress was laid not only upon the fact that action by an employee thereunder would be voluntary, but that the inventor would be protected at least to some extent in his private right of exclusion. It was recognized that the Government could not compel an assignment, was incapable of taking such assignment or administering the patent, and that it had shop rights in a patent perfected by the use of government material and in government working time. Nothing contained in the bill itself or in the hearings or reports indicates any intent to change the existing and well understood rights of government employees who obtain patents for their inventions made while in the service. The measure failed of passage.

In 1923 the President sent to the Congress the report of an interdepartmental patents board created by executive order to study the question of patents within the government service and to recommend regulations establishing a policy to be followed in respect thereof. The report adverted to the fact that in the absence of a contract providing otherwise a patent taken out by a government employee, and any invention developed by one in the public service, is the sole property of the inventor. The committee recommended strongly aganist public dedication of such an invention, saying that this in effect voids a patent, and, if this were not so, "there is little incentive for anyone to take up a patent and spend time, effort, and money * * * on its commercial development without at least some measure of protection against others free to take the patent as developed by him and compete in its use. In such a case one of the chief objects of the patent law would be defeated." [24] In full accord is the statement on behalf of the Department of the Interior in a memorandum furnished with respect to the bill introduced in 1919.[25]

With respect to a policy of permitting the patentee to take a patent and control it in his own interest (subject, of course, to the government's right of use, if any) the committee said:

"* * * it must not be lost sight of that in general it is the constitutional right of every patentee to exploit his patent as he may desire, however expedient it may appear to endeavor to modify this right in the interest of the public when the patentee is in the Government service." [26]

Concerning a requirement that all patents obtained by government employees be assigned to the United States or its agent the committee said:

"* * * it would, on the one hand, render difficult securing the best sort of technical men for the service and, on the other, would influence technical workers to resign in order to exploit inventions which they might evolve and suppress while still in the service. There has always been more or less of a tendency for able men in the service to do this, particularly in view of the comparative meagerness of Government salaries; thus the Government has suffered loss among its most capable class of workers." [27]

The committee recommended legislation to create an Interdepartmental Patents Board; and further that the law make it part of the express terms of employment, having the effect of a contract, that any patent application made or patent granted for an invention discovered or developed during the period of government service and incident to the line of official duties, which in the judgment of the board should, in the interest of the national defense, or otherwise in the public interest, be controlled by the government, should upon demand by the board be assigned by the employee to an agent of the Government. The recommended measures were not adopted.

Fifth. Congress has refrained from imposing upon government servants a contract obligation of the sort above described. At least one department has attempted to do so by regulation.[28] Since the record in this case discloses that the Bureau of Standards had no such regulation, it is unnecessary to consider whether the various departments have power to impose such a contract upon employees without authorization by act of Congress. The question is more difficult under our form of government than under that of Great Britain, where such departmental regulations seem to settle the matter.[29]

All of this legislative history emphasizes what we have stated—that the courts are incompetent to answer the difficult question whether the patentee is to be allowed his exclusive right or compelled to dedicate his invention to the public. It is suggested that the election rests with the authoritative officers of the Government. Under what power, express or implied, may such officers, by

[24] Sen. Doc. No. 88, 68th Cong., 1st Sess., p. 3.

[25] Hearings, Senate Patent Committee, 66th Cong., 2d Sess., January 28, 1920, p. 11.

[26] Sen. Doc. No. 88, 68th Cong., 1st Sess., p. 3.

[27] *Ibid.*, p. 4.

[28] See Annual Report, Department of Agriculture, for 1907, p. 775. See Selden Co. v. National Aniline & Chemical Co. Inc., 48 F. (2d) 270, 273.

[29] Queen's Regulations (Addenda 1895, 1st February); Ch. 1, Instructions for Officers in General, pp. 15-16.

administrative fiat, determine the nature and extent of rights exercised under a charter granted a patentee pursuant to constitutional and legislative provisions? Apart from the fact that express authority is nowhere to be found, the question arises, who are the authoritative officers whose determination shall bind the United States and the patentee? The Government's position comes to this—that the courts may not reexamine the exercise of an authority by some officer, not named, purporting to deprive the patentee of the rights conferred upon him by law. Nothing would be settled by such a holding, except that the determination of the reciprocal rights and obligations of the Government and its employee as respects inventions are to be adjudicated, without review, by an unspecified department head or bureau chief. Hitherto both the executive and the legislative branches of the Government have concurred in what we consider the correct view,—that any such declaration of policy must come from Congress and that no power to declare it is vested in administrative officers.

The decrees are affirmed.

Mr. Justice STONE, dissenting.—I think the decrees should be reversed.

The Court's conclusion that the employment of Dunmore and Lowell did not contemplate that they should exercise inventive faculties in their service to the government, and that both courts below so found, seems to render superfluous much that is said in the opinion. For it has not been contended and I certainly do not contend, that if such were the fact there would be any foundation for the claim asserted by the government. But I think the record does not support the Court's conclusion of fact. I am also unable to agree with the reasoning of the opinion, although on my view of the facts it would lead to the reversal of the decree below, which I favor.

When originally organized[1] as a subdivision of the Department of Commerce, the functions of the Bureau of Standards consisted principally of the custody, comparison, construction, testing and calibration of standards and the solution of problems arising in connection with standards. But in the course of its investigation of standards of quality and performance it has gradually expanded into a laboratory for research of the broadest character in various branches of science and industry and particularly in the field of engineering.[2] Work of this nature is carried on for other government departments,[3] the general public[4] and private industries.[5] It is almost entirely supported by public funds,[6] and is maintained in the public interest. In 1915, as the importance of radio to the government and to the public increased, Congress appropriated funds[7] to the Bureau "for investigation and standardization of methods and instruments employed in radio communication." Similar annual appropriations have been made since and public funds were allotted by Acts of July 1, 1916, c. 209, 39 Stat. 262, 324 and October 6, 1917, c. 79, 40 Stat. 345, 375, for the construction of a

[1] Act of March 3, 1901, 31 Stat. 1449; Act of February 14, 1903, § 4, 32 Stat. 825, 826. For an account of the origin and development of the Bureau and its predecessor, see Weber, The Bureau of Standards, 1-75.

[2] Much of the expansion of the Bureau's activities in this direction took place during the war. See Annual Report of the Director, Bureau of Standards, for 1919, p. 25; War Work of the Bureau of Standards (1921), Misc. Publications of the Bureau of Standards No. 46. The scope of the Bureau's scientific work is revealed by the annual reports of the Director. See also the bibliography of Bureau publications for the years 1901-1925, Circular of the Bureau of Standards No. 24 (1925).

[3] The Act of May 29, 1920, 41 Stat. 631, 683, 684, permitted other departments to transfer funds to the Bureau of Standards for such purposes, though even before that time it was one of the major functions of the Bureau to be of assistance to other branches of the service. See e. g. Annual Reports of the Director for 1915, 1916, 1917, p. 16; Annual Report for 1918, p. 18; compare Annual Report for 1921, p. 25; for 1922, p. 10.

[4] The consuming public is directly benefited not only by the Bureau's work in improving the standards of quality and performance of industry, but also by the assistance which it lends to governmental bodies, state and city. See Annual Reports of the Director for 1915, 1916, 1917, p. 14; Annual Report for 1918, p. 16; National Bureau of Standards, Its Functions and Activity, Circular of the Bureau of Standards, No. 1 (1925), pp. 28, 33.

[5] Cooperation with private industry has been the major method relied upon to make the accomplishments of the Bureau effective. See Annual Report for 1922, p. 7; Annual Report for 1923, p. 3. A system of research associates permits industrial groups to maintain men at the Bureau for research of mutual concern. The plan has facilitated co-operation. See Annual Report for 1923, p. 4; Annual Report for 1924, p. 35; Annual Report for 1925, p. 38; Annual Reports for 1926, 1928, 1929, 1931, 1932, p. 1; Research Associates at the Bureau of Standards, Bureau Circular No. 296 (1926). For a list of cooperating organizations as of December 1, 1926, see Misc. Publications No. 96 (1927).

[6] No fees have been charged except to cover the cost of testing, but the Act of June 30, 1932, c. 314, § 312, 47 Stat. 410, directs that "for all comparisons, calibrations, tests or investigations, performed" by the Bureau, except those performed for the Government of the United States or a State, "a fee sufficient in each case to compensate the * * * Bureau * * * for the entire cost of the services rendered shall be charged. * * *"

[7] Act of March 4, 1915, c. 141, 38 Stat. 997, 1044.

fireproof laboratory building "to provide additional space to be used for research and testing in radio communication," as well as "space and facilities for cooperative research and experimental work in radio communication" by other departments of the government. Thus, the conduct of research and scientific investigation in the field of radio has been a duty imposed by law upon the Bureau of Standards since 1915.

Radio research has been conducted in the Radio Section of the Electrical Division of the Bureau. In 1921 and 1922, when Dunmore and Lowell made the inventions in controversy, they were employed in this section as members of the scientific staff. They were not, of course, engaged to invent, in the sense in which a carpenter is employed to build a chest, but they were employed to conduct scientific investigations in a laboratory devoted principally to applied rather than pure science with full knowledge and expectation of all concerned that their investigations might normally lead, as they did, to invention. The Bureau was as much devoted to the advancement of the radio art by invention as by discovery which falls short of it. Hence, invention in the field of radio was a goal intimately related to and embraced within the purposes of the work of the scientific staff.

Both courts below found that Dunmore and Lowell were impelled to make these inventions "solely by their own scientific curiosity." They undoubtedly proceeded upon their own initiative beyond the specific problems upon which they were authorized or directed to work by their superiors in the Bureau, who did not actively supervise their work in its inventive stages. But the evidence leaves no doubt that in all they did they were following the established practice of the Section. For members of the research staff were expected and encouraged to follow their own scientific impulses in pursuing their researches and discoveries to the point of useful application, whether they involved invention or not, and even though they did not relate to the immediate problem in hand. After the inventions had been conceived they were disclosed by the inventors to their chief and they devoted considerable time to perfecting them, with his express approval. All the work was carried on by them in the government laboratory with the use of government materials and facilities, during the hours for which they received a government salary. Its progress was recorded throughout in weekly and monthly reports which they were required to file, as well as in their laboratory notebooks. It seems clear that in thus exercising their inventive powers in the pursuit of ideas reaching beyond their specific assignments, the inventors were discharging the duties expected of scientists employed in the laboratory; Dunmore as well as his supervisors, testified that such was their conception of the nature of the work. The conclusion is irresistible that their scientific curiosity was precisely what gave the inventors value as research workers; the government employed it and gave it free rein in performing the broad duty of the Bureau of advancing the radio art by discovery and invention.

The courts below did not find that there was any agreement between the government and the inventors as to their relative rights in the patents and there was no evidence to support such a finding. They did not find, and upon the facts in evidence and within the range of judicial notice, they could not find that the work done by Dunmore and Lowell leading to the inventions in controversy was not within the scope of their employment. Such a finding was unnecessary to support the decisions below, which proceeded on the theory relied on by the respondent here, that in the absence of an express contract to assign it, an employer is entitled to the full benefit of the patent granted to an employee, only when it is for a particular invention which the employee was specifically hired or directed to make. The bare references by the court below to the obvious facts that "research" and "invention" are not synonymous, and that all research work in the Bureau is not concerned with invention fall far short of a finding that the work in the Bureau did not contemplate invention at all. Those references were directed to a different end, to the establishment of what is conceded here, that Dunmore and Lowell were not specifically hired or directed to make the inventions because in doing so they proceeded beyond the assignments given them by their superiors. The court's conception of the law, applied to this ultimate fact, led inevitably to its stated conclusion that the claim of the government is without support in reason or authority "unless we should regard a general employment for research work as synonymous with a particular employment (or assignment) for inventive work."

The opinion of this Court apparently rejects the distinction between specific employment or assignment and general

employment to invent, adopted by the court below and supported by authority, in favor of the broader position urged by the government that wherever the employee's duties involve the exercise of inventive powers, the employer is entitled to an assignment of the patent on any invention made in the scope of the general employment. As I view the facts, I think such a rule, to which this Court has not hitherto given explicit support, would require a decree in favor of the government. It would also require a decree in favor of a private employer, on the ground stated by the court that as the employee "has only produced what he is employed to invent," a specifically enforcible "term of the agreement necessarily is that what he is paid to produce belongs to his paymaster." A theory of decision so mechanical is not forced upon us by precedent and cannot, I think, be supported.

What the employee agrees to assign to his employer is always a question of fact. It cannot be said that merely because an employee agrees to invent, he also agrees to assign any patent secured for the invention. Accordingly, if an assignment is ordered in such a case it is no more to be explained and supported as the specific enforcement of an agreement to transfer property in the patent than is the shopright which equity likewise decrees, where the employment does not contemplate invention. All the varying and conflicting language of the books cannot obscure the reality that in any case where the rights of the employer to the invention are not fixed by express contract, and no agreement in fact may fairly be implied, equity determines after the event what they shall be. In thus adjudicating *in invitum* the consequences of the employment relationship, equity must reconcile the conflicting claims of the employee who has evolved the idea and the employer who has paid him for his time and supplied the materials utilized in experimentation and construction. A task so delicate cannot be performed by accepting the formula advanced by the petitioner any more than by adopting that urged by the respondent, though both are not without support in the opinions of this Court. Compare Hapgood v. Hewitt, 119 U. S. 226; Dalzell v. Dueber Mfg. Co., 149 U. S. 315; Solomons v. United States, 137 U. S. 342, 346; Gill v. United States, 160 U. S. 426, 435; Standard Parts Co. v. Peck, 264 U. S. 52.

Where the employment does not contemplate the exercise of inventive talent the policy of the patent laws to stimulate invention by awarding the benefits of the monopoly to the inventor and not to someone else leads to a ready compromise: a shop-right gives the employer an adequate share in the unanticipated boon.[8] Hapgood v. Hewitt, *supra;* Lane & Bailey Co. v. Locke, 150 U. S. 193; Dalzell v. Dueber Mfg. Co., *supra;* Pressed Steel Car Co. v. Hansen, 137 Fed. 403; Amdyco Corp. v. Urquhart, 39 F. (2d) 943, aff'd 51 F. (2d) 1072; Ingle v. Landis Tool Co., 272 Fed. 464; see Beecroft & Blackman v. Rooney, 268 Fed. 545, 549.

But where, as in this case, the employment contemplates invention, the adequacy of such a compromise is more doubtful not because it contravenes an agreement for an assignment, which may not exist, but because, arguably, as the patent is the fruit of the very work which the employee is hired to do and for which he is paid, it should no more be withheld from the employer, in equity and good conscience, than the product of any other service which the employee engages to render. This result has been reached where the contract was to devise a means for solving a defined problem, Standard Parts Co. v. Peck, *supra,* and the decision has been thought to establish the employer's right wherever the employee is hired or assigned to evolve a process or mechanism for meeting a specific need. Magnetic Mfg. Co. v. Dings Magnetic Separator Co., 16 F. (2d) 739; Goodyear Tire and Rubber Co. v. Miller, 22 F. (2d) 353, 356; Houghton v. United States, 23 F. (2d) 386. But the court below and others have thought (Pressed Steel Car Co. v. Hansen, *supra;* Houghton v. United States, *supra;* Amdyco Corp. v. Urquhart, *supra*), as the respondent argues, that only in cases where the employment or assignment is thus specific may the employer demand all the benefits of the employee's invention. The basis of such a limitation is not articulate in the cases. There is at least a question whether its application may not be attributed, in some instances, to the readier implication of an actual promise to assign the patent, where the duty is to invent a specific thing (see Pressed Steel Car Co. v. Hansen, *supra,* 415), or, in any case, to the reluctance of equity logically to extend, in this field, the principle that the right to claim the service includes the right to claim its product. The latter alternative may find support in the policy of the patent laws

[8] See the cases collected in 30 Columbia Law Rev. 1172; 36 Harvard Law Rev. 468.

to secure to the inventor the fruits of his inventive genius, in the hardship which may be involved in imposing a duty to assign all inventions, see Dalzell v. Dueber Mfg. Co., *supra*, 323, cf. Aspinwall Mfg. Co. v. Gill, 32 Fed. 697, 700, and in a possible inequality in bargaining power of employer and employee. But compare Goodyear Tire & Rubber Co. v. Miller, *supra*, 355; Hulse v. Bonsack Mach. Co., 65 Fed. 864, 868; see 30 Columbia Law Rev. 1172, 1176-8. There is no reason for determining now the weight which should be accorded these objections to complete control of the invention by the employer, in cases of ordinary employment for private purposes. Once it is recognized, as it must be, that the function of the Court in every case is to determine whether the employee may, in equity and good conscience retain the benets of the patent, it is apparent that the present case turns upon considerations which distinguish it from any which has thus far been decided.

The inventors were not only employed to engage in work which unmistakably required them to exercise their inventive genius as occasion arose; they were a part of a public enterprise. It was devoted to the improvement of the art of radio communication for the benefit of the people of the United States, carried on in a government laboratory, maintained by public funds. Considerations which might favor the employee where the interest of the employer is only in private gain are therefore of slight significance; the policy dominating the research in the Bureau, as the inventors knew, was that of the government to further the interests of the public by advancing the radio art. For the work to be successful, the government must be free to use the results for the benefit of the public in the most effective way. A patent monopoly in individual employees, carrying with it the power to suppress the invention, or at least to exclude others from using it, would destroy this freedom; a shopright in the government would not confer it. For these employees, in the circumstances, to attempt to withhold from the public and from the government the full benefit of the inventions which it has paid them to produce, appears to me so unconscionable and inequitable as to demand the interposition of a court exercising chancery powers. A court which habitually enjoins a mortgagor from acquiring and setting up a tax title adversely to the mortgagee, Middletown Savings Bank v. Bacharach, 46 Conn. 513, 524; Chamberlain v. Forbes, 126 Mich. 86; Waring v. National Savings & Trust Co., 138 Md. 367; see 2 Jones on Mortgages (8th ed.), § 841, should find no difficulty in enjoining these employees and the respondent claiming under them from asserting, under the patent laws, rights which would defeat the very object of their employment. The capacity of equitable doctrine for growth and of courts of equity to mould it to new situations, was not exhausted with the establishment of the employer's shopright. See Essex Trust Co. v. Enwright, 214 Mass. 507; Meinhard v. Salmon, 249 N. Y. 458.

If, in the application of familiar principles to the situation presented here, we must advance somewhat beyond the decided cases, I see nothing revolutionary in the step. We need not be deterred by fear of the necessity, inescapable in the development of the law, of setting limits to the doctrine we apply, as the need arises. That prospect does not require us to shut our eyes to the obvious consequences of the decree which has been rendered here. The result is repugnant to common notions of justice and to policy as well, and the case must turn upon these considerations if we abandon the illusion that equity is called upon merely to enforce a contract, albeit, one that is "implied." The case would be more dramatic if the inventions produced at public expense were important to the preservation of human life, or the public health, or the agricultural resources of the country. The principle is the same here, though the inventions are of importance only in the furtherance of human happiness. In enlisting their scientific talent and curiosity in the performance of the public service in which the Bureau was engaged, Dunmore and Lowell necessarily renounced the prospect of deriving from their work commercial rewards incompatible with it.[9] Hence, there is nothing oppressive

[9] It has been said that many scientists in the employ of the Government regard the acceptance of patent rights leading to commercial rewards in any case as an abasement of their work. Hearings on Exploitation of Inventions by Government Employees, Senate Committee on Patents, 65th Cong., 3d Sess. (1919), pp. 16, 17; see also the Hearings before the same Committee, January 23, 1920, 66th Cong., 2d Sess. (1920), p. 5. The opinion of the Court attributes importance to the fact, seemingly irrelevant, that other employees of the Bureau have in some instances in the past taken out patents on their inventions which, so far as appears, the Government has not prevented them from enjoying. The circumstances under which those inventions were made do not appear. But even if they were the same as those in the present case there is no basis for contending that because the Government saw fit not to assert its rights in other cases

or unconscionable in requiring them or their licensee to surrender their patents at the instance of the United States, as there probably would be if the inventions had not been made within the scope of their employment or if the employment did not contemplate invention at all.

The issue raised here is unaffected by legislation. Undoubtedly the power rests with Congress to enact a rule of decision for determining the ownership and control of patents on inventions made by government employees in the course of their employment. But I find no basis for saying that Congress has done so or that it has manifested any affirmative policy for the disposition of cases of this kind, which is at variance with the considerations which are controlling here.

The Act of June 25, 1910, 36 Stat. 851, as amended July 1, 1918, 40 Stat. 704, 705, permitted patentees to sue the government in the Court of Claims for the unauthorized use of their patents. It was in effect an eminent domain statute by which just compensation was secured to the patentee, whose patent had been used by the government. See Richmond Screw Anchor Co. v. United States, 275 U. S. 331. This statute excluded government employees from the benefits of the Act in order, as the House Committee Report explicitly points out, to leave unaffected the shoprights of the government. See H. R. Report No. 1288, 61st Cong. 2d Sess. A statute thus aimed at protecting in every case the minimum rights of the government can hardly be taken to deny other and greater rights growing out of the special equity of cases like the present.

The Act of April 30, 1928, 45 Stat. 467, 468, amending an earlier statute of 1883 (22 Stat. 625), so as to permit a patent to be issued to a government employee without payment of fees, for any invention which the head of a department or independent bureau certifies "is used or liable to be used in the public service," and which the application specifies may, if patented, "be manufactured and used by or for the Government for governmental purposes without the payment of * * * any royalty," was passed, it is true, with the general purpose of encouraging government employees to take out patents on their inventions. But this purpose was not, as the opinion of the Court suggests, born of a Congressional intent that a government employee who conceives an invention in the course of his employment should be protected in his right to exclude all others but the government from using it. Congress was concerned neither with enlarging nor with narrowing the relative rights of the government and its employees.[10] This is apparent from the language of the statute that the patent shall be issued without a fee "subject to existing law," as well as from the records of its legislative history.[11]

The purpose of Congress in facilitating the patenting of inventions by government employees was to protect the existing right of the government to use all devices invented in the service, whether or not the patentee was employed to use his inventive powers. Experience had shown that this shopright was jeopardized unless the employee applied for a patent, since without the disclosure incident to the application the government was frequently hampered in its defense of claims by orders asserting priority of invention. But doubt which had arisen whether an application for a patent under the Act of 1883 did not operate to dedicate the patent to the public,[12] and reluctance to pay the fees otherwise required, had led government employees to neglect to make applications, even when they were entitled to the benefits of the monopoly subject only to the government's right of use. This doubt the amendment removed. It can hardly be contended that in removing it in order to aid the government in the protection of its shopright, Congress declared a policy that it should have no greater right to control a patent procured either under this special statute or under the general patent laws by fraud or any other type of inequitable conduct. Had such a policy been declared, it is difficult to see on what basis we could award the

it has lost them in this. Moreeover, there is no necessary inconsistency in the Government's position if it concluded in those cases that the public interest would be served best by permitting the employees to exploit their inventions themselves, and adopted a contrary conclusion here.

[10] Throughout the various speculations in committee as to what those rights were, it was generally agreed that they were intended to remain unchanged by the bill. See Hearings before the House Committee on Patents, 68th Cong., 2d Sess., on H. R. 3267 and 11403 (1925); Hearings before the same Committee, 70th Cong., 1st Sess. (1928), especially at pp. 8-18. The discussion on the floor of the House, referred to in the opinion of the Court (see note 19) does not indicate the contrary.

[11] In addition to the hearings cited *supra*, note 10, see H. R. Report No. 1596, 68th Cong., 2nd Sess.; H. R. Report No. 871, Senate Report No. 765, 70th Cong., 1st Sess. The bill was originally a companion proposal to the Federal Trade Commission bill discussed *infra*, note 18. See the references given there.

[12] See Selden Co. v. National Aniline & Chemical Co., 48 F. (2d) 270, 272; Squier v. American Telephone & Telegraph Co., 7 F. (2d) 881, 882, affirming 21 F. (2d) 747.

government a remedy, as it seems to be agreed we would, if Dunmore and Lowell had been specifically employed to make the inventions. There is nothing to indicate that Congress adopted one policy for such a case and a contrary one for this.

Other legislation proposed but not enacted,[13] requires but a word. Even had Congress expressly rejected a bill purporting to enact into law the rule of decision which I think applicable here, its failure to act could not be accorded the force of law. But no such legislation has been proposed to Congress, and that which was suggested may have been and probably was defeated for reasons unconnected with the issue presented in this case. The legislative record does show, as the opinion of the Court states, that it is a difficult question which has been the subject of consideration at least since the war, whether the public interest is best served by the dedication of an invention to the public or by its exploitation with patent protection under license from the government or the inventor. But the difficulty of resolving the question does not justify a decree which does answer it in favor of permitting government employees such as these to exploit their inventions without restriction, rather than one which would require the cancellation of their patents or their assignment to the United States.

The decrees should be reversed.

Mr. Justice CARDOZO concurs in this opinion.

Mr. Chief Justice HUGHES (dissenting).—I agree with Mr. Justice STONE'S analysis of the facts showing the nature of the employment of Dunmore and Lowell, and with his conclusions as to the legal effect of that employment. As the people of the United States should have the unrestricted benefit of the inventions in such a case, I think that the appropriate remedy would be to cancel the patents.

[13] The bill referred to in the opinion of the Court was one sponsored by the executive departments to endow the Federal Trade Commission with the power to accept assignments of patents from Government employees and administer them in the public interest. It passed the Senate on one occasion and the House on another but failed to become a law. (S. 5265, 65th Cong., 3d Sess., S. 3226, 66th Cong., 1st Sess., H. R. 9932, 66th Cong., 1st Sess., H. R. 11984, 66th Cong., 3d Sess.). In the course of hearings and debates many points of view were expressed. See Hearings on Exploitation of Inventions by Government Employees, Senate Committee on Patents, 65th Cong., 3d Sess. (1919); Hearing before the same Committee, 66th Cong., 2d Sess. (1920); Senate Report No. 405, H. R. Report No. 595, 66th Cong., 2d Sess., recommending passage. See 59 Cong. Rec., 2300, 2421, 2430, 3908, 4682, 4771, 8359, 8360, 8483, 8490; 60 *ibid.* 356; Conference Report, H. R. No. 1294, Sen. Doc. No. 879, 66th Cong., 3d Sess. And see 60 Cong. Rec., 2890, 3229, 3264-3269, 3537. Differences were stressed in the purposes and needs of different agencies of the Government. See especially Hearings (1919), *supra*, pp. 22, 24-5. The need of commercial incentives to private exploiters, as well as the general desirability of such exploitation were admitted, but the dangers were recognized as well. It was thought that the public interest would best be served by the establishment of a single agency for Government control, with the power to determine upon some compensation for the inventor.

After the death of this bill in the Senate, February 21, 1921, the subject was again considered by an Interdepartmental Board established by executive order of President Harding, August 9, 1922. Its report was transmitted to Congress by President Coolidge, in December, 1923. Sen. Doc. No. 88, 68th Cong., 1st Sess. The Board found that there had never been any general governmental policy established with respect to inventions, that whether public dedication, private exploitation or governmental control and administration is desirable, depends largely on the nature of the invention. Accordingly, legislation was recommended establishing a permanent Interdepartmental Patents Board with the power to demand assignments of patents on those inventions thereafter developed in the service which "in the interest of the national defense, or otherwise in the public interest" should be controlled by the Government. No action was taken upon this proposal.

Since that time the Director of the Bureau of Standards has recommended that a "uniform, equitable policy of procedure" be defined for the Government by legislation. (Annual Report for 1925, p. 40.) In the Report for 1931 it is said (p. 46) that the "patent policy of this Bureau has always been that patentable devices developed by employees paid out of public funds belong to the public," and the Report for 1932 adds (p. 40) "if not so dedicated directly, the vested rights should be held by the Government."

and this was recognized by plaintiff's expert, the patentee was not entitled to claim all structures which exercised the desired function, but only those which he himself invented, and a device which produces the same result through translation of force operates in a substantially different manner than one in which force is directly applied. This is not infringement, Westinghouse v. Boyden Power Brake Co., 170 U. S. 537, 568, especially where the patent is not a generic one and the patentee is entitled to but a narrow range of equivalents. See Directoplate Corp. v. Donaldson Lith. Co., 51 Fed. (2d) 199 (C. C. A. 6). There are two tests of equivalency (1) identity of function, and (2) substantial identity of way of performing that function. Walker on Patents, 6th Ed. 511. Primary as well as secondary patents are infringed by no substitutions that do not fully respond to these tests. Even if identity of function were present, the patent not being a primary one, the requirement of substantial identity of way should not be considered so elastic as to ignore important differences in manner of operation.

There is no infringement, and the decree below is affirmed.

Supreme Court of the United States

UNITED STATES OF AMERICA v. DUBILIER CONDENSER CORPORATION

Nos. 316, 317, 318 Decided Apr. 10, 1933

Patents—Patents—

Patent is not, accurately speaking, a monopoly, for it is not created by executive authority at expense of and to prejudice of all community except grantee of patent; inventor deprives public of nothing which it enjoyed before his discovery but gives something of value to community by adding to sum of human knowledge; he may keep invention secret and reap its fruits indefinitely; in consideration of its disclosure and consequent benefit to community, patent is granted.

Patents—Specification—Sufficiency of disclosure—

Law requires such disclosure to be made in application for patent that others skilled in art may understand invention and how to put it to use.

Patents—Title—Employer and employee—

Patent is property and title can pass only by assignment; if not yet issued, agreement to assign when issued, if valid as contract, will be specifically enforced; respective rights and obligations of employer and employee, touching invention conceived by latter, spring from contract of employment; one employed to make invention who succeeds during term of service in accomplishing that task is bound to assign to employer patent obtained; on other hand if employment be general, albeit it covers field of labor and effort in performance of which employee conceived the invention for what he obtained patent, contract is not so broadly construed as to require assignment of patent.

Patents—Patentability—Invention—

Invention consists neither in finding out laws of nature nor in fruitful research as to operation of natural laws but in discovering how those laws may be utilized or applied for beneficial purpose by a process, a device or a machine; it is result of inventive act, birth of an idea, and its reduction to practice; product of original thought; concept demonstrated to be true by practical application or embodiment in tangible form; embodiment is not the invention and is not subject of a patent.

Patents—Title—Employer and employee—

Employment merely to design or construct or devise methods of manufacture is not same as employment to invent; shop right is that, where servant during hours of employment working with master's materials and appliances conceives and perfects invention for which he obtains patent, he must accord master non-exclusive right to practice invention; but employer has no equity to demand conveyance of invention; this remains property of him who conceived it together with right conferred by patent to exclude all others than employer from accruing benefits.

Patents—Title—

Title of the patentee is subject to no superior right of Government; grant is not, as in England, a matter of grace or favor so that conditions may be annexed at

pleasure of executive; laws passed by Congress alone may be looked to for guidance as to extent of limitations of respective rights of inventor and public; Constitution evinces no public policy which requires holder of patent to cede use or benefit of invention to United States.

Patents—Applicants—

No servant of United States has by statute been disqualified for applying for and receiving patent for his invention save officers and employees of Patent Office during period for which they hold their appointments.

Patents—Title—Government employees—

Supreme Court has applied rules enforced as between private employers and servants to relation between Government and its officers and employees; United States is entitled, in same way and to same extent as private employer, to shop rights, that is, free and non-exclusive use of patent which results from efforts of those employed in their working hours and with material belonging to Government; statutes, decisions and administrative practice negate existence of duty binding one in service of Government different from obligation of one in private employment; United States like any other employer, if it desires assignment of employee's rights, must prove contractual obligation on part of employee to assign patents to Government; employees of Bureau of Standards who did not agree to exercise inventive faculties in their work and who made invention not within its scope need not assign patents to Government; written evidence of employment does not mention research, much less invention; never was word said to employees prior to discoveries concerning invention or patents or duties or obligations respecting these matters; other employees of Bureau of Standards and other departments had, while so employed, received numerous patents and enjoyed exclusive rights against all private persons without let or hindrance from Government;* no act of Congress authorizes United States to take patent or to hold one by assignment; no statutory authority exists for transfer of patents to any department or officer of Government or for administration of patents or issuance of licenses on behalf of the United States; inventors do not hold patents in trust for Government.

Patents—Title—Government employee—

Act of 1883 and as amended in 1928 provides patent without fee for Government employee who in course of employ conceives invention; he should afford Government free use thereof but should be protected in right to exclude all others; similar right accrues to Government employee paying fees for patent.

Patents—Jurisdiction of courts—

Until 1910 Court of Claims was without jurisdiction to award compensation to owner of patent for unauthorized use by United States or its agents; power extended only to trial of claims based upon express or implied contracts for such use; in 1910 Congress enlarged jurisdiction to embrace former class of claims, but imposing restriction that it should not extend to owners of patents obtained by employees of Government while in service.

Patents—Title—Government employees—

Congress has refrained from imposing upon Government servants contract obligation to assign to Government patent for invention discovered or developed during period of Government service and incidental to line of official duties, and court will not assume such contract obligations.

Patents—Radio Receiving Apparatus title transfer refused—

1455141, Lowell & Dunmore, Radio Receiving Apparatus, title transfer refused.
1606212, Dunmore & Lowell, Power Amplifier, title transfer refused.
1635117, Dunmore, Signal Receiving System, title transfer refused.

On writs of certiorari to the United States Circuit Court of Appeals for the Third Circuit.

THOMAS D. THACHER, Solicitor General (CHARLES B. RUGG, Assistant Attorney General, ALEXANDER HOLTZOFF, PAUL D. MILLER and H. BRIAN HOLLAND with him on the brief) for petitioner; JAMES H. HUGHES, JR. (E. ENNALLS BERL, JOHN B. BRADY and WARD & GRAY with him on the brief) for respondent.

MR. JUSTICE ROBERTS delivered the opinion of the Court.—Three suits were

*The remaining portion of the syllabus was based upon a paragraph deleted from the opinion by order of the court. (See Note, p. 161.)

brought in the District Court for Delaware against the respondent as exclusive licensee under three separate patents issued to Francis W. Dunmore and Percival D. Lowell. The bills recite that the inventions were made while the patentees were employed in the radio laboratories of the Bureau of Standards, and are therefore, in equity, the property of the United States. The prayers are for a declaration that the respondent is a trustee for the Government, and, as such, required to assign to the United States all its right, title and interest in the patents, for an accounting of all moneys received as licensee, and for general relief. The District Court consolidated the cases for trial, and after a hearing dismissed the bills.[1] The Court of Appeals for the Third Circuit affirmed the decree.[2]

The courts below concurred in findings which are not challenged and, in summary, are:

The Bureau of Standards is a subdivision of the Department of Commerce.[3] Its functions consist in the custody of standards; the comparison of standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with those adopted or recognized by the Government; the construction of standards, their multiple or subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connection with standards; and the physical properties of materials. In 1915 the Bureau was also charged by Congress with the duty of investigation and standardization of methods and instruments employed in radio communication, for which special appropriations were made.[4] In recent years it has been engaged in research and testing work of various kinds for the benefit of private industries, other departments of the Government, and the general public.[5]

The Bureau is composed of divisions, each charged with a specified field of activity, one of which is the electrical division. These are further subdivided into sections. One section of the electrical division is the radio section. In 1921 and 1922 the employees in the laboratory of this section numbered approximately twenty men doing technical work and some draftsmen and mechanics. The twenty were engaged in testing radio apparatus and methods and in radio research work. They were subdivided into ten groups, each group having a chief. The work of each group was defined in outlines by the chief or alternate chief of the section.

Dunmore and Lowell were employed in the radio section and engaged in research and testing in the laboratory. In the outlines of laboratory work the subject of "airplane radio" was assigned to the group of which Dunmore was chief and Lowell a member. The subject of "radio receiving sets" was assigned to a group of which J. L. Preston was chief, but to which neither Lowell nor Dunmore belonged.

In May, 1921, the Air Corps of the Army and the Bureau of Standards entered into an arrangement whereby the latter undertook the prosecution of forty-four research projects for the benefit of the Air Corps. To pay the cost of such work, the Corps transferred and allocated to the Bureau the sum of $267,500. Projects Nos. 37 to 42, inclusive, relating to the use of radio in connection with aircraft, were assigned to the radio section and $25,000 was allocated to pay the cost of the work. Project No. 38 was styled "visual indicator for radio signals," and suggested the construction of a modification of what was known as an "Eckhart recorder." Project No. 42 was styled "airship bomb control and marine torpedo control." Both were problems of design merely.

In the summer of 1921 Dunmore, as chief of the group to which "airplane radio" problems had been assigned, without further instructions from his superiors, picked out for himself one of these navy problems, that of operating a relay for remote control of bombs on airships and topedoes in the sea, "as one of particular interest and having perhaps a rather easy solution, and worked on it." In September he solved it.

In the midst of aircraft investigations and numerous routine problems of the section, Dunmore was wrestling in his own mind, impelled thereto solely by his own scientific curiosity, with the subject of substittuing house-lighting alternating current for direct battery current in radio apparatus. He obtained a relay for operating a telegraph instrument which was in no way related to the remote control relay devised for aircraft use. The conception of the application of alternating current concerned partic-

[1] 49 F. (2d) 806 [9 U. S. Pat. Q. 131].

[2] 59 F. (2d) 881 [12 U. S. Pat. Q. 887].

[3] See Act of March 3, 1901, 31 Stat. 1449; Act of February 14, 1903, Sec. 4, 32 Stat. 826.

[4] Act of March 4, 1915, 38 Stat. 1044; Act of May 29, 1920, 41 Stat. 684; Act of March 3, 1921, 41 Stat. 1308.

[5] The fees charged cover merely the cost of the service rendered, as provided in the Act of June 30, 1932, Sec. 312, 47 Stat. 410.

ularly broadcast reception. This idea was conceived by Dunmore August 3, 1921, and he reduced the invention to practice December 16, 1921. Early in 1922 he advised his superior of his invention and spent additional time in perfecting the details. February 27, 1922, he filed an application for a patent.

In the fall of 1921 both Dunmore and Lowell were considering the problem of applying alternating current to broadcast receiving sets. This project was not involved in or suggested by the problems with which the radio section was then dealing and was not assigned by any superior as a task to be solved by either of these employees. It was independent of their work and voluntarily assumed.

While performing their regular tasks they experimented at the laboratory in devising apparatus for operating a radio receiving set by alternating current with the hum incident thereto eliminated. The invention was completed on December 10, 1921. Before its completion no instructions were received from and no conversations relative to the invention were held by these employees with the head of the radio section, or with any superior.

They also conceived the idea of energizing a dynamic type of loud speaker from an alternating current house-lighting circuit and reduced the invention to practice on January 25, 1922. March 21, 1922, they filed an application for a "power amplifier." The conception embodied in this patent was devised by the patentees without suggestion, instruction, or assignment from any superior.

Dunmore and Lowell were permitted by their chief, after the discoveries had been brought to his attention, to pursue their work in the laboratory and to perfect the devices embodying their inventions. No one advised them prior to the filing of applications for patents that they would be expected to assign the patents to the United States or to grant the Government exclusive rights thereunder.

The respondent concedes that the United States may practice the inventions without payment of royalty, but asserts that all others are excluded, during the life of the patents, from using them without the respondent's consent. The petitioner insists that the circumstances require a declaration either that the Government has sole and exclusive property in the inventions or that they have been dedicated to the public so that anyone may use them.

First. By Article I, Section 8, clause 8 of the Constitution, Congress is given power to promote the progress of science and the useful arts by securing for limited times to inventors the exclusive rights to their respective discoveries. R. S. 4886 as amended (U. S. Code, Title 35, § 31) is the last of a series of statutes which since 1793 have implemented the constitutional provision.

Though often so characterized a patent is not, accurately speaking, a monopoly, for it is not created by the executive authority at the expense and to the prejudice of all the community except the grantee of the patent. Seymour v. Osborne, 11 Wall. 516, 533. The term monopoly connotes the giving of an exclusive privilege for buying, selling, working or using a thing which the public freely enjoyed prior to the grant.[6] Thus a monopoly takes something from the people. An inventor deprives the public of nothing which it enjoyed before his discovery, but gives something of value to the community by adding to the sum of human knowledge. United States v. Bell Telephone Co., 167 U. S. 224, 239; Paper Bag Patent Case, 210 U. S. 405, 424; Brooks v. Jenkins, 3 McLean 432, 437; Parker v. Haworth, 4 McLean 370, 372; Allen v. Hunter, 6 McLean 303, 305-306; Attorney General v. Rumford Chemical Works, 2 Bann. & Ard. 298, 302. He may keep his invention secret and reap its fruits indefinitely. In consideration of its disclosure and the consequent benefit to the community, the patent is granted. An exclusive enjoyment is guaranteed him for seventeen years, but upon the expiration of that period, the knowledge of the invention enures to the people, who are thus enabled without restriction to practice it and profit by its use. Kendall v. Winsor, 21 How. 322, 327; United States v. Bell Telephone Co., *supra*, p. 239. To this end the law requires such disclosure to be made in the application for patent that others skilled in the art may understand the invention and how to put it to use.[7]

A patent is property and title to it can pass only by assignment. If not yet issued an agreement to assign when issued, if valid as a contract, will be specifically enforced. The respective rights and obligations of employer and employee, touching an invention conceived by the latter, spring from the contract of employment.

[6] Webster's New International Dictionary: "Monopoly."

[7] U. S. Code, Tit. 35, § 33.

One employed to make an invention, who succeeds, during his term of service, in accomplishing that task, is bound to assign to his employer any patent obtained. The reason is that he has only produced that which he was employed to invent. His invention is the precise subject of the contract of employment. A term of the agreement necessarily is that what he is paid to produce belongs to his paymaster. Standard Parts Company v. Peck, 264 U. S. 52. On the other hand, if the employment be general, albeit it covers a field of labor and effort in the performance of which the employee conceived the invention for which he obtained a patent, the contract is not so broadly construed as to require an assignment of the patent. Hapgood v. Hewitt, 119 U. S. 226; Dalzell v. Dueber Watch Case Mfg. Co., 149 U. S. 315. In the latter case it was said:

"But a manufacturing corporation, which has employed a skilled workman, for a stated compensation, to take charge of its works, and to devote his time and services to devising and making improvements in articles there manufactured, is not entitled to a conveyance of patents obtained for inventions made by him while so employed, in the absence of express agreement to that effect."

The reluctance of courts to imply or infer an agreement by the employee to assign his patent is due to a recognition of the peculiar nature of the act of invention, which consists neither in finding out the laws of nature, nor in fruitful research as to the operation of natural laws, but in discovering how those laws may be utilized or applied for some beneficial purpose, by a process, a device or a machine. It is the result of an inventive act, the birth of an idea and its reduction to practice; the product of original thought; a concept demonstrated to be true by practical application or embodiment in tangible form. Clark Tread Co. v. Willimantic Linen Co., 140 U. S. 481, 489; Symington Co. v. National Castings Co., 250 U. S. 383, 386; Pyrene Mfg. Co. v. Boyce, 292 Fed. 480, 481.

Though the mental concept is embodied or realized in a mechanism or a physical or chemical aggregate, the embodiment is not the invention and is not the subject of a patent. This distinction between the idea and its application in practice is the basis of the rule that employment merely to design or to construct or to devise methods of manufacture is not the same as employment to invent. Recognition of the nature of the act of invention also defines the limits of the so-called shop right, which shortly stated, is that where a servant, during his hours of employment, working with his master's materials and appliances, conceives and perfects an invention for which he obtains a patent, he must accord his master a non-exclusive right to practice the invention. McClurg v. Kingsland, 1 How. 202; Solomons v. United States, 137 U. S. 342; Lane & Bodley Co. v. Locke, 150 U. S. 193. This is an application of equitable principles. Since the servant uses his master's time, facilities and materials to attain a concrete result, the latter is in equity entitled to use that which embodies his own property and to duplicate it as often as he may find occasion to employ similar appliances in his business. But the employer in such a case has no equity to demand a conveyance of the invention, which is the original conception of the employee alone, in which the employer had no part. This remains the property of him who conceived it, together with the right conferred by the patent, to exclude all others than the employer from the accruing benefits. These principles are settled as respects private employment.

Second. Does the character of the service call for different rules as to the relative rights of the United States and its employees?

The title of a patentee is subject to no superior right of the Government. The grant of letters patent is not, as in England, a matter of grace or favor, so that conditions may be annexed at the pleasure of the executive. To the laws passed by the Congress, and to them alone, may we look for guidance as to the extent and the limitations of the respective rights of the inventor and the public. Attorney General v. Rumford Chemical Works, *supra*, at pp. 303-4. And this court has held that the Constitution evinces no public policy which requires the holder of a patent to cede the use or benefit of the invention to the United States, even though the discovery concerns matters which can properly be used only by the Government; as, for example, munitions of war. James v. Campbell, 104 U. S. 356, 358. Hollister v. Benedict Mfg. Co., 113 U. S. 59, 67.

No servant of the United States has by statute been disqualified from applying for and receiving a patent for his invention, save officers and employees of the Patent Office during the period for which they hold their appointments.[8]

[8] R. S. 480; U. S. Code, Tit. 35, § 4.

This being so, this court has applied the rules enforced as between private employers and their servants to the relation between the Government and its officers and employees.

United States v. Burns, 12 Wall. 246, was a suit in the Court of Claims by an army officer as assignee of a patent obtained by another such officer for a military tent, to recover royalty under a contract made by the Secretary of War for the use of the tents. The court said, in affirming a judgment for the plaintiff:

"If an officer in the military service, not specially employed to make experiments with a view to suggest improvements, devises a new and valuable improvement in arms, tents, or any other kind of war material, he is entitled to the benefit of it, and to letters-patent for the improvement from the United States, equally with any other citizen not engaged in such service; and the government cannot, after the patent is issued, make use of the improvement any more than a private individual, without license of the inventor or making compensation to him."

In United States v. Palmer, 128 U. S. 262, Palmer, a lieutenant in the army, patented certain improvements in infantry accoutrements. An army board recommended their use and the Secretary of War confirmed the recommendation. The United States manufactured and purchased a large number of the articles. Palmer brought suit in the Court of Claims for a sum alleged to be a fair and reasonable royalty. From a judgment for the plaintiff the United States appealed. This court, in affirming, said:

"It was at one time somewhat doubted whether the government might not be entitled to the use and benefit of every patented invention, by analogy to the English law which reserves this right to the crown. But that notion no longer exists. It was ignored in the case of Burns."

These principles were recognized in later cases involving the relative rights of the Government and its employees in instances where the subject-matter of the patent was useful to the public generally. While these did not involve a claim to an assignment of the patent, the court reiterated the views earlier announced.

In Solomons v. United States, 137 U. S. 342, 346, it was said:

"The government has no more power to appropriate a man's property invested in a patent than it has to take his property invested in real estate; nor does the mere fact that an inventor is at the time of his invention in the employ of the government transfer to it any title to, or interest in it. An employe, performing all the duties assigned to him in his department of service, may exercise his inventive faculties in any direction he chooses, with the assurance that whatever invention he may thus conceive and perfect is his individual property. There is no difference between the government and any other employer in this respect."

And in Gill v. United States, 160 U. S. 426, 435:

"There is no doubt whatever of the proposition laid down in Solomons case, that the mere fact that a person is in the employ of the government does not preclude him from making improvements in the machines with which he is connected, and obtaining patents therefor, as his individual property, and that in such case the government would have no more right to seize upon and appropriate such property, than any other proprietor would have. * * *"

The distinction between an employment to make an invention and a general employment in the course of which the servant conceives an invention has been recognized by the executive department of the Government. A lieutenant in the navy patented an anchor while he was on duty in the Bureau of Equipment and Recruiting, which was charged with the duty of furnishing anchors for the navy; he was not while attached to the bureau specially employed to make experiments with a view to suggesting improvements to anchors or assigned the duty of making or improving. The Attorney General advised that as the invention did not relate to a matter as to which the lieutenant was specially directed to experiment with a view to suggesting improvements he was entitled to compensation from the Government for the use of his invention in addition to his salary or pay as a navy officer.[9]

A similar ruling was made with respect to an ensign who obtained a patent for improvements in "B. L. R. ordnance" and who offered to sell the improvements, or the right to use them, to the Government. It was held that the navy might properly make a contract with him to this end.[10]

---

[9] 19 Opinions Attorney-General, 407.

[10] 20 Opinions Attorney-General, 829. And compare Report Judge Advocate General of the Navy, 1901, p. 6; Digest, Opinions Judge Advocate General of the Army, 1912-1930, p. 287; Opinions, Judge Advocate General of the Army, 1918, Vol. 2, pp. 529, 988, 1066.

The United States is entitled, in the same way and to the same extent as a private employer, to shop-rights, that is, the free and non-exclusive use of a patent which results from efforts of its employee in his working hours and with material belonging to the Government. Solomons v. United States, *supra*, pp. 346-7; McAleer v. United States, 150 U. S. 424; Gill v. United States, *supra*.

The statutes, decisions and administrative practice negate the existence of a duty binding one in the service of the Government different from the obligation of one in private employment.

Third. When the United States filed its bills it recognized the law as heretofore declared; realized that it must like any other employer, if it desired an assignment of the respondent's rights, prove a contractual obligation on the part of Lowell and Dunmore to assign the patents to the Government. The averments clearly disclose this. The bill in No. 316 is typical. After reciting that the employees were laboratory apprentice and associate physicist and laboratory assistant and associate physicist respectively and that one of their duties was "to carry on investigation research and experimentation in such problems relating to radio and wireless as might be assigned to them by their superiors," it is charged "in the course of his employment as aforesaid, there was assigned to said Lowell by his superiors in said radio section, for investigation and research, the problem of developing a radio receiving set capable of operation by alternating current. * * *"

Thus the Government understood that respondent could be deprived of rights under the patents only by proof that Dunmore and Lowell were employed to devise the inventions. The findings of the courts below show how far the proofs fell short of sustaining these averments.

The Government is consequently driven to the contention that though the employees were not specifically assigned the task of making the inventions (as in Standard Parts Co. v. Peck, *supra*) still, as the discoveries were "within the general field of their research and inventive work" the United States is entitled to an assignment of the patents. The courts below expressly found that Dunmore and Lowell did not agree to exercise their inventive faculties in their work and that invention was not within its scope. In this connection it is to be remembered that the written evidence of their employment does not mention research, much less invention; that never was there a word said to either of them, prior to their discoveries, concerning invention or patents or their duties or obligations respecting these matters; that as shown by the records of the patent office, employees of the Bureau of Standards and other departments had while so employed received numerous patents and enjoyed the exclusive rights obtained as against all private persons without let or hindrance from the Government.[11]

---

[11] No exhaustive examination of the official records has been attempted. It is sufficient, however, for present purposes, to call attention to the following instances.

Dr. Frederick A. Kolster was employed in the radio section, Bureau of Standards, from December, 1912, until about March 1, 1921. He applied for the following patents: No. 1,609,866, for radio apparatus, application dated November 26, 1920. No. 1,447,165, for radio method and apparatus, application dated January 30, 1919. No. 1,311,654, for radio method and apparatus, application dated March 25, 1916. No. 1,394,560, for apparatus for transmitting radiant energy, application dated November 24, 1916. The Patent Office records show assignments of these patents to Federal Telegraph Company, San Francisco, Cal., of which Dr. Kolster is now president. He testified that these are all subject to a non-exclusive license in the United States to use and practice the same.

Burten McCollum was an employee of the Bureau of Standards between 1911 and 1924. On the dates mentioned he filed the following applications for patents, which were issued to him. No. 1,035,378, alternating current induction motor, March 11, 1912. No. 1,156,364, induction motor, February 25, 1915. No. 1,226,091, alternating current induction motor, August 2, 1915. No. 1,724,495, method and apparatus for determining the slope of subsurface rock boundaries, October 24, 1928. No. 1,724,720, method and apparatus for studying subsurface contours, October 12, 1928. The last two inventions were assigned to McCollum Geological Explorations, Inc., a Delaware corporation.

Herbert B. Brooks, while an employee of the Bureau between 1912 and 1930, filed November 1, 1919, an application on which patent No. 1,357,197, for an electric transformer, was issued.

William W. Coblentz, an employee of the Bureau of Standards from 1918, and still such at the date of the trial, on the dates mentioned, filed applications on which patents issued as follows: No. 1,418,862, for electrical resistance, September 22, 1920. No. 1,458,165, system of electrical control, September 22, 1920. No. 1,450,061, optical method for producing pulsating electric current, August 6, 1920. No. 1,563,557, optical means for rectifying alternating currents, September 18, 1923. The Patent Office records show that all of these stand in the name of Coblentz, but are subject to a license to the United States of America.

August Hund, who was an employee of the Bureau from 1922 to 1927, on the dates mentioned filed applications on which letters patent issued, No. 1,649,828, method of preparing Piezo-electric plates, September 30, 1925. No. 1,688,718, Piezo-electric-crystal oscillator system, May 10, 1927. No. 1,688,714, Piezo-electric-crystal apparatus, May 12, 1927. No. 1,648,689, condenser transmitter, April 10, 1926. All of these patents are shown of record to have been assigned to Wired Radio Inc., a corporation.

Paul R. Heyl and Lyman J. Briggs, while employees of the Bureau, filed an application January 11, 1922, for patent No. 1,660,751, on inductor compass, and assigned the same to the

In no proper sense may it be said that the contract of employment contemplated invention; everything that Dunmore and Lowell knew negatived the theory that they were employed to invent; they knew, on the contrary, that the past and then present practice was that the employees of the Bureau were alowed to take patents on their inventions and have the benenfits thereby conferred save as to use by the United States. The circumstances preclude the implication of any agreement to assign their inventions or patents.

*Moreover no court could, however clear the proof of such a contract, order the execution of an assignment. No Act of Congress has been called to our attention authorizing the United States to take a patent or to hold one by assignment. No statutory authority exists for the transfer of a patent to any department or officer of the Government, or for the administration of patents, or the issuance of licenses on behalf of the United States. In these circumstances no public policy requires us to deprive the inventor of his exclusive rights as respects the general public and to lodge them in a dead hand incapable of turning the patent to account for the benefit of the public.

The record affords even less basis for inferring a contract on the part of the inventors to refrain from patenting their discoveries than for finding an agreement to assign them.

The bills aver that the inventions and patents are held in trust for the United States, and that the court should so declare. It is claimed that as the work of the Bureau, including all that Dunmore and Lowell did, was in the public interest, these public servants had dedicated the offspring of their brains to the public, and so held their patents in trust for the common weal, represented here in a corporate capacity by the United States. The patentees, we are told, should surrender the patents for cancellation, and the respondent must also give up its rights under the patents.

The trust cannot be express. Every fact in the case negatives the existence of one. Nor can it arise *ex maleficio*. The employees' conduct was not fraudulent in any respect. They promptly disclosed their inventions. Their superiors encouraged them to proceed in perfecting and applying the discoveries. Their note books and reports disclosed the work they were doing, and there is not a syllable to suggest their use of time or material was clandestine or improper. No word was spoken regarding any claim of title by the Government until after applications for patents were filed. And, as we have seen, no such trust has been spelled out of the relation of master and servant, even in the cases where the employee has perfected his invention by the use of his employer's time and materials. The cases recognizing the doctrine of shop rights may be said to fix a trust upon the employee in favor of his master as respects the use of the invention by the latter, but they do not affect the title to the patent and the exclusive rights conferred by it against the public.

The Government's position in reality is, and must be, that a public policy, to be declared by a court, forbids one employed by the United States, for scientific research, to obtain a patent for what he invents, though neither the Constitution nor any satute so declares.

Where shall the courts set the limit of the doctrine? For confessedly, it must be limited. The field of research is as broad as that of science itself. If the petitioner is entitled to a cancellation of the patents in this case, would it be so entitled, if the employees had done their work at home, in their own time and with their own appliances and materials? What is to be said of an invention evolved as the result of the solution of a problem in a realm apart from that to which the employee is assigned by his official superiors? We have seen that the Bureau has numerous divisions. It is entirely possible that an employee in one division may make an invention falling within the work of some other division. Indeed this case presents that exact situation, for the inventions in question had to do with radio reception, a matter assigned to a group of which Dunmore and Lowell were not members. Did the mere fact of their employment by the Bureau require these employees

Aeronautical Instrument Company of Pittsburgh, Pennsylvania.

C. W. Burrows was an employee of the Bureau of Standards between 1912 and 1919. While such employee he filed applications on the dates mentioned for patents which were issued, No. 1,322,405, October 4, 1917, method and apparatus for testing magnetizable objects by magnetic leakage; assigned to Magnetic Analysis Corporation, Long Island City, N. Y. No. 1,329,578, relay, March 13, 1918; exclusive license issued to make, use and sell for the field of railway signaling and train control, to Union Switch & Signal Company, Swissvale, Pa. No. 1,459,970, method of and apparatus for testing magnetizable objects, July 25, 1917; assigned to Magnetic Analysis Corporation, Long Island City, N. Y.

John A. Willoughby, an employee of the Bureau of Standards between 1918 and 1922, while so employed, on June 26, 1919, applied for and was granted a patent, No. 1,555,845, for a loop antenna.

*This paragraph was deleted from the opinion by order of May 8, 1933.

to cede to the public every device they might conceive?

Is the doctrine to be applied only where the employment is in a bureau devoted to scientific investigation *pro bono publico?* Unless it is to be so circumscribed the statements of this court in Burns v. United States, *supra*, Solomons v. United States, *supra*, and Gill v. United States, *supra*, must be held for naught.

Again, what are to be defined as bureaus devoted entirely to scientific research? It is common knowledge that many in the Department of Agriculture conduct researches and investigations, that divisions of the War and Navy Departments do the like, and doubtless there are many other bureaus and sections in various departments of government where employees are set the task of solving problems all of which involve more or less of science. Shall the field of the scientist be distinguished from the art of as killed mechanic? Is it conceivable that one working on a formula for a drug or an antiseptic in the Department of Agriculture stands in a different class from a machinist in an arsenal? Is the distinction to be that where the government department is, so to speak, a business department operating a business activity of the government, the employee has the same rights as one in private employment, whereas if his work be for a bureau interested more particularly in what may be termed scientific research he is upon notice that whatever he invents in the field of activity of the bureau, broadly defined, belongs to the public and is unpatentable? Illustrations of the difficulties which would attend an attempt to define the policy for which the Government contends might be multiplied indefinitely.

The courts ought not to declare any such policy; its formulation belongs solely to the Congress. Will permission to an employee to enjoy patent rights as against all others than the Government tend to the improvement of the public service by attracting a higher class of employees? Is there in fact greater benefit to the people in a dedication to the public of inventions conceived by officers of government, than in their exploitation under patents by private industry? Should certain classes of invention be treated in one way and other classes differently? These are not legal questions, which courts are competent to answer. They are practical questions, and the decision as to what will accomplish the greatest good for the inventor, the Government and the public rests with the Congress. We should not read into the patent laws limitations and conditions which the legislature has not expressed.

Fourth. Moreover, we are of opinion Congress has approved a policy at variance with the petitioner's contentions. This is demonstrated by examination of two statutes, with their legislative history, and the hearings and debates respecting proposed legislation which failed of passage.

Since 1883 there has been in force an act [12] which provides:

"The Secretary of the Interior [now the Secretary of Commerce, act of February 14, 1903, c. 552, Sec. 12, 32 Stat. 830] and the Commissioner of Patents are authorized to grant any officer of the government, except officers and employees of the Patent Office, a patent for any invention of the classes mentioned in section forty-eight hundred and eighty-six of the Revised Statutes, when such invention is used or to be used in the public service, without the payment of any fee: Provided, That the applicant in his application shall state that the invention described therein, if patented, may be used by the government or any of its officers or employees in the prosecution of work for the government, or by any other person in the United States, without the payment to him of any royalty thereon, which stipulation shall be included in the patent."

This law was evidently intended to encourage government employees to obtain patents, by relieving them of the payment of the usual fees. The condition upon which the privilege was accorded is stated as the grant of free use by the government, "its officers or employees in the prosecution of work for the government, *or by any other person in the United States.*" For some time the effect of the italicized phrase was a matter of doubt.

In 1910 the Judge Advocate General of the Army rendered an opinion to the effect that one taking a patent pursuant to the act threw his invention "open to public and private use in the United States." [13] It was later realized that this view made such a patent a contradiction in terms, for it secured no exclusive right to anyone. In 1918 the Judge Advocate General gave a well-reasoned opinion [14] holding that if the statute were construed to involve a dedication to the public, the so-called patent would at most amount to

[12] Act of March 3, 1883, c. 143, 22 Stat. 625.

[13] See Squier v. American T. & T. Co., 21 F. (2d) 747, 748.

[14] November 30, 1918; Opinions of Judge Advocate General, 1918, Vol. 2, p. 1029.

a publication or prior reference. He concluded that the intent of the act was that the free use of the invention extended only to the Government or those doing work for it. A similar construction was adopted in an opinion of the Attorney General.[15] Several federal courts referred to the statute and in *dicta* indicated disagreement with the views expressed in these later opinions.[16]

The departments of government were anxious to have the situation cleared and repeatedly requested that the act be amended. Pursuant to the recommendations of the War Department an amendment was enacted April 30, 1928.[17] The proviso was changed to read:

"Provided, That the applicant in his application shall state that the invention described therein, if patented, may be manufactured or used by or for the Government for governmental purposes without the payment to him of any royalty thereon, which stipulation shall be included in the patent."

The legislative history of the amendment clearly discloses the purpose to save to the employee his right to exclude the public.[18] In the report of the Senate Committee on Patents submitted with the amendment, the object of the bill was said to be the protection of the interests of the Government, primarily by securing patents on inventions made by officers and employees, presently useful in the interest of the national defense or those which may prove useful in the interest of national defense in the future; and secondarily, to encourage the patenting of inventions by officers and employees of the Government with the view to further protection of the Government against suits for infringement of patents. The Committee stated that the bill had the approval of the Commissioner of Patents and was introduced at the request of the Secretary of War. Appended to the report is a copy of a letter of the Secretary of War addressed to the committees of both Houses stating that the language of the legislation then existing was susceptible of two interpretations contrary to each other. The letter quoted the proviso of the section as it then stood, and continued:

"It is clear that a literal construction of this proviso would work a dedication to the public of every patent taken out under the act. If the proviso must be construed literally we would have a situation wherein all the patents taken out under the act would be nullified by the very terms of the act under which they were granted, for the reason that a patent which does not carry with it the limited monopoly referred to in the Constitution is in reality not a patent at all. The only value that a patent has is the right that it extends to the patentee to exclude all others from making, using, or selling the invention for a certain period of years. A patent that is dedicated to the public is virtually the same as a patent that has expired."

After referring to the interpretation of the Judge Advocate General and the Attorney General and mentioning that no satisfactory adjudication of the question has been afforded by the courts, the letter went on to state:

"Because of the ambiguity referred to and the unsettled condition that has arisen therefrom, it has become the policy of the War Department to advise all its personnel who desire to file applications for letters patent, to do so under the general law and pay the required patent-office fee in each case."

And added:

"If the proposed legislation is enacted into law, Government officers and employees may unhesitatingly avail themselves of the benefits of the act with full assurance that in so doing their patent is not dedicated to the public by operation of law. The War Department has been favoring legislation along the lines of the proposed bill for the past five or six years."

When the bill came up for passage in the House a colloquy occurred which clearly disclosed the purpose of the amendment.[19] The intent was that a gov-

[15] 32 Opinions Attorney General, 145.

[16] See Squier v. American Tel. & Tel. Co., 7 F. (2d) 831, 21 F. (2d) 747; Hazeltine Corporation v. Electric Service Engineering Corp., 18 F. (2d) 662; Hazeltine Coropration v. A. W. Grebe & Co., 21 F. (2d) 643; Selden Co. v. National Aniline & Chemical Co., 48 F. (2d) 270.

[17] 45 Stat. 467, 468.

[18] Report No. 871, 70th Cong., 1st Sess., House of Representatives, to accompany H. R. 6108; Report No. 765, 70th Cong., 1st Sess., Senate, to accompany H. R. 6108; Cong. Rec., House of Representatives, March 19, 1928, 70th Cong., 1st Sess., p. 5013; Cong. Rec., Senate, April 24, 1928, 70th Cong., 1st Sess., p. 7066.

[19] Cong. Rec., 70th Cong., 1st Sess., Vol. 69, Part 5, p. 5018:

"Mr. LaGuardia. Mr. Speaker, reserving the right to object, is not the proviso too broad? Suppose an employee of the Government invents some improvement which is very valuable, is he compelled to give the Government free use of it?

"Mr. Vestal [who reported the bill for the Committee and was in charge of it]. If he is employed by the Government and the invention is made while working in his capacity as an agent of the Government. If the head of the bureau certifies this invention will be used by the Government, then the Government, of course, gets it without the payment of any royalty.

"Mr. LaGuardia. The same as a factory rule?

"Mr. Vestal. Yes; but the man who takes out the patent has his commercial rights outside.

"Mr. LaGuardia. Outside of the Government?

"Mr. Vestal. Yes.

"Mr. LaGuardia. But the custom is, and with-

ernment employee who in the course of his employment conceives an invention should afford the government free use thereof, but should be protected in his right to exclude all others. If Dunmore and Lowell, who tendered the Government a non-exclusive license without royalty, and always understood that the Government might use their inventions freely, had proceeded under the act of 1883, they would have retained their rights as against all but the United States. This is clear from the executive interpretation of the act. But for greater security they pursued the very course then advised by the law officers of the Government. It would be surprising if they thus lost all rights as patentees; especially so, since Congress has now confirmed the soundness of the views held by the law officers of the Government.

Until the year 1910 the Court of Claims was without jurisdiction to award compensation to the owner of a patent for unauthorized use by the United States or its agents. Its power extended only to the trial of claims based upon an express or implied contract for such use.[20] In that year Congress enlarged the jurisdiction to embrace the former class of claims.[21] In giving consent to be sued, the restriction was imposed that it should not extend to owners of patents obtained by employees of the Government while in the service. From this it is inferred that Congress recognized no right in such patentees to exclude the public from practicing the invention. But an examination of the legislative record completely refutes the contention.

The House Committee in reporting the bill, after referring to the law as laid down in the Solomons case, said: "The United States in such a case has an implied license to use the patent without compensation, for the reason that the inventor used the time or the money or the material of the United States in perfecting his invention. The use by the United States of such a patented invention without any authority from the owner thereof is a lawful use under existing law, and we have inserted the words 'or lawful right to use the same' in order to make it plain that we do not intend to make any change in existing law in this respect, and do not intend to give the owner of such a patent any claim against the United States for its use."[22] From this it is clear that Congress had no purpose to declare a policy at variance with the decisions of this court.

The executive departments have advocated legislation regulating the taking of patents by government employees and the administration by government agencies of the patents so obtained. In 1919 and 1920 a bill sponsored by the Interior Department was introduced. It provided for the voluntary assignment or license by any government employee, to the Federal Trade Commission, of a patent applied for by him, and the licensing of manufacturers by the Commission, the license fees to be paid into the Treasury and such part of them as the President might deem equitable to be turned over to the patentee.[23] In the hearings and reports upon this measure

out this bill, the Government has the right to the use of the improvement without payment if it is invented in Government time and in Government work.

"Mr. Vestal. That is correct; and then on top of that, may I say that a number of instances have occurred where an employee of the Government, instead of taking out a patent had some one else take out the patent and the Government has been involved in a number of suits. There is now $600,000,000 worth of such claims in the Court of Claims."

It will be noted from the last statement of the gentleman in charge of the bill that Congress was concerned with questions of policy in the adoption of the amendment. These, as stated above, are questions of business policy and business judgment—what is to the best advantage of the Government and the public. They are not questions as to which the courts ought to invade the province of the Congress.

[20] See Belknap v. Schild, 161 U. S. 10, 16; Eager v. United States, 35 C. Cls. 356.

[21] Act of June 25, 1910, 36 Stat. 851: (See Crozier v. Krupp, 224 U. S. 290.)

"That whenever an invention described in and covered by a patent of the United States shall hereafter be used by the United States without license of he owner thereof or lawful to use the same, such owner may recover reasonable compensation for such use by suit in the Court of Claims: Provided, however, That said Court of Claims shall not entertain a suit or reward compensation under the provisions of this Act where the claim for compensation is based on the use by the United States of any article heretofore owned, leased, used by, or in the possession of the United States: Provided further, That in any such suit the United States may avail itself of any and all defenses, general or special, which might be pleaded by a defendant in an action for infringement, as set forth in Title Sixty of the Revised Statutes, or otherwise: And provided further, That the benefits of this Act shall not inure to any patentee, who, when he makes such claim is in the employment or service of the Government of the United States; or the assignee of any such patentee; nor shall this Act apply to any device discovered or invented by such employee during the time of his employment or service."

The Act was amended in resepcts immaterial to the present question, July 1, 1918, 40 Stat. 705. See William Cramp & Sons Co. v. Curtis Turbine Co., 246 U. S. 28; Richmond Screw Anchor Co. v. United States, 275 U. S. 331, 343. As amended it appears in U. S. C., Tit. 35, § 68.

[22] House Report 1288, 61st Cong., 2d Sess.

[23] S. 5265, 65th Cong., 3d Sess.; S. 3228, 66th Cong., 2d Sess.; H. R. 9932, 66th Cong., 2d Sess.; H. R. 11984, 66th Cong., 3d Sess.

stress was laid not only upon the fact that action by an employee thereunder would be voluntary, but that the inventor would be protected at least to some extent in his private right of exclusion. It was recognized that the Government could not compel an assignment, was incapable of taking such assignment or administering the patent, and that it had shop rights in a patent perfected by the use of government material and in government working time. Nothing contained in the bill itself or in the hearings or reports indicates any intent to change the existing and well understood rights of government employees who obtain patents for their inventions made while in the service. The measure failed of passage.

In 1923 the President sent to the Congress the report of an interdepartmental patents board created by executive order to study the question of patents within the government service and to recommend regulations establishing a policy to be followed in respect thereof. The report adverted to the fact that in the absence of a contract providing otherwise a patent taken out by a government employee, and any invention developed by one in the public service, is the sole property of the inventor. The committee recommended strongly aganist public dedication of such an invention, saying that this in effect voids a patent, and, if this were not so, "there is little incentive for anyone to take up a patent and spend time, effort, and money * * * on its commercial development without at least some measure of protection against others free to take the patent as developed by him and compete in its use. In such a case one of the chief objects of the patent law would be defeated." [24] In full accord is the statement on behalf of the Department of the Interior in a memorandum furnished with respect to the bill introduced in 1919.[25]

With respect to a policy of permitting the patentee to take a patent and control it in his own interest (subject, of course, to the government's right of use, if any) the committee said:

"* * * it must not be lost sight of that in general it is the constitutional right of every patentee to exploit his patent as he may desire, however expedient it may appear to endeavor to modify this right in the interest of the public when the patentee is in the Government service." [26]

[24] Sen. Doc. No. 83, 68th Cong., 1st Sess., p. 3.

[25] Hearings, Senate Patent Committee, 66th Cong., 2d Sess., January 23, 1920, p. 11.

[26] Sen. Doc. No. 83, 68th Cong., 1st Sess., p. 3.

Concerning a requirement that all patents obtained by government employees be assigned to the United States or its agent the committee said:

"* * * it would, on the one hand, render difficult securing the best sort of technical men for the service and, on the other, would influence technical workers to resign in order to exploit inventions which they might evolve and suppress while still in the service. There has always been more or less of a tendency for able men in the service to do this, particularly in view of the comparative meagerness of Government salaries; thus the Government has suffered loss among its most capable class of workers." [27]

The committee recommended legislation to create an Interdepartmental Patents Board; and further that the law make it part of the express terms of employment, having the effect of a contract, that any patent application made or patent granted for an invention discovered or developed during the period of government service and incident to the line of official duties, which in the judgment of the board should, in the interest of the national defense, or otherwise in the public interest, be controlled by the government, should upon demand by the board be assigned by the employee to an agent of the Government. The recommended measures were not adopted.

Fifth. Congress has refrained from imposing upon government servants a contract obligation of the sort above described. At least one department has attempted to do so by regulation.[28] Since the record in this case discloses that the Bureau of Standards had no such regulation, it is unnecessary to consider whether the various departments have power to impose such a contract upon employees without authorization by act of Congress. The question is more difficult under our form of government than under that of Great Britain, where such departmental regulations seem to settle the matter.[29]

All of this legislative history emphasizes what we have stated—that the courts are incompetent to answer the difficult question whether the patentee is to be allowed his exclusive right or compelled to dedicate his invention to the public. It is suggested that the election rests with the authoritative officers of the Government. Under what power, express or implied, may such officers, by

[27] *Ibid.*, p. 4.

[28] See Annual Report, Department of Agriculture, for 1907, p. 775. See Selden Co. v. National Aniline & Chemical Co. Inc., 48 F. (2d) 270, 273.

[29] Queen's Regulations (Addenda 1895, 1st February); Ch. 1, Instructions for Officers in General, pp. 15-16.

administrative fiat, determine the nature and extent of rights exercised under a charter granted a patentee pursuant to constitutional and legislative provisions? Apart from the fact that express authority is nowhere to be found, the question arises, who are the authoritative officers whose determination shall bind the United States and the patentee? The Government's position comes to this—that the courts may not reexamine the exercise of an authority by some officer, not named, purporting to deprive the patentee of the rights conferred upon him by law. Nothing would be settled by such a holding, except that the determination of the reciprocal rights and obligations of the Government and its employee as respects inventions are to be adjudicated, without review, by an unspecified department head or bureau chief. Hitherto both the executive and the legislative branches of the Government have concurred in what we consider the correct view,—that any such declaration of policy must come from Congress and that no power to declare it is vested in administrative officers.

The decrees are affirmed.

Mr. Justice STONE, dissenting.—I think the decrees should be reversed.

The Court's conclusion that the employment of Dunmore and Lowell did not contemplate that they should exercise inventive faculties in their service to the government, and that both courts below so found, seems to render superfluous much that is said in the opinion. For it has not been contended and I certainly do not contend, that if such were the fact there would be any foundation for the claim asserted by the government. But I think the record does not support the Court's conclusion of fact. I am also unable to agree with the reasoning of the opinion, although on my view of the facts it would lead to the reversal of the decree below, which I favor.

When originally organized[1] as a subdivision of the Department of Commerce, the functions of the Bureau of Standards consisted principally of the custody, comparison, construction, testing and calibration of standards and the solution of problems arising in connection with standards. But in the course of its investigation of standards of quality and performance it has gradually expanded into a laboratory for research of the broadest character in various branches of science and industry and particularly in the field of engineering.[2] Work of this nature is carried on for other government departments,[3] the general public[4] and private industries.[5] It is almost entirely supported by public funds,[6] and is maintained in the public interest. In 1915, as the importance of radio to the government and to the public increased, Congress appropriated funds[7] to the Bureau "for investigation and standardization of methods and instruments employed in radio communication." Similar annual appropriations have been made since and public funds were allotted by Acts of July 1, 1916, c. 209, 39 Stat. 262, 324 and October 6, 1917, c. 79, 40 Stat. 345, 375, for the construction of a

[1] Act of March 3, 1901, 31 Stat. 1449; Act of February 14, 1903, § 4, 32 Stat. 825, 826. For an account of the origin and development of the Bureau and its predecessor, see Weber, The Bureau of Standards, 1-75.

[2] Much of the expansion of the Bureau's activities in this direction took place during the war. See Annual Report of the Director, Bureau of Standards, for 1919, p. 25; War Work of the Bureau of Standards (1921), Misc. Publications of the Bureau of Standards No. 46. The scope of the Bureau's scientific work is revealed by the annual reports of the Director. See also the bibliography of Bureau publications for the years 1901-1925, Circular of the Bureau of Standards No. 24 (1925).

[3] The Act of May 29, 1920, 41 Stat. 681, 683, 684, permitted other departments to transfer funds to the Bureau of Standards for such purposes, though even before that time it was one of the major functions of the Bureau to be of assistance to other branches of the service. See e. g. Annual Reports of the Director for 1915, 1916, 1917, p. 16; Annual Report for 1918, p. 18; compare Annual Report for 1921, p. 25; for 1922, p. 10.

[4] The consuming public is directly benefited not only by the Bureau's work in improving the standards of quality and performance of industry, but also by the assistance which it lends to governmental bodies, state and city. See Annual Reports of the Director for 1915, 1916, 1917, p. 14; Annual Report for 1918, p. 16; National Bureau of Standards, Its Functions and Activity, Circular of the Bureau of Standards, No. 1 (1925), pp. 28, 33.

[5] Cooperation with private industry has been the major method relied upon to make the accomplishments of the Bureau effective. See Annual Report for 1922, p. 7; Annual Report for 1923, p. 8. A system of research associates permits industrial groups to maintain men at the Bureau for research of mutual concern. The plan has facilitated co-operation. See Annual Report for 1923, p. 4; Annual Report for 1924, p. 35; Annual Report for 1925, p. 38; Annual Reports for 1926, 1928, 1929, 1931, 1932, p. 1; Research Associates at the Bureau of Standards, Bureau Circular No. 296 (1926). For a list of cooperating organizations as of December 1, 1926, see Misc. Publications No. 96 (1927).

[6] No fees have been charged except to cover the cost of testing, but the Act of June 30, 1932, c. 314, § 312, 47 Stat. 410, directs that "for all comparisons, calibrations, tests or investigations, performed" by the Bureau, except those performed for the Government of the United States or a State, "a fee sufficient in each case to compensate the * * * Bureau * * * for the entire cost of the services rendered shall be charged. * * *"

[7] Act of March 4, 1915, c. 141, 38 Stat. 997, 1044.

fireproof laboratory building "to provide additional space to be used for research and testing in radio communication," as well as "space and facilities for cooperative research and experimental work in radio communication" by other departments of the government. Thus, the conduct of research and scientific investigation in the field of radio has been a duty imposed by law upon the Bureau of Standards since 1915.

Radio research has been conducted in the Radio Section of the Electrical Division of the Bureau. In 1921 and 1922, when Dunmore and Lowell made the inventions in controversy, they were employed in this section as members of the scientific staff. They were not, of course, engaged to invent, in the sense in which a carpenter is employed to build a chest, but they were employed to conduct scientific investigations in a laboratory devoted principally to applied rather than pure science with full knowledge and expectation of all concerned that their investigations might normally lead, as they did, to invention. The Bureau was as much devoted to the advancement of the radio art by invention as by discovery which falls short of it. Hence, invention in the field of radio was a goal intimately related to and embraced within the purposes of the work of the scientific staff.

Both courts below found that Dunmore and Lowell were impelled to make these inventions "solely by their own scientific curiosity." They undoubtedly proceeded upon their own initiative beyond the specific problems upon which they were authorized or directed to work by their superiors in the Bureau, who did not actively supervise their work in its inventive stages. But the evidence leaves no doubt that in all they did they were following the established practice of the Section. For members of the research staff were expected and encouraged to follow their own scientific impulses in pursuing their researches and discoveries to the point of useful application, whether they involved invention or not, and even though they did not relate to the immediate problem in hand. After the inventions had been conceived they were disclosed by the inventors to their chief and they devoted considerable time to perfecting them, with his express approval. All the work was carried on by them in the government laboratory with the use of government materials and facilities, during the hours for which they received a government salary. Its progress was recorded throughout in weekly and monthly reports which they were required to file, as well as in their laboratory notebooks. It seems clear that in thus exercising their inventive powers in the pursuit of ideas reaching beyond their specific assignments, the inventors were discharging the duties expected of scientists employed in the laboratory; Dunmore as well as his supervisors, testified that such was their conception of the nature of the work. The conclusion is irresistible that their scientific curiosity was precisely what gave the inventors value as research workers; the government employed it and gave it free rein in performing the broad duty of the Bureau of advancing the radio art by discovery and invention.

The courts below did not find that there was any agreement between the government and the inventors as to their relative rights in the patents and there was no evidence to support such a finding. They did not find, and upon the facts in evidence and within the range of judicial notice, they could not find that the work done by Dunmore and Lowell leading to the inventions in controversy was not within the scope of their employment. Such a finding was unnecessary to support the decisions below, which proceeded on the theory relied on by the respondent here, that in the absence of an express contract to assign it, an employer is entitled to the full benefit of the patent granted to an employee, only when it is for a particular invention which the employee was specifically hired or directed to make. The bare references by the court below to the obvious facts that "research" and "invention" are not synonymous, and that all research work in the Bureau is not concerned with invention fall far short of a finding that the work in the Bureau did not contemplate invention at all. Those references were directed to a different end, to the establishment of what is conceded here, that Dunmore and Lowell were not specifically hired or directed to make the inventions because in doing so they proceeded beyond the assignments given them by their superiors. The court's conception of the law, applied to this ultimate fact, led inevitably to its stated conclusion that the claim of the government is without support in reason or authority "unless we should regard a general employment for research work as synonymous with a particular employment (or assignment) for inventive work."

The opinion of this Court apparently rejects the distinction between specific employment or assignment and general

employment to invent, adopted by the court below and supported by authority, in favor of the broader position urged by the government that wherever the employee's duties involve the exercise of inventive powers, the employer is entitled to an assignment of the patent on any invention made in the scope of the general employment. As I view the facts, I think such a rule, to which this Court has not hitherto given explicit support, would require a decree in favor of the government. It would also require a decree in favor of a private employer, on the ground stated by the court that as the employee "has only produced what he is employed to invent," a specifically enforcible "term of the agreement necessarily is that what he is paid to produce belongs to his paymaster." A theory of decision so mechanical is not forced upon us by precedent and cannot, I think, be supported.

What the employee agrees to assign to his employer is always a question of fact. It cannot be said that merely because an employee agrees to invent, he also agrees to assign any patent secured for the invention. Accordingly, if an assignment is ordered in such a case it is no more to be explained and supported as the specific enforcement of an agreement to transfer property in the patent than is the shopright which equity likewise decrees, where the employment does not contemplate invention. All the varying and conflicting language of the books cannot obscure the reality that in any case where the rights of the employer to the invention are not fixed by express contract, and no agreement in fact may fairly be implied, equity determines after the event what they shall be. In thus adjudicating *in invitum* the consequences of the employment relationship, equity must reconcile the conflicting claims of the employee who has evolved the idea and the employer who has paid him for his time and supplied the materials utilized in experimentation and construction. A task so delicate cannot be performed by accepting the formula advanced by the petitioner any more than by adopting that urged by the respondent, though both are not without support in the opinions of this Court. Compare Hapgood v. Hewitt, 119 U. S. 226; Dalzell v. Dueber Mfg. Co., 149 U. S. 315; Solomons v. United States, 137 U. S. 342, 346; Gill v. United States, 160 U. S. 426, 435; Standard Parts Co. v. Peck, 264 U. S. 52.

Where the employment does not contemplate the exercise of inventive talent the policy of the patent laws to stimulate invention by awarding the benefits of the monopoly to the inventor and not to someone else leads to a ready compromise: a shop-right gives the employer an adequate share in the unanticipated boon.[8] Hapgood v. Hewitt, *supra;* Lane & Bailey Co. v. Locke, 150 U. S. 193; Dalzell v. Dueber Mfg. Co., *supra;* Pressed Steel Car Co. v. Hansen, 137 Fed. 403; Amdyco Corp. v. Urquhart, 39 F. (2d) 943, aff'd 51 F. (2d) 1072; Ingle v. Landis Tool Co., 272 Fed. 464; see Beecroft & Blackman v. Rooney, 268 Fed. 545, 549.

But where, as in this case, the employment contemplates invention, the adequacy of such a compromise is more doubtful not because it contravenes an agreement for an assignment, which may not exist, but because, arguably, as the patent is the fruit of the very work which the employee is hired to do and for which he is paid, it should no more be withheld from the employer, in equity and good conscience, than the product of any other service which the employee engages to render. This result has been reached where the contract was to devise a means for solving a defined problem, Standard Parts Co. v. Peck, *supra,* and the decision has been thought to establish the employer's right wherever the employee is hired or assigned to evolve a process or mechanism for meeting a specific need. Magnetic Mfg. Co. v. Dings Magnetic Separator Co., 16 F. (2d) 739; Goodyear Tire and Rubber Co. v. Miller, 22 F. (2d) 353, 356; Houghton v. United States, 23 F. (2d) 386. But the court below and others have thought (Pressed Steel Car Co. v. Hansen, *supra;* Houghton v. United States, *supra;* Amdyco Corp. v. Urquhart, *supra*), as the respondent argues, that only in cases where the employment or assignment is thus specific may the employer demand all the benefits of the employee's invention. The basis of such a limitation is not articulate in the cases. There is at least a question whether its application may not be attributed, in some instances, to the readier implication of an actual promise to assign the patent, where the duty is to invent a specific thing (see Pressed Steel Car Co. v. Hansen, *supra,* 415), or, in any case, to the reluctance of equity logically to extend, in this field, the principle that the right to claim the service includes the right to claim its product. The latter alternative may find support in the policy of the patent laws

[8] See the cases collected in 30 Columbia Law Rev. 1172; 36 Harvard Law Rev. 468.

to secure to the inventor the fruits of his inventive genius, in the hardship which may be involved in imposing a duty to assign all inventions, see Dalzell v. Dueber Mfg. Co., *supra*, 323, cf. Aspinwall Mfg. Co. v. Gill, 32 Fed. 697, 700, and in a possible inequality in bargaining power of employer and employee. But compare Goodyear Tire & Rubber Co. v. Miller, *supra*, 355; Hulse v. Bonsack Mach. Co., 65 Fed. 864, 868; see 30 Columbia Law Rev. 1172, 1176-8. There is no reason for determining now the weight which should be accorded these objections to complete control of the invention by the employer, in cases of ordinary employment for private purposes. Once it is recognized, as it must be, that the function of the Court in every case is to determine whether the employee may, in equity and good conscience retain the benets of the patent, it is apparent that the present case turns upon considerations which distinguish it from any which has thus far been decided.

The inventors were not only employed to engage in work which unmistakably required them to exercise their inventive genius as occasion arose; they were a part of a public enterprise. It was devoted to the improvement of the art of radio communication for the benefit of the people of the United States, carried on in a government laboratory, maintained by public funds. Considerations which might favor the employee where the interest of the employer is only in private gain are therefore of slight significance; the policy dominating the research in the Bureau, as the inventors knew, was that of the government to further the interests of the public by advancing the radio art. For the work to be successful, the government must be free to use the results for the benefit of the public in the most effective way. A patent monopoly in individual employees, carrying with it the power to suppress the invention, or at least to exclude others from using it, would destroy this freedom; a shopright in the government would not confer it. For these employees, in the circumstances, to attempt to withhold from the public and from the government the full benefit of the inventions which it has paid them to produce, appears to me so unconscionable and inequitable as to demand the interposition of a court exercising chancery powers. A court which habitually enjoins a mortgagor from acquiring and setting up a tax title adversely to the mortgagee, Middletown Savings Bank v. Bacharach, 46 Conn. 513, 524; Chamberlain v. Forbes, 126 Mich. 86; Waring v. National Savings & Trust Co., 138 Md. 367; see 2 Jones on Mortgages (8th ed.), § 841, should find no difficulty in enjoining these employees and the respondent claiming under them from asserting, under the patent laws, rights which would defeat the very object of their employment. The capacity of equitable doctrine for growth and of courts of equity to mould it to new situations, was not exhausted with the establishment of the employer's shopright. See Essex Trust Co. v. Enwright, 214 Mass. 507; Meinhard v. Salmon, 249 N. Y. 458.

If, in the application of familiar principles to the situation presented here, we must advance somewhat beyond the decided cases, I see nothing revolutionary in the step. We need not be deterred by fear of the necessity, inescapable in the development of the law, of setting limits to the doctrine we apply, as the need arises. That prospect does not require us to shut our eyes to the obvious consequences of the decree which has been rendered here. The result is repugnant to common notions of justice and to policy as well, and the case must turn upon these considerations if we abandon the illusion that equity is called upon merely to enforce a contract, albeit, one that is "implied." The case would be more dramatic if the inventions produced at public expense were important to the preservation of human life, or the public health, or the agricultural resources of the country. The principle is the same here, though the inventions are of importance only in the furtherance of human happiness. In enlisting their scientific talent and curiosity in the performance of the public service in which the Bureau was engaged, Dunmore and Lowell necessarily renounced the prospect of deriving from their work commercial rewards incompatible with it.[9] Hence, there is nothing oppressive

[9] It has been said that many scientists in the employ of the Government regard the acceptance of patent rights leading to commercial rewards in any case as an abasement of their work. Hearings on Exploitation of Inventions by Government Employees, Senate Committee on Patents, 65th Cong., 3d Sess. (1919), pp. 16, 17; see also the Hearings before the same Committee, January 28, 1920, 66th Cong., 2d Sess. (1920), p. 5. The opinion of the Court attributes importance to the fact, seemingly irrelevant, that other employees of the Bureau have in some instances in the past taken out patents on their inventions which, so far as appears, the Government has not prevented them from enjoying. The circumstances under which those inventions were made do not appear. But even if they were the same as those in the present case there is no basis for contending that because the Government saw fit not to assert its rights in other cases

or unconscionable in requiring them or their licensee to surrender their patents at the instance of the United States, as there probably would be if the inventions had not been made within the scope of their employment or if the employment did not contemplate invention at all.

The issue raised here is unaffected by legislation. Undoubtedly the power rests with Congress to enact a rule of decision for determining the ownership and control of patents on inventions made by government employees in the course of their employment. But I find no basis for saying that Congress has done so or that it has manifested any affirmative policy for the disposition of cases of this kind, which is at variance with the considerations which are controlling here.

The Act of June 25, 1910, 36 Stat. 851, as amended July 1, 1918, 40 Stat. 704, 705, permitted patentees to sue the government in the Court of Claims for the unauthorized use of their patents. It was in effect an eminent domain statute by which just compensation was secured to the patentee, whose patent had been used by the government. See Richmond Screw Anchor Co. v. United States, 275 U. S. 331. This statute excluded government employees from the benefits of the Act in order, as the House Committee Report explicitly points out, to leave unaffected the shoprights of the government. See H. R. Report No. 1288, 61st Cong. 2d Sess. A statute thus aimed at protecting in every case the minimum rights of the government can hardly be taken to deny other and greater rights growing out of the special equity of cases like the present.

The Act of April 30, 1928, 45 Stat. 467, 468, amending an earlier statute of 1883 (22 Stat. 625), so as to permit a patent to be issued to a government employee without payment of fees, for any invention which the head of a department or independent bureau certifies "is used or liable to be used in the public service," and which the application specifies may, if patented, "be manufactured and used by or for the Government for governmental purposes without the payment of * * * any royalty," was passed, it is true, with the general purpose of encouraging government employees to take out patents on their inventions. But this purpose was not, as the opinion of the Court suggests, born of a Congressional intent that a government employee who conceives an invention in the course of his employment should be protected in his right to exclude all others but the government from using it. Congress was concerned neither with enlarging nor with narrowing the relative rights of the government and its employees.[10] This is apparent from the language of the statute that the patent shall be issued without a fee "subject to existing law," as well as from the records of its legislative history.[11]

The purpose of Congress in facilitating the patenting of inventions by government employees was to protect the existing right of the government to use all devices invented in the service, whether or not the patentee was employed to use his inventive powers. Experience had shown that this shopright was jeopardized unless the employee applied for a patent, since without the disclosure incident to the application the government was frequently hampered in its defense of claims by orders asserting priority of invention. But doubt which had arisen whether an application for a patent under the Act of 1883 did not operate to dedicate the patent to the public,[12] and reluctance to pay the fees otherwise required, had led government employees to neglect to make applications, even when they were entitled to the benefits of the monopoly subject only to the government's right of use. This doubt the amendment removed. It can hardly be contended that in removing it in order to aid the government in the protection of its shopright, Congress declared a policy that it should have no greater right to control a patent procured either under this special statute or under the general patent laws by fraud or any other type of inequitable conduct. Had such a policy been declared, it is difficult to see on what basis we could award the

it has lost them in this. Moreover, there is no necessary inconsistency in the Government's position if it concluded in those cases that the public interest would be served best by permitting the employees to exploit their inventions themselves, and adopted a contrary conclusion here.

[10] Throughout the various speculations in committee as to what those rights were, it was generally agreed that they were intended to remain unchanged by the bill. See Hearings before the House Committee on Patents, 68th Cong., 2d Sess., on H. R. 8267 and 11408 (1925); Hearings before the same Committee, 70th Cong., 1st Sess. (1928), especially at pp. 8-13. The discussion on the floor of the House, referred to in the opinion of the Court (see note 19) does not indicate the contrary.

[11] In addition to the hearings cited *supra*, note 10, see H. R. Report No. 1596, 68th Cong., 2nd Sess.; H. R. Report No. 871, Senate Report No. 765, 70th Cong., 1st Sess. The bill was originally a companion proposal to the Federal Trade Commission bill discussed *infra*, note 18. See the references given there.

[12] See Selden Co. v. National Aniline & Chemical Co., 48 F. (2d) 270, 272; Squier v. American Telephone & Telegraph Co., 7 F. (2d) 831, 832, affirming 21 F. (2d) 747.

government a remedy, as it seems to be agreed we would, if Dunmore and Lowell had been specifically employed to make the inventions. There is nothing to indicate that Congress adopted one policy for such a case and a contrary one for this.

Other legislation proposed but not enacted,[13] requires but a word. Even had Congress expressly rejected a bill purporting to enact into law the rule of decision which I think applicable here, its failure to act could not be accorded the force of law. But no such legislation has been proposed to Congress, and that which was suggested may have been and probably was defeated for reasons unconnected with the issue presented in this case. The legislative record does show, as the opinion of the Court states, that it is a difficult question which has been the subject of consideration at least since the war, whether the public interest is best served by the dedication of an invention to the public or by its exploitation with patent protection under license from the government or the inventor. But the difficulty of resolving the question does not justify a decree which does answer it in favor of permitting government employees such as these to exploit their inventions without restriction, rather than one which would require the cancellation of their patents or their assignment to the United States.

The decrees should be reversed.

Mr. Justice CARDOZO concurs in this opinion.

Mr. Chief Justice HUGHES (dissenting).—I agree with Mr. Justice STONE'S analysis of the facts showing the nature of the employment of Dunmore and Lowell, and with his conclusions as to the legal effect of that employment. As the people of the United States should have the unrestricted benefit of the inventions in such a case, I think that the appropriate remedy would be to cancel the patents.

[13] The bill referred to in the opinion of the Court was one sponsored by the executive departments to endow the Federal Trade Commission with the power to accept assignments of patents from Government employees and administer them in the public interest. It passed the Senate on one occasion and the House on another but failed to become a law. (S. 5265, 65th Cong., 3d Sess., S. 3228, 66th Cong., 1st Sess., H. R. 9982, 66th Cong., 1st Sess., H. R. 11984, 66th Cong., 3d Sess.). In the course of hearings and debates many points of view were expressed. See Hearings on Exploitation of Inventions by Government Employees, Senate Committee on Patents, 65th Cong., 3d Sess. (1919); Hearing before the same Committee, 66th Cong., 2d Sess. (1920); Senate Report No. 405, H. R. Report No. 595, 66th Cong., 2d Sess., recommending passage. See 59 Cong. Rec., 2300, 2421, 2480, 3908, 4682, 4771, 8359, 8360, 8483, 8490; 60 *ibid.* 356; Conference Report, H. R. No. 1294, Sen. Doc. No. 879, 66th Cong., 3d Sess. And see 60 Cong. Rec., 2890, 3229, 3264-3269, 3537. Differences were stressed in the purposes and needs of different agencies of the Government. See especially Hearings (1919), *supra*, pp. 22, 24-5. The need of commercial incentives to private exploiters, as well as the general desirability of such exploitation were admitted, but the dangers were recognized as well. It was thought that the public interest would best be served by the establishment of a single agency for Government control, with the power to determine upon some compensation for the inventor.

After the death of this bill in the Senate, February 21, 1921, the subject was again considered by an Interdepartmental Board established by executive order of President Harding, August 9, 1922. Its report was transmitted to Congress by President Coolidge, in December, 1923. Sen. Doc. No. 88, 68th Cong., 1st Sess. The Board found that there had never been any general governmental policy established with respect to inventions, that whether public dedication, private exploitation or governmental control and administration is desirable, depends largely on the nature of the invention. Accordingly, legislation was recommended establishing a permanent Interdepartmental Patents Board with the power to demand assignments of patents on those inventions thereafter developed in the service which "in the interest of the national defense, or otherwise in the public interest" should be controlled by the Government. No action was taken upon this proposal.

Since that time the Director of the Bureau of Standards has recommended that a "uniform, equitable policy of procedure" be defined for the Government by legislation. (Annual Report for 1925, p. 40.) In the Report for 1931 it is said (p. 46) that the "patent policy of this Bureau has always been that patentable devices developed by employees paid out of public funds belong to the public," and the Report for 1932 adds (p. 40) "if not so dedicated directly, the vested rights should be held by the Government."

53. Lung disease patients with negative DTHR-T had: caseating granuloma (1), silicosis (3), tuberculosis with pleural effusion (1), intravascular angiogenic tumor (1), chronic bronchiectasis (5), chronic organizing interstitial pneumonitis (4), recurrent cyst (1), coccidioidomycosis (1), sarcoidosis (2), chronic obstructive pulmonary disease (8), chronic asthma emphysema, and pneumonitis (5), pneumonia (3).
54. E. R. Fisher *et al.*, *Cancer* **36**, 1 (1975).
55. D. L. Page *et al.*, *J. Natl. Cancer Inst.* **61**, 1055 (1978).
56. Patients with the following cancers reacted negatively (one of each): B-cell lymphoma; extrapulmonary carcinoid; astrocytoma; glioma; glioma-astrocytoma; liposarcoma; leiomyosarcoma; sarcomatous chordoma; localized, encapsulated papillary-, mixed papillary-, and medullary low-grade thyroid carcinoma. In addition, four patients with acute or chronic myelocytic leukemia and two with Hodgkin's disease in remission reacted negatively.
57. M. I. Bernhard, H. J. Wanebo, J. Helm, R. C. Pace, D. L. Kaiser, *Cancer Res.* **43**, 1932 (1983).
58. J. H. Kaplan, S. H. Lockwood, T. J. Cunningham, G. F. Springer, E. E. Uzgiris, in *Cell Electrophoresis in Cancer and Other Clinical Research*, A. W. Preece and P. A. Light, Eds. (Elsevier, New York, 1981), pp. 197–202.
59. B. D. Janković and B. H. Waksman, *J. Immunol.* **89**, 598 (1962); E. J. Holborow and G. Loewi, *Immunology* **5**, 278 (1962).
60. W. O. Weigle, J. M. Chiller, G. S. Habicht, *Transplant. Rev.* **8**, 3 (1972); P. A. Bretscher, *J. Immunol.* **131**, 1103 (1983).
61. The two-sample comparisons of the statistical results on carcinoma patients with those on patients with benign disease of the same organ are in most instances extremely significant statistically, with *P*-values of the order of several one-thousands. This also applies to both categories of squamous-cell carcinoma. In the case of pooled pancreas and pancreas benign, *P* is 0.0043; there are only five benign pancreas patients. However, if all pancreas carcinoma is compared with all pooled noncarcinoma, *P* is 0.0000. The same pertains if breast carcinoma Stage I infiltrating is compared with all noncarcinoma, while for breast carcinoma Stages II and III *P* is 0.0001 when compared with all noncarcinoma. A two-sample Student test of the hypothesis that the combined carcinoma and the combined noncarcinoma populations are the same has a *P* of 0.0000 and yields the very large, extremely significant *t*-statistic of > 9.5. Additional statistical information will be furnished on request to the author, as will be the individual Q_M ranges.
62. P. M. Brickell *et al.*, *Nature (London)* **306**, 756 (1984).
63. G. F. Springer *et al.*, unpublished data.
64. J. C. Mottram, *J. Pathol. Bacteriol.* **40**, 407 (1935); P. C. Nowell, *Science* **193**, 23 (1976); D. Douer *et al.*, *Br. J. Haematol.* **49**, 615 (1981); B. G. Neel, W. S. Hayward, H. L. Robinson, J. Fang, S. M. Astrin, *Cell* **23**, 323 (1981).
65. D. v. Fournier *et al.*, *Cancer* **45**, 2198 (1980); N. Hayabuchi, W. J. Russell, J. Murakami, *ibid.* **52**, 1098 (1983).
66. G. W. G. Bird, J. Wingham, M. J. Pippard, J. G. Hoult, V. Melikian, *Br. J. Haematol.* **33**, 289 (1976); P. M. Ness, G. Garratty, P. A. Morel, H. P. Perkins, *Blood* **54**, 30 (1978).
67. A. F. R. Rahman and B. M. Longenecker, *J. Immunol.* **129**, 2021 (1982); S. Metcalfe, R. J. Svvennsen, G. F. Springer, H. Tegtmeyer, *J. Immunol. Methods* **62**, pM8 (1983).
68. M. K. Robinson and G. F. Springer, *Proc. Am. Assoc. Cancer Res.*, in press.
69. I thank M. Dwass, Northwestern University, for the statistics. This work benefitted from the contributions of my colleagues; their names appear in the references. I owe special gratitude to E. F. Scanlon, P. R. Desai, W. A. Fry, and H. Tegtmeyer. I thank M. J. Cline, E. R. DeSombre, P. Heller, W. H. Kirsten, S. E. Krown, R. D. Owen, and J. Rosenblum for criticism. I thank Evanston Hospital's physicians for continued encouragement to study their patients. I dedicate this article to Heather Margaret Springer, née Blight, who lived from age 48 through 54 with metastases from bilateral breast carcinoma. Her courageous participation in investigation of unknown immunological territory and her painstaking clinical observations remain an enduring obligation. Support was provided by grants CA 19083 and CA 22540 from the National Institutes of Health and by the Julia S. Michels Investigatorship.

National R & D Policy: An Industrial Perspective

Roland W. Schmitt

Industrial policy has become one of the hot issues on our national agenda, with various advocates telling us how to beat the Japanese and solve the problems of unemployment, inflation, and industrial stagnation. The 1984 presidential candidates are picking up these ideas and testing them.

Industrial policy has many components—fiscal, monetary, and regulatory, for example. It touches on many areas, from international trade to retraining the work force. I can bring my expertise to only one corner of this many-sided subject: research and development policy. To me, industrial policy means what the government must do to shape our national industrial posture, and a clear understanding of what government should not do.

There has been no lack of proposals. Bills put before Congress in recent years have called for such changes as the establishment of a National Technology Foundation, or a Cabinet-level Department of Trade and Industry; the selection of a National Commission on Technological Innovation and Industrial Modernization to tell us "what the economic, educational, and industrial priorities of the United States ought to be"; a Presidential Program for the Advancement of Science and Technology; and a Commission on High Technology and Employment Potential. Another proposal would establish a government program to conduct research and development on improved manufacturing techniques; others would exempt joint research and development efforts from the antitrust laws.

All these proposals to aid U.S. R & D show a healthy and encouraging concern about the state of American industrial technology, but they may at the same time distract politicians and policy-makers from the most important need and the most important step that government can take to strengthen U.S. innovation. That task is to ensure and strengthen the health of our university system—in both the performance of basic research and the training of research manpower. The distraction is especially great if Washington pays too much attention to the growing number of calls for the government to take over the job of selecting and supporting R & D programs aimed at commercial results.

The author is senior vice president, Corporate Research and Development, General Electric Company, Schenectady, New York 12301. This article is adapted from his keynote speech at the National Conference on the Advancement of Research, San Antonio, Texas, 10 October 1983.

The Federal Role

In the commercial R & D area there are some things that government must and can do, and other things it cannot and should not do. Government has a crucial role to play in creating favorable conditions for commercial innovation, but not in actually producing those innovations. There are several reasons for this.

First, successful innovation requires a close and intimate coupling between the developers of a technology and the businesses that will bring products based on that technology to market and are themselves in touch with that market. This is essential in a diversified company, and even more essential in a complex and diversified economy. The R & D people must comprehend the strategies of the business as well as know what the market constraints are and what the competition is up to. The business people, in turn, must understand the capabilities and limitations of the technology. They must possess the technical strength to complete the development and believe strongly enough in the technology's potential to make the big investment needed to bring it to market.

perspective, the Department of Energy's program expense for just one unproved, highly speculative energy technique, magnetically contained fusion, was $295 million in 1982 alone. We face the same problem in several other crucial areas of university research. This is particularly true of engineering research—fundamental research in such areas as software engineering, automation, machining systems, materials engineering, and computer-aided engineering techniques.

The crucial distinction again is between support of the underlying research (the job that the government should be doing) and support of efforts aimed directly at generating products (the job the government should stay away from). Some of the bills before Congress do not clearly make this distinction. Consider, for example, the calls for government support of R & D in manufacturing technology. If a program for conducting the underlying research at universities is to be established, I will support it wholeheartedly. But when programs to produce more efficient manufacturing technologies are proposed, I worry that someone has ignored the difference between broadly relevant research and the job of selecting specific technology targets for new products and processes. And when anyone proposes conducting research utilization activities to encourage widespread adoption of these technologies, then I have serious reservations.

In the technology of controls, for example, fundamental theoretical advances are needed to catch up with the speed and power of microelectronics. Such work should be strongly supported at universities. But the job of putting research to work in, say, robots or machine tool controls for commercial markets should be addressed by private companies.

Some may be concerned that with so much emphasis on support of academic research in fast-moving areas, such as microelectronics and computer science, the needs of core industries, such as automobiles and steel, will be neglected. That is not so. The increases in efficiency needed by these industries will be provided much more by some of these fast-moving areas than by advances in the core technologies. These industries, too, are dependent on strong university research in the fast-moving areas. Moreover, these industries suffer from a lack of investment in already available technology. Giving them new technology without the corresponding investment to use that technology is hardly likely to improve their plight.

Immigration Policy

Another policy issue that strikes at the heart of our universities, yet is rarely discussed in the context of R & D policy, is immigration policy. In 1982 as many foreign students received engineering Ph.D.'s in our universities as did American students. Some regard these foreign students as a problem, and there even have been proposals to reduce their numbers. But the real problem is that not enough Americans are entering doctoral programs. The solution is to encourage more of our students, through adequately supported graduate fellowships, to go on to graduate studies. What is clearly not a solution is to force foreign students to leave. They are an important resource for our country. They account for a disproportionately large portion of our skilled manpower in the fast-moving areas of science and technology. They are not taking jobs away from Americans. They are filling a void and advancing U.S. science and technology. Historically the United States has benefited immeasurably from opening our doors to immigrant scientists and engineers. I need only mention such greats as Steinmetz, Alexanderson, and Giaever at General Electric; Tesla, Zworykin, and Ipatieff at other companies; and Fermi, Debye, Mark, and many others at American universities. Yet current laws create obstacles for foreign scientists who seek employment here. If we are truly concerned about enhancing U.S. industry's capability to do R & D, we should ease the regulatory barriers to hiring foreign-born students, especially those trained in this country. Proposed amendments to the Simpson-Mazzoli immigration bill now before Congress would do exactly that. Unfortunately, for reasons that have nothing at all to do with science and technology, that bill is now stalled in the House. The critical role that foreign scientists play in the United States must be addressed directly, rather than as an afterthought to a bill intended to deal with the problem of illegal, and largely unskilled, aliens.

Technology Leaks

A related national issue also directly affects the health of our universities: the problem of leakage of technology to the Soviet Union. In an attempt to stop that leakage, the Department of Defense and the Department of Commerce proposed regulations that would prevent foreign nationals from taking part in advanced microelectronics research in universities and industry. This is intended as just a first step. In the long run, the two departments are proposing to impose the same restrictions on virtually all fast-moving areas of advanced technology considered to be militarily critical.

There is no question that we must do a better job of preventing the Soviets from acquiring our technology, but such regulations are overkill. The Defense and Commerce Departments propose to change the export control regulations in ways that would seriously disrupt the nature of scientific discourse in U.S. universities and industrial R & D laboratories. No doubt some technology does leak to the Soviets in the course of our open scientific discourse. But by the Administration's own account, this is a very small part of the problem. It is counterproductive to impose such major restrictions on U.S. science and technology for such a small part of the problem. Again, foreign scientists play a critical role in most of our important areas of science and technology. Deny them access to these areas of research and we will do far more to damage our technological capabilities than any of the proposals being made in the name of industrial policy will do to help.

Conclusion

National R & D policy today poses both risks and opportunities. The excitement and attention that proposals for industrial R & D policy have generated threaten to distract us from the federal government's most important tasks. We need to go back to the basics. We need to remind ourselves of what it is that the government can and cannot do, and what it is that industry can and cannot do.

In summary, I want to suggest four specific guidelines for federal R & D policy: (i) concentrate direct support on academically based research, not on government-targeted industrial R & D; (ii) concentrate on sunrise science and technology, not on sunrise industries and products; (iii) concentrate on strengthening the climate for privately based innovation, not on government-selected innovation; (iv) concentrate on development for the government's own needs, not on development for market needs. I believe that these simple guidelines—many of which we have followed with success in the past, some of which we have violated with pain—will go a long way toward greatly strengthening and rejuvenating the dynamic innovative powers of our American system of research and development.

Second, innovation works best if this close coupling is in place during the entire innovation process. It should exist when the R & D project is identified and should continue through planning and development. It must survive the inevitable adjustments during development, caused by shifting market constraints and technical surprises. It must withstand the decision points—when to go ahead or when to quit.

Finally, in a free-enterprise system, governments not only do not create the markets for products but are notoriously slow in reacting to shifts in the marketplace. They lack the crucial entrepreneurial spirit to perceive or acknowledge opportunities early in their development.

During the years of heavy government involvement in energy R & D, we used to hear over and over again the expressions "technology transfer," and "commercialization." Those terms embodied the notion that once a technology was developed by a government contractor or a national laboratory, the technology could then somehow be transferred to the marketplace and commercialized.

That did not happen for a simple reason. Technology transfer is not a separate process occurring downstream from R & D. The user and the performer of targeted R & D need to have established a close relation before there is anything to transfer.

In energy R & D, there were some who fell into the trap of thinking that if they got a concept defined, the technology to work, and someone to produce a favorable economic analysis, then commercialization would follow. They forgot to find out whether the customers would buy the product. The result was a misdirection of effort and money into technologies that never had a chance of commercial success.

Even in agriculture, where the United States has a great history of innovation, underlying research on corn genetics was performed at university research stations and largely supported by government. But private seed companies converted that research into hybrid corn products.

A close relation between the user and the performer of R & D cannot, in general, form when government selects commercial R & D targets. Instead, the government ends up being a third party—one that knows a great deal less about the technology than the developer and a great deal less about the market than the user.

As an example, there are proposals that the government fund R & D in manufacturing technology, in such application areas as programmable automation, robotics, advanced sensors, and computer-aided design and manufacturing. Part of this funding is to support R & D work to be done by industry.

These are key technologies for the future but, because they are so important, a large and growing number of companies are already addressing them. General Electric is investing millions of dollars in each of them. And, in each one, we are faced with a large number of tough competitors—foreign firms and U.S. firms, established firms and new ventures, joint ventures and industry-university cooperative programs. In just one corner of computer-aided design, for example, the field of solid modeling, we are competing against at least a dozen capable firms—established giants, smaller rivals, and newer ventures.

It is simply not plausible for an administrator in Washington—even with the help of a blue-ribbon advisory panel—to pick the winning solid-modeling product better than the dozen firms slugging it out in the marketplace. And even if government could pick the winner, that is only the first step. The suppliers of the funds, the performers of the R & D, and the businessmen who deal with the customers have to tie themselves together in a long-term relation. A government funding agency cannot create that kind of relationship.

There is, however, one important exception. It occurs when the government is the customer for innovation—as in defense R & D. Government should concentrate its development efforts on these needs of its own. If history is any guide, it will thereby also generate products and technology that can be tapped for commercial uses.

The government has clear needs in the area of supercomputers for weapons research, cryptanalysis, weather forecasting, economic modeling, the design of improved airfoils and projectiles, and many other uses. By meeting its needs in supercomputers, the government will also be sponsoring the development of a product that has many valuable civilian uses, such as improved oil exploration, better understanding of crack formation and propagation in alloys, new techniques in computer-aided engineering, and the design of new materials based on theoretical principles. The supercomputer is a prime example of a technology in which the government should take the lead.

In very large scale integrated circuits (VLSI) the government will also be a major customer and thus has a major role in sponsoring development work. One emerging opportunity is in the area of inference chips—VLSI implementations of intelligent electronic systems that work in real time, based on custom chips rather than computers. These inference chips could be used in military systems, for example, to help the pilot of an F-18 with an engine hit by shrapnel make the best use of the 3.6 seconds he has in which to decide whether he can limp home or should bail out.

Inference chips will also have great value in many commercial uses, such as in creating three-dimensional computer-aided design images in real time and in helping smart robots plan their paths. Again, by meeting its own development needs, the government may advance technology that can be used in commercial innovations. When the government is not the customer, government selection of developments is unlikely to promote such innovation and economic growth.

Summary. An analysis of how the government can and cannot use research and development policy to improve the nation's industrial posture suggests four guidelines for federal R & D policy: (i) concentrate direct support on academically based research, not on government-targeted industrial R & D; (ii) concentrate on sunrise science and technology, not on sunrise industries and products; (iii) concentrate on strengthening the climate for privately based innovation, not on government-selected innovation; (iv) concentrate on development for the government's own needs, not on development for market needs.

Competition from Japan

At this point, I would expect some people to be thinking about the Japanese. Did their government bureaucracy not pick the commercial technical winners and put money behind them? No, it did not. At the heart of that question is a misunderstanding about the Japanese government's Ministry of International Trade and Industry (MITI). The popular picture depicts MITI as selecting target industries, picking out the technological developments they need, establishing a consortium of Japanese firms, and supporting the commercial R & D needed

Boom Time for British Biotechnology?

Venture capital is now flowing into small companies and the government is encouraging the commercialization of university research it funds

London. After a relatively slow start in the late 1970's, Britian's biotechnology industry is beginning to pick up speed. Government officials, academics and industrialists all claim that a recent report from the U.S. Office of Technology Assessment (OTA) was excessively pessimistic in its claim that Britain lacks the "dynamism" to produce serious competitors to American companies. They also contest the OTA's conclusion that Britain ranks second behind West Germany among European nations.

"I think that conclusion is completely wrong, particularly if you take the combination of the science and its applications into account" says Gerard Fairtlough, chief executive of Britain's principal biotechnology company, Celltech, which is currently riding a crest of investor enthusiasm.

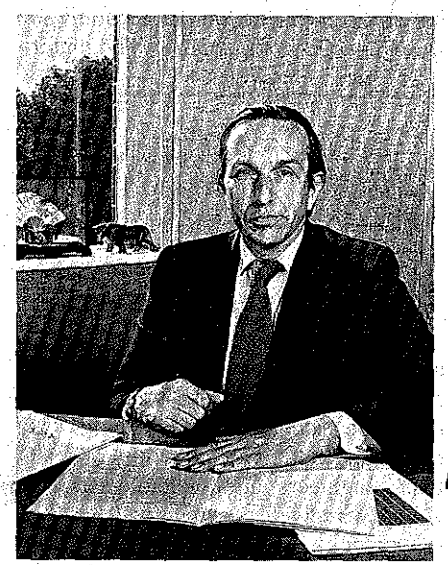
British industry has benefited from various forms of direct government support for biotechnology. Many smaller companies, for example, have made good use of consultancy grants and other special funds offered as part of a $24-million biotechnology package launched by the Department of Trade and Industry in November 1982. Other industrial initiatives in fields such as fermentation technology have been successfully catalyzed by the Biotechnology Directorate of the Science and Engineering Research Council (SERC).

According to Robin Nicholson, chief scientific adviser in Prime Minister Margaret Thatcher's Cabinet Office, broader political changes must also share the credit. "The policy of the government since 1979 has been to free restrictions and to remove barriers to enterprise," says Nicholson. "The relatively healthy state of biotechnology in the U.K. seems partly to reflect the success of those policies."

He picks out, for example, efforts to encourage Britain's venture capital market—now considered the second largest in the world after the United States—through developments such as the Business Expansion Scheme, which allows individuals to write off against tax an investment of up to $60,000 in a small company, provided the money is left in for up to 5 years.

"The Business Expansion Scheme was the first real fiscal change in small company funding for 50 years" says Peter A. Laing of Biotechnology Investments Limited (BIL), a venture capital fund set up by merchant bank N. M. Rothschild in 1981 and chaired by a previous top government science adviser, Lord Rothschild. BIL is said to be the largest biotechnology-oriented venture capital fund in the world. Partly due to this recent flow of venture capital, Britain now has more small biotechnology companies than any of its European competitors.

The government's willingness to let the commercial and industrial communities act as the senior partner in its efforts to boost biotechnology research and development has played a large part in both the establishment and subsequent operation of Celltech. The company was set up in 1980 primarily at the initiative of the National Enterprise Board, a government body recently amalgamated into the British Technology Group. Although initially providing 44 percent of Celltech's start-up capital, with the four remaining stakes of 14 percent each divided between a group of financial and industrial institutions, the government always intended to hand over its share to private enterprise. It moved in this direction last year when Rothschilds' venture capital company—previously criticized for not investing its funds in any British biotechnology company—bought out a proportion of the government's stock and gained with it a seat on the board of the company.



Gerard Fairtlough

Celltech chief says OTA misjudged Britain.

Like similar companies in the United States, Celltech has actively sought collaboration with larger companies with broader industrial interests or special marketing skills. A joint venture was launched last year with Britain's largest pharmacy chain, Boots, for example, to develop the application of monoclonal antibodies to new diagnostic products. And a technology licensing agreement has been signed with the Japanese company Sankyo to develop tissue plasminogen activator and calcitonin.

Fairtlough says that Celltech, with a current research staff of about 120 scientists and technicians, does not at present share the ambitions of companies such as Genentech to grow into a major corporation. However, with a number of clearly defined product lines, each in a potentially large market, "We could be talking about a turnover of hundreds of millions of dollars in a few years."

Celltech is already earning profits from a reagent for the purification of interferon and has recently created a Culture Products Division which, based on techniques developed with direct government funding, already claims to be the world leader in the in vitro bulk production of monoclonal antibodies.

One reason for Celltech's early success is a unique—and in some quarters highly controversial—agreement with Britain's Medical Research Council (MRC), under which the company was initially given first option on the rights to all results produced in the fields of genetic engineering and monoclonal antibodies in the council's laboratories. These include the prestigious Laboratory of Molecular Biology in Cambridge.

This arrangement was approved by the Conservative government over the opposition of officials in the Treasury, who felt it wrong that one company should be granted exclusive access to what was considered public property. One factor in the decision, it is widely rumored, was the failure in the late 1970's to take out a patent on the technique for producing monoclonal antibodies, which was first developed in the MRC's Cambridge laboratory. Giving Celltech exclusive rights to MRC's work might avoid such lapses in the future.

When Celltech started to register its

first commercial successes, criticism of its deal with the MRC shifted from the political to the industrial community. Both large and small companies complained at being locked out of access to MRC's research. "The academic excellence in places like the MRC should be treated as a national resource and the government should be providing even-handed access to it," says Chris Keightley, managing director of one of the newest and most active small biotechnology companies on the British scene, IO (Bio) Ltd. in Cambridge.

The main product of Keightley's company, set up in 1981 by Acorn Computers and recently recipient of a $1.2-million investment from Rothschild's BIL, is a technique for improving the sensitivity of enzyme-based diagnostic tests. It is based on the research of a scientist whose work was not supported by the MRC, Colin Self of Cambridge University's biochemistry department.

Given the growing pressure to encourage similar initiatives, the MRC has recently renegotiated its licensing arrangements with Celltech. The company will retain first option to developments in fields in which it has already started to develop products. In other fields, however, it will now have to become a competitive bidder, for the MRC is setting up an industrial liaison office to distribute licenses more widely among companies interested in turning its research into commercial products.

The new arrangements have met with general approval in both the industrial and academic worlds. Sydney Brenner, director of the MRC's laboratory in Cambridge, says that at the beginning "there is no doubt that in terms of goodwill, the MRC connection was a major asset to Celltech."

Since then, however, the laboratory has been receiving an increasing number of direct approaches from industry. "In the past, we have had to tell them to go away, since the first options on research in the defined fields had to be offered to Celltech. Now we no longer have to do so."

Brenner and other British scientists point out that there are several differences between the United Kingdom and the United States in the factors affecting the growth of links between the academic biomedical research community and the private sector.

One is a greater reluctance on the part of British academics to get involved in the process of transferring research results from the laboratory, a tradition which is admittedly changing as cuts in government support for the universities as well as general, increase the pressure for university scientists—and universities in general—to look elsewhere for financial support.

A second factor until now has been the tax structure, which has made it more difficult to offer stock options to employees in small companies with initially low turnovers (or profits). The budget proposed in mid-March brings British policy in this area more in line with that in the United States, however.

On the other side of the coin has been a greater willingness to combine public

Pressure for Patent Reform

Cambridge, England. British scientists contend that differences in patent laws between Europe and the United States give U.S. companies a potential advantage in the commercialization of biotechnology. Under European patent laws, a scientific discovery cannot be patented once it has been published in the open literature or even referred to in public debate. In contrast, up to 1 year is allowed after publication for a patent application to be filed in the United States.

"I believe that the greatest inhibitory influence on a closer working relationship between academic and industrial scientists, and the greatest management problem for people like me, comes from this business of prior disclosure," says Sydney Brenner, director of the U.K. Medical Research Council's Laboratory of Molecular Biology in Cambridge, England.

There has long been an awareness of this discrepancy, particularly among patent officers on both sides of the Atlantic, but until now no serious pressure for change. Large corporations, in particular, often welcome being able to scan the scientific literature for new (and unpatented) ideas while employing patent attorneys to keep a close watch on the proposed publications of their own scientists. They tend to argue that they find little wrong with the current system. Robin Nicholson, chief scientific adviser to the British Cabinet, claims that "no one brought the issue to our attention" when his office was preparing a recently published set of recommendations for changes in the British patent law, and expresses some doubt over whether change is really necessary.

Among smaller companies, however, the situation is seen differently. "In this field, the 1-year grace period after publication gives the Americans a considerable competitive advantage" says Gerard Fairtlough, chief executive of Celltech. "I feel that Europe should have the same system."

Although admitting that biotechnology patents can frequently be successfully challenged by sufficiently motivated competitors, such companies also argue that patent rights are seen as crucial assets by potential investors.

Brenner also argues that it would ease the management problem in basic research laboratories such as his—as well as taking some of the pressure off individual scientists—by removing the immediate conflict between the professional demands for fast publication and the commercial demands of patent application. "Patents could be the currency of the interaction between research scientists and industry" says Brenner. "At the moment they are just a burden."

Change will not come easily. Friedrich-Karl Beier, director of the Max-Planck-Institute for Foreign and International Patent Law in Munich, and long a campaigner in favor of a 6-month grace period in Europe to bring it more in line with the United States, points out that this would now require an internationally agreed change in the European Patent Convention. "To do this, it will mean finding sufficient support within the whole European community," says Beier. However, he has already convinced the International Association for the Protection of Intellectual Property to endorse the idea, and suggests that there may be a general move in this direction "within the next 2 or 3 years."

Some British government officials point out that a grace period would help avoid situations—such as that which occurred with monoclonal antibodies in the mid-1970's—where the commercial potential of a discovery is only realized after it has been published, and when it can no longer, under the present system, be patented in the United Kingdom.—**D.D.**

Boom Time for British Biotechnology?

Venture capital is now flowing into small companies and the government is encouraging the commercialization of university research it funds

London. After a relatively slow start in the late 1970's, Britian's biotechnology industry is beginning to pick up speed. Government officials, academics and industrialists all claim that a recent report from the U.S. Office of Technology Assessment (OTA) was excessively pessimistic in its claim that Britain lacks the "dynamism" to produce serious competitors to American companies. They also contest the OTA's conclusion that Britain ranks second behind West Germany among European nations.

"I think that conclusion is completely wrong, particularly if you take the combination of the science and its applications into account" says Gerard Fairtlough, chief executive of Britain's principal biotechnology company, Celltech, which is currently riding a crest of investor enthusiasm.

British industry has benefited from various forms of direct government support for biotechnology. Many smaller companies, for example, have made good use of consultancy grants and other special funds offered as part of a $24-million biotechnology package launched by the Department of Trade and Industry in November 1982. Other industrial initiatives in fields such as fermentation technology have been successfully catalyzed by the Biotechnology Directorate of the Science and Engineering Research Council (SERC).

According to Robin Nicholson, chief scientific adviser in Prime Minister Margaret Thatcher's Cabinet Office, broader political changes must also share the credit. "The policy of the government since 1979 has been to free restrictions and to remove barriers to enterprise," says Nicholson. "The relatively healthy state of biotechnology in the U.K. seems partly to reflect the success of those policies."

He picks out, for example, efforts to encourage Britain's venture capital market—now considered the second largest in the world after the United States—through developments such as the Business Expansion Scheme, which allows individuals to write off against tax an investment of up to $60,000 in a small company, provided the money is left in for up to 5 years.

"The Business Expansion Scheme was the first real fiscal change in small company funding for 50 years" says Peter A. Laing of Biotechnology Investments Limited (BIL), a venture capital fund set up by merchant bank N. M. Rothschild in 1981 and chaired by a previous top government science adviser, Lord Rothschild. BIL is said to be the largest biotechnology-oriented venture capital fund in the world. Partly due to this recent flow of venture capital, Britain now has more small biotechnology companies than any of its European competitors.

The government's willingness to let the commercial and industrial communities act as the senior partner in its efforts to boost biotechnology research and development has played a large part in both the establishment and subsequent operation of Celltech. The company was set up in 1980 primarily at the initiative of the National Enterprise Board, a government body recently amalgamated into the British Technology Group. Although initially providing 44 percent of Celltech's start-up capital, with the four remaining stakes of 14 percent each divided between a group of financial and industrial institutions, the government always intended to hand over its share to private enterprise. It moved in this direction last year when Rothschilds' venture capital company—previously criticized for not investing its funds in any British biotechnology company—bought out a proportion of the government's stock and gained with it a seat on the board of the company.



Gerard Fairtlough

Celltech chief says OTA misjudged Britain.

Like similar companies in the United States, Celltech has actively sought collaboration with larger companies with broader industrial interests or special marketing skills. A joint venture was launched last year with Britain's largest pharmacy chain, Boots, for example, to develop the application of monoclonal antibodies to new diagnostic products. And a technology licensing agreement has been signed with the Japanese company Sankyo to develop tissue plasminogen activator and calcitonin.

Fairtlough says that Celltech, with a current research staff of about 120 scientists and technicians, does not at present share the ambitions of companies such as Genentech to grow into a major corporation. However, with a number of clearly defined product lines, each in a potentially large market, "We could be talking about a turnover of hundreds of millions of dollars in a few years."

Celltech is already earning profits from a reagent for the purification of interferon and has recently created a Culture Products Division which, based on techniques developed with direct government funding, already claims to be the world leader in the in vitro bulk production of monoclonal antibodies.

One reason for Celltech's early success is a unique—and in some quarters highly controversial—agreement with Britain's Medical Research Council (MRC), under which the company was initially given first option on the rights to all results produced in the fields of genetic engineering and monoclonal antibodies in the council's laboratories. These include the prestigious Laboratory of Molecular Biology in Cambridge.

This arrangement was approved by the Conservative government over the opposition of officials in the Treasury, who felt it wrong that one company should be granted exclusive access to what was considered public property. One factor in the decision, it is widely rumored, was the failure in the late 1970's to take out a patent on the technique for producing monoclonal antibodies, which was first developed in the MRC's Cambridge laboratory. Giving Celltech exclusive rights to MRC's work might avoid such lapses in the future.

When Celltech started to register its

Boom Time for British Biotechnology?

Venture capital is now flowing into small companies and the government is encouraging the commercialization of university research it funds

London. After a relatively slow start in the late 1970's, Britian's biotechnology industry is beginning to pick up speed. Government officials, academics and industrialists all claim that a recent report from the U.S. Office of Technology Assessment (OTA) was excessively pessimistic in its claim that Britain lacks the "dynamism" to produce serious competitors to American companies. They also contest the OTA's conclusion that Britain ranks second behind West Germany among European nations.

"I think that conclusion is completely wrong, particularly if you take the combination of the science and its applications into account" says Gerard Fairtlough, chief executive of Britain's principal biotechnology company, Celltech, which is currently riding a crest of investor enthusiasm.

British industry has benefited from various forms of direct government support for biotechnology. Many smaller companies, for example, have made good use of consultancy grants and other special funds offered as part of a $24-million biotechnology package launched by the Department of Trade and Industry in November 1982. Other industrial initiatives in fields such as fermentation technology have been successfully catalyzed by the Biotechnology Directorate of the Science and Engineering Research Council (SERC).

According to Robin Nicholson, chief scientific adviser in Prime Minister Margaret Thatcher's Cabinet Office, broader political changes must also share the credit. "The policy of the government since 1979 has been to free restrictions and to remove barriers to enterprise," says Nicholson. "The relatively healthy state of biotechnology in the U.K. seems partly to reflect the success of those policies."

He picks out, for example, efforts to encourage Britain's venture capital market—now considered the second largest in the world after the United States—through developments such as the Business Expansion Scheme, which allows individuals to write off against tax an investment of up to $60,000 in a small company, provided the money is left in for up to 5 years.

"The Business Expansion Scheme was the first real fiscal change in small company funding for 50 years" says Peter A. Laing of Biotechnology Investments Limited (BIL), a venture capital fund set up by merchant bank N. M. Rothschild in 1981 and chaired by a previous top government science adviser, Lord Rothschild. BIL is said to be the largest biotechnology-oriented venture capital fund in the world. Partly due to this recent flow of venture capital, Britain now has more small biotechnology companies than any of its European competitors.

The government's willingness to let the commercial and industrial communities act as the senior partner in its efforts to boost biotechnology research and development has played a large part in both the establishment and subsequent operation of Celltech. The company was set up in 1980 primarily at the initiative of the National Enterprise Board, a government body recently amalgamated into the British Technology Group. Although initially providing 44 percent of Celltech's start-up capital, with the four remaining stakes of 14 percent each divided between a group of financial and industrial institutions, the government always intended to hand over its share to private enterprise. It moved in this direction last year when Rothschilds' venture capital company—previously criticized for not investing its funds in any British biotechnology company—bought out a proportion of the government's stock and gained with it a seat on the board of the company.



Gerard Fairtlough

Celltech chief says OTA misjudged Britain.

Like similar companies in the United States, Celltech has actively sought collaboration with larger companies with broader industrial interests or special marketing skills. A joint venture was launched last year with Britain's largest pharmacy chain, Boots, for example, to develop the application of monoclonal antibodies to new diagnostic products. And a technology licensing agreement has been signed with the Japanese company Sankyo to develop tissue plasminogen activator and calcitonin.

Fairtlough says that Celltech, with a current research staff of about 120 scientists and technicians, does not at present share the ambitions of companies such as Genentech to grow into a major corporation. However, with a number of clearly defined product lines, each in a potentially large market, "We could be talking about a turnover of hundreds of millions of dollars in a few years."

Celltech is already earning profits from a reagent for the purification of interferon and has recently created a Culture Products Division which, based on techniques developed with direct government funding, already claims to be the world leader in the in vitro bulk production of monoclonal antibodies.

One reason for Celltech's early success is a unique—and in some quarters highly controversial—agreement with Britain's Medical Research Council (MRC), under which the company was initially given first option on the rights to all results produced in the fields of genetic engineering and monoclonal antibodies in the council's laboratories. These include the prestigious Laboratory of Molecular Biology in Cambridge.

This arrangement was approved by the Conservative government over the opposition of officials in the Treasury, who felt it wrong that one company should be granted exclusive access to what was considered public property. One factor in the decision, it is widely rumored, was the failure in the late 1970's to take out a patent on the technique for producing monoclonal antibodies, which was first developed in the MRC's Cambridge laboratory. Giving Celltech exclusive rights to MRC's work might avoid such lapses in the future.

When Celltech started to register its

Boom Time for British Biotechnology?

Venture capital is now flowing into small companies and the government is encouraging the commercialization of university research it funds

London. After a relatively slow start in the late 1970's, Britian's biotechnology industry is beginning to pick up speed. Government officials, academics and industrialists all claim that a recent report from the U.S. Office of Technology Assessment (OTA) was excessively pessimistic in its claim that Britain lacks the "dynamism" to produce serious competitors to American companies. They also contest the OTA's conclusion that Britain ranks second behind West Germany among European nations.

"I think that conclusion is completely wrong, particularly if you take the combination of the science and its applications into account" says Gerard Fairtlough, chief executive of Britain's principal biotechnology company, Celltech, which is currently riding a crest of investor enthusiasm.

British industry has benefited from various forms of direct government support for biotechnology. Many smaller companies, for example, have made good use of consultancy grants and other special funds offered as part of a $24-million biotechnology package launched by the Department of Trade and Industry in November 1982. Other industrial initiatives in fields such as fermentation technology have been successfully catalyzed by the Biotechnology Directorate of the Science and Engineering Research Council (SERC).

According to Robin Nicholson, chief scientific adviser in Prime Minister Margaret Thatcher's Cabinet Office, broader political changes must also share the credit. "The policy of the government since 1979 has been to free restrictions and to remove barriers to enterprise," says Nicholson. "The relatively healthy state of biotechnology in the U.K. seems partly to reflect the success of those policies."

He picks out, for example, efforts to encourage Britain's venture capital market—now considered the second largest in the world after the United States—through developments such as the Business Expansion Scheme, which allows individuals to write off against tax an investment of up to $60,000 in a small company, provided the money is left in for up to 5 years.

"The Business Expansion Scheme was the first real fiscal change in small company funding for 50 years" says Peter A. Laing of Biotechnology Investments Limited (BIL), a venture capital fund set up by merchant bank N. M. Rothschild in 1981 and chaired by a previous top government science adviser, Lord Rothschild. BIL is said to be the largest biotechnology-oriented venture capital fund in the world. Partly due to this recent flow of venture capital, Britain now has more small biotechnology companies than any of its European competitors.

The government's willingness to let the commercial and industrial communities act as the senior partner in its efforts to boost biotechnology research and development has played a large part in both the establishment and subsequent operation of Celltech. The company was set up in 1980 primarily at the initiative of the National Enterprise Board, a government body recently amalgamated into the British Technology Group. Although initially providing 44 percent of Celltech's start-up capital, with the four remaining stakes of 14 percent each divided between a group of financial and industrial institutions, the government always intended to hand over its share to private enterprise. It moved in this direction last year when Rothschilds' venture capital company—previously criticized for not investing its funds in any British biotechnology company—bought out a proportion of the government's stock and gained with it a seat on the board of the company.



Gerard Fairtlough

Celltech chief says OTA misjudged Britain.

Like similar companies in the United States, Celltech has actively sought collaboration with larger companies with broader industrial interests or special marketing skills. A joint venture was launched last year with Britain's largest pharmacy chain, Boots, for example, to develop the application of monoclonal antibodies to new diagnostic products. And a technology licensing agreement has been signed with the Japanese company Sankyo to develop tissue plasminogen activator and calcitonin.

Fairtlough says that Celltech, with a current research staff of about 120 scientists and technicians, does not at present share the ambitions of companies such as Genentech to grow into a major corporation. However, with a number of clearly defined product lines, each in a potentially large market, "We could be talking about a turnover of hundreds of millions of dollars in a few years."

Celltech is already earning profits from a reagent for the purification of interferon and has recently created a Culture Products Division which, based on techniques developed with direct government funding, already claims to be the world leader in the in vitro bulk production of monoclonal antibodies.

One reason for Celltech's early success is a unique—and in some quarters highly controversial—agreement with Britain's Medical Research Council (MRC), under which the company was initially given first option on the rights to all results produced in the fields of genetic engineering and monoclonal antibodies in the council's laboratories. These include the prestigious Laboratory of Molecular Biology in Cambridge.

This arrangement was approved by the Conservative government over the opposition of officials in the Treasury, who felt it wrong that one company should be granted exclusive access to what was considered public property. One factor in the decision, it is widely rumored, was the failure in the late 1970's to take out a patent on the technique for producing monoclonal antibodies, which was first developed in the MRC's Cambridge laboratory. Giving Celltech exclusive rights to MRC's work might avoid such lapses in the future.

When Celltech started to register its

Boom Time for British Biotechnology?

Venture capital is now flowing into small companies and the government is encouraging the commercialization of university research it funds

London. After a relatively slow start in the late 1970's, Britian's biotechnology industry is beginning to pick up speed. Government officials, academics and industrialists all claim that a recent report from the U.S. Office of Technology Assessment (OTA) was excessively pessimistic in its claim that Britain lacks the "dynamism" to produce serious competitors to American companies. They also contest the OTA's conclusion that Britain ranks second behind West Germany among European nations.

"I think that conclusion is completely wrong, particularly if you take the combination of the science and its applications into account" says Gerard Fairtlough, chief executive of Britain's principal biotechnology company, Celltech, which is currently riding a crest of investor enthusiasm.

British industry has benefited from various forms of direct government support for biotechnology. Many smaller companies, for example, have made good use of consultancy grants and other special funds offered as part of a $24-million biotechnology package launched by the Department of Trade and Industry in November 1982. Other industrial initiatives in fields such as fermentation technology have been successfully catalyzed by the Biotechnology Directorate of the Science and Engineering Research Council (SERC).

According to Robin Nicholson, chief scientific adviser in Prime Minister Margaret Thatcher's Cabinet Office, broader political changes must also share the credit. "The policy of the government since 1979 has been to free restrictions and to remove barriers to enterprise," says Nicholson. "The relatively healthy state of biotechnology in the U.K. seems partly to reflect the success of those policies."

He picks out, for example, efforts to encourage Britain's venture capital market—now considered the second largest in the world after the United States—through developments such as the Business Expansion Scheme, which allows individuals to write off against tax an investment of up to $60,000 in a small company, provided the money is left in for up to 5 years.

"The Business Expansion Scheme was the first real fiscal change in small company funding for 50 years" says Peter A. Laing of Biotechnology Investments Limited (BIL), a venture capital fund set up by merchant bank N. M. Rothschild in 1981 and chaired by a previous top government science adviser, Lord Rothschild. BIL is said to be the largest biotechnology-oriented venture capital fund in the world. Partly due to this recent flow of venture capital, Britain now has more small biotechnology companies than any of its European competitors.

The government's willingness to let the commercial and industrial communities act as the senior partner in its efforts to boost biotechnology research and development has played a large part in both the establishment and subsequent operation of Celltech. The company was set up in 1980 primarily at the initiative of the National Enterprise Board, a government body recently amalgamated into the British Technology Group. Although initially providing 44 percent of Celltech's start-up capital, with the four remaining stakes of 14 percent each divided between a group of financial and industrial institutions, the government always intended to hand over its share to private enterprise. It moved in this direction last year when Rothschilds' venture capital company—previously criticized for not investing its funds in any British biotechnology company—bought out a proportion of the government's stock and gained with it a seat on the board of the company.



Gerard Fairtlough

Celltech chief says OTA misjudged Britain.

Like similar companies in the United States, Celltech has actively sought collaboration with larger companies with broader industrial interests or special marketing skills. A joint venture was launched last year with Britain's largest pharmacy chain, Boots, for example, to develop the application of monoclonal antibodies to new diagnostic products. And a technology licensing agreement has been signed with the Japanese company Sankyo to develop tissue plasminogen activator and calcitonin.

Fairtlough says that Celltech, with a current research staff of about 120 scientists and technicians, does not at present share the ambitions of companies such as Genentech to grow into a major corporation. However, with a number of clearly defined product lines, each in a potentially large market, "We could be talking about a turnover of hundreds of millions of dollars in a few years."

Celltech is already earning profits from a reagent for the purification of interferon and has recently created a Culture Products Division which, based on techniques developed with direct government funding, already claims to be the world leader in the in vitro bulk production of monoclonal antibodies.

One reason for Celltech's early success is a unique—and in some quarters highly controversial—agreement with Britain's Medical Research Council (MRC), under which the company was initially given first option on the rights to all results produced in the fields of genetic engineering and monoclonal antibodies in the council's laboratories. These include the prestigious Laboratory of Molecular Biology in Cambridge.

This arrangement was approved by the Conservative government over the opposition of officials in the Treasury, who felt it wrong that one company should be granted exclusive access to what was considered public property. One factor in the decision, it is widely rumored, was the failure in the late 1970's to take out a patent on the technique for producing monoclonal antibodies, which was first developed in the MRC's Cambridge laboratory. Giving Celltech exclusive rights to MRC's work might avoid such lapses in the future.

When Celltech started to register its

first commercial successes, criticism of its deal with the MRC shifted from the political to the industrial community. Both large and small companies complained at being locked out of access to MRC's research. "The academic excellence in places like the MRC should be treated as a national resource and the government should be providing even-handed access to it," says Chris Keightley, managing director of one of the newest and most active small biotechnology companies on the British scene, IQ (Bio) Ltd. in Cambridge.

The main product of Keightley's company, set up in 1981 by Acorn Computers and recently recipient of a $1.2-million investment from Rothschild's BIL, is a technique for improving the sensitivity of enzyme-based diagnostic tests. It is based on the research of a scientist whose work was not supported by the MRC, Colin Self of Cambridge University's biochemistry department.

Given the growing pressure to encourage similar initiatives, the MRC has recently renegotiated its licensing arrangements with Celltech. The company will retain first option to developments in fields in which it has already started to develop products. In other fields, however, it will now have to become a competitive bidder, for the MRC is setting up an industrial liaison office to distribute licenses more widely among companies interested in turning its research into commercial products.

The new arrangements have met with general approval in both the industrial and academic worlds. Sydney Brenner, director of the MRC's laboratory in Cambridge, says that at the beginning "there is no doubt that in terms of goodwill, the MRC connection was a major asset to Celltech."

Since then, however, the laboratory has been receiving an increasing number of direct approaches from industry. "In the past, we have had to tell them to go away, since the first options on research in the defined fields had to be offered to Celltech. Now we no longer have to do so."

Brenner and other British scientists point out that there are several differences between the United Kingdom and the United States in the factors affecting the growth of links between the academic biomedical research community and the private sector.

One is a greater reluctance on the part of British academics to get involved in the process of transferring research results from the laboratory, a tradition which is admittedly changing as cuts in government support for the universities as well as general, increase the pressure for university scientists—and universities in general—to look elsewhere for financial support.

A second factor until now has been the tax structure, which has made it more difficult to offer stock options to employees in small companies with initially low turnovers (or profits). The budget proposed in mid-March brings British policy in this area more in line with that in the United States, however.

On the other side of the coin has been a greater willingness to combine public

Pressure for Patent Reform

Cambridge, England. British scientists contend that differences in patent laws between Europe and the United States give U.S. companies a potential advantage in the commercialization of biotechnology. Under European patent laws, a scientific discovery cannot be patented once it has been published in the open literature or even referred to in public debate. In contrast, up to 1 year is allowed after publication for a patent application to be filed in the United States.

"I believe that the greatest inhibitory influence on a closer working relationship between academic and industrial scientists, and the greatest management problem for people like me, comes from this business of prior disclosure," says Sydney Brenner, director of the U.K. Medical Research Council's Laboratory of Molecular Biology in Cambridge, England.

There has long been an awareness of this discrepancy, particularly among patent officers on both sides of the Atlantic, but until now no serious pressure for change. Large corporations, in particular, often welcome being able to scan the scientific literature for new (and unpatented) ideas while employing patent attorneys to keep a close watch on the proposed publications of their own scientists. They tend to argue that they find little wrong with the current system. Robin Nicholson, chief scientific adviser to the British Cabinet, claims that "no one brought the issue to our attention" when his office was preparing a recently published set of recommendations for changes in the British patent law, and expresses some doubt over whether change is really necessary.

Among smaller companies, however, the situation is seen differently. "In this field, the 1-year grace period after publication gives the Americans a considerable competitive advantage" says Gerard Fairtlough, chief executive of Celltech. "I feel that Europe should have the same system."

Although admitting that biotechnology patents can frequently be successfully challenged by sufficiently motivated competitors, such companies also argue that patent rights are seen as crucial assets by potential investors.

Brenner also argues that it would ease the management problem in basic research laboratories such as his—as well as taking some of the pressure off individual scientists—by removing the immediate conflict between the professional demands for fast publication and the commercial demands of patent application. "Patents could be the currency of the interaction between research scientists and industry" says Brenner. "At the moment they are just a burden."

Change will not come easily. Friedrich-Karl Beier, director of the Max-Planck-Institute for Foreign and International Patent Law in Munich, and long a campaigner in favor of a 6-month grace period in Europe to bring it more in line with the United States, points out that this would now require an internationally agreed change in the European Patent Convention. "To do this, it will mean finding sufficient support within the whole European community," says Beier. However, he has already convinced the International Association for the Protection of Intellectual Property to endorse the idea, and suggests that there may be a general move in this direction "within the next 2 or 3 years."

Some British government officials point out that a grace period would help avoid situations—such as that which occurred with monoclonal antibodies in the mid-1970's—where the commercial potential of a discovery is only realized after it has been published, and when it can no longer, under the present system, be patented in the United Kingdom.—**D.D.**

and private ventures, and the lack of any moral imperative frequently felt in the United States to maintain, at least in principle, a sharp dividing line between the two. Furthermore, as with the Celltech/MRC deal, negotiations have often been conducted discreetly out of the public eye.

Either way, there has been little of the public controversy over the restructuring of traditional relationships between the research community and the rest of society that has accompanied similar moves in the United States.

The situation has not been without its critics. Edward Yoxen, lecturer in the University of Manchester's department of liberal studies in science, points out in a recent study *The Gene Business* that many significant policy changes, such as the dispensation on access to MRC research awarded to Celltech, have taken place with little open discussion, even

"The academic excellence in places like the MRC should be treated as a national resource and the government should be providing evenhanded access to it," says Chris Keightley.

though the basic discoveries on which the new technologies are based were financed largely from public funds. "There has been virtually no public debate on this type of issue," says Yoxen.

Few concerns were expressed, for example, over the government's recent decision to drop the "public interest" members from its main regulatory watchdog, the Genetic Manipulation Advisory Group, when this body was recently reformulated as the Advisory Committee on Genetic Manipulation, and its day-to-day responsibilities for registering and monitoring experiments passed to the Health and Safety Executive.

The lack of such debate, however, has certainly not hampered the gradual dismantling of barriers to open cooperation between the academic and the commercial communities, a process openly encouraged by the government. The SERC's Biotechnology Directorate, for example, has recently established what is described as a "protein engineering club," in which major companies such as Glaxo and Unilever will help sponsor research in various academic institutions into ways of producing proteins to order in large quantities.

Similarly, several university institutions are using government money, both from the research councils and the Department of Trade and Industry, to help set up commercial operations. The University of Leicester, for example, has recently obtained backing from five major corporations to establish a center for research into yeast genetics. And the Imperial College of Science and Technology in London has established a company known as Imperial Biotechnology to exploit its research facilities in fermentation techniques.

Keen that the nation should reap a profit from its past and present scientific investments, the government is increasingly engaging in as much industrial planning as it feels it can get away with behind its free-enterprise, non-investment image. Responding to demands from companies such as Imperial Chemical Industries, as well as officials within the SERC, for some form of "national biotechnology program" to cover the spectrum of possible initiatives from tax incentives to information networks, the Department of Trade and Industry has recently set up a special advisory committee made up primarily of senior industrialists to look at areas where an extra push might be useful.

Taken in isolation, none of these moves is itself seen as a guarantee of success. But behind them lie two additional factors that help account for the current bullishness of Britain's biotechnologists. One, as Nicholson of the Cabinet Office puts it, is that "there is more optimism in the business sector than there was 6 or 9 months ago; we certainly started pulling out of the recession faster than either Germany or France."

The other is the gradual emergence of a new spirit of entrepreneurialism among British academics. "In the past, most academics had no idea about how to start up in business; but all that is now changing," says Keightley of IQ(Bio), a Cambridge biochemist who was about to emigrate to the United States when Acorn offered him the opportunity of helping start up the new company.

Similarly, Celltech points out proudly that it has managed to persuade one of the top teams of MRC scientists, headed by immunologist William Hunter of Edinburgh University, to join the company's new venture with Boots. "We have a fabulous opportunity here in Britain," says Keightley. "We are now learning how to capitalize on it."—DAVID DICKSON

Meselson Meets a Shower of Yellow Rain from Bees

Matthew Meselson, the Harvard biochemist waging a one-man challenge to the U.S. State Department's version of Yellow Rain warfare, went into the jungles of Thailand last month to test his thesis. He returned at the end of March with a new evidence, declaring the trip a greater success than he had anticipated.

Along with two bee experts who joined him in looking for natural forms of Yellow Rain, Meselson was caught in a 5-minute shower of bee droppings, which he thinks may be the real source of Yellow Rain samples being analyzed by U.S. military labs. Meselson and Thomas Seeley, a biologist at Yale University, last year developed a theory that Yellow Rain spots regarded as chemical weapon deposits were actually the feces of the wild Southeast Asian honey bee, *Apis dorsata* (*Science*, 24 June 1983, p. 1356). The theory was based on the knowledge that honey bees periodically make "cleansing flights" away from the hive, that their droppings contain pollen, and that most of the government's samples of Yellow Rain collected from the environment contain pollen.

Meselson noticed that the government's data on Yellow Rain were gathered in Southeast Asia between February and May. Using funds recently awarded him by the John D. and Catherine T. MacArthur Foundation, he went to Thailand in the middle of this ripe evidentiary season hoping to find proof that Southeast Asian honey bees do produce yellow, pollen-laden rain.

Meselson and Seeley reported at a press conference at Harvard on 28 March that they have proof that *A. dorsata* performs "massive defecation flights which can cover a swath thousands of square meters in area with 100 or more spots of yellowish feces per square meter." They found and studied ten swaths in Thailand and were caught in a bee feces shower that left "about a dozen spots . . . on each member of our three-man team." Meselson says this occurred near a tree in which they had spotted *A. dorsata* nests, but the bees were so far above the ground that he could not see or hear them.

Will Deficits Put a Damper on R & D?

Ninth AAAS Colloquium on R & D worries about looming budgetary gaps, asks if some new initiatives are too much of a good thing

In its annual look at the new federal budget, the AAAS Colloquium on R & D this year found the prospect of outsize federal deficits to be a threat to a currently prosperous R & D regime. And there were also misgivings that initiatives in the new R & D budget would cause trouble in coming years.

As has become the colloquium custom, the President's science adviser was the de facto keynote speaker, providing an interpretation of the R & D budget to which later speakers frequently referred, although not necessarily deferred. Incumbent science adviser George A. Keyworth, II provided a bullish review of the Administration's R & D policy and its implementation, but, at the outset, took issue with what he described as the "generally gloomy view of federal R & D" found in the introductory chapter of the annual budget analysis issued by AAAS to coincide with the colloquium.*

The authors early state their ambivalence with the comment that "It is a strong budget for R & D, but analysis of the totals raises questions. The big increase is almost entirely on the military side. Total non-defense R & D budget authority increases only about as much as inflation." The main concern is not directed at the makeup of the new budget. Rather, "Questions on R & D spending plans in the FY 1985 budget are overshadowed, however, by the need for drastic actions to reduce the deficit. Beneath the political posturing on both sides there is a realization that something has to be done."

The analysis predicts a continuing pattern of deficits in 1985 and after. "Thus the FY 1985 budget is not a budget in the traditional sense of the President's plan for dealing with the problems of the nation. It is instead a statement of the problem with the answers left up in the air—to be found in bipartisan negotiations with Congress, unilateral Congressional actions, or a new Presidential initiative some time after the election."

Another strain of ambivalence was expressed by National Academy of Engineering President Robert M. White who seemed to be asking, in essence, whether the R & D budget amounted to too much of a good thing. Like other speakers, White was complimentary about the Administration's actions in fashioning a budget that reflects strong confidence in R & D, noting that the real growth in total federal R & D funds under its aegis has been the largest since the 1960's. But he questioned whether the Administration's commitment to technology might amount to an overcommitment.

Noting examples like plans for a manned space station, a space-based missile defense, "a multitude and diversity of defensive and offensive strategic and tactical systems," and an ambitious strategic computing program, he said these contributed to what he termed a "technological flood tide."

Citing the "bow-wave effects" of such initiatives over time on the economy, on the availability of manpower and materials, and on the industrial competitiveness of U.S. industry, he urged that the issues be examined with caution. "My concern is that, as a community of scientists, engineers and technologists, we will be perceived as careening from worrying about insufficient investments in science, engineering and technology to meet national needs to a concern that we may be embarked on a course with unanticipated ends."

> "... the FY 1985 budget is ... a statement of the problem with the answers left up in the air. ..."

Keyworth concentrated on an explication of the Reagan Administration's R & D policy, but along the way he did offer some general answers to the critics. He noted, for example, that they tend to lump funding increases and decreases together "with the result that we can't appreciate the impacts of either." And he observed, "That view seems to imply that changes are inherently bad."

He also took exception to the way comparisons between defense R & D and civilian R & D are made. Keyworth noted that many of those who insist on casting R & D policy "in that simple-minded mold of guns and butter" arrive "at the absolutely false conclusion—or maybe they start there—that the federal government's only R & D priority is for defense."

Keyworth said that the Administration had assuredly given a high priority to strengthening defense, but the point the critics miss is that it "also strongly stated a similar priority for university basic research." The core of Keyworth's case was contained in his remark that "Most of the increases in defense R & D come from development costs associated with the modernization of the nation's strategic forces—an action to restore strength that was eroded during the previous decade. On the other hand, the flat curve in civilian R & D reflects two countervailing trends—a steady drop in development and a steady rise in basic research. The essential point is that the Administration is targeting strong funding growth in both defense and basic research."

Keyworth dealt with the deficit issue obliquely. In his text, he said, "we all recognize that one of the most serious detriments to good science is what we might call roller coaster funding. The best protection against that phenomenon is for the science community to demonstrate, year after year, that R & D funds are being used wisely and effectively." And in his conclusion he developed the theme of shared responsibility. He acknowledged that the Administration had to articulate goals clearly and said "we have to stick to those goals in practice. I see this consistency as a major element of science policy, an element that I hope the Administration, the Congress, the science community and the public will be able to maintain in coming years."

In summarizing comments at the end of the colloquium, AAAS Executive Officer William D. Carey phrased his major point as the answer to the question, "What should science watchers watch?" Carey observed that in present circumstances they should not be preoccupied with minor trends in the R & D budget itself, but rather should consider such things as economic policy, export policy, and policies for defense. Carey noted that Reagan Administration treatment of basic research and higher education has been favorable. He suggested, however, that "consistency is not to be counted on," since future decisions will be determined by policies senior to science policy.—JOHN WALSH

*AAAS Report IX: Research and Development, FY 1985. AAAS. 284 pages.

Will Deficits Put a Damper on R & D?

Ninth AAAS Colloquium on R & D worries about looming budgetary gaps, asks if some new initiatives are too much of a good thing

In its annual look at the new federal budget, the AAAS Colloquium on R & D this year found the prospect of outsize federal deficits to be a threat to a currently prosperous R & D regime. And there were also misgivings that initiatives in the new R & D budget would cause trouble in coming years.

As has become the colloquium custom, the President's science adviser was the de facto keynote speaker, providing an interpretation of the R & D budget to which later speakers frequently referred, although not necessarily deferred. Incumbent science adviser George A. Keyworth, II provided a bullish review of the Administration's R & D policy and its implementation, but, at the outset, took issue with what he described as the "generally gloomy view of federal R & D" found in the introductory chapter of the annual budget analysis issued by AAAS to coincide with the colloquium.*

The authors early state their ambivalence with the comment that "It is a strong budget for R & D, but analysis of the totals raises questions. The big increase is almost entirely on the military side. Total non-defense R & D budget authority increases only about as much as inflation." The main concern is not directed at the makeup of the new budget. Rather, "Questions on R & D spending plans in the FY 1985 budget are overshadowed, however, by the need for drastic actions to reduce the deficit. Beneath the political posturing on both sides there is a realization that something has to be done."

The analysis predicts a continuing pattern of deficits in 1985 and after. "Thus the FY 1985 budget is not a budget in the traditional sense of the President's plan for dealing with the problems of the nation. It is instead a statement of the problem with the answers left up in the air—to be found in bipartisan negotiations with Congress, unilateral Congressional actions, or a new Presidential initiative some time after the election."

Another strain of ambivalence was expressed by National Academy of Engineering President Robert M. White who seemed to be asking, in essence, whether the R & D budget amounted to too much of a good thing. Like other speakers, White was complimentary about the Administration's actions in fashioning a budget that reflects strong confidence in R & D, noting that the real growth in total federal R & D funds under its aegis has been the largest since the 1960's. But he questioned whether the Administration's commitment to technology might amount to an overcommitment.

Noting examples like plans for a manned space station, a space-based missile defense, "a multitude and diversity of defensive and offensive strategic and tactical systems," and an ambitious strategic computing program, he said these contributed to what he termed a "technological flood tide."

Citing the "bow-wave effects" of such initiatives over time on the economy, on the availability of manpower and materials, and on the industrial competitiveness of U.S. industry, he urged that the issues be examined with caution. "My concern is that, as a community of scientists, engineers and technologists, we will be perceived as careening from worrying about insufficient investments in science, engineering and technology to meet national needs to a concern that we may be embarked on a course with unanticipated ends."

> " . . . the FY 1985 budget is . . . a statement of the problem with the answers left up in the air. . . ."

Keyworth concentrated on an explication of the Reagan Administration's R & D policy, but along the way he did offer some general answers to the critics. He noted, for example, that they tend to lump funding increases and decreases together "with the result that we can't appreciate the impacts of either." And he observed, "That view seems to imply that changes are inherently bad."

He also took exception to the way comparisons between defense R & D and civilian R & D are made. Keyworth noted that many of those who insist on casting R & D policy "in that simple-minded mold of guns and butter" arrive "at the absolutely false conclusion—or maybe they start there—that the federal government's only R & D priority is for defense."

Keyworth said that the Administration had assuredly given a high priority to strengthening defense, but the point the critics miss is that it "also strongly stated a similar priority for university basic research." The core of Keyworth's case was contained in his remark that "Most of the increases in defense R & D come from development costs associated with the modernization of the nation's strategic forces—an action to restore strength that was eroded during the previous decade. On the other hand, the flat curve in civilian R & D reflects two countervailing trends—a steady drop in development and a steady rise in basic research. The essential point is that the Administration is targeting strong funding growth in both defense and basic research."

Keyworth dealt with the deficit issue obliquely. In his text, he said, "we all recognize that one of the most serious detriments to good science is what we might call roller coaster funding. The best protection against that phenomenon is for the science community to demonstrate, year after year, that R & D funds are being used wisely and effectively." And in his conclusion he developed the theme of shared responsibility. He acknowledged that the Administration had to articulate goals clearly and said "we have to stick to those goals in practice. I see this consistency as a major element of science policy, an element that I hope the Administration, the Congress, the science community and the public will be able to maintain in coming years."

In summarizing comments at the end of the colloquium, AAAS Executive Officer William D. Carey phrased his major point as the answer to the question, "What should science watchers watch?" Carey observed that in present circumstances they should not be preoccupied with minor trends in the R & D budget itself, but rather should consider such things as economic policy, export policy, and policies for defense. Carey noted that Reagan Administration treatment of basic research and higher education has been favorable. He suggested, however, that "consistency is not to be counted on," since future decisions will be determined by policies senior to science policy.—JOHN WALSH

*AAAS Report IX: Research and Development, FY 1985. AAAS. 284 pages.

Will Deficits Put a Damper on R & D?

Ninth AAAS Colloquium on R & D worries about looming budgetary gaps, asks if some new initiatives are too much of a good thing

In its annual look at the new federal budget, the AAAS Colloquium on R & D this year found the prospect of outsize federal deficits to be a threat to a currently prosperous R & D regime. And there were also misgivings that initiatives in the new R & D budget would cause trouble in coming years.

As has become the colloquium custom, the President's science adviser was the de facto keynote speaker, providing an interpretation of the R & D budget to which later speakers frequently referred, although not necessarily deferred. Incumbent science adviser George A. Keyworth, II provided a bullish review of the Administration's R & D policy and its implementation, but, at the outset, took issue with what he described as the "generally gloomy view of federal R & D" found in the introductory chapter of the annual budget analysis issued by AAAS to coincide with the colloquium.*

The authors early state their ambivalence with the comment that "It is a strong budget for R & D, but analysis of the totals raises questions. The big increase is almost entirely on the military side. Total non-defense R & D budget authority increases only about as much as inflation." The main concern is not directed at the makeup of the new budget. Rather, "Questions on R & D spending plans in the FY 1985 budget are overshadowed, however, by the need for drastic actions to reduce the deficit. Beneath the political posturing on both sides there is a realization that something has to be done."

The analysis predicts a continuing pattern of deficits in 1985 and after. "Thus the FY 1985 budget is not a budget in the traditional sense of the President's plan for dealing with the problems of the nation. It is instead a statement of the problem with the answers left up in the air—to be found in bipartisan negotiations with Congress, unilateral Congressional actions, or a new Presidential initiative some time after the election."

Another strain of ambivalence was expressed by National Academy of Engineering President Robert M. White who seemed to be asking, in essence, whether the R & D budget amounted to too much of a good thing. Like other speakers, White was complimentary about the Administration's actions in fashioning a budget that reflects strong confidence in R & D, noting that the real growth in total federal R & D funds under its aegis has been the largest since the 1960's. But he questioned whether the Administration's commitment to technology might amount to an overcommitment.

Noting examples like plans for a manned space station, a space-based missile defense, "a multitude and diversity of defensive and offensive strategic and tactical systems," and an ambitious strategic computing program, he said these contributed to what he termed a "technological flood tide."

Citing the "bow-wave effects" of such initiatives over time on the economy, on the availability of manpower and materials, and on the industrial competitiveness of U.S. industry, he urged that the issues be examined with caution. "My concern is that, as a community of scientists, engineers and technologists, we will be perceived as careening from worrying about insufficient investments in science, engineering and technology to meet national needs to a concern that we may be embarked on a course with unanticipated ends."

> " . . . the FY 1985 budget is . . . a statement of the problem with the answers left up in the air. . . ."

Keyworth concentrated on an explication of the Reagan Administration's R & D policy, but along the way he did offer some general answers to the critics. He noted, for example, that they tend to lump funding increases and decreases together "with the result that we can't appreciate the impacts of either." And he observed, "That view seems to imply that changes are inherently bad."

He also took exception to the way comparisons between defense R & D and civilian R & D are made. Keyworth noted that many of those who insist on casting R & D policy "in that simple-minded mold of guns and butter" arrive "at the absolutely false conclusion—or maybe they start there—that the federal government's only R & D priority is for defense."

Keyworth said that the Administration had assuredly given a high priority to strengthening defense, but the point the critics miss is that it "also strongly stated a similar priority for university basic research." The core of Keyworth's case was contained in his remark that "Most of the increases in defense R & D come from development costs associated with the modernization of the nation's strategic forces—an action to restore strength that was eroded during the previous decade. On the other hand, the flat curve in civilian R & D reflects two countervailing trends—a steady drop in development and a steady rise in basic research. The essential point is that the Administration is targeting strong funding growth in both defense and basic research."

Keyworth dealt with the deficit issue obliquely. In his text, he said, "we all recognize that one of the most serious detriments to good science is what we might call roller coaster funding. The best protection against that phenomenon is for the science community to demonstrate, year after year, that R & D funds are being used wisely and effectively." And in his conclusion he developed the theme of shared responsibility. He acknowledged that the Administration had to articulate goals clearly and said "we have to stick to those goals in practice. I see this consistency as a major element of science policy, an element that I hope the Administration, the Congress, the science community and the public will be able to maintain in coming years."

In summarizing comments at the end of the colloquium, AAAS Executive Officer William D. Carey phrased his major point as the answer to the question, "What should science watchers watch?" Carey observed that in present circumstances they should not be preoccupied with minor trends in the R & D budget itself, but rather should consider such things as economic policy, export policy, and policies for defense. Carey noted that Reagan Administration treatment of basic research and higher education has been favorable. He suggested, however, that "consistency is not to be counted on," since future decisions will be determined by policies senior to science policy.—JOHN WALSH

*AAAS Report IX: Research and Development, FY 1985. AAAS. 284 pages.

Will Deficits Put a Damper on R & D?

Ninth AAAS Colloquium on R & D worries about looming budgetary gaps, asks if some new initiatives are too much of a good thing

In its annual look at the new federal budget, the AAAS Colloquium on R & D this year found the prospect of outsize federal deficits to be a threat to a currently prosperous R & D regime. And there were also misgivings that initiatives in the new R & D budget would cause trouble in coming years.

As has become the colloquium custom, the President's science adviser was the de facto keynote speaker, providing an interpretation of the R & D budget to which later speakers frequently referred, although not necessarily deferred. Incumbent science adviser George A. Keyworth, II provided a bullish review of the Administration's R & D policy and its implementation, but, at the outset, took issue with what he described as the "generally gloomy view of federal R & D" found in the introductory chapter of the annual budget analysis issued by AAAS to coincide with the colloquium.*

The authors early state their ambivalence with the comment that "It is a strong budget for R & D, but analysis of the totals raises questions. The big increase is almost entirely on the military side. Total non-defense R & D budget authority increases only about as much as inflation." The main concern is not directed at the makeup of the new budget. Rather, "Questions on R & D spending plans in the FY 1985 budget are overshadowed, however, by the need for drastic actions to reduce the deficit. Beneath the political posturing on both sides there is a realization that something has to be done."

The analysis predicts a continuing pattern of deficits in 1985 and after. "Thus the FY 1985 budget is not a budget in the traditional sense of the President's plan for dealing with the problems of the nation. It is instead a statement of the problem with the answers left up in the air—to be found in bipartisan negotiations with Congress, unilateral Congressional actions, or a new Presidential initiative some time after the election."

Another strain of ambivalence was expressed by National Academy of Engineering President Robert M. White who seemed to be asking, in essence, whether the R & D budget amounted to too much of a good thing. Like other speakers, White was complimentary about the Administration's actions in fashioning a budget that reflects strong confidence in R & D, noting that the real growth in total federal R & D funds under its aegis has been the largest since the 1960's. But he questioned whether the Administration's commitment to technology might amount to an overcommitment.

Noting examples like plans for a manned space station, a space-based missile defense, "a multitude and diversity of defensive and offensive strategic and tactical systems," and an ambitious strategic computing program, he said these contributed to what he termed a "technological flood tide."

Citing the "bow-wave effects" of such initiatives over time on the economy, on the availability of manpower and materials, and on the industrial competitiveness of U.S. industry, he urged that the issues be examined with caution. "My concern is that, as a community of scientists, engineers and technologists, we will be perceived as careening from worrying about insufficient investments in science, engineering and technology to meet national needs to a concern that we may be embarked on a course with unanticipated ends."

> "... the FY 1985 budget is ... a statement of the problem with the answers left up in the air. ..."

Keyworth concentrated on an explication of the Reagan Administration's R & D policy, but along the way he did offer some general answers to the critics. He noted, for example, that they tend to lump funding increases and decreases together "with the result that we can't appreciate the impacts of either." And he observed, "That view seems to imply that changes are inherently bad."

He also took exception to the way comparisons between defense R & D and civilian R & D are made. Keyworth noted that many of those who insist on casting R & D policy "in that simple-minded mold of guns and butter" arrive "at the absolutely false conclusion—or maybe they start there—that the federal government's only R & D priority is for defense."

Keyworth said that the Administration had assuredly given a high priority to strengthening defense, but the point the critics miss is that it "also strongly stated a similar priority for university basic research." The core of Keyworth's case was contained in his remark that "Most of the increases in defense R & D come from development costs associated with the modernization of the nation's strategic forces—an action to restore strength that was eroded during the previous decade. On the other hand, the flat curve in civilian R & D reflects two countervailing trends—a steady drop in development and a steady rise in basic research. The essential point is that the Administration is targeting strong funding growth in both defense and basic research."

Keyworth dealt with the deficit issue obliquely. In his text, he said, "we all recognize that one of the most serious detriments to good science is what we might call roller coaster funding. The best protection against that phenomenon is for the science community to demonstrate, year after year, that R & D funds are being used wisely and effectively." And in his conclusion he developed the theme of shared responsibility. He acknowledged that the Administration had to articulate goals clearly and said "we have to stick to those goals in practice. I see this consistency as a major element of science policy, an element that I hope the Administration, the Congress, the science community and the public will be able to maintain in coming years."

In summarizing comments at the end of the colloquium, AAAS Executive Officer William D. Carey phrased his major point as the answer to the question, "What should science watchers watch?" Carey observed that in present circumstances they should not be preoccupied with minor trends in the R & D budget itself, but rather should consider such things as economic policy, export policy, and policies for defense. Carey noted that Reagan Administration treatment of basic research and higher education has been favorable. He suggested, however, that "consistency is not to be counted on," since future decisions will be determined by policies senior to science policy.—JOHN WALSH

*AAAS Report IX: Research and Development, FY 1985. AAAS. 284 pages.

and private ventures, and the lack of any moral imperative frequently felt in the United States to maintain, at least in principle, a sharp dividing line between the two. Furthermore, as with the Celltech/MRC deal, negotiations have often been conducted discreetly out of the public eye.

Either way, there has been little of the public controversy over the restructuring of traditional relationships between the research community and the rest of society that has accompanied similar moves in the United States.

The situation has not been without its critics. Edward Yoxen, lecturer in the University of Manchester's department of liberal studies in science, points out in a recent study *The Gene Business* that many significant policy changes, such as the dispensation on access to MRC research awarded to Celltech, have taken place with little open discussion, even

"The academic excellence in places like the MRC should be treated as a national resource and the government should be providing evenhanded access to it," says Chris Keightley.

though the basic discoveries on which the new technologies are based were financed largely from public funds. "There has been virtually no public debate on this type of issue," says Yoxen.

Few concerns were expressed, for example, over the government's recent decision to drop the "public interest" members from its main regulatory watchdog, the Genetic Manipulation Advisory Group, when this body was recently reformulated as the Advisory Committee on Genetic Manipulation, and its day-to-day responsibilities for registering and monitoring experiments passed to the Health and Safety Executive.

The lack of such debate, however, has certainly not hampered the gradual dismantling of barriers to open cooperation between the academic and the commercial communities, a process openly encouraged by the government. The SERC's Biotechnology Directorate, for example, has recently established what is described as a "protein engineering club," in which major companies such as Glaxo and Unilever will help sponsor research in various academic institutions into ways of producing proteins to order in large quantities.

Similarly, several university institutions are using government money, both from the research councils and the Department of Trade and Industry, to help set up commercial operations. The University of Leicester, for example, has recently obtained backing from five major corporations to establish a center for research into yeast genetics. And the Imperial College of Science and Technology in London has established a company known as Imperial Biotechnology to exploit its research facilities in fermentation techniques.

Keen that the nation should reap a profit from its past and present scientific investments, the government is increasingly engaging in as much industrial planning as it feels it can get away with behind its free-enterprise, non-investment image. Responding to demands from companies such as Imperial Chemical Industries, as well as officials within the SERC, for some form of "national biotechnology program" to cover the spectrum of possible initiatives from tax incentives to information networks, the Department of Trade and Industry has recently set up a special advisory committee made up primarily of senior industrialists to look at areas where an extra push might be useful.

Taken in isolation, none of these moves is itself seen as a guarantee of success. But behind them lie two additional factors that help account for the current bullishness of Britain's biotechnologists. One, as Nicholson of the Cabinet Office puts it, is that "there is more optimism in the business sector than there was 6 or 9 months ago; we certainly started pulling out of the recession faster than either Germany or France."

The other is the gradual emergence of a new spirit of entrepreneurialism among British academics. "In the past, most academics had no idea about how to start up in business; but all that is now changing," says Keightley of IQ(Bio), a Cambridge biochemist who was about to emigrate to the United States when Acorn offered him the opportunity of helping start up the new company.

Similarly, Celltech points out proudly that it has managed to persuade one of the top teams of MRC scientists, headed by immunologist William Hunter of Edinburgh University, to join the company's new venture with Boots. "We have a fabulous opportunity here in Britain," says Keightley. "We are now learning how to capitalize on it."—**DAVID DICKSON**

Meselson Meets a Shower of Yellow Rain from Bees

Matthew Meselson, the Harvard biochemist waging a one-man challenge to the U.S. State Department's version of Yellow Rain warfare, went into the jungles of Thailand last month to test his thesis. He returned at the end of March with a new evidence, declaring the trip a greater success than he had anticipated.

Along with two bee experts who joined him in looking for natural forms of Yellow Rain, Meselson was caught in a 5-minute shower of bee droppings, which he thinks may be the real source of Yellow Rain samples being analyzed by U.S. military labs. Meselson and Thomas Seeley, a biologist at Yale University, last year developed a theory that Yellow Rain spots regarded as chemical weapon deposits were actually the feces of the wild Southeast Asian honey bee, *Apis dorsata* (*Science*, 24 June 1983, p. 1356). The theory was based on the knowledge that honey bees periodically make "cleansing flights" away from the hive, that their droppings contain pollen, and that most of the government's samples of Yellow Rain collected from the environment contain pollen.

Meselson noticed that the government's data on Yellow Rain were gathered in Southeast Asia between February and May. Using funds recently awarded him by the John D. and Catherine T. MacArthur Foundation, he went to Thailand in the middle of this ripe evidentiary season hoping to find proof that Southeast Asian honey bees do produce yellow, pollen-laden rain.

Meselson and Seeley reported at a press conference at Harvard on 28 March that they have proof that *A. dorsata* performs "massive defecation flights which can cover a swath thousands of square meters in area with 100 or more spots of yellowish feces per square meter." They found and studied ten swaths in Thailand and were caught in a bee feces shower that left "about a dozen spots . . . on each member of our three-man team." Meselson says this occurred near a tree in which they had spotted *A. dorsata* nests, but the bees were so far above the ground that he could not see or hear them.

Will Deficits Put a Damper on R & D?

Ninth AAAS Colloquium on R & D worries about looming budgetary gaps, asks if some new initiatives are too much of a good thing

In its annual look at the new federal budget, the AAAS Colloquium on R & D this year found the prospect of outsize federal deficits to be a threat to a currently prosperous R & D regime. And there were also misgivings that initiatives in the new R & D budget would cause trouble in coming years.

As has become the colloquium custom, the President's science adviser was the de facto keynote speaker, providing an interpretation of the R & D budget to which later speakers frequently referred, although not necessarily deferred. Incumbent science adviser George A. Keyworth, II provided a bullish review of the Administration's R & D policy and its implementation, but, at the outset, took issue with what he described as the "generally gloomy view of federal R & D" found in the introductory chapter of the annual budget analysis issued by AAAS to coincide with the colloquium.*

The authors early state their ambivalence with the comment that "It is a strong budget for R & D, but analysis of the totals raises questions. The big increase is almost entirely on the military side. Total non-defense R & D budget authority increases only about as much as inflation." The main concern is not directed at the makeup of the new budget. Rather, "Questions on R & D spending plans in the FY 1985 budget are overshadowed, however, by the need for drastic actions to reduce the deficit. Beneath the political posturing on both sides there is a realization that something has to be done."

The analysis predicts a continuing pattern of deficits in 1985 and after. "Thus the FY 1985 budget is not a budget in the traditional sense of the President's plan for dealing with the problems of the nation. It is instead a statement of the problem with the answers left up in the air—to be found in bipartisan negotiations with Congress, unilateral Congressional actions, or a new Presidential initiative some time after the election."

Another strain of ambivalence was expressed by National Academy of Engineering President Robert M. White who seemed to be asking, in essence, whether the R & D budget amounted to too much of a good thing. Like other speakers, White was complimentary about the Administration's actions in fashioning a budget that reflects strong confidence in R & D, noting that the real growth in total federal R & D funds under its aegis has been the largest since the 1960's. But he questioned whether the Administration's commitment to technology might amount to an overcommitment.

Noting examples like plans for a manned space station, a space-based missile defense, "a multitude and diversity of defensive and offensive strategic and tactical systems," and an ambitious strategic computing program, he said these contributed to what he termed a "technological flood tide."

Citing the "bow-wave effects" of such initiatives over time on the economy, on the availability of manpower and materials, and on the industrial competitiveness of U.S. industry, he urged that the issues be examined with caution. "My concern is that, as a community of scientists, engineers and technologists, we will be perceived as careening from worrying about insufficient investments in science, engineering and technology to meet national needs to a concern that we may be embarked on a course with unanticipated ends."

> "... the FY 1985 budget is ... a statement of the problem with the answers left up in the air. ..."

Keyworth concentrated on an explication of the Reagan Administration's R & D policy, but along the way he did offer some general answers to the critics. He noted, for example, that they tend to lump funding increases and decreases together "with the result that we can't appreciate the impacts of either." And he observed, "That view seems to imply that changes are inherently bad."

He also took exception to the way comparisons between defense R & D and civilian R & D are made. Keyworth noted that many of those who insist on casting R & D policy "in that simple-minded mold of guns and butter" arrive "at the absolutely false conclusion—or maybe they start there—that the federal government's only R & D priority is for defense."

Keyworth said that the Administration had assuredly given a high priority to strengthening defense, but the point the critics miss is that it "also strongly stated a similar priority for university basic research." The core of Keyworth's case was contained in his remark that "Most of the increases in defense R & D come from development costs associated with the modernization of the nation's strategic forces—an action to restore strength that was eroded during the previous decade. On the other hand, the flat curve in civilian R & D reflects two countervailing trends—a steady drop in development and a steady rise in basic research. The essential point is that the Administration is targeting strong funding growth in both defense and basic research."

Keyworth dealt with the deficit issue obliquely. In his text, he said, "we all recognize that one of the most serious detriments to good science is what we might call roller coaster funding. The best protection against that phenomenon is for the science community to demonstrate, year after year, that R & D funds are being used wisely and effectively." And in his conclusion he developed the theme of shared responsibility. He acknowledged that the Administration had to articulate goals clearly and said "we have to stick to those goals in practice. I see this consistency as a major element of science policy, an element that I hope the Administration, the Congress, the science community and the public will be able to maintain in coming years."

In summarizing comments at the end of the colloquium, AAAS Executive Officer William D. Carey phrased his major point as the answer to the question, "What should science watchers watch?" Carey observed that in present circumstances they should not be preoccupied with minor trends in the R & D budget itself, but rather should consider such things as economic policy, export policy, and policies for defense. Carey noted that Reagan Administration treatment of basic research and higher education has been favorable. He suggested, however, that "consistency is not to be counted on," since future decisions will be determined by policies senior to science policy.—JOHN WALSH

*AAAS Report IX: Research and Development, FY 1985. AAAS. 284 pages.

for the development of new products.

That picture represents a misunderstanding. Although MITI does indeed sponsor R & D programs, such as the highly publicized ones on integrated circuits and the fifth-generation computer, the R & D tends to be basic and engineering research. In the United States, such R & D efforts are centered in our universities.

The commercial R & D successes of Japan, as opposed to efforts to develop the underlying technologies, have been driven not by MITI but by Japanese industry, even in integrated circuits. The participants in the MITI-sponsored cooperative integrated circuits program went back to their own laboratories to develop the actual commercial 64K random access memory chips that have been so successful in the marketplace. Oki Electric, the fastest growing Japanese producer of 64K chips and the first Japanese company to test a 256K chip, did not even participate in the MITI program.

The Japanese government, which has played an important role in promoting its industries' fortunes through such means as protectionist trade policies, has not been a significant force in commercial technology selection and development. The successes of Japan in businesses based on advanced technology are mainly the result of smart, persistent industrial R & D management. Private corporations in Japan make long-term R & D commitments to relatively narrow areas. They pick a target, such as video recorders, assemble large teams to pursue that target, and stick with it for as long as is necessary to bring a winning product to market. They do not try to cover the R & D waterfront, and they do not back out if the payoff is not immediate. They also practice a technique that I call "innovation by experiment," whereby they put a product out on the market, even in imperfect and sometimes expensive form, and learn from the customers how to improve it. And finally, they are aggressive in acquiring, improving, and implementing technology that they did not develop.

These strategies do not explain all of Japan's success in commercial technology, but they do indicate that the real source of that success is Japanese industry. Also, they underscore the lesson that we should learn from Japan: that the selection of the product technology and its development is best left to the people intimately familiar with the technologies and the markets. Technology selection and development should not be managed from afar.

Creating Conditions for Innovation

What role should the U.S. government play with respect to R & D? That role is not to manage technology-based commercial innovation but to create the conditions for such innovation. The government should provide an encouraging and supportive environment and infrastructure within which industries select and develop commercial technology.

There are many features of such an environment that deserve attention: a favorable tax climate exemplified by R & D tax credits, by extension of those credits to software, and by fast depreciation of R & D equipment; modified antitrust laws that encourage cooperative R & D and limit damages for civil violations; export control laws and regulations that do not disrupt the interchange of scientific and technical information that is so vital to the progress of technology; and immigration laws that permit outstanding foreign scientists to remain in the United States to do R & D.

Support for University Research

The most important role for government in creating the conditions for commercial innovation is to support universities in their efforts to generate research and provide manpower. The most crucial issue we face is a lack of skilled manpower, a shortage of faculty in universities for training that manpower, and a deteriorating research capability in our great universities because of the shortages of both faculty and modern equipment for instruction and for research.

American industry today simply cannot get enough of the people it needs in such fields as microelectronics, artificial intelligence, communications, and computer science. The universities are not turning out enough R & D people in these areas, or enough research faculty. There is little that private companies can do about this. We contribute to the support of universities, but industry will never be able to meet more than a small fraction of university R & D funding needs. Even after a decade of steadily increasing industry support for universities, industry provides only about 5 percent of total university R & D funding. Congress is considering additional incentives for industry support of universities, but the fact remains that the primary responsibility for ensuring a strong, healthy academic research system and thereby for providing an adequate supply of research and skilled people must rest with the federal government.

There is wide agreement that the federal government should support the universities, and, in fact, federal basic research obligations to universities and colleges, measured in constant dollars, have grown by more than 25 percent over the past 3 years. But this is only a start in filling the needs. Department of Defense funding of basic research, for example, has only in the past 2 years returned to the level, measured in constant dollars, that it was in 1970. The Defense Department has traditionally played a vital role in supporting basic university research. A time of rapid expansion of the defense budget is no time to abandon that tradition.

Universities have had to compete with the national laboratories for the Department of Energy's research dollars. When research is funded at a university, not only does the research get done, but also students are trained, facilities are upgraded, faculty and students get more support, and thereby better faculty and students are attracted. Moreover, the students that go into industry help in the transition of advanced research into concepts for industrial innovation. When the same research is funded at a national laboratory, most of the educational dividends are lost.

Universities should not have to compete head on with national laboratories for mission agency funds. Unless the national laboratory will do a substantially better research job, the university should get the funds. The same holds for government funding of research in industry. Those funds that advocates of industrial policy propose to invest in government-directed industrial R & D would normally be much better spent in universities, unless there is a special reason why an industrial laboratory can do it much, much better.

I am not proposing that we simply throw money at universities. We need to be selective. To borrow a phrase from the industrial policy advocates, the government should stress the growth of "sunrise science and technology." Unlike the targeting of sunrise industries, the targeting of sunrise—that is, fast moving—areas of research can be done. We can identify these technologies, even if we cannot specify in advance precisely what products or industries they will generate. But we are not doing this as well as we can and should. In microelectronics, for example, a study by the Thomas Group, a Silicon Valley consulting firm, concludes that government support of university microelectronics programs totaled only about $100 million between 1980 and 1982. To put that into

Diurnal Variation of Stratospheric Chlorine Monoxide: A Critical Test of Chlorine Chemistry in the Ozone Layer

P. M. Solomon, R. de Zafra, A. Parrish, J. W. Barrett

Abstract. *This article reports measurements of the column density of stratospheric chlorine monoxide and presents a complete diurnal record of its variation (with 2-hour resolution) obtained from ground-based observations of a millimeter-wave spectral line at 278 gigahertz. Observations were carried out during October and December 1982 from Mauna Kea, Hawaii. The results reported here indicate that the mixing ratio and column density of chlorine monoxide above 30 kilometers during the daytime are ~ 20 percent lower than model predictions based on 2.1 parts per billion of total stratospheric chlorine. The observed day-to-night variation of chlorine monoxide is, however, in good agreement with recent model predictions, confirms the existence of a nighttime reservoir for chlorine, and verifies the predicted general rate of its storage and retrieval. From this evidence, it appears that the chlorine chemistry above 30 kilometers is close to being understood in current stratospheric models. Models based on this chemistry and measured reaction rates predict a reduction in the total stratospheric ozone content in the range of 3 to 5 percent in the final steady state for an otherwise unperturbed atmosphere, although the percentage decrease in the upper stratosphere is much higher.*

Chlorine monoxide (ClO) has for some years been recognized as a key tracer of the stratospheric ozone depletion cycle arising from natural and anthropogenic injection of chlorine-containing compounds, principally halocarbons, into the atmosphere (*1*, *2*). The reactions

$$O_3 + Cl \rightarrow ClO + O_2 \quad (1)$$

and

$$ClO + O \rightarrow Cl + O_2 \quad (2)$$

constitute the catalytic cycle by which chlorine atoms convert ozone, O_3, to diatomic O_2.

There is a strong diurnal variation expected in the concentration of ClO. After the recombination of atomic oxygen at sunset, reaction 2 ceases. At night, ClO is believed to combine in a three-body reaction with NO_2 to form chlorine nitrate,

$$ClO + NO_2 \xrightarrow{M} ClONO_2 \quad (3)$$

which is thought to be the dominant reservoir of chlorine in the absence of sunlight. During daylight hours, free chlorine is again produced from this reservoir by the photolysis of chlorine nitrate:

$$ClONO_2 + h\nu \rightarrow Cl + NO_3 \quad (4)$$

The rate of nighttime removal of ClO via reaction 3 is dependent on the NO_2 concentration and the total density, both of which decrease with altitude above 30 km: thus high-altitude ClO is expected to last through the night, while ClO at lower levels (altitude $\lesssim$ 35 km) disappears. Earlier measurements by in situ resonance fluorescence (*3*), infrared heterodyne spectroscopy (*4*), balloon-borne (*5*) and ground-based (*6*) millimeter-wave spectroscopy have established the presence, approximate quantity, and vertical distribution of daytime stratospheric ClO. A more critical test of the full complex of reactions of stratospheric chlorine may be obtained from measurements of the diurnal variation of ClO. Such observations avoid the complications and uncertainties introduced by vertical and lateral transport and long-term seasonal trends. Earlier balloon-based millimeter measurements over a limited portion of the diurnal cycle have shown a decrease in ClO at sunset and an increase after sunrise (*5*). In this article we present a complete diurnal record of ClO variation, with a time resolution of 2 hours, acquired by ground-based remote sensing of millimeter-wave line emission.

P. M. Solomon is professor of astronomy and R. de Zafra is professor of physics at the State University of New York, Stony Brook 11794. H. Parrish and J. W. Barrett are research associates at the same institution.

Observations of Emission Lines

The ClO molecule has millimeter-wave rotational spectral lines spaced approximately every 37 GHz. We have reported measurement (*6*) of the line at 204.352 GHz from the $J = 11/2 \rightarrow 9/2$ levels. Our current measurements are based on the $J = 15/2 \rightarrow 13/2$ transition at 278.630 GHz. We use a cryogenically cooled millimeter-wave heterodyne mixer receiver with a noise temperature of 1100 K, approximately 2½ times more sensitive than our earlier detector (*6*). Use of this more sensitive detector, combined with an increase by a factor of 2.4 in the theoretical line intensity for the higher frequency 278-GHz line as compared with the 204-GHz line, has led to a sixfold increase in observational sensitivity. For a fixed signal-to-noise ratio, the required measurement duration is reduced by about a factor of 6^2 or 36, allowing a relatively high time resolution to be achieved. The "back-end" spectrometer consists of a filter bank with 256 channels, each with a bandwidth of 1 MHz. The measurement technique, calibration method, and instrumental configuration described earlier (*6*) remain unchanged.

Our observations were carried out at the summit of Mauna Kea, Hawaii (elevation, 4250 m; latitude, 19.5°N) during two periods, from 8 to 11 October and from 9 to 16 December 1982. The atmospheric water vapor content, which dominates the tropospheric absorption of stratospheric emission lines at millimeter-wave frequencies, was very low and generally stable around the clock during these observation periods (*7*).

In the following discussion, we present emission intensities as brightness temperatures in kelvins. This custom, commonly used in radio astronomy, is derived from the Rayleigh-Jeans approximation for blackbody radiation, in which emitted power per unit frequency is linearly proportional to temperature. All intensities represent the values that would be observed if one were looking through one stratospheric air mass toward the zenith after removing the effect of tropospheric attenuation.

In Fig. 1, we present a sample of midday (1230 to 1630) and nighttime

tive) from that of 17 with small-cell lung carcinoma (15 positive) is striking (see Table 1). Both cancers have common ancestry, but the former is of comparatively low malignancy and the latter is extraordinarily malignant.

5) While patients with carcinoma generally showed cellular and humoral immune responses to carcinoma-associated T antigen, the humoral response was stimulated preferentially by tubular and early lobular breast carcinomas, which had T activity comparable to other carcinomas. Significantly, these carcinoma types have a favorable prognosis among breast carcinomas (*8, 54*).

The Tn/anti-Tn system may complement the T/anti-T system in elucidating aspects of the pathogenesis of carcinoma and in early diagnosis. While the link between Tn and carcinoma has been known for a decade (*10*), this system has not been studied in the present context. Research is complicated by the usually low concentration of anti-Tn. Tn's immunodominant structure, GalNAc-α, is also the dominant part of the blood group A and Forssman haptens, which may prevent some anti-Tn immune responses. Furthermore, Tn antigen is not readily obtainable from healthy tissues (*7*). There are, however, some highly instructive experiments by nature herself that show not only how unmasked Tn arises in hematopoietic stem cells, usually persisting indefinitely without malignant change, but that Tn, the epigenetic sequela of a rare, benign, somatic mutation, occasionally precedes and then accompanies leukemia, disappears upon chemotherapy-induced remission, and reappears in relapse (*66*).

Conclusion and Prospects

The studies described here have revealed, in a large number of carcinoma patients, a close link between malignant transformation and early, persistent changes in common carcinomas: unmasked precursor antigens T and Tn, that allow the patient's immune system to qualitatively differentiate carcinoma from noncarcinoma.

On rare occasions, demonstrable T and Tn antigens occur in premalignant lesions, which may either remain that way permanently or progress to frank malignancy. Some tissues with such changes are accessible to longitudinal study and thus aid in determining the decisive point of malignant transformation. This approach may be facilitated by manipulation of immune responses, as well as by locating incipient carcinomas with labeled mono- and polyclonal anti-T and anti-Tn reagents (*25, 26, 67*) [but see the introduction and (*27*)]. Our monoclonal antibodies to T and Tn were generated by desialylized human O erythrocytes. We obtained three relevant specificities: anti-T, anti-Tn, as well as a specificity directed toward a moiety shared by T and Tn haptens (*67*). The three types of antibodies reacted strongly and specifically with carcinomas in immunohistochemical analyses of surgical specimens but less well in antibody absorption studies (*27*).

Our recent observation (*68*) in carcinoma patients, but not healthy persons, of a significant increase in lymphoid cell cytolytic activity against target cells with surface-exposed T and Tn antigens supports T and Tn's importance in the malignant process—especially since there was often a concomitant decrease in natural killer cell activity. The findings discussed here, although they are in an emerging phase, indicate that uncovered T and Tn antigens endow the carcinoma cells with a multitude of novel functions. These functions may be fundamental to the multistep processes of invasion and spread of carcinoma, and clearly have a profound, measurable effect on the tumor bearer's immune system. T antigen is likely to be a powerful probe in early carcinoma detection.

References and Notes

1. E. Silverberg, *CA—A Cancer J. Clinicians* **34**, 7 (1984).
2. P. Ehrlich, *Ned. Tijdschr. Geneesk.* **5**, 273 (1909).
3. M. Bertrand, in *Travaux de la 2e Conférence Internationale pour L'Étude du Cancer*, P. Delbert and R. Ledoux-Lebard, Eds. (Alcan, Paris, 1910), pp. 753–758.
4. L. Hirszfeld, W. Halber, J. Laskowski, *Z. Immunitaetsforsch. Exp. Ther.* **64**, 61 (1930); E. Witebsky, *Klin. Wochenschr.* **9**, 58 (1930).
5. E. J. Foley, *Cancer Res.* **13**, 835 (1953); R. T. Prehn, *Fed. Proc. Fed. Am. Soc. Exp. Biol.* **24**, 1018 (1965).
6. M. M. Black and F. D. Speer, *Int. Abstr. Surg.* **109**, 105 (1959); L. E. Hughes and B. Lytton, *Br. Med. J.* **i**, 209 (1964); R. B. Herberman *et al.*, *Natl. Cancer Inst. Monogr.* **37**, 189 (1973).
7. G. F. Springer, P. R. Desai, M. S. Murthy, H. Tegtmeyer, E. F. Scanlon, in *Progress in Allergy*, P. Kallós, B. H. Waksman, A. L. deWeck, K. Ishizaka, Eds. (Karger, Basel, 1979), vol. 29, pp. 42–96.
8. E. C. Rosenow III and D. J. Carr, *CA—A Cancer J. Clinicians* **29**, 233 (1979); D. E. Williams *et al.*, *J. Thorac. Cardiovasc. Surg.* **82**, 70 (1981); J. D. Minna, G. A. Higgins, E. J. Glatstein, in *Cancer Principles and Practice of Oncology*, V. De Vita, Jr., S. Hellman, S. A. Rosenberg, Eds. (Lippincott, Philadelphia, 1982), pp. 396–474; A. R. Moossa, *Cancer* **50**, 2689 (1982).
9. T. G. Frazier, E. M. Copeland, H. S. Gallager, D. D. Paulus, Jr., E. C. White, *Am. J. Surg.* **133**, 697 (1977); G. F. Robbins, in *The Breast*, H. S. Gallager, H. P. Leis, Jr., R. K. Snyderman, J. A. Urban, Eds. (Mosby, St. Louis, 1978), pp. 181–191.
10. G. F. Springer, P. R. Desai, I. Banatwala, *J. Natl. Cancer Inst.* **54**, 335 (1975); G. F. Springer and P. R. Desai, *Transplant. Proc.* **9**, 1105 (1977).
11. D. R. Howard and C. R. Taylor, *Oncology* **37**, 142 (1980); C. R. Boland, C. K. Montgomery, Y. S. Kim, *Proc. Natl. Acad. Sci. U.S.A.* **79**, 2051 (1982); T. F. Örntoft, N. P. O. Mors, G. Ericksen, N. O. Jacobsen, H. S. Poulsen, *Cancer Res.*, in press.
12. J. H. Anglin, Jr., M. P. Lerner, R. E. Nordquist, *Nature (London)* **269**, 254 (1977).
13. J. C. Laurent, P. Noël, M. Faucon, *Biomedicine* **29**, 260 (1978).
14. C. Limas and P. Lange, *Cancer* **46**, 1366 (1980).
15. J. Coon, R. S. Weinstein, J. Summers, *Am. J. Clin. Pathol.* **77**, 692 (1982); J. L. Summers *et al.*, *Cancer Res.* **43**, 934 (1983).
16. T. P. Lehman, H. S. Cooper, S. G. Mulholland, *Cancer* **53**, 272 (1984).
17. M. Ghazizadeh, S. Kagawa, K. Izumi, K. Kurokawa, *J. Urol.*, in press.
18. G. F. Springer, M. S. Murthy, P. R. Desai, E. F. Scanlon, *Cancer* **45**, 2949 (1980).
19. V. Friedenreich, *The Thomsen Hemagglutination Phenomenon* (Levin & Munksgaard, Copenhagen, 1930); F. M. Burnet and S. G. Anderson, *Aust. J. Exp. Biol. Med.* **25**, 213 (1947); F. H. Caselitz and G. Stein, *Z. Immunitaetsforsch.* **110**, 165 (1953).
20. J. Dausset, J. Moullec, J. Bernard, *Blood* **14**, 1079 (1959).
21. G. F. Springer, H. Tegtmeyer, D. W. Cromer, *Fed. Proc. Fed. Am. Soc. Exp. Biol.* **43**, 6 (1984).
22. R. D. Owen, *Science* **102**, 400 (1945).
23. V. Boccardi, D. Attinà, G. Girelli, *Vox Sang.* **27**, 268 (1974).
24. G. F. Springer and H. Tegtmeyer, *Br. J. Haematol.* **47**, 453 (1981).
25. P. L. Zabel, A. A. Noujaim, A. Shysh, J. Bray, *Eur. J. Nucl. Med.* **8**, 250 (1983).
26. G. F. Springer, S. Metcalfe, H. Tegtmeyer, unpublished data.
27. G. F. Springer *et al.*, *Cancer*, in press.
28. N. Thatcher, K. Hashmi, J. Chang, R. Swindell, D. Crowther, *ibid.* **46**, 1378 (1980).
29. G. H. Vos, E. F. Rose, D. Vos, *S. Afr. Med. J.* **59**, 56 (1981).
30. J. Bray, G. D. Maclean, F. J. Dusel, T. A. McPherson, *Clin. Exp. Immunol.* **47**, 176 (1982).
31. G. F. Springer *et al.*, in *Cellular Oncology*, P. J. Moloy and G. L. Nicolson, Eds. (Praeger, New York, 1983), vol. 1, pp. 99–130; R. L. Goodale, G. F. Springer, J. G. Shearen, P. R. Desai, H. Tegtmeyer, *J. Surg. Res.* **35**, 293 (1983).
32. G. F. Springer and N. J. Ansell, *Proc. Natl. Acad. Sci. U.S.A.* **44**, 182 (1958).
33. K. O. Lloyd and E. A. Kabat, *ibid.* **61**, 1470 (1968).
34. G. Myllylä *et al.*, *Vox Sang.* **20**, 7 (1971); P. Sturgeon, S. J. Luner, D. T. McQuiston, *ibid.* **25**, 481 (1973).
35. G. F. Springer, P. R. Desai, H. Schachter, S. Narasimhan, *Naturwissenschaften* **63**, 488 (1976).
36. J.-P. Cartron *et al.*, *Eur. J. Biochem.* **92**, 111 (1978); P. R. Desai and G. F. Springer, *J. Immunogenet.* **6**, 403 (1979).
37. G. F. Springer and P. R. Desai, *Biochem. Biophys. Res. Commun.* **61**, 470 (1974).
38. R. Kaifu and T. Osawa, *Carbohydr. Res.* **58**, 235 (1977); R. M. Ratcliffe, D. A. Baker, R. U. Lemieux, *ibid.* **93**, 35 (1981); H. Paulsen, J. Jacquinet, W. Rust, *ibid.* **104**, 195 (1982); V. V. Bencomo and P. Sinäy, *ibid.* **116**, C9 (1983).
39. G. F. Springer, R. Cheingsong-Popov, V. Schirrmacher, P. R. Desai, H. Tegtmeyer, *J. Biol. Chem.* **258**, 5702 (1983).
40. G. F. Springer, J. L. Cantrell, P. R. Desai, H. Tegtmeyer, *Clin. Immunol. Immunopathol.* **22**, 9 (1982); P. R. Desai and G. F. Springer, in *Glycoconjugates, Proceedings of the Seventh International Symposium on Glycoconjugates*, M. A. Chester, D. Heinegård, A. Lundblad, S. Svensson, Eds. (Rahms, Lund, 1983), pp. 431–432.
41. H. Rauvala and J. Finne, *FEBS Lett.* **97**, 1 (1979).
42. B. Jirgensons and G. F. Springer, *Science* **162**, 365 (1968).
43. G. F. Springer and P. R. Desai, *J. Biol. Chem.* **257**, 2744 (1982).
44. A. Pierce-Cretel, M. Pamblanco, G. Strecker, J. Montreuil, G. Spik, *Eur. J. Biochem.* **114**, 169 (1981).
45. Z. Kim and G. Uhlenbruck, *Z. Immunitaetsforsch. Exp. Ther.* **130**, 88 (1966).
46. G. F. Springer and P. R. Desai, *Carbohydr. Res.* **40**, 183 (1975).
47. J. Bray, R. U. Lemieux, T. A. McPherson, *J. Immunol.* **126**, 1966 (1981).
48. G. F. Springer and P. R. Desai, *Naturwissenschaften* **69**, 346 (1982); P. Desai and G. Springer, in *Protides of the Biological Fluids*, H. Peeters, Ed. (Pergamon, Oxford, 1984), vol. 31, pp. 421–424.
49. G. C. Davey, G. A. Currie, P. Alexander, *Br. J. Cancer* **33**, 9 (1976).
50. V. Schirrmacher, R. Cheingsong-Popov, H. Arnheiter, *J. Exp. Med.* **151**, 984 (1980).
51. G. F. Springer, P. R. Desai, E. F. Scanlon, *Cancer* **37**, 169 (1976).
52. O. H. Beahrs and M. M. Myers, Eds., *Manual for Staging of Cancer* (Lippincott, Philadelphia, ed. 2, 1983).