to be here today," the absent Levy enthuses. At 11.45 a.m. precisely, Magnuson gavels the morning session to a close, having heard, at a machine-gun rate of delivery, some 35,000 words of oral testimony in a mere 105 minutes.

Remarks made by congressmen on the Senate or House floor are often edited before appearing in print in the *Congressional Record*. The practice of editing the truth just a little has slopped over into the hearing record of committees. Often a question asked by a staff aide on behalf of an absent senator will appear in the record as if posed by the senator himself. It is common and necessary practice for witnesses to be asked to supply written answers to certain questions, but some committees print up both question and answer as if the interchange had occurred in the hearing room.

The potential for abuse in these small inexactitudes has been fully realized in the wholesale fiction perpetrated on the public by Magnuson's subcommittee. Rarely if ever has an entire day's hearing been faked, let alone several days'.

Asked for an explanation of the affair, an aide to Magnuson told *Science* that "The Senator is willing to say that apparently the printed record doesn't reflect what transpired and that he has the matter under investigation."

The aide then added that the above statement should be attributed to Magnuson and not to him. To the suggestion that it would be more accurate to say that Magnuson made the statement through an aide, the aide replied that "We would rather you didn't do it that way. The Senator doesn't want aides quoted in the press. That's just our policy and it has been that way for years." The minor emendation of reality seems to be a routine occurrence in Magnuson's office.

How many of the actors connived in the fictitious script? Morton Schwartz, an aide to Senator Proxmire, said he checked in proofs the questions submitted on Proxmire's behalf and that he would have "screamed like hell" if they had been tampered with. Schwartz apparently did not trouble to scream like hell about allowing the public to think that Proxmire had attended the hearing on its behalf.

NIH officials say that they had no chance to protest the fictional use of their testimony because "We had no knowledge that Dirks would write up the material as if it had taken place." Harley M. Dirks is the chief aide to the labor and health appropriations subcommittee. He told *Science* that the hearings into the NIH's budget were canceled because NIH's testimony and witness list didn't reach the committee in time. "With most of the health agencies that was the principal reason," Dirks explains. The delay with the NIH material, he adds, "was mostly the fault of the HEW budget comptroller's office." Charles Miller, deputy head of the office, says he is not aware of any such delay.

As to making dead hearings seem live, Dirks explains that it was his printer who made the original sin of commission. The printshop "worked up" the front pages (which state the time and place of the hearings) in the usual way and "We didn't bother to change it," he says.

Dirks says he received no protests about this procedure from the staff of the subcommittee members or from HEW officials. Miller says he did not protest because it has been "long custom" for written questions and answers to appear as if they had been live, but he agrees that it is "precedent setting" for a whole set of hearings to be so treated. As for Magnuson, he must have wondered how the nonexistent hearings were to be printed up. Was he told of the plan to fictionalize them? "I guess I don't know," says Dirks.

The faking of the record underlines the strong element of playacting in the appropriations process. The President submits a low cost health budget which the officials must pretend to defend, and the senators berate them as if the pretense were real. Both sides know what is going on and only the public is deceived.

"If the exercise is futile anyway, it's a great time-saver to hold the whole hearing in writing," observes an HEW official. But senators, committee aides, and officials who can perpetrate and connive at a paper hearing to fool the public have attained a degree of cynicism at which they must presumably conceive of the public as paper people.

—NICHOLAS WADE

R & D and Economic Growth: Renewed Interest in Federal Role

Since World War II it has been an article of economic faith that research and development are vital factors in technological innovation, which, in turn, is an essential ingredient of economic growth. In recent years, however, there has been a disturbing decline in R & D spending in the United States, a lag in innovation, and a slowdown in economic growth.

One result is that a group of economists and analysts who specialize in the study of the relation of R & D to economic growth are being increasingly consulted and courted by legislators and policy-makers. What this seems to presage is a serious renewal of interest in Washington in the question of what measures can be taken by the federal government to encourage technological innovation in private industry.

One observation that has attracted the attention of the seekers of wisdom and been given prominence in the press is that investment in R & D by private industry brings a decidedly favorable return, probably in the range of 30 percent, on the average. If this is the case, it seems unaccountable at first blush that manufacturing companies, which enjoy such returns, don't plow money into R & D.

The catch is that the estimates apply to average rates of return—for industries in most cases—and that a particular R & D project carried out by an individual firm may bring a much more modest return or, in fact, be a total loss. Economists who work in the field emphasize the risks involved in R & D and say it is by no means clear that private firms, from the standpoint of their own interests, are underspending on R & D.

What then is really known about this seemingly paradoxical situation? Edwin Mansfield of the University of Pennsylvania's Wharton School of Finance, and one of the most widely known of the economists identified with the economics of R & D puts it this way: The rate of social return on R & D spending—the benefit to society as a whole—is known

by economists to be pretty substantial. The return to innovators themselves, however, is much less than to society.

To economists, says Mansfield, this is a sign that less money is being assigned to R & D than is desirable. But to the question of exactly where and how additional R & D money should be spent, the answer is, "We don't know."

What is certain is that concern about the state of technological innovation is percolating briskly at the levels where policy is made on science and technology. What accounts for the upsurge of concern? Several factors are suggested by J. Herbert Hollomon, who has been publicly and prominently involved with the problems of innovation ever since he was a Department of Commerce official in the Kennedy and Johnson administrations. Hollomon, now at MIT, points out that, in terms of productivity, perhaps the chief measure of innovation, the United States has not been doing well in recent years. He says that people are beginning to realize that the U.S. trade position depends on innovation and that the country is not very competitive these days. It is not due to lower labor costs abroad, he adds.

Hollomon also emphasizes that the start-up of new firms is lagging in the United States. Such firms, particularly small, high-technology companies have been major generators of innovation in the past.

Until recently the discussion of R & D and economic growth tended to be short on analysis because the picture of R & D practices by private industry lacked clarity. The overall trends were obvious enough. Since 1967, federal spending on R & D, which had grown at an annual rate of nearly 14 percent for nearly a decade, has actually shrunk an average of 3 percent a year in terms of constant dollars. The rate of growth of R & D spending by private industry, which had been rising at the rate of about 7 percent a year during the 1960's, dropped off to an average growth of less than 2 percent a year after 1967. (In 1975 private industry spent about $15.1 billion of their own funds for R & D. Federal R & D funds amounted to a total of $20 billion with some $9 billion of that going to private contractors.)

What has been obscure, however, were details of company-funded R & D. Information on investment on R & D, particularly of spending on specific products or processes, has been closely guarded from competitors. Data gathered by the government were viewed as being useful only as very general aggregates, and reporting practices varied so greatly from company to company that there was little confidence that figures were comparable. In recent years, however, new requirements for reporting and accounting procedures have come into force, with the result that it is possible to make comparisons such as appeared in a survey of company sponsored R & D by 730 firms in the 28 July issue of *Business Week*.

The figures in the survey confirmed the widely held assumption that R & D spending varies widely from industry to industry and that high technology industries do indeed spend more than other industries both as a percentage of sales and of profits. By and large, the heaviest investors in R & D were the drug industry, whose spending on R & D amounted to 4 percent of sales and 51 percent of profits; electronics, which spent 3 percent of sales and 81.5 percent of profits; and instruments, which spent 5.4 percent of sales and 68.6 percent of profits.

Energy companies, on the other hand, spent only 0.4 percent of sales and 8.3 percent of profits, but it should be noted that the heavy expenditures made by the industry for exploration for new energy reserves is not included in the R & D column.

What the survey does not show is the changes in the pattern of spending within industries or within companies. It is known that private industry puts most of its R & D money into engineering and development projects, but there is strong anecdotal evidence that major companies have shifted R & D emphasis to shorter-term projects aimed at improving existing products and processes. Cutbacks of longer-term, higher-risk projects have been a fairly widespread phenomenon. It is the decline in this category of research which disturbs many analysts who see such projects resulting in technological change in the future. Some economists predict that the effects of the starving of future-oriented research will begin to appear and to be measurable by the end of the decade.

Spokesmen for some industries argue that companies have had to shift R & D resources to work to meet new health, safety, and environmental requirements set by the government, with the result that R & D is less effective in increasing productivity. The drug industry and chemical industry, particularly manufacturers of agricultural chemicals, insist most strongly that this is the case.

Another complainant is the automobile industry, where General Motors, the biggest American company in point of sales, is also the biggest spender on R & D—more than $1 billion a year. Auto company officials argue that R & D for government imposed safety and emissions standards have diverted effort from such things as improving engine efficiency. These charges have stirred a debate inside and outside government and have bred a new subspecies of analysts who look at the effects of regulatory activity on productivity and innovation.

The R & D economists, somewhat surprisingly, are quite cautious about assigning R & D a central role in innovation. Technological innovation is a complex process, they say, requiring much more than the invention of a new product or process. Among the requirements are availability of capital at a manageable interest rate, and a favorable tax, antitrust, and regulatory atmosphere. Most important, perhaps, is the prospect that the innovation will pay off in the market. Mansfield and others stress the importance of the linkage of R & D to the market. Some companies do this well and some badly and a growing effort is being made to identify the attitudes and practices that distinguish the two sorts. Some observers feel that broad social attitudes as, for example, the attitude toward competition, may be very important. The Soviets, they note, spend a lot on R & D, but are not highly successful at innovation.

Economists emphasize the limitations of their techniques in this rather new field. For example, Nestor E. Terleckyj, director of the center of socioeconomic analysis of the National Planning Association, finds no evidence that R & D done under government contract has any effect in increasing the productivity of the industries performing it. This does not mean, however, that government-funded R & D yields no benefits. Terleckyj explains that most economic studies deal with "the measurement of expenditures for R & D and its impacts and effects as measured by economic quantities reducible to dollar valuation, directly in terms of profits, costs and prices in case of companies and products, or indirectly in terms of economic indexes, such as output, input, and productivity indexes, which are derived from the more detailed data for either companies or products."

In other words, it is hard to measure in market terms the effect of the kind of R & D funded by the government, difficult to make a dollar evaluation of military or space or health research. While precise measurement of the "fallout" effects of this sort of research are elusive, it is clear that development of such things as integrated circuits and numerically controlled machinery owe much to federally sponsored research, and that the social benefits of biomedical and agricultural research are considerable.

It may be true, as Mansfield says, that what is available is "a set of tentative, partial findings," but it is certainly also true that interest in these findings is waxing. Mansfield and Terleckyj, for example, testified at hearings on the subject of federal R & D and economic growth this spring before a House Science and Technology subcommittee.* The issue of technological innovation was a central concern of the President's Advisory Group on Contribution on Science and Technology, which wound up its work in early August. And both the National Science Foundation and the National Bureau of Standards have programs bearing on the subject. The best known of these is the NSB's Experimental Technology Incentives Program. ETIP is a program of small-scale experiments principally designed to encourage government agencies to remove "roadblocks" to innovation created by procurement and regulatory policies (*Science*, 26 September 1975). NSF has funded a number of studies on R & D productivity and related subjects that have provided grist for the mills of discussion. Economists seem to agree that it is too early to evaluate the effect of these programs.

The concern about R & D and economic growth is hardly new. The first serious discussion of broad government action to promote innovation in private industry came in the middle 1960's at the initiative of Hollomon. His proposal for a network of state efforts resembling the agricultural extension program finally was enacted into law in microcosmic form.

An even more ambitious attempt seemed to be in the offing in 1972, when President Nixon called for shifts in federal R & D policy to make the government a more effective agent in promoting innovation in industry outside the defense and space sectors. A major aim was to improve the competitive position of the United States in foreign markets. A major effort to come up with a comprehensive list of options for possible programs was directed by William T. Magruder, then a White House aide. "The Magruder exercise," as it was familiarly known, sputtered out, a victim, it would seem, of interdepartmental differences and the distraction of the Administration by Watergate.

Some of the ideas bruited about then are likely to come under consideration again. Tax measures, modification of patent and antitrust laws, and programs of direct federal spending on R & D to bolster technological innovation have had proponents for years. And proposals for other sorts of federal incentives—for R & D cost sharing and various kinds of guarantees against financial risk, for example—have been put forward. These ideas and the initiatives taken by foreign governments to stimulate innovation in industry—including Britain, France, and Japan—have been under scrutiny in recent years, with the result that the pros for taking a particular sort of action in many cases are virtually balanced by a set of cons.

At this point, no one is claiming that there is a federal quick fix to the problem of technological innovation. No snake oil remedies are being sold. On the contrary the experts are stressing the complexity of the problem and counseling caution and a modest trial-and-error approach to federal R & D policies. A statement by Mansfield at the conclusion of a paper he wrote at the request of Senator William Proxmire (D–Wis.) for a forthcoming collection on priorities for federal R & D sums up this attitude:

"There sometimes is a tendency to slur over—or perhaps not to recognize—the fact that very little really is known concerning the effects of many of these policy alternatives, or concerning the desirability of their effects. (Indeed, in some areas, no one really knows how to study these questions effectively, let alone provide answers here and now.) Given the current uncertainties, it would seem wise to proceed with considerable caution, and to build into any program the capacity and necessity to resolve many of the key uncertainties before too big a commitment is made." These caveats notwithstanding, what the economists have provided now with their econometric evidence of the substantial social rate of return of R & D, however, is a new justification for federal initiatives.—JOHN WALSH

*Hearings titled *Federal Research and Development Expenditures and the National Economy* before the subcommittee on domestic and international planning and analysis will be published soon and will be available from the House Committee on Science and Technology.

Environmental Research: EPA Plan Termed Myopic

The 5-year research plan prepared by the Environmental Protection Agency is heavily criticized by a group of academic and industrial scientists in a review undertaken for the Office of Technology Assessment.

The chief criticism is that EPA's research is excessively focused on short-term regulatory issues at the expense of longer range research, such as the study of the health effects of low level exposure to pollutants.

EPA research director Wilson K. Talley says he regards the review as useful criticism but that OTA "has faulted me for not taking on all the problems of the environment." Talley declines to characterize the report as either fair or unfair. Phyllis Daly, head of the research planning office that compiled the EPA 5-year plan, describes the OTA review as a "forum for saying that there are many gaps in environmental research—I don't feel that it was really meant as a criticism on the 5-year plan."

Asked about the criticism concerning short-term research, Talley and Daly told *Science* that only $25 million of EPA's research is devoted to short-term projects, whereas $135 million goes to intermediate research and $80 million to long-term projects.

On the other hand Robert Daly (no relation), the OTA project director, responds that his panel members "felt that almost everything identified was short-term. The long-term things which are identified mostly address the development of techniques. We asked EPA for further breakdowns of research categories described in the 5-year plan but they declined to supply them." EPA's Daly denies the charge, saying that OTA was given all the information it requested.

The OTA group notes that environmental factors are now thought to be involved in cancer, heart disorders, and other degenerative diseases, yet present air pollution standards, for example, are almost totally based on the effects of acute exposure to pollutants. What is needed is information about the effects of low level, long-term exposure to pollu-