of the remainder involves exceedingly costly experiments conducted at great distances above the earth. It is of interest, then, to note one facet of the study which can be undertaken at moderate expense in more conventional surroundings.

Plasma technology has advanced rapidly in recent years, to the point where some aspects of the natural phenomena may be modeled on a laboratory scale. The scaling of the processes from hundreds of kilometers in nature to a fraction of a meter in the laboratory is not without its difficulties, and indeed it cannot be carried out for all the relevant parameters simultaneously. Nevertheless, it is possible to separate some phenomena from others, and to scale them individually (see Fig. 4). Even this process is not without its dangers, and results obtained from it can never be considered definitive. But as a complementary program, designed to limit theoretical speculation and influence its course, or designed to suggest modifications in space probes and thereby increase their efficiency, this type of attack has a valuable part to play (*46*).

References

1. L. R. O. Storey, *Phil. Trans. Roy. Soc. London* **A246**, 113 (1953).
2. E. J. Opik and S. F. Singer, *Phys. Fluids* **2**, 653 (1959); F. S. Johnson and R. A. Fish, *Astrophys. J.* **131**, 502 (1960).
3. F. S. Johnson, *J. Geophys. Res.* **65**, 577 (1960).
4. M. Nicolet, *ibid.* **66**, 2263 (1961).
5. W. B. Hanson, *ibid.* **67**, 183 (1962); A. P. Wilmore, R. L. F. Boyd, P. J. Bowen, in *Proc. Intern. Conf. Ionosphere, London, 1962* (1963), p. 517.
6. J. W. Dungey, *Cosmic Electrodynamics* (Cambridge Univ. Press, Cambridge, England, 1958).
7. T. Gold, *J. Geophys. Res.* **64**, 1219 (1959).
8. H. Siedentopf, A. Behr, H. Elsässer, *Nature* **171**, 1066 (1953).
9. L. Biermann, *Z. Astrophys.* **29**, 274 (1951); *Z. Naturforsch.* **7a**, 127 (1952).
10. E. N. Parker, *Phys. Fluids* **1**, 171 (1958); *Astrophys. J.* **128**, 664 (1958); *ibid.* **132**, 175, 832 (1960).
11. J. W. Chamberlain, *ibid.* **131**, 47 (1960); *ibid.* **133**, 675 (1961).
12. J. E. Kupperian, Jr., E. T. Bryam, T. A. Chubb, H. Friedman, *Planetary Space Sci.* **1**, 3 (1959).
13. H. S. Bridge, C. Dilworth, A. J. Lazarus, E. F. Lyon, B. Rossi, F. Scherb, *J. Phys. Soc. Japan* **17**, suppl. A-II, 553 (1962).
14. M. Neugebauer and C. W. Snyder, *Science* **138**, 1095 (1962).
15. S. Chapman and V. C. A. Ferraro, *Terrest. Magnetism Atomospheric Elec.* **36**, 77, 171 (1931); *ibid.* **37**, 147 (1932); *ibid.* **38**, 79 (1933); *ibid.* **45**, 245 (1940).
16. V. C. A. Ferraro, *J. Geophys. Res.* **65**, 3951 (1952); S. Chapman, *Rev. Mod. Phys.* **32**, 919 (1960).
17. J. W. Dungey, in *The Physics of the Ionosphere* (Physical Society, London, 1955), p. 229.
18. F. S. Johnson, *J. Geophys. Res.* **65**, 141 (1960).
19. J. H. Piddington, *ibid.*, p. 93.
20. D. B. Beard, *ibid.*, p. 3559; *ibid.* **67**, 477 (1962); J. E. Midgley and L. Davis, Jr., *ibid.*, p. 499; R. J. Slutz, *ibid.*, p. 505; J. R. Spreiter and B. R. Briggs, *ibid.*, p. 37; J. R. Spreiter and B. J. Hyett, *ibid.* **68**, 1631 (1963).
21. H. Alfven, *Cosmical Electrodynamics* (Clarendon, Oxford, 1950).
22. K. G. McCracken, *J. Geophys. Res.* **67**, 435, 447 (1962).
23. P. J. Coleman, Jr., L. Davis, Jr., E. J. Smith, C. P. Sonett, *Science* **138**, 1099 (1962).
24. V. N. Zhigulev, *Soviet Phys. "Doklady" (English Transl.)* **4**, 514 (1959).
25. W. I. Axford, *J. Geophys. Res.* **67**, 3791 (1962).
26. P. J. Kellogg, *ibid.*, p. 3805.
27. J. W. Dungey, *Phys. Rev. Letters* **6**, 47 (1961); *J. Phys. Soc. Japan* **17**, suppl. A-II, 15 (1962); *Plantary Space Sci.* **10**, 233 (1963).
28. L. J. Cahill and P. G. Amazeen, *J. Geophys. Res.* **68**, 1835 (1963).
29. W. G. V. Rosser, B. J. O'Brien, J. A. Van Allen, L. A. Frank, C. D. Laughlin, *ibid.* **67**, 4533 (1962); J. W. Freeman, J. A. Van Allen, L. J. Cahill, *ibid.* **68**, 2121 (1963).
30. J. A. Van Allen and L. A. Frank, *Nature* **183**, 430 (1959); S. N. Vernov, A. E. Chudakov, P. V. Valukov, Y. I. Logachev, A. G. Nikolaev, in *Artificial Earth Satellites* (Plenum, New York, 1961), vols. 3–5, p. 503.
31. J. P. Heppner, N. F. Ness, C. S. Scearce, T. L. Skillman, *J. Geophys. Res.* **68**, 1 (1963).
32. W. I. Axford, *Can. J. Phys.* **40**, 654 (1962).
33. M. S. Bobrov, *Soviet Astron—AJ (English Transl.)* **4 (1960)**, 392 (1961); N. Fukushima, *J. Phys. Soc. Japan* **17**, suppl. A-I, 70 (1962); J. A. Jacobs and K. Sinno, *J. Geophys. Res.* **65**, 107 (1960); Y. Kato and T. Saito, *J. Phys. Soc. Japan* **17**, suppl. A-II, 34 (1962); P. A. Forsyth, F. D. Green, W. Mah, *Can. J. Phys.* **38**, 770 (1960).
34. A. J. Dessler and E. N. Parker, *J. Geophys. Res.* **64**, 2239 (1959); J. H. Piddington, *ibid.* **65**, 93 (1960).
35. A. J. Dessler, *ibid.* **66**, 3587 (1961); *ibid.* **67**, 4892 (1962).
36. P. J. Coleman, Jr., and C. P. Sonett, *ibid.* **66**, 3591 (1961).
37. W. I. Axford and C. O. Hines, *Can. J. Phys.* **39**, 1433 (1961).
38. J. H. Piddington, *Geophys. J.* **3**, 314 (1960).
39. J. A. Fejer, *Can. J. Phys.* **39**, 1409 (1961).
40. ———, *J. Geophys. Res.* **68**, 2147 (1963).
41. S. I. Akasofu and S. Chapman, *ibid.*, p. 125.
42. T. Gold, *ibid.* **64**, 1665 (1959); J. F. Steljes, H. Carmichael, K. G. McCracken, *ibid.* **66**, 1363 (1961).
43. B. Bell, *Smithsonian Contrib. Astrophys.* **5**, 69 (1961).
44. D. H. Jelly, *J. Geophys. Res.* **68**, 1705 (1963).
45. P. Rothwell, *ibid.* **64**, 2026 (1959); T. Obayashi and Y. Hakura, in *Proc. Intern. Space Sci. Symp., 1st, Nice, 1960* (1961), p. 665.

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News and Comment

Education Aid: University Survey Finds That Despite Difficulties, U.S. Programs "Highly Beneficial"

One of the myths surrounding federal support for university research and education is that government money is trouble in disguise.

Magnified bits of evidence, and an occasionally egregious case, exist to support this myth; and now and then a university administrator will drop out of the grants derby to issue an alarm on the perils of federal aid, thereby breaking into the popular prints and confirming the preconceptions of those who oppose a larger federal role in university finances. Nevertheless, when the pains of federal aid are compared with its benefits, it appears that the unhappy side effects have often been overemphasized while the extremely useful achievements have come to be taken as a matter of course. Such a comparison is contained in a study issued this week by the American Council on Education; hopefully, it will serve to increase the amount of realistic thinking that goes into discussions of what role the federal government is, and should be, playing in the support of the nation's universities.

The study, "Twenty-six Campuses and the Federal Government," was conducted by the Carnegie Foundation for the Advancement of Teaching. It is contained in a special issue of *The Educational Record*, available for $1.50 from the Publications Division, American Council on Education, 1785 Massachusetts Ave., NW, Washington 36, D.C.

Prepared by an advisory committee chaired by Nathan M. Pusey, president of Harvard University, the report is a compilation of "self-studies" by 26 fairly representative institutions on their involvement with the federal government. Although it is somewhat dated, covering the years 1959–60, it is prob-

ably the most illuminating body of information now available on the subject, and it is probably safe to say that the conclusions presented by the institutions would hold up pretty well today.

There *are* problems, the report points out, in heavy reliance on federal funds, but among the 26 institutions—which together received some 28 percent of all federal research funds given to universities in the years under study—"the effects have, on balance, been salutary." These include enlargement and improvement of research facilities, better faculty salaries, and expanded opportunities for graduate students and postdoctoral fellows.

Appraisals from individual institutions included the following:

Princeton: "The opportunity to make expenditures of this size has permitted a research effort far superior to anything that could have been done without recourse to government sponsors—this is the emphatic opinion of the chairmen of those departments that have been most directly involved in spending these sums."

Harvard: "It does not seem too much to say that scientific investigation at the present level in the Faculty of Arts and Sciences and the three schools in the medical area could not be carried on without the support of the federal government. Funds of the magnitude required are simply not forthcoming from any other source."

University of Louisville: "Most important of all is the fact that federal funds have helped establish an academic climate which stimulates instruction and research to new interest and vigor, and establishes a generally greater appreciation of and support for scholarly pursuits."

University of California, Davis: "The great influx of graduate students (in turn referrable to the existence of federal programs) has contributed to the institution of formal graduate courses and entire curricula which could probably not have developed so soon under the normal State budget allocations."

While emphasizing the bright side of federal support, several of the institutions acknowledged that the lure of federal funds has had a questionable effect on motivations for pursuing a particular line of research. "Faculties tend to submit proposals in subject areas known to be well financed and to design them in anticipation of the evaluation process by given federal agencies . . . ," Syracuse reported. "Research efforts are influenced by the 'easy' dollar. If the research is sound and basic, if it falls well within the general program, aims, and objectives of a department, little but good results. If and when programs within a department show a tendency to become too narrow, or to progress spirally from a broad circumference to a small center, instead of in the opposite direction, then concern should be felt and corrective university action taken."

Similarly, the statewide report of the University of California noted that "the availability of . . . support in specific disciplines has certainly had an influence on research in unsupported areas. Where possible, programs have been shifted in objective or area so as to meet the requirements for support. There has been some loss in the full freedom of faculty to choose their field and at the same time meet the panel or grant requirements. In addition, a well-supported research area is difficult to abandon in favor of a new area with unknown support."

Indirect Costs

The institutions participating in the study also raised the long-standing and thorny issue of indirect costs—that is, costs which arise as a result of research activities but which are not fully reimbursed by the government. Just about everything that can be said on this subject has been said in repeated efforts to get Congress to raise the present ceilings on indirect costs. [For the Department of Defense and the Department of Health, Education, and Welfare (which includes NIH), the ceiling is 20 percent; for NSF and NASA, it is 25 percent.] But Congress is first of all simply not convinced that the indirect costs are as high as the universities allege them to be; in addition, despite dire predictions about universities being unable to accept research projects with inadequate reimbursement of indirect costs, Congress has yet to see any significant decline in grant applications. Several of the respondents in the survey pointed out, though, that the effects are likely to be more subtle. "As federal contracts grow in number," the University of Pennsylvania stated, "if indirect costs are not completely covered, programs not supported by the federal government will inevitably suffer as university funds must in effect be withdrawn from their support."

Harvard reported that "problems of balance . . . arise when a university is not only heavily supported by govenment funds but finds in addition that its non-government sources of income must be committed increasingly to support its government programs. Harvard, for example, pays its tenure faculty from university funds almost without exception. This policy is jeopardized when non-restricted funds must go to provide facilities necessary to support government research programs."

However, other institutions expressed doubts that imbalances are uniquely attributable to the indirect-cost problem or the federal government's emphasis on support of sciences to the exclusion of other fields.

"In general," Cornell stated, "federal funds have shown up in areas in which an expansion and a change from an earlier balance would have been inevitable, because of the demands of the public for teaching and research in these fields." And Notre Dame reported that "Certainly government research programs create imbalances within and between departments but so do many other influences at work within a university. Predominant among these other influences are the relative impacts of the leadership in developing departmental programs. It is a serious matter to lay the dead hand of administrative control on the ambitions of faculty members rising to the challenges and opportunities provided both by government and non-government support. In other words, imbalances must be lived with and made the most of, if a level of uniform mediocrity is not to prevail."

Harassments

The most damning statement against federal practices came from an unnamed university which reported that it "is currently being harassed by the Department of Defense through the device of sending as auditor to the university a person with no understanding or concern whatsoever with a university's objectives, problems, or policies. Although the former resident auditor had gone over all our books, this man is doing it all over again and questioning, ad infinitum, matters of judgment on expenditures for a few stamps, travel to pick up a visiting scientist at the railway station, etc., going back as far as seven years, looking into contracts presumably closed where the principal investigator is frequently no longer with the university. . . .

"The university does not intend to maintain an accountant at the elbow of each principal investigator, and the university does not intend to cripple its research program by having each re-

search project operated as a completely separate operation where every stamp, test tube, etc., is meticulously charged to the proper budget. . . ."

When viewed against the tradition of the sanctity of the university, these very real irritations tend to take on a significance that is quite probably out of proportion to the actual significance of the federal-university relationship. Without doubt, there has been altogether too much all-thumbs handling of universities by federal agencies, but, as the report points out, "on balance, . . . federal support of project research is a highly beneficial feature of the postwar educational scene. Without it, . . . the whole character of many universities' research programs (and, in consequence, of their instructional programs) would change. Faculties, in many instances, would shrink. Many research efforts would have to be abandoned completely. Others would be sharply curtailed."

Of course, it would be useful, the report implies, to eliminate all nitpicking in federal surveillance of grant expenditures, but, more fundamentally, there is a need to reappraise the overall relationship between higher education and the federal government; for, as is pointed out, a great many of the most vexing difficulties arise from the fact that while Congress adamantly holds a narrow view of the justification for giving money to universities, grant funds have come to play a broad role in university finances.

"Today," the report notes, "the expenditures of most federal dollars—in instructional areas as well as in the dominant area of scientific research—are justified on grounds of the very specific, very immediate national needs they will meet. But would it not be wiser, asked many institutions participating in this study, for federal programs to be founded on the recognition that the *strengthening of higher education* is itself a pressing, perhaps *the* pressing, national need that justifies the government-campus relationship?"
—D. S. GREENBERG

Foreign Research: U.S. Agencies Take Steps To Limit Their Support for Programs Carried Out Abroad

The administration's effort to reduce dollar expenditures abroad are beginning to be felt by federal agencies that support research in foreign countries.

Tentative plans call for NIH, which is the largest single supporter of dollar-financed foreign research, to halt the annual growth of its overseas program and hold to the current level of about $15.5 million. Since 1960, the program had grown by at least 20 percent a year. Meanwhile, the Defense Department, which supports some $7 million of foreign research, has preliminary plans for reducing this total by 50 percent over a 3-year period. In addition, foreign grant recipients have been told that when funds are provided for equipment, it is desirable that the purchases be made in the United States. There is no hard and fast policy on this, and when prices here are higher by 50 percent, exceptions are likely to be made, but the trend is to apply pressure to encourage the spending of American dollars in the United States.

The effort to reduce foreign research expenditures is being conducted with a good deal of caution and delicacy; this has not always been the case in other efforts to cope with the balance-of-payments problem. For example, suddenly imposed restrictions on sending military dependents abroad unquestionably improved the balance sheets but had painful effects on service morale. However, in the case of foreign research, the amounts of money are relatively small as compared with the overall payments problem, thus there is no incentive for fast, large cuts. But perhaps even more important, the government's science advisory apparatus has been closely consulted to determine the least harmful approach to reducing expenditures. Along the way, serious consideration has been given to the fact that while the sums under scrutiny are only a small fraction of the payments deficit (as well as a small fraction of U.S. research expenditures), they are quite significant in foreign research budgets. (Sweden, which spends some $25 million of its own funds in the biomedical sciences, receives about $1.4 million annually from NIH.) Initially, the Bureau of the Budget spoke of an immediate 50 percent across-the-board reduction in foreign research expenditures, but it is now generally thought that this figure was thrown out more for the purpose of inspiring shock and careful thought than as a serious proposal. In any case, while the goal of reducing, or at least not enlarging these expenditures, is now accepted, the details are being closely supervised by the State Department's Office of International Scientific Affairs, the White House Office of Science and Technology, and the agencies immediately involved.

The balance-of-payments problem has developed because Americans spend more abroad than foreigners spend in this country, with the result that the deficit totaled some $2.2 billion in 1962. Since dollars held abroad must be exchanged for gold on demand, the imbalance presents a threat to the United States gold reserve and, ultimately, to confidence in the value of United States currency. As a result, the administration has been pressing all agencies to reduce their expenditures overseas, and the overall foreign research budget—estimated to be at least $25 million annually—has accordingly come under scrutiny. The changes are expected to take place in the fiscal year that started this month.

The basic principle underlying the reduction in expenditures is that existing work will not be interrupted and that future commitments will be honored. In line with this, NIH foresees no abrupt changes in its overseas programs, outside of a departure from the annual growth which has regularly taken place. However, the Air Force and the Army, which support a good deal of foreign research, particularly in western Europe, are tentatively headed for a major reduction in overseas research. Final plans are yet to be approved by Defense Secretary McNamara, but, as now formulated, they call for reducing current expenditures to 90 percent in the current fiscal year, to 70 percent the second year, and to 50 percent the third year. The Department of Agriculture, which is also a major supporter of foreign reseach, finances the bulk of its activities with foreign currencies obtained through the sale of surplus farm products. The use of these funds is not affected by effort to reduce the dollar drain. However, this has little effect on NIH and the Defense Department, since most of their research is conducted in nations outside the surplus food program.

According to persons administering the NIH and Defense programs, the result of the reductions is going to be that increasingly higher standards will be applied to foreign grant applications. They already are supposed to be judged by far stricter standards than their U.S. counterparts. "It's going to be even tighter from now on," according to one NIH official.—D.S.G.