

By T. H. Johnson

MORE than any other government agency, the AEC relies upon other people to do its work. The AEC has only 6000 employees, almost none of whom engage in technical work. Their function is to arrange for, and coordinate, the work of more than 80 000 employees of operating contractors, not to mention the construction. The atomic energy job is being done by American industry and American science—both operating in more or less their normal patterns.

The scientists of the nation have, of course, played a critical role in the atomic energy program. Moreover the southern institutions have borne a very significant share of the burden. Through their institutional research programs they have helped solve many critical technical problems and their educational programs have supplied scientifically and technically trained men and women. Their assistance to, and participation in, the Oak Ridge program through arrangements set up by the ORINS have been especially significant. No single individual knows the extent of those contributions nor would time permit their being listed. The contributions have been substantial, they are recognized and appreciated, and the AEC is counting on the continuing help we all know it is going to need, and get, from the scientists of the Southeast.

Not only have Southeastern scientists been a significant factor in the AEC program, but I think most would agree that the needs of the AEC and the response of scientists to those needs, have been significant factors in the development of the institutions of this region. The universities have always been responsive to the needs of society. Through their organization of the Oak Ridge Institute of Nuclear Studies and in many other ways the universities of the Southeast have responded to the needs of the atomic energy program. Scientists are also attracted into fields where their talents can be most effectively employed. Many of the great advances in our science resulted from economic or military needs for more extensive knowledge. Each such period of growth advances our capability to make new progress. Facilities become enlarged and improved, new instruments and techniques for scientific study become available, the frontier becomes lengthened from which new salients into the unknown can be launched, and we gain faith in the practical effectiveness of the methods of science for extending our control over nature.

To the university such periods of scientific progress bring improved facilities and equipment, new diversifications in their programs, livelier interest in learning, and greater responsibilities to society and the succeeding generations. These factors spell health, vitality, and growth. Everyone of the universities and colleges in this region must have experienced these effects of the atomic energy program to some significant degree. Many insti-

tutions are eagerly studying the situation as it develops in order to perceive as far in advance as possible what part they may be destined to play in the national effort to develop atomic energy for the use of mankind.

In furthering its own program the AEC is not unmindful of either its dependence on, or its effect on, the universities and their departments of science. Changes in these institutions have taken place in response to pressures of the program and there will continue to be stresses, as there always are during the periods of growth. It is not always possible to foresee these effects nor to optimize them.

The effects of the various programs of sponsored research on the well-being of the universities have been the subject of study and perhaps of concern on the part of both the institutions and the government. Commissions to study these effects have been sponsored by the Association of American Universities and by the American Council on Education, both of which have made reports. Last December the National Science Foundation appointed a Committee to consider the effects of government support to colleges and universities on their research and teaching functions. The AEC's program of research in the universities is an important aspect of the problem these groups are considering, and we are following with interest the facts and recommendations which these studies develop. Naturally the problems are involved and may not have unique solutions. Moreover we cannot call a halt to the program while these studies are carried on. After all, the conclusion may very well be reached that the interests of all concerned in a rapidly evolving situation are best served by giving free reign to the natural interplay between program requirements on the one hand and the abilities and desires of the scientists to carry out needed investigations on the other. Let us therefore turn our attention to program requirements.

In the atomic energy program research plays an important role. The industrial operations were set up at the inception of the program in great haste and they have been expanded rapidly in the face of urgent requirements for more fissionable materials. The particular processes chosen for the first production plants were the best of those known at the time, but further research has resulted in many improvements and replacements. There are still opportunities for further improvements to be achieved through the acquisition of additional basic data and a better understanding of the phenomena involved. The progress of other nations and the burden of the program on the American taxpayer provide strong incentives to improve the product, to accelerate production, and to reduce the cost. The responsibility falls upon the research laboratories, as well as upon the production plants; we must not only in-

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geniously apply what is already known but we must also seek to increase fundamental knowledge in fields of science which have a bearing on the program.

Fortunately the framers of the Atomic Energy Act realized that further research was desirable. The Act directs the Commission to insure the continued conduct of research and development by both public and private institutions and to assist in the acquisition of an ever-expanding fund of theoretical and practical knowledge in fields related to atomic energy. The Act authorizes the Commission to make contracts, loans, and other arrangements for research and development. Certain fields of research are prescribed within which the Commission has special responsibilities. These include nuclear phenomena, the processes and materials of use in the project, the uses of radioisotopes and other by-products, and the protection of health during research and production.

In order to understand the position of Research in the AEC Program it is important to know a little about the organization of all of the Commission's activities. In the main, these are carried out under contract with private organizations. The Commission's responsibilities for policy forming and financial planning are administered from Washington by several Divisions, each under a Program Director, who reports to the General Manager. There are programs for the procurement of raw materials, for the production of fissionable materials, for the development and fabrication of atomic weapons, for the development of reactors, for physical research, for the protection of health during operations and for research on the biological effects and uses of radiation and radioactive materials. The physical research program is the one to which most of my remarks will relate.

It is important to note that the research program has its own budget which is defended before the Bureau of the Budget, and before Congress. Within the organization of the Commission the Director of Research is coordinate with the Director of Production and the Directors of the other Programs. This provides the same independence for research which has been found most effective in the more progressive industrial companies.

The Physical Research Program includes activities in physics, chemistry, and metallurgy. The Research Division has a Branch devoted to each of these subjects. The program is intended to be farsighted and to encompass investigations and developments which would be overlooked by those responsible for meeting production schedules or other short-range goals. The objectives of the Research Program are: (1) to increase basic knowledge which will be a foundation for future developments in the use of atomic energy, (2) to gather data needed for more effective engineering design, and (3) to make technical evaluations of possible new processes. Important by-products of the research programs

are the men who receive scientific training while engaged in research. We try to be farsighted but we have no other motive than to advance the program. We recognize the value to society of supporting research from the point of view of advancing general scientific knowledge and we believe that such support could not fail in unforeseen ways to benefit our program. We therefore look forward to the day when the National Science Foundation can give increasing support to institutional research. However it is unlikely that the Science Foundation would ever give the emphasis to investigations related to atomic energy that appears necessary to those of us who are responsible for the AEC program. The AEC will continue with its present plan to support such investigations.

Twenty-eight percent of the budget for research is for off-site projects—that is, projects conducted in the main by university laboratories. The balance is spent at AEC laboratories: Brookhaven, Argonne, Oak Ridge, Berkeley, and Ames. In the off-site program ninety different universities and research institutions are engaged in 250 separate research projects. In addition to these the ONR administers forty contracts in nuclear physics to which the AEC contributes half of the costs. The university contracts are mainly for unclassified basic research in which graduate students can participate although some applied research is involved and some of this work is carried on under security regulations. The national laboratories have additional responsibilities for production process development, for reactor development, for weaponry, and for programs in biology and medicine. In these laboratories research is intermingled with production and development. But it stands along with those activities on its own budget as a fully authorized activity in its own right.

In the time available I can give no more than a vague impression of the scope of the Research Program. In general the investigations are intended to contribute to progress in fields related to atomic energy. These fields include all aspects of nuclear physics; the properties of elementary particles; techniques involved in nuclear research; the physical, chemical, and metallurgical properties of special materials used in atomic energy, such as U, Pu, Th, Zr, Hf, Na, graphite, boron, fluorine, the rare earths, and a host of other elements, compounds and alloys; the geochemistry and geophysics related to finding ore; the chemical and metallurgical effects of radiation on materials; the use of radioisotopes in chemistry and the use of chemistry in studying radioisotopes; finally, problems related to processes for pro-

T. H. Johnson, director of research for the Atomic Energy Commission since 1951, was formerly chairman of the physics department at Brookhaven National Laboratory. He is a Fellow of the American Physical Society.

ducing or using special materials such as those for treatment of ores, isotope separation, and the separation of elements produced in the piles. All of these topics relate directly to atomic energy. Many of them, although quite specifically related to current developments, are of basic interest. For example, studies of the decomposition of water by radiation, although of basic interest to the chemist, is also related to the corrosion of fuel tubes in water-cooled reactors. The measurement of neutron resonances contributes to the theory of nuclear structure and is also related to such practical matters as the calculation of the uranium requirement for reactors which are still on the drawing boards.

It is, of course, not possible to predict what the practical consequence of basic research will be. It is possible, however, to define fields for free basic research in which the results can be expected to have a high degree of relevance to the practical objectives of the program, and it is important to gain as complete an understanding as possible of such fields. This requirement is analogous to the highway engineer's need for a complete map of the territory through which he must lay out a road. It is not enough to know a possible route. He must also know that a better route is not just over the ridge.

It has been encouraging to find, in the Commission, at the Bureau of the Budget, and in Congress, that research is understood as something that must be done if we are to keep a healthy and progressive program, that there is an appreciation that the most rapid progress results from the use of the established methods of scientific reasoning, that there is no pressure to confine or stultify the aims of research, and that funds can be made available, frequently in large amounts, to provide facilities and operating expenses for investigation that our scientists themselves regard as fundamental and basic, and wish to carry out in the best traditions of our science.

We have had considerable success in the atomic energy program in acquiring facilities which are necessary to press forward into new and otherwise inaccessible areas of research. Usually no specific practical consequences can be promised of these facilities and no such promises are required. It is enough that they are needed for meaningful research in a field which our best scientists regard as most promising, and in which lie some of the unanswered questions related to the program. In this category I can cite the Argonne and Brookhaven reactors, the Brookhaven cosmotron, the Berkeley bevatron, the new AGS accelerator at Brookhaven, and the new linear accelerator at Minnesota.

Many facilities have been placed in university laboratories, while others have been constructed in the National Laboratories. An important element in the location of a large research facility is the ability of the laboratory to construct and use it to best advantage. Often such facilities can help maintain the vitality of the program of a National Laboratory and promote close liaison with other research activities in fields of interest. The Commission's policy is to strengthen these laboratories

and to make them more effective ties between the atomic energy program and the scientific community. The cooperation of university scientists in the programs of the National Laboratories has already proven of enormous benefit to the AEC. When imaginative research projects are centered in the National Laboratories the practical program is put in close touch with the frontier of science so that any practical consequence of the research findings will be quickly and effectively incorporated as an improvement in the program. Moreover, program personnel are made more alert to possible new developments through contact with fundamental research projects. For these reasons we have been *more* successful and have been able to go *much* further in providing modern facilities for research in AEC laboratories than could possibly have been provided at university sites alone.

Often the universities can do the jobs cheaper and better; and students trained in the program are an extra bonus to the operation. For these reasons many cyclotrons, betatrons, synchrotrons, and Van de Graaffs have been placed in the university laboratories. These have paid off handsomely to the program in new data and in trained men, and they have greatly strengthened the research and teaching of the institutions. Knowledge in fields of interest to the AEC has increased and the university scientists have maintained a helpful interest in the problems of the AEC.

I believe, too, that the sponsorship of institutional research in furtherance of the practical goals of the AEC is not contrary to the lofty aims of the academic scientist. The possibility of useful application is always an added incentive to discovery. Every research man takes pride in making natural phenomena more useful as well as more understandable. What the true scientist would resent is to have to apply the criterion of usefulness in planning his research program, and this we try to avoid. Obviously scientific exploration is more effectively carried on, whatever its ultimate motive, when the recognized methods of scientific reasoning are used. These methods give no consideration to possible applications of the findings.

This duality of the purpose of research has made it possible for the universities and the AEC to work together on programs of mutual interest. The AEC is interested in the acquisition of knowledge which may be usefully applied, while the academic scientist is interested in the pursuit of knowledge for its own sake and as a means of training students. In sponsoring these projects the AEC recognizes that a free rein to the scientist usually results in the most abundant yield of new knowledge. Without relaxing our interest in the results we believe that the scientist and his institution will provide the most effective direction of the work. For best results the program in an institution should develop gradually with a high degree of local interest. Without local interest on the part of both administration and scientific staff the investment of government funds would be neither profitable to the American taxpayer nor health-giving to the institution. To merit AEC assist-

ance the institution should have adequate scholastic standards, it should provide its faculty with free time for study, it should attract good students, and it should have a library, laboratories, and other facilities. In short it should already have a research program.

When, in 1948, the AEC began assisting university research projects it was thought that adequate assurance of the institution's self-interest in research proposed for AEC support could be had if the AEC should insist that the institution pay a substantial share of the costs. The AEC would assist going programs in its fields of interest to which university funds were already committed. Certain standards of participation were set up requiring the institutions to pay at least the academic year salaries of their staff, the overhead in excess of eight percent and other amounts so that its total contribution would at least equal the value of the equipment procured for carrying out the contract. These standards worked very well with the average university. They discouraged those institutions that had had no experience in research from starting projects incompatible with their educational functions, and for those which had going research programs of modest size the additional funds allowed a desirable program expansion. Under this policy, however, it was not possible to contract for research in the larger university research centers. These institutions were already stretching their budgets for research to the breaking point. Moreover they were also carrying heavy programs under sponsoring arrangements that paid the full costs. They had no uncommitted funds and they were unable to carry on more research unless the full costs were reimbursed. These were the places to which the government and industry had first turned for scientific help. They had proven ability and impressive records and they had learned how to integrate research with teaching. Many of their scientists had helped with the atomic energy program in the early days before Hiroshima. It was important to the AEC program to continue to receive the help of these institutions in the field of nuclear research. Therefore, exceptions to the policy had to be made. As the level of sponsored research has risen other institutions have gradually expanded their research programs and we are finding them in the same situation. We cannot do without their help and they are finding that research at the levels now reached can no longer be supported in full or in part by income from fees and endowments. It is a situation which seems to befall any institution when its research program increases in size. The alternatives are lower levels of research or fuller payment of costs. While some voices are raised against perverting the normal function of the university through too much research, the majority feel that educational opportunities are at their best where research is most active. We are gradually moving into an era where many American universities are more vigorously assuming the coordinate roles which have long been traditional both in Europe and in some American universities: to increase knowledge and to spread knowledge. To effectively carry on their role in research at the levels

reached in some institutions it is no longer possible to conceive of research as an avocation of the professor which can be carried on after regular hours with equipment procured from the normal department budget. Research has outgrown that position and it stands in many universities along with teaching as a primary function of the university. Without losing the close interplay between research and teaching, research must have its own independent source of support. In the universities where research has reached this stature those who want the research done must pay the full bill. On the other hand, in those universities where research has not yet developed it must get its start according to the normal growth cycle with a high degree of local support, and self-motivation. In the more hopeful of those situations the AEC can give encouragement through partial support.

To keep up with the trend the AEC has modified its contracting procedures so that it can now arrange for research which is needed in the AEC program on terms which most institutions can accept. For contracts which are less than \$100 000 per year—and these are in the majority—the AEC now makes a lump sum payment in consideration for carrying out the program and submitting a report. The AEC payment is intended to cover the difference between the total costs and what the university is prepared to undertake with its own resources. The institution's estimate of the indirect costs is recognized as one of the components of the total cost to which the AEC makes a contribution. Equipment purchased for carrying out the project can be left with the institution, if the institution has contributed to the costs of the project in an amount equal to its residual value or if it agrees to report on the results of work for which it is subsequently used. The amount which the AEC is willing to contribute is based upon our appraisal, assisted by advisers, of the ability of the investigator, the relevance of the work to the atomic energy program, and the environment for research at the institution.

The AEC must at all times guide its activities towards the objectives of its program. These objectives encompass the development and use of atomic energy, now and in the future, for the defense of America and the betterment of mankind. We will look to the National Science Foundation to progressively assume increasing responsibilities for the support of basic research when we cannot see its close relation to the AEC mission. However, in a development as important and as close to the frontier of science as ours is we must not be narrow-minded or shortsighted in restricting the scope of our scientific investigations. Moreover we must make maximum use of the best facilities and the best talents wherever they may be found. We seek the help of scientists in the universities to carry out many of these investigations and we also solicit their suggestions and advice on the assignment of problems for investigation. Our contracts are intended to help a university scientist carry on in his own laboratory a research program that he is prepared to undertake, when it lies in a field of interest to the AEC.