Office of Ordnance Research, 2127 Myrtle Drive, Durham, North Carolina

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ONE OF SEVERAL sub-themes that have been considered from time to time in these Washington Reports is the support of basic research by agencies of the Department of Defense. Previous articles of this nature appearing in *Physics Today* have described the work of one particular Navy office (September, 1951) and of a major Navy contractor (February, 1952). The present discussion, which extends the story to another branch of the Armed Services, concerns the Army's Office of Ordnance Research (OOR). Let me first state very briefly the "what, why, where, and when" of OOR and then take up in greater detail the thinking behind its organization and the nature of its program. The Office of Ordnance Research is established under the command of the Chief of Ordnance, U. S. Army, to have responsibility for instituting and administering contracts for basic research in fields of Ordnance interest. It is located on the campus of Duke University, Durham, North Carolina, and officially began operation during June 1951. The Commanding Officer of OOR is Colonel Walker W. Holler and its Chief Scientist is Dr. T. J. Killian, until recently Deputy Assistant Chief for Research, Office of Naval Research.

The Army Ordnance Corps has carried on a research and development program for many years with approximately ten per cent of the effort going into what might be called basic or semi-basic research. Prior to establishment of OOR, the work had been done almost entirely by the Corps' eight major manufacturing arsenals and the Ballistics Research Laboratory; each of these has an established scientific staff and has carried research and development responsibilities for a given subject area. All of this investigation, however, has been tied quite specifically to Ordnance end items—where the term "ordnance" as used in the Army Corps includes guided missiles, army aircraft, tanks, transportation vehicles, atomic energy applications, and fuels and lubricants, in addition to conventional guns and ammunition. Under this program, basic research projects necessarily were carried at a relatively low priority and had to be linked with definite ordnance uses somewhat more closely than always was desirable.

Recognizing the important role played by fundamental research in the advance of technical knowledge—both pure and applied—the Army Ordnance Corps realized a year or more ago the desirability of setting up within its organization a unit whose sole concern would be basic research which, although in fields of Ordnance interest, would be free from the necessity of direct, immediately foreseeable application to specific Ordnance end items or programs. Major credit for the creation of the Office of Ordnance Research as such an agency belongs to Brigadier General Leslie E. Simon, Chief of the Research and Development Division, OCO, himself a mechanical engineer known for his supersonic and hypersonic wind tunnel programs.

The basic organizational pattern is one in which the Office of Ordnance Research administers fundamental research programs carried out under contract with OOR by qualified private research institutions—mostly universities. The OOR itself is composed of two main groups—one military and the other scientific. The former is small, consisting of but five officers, and is concerned chiefly with the agency's nontechnical activities such as contract negotiation, fiscal operations, personnel administration, and the like. The scientific group, which includes fifteen scientists, comprises four major divisions—Mathematics, Physics, Chemistry, and Special Projects. The over-all administrative staff totals some twenty individuals. Library, translation and other similar facilities are provided by Duke University upon whose campus OOR's headquarters are located (see cut). Although these services constitute the University's only official connection with OOR, the staff of the latter enjoys all the privileges of the University faculty including access to the scientific research laboratories for OOR scientists who wish to devote a portion of their time to personal experimental research.

Any qualified research institution may propose basic research projects for inclusion in the OOR program. Fields in which research can be supported are limited only by the requirement of Ordnance Corps interest. As implied above, however, this condition is interpreted rather broadly, so that many basic areas of physical science and mathematics are deemed pertinent. In this

OF ORDNANCE RESEARCH

By ***Dwight E. Gray***

connection, one of the Corps' brochures on OOR states, "Routine basic work of sufficient scientific merit and Ordnance interest may be sponsored but off-the-beaten-path proposals which combine scientific soundness with a high degree of originality are particularly sought. The policy is to obtain a wide distribution of truly basic (and therefore usually moderate-sized) research projects among many institutions. In general, no one investigator will be assigned more than one project and no one institution more than $100,000 in the program. It is particularly desired to avoid situations in which the welfare of any one investigator, department, or institution depends substantially upon continued Ordnance Corps support." Projects may be for periods of one to several years with the possibility of renewal if the work appears to merit continuation. Financing, however, is presently limited to yearly approval of continuation, subject to availability of funds.

Selection and evaluation of research projects involve two fundamental criteria—Ordnance interest and scientific merit. Regarding the first, certain general ground rules have been established to be used in recognizing Ordnance pertinence; these, in summary form, concern the relation of the proposed basic research project to (a) applied fields in which Ordnance problems have been frequent in the past, (b) possible radically new and better devices or methods, (c) unique Ordnance skills or facilities, and (d) crucial areas on the periphery of scientific knowledge where results are likely to be of great importance to military or other human affairs. The question of specific subject fields of Ordnance interest was approached by asking each of the arsenals and the many scientists, engineers, and officers in the Ordnance Corps to submit ideas as to the general subject areas in which basic research might be expected to further Ordnance development.

Evaluation of research proposals with respect to the second fundamental condition—scientific stature—is carried out with the assistance of a committee of the National Research Council set up for this purpose. This group, mentioned briefly in an earlier article in this series (*Physics Today*, January 1952, page 23), is composed of two members each from four of the Council's scientific divisions and is headed by the Chairman of the Division of Physical Sciences. Each OOR proposal submitted to it is sent to three referees selected by the Committee on the basis of competence in the field of the proposed project and willingness to serve in this capacity. The referees' opinions, together with the Committee's own analysis of the proposal and independent appraisal by Ordnance arsenal research scientists, form the basis for its evaluation by OOR. Specific points considered in the over-all judgment of any specific proposed project are (a) scientific merit and originality, (b) qualifications of the proposed investigator, (c) probability of success, (d) extent to which the project is likely to contribute to the training of young scientists, and (e) the long-range usefulness of the work to the Ordnance Corps.

The complete list of topics of Ordnance research interest as prepared by the OOR is much too long to reproduce here. Any research institution interested in seeing it should write directly to the OOR address given at the end of this paper. The following major subject divisions, however, together with a few sample topics, will give some idea of the specific nature and the potential scope of the OOR basic research program:

EXPLORATORY BASIC ORDNANCE RESEARCH—including decomposition of nitrated compounds; new approaches to improved high explosives; synthesis of hydrocarbons, acids, phenols, etc.; study of metal structure by proton and neutron diffraction; ultrasonics; high temperature and pressure phenomena; flame spectra; quantum electrodynamics; and so forth.

BALLISTIC BASIC RESEARCH—including statistical study of accuracy of observational data; mathematical methods involved in weapon effectiveness; magnetic high-speed internal memory systems; electromagnetic propagation through the atmosphere; thermal decomposition mechanisms; air blast wave phenomena; basic measuring techniques; missile fragmentation; atmospheric optics; and so forth.

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MATERIALS AND CONSTRUCTION BASIC RESEARCH—including study of metal structures; factors which influence bend strength characteristics; rapid heating; ultrasonic vibration effects in cold welding of metals; metallography of various adherent coatings; principles of adhesion of erosion resistant coatings on passive metals; magnetic characteristics of Ordnance steels; thixotropic phenomena; equilibria and reactions in the solid state of metals; effect of chemical structure of organic liquids on physical properties; infrared absorption of propellent compounds; physical constants of lubricants at low temperatures; and so forth.

COMBUSTION BASIC RESEARCH—including a variety of problems in physics and in physical and organic chemistry.

In February 1951, letters were sent to some 70 universities outlining topics of interest to the Ordnance Corps and encouraging the submission of research proposals. To date (mid-January, 1952) about 450 such proposals have been received from approximately 125 institutions, of which about 100 have been approved for work in various fields of physics, chemistry, mathematics, metallurgy, and others, with the average project budget running something over $12,000. This does not mean, of course, that the remaining 350 all have been rejected, since a number are still in process of study and evaluation.

In a policy statement dated 17 January 1951 the Research and Development Board of the Department of Defense said, "Since basic research is the essential foundation for all military applied research and development, it is in the interest of the Department of Defense to insure that adequate attention is given to basic research in those areas affecting national security and that the level of effort for the conduct of such research is stabilized. Accordingly, in order to assure proper emphasis, the funds obligated annually by each Department in support of basic research shall not be less than six per cent of the average of its research and development budgets for the five preceding years." Programs like that of the Office of Ordnance Research described here, those discussed previously for the Office of Naval Research and the Applied Physics Laboratory, and others, some of which will be considered in future articles, indicate the awareness of the Department of Defense of the importance of fundamental research to any sound, long-range military research and development program and its intention to support such work in line with the RDB policy quoted above.

In closing, it should be noted that the OOR continues to encourage qualified private research institutions to submit proposals for projects to be supported under its basic research program. Any college, university, or other research organization desiring further details concerning the OOR should communicate with Colonel W. W. Holler, Commanding Officer, Office of Ordnance Research, 2127 Myrtle Drive, Durham, North Carolina.

News and views

Natural Radioactivity

Need for Work on Unsolved Problems Noted

It may seem astonishing that after radioactive substances have been known for over half a century there should still remain important unsolved problems in the domain of natural radioactivity. This field was the first of the great subdivisions of nuclear physics to be explored, and yet much remains to be done here. The reason for this situation becomes evident when we recall that radium is expensive, and that until comparatively recently radioactive substances were not available in any large amounts. The second contributing factor is the great improvement in recent years in instrumentation, an improvement which has rendered many of the classical techniques obsolete.

Many of the constants now available in the tables are inaccurate. Many of them were determined years ago, with samples which were impure, and often minuscule in amount. They were determined by techniques which today are no longer used. The common instruments available to most graduate students at the present time are far more precise and easy to operate than those used by the great savants fifty years ago. Another important consideration is that today enough is known about isotopes and that isotope separation is possible, so that the properties of the isotopically differing substances can be isolated and studied individually. Since the decay constants are different for each isotope, the older determinations made with mixed isotopes often led to confusing conclusions.

This situation applies both to the physical properties, such as the half-lives, decay constants and masses, the gamma and beta ray energies and alpha ranges, and to the chemical properties as well. To illustrate the point, we may cite the case of polonium. Its half-life is quoted in tables available today as ranging from 148 to 137 days. Yet a period of this conveniently measurable length can today be determined with sufficient precision so that it could be known to within plus or minus a tenth of a day. This task is not too difficult for a good doctoral dissertation.

Other illustrations can be found throughout the entire naturally radioactive family. The actinium series in particular has been neglected. Many if not most of the chemical and physical properties of the individual members of this series are inaccurately known. The masses and the decay scheme of mesothorium II is today a subject for differing opinion. Other instances are legion, and they add up to a situation crying for