ment of Science, a National Science Institute, or some other coordinated structure. A well-developed coordination must be established between the regrouped combination and those scientific agencies which remain separate, so as to insure an efficient and comprehensive National Science Program.

2) There should be a realignment of the distribution methods and responsibility for support of basic research in our educational institutions, with a movement toward university grants, administered largely by a department concerned with basic research, rather than by agencies concerned with applications. This may well need to be coordinated with the growing problem of support for our advanced-education program in all areas.

3) There should be some separation of governmentally sponsored, major research institutions from our educational and industrial system, especially of those institutions which are essentially concerned with applied science. There should be a greater acceptance of the idea of operation of such institutions under an improved, directly governmental administration.

4) The liaison of scientists in government with scientists in the academic field and in industry should be represented by a National Science Council in such a manner as to be compatible with the maintenance of our broad culture and balanced development.

Note

1. The opinions presented in this article are not intended to reflect the opinions of either the National Bureau of Standards (Department of Commerce), with which I was previously affiliated, or of the Department of State.

How Our Air Force Supports Basic Research in Europe

This unusual program of military support for open research abroad has won widespread approval.

Howard J. Lewis

A visitor to the European Office of the U.S. Air Research and Development Command (EOARDC), a unit of the U.S. Air Force that occupies suites on the top three floors of the Shell Building in Brussels, Belgium, is immediately struck by the absence of three powerful military symbols: the uniform, the armed guard at the gate, and the visitor's register.

When questioned recently about this apparent anomaly, Col. Nathan L. Krisberg, commander of the European Office, replied: "It is not our intention to disguise the essentially military nature of this enterprise, but we do want to emphasize to visiting European scientists that our mission can be accomplished only through the open support of open research."

Now in its eighth year of operation, EOARDC is administering 306 research contracts, totaling some $6,591,478, with scientists in universities, research institutes, and industrial organizations in 16 countries of Western Europe and the Middle East. In the course of its development, it has worked out a procurement system which seems, on the basis of interviews with some of its contractors, to be regarded as both strict in its demands and wise in its understanding.

The European Office is, in the words of its statement of mission, "established to procure in Free Europe research and development in support of the mission of the Air Force and provide a scientific liaison fostering mutually beneficial relations between the United States and European scientific communities."

The mission of the parent ARDC is to support the conduct of basic research on behalf of the Air Force, to develop new and improved devices, processes, and techniques, and to maintain qualitative superiority of materiel. From its headquarters at Andrews Air Force Base, a few miles across the Maryland border from Washington, D.C., ARDC divides its various responsibilities among ten research centers throughout the United States, which perform laboratory and contract research, development, and testing aimed at the improvement of vehicles, weapons, and personnel training. To tap the additional and often unique scientific resources available in Western Europe, ARDC established its European Office in 1952.

The generous allocation of support to the EOARDC program is positive evidence of its success in contributing to the military mission of the U.S. Air Force. But even more significant may be the contribution of the European Office to the cause of world peace, for it has demonstrated that an intelligently administered program of international support for scientific research weaves a sturdy fabric of understanding among nations that cannot be purchased with dollars alone and can serve as a template for long-overdue civilian enterprise in this direction.

Proposals Evaluated in U.S.

European investigators in all fields of the natural sciences are urged to submit proposals to the Brussels office for the support of their research. They are promised freedom to publish results of their work in the open literature and, indeed, are urged to publish. Incoming research proposals are screened in Brussels by a crew of Air Force scientists, all experienced in laboratory or bench work, and approximately 75 percent of the proposals are routed to one or more ARDC laboratories in the United States for evaluation. If an ARDC laboratory wishes the proposed research to receive support, it must provide the funds out of its own budget and authorize their transfer to EOARDC, where the final contract will be drawn up.

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The contract will call upon the contractor—in most cases a principal investigator representing a semiautonomous university-affiliated research team—to exercise his "best efforts" in the pursuit of a specified goal. The terms, based upon previous negotiations between the principal investigator and an EOARDC procurement officer, provide for payment by the Air Force of all or part of his expenses in salaries, expendable equipment, and—in some instances—the cost of new capital equipment. In return for this Air Force outlay, the contractor is required to file quarterly reports on progress, a final report on results, and technical notes at natural intervals in the research program. The contract may also call for a strict accounting of all expended equipment; whether this is the case depends upon the type of contract instrument chosen.

Contracts with scientists in each European country are preceded by coordination which involves explanation of EOARDC's objectives and methods, first through the United States Embassy in each country, then through the local foreign office, and finally through the appropriate civilian or military agency concerned with research and development. This sometimes tortuous path is one which fortunately must be broken only once for each country. Responsibility for the maintenance of diplomatic relationships is shared between EOARDC and the United States air attachés in each country.

Responsibility for the continuing relationships with contracting scientists, however, lies solely with the commander of EOARDC. Serving under him at the present time is a staff of 48, including 19 officers. Most of the officers are in line of command, assigned to one of three directorates: Resources, Technical Operations, and Procurement.

The staff is housed in a large office building containing no other military installation, in the capital of a country in which the United States has no fighting troops. Air Research and Development Command men stationed in the Brussels office wear civilian clothes during their three or four years of duty there.

Active Contracts Listed

It is the Directorate of Technical Operations which conducts the central assignment of the office. Acting director at the time of this writing was Lt. Col. Albert C. Trakowski, Jr., also chief of the Physical Sciences Division. There are also divisions of Bio-Sciences, Aeronautics and Propulsion, and Technical Information, but, as might be expected, the physical sciences occupy most of the technical-operations personnel, and a large part of the total of authorized funds is allocated to them. A summary of active European contracts as of 1 January 1959 is given in Table 1.

Table 1. Summary of active European contracts as of 1 January 1959.

Science	Authorized funds
Biosciences	$ 941,458
Chemistry	504,915
Electronics	1,904,293
Geophysics	936,816
Materials	164,662
Materiel	90,092
Mathematics	108,017
Mechanics	538,762
Metallurgy	305,192
Physics	633,431
Propulsion	199,509
Solid-state sciences	242,131
Armament	22,200

Substantial expenditures in support of the life sciences reflect the almost single-minded zeal of Lt. Col. James P. Henry. From April 1956 to November 1958 he handled alone the assignment of technical operations in the biosciences, monitoring some 50 contracts in his field, most of which he had played a large part in originating. Working closely with an old associate, Harvey E. Savely, Jr., of the Air Force Office of Scientific Research, Henry sees in his research-support program the means for developing deeper insight into the learning process, stronger defenses against the effects of sensory deprivation in space flight, and greater understanding of the nature of environmental stress in the piloting of supersonic aircraft.

Most of his leads, Henry says, emerge from conversation with European scientists, some of whom are already under EOARDC contracts; others are offered by visiting colleagues from ARDC and the Office of Naval Research, American contractors to ARDC, and private investigators in the United States. Henry pays close attention to European scientific journals and the proceedings of appropriate meetings in Western Europe. He will grant that the program he has helped develop for the ARDC among European scientists does not cover all parts of the life-sciences spectrum, but he feels that it is his mission to develop a program which corresponds to his own highly personal assessment of the most promising fields of research for the Air Force.

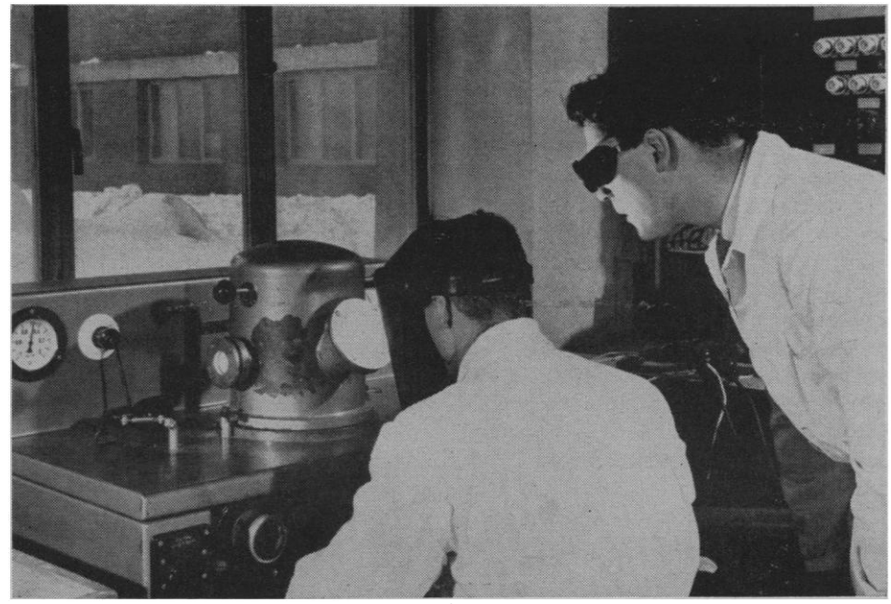
This highly motivated concentration of interest in a particular field of study has its counterparts in the Physical Sciences Division, particularly in the work of Trakowski. Organizer and first director of the Air Force's Geophysics Re-

The procurement officer and the technical project officer discuss a proposal for USAF-supported research with Prof. Pol Swings. (Left to right) Capt. Clifford C. LaPlante, Lt. Col. Albert C. Trakowski, and Prof. Swings.

search Directorate in 1946, he declares he has helped to introduce ARDC support to "every major scientific institute in Western Europe that can and is willing to contribute to our present objectives."

Although Trakowski is project officer for approximately 55 contracts at the present time, which cover a wide range of the physical sciences, he acknowledges happily that he has devoted most of his creative effort to the furtherance of fundamental research in the atmospheric sciences, to meet the needs of the Air Force for complete knowledge of its operating environment. During a recent interview, Trakowski wrote down these three principal goals: (i) to determine the electronic, nuclear, atomic, and molecular reactions and energy-transport mechanisms in the gases of the atmosphere under terrestrial, solar, and cosmic influences; (ii) to develop mathematical, hydrodynamic-thermodynamic models of the atmosphere to permit weather prediction by electronic-machine numerical computation; and (iii) to discover the physical processes underlying atmospheric water condensation and precipitation as the basis for weather modification.

Until recently, Trakowski observed, there had been a great deal of interest in supporting studies of atmospheric electricity as an avenue leading to weather control. Recently, however, ARDC research teams in the United States have shifted their emphasis to physical-chemical studies, and EOARDC has followed suit, terminating activities in the former field and encouraging investigators in the latter.



Scientists in Oslo are shown experimenting with an arc laboratory furnace. The project, called "Mechanism of the oxidation of titanium and titanium alloys," was supported by EOARDC.

European Scientists Satisfied

Although I did not have an opportunity to interview a large enough number of European scientists to guarantee complete representation, the near-unanimity evident in separate conversations with six contractors chosen at random would seem to indicate that there is a widespread feeling of good will toward EOARDC among European scientists and a general satisfaction with the latitude and flexibility of its contractual relationships.

In general, these contractors said that ARDC support enabled them to (i) pursue lines of research that would otherwise have been closed to them; (ii) train students and professional assistants who might otherwise be lost to basic research; and (iii) visit fellow investigators and their laboratories in the United States. Two individuals in this small sample expressed greatest satisfaction that their funds permitted them to hire young American scientists for work in European laboratories, thereby bringing about a day-by-day international exchange of ideas, information, and techniques, in contrast to the more sporadic exchanges made possible by publications and international conferences. It was pointed out that in some national support programs in Europe, the use of funds for the hiring of non-nationals is prohibited.

Even when hypothetical problems were introduced into the conversation, they were disposed of without any show of serious concern. It was not felt by any of those interviewed, for instance, that the present level of ARDC support could substantially influence the direction or the nature of scientific research within any particular nation, since it is relatively such a small part of the national expenditure. Nor did any of those interviewed feel that his particular line of study had been substantially deflected by its association with the quite different mission of ARDC. As one put it, "At intervals in research, there comes a time to branch out in any one of four or five different avenues of promise. We may, because we now have an idea of the kind of proposal that is attractive to the Air Force, choose one of the four or five that would not otherwise be our first choice. But they are all promising, and they are all a continuation of the fundamental research that interests us."

The scientists interviewed were equally resigned to the constant possibility of contract termination. Each said that all personnel employed on the project had been acquainted with the situation; in some instances, wages and salaries had to be increased over the local level in order to counterbalance the lack of security. All, however, expressed the belief that longer-term contracts would permit the hiring of more talented personnel at the same or even lower salaries. Similarly, although all appeared to be ready to accept, without reservation, the requirement that all capital equipment purchased under their contracts be returned to the U.S. Government, each expressed the belief that the goals of both parties would best be served if some mechanism could be developed that would permit European laboratories to gain title to such equipment. Serious consideration is now being given within the ARDC to an upward revision of time limitations on contracts and to the establishment of an authority that would allow contractors to earn title to capital equipment purchased with Air Force funds by conducting further research for a period of time to compensate the Air Force for the residual value of the instrument.

Only in two matters were there some murmurs of dissatisfaction. One contractor confessed to a lack of enthusiasm for the detailed accounting necessary to obtain reimbursement of costs

for expendable equipment. Another felt that contractors should be required to submit final reports at a logical breaking point in the research, rather than at the arbitrarily set date for termination of contract—especially, he said, in those cases in which a second contract has been granted in extension of the first.

Although an EOARDC contract can often provide a European scientist with an annual budget many times that which he could expect from his own university or government, it does not seem that the evident satisfaction with EOARDC merely represents approval of an agency that is playing Santa Claus. More credit must go to the clarity and continuity with which the several commanders of EOARDC have pursued their mission.

Early Ups and Downs

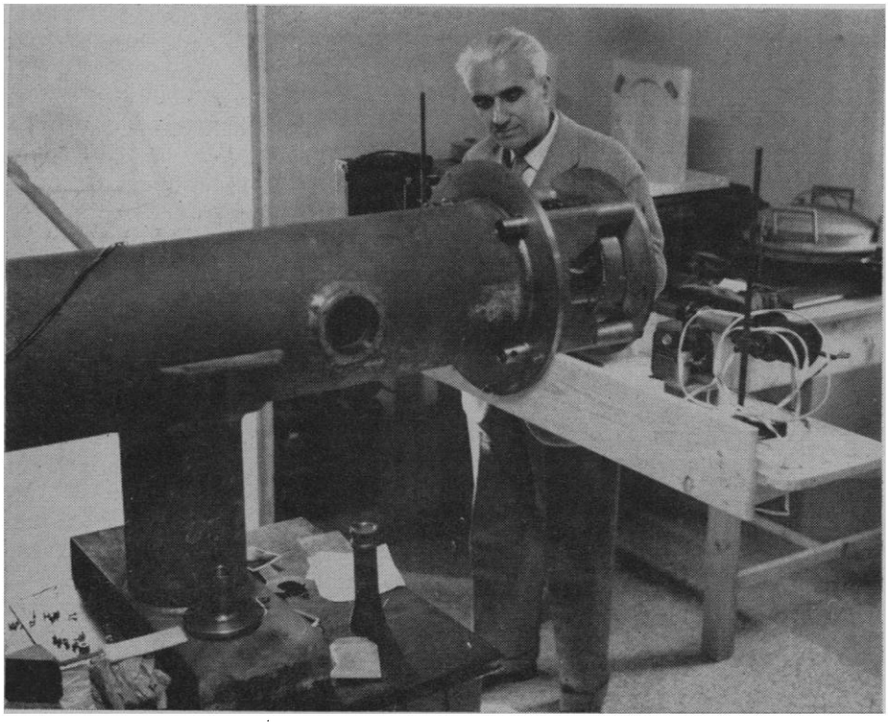
Those who were close to the initial operations of EOARDC report that at first its overtures were met with coolness. Some of the scientists originally approached indicated that their skepticism was based on a vision of Laocoön entangled in a serpentine of military red tape. But most of these fears seem to have been laid to rest.

Responsible in large part for the philosophy and initial success of the European Office was Colonel Oliver Haywood, who with the support of General Donald A. Putt drew up the initial plans that resulted in the establishment of EOARDC, in October 1952. A graduate of the U.S. Military Academy, with a Ph.D. degree earned later, Haywood had been one of the early advocates, within the military establishment, of greater participation in fundamental research, pointing out that such a relationship is essential for the rapid integration of new capabilities into any research and development program. The first expression of the Putt-Haywood collaboration had been the establishment of the Air Force Office of Scientific Research (in 1951), whose program of support for fundamental research is also within ARDC. It was after directing the successful AFOSR operation for approximately two years that Haywood proposed a European branch to advance the interests of the United States and the free world by providing a far broader support of scientific endeavor without a correspondingly greater increase in cost. Named as EOARDC's first commander was Lt. Col. Ralph Nunziato.

Within a short while after Nunziato's arrival on the European scene and after a series of interviews with leading European scientists, an operating procedure had been worked out whose basic elements obtain to this day. Pains were taken to assure the European scientific community that there was to be no restraint on the flow of information and that the main instrument of negotiation between the partners of an EOARDC contract was mutual trust and respect for the integrity of the professional scientist; the contract was to be the description of the relationship, rather than its bond. There would be no recruiting by ARDC personnel for emigration to America, nor would EOARDC allow itself to be used for this purpose by others. Inflation would be avoided by scrupulous observance of prevailing wage and salary scales. The office would endeavor to avoid saturation of any particular institution, in terms both of percentage of qualified personnel under contract and of percentage of total research budget. Only 100 copies of final reports would be required from contractors, in order that later journal publication should not be interfered with.

The EOARDC was not, however, allowed to climb steadily to its present position. Like most Air Research and Development Command units, it was adversely affected when the Command's budget was cut approximately 10 percent between fiscal years 1953 and 1954. Support for basic research was all but eliminated from the Air Force program. Haywood resigned his position and commission.

Then, from Air Force Secretary Harold E. Talbott and Lt. Gen. Thomas S. Power, came new and powerful support for a reinvigorated program. Talbott argued successfully for restoration of research funds; Power was moved to put part of the new funds into an expansion and revitalization of the ARDC's European Office. To help reestablish ties with European scientists, Power sent Brig. Gen. Don Flickinger to support the EOARDC staff in its missionary program. Command Surgeon and Director of Human Factors for ARDC and first commander of the Air Force Office of Scientific Research, Flickinger, with the staff of the European office, outlined EOARDC methods and goals, promised a new and better contract (one particularly suited to the support of fundamental research), and reemphasized the point that contract funds could be expected to cover expenses to and from



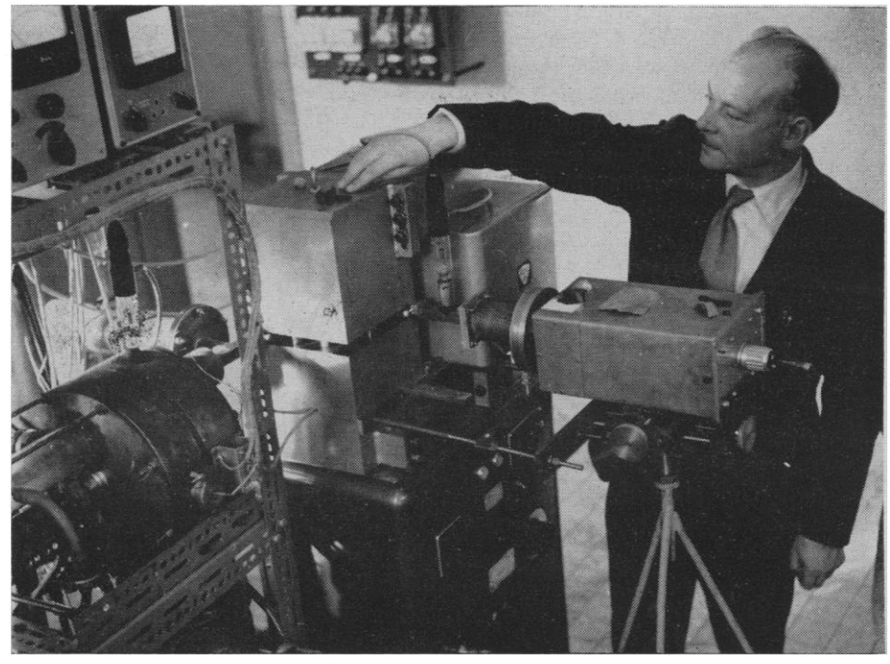
Prof. G. Righini, of the Arcetri Astrophysical Observatory, holds an EOARDC contract for research on stratification of the atmosphere. He is also studying the solar spectrum and for that purpose is building the spectroscope shown here. He obtained many of its components from dismantled optical equipment of the Italian Navy.

symposia and conferences in Europe and the United States.

The European office suffered another drastic curtailment of funds in 1957, but once more persuasive argument, by its then commander, Colonel Lee V. Gossick, and by highly placed stateside supporters, together with the timely appearance of the first Soviet artificial satellite, resulted in the speedy restoration of budgetary cuts. By the end of the 1957–58 fiscal year, 243 contracts, which totaled $3.1 million, had been written.

Part of the credit for the success of EOARDC must go to the contractual instrument itself. As explained by Captain Robert E. Rochfort, director of procurement at EOARDC, the particular contracts used for the procurement of basic research are of recent development and have been given separate listing in the Armed Services Procurement Regulations within the last few years, although the use by the Air Force of specific contracts for research came into existence before ARDC was constituted as a separate command.

But there has been even further specialization within the European context. According to Rochfort, it is the practice in the United States to use cost-reimbursable (C.R.) contracts for research, whether basic or applied. "A C.R. contract is used," he said, "when costs cannot be realistically estimated, but since most of our contract costs are generally predictable, EOARDC finds it advantageous to the contractor and the Government to use a Fixed Price [F.P.] Contract. When we run into a situation where we have both elements of costs (those that can be firmly estimated and those that cannot be), we use an F.P. Contract with a C.R. provision. Straight C.R. is also used when the situation demands." Joint support by ARDC and the scientists' home country often solves the problem of capital equipment purchases, since funds from the latter source can be used exclusively for such purchases, while ARDC funds can be devoted to salaries, wages, and the purchase of expendable equipment.



Prof. A. Van Tiggelen displays his apparatus for studying reaction kinetics of flame propagation in his laboratory at the University of Louvain—a study supported by EOARDC.

Advantages to This Country

To European scientists the program of EOARDC has meant support for research that would otherwise in many cases have been severely limited in scope or completely out of reach. What have been the rewards, so far, to the ARDC? These cannot be expressed in terms of military utility, since successful applications—if any—must remain shrouded in secrecy. Yet these rewards can be expressed generally—and often are—by EOARDC personnel. From their viewpoint, the participation of ARDC in the support of basic research has meant, first of all, that the bench scientists and technologists serving ARDC have the opportunity, almost literally, to look over the shoulder of European researchers in the pursuit of fundamental knowledge. The agreements permit the contractors to publish freely the knowledge gained under the program, but the critical lead time between research and development is sharply reduced for ARDC in two ways: Papers resulting from ARDC-supported research usually do not appear in the contractor's journal of choice for 6 to 18 months after they are submitted as final reports to the supporting development center, and the fact that the center has had continuing access to quarterly status reports enables it to utilize the new knowledge more quickly. Equally important are the personal contacts that are developed between ARDC personnel and the European scientific community, often extending far beyond the termination of the contract.

In addition, EOARDC has developed with the sister services of the Air Force what may well be a unique example of interservice cooperation. The success of the ARDC office in Brussels prompted, in part, the establishment of two similar groups, the Naval European Research Contracts Program and an Army European Research Office, in 1956. Representatives from the three offices meet quarterly to exchange information and coordinate efforts. Supplementing these quarterly meetings is a monthly exchange of information on proposals submitted to each office and notifications of approval. The quarterly status reports required by EOARDC contracts are distributed similarly to the Army and Navy groups.

Coordination at the operational level seems more attractive to those connected with the EOARDC operation than any suggestion of a merger of all offshore research support within a single Department of Defense agency. Flickinger pointed out that interdepartmental control would seriously attenuate the close relationship that has been developed between ARDC researchers and European contractors.

There remains one large consideration. Members of other military-oriented research organizations have questioned the wisdom of offering support to European investigators when men of equal talent may be available within the United States. Although many of EOARDC's contractors have

unique capabilities, it has not been stated that uniqueness must be established before individual proposals may receive supporting funds.

I do not consider the answer to that problem to be within the scope of this article. Nor was any answer demanded of the EOARDC staff. Yet one statement from Krisberg, made in another context, might be considered at least a partial answer. In a conversation with me one afternoon in Brussels, he said, "It must now be obvious to all that science is today one of the major battlefields in the cold war. It seems equally obvious to us that in this war, the brain power of the Western World is the maximum weapon. We feel that the European Office can, through initiative and understanding, contribute to a unity of purpose."

Louis N. Ridenour, Physicist and Administrator

When Louis N. Ridenour died on 21 May 1959, the scientific community lost a remarkable physicist and scientific administrator who had an uncanny ability to sense the areas in which a scientific or a technological "harvest" is likely. He devoted himself to helping achieve and exploit such break-throughs. This he did as a working physicist in his early years. In his later years he accomplished his goal as dean of the Graduate College at the University of Illinois, as chief scientist of the Air Force, as an executive with International Telemeter Corporation, and, finally, with Lockheed Aircraft Corporation.

He was born on 1 November 1911, in Montclair, New Jersey. He took a B.S. degree in physics at the University of Chicago, where he was the editor of the *Daily Maroon*, the student newspaper, in his senior year. This experience undoubtedly was closely coupled with his unusual facility as a writer of both technical material and fiction.

Ridenour received his Ph.D. degree in physics at California Institute of Technology, under Lauritsen, in 1935 and went to the Institute for Advanced Study, Princeton, New Jersey, in the fall of that year. He was to be an assistant to Fermi. Although the latter did not come to Princeton, Ridenour stayed as an instructor in physics at Princeton University until the fall of 1938.

At that time he joined Harnwell, the head of the physics department at the University of Pennsylvania. Since he felt that nuclear physics was badly in need of precise measurements, he undertook the construction of an electrostatic accelerator with accurate high-voltage control. This work was interrupted when he was called to the Radiation Laboratory at Massachusetts Institute of Technology in 1941. He tried to continue work on the machine by long distance and by making periodic visits to the University of Pennsylvania. His plans for this work never came to fruition, since the electrostatic generator was destroyed by fire soon after being placed in operation.

The years 1941–46 were crowded with great events for many physicists, particularly for Ridenour. He played an important role in determining which of the devices being developed at the Radiation Laboratory could be used effectively, in influencing the development of such devices, in persuading those involved in application to use them, and finally in working near the front of combat in order to make certain that the devices were used properly. He possessed an almost unique ability to influence all phases of a situation.

Louis N. Ridenour

He was appointed editor of the *Radiation Laboratory Technical Series* in 1945. The series consists of a set of 28 volumes which describe the topic of radar as it stood at the end of the war. Concerning this effort, F. W. Loomis [*Phys. Today* **12**, 18 (Sept. 1959)] made the following statement: "Rarely has a man so perfectly fitted a job. It called out all his qualities—his facility in writing, his talent for assembling and leading a group, his own encyclopedic knowledge of radar and electronics, plus his quick ability to learn and understand what he didn't already know; and especially his persuasiveness and influence in high military quarters, needed to overcome the timidity of the security-conscious bureaucrats. . . . It is used by all the engineers in the now huge radar industry and serves to educate the new generations as they come along."

Ridenour became dean of the Graduate College of the University of Illinois in 1947 after returning to the University of Pennsylvania for one year. During his three-year tenure as dean, he played a major role in initiating new programs and study groups at the University of Illinois. Among them are the Control Systems Laboratory, the Digital Computer Laboratory, the microbiology group under Luria and Spiegelman, the Radio Carbon Laboratory, and the solid-state group under Seitz. His enthusiasm, drive, and administrative wisdom contributed much to the successes these enterprises achieved.

In 1949–50 he served as chairman of an *ad hoc* committee to survey research and development in the Air Force. The report of this committee, the Ridenour Report, recommended the formation of the Air Research and De-