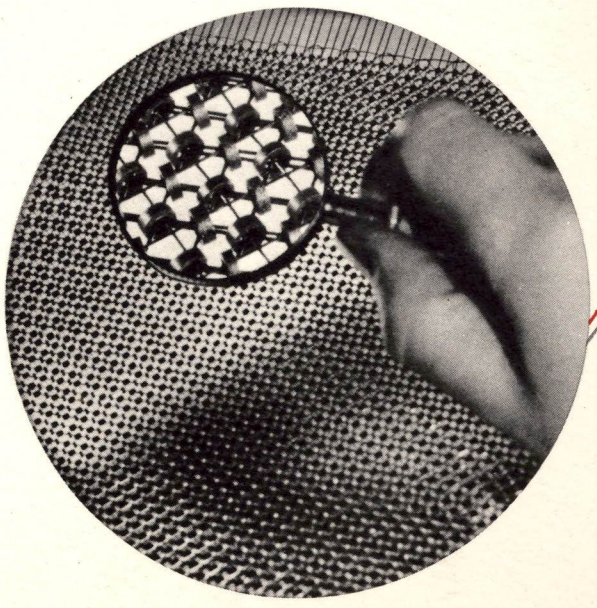
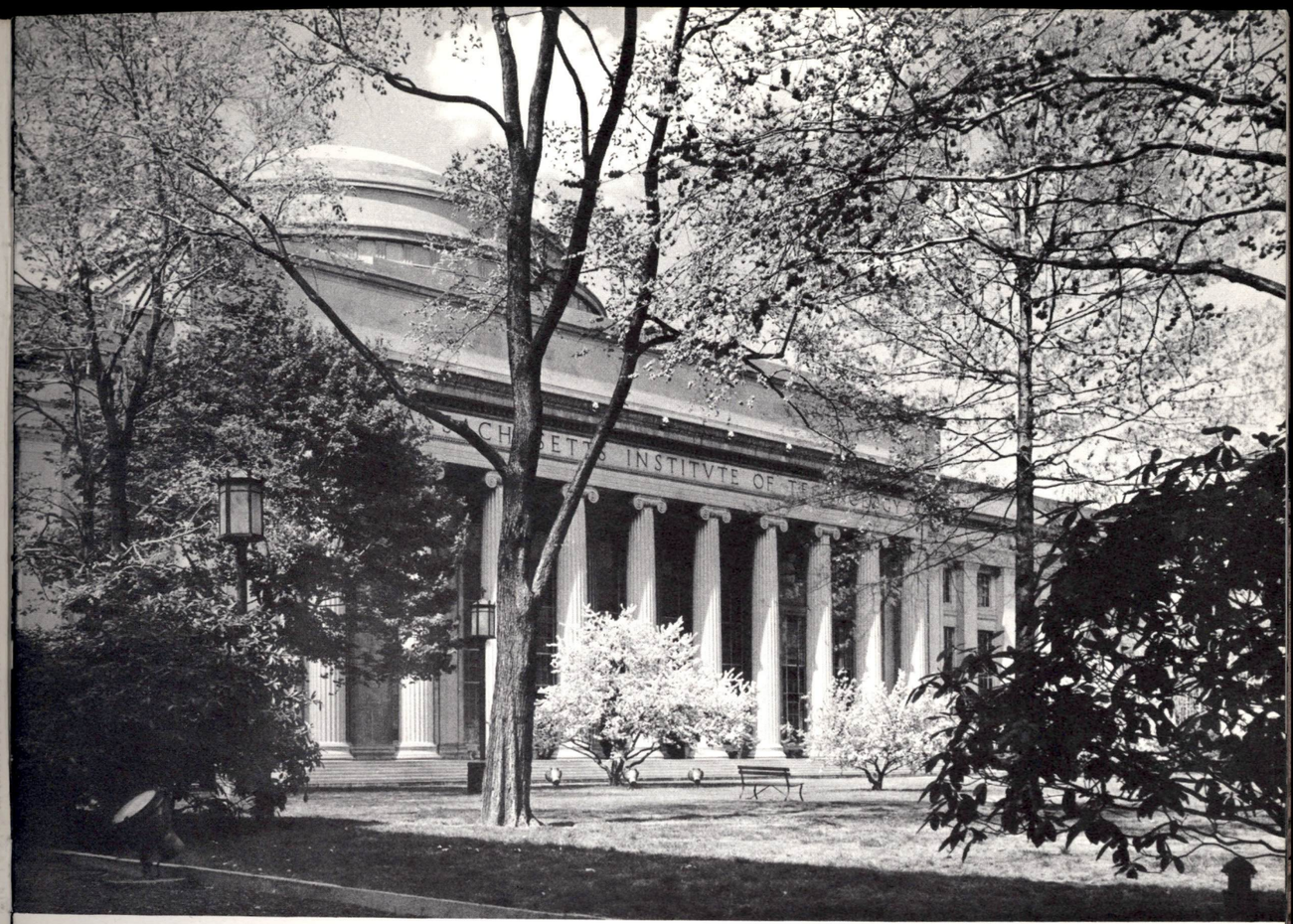
Lincoln Laboratory

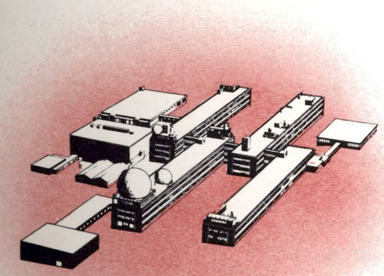
MIT



M. I. T. LINCOLN LABORATORY....



THE ORIGIN . . .



Lincoln Laboratory is an electronics research and development center established in 1951 by the Massachusetts Institute of Technology at the joint request of the U.S. Army, Navy, and Air Force; it is supported by the three Armed Services through the Air Research and Development Command of the Air Force. The field of work of the Laboratory is research and development oriented primarily towards the communications and electronics required in the defense of North America against air attack.

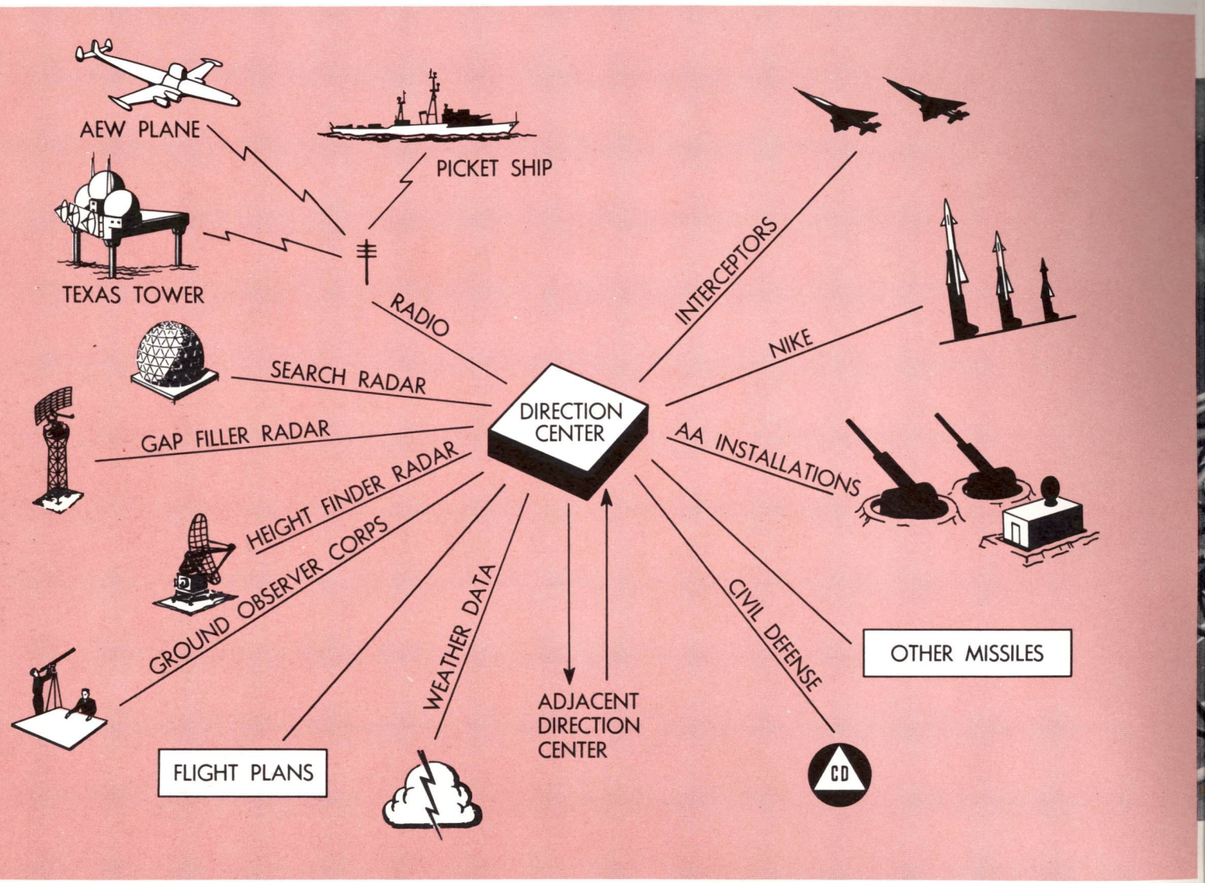
Scientists and engineers, already engaged in related work, made up the nucleus of Lincoln. From the M.I.T. Research Laboratory of Electronics came groups working on long-range radio communication, radar, and solid state physics; from the M.I.T. Digital Computer Laboratory came the Whirlwind I computer groups working on real time control applications of computers, random access magnetic storage, and computer design; and from various departments of M.I.T., from other academic institutions, and from industry came additional specialists in mathematics, physics, servomechanisms, and mechanical engineering.

Originally the Laboratory was housed in scattered buildings on the M.I.T. campus. In 1953 it was moved to new research buildings in Lexington, Massachusetts.

THE PROGRAM

SYSTEM DESIGN...

The dynamic growth and the complexity of our technology have created an acute demand for rapid automatic methods of handling vast amounts of information. Large electronic systems have been constructed to perform this function and to apply the results to the control of physical operations. The engineering fields involved in the design of such systems are in a stage of intensive growth: Digital computer technology, radar and communication system engineering, information theory, switching circuits, solid state research and development. The application of these and other fields to the design of integrated information processing systems is one of the principal tasks of the M.I.T. Lincoln Laboratory.



SAGE...

The largest information processing and control system by far that has been attempted up to now is the SAGE System for continental air defense. This "Semi-Automatic Ground Environment" is the electronic medium for the control of modern air defense interceptors and missiles. Its heart is a high-speed digital computer in a direction center which greatly surpasses the existing "manual" centers in both speed and range of control.

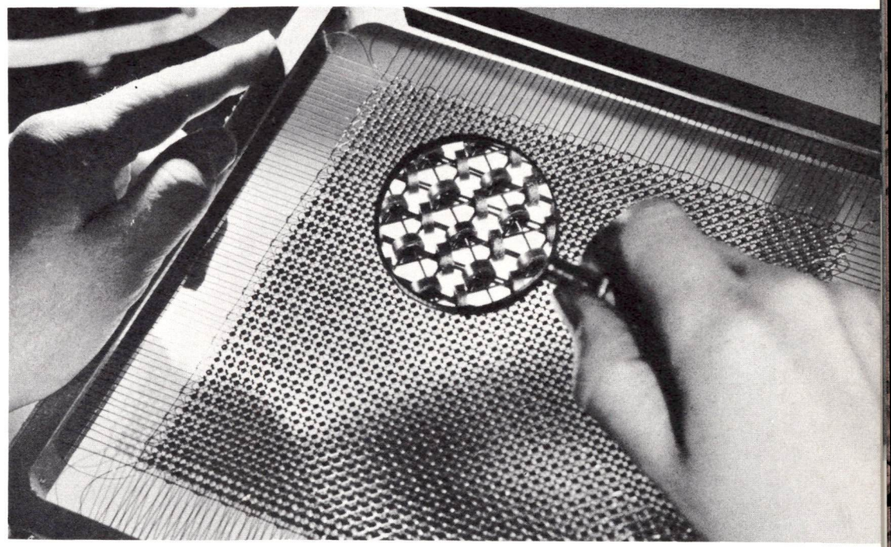
SAGE assembles information about aircraft, weather and weapons quickly and completely. Its automatic plottings provide human operators with the necessary facts to make sound, immediate decisions. The computer receives data from radars, height finders, weather stations, ground observers, and flight plans. It depicts the courses of all aircraft detected within the range of its radar sets and calculates for the operators the most effective application of manned interceptors and missiles. Vectoring instructions to guide these weapons to their targets are generated by the computer and transmitted by voice radio or by automatic data link. Finally, when the battle moves away from the region served by any one air defense center, all the pertinent information its computer contains will be entered automatically into the computer serving the appropriate adjoining area.

The SAGE System is ready in prototype form, and Lincoln staff members are currently engaged in testing a full-scale installation. Employing jet bombers and interceptors supplied by the Armed Services, these tests are probably the first application of scientific planning and analysis to a complete system of such size and complexity. Many aspects of performance and capability have to be investigated under realistic conditions, with the utmost exploitation of automatic techniques for recording and digesting the test data used by system analysts.

OTHER SYSTEM PROJECTS...

SAGE is only one example of development undertaken by the Lincoln Laboratory. The concept of the DEW Line (Distant Early Warning), now spread across the Arctic, was developed here. Members of the research staff are now studying the technical approaches to a ballistic missile warning network. A preliminary exploration is also being made of the potential uses of SAGE techniques to the air traffic control problem.

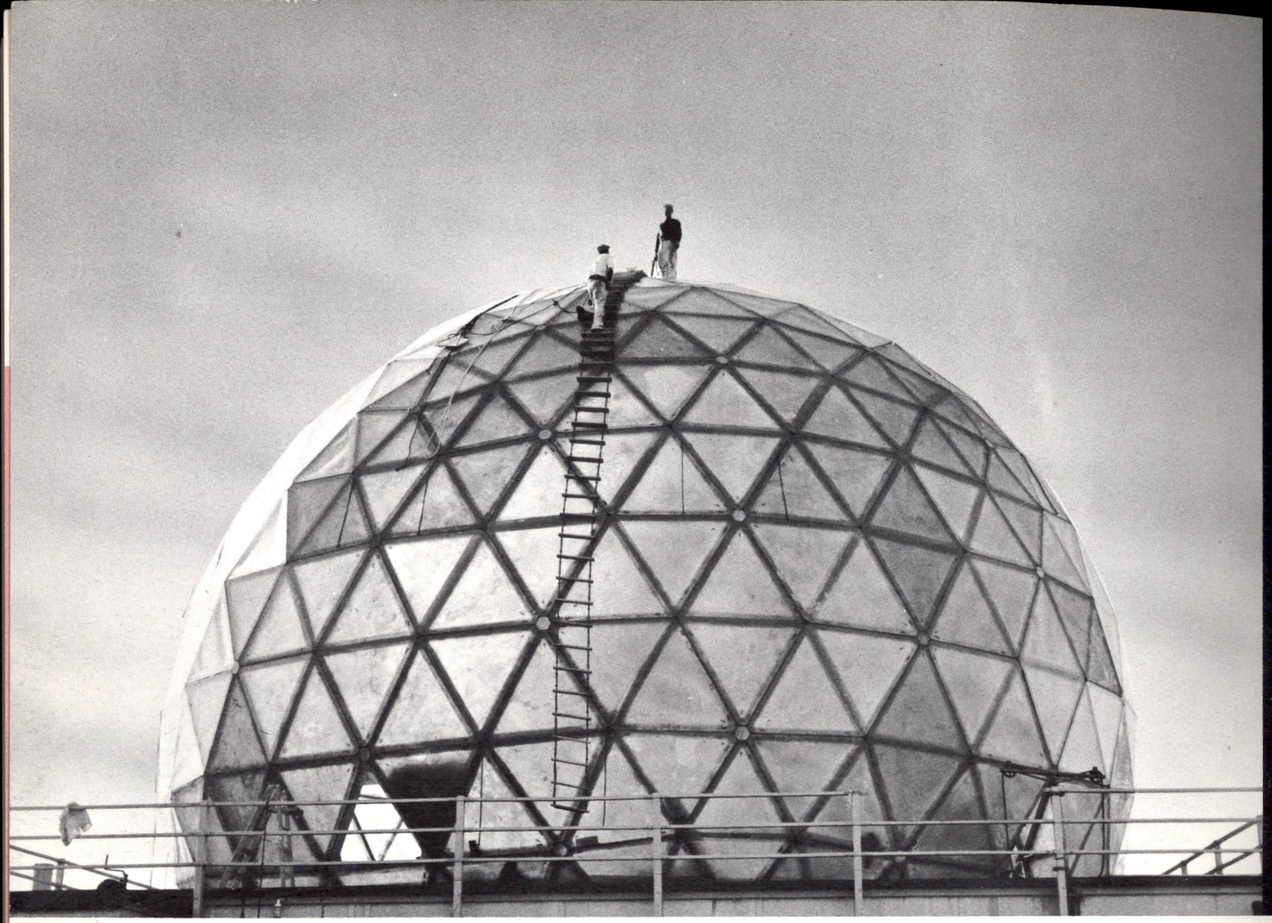
The idea behind "system research" is to break a problem into parts which will yield to independent work, and yet to keep these parts related to the whole. This approach helps discover the need for research on specific equipment, methods and links between units. It also helps keep research workers with different specialties in touch with one another. As Lincoln scientists use the term, system research is both a way of visualizing a complicated technical problem, and a means for organizing the best possible attack on it.



COMPUTERS...

Dating back to Whirlwind, M.I.T. and Lincoln Laboratory have a long and successful record in computer research. One of the principal advances of recent years in digital computers is the magnetic core memory, the basic patent for which was granted to a member of the Lincoln staff. Lincoln's Memory Test Computer, now operating around the clock, has provided the first full-scale use of this device. Based on the experience gained with these earlier machines, the central computer for SAGE was designed as a collaborative effort by Lincoln Laboratory and the manufacturer.

The next generation of computers will exploit the design advantages peculiar to transistors. Three such computers have been built at Lincoln Laboratory, and a pulse repetition rate of five megacycles per second has been achieved in arithmetic and control unit circuits using surface-barrier transistors.



RADAR . . .

Radar, for fifteen years a major field of electronic research, continues to develop rapidly to meet the requirements imposed by the age of turbo-jets and guided missiles. Work in Lincoln's new family of high-powered radars ranges from the design of components to final evaluation of operational results. New antennas, new transmitter power sources, new advances in information theory and new ways of overcoming the effects of background clutter have greatly improved the usefulness of radar — but there is still a host of design problems requiring further research.

New or improved component devices are themselves being constantly developed: duplexers, ferrite isolators, wave guide windows, rotating joints, traveling wave tubes and klystrons are all under study in the Laboratory. Methods for extracting the maximum amount of useful information from the input signal to the radar are being evolved. The problem of reducing the vulnerability of radars to electronic countermeasures is under constant attack.

Lincoln engineering design groups are tackling problems of mechanical and structural design, and the engineering of radar sites and radomes. This involves extensions of existing knowledge concerning the design of large bearings and the stability of large fixed and rotating structures.

COMMUNICATIONS . . .

Lincoln Laboratory's work in communication research was established on the foundations supplied by the M.I.T. Research Laboratory of Electronics in its investigations of "scatter propagation." By the time M.I.T. established the Lincoln Laboratory, RLE experiments had progressed far enough to offer a possible answer to the military need for reliable radio communications beyond the horizon.

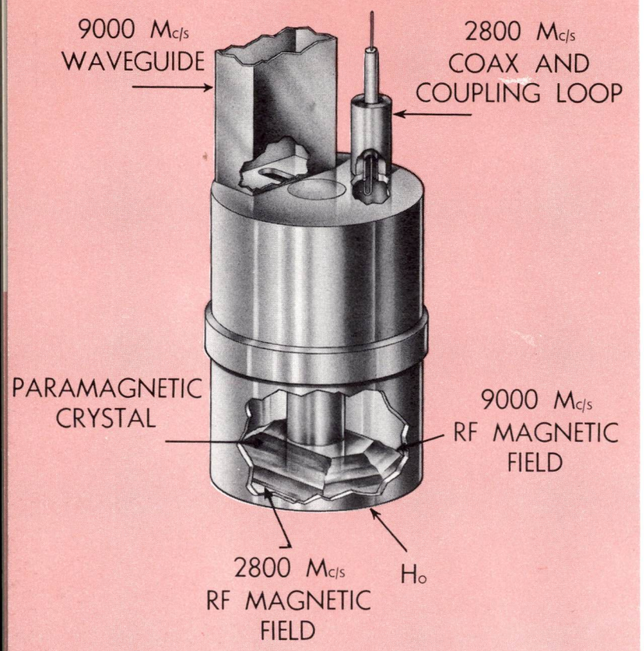
In recent years, Lincoln has exploited both of the known modes of scatter transmission. The communications net built into the DEW Line utilizes VHF ionospheric propagation for rearward channels; UHF tropospheric propagation for lateral contacts.

The Laboratory is engaged in broad studies of propagation phenomena, particularly those related to meteors and the aurora.

Statistical extensions of communication theory are also underway, along with new contributions to coding, information theory and the theories of detection and decision. Modulation techniques and ionospheric multipath transmission are under study, to increase the reliability of the new equipment, especially in the presence of jamming. SAGE communications research—from antenna farms and propagation tests to time distribution studies of circuit loads — continues to progress.

RESEARCH ON NEW TECHNIQUES . . .

Basic research is no longer far ahead of weapons system design. To help accumulate a reservoir of research data, M.I.T. has created the Lincoln Laboratory as a technical center permanently available to the military establishments.



Lincoln has extensive programs in the physics, chemistry and metallurgy of semiconductors. One of these has successfully applied cyclotron resonance techniques at microwave and infrared frequencies to the study of fundamental properties of materials. The Laboratory has made significant contributions to the study of semiconductor surfaces. Investigations of thin films of magnetic materials by resonance techniques provide necessary information for future applications. Other phenomena of the solid state, like electroluminescence, photoconductivity and light amplification, are under research consideration as possible aids to the effective display of information.

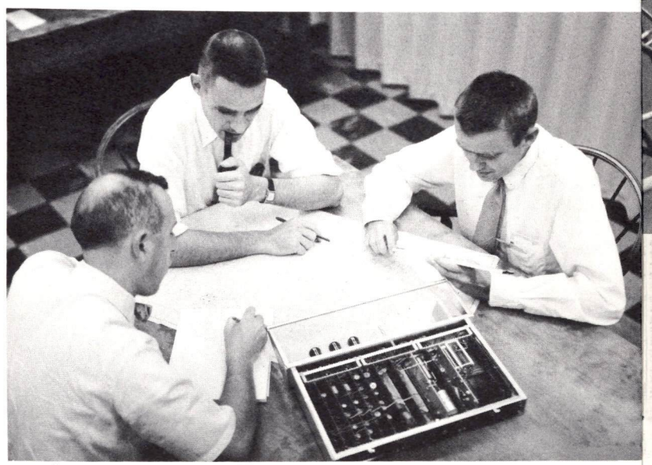
One of the earlier products of the semiconductor program was the punch-through diode invented at Lincoln. Its high forward conductance and high switching speed have made it useful in computers as well as in UHF and VHF equipment. More recently, the cryotron, developed by Lincoln-sponsored research, has proved the possibility of applying superconductivity to circuit elements operating at the temperature of liquid helium. Measurements of the basic microwave properties of ferrite materials and theoretical work have permitted the improvement and extension of non-reciprocal devices for stabilizing magnetrons and local oscillators. Thin evaporated magnetic films show desirable characteristics as computer circuit components. Lincoln Laboratory has recently succeeded in operating a solid state maser as an amplifier at frequencies near three thousand megacycles per second.

In one other field, that of adapting machines to the physiological and psychological requirements of use by human beings, Lincoln has a variety of work in progress. A typical problem is to bring visual signals to the operator without flicker, with proper image persistence, and at a sufficiently high light level. While the design of display devices is in the province of physics and engineering, the equally important problem of understanding what the observer's requirements really are, requires a background in psychology, physiology, mathematics and statistics.

One group of Lincoln scientists is using data processing systems to study pattern recognition and the learning process. If successful, these early attempts will be useful steps toward understanding the human process of recognition, and they will also lead us nearer the distant goal of building machines which can read printed pages or examine aerial photographs.

THE PEOPLE . . .

Membership of the Lincoln professional staff includes 750 full time scientists and engineers from 46 states and 19 foreign countries. A third of these came directly from some 230 colleges and universities, and more than a quarter transferred from faculties. These professional men and women profit from the advantages of laboratory management by scientists and engineers and the freedom and objectivity of an established scientific community with superior academic standing. About 1400 additional people provide technical and clerical support.



Members of the professional staff of Lincoln Laboratory hold research appointments at M.I.T. and therefore have full access to the academic and recreational resources of the Institute. Group life insurance is provided for all staff members, with additional coverage at modest cost. An excellent pension plan is offered as well as hospital and medical insurance and other perquisites.

To encourage staff members to advance in professional competence, the Laboratory offers opportunities to:

Combine study toward an advanced degree at M.I.T. with staff research appointments. These Staff Associate positions are open to a selected group of unusually well-qualified candidates. Detailed information may be obtained from the Committee on Graduate Study.

Enroll as special students in the M.I.T. Graduate School. Staff members meeting Graduate School requirements may register for one subject per semester. Tuition is paid by the Laboratory for the first semester and in subsequent semesters if high academic standards are maintained.

Participate in seminars and symposia, held regularly throughout the academic year, which are led by distinguished scientists from within the Laboratory, from M.I.T., and from other academic institutions and industrial organizations.

THE FACILITIES . . .

The breadth of the Laboratory's program demands an extensive variety of equipment and facilities. The Laboratory occupies approximately half a million square feet of modern well-equipped research space in permanent buildings in Lexington, Massachusetts.

Facilities at Lincoln Laboratory in Lexington and its affiliated M.I.T. Barta Building in Cambridge include a semiconductor physics laboratory, a physical chemistry laboratory, metallurgical and ferrite laboratories, low temperature research facilities, a vacuum tube construction shop used for special cathode ray display tubes, microwave research facilities, six large-scale digital computers, extensive shops, drafting rooms, and a photographic laboratory.

Further facilities located in various parts of New England and the United States include more than twenty field stations for testing and development work, an experimental radar and communications network covering eastern Massachusetts for air defense tests, and experimental test aircraft support from the Air Force and Navy.

THE ENVIRONMENT...

The diversification of the Lincoln program provides broad scope to individual abilities and interests. Combining the atmosphere of research freedom with the demands of urgent systems-development, Laboratory staff members are attracted by the unique opportunities for professional growth. As a research laboratory in a new and vital field, Lincoln encourages both fundamental and applied work; as an engineering laboratory with a national defense responsibility of major significance, it stresses reliability and quality. In the development of systems that are subsequently accepted for manufacture, the staff has opportunities for continuing analysis and study of the applications of electronic equipment, and for association with industrial production programs and field installations.

Situated in the growing electronic industrial area of the northeastern United States, the Laboratory is strengthened by close relationships with nearby industrial and academic research centers. Between 12,000 and 15,000 people visit the Laboratory annually.

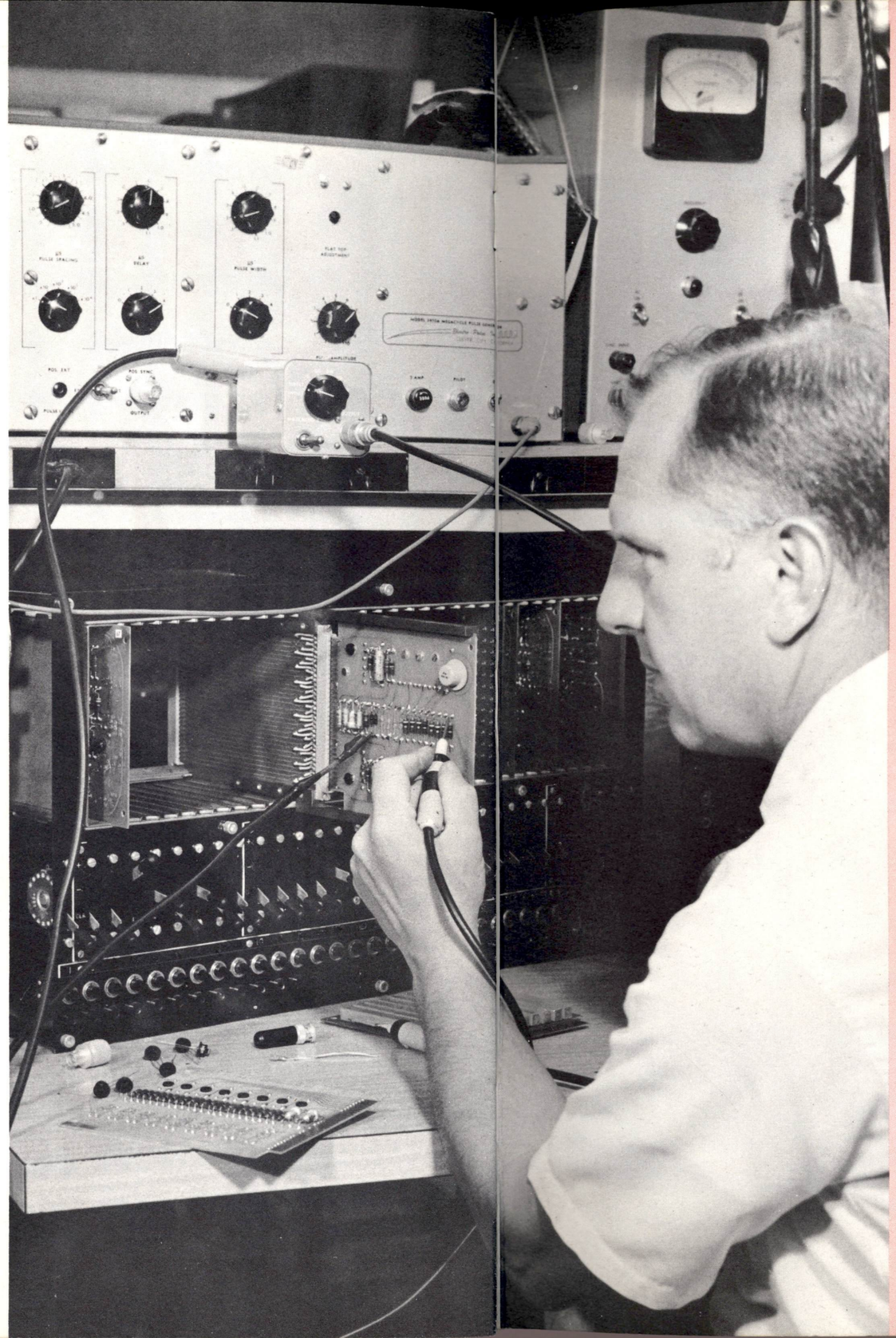
Much of the Laboratory's systems and applications work is classified. But basic research information is actively circulated; for instance, during 1956, 132 presentations were made by Laboratory staff members at national professional meetings, and 52 papers appeared in the technical press.

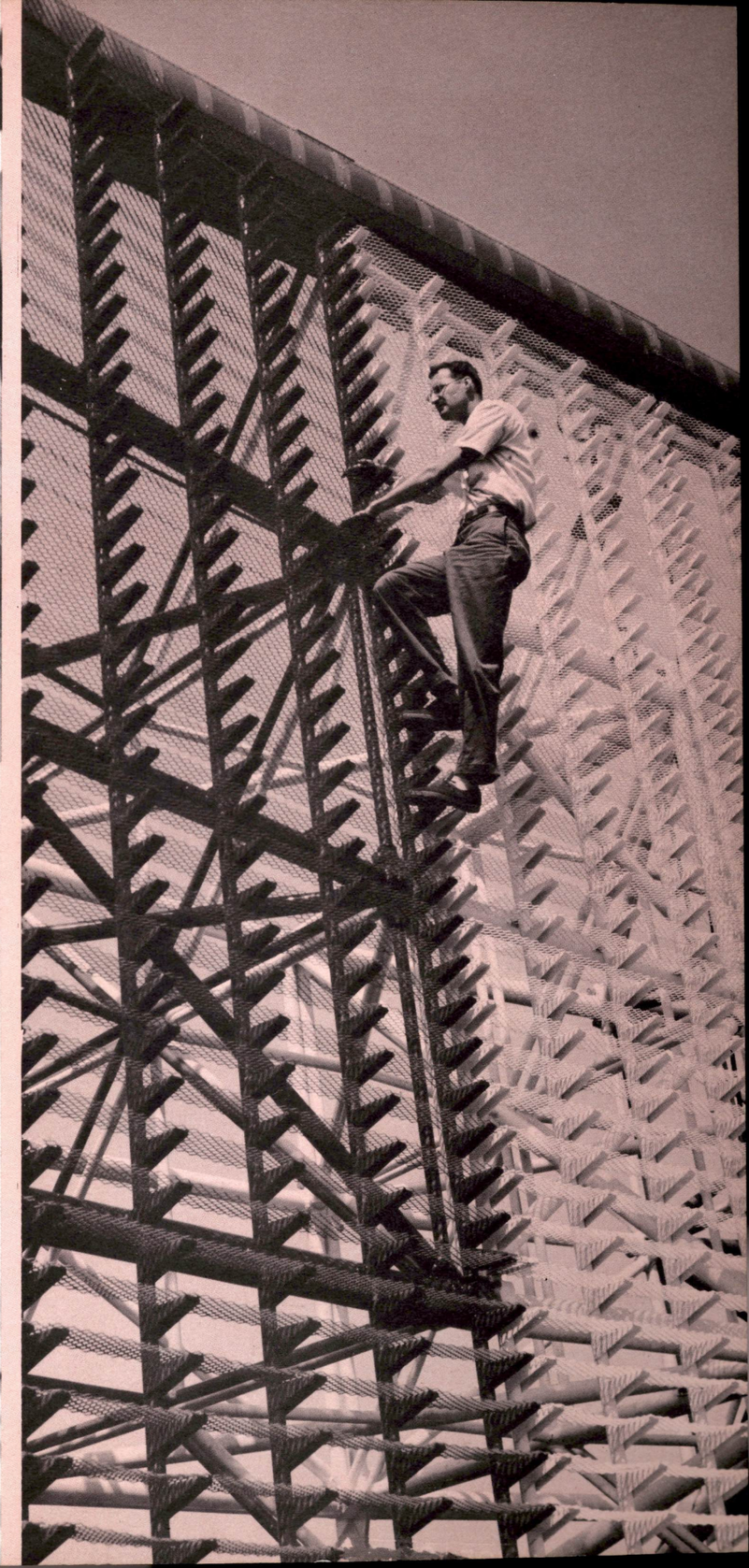
Lincoln Laboratory is constantly looking for exceptionally qualified men and women to join its community.

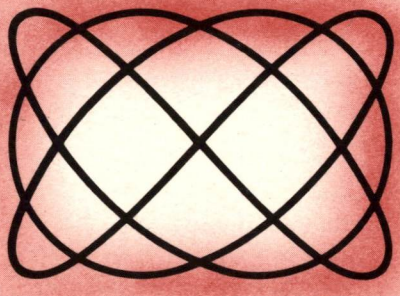
Research and Development

M.I.T. LINCOLN LABORATORY

Lexington, Massachusetts







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