The Antenna Laboratory Field Station

By Robert A. Fouty
Assistant Director of the Antenna Laboratory

Introduction

Early in 1956 The Ohio State University completed a building specifically designed for microwave research. The purpose of this article is to describe the functions of the Antenna Laboratory and to explain the unique facilities of the Field Station.

The objectives of the Antenna Laboratory are threefold: (1) to provide graduate students in Electrical Engineering, Mathematics, and Physics with programs and facilities with which they may complete modern theses and dissertations; (2) to discover and disseminate scientific information; and (3) to provide research programs and facilities which train scientists and provide information for the national defense effort.

The research programs are divided into three general classifications: (a) antenna research, (b) radar or echo reflection studies, and (c) radome research. Generally, all problems in these categories are investigated by a correlated theoretical-experimental approach. Because of the precise nature of the experimental research, the University built and equipped the Antenna Laboratory Field Station.

Research Programs in the Antenna Laboratory

The research programs are almost equally divided between theoretical and experimental investigations. The experimental programs provide the information for guiding theory and indicating the validity of theoretical assumptions, for predicting results which cannot be determined analytically, and for developing empirical information.

The annual operating budget is approximately $600,000. This budget supports 40 engineers and scientists, a technical supporting staff of 30, and the necessary materials and equipments. Of the 40 engineers employed, 24 are registered in the Graduate School and 11 are teaching part-time in the Department of Electrical Engineering. During the past quarter the graduate students in the laboratory completed two Ph.D. dissertations and two M.Sc. theses. Since January 1, 1956, 35 technical reports have been prepared. During the 1955 calendar year 12 articles were published in technical journals and 23 papers were presented at technical symposiums.

Programs on antenna research, radar reflection studies, and radome research are commonly grouped in electromagnetic or microwave research. Microwave research requires critical measurement facilities; for example, the radar reflection from an object as small as a ⅛-inch sphere must be measured precisely. To describe microwave measurements an analogy is made with optical measurements. In optics, the light source is the transmitting antenna and the eye is the receiving antenna. Lenses and shaped reflectors (such as an automobile headlight) may be used to control the distribution of energy. In microwave research, one of the most important tools used is the model technique.[1,2] This technique enables the engineer, by means of simple small-scale models of antennas and aircraft, to conduct measurements under carefully controlled conditions. Such information can in turn be used to determine the operation of actual aircraft systems. These measurements, for design and modification information, may be made at a very small fraction of the cost of the prototype equipment and with greater precision under these laboratory-controlled conditions.

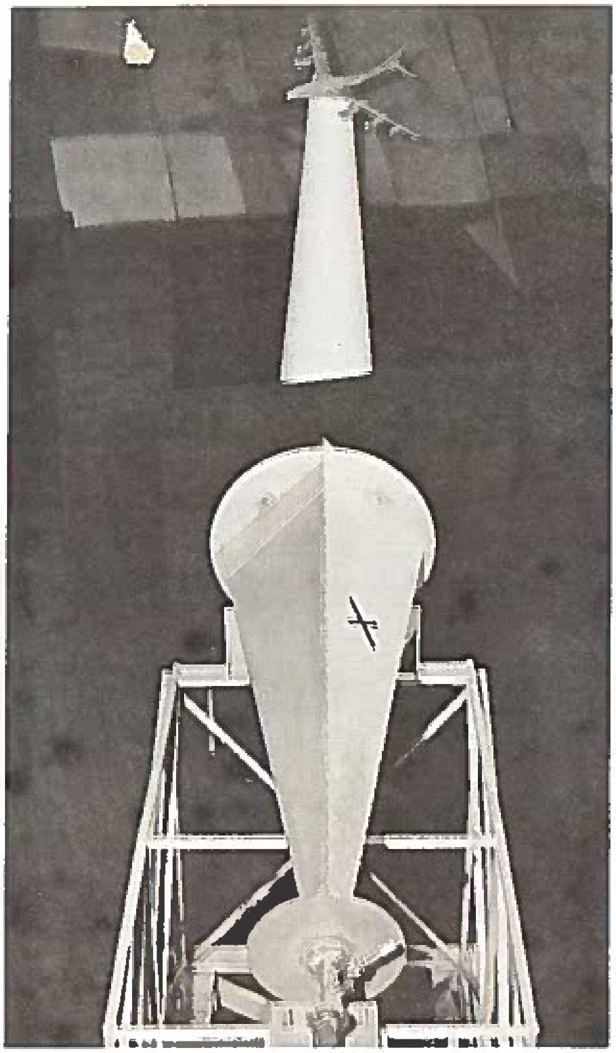

Fig. 2.—Balcony view of the 48-ft. "anechoic" room with model B-47 target on styrofoam column.

Antenna studies include both transmitting- and receiving-antenna designs for supersonic aircraft and missiles for the following operations: communications, navigation, direction finding, missile guidance, fire control radar, search, homing, jamming, landing approach, radar vision, and scanning radar. The problem in antenna research, to determine what factors are controlling the antenna radiation, is complex because the antenna in supersonic aircraft must be flush-mounted and because the aircraft structure itself causes distortion of the radiation pattern by acting like a collection of lenses and reflectors. A lens directs or misguides the energy and a reflector causes shadows. The solution is to design the antenna so as to compensate for, or take advantage of, the lens action and the shadow effects.

Radar-reflection studies include echo-reflection measurements (both monostatic and bistatic) for radar detection, radar enhancement, radar camouflage, and terrain return. In echo-reflection studies, the problem is to determine what factors are contributing to the radar return and to use these characteristics for tracking or guiding the aircraft to or from a target. In camouflage and enhancement, the problem is to change certain natural characteristics so that the aircraft identity is disguised or revealed.

Radome studies are made to determine the effects of covering the flush-mounted antennas with plastic and ceramic materials for protecting the antenna from damage while, at the same time, maintaining a streamlined aerodynamic shape. The problem is to design a covering, shaped to the contour of the aircraft, which will not act as a lens when it shields the antenna.

The Field Station

The Field Station is located at 1320 Kinnear Road on the West Campus of The Ohio State University. It is a two-story, concrete block building with a small penthouse on the roof. The building contains 28 rooms, 14 of which are laboratories. The 14 laboratories include two air-conditioned impedance labora-

[1] *Engineering Experiment Station News*, Ohio State University, *18* (5) 3–40 (Dec. 1946).

[2] George Sinclair, E. C. Jordan, and Eric W. Vaughan, "Measurement of Aircraft-Antenna Patterns Using Models," *Proc. I.R.E.*, *35* (12) 1451–1462 (Dec. 1947).

tories, two air-conditioned "microwave darkrooms" or indoor microwave measurement laboratories, four laboratories for antenna measurements with outdoor pattern ranges, four laboratories for radar-reflection measurements with outdoor pattern ranges, one electronics laboratory, and the penthouse laboratory. In addition to the measurement laboratories, the building

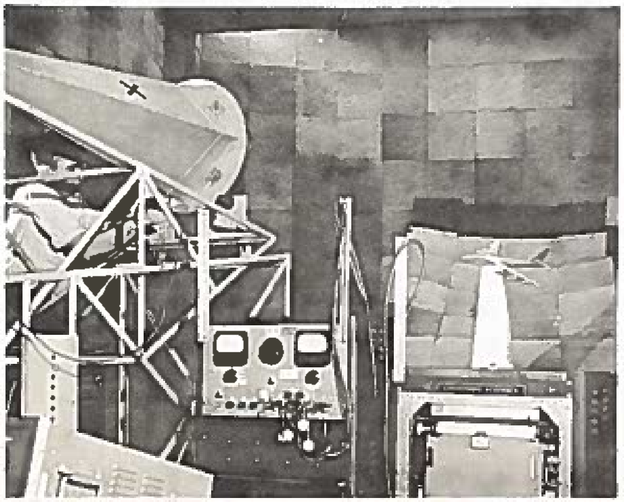

Fig. 3.—Ground-floor view of 48-ft. "anechoic" room with model B-47 target in background and recording instruments in foreground. Technical assistant James Upson is shown adjusting the plumb line.

is equipped with a photographic laboratory, a small machine shop, a library, a reception room, computation and data-analysis laboratories, and engineering offices.

The building was designed by the University Architect and constructed at a cost of $238,000. In addition, the University provided $80,000 for new technical equipment and office and laboratory furniture. Other technical equipment developed and accumulated over the past twelve years and valued at a half-million dollars was moved into the building. The laboratories are supplied with 120/208-volt a.c., 60-cycle single phase; 120/208-volt a.c., 60-cycle three phase; 120/208-volt a.c., 400-cycle three phase; and 6-, 12-, 24- and 120-volt d.c. Natural gas, water, and compressed air are available in each laboratory.

A photograph showing the rear view of the Field Station is seen in Fig 1. Some of the features of the building are: the location; the arrangement and design of windows and doors; direct coupling system between the first and second floors and the second floor through the roof; two indoor microwave measurement rooms; the flat roof available for antenna, impedance, or reflection measurements; the top of the penthouse for scanning antenna systems or propagation antennas; two air-conditioned impedance laboratories; a private laboratory for each experimental project; and private study space for scientists.

There are many advantages with the indoor "microwave darkroom" or "anechoic" rooms. Measurements are obtained independently of outside temperature, humidity, and wind velocity. Since outdoor measurements canot be made on rainy days or when the wind is traveling at velocities great enough to vibrate the targets, several additional days of measuring time are made available each month. Also, considerable time is saved in setting up and tearing down the experiments daily. This factor is especially important when alignment and position tolerances are critical. Angular accuracies of 0.1 deg. are often required and the distance between the target and transmitter must be accurate to 0.001 in. for special cases.

Figures 2 and 3 show one of the two "anechoic" rooms. The one shown is 48 ft. long, 20 ft. high, and 20 ft. wide and the other is 34 ft. long, 10 ft. high, and 20 ft. wide. These rooms are large enough to meet the range requirement for 70 per cent of the experiments. The absorbing qualities of the material are satisfactory for most antenna and radome measurements, and echo measurements can be made satisfactorily for higher echo targets, i.e., targets whose smallest reflection is greater than the reflection from a 6-in. sphere.

There are two pulse-type radar equipments shown in Fig. 4. The one on the right operates at 35,000 mc. and the one on the left at 25,000 mc. Both sets

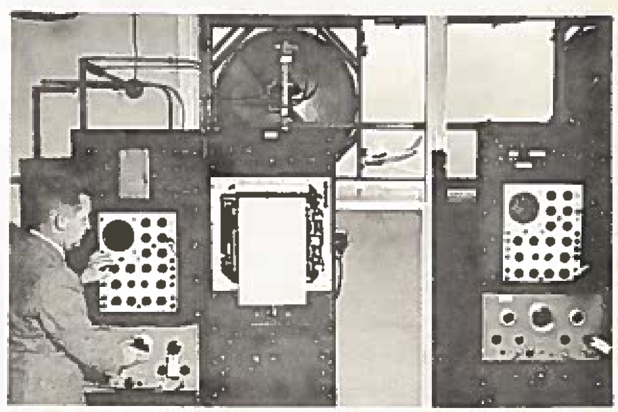

Fig. 4.—The two pulse-type radar equipments with Research Associate Leon Peters making necessary adjustments. The parabolic dish antenna is mounted just outside the window and the target, an F-86 model, can be seen in the background. ***(All photographs by the Department of Photography)***

are capable of measuring return from targets having several types of polarization: linear polarization (either horizontal, vertical or diagonal), circular polarization (right or left); and crossed linear. In addition, they are capable of measuring the return from the conical scan-tracking radar. The system shown functions as follows: a transmitter with a 35-kw. peak power is used, this transmitted power being connected to a parabolic dish antenna mounted outside the window; the signal from the transmitting antenna illuminates the targets (whose aperture may vary from 1/8 in. up to 12 ft.); the reflected signal from the target is picked up on the receiving parabolic antenna adjacent to the transmitting antenna; the receiving antenna is connected to the receiving set which in turn provides the signal used to drive the recorder; the angular motion of the rotating target is linked by means of a servo to the recorder capable of recording rapidly signal variation over a 50-db. range. The smaller models are supported by nylon string and the larger models (four feet or more) are supported on a styrofoam column.

Outside doors were provided for each individual laboratory because the engineers continually go from the laboratory to the target. There are two three-inch conduits between floors in each laboratory so that transmitting, receiving, and recording equipment might be permanently placed at the ground-floor level and, by using transmission lines, be coupled to the transmitting and receiving antennas at any elevation required. This arrangement further saves time in getting from the equipment to the model.

The windows are especially designed so that the antenna may be placed within the laboratory for antenna-measurement work at any elevation. This arrangement also protects the antenna from weather and eliminates the time required to put up and take down the equipment daily.

Research Programs at the University

The research programs at the University are of two types. One is the type sponsored through the development fund, grants-in-aid, scholarships, etc. The other is contractual research between the University and governmental agencies or industrial organizations. Such programs are essential and beneficial to the University because of the advancing technical developments during the last decade. The graduate student of today in the scientific field must really be considered an "intern." He must, in addition to completing a rigorous academic program, work with a "surgeon" (graduate advisor) for several years before he develops into a modern scientist. Therefore, "hospitals or clinics," such as the Antenna Laboratory Field Station, must be available for him to conduct experiments and gain experience. Modern technology requires more and more scientific equipment and adequate facilities. No longer can the scientist be expected to keep up to date if his experiments are restricted to the old "bee's wax and string" type of research. Nor can his analysis programs and calculations be completed with the slide rule.

In order to obtain the finances necessary for providing these expensive equipment items and facilities, the University, through the Research Foundation and Engineering Experiment Station, cooperates with organizations sponsoring basic research programs. Contracts are negotiated which are of mutual benefit to these organizations and the graduate students. The programs must be fundamental in nature to provide thesis and dissertation material as well as to have application for the cooperator. This arrangement enables sponsoring agencies to obtain the basic scientific information which is best produced in the academic atmosphere. In addition, because outstanding sources of technology and scientific development in Europe were largely destroyed or confiscated during and after World War II, many of the free people of the world look to the American universities for scientists and fundamental "know how." It is to these efforts that the Antenna Laboratory Field Station is dedicated.