

While the Signal Corps is primarily concerned with the problems of applied research and development, certain regions of basic physical research are also stressed in its laboratories.

physics in

Fig. 1

THE SIGNAL CORPS ENGINEERING LABORATORIES at Fort Monmouth, N. J., in staff, facilities, and annual budget, may be placed among the country's largest physical sciences laboratories. From a civilian staff of approximately 50 in 1930, a war-swollen peak of 14,800 was reached in 1943, largely resulting from the introduction of Army and Air Force radar as a combat weapon. The staff at present is slightly over 4000, of which approximately 1300 are professional scientists or engineers augmented by 75 highly trained officers and several hundred enlisted men. As the name implies, development of military gear under the purview of the Chief Signal Officer, Major General George I. Back, is the major responsibility of the organization. Most of this work is of an electronic type drawing heavily from all the physical sciences, and particularly physics. In addition to the major activity which is centered in the Fort Monmouth area, experimentation related to the prime tasks is spread throughout the U.S. and, in fact, to all the corners of the world through contract, field stations, and special task forces.

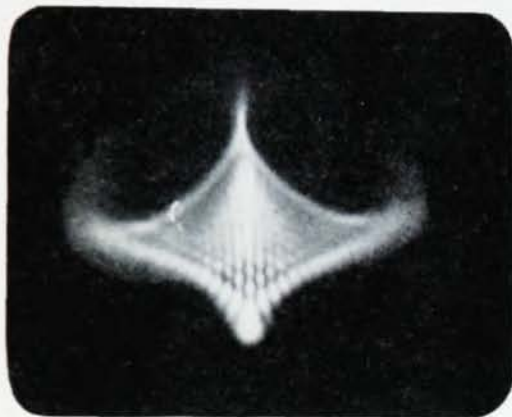


Fig. 2

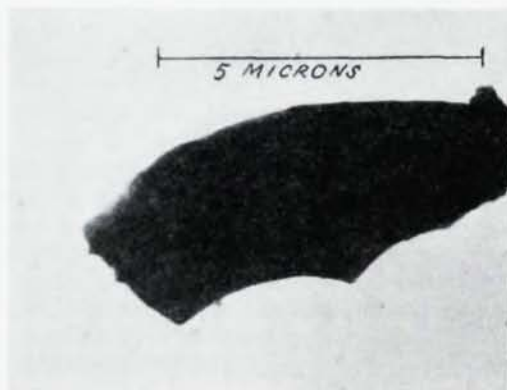


Fig. 3

Fig. 1. Surface area measurements being made at Signal Corps Laboratories by measuring absorption of nitrogen gas.

Fig. 2. Photomicrograph of image point of point source produced by $f/2$ lens, $F=2''$. Coma pattern approximately 6° off axis is shown. (Enlarged approximately 620 times.)

Fig. 3. Photomicrograph of crystal residue of ice (tentatively identified as quartz by its x-ray powder pattern) collected from cirrus clouds at 30,000 feet by Signal Corps scientists.

Fig. 4. Photomicrograph of image point showing deformation of airy disc, approximately 1° off axis, slightly out of focus. (Enlarged about 550 times.)

Fig. 5. (Opposite page) Photomicrograph of image point similar to that shown in Fig. 2. Coma pattern approximately 8° off axis. (Enlarged approximately 380 times.)



Fig. 4

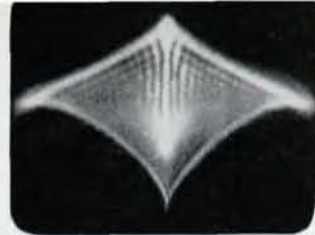


Fig. 5

the SIGNAL CORPS

By *Harold A. Zahl*

The Signal Corps is proud of its tradition of continually looking, through research, to better ways of accomplishing military objectives. In retrospect, the Signal Corps may look back and claim a major role in triggering or at least substantially aiding in the evolution of organizations or concepts which later outgrew the Corps' limited military assignment, for example: the U.S. Weather Bureau, the U.S. Air Force, radio broadcasting, radar, and television.

Today, with science formally recognized as a major power in both civilian and military planning, the pre-war situation of having to do much with little has virtually disappeared, and in its place, there now exists a heavy pressure to advance as quickly as possible on all fronts of military interest. No longer are individual investigators sweating out projects and hoping for the financial assistance which may make continuance of their work possible. Even though their work may not always be generally publicized, the eyes of the classified world continually follow our military scientists and urge them on with moral and financial support, particularly when application seems imminent. Everything is now provided, except that a shortage of adequately qualified research personnel exists at Fort Monmouth as elsewhere throughout the U.S.

Coinciding with the pressure to translate theory into reality is impatience, and concomitant with impatience we also find a tendency to unintentionally minimize basic research, since scientific success, in a strictly military sense, is understandably measured by accomplishments in the applied fields. However, it is a mistake to think that research has yielded, entirely out of proportion, to development or engineering in the applied fields of military interest today. More correctly, engineering and development, because of the exigencies of the times, have received greater attention than research, but simultaneously, within the Signal Corps, research has been under way at the highest level since the inception of the laboratories.

Naturally, security classification enters the scene, particularly in recent months. In fact, once it is seen how information or discovery in a field may signifi-

cantly influence a military requirement, the researcher finds he is more apt to be, temporarily at least, in the audience of the technical society rather than among those presenting papers. In these days, however, the necessity for certain security limitations is apparent. It is an unfortunate requirement.

In a bulk sense, the majority of the Signal Corps research program is based upon the medium of the research contract with educational institutions, research foundations, and industry. All the physical sciences, stressing the hybrid field of electronics, are included in this portion of the Signal Corps program. The pattern of research contracts, which gradually evolved over six years, includes the association of many outstanding investigators with the Signal Corps in projects of broad military interest. Problems assigned in themselves are challenging from most scientists' point of view, but as assurance against restrictiveness which might curb imagination, the investigator is encouraged to follow leads of his own choice which appear to have direct or indirect bearing in the assigned area. Every effort is made to have the contractual instrument sufficiently flexible to follow the path of discovery. These contracts are all closely followed by competent Signal Corps personnel and therefore represent an effective increase in the research supporting the applied effort of the Signal Corps. Most of the 132 contracts now in effect in the physical sciences are unclassified, and free interchange of information among other workers in related fields follows without complications.

Since much of the present national research program now looks to various government agencies for support, every effort is made directly and through the channels of the Research and Development Board to glean applicable information wherever it may be found and utilize it either as a prevention against duplication of effort or for direct military applications of Signal Corps interest. As a further step, and consonant with the prin-

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Fig. 6. One terminal of a two-mile experimental surface wave transmission line used by scientists of the Signal Corps Engineering Laboratories. Truck contains equipment for measurement of transmission characteristics.



ciples of Service unification, in many contractual research efforts the Signal Corps joins with the Office of Naval Research and the Air Research and Development Command and jointly supports efforts of common interest.

It is not the major purpose of this writing to discuss a rather large contractual program covering many fields. In the space remaining, it is proposed rather to focus attention on the smaller, but very important work being carried on within our own laboratories, stressing particularly cross sections of activities of interest to the physicist.

THERE ARE THREE broad categories of effort which we should look at: first, there is a development program with personnel engaged therein constantly seeking new information which may be useful in an end-item of military equipment; second, there is an applied research program in which the engineer and physicist join hands in such activities as fox hole to global communications experiments, problems of Army interest in air defense, electronic countermeasures, infrared applications, radiological and meteorological instrumentation, special weapons tests, electron tubes and solid state devices, components and materials, power sources, climatological factors, atmospheric physics, photography, etc.; and third, there is a more basic program, in which gifted individuals are allowed considerable freedom of choice in research problems of broad and not particularly specific military interest. The latter activities are most essential in maintaining the environment necessary for advanced development to flourish and/or prevent stagnation of engineering thought. It is a problem of management to maintain the proper balance and coordination among these three groups, since they mutually form the team required at this time to support the military effort. The question of balance is now particularly important, since decisions require the establishment of a program to meet the possibility of a global-war-tomorrow or to support an armed peace extending through decades.

Typical of some of the basic physics problems in the last-named category now being considered at Fort Mon-

mouth are: electron beam inter-actions, gas clean-up phenomena through use of radioactive isotopes and tracer techniques, comparison of point, line, and area contacts in current flow from a metal to a semiconductor, spectral distribution of light emitted by silicon carbide crystals under current pulses, field dependent secondary emission from magnesium oxide surfaces, the role of cathode temperatures in the gas discharge, interactions of ions from solids by electrons in very high fields, and interactions of slow electrons with ionic crystals.

Another group having more specific responsibilities in the broad field of materials directs a portion of its effort to such problems as properties of single crystals of barium titanate, electron and light microscopy, differential thermal and mass analyses techniques, photographic photometry in emission spectrochemical analysis, relations between current voltage and amplitude of vibration in piezoelectric crystals, ceramic magnetic materials, charge distribution and energy levels of trapped electrons in ionic solids, and others.

The powerful techniques of multiple beam interferometry have also recently been introduced into the materials research program. It is expected that these techniques will be of invaluable assistance in the study of surface microtopography, yielding new information on crystal surfaces and oscillations, the mechanism of cleavage, characteristics of plastics, thin film metal surfaces and a host of other equally interesting items.

Leaving the realm of basic effort for a moment, it may be of interest to take a quick look into an area of applied effort in which our physicists tend to become engineers and where the engineers transcend into the realm of the physicist. I refer to an activity broadly described as "circuitry research" which as such applies to communications, radar, electronic countermeasures, guided missiles—in fact, any application using electron tubes, condensers, transformers, plumbing and ordinary hook-up wire. Most of the Signal Corps effort in this field is of an engineering or development character, but applied research must always be in the vanguard. For instance, one of our investigators, using some concepts published by Sommerfeld in 1899, covering a surface

wave guided by a cylindrical conductor of finite conductivity, added reality to Sommerfeld's concepts by reducing the phase velocity on the conductor through the addition of a thin dielectric coat, thereby shrinking the field to usable dimensions which made it practical for the transmission of microwaves as a competitor to the wave guide or coaxial cable.

Typical of other subjects involving circuitry research underway at Fort Monmouth are studies of modulation, data transmission systems, generation of stable frequency sources, antennas for various applications throughout the entire radio spectrum, broad-banding, cavity circuit theory, computer circuits, magnetic amplifiers, single side band studies, frequency shift systems, generation and detection of microwaves, radar reflection studies through model techniques, and many others.

Perhaps the most pressing problem today confronting the circuit engineers within SCEL is not how to add another 100 electron tubes to a piece of field equipment and further "simplify" the problem of the combat GI, but rather the simplification of the entire field of electronics through the elimination of the electron tube in favor of solid state devices such as transistors. In at least six separate groups, we find engineers discovering the solid state, while simultaneously we find physicists discovering the intrigue associated with the removal of the electron tube from complex and frequently unreliable electronic circuits. A new field of research is rapidly taking shape in which the chemist, metallurgist, physicist and circuit engineer will combine forces to develop electronic equipments, which it is hoped, in not too many years, will exceed in capabilities many present designs and, in fact, go much further in accomplishing military objectives impracticable or even impossible with electron tubes.

ANOTHER PORTION of the SCEL program believed of interest deals with the physics of the atmosphere. Research is under way to learn more of the temperature, pressure, composition, wind direction and air speed to altitudes as high as military interest exists (defined as something less than the distance to the nearest fixed star). These experiments involve direct measurements through the use of rockets and balloons, and in addition use is made of such portions of the electromagnetic or sound spectrum as may yield information from transmission, reflection or refraction by the atmosphere. For example, rockets are sent up carrying grenades timed to explode at intervals which can be accurately fixed by observing the grenade flashes. Sometime later, the sound of the grenades reaches the earth in a time sequence which also can be measured. These two time measurements can be used to determine temperatures ambient to the probing rocket. Another powerful tool for probing the atmosphere is the use of radar, since certain frequencies are admirably suited to show atmospheric discontinuities which may be interpreted in terms of the weather about us or, of more interest, that to come.

In cloud physics some of the problems on which re-

search is being done include subjects such as problems of artificial rain, the effectiveness of artificial and natural freezing nuclei, formation of precipitation in cumulo nimbus clouds, formation of ice crystals and their structure as a function of temperature, humidity conditions in cirrus clouds and ice crystal structure, and others.

The field of optics, traditionally a favorite with the physicist, is also very important to the Signal Corps in accomplishing the Army's photographic mission. In this connection, Fort Monmouth is indeed fortunate in possessing perhaps the finest collection of Zeiss lenses in the world. In addition an unusual automatic flat field optical bench, of purely kinematic design, with all possible adjustments, capable of handling focal lengths up to 48 inches with a high degree of accuracy, has been constructed. Work is under way involving special lens and mirror design problems, analysis of high-quality lenses, oblique reflecting systems, on-film resolving power, nonintermittent cinematography, projection systems, and others.

Of interest also to the physicist would be several of the problems associated with research and development of nonconventional methods of photography, for example one which is called electrography in which a photoconductive substance acquires on exposure a latent image of a scene in terms of a surface electrostatic charge. A cloud of fine charged particles attracted to the plate produces the image in a matter of minutes, copies of which may be quickly made permanent by a contact transfer of the powder to a paper sheet. Physics research problems are very abundant in application studies of the type described.

As a closing thought, it would appear appropriate also to indicate that the Signal Corps recognizes the importance of the atomic age. Being assigned responsibility with the Department of Defense for portions of the combat radiological instrumentation program, considerable liaison naturally exists between our own nucleonics groups and certain branches of the Atomic Energy Commission. In addition to a substantial development activity on instruments, a small supporting research program is also under way. Facilities for a two million volt van de Graaff machine have been completed, while active research studies now include gamma ray spectroscopy using scintillation techniques, gamma ray scattering and intensification effects as applied to dosimetry, studies of scintillation in solids and liquids, and work on storage phosphors.

The above can at best only give a most cursory story of the role physics is playing in the Signal Corps. Whether the Signal Corps' balance between research and the application of physics through engineering and development is the correct one for the present turbulent world situation remains for time to decide. The Signal Corps is confident that when the blue chips are down in combat, the truths learned through the study of physics will conspicuously appear in the operational effectiveness of the men who use the equipment for which the Signal Corps has responsibility within the Department of Defense.