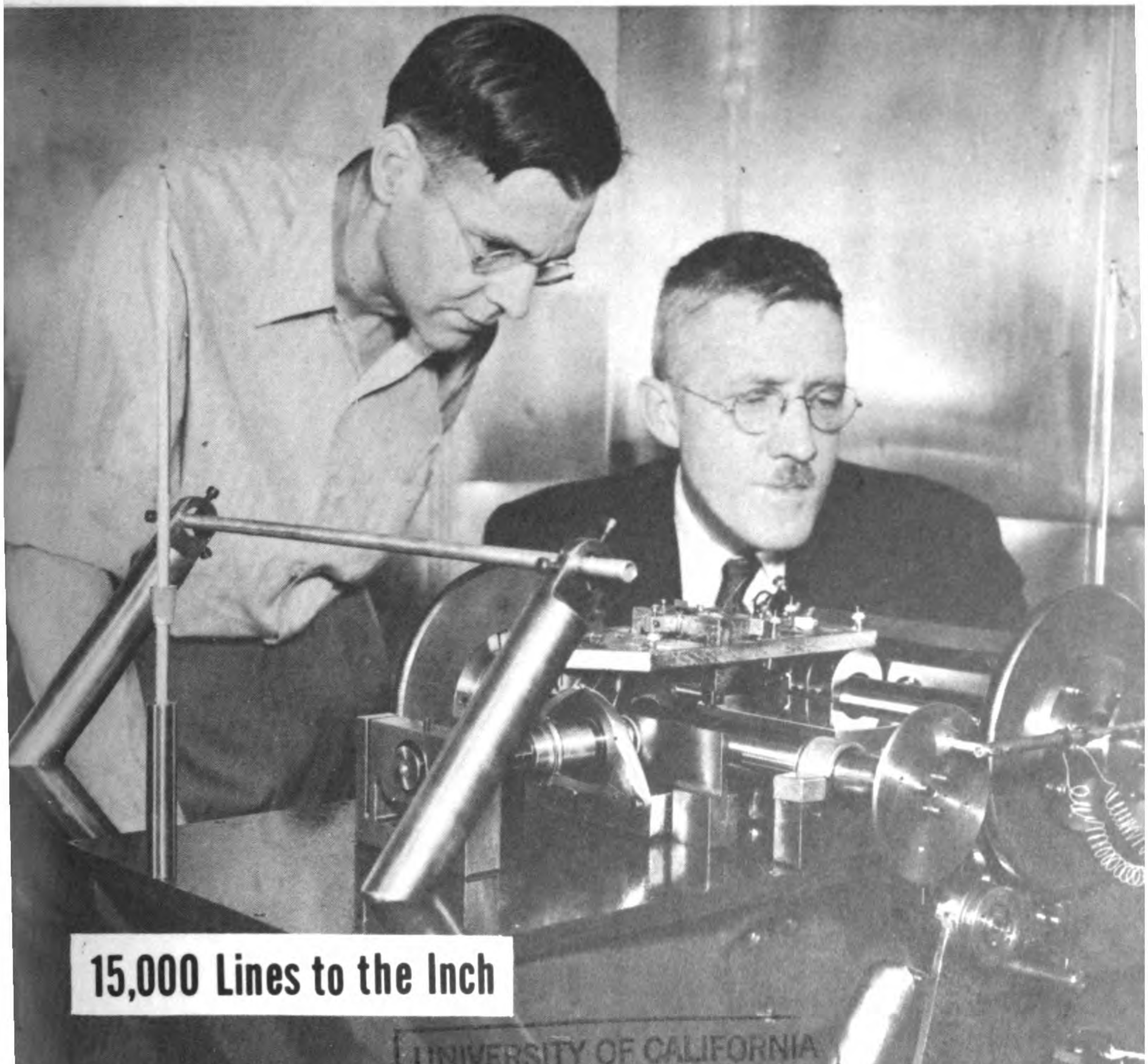
OFFICE OF NAVAL RESEARCH FEBRUARY 1953

RESEARCH REVIEWS



15,000 Lines to the Inch

NAVEXOS P-510

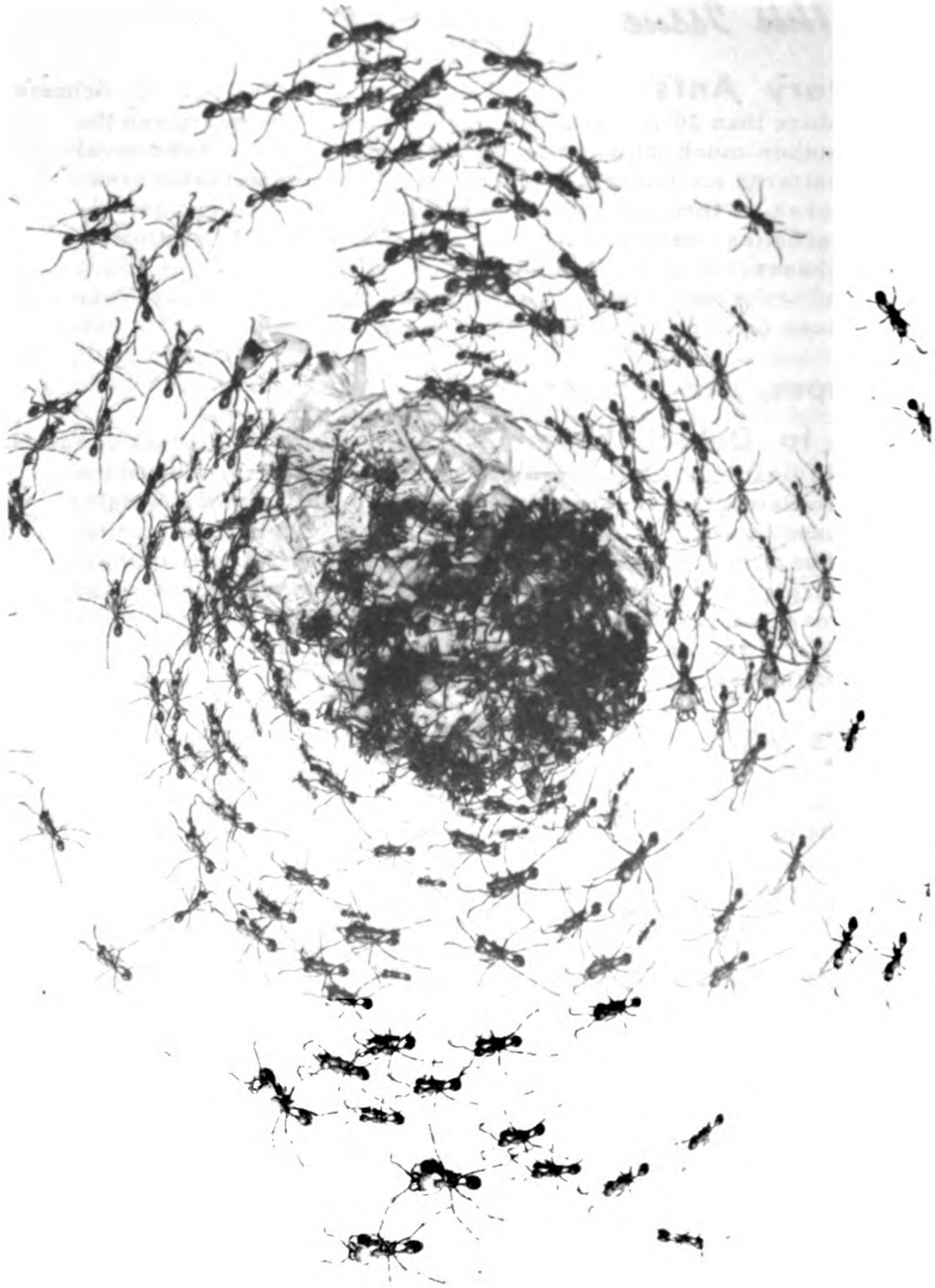
DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

COVER PHOTO: Dr. John Strong (right), inventor, and Mr. Wilbur Perry, chief technician, of Johns Hopkins University, are examining an amazing instrument which is so accurate that it can rule 90,000 lines, parallel and equidistant, on a glass plate six inches wide! This feat in precision, accomplished in three days' time, is furnishing spectroscopists with valuable diffraction gratings which can divide light into a hundred thousand "colors." Chemists use these gratings to identify molecules, metallurgists to analyze alloys, food processors to test food, and there are many other uses, so that the demand always exceeds the supply. For more about this instrument, see "The Story of Ruling Engines" on pages 16 to 20. (Photograph, courtesy J. H. U. Illustrations.)

Research Reviews endeavors to report briefly highlights of technical progress in research by Navy laboratories and contractors and the development of important naval research facilities. Articles which meet these broad criteria and possess a good degree of readability are welcomed. Manuscripts and changes of address should be sent to Code 250, Office of Naval Research, Washington, D. C.

Approved by Bureau of the Budget, 14 February 1952

In This Issue



This circular march of worker army ants occurred in a laboratory nest. In the forest, these ants carry out their pillaging raids on complex systems of branching trails; circles such as this one develop only in the laboratory or under very exceptional forest conditions. Excited by the presence of active larvae, the ants keep moving around the center cluster, often running in such endless columns for several days until all are dead from dryness.

Military Ants

T. C. Schneirla

...Curator of the Department of Animal Behavior, American Museum of Natural History, is chief investigator of an ONR contract on tropical field studies.

In the forests of tropical America are great colonies of pillaging or army ants which lead a purely predatory life, feasting on insects and other small forest life. Like a conquering army, they march in columns and plunder in great systematic raids. They are nomads, moving at regular intervals, settling down temporarily, and again moving on. The terrestrial species (mainly active above ground) form a "bivouac" each night composed of their own bodies clustered together worker upon worker.

My research on these ants began in 1932 with the aim of finding the causes underlying their nomadism, as a problem in so-called instinct. The idea then dominant was that a colony somehow is caused to move on when it has wiped out the booty in a nesting area. My investigations have disproved this idea, at least for the tropical American species, and also have led to numerous specialized problems of interest from different scientific standpoints.

If emigrations of army-ant colonies are not governed by the food supply, neither do they occur haphazardly: they are regular and have specialized causes. Continuous studies of particular colonies, some over periods longer than 4 months, reveal a life of regularly repeated cycles. Each colony exhibits two alternating activity phases: a nomadic phase, when they carry out a great raid each day and an emigration each evening or night to a new nesting site; and a statary phase, when raids are small and sometimes absent, and there are no emigrations. Eciton hamatum, which raids in far-flung branching columns, has a precise nomad-statary cycle. In this species, nomadic phases usually last 16 days and sometimes 17, statary phases usually 20 and sometimes 21 days, with infrequent variations. These cycles are repeated in each colony throughout the year.

The timing device, as it proves, is no external event such as lunar phases, but lies in periodic changes within each colony. Present in every normal colony is a great brood of young, which develops from one batch of eggs laid by the single colony queen within six or seven days. This brood passes through successive growth stages, emerging within a few days as young adult workers—all sterile females.

The development of this brood has a definite relation with colony activity. While it is passing through the larval stage, a nomadic phase occurs. This phase ends exactly when the larvae mature and spin their cocoons. As the brood passes through its pupal stages, the statary phase occurs. This phase of the colony comes to an end exactly when the brood emerges from cocoons as young adult workers. About midway through each statary phase, the queen delivers a new brood of eggs, which will be young larvae by the time the colony next enters a nomadic phase.

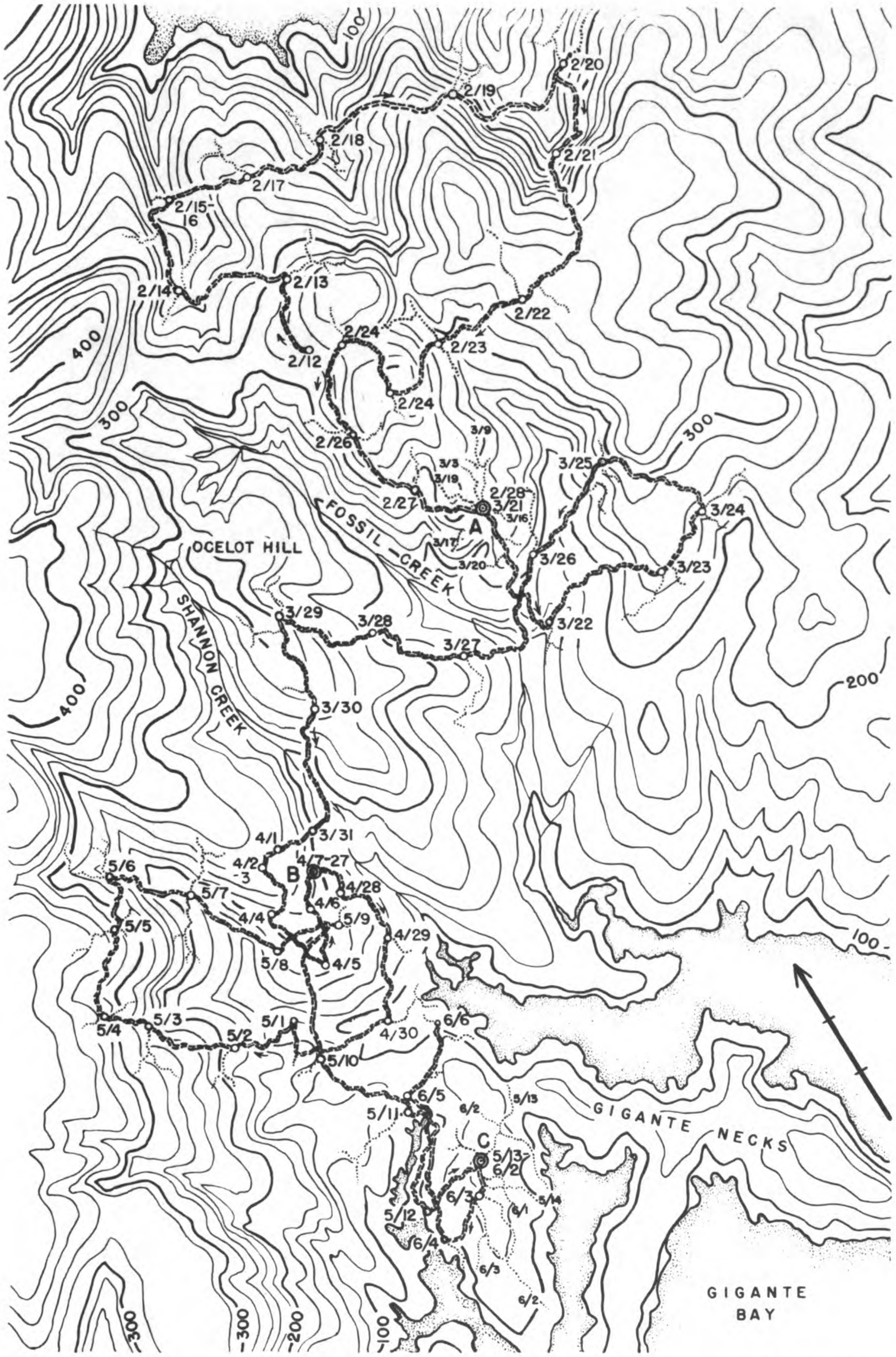
A causal relationship between brood condition and behavior of the adult colony population really controls the cyclic changes. An active larval brood as it grows provides more and more tactual and chemical stimulation to the adult workers, who are very responsive. The brood thereby energizes the colony in an accelerating manner during its larval development. A great raid is then certain to develop each day, starting at daybreak and leading by complex stages to a colony emigration sometime after dusk. But when the brood passes into the pupal stage in which all members are enclosed in cocoons and quiescent, its energizing effect drops sharply to a low level. Then daily raids become too small for emigration to occur. The emergence of this brood as hyperkinetic young workers again sets off a nomadic phase, which is maintained by the oncoming brood through its larval phase—and so on. The map opposite shows the winding course followed by a colony of E. hamatum, which ranged over about two miles of forest within four months. Between February 12 and June 6, 1946, there were three complete nomad-statary cycles, and three all-worker broods were produced.

The nomadic "instinct" in army ants thus finds its basis in a dynamic, repetitive relationship between reproductive processes and social behavior. Here we meet problems concerning the nature of emigration, nomadism, and also migration in animals. The army-ant pattern may be considered a case of migration since it meets the two criteria commonly accepted in other animals. First, nomadic movements occur as a result of reproductive processes, and, second, there is a reversible shift from one type of environmental situation (open sites in the nomadic phase) to another (enclosed sites in the statary phase). A contrast with the well known migration patterns of birds and fishes is of interest for migration theory in general.

A basic factor in this system is the colony queen. This curious individual, much larger than her sterile sisters, the workers, and wingless throughout life, is able to lay great quantities of eggs in precisely timed batches, at set intervals, for some years. The queen of E. hamatum lays 30,000 or more eggs within a few days, and repeats this process regularly each 36 days, for as long as five years. Behind such a prodigious and precisely regulated fertility there are some intriguing problems in the physiology of reproduction.

What sets the army-ant queen at regular intervals from a resting condition into a repetition of her prodigious feat of egg-production? The idea of a purely visceral rhythm or some other regular organic process as the timer has been weakened by studies of her relationships with the external situation in the colony. At a particular time in each repetition of the nomad-statary cycle (starting in the last four days of each nomadic phase) the queen is overfed for about one week, and thereby set into a reproductive condition. First her extensive fat bodies grow rapidly, then egg maturation begins and accelerates.

In an active colony with a healthy queen these complex events occur precisely and regularly, reaching a climax in a great egg-production



This map represents a critical test of the cycle theory, carried out on <u>Eciton</u> <u>hamatum</u> at Barro Colorado Island, C.Z. The double circles (marked 2/28, 4/7, and 5/13) represent statary sites; the small circles, nomadic sites. Broken lines are successive routes of emigration; dotted lines, typical raiding routes. Contour interval: 6.1 meters. Scale: length of N-S arrow (lower right) is 300 meters.

This temporary "bivouac" of the army-ant species Eciton hamatum, hangs from a raised log to the ground. Surrounding vegetation was cleared away for the photo (a 15-second time exposure). In the evening the entire colony moves to a new location; the brood is carried by workers, but the queen moves under her own power.

episode about midway through the following statary phase. The key event seems to lie in complex brood-colony relations, especially in the fact that when a larval brood nears maturity, its total energizing effect upon the colony continues although the brood consumes less and less food. The larvae are still active, but cease to feed as they begin to spin their cocoons. Raids are very large, so that a food surplus exists. Not only is an unusual amount of food available for the queen, but workers stimulate the queen to feed voraciously. This combination of events persists long enough for the queen to become fully gravid just as the brood ceases spinning and enters the fully quiescent prepupal condition (in which its excitatory effect on the workers is lowest).

Thus, in effect each new peak in the queen's reproductive rhythm is aroused in a feedback fashion by external events in the colony cycle. It is a striking fact, however, that the external trigger factor is an outcome of events in the growth of a brood produced by the queen herself at an earlier time.

Without stable conditions regulating brood development, the described pattern could not occur. For it is well known that insect development, expecially in larval stages, is delicately affected by environmental conditions. Among numerous problems in environmental physiology which have arisen in studying the army ants, an important one concerns the curious temporary nests, the "bivouacs." In terrestrial species such as E. hamatum, the bivouac is formed of the clustered bodies of the ants

Close-up of a portion of outer wall in the army-ant bivouac shown in the photograph opposite. Most of the ants are hanging head downward in the structure. They hang most frequently from their third (or rear) pair of legs, which are longest, and they have large double hooks on the end tarsal segments of their legs.

themselves, hanging worker upon worker in a more or less cylindrical mass. The outer wall constitutes a "skin" of ants which surrounds a looser internal meshwork of bodies. Queen and brood remain within this living structure, which therefore actually serves as an incubator.

The bivouac proves to be adjustable in its thermodynamics and humidity, so that the extremes of the external atmosphere are smoothed out. A striking measure of environmental control is managed within the army-ant bivouac, as in the bee-hive. In a typical case, when temperatures in the nearby open forest varied through more than 4°C daylight hours, within the bivouac near the brood the temperature range was no more than 0.6°C in the same interval. When external temperatures are higher (e.g., at midday) interior ventilation is increased through a looser clustering of ants hooked within the wall; a tighter clustering under lower external temperatures (as at night) opposes loss of internal heat. In the even environment thereby provided, an army-ant brood can develop in a regular manner of highly predictable duration. Control of the microclimate (or local environment) in these army ants is all the more remarkable because the process depends upon dynamic behavioral changes in a structure composed of living bodies.

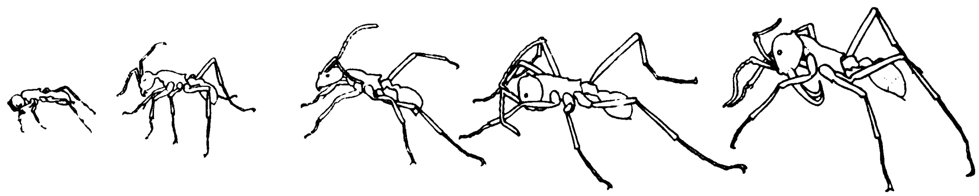
Population control in army ants is a complex process. A colony of _E. hamatum_ may produce an annual total of more than 350,000 new workers in ten possible broods, 30,000 of these being added about each 36 days to a colony population of less than 200,000. Even so, these colonies seldom increase greatly in size, and new broods usually seem only to offset losses. Colony population is held down not only by natural deaths, but also by heavy casualties in the daily raids and by other hazards such as the dry season.

The army ants live an exclusively predatory life in the tropical forests. In the large nomadic-phase raids, a colony must capture two or more quarts of insect flesh each day. The extensive inroads of these army ants on populations of arthropods from wasps and ants to scorpions and tarantulas, with their diverse relationships to the plants and animals of the forest, clearly must be a central factor in the balance of forest life.

These ants enjoy a remarkable freedom of movement in the forest, although almost without light in their way-finding. Each day new raiding columns are pushed out for distances of more than 300 meters from the bivouac, in a complex growing system of routes. Actually the raiders follow chemical trails which they lay down themselves, in relay fashion. Tests show that even one excited ant, advancing a short distance over new ground, leaves chemical traces which can be followed by others. Although these trails ordinarily are used only on the day they are made, they may remain in a usable condition for days and even for weeks. This is only one of numerous functions established for the Eciton colony chemical. Recently an Italian investigator isolated and analyzed the essential chemical of the Argentine ant, which he finds has repellent and toxic effects on many other ants and insects. Whether or not the "essence of army ant" has any such properties, it seems attractive to members of the home colony and repellent to strangers, and is most essential to the wide range of their nomadic, predatory life.

The great raids of an army-ant colony are not simply a matter of making and using chemical trails, but represent a distinctive problem in group organization. This problem is represented strikingly by the movement of the main raiding body in the swarm-raiding species *Eciton burchelli*. In the nomadic phase, a swarm of this species builds up from its start at dawn to a width of more than 15 meters just before noon, when it may have advanced more than 100 meters from the bivouac and contain more than 100,000 ants. Advancing through the forest at a rate of more than 20 meters an hour, they capture great numbers of victims which are torn up and carried back to the bivouac over connecting chemical trails.

Although this great mass of ants seems to be in complete disorder, it actually not only keeps together and advances in a main direction, but as it moves onward it carries out rhythmic flanking turns, wheeling alternately to right and to left at intervals of about 15 minutes. Although this procedure must increase the total haul of prey, there is no "plan" or "leadership" in the human sense. For example, the countless pioneers in the front ranks at any one time are in this role only briefly before they are replaced by newcomers. Systematic studies show that the organization process behind these effective mass deployments consists essentially in predictable series of expansions and contractions of large subcenters, influenced by the circulation of columns and cross-eddies, within the swarm itself. Swarm organization in army ants is complex in a behavioral sense but simple in a psychological sense.



Representative worker types in Eciton hamatum, ranging from the worker minor at left (body length about 4 mm) to the worker major at the right (body length about 12.5 mm). Army-ant workers can sting as well as bite. Note the large tong-like mandibles of the major worker. These are needle-sharp, and offer a formidable defense against molesting mammals including human investigators.

Interesting problems in organization arise from other unifying factors in a colony. Just as in a bee-hive, the queen is the central factor in the army-ant bivouac. Resting in the midst of the cluster, the single mother queen exudes her own peculiar odor (fragrant to man) which in various ways goes far toward holding the colony together. Ordinarily, when two colonies cross paths, they do not mix but operate separately behind quickly formed "picket lines" of workers, and finally go their separate ways. But even within two days after a colony has lost its queen, if it chances to cross paths with another colony of its species, the two may fuse without much friction. Analysis of such occurrences tells us much about the normal unity of a colony.

Paradoxically, we also learn about normal colony unity by studying colony division. This process never occurs as long as a colony continues to produce all-worker broods at regular intervals. But early in the dry season of each year, some of the colonies produce broods which contain no workers but only males and a very few young queens. This unique sexual brood, from its early larval stages, develops a strong attraction for a large part of the colony. As tests show, this attraction is based upon distinctive odor properties of the sexual brood. In time this counter-attraction competes more widely with the drawing power of the regular queen. A queen removed from a colony with an all-worker brood is later reaccepted without difficulty, but when a colony has a sexual brood, the queen is unlikely to be reaccepted after a removal.

Colony division thus evidently develops through conflicting odor-attractions of queen and sexual brood for sections of the worker population starting even while a colony still operates as a unit. The division process is more apparent when the fully developed young queens emerge from their cocoons, and becomes an actuality when the males emerge a few days later. Although there are about six young queens in an emerging sexual brood, colony division never seems to produce more than two "daughter colonies." Ordinarily, only one of the young virgin queens can win a place in a new colony, with the old queen in the other (unless she is "superseded"). The entire process, including both the ascendancy of the successful queens and the rejection (or "sealing off") of the others, seems to be based on worker reactions to queen odors of differing attractiveness, as well as a possible disturbance effect. Colony division in army ants thus apparently has its basis in an odor-competition process.

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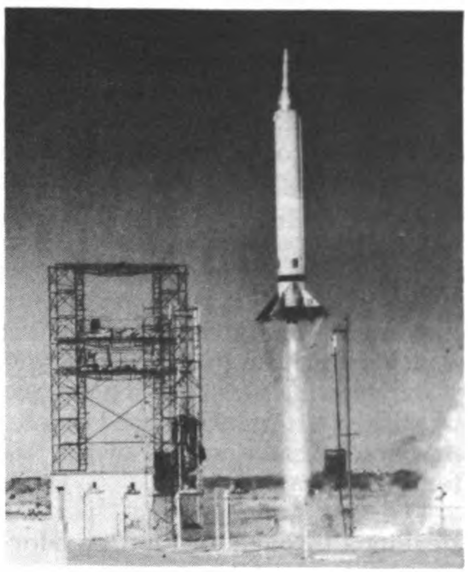
The army-ant case also has an interesting relation to problems of sexual dimorphism and caste determination, that is, what governs differences between queens and males, between workers and queens, and between different types of workers. Useful evidence on this long-standing biological problem is developing in comparative studies of the populations in worker broods and sexual broods in relation to the conditions under which they appear. One intriguing question concerns what happens to the army-ant queen early in the dry season, when she may produce a brood of about 1500 males and a few young queens, instead of a great all-worker brood as at other times of year.

In this research program, evidence has come from systematic field and laboratory observations, from experimentation, and from studies of preserved material. Both behavior and biological processes have been studied, since these are closely interrelated. Thus, to understand nomadism, we have studied many behavior problems from the organization of raids to colony division, and many biological problems from reproductive functions to thermodynamics of the bivouac.

Viking 9 Equals the Record



NRL Viking 9

The altitude record for single-stage rockets was equaled by the Naval Research Laboratory's Viking 9 on December 15 when it climbed to a height of 135 miles over the White Sands Proving Grounds at Las Cruces, New Mexico. By the time its fuel supply of liquid oxygen and ethyl alcohol was exhausted, the 7-1/2 ton, 42-foot rocket was traveling at a speed of 3900 miles an hour. NRL's Viking 7 had established the altitude record for single-stage rockets in August, 1951.

The Viking 9 carried instruments for measuring sunlight in various X-ray and ultraviolet regions. These included a spectrograph, automatically pointed at the sun, and three arrays of photon counters and photographic film detectors. Photon counters are similar to the more familiar geiger counters except that they count individual light particles, or photons, instead of electrons, protons, or heavier nuclei.

Specially prepared photographic emulsions were located in the nose of the rocket to detect cosmic radiation. The rocket also carried six cameras to determine the orientation of the experimental equipment during flight as well as to obtain wide-area infrared photographs of the earth's surface and atmosphere and of cloud formations.

Isotopes, Antibodies, and How to Detect Them

Ludwik Anigstein

... Professor of Preventive Medicine at the University of Texas Medical Branch, had wide experience in Europe and Asia before coming to this country in 1940.

The rapid developments in nuclear physics have provided us with radioactive isotopes, which in addition to their application in medicine have proved a most important scientific tool as tracers of basic body metabolism and of the channels through which antigens and antibodies are incorporated into our system.

Each of the 96 known elements lying in the atomic table between the hydrogen and the uranium has at least one radioactive twin element of the same chemical property, but of different atomic weight. These are radioactive isotopes* which occur in nature in ores, but may be produced in the laboratory by the bombardment of atoms with particles from other atoms. The newly formed atom may be stable or may disintegrate over a period of time ranging from a minute to a billion years. These disintegrating elements which emit nuclear energy (gamma and other rays) are radioactive. Because of the constant emission of energy, its intensity drops steadily and when it falls to one-half of its initial value, the "half-life" is reached. The time required for this diminution by half is characteristic for each radioactive isotope. For example, the half-life of phosphorus (P 32) is 14.2 days; that of radioiodine (I 131) 8 days; and for carbon (C 14) 5000 years. The measurements of radioactivity are accomplished by the electronic device (Geiger-Muller counter) which registers the number of nuclear explosions per second.

As a source of therapeutic radiation, the isotopes offer greater localization of rays in the desired tissues or organ than the irradiation by X-rays. This selectivity can still be increased by binding the radio-isotope with substances showing particular affinity to the organ chosen as a target. These substances are the essential factors of our existence and their nature and mechanism of formation constitute the vast subject of immunology, the basic fact of which is linked with our daily life.

In our struggle for existence we may be unaware of the fact that, from the first days of our lives, we are surrounded by micro-organisms which are our potential enemies. Some of these organisms are parasites which, for the sake of their own survival, are provided by nature not only with resistance, but also with offensive powers against the animal host.

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*The name was given by the British physicist Frederick Soddy in 1912 to these variant atoms of the same element (<u>isos</u>-same and <u>topos</u>-place).

Usually these invasive forces are in a dormant state, but under certain circumstances when the defenses of the susceptible host are lowered, a cold war between the micro-organism and macro-organism may lead to an open conflict. Whenever our first line of defense (skin or mucous membrane) is broken and invaded by such microbes as a malaria parasite, streptococcus, or a flu virus, they will be treated by the living tissue as foreign elements which should be eliminated. This tendency of elimination of a foreign substance is an inherent property of a living organism. If successful, the host will overcome the microbial invasion and survive the infection with immunity to a subsequent infection of the same kind. This striking phenomenon became the cornerstone of a new branch of biology—immunology—which has developed into the modern line of immunochemistry. We have reason to assume that the state of acquired immunity is associated with a profound transformation in the biochemical pattern of the surviving host, particularly in the structure of its body proteins and in the configuration of their elementary particles (molecules).

It was found that when the blood serum of immune animals is mixed with the disease-producing bacteria, the latter are clumped together or may be dissolved. These reactions which may be reproduced in a test tube are characterized by their specificity; i.e., the clumping (agglutination) will take place only with the causative agent of the particular disease or with related organisms. The strange substances which appear in the blood and tissue fluids of immune animals as a response to infection are called antibodies since they act as bodies against the invading microbes. These as well as any other foreign substances which may induce the formation of antibodies are called antigens.

Whereas these phenomena are active and specific responses of the host animal, the blood of animals with no direct contact with the infective agent or with other antigenic factors, also contains substances which act as antibodies. The origin and formation of these "normal" antibodies are perhaps still more puzzling than in the case of actively produced antibodies by a known antigen. One thing is certain: in both instances the antibodies are, chemically, serum proteins belonging to the "globulin" class. Furthermore, no essential differences will be found between antibodies and so-called "normal" globulins.

The formation of antibodies is by no means limited to microbial infections, but may be induced by manifold substances injected into the animal. When proteins are introduced into the digestive tract, the digestive juices will split and decompose them into simpler products which are no longer able to produce antibodies; in other words, they cease to be antigenic. If, however, the parenteral route (outside of the digestive tract) is chosen, then the formation of antibodies starts immediately after the injection of the antigen. Some antibodies are formed and depositited at the site of injection whereas others are gradually liberated from various tissues, mostly spleen, lymph nodes, and bone-marrow.

In most cases the rabbit is used for the production of immune sera by repeated injections of a suspension of the desired tissue from another animal species. The produced antibodies against the respective tissue can then be evaluated in the rabbit serum by adding to the serum the tissue suspension used for immunization. The resulting cloudy precipitate consists of antigen particles clumped together with the antibody particles. This precipitation test, which represents a conventional serological tool for detection of antibodies, is based on their specificity and on their combining power with the homologous antigen used for the manufacturing of the antiserum.

The mechanism of this intricate phenomenon led to various theories, among them the classical lock-and-key theory of Paul Ehrlich, who tried to solve the mysteries of immunity and chemotherapy. According to Enrlich, antibodies are normal constituents of our protoplasm and act as chemical groups or receptors responsible for the fixation of the antigen. In the light of the modern immunochemistry, the molecules of the antibody do not necessarily fit the antigen as a single key-lock combination, but may rather be compared with a series of master keys fitting a series of locks. In this regard, the theories concerning antibody formation advanced by investigators like Breinl, Haurowitz, Boyd, and more recently by Linus Pauling, tend to replace the chemical concept of Ehrlich's rigid receptors by dynamic molecular forces. For a better understanding, antibodies can be compared with chemical substances, and serological reactions with ordinary chemical reactions. According to Pauling, each antigen molecule attracts 2 antibody molecules, this process continuing until the framework of molecules reaches macroscopic size, constituting a precipitate, which resembles an ordinary chemical precipitate.

The prevailing theories of the structure of antibodies represent the surface configuration of an antibody molecule as being complementary in shape to that of the antigen molecule. When antigen is injected into an animal, its molecules which are retained by certain tissues (bone-marrow, spleen, liver) modify the shape of normal protein globulins in adapting them to the shape of the antigen molecules. These modified globulin molecules are the antibodies which differ from normal serum globulins only by their property to combine specifically with the corresponding antigen.

Without going into the pros and cons of the theories of antibody-antigen reactions, we have to admit that the controversy over the opinions of prominent immunochemists beginning with Ehrlich is still alive and that the various theories remain in a conflicting state. Pauling's concept and his tri-dimensional presentation of the dynamic antibody formation have didactic merits and have therefore been offered here for the reader fresh to the field, although the crucial experiment is still missing.

The structural and functional complexity of our body is manifested by specialization of its tissues and organs. The framework of our tissues is composed mostly of proteins which display a diversity of biochemical patterns specific to the organ. These proteins can be differentiated serologically just as the organs are identified by their structure and function. Even within the same animal species, there is a multitude of antigenically different proteins peculiar to the various organs. This organ specificity makes it possible for us to produce specific antiorgan sera from such laboratory animals as rabbits by repeated injections with tissue suspensions. The rabbit is then bled, and the serum separated from blood cells is used for serological reactions.

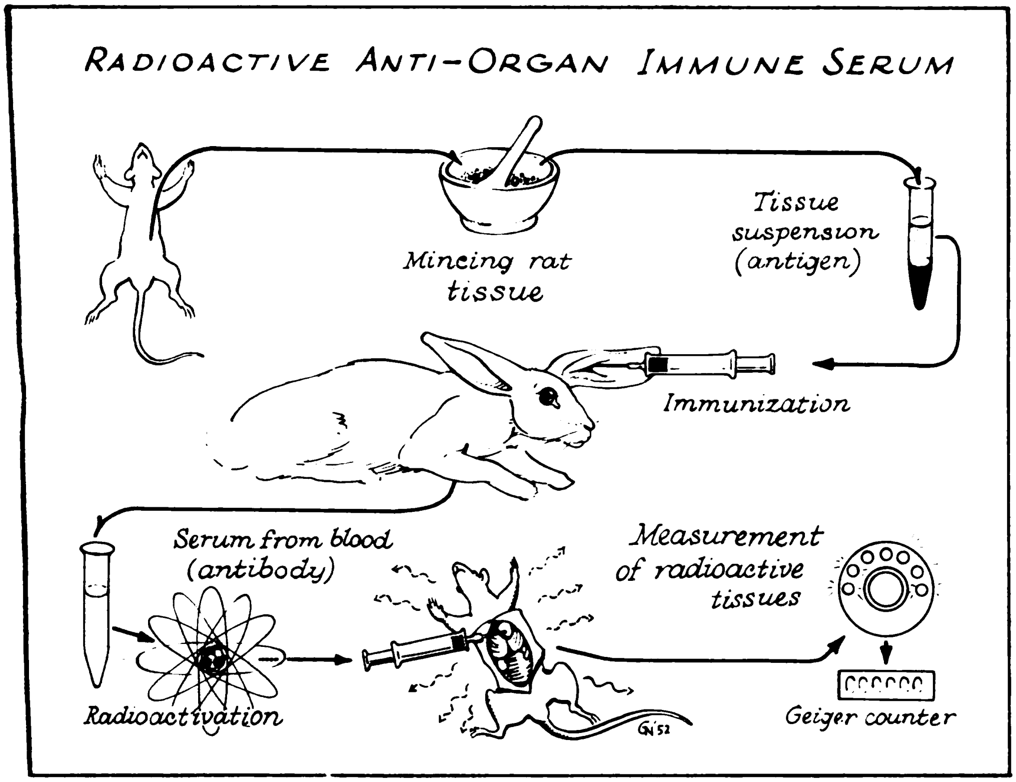
The concept of antiorgan sera is about half a century old and originated with Metchnikoff who showed that guinea pigs injected with spleen tissue of rats yield a serum which if injected into normal rats has a toxic, detrimental effect on the rat's lymphocytes (white blood cells and main components of the spleen). In making history, the "Early Father" of immunology was perhaps not aware either of the intrinsic value of his observation or of the mechanism of the phenomenon. His experiment is now recognized as a classic representing a drastic example of antigen-antibody combination. Giant protein molecules were formed in the rat by intermolecular forces which combined the organ specific antibody with the homologous antigen (spleen of the rat). According to our modern concept, the protein molecules of the rat spleen induced an adaptation of the guinea pig's molecules in molding them to the shape of the antigen. Such surface adaptation made this fixation possible.

Under certain conditions this irreversible process may involve the entire organ leading not only to a toxic effect, but to the abolishment of its physiological functions. In the case of the rat spleen as the main center of the defense mechanisms, the injected antispleen serum may cause an "immunological paralysis" of the organ. Consequently, the animal is deprived of its main weapon to combat infections. This drastic demonstration of the potentialities of antiorgan sera and their strong affinity to the homologous tissue can be compared with the selective activity of certain drugs which if applied in massive dose may be damaging to the tissue and fatal to the host. On the other hand, small doses of the same drug may exert a stimulating, beneficial effect. In applying this pharmacological principle, Metchnikoff was successful in promoting resistance to infection in animals treated with small quantities of antiorgan sera.

It took 25 years for this problem to be revived by one of his students, Bogomolets, who was able to show that extremely small quantities of ACS (anticytotoxic serum), which contained antibodies against spleen and bone marrow, stimulated the functions of the spleen, marrow, and the whole physiological system of the connective tissue. Work done in this country has shown that although ACS is not a specific cure for any disease, it is nevertheless a stimulator of the body's natural abilities for defense and repair. Minute amounts of the serum injected into the skin protected guinea pigs against spotted fever and typhus. The potentialities of antiorgan sera, their possible clinical application, and particularly their use as tools for the study of defense mechanisms became the subject of extensive investigations.

In this category the immunological approach to the mechanism of diseases like rheumatic heart or inflammatory condition of the kidneys tends to incriminate antibodies produced by the individual against his own tissues. According to this theory recently postulated by David Pressman, the process of autoimmunization leading to fixation of antibodies with the tissues involved is responsible for the disease.

It can be seen from the foregoing that the rapid progress of immunochemistry has reached a phase where the classical chemical methods are inadequate to answer some fundamental questions without further speculation. Whereas the demonstration of antigen-antibody compound in a test tube is a freshman's exercise, the direct evidence of this phenomenon



A specific rat antibody tagged with a radioactive element will carry the element with it and aim at the respective organ.

in living tissue was made possible only by the use of radioactive isotopes as tracers coupled either with the antigen or antibody. The new methods of tracer chemistry have enabled us to label antibodies by coupling them with radioactive substances without destroying the specific activity of the antibody.

Thus antisera against various rat organs were prepared in rabbits by repeated injections of tissue suspensions from spleen, kidney, lung, liver and pancreas (see diagram). The antisera (globulins) were then tagged with radioactive iodine and injected into normal white rats. These were sacrificed at intervals of several days and their tissues tested with the Geiger-Muller counter for radioactivity. When antikidney serum was injected, a definite accumulation of radioactivity was found in the kidney, exceeding considerably the radioactivity of other organs. Similarly, when the rat was injected with tagged antiliver serum, higher values were recorded by the Geiger-Muller counter for liver tissue as compared with other organs. In other words, the specific rat antibody when injected into a rat will aim at the respective organ and carry the radioactive element which will be deposited there in larger amounts than in other tissues.

Since it was shown that iodine attached to the globulins presents a fairly stable compound, it can be concluded that the accumulation of radioactivity in tissues is a visible evidence of the equally concentrated specific antibodies. Furthermore, the persistence of the antibodies in the blood and various organs can be estimated. Here again the measurements of radioactivity are the guiding factor in determining the biological half-life of the antibodies, preceding their disappearance from the body. This approach may have an important practical application in evaluating the length of time over which, for example, the injected globulins against measles or poliomyelitis will persist in the circulating blood as a protection against these diseases.

It may be concluded that the radioactive isotopes are most important scientific tools which have uncovered to a great extent some of the mysteries surrounding the antibodies which over the past five decades were a field of wide speculation. It is reassuring that the modern findings can be integrated with the older concepts of the specificity of antibodies and their combining power with the homologous tissue. Furthermore, new data were supplied in using the isotopes as tracers of the anatomical localization of the tissue antibody which evolved from mystery into a visible reality. Another aspect presents itself, namely the consideration of the anti-tissue antibody as an inert vehicle which will carry the radioactive element to the homologous organ chosen as the ultimate destination. A concentration of radioactivity of possible therapeutic value for an organ struck by malignancy can therefore be expected.

New NBS Laboratory at Boulder, Colorado

The National Bureau of Standards is constructing a new laboratory directly south of Boulder, Colorado, to house the Bureau's Central Radio Propagation Laboratory. (An architect's drawing, courtesy, National Bureau of Standards, appears on the back cover.) The new building will be situated on a 210-acre site, and will feature a central spine with one-story wings extending from either side. The main body is designed so that other wings can be added to meet future laboratory requirements. The front of the building is four stories high, reducing to one story at the rear. Completion is scheduled for the early part of 1954.

The NBS Central Radio Propagation Laboratory, established at the request of the Joint Chiefs of Staff, is engaged in basic and applied research in radio physics and associated geophysical phenomena of the upper atmosphere and the troposphere. A great deal of the work is specifically for Navy, Army, and Air Force communications.

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Who's Who in Naval Research

CDR F.L. Edmondson

The man chiefly responsible for the remarkable growth of the Research Reserve in four short years is CDR Francis L. Edmondson, the organization's First Training Officer and present Director. There is ample evidence of his energy and enthusiasm in the 90 units, located all over the continental United States, which have been activated since 1948. These 2,500 officers, many of whom are already engaged in research on Navy-sponsored projects, have established a vital manpower reserve for ONR and the Navy.

When CDR Edmondson came to ONR in 1947 as Public Relations Officer for the Naval Reserve Program, he had a 10-year Navy record behind him. He joined the Reserves in 1937 and went on active duty in 1940. During the war he served as Operational Training Officer with COMEASTSEAFRON, and later, in forward areas of the Pacific, as First Lieutenant and Damage Control Officer aboard the USS PRAIRIE (AD 15). His next duty, before coming to ONR, was Legal and Public Information Officer with the Florida Group Atlantic Reserve Fleet. Now, as VNRRU Director, CDR Edmondson's chief aim, more important than increasing the number of reservists, is to maintain the activity and spirit of those already existing.

Commander Edmondson graduated from his home-town Emory University with a degree in law. After graduation he stayed in Atlanta where he was engaged in legal and public relations work. Perhaps his law experience has made him the expert he is at putting across his ideas when it comes to organizing seminars and making other plans for the reservists. In any case, the "Judge", as his friends at ONR call him, has just the qualities that suit him ideally for the job. He also has the kind of personality that makes his office staff eager to please him.

CDR Edmondson lives in Arlington with his wife and 12-year-old daughter. An ardent sports fan, he is especially enthusiastic about baseball. Besides his other spare-time activities of playing cards and reading, the Commander likes to collect pictures, all kinds of pictures that happen to strike his fancy.

The Story of Ruling Engines

A staff-written article on an ONR contract under the direction of Dr. John Strong, experimental physicist and professor at Johns Hopkins University.

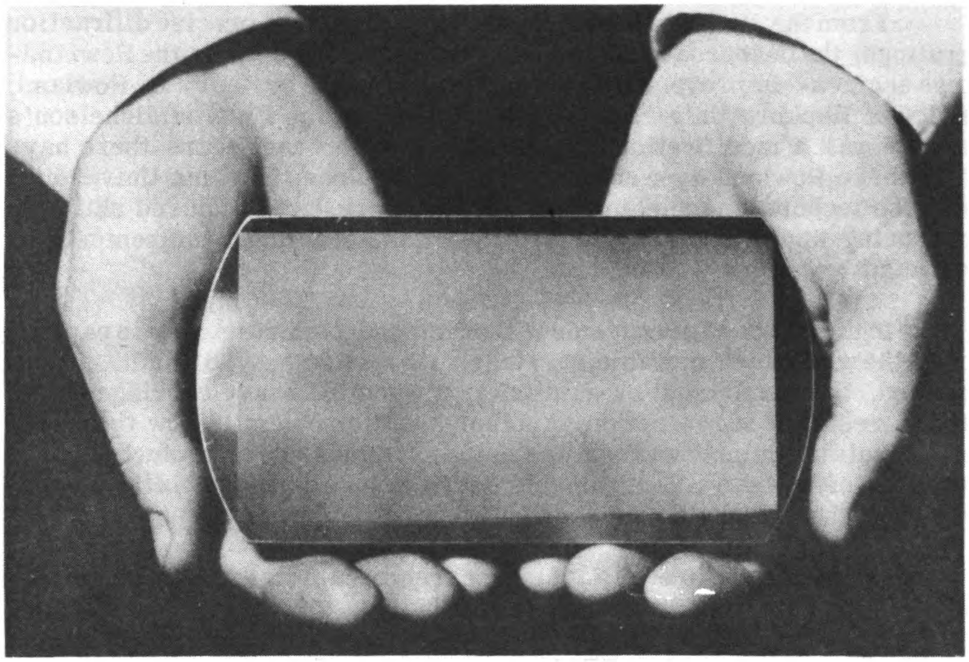
As scientists extend human knowledge farther and farther into the unknown, it is often an instrument of extra-fine construction and design that makes it possible to bring out and understand the secrets of nature. While the spectroscope has contributed substantially to major achievements in the advance of science, there is an even greater potential that is related directly to a single part or component of super-fine construction and design. This part is the diffraction grating. In its finest form, a grating in a spectroscope today can divide light into a hundred thousand separate wavelength intervals, as if it could see a hundred thousand colors.

Such an accomplishment in spectroscopy is not enough for modern scientists; a way must be found to make diffraction gratings, formerly rare, more available--especially the better and larger ones that can perform in greater detail and those that will operate over a much wider range of wavelengths. The ruling engine is the key to further possible progress. Already ruling engines in service have been pushed to performance so precise that 75,000 almost exactly parallel and equally spaced lines are routinely put onto the mirrored surface of a piece of Pyrex glass only five inches from edge to edge.

There is nothing new or novel about the job a ruling engine does, but the tasks of early machines were child's play as compared with precisions demanded today. Some of America's most eminent scientists and skilled technicians worked for years on the development of engines to produce these ultra-precise gratings. Astronomers, in particular, were quite aware of the magnitude of the progress that would follow if technicians were successful in making only a few diffraction gratings that met the highest specifications.

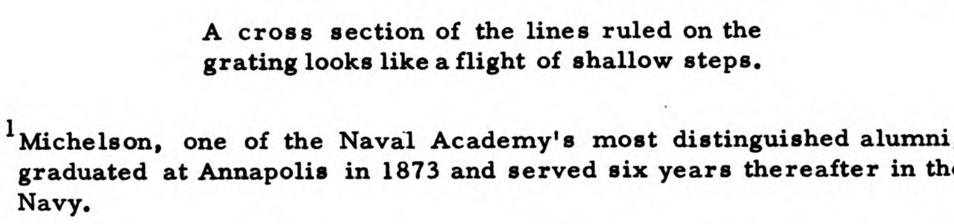
But it is not only the astronomers who are interested in extending the potentialities of the science of spectroscopy; that science serves a wider range of activity than star-gazing. Chemists use spectroscopy in investigating and identifying molecules, biologists for the exploration of living substances, metallurgists in analyzing and inspecting alloys, and food processors in testing food. Many other uses could be listed. Among the more recent, nuclear scientists are employing spectroscopy in exhaustive studies of the atom, fission, and other phenomena related to atomic energy.

A whole series of difficult problems had to be met in the design and operation of a ruling engine before a highly precise diffraction grating could be produced. In general, the problems hinge on friction, vibration, engine wear, and temperature control. The famous Nobel prize



Thousands of parallel, exactly equidistant lines on this small glass plate serve to divide light into more than 100,000 "colors".

winner, A. A. Michelson,[1] began serious work on an improved ruling engine in 1900. He found progress largely dependent on a delicate balance of mechanical and temperature factors, and after years of patient work he had only a few highly precise gratings to show for his labors. However, his first engine did turn out the world-record grating, 9.4 inches wide. He later built another machine and, finally, after eight years of work, came up with a good grating six inches wide and containing 110,000 lines, which was a 50-percent improvement over any previously made. This engine was turned over to Henry G. Gale at the University of Chicago and later to the Bausch and Lomb Optical Company. Michelson's original machine went to M. I. T. where it has been rebuilt by George R. Harrison.



Drawn by R. Hayward, Scientific American

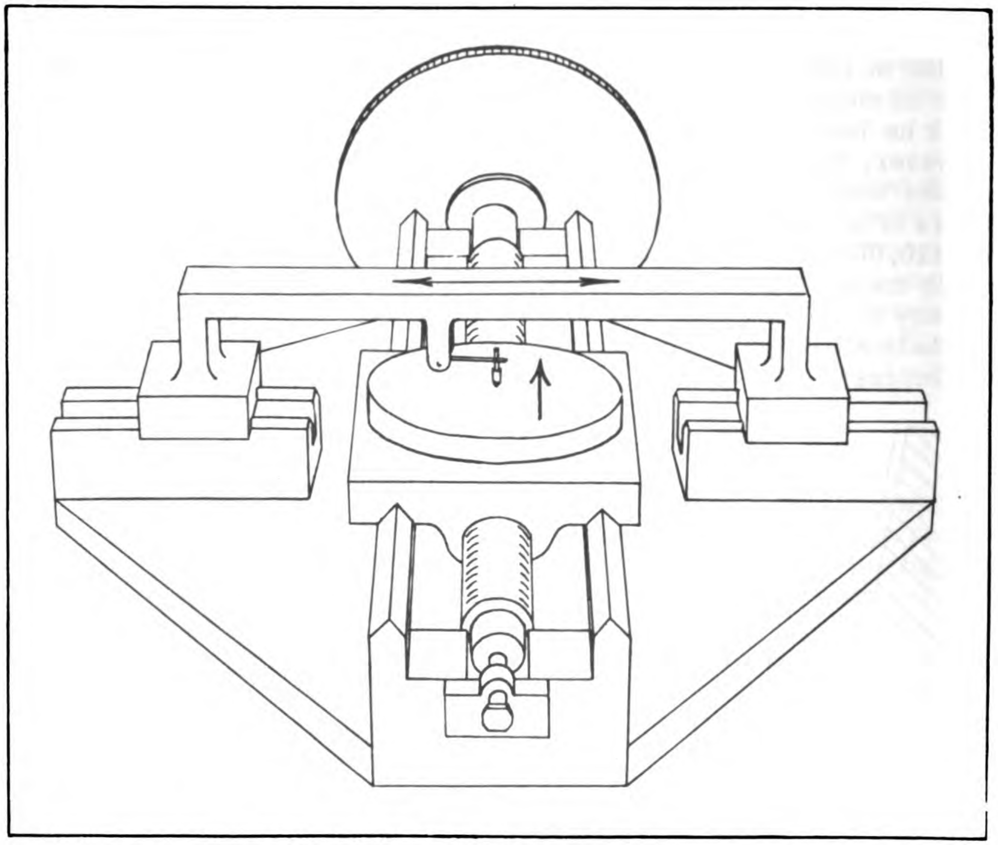
A cross section of the lines ruled on the grating looks like a flight of shallow steps.

[1]Michelson, one of the Naval Academy's most distinguished alumni, graduated at Annapolis in 1873 and served six years thereafter in the Navy.

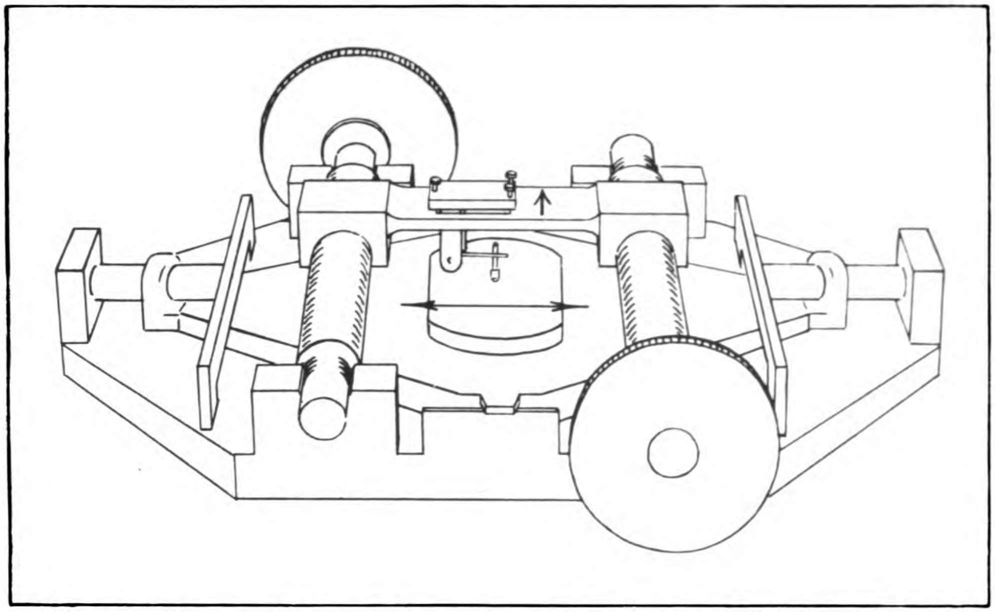
From the time men first started making highly precise diffraction gratings, the best production record has been chalked up by the Rowland-type engines--improvements on a design originated by Henry A. Rowland, a Johns Hopkins University physicist who died in 1901. (Michelson's engine was a modification of this design.) In recent years there have been three Rowland-type ruling engines at the Johns Hopkins University, and the technical people in charge of the work have acquired skills in producing high-quality gratings to meet the exacting requirements of more advanced spectroscopists.

In the Rowland arrangement the diamond-pointed etcher is carried over the glass by a movable carriage. It is extremely difficult, in this method, to overcome stick-slip friction when the heavy carriage shifts as the result of screw action. Another knotty problem is how to control effectively the minute wear on the engine. It does not take much friction wear to defeat the millionth-of-an-inch tolerance demanded in the 75, 000 shifts of the surface as the 75, 000 lines are successively ruled on it.

In 1947 the Office of Naval Research became interested in the development of a ruling engine that would be able to turn out considerably more large precision diffraction gratings than any existing machines could produce. It was only natural that the well-established operation at Johns Hopkins should harbor the personnel best acquainted with the problem. ONR therefore selected Johns Hopkins University to undertake



The Rowland engine shifted the grating blank with one screw and moved the ruling diamond back and forth over the grating.



The Strong engine shifts the diamond point with two screws and moves the grating back and forth under the diamond.

the research and development project under Dr. John Strong, who had been closely connected with the work of the three engines there.[2]

As a new machine began to emerge, the name popularly used in talking about it was "the Strong engine." The innovations were so pronounced that it was hard to recognize the Rowland-type engines as forerunners. In contrast with these engines, which shifted the grating blank with the precision screw and reciprocated the ruling diamond point, Dr. Strong reciprocated the grating blank and shifted the diamond point with two screws. Extremely accurate screw apparatus shifted the diamond point a distance so infinitesimally small that 25 parallel lines could be put on a section of mirror no wider than the thickness of a cigarette paper.

The important requirement of increased output is met by the Strong engine, which is capable of completing in three days a diffraction grating which has 90,000 lines in a six-inch space. The equipment in use for so long at Johns Hopkins takes six days to do the same job. The action of the Strong engine first built was such that it is reasonable to anticipate success in turning out larger-size diffraction gratings. On the premise that it is better to start modestly, the first engine was limited to the production of six-inch gratings. The second machine of the Strong-type kept the same size, but was aimed at 28,800 grooves to the inch; it is now completed and is being started in operation. If the second is as successful as the first, the third may go to a 12-inch size, opening up new horizons because the largest highly precise grating made so far is only 9.4 inches wide.

[2] Later, in 1951, ONR also supported the work at MIT under the direction of Harrison, who is at present incorporating optical and electronic devices for controlling spacing, depth, and parallelism of lines.

In making a diffraction grating of any kind or size, technicians must embark on some extremely painstaking preliminaries. The primary material is plate glass; blanks of proper size are cut. The disks must be slightly concave, so a cutting operation follows that curves the surface to an "error" tolerance of eight one-hundred-thousandths of an inch. Then the disk goes on a polishing device where it is judiciously polished for 20 hours with fine rouge to make its surface truly spheric to a millionth of an inch. Finally the concave surface is coated in a vacuum with a uniform layer of aluminum about one ten-thousandth of an inch thick. The rulings made by the diamond point go on this aluminum film. The result is the highly precise grating in which perhaps 75, 000 lines are identical in width, in depth, and in contour--to a tolerance of one-millionth of an inch. In the case of the average large grating, two and one-half inches wide by five inches long, the aluminum surface has three miles of lines ruled on it. At all times during the operation, the temperature around the ruling machine must be kept absolutely constant, for as small a change as one-thousandth of a degree will disturb the accuracy of the ruling. Such exacting requirements on temperature control caused much frustration on the part of early investigators and engine builders. Modern engineering which employs, in the case of the ruling operation, a vault with a double aluminum box, has paved the way for complex mechanical work under absolute temperature control.

The finished gratings in the various limited sizes and gradations are sold all over the world, to universities and laboratories, and to industries. The spectroscopes that use these gratings explore into hundreds of activities, and it all boils down to studying a light source. In examining the spectrum of any given light source, perhaps the investigator is looking for the presence of copper. If he finds a line at the position of 3248 angstroms, then there is copper. The identification is as precise as that of a seaman's serial number. But it is only with the modern diffraction grating that scientists can peer far deeper into the minute gradations of the spectrum of light sources. The thousands of parallel and exactly equidistant lines on the surface of the grating serve to divide light into more than 100, 000 "colors". Now that progress has been made in stepping up the production of these gratings, many more scientists can begin looking at some of these hundred thousand colors and in so doing contribute urgently needed information to the store of human knowledge.

ASTIA Announcement Premature

In December, Research Reviews briefly described the new Armed Forces Technical Information Agency. Although ASTIA has in fact been established, the merger of existing services is not yet complete. Therefore the statements made may be misleading and the announcement should be disregarded. We expect to publish an authoritative article on ASTIA in an early issue.

What Makes Things Stick

L. Reed Brantley

. . . Head of the Chemistry Department of Occidental College, is director of an ONR project on the adhesion of organic coatings to non-ferrous metals.

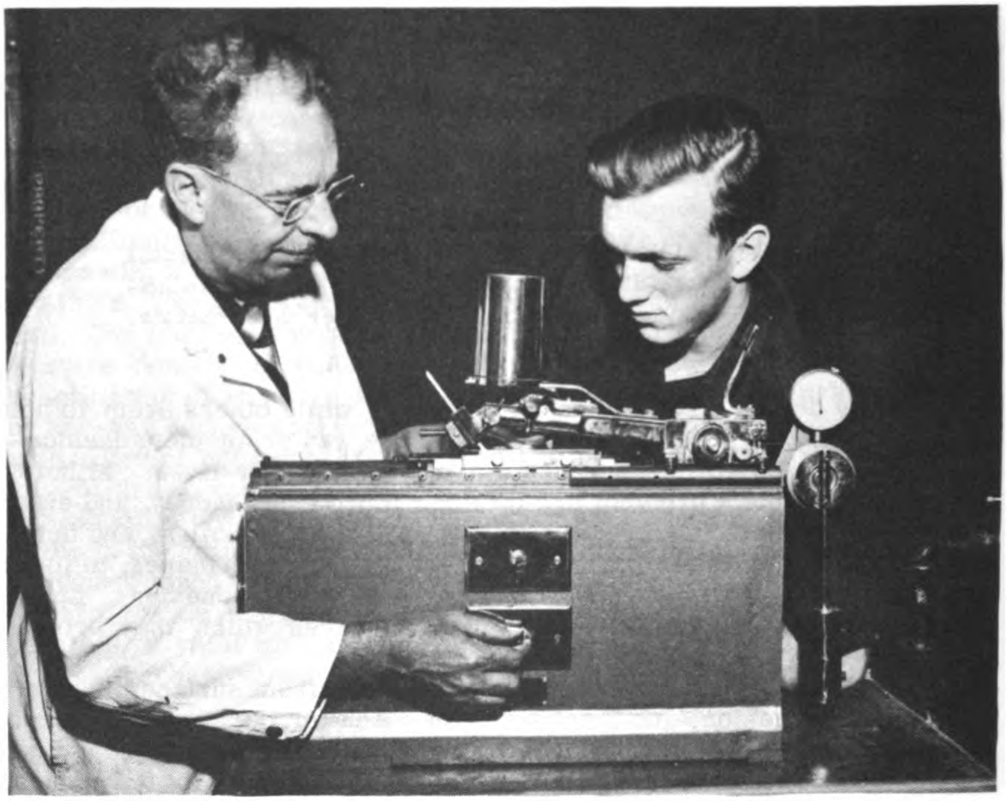
Why do some paints peel or flake off, while others seem to hold stubbornly to the surface they cover? In one way or another adhesion—too much or too little—is constantly influencing our lives. Milady's lipstick presents a problem in adhesion. Much time, money, and effort are spent in replacing the paint on battleships, automobiles, and buildings. The use of organic protective coatings on rocket planes, to lower the air resistance, presents a difficult problem in adhesion. Lubricants must have adhesion to the metal surfaces which they protect.

Yet the cleansing of undesired oil and dirt from surfaces is also a problem in adhesion—too much adhesion. And for the successful use of adhesive tape and stripping lacquer, there must be a controlled amount of adhesion, neither too large nor too small, but just right for the intended use. These numerous and vital problems are a challenge to science which can no longer be ignored.

In the dictionary, adhesion is defined as the force holding unlike substances together. What is the nature of this force? Is it mechanical or chemical? Is it due to long strings or coils of atoms which have one end anchored in the forest-like covering of oxide which makes up many metal surfaces? Or is it due to the attraction of certain parts of the molecule by the atoms in the surface of the metal?

There is a scientific axiom that before a thing can be understood or improved, it must be measured. Although there are nearly as many theories as investigators in the field, adhesion is little understood and, until the last few years, even its measurement has been very unsatisfactory. For many years, the evaluation of adhesion of organic coatings was limited to measuring the difficulty of removing the coating by scratching or gouging. The coated objects were bent over a curved mandrel or subjected to blows with a heavy object. Then there is the time honored method of removing the coating with the thumbnail or the blade of a pocket knife. In the hands of experts, the comparison of similar coatings was readily accomplished and satisfactory control was possible.

In the hope of obtaining more fundamental measurements, methods were developed to measure the force required to remove a coating by direct pull, shear, or peeling. These tests were found to be dependent upon other film properties as well as adhesion. The toughness, elasticity, and thickness of the coating contributed in varying amounts to the values obtained. Consequently, adhesion tests were seldom found in the specifications of paints and other types of organic coatings.



Dr. Brantley and one of his students, Mr. Ed Schlag, measure the adhesion of a coating with the adherometer.

Little wonder that the understanding and scientific investigation of adhesion was at a standstill until instruments for its measurement became available. Fortunately, in the last five or ten years not one but several instruments have been designed for the measurement of adhesion. Most of these have been developed under the sponsorship of the Navy. Of special promise are the ivory knife adherometer developed under a contract with the Office of Naval Research by Green, Dietrich, and Rolle of Interchemical Corporation; the ultrasonic method of Moses and Witt under the direction of Dr. Allen L. Alexander of the Naval Research Laboratory; and the ultracentrifuge method of Dr. Walter Soller with A. M. Malloy under contract with the Bureau of Aeronautics.

Three years ago the investigation of the nature of adhesion of organic coatings to non-ferrous metals was undertaken at Occidental College under a contract with the Office of Naval Research. There were several objectives. Fundamental knowledge of the physical-chemical nature of adhesion was desired. Although we hoped to obtain coatings with better adhesion from the results of this study, the immediate goal was to learn as much as possible about adhesion itself. Another objective was to provide research training in this field for graduate chemists. It was also hoped that interest would be aroused in industry resulting in wider participation in the investigation of adhesion and its measurement. In addition to the employment of several undergraduates, the program has provided one or more graduate fellowships each year. The Los

Angeles Paint, Varnish and Lacquer Association has sponsored the educational and research program from the beginning, generously providing supplies and funds for the purchase of the necessary instruments and equipment.

Simple coatings with poor adhesion were purposely selected for the investigation so that differences in adhesion could be easily detected. Lacquers were selected because the coatings did not change chemically during drying (as in the case of paints containing linseed oil, for example). The ivory knife adherometer, the only instrument of its type commercially available, was used for the measurements. To get reproducible results, it was necessary to make a number of refinements in the adherometer and to put the utmost care into the preparation of the coatings to be tested. Because of the difficulty of the investigations undertaken, statistical methods are being worked out for the design of the experiments and their interpretation.

The ivory knife adherometer, which, in some respects is just a refinement of the old thumbnail test for adhesion, consists of a platform to which the coated sample is fastened. A motor pulls the platform and coated panel, which is connected to a weighted pendulum by means of a beam and a wire, under a weighted ivory knife with a vertical leading edge. As the weighted knife is pulled forward by the edge of the coating, the pendulum is raised, causing an increase in the stripping force of the knife. At the moment the backward pull equals the force required to remove the coating, the knife becomes stationary and continues to strip the coating from the panel as it moves past. The stripping force exerted by the knife is obtained from the calibration of an Ames gage attached to the pendulum. This stripping force is then corrected for the friction of the knife on the metal surface by subtracting the force required to drag the knife over the stripped area.

Green and Lamattina found that the stripping force per unit width of the coating was independent of the speed of removal and also of the weight holding the knife to the bottom surface of the coating. Rolle and Dietrich found that the stripping force per unit width, corrected for friction, could be expressed as the sum of three component forces: the adhesive force at the interface, the tear resistance of the two sides of the film, and the resistance to plastic flow of the film.

The tear resistance of the film can be eliminated in advance by trimming both sides of the strip to be removed. The stripping force values per unit width of coating removed are then plotted against film thickness and extrapolated to zero film thickness. This value of the stripping force at infinitesimal film thickness is taken as the adhesion of the coating. That the coating can be satisfactorily removed from the surface is shown by the fact that grooves in the film have the same pattern as those originally present in the surface of the metal. We hope that our investigations will also provide an understanding of the mechanism for the removal of the coating by the knife. With an ivory chisel one-sixth of an inch wide and sharpened to a feather edge, we have tried to learn the secret of the forces of adhesion residing in the region approximately a millionth of an inch thick lying between the metal surface and the coating.

The influence of the chemical make-up of the coating on its adhesion was the first factor investigated. For the lacquer formulations studied, greater adhesion resulted from an increase in the percentage of polar groups in the resin or polymer making up the body of the coating. For example, it was shown that for nitrocellulose lacquers differing only in the percent nitration of the cellulose, the adhesion to aluminum more than doubled over the range of percent nitration used. A much smaller effect was observed for ethylcellulose lacquers differing only in percent ethoxy content of the ethylcellulose. Also we have shown that the longer the chains of atoms used, resulting in increased molecular weight of the polymer, the greater the adhesion. For nitrocellulose the adhesion increased several fold for an increase in the degree of polymerization from approximately 50 to 200. We have shown that the addition of a plasticizer such as dibutyl phthalate to the lacquer greatly altered the adhesion of nitrocellulose and ethylcellulose coatings. The optimum amount of plasticizer was found to be between 10 and 15 percent by weight.

For many years, treatment of the surface to be coated has been known to affect adhesion. The difficulty of obtaining good adhesion to aluminum is often due to improper surface cleaning and improper pre-treatment. Quite often the fact that preparation of the metal for painting has a definite relation to the useful life of the paint finish is overlooked.

The surface of a metal such as 24S aluminum alloy, viewed through a high-power microscope, looks like a Lilliputian forest of trees closely grown together, with patches of bushes breaking up the pattern here and there. What appear to be trees are actually bundles of aluminum oxide crystals, and the bushes are oxide clusters of the alloying impurities such as copper and magnesium. If a crack or scratch should occur in the oxide layer, the aluminum metal exposed would immediately grow an oxide covering. This naturally occuring protective oxide layer is known as the barrier layer and has a thickness of approximately one half-millionth of an inch. The tightly packed columns of aluminum oxide prevent any more oxygen gas from penetrating to the reactive aluminum beneath. Thus, although the surface is not perfectly flat, it does offer relatively little opportunity for the sinuous chains of atoms making up the organic coating to snuggle into openings in the oxide layer.

Therefore, mechanical adhesion probably does not become an important factor unless the metal has been purposely treated to create large cracks and crevices. In the treatment known as anodizing, strong chemicals leach out sections of the oxide columns at random in order to expose the surface for further oxide growth in that area. This results in a surface which, highly magnified, might be likened to the sky line of a large city. Burwell, Smudshi and May at the Naval Research Laboratory reported that the surface area was increased as much as one hundred times by an anodizing treatment. Anodizing, or a similar electrolytic treatment, has long been used to obtain better adhesion to aluminum. We are presently investigating how much this treatment increases adhesion.

The coefficient of expansion of most organic coatings is many times greater than that of the metal which they cover, and on heating or cooling, the unequal change in dimensions causes the coating to pull away from the surface. In this connection, a series of metals covered with an unplasticized ethylcellulose lacquer were studied. Repeated heating and cooling caused serious loss in adhesion, which was shown to be roughly proportional to the difference in the coefficients of expansion of the metal and the coating. However, this loss of adhesion can be overcome, to a large extent, by the addition of plasticizer to the lacquer.

The fluid interface theory of adhesion postulates that the metal and the coating are separated by an extremely thin film of fluid, such as solvent or plasticizer, in which the ends of the chains of polymer orient more freely and through which the forces of adhesion act. This offers an alternate explanation to the picture of a solid film of lacquer clinging to the metal surface by anchorages many of which are severed by the shearing action of unequal thermal expansion. The presence of this fluid interface has not been proven although its value is well accepted. By tagging the components of the lacquer with radioactive elements, we hope to find out whether there is a migration or concentration of any ingredient of the lacquer coating at the interface between the metal and the coating.

The choice of solvent from which the coating is deposited by evaporation determines to a large extent many of the physical properties of the coating. A good solvent separates the clusters and tangles of molecular chains in the solid so that they stretch out and flow or slide over one another to give a viscous solution. On the other hand a poor solvent causes the polymer chains to draw up into balls which give a low viscosity to the lacquer. A poor solvent is often used, however, since it allows higher solids content in a lacquer for a given viscosity. For a given percentage of solids content, the more viscous solutions resulting from the use of a good solvent should produce better tack and adhesion. This effect is being investigated.

The choice of solvent also plays an important part in the texture of the coating. It would be deposited as a continuous film from a good solvent, but would probably be lumpy and frosty with poor adhesion when a poor solvent is used. The completeness of solvent evaporation before the lacquer solidifies as a jelly-like coating could be expected to affect the adhesion because the loss of the remaining solvent would cause shrinkage of the coating and a tendency for it to pull away from the surface.

It is known that many of the desirable properties of the coating—gloss, toughness, flexibility, and probably even adhesion—are influenced by the method of application of the coating to the surface. Application of a lacquer by brushing, dipping or spraying could be expected to produce different types of coatings, at least until the coating reached a condition of equilibrium. This could explain the continued increase in adhesion of some coatings over a period of a year or more.

The magnitude and complexity of the factors making up adhesion are only matched by their importance and frequent occurrence. It is evident that, if we are ever to arrive at a full understanding of the basic principles of adhesion, the continued team work of trained scientists from many laboratories will be required. If the investigations of this laboratory contribute materially to the achievement of this goal, our efforts will have been amply rewarded.

On the Naval Research Reserve

Armed Forces Reserve Act of 1952 Goes Into Effect

On 1 January 1953, the new Armed Forces Reserve Act became effective. Many aspects of this Act and their effect on the members of the Research Reserve Program have not yet been clarified. In the 22 December issue of the Eighth Naval District THE WORD there appeared an article which clearly defines certain parts of the Act. It is reproduced in part below:

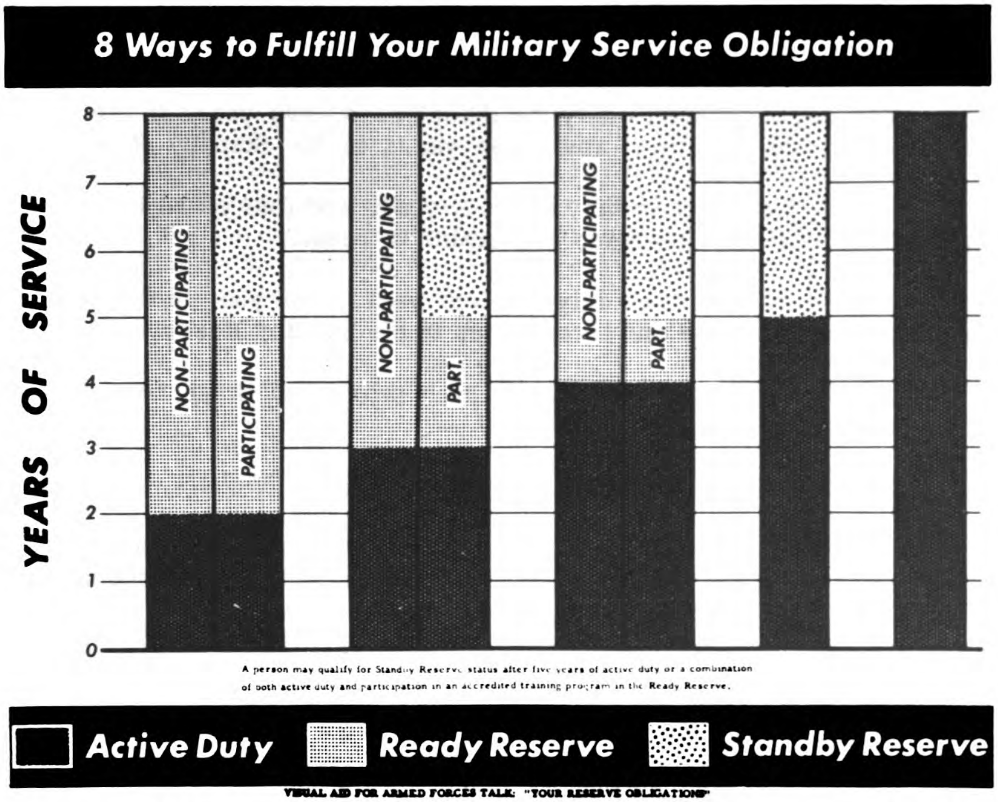
Under the Armed Forces Reserve Act there will be three categories of liability for active duty. The Ready Reserve will consist of those units or members, or both, who are liable for active duty either in time of war, in time of national emergency declared by Congress or proclaimed by the President, or when otherwise authorized by law. The Standby Reserve will consist of those units or members (other than members of the Retired Reserve) or both, who are liable for active duty only in time of war or national emergency declared by Congress, or when otherwise authorized by law. The Retired Reserve will consist of those members whose names are placed on reserve retired lists. Members of the Retired Reserve may, if qualified, be ordered to active duty involuntarily, but only in time of war or national emergency declared by Congress or when otherwise authorized by law.

The liability of Naval Reservists for involuntary orders during time of future war or national emergency which has been proclaimed by the President will be determined by the status of the individual. However, during the present emergency, which has been proclaimed by the President, Reservists may continue to be ordered to active duty under the authority of Section 21 of the UMT&S Act, as amended, which is in effect until 1 July 1953. Reserves may still be ordered to active duty on the same basis used prior to the passage of the Act.

Legislation has been proposed to extend Section 21; if this is granted the provisions of the Act will be delayed and Reservists may be recalled to active duty under the present policies. These are:

(1) Naval Reserve personnel who are veterans and who served 17 or more months active duty since 25 June 1950 will not again be ordered to active duty for periods in excess of 30 days without their consent except in time of war or national emergency hereafter declared by the Congress. As defined by law, a veteran is, "any member of the inactive or volunteer Reserve who served on active duty for a period of 12 months or more in any branch of the Armed Forces between 7 Dec 1941 and 2 Sept 1945." Current Navy policy is not to recall involuntarily any Naval Reservist separated from active duty since 25 June 1950. (This does not apply to separation from active duty for training or temporary active duty, either as a regular or reserve member of any branch of the service.)

(2) Reservists, non-veterans, who were transferred to the Organized Reserve (pay status) prior to 15 Oct 1950 and who subsequently are



VISUAL AID FOR ARMED FORCES TALK: "YOUR RESERVE OBLIGATION"

transferred to the Volunteer Reserve (non-pay status) on or after 20 July 1950 will continue to be considered liable for involuntary orders to active duty on the same basis as if they had remained in the Organized Reserve.

(3) Reservists, non-veterans, who are transferred to the Organized Reserve (pay status) on or after 15 Oct 1950 and who subsequent to that date are transferred to the Volunteer Reserve (non-pay status) will be considered liable for involuntary orders to active duty as if they had never been members of the Organized Reserve.

(4) Reservists, non-veterans, who remain, or become attached to or associated in pay status with pay units of the Naval Reserve on or after 1 Jan 1953 will be considered as liable for involuntary orders to active duty prior to Reservists in non-pay status having the same qualifications.

If you have become a member of the Naval Reserve since 19 June 1951, you have a total of eight years service to perform from the date of your enlistment. This obligation applies to every Reservist in ANY branch of the Armed Forces. You have a choice of eight different ways to fulfil your obligations for the required eight years.

(1) Serve on active duty for two years and spend six years in the non-participating Ready Reserve. Anytime during the latter six-year period you will be mighty vulnerable to recall.

(2) Serve on active duty for two years, three years in the participating Ready Reserve, and three years in Standby Reserve.

(3) Serve on active duty for three years, five years in the non-participating Ready Reserve, and be vulnerable to recall.

(4) Serve on active duty for three years, two years in the participating Ready Reserve, and three years in the Standby Reserve.

(5) Serve on active duty for four years and four years in the non-participating Ready Reserve, vulnerable to recall.

(6) Serve on active duty for four years, one year in the participating Ready Reserve and three years in the Standby Reserve.

(7) Serve on active duty for five years and three years in the Standby Reserve.

(8) Serve on active duty for eight years.

From these eight ways, you can select the method that is best suited to your individual situation. Remember, the way you choose will determine your degree of vulnerability to call.

LCDR Rae New York Program Officer


LCDR Rae

LCDR George R. Rae has relieved CDR Joseph H. Graham as Program Officer in the New York Branch Office. LCDR Rae, previously connected with the Geography Branch at ONR for 18 months, received his B.A. from Michigan State Normal College in 1941. After serving overseas in the Navy during the war, he came back to obtain his M.A. in geography in 1948 from the University of Michigan. As a candidate for his PhD he was studying the geography of the Great Slave Lake region in Canada when he returned to active duty in 1950.

CDR Graham, whom LCDR Rae has relieved, has been transferred to the San Francisco Branch Office of ONR, where he in turn relieved CDR Ralph Jack as Research Reserve Program Officer. CDR Jack has been transferred to Los Alamos, New Mexico, for duty.

NRL Seminar Ahead

The Naval Research Laboratory will be opening its gates to reservists next summer for a two-weeks' seminar scheduled to begin August 23. Fifty officers will have an opportunity to see and hear about research being done by some of the Navy's best scientists.

LCDR Robison Goes to Chicago as Training Officer

LCDR Robison

LCDR William L. Robison, USNR, is the new Reserve Research Program Officer in the ONR Branch Office, Chicago, Ill. LCDR Robison brings with him a wealth of experience in administration of the Reserve Program. His Navy career began in 1943 when he was stationed at the Florida and Pacific Fleet Radar Center (Hollywood). In 1944 and 1945 he served on the USS Massachusetts, then came to the Fifth Naval District, Norfolk, acting first as Officer in Charge, Training Aids Section, later as Administrative Assistant to the Director of the Naval Reserve, and, just before his present duty, as Volunteer Reserve Program Officer for the Fifth District.

Promotions to Commander Announced

We are both proud and pleased to announce that the following members of the Reserve Research Program have recently been selected for promotion to Commander in the Naval Reserve. Congratulations!

Nazzareno P. CEDRONE,	Brighton, Mass.	Company 1-1
Charles S. TILTON	Arlington, Mass.	1-1
Robert W. WAGNER	Belmont, Mass.	1-1
Mary SEARS	Woods Hole, Mass.	1-2
Francis J. BOYLE	Springfield, Vt.	1-7
George W. HYDE	New York 17, N. Y.	3-1

Ethelbert A. HUNGERFORD	Chappaqua, N.Y.	Company 3-2
Gabriel P. BETZ	Buffalo, N.Y.	3-3
Webster H. HOUSEL	Whitehouse Station, N.J.	4-1
George K. HOLMES	Haddonfield, N.J.	4-2
John C. MacFADYEN	Philadelphia, Pa.	4-2
Edmund N. THELEN	Philadelphia, Pa.	4-2
Ellis D. VERINK	New Kensington, Pa.	4-3
Viktor SCHRECKENGOST	Cleveland, Ohio	4-8
Marshall D. EARLE	Ridley Park, Pa.	5-4
Fred P. LAWRENCE	Gainesville, Fla.	6-4
Charles R. HUGHES	Gainesville, Fla.	6-4
Frank E. RICHART	Gainesville, Fla.	6-4
Charles F. MILNER	Chapel Hill, N.C.	6-6
Donald T. HAWLEY	Orlando, Fla.	6-8
Norman R. BUCHAN	Homestead, Fla.	6-10
Gilbert H. AYRES	Austin, Texas	8-5
William E. BOSTWICK	Albuquerque, N. Mex.	8-7
Sherman A. WENGERD	Albuquerque, N. Mex.	8-7
E. O. BOX	Bartlesville, Okla.	8-8
Olan H. HAMILTON	Stillwater, Okla.	8-8
Orlando C. KREIDER	Ames, Iowa	9-5
Royal F. BLOOM	St. Paul, Minn.	9-6
Edwin F. PETERS	Des Moines, Iowa	9-13
Verne J. VARINEAU	Laramie, Wyo.	9-17
William P. SMITH	Lawrence, Kansas	9-20
Glen L. HAWKS	LaGrange, Ill.	9-23
Hubert J. PEDERSEN	Pasadena, Calif.	11-1
Harris K. MAUZY	Long Beach, Calif.	11-4
Serafino L. GIULIANI	San Diego, Calif.	11-5
Ennis B. WOMACK	Fresno, Calif.	12-4
James D. FAHEY	Berkeley, Calif.	12-5
Gilbert F. KINNEY	Monterey, Calif.	12-8
Garrett N. BUNKER	Richland, Wash.	13-2
Mahlon H. BARTZ	Idaho Falls, Idaho	13-6
Govert FLOHIL	Wash. D.C.	W-1
Albert E. SMITH	Wash. D.C.	W-1
James W. SMITH	Wash. D.C.	W-1

Psychological Warfare Panel Established

A panel for Reserve Officer Training in Psychological Warfare Duties has been approved by CNO for establishment in Company 3-1, New York City. Reserve officers interested in becoming members are invited to attend the first meeting, which will feature an address by CAPT Charles M. Smith, USN, Psychological Warfare Programs Division, CNO. Place and time: the Cornell Medical College Auditorium, New York City, 19 February, at 1915.

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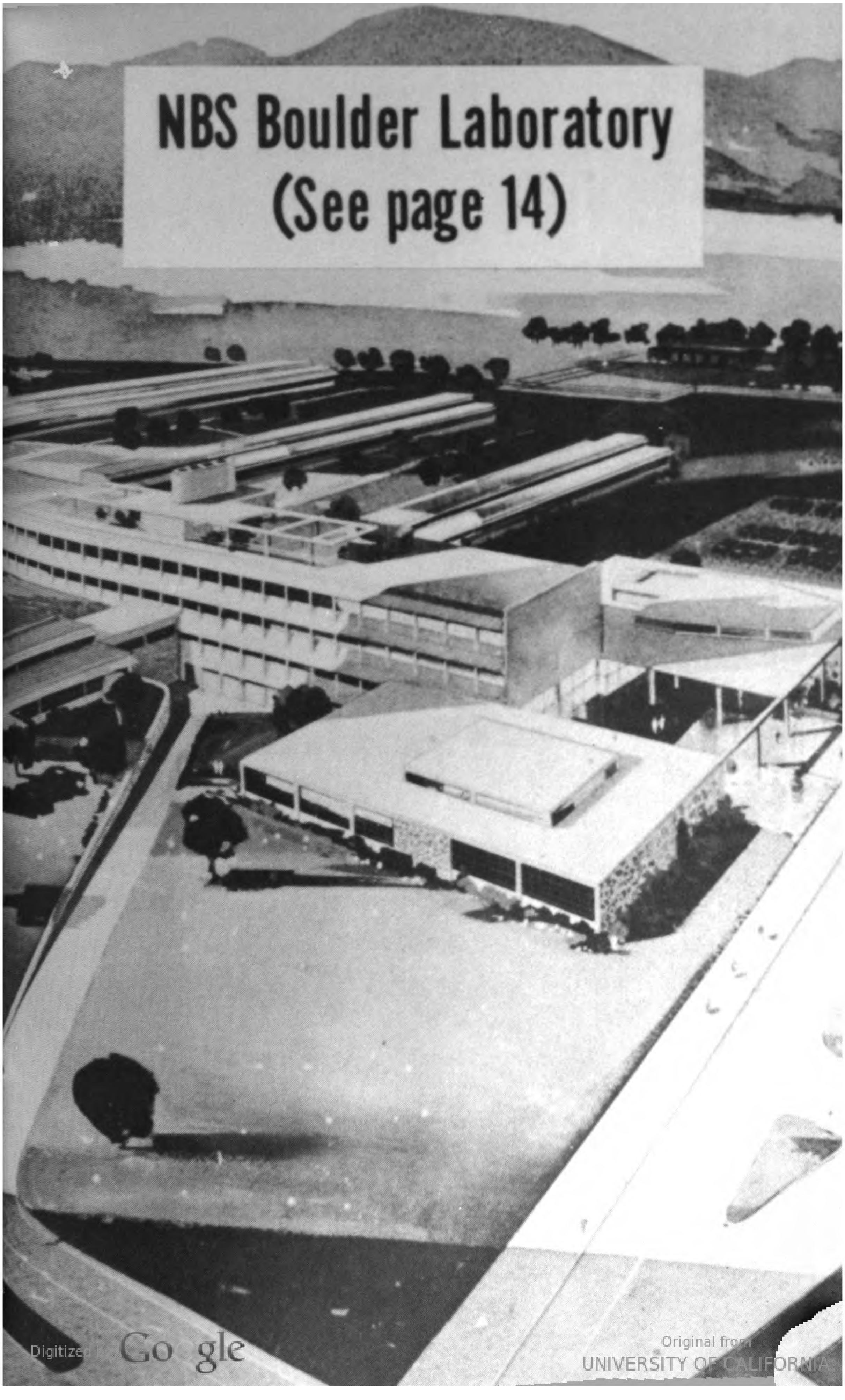
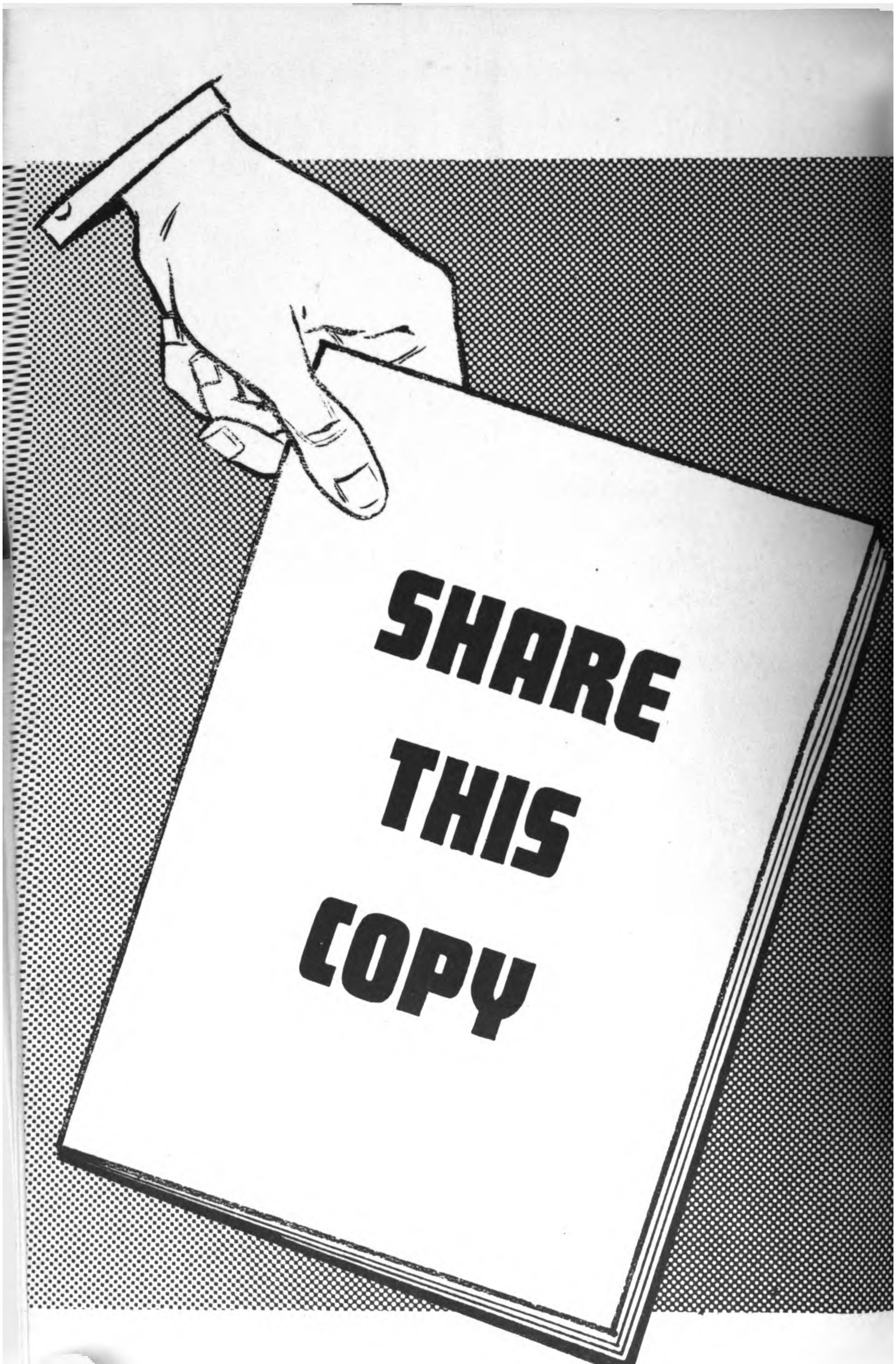

NBS Boulder Laboratory
(See page 14)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