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RESEARCH REVIEWS

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COVER PHOTO: Though this high-speed glider, piloted by D. F. S. Meise, was designed for Olympic competition, the Navy has more vital uses for these craft. It is expected that as a result of research on sailplanes they will eventually be adopted by the major aerodynamics research centers of the world as a safe and effective means for improving the performance, control, and stability of larger, powered aircraft. For more on the subject, see "The Sailplane in Aerodynamic Research" by August Raspet, pp. 15 to 24 of this issue.

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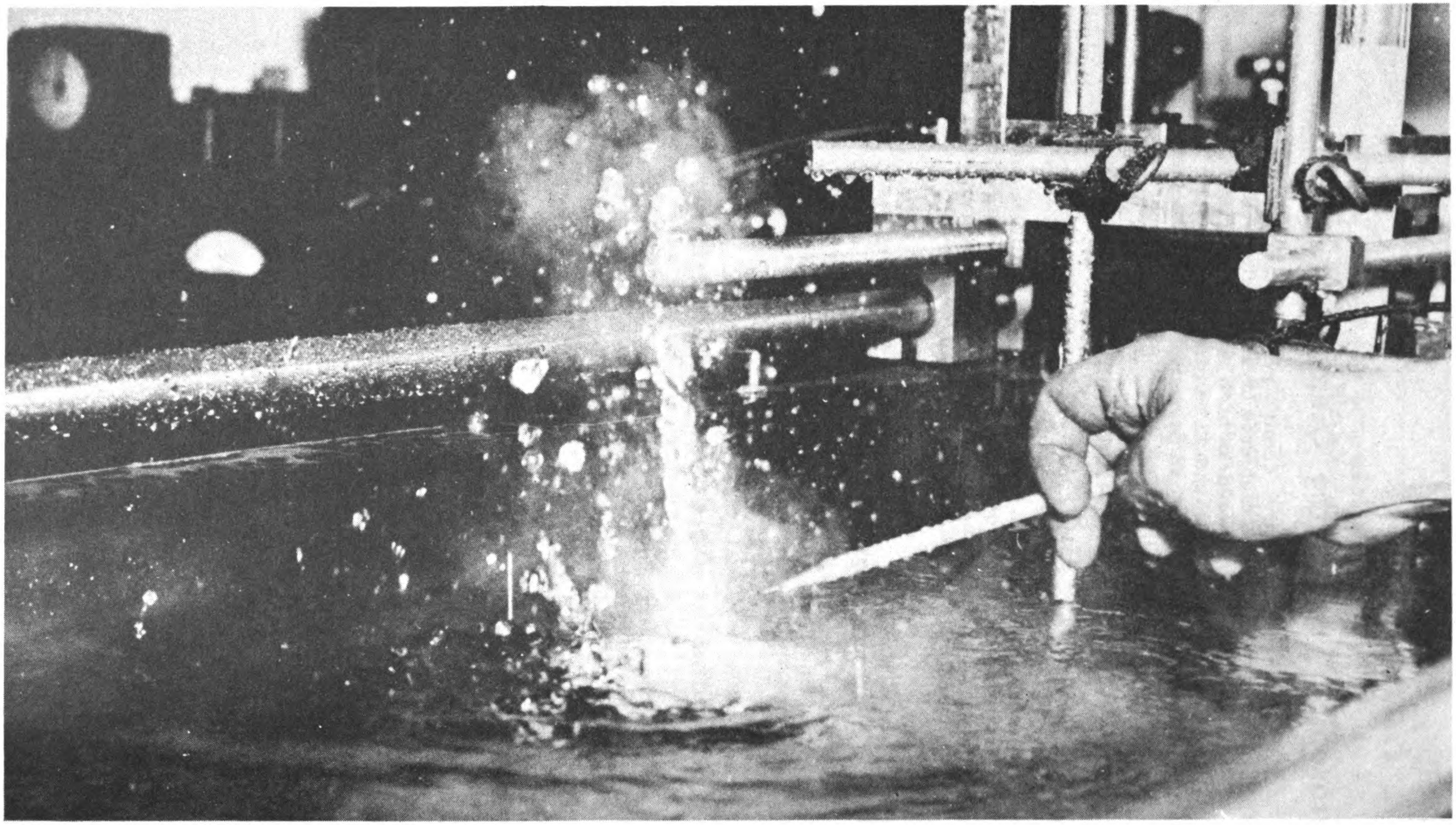

Intense ultrasonic waves produced this fountain of water. Scientists are investigating this and other effects of such radiation.

Ultrasonics-
Tool of the Chemist

by

Ernest Yeager and Frank Hovorka
Western Reserve University

As part of the chemist's quest to find new techniques for the study of chemical systems, many phases of physics have been applied in chemistry. During the past century, for example, optical methods have been used in chemical applications ranging from the initiation of chemical reactions with ultraviolet light to the analysis of complex mixtures in terms of the light emitted upon burning the samples.

In contrast, only during the past two decades has any serious consideration been given to sound waves as a tool for the chemist. Even today relatively few chemists are aware of the possible uses for acoustical techniques in their field. While it is not likely that acoustical methods will soon attain the prominence of optical methods in chemistry, several interesting applications have already been developed for sound waves and a relatively large number are anticipated.

Sound waves can be divided into three categories (Figure 1) on the basis of frequency or, essentially, pitch: infrasonic, sonic, and ultrasonic. This classification stems from the frequency limits of the human ear. The term sonic refers to sound waves within the range of normal hearing, i.e., 15 to 15,000 vibrations or cycles per second, while the terms infrasonic and ultrasonic[1] represent sound waves at frequencies below and above the limits of hearing, respectively. Ultrasonic waves have been produced at frequencies as high as 500 megacycles per second and it is probable that even higher frequencies will be reached in the near future.

While chemical applications have been developed for sound waves at frequencies in all three classifications, the majority of the applications

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[1] Prior to 1946 the term "supersonic" was widely used for sound waves at frequencies above the limit of the human ear. At present, however, the term supersonic is reserved for phenomena which involve speeds greater than that of sound (e.g., supersonic flight).

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Frank Hovorka (B. A. Iowa State Teachers College; M. S., Ph. D. University of Illinois) is Chairman of the Department of Chemistry and Director of the Ultrasonic Research Laboratory at Western Reserve University. Dr. Hovorka has engaged in research in electrochemistry and other phases of physical chemistry since he came to Western Reserve in 1925.

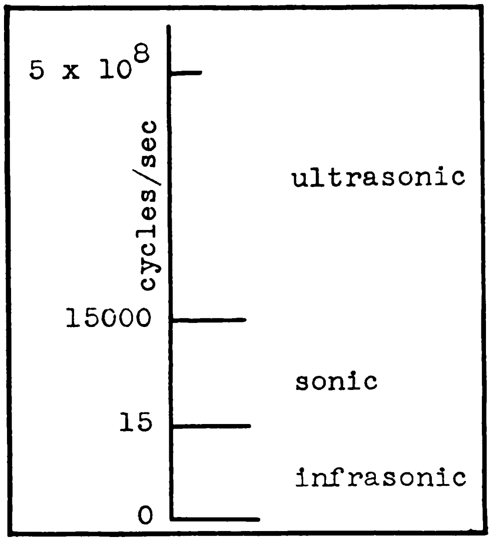

Figure 1. The acoustical spectrum.

involve ultrasonic waves. A special laboratory (the Ultrasonic Research Laboratory) has been established in the Department of Chemistry at Western Reserve University to study and develop such applications.

The piezoelectric effect is often used to produce ultrasonic waves for these purposes. Substances—such as a phonograph crystal—which exhibit this effect can be made either to expand or contract when placed in an electrical field—a situation represented in Figure 2. A thin film of a metal such as silver or gold is deposited on two opposite parallel surfaces of the piezoelectric material. If one metal surface is charged plus relative to the other, the material will either expand or contract. Reversing the polarity of the potentials on the metal surfaces will produce the reverse mechanical effect. When an alternating potential difference is applied between the two metal surfaces, the material will expand and contract periodically. Sound waves of the same frequency as the alternating potentials will then be radiated into any solid, liquid, or gas in contact with the vibrating surfaces. Thus, the piezoelectric material is equivalent to a transformer or transducer for the conversion of electrical energy into sound energy.

Crystalline quartz, as well as barium titanate is now used extensively for the generation of ultrasonic waves by the piezoelectric effect. Frequently these materials are prepared in the form of circular disks with the two plane surfaces covered with a thin metallic film. The system into which the ultrasonic waves are to be transmitted is placed in contact with one of the plane surfaces. For very high intensities, a sound source with a concave surface may be used to focus the sound waves (Figure 3) in much the same fashion that light rays are focused with a concave mirror.

Figure 4 shows an ultrasonic generator constructed at Western Reserve University. The cabinet on the left contains the electronic unit which generates the high-frequency electrical energy. The glass tank or jar on the right contains an oil bath in which a concave barium titanate

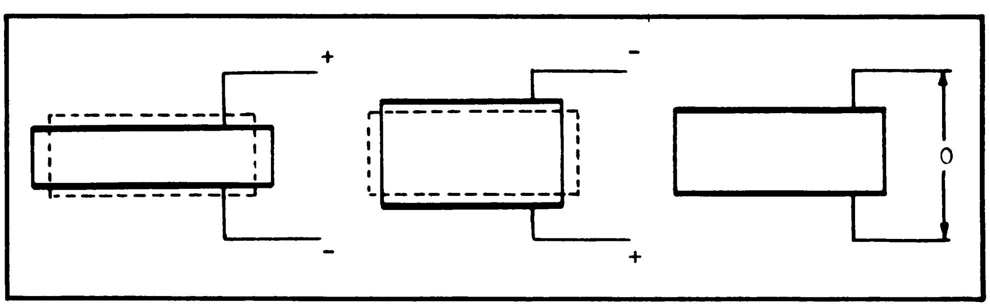

Figure 2. The piezoelectric effect.

ultrasonic source, shaped like a small bowl, is mounted. This transducer converts the electrical energy into sound energy. Liquids and solutions to be irradiated are placed in a small glass vessel, (see Figure 4) which is so placed in the oil bath that the sound waves converge within the liquid.

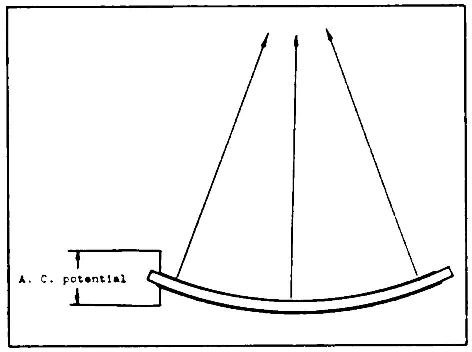

Figure 3. A diagram of a focussed ultrasonic source.

With the apparatus shown in Figure 4, ultrasonic waves may be obtained with a frequency of 600,000 vibrations per second, or approximately 40 times the highest sound which the human ear can hear. Furthermore, the intensity of the ultrasonic waves (related to the loudness of ordinary sound) is more than one million times the intensity of the sound waves next to the motors of an airplane at take-off. The particles or molecules of any liquid exposed to such intense ultrasonic waves (100 watts/cm^2) are shaken so violently that they experience an acceleration of 10,000 miles per second, or more than a million times the acceleration of gravity at the earth's surface.

Spectacular results occur if intense ultrasonic waves within a liquid are directed at the surface. The fountain in the photograph in Figure 5 was obtained with the apparatus shown in Figure 4. The barium titanate ultrasonic source has been placed in the oil bath so that the ultrasonic waves converge near the surface of the oil. When not confined, the fountain is reasonably dense through a height of four feet, with spray extending to the ceiling. This effect is associated with the radiation pressure or directional force which intense ultrasonic waves exert on any surface in their path.

If intense ultrasonic waves are transmitted through liquid containing dissolved gases a large number of bubbles are formed in the path of the sound waves. Figure 6 shows the air bubbles produced by such radiation in water. As each gas bubble forms, it rises to the surface of the liquid and the gas escapes into the surrounding atmosphere. If the water is thus irradiated for a long period, virtually all the dissolved air will be removed from solution. Thus, ultrasonic waves can be used to de-gas liquids.

When such waves are absorbed within a system, the energy associated with the wave motion is converted into heat. Unless this heat is readily dissipated, the sample may become hot enough to decompose or burn. For example, if a small piece of plastic is placed in a liquid in the path of intense ultrasonic waves, the plastic will quickly absorb them and may heat up internally to a temperature at which it decomposes with charring, or even explodes, though the liquid surrounding the plastic remains at room temperature. Such effects are undesirable to the chemist because they often obscure other effects more directly associated with ultrasonic irradiation.

The applications of ultrasonic waves in chemistry can be divided into three classifications:

(1) the chemical effects of ultrasonic waves,

(2) the physical effects of ultrasonic waves, and
(3) ultrasonic waves as a tool for the study of chemical systems.

The first classification represents a specific phase of the more general subject of sonochemistry, the production of chemical reactions with sound waves. The second classification is concerned with physical effects which have practical significance to the chemist, while the third involves the determination of the properties of chemical systems through measurements with ultrasonic waves. Each will be discussed individually.

There are several chemical effects produced by ultrasonic waves. For example, if intense ultrasonic waves are passed into water containing dissolved oxygen gas, hydrogen peroxide (a chemical used for bleaching) is produced. Similarly, if ultrasonic waves are introduced into water containing dissolved nitrogen gas, various nitrogen acids and even ammonia result. These are but two of a number of similar reactions which can be initiated with ultrasonic waves. Other reactions of interest include the formation of chlorine gas from carbon tetrachloride (Pyrene or Carbona) and the modification of the chemical nature of plastics such as Plexiglas. But despite many such reactions reported in the literature, ultrasonics does not seem to be a practical tool for commercial chemists at present. Relatively large amounts of acoustical energy are required and the yields are low. The real promise of ultrasonic waves in chemistry, however, does not lie in the chemical effects they produce but rather in the physical effects obtained, and in the use of such waves to study properties of chemical systems.

The most significant physical effects of ultrasonic waves which are of interest to the chemist are the de-gassing of liquids, the dispersion of solids and liquids, and the coagulation action.

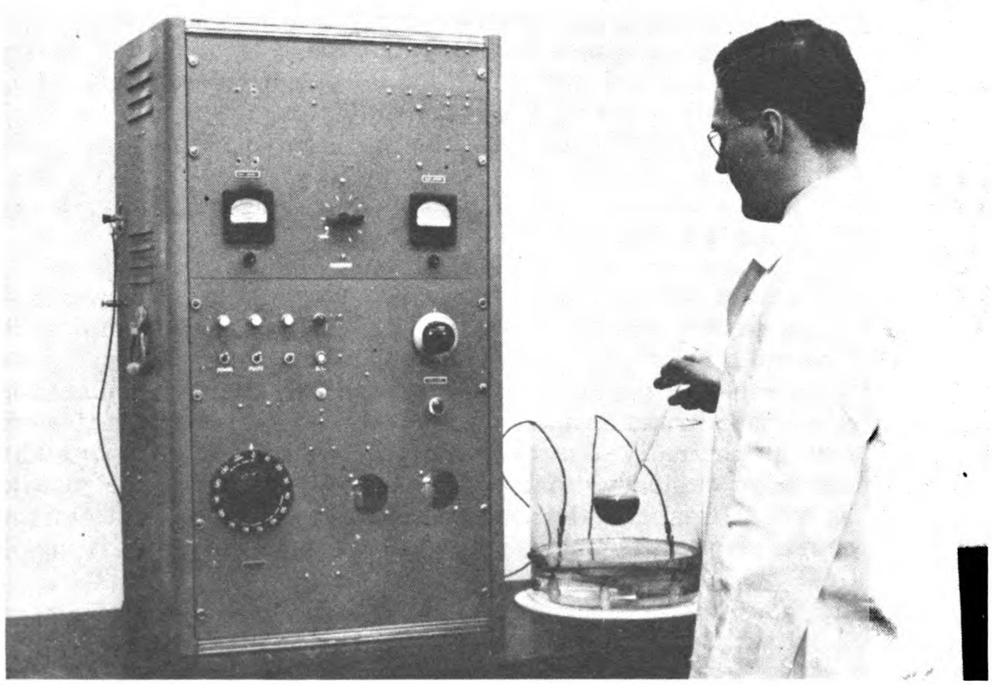

Figure 4. A generator for the production of intense ultrasonic waves.

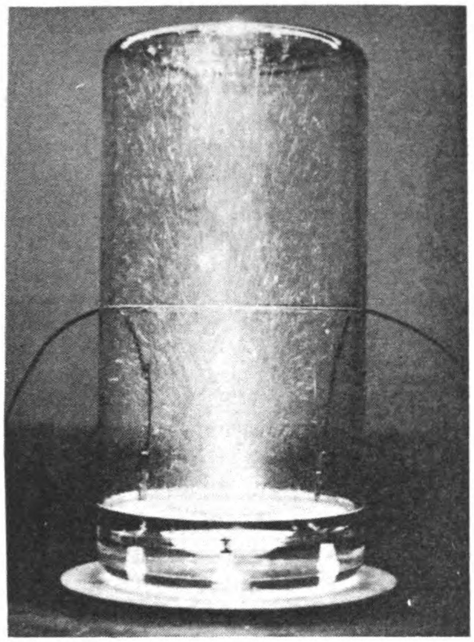

Figure 5. This fountain was produced by intense ultrasonic waves in oil.

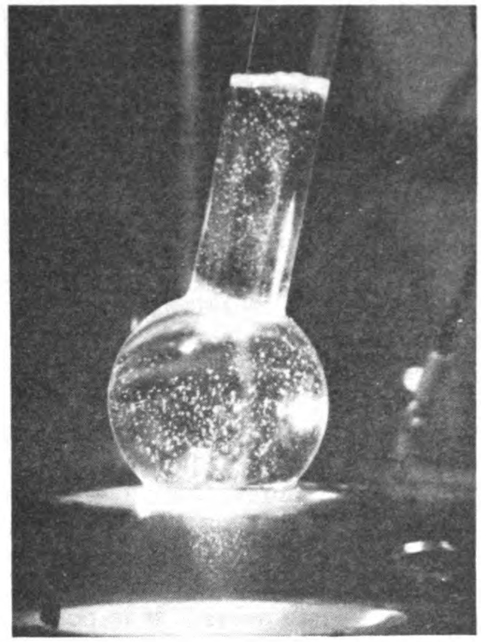

Figure 6. Gas bubbles produced by intense ultrasonic waves in water containing dissolved air.

Reference has already been made to the use of ultrasonic waves as a means for de-gassing liquids. In the case of water and similar liquids, it is not likely that ultrasonic waves will replace such techniques as boiling. Ultrasonic waves may be practical, however, in de-gassing fused metals prior to solidification, when it is very important to avoid the holes made by the gases liberated.

At our laboratory ultrasonic waves have been used to disperse in water everything from cooking fats to aluminum. This action is associated with the ability of such radiation to break any solid or liquid into particles small enough to stay suspended in water or a similar liquid despite the force of gravity. For example, if a few drops of mercury are placed in a vessel containing water, a 10-second irradiation is sufficient to produce an opaque suspension of the metal. Ordinary mechanical shaking is not capable of producing this effect. Yet virtually any solid (including the glass of the container) can be suspended in water with ultrasonic waves. It is probable that such radiation will find commercial application in the near future in producing suspensions.

While ultrasonic waves can produce suspensions in liquids, the reverse effect tends to predominate in air and in gases in general. That is, if these waves are passed through air containing suspended particles such as dust or water droplets, the particles tend to coagulate and to settle out. This is the basis for the use of ultrasonic waves as a means for smoke precipitation.

Other possible physical applications of interest involve the removal of oxides from the surface of aluminum in soldering, the removal of grease from the surfaces of metals, and the modification of the structure of alloys during solidification.

As we have pointed out, ultrasonic waves have served as a tool for the study of chemical systems. Through measurements involving such waves, much information has been obtained as to the fundamental nature of materials. The majority of these measurements involve the determination of the speed as well as the extent of absorption of ultrasonic waves in various samples. For gases, such data can be used to study how the molecules of the gas behave in collisions with each other. In liquids, measurements with ultrasonic waves indicate how closely packed and, in some cases, how large the molecules are. Velocity data for crystalline solids indicate the strength of the forces holding the elementary particles of the crystals together.

In the laboratories at Western Reserve University, ultrasonic waves are being used to obtain fundamental information as to the processes involved in electroplating metals and in the production of hydrogen and oxygen from water by electrochemical methods. Though electrochemistry, as a formal science, is more than 150 years old, a reasonably complete picture of what occurs when a metal is electrodeposited from solution is not yet available. By disturbing the electroplating processes with ultrasonic waves, it is possible to study these processes in terms of changes in the voltages at which the metals are deposited as well as in terms of the structure of the electroplated metal. Similar measurements are being made for other electrochemical systems. Once these processes are understood thoroughly, it should be possible to have much better control over them in commercial applications. The day may be near when the chromium-plated bumpers on automobiles will remain bright for the life of the automobile and the battery will not always manage to fail on the worst morning of the year.

Ultrasonic waves may also find direct applications in electrochemistry as a means for improving the structural characteristics of electrodeposited metals, e.g., decreasing the porosity of the metal plates.

It is interesting to note that the application of ultrasonics to chemistry is not a one-sided affair. The chemist has done significant work in the study of ultrasonics as a phase of acoustics. His contributions range from the development of synthetic piezoelectric materials for the generation of ultrasonic waves to electrochemical devices for the detection of such radiation.

Dr. C. M. Pomerat Honored

Dr. Charles M. Pomerat, at present conducting immunity studies under ONR contract at the University of Texas School of Medicine, has received the 1951 award of A. Harris & Co. for his work in growing brain cells from human tissue. The $1,000 award is given annually in recognition of work which has contributed appreciably to advancement in our country.

Dr. Pomerat, a professor of cytology, has published nearly 100 articles on cell research problems. He was author of the article "Pictures for Visualizing Allergy", which appeared in the June 1951 issue of Research Reviews.

Grain Refinement in Aluminum and its Alloys

by
Harold Bernstein
U. S. Naval Gun Factory

The grain is the building block of the cast metal. Grain size, and to a lesser extent grain shape, exert considerable influence upon important properties of light metal castings. A fine, equiaxed grain (one that tends to be round, not elongated) is desirable because of the associated improvement in casting properties, mechanical properties, hot and cold workability, and response to heat treatment. The effect of grain size upon the cold-working characteristics of 1/2-inch rounds of cast aluminum may be seen in Figure 1. These specimens were reduced approximately 50 percent in a compression machine at room temperature. The regular symmetrical shape of the fine-grained specimens presents a

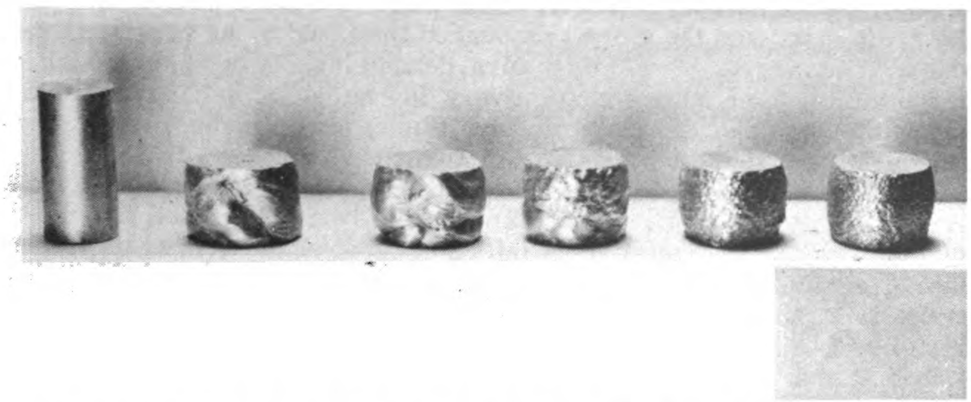

Figure 1. Effect of grain size on the cold-working characteristics of cast aluminum. The specimen before compression is at the extreme left. Grain size varies from coarse at left to fine at right. (Approximately 2/3X.)

striking contrast to the irregular exterior of the coarse-grained specimens, the coarsest of which exhibits surface cracks.

The grains of aluminum and its alloys are perceptible to the unaided eye after suitable surface preparation. In absolute dimensions, their size may vary from 1-inch-long, columnar grains to equiaxed grains with a diameter of 0.007 inch. The grains of pure aluminum tend to be column-shaped, while aluminum alloys usually have an equiaxed structure. Figure 2 illustrates the principal types of grains in small ingots for compositions ranging from high-purity aluminum to alloys of aluminum and copper. Apparently, an inherent relationship exists between

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Harold Bernstein, a metallurgist at the U. S. Naval Gun Factory, has been co-author of several articles on grain refinement in aluminum and aluminum alloys, published in Transactions of the American Society of Metals and in Iron Age. Mr. Bernstein received a B. S. from Brooklyn College and has been at the Gun Factory since 1941.

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composition and grain characteristics. Other factors which influence structure are melting temperature and time, method of pouring, and cooling rate.

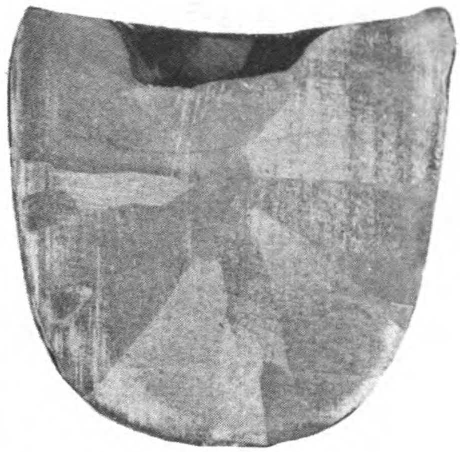
It is generally recognized that the process of solidification in a molten metal begins with a nucleus, assumed to be a minute solid particle which acts as a focal point of crystallization. These particles are present in the charge, or are formed by chemical reactions in the melt. They may be either metallic or nonmetallic, but their crystal structure must be compatible, to some extent, with the matrix metal. As cooling progresses, the nucleus builds up into a crystal by adding metal from the molten reservoir. If allowed to develop unhindered, the external surfaces of the crystal will bear a definite relationship to the internal structure.

Under ordinary conditions of solidification, like those in a mold, many nuclei begin to grow simultaneously in the same area. Since the growth of any particular crystal is arrested by contact with its neighbors, its final shape is determined by external forces. Thus, a grain, or "limited" crystal is formed. The size and shape of the grain depend, in part, on the number of nuclei in the melt; the more nuclei, the finer the grain size, and the more pronounced the trend to an equiaxed grain shape. The number of nuclei, in turn, depend largely on the composition of the melt. Pure metals contain very few nuclei while impure metals and alloy combinations contain many. Nuclei may also be formed spontaneously upon cooling; the rate of formation varies with the rate of cooling. An example of this is provided by the columnar grains formed in high-purity aluminum (Figure 2). Evidently solidification began with nuclei formed at the metal-mold interface, which experienced the fastest rate of cooling in the system. These nuclei grew inward at right angles to the mold, until they met opposing crystals. There is evidence that a few grains were formed at the center of the melt, but the majority originated at the mold wall. The difference between the high-purity ingot and commercial-purity ingot is obvious, and this is attributed to the difference in impurities, a prime factor in nucleation.

Prolonged heating in the molten state, or superheating the liquid metal tends to dissolve remanent particles of solid as the melt progresses toward equilibrium, thus eliminating potential nuclei. The structure of a metal whose history includes such a treatment is correspondingly coarse.

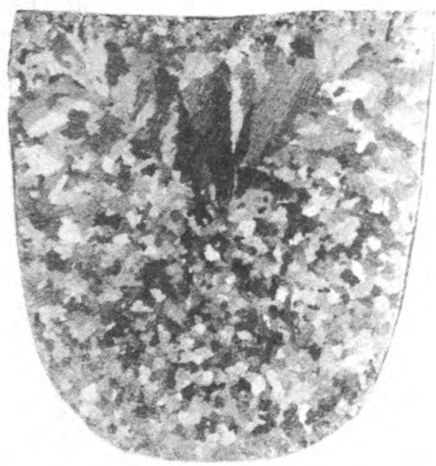
Another factor which influences the final grain size is the rate of crystallization, or crystal growth. A rapid rate of growth may produce elongated, columnar grains. Conversely, a slow rate affords opportunity for the formation of more nuclei, and consequently of finer, more regular grains. The rate of crystal growth is associated with certain physical characteristics of the melt such as viscosity and surface tension, and the rate of heat flow in the mold.

In this investigation, the emphasis has been placed, to date, upon how the composition affects grain size. One phase of the research dealt with the structure of binary alloys of aluminum. Starting with commercial purity aluminum, a series of 3/4-pound ingots were made up, containing aluminum and an added element. The melts were prepared in small graphite crucibles in a muffle-type resistance furnace. After the



High-purity aluminum
(99.99%)

Commercial purity aluminum
(99.81%)



Alloy containing c. p. aluminum
and 4.5% copper

Alloy containing c. p. aluminum,
4.5% copper, and 0.15 titanium

Figure 2. Types of aluminum grain structure. (Approximately 4/5X.)

addition had been made, and the melts brought up to the proper temperature, the crucibles were removed from the furnace and the melts were allowed to solidify in still air. The ingots were sectioned longitudinally along the centerline, then polished and etched with suitable chemical reagents. The grain sizes were then measured under a low-power microscope.

On the simple basis of weight percentage required to accomplish refinement, the elements investigated fall into two groups. Group 1 includes elements which refine at very low weight concentrations: titanium, tungsten, zirconium, boron, molybdenum, and columbium, in that order of refining ability. These elements possess high melting points from 3272° F for titanium to 6066° F for tungsten. Their solubility in aluminum at ordinary melting temperatures (about 1350° F) is very limited, the maximum being about 0.36 percent for molybdenum.

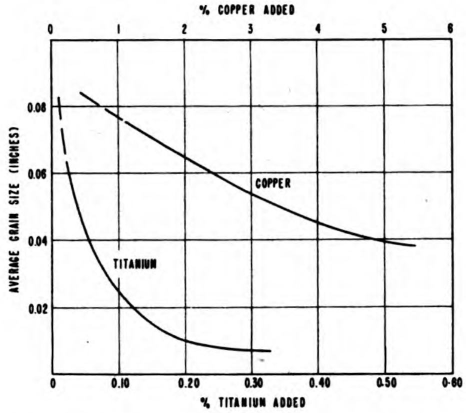


Figure 3. Comparison of effects of copper and titanium on grain size of commercial-purity aluminum.

Group 2 contains elements which require sizeable weight concentrations to refine or modify: magnesium, copper, zinc, iron, nickel, tin, manganese and silicon, in that order of effectiveness. The melting points of these elements fall in the lower end of the temperature scale, ranging from 440° F for tin, to 2795° F for iron. Their solubility in aluminum (at 1350° F) varies from 4 percent for iron to 100 percent for tin and zinc.

A comparison of the refining effects of the two groups is illustrated in Figure 3.

From this data, it was concluded that the elements in Group 1 participate directly in the formation of fine colloidal particles which act as centers of crystallization and are stable in molten aluminum under ordinary conditions of time and temperature. From the relatively large amounts used of the elements in Group 2, it appeared that refinement was indirectly accomplished by altering the physical characteristics of the melt.

The experimental method described above was used to determine the effects of various added elements on the grain size of the

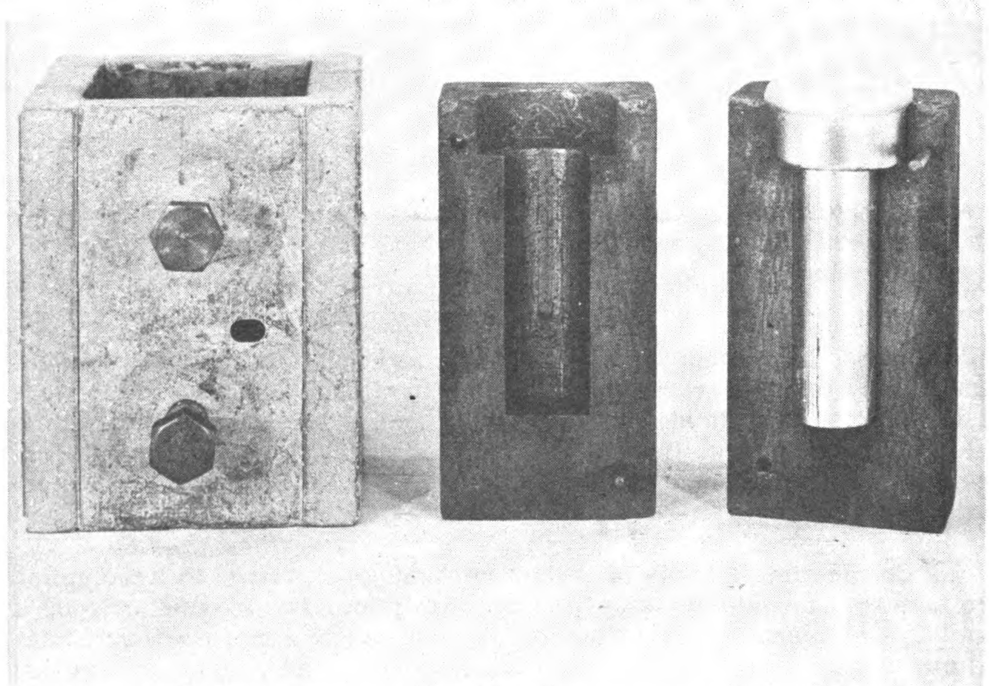


Figure 4. Transite Flask, split graphite mold, and aluminum alloy casting used for grain size determinations. (Approximately 1/2X.)

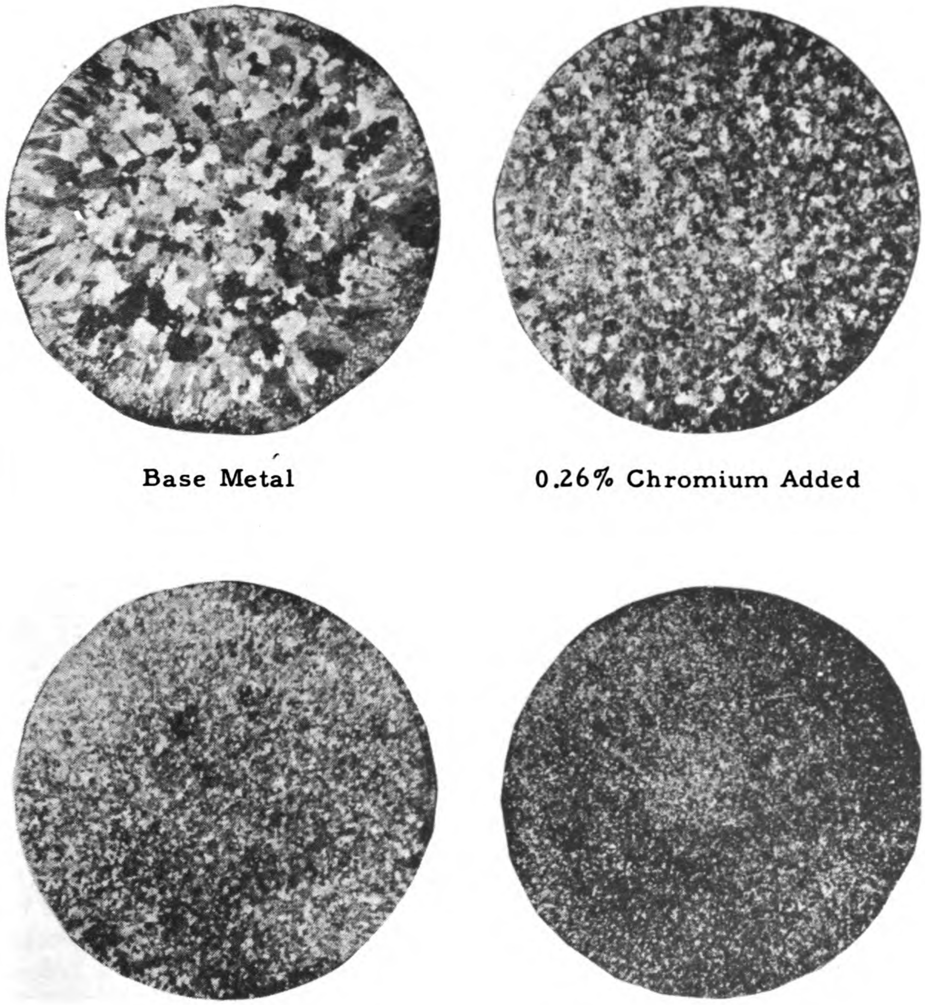


Figure 5. Grain size of various specimens of 7% Silicon-Magnesium-Aluminum alloy. (Approximately 3X.)

aluminum - 4-1/2 percent copper casting alloy. This alloy has wide usage and is known commercially as 195. All of the elements listed in Group 1, with the exception of zirconium, acted as refiners for it; titanium was found to be the most efficient. The addition of two refining agents such as titanium and columbium to the same melt produced a subtractive rather than additive effect. The resultant refinement lay in between the individual effects. Certain elements such as chromium and beryllium acted as coarseners on the base alloy. It was found, however, that coarseners were ineffectual in the presence of an active refiner.

The next alloys to be investigated were the aluminum-silicon alloys, whose commercial designations are 43 and 356. Number 43 is a binary alloy (i.e., made up of two metals) containing 5 percent silicon, and 356 is a ternary alloy, containing 7 percent silicon and 4 percent magnesium. The test specimen was changed from a 13-ounce ingot to a 3-ounce rivet which was cast in a preheated graphite mold. This permitted greater

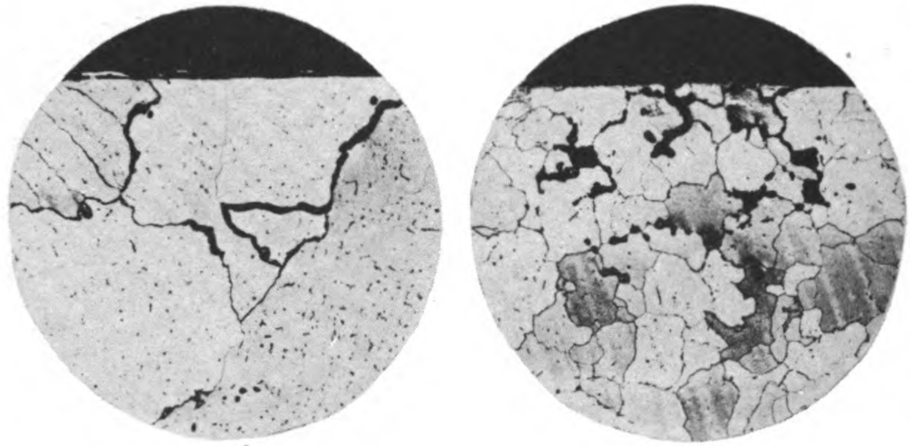


Figure 6. Microstructures of coarse and fine grained aluminum - 4.3% copper alloy after salt spray corrosion test. (68X)

efficiency in operation. The mold used and a specimen casting are shown in Figure 4. Grain size measurements were made on cross sections of the shank at a set distance from one end. Typical structures are presented in Figure 5. The results showed that boron in minute quantities (less than 0.05 percent) was the most efficient grain refiner for the silicon alloys.

Since certain types of corrosion occur principally through the grain boundaries, the relationship between corrosion resistance and grain size in the aluminum-4-1/2-percent-copper alloy was investigated. The corrosion resistance was measured in terms of weight loss. The specimen used was the shank of the rivet described above, turned to a 5/8-inch round, 2 inches long. The specimens were exposed to 4 percent synthetic salt spray for 1200 hours. While considerable variation in weight loss was noted, there was no apparent relationship to grain size. The microstructures, nevertheless, are of interest. Figure 7 presents coarse- and fine-grained specimens after corrosion test. It appears likely that a relationship might be demonstrated between loss of tensile strength (by corrosion) and grain size.

Of great practical importance is the effect of grain size upon the mechanical properties of aluminum casting alloys. Improvements in both tensile strength and elongation (ductility) may be achieved by the relatively simple method of adding small amounts of the active grain refiners. At the present time, the effect of grain size upon the mechanical properties of the aluminum-5-percent silicon alloy is under investigation. Preliminary results have shown that an increase in tensile strength of approximately 15 percent can be obtained by refining the grain with titanium or boron.

The study of grain refinement in aluminum alloys has yielded interesting and constructive results to date. Future work will be concerned with other alloys of commercial importance such as the aluminum-zinc alloy, and applications of grain size with respect to the alloys previously discussed.

Who's Who in Naval Research

Dr. Mina S. Rees

Since this is the first time Who's Who in Naval Research has dealt with the accomplishments of a woman, it is a unique occasion. But then the Director of the Mathematical Sciences Division—Dr. Mina S. Rees—has achieved some unique distinctions that transcend the mere fact that she is the only woman at division-head level in the Navy's far-flung research program. She is also one of the nation's well-known mathematicians and a recognized authority on electronic computers.

Miss Rees began collecting honors early in her career by graduating summa cum laude—and of course Phi Beta Kappa—in mathematics from Hunter College. Shortly thereafter she obtained her M. A. at Columbia and then went on to a Ph. D. (abstract algebra) in 1931 at the University of Chicago. As soon as she had obtained her doctorate Miss Rees returned to Hunter College as a member of the faculty. She remained there until 1943, climbing the academic ladder to a professorship.

By this time Dr. Rees had established her reputation as an unusually competent mathematician. Consequently, in 1943, she was "drafted" (actually she took an extended leave of absence from Hunter) by the National Defense Research Committee. She soon found her niche as technical aide and executive assistant to Dr. Warren Weaver, the Chief of NDRC's Applied Mathematics Panel. A portion of her work dealt with the development of large-scale computers—a field then in its infancy. For her wartime contributions Miss Rees was recognized by two notable decorations: The (British) King's Medal for Service in the Cause of Freedom, and the (U. S.) Presidential Certificate of Merit. Since the war she has been honored by a number of distinguished appointments: National Academy of Sciences Liaison Representative with ONR, U. S. Government Representative on the UNESCO Panel on Applied Mathematics, Navy Member and Chairman of the National Bureau of Standards Applied Mathematics Advisory Council, and a member of the National Research Council's Committee on High Speed Computing Machines.

This, then, is the scientist who is directing ONR's Mathematical Sciences Division. The contract research under her supervision embraces an expanding program of basic research on mathematics, hydrodynamics, aerodynamics and other fields of mechanics. A second effort deals with the continuing development of ever-faster computers and with new applications and uses for these "mechanical brains".

Recently the Division has accepted two new programs: One, being done at the request of the Secretary of the Navy, is the application of mathematics to the improvement of naval logistic procedures; the other, a development of sampling and statistical techniques for application to procurement problems, is important to the entire Defense Department.

In spite of her long list of academic and professional honors, Dr. Rees is far from the scholarly type. Pleasant and easy to talk to, she has a friendly charm that enables her to carry her assorted distinctions with poise and naturalness. Probably much of this ability stems from the fact that she has not let her professional duties crowd out a variety of other interests from her life. Her outside activities range from the athletic (she is a better-than-average tennis player) to the artistic (her hobby is oil painting—marines and landscapes mostly). In short there is plenty of justification for the opinion of her colleagues that Dr. Mina Rees is not only exceptionally talented but also a thoroughly likable and interesting personality.

Viking 8 to Reach for New Altitude Record

Another assault on the world's altitude record for single-stage rockets will be made next spring by a Navy Viking. The present world mark, established by Viking No. 7 last August at the White Sands Proving Ground, N. M., is 135 miles, some 21 miles greater than the previous record of a German V-2. The next rocket is expected to better the present mark by a considerable number of miles.

The forthcoming Viking will, however, be somewhat different from its predecessors. In cooperation with ONR's Naval Research Laboratory, for which the rockets have been developed, Glenn L. Martin Co. engineers have redesigned No. 8 so that it will be greater in diameter, slightly shorter and have fins about three-quarters the size of those on the first seven rockets. The new size will allow considerably more fuel (liquid oxygen and alcohol) to be carried, thus providing thrust for a longer time. Then it will be possible for the Viking to attain higher speed, and consequently greater altitude. The power plant will again be made by Reaction Motors, Inc., and will generate approximately 20,000 pounds of thrust.

Vikings are being used in scientific studies of the upper atmosphere. Telemetering equipment in the nose section sends information back to a ground station. This is permanently recorded on moving tape for future study. In addition, a camera in the nose takes pictures.

NRL has been probing the upper atmosphere since early 1946. Under the direction of Dr. Homer E. Newell, Jr., Head of the Rocket-Sonde Branch, the present aims of this program are to extend knowledge of: (1) the physics of high-energy particles; (2) the physical state of the earth's atmosphere to as great an altitude as possible; (3) the fundamental nature and properties of the ionosphere and the processes which lead to its formation; and (4) solar and terrestrial radiation.

The Sailplane in Aerodynamic Research

by

August Raspet
Mississippi State College

The application of the sailplane, or glider, to research distinguishes it from its more romantic use in sport, in which the quality of the craft and the skill of the pilot are employed to gain energy from the discontinuities in the atmosphere. The aim in soaring is to fly long distances or to gain high altitudes. In research flying with the sailplane, however, the pilot strives to fly when the atmosphere is perfectly uniform. During a measurement, he makes an effort to maintain, as accurately as possible, a constant airspeed and a constant angle of attack (i.e. inclination to the relative wind) with the skid angle maintained at zero. Under these conditions the exact counterpart of the wind-tunnel test is attained.

One classical use for the sailplane is that of a prototype for determining the performance, control, and stability of a larger, powered airplane. The slow speed of the sailplane prototype permits the researcher to make "cheap and dirty" changes in outside geometry by means of putty, balsa or cardboard, and scotch tape.

AERODYNAMIC MEASUREMENTS ON THE COMPLETE SAILPLANE

Since the principal aim in sport soaring is that of setting cross-country distance records, the sailplane must, for this purpose, be designed for gaining altitude by making the most efficient use of the energy in the atmospheric anomalies. When the rate of energy use begins falling off, the pilot converts his excess potential energy to distance by means of a long high-speed glide. For this reason sailplane designers strive to achieve minimum induced drag when the plane is climbing and a very low drag at high speeds, so that during the glide the high speed may be flown without excessive altitude loss. This emphasis on high-speed glide is dictated by necessity, for the distance flight must be made in the fixed number of hours during which upcurrents are present in the atmosphere.

Because of the penalty paid for high profile drag many sailplane designers have recently adopted the laminar airfoil—the shape that allows

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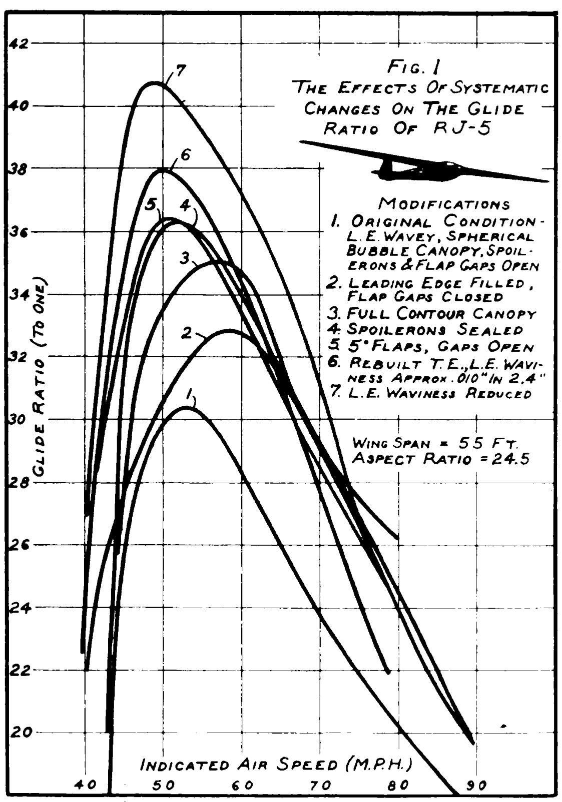
the air stream to flow over the wing in undisturbed layers. The use of these airfoils on the currently outstanding American Sailplane RJ-5 established the importance of a wave-free contour. Previous applications of these airfoils to sailplanes had been disappointing, simply because the criterion for contour accuracy had not yet been established.

The technique for aerodynamic measurements with sailplanes consists of towing them to altitude by means of an airplane and then, during the glide, determining their rate of altitude loss for various forward speeds. From these data, and from knowledge of the weight of the craft, the drag coefficient and the corresponding lift coefficient may be computed. Analysis of the behavior of drag and lift coefficient permits the induced drag and parasite drag to be separated.[1] From this information the aerodynamicist is able to predict what change in external geometry should be made to improve performance. On the RJ-5 sailplane, for example, a series of systematic changes made in this manner permitted the maximum glide ratio to be raised from 30-to-1 to 40.5-to-1 (Figure 1). A similar gain on a transport airplane would raise its cruising range 30 percent.

Since the early days of aeronautics the motorless aircraft has contributed much toward solution of the perplexities of control and stability. Before engines were available, aeronautical engineers sought, by flying gliders, to obtain a solution to these little-understood problems. And if we look into the reports of Lilienthal, of the Wright Brothers, of Langley, of Cayley or of any number of early experimenters, we will find that each first solved his problem without an engine in place. Perhaps this is fortunate for aviation today, for if the weight and inertia as well as the effect of thrust and slipstream had been included in the early designs, the problem would have been confused by too many variables. Such a confusion would have resulted not only in a delay in achieving stable controlled flight, but also in numerous mistakes and fatal accidents to researchers. In this connection a quotation from A. R. Weyl, in Aircraft Engineering (1944-1945), concerning motorless prototypes of A. M. Lippisch is most illuminating:



"It is worthwhile noting that during all these years of

[1] "Parasite" drag is all the drag offered by an airplane with the exception of "induced" drag, which is that part of the wing drag induced by the lift.

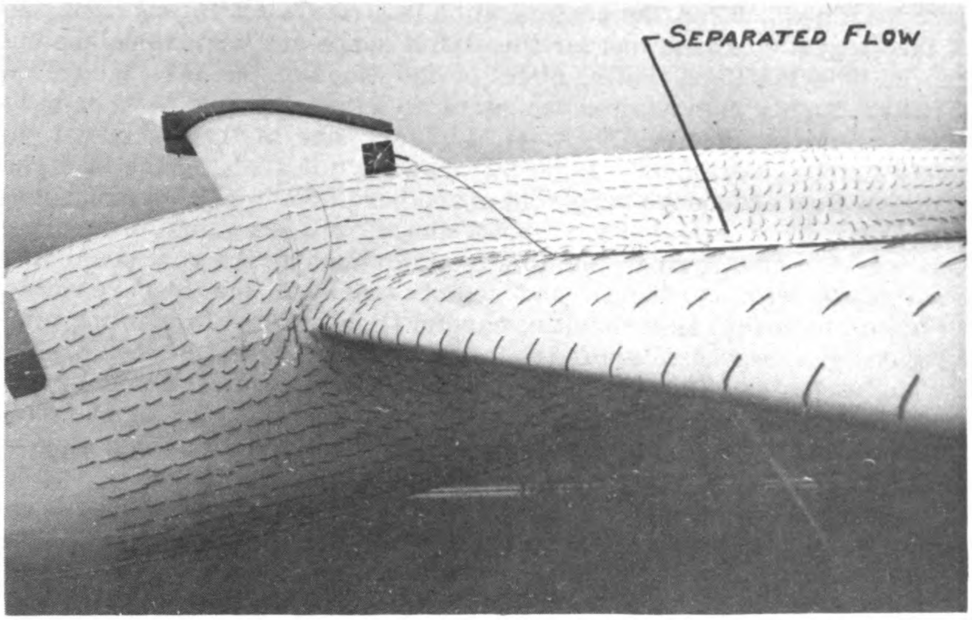


Figure 2. Free-flight tuft photo showing separated flow at wing root of high-performance German sailplane

experimenting not a single accident occurred and not one of the gliders suffered damage to such an extent that it became a complete loss."

A pilot possesses a definite advantage over a contrary aircraft if that aircraft's kinetic energy is low (low speed and small weight) and if the natural periods of unstable oscillation are long. Under these conditions he can "outwit" the aircraft by compensation of the controls, in much the same way that a sailboat skipper compensates for sudden gusts or lulls in the wind.

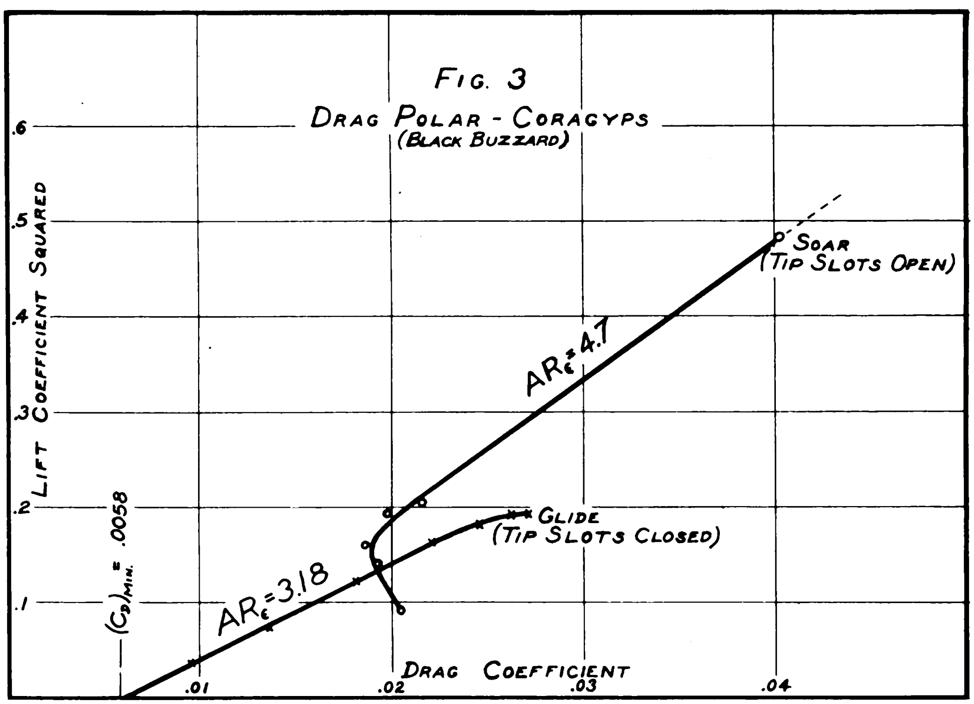
One cannot, in fact, overemphasize the advantages of a low-weight, low-speed motorless prototype over a powered prototype. The low speed results in less landing shock, as well as in a long period for any dips or rolls—oscillations that are long enough to be easily controlled by the pilot. The motorless craft, moreover, has no interference from the gyroscopic effect of the engine or from the slipstream. Furthermore, when a researcher desires to explore a large family of configurations, the economy of building simple gliders of wood is important in allowing him to obtain nearly full-scale effects. At the same time, the various configurations may be used as structural prototypes to learn the relative loadings of the various structures and their ability to carry these loadings.

INTERFERENCE STUDIES

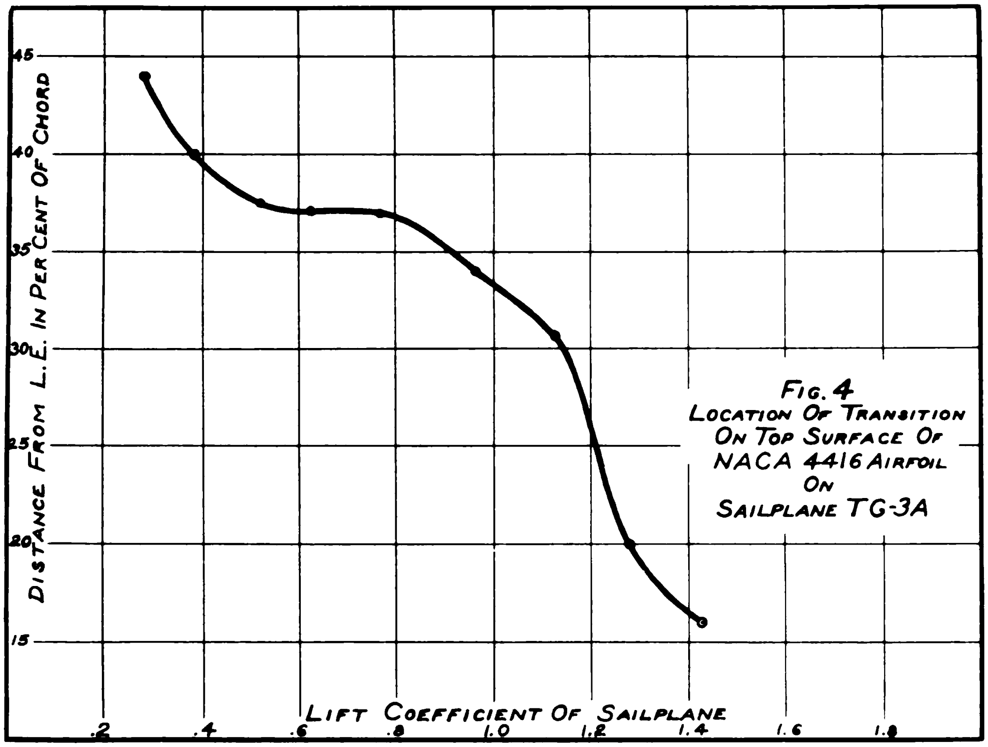
The interference of the flow around a fuselage with that of a lifting wing attached to the fuselage is a fundamental problem of fine aerodynamics. When the configuration is a mid-wing or low-wing, all of the elegant computations for the airfoil shape are useless unless one can include the decelerating effect of the sides of the fuselage on the airflow. Such a computation was made on an outstanding German sailplane design in 1934 by Dr. A. M. Lippisch, one of the fathers of the world soaring movement. Figure 2 shows a tuft study, made in flight, of the air flow around the wing root of another German high-performance sailplane. This examination shows the flow separating toward the trailing edge of the wing. Suitable modifications to the root could have been made with cardboard and scotch tape and the test repeated. Recently, however, as a result of careful flight tests with existing mid-wing designs, a general approach to this problem has been developed in the United States. This approach is based on a concept of volume expansion of the airflow in the wing root. By suitable filleting,[2] or by modifying the after-portion of the fuselage, this volume expansion may be minimized. In fact, some designs have been modified in such a way as to pressurize the wing-root and thereby achieve a pressure gradient favorable to resisting separation of the airflow.

WING TIP RESEARCH

In the early days of aviation, experimenters placed considerable emphasis on wing-tip design. Perhaps they realized the influence on performance and stability of three-dimensional flow around a tip, but



[2]False covering or molding that rounds out the angle between the wing (or tail) and the fuselage.



certainly they were not able to measure the effects in full-scale flight. Attempts to study space flows around tips in small turbulent tunnels were made later, but no recent studies in low-turbulence tunnels are known. Some work in Germany during the War showed an improvement of as much as 11 percent in a specially designed tip, compared to a conventional rounded one. It should be realized that tunnel wall interference is difficult to remove from the measured results when there are changes taking place in the tip flow. For this reason full-scale flight tests offer the most reliable results. Figure 3 shows the influence of slotted wing tip and pointed wing tip taken from comparison measurements made by tracking the bird with a calibrated sailplane.

BOUNDARY LAYER RESEARCH

The recent great strides made in understanding viscous flow in in the boundary layer[3] are, in large measure, due to experimental confirmation of the stability theory in low-turbulence tunnels. Laminar airfoils could not have been developed without this valuable tool. Since transition from laminar to turbulent flow is initiated by turbulence in the free stream, the importance of reducing the degree of turbulence in the testing environment is evident. There are, however, other causes of transition: namely, pressure gradients due to airfoil waviness, to vibration of the surface of the airfoil, or to noise in the tunnel. While suitable precautions to reduce waviness and the effects

[3]Between the surrounding air that flows freely around a surface and the surface itself, there is a thin layer of air that has been slowed by friction.

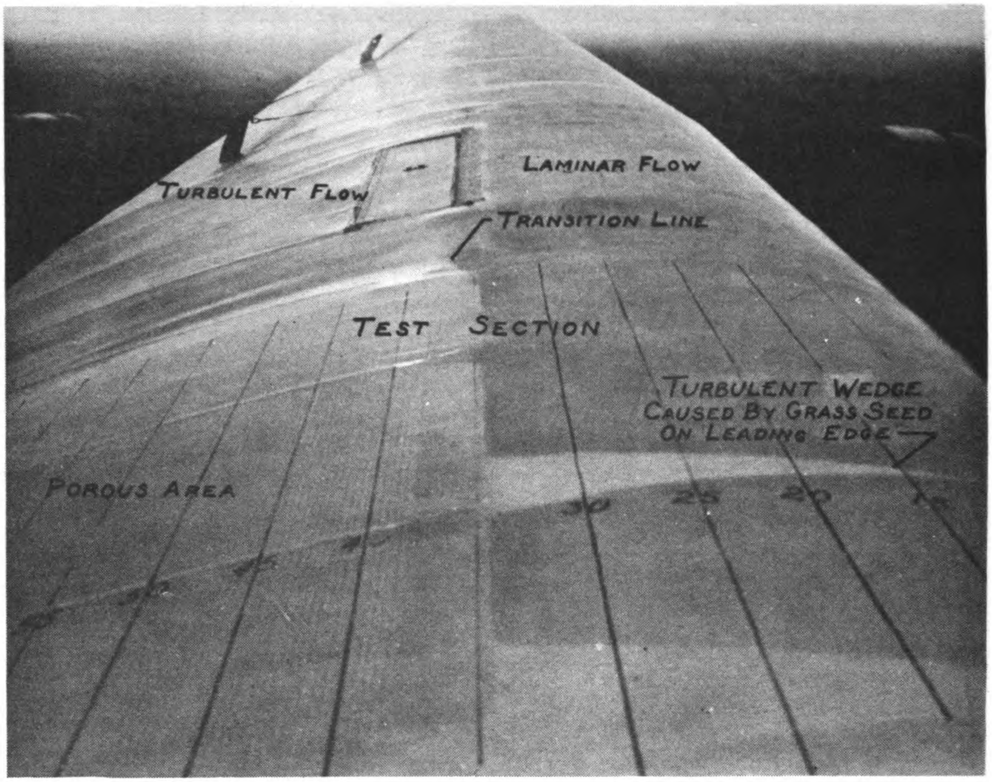


Figure 5. Display of transition by dew evaporation method on sailplane wing (obtained in flight with suction blower off).

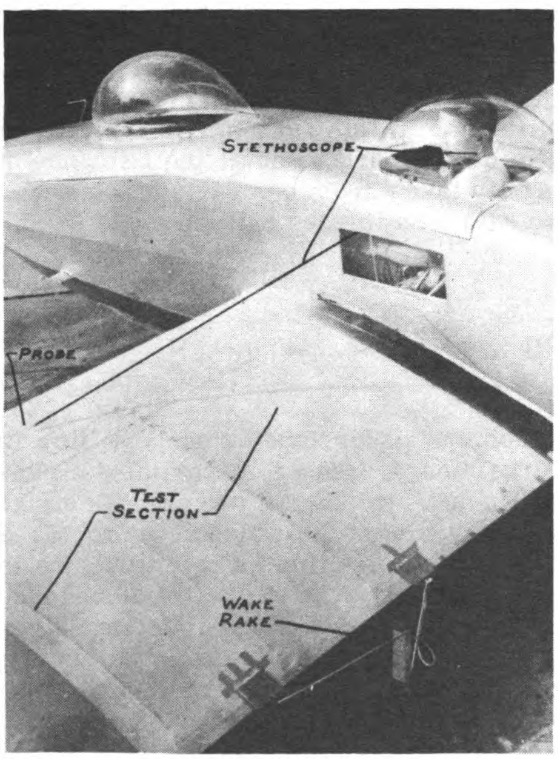


Figure 6. Research sailplane fitted for boundary layer studies.

of vibration can be taken in building the model, it is rather difficult to reduce the noise of a wind-tunnel without reducing the flow velocity. It is in this respect that the sailplane provides a unique solution; tests can be made in an environment in which free-stream turbulence and noise are extremely low.

Recently measurements of transition (from laminar to turbulent flow) were made on a non-laminar airfoil on a sailplane (Figure 4). These measurements show the transition at cruising conditions to be at 44 percent of the chord from the leading edge. Here is proof of the small disturbing influence of noise in free-flight measurements made on sailplanes. The wing had been surfaced so that it was

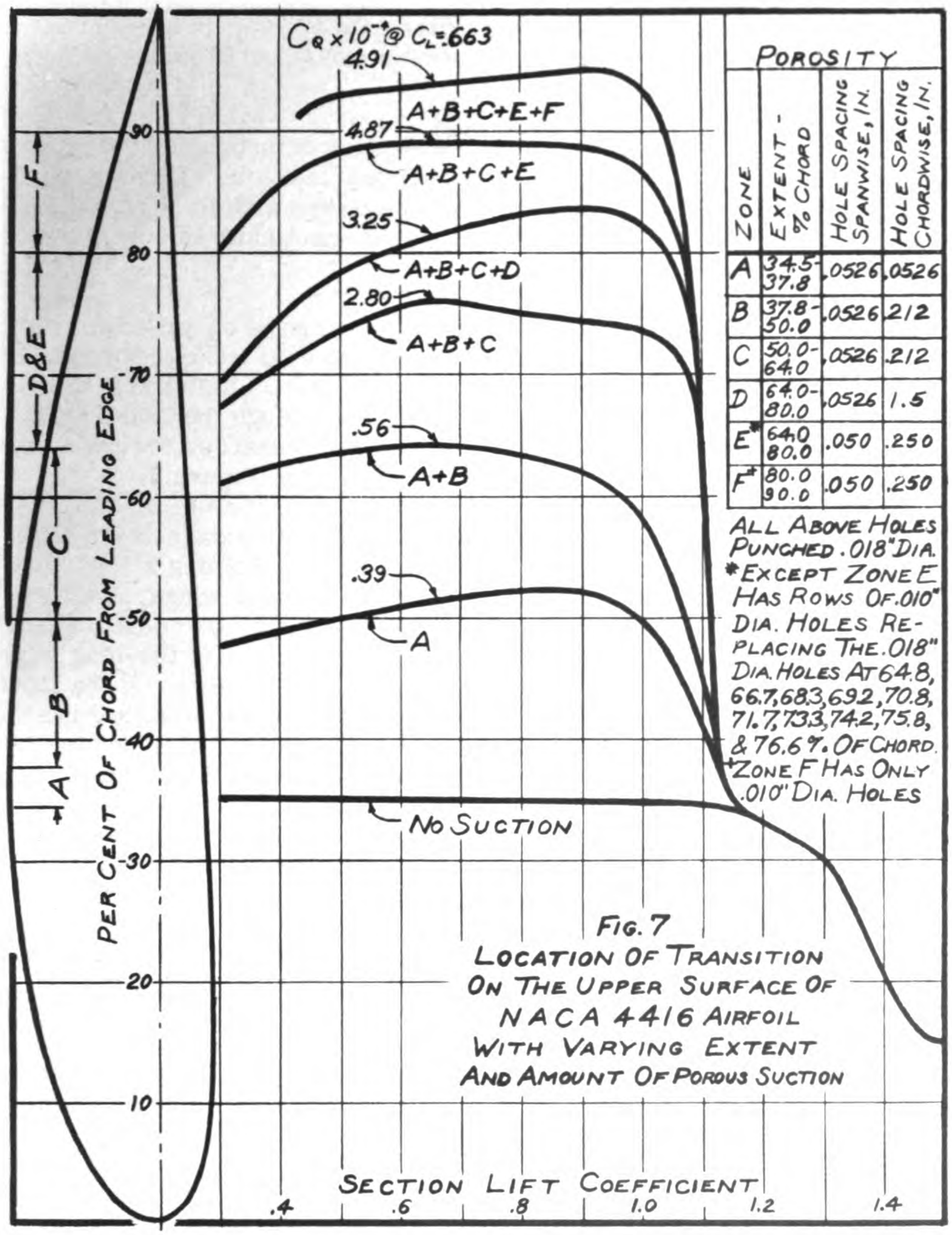


Fig. 7
Location Of Transition On The Upper Surface Of NACA 4416 Airfoil With Varying Extent And Amount Of Porous Suction

wave-free to an accuracy of ± 0.002 inch measured over points spaced each 4 percent of the chord; therefore transition due to this cause was delayed.

The quality of the flow over a sailplane wing which had not been specially surfaced can be seen from Figure 5. This photograph was taken in towed flight shortly after take-off. Dew was allowed to settle on the wing until a thin uniform coat of moisture was deposited on the upper surface of the airfoil. Dew will usually deposit at dawn except on very dry mornings, after a cold front, or in desert areas. Under these conditions, however, moisture can be sprayed on the wing.

As soon as the sailplane begins moving, a differential evaporation of the moisture occurs between the laminar region and turbulent region.

The turbulent region has a much greater rate of evaporation and, as a result, a sharp line of demarcation between moist and dry wing results. This is the line of transition.

Near the wing root can be seen two wedges of turbulent flow caused by grass seeds deposited on the wing during take-off. These wedges would occur behind any small protuberance on the airfoil; a rivet head, or even a fly speck would cause sufficient discontinuity in curvature to initiate transition.

Inboard, behind the leading edge, a region can be observed in which the cloth surface has been pricked with a needle to make it porous. If the air is sucked into the wing the boundary layer is stabilized so that it remains laminar, but if air flows outward through the holes in the surface, the boundary layer is de-stabilized and transition occurs along the forward edge of the porous section, as shown in Figure 5.

In Figure 6 a sailplane fitted specifically for boundary-layer studies is shown. The observer is in the rear cockpit holding a long tube which may be moved fore and aft and spanwise over the wing from inside the cockpit. To the end of this tube inside the cockpit is connected the stethoscope which the observer wears. The outer end of the long tube has a probe consisting of a small tube facing into the flow. If the flow is turbulent the observer hears the velocity fluctuations as a loud rushing noise, but if it is laminar there is only a weak hissing sound in the stethoscope. This simple instrument, an ideal device for studying the boundary layer, may be used to detect transition as well as a separated boundary layer. In a similar manner one may use such probes as static pressure sondes, boundary-layer velocity distribution probes, and acoustic microphones for presentation of the fluctuations on a cathode-ray tube.

Also installed in this sailplane is a blower, powered by a storage battery, which is used to provide suction for the investigation of boundary-layer control over the test section of the wing. Figure 7 shows the results of some studies of porosity of the wing on the extent of the laminar boundary layer. There is a slot near the trailing edge into which the laminar boundary layer was to be drawn for later studies of lift augmentation. If it were not for this slot the boundary layer could have been maintained laminar to the trailing edge.

In some flight operations a device is needed which will increase the drag and decrease the lift. In particular, carrier landings of high-performance aircraft would be made safer if, at the throttle cut, the airplane would assume a steeper glide angle. At the same time the drag should be increased by some large factor. Though flaps, dive flaps and spoilers in general function in this manner, they do not take effect quickly enough. Figure 8 shows the aerodynamic spoiler action of a section of porous wing from which air is allowed to flow outward. The tufts indicate that the flow is separated far forward on the wing. Measurements show that the drag is ten times that of the plain wing. When suction is applied, the flow is seen to be improved over the impervious wing (plain airfoil). In this state the wing permits a steeper climb and a shorter take-off with a given power.

In essence, using the sailplane for boundary-layer research permits close study of viscous flow under free-flight conditions. Moreover,

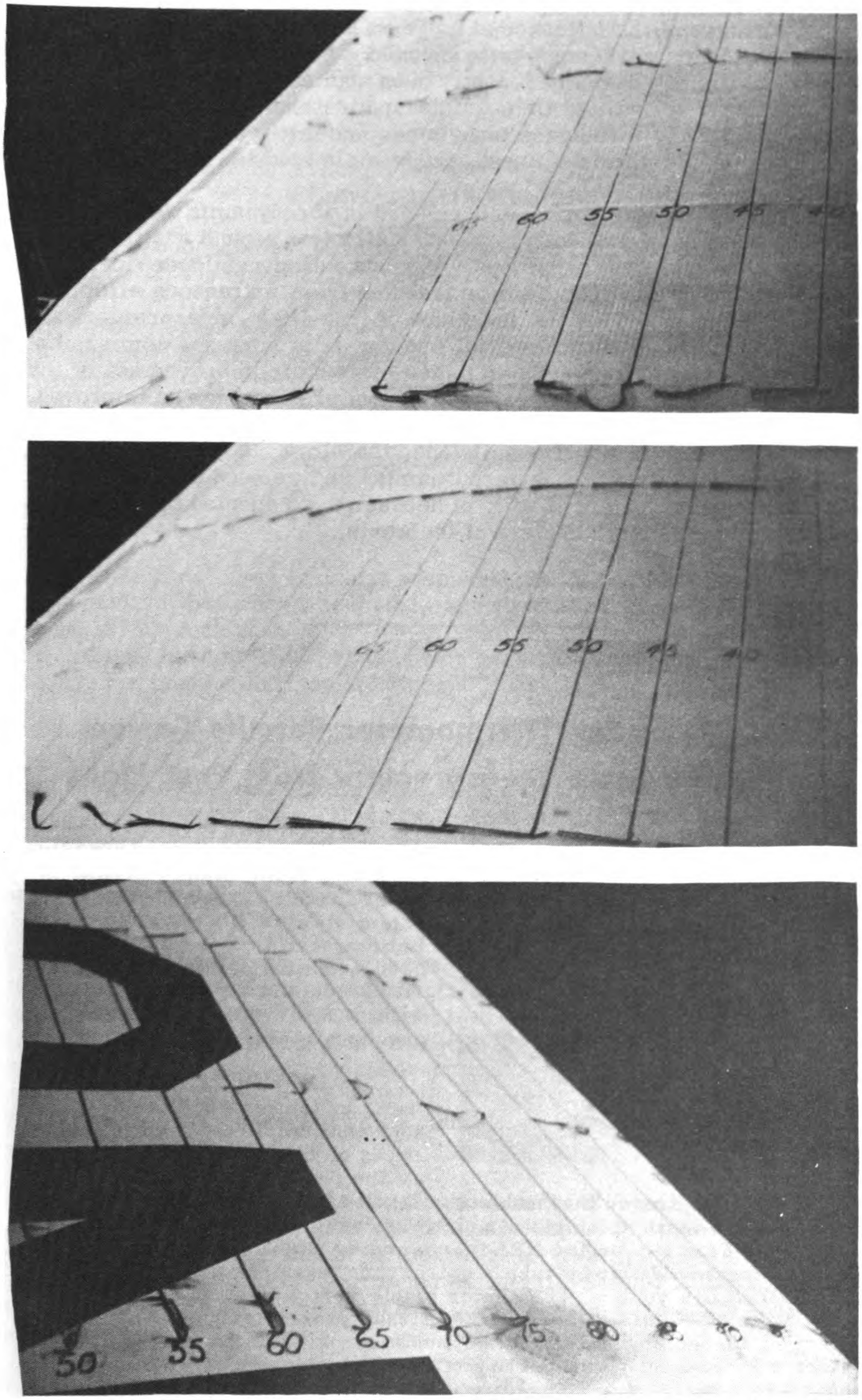
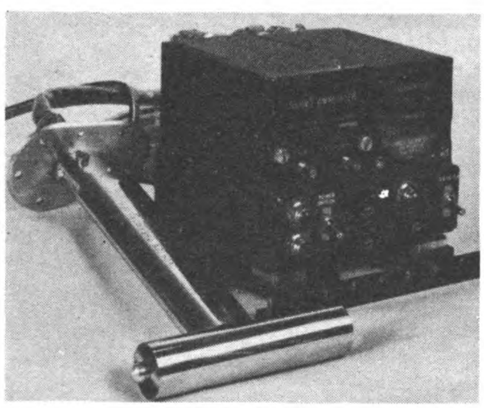


Figure 8. Aerodynamic spoiler action of a section of porous wing: Top, blower off; center, blower on; bottom, impervious surface.

the flow is free of the influence of noise as a cause of transition. Consequently closer agreement with boundary-layer theory is possible. Since the sailplane has only recently been applied to these studies, it is still too early to outline all possible applications for it in this field. However, until low-turbulence tunnels can match it in noise level, it will remain the medium for the finest aerodynamic studies.

Thus far the sailplane has been used in aerodynamic research for the investigation of low-loss flows over airfoils, around wing-fuselage intersections and over wing tips. Various aerodynamic devices have been tested on the sailplane where freedom from extraneous effects is dictated by theory. That the technique of free-flight measurement and subsequent analysis is a powerful one for improving our command of aerodynamics was clearly shown in the systematic improvement of the sailplane RJ-5. Even this extremely efficient craft can now be improved, however, by such techniques studied—on a sailplane—to improve the extent of laminar flow. The sailplane, therefore, is just beginning to contribute to the field of fine aerodynamics and we need only work with it for a few years before it will, of necessity, be adopted by the major aerodynamics research centers of the world.

NRL's "Vortex" Thermometer Permits Correct Air Temperature Measurement from Fast Plane



A thermometer which allows a correct measurement of air temperature from planes flying 500 miles an hour has been developed by scientists at ONR's Naval Research Laboratory. Temperatures measured by means of this equipment at all speeds and altitudes obtainable with a B-29 showed an over-all accuracy of one-half a degree.

In the past, measurement of true air temperature from planes has been complicated by the heating effect of compression and friction as the plane sped through the air. NRL scientists solved the problem with what is called a "vortex" thermometer, the basic principle of which was developed by Bernard Vonnegut of General Electric. In the NRL thermometer a tube extends axially into the air stream. Within the tube a spiral vane produces a whirling motion of the air, i.e., a vortex. The center of this vortex is a region of lowered pressure, which has a cooling effect that exactly cancels the heating effect of the compression. When the aircraft goes faster the heating effect is increased, but the cooling effect is also enhanced. Consequently the thermometer or temperature element placed within the vortex will record the correct air temperature, regardless of the speed of the plane.

"Oral" Electricity

by

William V. Schriever and Louis E. Diamond
University of Oklahoma

Most people would be surprised to learn that they carry around in their mouths the elements for two batteries or electric cells. Yet anyone with an elementary knowledge of electricity is aware that pieces of two different metals immersed in a liquid which conducts electricity (an electrolyte) constitute an electric cell, and that if the two pieces are connected with a wire, an electric current results. Except for the wire, this is exactly the situation which exists in a mouth which contains—for example—a gold filling and an amalgam filling. Normally these metals contact saliva at the exposed surfaces and bone-fluid down in the teeth—and since both these liquids are electrolytes, we thus have the elements for two electric cells.

This is not news to dental researchers. Electrical phenomena in oral cavities have been described and discussed in numerous papers since 1878. Such phenomena are of interest because many aspects of the subject have not been studied and because metal fillings have been accused of causing serious mouth conditions.

Until 1940 it was believed that electric cells were caused only by the saliva. In that year, however, three investigators (Lain, Schriever and Caughron) showed that the bone-fluid was just as important as saliva in causing electric cells. Up to the present time, however, neither the electromotive force caused by fillings nor the normal current in an oral cavity have ever been measured; in fact in no instance have measurements been made from which these quantities could have been calculated.

Moreover, the problem is even more complicated than has been suggested above. Even a <u>single</u> metallic dental filling, contacting both saliva and bone-fluid, constitutes an electric cell because the bone-fluid contacts the saliva through the tissue outside the tooth. A simple cell of this type may be made by connecting a glass of salt water and one of vinegar with a cloth wick in which the two solutions contact. Then, when the solutions are connected with a piece of bent wire, an electric current will pass through the wire.

The purposes of this investigation were: (1) to devise methods, including the necessary theory and apparatus, with which it would be possible to measure, under ordinary oral conditions, electromotive forces and electric currents caused by metallic dental fillings; and (2) to make such measurements on a large number of fillings in "normal" oral cavities.

William Schriever (Chairman, Physics Department, University of Oklahoma) and Louis E. Diamond (Department of Biochemistry, University School of Medicine) are respectively Principal Investigator and Research Associate on ONR Project NR 182-510.

A sensitive standard potentiometer (an instrument used to measure or compare electromotive forces) was first employed in an attempt to measure the potential difference between pairs of metallic dental fillings. It was found, however, that it was impossible to duplicate results obtained this way because the sensitive balancing galvanometer used so much electric current that the fillings were polarized.

Further work showed that such potential differences could be measured by connecting a high-grade oil-filled condenser to the fillings and then discharging the condenser through a sensitive ballistic galvanometer. This condenser-galvanometer apparatus was calibrated by using known potential differences to charge the condenser. This apparatus gave reproducible data on most pairs of fillings.

With this apparatus the electromotive force, caused by the bone-fluid action on two fillings, and the electrical resistance between the pair of fillings through the bone-fluid, were measured. The two teeth were carefully dried and their potential difference was measured, with no current passing. This gave the emf of the two-filling-bone-fluid cell. The potential difference of the two fillings was again measured when they were connected with a one-megohm resistor. From these two measurements it was possible to calculate the electrical resistance between the fillings through the bone-fluid. These electromotive forces were greatest for gold-amalgam pairs, on the average, and least for gold-gold pairs. The average value of the resistance was greatest for amalgam-amalgam pairs and least for gold-amalgam pairs.

Such measurements were made on pairs of fillings in the mouths of many persons. The data were divided into three sets: (1) data on fillings in adjacent or nearly adjacent teeth; (2) data for fillings in the same jaw but nearly across the mouth from each other; and (3) data for pairs of fillings, one above and one below, and across the mouth from each other. It was found that the average values of resistances for the three sets of data were the same. This confirmed a well known fact that the resistance between a pair of electrodes (fillings) immersed in an electrolyte (bone-fluid), is concentrated in the electrode-electrolyte contacts, i.e., in the very thin layers next to the metal electrodes. This made it possible to develop a relatively simple procedure and theory for determining the emf caused by a single metallic filling, and the electric current which passes through that filling under normal oral conditions.

This experimental fact also made it possible to prove (with the aid of the well-known Kirchhoff's principles), that the magnitude of the electric current through any metallic dental filling is independent of the number of fillings in the mouth, provided that particular filling does not make contact with another metallic filling.

The work with single fillings required two types of platinum electrodes, and a platinum-tipped probe for making metallic contact with a filling. One electrode, called an "auxiliary electrode," consisted of a four-inch-long, thick platinum wire, wound into a spiral, which served to make contact with the saliva at the side and under the tongue. The second electrode, called a "saliva-probe," consisted of a group of tiny platinum wires arranged to hold a minute drop of saliva by capillary action. With this probe a filling was contacted with the tiny drop of saliva only, i.e., the platinum wires did not touch the metallic filling.

The required potential differences were measured with a vacuum tube electrometer instead of the condenser-galvanometer apparatus. This new special potential difference meter had the advantage of requiring a closed-circuit time of only a fraction of a second (instead of five seconds), which reduced the polarization effect to a negligible factor.

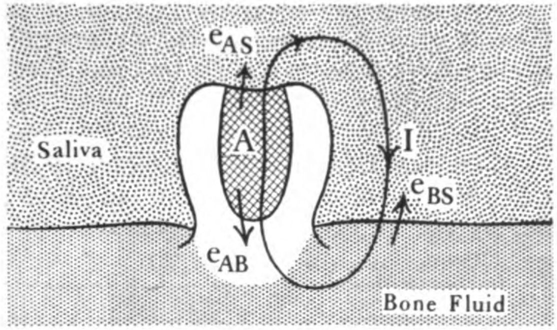


Figure 1. The electric current associated with an amalgam filling under normal oral conditions. A is an amalgam filling contacting saliva above and bone-fluid below. Net emf in the circuit is the algebraic sum of e_{AS}, e_{BS}, the emf's generated at the metal-saliva, metal-bone-fluid and bone-fluid saliva contacts. I shows the direction of the net emf and the resulting electric current.

Only four electrical potential difference measurements were required. First the potential difference between the filling in a carefully dried tooth and the auxiliary electrode was measured; the filling was contacted by the platinum probe. Second, this potential difference was again determined when a resistor (one-quarter megohm) connected the filling and the auxiliary electrode. Third, the potential difference between the auxiliary electrode and the saliva-probe, when the tiny drop of saliva contacted the filling, was measured. And fourth, this third potential difference was again ascertained when a resistor (one-quarter megohm) connected the saliva-probe and the auxiliary electrode.

For these four circuits it was possible to write six equations showing relations between the four measured potential differences, the two known resistances, the various unknown emf's and unknown resistances. A seventh equation expressed the current through the filling under ordinary oral conditions in terms of certain of the unknown emf's and resistances. The small net emf caused by the unavoidable differences between the platinum of the auxiliary electrode and the platinum of the saliva-probe, was measured in each oral cavity.

The resistance introduced by the auxiliary electrode-saliva contact was measured by inserting two such electrodes in the same mouth, and taking half of the measured resistance. This was found to be independent of the relative locations of the electrodes in the mouth.

The resistance introduced by the saliva-probe was determined by taking half of the measured resistance between two such probes while they were connected by a small drop of saliva. Here again the resistance was found to be independent of the size of the drop of saliva which was used, and independent of the small distance between the probes in the drop.

These two resistance measurements confirmed the important result of the preliminary work—namely, that the resistance between small electrodes immersed in an electrolyte is concentrated almost entirely in, and very near, the electrode-electrolyte contacts.

By using the measured values of the saliva probe-auxiliary electrode emf, and the measured values of the two resistances which they introduced, it was possible to solve the seven equations for the desired unknown quantities.

Usable data were obtained on 78 fillings in the oral cavities of 66 subjects, whose ages ranged from 18 to 30 years. These data are summarized in Table I, which gives average values of the desired electrical quantities.

Table I - Average Values for 78 Single Fillings in Mouths of 66 Persons

	66 Amalgam	12 Gold
Resistance of the bone-fluid contact	0.067 megohm	0.097 megohm
Resistance of the saliva contact	0.24 megohm	0.44 megohm
Total resistance in circuit	0.31 megohm	0.54 megohm
Net electromotive force associated with filling		
Positive*	87 mv. (29)**	67 mv. (7)
Negative	54 mv. (37)	136 mv. (5)
Normal electric current through filling		
Positive*	0.48 microamp.(29)	0.30 microamp.(7)
Negative	0.48 microamp.(37)	0.22 microamp.(5)

*Positive direction of emf and current is from filling-to-saliva-to bone-to-filling.

**In parenthesis is given the number of fillings used to compute the average value.

The magnitudes of the three largest observed values of each of the electrical quantities are: For Gold: resistance to bone, 0.31, 0.19, 0.14; resistance to saliva, 1.4, 1.3, 0.87; total resistance, 1.5, 1.3, 0.90; normal current, 1.07, 0.44, 0.24; electromotive force, 245, 160, 150. For Amalgam: resistance to bone, 0.42, 0.31, 0.30; resistance to saliva, 1.7, 1.5, 1.3; total resistance, 2.0, 1.6, 1.3; normal current, 3.4, 2.8, 1.9; electromotive force, 160, 151, 145.

While the electrometer-tube potential difference meter was being constructed and perfected, many data on single fillings were taken with the aid of the ballistic-galvanometer-condenser apparatus used in the preliminary work. Usable data were obtained on 127 fillings in the mouths of 77 persons. Eleven fillings were gold and 116 were amalgam. Since the charging time for the condenser was at least five seconds, serious polarization effects occurred whenever the resistors were used.

The results obtained for the potential differences in which resistors were not used agreed very well with those obtained with the electrometer tube meter. In fact, the average positive emf associated with an amalgam filling was found to be 87 mv with each meter. The average negative emf's were 60 mv for the ballistic galvanometer meter and 54 mv for the electrometer meter. Since the ballistic galvanometer measurements required current for an appreciable time, polarization did take place. This caused higher values for the resistances and correspondingly smaller values for the currents. Even so, the lack of good agreement was less than half an order of magnitude even in the worst case.

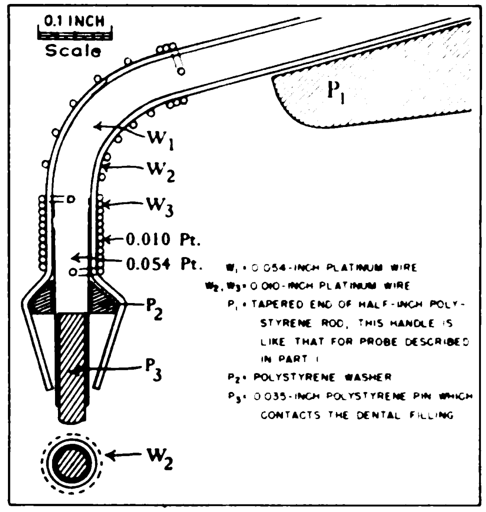


Figure 2. Much-enlarged diagram of tip of probe used to contact, with saliva only, filling in a carefully dried tooth. The saliva stuck to the wires of the probe by capillary action.

In addition to the results described in this report under "Preliminary Experiments," other interesting observations were made on pairs of fillings.

Potential difference measurements were made on 213 different pairs of saliva-wet fillings in the oral cavities of 137 persons, 84 male and 53 female, nearly all in the age range of 18 to 30 years. There were 155 amalgam-amalgam pairs (83 male, 72 female), 45 gold-amalgam pairs (32 male, 13 female), and 13 gold-gold pairs (10 male, 3 female). The average values of these potential differences (for males and females) were, respectively: 142, 162; 207, 271; and 63, 91 millivolts. Thus, gold-amalgam pairs yielded the greatest average value while gold-gold pairs yielded the least average.

The average values of the emf due to the bone-fluid only, acting on the fillings, were respectively: 147, 156; 215, 271; and 65, 101 millivolts. The resistances through the bone-fluid were respectively: 1.30, 1.32; 0.47, 0.89; and 0.85 and 0.82 megohm. These data demonstrate that the bone-fluid is just as effective as the saliva in causing electric currents to be associated with metallic dental fillings.

The greatest observed potential differences of pairs of fillings when wet with saliva were 564 and 511 mv; and there were six others above 400 mv. The greatest observed emf's caused by the bone-fluid alone were 560 and 510 mv; there were five others above 400 mv.

The pH of each saliva was determined by a paper indicator; the observed values ranged from 6.2 to 7.4. None of the measured electrical quantities showed any dependence on this quantity.

Although relatively few subjects were in the age range from 35 to 60 years, there was no indication of a dependence of any of the measured quantities on age. Moreover, there appears to be no significant dependence of the electrical constants on the sex of the subjects.

Five subjects were patients of a prominent local physician. All were afflicted with lesions in their mouths. One, in fact, had a large white patch on the cheek. Six pairs of fillings were studied in the mouths of three of the patients; these exhibited potential differences and emf's which were two to three times the average for "normal" subjects. A number of subjects having apparently normal mouths, however, yielded values of these quantities which were even larger. The other two patients yielded values only about half those obtained on normal subjects. There was no convincing evidence that any of the lesions were caused by dental fillings. In some cases, however, the subject might exhibit great sensitivity to certain metallic ions (charged metallic particles) supplied by the dental fillings. Thus, an electric current could exert an indirect detrimental effect, since it hastens the solution of fillings and thus assists in transporting ions to the tissues.

Information concerning recent illness was obtained from each subject examined. There was no indication that the size of the electrical quantities depended on recent illnesses, which included occasional lesions in the oral cavity.

A critical review of the literature from 1878 to date reveals that our work has shown for the first time:

1) That bone-fluid is just as important as saliva in causing electric currents;

2) Methods for determining the net electromotive forces associated with metallic dental fillings;

3) Methods for determining the electrical resistances associated with metallic dental fillings;

4) That these resistances are concentrated at metal-saliva and metal-bone-fluid contacts;

5) A method for determining the net electric current passing through a metallic dental filling under ordinary oral conditions; and,

6) That the magnitude of the current through any metallic filling is independent of the number and kinds of other fillings in that mouth.

Acknowledgements

Dr. Schriever is indebted to Dr. E. S. Lain of Oklahoma City for introducing him to this problem, for inviting him to cooperate in some early work, and for loaning him a collection of reprints and some private correspondence.

Both authors are indebted to Dr. Onis Hazel of Oklahoma City for referring several of his patients to them, and to Constance Raab, Loretta Graham, Charles Engles, Arthur W. Buswell and Leo Cawley, research assistants, for doing much of the routine experimental work.

On The Naval Research Reserve

ONR - Sponsored Research at MIT Discussed at Recent Meeting of VNRRU 1-1 in Boston

At a recent meeting of VNRRU 1-1 in Boston Professor S. Q. Duntley of the Physics Department at MIT discussed the research which he is conducting under ONR sponsorship. In the picture above: CDR H. Wray Rohrman, USNR, VNRR Program Officer; Professor Duntley; CAPT F. B. Eggers, USN, Commanding Officer ONR Branch Office, Boston and LCDR H. C. Dobbs, Jr., Branch Office Executive Officer.

LCDR Schreckengost, CO of VNRRU 4-8 Honored for Sculpture by Syracuse Museum

One of the notables in VNRR ranks has added another laurel to the many distinctions he has received for his work. LCDR Viktor Schreckengost, CO of VNRRU 4-8 in Cleveland, was the recipient of a new award instituted last year by the Syracuse Museum--a citation for the best ceramic sculpture used as part of an architectural project completed within the past three years.

The occasion for the award was the sixteenth national exhibition of ceramics sponsored by the Syracuse Museum of Fine Arts, held in Syracuse, N. Y. Hundreds of artists from 38 states, Hawaii and Canada were represented by 500 works, including pottery and ceramic sculpture. The work for which LCDR Schreckengost received the award, however, was not actually shown at the exhibition, for it is the ceramic structure which decorates the new Bird Building of the Cleveland Zoological Park. The citation which accompanied the award read, in part:

"Throughout the years you have achieved distinction as sculptor, ceramist and industrial engineer. Your creative genius--your tremendous energy and zeal for accomplishment--have resulted in outstanding work in each of these fields."

Some readers of Research Reviews may not be entirely unfamiliar with LCDR Schreckengost's talents in another field of art. He drew a cartoon depicting one of the ONR-Washington seminars, which was published in the August 1951 issue of Research Reviews. During World War II the Navy had more serious use for his talents; he was head of the Visual Design Section of the Special Devices Center.

VNRRU 11-1 is Host to 11-7 on Highly Successful Tour of NOTS, Inyokern

A fine example of the type of field trip available to units of the Research Reserve was the tour made recently by members of the VNRRU 11-7 (Tucson, Ariz.) of the Naval Ordnance Test Station, Inyokern. The idea of the tour was conceived when the reserve program officer for the area suggested that the project would be a profitable one for Unit 11-7.

NOTS, Inyokern was established in 1943. The station conducts research, development and testing of all types of rockets (including guided missiles) for all branches of the Department of Defense. While some phases of the research and development are conducted by other institutions and stations, NOTS co-ordinates the over-all program.

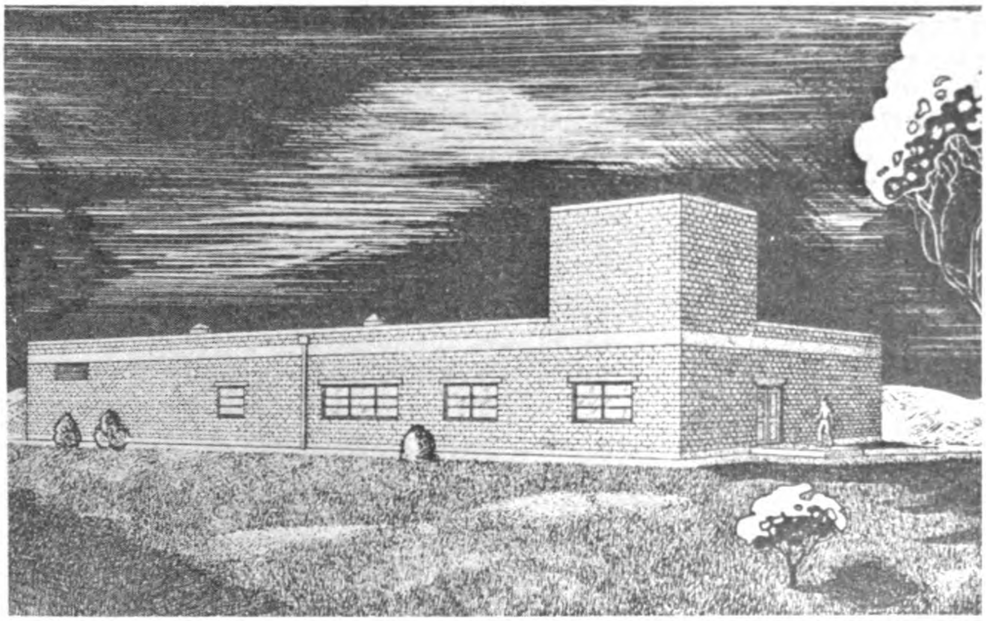
Unit 11-7 left Tucson in a Navy R4D (DC-3) and arrived 45 minutes behind schedule at China Lake because of a stiff head-wind. In spite of this time lag, the members of Unit 11-1 had the tour planned so efficiently that it was never over five or ten minutes behind schedule. Moreover, the tour,which was conducted on Saturday and Sunday, represented extra duty for key military and civilian employees of the station, since most departments ordinarily secure at noon Saturday.

The visitors saw demonstrations and heard explanations of the methods used in evaluating the performance and fire-control methods of the four basic types of rockets or guided missiles: air-to-air; air-to-ground; ground-to-air and ground-to-ground. There was also an actual air-to-ground firing test and a ground-to-ground test.

On the following day a trip was made through the eleven-million-dollar Michelson Laboratory, which also houses the rocket museum. The last part of this trip was devoted to showing the reservists the complex series of steps involved in getting an idea from the drawing board or test tube--i.e., from the planning stage--into an actual operating device.

The members of 11-7 who made the trip to NOTS, Inyokern felt that it was an outstanding success and that it broadened the scope of their training and materially increased their interest in the Naval Research Reserve Program.

Oak Ridge School of Reactor Technology Offers Unique Opportunities for Study



Artist's conception of new ORSORT Laboratory

Considerable interest in the Oak Ridge School of Reactor Technology (ORSORT) was displayed by officers attending the ONR Nuclear Science Seminar held recently at Oak Ridge. Reservists may be interested in more facts about the school.

ORSORT was established by the United States Atomic Energy Commission at the Oak Ridge National Laboratory to provide advanced, specialized training in reactor theory and technology to engineers and scientists who will engage directly in reactor research, development and design. This training, which cannot be given in universities because of its classified nature, deals with the various phases of reactor technology and is under the direction of experienced nuclear engineers and scientists. Students are trained to apply the basic sciences, the applied sciences and the modern engineering arts and practices to the development and design of reactor systems and their components.

The school provides a source of experienced technical personnel for the AEC's reactor development program by training selected recent graduates who join various government agencies and AEC contractors as regular employees at the end of the training period. The school also supplements the training of professional engineers and scientists from industry to enable them to participate, through their sponsoring organizations, in atomic energy development work. Students are selected by the AEC's Committee on Admissions from recent graduates of colleges and universities and from sponsored representatives of industry and government agencies.

To accommodate the enlarged student enrollment, existing facilities have been remodelled, the faculty and staff have been increased, and a new student laboratory, now under construction (see Figure) is approaching completion.

For the 1952-53 class, scheduled to begin a full 12-month session on September 8, 1952, applications for admission will be accepted no later than March 1. Tuition is free and materials and equipment required in the school will be furnished by the Laboratory. Lectures and laboratory work will be supplemented by specialized practical training.

Although the Oak Ridge School of Reactor Technology has no working agreement with any university for application of course credit toward advanced degrees, the school will continue its policy of cooperation by furnishing necessary information upon request to educational institutions interested in accrediting work at ORSORT.

Students must be citizens of the United States. All those enrolled in the school must have full AEC security clearance, and appointments are made contingent upon a satisfactory investigation prior to enrollment.

Naval Reserve Public Relations Seminar to be Held in April

A two-week Seminar for Volunteer Reserve Public Relations officers is planned for April 1952. The location of the Seminar will be announced as soon as arrangements can be completed.

The Seminar will include instruction by representatives of the naval establishment on current plans and operations of the Navy. It is also planned to provide an opportunity for observing some of the latest developments in training and operations of the Fleet.

Quotas for the Seminar are assigned as follows:

Naval District	Quota
1	3
3	6
4	5
5	3
6	4
8	5
9	10
11	3
12	4
13	2
14	1
PRNC	2
CNARESTRA	2
TOTAL	50

Travel via government air will be directed, where available, for Reserve Officers from outlying naval districts. If government air is not available, travel will be performed at no expense to the government.

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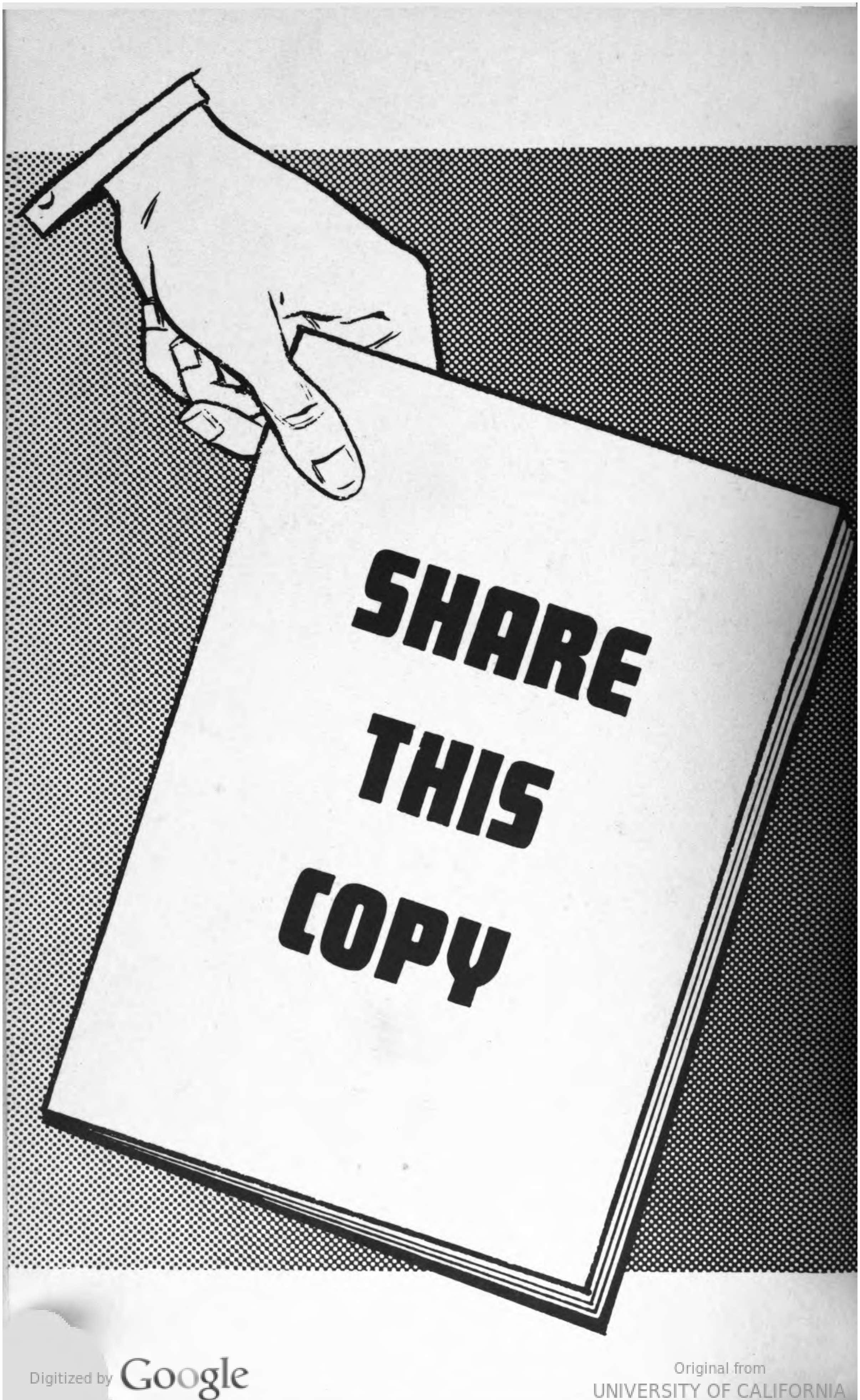
Navy Metallurgy Research
(See Page 7)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