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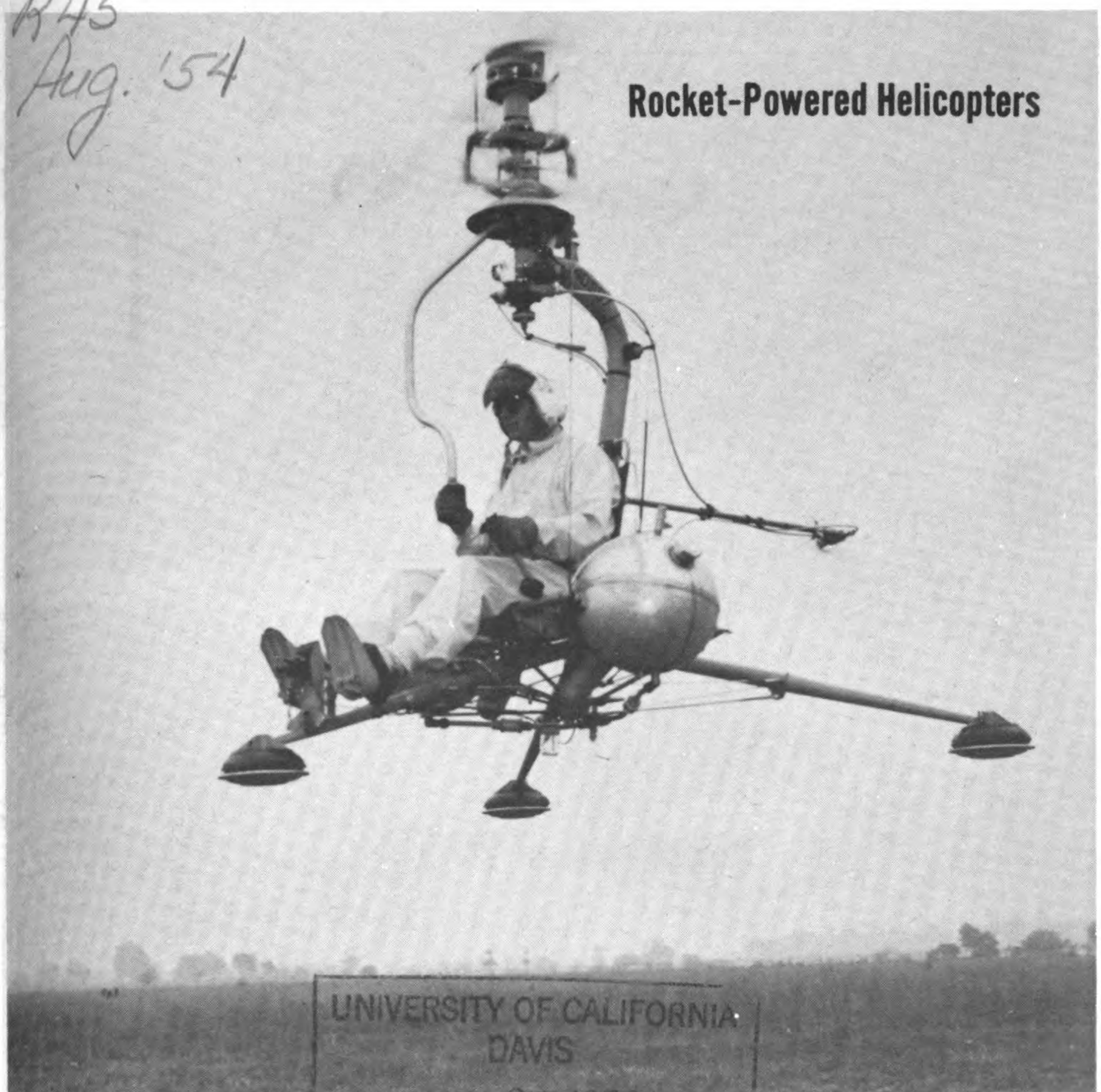
RESEARCH REVIEWS



Rocket-Powered Helicopters

NAVEXOS P-510

DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

COVER PHOTO: The Kellett KH-15 one-man helicopter, a Navy rocket-powered craft designed for research into gyro-stabilizing controls for helicopters, in flight at Camden, New Jersey. The KH-15 has incorporated controls to give helicopters greater stability in air than has been heretofore possible. For the story on this and another recent helicopter innovation, see p. 7.

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 740, Office of Naval Research, Washington, D. C.

Approved by Bureau of the Budget, 14 February 1952

In This Issue

Experimenters' observation and control room.

Simulation Laboratory for CIC Systems

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Included among the various research facilities of the Applications Research Division at NRL is a unique layout, a Simulation Laboratory. Over the past two years, it has been utilized for research on large man-machine systems. Attention has been focussed upon the study of information processing systems with particular emphasis on the Naval Combat Information Center (CIC). Any operating CIC includes men as well as materiel. Hence, this research program treats the psychological as well as the "hardware" aspect of such centers. This article describes the Simulation Laboratory, reviews some of the specific studies performed in it, and points out some of the theoretical and long-range implications of simulation research at NRL.

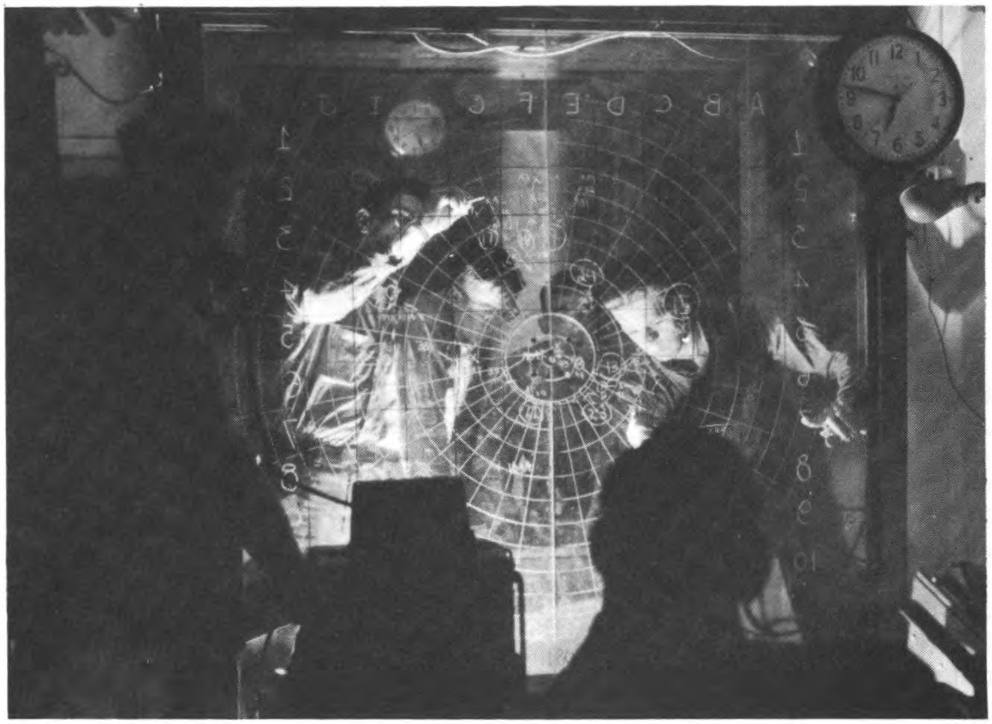
The basic problem in this work is the development of a modus operandi for studying complex man-machine systems. Adequate techniques for carrying out such research have not been worked out before, and there have been insufficient criteria for evaluating them. While a number of scientific findings and methods relating to single component aspects of man-machine systems have been established, the study of large man-machine systems is relatively new. A sound approach to this problem requires the talents of people from a variety of professional backgrounds. Accordingly, the staff of this simulation facility has included experimental psychologists, engineers, and operationally experienced naval officers.

The versatility of the NRL set-up, makes it possible, moreover, to conduct a variety of studies: those utilizing realistic models of currently operating information-handling systems, those in which prototype systems are set up, and finally purely theoretical systems designed for research purposes only. While chief interest is currently centered on the development of a methodology for studying systems, the simulation laboratory has gone ahead with the evaluation of various existing or proposed information-handling systems.

The following basic assumptions underlie the approach of the simulation group:

(1) The more realistic the models, the more valid are the findings; this assumption has ruled out the use of hastily conceived analog techniques and necessitated painstaking examination of the systems studied in order to achieve as much realism as possible.

(2) The closer the adherance to standard principles of experimental and statistical design, the more reliable are the findings. The acceptance of this assumption has minimized changes in experimental conditions during "runs."



Radarmen during CIC experiment.

(3) Techniques of measuring component units of systems are not necessarily applicable to large system complexes. For this reason the research group has had to devise entirely new techniques of observation.

Located in the basement of one of the buildings at NRL, the simulation laboratory occupies a space which was formerly the "little theatre" of the wartime radar school. The control space of the Laboratory contains electronic equipment used to generate simulated radar information which acts as input material for the systems under investigation. Magnetic-tape sound recorders permit selective recordings of various voice channels. In certain experimental situations, the control room is used as the point from which simulated radio messages are introduced into the systems.

The generation of radar information—in the form of realistic "pips" on repeater consoles of the various systems—is accomplished largely through the use of a Flying-Spot Scanner. The scanner, originally developed by MIT's Lincoln Laboratories, uses a 35 millimeter film input, each frame of which contains the information from one radar antenna sweep. The film is fed through the scanner, usually at the rate of one frame every 15 seconds. When frames are scanned, the light spots (or pips) are transmitted to remote repeater scopes. In this way, two or more CIC's may be operated simultaneously and independently, and yet receive identical radar input material. This feature of the Simulation Laboratory has enabled experimental control of a variety of stimulus variables—for example, target density.

In planning the simulation studies, emphasis has been placed on the use of people (as well as equipment) who are representative of actual or potential operators in the fleet. It has been felt that in order to operate satisfactorily any real or projected system the valid performance would result from using, as laboratory subjects, men trained as radarmen and CIC officers in the Navy. Suitable experimental crews are recruited from various naval facilities. When the occasion demands, 20 or 30 are transferred to NRL for periods up to six weeks.

In addition to careful personnel sampling within a specified range of conditions, consideration has been given to sampling as adequately as possible a range of situations which might be considered representative either of present or future fleet conditions. For example, a recent study was carried out of three different systems, each of which had been proposed as a possible means of increasing CIC capacity for handling information on large numbers of high-speed air targets. In designing the stimulus material for that study, problems were created which included very large numbers of targets—based on estimates by naval officer consultants as to future enemy capabilities. Real aircraft, with their limitations in availability, endurance, and speed, would not have been satisfactory for this study. Rather accurate results were obtainable, however, with the Flying-Spot Scanner which made it possible to generate at will targets approximating the speed of guided missiles or better.

The simulation approach to systems problems has made it possible to obtain determinations of the capabilities of systems, based upon large numbers of trials, under identical conditions, and at low cost. Some of the radar tracking and display systems used in a recent experiment were studied under several types of raid conditions and, in each condition, as many as 40 times. Statistical inferences based upon repeated measures of a system confronted with the same stimulus material are more valuable for predictive purposes than are "one-shot" measures. The fact that the systems studied can be exposed to the same stimuli many times also makes it possible to investigate "learning," an important factor in any operation which includes human components.

In the attempt to mock-up or simulate realistic tasks and situations to be handled by CIC systems, the question of motivation of the experimental subjects—radarmen and officers—often arises. Does a team of 12 sailors operating a simulated radar-detection center in the basement of an NRL building really concentrate on its task? Do the men as individuals regard their participation as realistic or meaningful? The answer to these questions is a qualified "yes," based upon our experience over the past two years. Problems of maintaining a high level of subject-motivation are ever present. However, as in all psychological research, special considerations given the people who are to run the systems under study appear to pay off in terms of achieving a high degree of interest and personal identification with real problem conditions.

It is obvious that certain important elements of shipboard conditions cannot be duplicated in any laboratory. Ship motion and vibration, as well as conditions giving rise to the emotional stresses of battle have not been simulated here. However, in the study of two or more CIC systems under identical conditions, it has been assumed that the factors mentioned above would have equal effects on any system when installed in the fleet. In specific cases this may not be true and whenever there is reason to believe that it isn't, an attempt is made to qualify stated conclusions accordingly.

The Simulation Laboratory has devised and tried many types of measures of system efficiency. Generally, they may be classified as performance measures (e.g., accuracy of handling radar information, time delays in detection of signals) or attitudinal. Attitudinal measures have included psychological rating scales administered to experimental subjects (e.g., CIC officers) and to observers. Military and civilian specialists in operational and technical fields related to information systems have taken part in the experiments of the simulation laboratory as observers.

Although much data are collected automatically, the data-taking phases of simulation runs may sometimes involve as many experimenters as there are subjects. In addition, there are skilled observers who work with advance information as to the appearance of certain radar signals, and note the delays caused by very high information densities. (The information, of course, is based upon pre-programmed scripts generated in the Flying-Spot Scanner.) While photographs have been used to measure information-loss or track-holding ability of systems, it has been found that such techniques are extremely time-consuming in terms of subsequent data reduction, and that they offer little, if any, improvement over the simultaneous recording and sampling of responses by human observers. The data obtained in simulation experiments are reduced by an information-analysis section. This group maintains a full-scale IBM installation, and has developed its own high-speed methods of tabulating observers' records and carrying out computations with the resulting data.

Plotters at expanded vertical display

The first and most primitive experiment carried out in the Laboratory was aimed at determining (1) the capacity, in terms of the amount of information that could be accurately plotted and (2) the ease of operation, of an expanded vertical plotting display. Crews of trained CIC plotters were brought to NRL and given problems which required them to work as six-man teams with the new plotting board. Rates of information-transmission were controlled

Information filtering system.

experimentally. The data collected by the experimental staff consisted of photographs of the plotting board taken at intervals during each problem. Subsequent analysis of the photographs established an upper limit on the accuracy with which radar information could be plotted, as well as some related facts about the behavior of the human plotter under stress. In addition to contributing constructively to the methodology of systems study, the plotting-board experiment answered some important questions for people who must make decisions about the design of plotted displays for CIC's.

The second study in the Simulation Laboratory used a proposed information-filtering center as a vehicle for further development of systems techniques. In this experiment crews of 13 enlisted radarmen-subjects were required to operate a prototype, manually plotted, horizontal filtering display. Inputs to the plotters came in the form of telephoned target-position information. Data taken included: Voice recordings of transmissions by the filter plot officer, photographs of both the filter plot and a vertical plotting board to which information from the filter center was relayed, and time-motion observations of certain key people in the system. Results of this study established the saturation, or upper capacity limits of the system. It was also shown that as information-flow into the system reached a high level, it was necessary to alter the filtering procedures by delegating responsibility for decision-making to plotters, as well as the filter plot officers. The learning effects evidenced in this study pointed toward the necessity of giving greater attention to matters of training in subsequent experiments.

A third simulation experiment, performed in the spring of 1953, represented a major departure from previous studies. A radar simulation device (the Flying-Spot Scanner mentioned earlier) was used to provide realistic information on actual repeater consoles in the systems being studied. Another innovation was the method of running an experimental system (in this case a prototype photographic-display device) against a standard Navy "manual" system used as a control, in order to obtain comparative performance measures. In evaluating the new system it was felt that a standard, or yardstick, against which to make comparisons about capacities, etc., was necessary, and by operating a conventional shipboard CIC as a collateral system, some measure of what the present-day CIC could do under the simulated circumstances was available. Two crews of trained radarmen, operating independently, ran each of the systems under identical conditions of stimulus information. The data included photographs of plotting displays, voice recordings of certain sound-powered communications channels, and written observations by the experimental stall. It was found that the photographic-display system offered only slight improvement over the manual plotting system now in use in the fleet, and that gross engineering and design limitations of the new system made it unsuitable for application to shipboard CIC's.

Finally, in a study made during January and February of this year, four different display systems were operated in a manner similar to that described above. An improved model of the Flying-Spot Scanner was used to provide radar input material. Several "scripts" or problems were prepared to test varying aspects of the four systems' capabilities. Many new observational techniques were devised and some were set up to be handled by selected members of the enlisted man crews. Some of these techniques involved (1) the use of psychological rating scales to obtain opinions from both CIC officer-subjects and visitors observing the experiment, and (2) efforts to obtain qualified views on the interpretability of the displays by requiring the CIC officer-subjects to answer questions about the display while the experiments were actually in progress. Results of this study indicated the relative merits of the four display systems when each was tested under similar conditions. One of the systems, a streamlined version of the standard manual technique, was considered to possess sufficient merit to make it the subject of a further, more intensive, study with the view of recommending the system for fleet use. Another system, which utilized an optical projection method for transferring information to a summary plotting board, was shown to be vastly superior to each of the other systems. The latter finding has been used to support the recommendation by other Navy groups that the optical system be investigated further for possible incorporation into CIC's of the future.

The four experiments described here have served a dual function. On the one hand they have produced certain significant findings about the organization and use of personnel and equipment in large man-machine systems; on the other hand they have served to educate the research workers in techniques of conducting experiments on complex man-machine information systems. A number of apparently effective methods of organization, stimulus presentation, and data collection have evolved.

Evidence points to the fruitfulness of the simulation approach for future studies in this area. Among the experiments planned are investigations of the effects of various radar phenomena on the performance of information processing systems. Such variables as blip/scan ratio -- less-than-100% signal return -- and poor signal strength will be systematically varied and their influences upon overall system productivity measured. These variables have long been felt to be important factors in the output of CIC systems and it is likely that analysis of them in a simulated situation will provide valuable data for future improvements by shipboard systems designers.

Rocket-Propelled Helicopters Developed for Navy

Successful tests have been made of two significant developments in the helicopter field. One is a new system of propulsion using tiny rocket engines on the blade tips of a midget helicopter. The other is a new system for the stability and control of helicopters. Both are research projects on separate phases of helicopter development for the Navy.

The first U. S. rocket-powered helicopter, the RH-1, was developed for the Navy by Gilbert Magill, president of Rotor-Craft Corporation, Glendale, California. The rocket system for the tiny, one-man craft uses two thumb-size motors at the tip ends of the helicopter blades. As project "Pinwheel" it has been under development for nearly four years, and first flew under tethered tests in mid-1953.

The other research project has been under development by Kellett Aircraft Corporation at its Camden, New Jersey plant. This firm is investigating an entirely new system of stability control for helicopters.

The Kellett KH-15, which also is rocket-powered, flew recently after only eight minutes of tethered test. The KH-15 has incorporated gyro-stabilizing controls designed to give helicopters greater stability in the air than heretofore possible. In its successful flights the small Kellett craft has shown the new system to give the helicopter a high degree of stability and has cut vibration considerably.

Both the Rotor-Craft RH-1 and the Kellett KH-15 are research projects originally begun by the Air Branch of the Office of Naval Research. In cooperation with the Bureau of Aeronautics the first has explored the field of rocket propulsion for helicopters; the second has investigated and flight tested a new gyro-stabilizing system invented by Dr. G. J. Sissingh, Chief of Aerodynamics for the Kellett Corporation. The Army's Transportation Corps has also participated in the Rotor-Craft project. Both rocket motors for the two craft were built by Reaction Motors Incorporated, Rockaway, New Jersey.

A New Variable for Aircraft Designers

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Under the sponsorship of the Air Branch of the Office of Naval Research, a new design tool for the airplane designer and aerodynamicist is being forged into shape. Spurred by the necessity of conducting research to relieve the problem of operation of carrier-based aircraft, the investigation, since its initiation in 1949, has broadened to a basic program from which benefits for all types of aircraft will be derived. This new tool consists of detailed design information pertaining to the field of boundary-layer and circulation control. A brief review of the nature of the boundary layer and its characteristics will show the significance of this research activity.

Any object completely immersed in a fluid, and in motion with respect to that fluid, attracts a thin layer of the fluid to its surface as a result of the viscosity of the gas or liquid. This thin film of fluid immediately adjacent to the surface of the body is called the boundary layer. In this layer the viscous forces between the layers of fluid cause flow conditions which differ from those which are predicted by potential theory. Potential theory assumes that no shearing force exists in the fluid and that all motions are the result of pressure fields. This theory describes the flow which would occur in a perfect fluid, while the boundary layer is that section of the flow which results from the motion of an imperfect fluid.

The concept of the boundary layer is by no means new. Fifty years ago, Ludwig von Prandtl first described this phenomenon. A tremendous amount of work has been done since then. It is only now, however, that systematic research is furnishing the information that will enable the aerodynamicist to tackle some of the fundamental problems which still beset the operation of heavier-than-air aircraft.

A diagram of the velocity distribution in the boundary layer is given in Figure 1. Immediately adjacent to the surface over which the fluid is moving, the velocity is said to be zero; i.e., the fluid is adhering to the surface and is not moving with respect to that surface. The free stream is at some distance from the surface; its velocity is indicated by V_o. Intermediate between this free stream and the surface itself is a region of diminishing velocities with a profile as shown in this diagram. At any distance, y, from the surface, the velocity is V_y.

Boundary layers are of two different types as shown in Figure 2. At the leading edge of any surface which is moving through the air, the boundary layer immediately starts to build up as the particles of fluid next to the surface are attracted to it by the viscosity of the medium. At first the difference between the velocity of air at the surface and the free-stream velocity produces a profile of velocity variation similar to that shown near the leading edge. The velocity vectors are

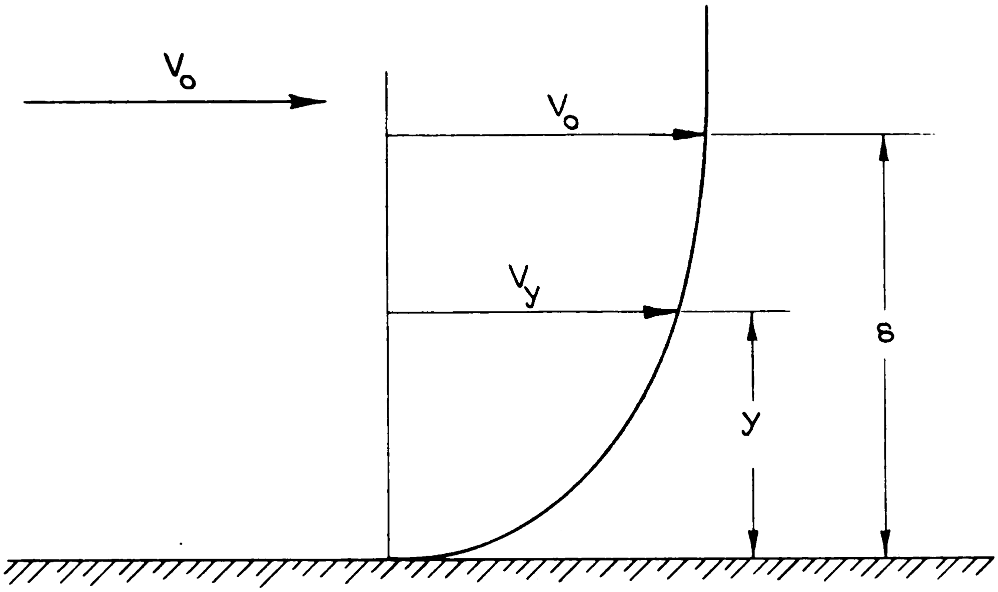


Figure 1. Velocity distribution in boundary layer.

parallel to each other and the gradient is somewhat uniform across the boundary layer. This flow is called a laminar boundary layer.

At some point along the surface over which the air is moving, the velocity differences between adjacent layers of air in the boundary layer become so great that the shearing forces produce turbulence and the entire boundary layer suddenly degenerates into a turbulent region. The boundary layer at this point becomes thicker and the profile changes to give the appearance of a larger velocity nearer the surface. This is called a turbulent boundary layer and is the type which produces the greatest dissipation of energy. The act of changing from a laminar to a turbulent boundary is known as transition. The transition point is a function of the roughness of the surface over which the air is moving as well as of the velocity, viscosity and density of the air. Very few aircraft fly with any major portions of the aircraft exposed to only laminar boundary layer. By far the majority have a turbulent boundary layer, with the greater thickness and greater energy dissipation characteristic of this type.

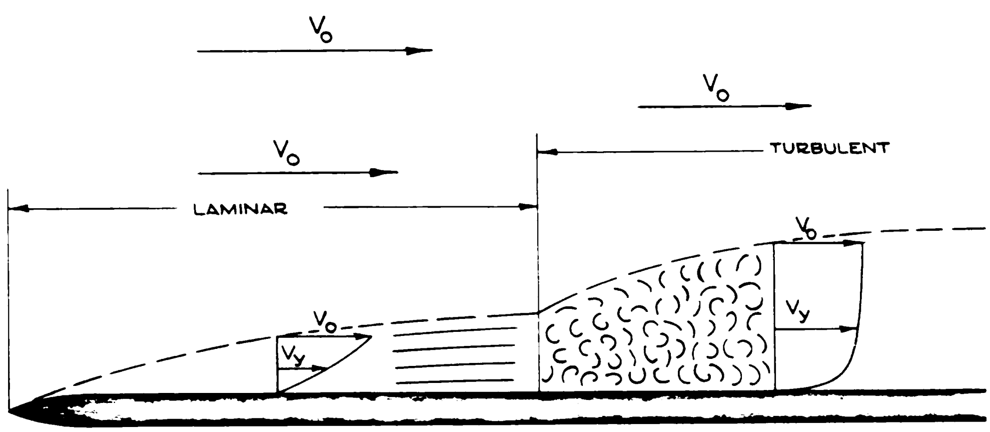


Figure 2. Air flow on a leading edge.

The fact that the boundary layer exists upon a moving surface results in three rather distinct actions:

1. the dissipation of energy through fluid friction and turbulence.
2. the production of thick, low-energy wakes aft of regions of moderate pressure gradients with resultant high drag or high loss of energy.
3. the production of reversed and separated flow in severe adverse pressure gradients, producing a strong turbulent wake behind the body.

These actions are shown in Figure 3 on an airfoil moving at three different angles of attack. At the low angle of attack, the wing is completely enclosed in the boundary layer which is gradually increasing in thickness as the flow approaches the trailing edge. At the trailing edge, the boundary layer thickness is only moderate, however, and the airfoil drag is composed largely of the skin-friction drag due to energy dissipation in the boundary layer.

As the angle of attack is increased slightly, the pressures at the maximum-thickness point of the airfoil decrease, whereas the pressures at the trailing edge remain almost constant. The flow is then required to move from a region of low pressure at the maximum-thickness point to a region of moderately high pressure at the trailing edge. Since energy is being dissipated in the boundary layer, there is insufficient kinetic energy to move this boundary-layer air against the adverse pressure gradient and some of the air gradually decelerates and the

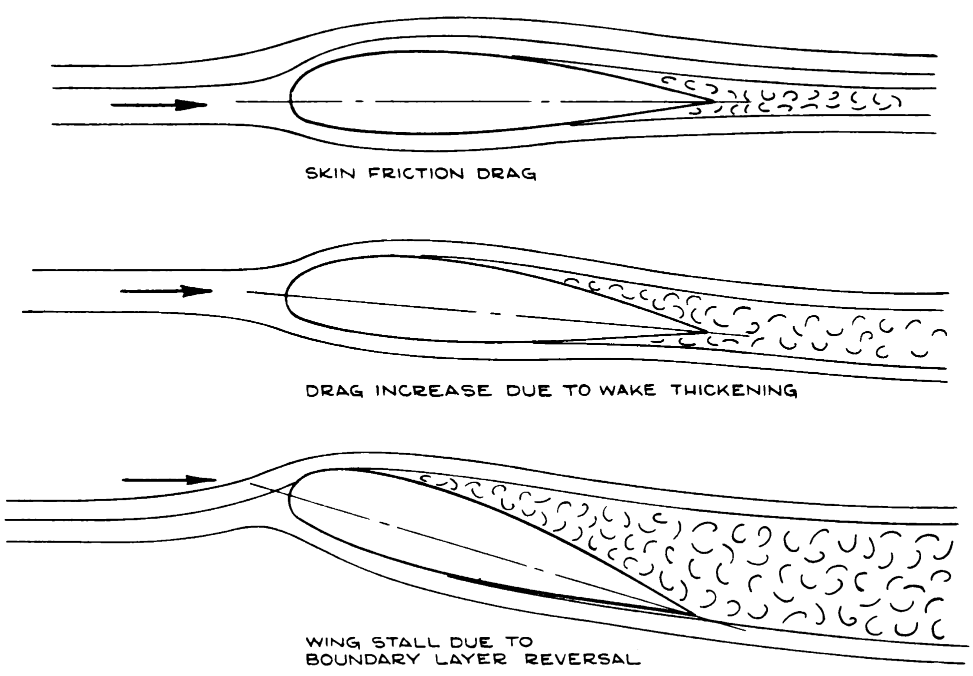


Figure 3. Boundary layer effects on an airfoil moving at three different angles of attack.

boundary layer thickens. The wake behind the airfoil then becomes still wider and a greater quantity of energy is dissipated. This is known as the drag rise on a profile and is found on any airfoil just a short time before the wing actually stalls. This action should not be confused with wing stall, since the flow has not reversed and the pressure distribution over the airfoil is not disturbed.

On ordinary propeller-driven aircraft, this particular phenomenon is of no serious consequence, since the thrust forces of the propeller generally are high enough to compensate for the increased drag at this moderate angle of attack. The energy which is in the slip stream of a propeller is also useful in decreasing the thickness of the boundary layer and thus actually prevents the slight drag rise.

For jet-propelled aircraft, however, the situation can be quite serious. If the angle of attack is increased to too high a value, without stalling the wing, the drag of the wing and airplane together may actually become greater than the thrust value of the engines. If this happens, the airplane cannot accelerate to a higher speed and cannot become airborne. This situation is usually not identified until the aircraft has proceeded in its take-off to a point where it has not enough runway remaining to either accelerate to a higher speed and thus take-off, or decelerate and come to a stop. Unless a long runway is available, the aircraft will probably run off the end of the runway. The pilot of the aircraft must exercise caution not to increase the angle of attack of the wing above the point where the total airplane drag exceeds the engine thrust. It again should be emphasized that this is not a wing stall, but instead is merely a drag-rise phenomenon which precedes the stall by some 3 or 4 degrees.

If the wing angle of attack is increased still further, the boundary layer is unable to move from the region of low pressure at the maximum thickness to the trailing edge of the airfoil and instead actually reverses and flows toward the leading edge. When this occurs, the flow coming from the leading edge is required to move directly out from the airfoil profile and a turbulent wake is produced with a breakdown of the potential flow around the wing, producing wing stall. In a wing stall, the drag not only increases very severely, but the lift also decreases and the airplane can no longer be airborne without decreasing the angle of attack and increasing the forward speed.

A similar phenomenon occurs on a wing equipped with a trailing-edge flap. The pressure gradients in the vicinity of the flap leading edge are sufficiently high so that the boundary layer is unable to proceed around the corner, but instead reverses and separates at the point of the flap bend. A wide turbulent wake is thus produced behind the airfoil with consequent high drag and only moderate increases in lift. This phenomenon is quite useful for aircraft as it produces drag to steepen landing approaches. It is unusable for take-off, however, since the high drag would prevent the airplane from accelerating to take-off speed unless large quantities of power were made available.

If the boundary layer is accelerated by the action of a blowing jet around the surface of the flap, as shown in Figure 5, the turning action of the air is increased in such a manner that it flows downward along the upper surface of the deflected flap and the flow quantity around the wing is deflected through a much higher angle. This deflection of the air produces an increase in lift with an actual decrease in total drag. This type of flap, therefore, would be useful for take-off and would permit an airplane of given weight to become airborne at a lower speed, since the lift is increased at any given speed.

Much the same action as above can be produced by sucking the boundary layer into a slot or through a porous surface at the flap hinge point. This serves to remove all low-energy air and permit the high energy air which exists in the potential flow to move around the flap hinge. It will also increase the deflection angle of the total air mass moving past the wing.

The preceding explanations now permit the reader to see some of the methods by which boundary-layer or circulation control may be used by aircraft designers. Some of the results which can be achieved are as follows:

1. The transition from laminar to turbulent boundary layer can be prevented. The act of retaining a laminar boundary layer decreases the drag of even very thin bodies operating at low angles of attack. Where a body operates at extremely high speeds with quite low pressure gradients, this is about the only technique which is available for reduction of total drag. This possibility is attractive, however, since the major portion of the drag of such a body is skin friction, and drag reductions as high as 60 percent can be made by preventing the transition from laminar to turbulent boundary layer. Since the power is a direct function of the drag, it may be decreased by over one-half at a given speed. The possibilities for longer range, higher speeds, greater pay loads, higher altitudes, and other operating improvements are quite apparent when this scheme of boundary-layer control is utilized.

One method of applying this particular type of boundary-layer control consists of drawing the low-energy boundary layer into the surface through perforated, porous, or slotted surfaces. Projects on this problem are being conducted at the Mississippi State College under the guidance of Dr. August Raspet and at the Northrop Aircraft Corporation, under the guidance of Dr. Werner Pfenninger. The design of a structure to perform this type of boundary-layer control is critical, and care must be taken in the design to avoid excessive power requirements. Obviously, if the power required to pump the air is greater than that which would be required to overcome the skin friction drag, it is by far more economical to apply the power in the form of thrust than to apply it in the form of suction power. The results which are now being reported, however, give promise that the airplane designer can utilize this technique in reducing the drag of bodies operating at small angles of attack.

2. Boundary-layer control may be applied to decrease the drag of wings operating at moderate angles of attack or may be used to reduce the drag of very thick or blunt bodies such as airplane fuselages, landing gear struts, engine nacelles, fuel tanks, or external pods. When

boundary-layer control is used for this purpose, the trailing edge of the body is usually manufactured of perforated or porous material and a pump is provided to draw the low-energy boundary layer through this surface. This permits the potential flow to close in behind the body and makes a low drag coefficient possible, as shown in Figure 4. The use of this technique will permit a designer to use a greater variety of shapes than he has heretofore had available. Whereas he has been limited to certain fineness ratios, usually greater than four to one, he now may consider fineness ratios such as one to one, and still have drag values which are entirely usable.

3. A third technique for the application of boundary-layer control consists of preventing the separation on the upper surface of a deflected flap. Glauert, in his thin-airfoil theory, has demonstrated that a trailing-edge flap is capable of increasing the circulation around a profile. This increase in circulation is the result of maintaining a true stagnation point on the trailing edge of the profile even if it is deflected through a large angle. Unfortunately, the action of the boundary layer prevents the flow from following the contour of the flap on the upper surface and the flow separates, producing a strong turbulent wake behind the flap, as shown in Figure 5.

Several methods are at hand for preventing this separation on the upper surface of the flap. The boundary layer may be sucked in at the point where the flap is bent through either an open slot or through a porous or perforated surface. These actions remove the low-energy boundary layer and permit the potential flow, which contains full free-stream energy, to follow the upper contour of the flap and be deflected downward in accordance with the deflection angle of the flap.

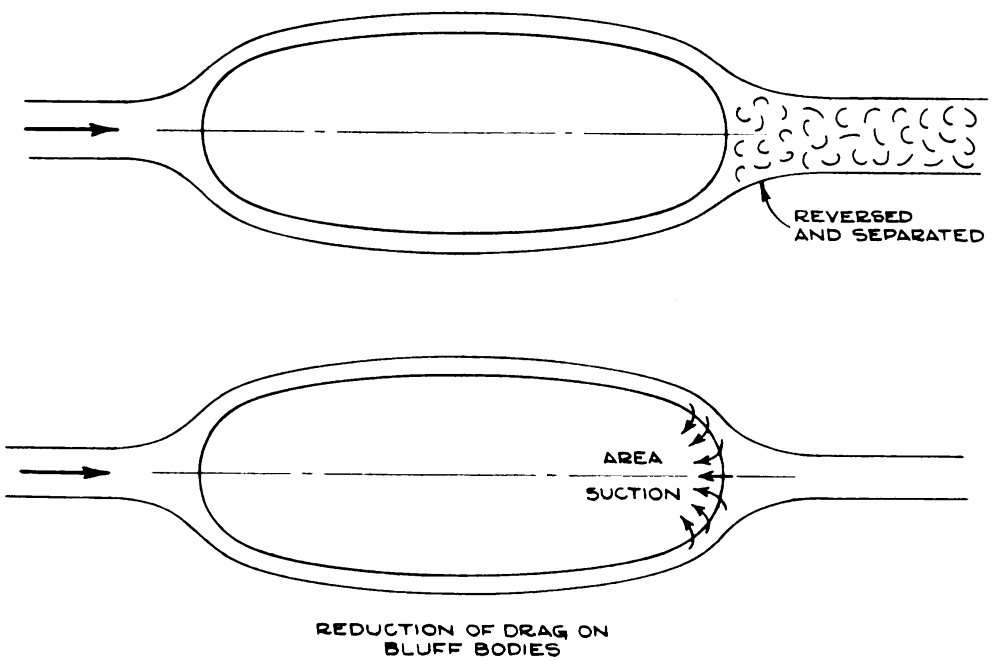


Figure 4

Another technique consists of ejecting air from a slot in the main body of the airfoil above and ahead of the flap itself. This high-energy air follows the contour of the flap, displaces the boundary layer from the surface, and adds sufficient energy to cause it to follow the contour of the flap to the trailing edge. This again permits the potential flow to follow the upper profile and produces a stagnation point at the trailing edge.

An extended ONR research program is underway at the University of Wichita to investigate the application of boundary-layer control to flaps. Detailed studies have been conducted at the University concerning methods of designing the airfoil profiles, with both suction and blowing arrangements, together with the methods of designing these airfoils into an actual wing for flight test purposes.

The action of either removing the low-energy boundary layer or accelerating it by use of suction or blowing, permits the potential flow to follow the contour of the flap and increases the basic circulation of the profile. To this extent, such action may then be called circulation control, since it permits a circulation higher than that which could be secured without this form of reaction to the boundary layer. If sufficient energy is ejected from the blowing slot, the actual lift-coefficient of the profile may exceed that which can be secured from thin-airfoil theory. This is true circulation control, but it is difficult to judge precisely where boundary-layer control terminates and where the action of circulation control begins.

If a system including these flaps is installed on a wing, the flaps may be deflected to angles as high as 90 degrees without separation on the upper profile. The increased circulation which results will increase the lift coefficient of the airfoil, at ordinary angles of attack, to values as high as 5.0 or 6.0. When these airfoils are combined into wings on

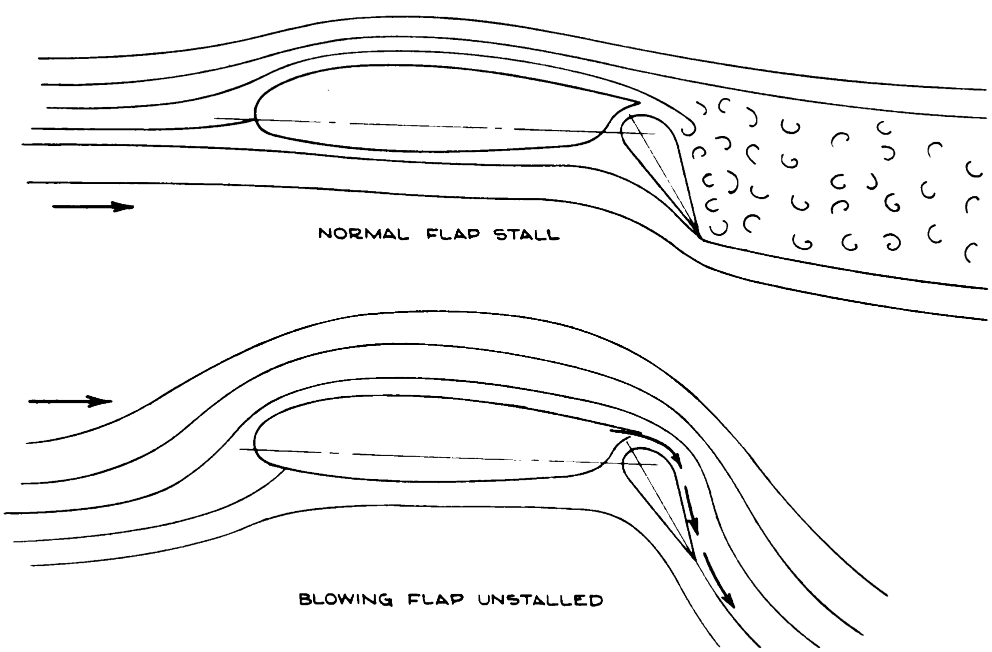


Figure 5

a particular design problem, the wing lift-coefficient may reach values as high as 4.5 to 5.0. When these values are compared with the ordinary values of 2.6 to 2.8, the nature of the improvement is readily apparent.

If such a wing is applied to an aircraft, the landing and take-off run may be materially shorter, because an aircraft with a given gross weight can become airborne and land at a lower speed. Conversely, the use of the improved flaps may permit an aircraft of a given gross weight to be designed with smaller wings which in turn will permit the airplane to fly faster or provide it with greater range, with a given power and fuel. Still another choice which the designer can make is to retain a given wing area and power and increase the load which he can take off, thus improving either the pay load or range of the aircraft. These choices are available to the designer, and he must understand the nature of the results for which he is searching in order to make the proper selection.

Figure 6 is a plot which shows the results which can be secured by the use of various forms of unflapped and flapped airfoils including one wing equipped with boundary-layer control. The improvements in performance which have been made possible through the development of the flap shapes is only a beginning to that improvement which will be possible when the full value of boundary-layer control is utilized.

If the concept of the boundary layer was first expressed over 50 years ago, it is entirely logical to ask why the sudden interest in the techniques in applying boundary-layer control at this particular time. Two reasons exist for this interest. First, the nature of the aircraft which are now being developed require assistance for both the production of higher speed and the improvement of landing and take-off performance. Second, a systematic research program has been necessary to produce the detailed information from which the designer may select that particular information which is pertinent to his project. The mere knowledge that removal of the boundary layer would produce a lower drag airfoil in itself was not enough. It was necessary to have, in addition to this knowledge, the specification of the type of surface, the amount of air flow, the pumping power required, and the particular phenomena which are associated with Reynolds number, surface roughness, airfoil shape, and other parameters--all of which were variables in the problem. The designer who chose to investigate boundary-layer control before this full field of knowledge was developed, found it necessary to make very rash assumptions, with the direct possibility that his assumptions would not produce satisfactory results. He, therefore, either had to initiate extended and systematic series of tests to evaluate all variables in terms of the basic parameters, or await a research program which could perform this task for him.

The same situation is true concerning the use of boundary-layer control for improved flap operations. Here again, many variables such as the shape and position of the flap, the size and position of the blowing slot, the quantity and pressure of the blowing air, the shape and location of a suction slot, the quantity and method of pumping of suction air, and many others all had to be completely explored before the designer could make an intelligent selection of any given combination of blowing or

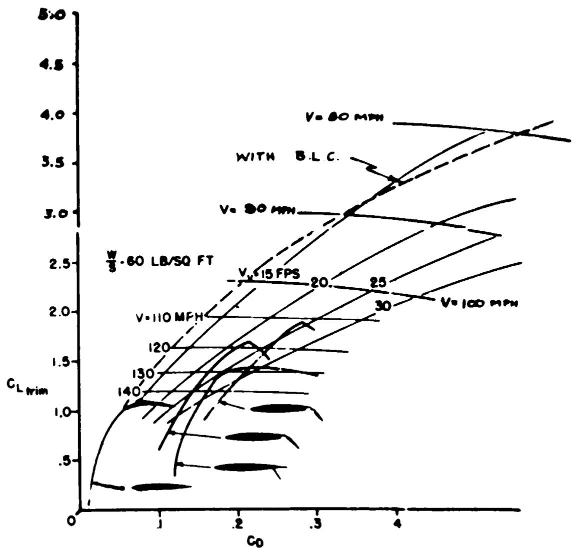


Figure 6. Effect of split, single-slotted, and double-slotted flaps on the lift-drag characteristics of a wing with NACA 65-210 airfoil sections.

suction flaps. The programs being conducted at the University of Wichita, Mississippi State College, Princeton University, Northrop Aircraft Corporation--together with work performed by the Navy Department, NACA, and the Air Force--are slowly but steadily assembling the large amount of detailed and specific data which are required before airplane designers can make full use of these new design variables. This program has already been operating five years, and it will require considerable time before it will be completed. The important thing, however, is that in the course of gathering these data, new discoveries are being made which may have significant effects upon the type of aircraft which are capable of being designed and will permit the designer to move into areas where he now finds it impossible to venture.

Symposium on Radio Propagation and Standards

A Symposium on Propagation, Standards, and Problems of the Ionosphere will be held September 8-11 at the new Boulder (Colorado) Laboratories of the National Bureau of Standards. The meeting is being sponsored by the NBS Central Radio Propagation Laboratory, which was recently transferred from Washington, D.C. to Boulder. Papers will be presented on such topics as ionospheric radio propagation, tropospheric propagation, high-frequency standards, microwave standards, microwave techniques and applications, radio systems, radio spectrum utilization, atmospheric radio noise, radio astronomy, and upper atmosphere physics.

In addition to the technical sessions, field trips to the High Altitude Observatory at Climax, Colorado and the NBS Cheyenne Mountain Field Station at Colorado Springs have been arranged. The Symposium will take part in the official dedication of the NBS Boulder Laboratories on September 11, 1954. A Conference on Cryogenic Engineering will also be held by the NBS-AEC Cryogenic Engineering Laboratory on September 8, 9, and 10 in connection with the dedication.

In general, the topics scheduled for discussion at the Symposium are closely related to the activities of the NBS Central Radio Propagation Laboratory. As the Nation's primary agency for research and coordination of data in radio propagation, CRPL analyzes and disseminates information on propagation conditions that aids global aviation, all-weather shipping and harbor control, and worldwide communications. The Laboratory is also responsible for the development and custody of the national primary standards for electrical quantities at radio frequencies.

Moving Pictures of Body Cells at Work

Dr. C. M. Pomerat and McDonald Smith

Tissue Culture Laboratory, University of Texas

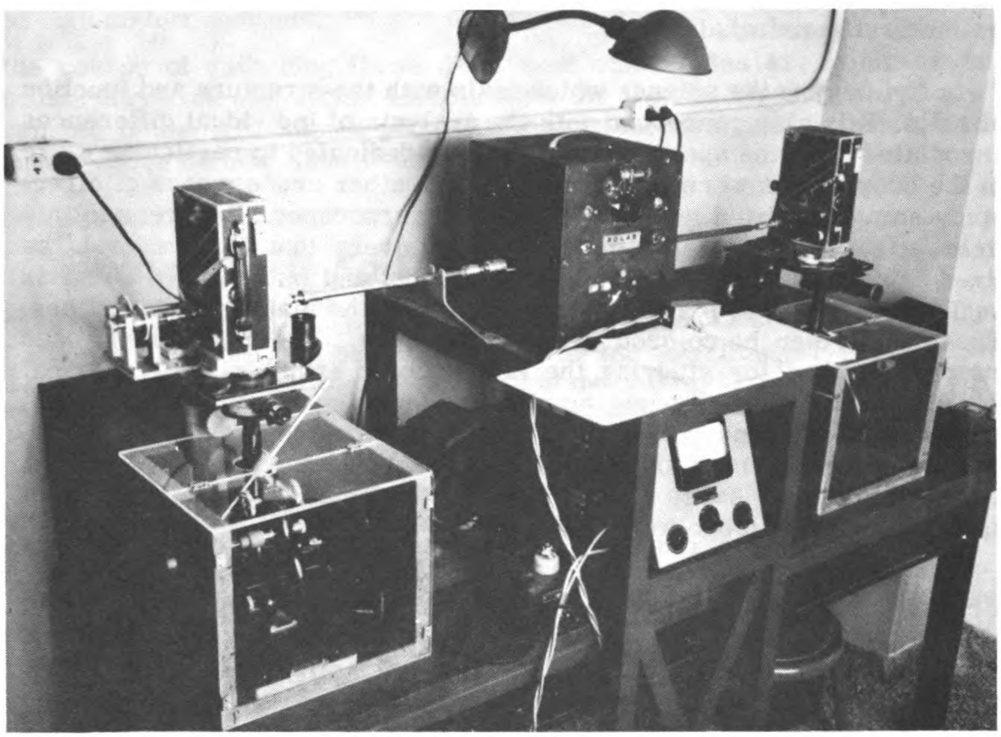
The billions of cells which make up the human body are divided into various groups devoted to specialized tasks. While functions such as absorption, respiration, irritation, etc., are performed by all of them, microscopic anatomy usually reveals that specialization is reflected by cell shape. For example, glands are composed of block units of cubical cells which contain the necessary equipment for producing secretions. The long, spindle-shaped form of muscle fibers renders them ideally suited to the contraction and relaxation motions involved in muscular performance. In keeping with its telephone-like character, the essential cellular agent in the nervous system—the neuron—is characterized by long, thin, wire-like processes. In the leg, such a nerve fiber may be as much as 3 feet in length and several times that size in the giraffe and whale.

Cytology is the science which deals with the structure and function of cells. It is also concerned with the analysis of individual differences associated with the specialization of cells dedicated to particular tasks in the body. Cells were first examined by rather crude means of direct study employing hand lenses and simple microscopes. Progress in this field was greatly accelerated by the discovery that tissues could be fixed and made rigid with formalin or alcohol and imbedded in a matrix such as collodion or paraffin which permitted the making of thin slices. These could then be colored with various dyes. The most widely used current method for studying the microscopic architecture of normal and diseased human tissues employs such stained-cell preparations, averaging 5 microns (1/200 mm) in thickness. However, there is the drawback—sometimes forgotten—that such slides merely give us an almost completely static view of nature. To visualize actual cell processes, something more was necessary.

The something more evolved out of a discovery made nearly half a century ago, when it was found that cells could not only survive but also grow in glass dishes. The know-how obtained by means of this technique now permits us to state that animal cells are potentially immortal outside of the body, that human cells can be grown in gram quantities, and that various species of cells can be started from one individual and maintained in pure cultures.

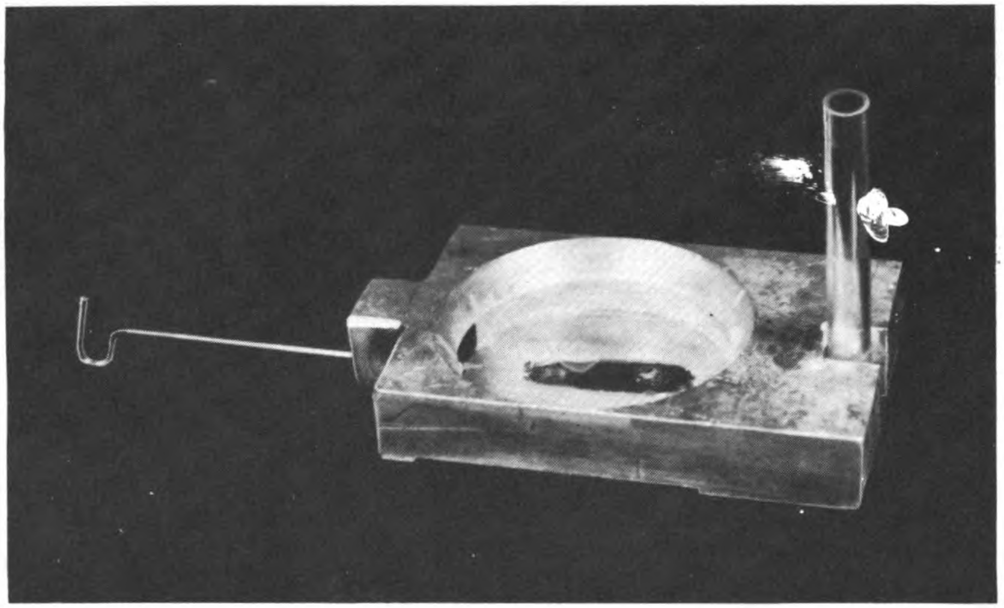
Tissue culture, as this field is called, is providing us with rich opportunities to inspect the dynamics of living cells with all the advantages of modern technological instrumentation. Particularly significant is the use of phase-contrast microscopy. This enables us to see cell structures, having almost the same index of refraction as the background substance, while they are still living and eliminates the necessity of using damaging stains. Moving pictures can be made by microscopes equipped with phase-contrast optics. Time-lapse cinematography permits us to show accelerated action by taking pictures at infrequent intervals and then projecting them at usual motion picture speed. Thus, records taken at 8 frames per minute and projected at 16 frames per second are accelerated 120 times. In other words, what is seen on the screen in 1 minute was recorded by the microscope during a 2-hour period. This technique of time-lapse photography was popularized by the Walt Disney films, particularly in the sequences depicting the "explosive" opening of flowers.

The challenge of phase-contrast, time-lapse cinematography has been further enhanced, as a tool for investigations on the living cell, by the introduction of suitable perfusion-chamber devices. These consist of enzymes by means of which cells in culture can be inspected through the microscope while still surrounded by fluid. The chamber makes it possible to perfuse various solutions, including the nutrient media employed to study cell growth, while moving pictures are being made, even at very high magnification, of the activities of cell groups or of the internal parts of an individual cell.* By way of illustration, the picture below shows a double-moving picture assembly and the one at the top of the next page represents a simple type of perfusion chamber.



Moving Picture Setup Used for Photographing Cell Activity At High Magnification. The picture shows a double-microscope assembly by means of which living cells growing in a chamber on the stage of the microscope can be maintained at body temperature. Moving-picture cameras actuated from the box in the center of the apparatus make it possible to photograph the cells at regular time intervals.

*A description of this procedure was published in the June 1951 issue of RESEARCH REVIEWS under the title of "Pictures for Visualizing Allergy."



Perfusion Chamber. A metal frame is used as a skeleton for the set-up which is put together with a mixture of melted paraffin and beeswax. The tissue culture hangs from the ceiling of the upper cover glass forming the chamber. The larger glass tube serves as an inlet and the smaller as an outflow tube for perfusion fluids introduced while moving pictures are made of the cells.

To show what can be learned by means of this instrumentation, let me give a brief review of the active parts of cells. These are shown below. As we watch the moving parts with the time-acceleration technique described above, we gain an appreciation of how dynamic the cells can be. This is especially evident in their responses to changes in the conditions of their environment. Thus a culture which has been growing for a long period of time in the same medium becomes enormously activated when fresh nutrients are introduced. Cells begin to divide some 10 hours after the replenishment of the foodstuff in their cultures. On the basis of these observations, we have been making film records of the way each of the moving structures change under ideal conditions and then of how they are modified in experimental situations.

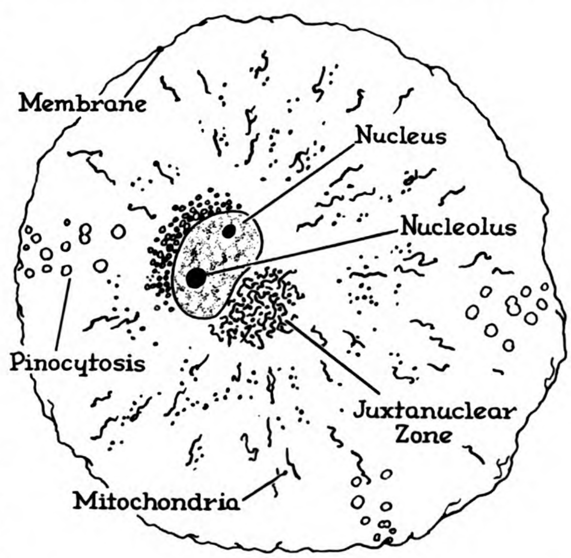
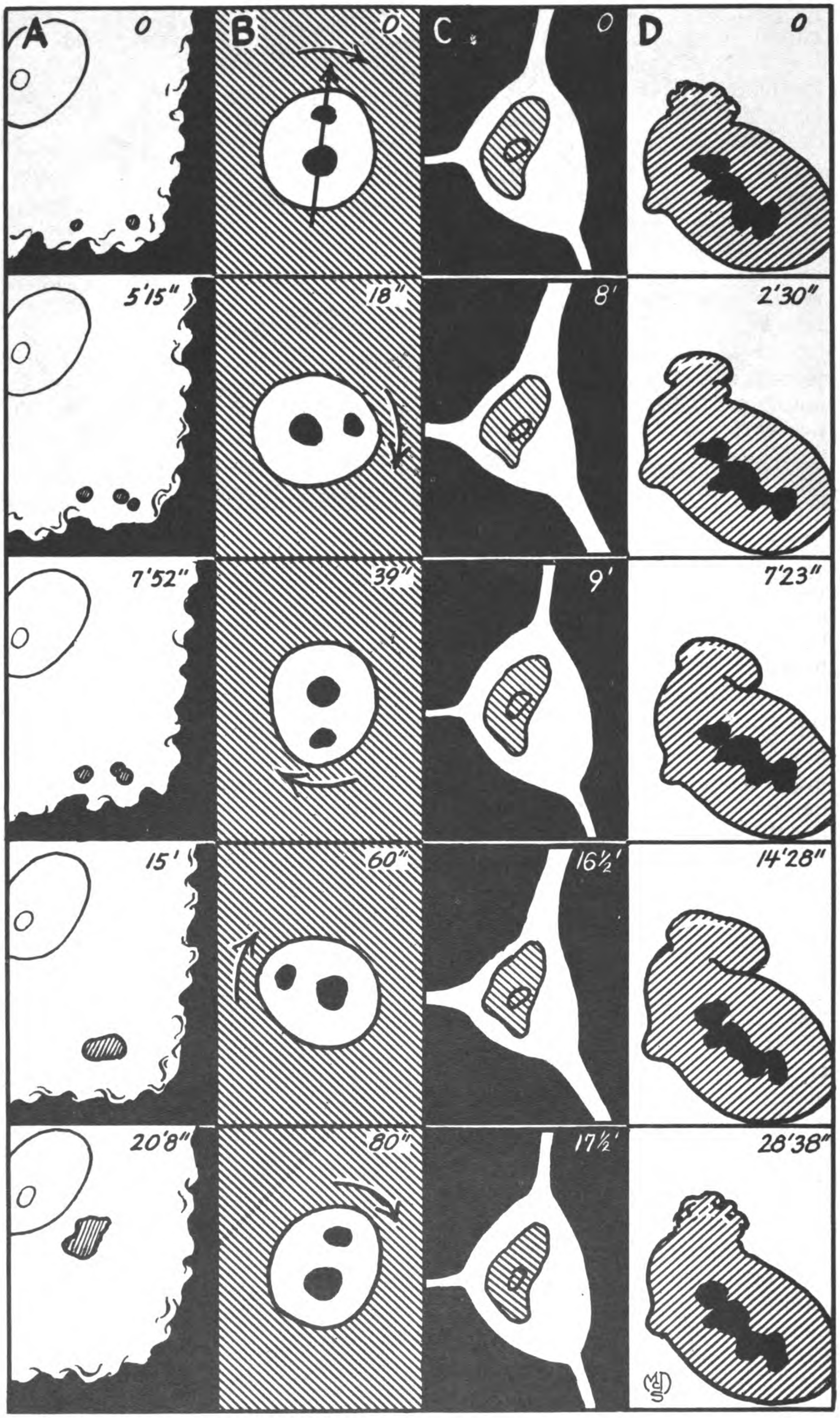


Diagram of a typical cell giving the names of the various structures whose movements are studied with time-lapse photography.

Some of the more striking results concerning the behaviour of normal cells are shown on the following page. Column A shows the margin of a cell membrane actively engaged in the process of taking in food. The very delicate extension of the cytoplasm can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8'
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39"
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15'
60"
16½'
14'28"
20'8"
80"
17½'
28'38"

be seen curling up in such a way as to form little spheres which move rapidly towards the nucleus. As they progress, the small droplets collect to form relatively large vacuoles, which ultimately disappear in the juxtanuclear area. Cell drinking, or pinocytosis—as this phenomenon was termed many years ago by Dr. Warren H. Lewis of Philadelphia—has been an almost completely neglected subject in cell physiology, but is now beginning to receive great attention.

Column B illustrates the rotatory activity of the nucleus. This is a good example of how the study of living cells can contribute to science information which could not possibly have been attained by the classic methods of fixation and staining. In the course of many sequences of film records of nasal mucosa and of various types of cancer, nuclei have been seen to whirl rapidly. Selected areas of film strips are projected on drafting paper and outlines are made of the nuclear membrane and the position of the nucleoli. A line is then drawn through the two nucleoli and a protractor is used to measure the angle of rotation; the data are then plotted graphically as a function of time.

Column C illustrates how evidence is being accumulated regarding the fact that a small species of cell, which is extremely numerous in our brain, may be involved in a process of contraction. The rythmically pulsatile element is known as oligodendroglia, which merely means a cell with glue-like affinities having very few processes. Moving-picture studies show that such cells pulsate like little hearts. Since there are millions of these and because they are very frequently in close association with nerve-cell bodies, it is believed that they may provide a pump-like action which may be of great significance in the general metabolism of the nerve cell.

Column D shows a series of individual frames describing the events taking place between the nucleus and cytoplasm in a cell cultivated from a human tonsil. A bulge can be seen developing upon the surface of the nucleus; this may represent a stage in the expression of secretion formed within the nucleus, which then passes out in the cytoplasmic area. Recent studies in several directions have given evidence that nuclei are not static when they are not actually engaged in the process of division. There may be a large amount of synthesis going on in the nucleus. These films suggest the process whereby this secretion may be delivered to the cytoplasm.

Thus, as in many other branches of science that go back a half century or more, the study of tissues has been greatly accelerated in recent years by the adaption of a mechanical invention. The slowed-down motion-picture, coupled optically to a powerful microscope, has been as outstandingly helpful in this field as the opposite development—high-speed motion pictures at thousands of frames per second—has been in others.

Outline drawings of selected frames from time-lapse movie records of the activity of cells in tissue culture. The time between adjacent film frames in each of the series is given in the upper right hand field.

Radioactive Deck and Personnel Markers

Dr. L. H. Dawson
Optics Division, Naval Research Laboratory

Prior to the introduction of strontium-90, the self-luminous radioactive marker adopted by all branches of the Armed Services was activated by radiation from either radium bromide or radium sulfate. Until the production of artificial radioisotopes in large quantities was well underway, these were the most satisfactory substances available for this purpose. Radium markers successfully met the rigorous requirements of military use and were employed extensively during World War II. However, they had two major defects. First, an undesirable decrease in brightness occurred with the passage of time and secondly, certain physiological hazards were associated with the high emission of penetrating gamma rays.

A comprehensive survey of artificially produced radioisotopes showed that strontium-90 is probably the only one that can replace radium successfully. Furthermore, both of the defects of radium markers were practically eliminated in markers activated by strontium-90. In this article, the properties and possible military applications of these markers will be described.

The principle under which radioactive markers function is as follows: when a radium salt such as radium bromide or sulfate is thoroughly mixed with luminous zinc sulfide in a proportion of 5 to 10 parts of radium to approximately one million parts of zinc sulfide, the latter radiates light in the visible portion of the spectrum. The intensity of the radiation increases from the date of compounding to about the 25th day. At this time it reaches a maximum, and then a slow, approximately logarithmic decay sets in and continues throughout its life. The maximum brightness and rate of decay depend on the amount of radium present; the greater the amount, the higher the brightness and the greater the rate of decay. However, when the zinc sulfide and radium mixture is compounded and mixed with a vehicle that makes it suitable for surface application, the luminosity reaches a maximum brightness in 100 days and then a subsequent decay takes place. This rate of decay is due primarily to the amount of radium used. Since the half-life of radium is 1590 years, it is evident that the decrease in the intensity of luminescence is caused by destruction of the zinc sulfide phosphor and not by a decrease in the amount of radium present.

Besides an undesirable decay in brightness, this type of marker also has the disadvantage of radiating the highly penetrating gamma rays; these introduce physiological hazards that make handling and storing difficult. Safely shielding personnel from radiation given off by the most common substances used in deck markers is relatively difficult. To reduce the gamma-ray intensity from radium to one-half its value, about 25 mm of aluminum, or 7.5 mm of copper, or 5 mm of lead are needed as a protecting shield. By contrast, only about 0.2 mm of copper is required to stop completely the beta rays given off by strontium-90. A plastic material like "Lucite" about 3 mm thick also entirely absorbs the beta rays from this isotope.

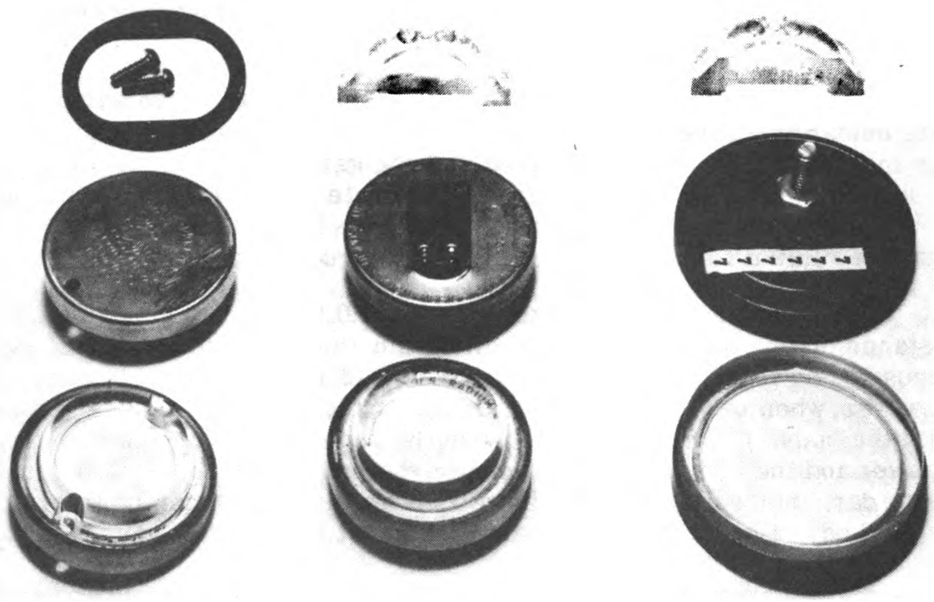
Safety regulations give 0.10 roentgen per day as the maximum for safe human exposure to gamma radiation. Some conception of this quantity may be gained if it is realized that the gamma rays from one gram of radium will produce ionization at the rate of 207 roentgen per day at a distance of one meter from the radium. Remaining this close to a gram of radium for any length of time will produce detrimental effects.

The standard Navy marker produces 0.002 roentgen per day at a distance of one meter which is well within the tolerance limits of safe exposure, so that under ordinary conditions of use no danger is present. However, when used as personnel markers, they may be in close contact with the body. If the distance between the radioactive surface of a Navy marker and the body is one centimeter, the body will receive 4.0 roentgen a day. Since this amount is well above that which can be tolerated by the body, a certain danger exists and must be recognized.

Safe storage and handling are complicated when large numbers of markers are involved. For example, 1000 standard Navy markers packed in a box will produce approximately 2.0 roentgen per day (20 times the safe-exposure tolerance) at a distance of 1 meter. Thus, care must be taken so that the boxes containing such quantities will be placed at a safe distance from personnel and photographic film.

A few words should be said about the physiological hazards of strontium-90 since this isotope is by no means harmless. In fact, it is one of the most dangerous of the radioisotopes in that the maximum permissible uptake in the total body is one of the smallest values of all known radioisotopes. A quotation from the National Bureau of Standards Handbook No. 52 (20 March, 1953) says, "In the case of Strontium-90 in equilibrium with yttrium-90, the maximum permissible amount of Strontium-90 in the body is 1 microcurie or only 6.3×10^{-9} grams, which is about 10^{-13} of the mass of the human body. This concentration is so small and the rate of elimination so low that once it becomes fixed in the bone, it is very difficult if not impossible, to make an accurate estimate of the amount present. Therefore, if there is exposure to such radioisotopes, every precaution should be taken to minimize the body uptake and urinalyses should be made frequently so that the amount going into the bone can be estimated from concentrations in the urine during the early portion of the exposure period when the elimination rate is much higher." The maximum permissible concentration of strontium-90—yttrium-90 in water is 8×10^{-7} microcuries per ml of water, and in the air 2×10^{-10} microcuries per ml. Thus every care should be taken in the handling of the markers to see that the plastic envelope is not broken. Should this occur, immediate steps should be taken to dispose of the marker either by burial or dropping into deep water. However, the fact that gamma radiation from the strontium-90 marker is 30 times smaller than for the service marker excited by radium simplifies storage and exposure problems.

Little is known regarding the mechanism by which phosphors are excited to luminescence by radioactive substances. When the alpha or



A B C

A. Front and back views of deck markers with plastic shield and ring for attachment. B. Front and back views of personnel markers and cross-section thickness of plastic shield. C. Larger markers used mainly by the Army to identify trucks and bridges.

beta particles strike an atom of zinc sulfide, electrons are forced to higher energy levels. From here they fall again to definite, lower levels, and in this process they emit energy in the form of visible light. In some phosphors like zinc sulfide, the electrons may fall to levels where they are temporarily trapped. After remaining in these energy states for a period that depends mainly on the temperature and phosphor material, they are released and fall back to their original energy level. In this process, they give off visible radiation that may be observed after the excitation has ceased. This phenomenon is known as phosphorescence. Zinc sulfide is preferred to other phosphors in the manufacture of deck markers because it is quickly excited to high brightness and the color of the visible radiation emitted is determined by the amount and kind of metallic impurity incorporated in the phosphors.

Because of the rapid disintegration of zinc sulfide by radium and the large amounts required to produce luminosity only a limited range of colors from yellow-green to the yellow of the visible spectrum can be obtained. With strontium-90, however, practically the whole range of colors has been successfully obtained without the use of an undue amount of exciting material. This phenomenon can extend, quite materially, the usefulness of self-luminous radioactive materials as aids to night activity. There are many ways in which such markers can be used to assist in military operations under cover of darkness.

During the last war, radioactive self-luminous deck and personnel markers were used extensively on board ship to mark stations, obstructions, exits, and other strategic points. The markers were also used to identify personnel on the deck of a darkened ship. On land they were used to mark tanks, trails, bridges, and other objects needing identification in the dark. Two sizes were available; one used mainly by the Navy had a circular, luminous area of 1 inch diameter, while the larger, used mostly by the Army, had a luminous area with a diameter of 1-3/4 inches. These markers were excited by radium and were of low brightness. With the introduction of strontium-90 as the exciting agent, both color and much higher brightness values may be obtained which will greatly enhance their value in such applications.

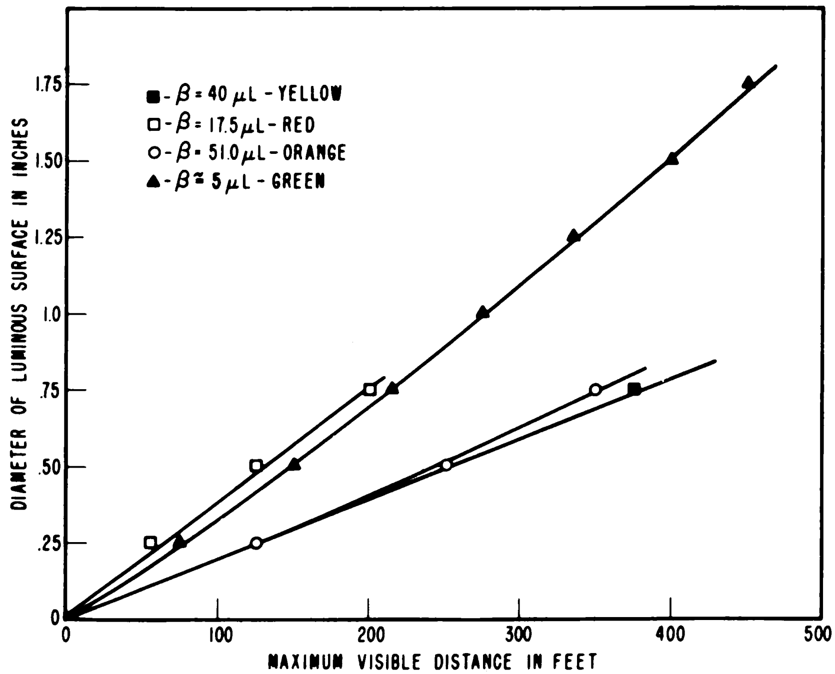
The Navy uses different kinds of ammunition depending upon the situation at hand. These may be star shells, armor piercing, general purpose, anti-aircraft, and other types. For small craft and topside guns not fitted with ammunition hoists this ammunition is usually kept in ready boxes near the gun. During night operations it is desirable that the correct ammunition be selected quickly and accurately in total darkness. A solution to this problem would be to place different colored markers on the racks within the ready box to designate each kind of ammunition. Such markers are readily distinguishable, require no power supply, and will last for many years.

The high brightness and variety of colors of the self-luminous radioactive marker obtained by exciting the phosphor with strontium-90 can greatly extend the usefulness of the personnel marker. At distances where markers are used for personnel identification, color is easily and accurately distinguishable; thus colors or combinations of colors can be made the basis of identification. The possible number of identifying symbols can be extended by attaching to the luminous surface of the marker a letter, number, or insignia of rank made of black opaque material.* Because of the high-brightness background, such a symbol is easily legible at useful distances.

The logistics of an amphibious operation is a complicated problem. It is necessary to land a desired contingent of men with its own equipment on a certain beachhead and to keep these men supplied day and night with adequate food, ammunition, medical supplies, and other equipment. This requires shuttle service from the attack transport and cargo ships to the beach a few miles away. Usually, as set up in the original battle plans, each division has certain ships carrying its equipment and supplies. In some cases, one ship may be carrying supplies or spare parts for more than one division, in which case the supplies for each particular division should be so designated. Each beachhead should be marked with the colored marker assigned to the division landing on that beach. All the supplies assigned to a certain division would then be marked with the luminous color designated for that division. In this manner the coxswains of the LCVP's and the beachmaster ashore would be less confused as to where supplies should be landed.

Underwater demolition teams in their work are confronted with the problem of reading the dial of a depth gauge while underwater. The depth gauge is a small instrument the size of a wristwatch and is worn on the wrist of the swimmer. The numerals and letters of the gauge are usually painted with radium-excited low-luminosity material. The illumination of the gauges has been unsatisfactory. Radioactive self-luminous

*This use was suggested by Captain E. W. Longton, USN, now at NRL.



Maximum visible distance of markers with various diameters.

material activated by strontium-90 is about 10 times brighter than the radium-activated material. It is, therefore, ideal for use on the dial of the gauge since the transparent face of the gauge would be sufficient protection against the beta rays of the strontium-90. A high-brightness marker might be used by a member of the underwater demolition team as a source of illumination for his activities by attaching it to the wrist which did not have the depth gauge.

The high-brightness markers can be used at night as semaphore for short ranges. A plaque 4 inches on a side used as a flag in either hand can be seen at about 1000 feet with the naked eye; with binoculars the distance can be increased a number of times depending upon the power of the binocular. Larger plaques would also increase the visible distance. Since the markers are visible only in one hemisphere and produce no light beam, they could be used to signal from forward to rear areas without compromise in cases where no message acknowledgement is required.

It is also possible to use a plaque of radioactive self-luminous material as the light source in a flashing-light system. The signal may be made directional by a beehive mechanism such as is used in the Aldis lamp. On a moonless night, a plaque 9 inches on a side may be seen as a flashing signal at more than 1000 feet. This type of marker would thus make available a light-weight, low-intensity light source requiring no external source of power and having a useful life of many years.

Another suggested use of high-brightness radioactive self-luminous markers is to aid planes in their night search for aviators who have been downed and are aboard life rafts. An orange plaque of self-luminous material having a brightness of 50 to 60 effective microlamberts and being 6 inches in diameter is visible at a range of 2500 to 3000 feet. A plaque 12 inches in diameter and of the same brightness would be visible at 5000 to 6000 feet with the naked eye. These plaques should be designed with a cover so that they could be exposed only when desired. Such plaques would be light in weight, rugged, and have a useful life of 10 to 15 years. A replacement of the present radioactive self-luminous marker activated by radium with the marker activated by strontium-90 for marking tanks, trucks, and vehicles on the battle front would result in more satisfactory operation because of its increased visibility range.

On board Navy ships, certain watertight fittings are designated by the letters X, Y, Z and W. Whether any given fitting is open or closed depends upon the material condition set on the ship at the time considered. It is imperative that these closures be opened or closed as fast as possible when a ship changes its material conditions. At night or in the case of power failure the use of some light source, either a flashlight or battle lantern, is required to determine the letter on the closure. The colored high-brightness radioactive self-luminous markers could successfully replace the letter and flashlight. The marker can be identified at a distance great enough that no time would be lost by the person assigned to the particular closure. The use of the marker with its compactness, absence of external sources of energy, and long life eliminates the worries connected with the use of flashlights and lanterns.

Sufficient light is given off from the high-brightness radioactive self-luminous markers excited by strontium-90 to carry on certain types of activity in a perfectly dark space when the eyes have become fully dark-adapted. Coarse print can be read when the marker is held close to it. The situation of objects in a room approximately 20 x 10 x 15 feet can be determined. To personnel in a compartment darkened by power failure, such a simple rugged and long-lived source of light is invaluable.

A more recent development in this field involves two other isotopes which have been studied for their value in military applications. They are thallium 204 and promethium 147. Both have a considerably shorter half-life than strontium-90. In other words, they will not last as long. This drawback is compensated, however, by the fact that they emit less beta radiation and therefore, fewer safety precautions are required with them. The relatively thick plastic shield required with strontium-90 can be replaced by one only one-third as thick. Like the latter material, they produce light in all the colors of the visible spectrum—blue, green, yellow and red. This is of prime importance in view of the military applications of these markers discussed above. Their properties are given below.

Element or Isotope	Mass Number	Half-Life	Type of Radiation and Energy (Mev)
Strontium-89	89	55 days	β 1.5
Strontium-90	90	25 yrs	β 0.61
Thallium	204	2.7 yrs	β 0.775
Promethium	147	4.4 yrs	β 0.223

Further study will undoubtedly disclose other uses for these materials. It is the purpose of this article to help stimulate thought throughout the Navy in regard to possible uses as well as to present some of the properties of these markers.

On the Naval Research Reserve

Husband and Wife Team Members of NRRC 12-4

NRRC 12-4, Fresno, California, is unique, in that it is the only Research Reserve Unit which can boast of having a Mr. and Mrs. aboard. They are CDR Frank and LCDR Thelma Prescott, pictured above with CDR E. B. Womack, Commanding Officer of 12-4, on the right.

These officers have an enviable record in the Reserve Program. They have been members of this unit since it was activated in 1949 and have attended just about every scheduled drill since then. Not only have the Prescotts been very faithful, but their enthusiasm about all phases of the unit's activities has shown itself in the many valuable contributions they have made to the drill program. Both were Lieutenant Commanders until Oct., 1953 when Frank was promoted to Commander.

CDR Frank Prescott received his B.A. degree in Engineering from Stanford University in 1935 and is Secretary of the Prescott Lumber Co. in Sanger, Calif. During World War II, he was stationed at the Naval Gun Factory in Washington D. C., where he was responsible for research on design changes to facilitate production of weapons.

Mrs. Prescott received her LL.B. from Columbia University's School of Law in 1942. During World War II, she was assigned to the Office of the Judge Advocate General as Chief of the Research Section. Many of the laws by which the Navy is governed were written by her.

Pictured above are the members of NRRC 12-4 which recently celebrated its fifth anniversary. Left to right LCDR. Herman D. Graham, LT. Charles C. Huey, LT. Robert M. Warner, LCDR. Nicholas R. Bondoc, LT. (W) Elizabeth B. Landrum, LCDR. John A. Drenth, LCDR. (W) Thelma S. Prescott, LCDR. John A. Buehler, CDR. Ennis B. Womack, CO, CDR. J. R. O'Halloran (CO, USNTC Fresno), LCDR. E. S. Churchill (Training Officer, ONR Washington), LT (jg) Louis A. Follansbee, LT. Jack Slaughter, LCDR. James R. Ryles, CDR. Frank K. Prescott, LCDR. Forrest D. Brown, CDR. Joseph H. Graham (RPO, SF), and CDR. Ralph A. Jack.

Four Seminars to Convene This Month--West Coast, ONR, NRL and Idaho Falls

The seventh annual Research Reserve Seminar will convene at ONR on 23 Aug. Approximately one hundred Research Reservists will be ordered to active duty for two weeks training at this time. As in the past, a full program has been arranged to bring reservists up to date on current developments in the research program of the Dept. of Defense. Recent information on the Reserve Program will also be discussed. The program features addresses by ONR personnel and representatives of other research activities in the defense establishment. Field trips in the Washington area will include visits to the Applied Physics Laboratory at Johns Hopkins University, David Taylor Model Basin, Naval Medical Research Inst., Naval Engineering Experiment Station at Annapolis and the Army Engineering Research Station at Fort Belvoir, Va.

The West Coast Seminar convenes on 29 August. The number of applications received indicate full attendance for this seminar also. Points of interest to be visited include the San Francisco Naval Shipyard, Moffett Field, Stanford University Physics Laboratories, California Research Corp., Richmond Refinery, University of California Radiation Laboratory, Stanford Research Institute, Western Regional Reserve Laboratory, Mare Island Naval Shipyard and the Naval Air Station at Alameda.

Both the NRL and Idaho Falls Seminars commence 9 August and each will be attended by 50 officers. This is the first seminar for the Idaho Falls Group and the subject will be nuclear reactors.

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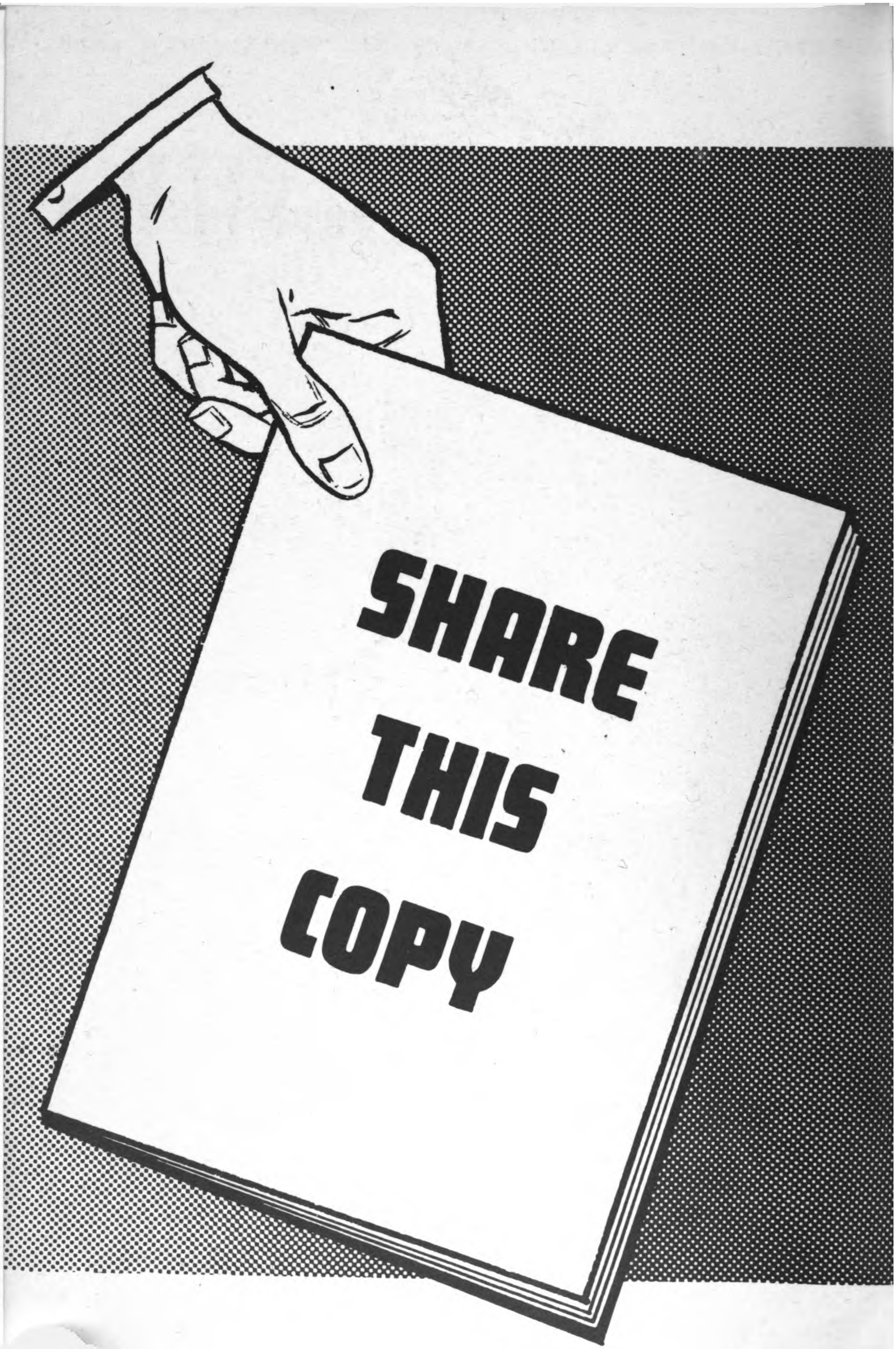
PROJECT PINWHEEL
(See p. 7)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