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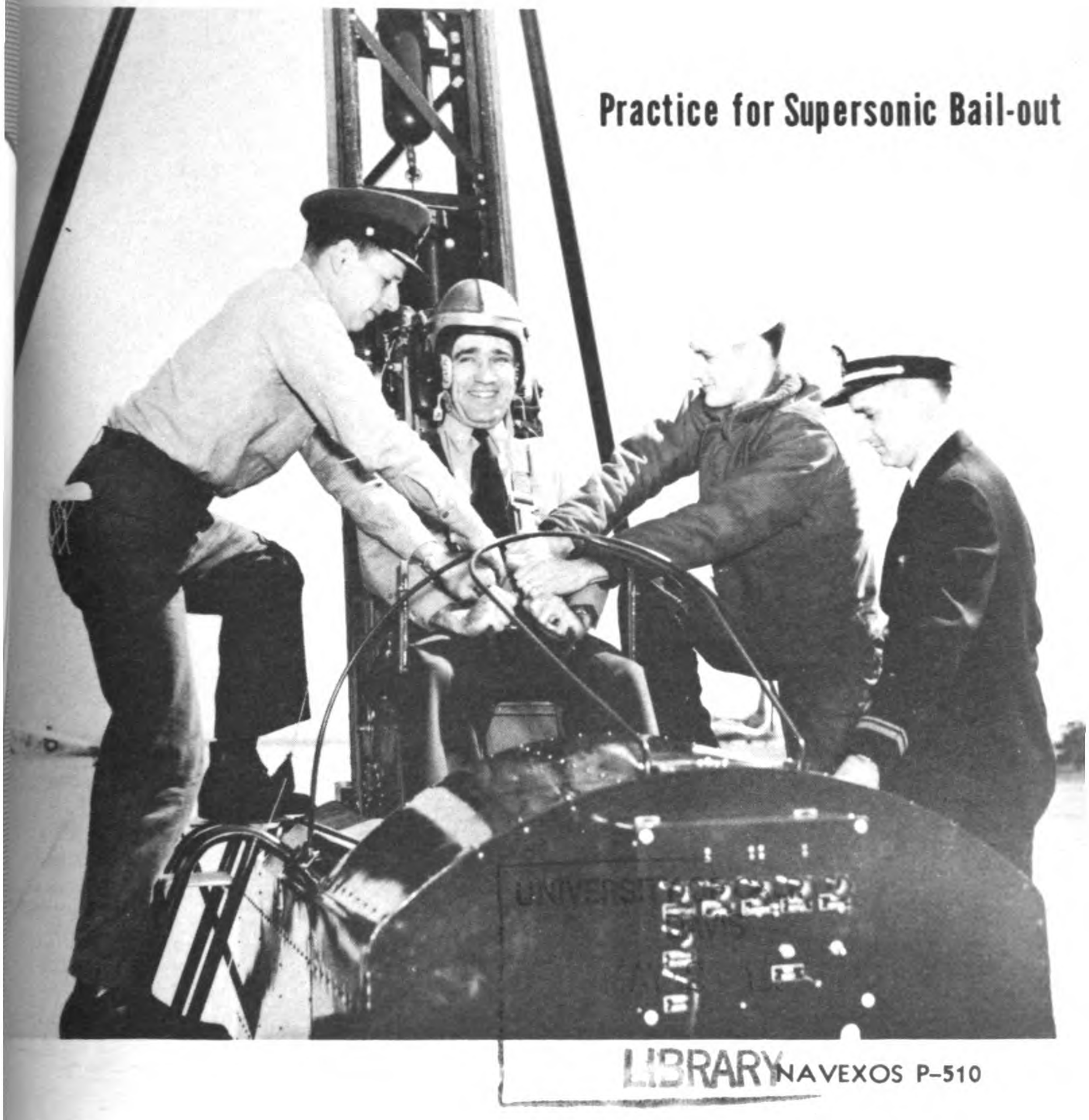
RESEARCH REVIEWS



Practice for Supersonic Bail-out

NAVEXOS P-510

DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

COVER PHOTO: The happy expression on this Navy pilot's face may come from the realization that the gadget in which he is strapped may help to save his life someday. It is the so-called seat-ejection trainer, used by the Special Devices Center and other Armed Forces activities to train pilots to escape from today's fastest aircraft. For more about it see "Pilots Away!" pp. 10-11.

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

Approved by the Bureau of the Budget, 14 February 1952

In this issue

Pilots who have been faced with the problem of landing planes on rolling "flat tops" like this one are well aware of the necessity for more efficient ship stabilization. The picture was taken during World War II when heavy seas were pounding the USS HOGGATT BAY (CVE 75). Though some progress has been made in anti-roll stabilization since that time scientists investigating the problem feel that far better systems can be devised than those that are now being widely used.

Ship Stabilization for a Better Navy

by
Joseph H. Chadwick and Albert J. Morris
Stanford University

Can the rolling of ships at sea be considerably reduced? The answer is yes. More than one hundred British craft are now equipped with practical devices for this purpose and more widespread and successful ship stabilization appears to be in the offing.

Why is the Navy interested in stabilizing ships? Obvious considerations are the comfort and efficiency of crew and passengers, who would be relieved of seasickness and the handicaps of living and working in a rolling environment. Moreover, not only the passengers but the ship itself would benefit, for roll stabilization would result in reduction of both internal and external stresses on the hull. This would lead to greater propulsion efficiency, since the same pounding that strains the hull also increases the power required to propel the ship at a given speed. Military craft would benefit in additional ways if rolling could be reduced to a degree or two: the stabilization equipment needed for components such as search radar antennas might be eliminated entirely and the performance of all the stabilizers on individual components such as guns would be vastly improved. The problem of air operations on rolling carriers alone justifies military consideration of a roll stabilizer. All these factors make it obvious that the Navy and the shipping industry both have much to gain by roll stabilization.

Since none of this is news, it is scarcely strange that many attempts have been made during the past century to stabilize ships. Varying degrees of success have been attained. The different systems can all be classified into two general categories: (1) passive systems in which no control devices are used and in which anti-rolling forces are created directly by motion of the ship itself; and (2) active systems employing sensing elements which, through power amplifiers and positioning devices, control the anti-rolling forces. In all cases passive systems have preceded their active counterparts.

Among the chief methods which have been used for ship stabilization are gyroscopic stabilizers, anti-rolling tanks, moving weights, and fins. Some success (roll reductions up to 50 percent) was attained with both passive and active gyroscopic stabilizers but the systems presented some very serious disadvantages. The large initial cost of the

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Joseph H. Chadwick earned his Ph. D. from Stanford last year with a thesis on ship stabilization and is now Project Director of that University's program in the field. During the war he was on active duty with the Navy.

Albert J. Morris, a member of the scientific staff of ONR's San Francisco Branch Office, is participating in Stanford's ship stabilization program as an "honorary" research associate. During the war he was an electronics officer and he now serves as Executive Officer of VNRRU 12-3.

big gyros and the space they take in the center of the ship provide two outstanding arguments against their use. Moreover, since the action of a gyro depends on inertia alone, it is primarily effective against moderate- to high-frequency waves and can provide little stabilization against the low-frequency waves met in following seas.

In systems involving the movement of solid mass, it is obvious that transferring a large mass rapidly back and forth across a ship in still water would cause it to roll; conversely rolling can be reduced by the same procedure, properly timed. Unfortunately, moving sizable concentrated weights across a vessel is dangerous, so earlier work on such systems by Cremieux and Thornycroft is not being pursued.

Anti-rolling tanks, like the moving weight systems, use displacement and inertia type forces, but they offer better possibilities for successful development. In the passive version, like the one (Figure 1) invented by Frahm of Germany and used on over 1,000,000 tons of German shipping prior to World War II, fluid is allowed to oscillate between two tanks located on opposite sides of the ship. Motion of the ship causes motion of the fluid, which, in a narrow range of frequencies, can produce excellent roll reduction. The system is, however, inherently dependent on resonance phenomena and is therefore of limited usefulness in confused seaways. The active counterpart of passive tanks was invented in this country by N. Minorsky about 1928. This system included an accelerometer as a roll-sensing instrument and a power amplification system driving a variable-pitch pump which effected fluid transfer. Though model tests were successful, a full-scale installation encountered control problems, and World War II intervened before they were solved.

Roll reduction by any fin system depends on the ship's speed. Bilge keels, which are passive fins running parallel to the craft's longitudinal axis, act to increase damping. They are used on most naval vessels because they provide effective roll reduction—up to 50 percent in some cases. They are generally installed at right angles to the hull at the turn of the bilges and extend outward as much as 2 feet.

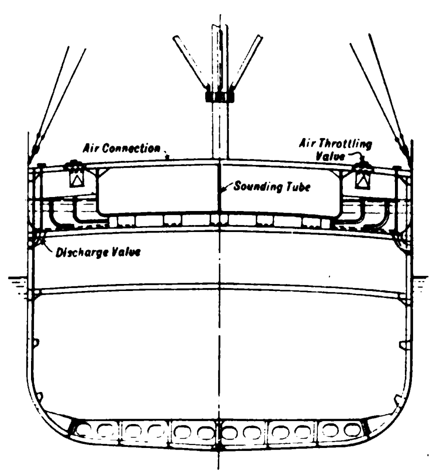
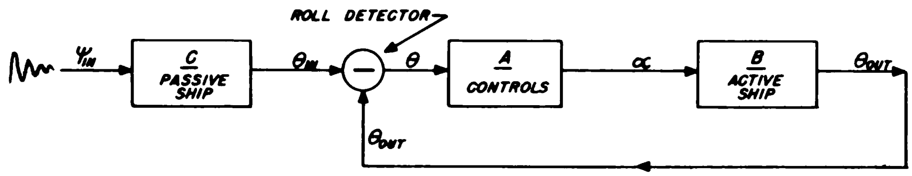


Figure 1. Original Frahm tank installation on the S. S. Ypiranga.

Activated fins, first successfully applied by S. Motora of Japan in the 1920's, act as ailerons do on an aircraft. As they are rotated they produce lift forces which develop a righting torque on the ship. Located in the same general area as the bilge keels, they extend fore and aft only a few feet. Their length away from the ship however, may be several feet. Generally designed for a certain average ship's speed, their effectiveness increases at higher speeds but at lower speeds tapers off rapidly. Many British ships are stabilized by the Denny-Brown "activated fin" system.



Figures 2a and 2b

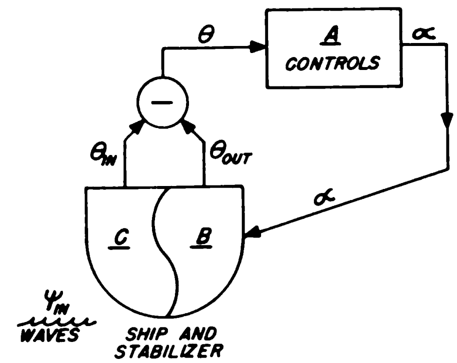


Figure 2a. Properties of automatically controlled, stabilized ship as a closed loop servomechanism: sequence of events that would occur if measurement of ship's roll were used to position stabilizing device. Waveslope χ in acts on unstabilized (passive) ship C and produces roll angle θ_{in}. θ_{in} is measured by roll detector which feeds the information to controls A. Controls position stabilizing device to some angle α. Stabilizing device produces torque on the Ship B (active ship) which, if produced in calm water with no waves, would cause the ship to roll to the angle θ_{out}. Difference between θ_{in} and θ_{out} is what the roll detector actually measures. In typical systems the angle $\theta = \theta_{in} - \theta_{out}$ is designated as the "error" angle. In such a system it is necessary to tolerate a finite error, however small, to have sufficient signal to actuate the controls. Figure 2b. 2a redrawn. There is no change except in appearance; ship and stabilizer are now pictured as one inseparable device. θ_{in} and θ_{out} are clearly hypothetical angles, real only if one measures motion due to waves alone or due to stabilizer alone.

These, then, are the high spots of anti-roll ship stabilization history. It can be said, without exaggeration, that prior to World War II no attempt at ship stabilization was made in which the dynamic behavior of the force-producing elements and the controls thereof were sufficiently understood to enable the designer to predict system performance and to design high-performance systems. This situation no longer prevails.

After the war the U. S. Navy undertook support of research on ship stabilization at Stanford University. Particular emphasis has been given there to activated tanks and activated fins, but studies have also been made of all other possible means for producing anti-rolling forces on ships. In this article we are merely trying to provide background material based on our research, indicate some of the problems involved, and state what we believe may be achieved in anti-roll stabilization in the immediate future.

Actually, a ship stabilized with an active system is a servomechanism—that is, it is a system in which a small amount of power produced by a sensing element is used to control the large amount of power required by the stabilizing element. Figure 2 is a block diagram of an automatically controlled stabilized ship and illustrates its properties as a closed-loop servomechanism. In the language of servo theory, the blocks labeled A, B and C are designated transfer-response functions. They describe in mathematical terms the dynamic behavior of the elements which they represent. If one knows these functions it is possible to predict the performance of the system in response to wave forces.

The problem has been set up in very general terms which are applicable to all types of stabilization systems. It will now be appropriate to discuss the nature of the basic elements in any stabilization system, which can be divided into three fairly distinct categories: (1) the forcing function, in this case the waves, (2) the ship and stabilizing element, and (3) the control elements which govern the stabilizing element.

Obviously the waves, with which the stabilization system must contend, are a given element in the problem which can be measured but not changed. The slope of the wave and its frequency determine how much the ship will roll. Anyone who has watched enormous seas crashing will probably be surprised to learn that effective waveslopes seldom exceed 10 degrees even in severe storms. The frequencies of significant waves lie between 0.03 - 1 cps.

Actually the slope of a wave as measured in the open sea is not the slope which is effective in rolling a ship, for there are various modifying factors. Wave action decreases with depth, low-frequency waves dying out less rapidly than high-frequency waves. In addition the course, speed and size of a ship all result in modifying factors. Considering all these factors, it would be unusual to encounter effective waveslopes greater than 5-7 degrees. A typical distribution of effective waveslopes is shown in Figure 3. Since the stabilization-system design is based on expected waveslopes it is unfortunate that available data are not more complete; nevertheless, for ships of destroyer size, a reasonable maximum estimate of 6 degrees should enable complete stabilization in all but the most severe storms.

In considering the waveslopes in relation to the second basic element—the ship and stabilizing system—it is important to remember that a vessel subjected to wave forces behaves much like a pendulum. This means that ships in seas with wave periods corresponding to the ship's resonant frequency will roll to 5 to 15 times greater angles than if subjected to waves of the same magnitude but of appreciably lower or higher frequencies. Figure 4 shows how waves of the same height but different frequencies affect the rolling of a typical ship. This type of presentation is known as the "frequency response" of the ship.

To stabilize a ship completely it is necessary to exert on it at all time forces equal and opposite to those produced by the waves. The fact that a stabilizer has sufficient capacity is not enough. The stabilizing torque must always be exactly opposite to the wave torque. It follows that a roll stabilizer which can cause a ship to roll at large angles in still water is not necessarily efficient—a point which has not been clearly understood in the past.

Of the various stabilizing systems only the two most interesting —those involving tanks and fins—will be discussed further.

Prior to World War II, the theory governing the dynamic behavior of a ship fitted with a set of U-tube-type anti-rolling tanks was not complete. As a result of intensive effort at Stanford, both theoretical and experimental, tank systems with cross ducts are now well understood and their behavior with any arbitrary set of controls can be predicted. This was demonstrated by experiments (Figures 5 and 6) with a 1/5 dynamically scaled model of the World War I destroyer, USS HAMILTON, the same model Minorsky used in his original experiments in 1938. The control system on this model is far from ideal, yet the results shown in Figure 5 indicate two encouraging things: How well one can do with even crude controls and how closely one can predict system performance. Note that, for passive operation, effective stabilization is obtained near the ship's resonant frequency but that above and below resonance the ship rolls more heavily than when it is unstabilized. This is typical of passive systems depending on resonance phenomena. The residual rolling of the ship with active stabilization is shown by Curve (3). An accelerometer was the only roll-sensing element used in this case. Note that the rolling increases at the higher frequencies, because of uncompensated time lags in the controls. Adding compensation results in Curve (4 The solid curves in all cases

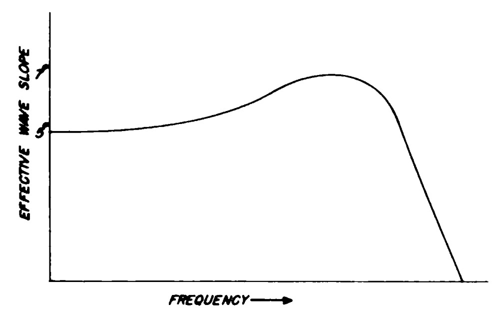


Figure 3. Typical distribution of effective waveslopes vs. frequency.

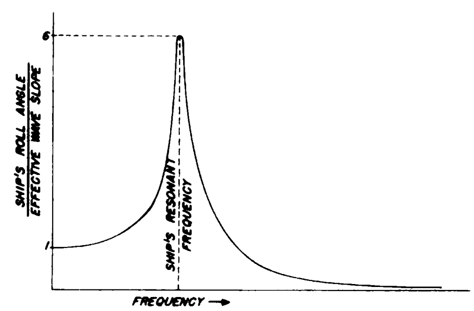


Figure 4. Rolling of ship subjected to waves of same height but varying frequencies.

represent theoretical calculations. The points shown are experimental. Clearly, the two agree very well. Figure 7 shows the remarkable reduction in rolling which can be attained by using combinations of position, velocity and acceleration control.

With the use of about 3 percent of a typical Navy ship's displacement in stabilizing fluid, one could stabilize the ship to roll no more than 1/4 of the forcing waveslope except under extreme sea conditions. However, in a good percentage of naval vessels, wing tanks which generally contain fuel oil already exist. If existing tanks and fluid can be utilized, the weight which must be added for effective stabilization is small.

It is possible for a ship to roll heavily in fairly small waves if, because of its course and the speed and frequency of the waves, it approaches synchronism with the waves. Under such conditions, waveslopes of 4 degrees could easily cause the unstabilized ship to roll 20 degrees. With stabilization, this same ship would roll not more than 1 degree. Numbers like this are entirely feasible; it is now possible to engineer tank systems to achieve this performance.

Unlike passive tanks, passive fins do not have a resonant or "tuned", stabilizing action; they simply add to the damping of the ship. Within the range of its capacity, each fin produces a force (and hence a pair of fins, one on each side, produces a torque) essentially proportional to its angle of attack. Because this torque is also proportional to the square of the ship's speed, fins are not very effective at low speeds. In fact, for installations of practical size they would be essentially useless below five knots, and really effective only above ten knots. This, however, is within the range of the usual operating speeds of naval vessels. Fins have an advantage over tanks of requiring a minimum of weight and space.

Active fins have a particularly interesting behavior. The effect of an active-fin stabilizing system is to provide, in one ship, what amounts to an "infinity" of ships! Depending on the type of control used, it is possible to vary over a wide range the apparent inertia, damping, and restoring parameters of a given ship.

This is not pure speculation for it has been shown that this is the way a fin stabilizer actually works! In fact, completely analogous methods are now being used in aviation research to provide aircraft with controllable parameters. A high-performance fin stabilization system on a given ship can therefore be used not only for practical reduction of roll, but also as a research tool, whereby the characteristics of ships with various parameters can be compared.

Figure 8 shows typical frequency-response curves for a ship with an activated fin stabilizer. Curve 1 shows the response of the unstabilized ship. Curve 2 shows the effect of controlling fin angle by roll-velocity signal alone. This simply increases the apparent damping. Curve 3 shows the expected stabilization using all three roll signals to control the fin angle. It might seem that one could make the stabilization as complete as one desired by simply increasing the gain of the control system <u>ad infinitum</u>. However, small but inevitable time lags in actual control systems put a finite limit on this control gain. Curve 3 represents a degree of stabilization which can be achieved without excessive difficulty.

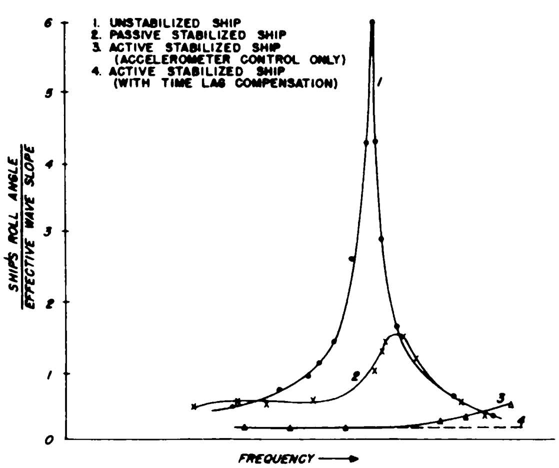


Figure 5. Performance curves of tank stabilized model ship.

Whatever the type of stabilizing system, its success in large measure depends upon the controls used. Unfortunately, until recent times, most people working on ship stabilization have been primarily concerned with stabilizing devices, rather than with the controls for these devices. In the early days of ship stabilization, a formal science of control simply did not exist, and even as elegant and powerful theories were developed, they somehow failed to be car-

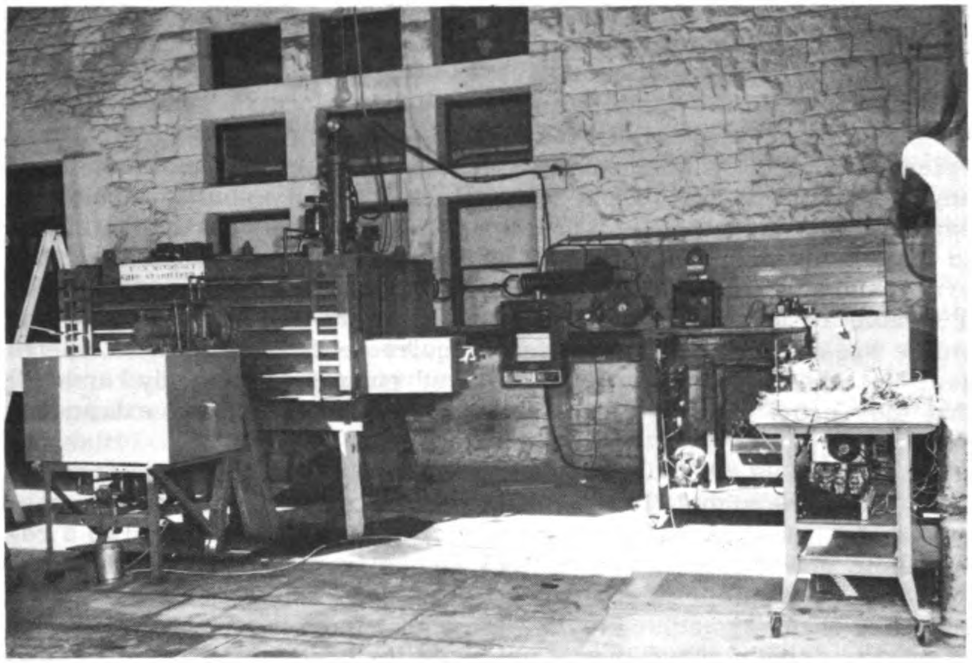


Figure 6. Five-ton ship stabilizer model used by Minorsky in 1938 and more recently by Stanford.

ried over into the ship-stabilization art. Most of the difficulties that designers of active ship-stabilization systems have had in the past can be attributed to this lack of knowledge of controls. An important function of the Stanford University program has been to emphasize and illustrate the use of modern servo theory methods in ship stabilization design.

The sole function of the controls is to assure that the forces produced by the stabilizing device are produced at the right time. The control system measures the ship's roll, roll velocity, roll acceleration, waveslope, speed, or whatever is required and uses the information obtained to position the stabilizing device. The stabilizer reduces the roll to some minimum angle, determined by such factors as the sensitivity of the sensing elements, and the capacity of the system, all of which vary with the frequency of the forcing waves.

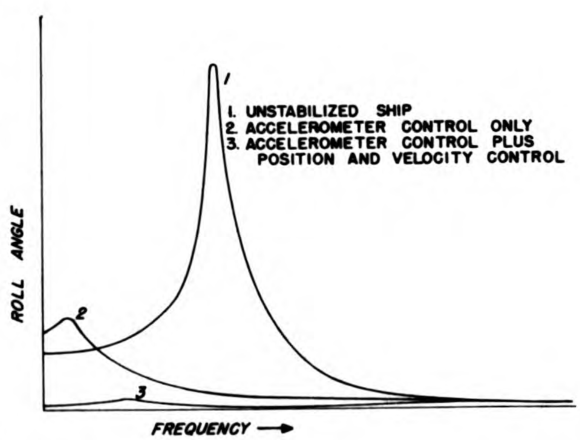


Figure 7. Synthesized performance of tank stabilized ship.

Since automatic controls replace manual control, one might expect such controls to have features analogous to those of the human being replaced. The three basic elements of the control system—the sensing elements, the control amplifier, and the positioning motor—are, in fact, roughly analogous to the sensory apparatus, the brain, and the muscles of a human being.

Assume that the stabilizing device is to be controlled proportional to three functions of roll (i. e., roll angle, roll velocity, and roll acceleration). This signal could be generated either by measuring roll angle only and deriving from it the other quantities, or by measuring each quantity directly. For practical purposes it is usually preferable to make a direct measurement of each quantity, which means that several sensing elements are required. In some cases it may also be desirable to use sensing elements to measure the waveslope or the ship's speed. The most important requirements of sensing elements are: (1) that they measure the desired quantity accurately; and (2) that they provide a "clean" signal, i. e., one free from extraneous noise.

Since the signals from sensing elements are usually quite weak, the first function of the control amplifier is to boost the signal to a respectable power level. The control amplifier may also contain some kind of a computer or compensating device, which "improves" the response of the system. Finally, the signal from the control amplifier is used to drive a servo-motor which, in turn, positions some critical part of the stabilizing device (e. g., in stabilization by fins the servomotor controls the angle of attack of the fins). The significant lags in the control system response are likely to be due to this positioning motor, but these lags may be taken into account in the design of the control amplifier circuits and partially compensated for.

The over-all problem in control design is to find that control system which most nearly complements the response of the ship and stabilizing device. An empirical approach to this problem is not satisfactory. There are simply too many variables, both in the controlled elements and in the controls. Moreover, an empirical approach requires excessive and usually costly experimentation, and in the end there is no assurance that a markedly superior system might not still be possible.

For example, a general theory (such as developed at Stanford) not only shows that roll acceleration should be the primary signal for stabilization by tanks, but it also shows that by using the three signals previously described, one can obtain performance markedly superior to that possible using any one of these signals alone.

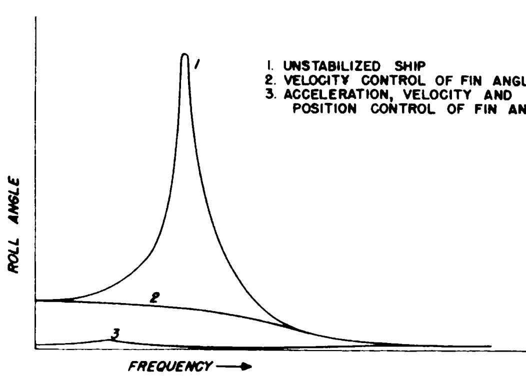


Figure 8. Performance curves of fin stabilized ship.

It is possible to synthesize a high-performance control system if, and only if, the dynamic behavior of the controlled elements is well understood. Once this is accomplished one can then design for maximum performance, and at the same time avoid the parasitic oscillation or "hunting" which is the bugaboo of an automatic control system. This design can be achieved in large part by inexpensive tests of components, and by mathematical analysis and synthesis, rather than by costly and unsatisfactory ship trials. Not only is the control problem sufficiently understood so that important advances can now be made in the design of ship-stabilization systems, but to a considerable extent high-performance components suitable for ship-stabilization control systems are already available, and do not require costly development programs.

If roll reduction has been important in the past, it is even more so now, as naval requirements become more stringent. As our ships become faster, and as the accuracy required of their radars, sonars, and guns increases, stabilization ceases to be a luxury and becomes a necessity. Commercial ships also must increase their speeds and efficiencies if they are to continue to compete with the plane, the truck, and the railroad. Stabilization has a part to play here also.

The modern development of the control art has vastly increased the possibilities of the active or controlled variety of stabilizer; for most applications the active systems are now more suitable than their passive counterparts.

It is probable that ship stabilization is about to come of age. Certainly high-performance stabilization systems can be attained now. We believe that a new era in ocean travel awaits the initiative of the shipbuilding industry.

ONR-Sponsored Magnetism Conference Held

Some 48 papers by distinguished foreign and American scientists were presented at the ONR-sponsored Washington Conference on Magnetism, held 2-6 September at the University of Maryland. The conference was the first in this country to be devoted entirely to fundamental research in magnetism.

Both review papers and the results of recent work were presented in the ten sessions, which were titled: The Magnetization Curve, Ferrites, Neutron Diffraction and Atomic Moments, Magneto-elastic and Magneto-electric Effects, Paramagnetism, Symposium on Exchange, Ferro-Magnetic Resonance, Paramagnetic Resonance, Fine Particles and Permanent Magnets, and Anti-Ferromagnetism.

One feature of the conference made it unusual in a very useful way. The lecture hall, dining room, and sleeping quarters provided for those who attended were all located near one another on the University of Maryland campus. Thus for a few days a select community of specialists was created. The close associations encouraged by these arrangements offered a genuine opportunity for both young scientists and their more experienced colleagues to become acquainted and readily exchange ideas with leaders in various areas in the field of magnetism.

Pilots Away!

by
LT R. W. Dibling
Special Devices Center

Back in 1946 a small aircraft was flying over a water area someplace between New York and Washington, D. C. At the controls on the pilot's side was RADM (then CAPT) Luis de Florez. The co-pilot was LCDR (then LT) Robert Wingfield. All at once Admiral de Florez verbally exploded, "Boom!" Wingfield had heard that the "Old Man" might be somewhat unusual in his actions and thought perhaps Admiral de Florez had flipped his lid. He was all ready to take over the controls, when the Admiral began an explanation. "What we need," he told Wingfield, "is a seat in an aircraft that will fire a man, just like out of a gun, for the fast-flying aircraft." An idea was thereby born which bore fruit only recently in the form of the seat ejector for jet aircraft, and a trainer for such a device.

The Special Devices Center has a long record of developing such devices, which have been of incalculable value in saving lives. The Center forms the liaison between Navy men and Navy research; here men are trained to use the latest products of laborious research and development programs. The largest training program is the one in aviation, in which all kinds of gadgets are used to simulate closely the operational characteristics of aircraft. Thus pilot and crew may learn their jobs without actually encountering hazardous flight situations before they have acquired adequate experience. The ejection seat trainer is one of these life-saving gadgets.

The trainer consists of a cockpit mock-up with a geared track mounted upon it. The seat in the cockpit is situated over a black powder charge which explodes and sends the seat up the track for distances of as much as fifteen feet. The current practice charge is sufficient to give a 9G acceleration (i. e., 9 times the acceleration of gravity) to the subject in the seat, but if it were a full charge it could give as much as an 18G acceleration.

Along the sides of the cockpit mock-up are hinged extensions so that if the pilot, during ejection, has his elbows out, the sides are moved and a buzzer sounds to indicate that something is wrong. This is essential, for in an actual "firing", the pilot's elbows could be broken from a faulty ejection.

Within the cockpit, prior to the explosion, the pilot must act just as he would in the actual aircraft. He must release his oxygen mask

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LT R. W. Dibling, who serves as co-ordinator of officer training and public information officer of SDC, is a graduate of the U. S. Naval Academy. After service on the USS COTTEN, the FRESNO and the NORTH CAROLINA, he returned to civilian life as administrative assistant in a research laboratory run by the Standard Oil and Atlantic Refining Cos. Recalled to active duty in 1949, he edited Our Navy until assigned to his present post.

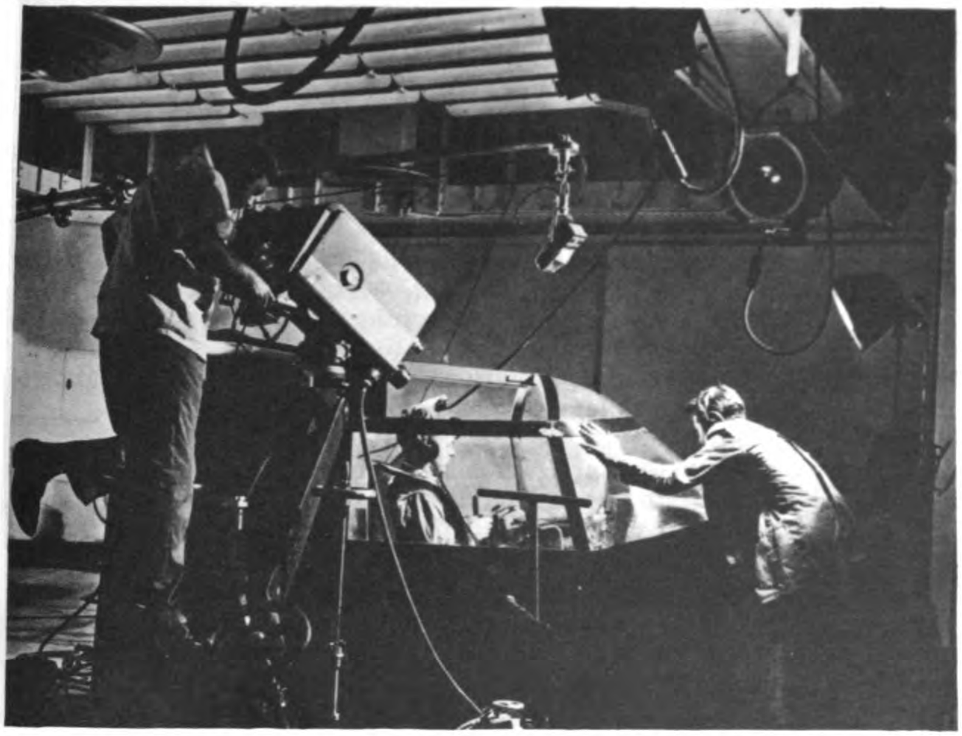

Figure 1. Another phase of aviation training at SDC: Telecast demonstration in a mock-up of a P2V aircraft.

connection, place his feet in stirrups designed to help close the circuit, and pull a hood over his face (the high speeds of today's jet aircraft could conceivably result in a wind force sufficient to tear the flesh away from his bones).

The whole procedure must be followed through correctly and chronologically or buzzers sound indicating errors. Lights on the outside front of the mock-up cockpit indicate the pilot's compliance with each of the procedures required in the trainer, and then the instructor closes a switch which fires the seat into the air. Braking begins immediately and the car stops before it reaches the end of the rails.

The use of the ejection seat trainer is carefully controlled. Navy doctors make certain that persons ejected have had no spinal or heart trouble, for the ejection seat could be dangerous to someone suffering from either of these ailments. Naturally, the Navy's pilots are supposed to be in perfect health so they are good subjects for the trainer. In addition, they are the most likely individuals to be using such a bail-out procedure, so they should know and use the trainer.

This ejection seat trainer is not only used by the Navy, incidentally, but also by the Air Force.

Quonset Point, R.I., is one Navy installation which is finding the seat ejection trainer extremely valuable. Pilots are eager to try the equipment, not only to learn the procedure, but also to get the feel of ejection. One hope is that the trainer will overcome the pilots' possible fears of ejection. Apparently it will do just that.

The Healing of Wounds

by
John A. Schilling
University of Rochester

The very existence of the animal kingdom, including man, is dependent upon the healing of wounds. A wound may be defined as an injury (or trauma) to any of the tissues of the body, with or without loss of continuity—i. e., severance of tissue. Healing implies repair of this tissue with restoration of continuity when it has been lost. Healing of wounds is as essential biologically as reproduction and growth.

Wound healing is similar in many respects to the inflammatory response of the body to bacterial infection. Startling as it may seem, it is obvious upon careful thought that bacteria injure tissue; that all wounds, no matter how cleanly made, are bacterially contaminated; and that the body's response to local infection may involve many of the same mechanisms of repair. There are also many similarities between wound healing and cancer, except that one is an orderly, controlled process and the other an uncontrolled mechanism leading to death. Thirdly, there are many factors common to the body's general response to a major wound and infectious or metabolic diseases. Finally, wound healing seems to have priority on the existing biological reserves of the animal or man.

The nature of a wound can be better understood by observing, either with the naked eye or through the microscope, the local changes that occur during healing. First bleeding must stop, and this involves such basic mechanisms as clotting of blood inside and outside of the severed vessel, retraction of the vessel with narrowing of its lumen, local tissue pressure, and sometimes reduction of blood pressure. Obviously this can be materially assisted surgically by pressure or ligature or both.

Shortly after this initial period there is capillary dilatation which allows these small blood vessels to be permeated by certain substances essential in the healing process. These are: fibrinogen (a fibrin-forming protein formed during coagulation), antibodies (chemicals which combat bacteria), plasma proteins, white blood cells and many other known and unknown ions and substances. Thus during the first few hours the wound

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is filled with a blood clot of varying magnitude containing a fibrin network, white cells, and serum. Unfortunately such a clot is an ideal medium for the growth of bacteria. Consequently at this stage a very critical struggle occurs between the contaminating bacteria and the host. The outcome depends on the number and virulence of the bacteria and the resistance of the host. If the body overcomes the bacterial invaders, the normal processes of repair begin immediately. Otherwise, the bacteria destroy by infection an area much greater than the wound itself and sometimes endanger life. Here medical assistance can perform invaluable services by removing heavily contaminated injured tissue, the blood clot, and foreign material; by controlling hemorrhage; by sewing up injured tissues; and by administering blood and anti-bacterial agents.

The repair of wounds varies somewhat with the type of tissue injured. Some cells (skin, mucous membranes, the lining of blood vessels, liver, and certain nerve fibers) are capable of regeneration. That is, similar tissue is completely re-formed or regenerated to take the place of that which was damaged. In other cases healing is accomplished by a binding together of the injured parts with fibrous tissue arising from the fibroblast, a primitive cell existing in almost every area of the body except certain portions of the brain and eye. Ordinarily wounds are repaired in their deeper portions by fibrosis and covered superficially by regeneration of the skin or mucous membranes. Following a lag period of about 24 to 36 hours after the wound is inflicted, there is a multiplication of young fibroblasts and small capillaries at the edge of the wound. These new fibroblasts and capillaries are called granulation tissue and occur in every wound, ultimately filling the space between the wound edges or in the wound cavity.

Following the lag phase, the fibroblasts increase at a rapid rate during the next 7-10 days, increasing greatly the strength of the wound, which reaches its maximum toughness in the period from 14 to 18 days after it was inflicted. During this time the new fibroblasts are laying down a ground substance of tough fibers called collagen. Unfortunately these fibers affect the extent of the scar and sometimes cause a contracture or tightening of the skin that necessitates surgical correction. Obviously the smaller and cleaner the wound, the less granulation tissue, fibrosis, scarring, contracture, or adhesion there will be. After two weeks the activity of the fibroblasts slows down, skin by regeneration covers the surface, and slowly the capillaries are squeezed out by the collagen fibers, ultimately changing the red scar to white. Thus wound healing consists of an initial lag phase, when the host is mobilizing his reserves and overcoming the immediate shock of the injury; a phase of increasing regeneration of the cells essential to repair, accompanied by strengthening of the wound; and finally, a period of waning activity when repair is completed and when contraction of scar tissue occurs.

The healing process seems to have priority on the nutritional stores and reserves of the animal and involves local as well as general body components. Nothing is known to date that will accelerate these normal mechanisms significantly; many things are known, however, that will slow them down. The most important inhibiting factor is infection. Another is lack of Vitamin C, which prevents the formation of the ground substance and collagen from fibroblasts. Lack of adequate body proteins, particularly those containing the sulfur amino acids, also deters healing and renders the host much more vulnerable to infection. Local factors—foreign body contamination, dead tissue, blood clots, poor joining (approximation) of tissue, excessive tissue tension, and poor blood supply to the area—may hinder healing by facilitating infection or interrupting the supply of key substances from other parts of the body.

Any study of wound healing necessitates the establishment of a "standard" wound and standard methods of observation. Studies of the phenomena of wound healing, of wound closure or tensile strength, of the biochemistry of wound and body fluids, and of metabolism are then made. Since the bodily influences on a wound are numerous and complex, some of the cells important in healing often are transferred to tissue cultures where external conditions may be controlled.

Various types of wounds have been used in the past, but two types have been employed most frequently. The first is simple excision or removal of a known area of skin and underlying tissue; the rate of closure can be ascertained each day by any of a number of methods. Tissue paper tracings or photographs are commonly employed and a special instrument, a planimeter, gives a measurement of area. Wound diameter too can be measured. The open wound unfortunately is subject to infection. The advantage of this type of wound, however, is that it allows measurement of the total healing curve in a wound in one animal. Thus fewer animals are needed.

The second type of wound is a simple incision and closure by suture of skin and subcutaneous tissue, the abdominal wall, or a hollow organ like the stomach. The bursting or tensile strength of the wound is measured by direct pull, by air pressure in the peritoneal cavity or hollow viscus, or by direct air pressure in a rubber balloon placed under the wound or inside the body cavity. It is assumed that the tensile strength is directly proportional to the rate of wound healing and therefore provides a good index of the entire process. The disadvantage of this type of wound is that a larger number of animals is needed, direct observations are impossible, and the dynamics of wound healing in any one animal cannot be observed. The great advantage is the absence of gross infection.

Besides "standard" wounds, other approaches are used to study various aspects of healing. Transparent chambers have been used to observe the growth rate of capillary buds and granulation tissue. Fractures have been employed where the strength of the healing bone is an index of the total process. Microscopic studies using special stains have afforded an excellent insight into the cellular changes described earlier. Chemical studies of local changes in Vitamin C levels, electrolytes, protein concentrations, and pH have been or are being carried out. Radioactive tracers, particularly phosphorous, sulfur, and strontium, have been used in the hope that they will give an index of metabolic activity. The effect of the wound on metabolism and the effect of metabolism on the wound have been studied. Other factors—the effects of age and anemia—have been investigated and recently there has been a revival of interest in hormones. Local cellular enzyme systems are now being studied and may throw additional light on the process. Finally the effect of the deprivation or excess of essential substances like vitamins

Figure 1. Standard excised wound extending through rat muscle.

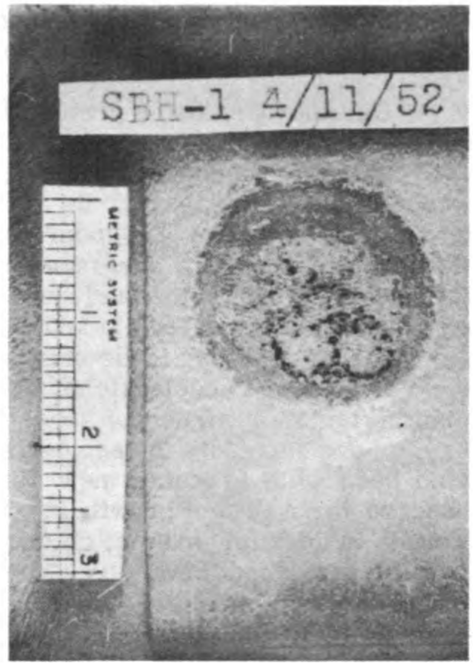

Figure 2. Standard burn produced by a carbon arc.

and amino acids are being studied. Thus many approaches have been used, though it must be confessed that collectively they have but scratched the surface of the remarkable phenomenon of wound healing.

A word about experimental animals. Such basic studies would be impossible without their use and almost all types have been employed. Wound healing proceeds according to a pattern, similar not only in all types of wounds, but also in all animals. In the more primitive type of organism, regeneration is more prominent than in the warm-blooded animal. The small animals, such as the rat and guinea pig, have been experimental favorites. The latter has been quite useful, for it resembles man in that it does not synthesize Vitamin C. The dog is preferable in almost every other respect, however, but is more expensive to use in large numbers. Care must be taken in applying to man the data from such studies, particularly those employing herbivorous animals, because species differences may invalidate conclusions. On the other hand,

Figure 3. Method of photography of standard wounds and burns

the remarkable similarities of wound healing throughout the animal kingdom make possible direct application of many experimental studies to man.

Our approach to the problem has been the establishment of a standard excised wound (Figure 1), with observation of the rate of closure every third or second day. This was accomplished by photographing the wound and then measuring its area with a planimeter (Figure 3). We have also been using a standard burn (Figure 2) as a standard wound, though its observation and measurement are more difficult because of the eschar (scab) on the surface. More recently we have been gathering observations on the tensile and bursting strengths of wounds (Figures 4 and 5). In utilizing these standard wounds we are searching for substances that will accelerate or decelerate the rate of healing. By implanting tantalum wire-mesh spheres or cylinders subcutaneously (Figure 6), we have been able to secure tissue fluid with great facility. We have also been able to obtain new fibroblasts for tissue culture, and to observe their rate of growth into the mesh. We have analyzed muscle wounds in dogs for sodium, chloride, potassium, and phosphorous content and compared the findings with normal muscle in the same and control animals.

One of the results of our work has been the establishment of a curve for the closure of an excised superficial wound that is statistically valid (Figure 7). While making this study we found that whole body radiation, up to amounts that are lethal (650R), does not delay wound closure in rats. This seems particularly important, as wounds incurred during an atomic explosion may be and should be repaired as early as possible. Wound closure is slowed by the administration of ethionine, an antagonist to the essential amino acid, methionine, and aureomycin. In each instance, however, the pathological studies showed severe liver damage caused by the drug, and this organ must be intact for adequate wound healing. Such drugs as thiouracil, thyroxin, the growth hormone papain, and trypsin had little effect on wound closure. Phenyllactic acid seemed to stimulate wound closure in the rat and this may be related to the metabolism of the essential Vitamin C.

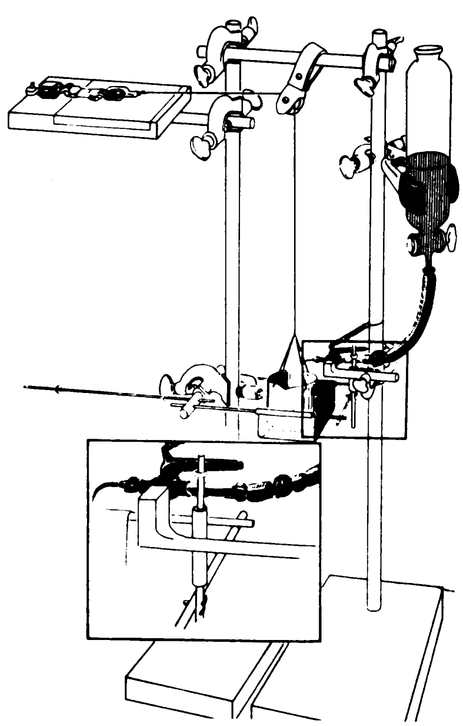

Figure 4. Diagram of apparatus for determining wound tensile strength.

Electrolyte changes in healing wounds follow a consistent pattern. Sodium and chloride are significantly increased in amount at the site of the wound with an increase in wetness which is mostly extracellular water at the expense of the intracellular water. Potassium and phosphorous are decreased at the site of the wound, indicating cellular damage and loss of intracellular ions. In extensive wounds these changes must be compensated for, either from other parts of the body or by judicious administration of salt and water. As far as the wound itself is concerned, administration of large amounts of sodium chloride or adrenocorticotrophic (ACTH) hormone or both, has little effect.

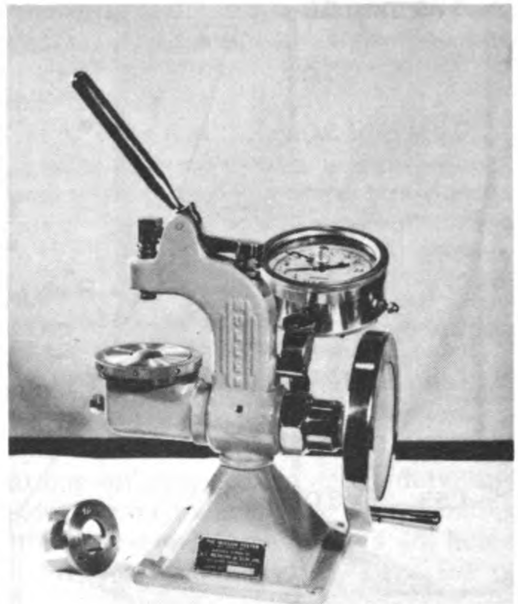

Figure 5. The Mullen paper tester, used to determine bursting strengths of standard wounds and burns.

Early studies with subcutaneous implantation of tantalum mesh spheres or cylinders revealed that there was an explosive outburst of fibroblastic activity after a lag period of about 24 to 36 hours. When these new fibroblasts were transferred to tissue culture they had a growth potential equal to that of a cancer or embryonic tissue, compared to the normal, unstimulated, sluggish fibroblast. The behavior of the fibroblast in tissue culture was very similar to its behavior in and around the mesh. ACTH had very little, if any, effect and cortisone had none. Of particular interest, however, is the observation that ACTH plus Vitamin C caused the greatest fibroblastic response in the guinea pig. The tissue juice secured from within the meshes had a very definite growth-stimulating effect on adult sluggish fibroblasts in tissue culture. This effect is lost after the fluid remains in the ice box for a period of a few days but it is regained when Vitamin C is added. Thus, Vitamin C under these experimental conditions must potentiate some key substance in this wound serum in the proliferation of fibroblasts. Preliminary studies of Vitamin C concentrations in the wound serum from within the mesh chambers indicates that there may be a definite relation of Vitamin C concentration to the dynamics of wound healing. The practical implication of this phase of our work is that Vitamin C (as well as the sulfur-containing amino acids) therefore should be given in adequate amounts to the injured or surgical patient.

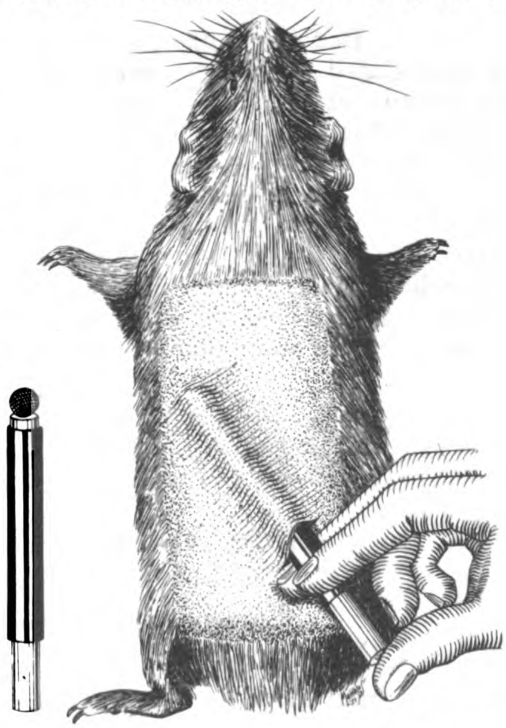

Figure 6. Method of implanting tantalum wire mesh spheres or cylinders

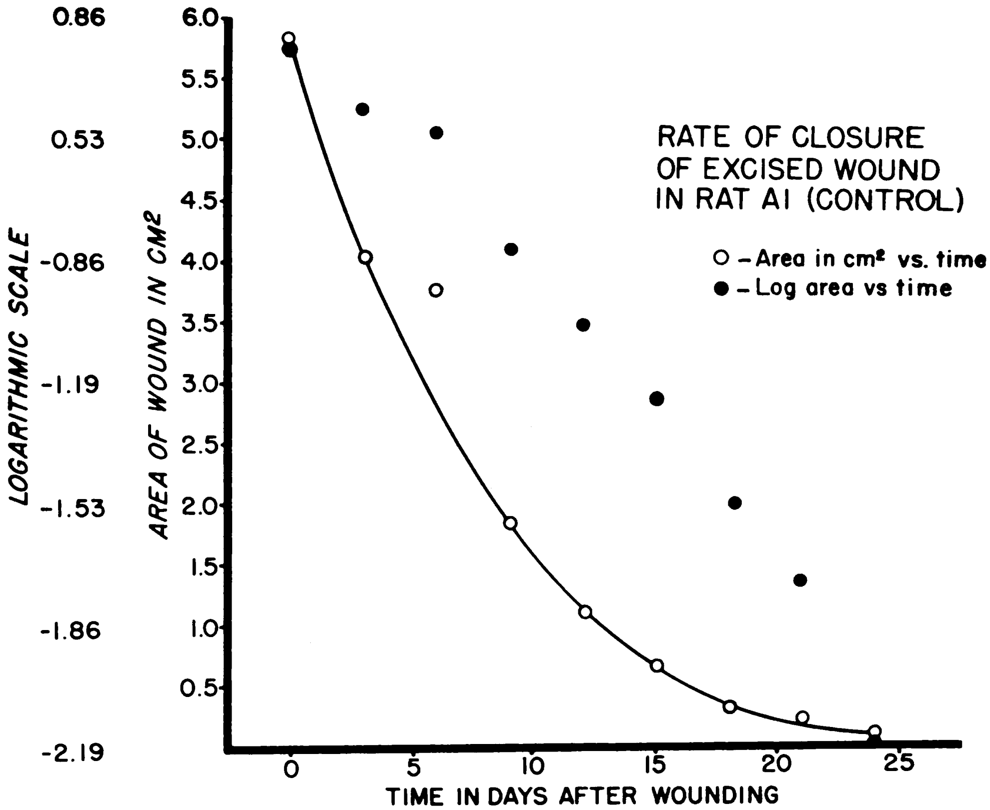

Figure 7. Healing curve for wound closure in rats used as a standard of reference for experimental observations.

Our findings to date, some of which are only preliminary, must be substantiated during the next year by further experiments employing slightly different methods and utilizing, if possible, a burn as a standard wound. Healing is a complex biologic process, and we do not expect to find any shortcuts to understanding it. Only by piecing together facts from many painstaking experiments will we be able to get a complete picture—and that will probably take a long time. In the process, however, it is likely that important basic facts about body chemistry will be revealed. Thus studies of wound healing will contribute not only to the solution of the specific medical problem of repairing injuries but also to advances in many other fields of medicine.

They Weren't Flying Saucers!

If you happened to see them, the 37-foot "disks" drifting eastward from Tillamook, Ore., were balloons built and launched late in August, by General Mills, Inc. under an ONR contract. They carried some NRL radio equipment and were a part of a series of experiments on atmospheric radio-wave propagation.

Who's Who in Naval Research

In this day of "specialists", CAPT Edwin Otto Wagner exemplifies the Old Navy tradition that a line naval officer can do anything. Certainly he has had almost every kind of duty the Fleet has to offer—seaman, torpedo officer, gunnery officer, naval aviator, operations officer, development duty, instruction duty, air-group commander, carrier exec and commanding officer of a seaplane tender. Now this still-young officer (he's 46) holds down one of the critical captain's billets of the Service: Director of ONR's Naval Sciences Division.

Unlike most of the senior officers at 17th and Constitution Avenue, CAPT Wagner has had no formal scientific schooling. He hails from Brooklyn and "ran away to sea", joining the Navy as a boot seaman when he was just 18. Two years later he earned a from-the-ranks appointment to the Naval Academy and graduated in the Class of 1930. He became a naval aviator after "checking out" in battleships, cruisers and destroyers.

CAPT Wagner entered the research and development field in 1938 as Assistant Superintendent and test pilot of the Aeronautical Engine Laboratory, Naval Aircraft Factory. He commanded the first squadron (VP63), completely equipped with magnetic airborne detector and retro bombing, and developed installation procedures and tactical doctrine for this system.

Typically, the outbreak of World War II found him serving as Assistant Naval Attache and Naval Attache for Air, and as an observer and flight instructor with the Royal Air Force in England. Later on he was Assistant Operations Officer and Group Commander of Fleet Air Wing Seven.

In early 1944 CAPT (then Commander) Wagner got his second assignment in the research and development field as Officer-in-charge of the Aircraft Division, Anti-Submarine Development Detachment, Atlantic Fleet. He took hold of that job with the same hearty self-confidence he does everything else, and came out with a Bronze Star Medal. This was followed by a tour as Exec of the LEXINGTON.

By the time the war was over, Wagner had won his captaincy (temporary) and was sold on the importance of "R and D". Accordingly, when he heard that an Office of Research and Inventions had been formed he asked for assignment and was put in charge of the Inventions Section. Then—in 1946—he set up the Air Branch of that Office and was its first Head. Following this he was Chief Staff Officer to Commander Fleet Air Wing Eleven, after which he commanded the seaplane tender USS TIMBALIER. He has been a permanent captain since 1949 and an ONR division director since January 1951.

CAPT Wagner obviously enjoys his job and enthusiastically believes in the strategic importance of the Naval Sciences Division's effort. After all, of ONR's seven research groups it stands much the closest to current naval development. Operationally, the Division acts as the recipient of new ideas—sometimes from civilians, sometimes from ONR's basic-research branches or from naval laboratories and sometimes self-generated. The fertile ideas are then given to contractors to implement, develop, or prove practical. Once an idea or gadget has reached an acceptable stage it is turned over to a bureau for translation into a weapon or piece of equipment or system.

"One can't," says Wagner, "have 'tunnel vision' in guiding research and development. You have to be able to see the big picture—what the Navy really needs versus what is just a good-looking waste of time and money to make a small improvement on last year's model of some gadget or black box." CAPT Wagner thinks that the Navy, scientists, and industry can do the job through effective teamwork. And he also thinks that many of the best ideas are going to come more and more from the officers and men of the Fleet itself.

The Captain and his wife, the former Miss Anne M. Wisloh of New York, live across the Potomac in Annandale, Virginia. They have two sons, Robert 17, and Frank 13.

NRL Develops Durable Lubricants

Operation of electric motors at higher temperatures with longer intervals between lubrications is promised as a result of a five-year cooperative Navy—and—industry program.

A study revealed that by using the new high-temperature lubricants, now commercially available, electric motors can be operated continuously at 150°C (300° F) and require relubrication only at intervals of between 500 and 1000 hours. Moreover, these intervals can be much longer if the motors are operated below that temperature for over 50 percent of the time. And still longer intervals between lubrications will be possible when the motor design changes indicated by the study have been made.

Research facilities of the Naval Research Laboratory of the Office of Naval Research were coupled with those of leading manufacturers in the program, which was organized and actively supported by the Bureau of Ships, under the leadership of Captains R. E. Cronin and Henry P. Walker. Dr. W. A. Zisman, of NRL, served as the coordinator for the program.

Nine newly developed greases were investigated and tested jointly by the cooperating members of the committee. Only the silicone-lithium soap greases originated by NRL were useful at 150° C for over 500 to 1000 hours of operation without regreasing.

Making Figures Tell the Truth

by
Neal Chilton
Columbia University

As research in medicine began to deal more and more with basic scientific problems, rather than with merely empirical phases, it was only natural for trained investigators to apply statistical methods in planning and analyzing their research. The great English scientist Francis Galton (1822-1907) became interested in the applications of mathematical statistics to biologic research about the time that his cousin, Charles Darwin, was elaborating his concepts of evolution. Thus Galton may be considered the founder of the science of biometry. Today, any competent medical researcher, either in the basic sciences or in clinical medicine, should have a sound background in statistical methods.

Just as medicine has made use of statistical methods in the design and analysis of research studies, so has dentistry. Unfortunately, however, while the mathematical basis of the statistical procedures applied to education, economics, psychology, medicine and dentistry is the same, special applications of these techniques are indicated in the different fields. Thus, certain problems in oral biologic research are actually special types of problems encountered in general biology and medicine. Only slight variations in procedure may be necessary, but, to the uninitiated, these slight differences may be great obstacles. Moreover, a number of statistical procedures can be readily copied and applied without an understanding of their use, so that unwarranted conclusions can be drawn.

Realizing all this, the Office of Naval Research undertook the support of a project to write a manual on the application of statistical methods to problems in dental research. The purpose was to develop statistical concepts in the design and analysis of experiments in dentistry for both the beginner and the established research worker. All illustrative problems were taken from the dental research literature or from unpublished data in the files of recognized workers in the field. The project was completed in 1951 and the resultant manual, "Analysis in Dental Research", is now awaiting publication.

As work on this manual progressed, it became obvious that there were a number of problems for which there had as yet been no definite application of statistical methodology. While some slight statistical

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approaches had been made to solving these problems, many elaborate experiments had been performed and statistical analyses applied which did not fully cull out the results of these studies.

One type of research in this category, with which most people are familiar, deals with the efficacy of different agents in controlling or preventing tooth decay (dental caries), a disease affecting about 97 percent of our American population. Many agents have been found which, in the laboratory, give high promise of helping to eradicate it. Since the commercial possibilities of such agents are tremendous, advertising pressures both on the public and on the profession are very great. The final proof of the relative importance of these different agents depends upon actual clinical trial in patients. The setting up of such clinical trials and the evaluation of results are, to a large extent, a problem of statistics. Yet a number of elaborate studies have been conducted and conclusions drawn without an understanding of the statistical problems involved.

One example of such research comes readily to mind. Dental caries in general attacks the teeth of younger individuals, becoming less severe with advancing years. Thus, a study which compares people without reference to age is not reliable. For example, if a 12-year-old who has, up to the time of the experiment, suffered two or three cavities a year, finds himself with no tooth decay over a long period while using a new dentifrice, the improvement may be significant. But if a man of 40, whose dentist has given him a clean bill of health for ten years, uses the new dental agent and continues to have sound teeth, it is difficult to find any meaningful indications in his good fortune.

Many workers have tallied the results of their clinical trials by adding together all of the newly decayed teeth in the treated and in the untreated groups, and compared these figures with the number of originally healthy teeth in each group. They have failed to realize that each patient ordinarily differs from other patients in susceptibility to decay, so that one cannot "pool" or add together all of the teeth in each group for final comparisons. For this reason it is necessary to record the caries status of each individual before and after the experimental period. With problems like these in mind, further research in the application of statistical methodology is now proceeding in order to present definite ways of designing and analyzing experiments on new decay-inhibiting agents.

Work is also proceeding on the design of animal experiments in which the median effective dose of different drugs can be assessed from repeated trials on the same animals. As part of these experiments, special experimental designs are being arranged so that complete randomization of the different treatments is obtained. This type of experiment has heretofore been widely used in agricultural research and the applications to oral biologic research are now being further studied.

For example, in a very small model experiment, the investigator may wish to study the effect of three concentrations of a drug on three guinea pigs. In order to rule out any bias and obtain complete randomization, each guinea pig should be used only once in a given run of the experiment and during this run, each guinea pig is assigned one of the three concentrations. Furthermore, the order in which the animals are utilized in any run is determined at random, with the restriction that each guinea pig occupy each order of testing only once. In order to do this, an experimental design known as a Graeco-Latin Square is used. This type of design has been used many times in field-plot experiments and has a number of possible applications in medical and dental research. In the following example letters represent different animals and subscript numerals represent different concentrations.

A Model Experiment Design

	Order of Testing 1	2	3
First Run:	B_3	A_1	C_2
Second Run:	A_2	C_3	B_1
Third Run:	C_1	B_2	A_3

This type of experimental design enables the investigator to analyze the variation in results caused by the different concentrations, the different order of giving these different concentrations, and the different reactions of the different animals, all from the one experiment. This is a great help in simplifying long and complicated studies, since such a design permits the study of all these factors at one time. The importance of giving the different concentrations in different order during each run is to enable one to measure what effect the sequence of drug administration (or "treatment" in general) has upon the results obtained. This is particularly important in studies where a tolerance to drugs or a learning effect may occur. Such an effect could conceivably produce a systematized scoring of the "treatments" depending upon whether the particular treatment occurred early or late in the sequence of testing. By some such scheme as the one illustrated here, each treatment is given an equal opportunity of occurring first, second or third in the order of testing. This is what is meant by "randomization."

A problem which is frequently faced by research workers is how many cases should be included in a particular experiment. As the investigator will often phrase the question: "How large a sample must I study to make my experiment mean something?" This is not a simple question to answer, since certain preliminary information is usually necessary before any estimate of sample size can be given. Although there are methods for estimating such sample size, they usually involve mathematical approaches which may not be familiar to the investigator. Efforts are therefore being made to devise simpler explanations of estimating sample size to assist the research worker in planning his experiments.

It is expected that studies like these on designs and analyses of experiments will assist research workers in the applied biologic phases of medicine and dentistry. Improved statistical methods will be a valuable tool for the scrupulous researcher who wants to know exactly what his figures mean and whether they can provide him with reliable conclusions. Such considerations can easily make the difference between a valid piece of research and a meaningless jumble of data.

ACKNOWLEDGEMENT

The advice and assistance of John W. Fertig, Ph.D., Professor of Biostatistics, School of Public Health of the Faculty of Medicine, Columbia University, is gratefully acknowledged.

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Experiments at Geomagnetic Zero

All through the month of August, nine naval officers and civilians, representing ONR projects, were at the North Geomagnetic Pole. The latter shifts around a bit from year to year, but at present it is at 78.5° N, 69.0° W—in Western Greenland, near Smith Sound. Led by LT M. S. Jones, USN, of the Nuclear Physics Branch, the scientists were flown up there to carry out cosmic-radiation observations.

A number of plastic high-altitude balloons were launched from naval vessels (of the 1952 Arctic Resupply Mission) cruising in Baffin Bay, Davis Strait and Kane Basin. The big balloons sometimes carried radiation-measuring instruments and telemetering equipment, and at others small rockets, or nuclear emulsion packets, or special photographic films. The payloads varied because a number of independent investigations were included in the series of flights. For instance, Dr. M. A. Swetnick (NYU) was interested in the neutron component of cosmic radiation, and Dr. James A. Van Allen (Iowa State) was using the rockets to measure the total charged primary cosmic-ray intensity. The Naval Research Laboratory, National Institutes of Health, Bartol Research Foundation, University of Rochester, University of Chicago and University of Minnesota were interested in similar experiments. The balloons were prepared and launched by General Mills, of Minneapolis.

At the geomagnetic pole,.the earth's magnetic field causes a minimum of deviation on the path of an incoming cosmic-ray particle, and therefore represents a minimum "cut-off" energy. If it is possible to get above an appreciable fraction of the earth's atmosphere at this location, it is possible to measure the energy and charge spectrum of the incoming primary cosmic radiation down to much lower energies than at any other place on earth.

On the Naval Research Reserve

Fifty Research Reservists to Participate in Brookhaven Seminar Opening October 19

Some fifty research reservists from the Eastern United States will have the opportunity next month of seeing some of the most unusual and up-to-date developments of this atomic age. For the first time the Brookhaven National Laboratory is opening its doors to members of the Volunteer Research Reserve for a 14-day seminar to begin there October 19 under the auspices of the Commandant Third Naval District.

One of the features at Brookhaven that will interest many reservists is the large cosmotron, the greatest power potential ever created by man. The officers will actually see this great accelerator in operation. Another interesting phase of the Brookhaven operations which they will have a chance to inspect is the 28-bed cancer hospital, where patients with the severest malignancies are treated by radical radiation therapy. Brookhaven is the only atomic energy center equipped to perform cancer research and remarkable progress has been made in treating the disease.

There are many other interesting sights at Brookhaven—a cyclotron, three Van der Graff accelerators, and physics, physiology, biology and health labs. The general plan of the seminar provides for lectures in the morning with actual practical demonstrations in the laboratories in the afternoon. Department heads and leading scientists of Brookhaven will participate in these activities.

VNRRU 3-9, located at Brookhaven and headed by CDR John S. Medd will arrange many details connected with the seminar. CDR Medd in civilian life is an administrative engineer in charge of cosmotron building construction at Brookhaven.

Training Duty Available on Mt. Washington, N. H.

Tired of routine training duty? Here's your chance to perform service that is not only different and adventurous, but also of great practical importance to the Armed Forces.

Though this may sound a little too much like a recruitment poster, there really is a good opportunity for reservists to participate in a very unusual project. The Naval Clothing Depot has some specially designed cold-weather clothing which it wants to test during the winter atop New Hampshire's frigid Mt. Washington (temperatures as low as -20°, winds up to 160 mph). Needless to say, the duty has not been popular. Moreover, some of the participants have not been very stout-hearted, in fact have been discovered in the bushes warming themselves over campfires. Others have been conscientious, but unable to evaluate the results of the tests. Personnel at the clothing depot have ascribed both the lack of conscientiousness and the inability to evaluate results to the fact that most of the human guinea pigs were not scientifically trained. Consequently the Depot sent some of its own personnel, but it cannot keep doing this indefinitely.

The situation has boiled down to this: The Clothing Depot would like to have five Research Reserve officers with the necessary technical qualifications for every two-week period from 1 January 1953 through April. These officers would report to the Clothing Depot, Brooklyn, receive instructions and proceed thence to the top of Mt. Washington. There they would install, regulate and operate the testing equipment and also serve as guinea pigs in the testing of clothing and other equipment.

The specialists needed for the testing are: physiologists, electrical engineers, mechanical engineers, physicists, textile engineers and psychiatrists. It is expected that these personnel will be able to make recommendations not only on the methods of testing human subjects, but also on the improvement and development of the equipment used.

The value of such service to the Armed Forces is too obvious to need explanation. Moreover, it provides training duty of an unusual type which should interest reservists tired of desk work. The successful completion of the project will not only aid the Clothing Depot immeasurably, but will reflect great credit on the Volunteer Research Reserve.

Distinguished Reservist on Retired List

"During the time you have so faithfully and efficiently served you have witnessed many advancements in the morale, strength, and efficiency of the Navy and you have the satisfaction of knowing that you have contributed materially to the accomplishment of these results." Thus reads the formal notification to George E. Bowman of his transfer to the retired list with the rank of Rear Admiral. A charter member of VNRRU 12-4 in Fresno City, Calif., RADM Bowman can look back on a colorful and distinguished naval career.

RADM Bowman enlisted in March 1918 as machinist's mate second class and was commissioned the same year. Honorably discharged in 1919, he reentered the service during the reorganization of the Reserve in 1921. In June 1941 he was recalled to active duty and was aboard the SARATOGA as engineering officer when the ship was torpedoed twice. After the second torpedoing RADM Bowman received the Silver Star for planning and supervising the installation of emergency electrical circuits which permitted the badly damaged ship to escape enemy action. Later the vessel was destroyed in atom bomb experiments at Bikini.

A secret foreign mission in 1943 took Bowman by air over The Hump into Kunming and thence into Chungking, China where for a year he was Commanding Officer of the Naval Reserve and on assignment to the former head of the Chinese Secret Service, a right-hand man of Generalissimo Chiang Kai-Shek. Later he was admiral's representative and liaison officer with the Chinese Army. In recognition of his combat service, the Chinese Government awarded Bowman the cloud and banner (Yun Hui) medal. Bowman's last active-duty billet was judge in the general courts martial at Treasure Island in the final months of the war. He returned to civilian life as an electrical engineer for the Fresno City Government, a position he still holds.

Muscle Soreness and Vitamin C

by
LT Wesley M. Staton
University of Florida

Muscles and their function have long been the object of searching physiologic analysis. To the layman, and especially to the "week-end athlete," the phenomenon of muscle soreness provides an occasional sharp reminder of the need for proper conditioning before indulging in strenuous exercise.

Recent evidence indicates that despite marked technological advance and continuing research in new weapons and techniques of warfare, the degree of physical fitness of military personnel remains a significant factor in the outcome of any battle. For this reason recruit training programs for Navy and Marine personnel have included activities which aim at the development of peak physical condition among trainees.

One of the major deterrents to fitness among recruits during the early stages of training is localized muscle soreness. This problem becomes particularly acute in a period of national emergency when recruit training programs are, necessarily, accelerated. These muscular aches and pains, in addition to being physically enervating, are probably not entirely without detrimental psychic effect on the trainee's response to the broad range of training experiences.

Symptoms of muscle soreness usually develop in muscles taxed beyond their present capacity, between eight and 24 hours after unusually strenuous exertion. The rather sharp, sometimes excruciating, pain is often combined with tenderness and stiffness and is aggravated by subsequent activity of a similar nature.

Although investigation of this condition has been scanty, theoretical analysis indicates that three factors may contribute to it. These include: (a) minute ruptures within the muscle fiber or in the connective tissue surrounding it; (b) chemical irritation of sensory nerve endings in the muscle fiber as a result of the greater concentration of lactic acid and other metabolites; and (c) physical irritation of sensory nerve endings caused by increased pressure from accumulation of excess fluid within and between the muscle fibers.

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In unusual cases it has been shown that severe soreness may result from the individual's inability to break glycogen down to lactic acid during the process of muscular contraction. Such cases, however, are within the realm of medical treatment rather than nutrition and physical fitness.

Research on preventing or minimizing muscle soreness has been extremely limited. Probably this is because "charley horse" is a rather undefinable condition, difficult to appraise. As a consequence, studies concerned with its prevention or minimization are not currently available in the indexed literature. Of course every athletic coach has his strictly empirical methods of treating it but these have no firm scientific basis.

However, Daumezon, Cassan and Delamarre, in November of 1945, presented a rather intriguing report before the Societé Medico-Psychologique in Paris. These investigators claimed that daily dosages of Vitamin C gave markedly favorable results in eliminating the severe muscle soreness experienced by mental patients after shock therapy. Although this experiment suffered somewhat from the subjectivity of muscle soreness determination and the failure to offset the psychic factor by including a placebo[1] group, the conclusions strongly suggested the potential value of ascorbic acid.

Moreover, on the basis of available data there seems to be general agreement that ascorbic acid plays a prominent role in the formation of the so-called "cement" substances which hold together the cells of the capillaries and connective tissue. It has also been reported that ascorbic acid contributes substantially to the efficiency of tissue respiration.

In view of these attributes of Vitamin C, it is significant that the vast majority of nutrition studies reflect widespread inadequacy of this substance in the American diet. From these data it seems justifiable to assume that many recruits suffer from ascorbic acid insufficiency at the beginning of training. Of further significance is the recent evidence which indicates that Vitamin C may be lost in mass feeding.

Accordingly, it was felt that controlled experimentation along these lines might shed some light on the problem. The idea was based upon the established contribution of ascorbic acid to the maintenance of elasticity, rigidity, and density of muscle fibers and its possible favorable influence on tissue respiration. Thus, it was speculatively assumed that liberal amounts of Vitamin C might help greatly in dissipating accumulated lactic acid, as well as lesser metabolites, and in toughening the muscle fiber.

Thus, the primary purpose of this investigation was to determine the effect of increased ascorbic acid ingestion on localized muscle soreness resulting from unusually strenous activity.

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[1]A placebo is an impotent medication given to one group of individuals in an experiment, who think they are receiving genuine medication. The number of the placebo group who claim freedom from symptoms, compared to those in the group who are receiving genuine medication, indicates the extent to which the beneficial effects are influenced by psychological factors.

The study was carried out at the University of Florida's College of Physical Education and Health as a joint project of that College and VNRRU 6-4 of Gainesville, Florida. The group from which the data were derived included 103 healthy male college students ranging in age from 18 to 22 years. These volunteers were randomly separated into three groups: control,[2] experimental, and placebo.

Each subject completed a questionnaire concerned primarily with daily diet and general regimen. While none of the subjects appeared to be subsisting on a diet actually deficient in ascorbic acid, few indicated that they were ingesting liberal amounts of the vitamin. All subjects were non-athletes, in the varsity sense, and did not participate in any special conditioning program during the thirty-day feeding period preceding the testing phase of the experiment.

Throughout the preparatory period the 33 subjects in the experimental group ingested 100 mg of ascorbic acid daily. This dosage was based upon reported evidence indicating that the daily intake necessary to maintain the saturation level in adults ranged between 75 and 100 mg.

The 33 men in the placebo group ingested one placebo tablet each day during the thirty-day feeding period. None of the subjects in either the experimental or the placebo group were aware of the nature of the dietary supplement; they were told only that the tablets, both placebo and ascorbic acid, were a type of food concentrate. The 37 members of the control group did not alter their usual diet in any way.

Following the thirty-day preparatory period, the three-minute form of the sit-up test was administered to all subjects. The validity of continuous sit-ups as a measure of strength and endurance of the thigh flexor and the abdominal muscles has been established. Raw scores, indicating the total number of sit-ups performed within a three-minute time limit, were recorded on the occasion of the first testing. Approximately 24 hours later each subject was retested in precisely the same manner. It was assumed that the more closely the second raw score approached the first, the less intense was the localized soreness resulting from the unusually strenuous muscular activity of the first day of testing. On the basis of the two raw scores a percentage, or index, of retest efficiency was calculated. For instance, if a subject performed 50 sit-ups on the first test and 40 on the retest the next day, his retest efficiency index was 80.00. This percentage, then, representing the precise degree of retest efficacy, could be considered to indicate the gross severity of post-exercise muscle soreness.

Mean percentage indices for the groups studied were as follows: experimental, 96.52; placebo, 93.76; control, 90.57. Thus, the difference obtaining between the experimental group and the control group was 5.95; between the experimental group and the placebo group, 2.76; and between the placebo group and the control group, 3.19.

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[2]The control group was subject to the experiments but was not given either real or fake pills. Thus it provided a "standard" to judge the reactions of the other two groups.

The differences between the experimental and the placebo groups, and the control and placebo groups, were not statistically significant. The variance observed between the experimental group and the control group, however, was significant—that is, it could be assumed that the difference between these groups was a result of the experimental variable, Vitamin C.

Although the groups were not equated at the beginning of the investigation, it is worthy of note that there was no significant difference existing between group raw score means for the initial sit-up test. These means were: experimental, 67.36; placebo, 66.18; control, 66.38.

On the basis of the obtained data, and to the extent that the retest technique validly appraises the severity of muscle soreness, the following conclusions would seem justifiable:

1. The degree of post-exercise muscle soreness is apparently lessened to a significant extent by the addition of 100 mg of ascorbic acid to the typical daily diet for 30 days prior to strenuous activity.

2. The significant superiority in retest performance of the experimental group over the control group cannot be accepted without reservation, inasmuch as no true difference existed between the placebo and experimental groups.

3. Although the variance between the placebo and the control groups was not significant, the possibility of influential psychogenic factors must be recognized in the limitations imposed upon retest performance by muscle soreness.

4. Further experimentation, to corroborate or reject the favorable indications of these data, is recommended. In this connection a dietary supplement combining ascorbic acid with rutin or citrin is suggested.

5. Pending additional experimentation, it might be advisable to reappraise the diet of recruits, with respect to its contribution to ascorbic acid saturation, during the early stages of the training program.

Psychological Warfare Seminar

More than 50 high-ranking Naval officers and several Air Force and Army officers assembled at the University of North Carolina at Chapel Hill last month to give Research Reservists a thorough review of all aspects of psychological warfare. The seminar was the first of its kind to be held at an educational institution.

The two-week program, which consisted of a number of lectures and closed-door discussions on modern psychological warfare, was sponsored by VNRRU 6-6, headed by LCDR R. F. Schenkkan.

Many officers and civilians on the staff of the Office of Naval Research participated in the lectures and discussions. CAPT F. V. Rigler, Assistant Chief for Administration, welcomed the officers at the opening session. Other ONR staff members who participated in the seminar, and reservists who attended, are shown opposite.

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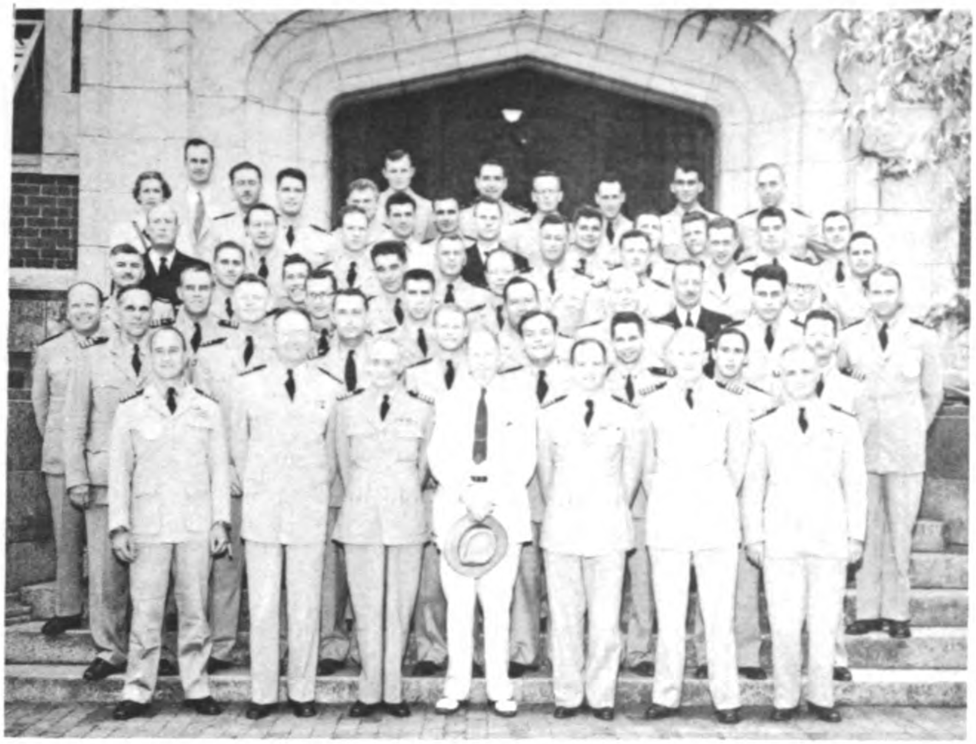
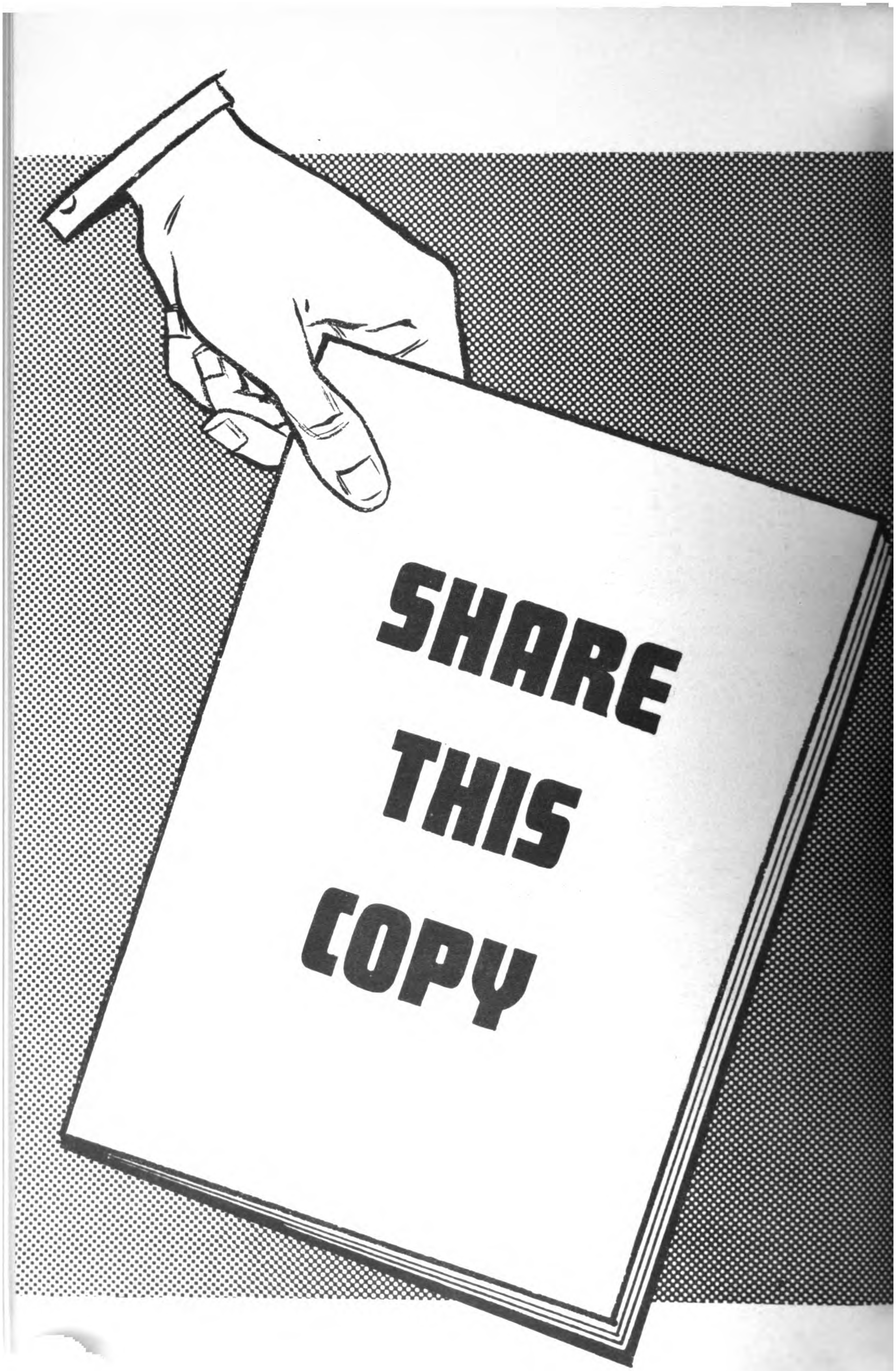


Members of the Chapel Hill Psychological Warfare Seminar.

Dr. H. E. Page, Head of ONR's Human Relations Branch, talks things over with CDR T. H. Carroll, co-chairman of the seminar, while LCDR D. O. Price, LTJG C. Corrigan, and Maj. J. L. Monroe (USAF), look on.

CAPT C. W. Shilling MC, USN (front center), Special Asst. for Bio Sci., is shown with (front, left to right) LCDR M. Woodward, LCDR Schenkkan, (back) CDR Carroll, LCDR Price, CDR J. P. Dickson and LTJG W. Matthias.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