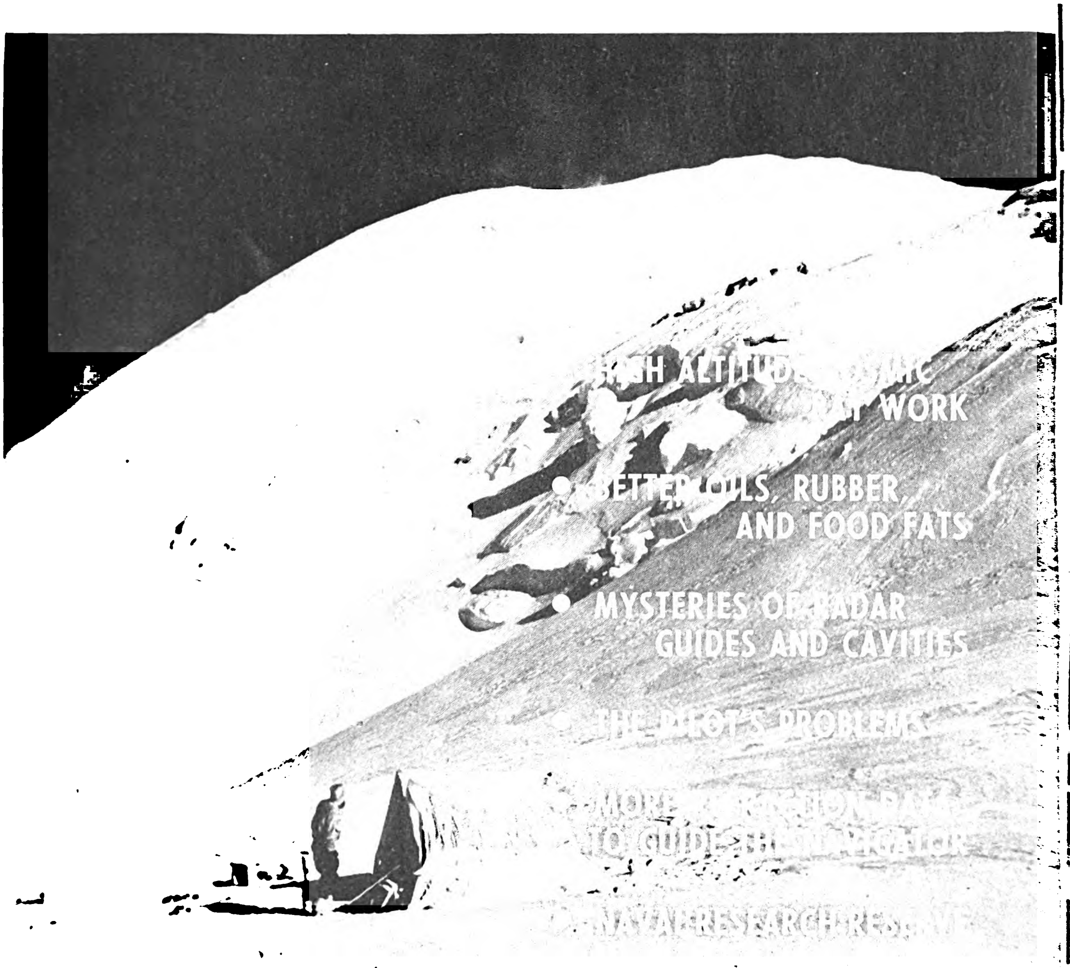
● FEBRUARY 1949 FOR OFFICIAL USE ONLY

RESEARCH REVIEWS



OFFICE OF NAVAL RESEARCH
DEPARTMENT OF THE NAVY
WASHINGTON, D. C.

NATIONAL MILITARY ESTABLISHMENT · UNITED STATES OF AMERICA

NAVEXOS P-510

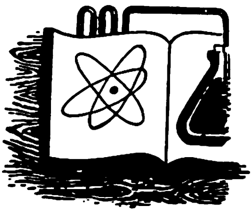
COVER PHOTO: The cosmic ray laboratory located near the top of Mt. McKinley, the highest mountain in North America.

CONTENTS

Approved by Bureau of Budget, 13 April 1948

RESEARCH REVIEWS--

A monthly journal for the Fleet devoted to ONR-sponsored research



Editorial musings

The new policy with regard to Research Reviews was announced by a memorandum inserted in the January 1949 issue. The announcement stated that Research Reviews had been declassified, beginning with the first issue (January 1948) up to and including January 1949, and that future issues would be unclassified. A review of the past issues disclosed that no material had been included having a military classification. The classification was primarily placed on this journal to protect authors against republication of their material by unauthorized persons. In the light of the year's experience, it appeared an insufficient reason for classifying the journal "Restricted," since classification raised more obstacles than its use would seem to warrant.

This journal serves as a connecting influence between the Fleet, ONR contractors, and the Research Reserve units. It is the only continuing medium through which the scientists engaged in ONR-sponsored research can reach the men of the Fleet.

In the past year of its production, Research Reviews has striven to fulfill its purpose and during the course of that year the response from readers has been heartening, indeed.

The editors welcome among the readers of Research Reviews, the Naval Research Reserve units, our newly acquired audience. (See p. 28) Their ideas and comments will help us to meet our goal. So here we go for a big year ahead! There are lots of interesting articles to come. Keep up with us and we'll try to keep up with you.

ERRATUM, Research Reviews, December 15, 1948, p. 13, "How Much Energy?":

The report by Professor E. Teller should have read as follows: ". . . if it is assumed that cosmic rays are present in inter-galactic space with the same average density as they are found to have on the earth's surface, their total energy would be 10^{-4} times the energy represented by all of the rest mass present in space. . . ."

Letters

To all our readers who have written in response to receipt of Research Reviews, we wish to thank you for the complimentary and entertaining comments.

Dr. R. D. Vold, professor, University of Southern California, was the author of "What Makes the Wheels Roll," an article in the December 15, 1948 issue of Research Reviews. When he wrote us recently, he made the following comment:

"I note with interest that you plan to have your publication declassified. Probably no single factor could contribute as much to developing an adequate awareness of science in the general public as a widely circulated accurate series of accounts of research developments written in non-technical language. In Research Reviews . . . you are achieving this objective in an outstandingly successful manner."

The Editors thank Dr. Vold for his comment and wish to state that he presents in an interesting manner the need which Research Reviews is attempting to meet in reaching certain Naval groups. A fuller discussion of this subject appears this month under "Editorial Musings."

Contributors this month originally submitted their articles with the understanding that Research Reviews was "Restricted." Therefore, we queried them to ascertain whether they had any objections to the use of their material in Research Reviews in its present unclassified status. Dr. Fred A. Kummerow, Associate Professor of Chemistry, Kansas State College of Agriculture and Applied Science, is one of the authors this month. His reply is typical of those received from contributors: He stated that he had no objections to having his article published as unclassified material. He further stated,

"I think if Research Reviews could enjoy a larger number of readers, it will help . . . the general public understand what a great service the Office of Naval Research is doing for the welfare of the country."

HIGH ALTITUDE COSMIC RAY WORK

Albert B. Weaver and Marcel Schein
University of Chicago

Recent cosmic-ray work has contributed so much to our basic knowledge in physics that it is of interest to those who follow the general development in science. The importance of cosmic-ray studies is principally because of the fact that many of the particles which compose cosmic rays possess energies which have not yet been approached by our most powerful atom-smashing machines. For this reason, they can produce entirely new types of nuclear reactions which cannot be observed in the laboratory. For instance, until a few months ago mesons had been observed only in cosmic-ray studies because no machines were available which would develop sufficient energy to create them artificially.

Knowledge about the meson (sometimes called mesotron) is very important because it is generally believed that mesons are responsible for the large forces which hold atomic nuclei together.

Because cosmic rays interact extremely strongly with matter present in the upper atmosphere, their study is important for a better understanding of what happens in that region. Cosmic rays are affected by the magnetic field of the earth, as is described later, and hence they are very valuable to a study of the magnetic field of the earth and the correlation of magnetic storms with sunspots.

Albert Weaver, research assistant at the University of Chicago, was born in Anaconda, Montana, 1917. He attended the universities of Montana, Idaho, Minnesota, and Chicago. During the war he worked on magnetic problems at the Naval Ordnance Laboratory in Washington, D. C. At present he is working in the field of cosmic rays.

Marcel Schein, professor of physics in the Physics Department and in the Institute for Nuclear Studies of the University of Chicago, was born in Czechoslovakia, 1902. He studied physics at the universities of Prague, Vienna, Wurzburg, and Zurich, and received his Ph.D. in physics (*summa cum laude*) University of Zurich 1927, his thesis subject being "The hyperfine structure and the Zeeman effect of mercury resonance radiation." He was a Fellow of Rockefeller Foundation at the University of Chicago 1929-1930, working on the optical properties of very long wave-length x-rays ($\lambda \sim 40$ Å). He did teaching and research at the University of Zurich until 1938 when he joined the faculty of the University of Chicago. His fields of interest have been construction of sensitive photon counters, measurement of ozone in the atmosphere, and investigation of the short wave ultraviolet spectrum of the sun. Since 1938 he has been working in the field of cosmic radiation, his chief interest being the nature of the primary cosmic radiation, meson production, and interaction of mesons with atomic nuclei.

Biologists have considered the possibility that cosmic-rays may cause mutations which occasionally appear in plants and animals. Such mutations lead to the production of new types of life.

Scientists are trying to learn in what part of the universe the rays have their origin and how they get such tremendous energies.

To carry on these studies to best advantage, it is necessary to make measurements at various latitudes and altitudes. Before describing a few of the experiments made by the University of Chicago cosmic-ray group, it might be well to point out why such measurements are necessary and to review what is now known about cosmic rays.

High energy particles, very probably protons (hydrogen nuclei), are bombarding the earth from outer space in large numbers, 0.67 particles per square centimeter every second. These particles come from all parts of the sky, day and night, with approximately equal intensity. Some of the energies found are in excess of a million billion electron volts. This is more than ten million times that liberated in a fission process of uranium.

These primary rays do not penetrate very deeply into the atmosphere but rapidly transfer their energy to a variety of secondary particles by disruption of the nuclei of the air. Thus, throughout the atmosphere one encounters a large number of high energy secondary particles. These particles can be divided into what are termed hard and soft components on the basis of their ability to penetrate dense materials such as lead. The hard component is formed chiefly of the mesons previously mentioned. Mesons are particles which have mass intermediate between that of electrons and the heavier protons and neutrons. The "mu" meson has a mass of 198 electron masses and the "pi" meson, a mass of 313 electron masses. Protons and neutrons weigh about as much as 1800 electrons. Both types of meson occur with positive and negative electrical charge and the possibility of neutral mesons is being considered.

The meson is not commonly observed in nature because it requires a large amount of energy to create it; and because, once it is created, it decays spontaneously in an average time of two-millionths of a second in the case of the "mu" meson, and a time which is approximately a hundred or a thousand times shorter than this in the case of the "pi" meson.

It is important to measure cosmic rays at various altitudes because the intensity and composition of the rays vary with altitude. The intensity is much greater at 50,000 ft than at sea level, for instance, because the atmosphere tends to slow down and absorb the particles as they penetrate further into it. Nuclear disruptions are several hundred times more abundant at 50,000 ft than at sea level.

There are various means of making high-altitude measurements which, as we will see, complement one another. For the very highest altitudes, more than one hundred miles straight up, rockets are used. Rockets can carry a rather heavy load; but it must be compact and the time during which data can be gathered is of course limited.

Balloons go as high as from 60,000 to 100,000 ft (about 18 miles) and remain at these altitudes for periods of from three to ten hours. We have found it convenient to use a number of hydrogen-filled balloons as shown in Fig. 1. The balloons used at present are usually inflated to

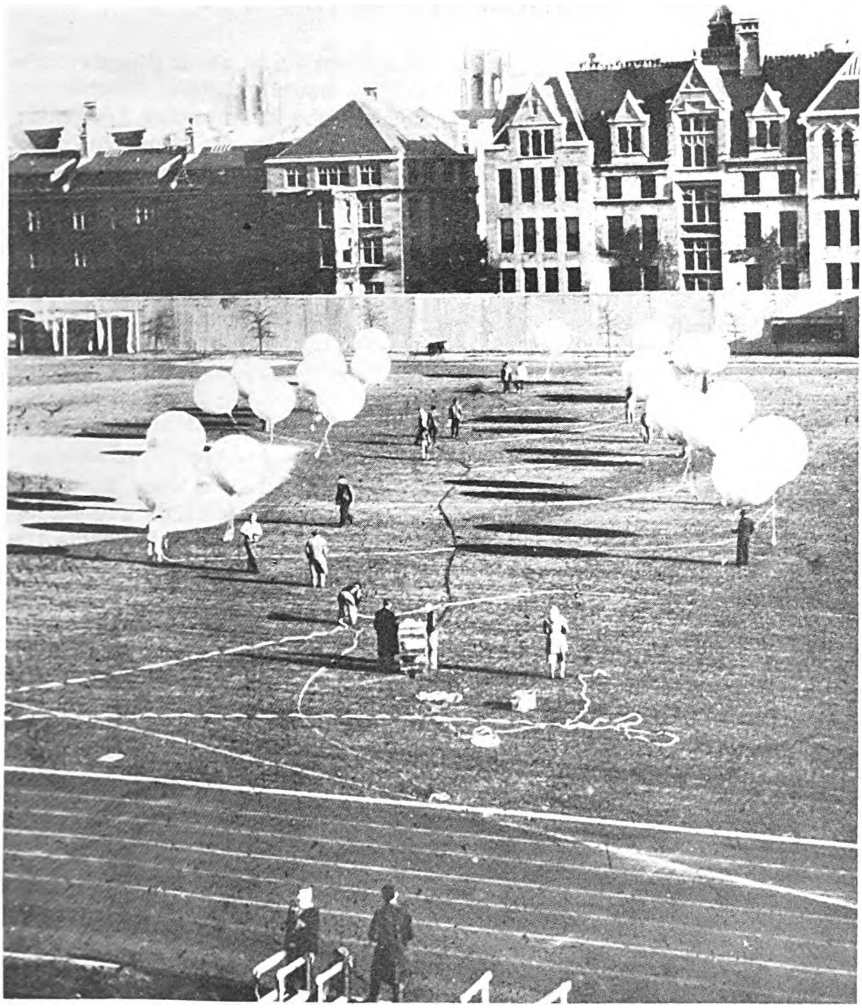


Fig. 1. A balloon flight launching from Chicago's Stagg Field. The ropes in the foreground are used to control the balloons, allowing them to ascend slowly, until the apparatus in the center foreground is clear of the ground.

lift six or seven pounds each; but in order to gain a fast ascent, the actual load placed on the balloon is only half of this. These balloons are about nine feet in diameter when inflated at sea level and they expand to about thirty feet in diameter by the time they reach their maximum altitude in the stratosphere. Use of a string of balloons makes it possible to lift apparatus of varying weights simply by varying the number of balloons. An average flight of fifty pounds would require something like twenty balloons. A special launching technique has to be used, however, to launch flights in which the apparatus weighs more than sixty or seventy pounds. (See Fig. 2.)

Temperatures in the stratosphere are very low, about fifty degrees below zero at the heights to which balloons usually attain. Therefore, special precautions are necessary to keep the cosmic-ray apparatus from freezing, which is accomplished by placing the apparatus in a cellophane box which tends to admit and trap the heat rays in the sunlight. This device is so efficient when the balloons are above the clouds and dust of the lower atmosphere that usually silver paper is put around part of the box to reflect sunlight so that the apparatus does not overheat.

Because of the intricacy and weight of telemetering equipment which would automatically radio information to the ground, we generally attempt to use recorders and then to recover the apparatus after it returns to the ground. This is a much simpler system, particularly for a large number of experiments requiring many data, simultaneously.

As far as recovery is concerned, Chicago has a very fortunate position. If a day is chosen on which the stratospheric winds are strong enough to carry the flight over Lake Michigan or South of the lake, the chances are excellent that the apparatus will land on a farm in Michigan, Ohio, or Indiana. As a matter of fact, we have been very fortunate even on those few occasions when the winds played tricks on us. One flight, for instance, landed in a fisherman's net in Lake Erie. Another stayed aloft fourteen hours and came down in a potato patch in the hills of West Virginia. This region is so sparsely populated that, if it had missed the potato patch by as much as half a mile, the chances of recovery would have been very slim.

Balloon experiments have given information on the primary component, on the production of mesons, and on the number of particles of various energies throughout the atmosphere.

The Navy has made available B-29 airplanes for use in prolonged experimental flights. B-29's are particularly adapted not only because they can carry heavy apparatus and observers as high as 40,000 ft, but also because B-29's permit greater facility in measuring at different latitudes. Much information may be gained about the character of the primary cosmic-ray particles by conducting measurements near the earth's equator.

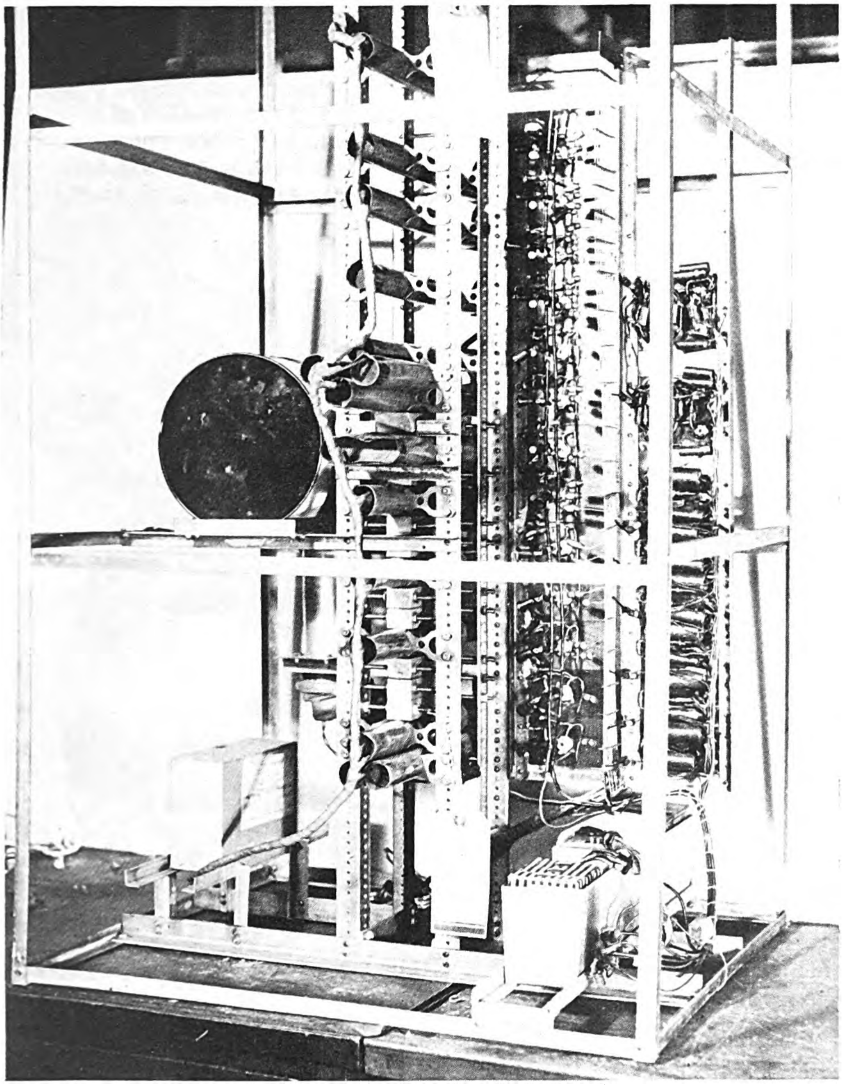


Fig. 2. A closeup of the equipment sent up on a recent balloon flight. The large cylindrical can contains the recording unit. The Dow metal frame supports a cellophane box which is put around the apparatus before launching.

The horizontal magnetic field of the earth is stronger near the equator than at higher latitudes. The motion of charged particles is altered by a magnetic field; and studies of the effect of the earth's magnetic field on the motion of incoming cosmic rays give information about the nature of these particles. For instance, from the fact that more particles of a given energy come from a given part of the western sky than from a corresponding part of the eastern sky, one can conclude that a large fraction of the primary particles are positively charged.

Besides giving information about the primary component, B-29 experiments have contributed to our knowledge of the relation of neutrons (the particles which cause fission in uranium) to other components of cosmic rays and to our knowledge of large cosmic-ray air showers. These air showers, consisting principally of electrons and photons (light

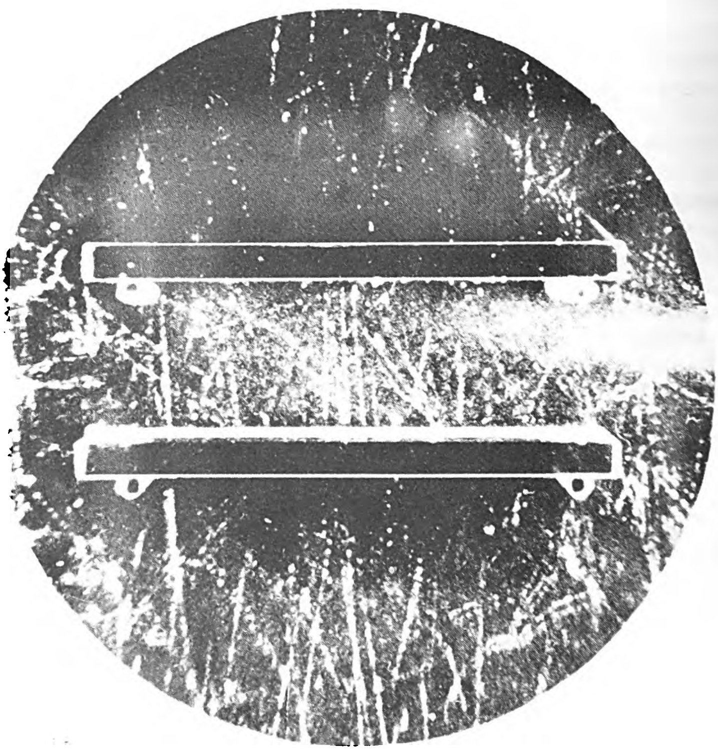


Fig. 3. A cloud chamber picture of an air "shower" of cosmic-ray particles. These showers sometimes extend over an area of 10,000 square meters. The particles easily penetrate the two lead plates which are seen resting on metal supports in the center of the chamber.

particles), contain energies as high as a million billion electron volts. Scientists are seeking to determine the origin of such enormous energies. Measurement of the frequency, density, and rate of growth of these showers at high altitudes will contribute to this end. We have determined that the frequency of showers increases about fifty-fold from sea level to 27,000 ft, and then decreases as the top of the atmosphere is approached. We have made flights lasting from six to eight hours from Peru and from Panama as well as from more northerly latitudes.

For measurements requiring very heavy equipment or taking long periods of time, mountains are used. Probably the most interesting

Fig. 4. The highest mountain in North America, Alaska's Mt. McKinley, seen from a distance. The cosmic-ray laboratory was located at the position marked by a black spot near the top of the mountain.

expedition of this type which we have made was to the top of Mt. McKinley, Alaska. A shelter, equipment, and supplies were parachuted to a saddle of the mountain some 18,000 ft high, and the experimenters climbed up to the supplies. Maintenance of reasonable temperatures was possible inside the laboratory despite outside temperatures of -20°. (See cover photograph.)

One result of the experiments performed on Mt. McKinley is the indication that mesons of energies around a hundred million electron volts are appreciably produced in the atmosphere at heights lower than 18,000 ft.

An interesting recent result of experiments at sea level is that positive and negative mesons do not have equal apparent mean lives when stopped in light elements. This is because negative mesons are attracted to the positively charged nuclei and are captured while positive mesons are repelled and hence disappear only after spontaneous decay.

Fig. 5. A highly magnified picture of a meson track in a photographic emulsion. The meson first appears at the right and after being deflected a number of times by nuclei in the emulsion, comes to rest and is captured by a nucleus at the left. This nucleus then breaks up into a number of charged particles, the short heavy tracks of which are seen branching from the point at which the meson stopped.

The fact that there are two ways for a negative meson to disappear, by capture or spontaneous decay, tends to shorten its lifetime by an amount which depends on the probability of capture, and hence on the particular element in which it stops. Negative "mu" mesons last about 0.6 microsecond in sulfur, for instance, compared to a lifetime of about 2 microseconds for positive "mu" mesons.

At the moment, cosmic-ray research is in a very fluid state, because the full importance of many experiments is not yet clear, and because the general theory of nuclear phenomena at high energy is not yet developed. Therefore, further experiments in the field are of great importance.

BETTER OILS,

RUBBER, AND FOOD FATS

F. A. Kummerow
Kansas State College

When you twirl the wheel on a cigarette lighter, the flame you see indicates that complete and instantaneous combustion of the lighter fluid has taken place. The building units or molecules in the fluid react with the oxygen in the air and are torn apart, yielding heat and light in the process. However, there are other combustions or oxidations in which the building units are not torn apart so violently. It is this slower type of oxidation which affects the autoxidation of unsaturated fatty acids.

Familiar examples of many of these gradual reactions with oxygen include the building up and breaking down of paint films, the hardening of rubber, the formation of gums in gasoline, the accumulation of sludges in lubricating oil, and the production of rancidity in foods during storage. These materials may seem somewhat unrelated. However, they all have the same type of building unit, namely, "unsaturated" molecules. The term, unsaturated, indicates that the molecule contains extra valence bonds or links between atoms which are capable of reacting readily with oxygen. When two valence bonds are linked together, they are called double bonds; this type of bond is found in paint oils, rubber, and food fats.

Oxygen can either join these substances, that is, act like mortar which cements unsaturated molecules together, or break them into smaller units. A discussion of a few cases may help to clarify these points.

For example, paints are made up of a pigment, a "drying" oil and a volatile solvent. The drying oils, such as linseed oil, contain highly unsaturated molecules of fatty acids which combine readily with oxygen. If you could examine the dried paint under a microscope more powerful than any now known, you would find two or three layers of unsaturated molecules cemented together or polymerized. This same principle of polymer formation applies to gum formation in gasoline.

Fred A. Kummerow received his B. S. (1939), M. S. (1941), and Ph. D. (1943) from the University of Wisconsin. He has been associated with Clemson College, Clemson, South Carolina, and is now associate professor of chemistry at Kansas State College. He is directing research on an Army Quartermaster Corps project and supervising a project under ONR sponsorship on the factors which affect the stability of unsaturated fatty acids.

Rubber, however, is already a loosely knit polymer. In rubber the molecules are laid down in a spongy structure with plenty of air holes throughout. Oxygen fills these holes and cements or hardens the polymer into a rigid structure with no more elasticity than a brick wall. On the other hand, fresh lubricating oil does not possess either unsaturated fatty acids or ready-made polymers. Polymerized substances are produced and polymerized in the oil as the rapid movement of the pistons forces the air in and splashes the oil against the hot cylinder wall.

Research in England on the oxidation of lubricating oil in internal combustion engines has shown that as much as 20 volumes of air are beaten into one volume of oil. During engine operation the maximum temperature in the oil pan is usually below 120°C., but the oil which is splashed against the cylinder wall reaches a temperature of 200 to 300°C. Exposed to this heat the lubricating oil gradually breaks down into unsaturated fatty acids which can corrode bearing alloys or combine to form sludges and lacquers. It can easily be appreciated that this breakdown of the lubricating oil in an airplane engine can be a limiting factor in the effective range of a bomber plane.

The production of rancidity in foods during storage involves the breakdown of unsaturated fatty acids in food fats. Products of this breakdown are responsible for the development of off-flavors in bacon, coffee, butter, and dehydrated foods. Ordinarily, polymer formation is not a problem in the development of rancid fat in food.

You can thus see that the addition of oxygen to different types of unsaturated building units involves the same fundamental problem. If you could solve this problem in the paint field, the knowledge gained could be used to help solve the same problem in other fields. A tremendous amount of work has been done with this purpose in mind.

The problem has been attacked from two different directions, an actual study of the fundamental reaction mechanism, and a search for better materials to retard oxidation. Although the latter is empirical, that is, hit and miss, it has produced better rubbers, gasoline, and lubricating oils. Most of the work on the study of the fundamental reaction mechanism has been carried out with the naturally occurring materials. However, the naturally occurring materials also contain building units which do not have points of unsaturation. Fortunately, unsaturated building units can be isolated from such sources as corn or cottonseed oil. We have used linoleic acid isolated from corn oil in our study of mechanisms involved in the oxidation of unsaturated building units.

To date work in our laboratory has indicated that the initial stages of oxidation involve the group adjacent to the double bond rather than the double bond itself. The number and position of double bonds are of the utmost importance. When the double bonds are in a conjugated or adjacent position, very little oxygen is absorbed as active oxygen or "hydroperoxides," but the formation of hydroperoxides is fundamental to oxidation. Hydrogenation studies with the apparatus shown in Fig. 6 indicate that peroxides are not found at double bonds but adjacent to them. It is interesting to note that the addition of peroxide to gasoline causes engines to "knock."

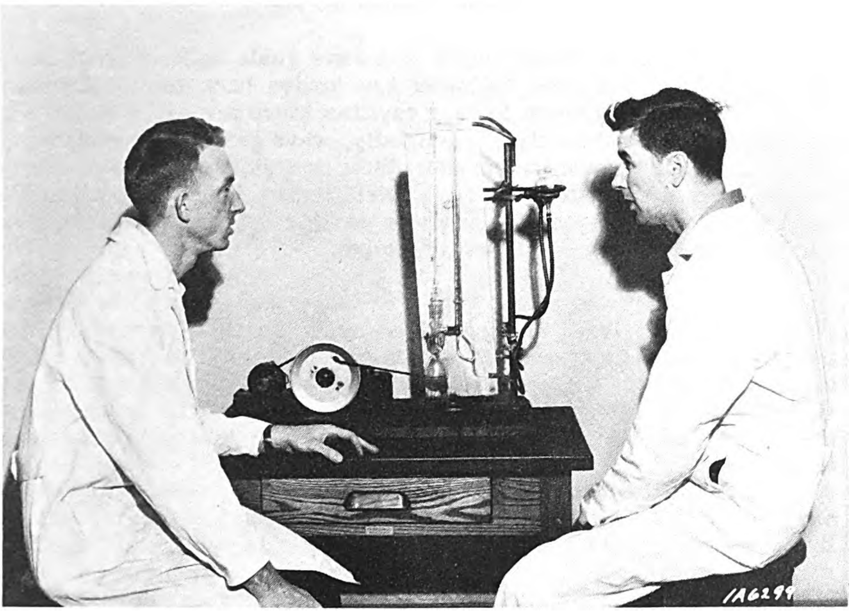


Fig. 6. Two former Navy men now working under ONR contract discuss the merits of a laboratory micro-hydrogenator built by them. R. R. Allen, Lt. (jg) USNR, (left) flew a patrol bomber in the Southwest Pacific Area. He has had more than 400 hours of combat flying. He will receive his M. S. degree this June and will begin work on his Ph. D. degree under ONR research funds. W. M. Kipp, Ens. USNR-Ret., (right) was gunnery officer on the USS Peril, a 180-ft minesweeper on patrol duty in the North Atlantic. He will receive a B. S. degree in June.

Because the secrets of oxidation reactions are locked up in the initial hydroperoxide formation, we will continue our studies on hydroperoxide formation before following the various steps to eventual formation of polymers. Much work still remains to be done, but with the advent of modern electronic equipment and the combined work in many laboratories, the solution to the problems of autoxidation is nearer now than it has been in the past. With its solution, a number of applications will be possible, among which are overcoming rancidity of foods, better paint oils, lubricating oils, and gasoline.

MYSTERIES OF

RADAR GUIDES AND CAVITIES

Karl Spangenberg
Stanford University

Have you ever looked inside of a wave guide and wondered how it worked? Have you ever followed the guides back to the tubes and wondered how the strange looking cavities there worked? Well, if so, you're surely not the only one. Briefly, wave guides are rectangular tubes connecting radar antennas to their transmitters. An exact determination of the nature of the electric waves inside of such guides and cavities has presented a problem which has been difficult for even our best scientists and engineers to solve.

The shape of the waves inside of guides and cavities is very important. If the waves get bunched too much the characteristics of the guide will generally be undesirable in that there will be tendencies for the guide to spark over or to present high losses to the passing radio waves. Likewise in the cavities if the fields are not of the proper shape, the cavity will lose its sharpness of resonance and will have excessive losses associated with the currents that flow over its surface. Now it is possible to calculate the shape of the waves inside of guides and cavities, but for any except the simplest shape, this becomes a very laborious and time-consuming procedure. Examining this problem, research workers at the electronics laboratory of Stanford University have devised an electrical circuit which simulates the condition inside

---

Dr. Karl R. Spangenberg, specialist in vacuum tube research, has, since writing this article, joined the Office of Naval Research staff as head of the Electronics Branch. Dr. Spangenberg received his B. S. and M. S. degrees in electrical engineering from the Case Institute of Technology. After obtaining a Ph. D. in the same field from Ohio State University, he taught radio and electronics at Stanford University. In 1944 he was consultant to the Signal Corps in the European Theater for the Office of Scientific Research and Development. He made investigations on the status of German research and development in electronics for which he was awarded the Medal of Freedom by the U. S. Army.

In 1945 Dr. Spangenberg was head of the research group working on broad-band microwave oscillators for the Radio Research Laboratory at Harvard University. He is the author of a book entitled Vacuum Tubes.

He is currently on leave of absence from the Department of Electrical Engineering, Stanford University. His appointment is in keeping with the policy of this Office to engage active research scientists to evaluate and administer its scientific programs. The flow of scientific personnel between university laboratories and the scientific branches of ONR has been increasing rapidly since inauguration of the plan a year ago.

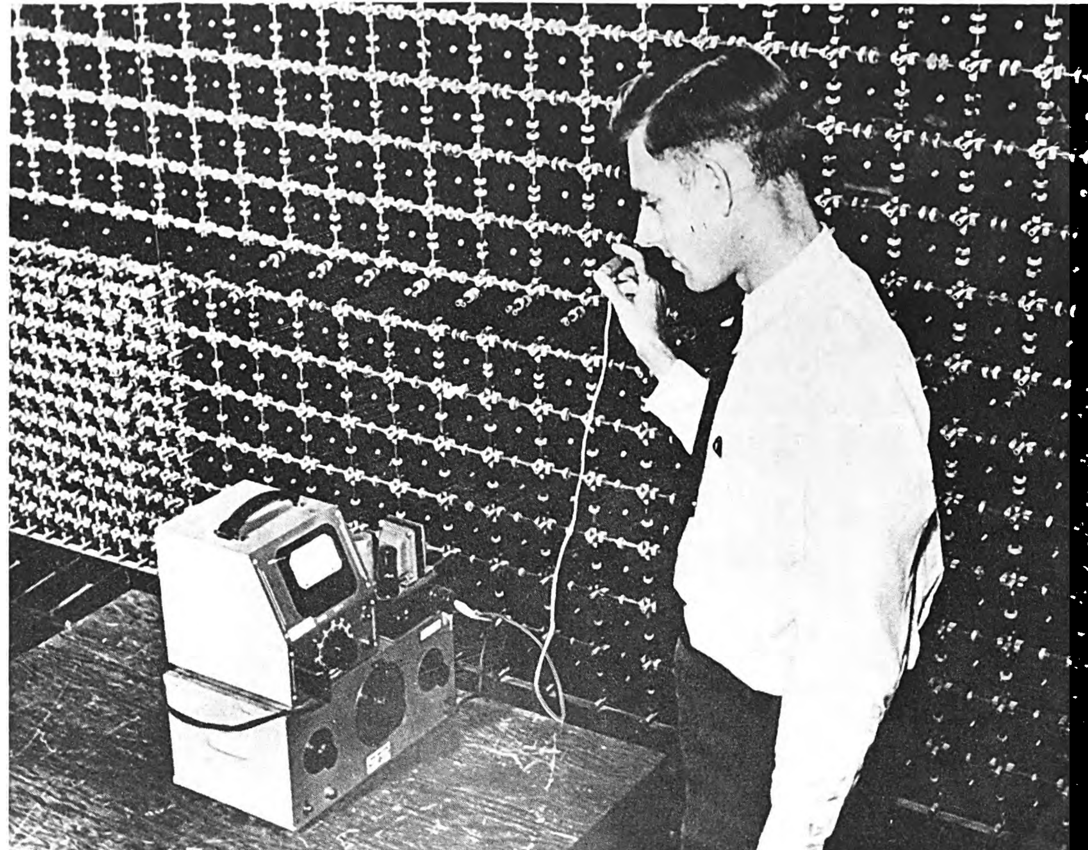


Fig. 7. Stanford Network Analyzer for electromagnetic field problems.

the guides and cavities and calculates automatically the resultant wave shapes which may then be observed with ordinary electronic instruments.

Shown in Fig. 7 is a picture of the network analyzer which computes the wave shapes inside of guides and cavities. This analyzer consists of some 1300 coils and some 650 condensers which are interconnected to form a lattice of inductances with connections to a ground plane through the condensers. In this network of elements electrical waves will travel around in just the same fashion as they do in guides and cavities except that the simulated operation occurs at frequencies which are lower by a factor of many thousands, thus making it possible to use ordinary electronic instruments to observe the results. Shown in Fig. 8 is a sample field plot which shows the electric field inside of a cavity resonator such as that used with certain types of microwave local oscillator tubes. This field exhibits a large number of irregularities which would make its computations extremely difficult, yet with the network analyzer at Stanford such a field plot can be obtained in a matter of minutes literally saving days of computation time.

With the analyzer shown and a counterpart for other systems the Stanford group has probed the mysteries of guides and cavities and collected great quantities of data which are being carefully tabulated for the reference of future workers in the field. No longer necessary are the costly computations or expensive experimentation with actual models which are difficult to machine.

THE BEGINNING AND THE END

A problem puzzling many scientists for centuries immemorial has been the matter of how the universe began. Was it by the explosion of a great "primordial atom" of supercompressed matter? During the past year, three American scientists hypothesized that ten minutes after this atomic explosion the process of building most of the universe's elements had been completed. Of course, alpha, beta, and gamma rays must have resulted during those historic minutes. The names of the scientists describing this theory were Alpher, Bethe, and Gamow.

Editor's Note: Dr. George Gamow, consultant to the Nuclear Physics Branch of the Office of Naval Research, is professor of physics at George Washington University; Dr. H. Bethe is at Cornell University; Dr. R. A. Alpher is with the Applied Physics Laboratory, Johns Hopkins University.

THE PILOT'S PROBLEMS

E. L. Corey and S. W. Britton
University of Virginia Medical School

Unfortunately, the most desirable features in the combat airplane tend to place physiological stresses upon air crews which may undermine their well-being, or even be incompatible with life. Unless the characteristics of aircraft now being developed by aeronautical engineers and the performance demanded by military standards are ameliorated by means of special devices and precautionary measures, occupants of aircraft cannot operate the machines themselves because of the attendant environmental conditions and physical forces.

Moreover, in the production of airplanes of the highest possible performance, we find ourselves considerably handicapped by the fact that although the structural strength, flight characteristics, speed, rate of climb, and similar mechanical features of the plane may be accurately predicted for a given design, knowledge of the stresses imposed upon the human occupants remains relatively inadequate. For this reason aeromedical studies to increase our knowledge of physiological responses to the stresses of flight are important. In piloted aircraft, man himself has become the weakest element; hence a thorough knowledge of his ultimate limits of resistance to stresses imposed by the machine he operates is not only necessary, but is also of paramount concern.

The significance of these investigations is evident upon consideration of the conditions under which aviators are required to operate their highly intricate machines at peak efficiency.

(1) Cramped quarters and a fixed position over ever longer periods of time cause pronounced mental and physical fatigue.

Edward L. Corey and Sidney W. Britton are professors of physiology at the University of Virginia Medical School, Charlottesville, Virginia.

Dr. Corey received his A. B. degree (1924) from Western Reserve University and Ph. D. degree from Yale University (1928). From April 18, 1942 until December 4, 1945, he served on active duty in the Navy, at present holding permanent rank as Commander, HS USNR.

Dr. Britton received his B. Sc. from McGill University (1922) and both M. D. and C. M. degrees (1924) from the same institution. He is Chairman of the Department of Physiology at Virginia Medical School, and the chief investigator for the work described in this article. He began an intensive program of aeromedical research in 1941, under contract with the Office of Scientific Research and Development; since the close of the war the investigations have been carried forward under Office of Naval Research sponsorship.

(2) Ever higher altitudes necessitate breathing an artificial atmosphere to survive, with intense cold requiring artificial heat. In certain aircraft a reverse condition of great heat prevails, owing to air-friction and admission of compressed air to the cockpit, so that artificial cooling is necessary to produce an atmosphere for survival.

(3) Inherent dangers in the modern airplane are engine fumes (carbon monoxide), explosive decompression of the cockpit (cabin rupture, gunfire), structural fault, power-plant failure with the hazard (in jet engines) of almost explosive disintegration of the engine and plane, and failure of the ever-increasing number of instruments and devices. All tend to induce great mental and emotional stresses.

(4) Ever higher acceleratory forces accompany the improvement of plane performance. These inject the dangers of impaired vision, temporary blindness, and loss of consciousness, and disabling stresses upon the heart and circulation, abdominal viscera, and even the skeletal structure. Such powerful acceleratory forces act upon the aviator in very fast take-offs (JATO, catapult), turns, recovery from dives, loops (and indeed in any abrupt alteration in the course of flight), and in sudden decelerations (arresting devices, crash landings).

The Virginia Laboratory has dealt particularly with the effects of acceleratory forces since 1941, when the necessity for a clearer understanding of the physiological stresses imposed by high accelerations was first generally recognized in this country. Since 1945, these studies have been and are being made possible through the encouragement and support of the Office of Naval Research.

Acceleratory force, or g as it is called, is, like the law of gravity, unavoidable. One g is defined as the "acceleration due to gravity"; under a force of 2 g's a man (or an airplane) doubles in weight, and so on for 3, 4, 5 and higher g forces. As long as the aviator flies along in a straight and level path he is under no more g stress than when standing on the ground, but upon altering the direction of flight in any way he adds to his g load. The intensity of this force depends on the abruptness of the maneuver and the speed of his plane, so that the more "efficient" and maneuverable the machine, the greater becomes the g force that the pilot must withstand.

In this laboratory g force is obtained by means of a large (20-ft) centrifuge (Fig. 9). With this machine, forces as high as 50 times that of gravity may be produced. Studies have been made on many different mammalian species from rats to monkeys, the latter being found to give responses most nearly approximating those of man. As the animals are spun on the centrifuge, electronic devices record brain waves, blood pressure, blood flow, heart rate, and respiratory rate and depth, as indices of the effects of the g imposed. (See Fig. 10.)

When the normal responses of the test subjects have been well established, various means of "protecting" the animal from the adverse

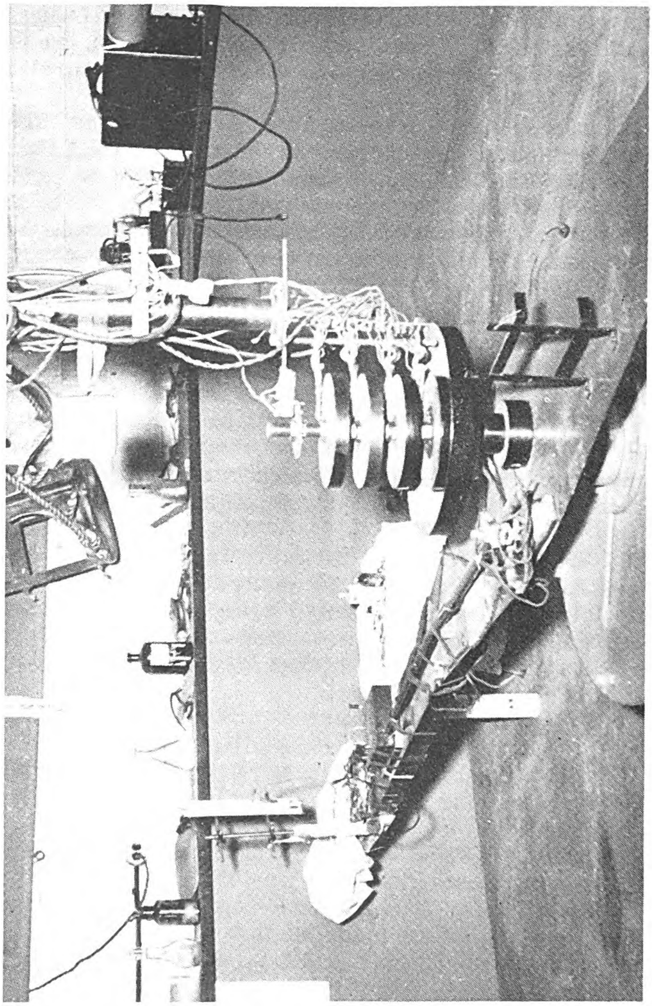


Fig. 9. Centrifuge used in studying physiological effects of g-force. An animal is placed at the far end of the long rotor. Electrical currents from the beating heart, brain, and respiratory muscles, and from electrical devices for registering blood pressure and rate of flow are carried on wires to the mercury-filled rings at the hub of the centrifuge. Here another set of electrodes, in contact with the rotating mercury, carries the electrical impulses to the recording apparatus.

effects of g are studied and evaluated. Such protective measures have included an anti-g suit or belt, which prevents the rush of blood to the abdomen and lower extremities during centrifugation, and results in a better blood supply to the brain. Since the outstanding effect of g in pulling out of a dive is to drive the blood away from the pilot's head, with resultant dimming of vision or even unconsciousness, the anti-g suit would appear to constitute the aviator's main protection from acceleratory force. Actions of various drugs such as adrenalin, pitressin, and hormones of the adrenal cortex have been investigated; some of these appear to improve the circulation in the body and perhaps in the brain. Administration of certain gas mixtures, especially carbon dioxide

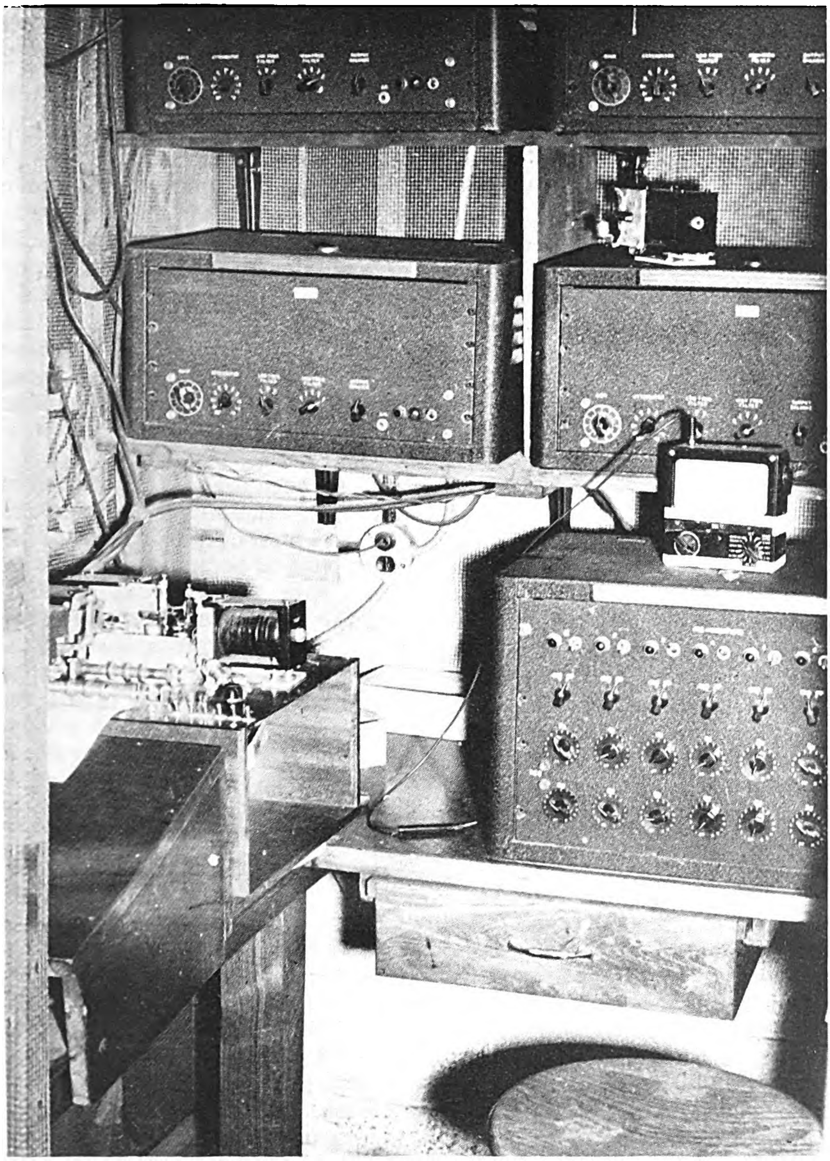


Fig. 10. Recording apparatus used in conjunction with centrifuge. The small currents, coming from the subject on the rotor are amplified, and so caused to operate an ink-writing oscillograph. Thus the physiological disturbances taking place under g-force may be continuously recorded on a moving strip of paper.

with oxygen, improves circulatory and also respiratory efficiency, and has a very desirable action in offsetting the effects of acceleratory forces. This work, alone, has involved several thousands of experimental tests.

More recently interest has been centered on many deleterious environmental and other factors which upset the normal body economy, and hence may lower the aviator's g-tolerance. Many studies were designed to simulate possible conditions confronting the aviator, such as heat (hot climate, failure of cooling devices in jet aircraft), cold (arctic flying, high altitudes, failure of electrically-heated clothing or heating systems in airplanes), smoke (engine malfunction, smoke clouds), injury and trauma, hemorrhage (wounds in combat), and insufficient supply of oxygen (malfunction or failure of the oxygen-breathing equipment). These studies mainly on animals have given valid data regarding the influence of these factors on the aviator's resistance to g under similar physiological conditions.

One interesting phase of the study has been that of the effects of g-load upon certain organs of the body. For example, while positive g, i.e., head to foot, quite definitely interferes with cerebral function as shown by the electroencephalogram (brain waves) of centrifuged animals, no permanent structural damage to the brain was generally noted. Negative g forces i.e., foot to head, on the other hand, may in some cases produce rupture of the cerebral vessels with possible death. Kidney function during and following severe acceleration was found to be considerably altered. Under g-load, urinary secretion is all but stopped, probably owing to anemia of the organ during centrifugation; following release from g-load, the urinary output significantly increased for several hours. Evidence indicates that the kidney may even suffer structural damage as well as functional change by frequent exposure to high degrees of acceleration.

The study of acceleratory effects has from its beginning propounded many varied technical problems, since the investigations were "started from scratch." Early centrifuges were crude, even though effective, while instrumentation proved difficult and, in retrospect, primitive. Present equipment leaves relatively little to be desired. Electronic instruments are, of course, sensitive to outside interferences, and the design and construction of apparatus necessary to transmit the tiny electrical discharges from the brain, heart, and skeletal muscles have not been without difficulties. The electrical recording of blood pressure changes within an animal's arteries is a rather technical and difficult matter, and when the animal is travelling at high speed on a 20-ft rotor the problem is greatly complicated. Recently, the design of a g slide-rule has been of considerable help to the "physiologists-turned-physicists" of our staff, since by its use one can almost instantly determine the proper revolutions per minute for the rotor to procure the desired g when animals are set at any distance from the axis of the centrifuge. These technical improvements and devices, while perhaps somewhat removed from the purely physiological, nonetheless have to be made to perform functional experiments with better and better precision.

The future course of any research cannot, obviously, be accurately foretold. At Virginia Medical School, we plan in the near future to study accelerations and decelerations of very high magnitude, and equipment for this work is taking shape. This phase of the work has been instigated because of the generally increasing importance of such forces in military aviation.

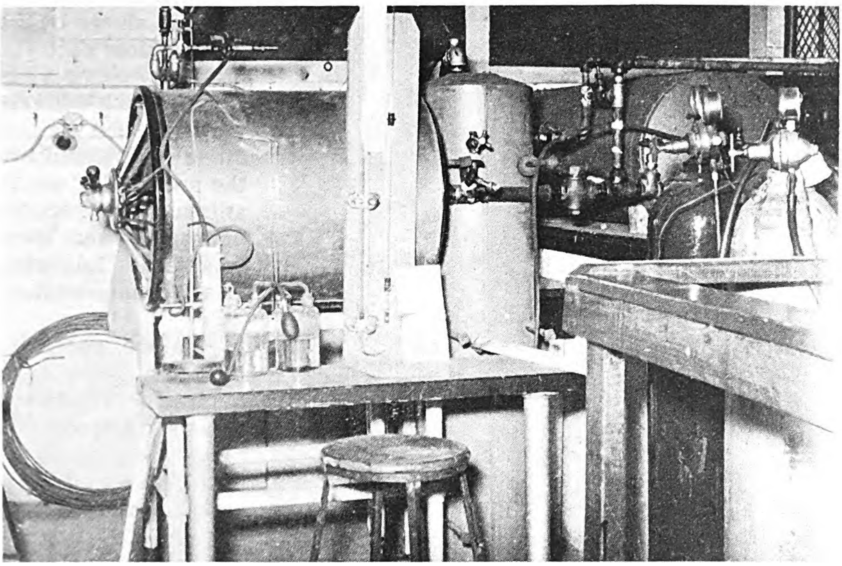


Fig. 11. Equipment used in studying effects of rarefied atmospheres. The subject for study is placed in the horizontal tank at the left. Pumps (not shown) evacuate the large metal drum at right and, by means of interconnecting valves, the animal chamber may be kept at any desired barometric pressure while, at the same time, an adequate ventilation is maintained. Various gas mixtures (from the cylinders at right) may be admitted, while heart action, brain waves, respiratory rate and depth, and the blood pressure are electrically recorded.

A second major phase of the aeromedical studies at Virginia is concerned with anoxia and explosive decompression. In specially constructed chambers, animals have been studied at simulated altitudes up to 80,000 ft, or a barometric pressure of only 21 mm Hg, and the effects of these rarefied atmospheres noted. (See Fig. 11.) These tests have included the effects of anoxia at altitude on the heart, blood pressure, cerebral activity (brain waves), respiration, kidney function and many other bodily activities. Further, the effects of high carbohydrate diets, of heat and cold, and the breathing of various gas mixtures have been studied, as they may affect activity of the organism at high altitude.

In the observations on explosive decompression, animals are decompressed to rather high vacua (e.g., from 760 to 21 mm Hg) within a fraction of a second. (See Fig. 12.) These studies were designed to simulate conditions which might arise on failure of pressurized cabins, rupture of the canopy of a pressurized fighter plane, or which might be caused by the tearing of such cabins by gunfire. Under laboratory conditions, injury and death are commonly ascribed to the tearing of the tissues of the lungs, owing to the rapid expansion of their contained gases on the sudden release of external pressure. Anoxia at high altitude and formation of gas bubbles in the blood are also potent factors causing death from explosive decompression. The latter is shown by the observation that the mortality percentages in such experiments bear a rather close relationship to the speed with which animals are recompressed to sea-level conditions following the decompression.

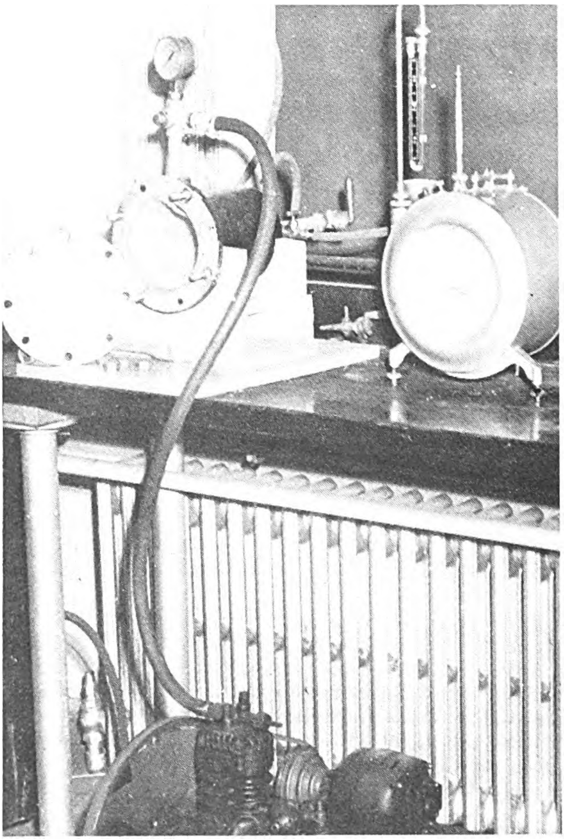


Fig. 12. Apparatus currently in use for experiments on explosive decompression. Small animals are placed in the heavy metal chamber with flanged door. Compressed air can then be admitted and the chamber later explosively decompressed through a valve of large diameter. On the other hand, the chamber may be just as speedily evacuated by means of the vacuum tanks visible at the lower left.

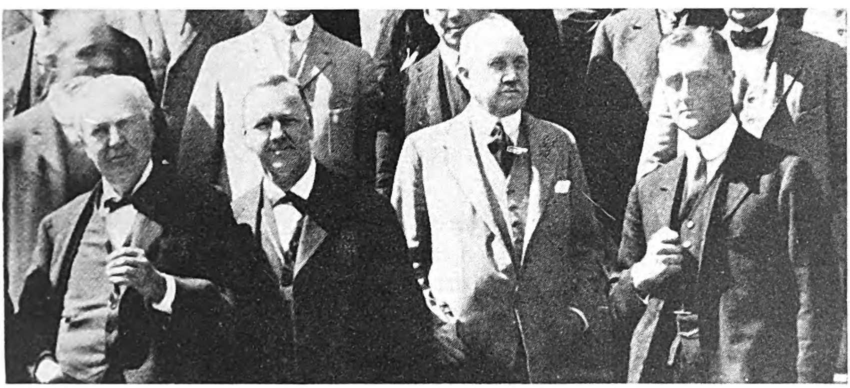
More recently, attempts have been made to evaluate the relative importance of the expansion of the intrapulmonary gases, anoxia, and air embolism as factors in explosive decompression injury. These experiments are really performed "in reverse." Thus, animals have been placed under many atmospheres of pressure for certain desired time intervals and then "exploded" to normal atmospheric pressure. In such tests the animals never become anoxic and the factor of anoxia can be independently studied.

Results to date have indicated that the physical expansion of the gas within the lungs is relatively less important in the production of injury than we had hitherto supposed.

Certain aeromedical problems appear to require much fundamental laboratory study, as a necessary basis for the future practical solution to the problem of adjusting man to the stresses imposed by new environments and machines -- and adjusting these new environments to man. Perhaps in the establishment of these basic and fundamental concepts the university scientist can be of most service in the solution of military problems.

Those of us who have worked on these problems over a period of years, in close cooperation with the Office of Naval Research, have had the interesting experience of seeing how the university scientist can actively participate in research of interest and help to the military establishment.

THIRTY FOUR YEARS AGO



Creation of the Navy Consulting Board (1915) marked the first gathering of distinguished scientists and inventors called together by then Secretary of the Navy Josephus Daniels to provide ". . .machinery and facilities for utilizing the natural inventive genius of Americans to meet the new conditions of warfare as shown aboard. . . ."

In this group which included two representatives from each of 12 of the country's leading scientific societies are (left to right) Thomas A. Edison, President of the Board, Secretary of the Navy Daniels, Hudson Maxim of the American Aeronautical Society, and Franklin D. Roosevelt, Assistant Secretary of the Navy (1913-20)

MORE REFRACTION DATA TO GUIDE THE NAVIGATOR

Charles H. Smiley
Brown University

Every time a navigator uses a sextant to measure the altitude of a celestial body to determine his position, he must first correct the observed altitude for atmospheric refraction.

The basic principle which is used is that the lower limb of the sun is always lifted more by atmospheric refraction than the upper limb, making the sun appear flattened when it is near the horizon. (See Fig. 13.) The difference between the refractions for the two limbs is equal to the difference between the horizontal and the vertical diameter of the sun at any given time. Each of these diameters can be measured with a sextant and by adding up the differences (integration), one can find the atmospheric refraction corresponding to any given altitude.

The first tables for atmospheric refraction corrections were published by Tycho Brahe in 1602.(1) In 1830, the German, F. W. Bessel(2) published a table with corrections based on barometric pressure and temperature. Most refraction tables appearing in modern navigation tables are based on Bessel's table or the Pulkova table of 40 years later. The Japanese have published tables(3) based on their own modern observations with three adjustments for temperature, barometric pressure, and the difference between air and water temperature. The latter adjustment as a correction to the dip of the horizon also appears in recent Danish tables.(4)

No attempt appears to have been made to determine whether an additional adjustment was needed to take care of latitude. When one recalls that the earth itself is oblate due to its rotation, it would appear reasonable to expect the atmosphere to have the shape of an oblate spheroid, not necessarily the same as that of the earth.

<u>Charles H. Smiley</u>, Chairman of the Department of Astronomy at Brown University and Director of Ladd Observatory, received his Ph.D. from the University of California at Berkeley (1927). After two years as instructor at the University of Illinois, he received a Guggenheim Fellowship, under which he did research for a year in mathematical astronomy at the Royal Observatory at Greenwich and at several European observatories.

For eighteen years, he has been connected with Brown University. He led an eclipse expedition to Brazil in 1947, and at that time began his work on the observation of atmospheric refraction at low angular altitudes. Early in 1948 he led another eclipse expedition to Bangkok, Siam, for the National Geographic Society. Dr. Smiley said, "It was a shame to be so near the Indian Ocean with its well-known anomalous atmospheric refraction and not be able to make a long series of measures."

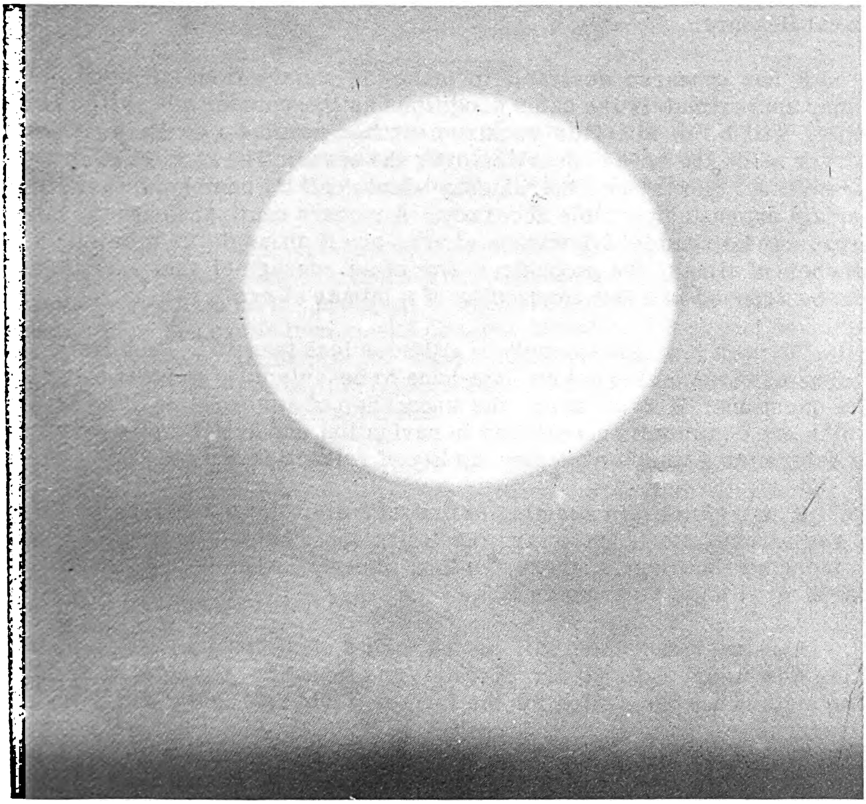


Fig. 13. The lower limb of the sun is always lifted more by atmospheric refraction than the upper limb, making the sun appear flattened when it is near the horizon.

Also the tradition has been that observations at altitudes at less than 10° were uncertain and should not be used. Many persons have examined the problem, have concluded that some observations at less than 10° altitude may be reliable, and have urged permitting their use in the preparation of tables. In any case, it would be desirable to consider lowering the altitude limit of useful observations.

To gather the data needed to reexamine the problem, a program of observations made from the bridge of surface vessels, to cover latitudes 90°S to 90°N, or as much of this range as possible, was undertaken. With the support of the Office of Naval Research, 15,000 observations were made by the members of the Brown University Eclipse Expedition between New York (40°N) and Santos, Brazil (24°S) in the spring and early summer of 1947. Mr. Harries-Clichy Peterson of the Finn Ronne Antarctic Research Expedition has made observations from 20°S into the Antarctic. Now observations are being made between 38°N and the

North Pole. The observations are being reduced at Ladd Observatory, Brown University, as a part of the program sponsored by the Office of Naval Research.

It has appeared desirable to make the observations of refraction under approximately the same conditions as those under which the final tables will be used. This requirement has necessitated that the observer be on the ocean observing over the ocean. The motion of a surface vessel limits the instruments which can be used and thus to a certain extent the possible accuracy. A modern nautical sextant, however, can be read to 0.1 minute of arc, and if an angle is measured a number of times, the probable error of an average of these readings can be reduced to a few hundredths of a minute of arc.

We have limited our study to altitudes less than 10°. Besides providing new refraction tables, we hope to be able to give an answer to the questions: How great are the anomalies of atmospheric refraction which are commonly encountered in navigation, and are there easy ways of determining whether an abnormality of refraction is likely?

It will also be interesting to find how atmospheric refraction behaves as one moves in toward the North (or South) Geographic Pole. In those neighborhoods, there are long intervals when the sun does not reach an altitude as great as 10°.

A natural sequence will be the study of atmospheric refraction from elevations of 5,000 and 10,000 ft and including negative altitudes. The method of observation for the former could be carried out from an aircraft.

Through these studies the Brown University project under ONR sponsorship will contribute materially to the navigator's ability to find his position anywhere on earth at any time.

REFERENCES

(1) Astronomiae Instaurate Progymnasmata, p. 79, 124, 280 Prague, 1602

(2) Tabulae Regiomontanae Reductionum, F. W. Bessel

(3) Celestial Navigation Computation Tables, Tokyo, 1942
Skew Angle Celestial Navigation Method, Tokyo, 1944

(4) Nautisk Tabelsamling, H. A. Guldhammer, Copenhagen, 1946

NAVAL RESEARCH RESERVE

ANNOUNCEMENT

The annual seminar for a group of selected officers of the Naval Research Reserve, sponsored by the Office of Naval Research, will be held in Washington, D. C., June 8 to 22, 1949 for 100 Naval Reservists.

The course will provide an opportunity to observe and study the plans, objectives, and functions of the Office of Naval Research, with special emphasis on the program of the Research Reserve units. Participants in the seminar also will observe Naval research and development activities, including the Naval Research Laboratory, Applied Physics Laboratory, David Taylor Model Basin, and the Engineering Experiment Station, Annapolis, Md.

In selecting officers to attend the seminar, members of Research Reserve units will be given priority. Naval Reservists who desire to attend may obtain application forms from the Commanding Officer, Office of Naval Research Branch Office, at the following locations:

Reservists whose record of home address is in:	Branch office
First Naval District	495 Summer Street Boston 10, Mass.
Third and Fourth Naval Districts	50 Church Street New York 7, N. Y.
Fifth, Sixth and Seventh Naval Districts	Director, Research Reserve, Code 103R, Bldg. T-3, Department of the Navy Washington 25, D. C.
Eighth and Ninth Naval Districts	844 N. Rush Street Chicago 11, Ill.
Eleventh Naval District	1030 East Green Street Pasadena, Calif.
Twelfth Naval District	U. S. Naval Shipyard Hunter's Point San Francisco, Calif.

All applications must be received in the branch offices by April 15, 1949.

OFFICERS ASSIGNED TO NAVAL RESEARCH RESERVE PROGRAM

As reported in the January 1949 issue of Research Reviews, a billet has been established to assist the Naval Research Reserve program in each of ONR's branch offices listed in the previous paragraph (including one for the Southeastern area).

The duties of these officers will be to select from the applicants for the Naval Research Reserve program those judged to qualify for membership; also they will select from Naval Research Reserve personnel those judged to be qualified for Office of Naval Research war mobilization billets and will submit specific recommendations for assignment.

Officers will recommend locations and composition of Naval Research Reserve units and subunits. They will interview candidates for the position of Commanding Officer of the Naval Research Reserve units and subunits and submit nominations. They will assist new units in getting established on a sound basis and in procuring speakers for initial seminars. They will submit recommendations for assignment of research training projects and material (including classified) to units and subunits. The officer will familiarize himself with the potentialities of the units to assure optimum results from the training program. He will maintain close liaison with Naval Research Reserve personnel and make appropriate recommendations for changes in the units. He will disseminate information to reach potential candidates for the Naval Research Reserve, and publicize the Research Reserve program through personal contacts with leading authorities at colleges and institutions engaged in research projects. He will also review semiannual reports submitted by commanding officers of units and subunits.

LIST OF OFFICIALLY ACTIVATED VOLUNTEER RESEARCH RESERVE UNITS

DESIGNATION	TYPE	LOCATION	COMMANDING OFFICER
3-1	Composite	Cornell University Medical College 1300 York Avenue New York 21, N.Y.	Cdr. James S. Hardy, USNR
3-2	Special Devices	Special Devices Center Sands Point, Port Washington Long Island, N.Y.	Cdr. Len E. Yoder, USNR
4-1	Composite	Princeton University Princeton, N.J.	LCdr. Paul Busse, USNR
W-1	Composite	Department of the Navy Washington, D. C.	Cdr. Fred C. Wiesner, USNR
5-1	Composite	University of Virginia Charlottesville, Va.	Lt. (jg) Peter B. Buck, USNR

DESIGNATION	TYPE	LOCATION	COMMANDING OFFICER
6-1	Composite	Georgia Institute of Technology Atlanta, Georgia	Cdr. James E. Boyd, USNR
6-2	Composite	Alabama Polytechnic Institute Auburn, Alabama	Lt. James E. Land, USNR
9-1	Composite	University of Chicago Chicago, Ill.	Capt. George Lamb, USNR
9-2	Composite	University of Illinois Urbana, Ill.	LCdr. A. O. Williams, USNR.
9-3	Composite	University of Michigan Ann Arbor, Mich.	Cdr. Charles M. Davis, USNR
11-1	Special Devices	510 W. 6th Street Los Angeles, Calif.	LCdr. H. J. Pedersen, USNR
11-2	Composite	680 E. Colorado Drive Pasadena, Calif.	LCdr. John H. Biggar, USNR
11-3	Composite	University of California Los Angeles, Calif.	Cdr. L. P. Delsasso, USNR
12-1	Composite	ONR San Francisco Branch Office U.S. Naval Shipyard Hunters Point San Francisco, Calif.	Cdr. J. E. Laurance, USNR
12-1	Composite	Fresno State College Fresno, Calif.	Cdr. Ralph A. Jack, USNR
12-2	Biological sciences	University of California Berkeley, Calif.	LCdr. Nello Pace, USNR
12-3	Composite	Stanford University Palo Alto, Calif.	Cdr. L. S. Jacobsen, USNR
12-4	Composite	University of California Berkeley, Calif.	Cdr. Carl J. Vogt, USNR

ENCL: (A)

List of Figures

U. S. GOVERNMENT PRINTING OFFICE : O—1949

DISTRIBUTION LIST

From "Catalog of Activities of the Navy, including Standard Navy Distribution List, Part II:"

8MM Reserve Training Centers
7E1 Air Bases Command Naval Districts
6B4 Air Reserve Training Command

From "Standard Navy Distribution List, Part I:"

3-b. Aircraft Carriers (CV) (CVB)
3-c. Aircraft Carriers, Small (CVL)
3-d Aircraft Carriers, Escort (CVE)
3-e. Ammunition Ships (AE)
3-f. Amphibious Force Flagships (AGC)
3-j. Surveying Ships (AGS) (AGSc)
3-o. Cargo Ships (AK)
3-p. Cargo Ships, Attack (AKA)
3-x. Destroyers (DD)
3-bb. Drydocks, Floating (ARD)
3-kk. Hospital Ships (AH)
3-mm. Landing Craft (LC (FF)) (LCI)
3-oo. Landing Ships, Dock (LSD)
3-pp. Landing Ships, Medium (LSM)
3-ww. Minesweepers (AM)
3-yy. Minesweepers, Coastal, Underwater (AMc(U))
3-zz. Minesweepers, High Speed (DMS)
3-fff. Net Laying Ships (AN)
3-lll. Repair Ships (AR)
3-ooo. Repair Ships, Heavy (ARH)
3-ppp. Repair Ships, Landing Craft (ARL)
3-ttt. Salvage Vessels (ARS)
3-uuu. Salvage Lifting Vessels (ARS-D)
3-www. Seaplane Tenders (AV)
3-yyy. Seaplane Tenders, Small (AVP)
3-bbbb. Submarines (SS)
3-cccc. Submarine Chasers (PC) (PCE) (PCS)
3-dddd. Submarine Rescue Vessels (ASR)
3-eeee. Submarine Tenders (AS)
3-ffff. Transports (AP)
3-gggg. Transports, Attack (APA)
3-jjjj. Transports, High Speed (APD)
3-ssss. Underwater Demolition Teams

ONR Special Distribution List #75.