SEPTEMBER 1950

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RESEARCH REVIEWS

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- HIGH TEMPERATURE MEASUREMENTS
- ON THE NAVAL RESEARCH RESERVE

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

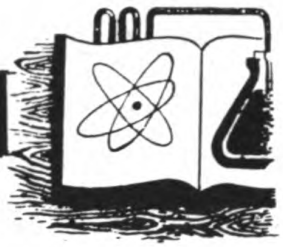
NAVEXOS P-510

COVER PHOTO: The eight-ton "radio telescope" shown is the chief instrument of Cornell University's ONR-supported project for studying radio waves originating in outer space. Dr. Charles R. Burrows, who is conducting this research at Cornell's School of Electrical Engineering, describes the progress made in this field in the article "Radio Astronomy" which appears on pp. 14-17 of this issue.

Approved by Bureau of the Budget, 13 April 1948.

RESEARCH REVIEWS

● *Informs the Fleet of ONR-sponsored Research*



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September 1950

Editorial Notes

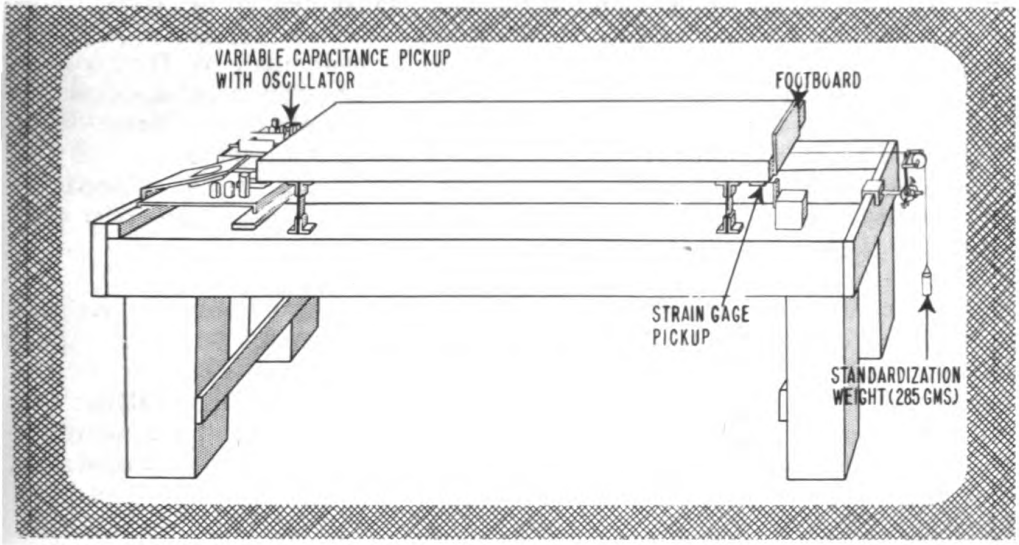
One of the most complicated problems facing our country today--the proper use of its manpower--has been a primary concern of the Office of Naval Research for a long time. Naturally the segment of the Nation's manpower that ONR is most interested in includes the men with scientific and technological knowledge which might be wasted if they were drafted indiscriminately into billets for which they have no talent or training.

Merely knowing where to locate the country's specialized manpower is in itself a problem, and the first one which must be solved if the situation is to be handled intelligently. Of course there are obvious concentrations of highly trained talent--the universities, certain industries and government laboratories--but it is important to have specific information on these sources readily available. In anticipation of this need, the ONR Manpower Branch has compiled rosters of specialized personnel which at least offer starting points in locating men needed for certain jobs. Of course, merely finding qualified men is by no means the whole story; they must then be directed in such a way that the richest harvest of results can be gleaned from their talents. It is for this reason that the Manpower Branch is conducting studies on the supervisory problems connected with the work of scientists.

In addition to the highly trained specialist who is already recognized in his field, there are other potential sources of technological manpower available to the Nation. These exist in the undeveloped talents of men whose specific native abilities, though they may be very great, have never been extensively trained. It is vital that such special abilities be discovered and used. But the task of finding men with special talents among the thousands who may be drafted is a gigantic project. Certainly a perfect method for accomplishing it is far in the future. But the Personnel and Training Branch of ONR has done a considerable amount of promising work along these lines. Aptitude tests have been devised which permit a quick screening of individuals in such a way as to indicate their probable potential capabilities. Eventually it is hoped that such techniques will eliminate a great deal of manpower wastage.

These measures apply for the most part to culling talent from civilian sources of scientific manpower. But it is also highly important to have available data on scientist members of the Naval Reserve. It is toward this goal that the Volunteer Naval Research Reserve has directed its efforts. This group is composed of officer-scientists who have voluntarily devoted sizable amounts of time and effort to projects that are of potential technical value to the Navy. One of the accomplishments of this group which may prove of great value in the present military situation has been the establishment of an index which lists each officer according to his speciality. An indication of the care with which each man's qualifications have been scrutinised is given by the fact that the list is broken down into 150 separate categories, so that the exact abilities of each man are fairly well delineated. At present all of these men have been nominated for mobilization to billets in the Office of Naval Research.

There is no question that all of these measures will be of considerable aid to the Nation in utilizing its best brains in the present military expansion or for a future emergency. Similar methods were used in World War II with some degree of success, and these have been revised and improved since that time. Nevertheless the task of finding the right man for the right job in a period like the present, when speedy, large-scale deployment of personnel is essential, remains a difficult problem. Although much has been accomplished in preparing to meet the situation, much more remains still to be done. It will be a continuing concern of the Office of Naval Research to see that measures are taken to minimize squandering of the talent of men who today are so essential to their country's welfare.



The Ballistocardiograph

by
Marvin A. Epstein and Herbert R. Brown, Jr.
University of Rochester

For some 50 years the ballistic forces produced by the beating of the heart have been known. In the early part of this century Yandell Henderson, a famous physiologist, devised an apparatus sensitive enough to record the body movements representing these forces (1). Anyone may demonstrate these for himself by standing on a bathroom scale and observing the slight movement of the pointer coincident with each heartbeat.

Starr of Philadelphia, 11 years ago, was the first in this country to attempt the clinical application of this knowledge, and he called the record of body movements with the heartbeat a ballistocardiogram (2). To obtain his records he had the subject lie on a wooden platform which was supported on four strips of stiff spring steel. These springs, mounted in turn on a heavy wooden base, were arranged so that the platform or table could move in a headward and footward direction but not laterally. (Starr's apparatus is shown above.) A sensitive spring, mirror, and light beam arrangement were attached to the foot of the table in such a way that the beam from the mirror would move a perceptible distance with each tiny displacement of the table. Since the table moves about .0002 inch with each heartbeat, a deflection of one

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Marvin A. Epstein received his B. S. degree from Harvard and his M. D. from the University of Rochester, where he was engaged in OSRD research on high-altitude and respiratory physiology and where he is now a Post-graduate Research Fellow in Medicine.

Herbert R. Brown, Jr. also received his M. D. from the University of Rochester, after being awarded the A. B. degree from Harvard. As a lieutenant commander in the Navy (1942-46) he was associated with problems on fluid balance and blood transfusions. He is at present a Bertha Hochstetter Buswell Research Fellow in Medicine.

inch on the record would require the table movement to be magnified about 5,000 times. The drawing of this table shows two types of pickups attached. The variable capacitance method is described in Reference (3). The strain gage is a Statham G1 transducer. The weight is added to the end of the table to cause a baseline shift as shown on page one. To produce the ballistocardiogram Starr allowed the light beam to fall on a moving strip of photographic paper, but now a more sensitive electronic method for obtaining a record has been developed in this laboratory (3).

The emphasis of Starr and his co-workers was mainly on the use of the ballistocardiogram (or BCG) for calculating cardiac output. They felt that the size of the ballistic impulse should be dependent on the amount of blood ejected and, thus, correlated with cardiac output (4). They devised a formula for calculating the output from the tracings; however, they made several assumptions, and since they used constants that were doubtfully valid, their technique has been criticized on mathematical grounds.

Recent work in this laboratory and others has focussed attention on the qualitative aspects of the BCG (5). Since early work in this field clearly demonstrated that a repeatable pattern of headward and footward movements accompanies each heartbeat, it was felt that a study of this pattern would give valuable information on heart function. A normal BCG and an enlarged drawing of a single complex are shown in Figure 1. The headward deflections have been named the H, J, L and N waves by Starr (2) while the I, K, and M waves are in a footward direction. The normal record shows a regular pattern with well-defined complexes

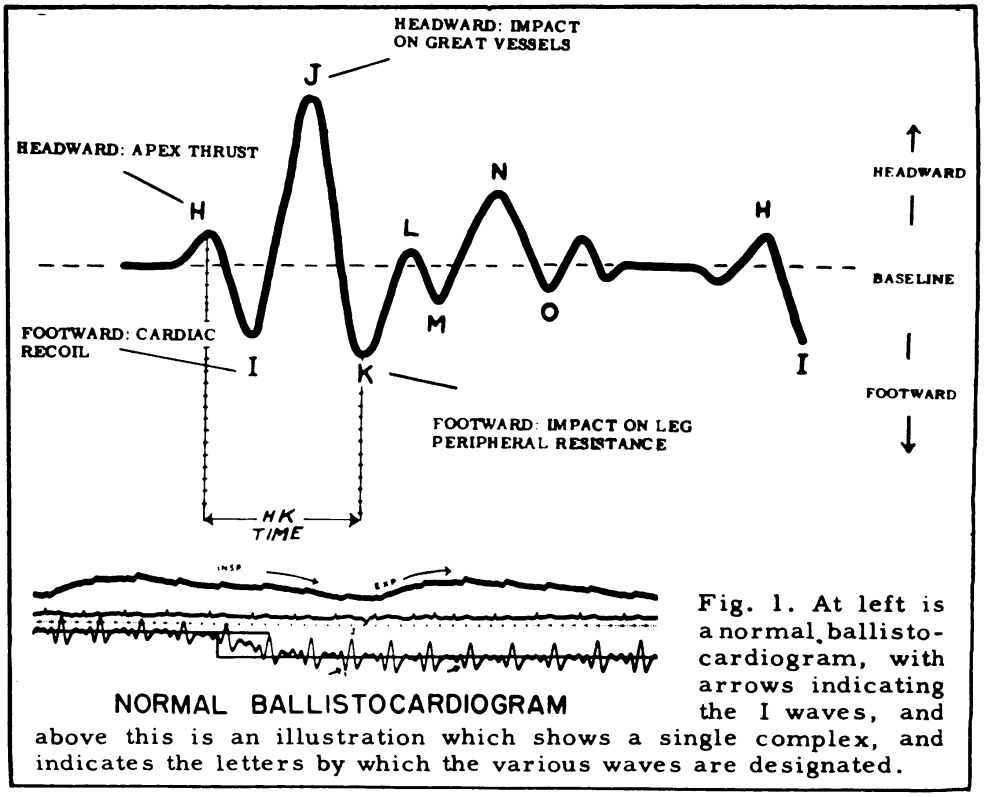

Fig. 1. At left is a normal ballistocardiogram, with arrows indicating the I waves, and above this is an illustration which shows a single complex, and indicates the letters by which the various waves are designated.

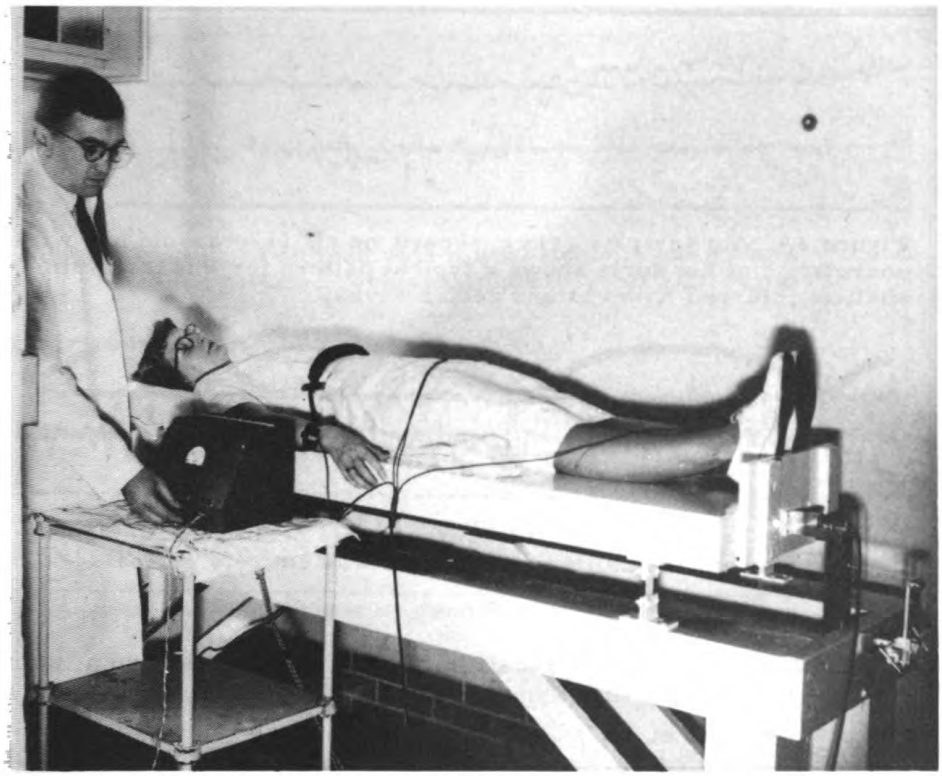

Figure 2. A subject is undergoing tests on the ballistocardiograph.

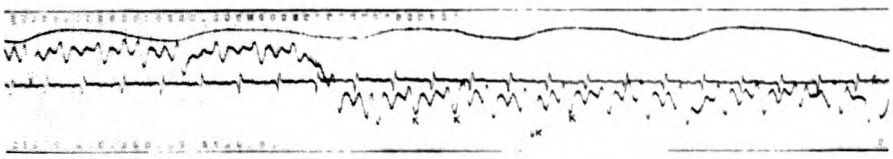

Figure 3A. In this record (taken prior to treatment) on a woman with cardiovascular heart disease, the deep K waves are marked. In addition, the amplitude of the I-J stroke is decreased.

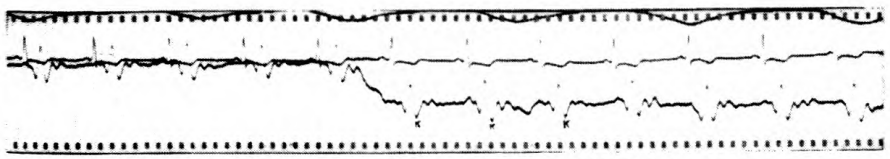

Figure 3B. A ballistocardiogram taken at noon on the third day of treatment of the patient with vertavis was normal. She had been given a total of 110 craw units, 40 of them administered on the day of the tracing.

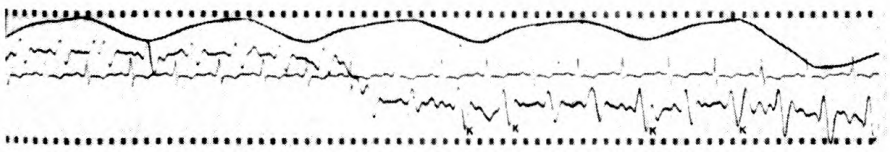

Figure 3C. The effect of reducing the dosage to 30 units daily is shown here. The abnormalities have returned.

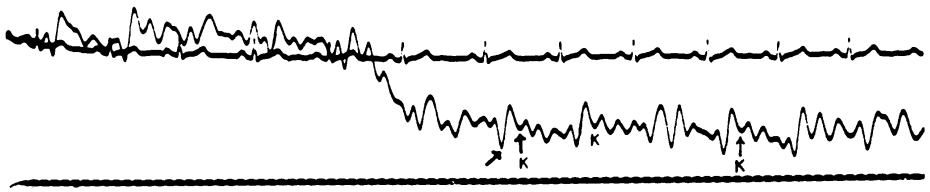

Figure 4A. A preoperative record on an 11-year-old boy with coarctation of the aorta shows a typical pattern for this condition--shallow, slurred K waves and deep I waves.

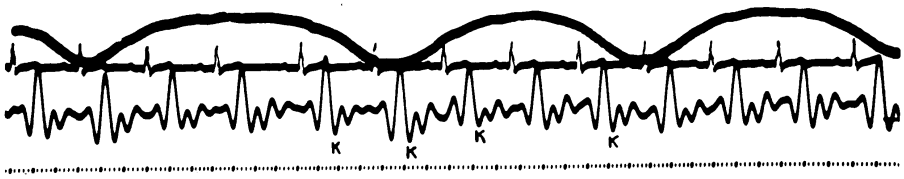

Figure 4B. Seven months after surgery was performed to remove the coarctation, the ballistocardiogram was entirely normal.

of normal H - I - J - K configuration. The complexes have an adequate amplitude and there is little change in amplitude with respirations.

The H wave is a small wave due to the apex thrust of the heart while cardiac recoil due to the ejection of blood is probably responsible for the I wave. The I-J stroke, the largest deflection of the normal BCG, is due to the impact of the pulse wave on the arches of the aorta and pulmonary arteries. The J-K stroke represents the impact of this wave on the peripheral resistance. Little is known about the waves following the K wave.

The BCG can be used clinically because it has been found that certain changes occur in the pattern when various disease states are present. In certain clinical conditions, fairly specific changes have been found. In hypertension with little or no cardiac involvement the H waves are low, and the I waves shallow, but most important, the K waves are deep, due to increased peripheral resistance (see Figure 3A). When the peripheral resistance and the blood pressure are lowered with veratrum viride, the pattern returns to normal (see Figure 3B). When the patient is put on a reduced dosage, the blood pressure rises again and the pattern becomes abnormal (see Figure 3C). Similarly, the results of sympathectomy can be evaluated. When there is a coarctation or constriction of the aorta (the great trunk artery) within the chest, the K waves are shortened and slurred (Figure 4A), but the pattern returns to normal when the coarctation is removed surgically (Figure 4B) (6).

In rheumatic heart disease without failure, the pattern may be entirely normal, although in some cases of mitral stenosis (narrowing of one of the heart valves), high N waves are seen (Figure 5A). When the rheumatic heart fails, however, the pattern becomes irregular, low in amplitude, and the complexes lose their identity (Figure 5B). Likewise, when prolonged hypertension damages the heart muscles the pattern becomes irregular and low in amplitude (Figure 5C); when the heart fails the pattern is even more abnormal.

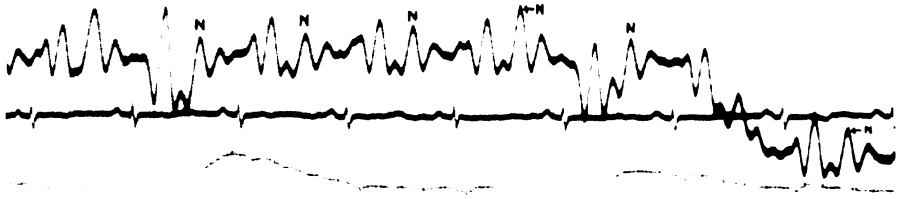

Figure 5A. Record on man with mitral stenosis but no failure shows normal amplitude, regular complexes, but high N waves.

Figure 5B. This ballistocardiogram shows the typically irregular, indefinite, low amplitude of rheumatic heart disease in failure.

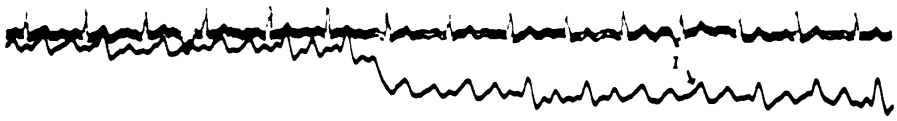

Figure 5C. Hypertensive heart disease without failure is illustrated here. Note the low amplitude with slight irregularity.

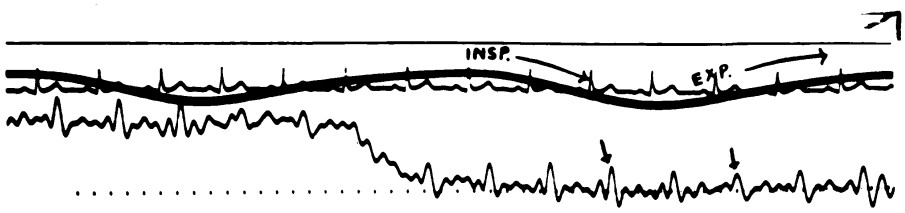

Figure 6A. In record of patient with coronary occlusion, arrows show normal I-J complex during inspiration and low-amplitude complex during expiration.

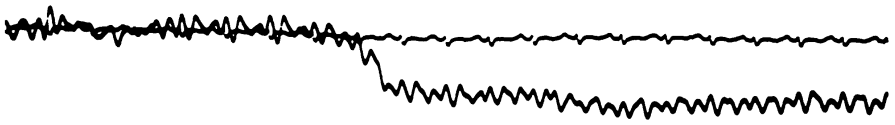

Figure 6B. An irregular low-amplitude pattern is seen in another patient with a recent coronary occlusion.

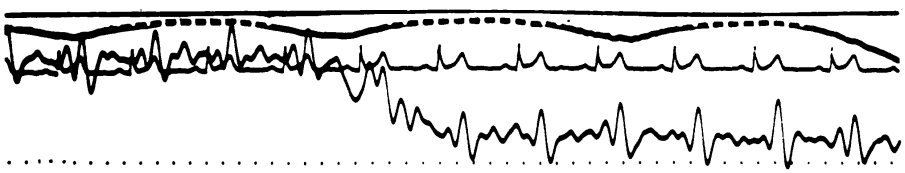

Figure 6C. A record made on a patient who had coronary occlusion seven years previously is normal, except for occasional deep K waves.

Early coronary disease is revealed by a relatively mild abnormality of the BCG - usually seen (Figure 6A) as a marked variation in the amplitude of the pattern with respiration (7, 8, 9). Since this can be remedied in some subjects by the application of an abdominal support, it is highly useful to have a method whereby patients may be screened for treatment by such measures (10). In coronary failure and myocardial infarction (a condition in the heart muscle caused by obstruction of a terminal vessel) the pattern loses its regularity and its amplitude is lowered (Figure 6B). Recovery from myocardial infarction can be evaluated by serial tracings (5, 11) which have shown that the degree of recovery varies considerably and in some cases is actually complete (Figure 6C).

Obviously the BCG is valuable in clinical medicine as a diagnostic and prognostic tool. Early studies of the device showed clearly that it gives us quite different information from that obtained with the electrocardiogram (ECG). The latter records the electrical potential changes occurring as a part of the heartbeat, whereas the former reflects the mechanical action of the heart and is more likely to be correlated with functional capacity. Often when the ECG is negative the BCG affords positive evidence of mechanical heart abnormality.

The BCG offers many possibilities for practical use in industry, where it can be helpful in determining the capacity of the heart for heavy work, and can aid in determining what the retirement age should be. Many further applications to the broad aspect of preventive medicine are possible. The BCG technique is also helpful in determining the effect of such stresses as exposure to cold environments on relative cardiac output. Use of instrument is, in addition, suggested in the high-low-altitude chamber experiments aimed at measuring continuously relative cardiac output. Thus, it appears that this instrument offers wide opportunities for making new and valuable studies of the heart.

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Amino Acids--Body Building Blocks

by
James B. Allison
Rutgers University

Amino acids are the building blocks for body proteins, the chemical structures which form the warp and the woof of living material. A bit of this material, called protoplasm, is organized into a microscopic unit of life, the cell. Cells, in turn, form the tissues and organs which are characteristic of each type of multicellular plant or animal. The liver, heart, kidney, lungs, muscles, nerves and other tissues and organs of the animal body are constructed from thousands of different types of these minute cells. This body is like a well-organized industrial community with a receiving and processing system in the alimentary tract; a transportation system in the blood and lymph; and factories, powerhouses, and disposal plants in various tissues. All these facilities are under local as well as central control through the nervous and hormonal systems. In this coordinated community, there is a continual interchange of raw materials, manufactured products, and wastes, --an interchange which the biologist calls a "dynamic equilibrium". Amino acids are an important factor in this equilibrium.

Plant and animal foods provide proteins to be broken down in the alimentary tract into amino acids which are then absorbed into the blood stream. The portal part of the blood circulatory system carries the acids to the liver, where the actual process of building body proteins starts--a process illustrated in Figure 1. This figure is a diagrammatic representation of the dynamic equilibrium which exists between blood and other body proteins, with the arrows representing the continual interchange which takes place between them. The figure shows the lungs, which are the entrance for the oxygen needed to burn the fuel in the engines of the body, and the exit for the carbon dioxide resulting from this burning. The kidneys are set apart in the diagram as a unique disposal plant and the heart as the pumping station for the circulatory system.

There are some twenty-two different amino acid building blocks which are needed by an animal to construct body proteins. Most of them can be manufactured in the body from the raw materials of food, but some cannot be made in sufficient amounts to meet the requirements for growth, repair of damaged tissue, or even maintenance. The amino acids which cannot be manufactured in adequate amounts are called indispensable or essential, and they must be included in the diet of the animal every day to maintain the integrity of living cells. The number

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James B. Allison received his undergraduate training at Penn State and his graduate instruction at Iowa State. At Rutgers he is Professor of Physiology and Biochemistry and Director of the Bureau of Biological Research in the College of Arts and Sciences. His researches have been in the fields of: carbohydrate chemistry; chemical structure and physiological effects; chemistry of body fluids of animals in health and disease; shock; protein nutrition and metabolism; and cancer.

of essential amino acids required by the animal varies with the species; ten are required by the rat. nine by the dog, and eight by man. Since there are no storage depots in the body for any of the amino acids, the omission of the essential acids from the diet quickly stops growth and results in the breakdown of body tissues. This naturally leads to many changes deleterious to life. The feeding of amino acids to prevent these changes or to correct them is called amino acid therapy.

The drastic changes in the animal body, associated with the lack of essential amino acids in the diet, are the results of breakdown of the

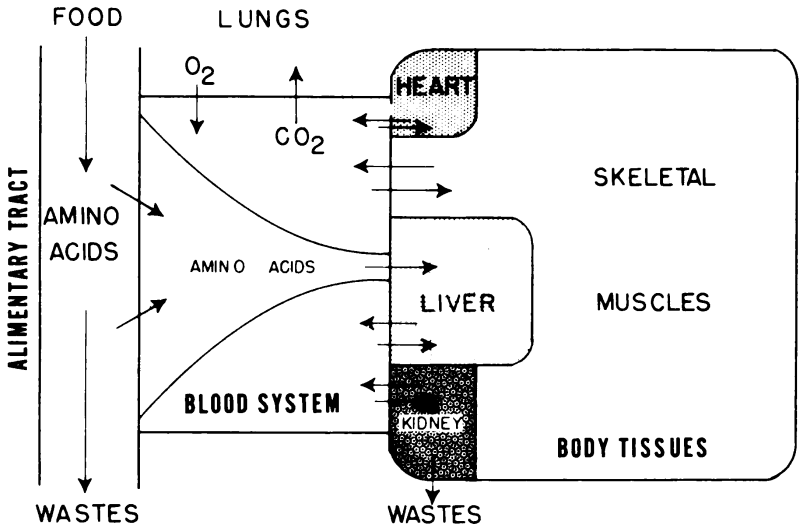

Figure 1. --Dynamic equilibrium between blood and other body proteins.

proteins of the cells without normal growth and repair processes taking place. Of course body proteins are continually being broken down--a disintegrating process that is called catabolism. When amino acids are supplied in the diet, however, a building-up process also takes place which permits growth, the development of new cells, and the repair of old ones. This building up process is called anabolism. In the absence of essential amino acids, catabolism is dominant. resulting in a lack of protein in the cells and a depletion of the protein stores of the body.

The protoplasm of the cells of the liver and of the gut are depleted in proteins most rapidly when an animal is placed on an amino-acid-deficient diet. Such an animal is very susceptible to the development of abnormalities of the stomach, intestinal tract, and liver. Prolonged depletion results in a loss of proteins from all of the tissues and organs of the body including the blood.

The effects of amino-acid depletion on blood proteins have been studied most because of ease of sampling for analysis. It has been found that lack of essential amino acids in the diet causes a marked loss in albumin, a blood protein which has much to do with maintaining a proper water balance in the body. Hence, the reduction in albumin sometimes leads to a decrease in the content of water in the blood, and an increase of fluid in the tissue spaces, a condition called nutritional edema. Another group of blood proteins (called gamma globulins) is also reduced in amount. This reduction is particularly harmful because the antibodies

to disease are associated with the gamma globulins. Thus, animals depleted in proteins are very susceptible to infections. Another group of blood proteins, however, (called alpha globulins) is not often decreased but may even be increased in amount when the diet is deficient in essential amino acids.

The blood proteins, when placed in an electric field, are characterized in part by their varying mobilities. The order of decreasing mobilities of the components of plasma protein is: albumin > alpha globulin > beta globulin > gamma globulin. If the blood proteins are dissolved in a salt solution and placed in an electric field, the different mobilities will gradually lead to their separation. Such a separation is called an electrophoretic analysis. The data plotted in Figure 2 illustrate a type of pattern obtained by electrophoretic analysis of plasma proteins from (A) normal and (B) protein-depleted dogs. The tallest peak in 2A represents the albumin fraction, while the other peaks represent separations into the various globulin fractions. In 2B the tall peak has been reduced in height, proving that depletion in proteins reduces the amount of the albumin fraction.

Other proteins or protein fragments of relatively small size also increase in quantity during depletion of amino acids. These protein fragments may be detected by precipitating the large protein particles from the blood by using a chemical such as sulfosalicylic acid, leaving the smaller fragments in solution. These increases in the smaller fragments together with a reduction in albumin characterize, in part, the effects of depletion of proteins in the animal on the blood. Changes in the blood proteins, in dynamic equilibrium with those of the tissues and organs, reflect the depleting process throughout the body. These changes in the blood can be used to diagnose and estimate the magnitude of protein depletion whether it be the result of inadequate diet or of disease. It should be emphasized that depletion in proteins is associated with most illnesses.

Loss of proteins from the blood and cells of the body not only alters the structure of the cell but also changes some of its activities. Proteins form the catalysts that are the spark plugs of the living machine. These catalysts, called enzymes, are reduced in activity by a lack of essential amino acids in the diet. One of the enzyme systems which is reduced in activity most markedly is called the succinic acid oxidase system of the liver, an important catalyst for the utilization of raw materials in that organ. Reduction in enzymatic activities results in the impairment of both anabolism and catabolism, the normal processes for building up and tearing down of protoplasm.

Normally, as we have explained, dietary amino acids are obtained through the protein foods which are broken down in the stomach and intestine. The biochemist calls this process digestion or hydrolysis. Proteins are classified for food purposes according to the amounts and kinds of amino acids liberated in the intestinal tract for absorption into the animal. Some proteins, like those found in whole egg, provide the animal with all of the essential amino acids and in the proper proportions. Whole egg, therefore, is rated as an excellent source for food proteins. Wheat gluten, on the other hand, is somewhat deficient in one of the essential amino acids called lysine. Wheat gluten must therefore be fed in much larger amounts than whole egg to meet the needs of the animal.

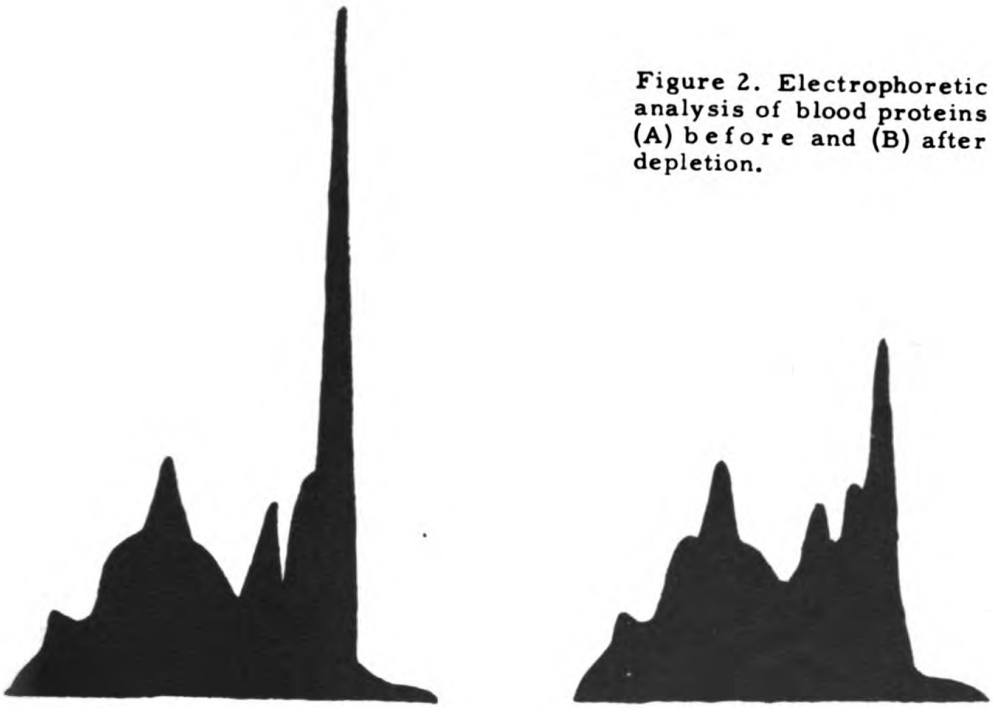

Figure 2. Electrophoretic analysis of blood proteins (A) before and (B) after depletion.

Presumably, feeding an animal a sufficient amount of protein will insure the proper proportions of amino acid in his system, but unfortunately the problem of correct nutrition is not solved so simply. Sometimes the essential amino acids are present in the protein but are not made available by proper digestion in the stomach and intestine. The essential amino acid, methionine, for example, is not easily freed in the intestinal tract from raw soy bean protein, which consequently is not a good food protein. Proper cooking, however, alters the structure of the soy bean protein so that the methionine is liberated easily in the intestine.

The digestion or hydrolysis of protein foods is catalyzed in the stomach by an enzyme called pepsin and in the intestine by another enzyme called trypsin. Some food proteins have anti-enzymes, substances which inhibit the activity of enzymes and thus prevent digestion. Raw egg white, for example, has an anti-tryptic factor, a substance which inhibits the activity of trypsin. Normally pepsin in the stomach destroys this anti-tryptic factor so that raw egg white can be fed without any deleterious effects. But since pepsin activity is often markedly reduced in an animal depleted in proteins, the anti-tryptic factor is not destroyed completely and thus, raw egg white is not digested nor utilized properly by such animals. Proper cooking, however, destroys the anti-tryptic factor and makes egg white an excellent food for such animals.

Unfortunately it is not always possible to depend upon the gastro-intestinal tract to hydrolyze the protein foods to amino acids. Lack of proper enzymatic activity or other abnormalities may make the feeding of proteins inadvisable. For that reason proteins have been hydrolyzed in the chemical laboratory into amino acids which may be fed either orally or intravenously when normal digestion has been impaired. Predigested proteins called protein hydrolysates have been particularly valuable for intravenous administration when oral feeding is impossible

or inadvisable. Studies of such feeding have demonstrated that it is necessary to feed all of the essential amino acids together in the proper proportions to obtain maximum synthesis of new body proteins or to repair old ones. Omission of one of the essential acids from the mixture prevents the utilization of all of the other amino acids, causing them instead to be catabolized or burned for fuel to make energy. Indeed the essential amino acid in lowest concentration in a mixture limits, to a large extent, the utilization of all of the acids for synthesis into protein. In other words, it appears that all the amino acids must be present in proper proportions for synthesis or none will be used for that purpose, but rather will be burned for energy. The generation of energy, however, is an important function of any food and if the diet does not supply sufficient energy in the form of fat and carbohydrate, dietary amino acids and even body proteins are sacrificed for this purpose. To prevent this, it is customary to add carbohydrate to the protein hydrolysate for intravenous feeding.

Amino acids are also essential for purposes other than building body proteins. The amino acid methionine, for example, is part of a methylating mechanism of the body, a mechanism important to the synthesis of a number of key compounds in the economy of life. The methyl group (CH_3) for these reactions may be supplied by methionine. If the demand for methyl groups by the machines of the body is greater than the supply in the diet, body tissue protein may be broken down to supply methionine. Thus this amino acid in the diet may spare body tissue. Large excesses of methionine added to the diet, however, result in loss of weight and depletion in body proteins. It is believed that the excess speeds up the methylating mechanism of the body, thereby creating a greater demand for certain raw materials, such as the amino acid glycine. To supply the increased demand for glycine, body proteins may be torn down. But the addition of large amounts of glycine to the diet will protect the animal from this depleting effect. It is interesting, in this connection to note that the liver, an important center for methylation, is not depleted by excess methionine but may even be increased in size and the kidney is definitely enlarged. Thus, these organs may be said to be growing at the expense of the others. These results suggest that methionine may have a therapeutic value in the treatment of liver and kidney disorders.

But excess methionine in the diet does more than increase the methylating machines of the body. By some as yet unknown mechanism it also depletes the fat depots of the body. Since fats are usually burned to supply energy (measured in calories of heat) for the living machine, it is possible that energy requirements are increased by reactions associated with large amounts of methionine. It should be emphasized again that when the fat and carbohydrate portion of the diet has been reduced, so that sufficient calories are not being supplied, body proteins will be broken down for fuel. First, certain labile body proteins are depleted, then both dietary and body proteins are thrown in as fuel for energy--a process which is particularly rapid if the dietary caloric intake is less than fifty percent of normal. Animals which have great reserves in protein stores may resist the caloric stress over a long period of time, while those with inadequate reserves succumb rapidly to it. Part of this resistance to stress may also be associated with the hormones of the body.

Part of the resistance to caloric or any other nutritional stress, as well as shifts in protein stores from one organ to another, can be correlated with the hormonal system. Hormones, which may be termed chemical "messengers," manufactured by endocrine glands, are carried by the blood to tissues and organs of the body, where they influence anabolism or catabolism, often in such a way as to reduce or increase the protein stores. The sex hormone, testosterone propionate, for example, increases body proteins. Lack of the thyroid hormone increases blood globulins, but does not alter in general the retention of dietary amino acids. Too much thyroid hormone, on the other hand, decreases the protein stores of the body. The relationships between amino acid therapy and the hormones of the body form a new and important field of research.

Much research, however, is needed to take advantage of the knowledge we now have of amino acid therapy. Already, however, protein hydrolysates of various kinds are being widely used to treat a variety of disorders: to counteract pre- and post-operative malnutrition; to speed up the healing of wounds; and to expedite convalescence. Although the general results are spectacularly successful, details of preparation, composition, dosage, and administration, are still in the experimental stage. More study is needed to discover what each hydrolysate can do in restoring protein deficiencies of various kinds, in rebuilding damaged tissues, and in restoring general resistance to infection. Moreover, a better understanding of the relationship between hormonal and amino acid therapy is essential to a full utilization of either one, and the specific therapeutic effects of amino acids such as methionine should be evaluated in great detail. It is believed that such researches are opening a new era in nutrition and in medical science.

* * *

Radio Astronomy

by
Charles R. Burrows
Cornell University

Radio astronomy is a new branch of science which is concerned with the measurement of radio waves received on the earth from extra-terrestrial sources. The transmitters of these waves are located on the stars or in interstellar space.

The first measurements of radio signals originating outside the earth's atmosphere were made in 1931 by Karl Jansky during an investigation of the atmospheric radio noise which interferes with transoceanic radio telephony. In the course of these experiments he observed that the maximum received noise was coming from a fixed direction in space -- in fact, from the direction of the constellation of Sagittarius, in the center of our own galaxy. This discovery was highly significant for two reasons. First, it offered a new method of investigating the constitution of the universe and second, it was highly important in the realm of radio communication. Yet little further work was done in this field for several years.

During the war J.S. Hey, in an effort to determine the position of what was thought to be a German jamming transmitter which was interfering with all of the radar sets in England, found that this interference was actually coming from the sun. Hey was, in fact, analyzing data which is now being investigated by a branch of radio astronomy known as "solar noise". During the period of his investigation, the sun was unusually active. It contained many sunspots and was transmitting radio signals which were of considerably greater magnitude than normal.

In 1946 the Office of Naval Research agreed to sponsor research in radio astronomy at the School of Electrical Engineering at Cornell University. With the aid of ONR funds Cornell has built the radio telescope shown in the drawing on the cover. The operation of this telescope is very similar to that of the usual optical telescope except for the large difference in the wavelength of the received radiation. Because the waves received by the radio telescope are about a million times longer than those of visible light, the wire screen on the parabolic reflector is just as effective as a polished mirror is in the optical telescope. The directivity of the radio telescope is decreased in the same ratio. As a result, signals are picked up over a fifteen-degree cone. While this greatly increases the difficulty of interpreting the signals received from the galaxy, it is only a minor handicap in interpreting the radio signals transmitted by the sun.

Charles R. Burrows, an authority on the propagation of radio waves, has the B.S.E. (E.E.) and E.E. degrees from the University of Michigan and the A.M. and Ph.D. from Columbia. A former engineer with the Bell Telephone Laboratories, he joined the Cornell faculty in 1945 in his present capacities of professor of electrical engineering and director of the School of Electrical Engineering.

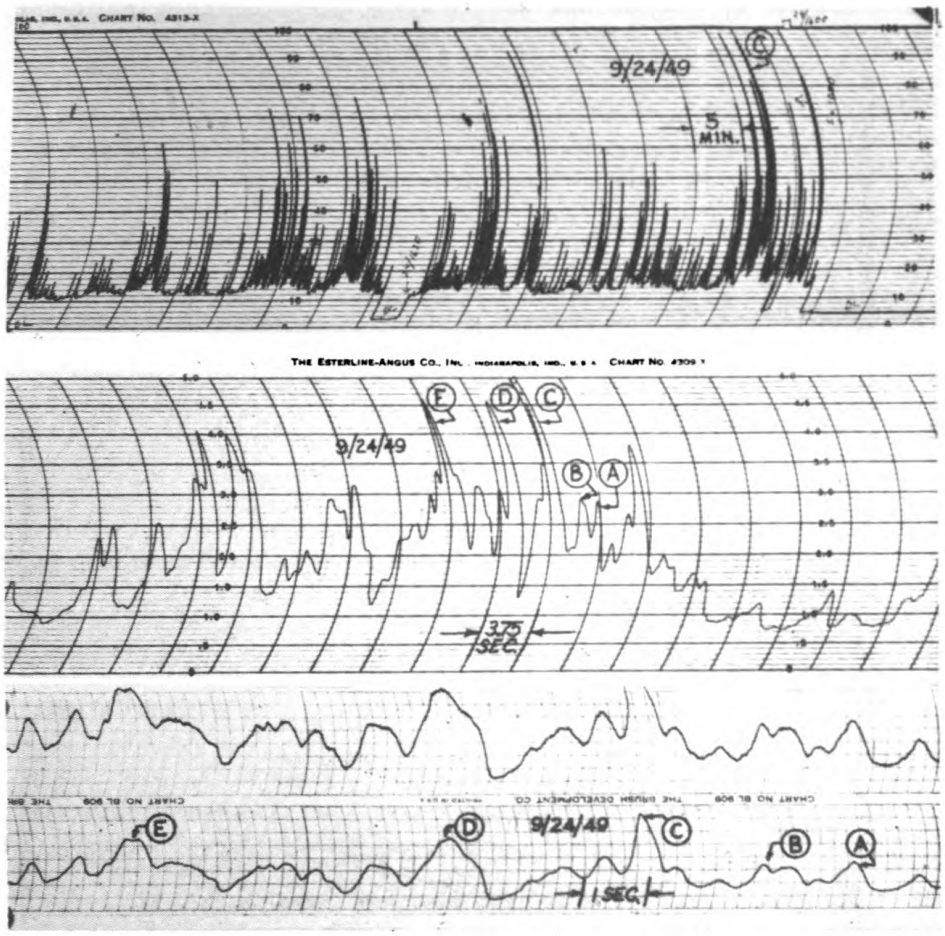

Figure 1. Sample records of solar noise. Abcissa gives the time on three different scales. Ordinate is proportional to intensity of solar noise on 200 Mc.

The intensity of visible radiation received from the sun is that which would be expected from a black body of the same size at a temperature of some 6000°K, but the intensity of the radio-wave radiation received is many times this value. It might be said that the sun appears to be very much "hotter" at radio frequencies. This is a natural result of the fact that the radiation from the sun in the meter-wavelength (radio-wave) range originates in the upper atmosphere of the sun, which is known as the solar corona. From spectroscopic measurements, it is known that the temperature of the solar corona is closer to 1,000,000°K than to the 6,000°K which corresponds to the photosphere, or visible part of the sun.

Radiation from the sun is subject to several types of fluctuations. There are large changes in intensity which are complex and markedly variable. Figure 1 shows a sample of the record of the variation of solar intensity with time on a wavelength of 1.5 meters. The horizontal axis shows the variation in intensity for three different recording speeds, while the distance along the vertical curved axis is proportional to the intensity of the received signal. The lower record shows several increases whose duration is as short as one second.

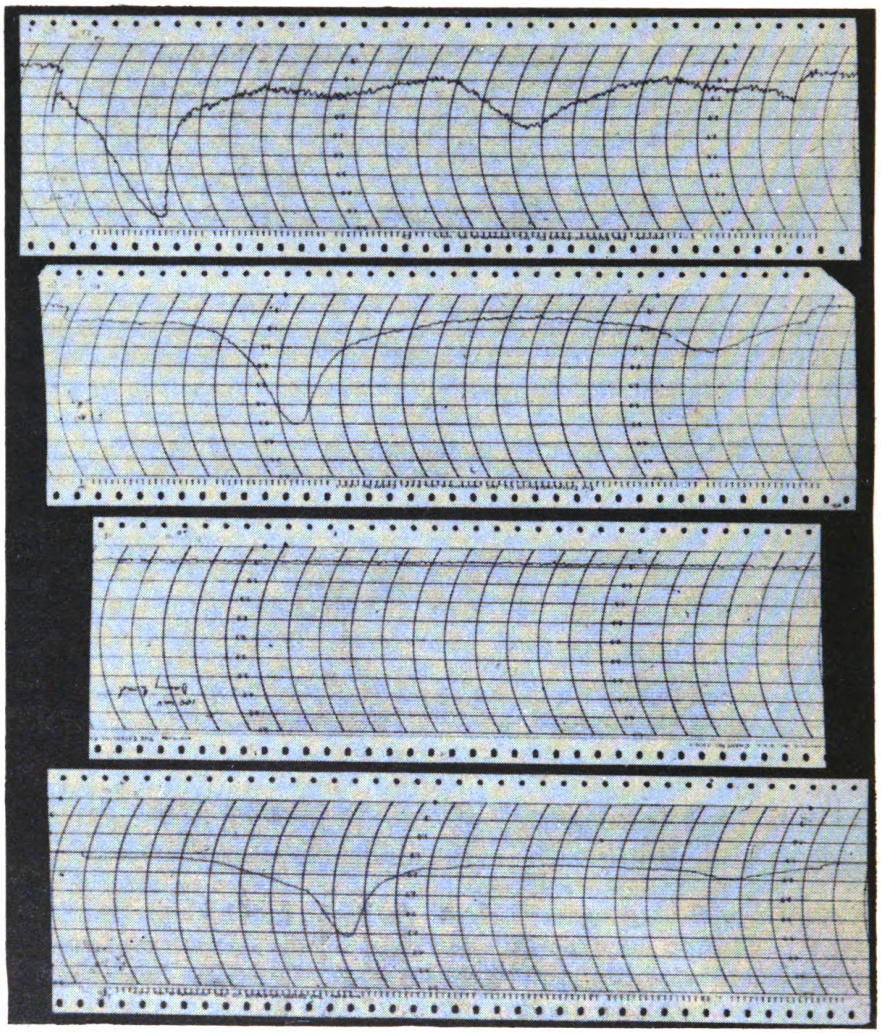

Figure 2. Records of sweeps throughout the Milky Way.

From the study of these variations, it is hoped to learn more about the sun. It has been found that some of the bursts of solar noise are confined to a very narrow frequency interval. This is indicated by measurements made on neighboring wavelengths which show bursts occurring at different times. Some of the larger bursts which appear to occur over a wide frequency interval do not happen simultaneously at all frequencies; those at the higher frequencies occur earlier. This is as if the bursts were caused by a disturbance moving toward the earth through the solar atmosphere at speeds corresponding to winds there. Since the radiations from the sun at the higher frequencies come from deeper down in the solar atmosphere than radiations at the lower frequencies, this is what should be expected.

Some of the larger bursts of solar noise have been identified with active areas on the solar surface, which include sunspots. These larger bursts have been found to be circularly polarized - exactly what would

be expected if the increased solar energy were caused by the motion of electrons in the magnetic field of a sunspot.

It is well known that solar radiation is the primary cause of the earth's ionosphere, upon which all long-distance radio communication depends, and that variations in solar activity greatly affect the ionosphere and through it, the reliability of radio communication. Consequently the study of solar noise should lead to a better understanding of the vagaries of radio communication.

Besides the study of radio signals received from the sun, radio astronomy includes the study of radio signals received from elsewhere in our galaxy. Measurements made at various wavelengths indicate that the distribution of radio transmitters in the galaxy is roughly the same as the distribution of the visible stars. The most intense radiation comes from a narrow strip coincident with the Milky Way. The position of this strip has been determined at Cornell by sweeping the radio telescope across the Milky Way almost at right angles to it. Samples of the records of the galactic noise obtained in this way are shown in Figure 2. By analyzing these records, it has been found that the plane of maximum radiation is not a great circle but a small circle, approximately one degree away from the great circle. This means that the sun is not on the plane which bisects the Milky Way but is slightly north of it. This is in accordance with similar determinations made by counting stars.

One of the startling discoveries in radio astronomy has been the location of a large number of "radio" stars. In certain directions it has been found that there are radio transmitters of extremely high intensity whose extension in space is so small as to appear as a point to the most precise measurements available in the field of radio astronomy. In no case can an object be observed with an optical telescope that can be identified definitely with a radio star. One radio star, however, does appear to be in the same direction as the crab nebula, an expanding gaseous mass which is the remains of a star explosion in 1054 A.D. But there are reasons to believe that this is only a coincidence. Many hypotheses have been made to explain both the general galactic noise and the radio stars, but they all fail when subjected to quantitative tests.

Radio astronomy promises much, both in helping us to understand the universe in which we live and in allowing us to make better use of long-distance radio communication. It provides the scientist with a new tool to use in unraveling the secrets of nature.

* * *

High-Temperature Measurements

by
Harold T. Smyth
Rutgers University

The use of ceramics in engineering includes their application in a wide variety of fields. One of the most important of these applications is in protective coatings. In spite of the very prevalent use of such coatings, however, certain phenomena have been noted in connection with them that are not well understood from a basic point of view. For example, certain observations have been made in work on the application of mixtures of alumina and silica to graphite and molybdenum. If a mixture of 80 percent alumina with 20 percent silica is applied to a molybdenum surface and heated in a vacuum, the ceramic material will ultimately melt and form a strongly adhering coating. If, however, the same sample is heated in a hydrogen atmosphere the coating will melt and gather itself up into beads.

If a similar coating is applied to graphite and heated at atmospheric pressure inside a closed graphite furnace chamber (so that the atmosphere is essentially nitrogen and carbon monoxide) it can be melted to form a well adhering coating. But if complete melting is not attained, there is no adherence between the coating and the graphite. Moreover, if a temperature is obtained which is slightly too high the coating runs completely off the graphite and leaves it bare. If the sample is heated in a vacuum, the coating melts, but does not adhere to the graphite. These are but a few examples of the many complex and puzzling problems which arise in the art of preparing ceramic coatings.

To improve ceramic coatings, the basic reasons for such phenomena must be discovered. This involves studies of the physical properties of the ceramic materials which might influence their behavior and also some physical properties of a more fundamental importance. In order to make these studies a furnace is needed which will provide the necessary temperatures (2300+^{o}C) with controllable atmospheres. We have been developing such a furnace at Rutgers University.

The most flexible furnace for this type of work is an induction-heated furnace. The heating element, or susceptor, is a tube of molybdenum or tantalum about one inch in diameter, and 5 or 6 inches in length, made from sheet about .055-inch thick. The element is placed inside a helix of 1/4-inch O. D. copper tubing with about 20 turns in an eight-inch length, wound on a 2-1/4-inch mandrel. This coil is connected to a high-frequency generator with an output of 10 kw and a frequency of 200-600 kc.

Harold T. Smyth was born in Lisburn, Northern Ireland, and received his bachelor's and master's degrees in physics from Queen's University of Belfast. After completing his Ph. D. at the Massachusetts Institute of Technology in 1936, he became a research physicist, first at Corhart Refractories Co. (where he was eventually Director of Research) and later at The Johns Hopkins University Applied Physics Laboratory. He is now Research Professor in Ceramics at Rutgers University.

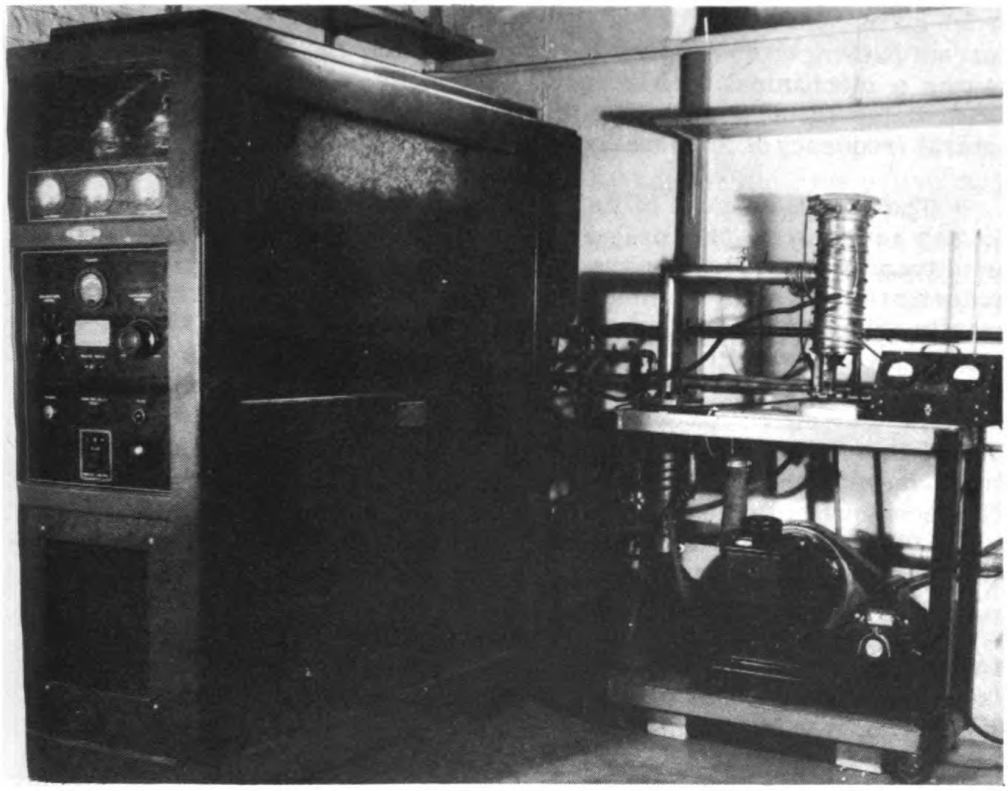

Figure 1. Vacuum induction furnace. Note the pumping system and high-frequency generator.

The coil and susceptor are enclosed in a brass cylindrical shell which can be evacuated. Since the voltages applied to the coil are quite high, the vacuum must be maintained below 10 microns to prevent discharges around the coil. An oil diffusion pump backed by a mechanical pump can maintain such a vacuum without much difficulty.

As thermal insulation in the furnace, a spiral of sheet molybdenum wound around the susceptor but insulated from the coil is quite effective because of its low emissivity.

Temperatures in excess of 2300°C can be obtained in the furnace in a few minutes. For such temperatures tantalum is preferred to molybdenum for the susceptor tube because of the rapid volatilization of the molybdenum.

As an example of the way the furnace can be used to measure physical properties, we shall briefly describe the method used for viscosity measurement. The liquid to be studied is contained in a simple cylindrical cup of molybdenum or tantalum, which is held in the hot zone of the furnace by a bifilar suspension. This allows torsional oscillations of the cup with a period governed by the geometry of the cup and suspension.

The cup is also located at the centre of a pair of Helmholtz coils outside the furnace, through which an alternating current of low and controllable frequency can be sent. This frequency is of the same

order as the natural period of torsional oscillation of the cup. A direct current passing down one wire of the bifilar suspension and up the other causes a mechanical torque on the cup which varies sinusoidally with time. If the frequency applied to the Helmholtz coils is close to the natural frequency of torsional oscillation, the cup is set into oscillation.

The liquid, because of its inertia and viscosity, causes a drag on the cup as it turns. This drag has the effect of flattening the curve of amplitude of oscillation plotted against the applied frequency. The mathematics is a little complicated, but the response curves can be exactly calculated for any given set of conditions. In this way viscosity can be measured with a minimum of complicated apparatus in the hot zone.

For surface tension measurements, the most promising procedure is the measurement of the contour of a drop (as in Quincke's method). The technique is to measure the contour of a drop at maximum diameter. This is attained by studying the drop on a solid which is not moistened by the liquid. The measurements are made in the hot zone.

It was noticed in operating the furnace that it allows the operator a very rapid and also a very precise control of the furnace walls as "seen" by a sample hanging in the furnace. This permits regulation of the heat input to the sample by control of the differential between the sample and its surroundings. Alternatively we can control the rate of rise of the sample container (and this can actually be very precisely done). By knowing the gradient through the sample we have a measure of the diffusivity. By knowing the differential between the sample container and the susceptor, we have a measure of the heat input, which, together with the rate of rise, enables specific heat to be measured.

It is hoped that such measurements, made on ceramic materials under the conditions which obtain during the coating process, will provide a scientific instead of an empirical basis for future ceramic coating technology.

* * *

Dr. Stebbins to Receive High Award

Dr. Joel Stebbins, Investigator under ONR Contract with the University of California, will be presented with the Gold Medal of the Royal Astronomical Society at a meeting in London on 13 October 1950. This is the highest award which an astronomer can receive.

In connection with the award Dr. Stebbins has been invited to deliver the George Darwin Lecture before the Society. He will review the work which led to the award and in a major portion of the lecture will deal with the investigations in multicolor photometry of stars carried on during the past two years under the Office of Naval Research at the Lick Observatory of the University of California.

Dr. Stebbins is a leading authority on the color measurement of stars and pioneered in the application of the photo-electric method to astronomical problems nearly forty years ago. His research which is being continued at Lick will extend our knowledge of the structure of the galaxy and of the nature of interstellar particles and may well lead to a new criterion for the absolute luminosity of stars.

On the Naval Research Reserve

Active Duty

At present, the majority of reserves being called for active duty are those needed for the expansion of the Commandants' offices, recruiting stations and, of course, the fleets and the supporting bases in the Pacific. It is possible that further expansion will soon occur, as Bureaus and Offices of the Navy Department find it necessary to grow in order to support the Fleet. It is expected that more information on this score, of interest to Research Reserves, will be available in the near future.

VNRR Units Working in Civilian Defense Plans

Because of the current international situation, all units of the Volunteer Naval Research Reserve have been advised by the Chief of Naval Research, RADM T. A. Solberg, to begin working on civilian defense plans in cooperation with local authorities.

Although there have been no definite "ground rules" established for civilian defense, local officials are extremely anxious to get any qualified assistance that is available in working out suitable plans. In some instances, Commanding Officers of Research Reserve units are working directly with members on such projects, but insofar as future mobilization planning will permit, execution of these projects will be left entirely up to individual units and their cognizant authorities.

A film entitled "Medical Effects of the Atomic Bomb" is available from the Commanding General of each local Army Area for any units which are interested in setting up plans for radiological defense. The film contains much information pertinent to this highly important aspect of modern warfare.

A number of Reserve units have already made considerable progress on civilian defense projects and have reported that such undertakings are an "all hands" effort. These units are providing a real service to our Nation. (A description of the recently organized Radiological Defense Squad composed of Reservists of the Oak Ridge Unit is given on page 22.)

Unit 9-21 Activited in Detroit

VNRRU 9-21, formed in Detroit on 28 June, has turned out to be a going concern. Twenty-seven applications for membership have been received to date. Further information concerning this new group may be obtained from the Commanding Officer.

This unit is restricted to employees of the General Motors Corporation. Commanding Officer is LCDR Ralph A. Richardson, Research Laboratories Division, General Motors.

TRAINING DUTY BILLETS AVAILABLE

Subsequent to the cancellation of the seminars scheduled for the first quarter of this fiscal year, a few billets for on-the-job training have become available. It is planned at present that the 8-21 October NRL seminar will be held, as well as seminars scheduled on the West Coast (in November) and at Oak Ridge (in December).

It should be remembered that on-the-job training requires that the duty station be approved for training of an individual in the type of duty for which he might be mobilized--not merely in the type of duty which is precisely appropriate to his individual background and interest. It should be emphasized that it is essential to request training duty orders six weeks in advance of the date of duty desired, since the Program Officer needs time to find billets and the Commandant must have time to write orders.

Affidavits are required attesting the availability of the applicant within 30 days, in the event that mobilization occurs.

Reserve Units Studying Radiation Defenses

Teams of Reservists are being organized in key southern cities in order to assist local civilian defense units in the event of a surprise atomic attack.

One group is already established. VNRRU 6-3, located at Oak Ridge, has completed plans for an emergency Radiological Defense Squad, composed of officers who are experts in this field. Members of the squad are employed in the Oak Ridge National Laboratory and other Oak Ridge atomic facilities. Their special knowledge of radiation protection problems naturally makes them particularly well qualified for this work.

Officers who have volunteered for service on the Oak Ridge squad include LCDR David J. Mallon, USNR, Commanding Officer; LCDR V. Hendrix, USNR, Radiological Defense Engineer; LT D. Zachry, USNR, Instrument Engineer; LTJG W. Smith, USNR, and LTJG W. Pryor, USNR, both Health Physicists; CDR C. Bozzi, USNR, Radiation Safety Coordinator; and LCDR E. R. King, USNR, Radiation Sickness Therapist.

Officers assigned to this unit have volunteered to rush into any area hit by an atomic bomb and, by means of their special techniques and equipment, to measure the extent of radiation danger and recommend measures for the protection of the population. It is likely that the group would follow safety rules very similar to the very successful ones used during the Bikini bomb test.

It is probable that after the Oak Ridge unit is fully developed it will serve as a pattern for the formation of radiological defense squads in other Naval Research Reserve units in this area.

Officially Activated

Volunteer Research Reserve Units

Desig-nation	Time and Place of Meeting	Commanding Officer and Mail Address
1-1	2000, 1st & 3rd Mon. Navy Bldg. Auditorium 60 495 Summer St. Boston, Mass.	CAPT L. M. SMITH, USNR 34 Parkland Ave. Lynn, Mass.
1-2	1930, 2nd & 4th Tues. USNROTC Bldg. Brown University Providence, R.I.	CDR Carl PFAFFMAN, USNR (O in C) 16 Cabot St. Providence, R.I.
1-2 Sub-Unit	1600, 1st & 3rd Tues. Ranger Hall, Rm. 305 R. I. State College Kingston, R. I.	CDR Charles J. FISH, USNR (O in C) Narragansett Marine Lab. Kingston, R.I.
1-2 Sub-Unit	2000, 1st & 3rd Tues. Oceanographic Institute Woods Hole, Mass.	LCDR F. C. RYDER, USNR (O in C) County Rd. Woods Hole, Mass.
1-3	1900, 1st & 3rd Tues. University of Massachusetts Amherst, Mass.	LCDR E. D. EMERSON, USNR Mech. Eng. Dept. University of Massachusetts Amherst, Mass.
1-4	2000, 1st & 3rd Tues. Coburn Hall University of Maine Orono, Maine	LT Francis J. SULLIVAN, USNR 25 Myrtle St. Orono, Maine
1-5	2000, 1st & 3rd Mon. Stratton Hall Worcester Polytechnic Inst. Worcester, Mass.	CDR Emerson A. WIGGIN, USNR 25 Bay State Rd. Worcester 6, Mass.
1-6	1930, 1st & 3rd Mon. Smith Hall, Room 104 Lowell Textile Institute Lowell, Mass.	LTJG Joseph B. MASASCHI, USNR 3 Hilltop Terrace Chelmsford, Mass.
1-7	2000, 1st & 3rd Tues. Wentworth Hall Dartmouth College, Hanover, N. H.	CDR George Z. DIMITROFF, USNR Shattuck Observatory Dartmouth College Hanover 30, N. H.
3-1	1930, Alt. Thurs. Cornell Univ. Med. Coll. Auditorium 1300 York Ave. New York 21, N. Y.	CAPT. Robert H. GRIFFIN, USNR 105 Pennsylvania Ave. Tuckahoe 7, N. Y.

Desig-nation	Time and Place of Meeting	Commanding Officer and Mail Address
3-2	1930, 2nd & 4th Mon. Special Devices Center Engineering Bldg. Port Washington Long Island, N. Y.	CDR L. E. YODER, USNR Special Devices Center Port Washington Long Island, N. Y.
3-3	2000, 1st & 3rd Mon. USNRTC & MCRTC 3 Porter Ave. Buffalo, N. Y.	CDR Morris BIERMAN 479 Eggert Road Buffalo, N. Y.
3-4	1930, 1st & 3rd Tues. Harkness Hall University of Rochester Rochester, N. Y.	CDR Henry C. SHEVE, USNR USNRTC & MCRTC 900 East Main St. Rochester 7, N. Y.
3-5	1930, 2nd & 4th Thurs. USNRTC Fort Nathan Hale Park New Haven, Conn.	CDR D. S. ROWELL, USNR USNRTC Fort Nathan Hale Park New Haven, Conn.
3-6	2000, 2nd & 4th Mon. USNRTC Syracuse (Liverpool), N.Y.	LCDR Leslie R. PARKINSON, USNR 117 Harrington Rd. Syracuse, N. Y.
3-7	2000, 2nd & 4th Thurs. USNRTC Scotia, N. Y.	LCDR Edward E. VEZEY, JR., USNR USNRTC Scotia, N. Y.
3-8	1930, 1st & 3rd Tues. 247 Park Ave. New York City, N. Y.	CDR Alfred WEEKS, USNR 247 Park Ave., Rm. 1205 New York, N. Y.
3-9	2000, 1st & 3rd Wed. Brookhaven National Lab. Upton, Long Island, N.Y.	CDR John S. MEDD, USNR Brookhaven National Lab. Upton, Long Island, N. Y.
4-1	2000, 1st & 3rd Wed. Nassau Tavern Princeton, N. J.	CDR Herbert G. DYKE, USNR c/o CDR Harry C. HART, USNR 21 Lilac Lane Princeton, N. J.
4-2	1930, Alt. Thurs. Franklin Institute 20th St. & Parkway Philadelphia, Pa.	CDR John H. NEHER, USNR Philadelphia Electric Co. 1000 Chestnut St. Philadelphia, Pa.
4-3	2000, 2nd & 4th Thurs. Cathedral of Learning, Rm. 232 University of Pittsburgh Pittsburgh, Pa.	CDR Neil D. COLE, USNR Office of Naval Research University of Pittsburgh 303 Thaw Hall Pittsburgh, Pa.

Desig-nation	Time and Place of Meeting	Commanding Officer and Mail Address
4-4	1900, 1st & 3rd Wed. Engineering "E" Rm. 200 Pennsylvania State College College Station, Pa.	LT Robert F. MARBOE, USNR 215 West Foster Ave. State College, Pa.
4-5	2000, Alt. Mon. USNRTC Foot of Madison St. Wilmington, Del.	LCDR Donald MacCREARY, USNR USNRTC Foot of Madison St. Wilmington, Del.
4-6	USNRTC Bethlehem, Pa.	LCDR John O. CHELLEVOLD, USNR USNRTC Bethlehem, Pa.
4-7	1930, 2nd & 4th Tues. Old Armory, Rm. 107 Ohio State University Columbus, Ohio	LCDR Karl E. KRILL, USNR Engineering Exp. Station Ohio State University Columbus, Ohio
4-8	2000, 1st & 3rd Mon. USNRTC 1089 E. Ninth St. Cleveland, Ohio	LCDR Viktor SCHRECKENGOST, USNR 2366 Noble Rd. Cleveland 21, Ohio
4-9	1930, 2nd & 4th Mon. USNRTC Dayton, Ohio	LT Nathan L. WENER, USNR 1007 Amherst Place Dayton 6, Ohio
W-Battalion	2000, 3rd Thurs. Interior Dept. Auditorium Washington, D. C.	CDR Fred C. WIESNER, USNR Navy Dept., Bldg. T-3, Rm. 2714 ONR Code 429; Re. 7400, Ext.5755 Washington, D. C.
W-1	2000, 1st Thurs. Bldg. T-3, Rm. 1515 Navy Department Washington, D. C.	CDR. W. M. RICHARDSON, USNR Navy Dept., Bldg. T-3, Rm. 2602 ONR Code 427; Re. 7400, Ext.2135 Washington, D. C.
W-2	1900, 1st Thurs. NRL, Bldg. 8 Auditorium Washington, D. C.	LCDR H. A. TANNER, USNR NRL Code 3210; JO 3-6600,Ext.256 Naval Res. Lab., Rm. 152, Bldg. 8 Washington 20, D. C.
W-4	2000, 2nd & 4th Wed. Bldg. T-3, Rm. 1803, Washington, D. C.	ChW Foster A. C. SHEPHERD, USNR 6323 Luzon Ave., N. W., Apt. 306, Washington, D. C. NBS, OR 4040, Ext. 265
W-5	2000, 2nd & 4th Thurs. NMRI, Conference Rm. Bethesda, Md.	CDR Barry G. KING, USNR OL. 7097 (Office, St. 9200, Ext. 4058) 8517 Bradmoor Drive Bethesda, Md.

Desig-nation	Time and Place of Meeting	Commanding Officer and Mail Address
5-1	1930, 1st & 3rd Wed. Rouse Physics Lab. University of Virginia Charlottesville, Va.	LTJG Gilmer T. FITCHETT, USNR Cobb Chem. Lab. University of Virginia Charlottesville, Va.
5-2	1915, 1st & 3rd Fri. Virginia Polytechnic Inst., Bldg. 364 Blacksburg, Va.	LT Burt C. HORNE, USNR University Club Blacksburg, Va.
5-3	2000, each Tues. Camp Detrick Frederick, Md.	CAPT LeRoy D. FOTHERGILL, USNR Camp Detrick Frederick, Md.
5-4	2000, 1st & 3rd Thurs. Maryland Hall, Rm. 202 The Johns Hopkins Univ. Baltimore, Md.	LT Joseph T. MORAN, USNR 1801 Tower Rd. Harundale, Glenburnie, Md.
5-5	1700-1900, 2nd & 4th Mon. Medical College of Virginia Richmond, Va.	CAPT Roscoe D. HUGHES, USNR Powhickory Farm, Ellerson, Va.
6-1	2000, Alt. Thurs. Physics Bldg., Rm. 103 Georgia Inst. of Technology Atlanta, Ga.	CDR J. E. BOYD, USNR Physics Bldg. Georgia Inst. of Technology Atlanta, Ga.
6-2	1915, 1st & 3rd Mon. Ross Lab., Rm. 204 Alabama Polytechnic Inst. Auburn, Ala.	LTJG J. E. LAND, USNR Chemistry Department Alabama Polytechnic Inst. Auburn, Ala.
6-3	2nd & 4th Tues. AEC Townsite Oak Ridge National Lab. Oak Ridge, Tenn.	LCDR D. J. MALLON, USNR P. O. Box P Oak Ridge, Tenn.
6-4	1930, 1st & 3rd Tues. Engineering Bldg. University of Florida Gainesville, Fla.	LCDR E. G. RIETZ, USNR Chemistry Department University of Florida Gainesville, Fla.
6-5	2000, 1st & 3rd Thurs. USNRTC Gulfport, Miss.	LT V. O. SMALLWOOD, USNR 2412 East Ave. Gulfport, Miss.
6-6	1945, 2nd & 3rd Wed. USNROTC Armory University of N. C. Chapel Hill, N. C.	LT Robert F. SCHENKKAN, USNR 103 Stephen St. Chapel Hill, N. C.

Desig-nation	Time and Place of Meeting	Commanding Officer and Mail Address
6-7	2000, 2nd & 4th Thurs. (Irreg) Biology Bldg. Duke University Durham, N. C.	LCDR John H. ROBERTS, USNR 2813 Legion Ave. Durham, N. C.
6-8	2000, 1st & 3rd Mon. Underwater Sound Ref. Lab. Orlando, Fla.	LCDR D. T. HAWLEY, USNR Underwater Sound Ref. Lab. 3710 S. Ferncreek Ave. Orlando, Fla.
8-1	1930, 1st & 3rd Tues. USNROTC Bldg. Tulane University New Orleans, La.	LCDR John M. SCOTT, USNR Chemistry Department Tulane University New Orleans, La.
8-2	2000, 1st & 3rd Wed. Coates Lab., Rm. 221 Louisiana State University Baton Rouge, La.	LTJG H. B. WILLIAMS, USNR Chemistry Department Louisiana State University Baton Rouge, La.
8-3	1930, 2nd & 4th Mon. PMA Bldg. or Bolton Hall Texas A&M College College Station, Texas	LCDR Norman F. RODE, USNR Elec. Engineering Department Texas A&M College College Station, Texas
8-3 Sub-Unit	Dallas, Texas	LT Homer B. HIX 2516 So. Lewellyn Ave. Dallas, Tex.
8-4	1930, Alt. Wed. USNROTC Bldg. The Rice Institute Houston, Texas	LCDR L. J. CASTELLANOS, USNR 6513 Rutgers St. Houston, Texas
8-4 Sub-Unit	Orange, Texas	LCDR Hugh F. SMITH Box 232-A Route 2 Orange, Tex.
8-5	2000, Alt. Tues. & Wed. Chemistry Bldg., Rm. 15 University of Texas Austin, Texas	LCDR G. H. AYERS, USNR Chemistry Department University of Texas Austin, Texas
8-6	1930, Last Mon. USNRTC Galveston, Texas	LTJG C. N. SECHRIST, USNR 1235 3rd Ave., North Texas City, Texas
8-7	2000, 1st & 3rd Wed. USNRTC 1805 S. Yale Ave. Albuquerque, N. M.	LCDR Sherman A. WENGERD, USNR P. O. Box 346 Albuquerque, N. M.

Desig-nation	Time and Place of Meeting	Commanding Officer and Mail Address
8-8	2nd & 4th Wed. Senior High School Bartlesville, Okla.	LCDR E. O. BOX, JR., USNR 1642 Hickory St. Bartlesville, Okla.
8-8 Sub-Unit	Stillwater, Okla.	LT Dariel E. HOWELL, USNR 1408 Lewis St. Stillwater, Okla.
8-9	Room B-117 Los Alamos Scientific Lab. Los Alamos, N. M.	CDR Norris E. BRADBURY, USNR P. O. Box 1663 Los Alamos Scientific Lab. Los Alamos, N. M.
9-1	1900, 2nd & 4th Tues. Navy Pier Campus University of Illinois Chicago, Ill.	LCDR Walter E. PETERSON, USNR 411 South 15th Ave. Maywood, Ill.
9-2	1930, 1st & 3rd Mon. Gregory Hall, Rm. 319 University of Illinois Urbana, Ill.	CAPT Chauncy M. LOUTTIT, USNR Psychology Department University of Illinois Urbana, Ill.
9-2 Sub-Unit	Peoria, Ill.	LT Thomas J. PRIDHAM, USNR 1004 N. Underhill St. Peoria, Ill.
9-3	1930, Alt. Wed. Angell Hall, Rm. 18 University of Michigan Ann Arbor, Mich.	CDR Freeman D. MILLER, USNR 1012 W. Washington St. Ann Arbor, Mich.
9-3 Sub-Unit	Houghton, Mich.	LCDR Roy W. DRIER, USNR
9-5	1930, Wed. USNROTC Bldg. Iowa State College Ames, Iowa	LCDR O. C. KREIDER, USNR Dept. of Mathematics Iowa State College Ames, Iowa
9-6	1930, 1st Mon. & 3rd Tues. Mech. Eng. Bldg. Rm. 4 University of Minnesota Minneapolis, Minn.	LCDR J. A. WISE, USNR Aeronautical Eng. Bldg., Rm. 222 University of Minnesota Minneapolis, Minn.
9-6 Sub-Unit	Brookings, So. Dakota	LT Gerald B. SPAWN, USNR So. Dakota State College Entomology - Zoology Department Brookings, So. Dakota
9-7	1930, 2nd & 4th Thurs. Stanley Coulter Hall, Rm. 111 Purdue University Lafayette, Ind.	LT L. M. BAKER, USNR Psychology Department Purdue University Lafayette, Ind.

Desig-nation	Time and Place of Meeting	Commanding Officer and Mail Address
9-8	2000, 1st & 3rd Thurs. Crew Hall, Rm. 101 Washington University St. Louis, Mo.	CDR. R. M. VARNEY, USNR Physics Department Washington University St. Louis, Mo.
9-8 Sub-Unit	Louisiana, Mo.	LT Tracey P. MOORE Bureau of Mines Louisiana, Mo.
9-9	1930, 1st & 3rd Thurs. Mechanics Hall, Rm. 204 Missouri School of Mines and Met. Rolla, Mo.	CDR R. A. COOLEY, USNR Mo. School of Mines and Met. Rolla, Mo.
9-12	1930, 2nd & 4th Thurs. Botany Bldg. Annex, Rm. 2 Colorado A&M College Fort Collins, Colo.	LTJG W. D. THOMAS, USNR Botany & Plant Pathology Department Colorado A&M College Fort Collins, Colo.
9-12 Sub-Unit	Boulder, Colo.	LTJG George J. MALER, USNR Elec. Engineering Department University of Colorado Boulder, Colo.
9-13	1930, Thurs. USNRTC Des Moines Still College Des Moines, Iowa	LCDR J. R. MALONEY, USNR 2920 48th St. Des Moines, Iowa
9-14	1930, Wed. or Thurs.(2/mo.) USNRTC University of Wisconsin Madison, Wis.	CDR W. B. SARLES, USNR Agricultural Hall, Rm. 310 University of Wisconsin Madison 6, Wis.
9-14 Sub-Unit	Appleton, Wis.	LTJG Edward G. SNYDER, USNR Institute of Paper Chemistry Appleton, Wis.
9-15	1900, 2nd & 4th Thurs. Conference Room Dow Chem. Co. Pers. Bldg. Midland, Mich.	LTJG D. D. McCOLLISTER, USNR 1220 Michigan St. Midland, Mich.
9-16	1900, 2nd & 4th Mon. EE Bldg., Rm. 206 Michigan State College East Lansing, Mich.	LT Elbert S. CHURCHILL, USNR Bacteriology Department Michigan State College East Lansing, Michigan
9-17	1930, 1st & 3rd Mon. Eng. Bldg., Rm. 103 University of Wyoming Laramie, Wyoming	LTJG Fred K. ELDER JR., USNR Physics Department University of Wyoming Laramie, Wyoming

Desig-nation	Time and Place of Meeting	Commanding Officer and Mail Address
9-19	1945, 3rd Thurs. Senate Chamber, Old Capitol State University of Iowa Iowa City, Iowa	CDR Arthur L. BENTON, USNR Psychology Department State University of Iowa Iowa City, Iowa
9-20	2000, 1st & 3rd Mon. Naval Science Bldg. University of Kansas Lawrence, Kansas	LTJG Russell C. MILLS, USNR Biochemistry Department University of Kansas Lawrence, Kansas
11-1	2000, 1st & 3rd Tues. 1030 E. Green St. Pasadena 1, Calif.	LCDR Frederick P. DILLON, USNR 1030 E. Green St. Pasadena 1, Calif.
11-2	2000, Alt. Thurs. USNRTC Pasadena, Calif.	LT Herbert D. STRONG, USNR 3437 Las Palmas Ave. Glendale 8, Calif.
11-3	2000, Alt. Mon. USNRTC & MCRTC 851 Chavez Ravine Rd. Los Angeles, Calif.	CDR F. W. HINRICKS, USNR 9425½ W. Olympia Blvd. Beverly Hills, Calif.
11-4	2000, 1st & 3rd Wed. USNRTC San Pedro, Calif.	LCDR Philip B. WILSON, USNR 2633 E. 7th St. Long Beach 4, Calif.
11-5	1930, 2nd, 3rd & 4th last Tues. USNRTC San Diego, Calif.	CDR Gifford C. EWING, USNR 1205 Muirlands Drive LaJolla, Calif.
11-6	2000, 1st & 3rd Wed. USNRTC Phoenix, Ariz.	LCDR J. A. BENEDICT, USNR 929 McAlister Ave. Tempe, Ariz.
12-1	2000, 2nd & 4th Mon. 801 Donahue St. San Francisco, Calif.	CDR J. E. LAURANCE, USNR ONR Branch Office 801 Donahue St. San Francisco, Calif.
12-2	1945, 2nd & 4th Mon. Donner Lab., Rm. 201 University of California Berkeley, Calif.	LCDR Nello PACE, USNR Life Science Bldg., Rm. 2519 University of California Berkeley, Calif.
12-3	2000, 2nd & 4th Wed. Engineering Corner, Rm. 208 Stanford University Stanford, Calif.	CDR L. S. JACOBSEN, USNR Mechanical Eng. Department Stanford University Stanford, Calif.
12-4	2000, 2nd & 4th Thurs. McLane Hall, Rm. M-103 Fresno, Calif.	CDR R. A. JACK, USNR Physics Department Fresno State College Fresno 2, Calif.

Desig-nation	Time and Place of Meeting	Commanding Officer and Mail Address
12-5	1930, 2nd & 4th Wed. LeConte Hall, Rm. 208 University of California Berkeley, Calif.	CDR C. F. GARLAND, USNR Div. of Engineering Design University of California Berkeley, Calif.
12-6	1945, 2nd Mon. Tower Room, Animal Science Bldg. University of California Davis, Calif.	LCDR T. R. HEDGES, USNR T. B. 2, Room 7, University of California Davis, Calif.
12-7	2000, 2nd & 4th Fri. USNRTC Fort Douglas Salt Lake City, Utah	LCDR H. L. FOOT JR., USNR 136 East South Temple St. Salt Lake City, Utah
13-1	1930, 2nd & 4th Mon. Health Science Bldg., Rm. G-516 University of Washington Seattle, Washington	CDR H. S. BENNETT, USNR Anatomy Department School of Medicine University of Washington Seattle, Washington
13-2	1900, 2nd & 4th Tues. American Legion Hall Richland, Washington	LT W. W. GONDER, USNR 95 Atkins Ave. Richland, Washington
13-3	1930, 2nd & 4th Mon. YMCA Pullman, Washington	LCDR W. G. GNAEDINGER, USNR 601 High St. Pullman, Washington.
13-4	1930, 1st & 3rd Mon. Swan Island Portland, Oregon	LCDR Richard F. STEVENS, USNR 811 N. E. Oregon St. Portland, Oregon
13-5	1930, 2nd & 4th Mon. Chem. Bldg., Room 104, Oregon State College, Corvallis, Oregon	LCDR Albert V. LOGAN, USNR Chemistry Department Oregon State College Corvallis, Oregon

ONR, Code 230, Bldg. T-3, Room 1059, should be notified of any change in address or time and place of meeting.

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