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RESEARCH REVIEWS

DEPARTMENT OF THE NAVY

WASHINGTON, D. C.

NAVEXOS P-510

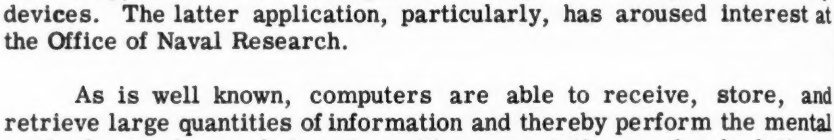
is applied to the photoconductor while it is being irradiated, the electrons travel toward the external positive electrode (anode), while the holes are pulled to the external negative electrode (cathode). If, as a third step, one removes the radiation, the number of mobile charges is very sharply reduced. By the nature of the material, negative charges are trapped near the external anode and positive holes near the cathode. These will remain separated within the photoconductor for periods as long as years if the photoconductor is shielded from radiation. Therefore, the process is called persistent internal polarization (p.i.p.). Re-exposure of the polarized material to radiation, which may range in wavelength from that of gamma-rays to that of the middle infrared, again produces mobile charges which move in the internal field. As a result, the field tends to deteriorate, the extent of deterioration depending on the amount of radiation exposure.

Zinc and cadmium sulfides, anthracene, and other chalcogenides of group 2 metals, as well as polynuclear aromatic compounds, exhibit this behavior.

By means of the internal fields it is possible to store considerable electrical energy (about 10^2 ergs per $cm.^2$) for long periods in phosphor plates. It is also possible, through irradiation, to release specific amounts of this energy—the amounts being determined by simple measuring circuits. Because of these facts, a number of possible practical uses of the process have been considered. These include applications in electrophotography, infrared detection and photography, dosimetry, and in the development of improved computer memory devices. The latter application, particularly, has aroused interest at the Office of Naval Research.

As is well known, computers are able to receive, store, and retrieve large quantities of information and thereby perform the mental work of many human beings in making computations and calculations. They are able to do these things so well because of the large capacity of their memories and the speed with which they function. In a practical way, then, some of the main objectives in improving memory devices are faster writing and reading of information, greater compactness (information storage per unit volume), and greater economy (storage per dollar).

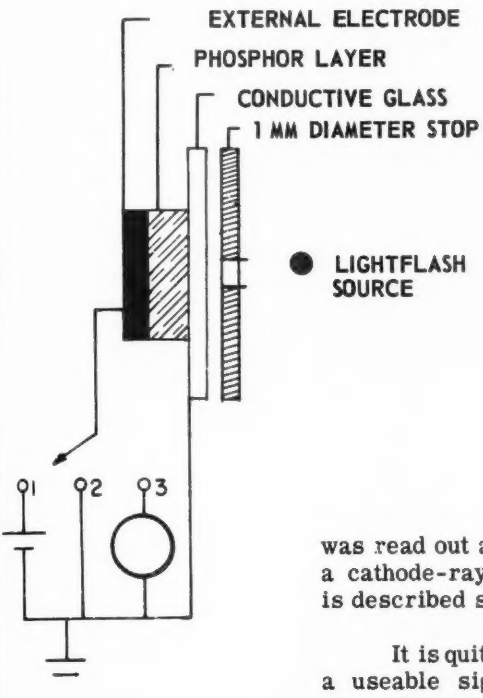
It is possible to use p.i.p. plates as memory devices by selectively polarizing small spots on them. Information can be impressed on the plates either by applying a voltage across the entire photoconductor layer and selectively irradiating desired locations, or by irradiating the entire phosphor plate and selectively applying voltage. This process is called writing. Reading would consist of detecting either



Cross section of p.i.p. plates.

the presence or absence of a polarization voltage on a given location of the p.i.p. phosphor memory.

We have already demonstrated in this laboratory that a single location about one square millimeter in size on a p.i.p. plate can be polarized. To do this we applied a voltage and a two-microsecond light flash to the plate concomitantly. After both electrodes were then grounded momentarily, part of the image charge on the external electrode was released. This was done by exposing the plate to another light flash—this one in the absence of an external voltage. Within the time of the light pulse, a polarization voltage of about 100 millivolts



Writing and reading by means of p.i.p. An external voltage is applied (1) to p.i.p. plate with concomitant 2/1,000,000-second light-flash irradiation. After external electrodes are temporarily grounded (2), the electrode is switched to an oscilloscope (3) which displays a polarization voltage signal when the polarized phosphor is exposed to a second light flash (in the absence of an external voltage).

was read out and simultaneously displayed on a cathode-ray oscilloscope. The procedure is described schematically at left.

It is quite significant that one can obtain a useable signal from the polarized area several times. This means that information impressed once by the polarization method can be retrieved a number of times. In addition, the written message can be erased completely by radiation, heat, or electrical fields, or a combination of the three. It is thus possible to correct errors in writing or to utilize the same polarization plate for writing any number of different messages.

Quite significant, also, is the fact that it has been possible to read in this way at very fast speeds, comparable to those attainable with the best of today's memories. The speed which the p.i.p. material itself is capable of is probably greater. At the present time we are studying the intrinsic speed and resolution of the polarizable material.

Indications are that persistent internal polarization will provide the basis for the development of a new economical high-speed memory.

Preview of Ration Dense Foods*

Since the days of "plum duff" and "bully beef," the Navy has come a long way in the development of foods for the Fleet. This was indicated recently by tests held aboard the nuclear-powered submarine NAUTILUS and aboard the destroyer UHLMANN of the Pacific Fleet. The foods tested, called "ration dense," are the result of research and development carried out cooperatively by industry, the Quartermaster Food and Container Institute for the Armed Forces, and the Navy. Simply stated, they are foods which have been specially processed to eliminate waste and bulk without sacrificing any of their nutritional or taste value.

The new food preparations encompass dehydrates, concentrates, precooked, precut, compressed, and frozen foods. Some of these are similar in nature to the "convenience" foods carried in the supermarkets, but to the Navy they are more than a "convenience," they are vital—vital, that is, in their space-saving qualities. Restricted storage space, especially refrigerated space, aboard ship is an old problem. Consistent use of these space-saving foods will help a great deal to solve it.

The Pacific Fleet Supply Office recently got a "sneak preview" of the actual test items and a chance to sample some of them when USS UHLMANN (DD687) stopped at Pearl Harbor. Judging from the comments heard from all sources, it was difficult to determine just who was the most enthusiastic about the food: the skipper, the supply officer, or the cooks.

All doubt was removed, however, when the crew's evaluation sheets were studied. Their comments about the quality, palatability, and attractiveness of the test foods were enough to gladden the hearts of the cooks in the Fleet. To put it mildly, the hardest part of the test—consumer acceptance—was an unqualified success.

The most important phase of the test, however—endurance extension—is still under investigation, and the results will not be known until all the technical aspects have been thoroughly evaluated and studied. Nevertheless, informal reports from the test ships indicate that the new items are meeting all expectations in this phase also.

The space saved ranges from 13 percent for dehydrated cheese to a high of 92 percent for dehydrated green peppers. Dehydrated, diced white potatoes show a space saving of 71 percent when compared with their bulky, high-use counterpart of white fresh potatoes, and dehydrated potato granules show an even higher space saving of 88 percent compared with the raw product. Some of the other bulky parts of the ration were also represented. Whole milk, for instance, could be partially replaced with instant, nonfat milk, with a resulting saving of 74 percent in critical refrigerated space. Whole, dried eggs represent a whopping 63 percent space saved when compared with those fresh in-shell. Even dehydrated shrimp, although it represents a savings of but 7 percent is important because the space saved is in refrigerators, allowing more room for items for which suitable substitutes have not yet been developed.

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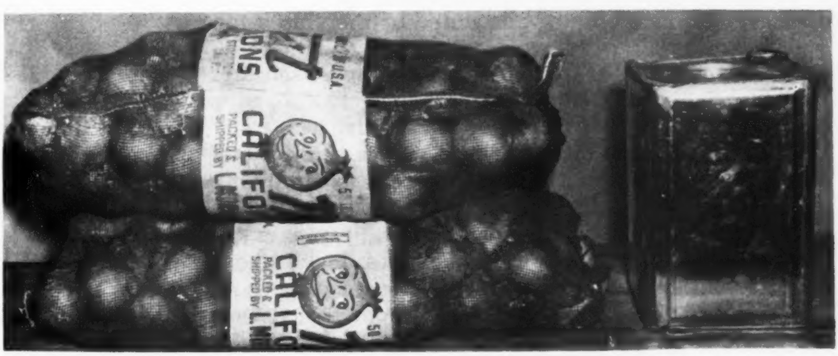
*Adaptation of an article appearing in Monthly Newsletter, June 1958, Bureau of Supplies and Accounts.

Officers sample dehydrated rhubarb aboard the UHLMANN.

Critical destroyer storage space underlines need for dense foods.

The sacks of fresh onions shown below weigh 100 pounds and occupy almost four cubic feet of space, whereas their dehydrated counterpart, in can, weigh only ten pounds and occupy less than one cubic foot of space.



Three times as much fresh milk; one-third again as much flour, two and one-half times as much pork sausage, two and one-half times as much turkey, twice as much ham, seven times as much shrimp, four times as much chili con carne, two and one-half times as much potatoes and cabbage, and twice as much green beans can be carried in the space previously occupied by the "old fashioned" products.

In addition to the increased space utilization in initial loading, the new items further extend the ship's endurance by virtually eliminating scraps and waste through such devices as careful preportioning and the use of uniform sized meat cuts to reduce shrinkage in cooking.

Dehydrofrozen peas and carrots, low-moisture pitted prunes, dehydrated fruit cocktail mix, instant dry vinegar, instant milk, dehydrated and concentrated juices all achieve comparable space savings with no loss of consumer appeal.

These items are indeed a far cry from the World War II concentrates that were fed to the crew only as "last-resort" measures. Many of the vegetable items, when prepared as directed, are reported to surpass even the fresh varieties in the important test of palatability. Many require no special handling or stowing techniques.

However, limited production and the prohibitive cost of some of the new items prevent their immediate adoption in the supply system. Increased demand by both military and civilian markets will result in increased production and an eventual price decrease, making the items more attractive to military consumers. An excellent example of this is the canned prefried bacon, which represents a space saving of 74 percent but at a cost of $0.19 per serving, as opposed to the bulky conventional canned bacon items costing $0.09 per serving and slab bacon (without rind) costing $0.08 per serving. It is estimated that continuous military demand would reduce the cost of the pre-fried bacon to $0.11, and any commercial demand would, of course, reduce the cost still further.

Sponsored by CinCPacFlt, the test aboard UHLMANN is being conducted under the general supervision of the Navy Supply Research and Development Facility, Bayonne, N. J., with the assistance of the Navy Subsistence Office, but food preparation, menu planning, and on-the-spot evaluation are being conducted by the ship's force.

Of the items tested so far, the compressed turkey roll, dehydrated rhubarb, dehydrated shrimp, and strangely enough, pre-portioned liver have been the biggest favorites. Indicative of the acceptance given to all the test items is the fact the entire ship's company ate and enjoyed liver, usually one of the most poorly accepted items in any ship's menu.

This test, showing that a "tin can" can carry more and better food with no increase in space requirements, looks like the forerunner of a real revolution in Navy food service operations. After having seen the "sneak preview," the Pacific Fleet reports that they would like to see the whole show as soon as possible.

Russian physiologist Ivan Petrovich Pavlov (1849-1936) at the research laboratory at Koltushi. Reluctant to spare the time to sit for this painting, Pavlov asked the artist--Mesterov--how long it would take. On being told, he thrust out his arms in exasperation, and Mesterov captured him in this impatient pose.

The Background and Rise of Russian Neurophysiology*

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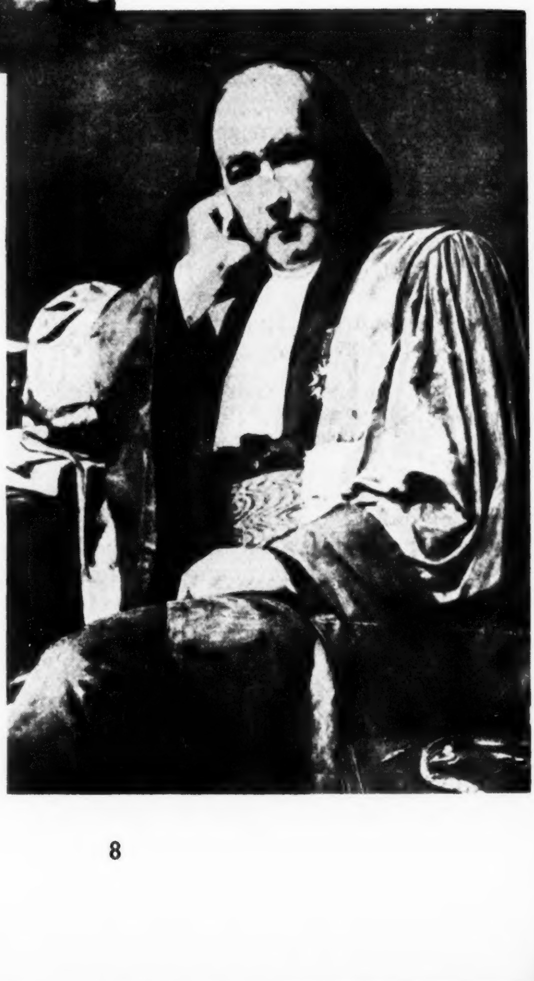
The rise of science in modern civilization, one of the last features of the Renaissance, began with the accomplishments of isolated investigators in 16th-century Europe. By the 17th century interest had spread, and the first scientific societies were formed. Like other movements of the Renaissance, these originated in Italy and developed later in France and England and still later in Germany. Whereas in the West

*This article has been reprinted from an historical survey of Russian science prepared for the Transactions of the first conference of the Josiah Macy Jr. Foundation on "The Central Nervous System and Behavior" held at Princeton, New Jersey, February 1958.

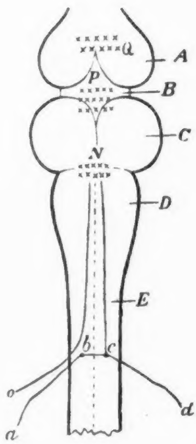
†Both authors are engaged in research for the Office of Naval Research in the field of neurophysiology.

Ivan Mikhailovich Sechenov (1829-1905) graduated in Medicine from the University of Moscow and spent two periods in the West, studying first in Germany and Austria and later in France. He is seen here in his laboratory in the Medical-Surgical Academy at St. Petersburg.



During his second visit to the West, Sechenov worked in the Paris laboratory of Claude Bernard, pictured above. Bernard's accomplishments in neurophysiology related principally to control by the central nervous system of visceral processes, such as the regulation of blood sugar and the vasomotor mechanism. It was in this laboratory that Sechenov discovered the central inhibition of reflex activity in the frog.

With characteristic liberal and progressive views, Sechenov encouraged the education of women. One of his first students, M. A. Bokova, later became Madame Sechenov. She continued her professional career, however, obtaining her medical training abroad and returning as Russia's first woman physician. In Russia today women occupy the majority of positions in the medical profession.



In this diagram of the nervous system of the frog, Sechenov marked with crosses the regions of the brain capable of inhibiting spinal reflexes. Sechenov was the first to demonstrate central neural inhibition. This conflicted with the traditional view that movement of skeletal muscle was controlled entirely by the will. Sechenov generalized from his experiments with frogs that all mental processes of man are reflex in nature.

Sechenov had an active interest in social reform. In his later years, he inaugurated the study of the physiology of work and exercise, with particular relation to fatigue and the optimum duration of the working day. He is shown here in an apparatus with which he made personal observations on the physiology of work.

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these societies or academies marked a late stage in the establishment of scientific activity, in Russia, in the succeeding 18th century, an Academy of Sciences was formed to initiate scientific pursuits.

All of the early academies received some Royal patronage. It was Czar Peter the Great who founded the Russian Academy. Earlier he had provoked war with Sweden for a port on the Baltic—as he put it, "to open a window on Europe." This phrase can express, as well, his goal of introducing scientific activity into his new port and capital, St. Petersburg. Through Peter's efforts, the translation of books, the purchase of scientific collections, the appointment of academicians from Germany and Switzerland, even the importation of the first students to the Academy school, amounted to a mass transplantation of 18th century Western scientific developments onto previously uncultivated Russian soil. The Academy of Sciences, founded by Peter and formally opened in 1725 by his widow, Catherine I, was the center and focus of all of these developments. The prominence of its founding members and the distinction of their contributions almost immediately placed Russia in a rank with the rest of Europe in scientific achievement.

Additionally, the Academy school soon began to train native Russian scientists. One of the first of its students—Lomonosov—became one of its most outstanding. After attending the Academy school, he studied further in Germany and Holland, then returned to membership in the Academy. In the unspecialized manner of that time, he contributed to chemistry, astronomy, and atmospheric electricity, as well as to ceramics and to literature. Although he did not directly train student successors, he contributed greatly to Russia's future in science by formulating plans for the University of Moscow. He is called the Father of Russian Science.

The singular accomplishments of Lomonosov and, somewhat later, of Lobachevsky in mathematics, with which Russian science began, were broadly extended in the 19th century by an upsurge in all fields of learning. The sense of peril which had existed among Russians during the Napoleonic wars, and the experience of triumph which followed it, gave rise to a stronger feeling of nationalism. At mid-century, with the reign of the liberal Czar Alexander II, a general cultural upswing in art, music, and literature occurred. This coincided with the growth of a democratic reform movement which led to the abolition of serfdom in 1861. Science shared prominently in this belated flowering of Russian culture.

After completing their initial education in the universities which had by then been established in St. Petersburg, Moscow, Kharkov, Kiev, and Kazan, eager young Russians of the period went off to the laboratories of Germany or France for advanced training. On their return, these men initiated their own research and began training their own students. As a consequence, independent scientific activity developed and flourished in Russia on a broad scale.

As instances of the growth of Russian science in the 19th century, one may cite the work of Mendeleev, Zinin, Butlerov, and Borodin in chemistry; Lebedev and later Popov and Zhukovsky in physics; Michurin and Timiryazev in botany; Metchnikov, Pirogov, and Botkin in pathology,

Vasily Yakovlevich Danilevsky (1852-1939) was interested mainly in neurophysiology and endocrinology. Graduating from the University of Kharkov, he ultimately became Professor and head of an institute there. He was one of the first to study, by galvanometric methods, the responses of the cortex to sensory stimulation.

surgery and medicine; and Sechenov, Wedensky, Pavlov, and Bechterev in neurophysiology. Such a list of achievements would distinguish any land or period, but they are all the more remarkable for appearing only a century after the beginning of science in Russia.

To a degree unusual today, these scientists of 19th century Russia enjoyed association with leaders in art, music, and literature. Mendeleev was made an honorary member of an association of artists for his interest in and appreciation of painting. He was a personal friend of Repin, whose portraits of Pirogov, Sechenov, Borodin, Tolstoy, and Mendeleev himself bring these figures alive today. Borodin is remembered now, not as an organic chemist, but as the composer of "Prince Igor." He was a member of the "Five," with Rimsky-Korsakov, Balakirev, Cesar Cui, and Moussorgsky, who established the Russian tradition in music. Chekov was a physician, and Turgenev is said to have chosen Sechenov as his model for Bazarov in "Fathers and Sons." From his boyhood, Pavlov was devoted to Krylov's "Fables" and, in his later years, acquired a collection of Russian paintings, almost daily contemplation of which gave him great enjoyment. In 19th century Russia, the social insularity of the intelligentsia between the aristocracy and the unenlightened mass

Ivan Romanovich Tarkhanov (1848-1909), a student of Sechenov, became interested in electrophysiological techniques and in the study of cutaneous sensation and reflex activity. By combining these pursuits he discovered the psychogalvanic reflex which, for a long time, was known as the Tarkhanov effect.

Nikolai Yevgenevich Wedensky (1852-1922) was the outstanding pupil of Sechenov. After working abroad, he undertook the study of excitatory and inhibitory phenomena in peripheral nerve. His demonstration that increasing the frequency of excitation led to a depression of activity influenced Pavlov's concepts of higher nervous activity in the cerebral cortex. He is seen here in his laboratory at the University of St. Petersburg.

of the populace undoubtedly contributed to the close association between scientists and men of the arts.

In addition, many of these Russian scientists were closely associated with the social reform movement of the sixties and seventies, and here the progressive, liberal tendencies of many of the group found their greatest expression. The writings of the reformist Chernishevsky exerted a deep influence on the youthful Sechenov, as on Timirlasev, who also is known to have memorized long passages from the revolutionary democrat Herzen. Pavlov acknowledged that the writings of

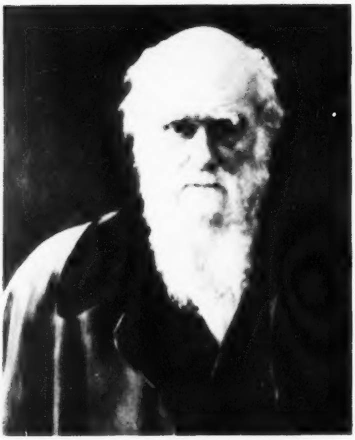
Alexei Alexeivich Ukhtomsky (1875-1942), the son of a prince, was a student of Wedensky at St. Petersburg University and succeeded his chief in the Chair of Physiology there. Directing his efforts along lines similar to those of Wedensky, he developed the theory of dominant action. His name is commemorated today in the Ukhtomsky Institute of Physiology in Leningrad. (Photograph courtesy of Professor S. A. Sarkisov).

Pisarev turned him from theology and provided a general orientation toward the sciences for the youth of his generation.

Following the assassination of Alexander II in 1881, liberal policies were abandoned, and the reactionary authoritarianism of Czar Alexander III made every attempt to root out reform and "nihilism" in all spheres of national life. As is customary in such efforts, the universities were a special target for attack. As a result, freedom of thought and expression all but vanished, and the careers of many scientists were severely dislocated. Mendeleev resigned his Professorship at the University of St. Petersburg. Timiryazev was dismissed from the Petrovsky Academy. Metchnikov resigned his Professorship at Odessa and attempted suicide. Sechenov quit his Chair at the Military Medical Academy, and later Pavlov resigned his first academic appointment when his Professor, Cyon, was dismissed.

It was in this stressful period and against these difficulties that Russian neurophysiology began and flourished. Its initiator, Sechenov, in his two periods of study abroad, had made intimate contact both with the German mechanistic and the French deterministic schools, into which 19th century Western physiology had divided. In 1847, a year before the Communist manifesto of Marx and Engels, DuBois-Reymond, speaking for the German school, enunciated the manifesto of mechanistic materialism: that all properties of living matter are subject to chemical and physical laws. When Sechenov first visited Germany, he found that country's physiologists preoccupied with the application of this principle to the analysis of the more peripheral functions of the nervous system. A portion of Sechenov's own work and the Russian school of nerve-muscle physiology, developed later by his pupils, followed directly in this tradition. Included in this group were Vasily Danilevsky, Tarkhanov, Wedensky, Ukhtomsky, and through training with Tarkhanov, the Polish physiologists Cybulsky and Beck.

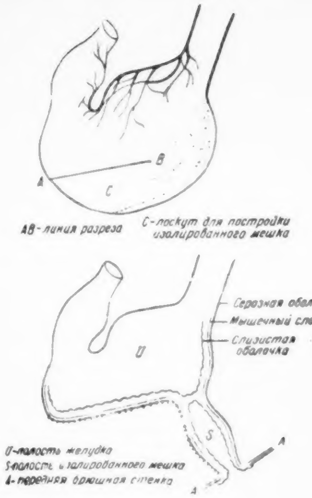
Ivan Petrovich Pavlov (1849-1936), the son of a priest, studied medicine at St. Petersburg University. During his youth he knew the meaning of poverty. This became apparent later in his career when, upon failing one of his students, an attempt was made to reverse the decision on the basis of the student's financial need. "Don't speak to me of need," Pavlov exploded. He then went on to tell how, years before, he had walked many miles to attend the University, and how he had made it a practice to go to funerals in wealthy families to obtain the food he needed.



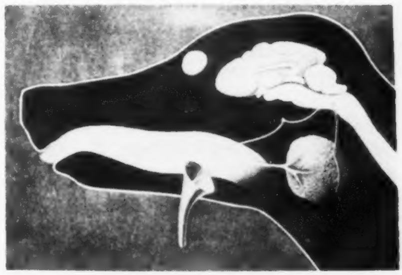
Darwin's "Origin of Species" was published in 1859. More than any other single work, it intensified the development of materialistic thinking in all fields in the 19th century. Extremes of the areas in which its influence was acknowledged are Pavlov's concept of the role of conditional reflexes in adapting the organism to its environment and Marx's letter to Engel, in which Marx wrote, "This is the book which contains the basis in natural history for our view!" Collier's portrait shows Darwin in his early seventies, near the end of his life.

On his second Western visit, to Claude Bernard in Paris, Sechenov was influenced by the deterministic outlook of the French school, which emphasized synthesis of function in the integral organism. Sechenov's work on central neural inhibition and his monograph "Reflexes of the Brain," written after his return to Russia, were obvious expressions of determinism. The influence of this book, which was attacked by the government censor, was acknowledged repeatedly by Pavlov as having guided the development of his concepts of conditional reflexes and higher nervous activity in the behavior of the whole organism. The influence

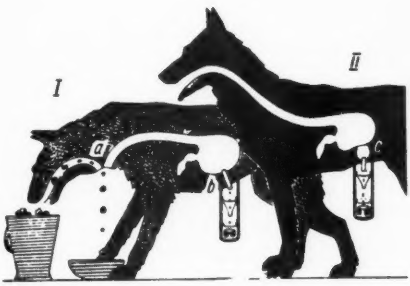
Pavlov was invited to London in 1928 to participate in the tercentenary celebration of the publication of Harvey's De Motu Cordis. He is seen here leaving Buckingham Palace after visiting the King. Note that he is the only member of the group not wearing a top hat, which was considered appropriate for such an occasion.



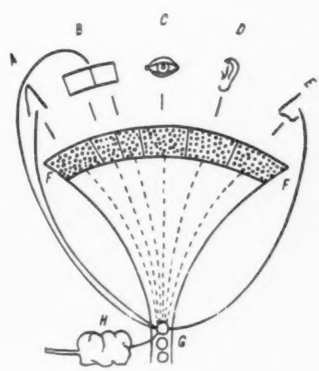
The famous Pavlov pouch, shown in the lower drawing, was prepared surgically from a portion of an animal's stomach. As the cavity is isolated from contamination by ingested food in the stomach itself, it permitted study of the secretion of digestive glands. The upper drawing shows where the stomach was cut to form the pouch.



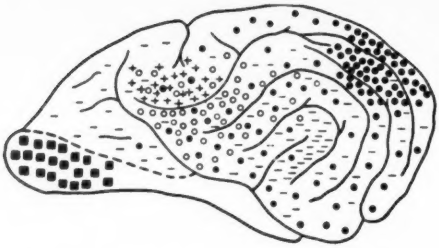
In this drawing of the head of a dog are shown the structures involved in Pavlov's study of conditional reflexes. The fistula permitted observation of the salivary response to direct stimulation. After a signal such as the sound of a bell had been paired with this natural reflex a number of times, the signal itself would evoke salivary secretion. This, Pavlov described as a conditional reflex.



Sketched here are examples of Pavlov's experiments with sham feeding (I) and psychic secretion (II).



Pavlov postulated that the cerebral cortex of higher animals possessed a coupling or linking capacity that enabled it to create new connections interrelating the organism with its environment. Diagrammed here is his conception of the manner in which new functional linkages were established between analyzers for the various organs of sense and the subcortical innervation of the salivary gland. A, tongue; B, skin; C, eye; D, ear; E, nose; F-F, cortex; G, connections to brain; H, salivary gland.



Pavlov's studies suggested that the mechanism responsible for conditional reflexes had its seat in the cerebral cortex. This diagram of the cerebral hemisphere of the dog shows the location of the cortical areas concerned with the various modalities of sense. Pavlov called these areas analysers.

of Sechenov's theory on Bechterev was also strong. Thus, the two streams of 19th century Western physiology absorbed by Sechenov during his European visits were transported back to his homeland to freshen again and flow down to the present in the Wedensky-Ukhtomsky and in the Pavlov-Bechterev trends of Russian neurophysiology.

The Pavlovian school, developing indirectly from Sechenov's influence, is the best-known feature of physiology and probably of all of science in Russia. Commencing with Botkin's concept of nervism, which stressed management of all processes of the body by the central nervous system, Pavlov went on to study higher nervous activity and the means by which animal and man adapt to their environment, an interest derived from his early study of Spencer and Darwin. Accomplishments of the first half of Pavlov's career, devoted to the work of the digestive glands, received the Nobel award in 1904. When Pavlov was past 50, the program was extended to include the study of psychic secretion. This led to the development of objective conditional reflex methods for analysis of the activity of the cerebral hemispheres. In this latter work, which continued for some 30 years more, Pavlov was joined by an increasing number of students and associates, many of whom have continued the program he began.

During his long career, Pavlov was a leading figure in science, first in the Czarist and later in the Soviet periods. Until his final years Pavlov was openly hostile to the new regime, but its respect and support for science finally provided him with a means through which he felt his profound patriotism and love of Russia could find expression. This high regard for science and learning has become a prominent feature of the Soviet system. The increasing support given to its schools, libraries, institutes, and laboratories, the high prestige attached to its scientists, and the augmented role played by its Academy of Sciences and by its Academy of Medical Sciences, founded in 1947, have all been developments of the Soviet program.

The overwhelming need of the Soviet government to achieve practical goals in its general economy has in some degree carried over into the sciences as well. At least some areas of biomedical research have been included in five-year planning and the pursuit of activities toward definitely specified ends. In the extreme nationalism of the latter part of the Stalinist period, there was an increased tendency for Soviet scientific writing to deprecate the subjectivist idealism of bourgeois-imperialist-capitalist science and to compare it unfavorably with the objective, materialistic outlook that favored science in the Communist society. This same period was marked by Academy-sponsored conferences in genetics and in neurophysiology in which lines of doctrinaire orthodoxy were established for attitudes and pursuits, and deviationists were castigated until they recanted, in a manner reminiscent of the reign of Czar Alexander III.

Currently, Russia is emerging from her period of recent segregation from the West. Peter the Great's "windows" are opening again on Europe. Translations and library services, which have enabled Russian scientists to keep informed of Western activities, are now being reciprocally developed, though on a smaller scale in this country. Russian scientists once more attend international congresses and, either individually or in small groups, are interchanging visits with scientists of other countries. Most recently, government-sponsored cultural-exchange programs have been established between the U. S. and the U.S.S.R. It is hoped that these signs of tolerant relations will continue to increase and thereby stimulate the general growth of scientific knowledge.

"With Exceptional Vision . . . ."

Dr. Richard Courant, Director, Institute of Mathematical Sciences, New York University, was recently presented the Navy Distinguished Public Service Award--the highest commendation the Navy confers on civilians. The award was given to Dr. Courant for his outstanding contribution to the Department of the Navy in the field of mathematics.

Dr. Courant, a native of Germany, had a distinguished career at the University of Gottingen before coming to the United States. There he established a mathematical institute which served as the basis for the organization he founded and now heads at New York University.

Under his direction, the N.Y.U. team of distinguished research mathematicians has contributed immeasurably to the understanding and ultimate control of the phenomena with which physicists and engineers deal. The Institute, which is unique in this country, is maintained co-operatively by the three branches of the Armed Services, the Atomic Energy Commission, and the National Science Foundation.

Through his broad knowledge, his service on many advisory committees, and his contacts with fellow scientists, Dr. Courant has helped the Navy solve many problems. The deep appreciation felt in the Navy for this work is indicated by the citation accompanying the award given him. It reads in part as follows: "With exceptional vision and indefatigability, Professor Courant has sought out and clarified major problems confronting the Navy as well as the other armed services and the Atomic Energy Commission in their technical developments, whose solution could be furthered only by advancing current methods of mathematical analysis. He has been a major contributor to the scientific progress of applied mathematics as an integral part of the technology on which the Navy relies in the design and evaluation of its latest weapons."

Application of Models to Research in Cardiovascular Physiology

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University of Pennsylvania

Scientists commonly develop concepts by analogy. In other words, they liken the properties of an unknown system they are studying to those of a system with which they are already familiar. The analogue, which may take the form of a mathematical equation or of a physical or conceptual model, gives the scientist something to work with. Before he can use the proposed model, however, he must first test it to determine if it truly represents the unfamiliar system—in other words, if the two have properties that are similar.

Good examples of this procedure are to be found in the field of hemodynamics, which deals with the relationships of force and motion of the blood, blood vessels, and heart. In fact, the history of investigations in this field is a striking chronology of efforts to select mathematical or physical models, or both, which represent the properties and behavior of the cardiovascular system. Although many of these models have been of great benefit in describing the obscure mechanics of the cardiovascular system, some have had the opposite effect. This is because once the models have been accepted, they enjoy the protection of prejudice. Thus, whether they present a true picture or not, they are often perpetuated.

Stephen Hales, an 18th century English clergyman, was apparently the first to suggest what has become a commonly accepted analogue of the cardiovascular system. It has been perpetuated by physiologists in essentially its original form for more than 200 years. Hales, who is also credited with the first measurement of arterial blood pressure, noted that the blood of the large arteries of an injured horse he treated had a pulsating flow, whereas that of the small vessels within the wound had an almost steady flow. He suggested that the arterial system was, therefore, analogous to a bellows whose compression chamber may be alternately expanded and compressed while air flows from the nozzle in an almost steady manner.

Later, German physiologists used the fire engines of their time as an equivalent analogue. In such engines water was forced into a closed dome-like air chamber, thus compressing the entrapped air. The compressed air was later used to force the water through the fire hose. The air chamber (Windkessel) was considered to be analogous to the arteries, and the fire hose was considered to be analogous to the minute arteries (arterioles) at the periphery of the arterial system.

It is important to note that the Windkessel model implies that the arterial system may be separated into two functionally discrete parts. The part leading from, but adjacent to, the heart is considered to have elasticity as its major property, while the second, or peripheral, part is supposed to supply viscous resistance to blood flow out of the elastic part. It is thought that the major function of the elastic part is to store blood ejected by the heart during its periodic contraction and then to utilize the resultant force of the stretched arteries to cause blood to flow into the capillaries during the non-contracting phase of the heart's cycle. Such activity serves to maintain a more-or-less steady flow in a system containing a cyclic or periodic pump.

The literature of hemodynamics is amply supplied with mathematical equations intended to relate pressure and flow; however, a careful review reveals that most of these are mathematical expressions of models having essentially the form suggested by Hales.

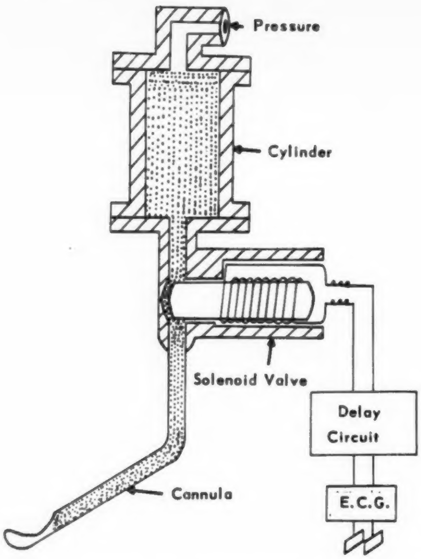
Although the Windkessel analogue serves admirably in illustrating the storage property of the arteries, there are many reasons for questioning its usefulness as a reliable model from which to deduce cardiovascular function. The arterial tree does not naturally divide itself into two such discrete and symmetrical yet dissimilar parts. Indeed, it consists of a complex, unsymmetrical, continuous system of branching visco-elastic vessels. The variation of vessel geometry and wall properties is continuous from the heart throughout the vessels of the body and back again to the heart. Further, due to its extensive branching, the total cross-sectional area of the arterial system continues to increase rather than to decrease as implied in the models. Nor does the Windkessel model provide a basis for satisfactorily explaining the behavior of the vascular system under normal conditions and under such abnormal conditions as those brought on by disease and environmental stress. It has seemed desirable, then, to have a new look at the reliability of our conceptual model of the vascular system.

As has been pointed out, physical scientists develop techniques for characterizing complex, unfamiliar systems in terms of classes of models or analogues These are simply analytical methods for testing the reliability of analogues. One method is to introduce specific disturbances within the system and measure simultaneously the responses of the system to them. For example, if the arterial system is analogous to a Windkessel, and a similar disturbance is applied to both the vascular system and the analogue, the response should be similar in both.

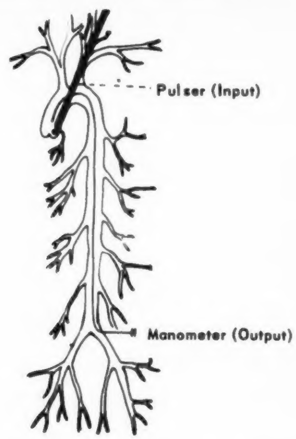
Such studies have been supported by the Office of Naval Research in the Department of Physiology of the University of Pennsylvania's School of Medicine. The disturbance utilized for the experiments consisted of a prescribed flow of liquid (blood or salt solution). This was introduced into the trunk (aorta) of the arterial tree and into the Windkessel. At the same time, the pressure induced in the two systems by the flow pulse of the liquid was measured. The flow pulse closely approached that of a "square wave." This is analogous to introducing a square electrical current pulse into an electrical circuit and measuring the voltage developed across the input. As a forcing function, the square wave has certain advantages over other types of disturbances.

A schematic drawing of the pump used to introduce the square wave flow and of the two systems to which it is applied—the Windkessel model and the arterial system—appear on page 20. In the physical

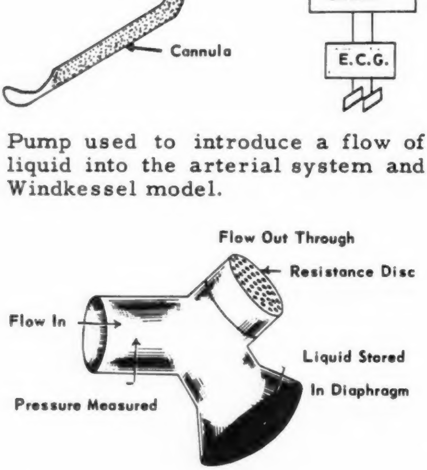
A METHOD FOR TESTING THE RELIABILITY OF ANALOGUES



Pump used to introduce a flow of liquid into the arterial system and Windkessel model.



Arterial system, showing the position of the cannula and of a manometer, which records the pressure generated by the flow of liquid from the cannula into the aorta. The manometer is connected to a small plastic catheter.



A model analogous to the Windkessel.

The liquid to be forced by the pump into the arterial system and Windkessel model is contained in the cylinder. When the pump is used with the arterial system, it is coupled to the aorta by means of a cannula. A pressure of such magnitude is applied to the cylinder that variations in arterial pressure will not affect the rate of flow from the cylinder. Flow is begun and stopped by the action of the valve, which opens and closes in about 3 milliseconds. The valve may be actuated manually or may be triggered by the electrical signal from the heart itself. The latter type of actuation allows delivery of the flow pulse in any desired part of the heart's cycle. The cannula tip is so designed that it disperses the flow jet.

model an exponential rise in pressure occurs on introduction of the square wave flow, followed by a rapid decrease in pressure. In the arterial system a sudden rise in pressure occurs also, but instead of decreasing afterward, the pressure is sustained owing to a significant viscous resistance to flow. Thus it can be seen that the responses of the Windkessel model and the vascular system are fundamentally different.

Through studies of this type a number of deductions regarding the physiology of the vascular system have been made. A few of these are listed below.

Genesis of the Arterial Blood Pressure Pulse. In the Windkessel model, the pressure pulse is a function of the volume change within the elastic unit, the modulus of the elastic part, and the resistance of the outflow part. In the arterial system, however, the pressure pulse is a function not only of these factors, but also of the mass of blood being accelerated and the viscous resistance to flow within the aorta. These additional factors are of significant magnitude. The pressure pulse generated at the source of the input is a manifestation of the load which the vascular system imposes on the source of the input flow; that is, if there were no resistance to the inflow there would be no pressure developed at the inflow site. This dynamic load which the arterial system impresses upon the heart is, therefore, due to the inertia of blood being accelerated, the viscous resistance, and the stiffness of the vascular walls which oppose the outflow of blood from the heart.

Our studies have shown that the load against which the heart works is variable. This gives rise to an interesting concept. It appears from experimental data obtained from studies of animals that the input load is minimal when the arterial blood pressure is normal; that is, a standard input pulse induces a lower pressure pulse at "normal" arterial blood pressure than when the average arterial blood pressure is higher or lower than normal. This suggests that the vascular system is regulated in such a way that it normally operates at optimal mechanical loading. This may be why "normal" blood pressure is normal.

Propagation of the Arterial Pressure Pulse. The pressure pulse is propagated peripherally along the arteries. It has been known for many years that although the average arterial pressure drops toward the periphery, the pulse pressure increases. The classical explanation for this phenomenon is that the distortion is due to a fusion of the incident pressure wave, generated in the aorta by the action of the heart, and a pressure wave reflected from the end of the arterial system. Our studies have demonstrated that this hypothesis, derived from the Windkessel model, is incorrect and that a more likely cause is harmonic dispersion and selective damping. In other words, the arterial pressure pulse may be thought of as being composed of an array of sine waves, just as a complex sound wave is considered to be composed of fundamental and higher harmonic wave frequencies. In a purely elastic medium the propagation velocity of waves is governed only by the properties of the medium and is not a function of the frequency of the wave. In a visco-elastic medium, however, each wave frequency will be propagated at a different velocity. The arteries have been shown to be viscoelastic rather than purely elastic, and the arterial pressure pulse does contain several harmonic frequencies. Therefore, as the pressure pulse is propagated toward the periphery, the wave form will change due to different velocities and damping of the different frequencies.

These results suggest that physiologists should reconsider and reinvestigate the theories of the physiological regulation of cardiovascular functions. The nerve receptors which monitor the mechanical behavior and properties of the vascular system lie within the blood vessels and are subject to the principles outlined above. These nerve receptors generate nerve impulses as a function of their distortion and their rate of distortion, which in turn are functions of the contour of the pressure pulse and the properties of the vessel walls in which they lie. Such a "new look" into the regulation of blood circulation is important, especially since the older ideas have not furnished so much as a clue to most disorders of regulation, such as hypertension and hypotension.

The cardiovascular system is a very complex fluid mechanical system, and its properties and behavior are difficult to understand. It is important, therefore, that physiologists avail themselves of the knowledge and techniques which physical scientists have developed for studying complex, multivariable systems.

Highest Tribute

Recently, the Navy paid its highest tribute to Dr. Jerome C. Hunsaker, Emeritus Professor, Massachusetts Institute of Technology--a civilian scientist who has contributed outstandingly to achievements in naval research. The tribute was in the form of the Navy Distinguished Public Service Award.

Dr. Hunsaker joined the faculty of the Massachusetts Institute of Technology in 1908, after graduating from the U. S. Naval Academy at the head of his class. At M.I.T. he instituted and taught the first formal academic aeronautics course in the United States, established a course in aerodynamics which has served as a model for similar courses in many other schools, and pioneered in the development of the M.I.T. wind tunnel.

During World War I, he supervised the design, construction, and procurement of naval aircraft. After the war, he assisted in organizing the Bureau of Aeronautics and served as its Chief of Design from 1921 to 1923. During this period, he contributed to many improvements and innovations in naval aviation, such as catapults, radial air-cooled engines, and arresting gear. Later, while Vice President of the Goodyear Zeppelin Company, he monitored construction of the AKRON and MACON for the Navy.

Dr. Hunsaker played an important role in the establishment of the Office of Naval Research, for it was at his suggestion that an Office of Coordinator of Research and Development was established by the Navy in 1941. As first head of this office, forerunner of ONR, he coordinated the technological resources of the Navy for war. He has also been an influential member of many government committees, including the National Advisory Committee for Aeronautics and the Naval Research Advisory Committee.

Some years ago, the title "Mr. American Aeronautics" was bestowed on Dr. Hunsaker. That it was deserved and has "stuck" is not surprising when one reviews his career. As the citation given him points out, he has been "a creative pioneer in every scientific and technological phase in Naval Aviation since its inception."

On the Naval Research Reserve

Three Research Reserve Seminars Concluded

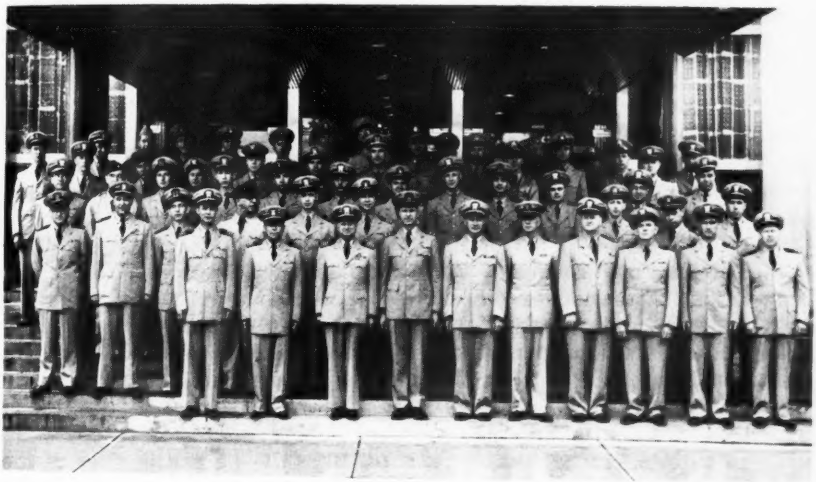
Fiscal year 1959 had barely begun when the first Research Reserve seminar for that year convened in Columbus, Ohio. This was the Fourth Annual Seminar in Research Methodology. It was followed by the Nuclear Science Seminar at Idaho Falls, Idaho, and by the West Coast Seminar at Pasadena, California. Five other Research Reserve Seminars are scheduled for the remainder of the year.

FOURTH ANNUAL SEMINAR ON RESEARCH METHODOLOGY

The Fourth Annual Seminar on Research Methodology was held in Columbus, Ohio, during the period July 6 through 19. It was conducted by NRRC 4-7 and sponsored by the Office of Naval Research. LCDR Daniel Howland, USNR, Commanding Officer of the local company, was seminar chairman. Fifty reserve officers from the Navy, Air Force, and Army attended. Seven Naval Districts were represented. Most of the sessions were held in the air-conditioned Ohio Union Building on the Ohio State University campus. Each session was chaired by the member of the local company who had arranged that day's program. Officers were housed in a nearby dormitory.

At the opening sessions, the Chief of Naval Research was represented by the Deputy and Assistant Chief of Naval Research, CAPT A. B. Metsger, USN, and by his Special Assistant for Research Reserve,

Reserve officers attending Seminar on Research Methodology. Front row, third from left, CAPT A. B. Metsger, USN, Deputy and Assistant Chief of Naval Research; fourth from left, LCDR D. Howland, USNR, Commanding Officer, NRRC 4-7; fifth from left, CAPT J. P. Aymond, USN, Special Assistant to the Chief of Naval Research (Research Reserve); and sixth from left, CAPT O. C. Woolpert, USNR, former Commanding Officer, NRRC 4-7.



CAPT J. P. Aymond, USN, who spoke on the Navy's approach to current and future scientific problems and on the Research Reserve program, respectively. The keynote address, "Research and Research Methods," was given by Dr. Frederic Heimberger, Vice President for Instruction and Research of the Ohio State University, who emphasized that returns on the research dollar must be counted not only in terms of hardware developed immediately, but also in terms of minds and ideas developed, a benefit which is compounded over the generations.

As in the three previous seminars, emphasis was placed on methods of research rather than on solutions to specific problems. The attempt was made to give a broad view of problems and approaches to them, including interdisciplinary action. Speakers were principally from the University faculty and the staff of Battelle Memorial Institute. They represented physical, biological, and social sciences, and many fields of engineering and medicine. Audience participation was encouraged through panel discussions following formal presentations, and through question and answer sessions following all presentations.

Part of the first morning was devoted to Naval administrative matters, after which CAPT Aymond gave his address. In the afternoon, CAPT Metsger and Dr. Heimberger spoke.

The second day was devoted to problems of space travel. In previous years, inclusion of this subject in such a seminar has been criticized as being too visionary. But not so this year, owing to its sudden increase in popularity. Two aeronautical engineers discussed propulsion systems and reentry problems; a physiologist spoke about the internal atmospheres of ships suitable for manned space flight, and a panel from Wright Air Force Base discussed human factors involved in space crew performance.

The third day was concerned with the use of statistics and computers in research. Emphasis was placed on two major aspects of statistics: determination of the form of relationships and testing of hypotheses concerning such forms. A note of caution was sounded with the indication that statistical analysis is accurate only if data are normally distributed and if all factors involved are accounted for. In the afternoon, the use of machine methods for bibliographic literature searches was described, and relative costs of this and other methods were discussed. The uses of digital computers in research problems were also treated. This discussion was highlighted by the assignment of two problems to the attendees concerning construction of flow diagrams and programs for computer solution of the problems.

The next day's session was concerned with problems of education. The Russian educational system was described, both in its current patterns and in its historical context. The main problems in education were described as being the identification of talent and the organization of the educational experience. Encouraging the talented child and building up his confidence that he possesses talent seem to be key steps in the development of scientists as well as other scholars. Development of maturity of outlook is necessary, and for this the humanities as well as scientific subjects are important.

Two days were spent on considerations of systems analysis and operations research. On one of the days, Ohio State University's Operations Research Group discussed basic concepts of systems analysis, including recognition of and allowance for the existence of uncertainty; functions of the human being in a system containing himself, machines, and environmental factors; laboratory simulation studies; and field measurement techniques. On the other day, uses of the systems-analysis approach in the social sciences were discussed by an economist, a sociologist, an anthropologist, and a research organization administrator. A principle point made was that the presence of an investigator influences the situation he is trying to measure, and that better ways of accounting for this factor are needed.

Two days were devoted to research in medical science. The first day was spent in the hospital of the Columbus Psychiatric Institute in the Ohio State University Health Center. The problems and effects of cross-fields cooperation among workers in psychiatry, neurophysiology, biophysics, biochemistry, endocrinology, sociology, psychology, and pathology were covered. A tour of the Research Division laboratories was included in the day's activities. Another day was devoted to research in nutrition, infectious diseases, dentistry, and endocrine disorders. The discussions were followed by demonstrations of research methods in medical and dental department laboratories. In the panel discussion, some of the fads and fancies in medical research and practice were taken up.

The programs for the remaining two days were concerned with practical problems in food technology research and with presentations by the attendees. Members of the departments of Horticulture, Dairy Technology, Poultry Science, and Animal Science of the College of Agriculture reviewed research efforts in their fields. The last day included an address by CAPT C. E. McCombs, USN, on the NROTC programs, and five presentations on research problems by members of the seminar. These included studies on quantitative relationships between structure and reactivity of organic compounds, small-scale digital computers in research, forecasting industrial production from various indices, methods of explosive-effects research, and school achievement of underage children.

FIFTH ANNUAL NUCLEAR SCIENCES SEMINAR

The Fifth Annual Nuclear Sciences Seminar at Idaho Falls, Idaho, concluded on August 2, 1958, after an informative and interesting two-week session. The program consisted of lectures by 28 speakers on various phases of nuclear developments, and there were two days of field trips. These trips were made to a number of the installations at the National Reactor Testing Station.

In attendance this year were a total of 41 officers—24 from the Navy, 11 from the Army, and 6 from the Air Force. They represented 22 states.

LCDR Mark Baum, MC, USNR, Commanding Officer of NRRC 13-6, the Research Reserve Company that arranged and conducted the seminar, opened the first session. He was followed by LCDR Walter McHargue, USNR, Seminar Program Officer, who introduced the following distinguished speakers: HON John B. Rogers, Mayor, Idaho Falls, Idaho; CAPT H. A. Knoertzer, USN, representing the Commandant, Thirteenth Naval District; Mr. S. J. Levine, Manager, Idaho Test Station, General Electric Company; RADM R. Bennett, USN, Chief of Naval Research, who presented the Department of Defense Reserve Award to the Phillips Petroleum Co.; and Dr. R. L. Doan, Manager, Atomic Energy Division, Phillips Petroleum Co.

In the course of the seminar scientific material of the nuclear-reactor field was presented by representatives from the Idaho Operations Office of the Atomic Energy Commission, the Argonne National Laboratory, Westinghouse Electric Corp., and Phillips Petroleum Co.

SIXTH ANNUAL WEST COAST SEMINAR ON GUIDED MISSILES

The Sixth Annual West Coast Seminar was held at the ONR Branch Office, Pasadena, California, during the two-week period beginning August 3, 1958. The seminar was concerned primarily with guided missiles. Also, some of the nation's leading industrial and governmental research and development concerns in the missile field were visited. LCDR N. L. Fish, USN, Reserve Assistant at the ONR Branch Office, Pasadena, served as Seminar Chairman. Seventy-one reserve officers attended, 65 of the Naval Reserve, 2 of the Army, and 4 of the Air Force.

The conferees were given a comprehensive review of the progressive steps involved in the Navy's missile program—from research and development to evaluation testing and operational use.

The seminar opened with a "Program Preview" by CDR Joseph Cryden, USNR, Physicist, Hughes Aircraft. He was followed by CAPT J. P. Aymond, USN, Special Assistant to the Chief of Naval Research (Research Reserve), who discussed the Research Reserve Program, and by CAPT A. M. R. Fitzsimmons, USN, Commanding Officer, ONR Branch Office, Pasadena, who welcomed the conferees.

The seminar got off to a good start with an indoctrination course presented by the U. S. Naval Guided Missile School at Pomona. Presentations were made at Pomona and during the remainder of the first week by some of the top guided-missile representatives of both military and industry.

The second week the group visited the Naval Air Missile Test Center, Point Mugu, and the Naval Ordnance Test Station, China Lake. At these activities such missile subjects as mission, technical developments, power plants, guidance, testing, maintenance, responsibility, and economics were presented.

Among the speakers who addressed the seminar were RADM R. Bennett, USN, Chief of Naval Research; RADM J. P. Monroe, USN, Commander, U. S. Naval Air Missile Test Center, Point Mugu; RADM C. F. Horne, USN, (Ret.), Vice President, Convair, Pomona; Mr. William M. Duke, Vice President and Assistant Director of Systems Engineering Division, Space Technology Laboratory, Ramo-Wooldridge Corporation; Dr. A. B. Focke, Technical Director, U. S. Naval Air Missile Test Center, Point Mugu; Dr. William B. McLean, Technical Director, Naval Ordnance Test Station, China Lake; and Dr. Rectin from the Jet Propulsion Laboratory, California Institute of Technology.

New Reserve Assistants

Two Reserve Assistants have reported for duty at ONR Branch Offices. LCDR W. B. Lower, USN, reported to the New York Branch Office, relieving LCDR G. F. Cronin, USN; and LCDR H. A. Wellemeyer, USN, relieved CDR H. B. Joslin, USNR, at the San Francisco Branch Office.

LCDR W. B. Lower

LCDR H. A. Wellemeyer

LCDR W. B. LOWER

LCDR Lower, a native of Altoona, Pennsylvania, entered the Navy in 1935 as an apprentice seaman. After attaining the rating of Aviation Chief Machinist Mate in 1942, he attended Flight School, and upon receipt of his wings in 1943, he was commissioned as Ensign. During World War II LCDR Lower served as patrol plane commander in Patrol Bombing Squadrons 18 and 32 in the Atlantic and Pacific respectively.

After participating in Operations Crossroads at Bikini in 1946, LCDR Lower was assigned to the Naval Air Technical Training Command at Memphis, Tennessee, for a two-year tour as officer-in-charge of a crash fire-fighting school. His next assignments, which lasted until June 1950, took him back to patrol squadrons at Whidbey Island, Washington, and in the Alaskan area. From 1950 to 1952 he was assigned to the Naval Communication Station in Seattle, Washington, and from 1952 to 1954 to the Staff, Commander Naval Forces, Marianas. After a tour of duty as a liaison officer at the Air Force Missile Test Center, Cocoa, Florida, LCDR Lower was made Commanding Officer of the U. S. Naval Facility, San Salvador, BWI. From 1957 until reporting for his present duty, LCDR Lower served as officer-in-charge of the Oceanographic Unit in New York under Commander, Eastern Sea Frontier.

LCDR H. A. WELLEMEYER

On July 31, 1958, LCDR Herbert A. Wellemeyer, USN, relieved CDR Hamilton B. Joslin, USNR, as Assistant to the Commanding Officer (Research Reserve) in the ONR Branch Office, San Francisco. CDR Joslin retired after completing 20 years active duty.

LCDR Wellemeyer, a Kansan, entered the Naval Reserve in 1938 while attending Friends University in Wichita. In 1940, while working in the Census Bureau, he transferred to the Third Battalion in Washington, D. C., and from there went to active duty on the USS J. FRED TALBOT (DD-156) as a radioman. He was serving on the USS GOLF (DD 247) when the United States entered World War II. He continued serving on this ship until January 1943, at which time he was transferred to the Naval Academy. In May 1943, he was graduated from the V-7 engineering officer course and was commissioned as Ensign. His assignments during the war included duty with a ship-repair unit and the Naval Repair Base, San Diego, where he operated the Informal Radar School.

Following the war LCDR Wellemeyer served with the Electronic Field Service Group aboard the USS LEYTE (CV-32) in the Atlantic and Mediterranean, and with Ground Controlled Approach Unit 26 at the Naval Air Station, Minneapolis. During the hostilities in Korea he served with the GCA Unit at Atsugi, and later on the staff of Commander Naval Forces, Far East.

Since then LCDR Wellemeyer has had duty as Production Officer at the office of Assistant Inspector of Naval Material, Redwood City; Security Officer at the office of Supervising Inspector of Naval Material, Western District; and Communication Officer of the USS LOS ANGELES (CA-135).

Naval Reserve Selection Boards

Selection boards for Naval Reserve officers for fiscal year 1959 will be convened as follows: Captain (Line), January 6, 1959; Commander (Line), January 6, 1959; Captain (Staff Corps), February 24, 1959; Commander (Staff Corps), February 24, 1959; Lieutenant Commander (Line), March 10, 1959; Lieutenant Commander (Staff Corps), April 28, 1959; Lieutenant (Line), April 14, 1959; Lieutenant (Staff Corps), June 2, 1959.

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Presentation of the Department of Defense Reserve Award. Left to right, CAPT H. A. Knoertzer, USN; RADM R. Bennett, USN; Mr. J. P. Lyon; LCDR G. V. Wheeler, USNR; and LCDR Mark Baum, Commanding Officer, NRRC 13-6.

Department of Defense Reserve Award Presented to Phillips Petroleum

The presentation of the Department of Defense Reserve Award to the Phillips Petroleum Co., Idaho Falls, Idaho (announced in Research Reviews, February 1958), took place at the opening session of the Fifth Annual Nuclear Sciences Seminar in Idaho Falls.

The presentation was made by RADM R. Bennett, USN, Chief of Naval Research, to Mr. J. P. Lyon, who received the award for the Phillips Petroleum Co. The award was made for outstanding cooperation by this company in the presentation of the Annual Research Reserve Nuclear Sciences Seminar, as well as for liberal company policies in regard to employees who are members of the reserve.

The nomination for the award was made by LCDR G. V. Wheeler, USNR, an employee of the company and a member of NRRC 13-6, Idaho Falls. CAPT H. A. Knoertzer, USN, represented the Commandant, Thirteenth Naval District, in the ceremony.

CDR R. O. Blau Receives Award

CDR Robert O. Blau, USNR, a member of Naval Reserve Research Company 5-8, Washington, D. C., has been awarded the Exceptional Civilian Service Award in connection with his services as a civilian employee of the Air Force.

The Award was presented recently at a Pentagon ceremony to Mr. Blau by MAJGEN J. E. Smart, Assistant Vice Chief of Staff, USAF, for "outstanding service to the U. S. Government." It is the highest civilian decoration awarded by the Secretary of the Air Force.

Mr. Blau's citation stated that "his work has brought great honor to the Department of the Air Force, and that the success of his scientific achievements has received international recognition."

In This Issue

COVER PHOTO: Ivan Mikhailovich Sechenov (1829-1905), "Father of Russian Physiology." Modern recognition of Sechenov's role in Russian science includes the designation, at the University of Moscow, of the Physiological Institute in his name. Portrait by Repin. See article beginning on page 7.

RESEARCH REVIEWS endeavors to report briefly highlights of technical progress in research by Navy laboratories and contractors and the development of important naval research facilities. Articles which meet these broad criteria and possess a good degree of readability are welcomed. Manuscripts and changes of address should be sent to Code 740, Office of Naval Research, Washington, D. C. ... Research Reviews is listed for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Subscription price: \$1.50 per year in U. S. and Canada; \$2.00 per year, foreign; \$0.15 per individual copy. Use of funds for printing this publication was approved by the Director of the Bureau of the Budget, February 12, 1958.