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RESEARCH REVIEWS

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COVER PHOTO: The balloon being released by this aerologist on a carrier vessel in the Pacific represents only one phase of the Navy's around-the-clock, around-the-world activities in gathering and disseminating weather information. Not only ships but shore stations as well participate in this vital task. At the same time, scientific methods are constantly being sought to improve the accuracy of the forecasts obtained. Some research of this type is described in "An Aerologist Puts an Ear to the Ground", on pp. 26 to 30 of this issue.

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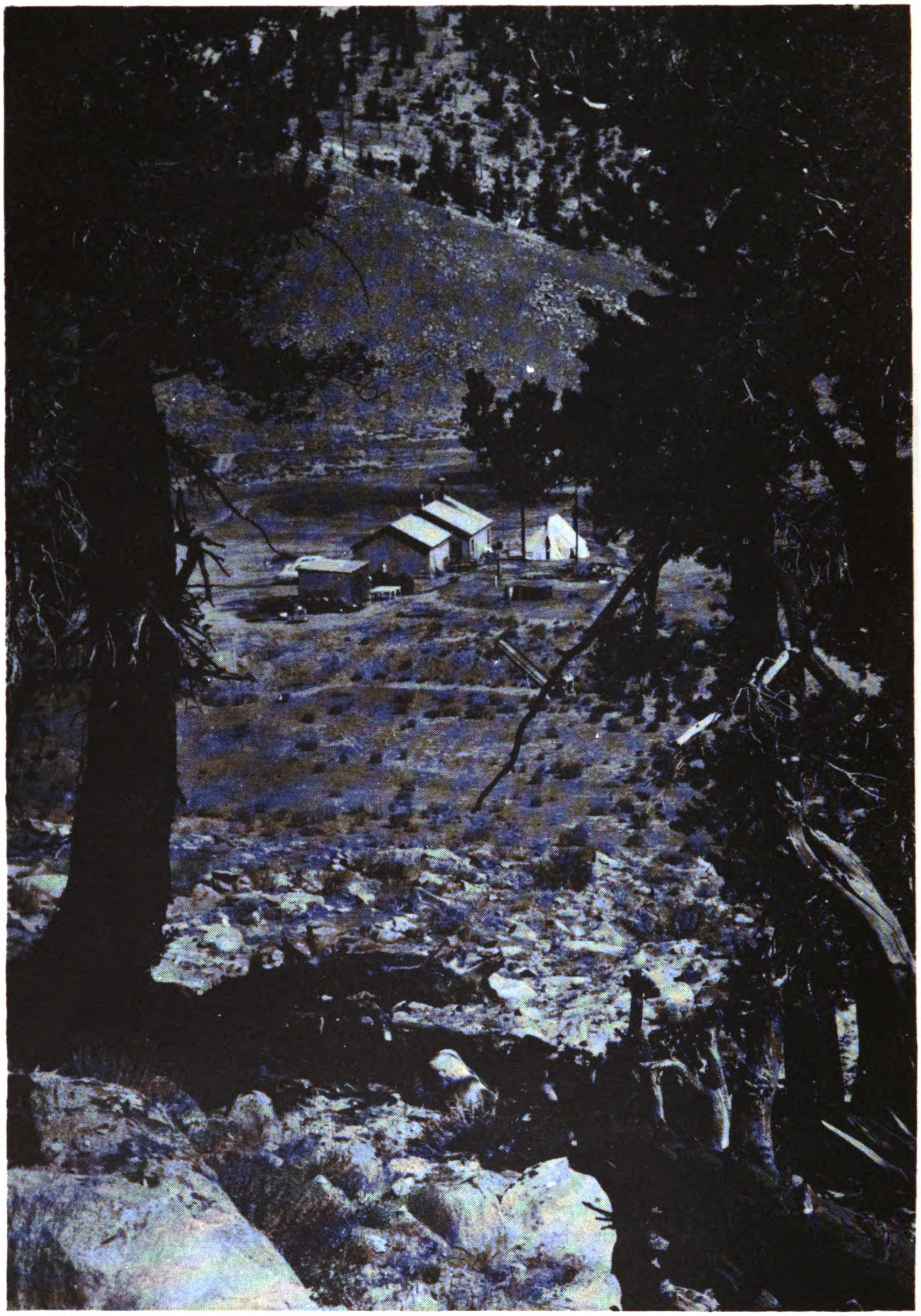

As the numerous plants show, this is the "lower" part of California's High-Altitude Research Station--located a mere 10,500 feet above sea level! Some very important high-altitude studies were made here, before the higher installation became available. The bristle cone pine trees through which the photographer took the picture are believed by some to be older than the redwoods. Further up the mountain plant life grows sparser and sparser until finally, above the timber line, the terrain begins to look as if it belonged to another world.

California's Laboratory Above the Clouds

by
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As Alice in Wonderland would have put it, scientists are becoming "curiouser and curiouser" about the regions above the earth's surface. This is probably the result of the huge advances made in the past half-century in man's ability to send men and equipment higher and higher. Soaring planes and electronically guided rockets have torn aside the barriers that once made the sky a romantic mystery, and the new accessibility of its "wide open spaces" has prodded men of science to ask a thousand questions about it. What is the composition of the atmosphere at great distances from the earth's surface? What kind of radioactive particles does it contain? What are the effects of the temperatures and pressures encountered on animals, humans and plants?

Some of the information sought has definite military or other practical applications. Some, on the other hand, is of interest solely as fundamental scientific fact, helpful in guiding man to a better understanding of the universe in which he lives. In either case, the establishment of a new high-altitude research laboratory is a development of very great importance.

Within the past two years ONR has been instrumental in making available a much-needed new year-round, high-altitude research facility for scientists of the United States. This laboratory, open to any investigator interested in the problems of high altitude, is located in the White Mountains of central California near the eastern edge of the state, 200 miles from San Francisco.

Access may be had to the White Mountains by way of Westgard Pass from the little town of Big Pine on the Owens Valley floor (4000 feet above sea level!). A paved road leads from Big Pine through Westgard Pass over into Nevada in the region of Tonopah, Goldfield and Lida—names that recall legends of gold and desert thirst. At the summit of the pass, 13 miles from Big Pine, a good dirt road branches off to the north and winds upward for 30-odd miles along the crest of the White Mountains to an altitude of 13,200 feet and just short of White Mountain Peak itself (at 14,246 feet). Although extension of the road to the top of the peak is quite practical, it has not yet been done.

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S. F. Cook was formerly a member of the Donner Laboratory Aero-Medical Unit at the University of California, where he is now Professor of Physiology. He is conducting ONR-sponsored research on burn shock.

The road was built in 1948 by the Bureau of Ordnance's Naval Ordnance Test Station at Inyokern, and a laboratory installation erected at an elevation of 10,500 feet. This installation is located on the headwaters of Crooked Creek in the lee of Campito Mountain, an 11,500-foot peak, about 20 miles north of Westgard Pass on the White Mountain Road. The installation consists of a wooden frame building which serves as living quarters and a Quonset hut which houses a weather station and provides laboratory space. At present, a colony of laboratory rats and mice is also located in the Quonset.

Although the original installation was used for classified work by NOTS, it was soon made available to outside investigators for high-altitude research. Thus, in 1949, investigators (led by Dr. Carl D. Anderson under an ONR contract with the California Institute of Technology) discovered the important and still-mysterious V-particles in cosmic radiation. During that same summer Professors R. B. Brode and W. B. Fretter, under ONR contract with the University of California, also made extensive cosmic-ray studies.

A full year's data on relative atmospheric purity of the White Mountain Station was obtained by Dr. Fritz Zwicky of the California Institute of Technology under an ONR contract in 1949. A comparison of these data with similar data from Sacramento Peak in New Mexico and from Climax, Colorado was made by Dr. Walter Orr Roberts, Superintendent of the High Altitude Observatory of Harvard University and the University of Colorado, and it was clear that the White Mountains are definitely the superior site for solar coronal research, although both the other sites are very satisfactory. In the fall of 1949, the White Mountain Station was turned over temporarily to two groups of investigators working under government contracts. One of these groups, comprised of scientists from the University of California at Los Angeles and led by Professors L. P. Delsasso and R. W. Leonard, conducted extensive experiments on the velocity of sound under various conditions.

Thus for the first two years of its existence the White Mountain Station was used exclusively for physical research in a wide variety of fields. During this time, the authors had been seeking a suitable location for investigating the problems of adaptation to high altitudes in animals and man. Although higher altitudes existed in the region of Mt. Whitney (elevation, 14,495 feet) in the Sierra Nevada, the White Mountains possessed marked advantages from the point of view of year-round accessibility and relative gentleness of terrain. Accordingly, plans were formulated for the construction of another installation some nine miles north of the Crooked Creek quarters, and 2,000 feet higher, on the slopes of an unnamed peak just south of White Mountain Peak itself. The peak chosen, reaching 13,023 feet above sea level, has now been officially named Mt. Barcroft in honor of Sir Joseph Barcroft, the British physiologist who pioneered in high-altitude physiology. Many factors influenced the selection of Mt. Barcroft as the site for the second installation, but the chief ones were the presence of an adequate water supply and the matter of protection from the prevailing westerly winds of the region.

In the summer of 1950, the entire Crooked Creek installation was transferred to the cognizance of ONR, and operation of the Station was delegated by contract to the University of California at Berkeley in the fall of 1950. This arrangement is still in effect. Thus the Crooked Creek installation has been kept in continuous operation for over three years.

Maintenance of the Crooked Creek quarters through last winter made it possible to start construction of the Mt. Barcroft quarters at 12,500 feet above sea level in the spring of 1951. The installation here consists of a 40- by-100-ft Quonset hut, erected on a concrete slab and specially reinforced to withstand the high-velocity winds encountered at these elevations, which are well above the timber line. One end of the hut is devoted to a 30- by- 40-ft heated garage, and the remaining two thirds has been partitioned off into a number of rooms on two stories. Besides complete living accommodations for 24 persons there are two laboratory rooms, each 17 by 25 feet, and a third room which houses some of the meteorological instruments and radio equipment. Construction on this building is essentially complete, but numerous finishing details still must be taken care of.

Figure 1. The site for the upper station looked like this in July of last year.

The story of the building of the Mt. Barcroft laboratory, some 45 miles from the nearest human habitation, almost constitutes a saga. It involved the transformation of a poor jeep trail into a good truck road, the development of a water supply, the pouring of almost 100 cubic yards of concrete, the erection of the Quonset building itself, and the roughing-in of a two-floor interior. The pressure of time was constant because of the sharply limited building season (from the middle of June to the end of September) and the accomplishment is a tribute to all who were involved.

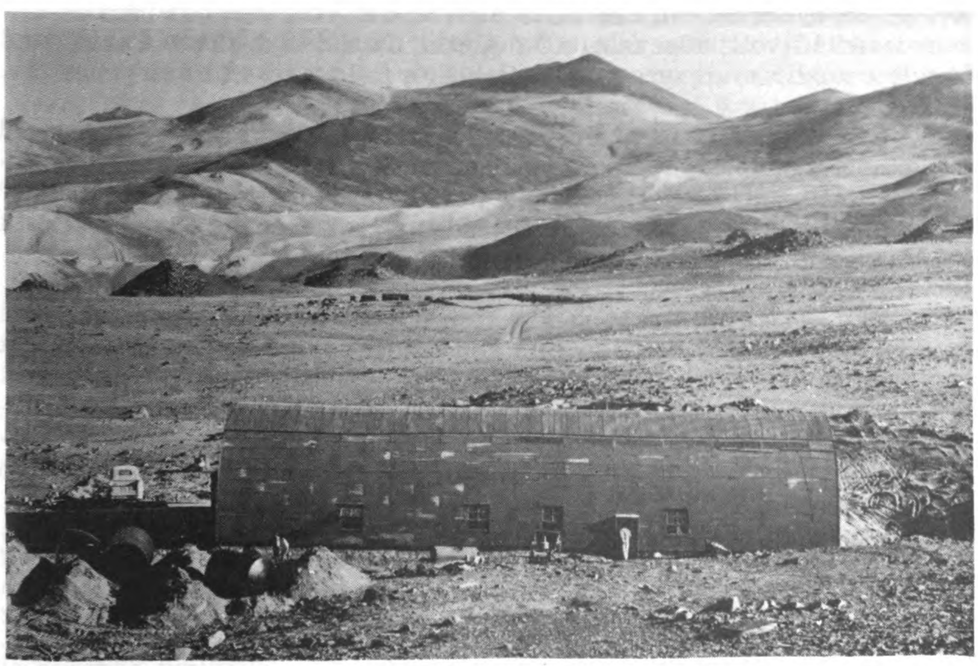

Figure 2. By October plenty of hard work had produced this result.

In the course of the summer, 14 graduate students in physiology, two Ph.D.'s, and three physiologists at the professional level (led by Robert B. Choate, a professional engineer), had learned about road blasting, concrete-concocting and Quonset hut assembly under the very trying conditions of cold and low oxygen encountered at 12,500 feet above sea level. At this altitude, physical exertion becomes difficult, and the very reason for establishing an installation here operates against those constructing it. Moreover, a pronounced mental depression developed in most individuals after a few days, which made it difficult to continue the effort, but continue it they did. Consequently there are now some two-score physiologists who have a far keener appreciation of the problems faced by man at altitude than do their "flatlander" colleagues.[1]

A rather humorous and very fortunate incident occurred during the construction work, which illustrates how adversity may sometimes be turned to advantage. Early in July, when excavation for foundations was begun, the same difficulty that beset Mr. Blanding in building his dream house was encountered--the continual seepage of water into the excavation. It was believed that this was caused by snow melting on the flank of Mt. Barcroft. When the snow was all melted and gone by the end of August, however, the seepage continued. It had been originally intended to pump water for the building from a spring several hundred yards away, but instead, a well-driller was persuaded to bring in his rig and a well 30 feet deep was installed right beside the building. It continues to supply water at this writing, in the dead of winter. It is, possibly, the highest well in the United States, and a much less costly water system than the one originally planned.

Both the Mt. Barcroft and the Crooked Creek quarters boast hot and cold running water and modern plumbing of the indoor variety. Heat is provided by oil stoves, and electric power by Diesel generators. There are two generators at each installation capable of producing 25 kva of 60-cycle AC at 220 volts and all the buildings are wired with standard 110-volt, 60-cycle, AC outlets. In addition, there are several smaller auxiliary generators available for field work or emergency use.

Both installations are provided with short-wave transmitters and receivers, and daily radio communication is maintained with the University of California at Berkeley and NOTS, Inyokern to provide weather reports. In addition, a telephone land line connects the Crooked Creek quarters with the Bishop telephone exchange.

The entire White Mountain Range lies within the Inyo National Forest, and Special Use Permits have been issued by the U.S. Forest Service to allow the construction of the Crooked Creek quarters at 10,500 feet and the White Mountain Road. A slightly different arrangement is in effect with the Forest Service for the Mt. Barcroft installation at 12,500 feet. In this case, a cooperative agreement has been

[1]Considerable assistance was rendered by various Naval facilities in central California in the form of loans of mechanized equipment of all sorts. Great help was also received from the San Francisco Branch of the ONR in making the necessary arrangements. The continuing interest and material assistance of Mr. C. L. D'Ooge and Dr. H. W. Hunter of NOTS, Inyokern was also an integral part of the success of the entire project.

formulated between the Forest Service and the ONR under which an area of 20 square miles has been set aside for purposes of high-altitude research. This area not only includes the Mt. Barcroft site and White Mountain Peak itself, but also is essentially all above 11,000 feet. Furthermore, the terrain is quite gentle with mild to moderate slopes interspersed with numerous broad, flat, grassy alpine meadows. The whole area is of course above timber-line, and in character resembles an altiplano of the Andes.

Because the White Mountains lie just east of the Sierra Nevada, the moisture-laden prevailing westerly winds coming off the Pacific lose most of their water on the latter and as a result a yearly total of only about ten inches of water fall on the White Mountains. Of this, about one-third falls as rain during the summer months and the other two-thirds as snow in the winter. The latter represents a total snowfall of about 100 inches. While the limited precipitation results in a semi-arid environment, it also determines a very marked advantage of the White Mountains as a site for a high-altitude station in that year-round access is possible. The snowfall is, of course, moderately large but can be coped with, and in comparison with other high-altitude regions of the United States it is far less.

Continuous weather observations have been taken at the Crooked Creek site for over three years, and similar observations have just been started at the Mt. Barcroft site. The coldest recorded temperature at Crooked Creek was -19° Fahrenheit. Although this is not as low a temperature as that found on other parts of the earth, the mercury commonly hovers in the vicinity of zero for days at a time during the winter months. The maximum summer temperature has been consistently in the low 70's with 73°F the highest recorded. During July and August the temperature does not fall below freezing at night. The relative humidity fluctuates from about 40 percent in the summer to about 60 percent in the winter, and wind velocities up to 50 knots average for one hour have been recorded during the winter months. The barometric pressure exhibits a regular and rather large cyclic variation over the year. The monthly average pressure falls from a value of about 515 mm Hg in the summer to approximately 506 mm Hg in the winter, which represents a change of about 500 feet in equivalent altitude.

It has been no surprise to find that weather conditions are more severe at the higher White Mountain Station. The limited observations made thus far at the Mt. Barcroft laboratory indicate that the air temperatures are quite consistently about 10°F lower than those at Crooked Creek. Moreover, higher wind velocities are encountered; an average one-hour velocity of 71 knots has already been logged.

The meteorological conditions over the White Mountains appear to be unique. Within the past year or two, it has been discovered that a tremendous updraft exists here, and the town of Bishop in the Owens Valley has become the glider capital of the world. All previous altitude records for gliders have been broken recently, and flights to 45,000 feet have become almost commonplace.

Two maintenance crews, each consisting of two men, live at both the Crooked Creek and Mt. Barcroft quarters throughout the year. The Operations Manager is Mr. Jack Rose. A rotation plan is in effect under which each man works twenty days and then is off for five; thus, there are four men in residence at all times. It is seldom that they cannot get into Big Pine or Bishop at least once a week for mail and fresh food. Between storms the road is usually kept clear of snow with a bulldozer, but two snow weasels are also a very important part of the Station equipment.

The duties of the crews are varied and on a 24-hour-a-day basis. In addition to the routine care of the laboratory animal colony and weather observations three times daily, there is a never-ending stream of maintenance and repair problems on the mechanical equipment, together with the task of completing the construction at both installations. In the winter there is the additional burden of snow-clearing, and in the summer of road maintenance and improvement. Then there are the sporadic visits of the "flatlanders" — scientists who arrive to work. While all visitors share in the cooking and k.p. duties, the arrival of eager investigators always means time diverted from the basic maintenance effort. The Station exists solely for them, however, and their needs must be served.

Both the biological and the physical sciences are represented in the research being conducted or planned at White Mountain. In general, the biological research is concerned with the effects of low oxygen and low temperatures on living organisms, and with what kinds of adaptations the organisms can make in combating these environmental extremes. More specifically, experiments are being carried out on the acclimatization of man and laboratory animals, and parallel observations are being made on the native species which have successfully adapted themselves to the extreme conditions over many generations.

The experimental colony of pure-strain laboratory rats and mice was established over a year ago, so that successive generations of these animals may be compared for adaptive changes with the same strains kept at sea level. The native fauna above 10,000 feet include numerous marmots, ground squirrels, deer mice, meadow mice, coneys, snowshoe rabbits, jackrabbits, coyotes, a few mountain lions, deer, wild horses and bighorn sheep. An extensive bird population is also found at these higher altitudes, and a conservative estimate places the number of plant species occurring above the timber-line at least at 500, many of them yet to be described. Thus an amazingly varied native population is available for comparative studies.

The purpose of these researches is to obtain information on how acclimatization of man to these environmental extremes might be hastened or even induced artificially, an objective of great importance in aviation and in cold-weather or alpine operations of either military or civilian nature.

Related experiments are being planned on the effects of cold and low oxygen on domestic stock animals. The broad objective in this case is of economic as well as of fundamental importance in that much of the marginal land of the United States suitable for grazing and farming lies above 5,000 feet. In order to utilize this land more effectively it is essential to know and make allowance for the effects of altitude upon the stock animals involved.

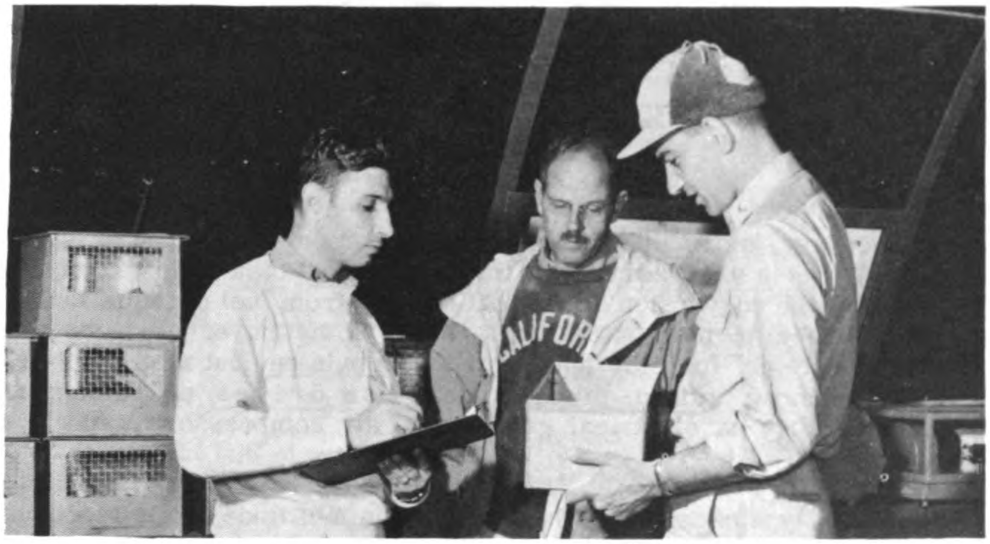

Figure 3. Dr. Cook (center) and Dr. Pace (right) discuss their notes on some experimental white mice with assistant Donald Green.

Another problem of importance being attacked at White Mountain is that of long-term bulk food storage. The "keeping" qualities of rations stored in a cold, low-oxygen environment will be compared to the preservation of those stored in the warmer, relatively high-oxygen environment near sea level. It is possible that less deterioration in foodstuffs may occur under the former conditions.

The researches conducted in the physical sciences are concerned chiefly with the study of cosmic rays. It is becoming increasingly evident that a detailed analysis of the nature of cosmic radiation is one of the keys to a complete understanding of the forces in the atomic nucleus, and hence of the most efficient utilization of atomic energy. The marked superiority of American atom-smashing machines has, in the past few years, resulted in a relative lack of attention in the United States to natural cosmic radiation; however, it is now generally recognized that both approaches to the problem of nuclear forces, used together, will probably be the most fruitful. Since much present-day cosmic ray research must be conducted at high altitudes, the White Mountain Research Station represents an excellent site for some phases of this work.

Although the Station is administered by the University of California, it is open to any qualified investigator interested in high-altitude research. Living quarters and basic laboratory facilities such as power, water, and gas are available, but very little laboratory equipment is on hand at the Station and investigators must bring along their own. It is also necessary to levy a small charge on individuals using the Station to help defray operating costs. Details of such arrangements may be obtained either from the authors or from Dr. Louis Levin, Head of the Biochemistry Branch, ONR, Washington, who has been instrumental in making possible the recent development of the Station.

The White Mountain Research Station represents a significant addition to the high-altitude laboratories of the world. Not only is it the second or third highest but it is one of the very few operating all year long. ONR can well be proud of supporting research not only in institutions of higher learning, but also in this case in an institution of highest learning!

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Free-Piston Engines

by

A. L. London
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The Navy, more than any other organization — military or commercial — has a vital interest in the development of a wide variety of engines for the conversion of thermal energy (from fuel combustion or nuclear fission) to mechanical work. Such prime mover systems are employed not only for ship and aircraft propulsion, but also for air- and water-borne guided missiles, and for drives of numerous auxiliaries such as electrical generators, air compressors, and fire pumps.

No one type of engine can best serve this multitude of applications. For this reason the Navy has always encouraged not only the use of existing prime movers in new applications — for example, the diesel for submarine propulsion — but, what is possibly of greater long-range importance, has pushed new and revolutionary systems such as the gas turbine plant and the atomic-powered submarine.

One of these revolutionary prime movers is the free-piston engine. This system, in one of its several variations, may ultimately supplant the conventional diesel as a main propulsion plant for the smaller Naval surface ships and submarines, or for auxiliary electrical generator service on the larger combat vessels. In other variations it may replace, to some extent, electric-motor-driven air compressors, which are used in substantial numbers on the larger surface ships and submarines.

A free-piston machine (see Figure 1) consists essentially of an opposed-piston two-stroke diesel driving a reciprocating air compressor. The reciprocating work derived from the diesel pistons is used directly to provide the compressor piston work requirement, without the intermediary of the two crank mechanisms employed in the conventional system, wherein the reciprocating work of the diesel engine is converted to rotary shaft work by the engine crank, and then back to reciprocating work for the compressor by the compressor crank.

Consider specifically the free-piston diesel compressor described schematically in Figure 1a. On the outward or power-stroke of the pistons, air is compressed in both the compressor and the "bounce" cylinders. From the compressor cylinder the high-pressure air is delivered to the "load". The air compressed in the bounce cylinder, however, remains there to provide the energy required for the return of

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A. L. London, Professor of Mechanical Engineering, Stanford University, is Supervisor of ONR-sponsored research on convective heat transfer and the thermodynamic-dynamics aspects of free-piston machines. As a Lieutenant Commander (USNR) on active duty at the Bureau of Ships, 1943-46, he worked on new developments in propulsion machinery.

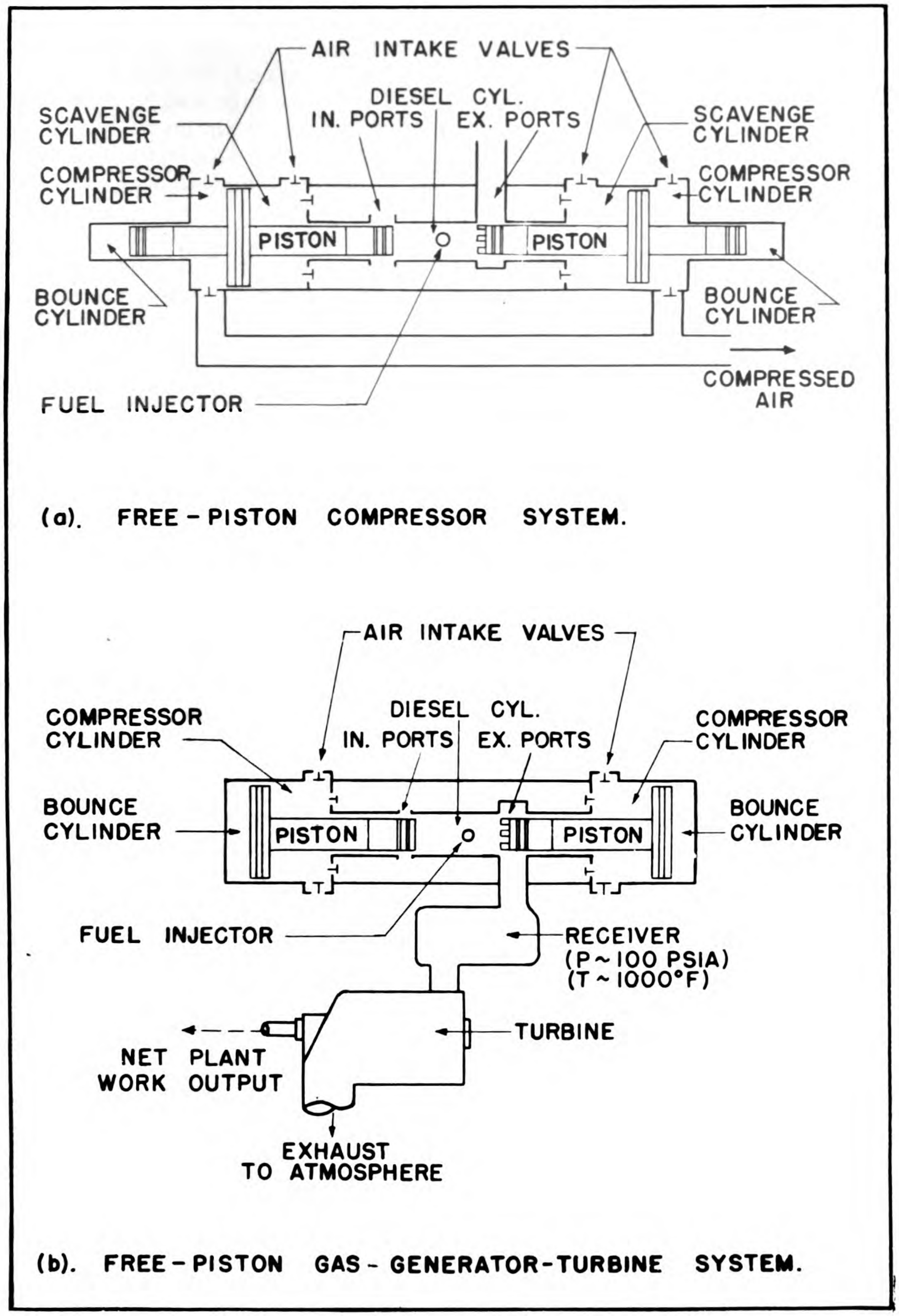

Figure 1. Two variations of free-piston engines. Note that the mass of the right- and left-hand piston assemblies are identical and that synchronized, exactly opposed operation of the pistons is insured by a mechanical linkage (not shown in the sketches).

the diesel piston to the firing position prior to the next power-stroke. Also on this inward-stroke, air for diesel combustion is pressurized to a small extent (10 - 20 percent above atmospheric pressure) in the scavenge cylinder before passage to the diesel cylinder.

This is just one of several possible cylinder configurations for a single stage of compression. Other alternatives include: (a) the use of air, compressed in the clearance space of the compressor cylinder, to provide the return stroke energy instead of a separate bounce cylinder; and (b) the use of several stages of compression with intercooling, in order to realize pressure ratios greater than 7:1. In any design, however, it is important that the right- and left-hand piston assemblies have essentially equal mass.

It is to be noted, too, that the stroke length is not limited by the kinematics of a crank, but rather by the compression of the gases within the cylinders. Piston movements are not completely free, however, as the two piston assemblies are linked by a synchronizing mechanism which insures exactly opposed motion. Unlike the crank, though, only negligible amounts of power have to be transmitted by this linkage.

In contrast to the air-compressor system, Figure 1b is a schematic description of a free-piston, gas-generator turbine engine. On the out-stroke, all the work done by the combustion gases on the diesel pistons goes into compressing air in the bounce cylinder. Then, on the in-stroke, this stored energy in the bounce cylinder is employed to deliver compressed air, at four to eight times atmospheric pressure, to the diesel cylinder. As a consequence of this high "supercharge", the diesel exhausts at a high back pressure, about 10 - 15 percent lower than the charge pressure. The resulting high-pressure, hot exhaust is then employed in a gas turbine to produce shaft work. In principle this prime mover system has a better fuel economy than the modern diesel, which has the lowest specific fuel consumption (lbs/hr per unit of power output) of all heat-power systems now known. Effectively, thermodynamic performance equivalent to that of a 40:1 compression ratio, internal-combustion engine can be obtained. Such a high compression ratio cannot be designed into crank engines, because load limitations in connecting-rod and crank-shaft bearings preclude compression ratios above 8:1 for gasoline and 16:1 for diesel systems. Moreover, crank engines with compression ratios even approaching these limiting values need expensive fuels, highly refined and with suppressor additives such as Ethyl Fluid.

Two variations of free-piston systems have been described: (a) the diesel-compressor system for producing compressed air for pneumatic purposes; and (b) the gas generator system for producing "power gas" for a gas turbine. A third variation, representing a combination of these two, consists of a diesel compressor (Figure 1a), a combustion chamber, and a gas turbine. Atmospheric air is compressed in the compressor, heated in the combustion chamber, and then delivered to the turbine for the production of shaft work. This system has a fuel economy better than that of the simple gas turbine system but poorer than the gas-generator-turbine engine of Figure 1b. It does not, however, involve the development problems of the latter system and appears to be capable of much earlier general usage—for example, in a small boat or a truck power plant.

The most notable mechanical features of free-piston systems in general are: (a) constructional simplicity arising from the absence of cranks and associated bearings; (b) essentially vibration-free operation provided by the opposed-piston, crankless design; and (c) reduced

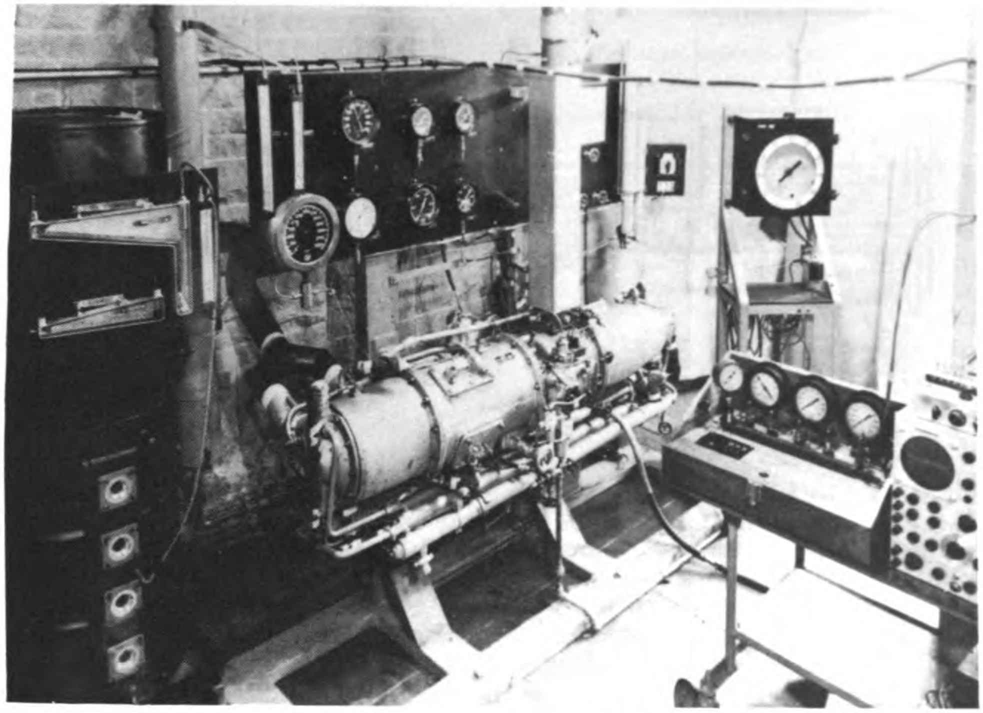

Figure 2. This free-piston four-stage, 45-hp air compressor was intended for use in compressing torpedo launching air on a German submarine. Water-cooled intercoolers and an aftercooler are located below the unit.

cylinder wear, in principle at least, because of the absence of piston side-thrust normally introduced by the crank-connecting-rod mechanism. All these advantages are gained with no sacrifice of thermodynamic performance within the cylinders, and theoretically, with a substantial gain in mechanical efficiency as a result of fewer moving parts and lower loadings on the remaining bearing surfaces.

The compressor application has already been convincingly demonstrated as a military and commercial reality in Germany and France.

The German Junkers organization furnished free-piston compressors as standard operational units to the German Navy. These were installed in submarines and destroyers, for compressing torpedo-launching air. Such a system, now undergoing tests at Stanford University, is shown in Figure 2. The unit pictured is from a German U-boat, and was obtained through the Bureau of Ships as captured enemy equipment. Four stages of air compression are provided, with intercooling and aftercooling to furnish compressed air at 3,000 pounds per square inch pressure (200 times atmospheric). In a conventional crank unit, a 45 - 50-hp diesel or electric motor would be required, in addition to a four-stage air compressor for an equivalent service. Further details of this free system may be derived from a study of Figures 3 and 4. The essential simplicity of the free-piston machine is strikingly illustrated by comparing its relatively few working parts to the numerous parts of an automobile engine. Furthermore, this is more than an internal combustion engine, for it includes a four-stage air compressor.

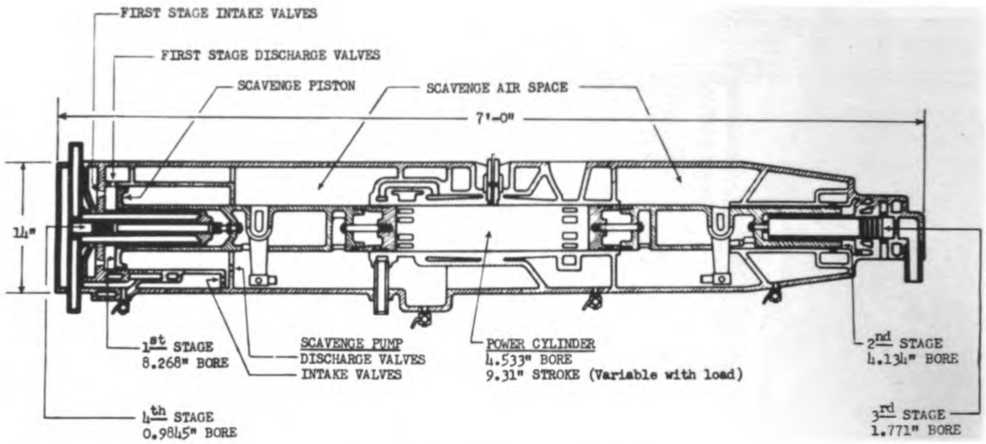

Figure 3. Further details of the free-piston engine pictured in Figure 2. The essential simplicity of the machine can be demonstrated by comparing its few parts to the more numerous ones required in an automobile engine.

The French organization SIGMA (Société Industrielle Générale de Mécanique Appliquée) has supplied over 1,000 compressors for commercial use, not only in Europe but also in Africa, South America, Central America and, more recently, in Mexico. These units are of the rugged portable type employed on construction projects to furnish air at roughly 7 - 8 atmospheres pressure for driving pneumatic tools.

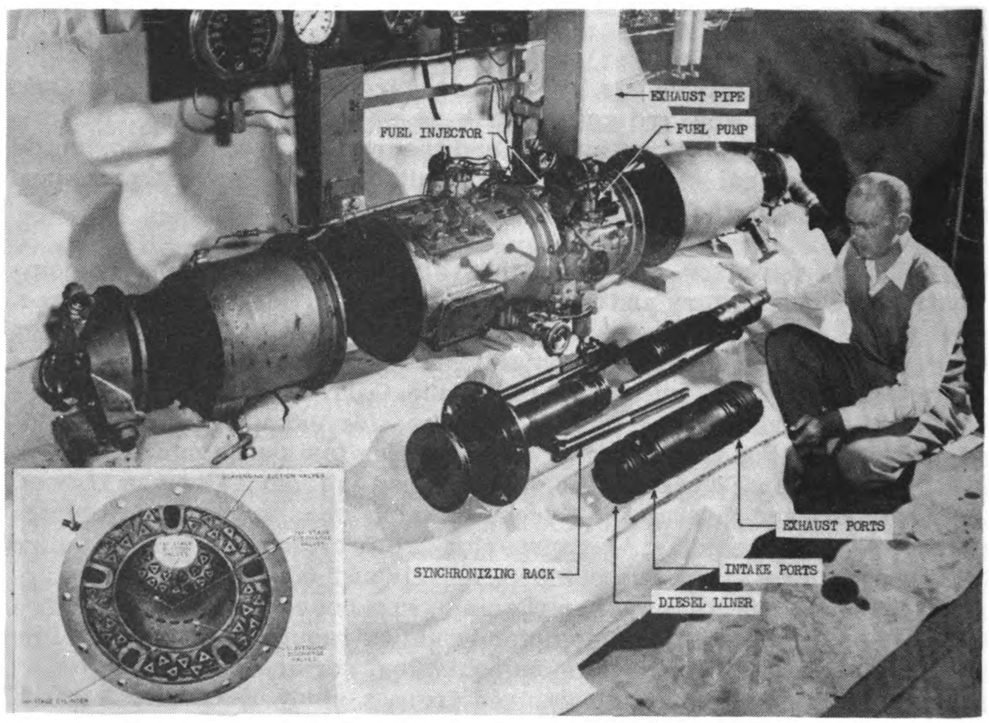

Figure 4. Breakdown of the free-piston compressor shown in Figure 2. Note the synchronizing racks on the piston assemblies which mesh with geared pinions located at the fuel injector section. This mechanism insures the opposed piston motion.

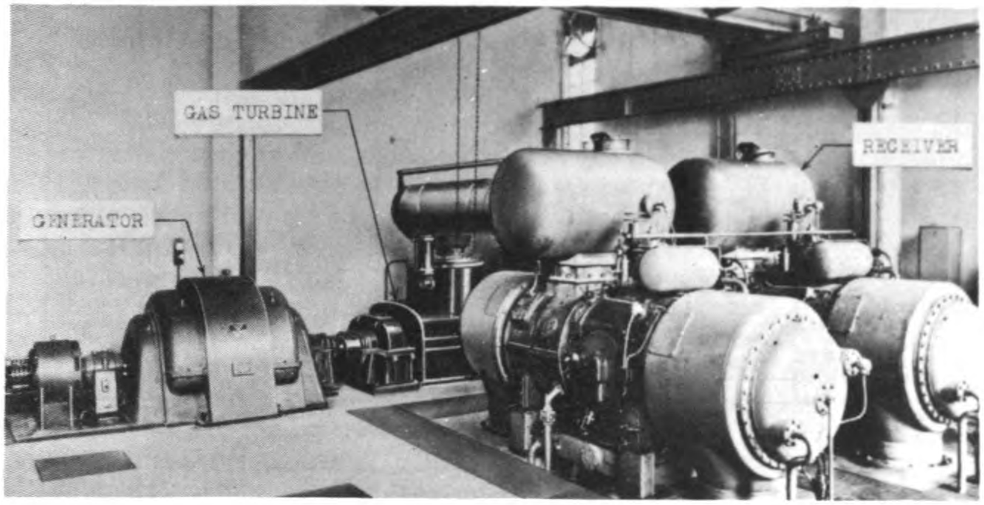

Figure 5. Two SIGMA G-34 free-piston gas generators installed in a central station. Turbine shaft specific fuel consumption at full load is 0.38 lbs/(shaft hp hr), comparable to that of modern crank-type diesel. Piston cylinder configuration is the same as that pictured in Figure 1b.

In addition to its compressors, SIGMA, after 25 years of development, has a commercial gas generator model suitable for use in small central stations to generate electricity for railroad locomotive drives, and for ship propulsion. Figure 5 pictures a 1400-kilowatt central-station plant where two free-piston gas generators are paralleled to provide "power-gas" to a single gas turbine which, in turn, drives an electrical generator. The marine drive applications planned for 13 French Navy minesweepers employ the same model gas generator unit.

In spite of these successes in Europe, no major effort has been made on the air-compressor development in this country. Only one U. S. manufacturer, under Navy BuShips sponsorship, has made any progress on the gas generator application. This lack of effort here is partly due to conservatism; but it is also due to the fact that the design procedure, based on the thermodynamic-dynamic analysis of free-piston engines, is sufficiently complex and different from that for the conventional crank system so as to inhibit preliminary thinking on the subject.

While free-piston engines are commercial realities in Europe, and will, in the opinion of the author, ultimately find their place in this country, their acceptance here will be accelerated and better systems will evolve if certain engineering research problems are successfully investigated at an early stage. Some of these problems will be discussed briefly.

In the conventional crank engine, engine speed, by virtue of the mechanical constraints imposed by the crank, is an independent variable for the designer. That is, he arbitrarily specifies the magnitude of a speed, which, according to his experience, is suitable. This permits a complete separation of the thermodynamic from the dynamic design considerations. In fact the crank-engine designer, aside from combustion considerations, is primarily concerned with mechanical problems. The thermodynamical considerations, for the most part, may be based on simplified approximations derived from current "good practice". In

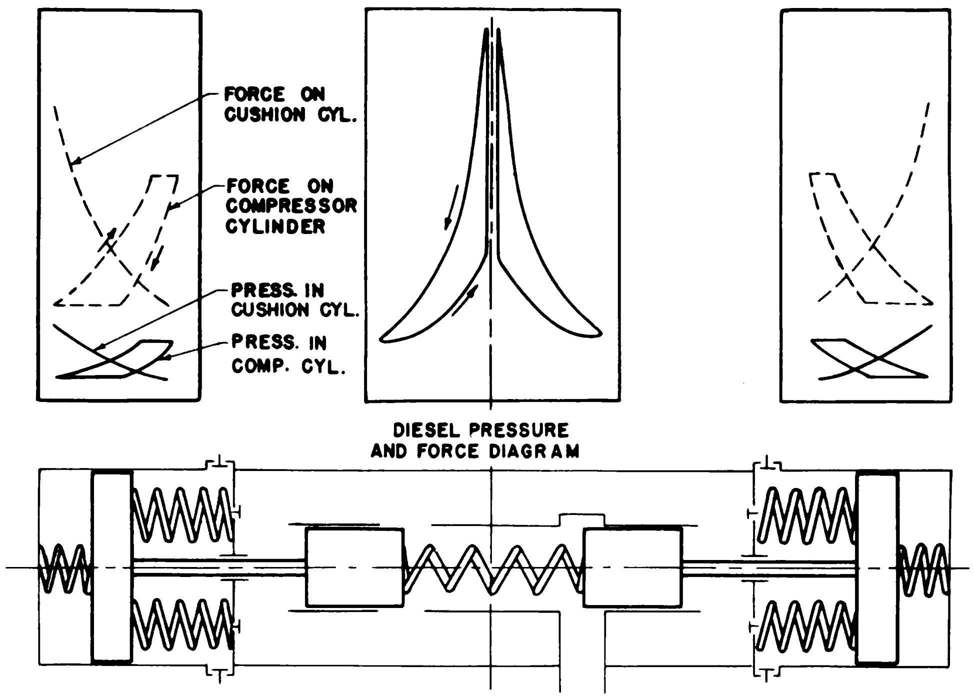

Figure 6. A schematic representation of the "gas" spring-mass nature of free-piston machines. The thermodynamic processes of the gases with the cylinders establish the character of the gas springs.

contrast, for the free-piston engine, the absence of the crank results in a "spring-mass" system (Figure 6) which operates at a "natural frequency", or speed, established by the mass of the piston assemblies and the nature of the "gas springs" within the various cylinders. Consequently, the thermodynamic considerations, which fix the character of the gas springs, cannot be separated from the dynamic considerations, even in preliminary design calculations. Moreover, in a crank-engine system the volumetric compression ratio is fixed, while in the free-piston system it varies as the piston stroke length changes with load.

For these reasons one of the first objectives of the Stanford-ONR free-piston project was to outline a procedure for the thermodynamic-dynamic design of such engines and to prepare several illustrative designs of compressor and gas generators.

In the free-piston compressor variation (Figure 1a) the combustion rate per unit of diesel cylinder volume is comparable in magnitude to conventional crank, two-stroke diesel engines. Consequently the cylinder heat transfer intensities are not severe and the associated cylinder wall lubrication and ring wear problems pose no more difficulties than in current engines. In contrast, for the gas generator system (Figure 1b) the combustion rate, and consequently the cylinder heat transfer intensities, increase roughly in proportion to the supercharge pressure level — a factor of from four to eight-fold compared to conventional engines. The associated lubrication and ring wear problems may prove to be a serious hindrance to the development of gas generators operating at the higher pressures resulting from, for example, an 8:1 as compared to a 4:1 supercharge ratio.

In the SIGMA gas generator of Figure 4, the pressure ratio is just 4:1 at maximum load. For these conditions the diesel combustion occurs with a larger amount of excess air, which reduces the gas temperatures sufficiently so that in spite of higher gas density (due to the 4:1 supercharge) the cylinder wall heat transfer intensities are not excessive. Nevertheless, as the fuel economy for the gas generator-turbine system is improved by operation at higher pressures, future developments will probably carry into the region where heat transfer problems may prove to be a limiting consideration. As a consequence, a theoretical study of heat transfer in highly supercharged engines is one of the objectives of this research project.

There are other problems which need investigation. Although the fuel injection timing requirements of free-piston engines are essentially conventional, proper injection timing must be obtained by other than conventional means, because of lack of a continuously rotating shaft to drive a fuel-pump. Another problem involves the fact that the control of a single gas generator is affected by changing the fuel pump delivery as in a conventional diesel. However, when gas generators are used in parallel to obtain increased capacity, as described in Figure 4 (where two units supply a single gas turbine) the gas generators have to be operated out of phase in order to smooth out the flow to the turbine and to minimize the pressure fluctuations at the gas generator discharge. Reflections of these pulsations back through the engine and compressor valves may cause serious malfunctioning of the system.

Reorganization of Human Resources Division

In line with a recent reorganization within ONR's Research Group, the Human Resources Division is now designated the Psychological Sciences Division. The Division, with Dr. J. W. Macmillan as Director (Code 450) will consist of three branches as follows:

Human Relations Branch
Dr. H. E. Page, Head (Code 452)

Physiological Psychology Branch
Dr. William Berry, Acting Head (Code 454)

Personnel and Training Branch
Miss Marguerite L. Young, Acting Head (Code 458)

Dr. Ralph M. Hogan, the former Head of the Manpower Branch, is now the Scientific Manpower Consultant to the Director of the Psychological Sciences Division. The Psychological Warfare Officer, CDR J. P. Dickson, is assigned to the Office of the Director of the Psychological Sciences Division.

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Rheumatic Fever Resear

Investment In Youth

. . . a better future is in the making at Northwestern University for the victims of a long-neglected disease.

Of all man's diseases, the ones with the most tragic effects are those which strike early and cripple during the most promising years of youth. That is why the efforts of a small group of men and women at the Rheumatic Fever Research Institute in Chicago may eventually mean so much to the health of the whole world.

Few people have any idea of the terrible toll which rheumatic fever takes of the vitality and lives of millions. Most consider it exclusively a children's disease. If this were true, the United States Navy probably would not be supporting the work of the Rheumatic Fever Research Institute. Unfortunately the Navy has learned about the disease the hard way; during the war it had to spend millions battling its ravages among young recruits. This is not surprising, considering the statistics, which show that rheumatic fever is the leading cause of death between the ages of 5 and 19, and the second commonest between 20 and 24. Moreover, many adults find themselves with seriously crippled hearts as a result of youthful bouts with the disease. No wonder that the group at the Institute consider that the understanding and alleviation of rheumatic fever are essential!

In spite of the terrible toll exacted by rheumatic fever, no large-scale attack on the disease had been undertaken until a few years ago. Dr. Alvin F. Coburn, Director of the Institute, points out that not only were the laboratory studies brief and inadequate but there was only one full-time rheumatic fever research position in the United States which offered continuity of work and some financial independence. When you consider that the disease kills more children

Figure 1. Dr. W. Eugene Knox III, chemist, studies the relation of metabolism to rheumatic fever.

Figure 2. These children are patients at the Municipal Contagious Disease Hospital, where much of the Institute's clinical work is done.

each year than almost all other diseases combined (five times as many as polio!) and that it is known to be vulnerable to treatment, such neglect is almost incomprehensible.

Actually the reasons for the by-passing of rheumatic fever as a research problem stemmed from several sources. For one thing, the disease is not contagious, nor are its crippling effects immediately obvious; consequently its public health importance has not been fully appreciated. Moreover, it occurs chiefly among the underprivileged. These factors, plus difficulties involved in rheumatic fever research and the lack of suitable facilities led to a shocking neglect of the disease—at least until the Institute stepped into the gap.

Just what is the Institute up against in its battle against rheumatic fever? What causes it and what is its nature? What has been accomplished in its prevention and cure? And last, but very definitely not least, what can be done to halt its yearly ravages on the youth of this and other countries?

Usually rheumatic fever follows a bout of tonsilitis, scarlet fever, inflammation of the ear or strep sore throat. All these ills are caused by an invasion of the body by what biologists call a Group A hemolytic streptococcus, a chainlike germ. Such bacteria do not cause rheumatic fever, however, unless an inflammation of the human upper respiratory tract has first occurred.

But except for these meager facts, rheumatic fever still remains a mysterious disease, baffling doctor and researcher alike. One of the strangest things about it is that most people recover beautifully from infections by the causative germs while in others rheumatic fever attacks the connective tissues of the body and causes inflammation of the muscle valves and outer lining of the heart. It is suspected that a peculiarity may already have existed in the body chemistry of these people; the findings of the clinics indicate that a combination of inherited tendencies, metabolism, diet and chemicals may determine the development and severity of the disease. But actually medical men are still pretty much in the dark about why certain people develop rheumatic fever, while others who have apparently harbored the same type of germs remain unscathed; neither do they know why the heart becomes so involved.

Figure 3. Dr. Edgar Todd, a well-known British scientist, who is working in immunology at the Institute.

There are numerous other "unknowns" in the rheumatic fever picture. There seems to be some undiscovered factor which gives certain Group A bacteria the ability to induce the disease while others are ineffective. And no one has yet found out why man fails to develop an immunity to hemolytic streptococcus or why one strain of these bacteria is so communicable while others are not. In fact the whole process of infection is very little understood—how the germs are transmitted, what persons may be "carriers", or why infections occur most frequently in the temperate zones during winter and spring months.

With all these unanswered questions confronting them, and little previous

Figure 4. The cold room, a sort of glorified ice box, for storing plasma and other items that need refrigeration.

Figure 5. One of the many laboratories of the Institute, where studies are being made in almost every branch of science that may throw light on the cause of rheumatic fever.

research to guide them, it was obvious that scientists of the Rheumatic Fever Research Institute had a big job on their hands. Just to organize the program of research along logical lines was a difficult task. This was accomplished, however, by Dr. Coburn, whose years of experience with the rheumatic fever problem gave him the necessary insight into the needs of the Institute.

As Dr. Coburn sees the rheumatic fever problem it may be arbitrarily divided into three parts: prevention, cure and suppression of inflammation. Naturally the best solution to the problem would be to keep people from ever acquiring the disease. Researchers feel that this may eventually be possible by treating people susceptible to rheumatic fever by modifying their diet or by immunizing them with various substances. Unfortunately information is lacking both on the essential dietary factor and on the appropriate immunizing agent. In Dr. Coburn's words, "We blindly test keys for a lock that we cannot see".

Next to preventing the disease entirely the best remedy would obviously be to find a cure for it. Unfortunately, according to Dr. Coburn, no rheumatic fever patient has ever been cured by man; this means that once the rheumatic process has started in the body doctors are helpless to treat the victim so that he will be immune to a future attack. Furthermore, no promising ideas have been forthcoming on the treatment of the disease because the basic causes of it are unknown.

So far, then, doctors have had to be content with the third item on Dr. Coburn's list—i.e., the suppression of rheumatic fever. This means that though the patient is not permanently freed of the disease some of its effects on his body can be counteracted. Two types of agents have been successful in accomplishing this—a class of chemicals known as salicylates and the famous wonder workers, ACTH and cortisone.

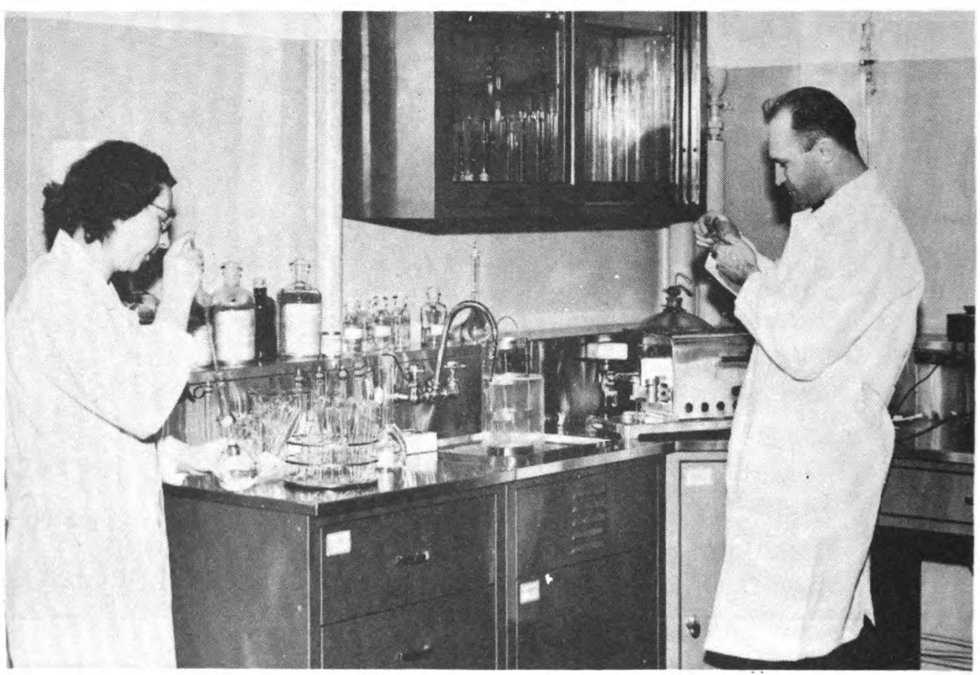


Figure 6. Here staff members are making some of the countless laboratory tests that are necessary in the battle against rheumatic disease.

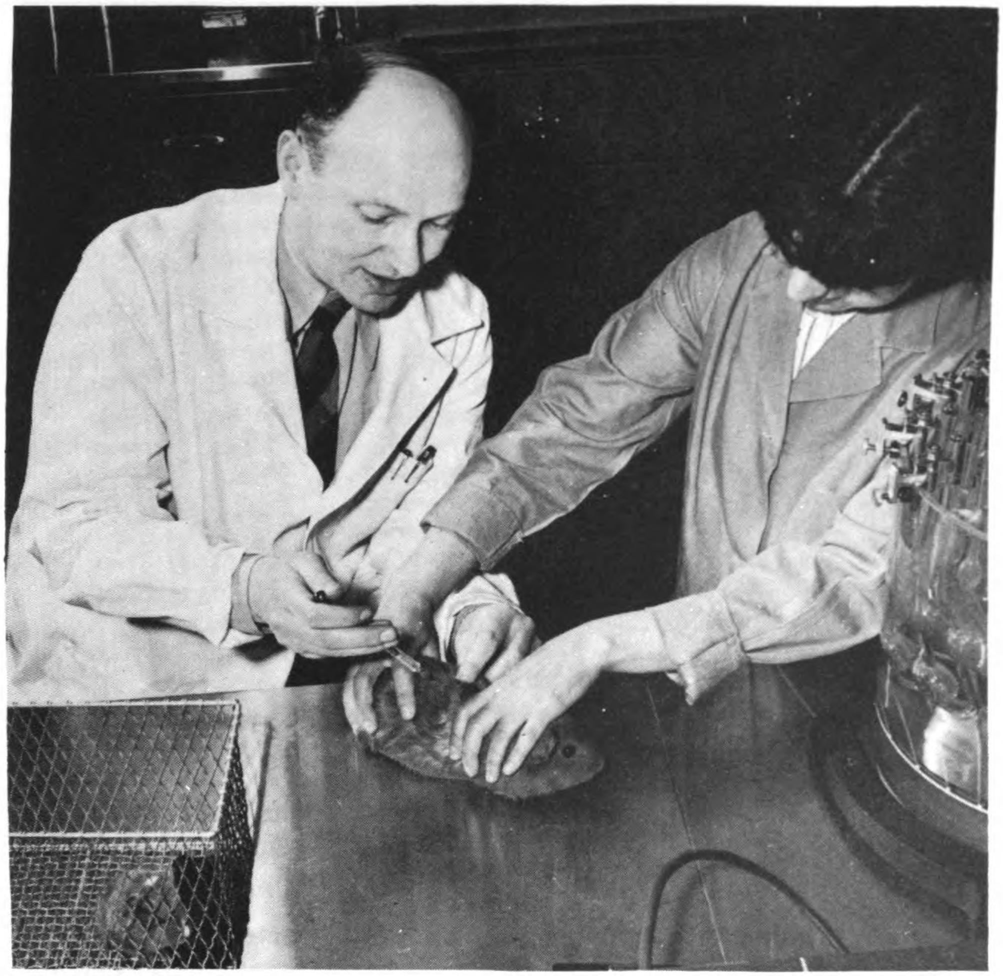


Figure 7. Dr. Georges Ungar, Head of the Institute's Physiology Unit, gives an injection to an experimental guinea pig.

Unfortunately both these types of agents must be used in large doses, and although they do suppress the inflammatory reaction to the rheumatic process they also produce many undesirable effects on the patients, some of which have not yet been fully evaluated. Consequently medical men are still looking for a safe, reliable suppressive agent with which to fight the effects of rheumatic fever.

Progress in all three phases of the struggle against rheumatic fever—prevention, cure and suppression—still awaits an explanation of the basic causes of the disease. At the Institute, long-range plans have been made to acquire fundamental knowledge on every phase of the problem which researchers feel can contribute to its ultimate solution.

Since no single lead has thus far given promise of such a solution many pieces of information from widely different investigations must be fitted together. Thus, the Rheumatic Fever Research Institute has divided its work into divisions embracing 8 laboratory units: bacteriology and immunology, experimental pathology and physiology, general biochemistry, enzyme chemistry, steroid chemistry, isotope chemistry, organic chemistry and physical chemistry. This does not mean that the Institute's ten principal investigators work separately, each

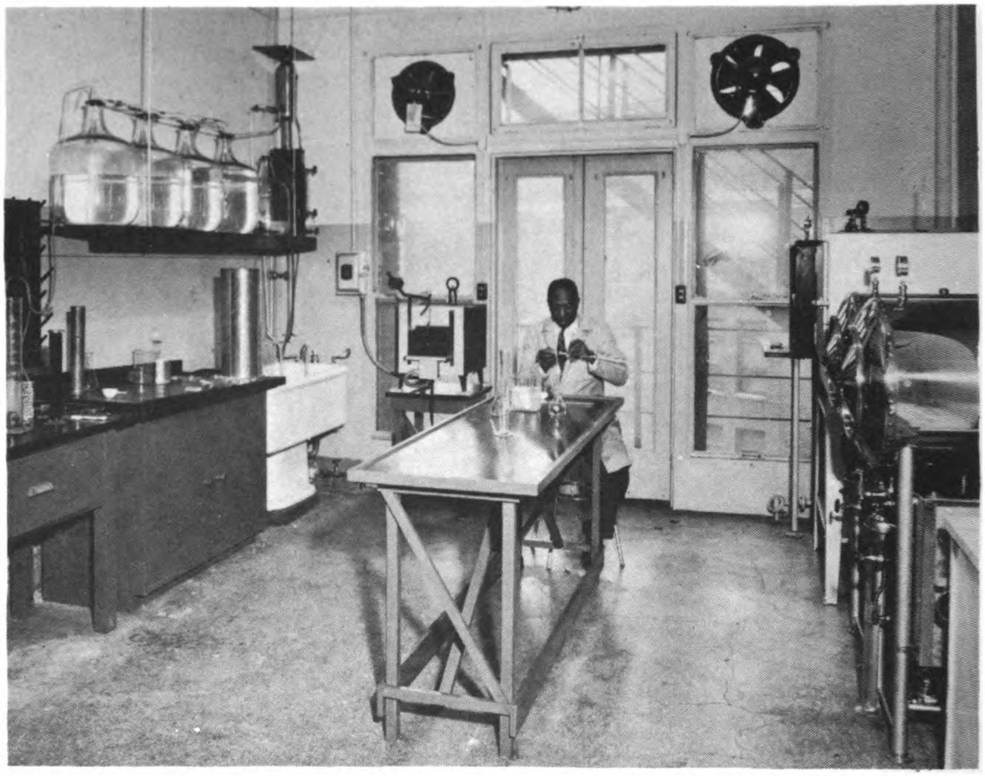


Figure 8. The Institute's Media Room—which might well be called a bacterial diet kitchen. Here cultures are prepared for growing specific bacteria which thrive only on certain kinds of food.

remaining secluded within his own niche. On the contrary, a biological problem can move into the laboratory of the physical or organic chemist and back to the biologist; such shifts are unpredictable, but free intermingling and teamwork are essential to solving a problem that is too big for any one man to conquer alone.

The description of the division of the Institute into "laboratory units" may give the false impression that it is an "ivory tower" sort of establishment, with its researchers working in "splendid isolation" from the world. Such an impression is completely false. There is no disease that requires more field work than rheumatic fever, for one of its peculiarities is that only human beings develop it. Thus, unlike cancer and many other diseases, it cannot be given to animals for the purpose of scientific study. As a result, laboratories must have clinics near at hand to permit the study of the disease in human patients. For this reason the Institute was established in an area of Chicago where family incomes are low and the incidence of rheumatic fever is high. Similarly advantageous is the direct association with the scarlet fever wards of the Contagious Disease Hospital, where some children, while recovering from scarlet fever, develop the first dreaded symptoms of rheumatic disease. To augment the clinical facilities immediately available to the Institute at this hospital, collaboration is in progress between the Institute and other hospitals and clinics in the Chicago area where rheumatic fever patients are treated.

Within this flexible framework, then, the work at the Institute is divided into two parts, one pertaining to the study of the bacteria that activate the disease and the other to the human being who is subject to the disease. While scientists in the laboratory study the biochemical change that occurs when the disease strikes, field studies are made to find out what factors in diet might correct an inherent susceptibility to the rheumatic process. As each problem is explored, others are raised. Each scientist in the Institute, pursuing problems in his field of specialization, uncovers new possibilities and stimulates his colleagues in other aspects of the inquiry. Workers at the Institute have high hopes that this amassing of knowledge will eventually snowball into a solution of the rheumatic fever problem, or at least into an understanding of the mechanism of the disease, which would eventually lead to its conquest.

At present the status of the rheumatic-fever problem seems comparable to that of diabetes before an understanding of the relation between abnormal urinary findings and pancreatic function led to the development of insulin treatment. In the same way, the discovery of a significant substance in the urine or blood of rheumatic-fever patients would indicate which of the body's many chemical systems is poisoned at the onset of the illness.

When science finally conquers rheumatic fever, Dr. Coburn believes the story of its conquest will read like a detective story in which no single clue was decisive, in which every lead had to be explored and the whole jig-saw puzzle of evidence assembled before the murderer could be apprehended. When that time comes, millions of people will have a chance for a more healthful, productive life and the Rheumatic Fever Research Institute will have performed its function in hastening the day.

* * *

Medicine and Basic Research

He who attempts to contribute to fundamental knowledge in medicine must do so through basic research. However, one may also accelerate the progress of medicine through applied research or through the care of the patient. The differences between these three functions: (a) the practice of art; (b) the application of knowledge resulting from basic research; (c) the discovery of fundamental principles, are apparently not generally understood.

Perhaps an illustration will bring clarification. The average housewife knows that she needs freshly ground coffee beans to prepare excellent breakfast coffee. She is an artist in the kitchen and cooks without knowledge of the principles underlying her task. In contrast, the biochemist knows that the bouquet from coffee is due to liberation of volatile oils by oxidative enzymes; he has worked out first principles and replaced empiricism with knowledge. This is basic research. Later, coffee manufacturers, utilizing the fundamental knowledge made available by the biochemist, devise means for packing coffee in oxygen-free, vacuum-sealed tins. The preservation of the appealing aroma is thereby assured; this has been accomplished by applied research.

In medicine, the physician practices an art; the clinical investigator collects observations on man through his ability to apply basic knowledge; the scientist...makes his contribution through basic research.

---Alvin F. Coburn, in a report to ONR

Dr. Randal Robertson

Who's Who in Naval Research

"My checkered career" is Dr. Randal Robertson's characteristically unassuming way of describing the varied achievements which have made him a top scientific administrator and ONR's new Scientific Director. Though it would be difficult to parcel out the credit for ONR's growth and success during the past five years, it is certain that a large share would have to go to Dr. Robertson. Probably he has had as much to do with the nationwide respect that the OFFICE now enjoys as any other single individual. Certainly his thoughts and ideas have become an integral part of the organization and his influence and guidance will become even more important in the immediate future.

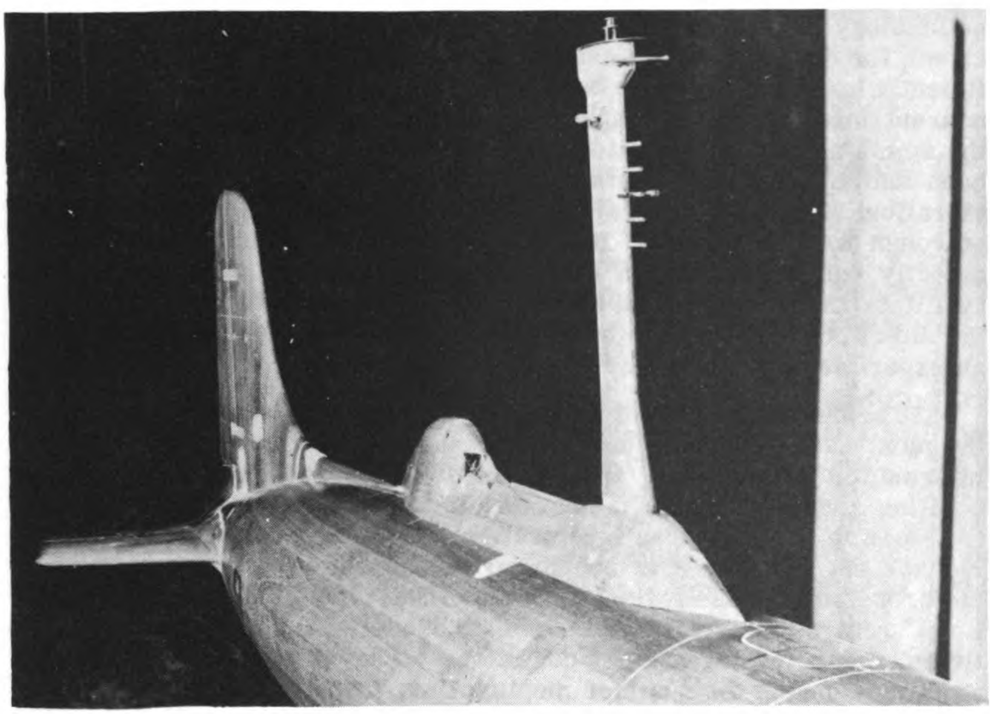
This, his colleagues feel, is all to the good, for they share not only a great respect for Dr. Robertson's abilities, but also a genuine personal liking for him. A tall, prematurely graying man, he gives an impression of dignity and seriousness which is considerably softened by his quick smile, his straightforward friendly manner, and his ability to express his thoughts fluently and clearly. His non-professional activities reflect this outgoing personality, for he is a member of the Appalachian Mountain Club, the American Forestry Association and the Massachusetts Horticultural Association (though he claims most of his exercise lately has "boiled down to a little gardening"). In addition he is a member of the Vestry of the Falls Church and is active in PTA affairs in Arlington County.

Dr. Robertson's unusual versatility has given him a unique understanding of the problems of research and of administration. For ten years after receiving his Ph.D. in Physics from MIT he did not have anything remotely resembling a "desk job". A year of post-doctoral work on molecular beams at Columbia under Nobel Prize Winner Rabi was followed by five years of research with the Norton Co. in Worcester, Mass. Dr. Robertson found his work there (concerned with studying the properties of abrasives) extremely absorbing, but he soon became more absorbed, along with the rest of the country, in contributing something toward winning the war. In Dr. Robertson's case the contribution turned out to be a vital one; he was in charge of the development of precision antennas for a microwave radar system which was eventually used in the night bombing of Japan. This research, which was conducted at the Radiation Laboratory, MIT, under OSRD, often took Dr. Robertson far afield from the seclusion of a laboratory; he now rather proudly displays a photograph of a plane carrying a strange-looking antenna, of which he says, "I lay on the concrete floor of the hangar and attached it myself!"

After the war Dr. Robertson had the opportunity to return to his own research, but he elected instead to join ONR's predecessor, the Office of Research and Inventions, as Head of the Mechanics and Materials Branch. "It was necessary to make a choice", as Dr. Robertson puts it, "as to where I could make the greatest contribution. I felt the work of this new organization was extremely important." ONR had reason to be happy with Dr. Robertson's decision, for he eventually became Director of the Physical Sciences Division and later Deputy for Natural Sciences. In the latter position he has had broad responsibility for the program of contract research in physical, mathematical, earth, and material sciences.

Dr. Robertson feels that it is vital for the men in the laboratories and those who are directing ONR's contract research program to comprehend each other's viewpoints and to work together harmoniously toward their common goals. This is an objective that seems likely to be fulfilled as long as scientific administrators of Dr. Robertson's calibre are working for it.

NRL Develops Apparatus for Measuring Rain Drop Size



The strange-looking appendage attached to the scale model of the plane shown above is called a "disdrometer" and is designed to measure the size of raindrops from an aircraft in flight. The mechanism functions by measuring the momentum of the raindrops through which the aircraft is flying.

Scientists expect the disdrometer to be useful in calculating how a rainstorm affects radar operation and possibly in weather research.

The Aerologist Puts An Ear to the Ground

by

Erwin Kammer and J. E. Dinger
Naval Research Laboratory

One of the problems confronting aerologists is the composition of up-to-date and comprehensive weather maps for ocean areas. This task is difficult because there are so few observing stations on the oceans which report meteorological data on a systematic basis. During peacetime, ships and aircraft plying the normal trade routes supply some information during transit, but the oceans are so vast in area that this coverage is far from comprehensive. Moreover, radio reports from these sources are, of course, unavailable in wartime. Yet the importance of knowing weather conditions at sea is very great, both for naval operations and shore activities. Little wonder, then, that the aerologist is eager to try any suggestion which might add to the small stock of meteorological information he now receives from the sea.

One such suggestion has carried the aerologist into the field of seismology. It was suggested that large intense storms at sea—hurricanes, for example—might cause in the ocean bottom vibrations of sufficiently large amplitude to be detected by seismographs located on the nearest land areas. Perhaps these vibrations could be identified with the small, persistent vibrations termed "microseisms" which have long been known to seismologists as a seemingly useless nuisance. These vibrations seemed in general to increase in amplitude with the existence of rough weather at sea. It was thought that they might travel from directly beneath the storm center to distant shores. If so, they would facilitate the detection and location of the larger storm areas without the aid of conventional meteorological data. The possibility was worth an experimental field test.

The hurricane type of storm was selected, for several reasons, as the most satisfactory to use as a test for this hypothesis. Accurate information is available, from systematic air reconnaissance, on the position and character of such storms. Thus, the results obtained by the seismic technique can be objectively evaluated. Furthermore, hurricanes occur in the Caribbean during the summer months when the "microseismic noise level" is lowest. The term "microseismic noise level" refers to the fact that some microseisms are detectable at all times, regardless of weather conditions. They are, however, of lower amplitude during the summer months; thus, those created as a result of a storm are more apparent. It is a situation analogous to listening to a speaker on the radio. He will be heard much better in a quiet room than in one where a number of people are talking.

Erwin W. Kammer received his Ph.D. in applied physics from Iowa State College and has been a physicist in the Aerology Branch of NRL's Mechanics Division since 1943.

J. E. Dinger, who also received a doctorate in applied physics from Iowa State College, is Head of the Aerology Branch.

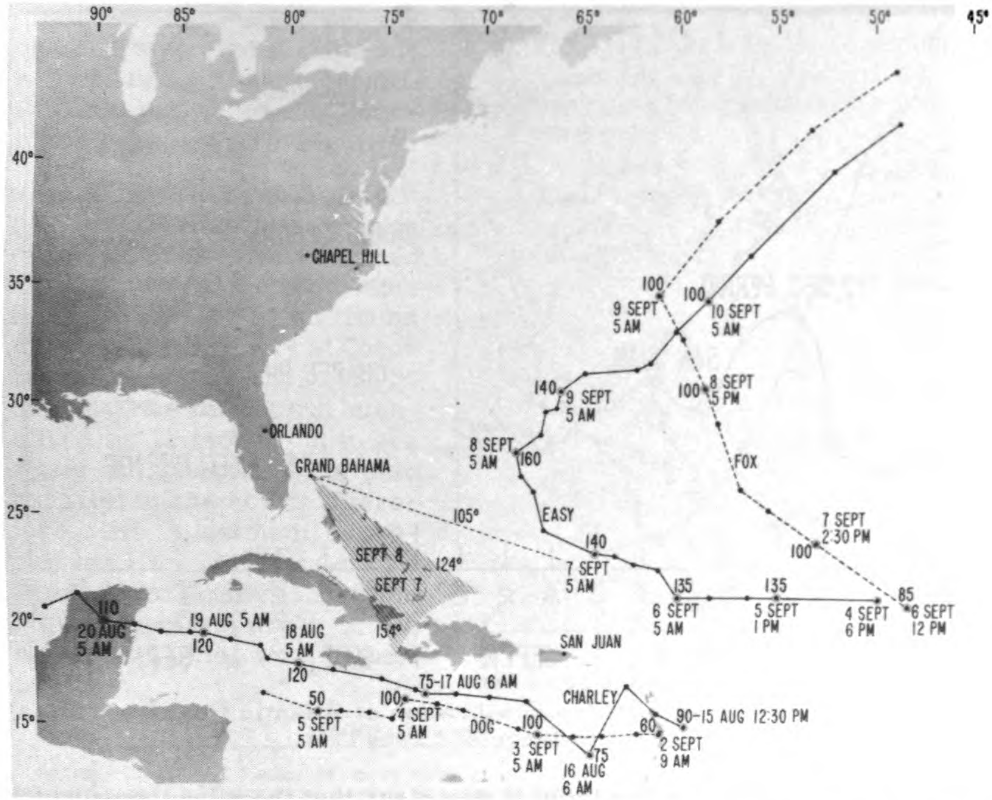


Figure 1. The hurricane situation for the first week in September 1951.

Under such low-noise-level conditions a greater likelihood exists for a clear-cut test situation with a single storm over the ocean.

Consequently the seismograph station sites indicated in Figure 1 were selected. The apparatus at Grand Bahama was so devised that the direction of travel could be determined for any vibrations existing during the presence of a hurricane over the ocean to the east.

A typical test situation is summarized in Figure 1 for the first week in September 1951. The storm "Charley" had expended itself over Mexico and "Dog" was disintegrating in the Western Caribbean. "Easy" and "Fox" were approaching from the east. Hurricane "Easy", in particular, furnished an ideal test subject for the Grand Bahama Station. During the time of closest approach to Grand Bahama its center was about 600 miles away. It was above average in intensity, with the lowest pressure about 950 millibars; central winds reached 160 mph and 75-mph winds extended 100 miles out from the center.

Seismic vibrations did not increase in amplitude significantly above the noise level until late afternoon on September 7. These vibrations were arriving from a southeasterly direction (the shaded sector in Figure 1). At no time during the two days of closest approach to Grand Bahama did the direction determinations lie outside this sector. A bearing of about 145° was emphasized more than any other, whereas the nearest bearing to the storm center was about 105°. In other words, the seismic vibrations were not coming from the center of the storm but from considerably southwest of it, along the Bahama Island chain.

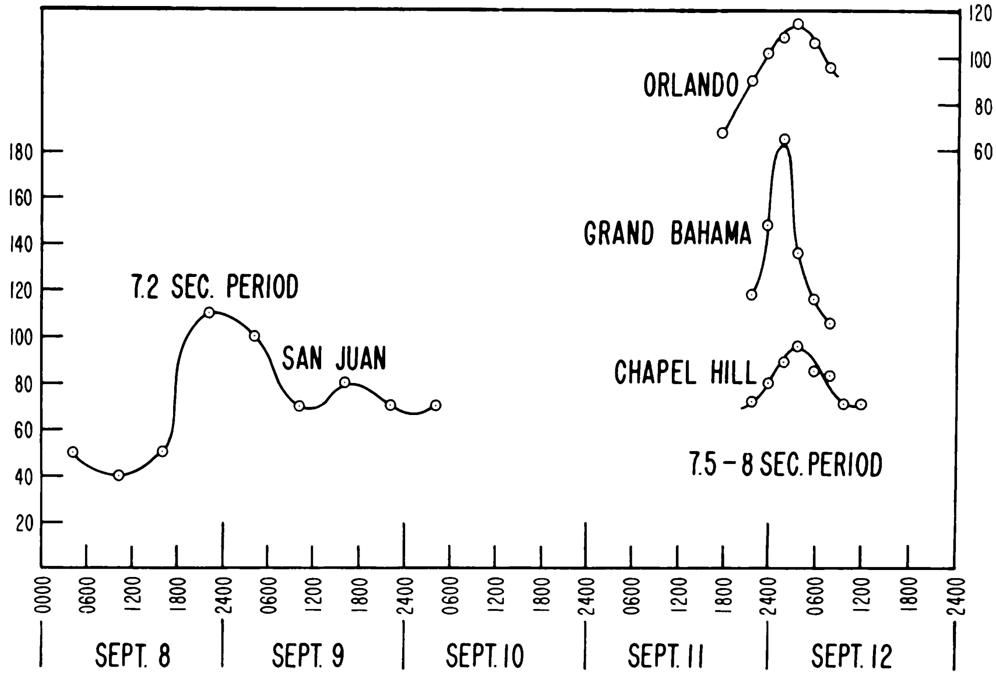


Figure 2. Average amplitudes of vibration at Atlantic Coast stations after passage of "Easy".

From this and similar tests it was clear that the vibrations which exist during the critical time when a storm is approaching from the sea provide no relevant information for early warning or location purposes. Disappointing as these facts were, there still remained the intriguing question: Where do these vibrations come from?

The answer is suggested in Figure 2, which shows plots of the average amplitudes of vibration at the various stations along the Atlantic Coast after the passage of Hurricane "Easy". These graphs have been adjusted on the ordinate scale to avoid overlap. The important data they show are the times during which signals of indicated periods existed with sufficient amplitude to be recognizable above the noise level. It is seen that a signal of 7.2-sec period arrived at the San Juan Coast and Geodetic Survey Seismograph Station about midnight September 8. The storm, however, was actually closest to San Juan early on the morning of the seventh; thus, a lapse of about a day and a half exists between the time the signal was at a maximum and the time the storm was the closest. The signals at Grand Bahama, Orlando, and Chapel Hill indicate a maximum during early morning on the twelfth. But the storm was closest to these stations during the morning of the eighth—a lapse of about four days. Furthermore, the period is slightly longer than at San Juan, averaging a little less than eight seconds per cycle. These time lapses and period changes would be expected if the vibrations (microseisms) were generated close to shore by the swell radiating from the storm. The distances traveled in the time intervals indicated are consistent with the rate at which energy is being transported by these waves.

Additional confirmation of this interpretation was available from the Hurricane "How", whose path is shown in Figure 3. Two wave gages installed at PAFB on the eastern shore of Florida and a seismograph at USRL Orlando provided the information displayed in Figure 4.

From Curves B and C it can be seen that the amplitude of the microseisms reached a maximum at Orlando some time after the maximum water wave activity at Cocoa Beach. This was to be expected as this storm intensified as it moved out to sea along a northeastward path parallel to the coast. Therefore, the maximum microseisms as recorded at Orlando probably came from highly excited areas to the north of the wave gage position.

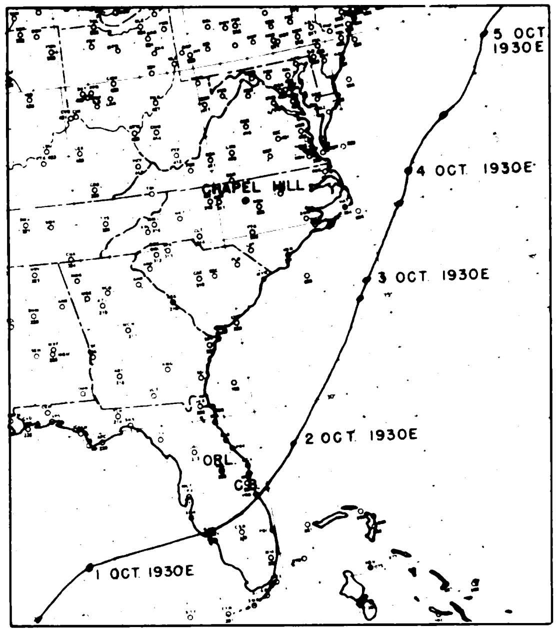


Figure 3. Path of "How".

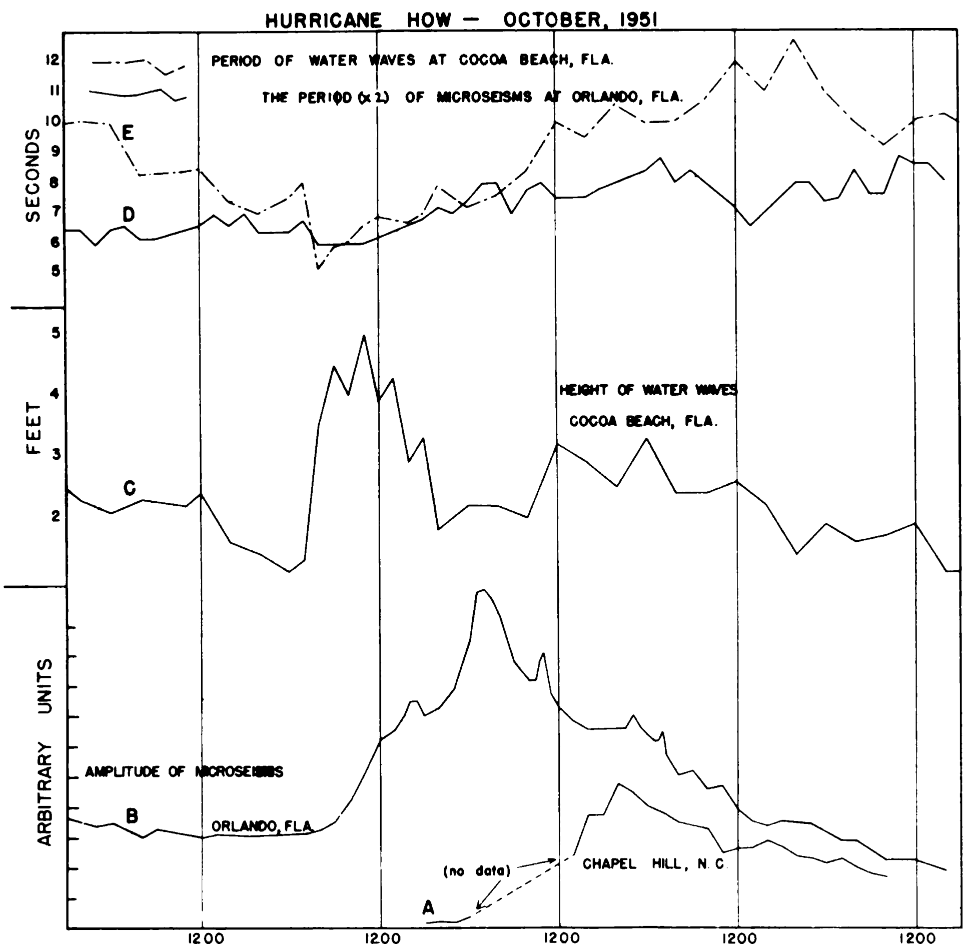


Figure 4. Correlation between microseismic and water wave activity.

The correlation between the water-wave periods and ground-vibration periods is even more striking. During the interval of maximum water-wave activity, the water-wave period is double the microseismic period. When stationary patterns are set up by reflection of the swell from a coast, the resulting synchronous forces on the ocean bottom beneath these wave patterns have a period 1/2 that of the swell. Thus, microseisms could be excited whenever storms are able to set up coherent stationary or standing wave patterns in the water. This condition apparently can be achieved by reflections of the waves from a shore. The fact that this vibration source is so remotely related to the storm in both time and space means that little more information about a distant weather disturbance at sea can be derived from microseisms than could be gleaned from direct observations of ocean swell emanating from that storm.

The aerologist, then, is faced with the discovery that putting his ear to the ground has enabled him to hear, not the wind as he had hoped, but only the waves. Reluctantly he relinquishes the seismograph to the oceanographer, for whom it can provide valuable information about ocean waves under conditions similar to those described above. The prospects are bright for applications of the seismograph in this field, for it has two advantages over the wave gage. First, it is considerably less expensive to install and maintain than the latter instrument; second, it can sense signals arriving from any point on the compass, whereas the wave gage can detect activity only on the shore in which it is submerged. Actually, since seismographs have been accumulating records in all parts of the world for many years, there is no doubt that seismological observatory files already contain much interesting data which the oceanographer can now interpret systematically.

Project "SNEEZE"

A World War II project, held under high security classification until recently, has been declassified and can now be described. This was the "gesundheit mine", developed for the Navy during the Battle of the Atlantic but never put to operational use.

It is well known that we, as well as our enemies, had proximity mines—usually acoustic or magnetic—which would detonate without actually being struck by the ship. The chief shortcoming of these weapons was that they were non-discriminating; they were just as effective against friendly ships as those of the enemy. Project "SNEEZE" was an ingenious attempt to make the mines more choosy.

The mine was moored, set to float about twelve feet beneath the surface. When a ship approached within attack range a proximity device released the mine, allowing it to rise to the surface. A small projectile launcher, mounted on the top of the mine and trained by magnetic attraction of the ship, would then fire a canister missile onto the deck of the ship. The canister was loaded with red pepper.

A sensitive microphone pickup on the mine did the rest. If a crew member on the ship said "Gesundheit" the mine would explode; if he merely said "God Bless You" the mine would remain unarmed.

On the Naval Research Reserve

VNRRU Members at University of Nebraska Receive Recognition for Research Work

Two publications issued recently by the University of Nebraska show the prominent part that members of VNRRU 9-22 are playing in the research activities of the institution.

In one publication, Research Report, the unit's commanding officer, LCDR L. W. Hurlbut (Chairman of the University's Department of Agricultural Engineering) is credited with important work in developing a new method for preserving stored grain, a problem that has proved costly to farmers the world over. The bumper grain crops of recent years have increased such difficulties but the new method of storage promises to save the waste caused by spoilage and insects. Since moisture is the principal cause of the trouble, a cheap, efficient drying system was needed that would not harm the grain. Such a system has now been developed which will allow ordinary air to be blown through the grain. It will be possible for most farmers to install the necessary blower and duct system for less than $400.

In the same issue of Research Report the work of LTJG James Heotis, an advanced student, is mentioned in connection with work on enzymes—the mysterious catalysts of life processes.

Another publication, "Bulletin Board," announces the appointment of LT W. G. Leavitt, LTJG R. G. Lomasson and LTJG J. H. Looker to faculty research fellowships for the summer of 1952. All three are faculty members at the University.

SDC Seminar Plans Announced

The annual seminar at ONR's Special Devices Center is scheduled this year for April 20 to May 3. VNRR officers may be ordered to this 14-day seminar at Sands Point for training within the following quotas:

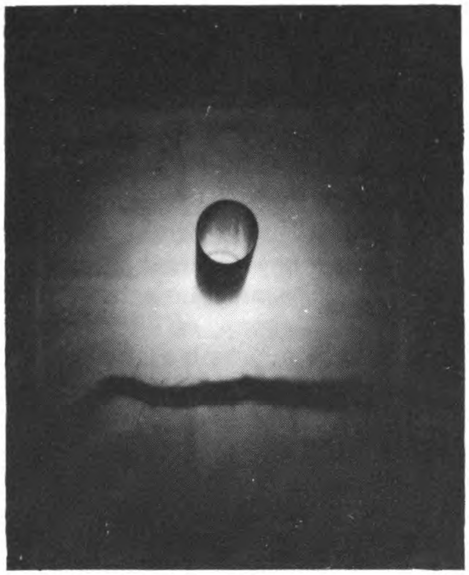
Naval District	Quota
1	7
3	10
4	6
5	2
6	10
8	3
9	6
11	1
12	1
13	1
PRNC	3
Total	50

Officers ordered to this seminar from the 11th, 12th, and 13th Naval Districts will be required to travel by government air or at their own expense.

Cooking With Hot Atoms

by

Robert V. Horrigan
Brookhaven National Laboratory



Apparatus containing a 1,000-curie source of cobalt 60 under 10 feet of water. The only light used for this time exposure was that emitted by water fluorescing under the influence of gamma radiation.

Before World War II, the world's entire supply of the naturally occurring radioactive element, radium, was estimated to be about one thousand grams. Because of its scarcity and astronomical cost ($18,000 per gram), hospitals and research centers were the only places where significant amounts were used.

The therapeutic value of radium lies in the penetrating gamma radiation which the element and its decay chain constantly emit. The unit of measure of this and similar radiation is the curie, which is equivalent to 3.7×10^{10} d/sec, the number of nuclear disintegrations occurring per second in a gram of pure radium. Thus, before the advent of atomic reactors, only about 1,000 curies of radioactivity were available in the entire world.

Today, only ten years from the start of World War II, uncounted millions of curies of radioactive materials are piling up in huge underground storage tanks. Such materials are fission products formed when uranium 235 splits apart in an atomic reactor. When the spent fuel is chemically processed to recover plutonium, the unreacted uranium and the fission products are left behind. The unreacted uranium can be reprocessed for further use, but to date, no use has been made of the fission products. Since these highly radioactive materials cannot be disposed of in usual ways, they are now being stored in special expensive underground tanks (above). If the Atomic Energy Commission can sell these radioactive wastes to industry after suitable concentration, separation and packaging, it will have turned a great liability into an asset, and added greatly to the public benefits from its program.

To implement this idea, the Atomic Energy Commission recently commissioned the Stanford Research Institute of Palo Alto, California,

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to make an industry-wide survey of the possibilities of utilizing fission products in large quantities in manufacturing processes. The survey showed that a potential market for millions of curies of radioactive fission products exists if certain technical difficulties can be overcome and a low price per curie can be established.

This technician is remotely lowering a plug and sample canister into a lead "pig" containing a 1,000-curie cobalt radiation source. Note reading on radiation instrument at right.

At Brookhaven National Laboratory a program of application research on fission products has been underway for the past year. One phase of the project is the development of processes for concentrating the fission product "soup" to dryness, and packaging the resulting radioactive salts. This work is still on a laboratory scale, but is scheduled for pilot plant expansion in 1952 and 1953. Another phase of the project involves making thousand-curie radioactive sources by irradiating tubes of cobalt and tantalum metal in the Brookhaven atomic reactor. Such sources, which closely simulate those to be made in the future from fission products, are being used in four ways:

1. At Brookhaven in investigations into applications of the radiation.

2. At Brookhaven in services performed for organizations interested in determining radiation effects on various materials.

3. At the laboratories of various AEC contractors where research on specific problems will be carried out.

4. At the laboratories and plants of qualified industrial organizations interested in pilot plant-scale research, using a simulated fission product source.

Since few industrial concerns have the know-how to manipulate and handle highly radioactive sources safely, Brookhaven is working cooperatively with the research and development departments of many companies. There are now two aspects of Brookhaven's participation in industrial application of high-level gamma radiation:

1. Immediate development of uses, which previous research with X-rays and cathode rays have shown to be practicable, useful, and economically attractive to the industries concerned.

2. A search for new uses for intense gamma radiation. This is aside from the service in which the company requests an irradiation, and then analyzes the results in its own laboratories.

An example of the work described in (1) above is the cold sterilization of heat-sensitive drugs and pharmaceuticals. This utilization of intense gamma irradiation is undergoing active development at Brookhaven in cooperation with drug houses that want to build such sterilization facilities at their plants as soon as possible. The economics of the drug business is such that the cost of a source produced by pile irradiation is not prohibitive. Consequently, development in this particular field need not await production of the cheaper fission product sources. Another application now being developed elsewhere is the use of multicurie radioisotope sources in industrial radiography.

Some possible uses require further research before ultimate application. These include cold sterilization or pasteurization of packaged foods, the initiation of the polymerization of plastic monomers, and the improvement of flame propagation characteristics in internal combustion and jet engines. Although it is well-known that penetrating gamma radiation will readily sterilize or pasteurize the contents of meat or other food, the problems of changes in texture, flavor, and color must be examined in detail. An added deterrent is the fact that the food industries could afford to use this new method of sterilization only if the cost per curie of the radioactive source were quite low (20 cents to two dollars per curie).

Promising results are being obtained at Brookhaven using kilocurie sources of gamma radiation to initiate polymerization in a wide variety of pure plastic monomers in the absence of heat, pressure, or catalysts. There is an excellent chance that the dielectric properties and stability of a plastic polymerized in this way may be much improved, because there are no extraneous chemical agents present, such as catalysts or initiators. In addition, many monomers or copolymers which are difficult to polymerize by conventional methods, may be induced to polymerize more readily, thus opening the way for new plastics with new and improved properties. For this reason many manufacturers of plastics and plastic monomers have been invited to cooperate in Brookhaven's program.

It is expected that this entire program at Brookhaven will reveal worthwhile applications for the radioactive fission products which are a by-product of all atomic reactors. If such uses can be widely applied in industry, our technology will benefit, and the Atomic Energy Commission's radioactive waste problem will be ameliorated.

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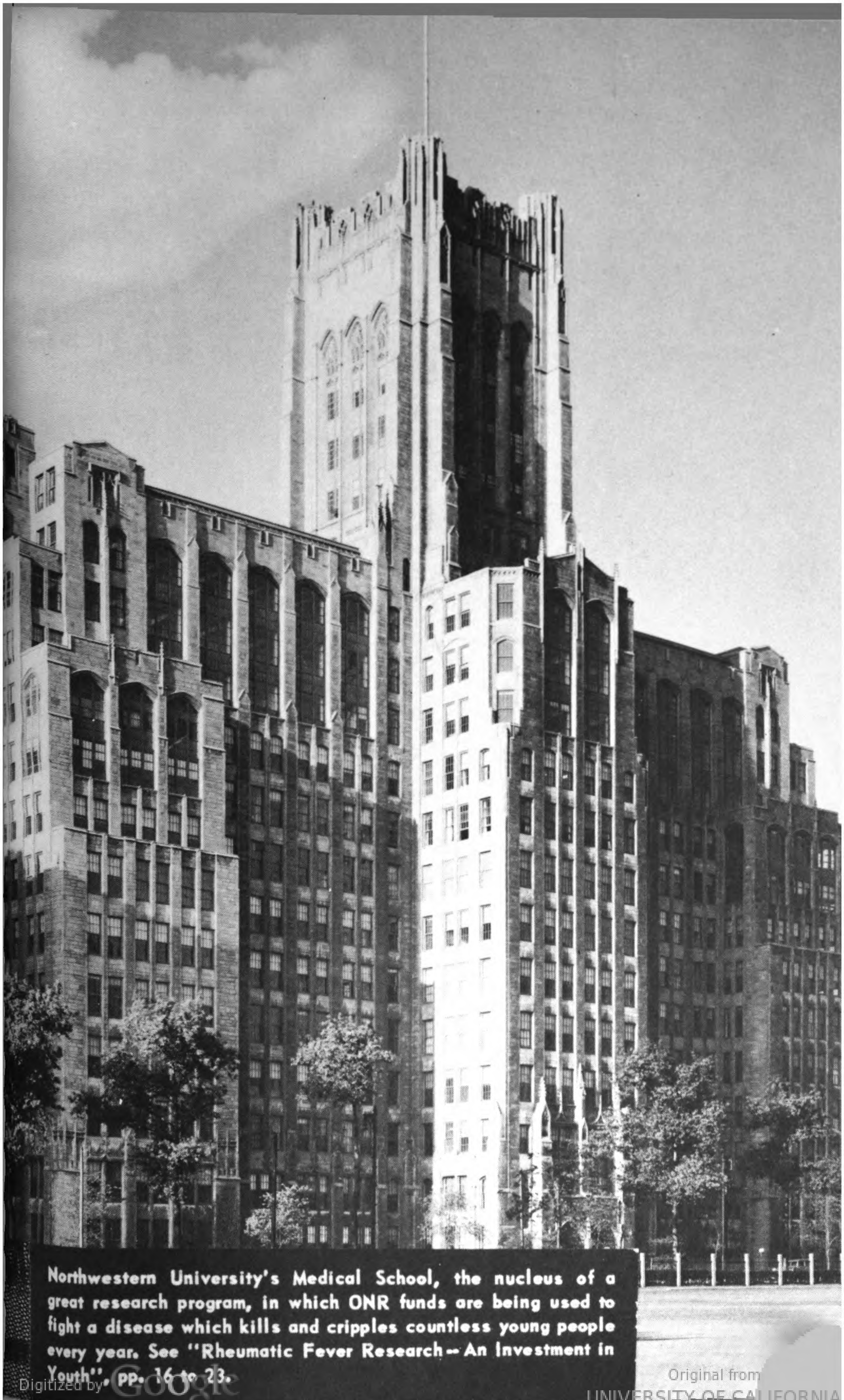
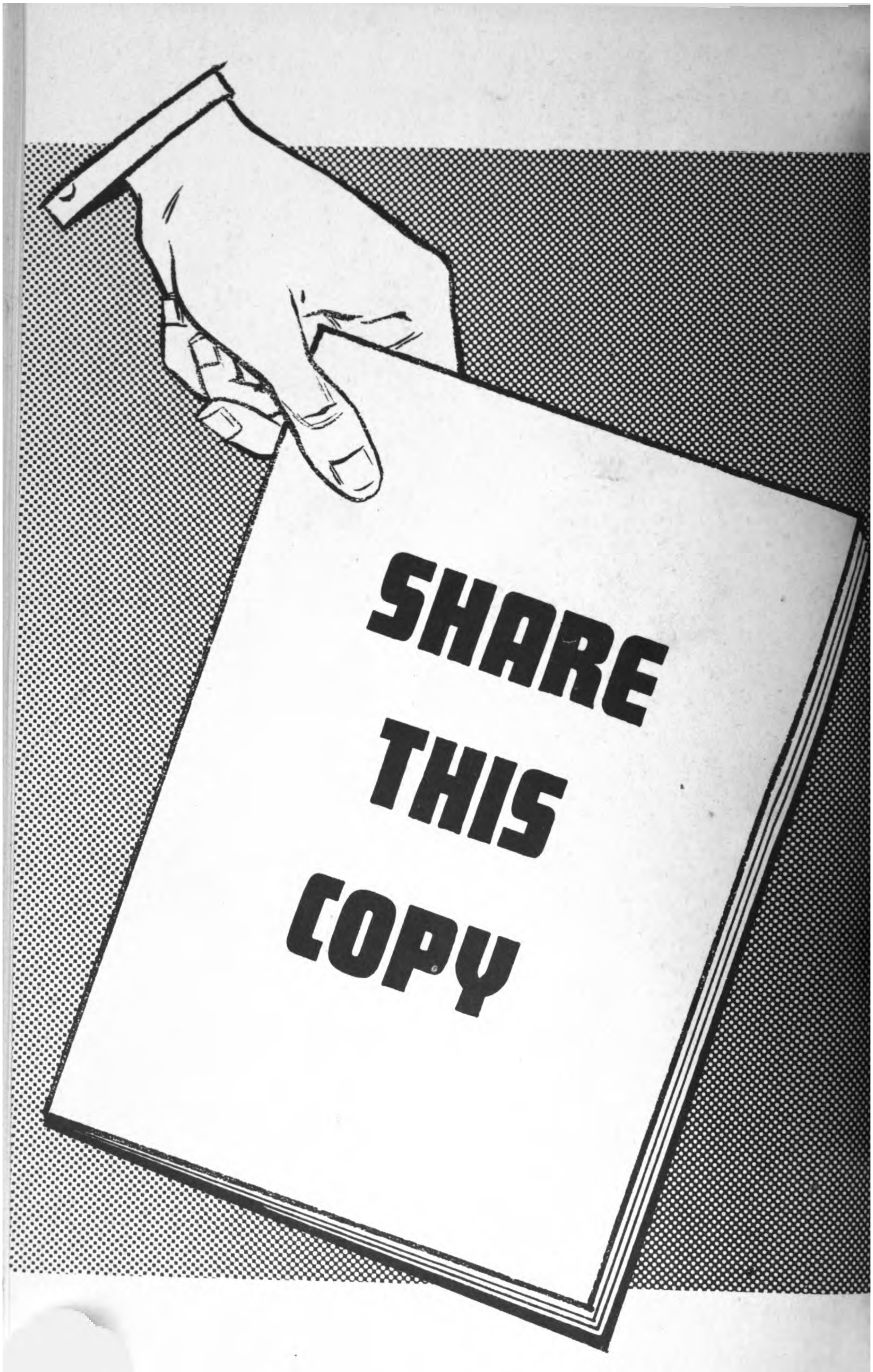


Northwestern University's Medical School, the nucleus of a great research program, in which ONR funds are being used to fight a disease which kills and cripples countless young people every year. See "Rheumatic Fever Research—An Investment in Youth", pp. 16 to 23.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