OFFICE OF NAVAL RESEARCH JUNE 1957

RESEARCH REVIEWS

DEPARTMENT OF THE NAVY

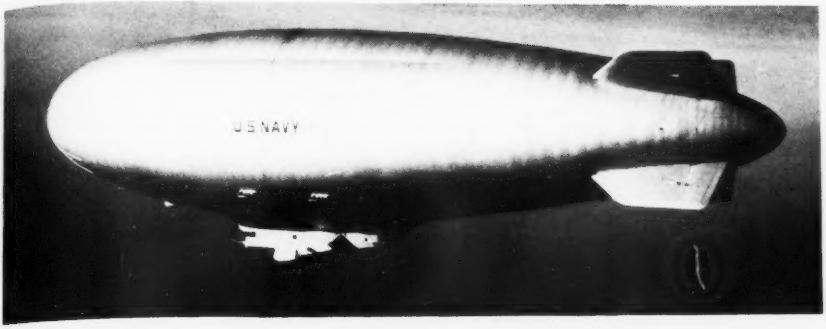
WASHINGTON, D. C.

NAVEXOS P-510

CDR Jack R. Hunt (center) briefs Snow Bird's crew on flight plan.

FINAL PREPARATIONS FOR RECORD-BREAKING FLIGHT

Airmen load supplies in Snow Bird's car.



The Flight of the Snow Bird

"I have the watch. The C.O.'s in the pilot's seat, Fitz in co-pilot's seat. I'm in jump-seat. Uneventful. A little rough weather, but no difficulty. I imagine we're all thinking about the long flight and how small a beginning we've made. . . ."

These words were written by CDR Jack R. Hunt early on the morning of March 5, 1956, about 8 hours after he and 13 other airmen took off from South Weymouth, Mass., in the Snow Bird, a ZPG-2, the Navy's newest and largest non-rigid airship. The Snow Bird's flight plan called for her to cruise across the Atlantic to the Azores and return without stopping or refueling. The purpose of the trip was to determine whether so long a flight was practical for this type of airship and to evaluate its all-weather capability.

The C.O. referred to in the passage above was CDR Ronald W. Hoel, Commanding Officer of the Naval Air Development Unit (NADU), which had been given the job of testing the airship. "Fitz" was LT John R. Fitzpatrick, a flight engineer. CDR Hunt, who described these early hours of the flight, was the airship's commander and a veteran of 13 years of airship piloting. Other crew members included 2 pilot-navigators, a second flight engineer, 2 radio-radar men; 2 mechanics-riggers; 1 aerologist; 1 rigger; and 1 electrician. All were members of NADU except the second flight engineer, who represented the airship's builder—the Goodyear Aircraft Company.

In a sense, they had, as CDR Hunt had written, made but a small beginning. They had passed only 8 hours of a total of 264 that would elapse before the trip would end. But in another sense, the flight marked the end of their work—the culmination of years of testing necessary to prove that the ship could handle the job it was being groomed for—all-weather sentry duty at sea.

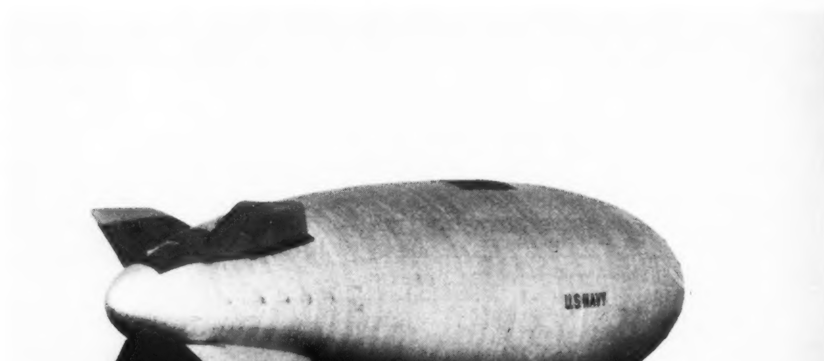
"First breakfast. Tomato juice, cereal, bacon, and eggs. Been making 70 knots for last three hours. Altitude, 700 feet."

The Snow Bird was now more than 600 miles at sea and bucking a storm. "Snow. . . .slightly rough," the log reads. But apetites were good, and no one gave the weather a second thought, except as it might affect their speed. The crew's confidence stemmed from its knowledge

Crewmen and ground handlers unmast the Snow Bird just before take-off.

DEPARTURE

The airship begins her 264-hour flight.



of the ship's performance in many other storms. In particular, it remembered the flight she made in severe weather over the North Atlantic in December 1955 under the command of LCDR Charles A. Mills, Jr. NADU had flown the ship into the storm to find out how she would function when ice formed on her. It found out, all right, for before the flight was over the ship's envelope and car were jacketed by about 4,000 pounds of ice. The ice formed a glaze over the cabin windows that almost completely obstructed vision, it gathered in ridges as much as 1-1/2 inches high on the radar antennas and the control cables, and it stuck to the propellers. Owing to the heavy accumulation, the instrument panel vibrated so violently it appeared as if it would be wrenched from its mountings. As the ship descended, ice peeling from the envelope whirled through the air around her. Nevertheless, the crew kept the ship in normal operation and made a ground-controlled approach to a successful landing. For his skillful piloting, LCDR Mills was awarded the Harmon trophy.

The ZPG-2-type airship had been turned over to NADU for testing in July 1954. During the winters of 1954-55 and 1955-56, the Unit conducted 8 other ice-accretion tests on the airship. To determine how much ice she was taking on, accretion meters, mass meters, and 14 movie cameras were installed at various locations on the airship, and a closed-circuit television camera was mounted on the ship's top. When the tests were completed and the information recorded by these instruments had been studied, NADU recommended that several measures be taken to prevent objectionable ice accumulation. In response, Goodyear Aircraft Company made the necessary modifications. For example, it installed electrically-heated propellers, mounted the radar antennas flush to the envelope, and placed covers on the control cables.

"ZW-1 and ZP-3[1] send 'Good luck and bon voyage.' Warned of approaching turbulence by WV-2.[2] Altitude, 900 feet. Valved helium for 20 seconds. . . ." The Snow Bird had been flying eastward for about 24 hours and was now about two-thirds of the way to the Azores. Except for the fact that the controls had not functioned properly on take off (they were quickly put in order) and that "Chuck Eadie[3] smashed his bunk" (the "C.O., Locklear,[4] and I[5] took an hour to fix it"), all was going well and the flight proceeding according to plan.

That the Snow Bird was living up to expectations is not surprising when one considers how thoroughly she had been checked out. The flight had been planned only 5 months earlier, yet in the time that had elapsed since then she had been put through two rigorous tests and had been made ready for a third. The test program, which these 3 phases constitute, was conceived at a conference held at South Weymouth last October and was sponsored by the Office of Naval Research. Sitting down together at that meeting were representatives of the Chief of Naval Operations, the Bureau of Aeronautics, the Chief of Naval Research,

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[1] Airship Early Warning Squadron 1 and Airship Patrol Squadron 3.
[2] A Super Constellation flying ahead of the Snow Bird with mooring mast and other equipment that might be needed in the event of an emergency.
[3] LT Charles J. Eadie, pilot-navigator.
[4] George A. Locklear, AN2, rigger.
[5] CDR Jack R. Hunt, the Snow Bird's commander.

the National Advisory Committee for Aeronautics (NACA), Goodyear Aircraft Company, Naval Airship Early Warning Squadron 1 and Airship Patrol Squadron 3, and Commander, Fleet Airship Wing 1. Phase 1 of the program was to consist of further ice-accretion tests; phase 2, of a 10-day on-station patrol operation; and phase 3, of the flight the Snow Bird was now making.

Phase 1 of the project was completed during the winter of 1956-57. Sixteen flights, each of 30 hours duration, were made over the North Atlantic Ocean. The flights were made during the worst weather that occurred during the test period. Snow, sleet, freezing rain, high winds, and blinding fog were encountered.

From January 15th to 25th, NADU, flying from South Weymouth, and Airship Early Warning Squadron 1, flying from Lakehurst, N. J., carried out phase 2 of the program. The purpose of this exercise was to determine the feasibility of maintaining a simulated patrol station continuously for 10 days over the North Atlantic Ocean 200 miles from the coast. Five airships participated, those from each squadron flying over the area during alternate 24-hour periods. Again the blimps were pitted against fog, rain, sleet, freezing rain, snow, and high winds (as high as 60 knots)—the worst weather experienced in the North Atlantic in 75 years. They were forced to land under cloud ceilings as low as 200 feet and while visibility was only 3/16 of a mile, and to take off under cloud ceilings as low as 100 feet. At South Weymouth, all ground maintenance on the airships was performed in below-freezing temperatures and several times while temperatures were below zero and during snowstorms.

"Lights below. . . .freighter. Radar shows no land. . . .good. . . . there are peaks in the Azores."

It was now early morning, March 6th, and the Snow Bird was well into its second day of continual flight and about one-fifth of the way through phase 3 of the test program. They had been making good speed—"63 knots all night"—and were a few hours ahead of the time schedule they had calculated for the trip across the Atlantic. According to this schedule, which was based on more than 80 dry-runs made during the months preceding their departure, they would be in the air 67-1/2 hours before reaching Europe. Whether or not they would actually go all the way to Europe before turning southward toward latitudes in which the easterly trade winds blow (they were counting on these to help push the airship back home) would depend on the strength of the winds they would have to buck to reach them. Although the wind was now blowing to the northeast, it was more of a tail wind than a cross wind and, therefore, was pushing them right along. But if they turned southward at this time, they would meet it almost head on. If, on the other hand, they continued to the coast of Europe where they knew the headwind they would meet upon turning southward was weaker, they would make better time on the southward journey, but would be going far out of their way. Such comments as "Awaiting weather reports from Fleet Weather Central,"[6] and

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[6] This unit, located in Washington, D. C., was the Snow Bird's chief source of weather information during the flight. The special reports it prepared for the Snow Bird's crew were based on all weather data that could be obtained and included recommendations on the best way for the Snow Bird to proceed. They were radioed to the airship twice daily.

"WV-2 to get better information," which were written into the log that morning, reflect the concern the crew was now feeling for the problem.

"Bad weather report," CDR Hunt wrote that evening. "If we make for Portugal, we get headwind. Decided to head due south from 42°20' N., 18°15' W. Fitz must now economize, find winds to help his slow speeds. I decided to forgo recommendation to head toward Africa. We'll continue south." But at midnight their situation had not changed. "Disappointing to be going so slowly," the log reads. In the morning they received another unfavorable report—this one on the area south of them, into which they were heading. Again, they had to make a decision. "We can plow ahead hoping system doesn't deepen, increase power and fight through, or go east to try to circumvent it." They decided to head east, and later that morning went on single engine to conserve fuel.

"Engine sputtered. Burkett[7] and Stan[8] jumped, ran into each other." A short while later they were startled again. "C.O. let air pressure down,[9] alarm bell went off for first time." But these incidents caused only momentary tenseness and uncertainty. When they had passed, the crew was coping again with the larger problem of the wind. This problem existed because the Snow Bird's maximum speed is only 70 knots. Therefore, if she met a 40-knot headwind, she could, at best, proceed at a speed of only 30 knots; and if she met a 60-knot headwind, as she did on the southward course, she could make only 10 knots headway. Although the airship had taken off with enough gasoline to keep her in the air 12 days at her modest rate of fuel consumption, that amount was not enough to carry her all the way home if she had to fight the wind much of the way. So the crew held a meeting on endurance and talked about landing at Port Lyautey, Morocco, to refuel.

If they had to make an emergency landing, they were prepared for it. Before the flight was begun, facilities at each airfield where the Snow Bird might need to stop had been evaluated, and permission had been requested for her to land, if necessary. To compensate for the fact that there are no lighter-than-air facilities on the eastern side of the Atlantic, use had been obtained of a 4,000-pound transportable mast for receiving the ship. This giant erector set was being carried by the Super Constellation, which, upon being advised of the Snow Bird's intent to put down, would fly ahead of it to the field designated and set up the mast to receive her.

Their eastward course took them to the southwest tip of Portugal, where they sighted a light on the evening of the 7th. Although they were still a few hours ahead of schedule, they were still undecided about landing. So they sent the Super Constellation ahead to Port Lyautey to make preparations, just in case. From Portugal, they turned the

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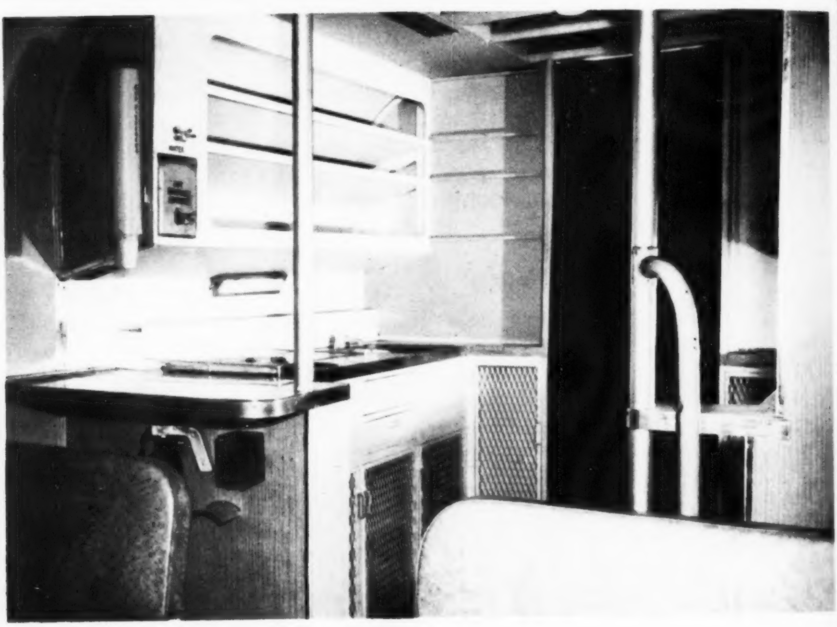
[7]James R. Burkett, AD2, mechanic-rigger.
[8]LT Stanley W. Dunton, pilot-navigator.
[9]Refers to air pressure of ballonets, which are air sacs within the envelope. By regulating this pressure, the pressure of the helium and, therefore, the shape of the envelope can be controlled.

Sleeping quarters

THE CAR AFFORDS ABOUT THE SAME CONVENIENCES AS A SMALL SURFACE SHIP

Galley



Snow Bird southward toward the Canary and Cape Verde Islands, where they hoped to pick up the trade winds that would speed them back across the Atlantic. Along the coast the headwind was not as strong as it was at sea, being only 10-15 knots. They made relatively good time on this leg of the flight and by the next morning, when they passed Casablanca abeam, they had made up their minds not to land. "Now we're committed," CDR Hunt wrote. The weather continued to improve, and late that night, as they neared the Canary Islands, he reported, "Good tail wind. Crew happy."

When the Snow Bird passed north of the Cape Verde Islands on the evening of the 9th, it had been in continuous flight for 5 days. Yet no one had complained about the confinement or shown signs of ill effects. In fact, morale was high. Of course, the job at hand kept the men occupied most of the time. And there were interesting diversions—they had seen an ice floe, had sighted birds, sharks, whales, and ships, and they had waved to a crowd of people on the coast of Africa. Relief—if such it can be called—was also provided when the engine occasionally backfired and sputtered. The alarm bell served to break the "monotony," too. An entry in the log for March 10th reads, "C.O. and Fitz have each rung alarm bell once, owe everybody a beer. We hang a 'Welcome to the Bell-Ringer's Club' sign out when they come on watch." In addition, there was an important social event to attend—the aerologist's[10] birthday party, which was held on the 12th. Locklear baked a cake in an electric frying pan, and the crew celebrated. No provision had been made for candles, but, as the log explains, ingenuity was not lacking: "Cake's candles are filter-tip cigarettes."

Life aboard the Snow Bird went on much the same as it might aboard a small surface vessel. The car, which is 83 feet long, 11-1/2 feet wide, and 16 feet high, affords about the same conveniences. For example, it has comfortable bunks and a wardroom and is equipped with deep freeze, refrigerator, and electric cooking units. Also, the rolling motion of the airship is similar to that of the surface ship. Food, an important item on any long journey, whether by sea, land, or air, was given careful attention by the flight planners. Diet needs, variety, space requirements, and methods of preservation were all considered. One of the decisions reached during the study was to pack each day's ration into separate bags, so that the supply of one item would not be used up ahead of schedule. A total of 1,017 pounds of food—fresh, frozen, and canned—was taken on the trip.

Everything considered, the ZPG-2's habitability was proving to be consistent with its endurance.

On the evening of the 12th, 8 days after the Snow Bird left South Weymouth, the effect of an impending historic event was recorded in the log. "Everybody tense, awaiting the record." The airship was then nearing the Virgin Islands and was about to break the existing airship record for any aircraft for continuous non-refueled flight. The record—200 hours and 12 minutes—was set in May 1954 by another ZPG-2. That airship took off from the Naval Air Station at Lakehurst, N. J.,

[10] William S. Dehn, Jr., AGI.

ADM "Bull" Halsey presents Distinguished Flying Cross to CDR Hunt.

flew over the Bermuda-Nassau-Miami area, and landed at the Naval Air Station at Key West, Florida. The Snow Bird broke the endurance record at 2:45 A. M. (EST) on March 13th Later in the day she broke another record—the unofficial distance mark for airships. That mark—6,980 miles—was set by the Graf Zeppelin in August 1929 while on the first leg of a round-the-world trip.

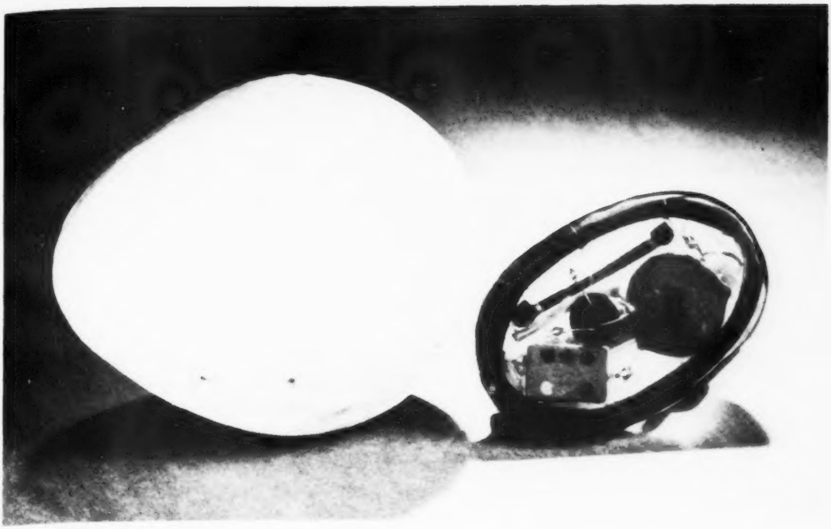
Although the Snow Bird reached Key West on the 14th, it did not land that day. Instead, it turned back over the Caribbean to put more miles and time behind it. On the 15th, when it did put down, it had been out 264 hours, 14 minutes, and 18 seconds and had travelled 9,740 land miles.

The Navy's high regard for the ship and for NADU's development of her is indicated in a message sent by ADM Arleigh Burke, Chief of Naval Operations, to the Snow Bird's crew on March 13 as the ship passed over the Virgin Islands. It reads, "Heartiest congratulations on establishing a new world endurance record for airships. Your untiring efforts and devotion are most commendable. This flight demonstrates an increased ASW[11] and AEW[12] capability and is another achievement which serves to demonstrate the continuing search for technological advances by the U. S. Navy. Well done."

ZPG-2 AIRSHIP SPECIFICATIONS

Length	342.6 feet	Volume . . .	975,000 cubic feet
Height	96.7 feet	Engines (2). . .	800 horsepower each
Width	74.4 feet	Propeller diameter . .	16.6 feet

[11]Antisubmarine warfare.
[12]Airborne early warning.



The transistorized radio thermometer and a replica of a King penguin egg.

Radio Thermometer That Fits in a Penguin Egg

John H. Busser
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The paths of instrumentation in the life sciences lead in many strange and wonderful directions, and quite often pose problems which call upon all of the experience and skill of the instrument designer for solution. Such was the nature of the problem presented last fall to Dr. Orr Reynolds, then Director of the Biological Sciences Division of the Office of Naval Research, by Carl Eklund of the National Research Council. Dr. Reynolds was asked for help in developing an instrument by means of which the temperature inside penguin eggs could be measured from a distance. Inasmuch as some penguins carry their eggs with them when they move from place to place, the device—called a radio thermometer—had to be wireless.

Within a few days of Carl Eklund's inquiry, Dr. Reynolds was requested by Dr. Sidney Schwart of the Navy Clothing Supply Office, Bureau of Supplies, to furnish a method for obtaining remote temperature data from men swimming in the ocean in order to test the effectiveness of immersion suits developed by the Supply Office. These suits were designed to protect aviators from exposure should they be forced to ditch their aircraft in cold waters.

The application of the data to be obtained by means of the clothing tests is, of course, rather obvious. It will be used to determine if the exposure suits fulfill the mission for which they were designed. But to understand the use to which the data obtained from the penguin eggs is to be put, we must first consider some of the facts about life in very cold environments. The first of these is that humans can be made very uncomfortable by extremely low temperatures and may even perish when subjected to them. Second, some animals can exist in environments that are so cold they would be fatal to others that appear to be anatomically identical to them. One of these is the Arctic Cod, which can live in waters 8 degrees colder than those in which the cod of more temperate latitudes lives. Research has shown that an enzyme that occurs in all cod has been altered in a small but essential manner in the Arctic Cod, thus enabling it to withstand such cold. The investigation of the penguin eggs is expected to extend our knowledge on this subject into the field of warm blooded animals.

The first question to be answered by means of the radio thermometer is just how cold does the embryo get? As the instrument was to be designed to fit inside the penguin egg, the eggs selected for testing would have to be opened carefully (techniques have already been perfected for this purpose). Next, the embryo would be removed from the shell. The cavity would then be filled partly by gelatin and partly by the radio thermometer. Finally, the shell would be reassembled and the 'loaded' egg returned to the penguin, which would handle it in the same way it does its living eggs.

Data provided by the radio thermometer may lead to some applications of great interest to man. A not too far-fetched example is the injection into man of a modified enzyme that will increase his ability to adapt to cold. Such injections might also permit doctors to lower the temperature of the human body for longer periods than are now possible, thereby extending the time available for certain operations, the performance of which requires that the body's metabolism be slowed down. Such applications are many years in the future, if they are possible at all.

The unusual and challenging aspects of the problem of designing the radio thermometer aroused considerable interest at American Electronic Laboratories, Inc., which was asked to submit a proposal for developing and manufacturing the instrument. A proposal was submitted on September 26, 1956, and the project started on October 15. Target dates for delivery of the completed instrument were (1) November 8, the day a ship was to sail from Seattle for the Antarctic; (2) November 23, the day a plane was to leave Brooklyn for the same destination; and (3) December 7, when the ice breaker NORTHWIND was to leave Wellington, New Zealand, for the Antarctic. Thanks to the magnificent aid of Martin Korsen and Roland Behle of the A.E.L. staff, the instrument was delivered on November 21.

It is interesting to note that the instrument could not have been built without relying on some components that have been made available only during the last few years. One of these is the cornerstone of the entire device—the transistor. A vacuum tube, however small, could not have been used because of the heat generated by its filament; building a heat source into a thermometer is not, shall we say, recommended practice! The principle of transmission used, and the circuit needed for the radio thermometer, happily wedded several requirements to the electrical characteristics of the transistor.

The decision was made early in the development of the instrument to use magnetic-field transmission. There were several reasons for doing so. First, good results could not have been obtained by means of the usual radiated transmission because of the salt water or flesh which would surround the transmitter and absorb the transmitted energy. Second, the difficulty of building a reasonably functional, let alone efficient, antenna into a penguin egg posed a development project in itself, whereas a small coil of wire could be produced easily. Third, harking back to basic physics, the magnetic field from a coil is proportional to the ampere turns of the coil; as the transistor is primarily an ampere or current device, it is ideally suited to this type of transmission.

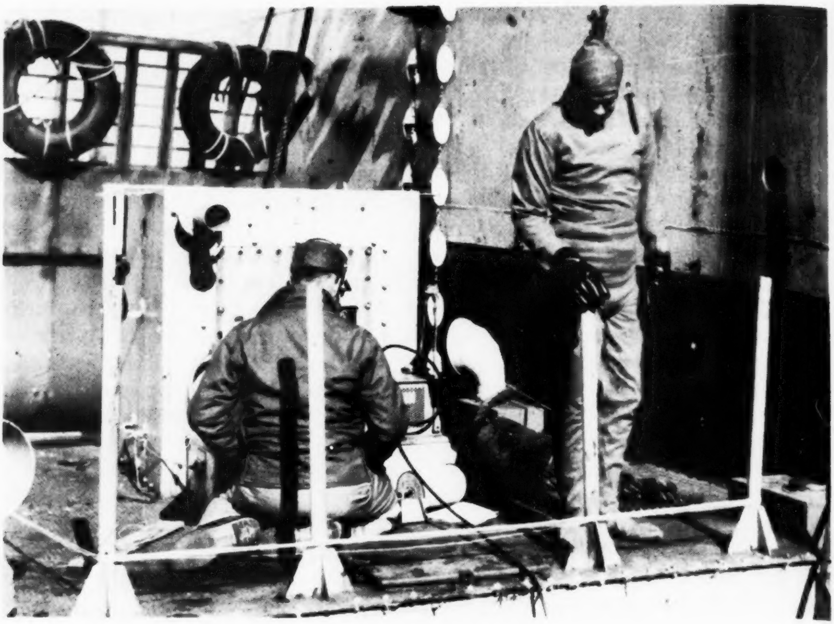
Two other relatively new components were used. One was the thermistor, or temperature-sensitive resistor, which is the primary temperature-sensitive element in the unit. Most resistance elements are made to have as small a change of resistance with temperature as possible. In the thermistor we see the exact opposite—a relatively small change in temperature causes a very large change in resistance. There are other elements which are temperature sensitive, but none quite as attractive for this application.

Although the battery, which consists of 3 mercury dry cells, is also a relatively new component, it is no longer a novelty for it is used in many devices, including hearing aids and guided missiles. The radio thermometer could not have been built without it, however. It is less than half a cubic inch in volume, yet provides electricity for 150 hours of continuous transmission.

The electronic circuit used with these new components is probably one of the oldest in existence. If one's experience reaches back to the beginning days of radio, he will recall that tuning in a station was accompanied by much squealing in the head phones and twiddling of knobs. The super-regenerative receiver having given way to the super-heterodyne, this squeal has been pretty much forgotten, along with the annoyance brought about by its transmission into all of the neighbors' sets. The radio thermometer uses the old circuit, adjusted to squeal continuously, the pitch of the squeal being regulated by the temperature, or the thermistor.

The final design of the radio thermometer called for a three-cell battery, a transistor, a coil, two small capacitors, and the thermistor. These eight components fit quite comfortably into a King penguin egg and even into the smaller Skua gull egg. Although they will not fit the Daily and Adelie penguin eggs, a smaller unit having a shorter range could have been built that would fit them.

That the radio thermometer assembled for measuring penguin-egg temperatures be very small was not only necessary—because it had to



Dr. Schwart calibrates equipment that receives temperature measurements transmitted by the radio thermometer.

A swimmer, wearing the radio thermometer against his body, tests exposure clothing in McMurdo Sound.

fit inside the egg—but also desirable—because of the favorable effect it was believed the small components would have on the temperature of the unit itself. The premise here was that if the unit were small enough, all of its parts would be at the same temperature; thus the unit would have one composite temperature characteristic, which would be made up of the temperature coefficients of all the unit's parts. Consequently, one would not have to worry about the known effects of temperature on such components as the transistor and the battery. Experimental evaluation of the unit has confirmed the validity of this assumption.

In the application of the radio thermometer to the measurement of human deep-body temperatures, however, this premise was no longer tenable. As a rectal thermometer was required, the size of the capsule containing the temperature-sensitive elements was limited by such considerations as irritation and comfort. Thus a two-part unit was built. The temperature-sensitive elements, which were to be inserted in the rectum, were enclosed in an inert plastic capsule about three-eighths of an inch in diameter and a little more than an inch in length. The other part, which was to be taped to the inner thigh, consisted of the transmitting coil and battery assembly. The two parts were connected by a short plastic tube containing the wires. It was felt that if the external components, which are relatively insensitive to temperature, were taped to the inner thigh, where maximum protection is provided, unwanted effects would be minimized.

The radio thermometer, completely assembled and ready for use, is shown on page 9 with a replica of a King penguin egg. This model has a range of 80 feet, is accurate to within 0.2° F, and weighs 80 grams. As the experiments on the penguin eggs were not scheduled to begin until after the Antarctic winter set in, when communication with the rest of the world is difficult to effect, the results of the experiments have not yet been received here.

Reports sent from the Antarctic on the clothing test include both a rather vivid word picture of LT Lester Halsema swimming in 28.5° F waters known to abound with killer whales, and a detailed log of his body temperature over a 20-minute period. During the first 12 minutes of active swimming, LT Halsema's temperature rose from 98.6° F to 98.9° F. While he rested, his body temperature dropped at a rate of about three-tenths of a degree every 2 minutes. At the conclusion of the test, Dr. Schwart remarked that he was ". . . .very satisfied with the experiment, which proved the versatility and usefulness of the instrument and the adaptability of this type of suit for sea rescue work."

We are just beginning to realize the scope of usefulness of the radio thermometer. Not only does the instrument have prospective uses in the clothing field, but also further applications are expected to be made of it in the studies of animals, including chickens and reindeer.

Those of us who were privileged to be associated with this unique project feel both happy and proud about its successful conclusion. The satisfaction that results from surmounting a challenge is amplified by that of having contributed to a fundamental research endeavour. We look forward with great interest to receiving the 'word' from the penguins.

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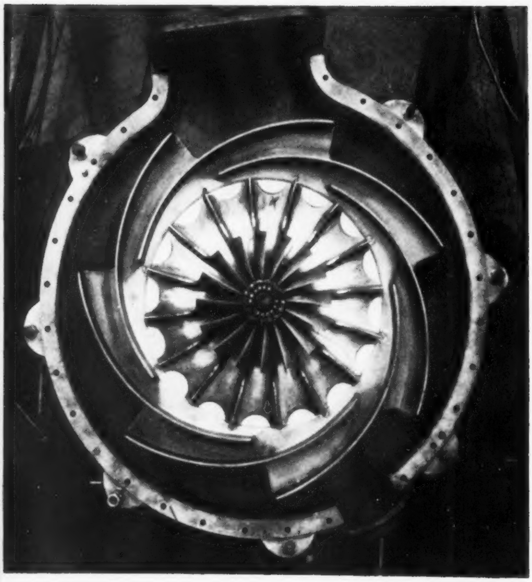


"Cooling" the Gas Turbine

M. J. Zucrow
Professor of Gas Turbines
and Jet Propulsion

B. A. Reese
Associate Professor of
Mechanical Engineering

Purdue University

The radial-inflow turbine with front casing removed.

One of the outstanding characteristics of the gas turbine engine is its high power output per pound of engine weight. As this output is several times higher than that of the piston engine, it is not surprising that the gas turbine is generating a lot of interest among potential users. One of the interested organizations is the Navy, which has already replaced some of its piston engines with gas-turbine engines for such purposes as driving fire pumps and propelling small craft.

The principal components of a simple gas turbine are the compressor, which may be of the centrifugal or axial flow type, the combustion chamber, and the turbine, which may be of the radial or axial flow type. Gas entering the engine is first compressed, then heated, and finally admitted to the turbine, where it expands to about the atmospheric pressure and sets the turbine rotor in motion. At the present time, axial-flow turbine engines operate with inlet gas

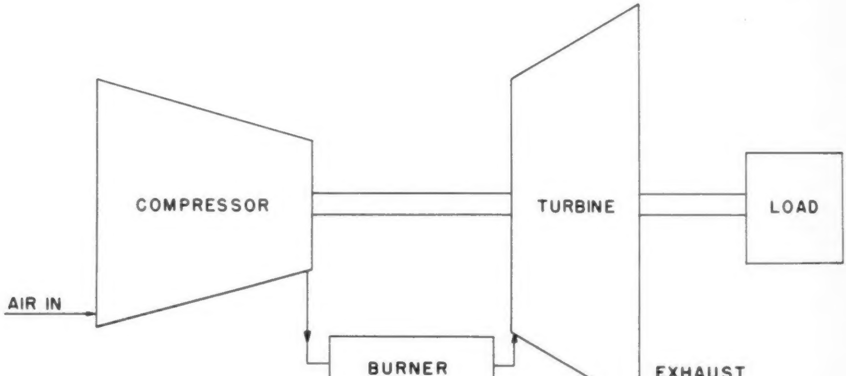


Diagram of a simple gas turbine.

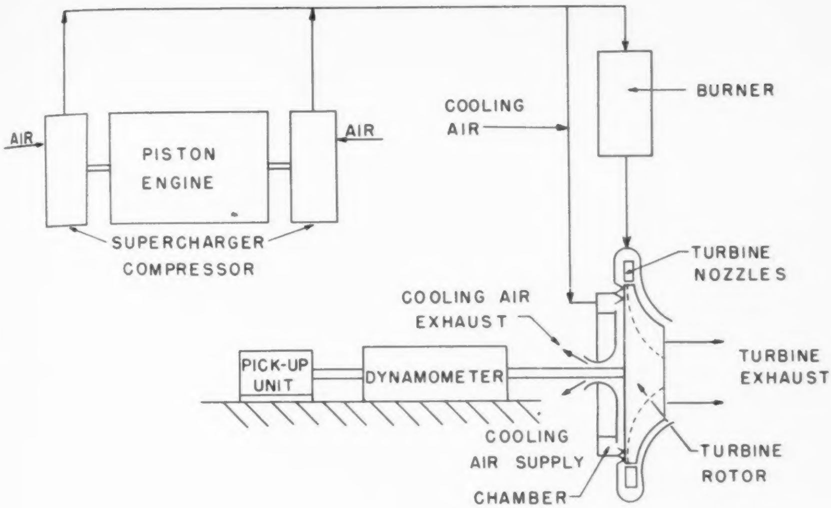


Diagram of apparatus used in the investigation of a cooled radial-inflow turbine.

temperatures ranging from 1,200° F to 1,600° F and with forces as large as 20 tons per square inch at the base of the rotor blades.

Of course, the more the inlet gas temperature is increased, the more the engine's power output is increased. For example, the power output of a typical gas turbine operating with a gas inlet temperature of 1,400° F would be raised 26 percent if the temperature were raised to 1,600° F. Thus increases above 1,600° F are being achieved as rapidly as the technology will permit. The big problem in effecting them is that of giving the component parts of the engine the strength they need to withstand the stresses they are subjected to at the higher temperatures.

There are essentially two ways of getting around this problem. One is either to improve the alloys used in the engine (those now being used contain such critical metals as tungsten, cobalt, columbium, and nickel) or to use other materials that will withstand the higher temperatures. The other is to cool the critical parts of the turbine.

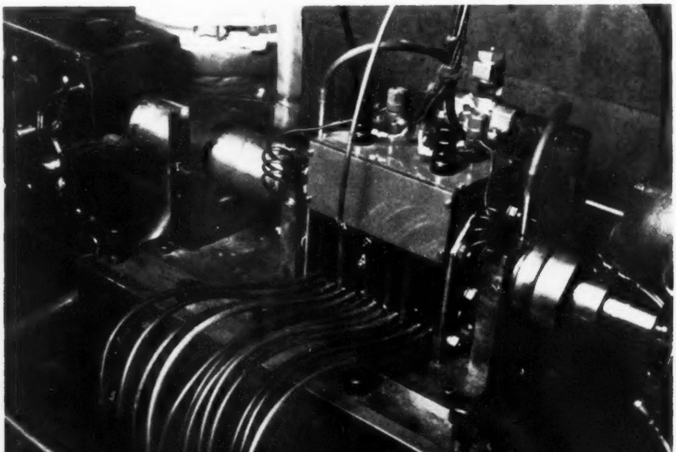
Under the sponsorship of the Office of Naval Research, an investigation of an air-cooled turbine is now underway in the Gas Turbine Laboratory at Purdue University. The purpose of the study is to determine what effect the cooling of the engine has on the engine's efficiency, and to determine the temperatures and stresses that occur in the alloys that make up the component parts of the engine.

Although the turbine used for the experiments (see photograph on page 14) is quite similar in appearance to a centrifugal compressor or centrifugal pump, its operation is quite different. In the experiments, the hot gas was made to flow from the casing surrounding the rotor through the nozzles and into the rotor at its tip, and then to flow radially inward. Because of this characteristic, the engine was called a radial-inflow turbine. In most of the experiments carried out so far, an aluminum rotor was used. With this rotor the turbine developed from 95 to 200 horsepower when operated at inlet pressures of from 28 to 38 pounds per square inch and inlet temperatures of from 500° F to 600° F. The adiabatic efficiency of the turbine is about 70 percent.

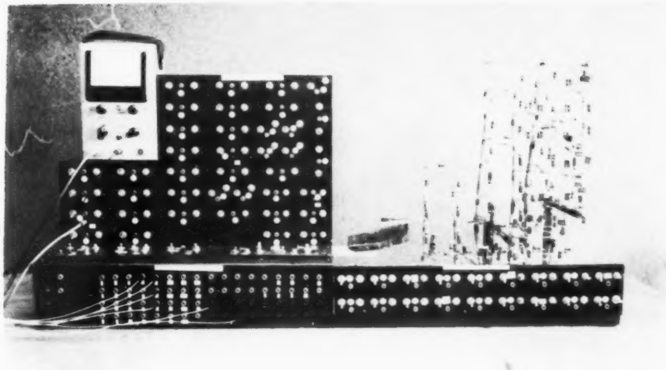
The complete apparatus used in the tests is illustrated on page 15. The air for operating the turbine was supplied by two auxiliary stage supercharger compressors driven by a piston engine. From the compressors the air flowed to a combustion chamber, then to the turbine. The engine was cooled by bleeding some of the compressed air from the line leading to the combustion chamber, running it through a cooling system, then directing it against the back side of the rotor (the side of the rotor not visible in the photograph on page 14). The air flowed from a point near the tip of the rotor through a small space between the rotor and the casing and was discharged near the center of the rotor. In some experiments the cool air was made to flow in the opposite direction; that is, it was directed against the rotor near its center and exhausted near its tip.

In addition to the standard instruments used for measuring pressures, temperatures, speed, power, and other characteristics, thermocouples and a special pick-up unit developed at the Gas Turbine Laboratory were used. By means of the thermocouples and the pick-up unit, the temperatures at eleven points on the rotor were measured. The development of the pick-up unit was complicated by the fact that the small thermocouple voltages had to be transferred to it from the rotor while the rotor was operating at speeds as great as 20,000 rpm.

The heat-transfer coefficients on the back, or "cooling-air," side of the turbine rotor were calculated from measurements of the flow rate of the cooling air, of the temperatures of the cooling air, and of the temperatures on the rotor. By applying standard methods, the results



Pick-up unit.



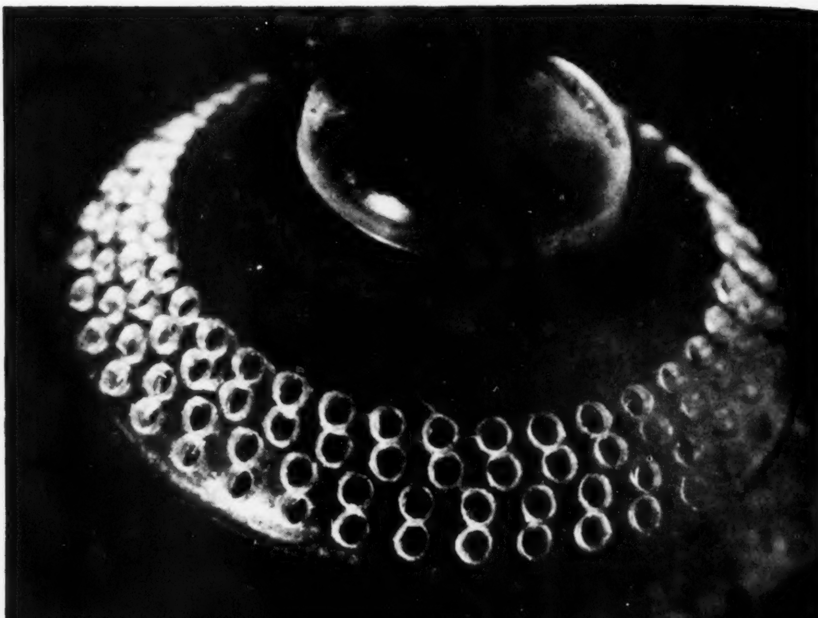
Thermal analyzer.

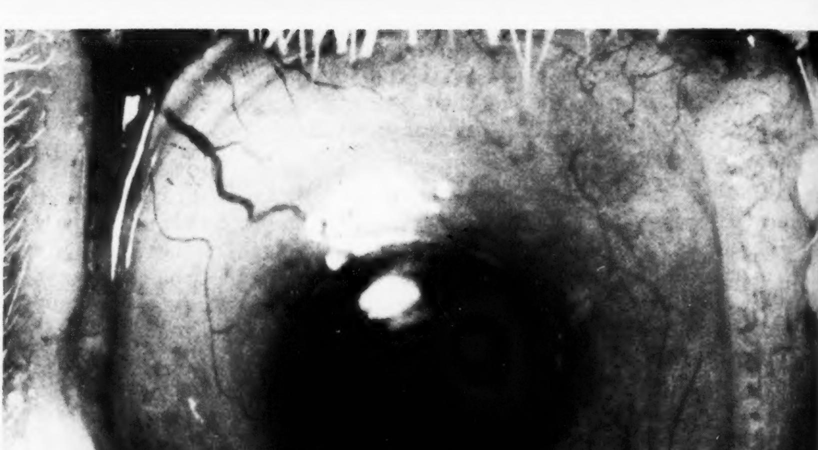
were then generalized so as to be applicable to a wide range of operating conditions.

The analysis of the heat transfer from the hot gases to the turbine rotor was more difficult because of the complicated shape of the rotor. The area of the passage, the heat-transfer coefficient, and the temperature of the hot gas are all functions of the radius of the rotor. The heat removed by the cooling air also varies as a function of the radius; at a given radius it does not, in general, coincide with the rate of heat input because of conduction in the radial direction within the rotor. Therefore, the analysis had to take into consideration conduction through the rotor and convection on the hot-gas and cooling-air sides of the rotor, in three dimensions. Several trial-and-error methods can be used to solve this problem. The method selected involved constructing an analogue computer, called a thermal analyzer.

Because the flow of heat due to a temperature difference is similar to the flow of electrical current due to a voltage difference, it is possible to simulate the flow of heat by the flow of electrical current, which, of course, is much easier to control and measure. The thermal analyzer is constructed so that the electric currents in its network are proportional to the corresponding heat-flow rates, the voltage differences to the temperature differences, and the electrical resistances to the thermal resistances. By feeding data already obtained from both the cooling-air and hot-gas sides of the rotor into the thermal analyzer, and by doing some analytical work, the heat coefficients on the hot-gas side of the rotor were determined.

In order to verify the general applicability of the results of the investigation conducted with the aluminum rotor to other radial-inflow turbines, an investigation employing a stainless-steel turbine is being conducted. The heat-transfer coefficients for the stainless-steel rotor have been calculated, and by means of the thermal analyzer the temperature distribution in the rotor has been predicted. The results of the analysis indicate that when the turbine is operating at an inlet gas temperature of 1,500° F the temperature of the stainless-steel rotor can be reduced 150° F by using 5 percent of the total air flow to the turbine for cooling purposes. This indicates that the inlet gas temperature can be increased 150° F, thus permitting either an increase in the power output or the use of less critical alloying elements in the construction of the turbine.





"Artificial" cornea that holds out promise of restoring sight to thousands of persons blinded by corneal opacity. Top photograph shows plastic disc before being implanted in the eye of an experimental animal. Bottom photograph shows the animal's eye--to which sight has been restored--after the disc was implanted. Courtesy of Dr. W. Stone, Jr., Massachusetts Eye and Ear Infirmary.

Tissue Preservation and Transplantation

Joseph F. Saunders
Medicine and Dentistry Branch
Biological Sciences Division
Office of Naval Research

According to medical history, the first attempts to transplant human tissues were made by Herophilus of Alexandria. Herophilus is said to have tried, unsuccessfully, to transplant limbs from one person to another. Successful transplantations of bone from one site to another in the same person (autogenous graft) and from one person to another (homogenous graft) were not made until the early 1800's. And another 100 years went by before autogenous and homogenous cartilage and fascia lata (dense fibrous connective tissue) were successfully grafted.

Although we have made much progress in this field since the early 1900's—not only have better techniques been developed for transplanting tissues, but also procedures have been established for preserving some tissues—we still have a long way to go. Many of the basic but complex biologic principles which control successful tissue transplantation are still not clear to us. For example, information concerning the best methods of acquiring, preserving, and stockpiling tissues, and of evaluating them clinically, is limited. And we do not know yet why the host rejects homografts (it does this within about 3 weeks after grafting); until we learn more about the response of antibodies of the host to homografts the reasons for these rejections will remain a mystery.

The development of antibiotics and the occurrence of the two recent wars have, perhaps, provided most of the impetus for developing means of preserving tissues for transplantation. During and after World War II an enormous number of men required reconstructive surgery. To the Navy and the other military services, this has been a very serious problem. And during future wars it will be even more serious, for personnel may then be exposed to the destructive forces unleashed by thermonuclear weapons. Thus it is highly desirable that tissues for repairing large areas of burned skin, damaged blood vessels, fractures, and other traumatic conditions be stockpiled at strategic locations throughout the country. For example, "banked" fascia lata could be used to replace musculoskeletal framework torn from the chest by shrapnel, thus providing such wounds with a temporary lattice until the body regenerates its own supportive tissue. And "banked" skin could be used to treat severe radiation burns; such treatment would save many hands, arms, and legs from amputation.

Tissue "banks" would also serve the nation well during peacetime, particularly when disasters occur. Consider, for example, the benefits that would have been derived from such a bank had it existed in 1954 in the New England area when the USS BENNINGTON exploded and burned. Many of the personnel who were seriously injured by the fire died. Had a supply of preserved tissues been available for use as biologic dressings, for curtailing burn shock, for preventing the loss of body fluids, electrolytes, and proteins, and for minimizing bacterial invasion, many of these lives probably would have been saved.

Because of the pressing need for tissues, the Office of Naval Research is sponsoring many investigations in the field of tissue preservation and transplantation. These include studies of arterial transplants and synthetic substitutes; clinical use of freeze-dried tissues; skin and cartilage preservation; bone metabolism, development, and repair; tooth preservation; and artificial corneal substitutes.

Although there is universal agreement that the autogenous graft is far superior to the homogenous graft, the demand for the latter continues to increase. Homogenous grafts are used so commonly today that there is always a shortage of some types. The general clinical impression is that autografts are less susceptible to infection, to antigenic response, to absorption, and to other physical alterations than are homografts and heterografts (tissue transplanted from an individual of one species to an individual of another species*). In certain cases, however, these differences may be minor. The homogenous tissues most commonly preserved and frequently transplanted have been those that are relatively inert, such as bone, cartilage, fascia lata, and blood vessels. Although the cellular components of these grafts do not survive transplantation permanently, the grafts maintain their original physical characteristics sufficiently to serve their intended clinical and physiological function.

The large demand for preserved blood vessels for use in cardiovascular surgery emphasizes the need for homografts, heterografts, and other substitutes; autogenous arterial grafts cannot be procured consistently. The use of preserved homogenous bone grafts in orthopedic surgery shortens the operative time, decreases shock, and, because the grafts are not obtained from the patients, reduces the amount of pain to which the patients are subjected. Homogenous skin may very well be life-saving to severely burned patients. Other tissues, such as cartilage and fascia lata are needed to correct gross defects which result from serious injury, radical surgery, and other traumatic conditions.

A few of the tissues which are much needed today, some of the problems that interfere with their free widespread use, and the approaches being made to these problems by ONR contractors are discussed in the following paragraphs.

SKIN

One of the most important functions of the skin is to protect vital organs, peripheral nerves, blood vessels, muscles, and other parts of the body. If the skin is severely damaged, the wounds must be promptly closed to minimize fluid loss and infection. Often, however, it is not wise to replace the damaged skin by autogenous grafts—for example, in the case of severely and extensively burned patients. Thus the skin homograft or heterograft must be relied on to save the injured person's

*For example, a cow's artery that is used to replace a piece of damaged artery in a human.

life. As demonstrated by studies carried on by Dr. N. G. Georgiade and his group at Duke University, the use of preserved homogenous skin has proved very beneficial. Many studies by other investigators have confirmed these results.

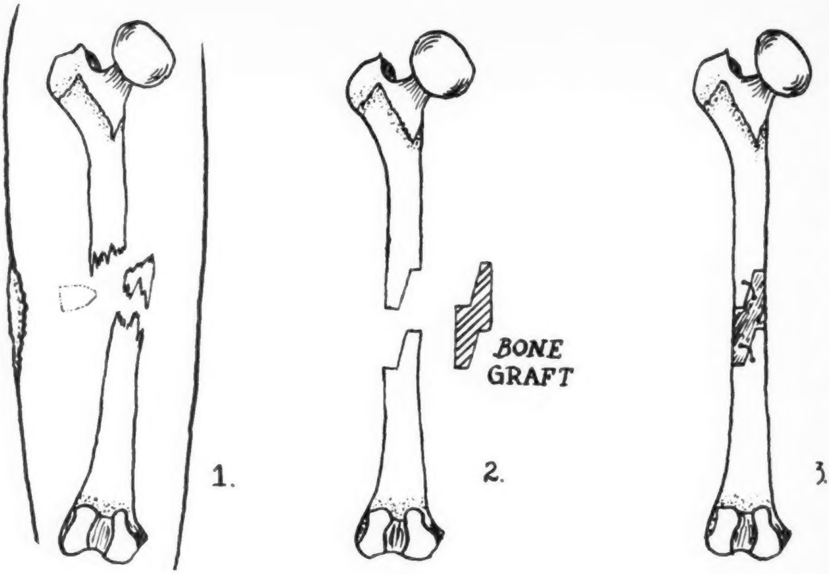
There is one serious obstacle to the use of "banked" human skin. It can not be made available now or in the forseeable future in large enough quantities to treat many persons whose bodies are extensively covered by second or third degree burns. Embryonic bovine skin, which can be made available in almost unlimited quantities, may fulfill the requirement. Dr. A. N. Silvetti of NMRI, who originated the idea of stockpiling this skin in the Navy, and Drs. J. M. Converse and B. O. Rogers of New York University have carried out limited grafting trials with it. The use of this tissue appears to be practicable and safe as a temporary covering for large burned areas of the body. The field is very young, however, and more fundamental information is needed about the body's acceptance or rejection of this tissue, methods of preserving it, and other problems which arise in connection with its use.

BONE

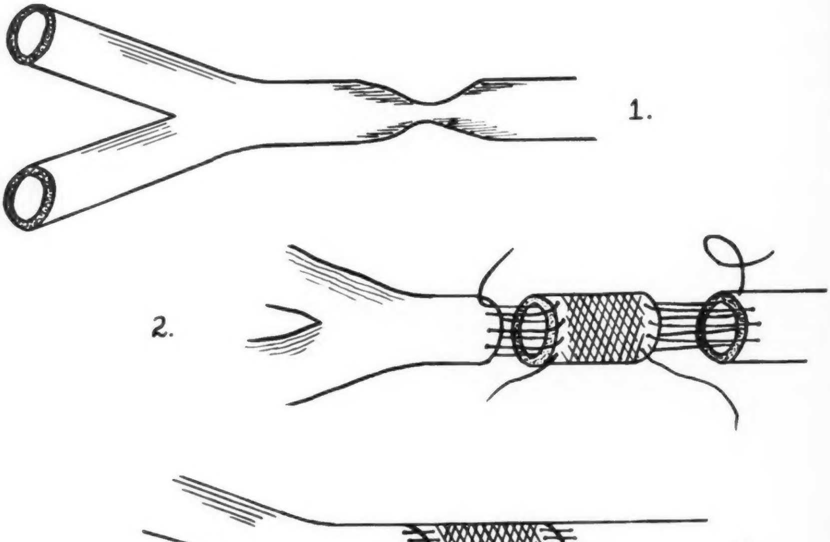
Perhaps the most energetic efforts in the preservation of bone and its clinical use are those of the staff of the Navy's Tissue Bank. The idea for a tissue bank was conceived by CDR G. W. Hyatt, MC, USN, and his coworkers when orthopedic surgeons at the Naval Hospital in Bethesda, Maryland, made use of a small deep freeze to store bone for grafting.

Homogenous bone grafts are being used clinically with good results to repair fractures (see drawing on upper half of page 22), to reconstruct joints, to effect spinal fusions, and to correct other orthopedic deficiencies. Wide-scale use of this bone in clinical surgery, however, is dependent upon simplified methods of preparation and storage. Although most of the bone used in orthopedic surgery is either autogenous or homogenous, heterogenous bone is also being used experimentally. Some success has been reported in the use of calf bone as a grafting material for humans.

Surprisingly little is known about bone metabolism, development, and natural repair, particularly the mechanisms under which calcification and mineralization take place. Dr. A. E. Sobel of the Jewish Hospital of Brooklyn is seeking solutions to some of these problems through work concerned primarily with the mechanisms of calcification in bones and teeth. As part of this work, Dr. Sobel is investigating the effects of preservation on calcification. At George Washington University Drs. I. R. Telford and L. E. Church are studying another phase of the problem—the development of bone under abnormal conditions, such as physical and chemical stress, and normal conditions. A third study—on the organic constituents of bones and teeth—is being conducted under the direction of Dr. W. C. Hess of Georgetown University. This work has been undertaken to determine how the composition of bones and teeth might affect their hardness, mechanical strength, and their resistance to physical and chemical agents and to bacterial invasion.



Repair of fractured thigh bone with preserved bone graft. (1) Bullet strikes bone causing compound fracture. (2) After bone has been notched to receive graft. (3) After insertion of graft. Note that the bone has not been shortened.



Repair of a blood vessel with homograft or plastic tube. (1) Constricted vessel. (2) After constriction has been removed. (3) After repair has been completed.

BLOOD VESSELS

Unlike the supply of autogenous and homogenous bone, which is relatively large, that of autogenous arterial grafts is virtually nonexistent because it can rarely be obtained without running the risk of seriously impairing the circulatory system. Thus the preservation of homogenous and heterogenous blood vessels is a very important phase of the tissue-preservation program. Preserved vessels are widely and successfully used in surgery attending stricture of the aorta and arterial dilation and to replace diseased vessels.

Because of the constant shortage of preserved blood vessels, some synthetic materials are being evaluated for use in bridging arterial defects. Although there are differences of opinion as to the use of vessel homografts in preference to inert synthetic substitutes, the need for the latter is imposing. ONR's interests in synthetic materials are represented by two contracts. Under the direction of Dr. A. H. Blakemore of Columbia University, plastic textile tubes are being studied. These seamless tubes (Vinyon-N) are flexible but do not wrinkle, they are elastic and, therefore, can be fitted precisely, and they maintain their tubular shape during implantation. They have been used successfully in humans (see drawing on lower half of page 22). Dr. H. B. Shumacker, Jr., of the Indiana University Medical Center has recently completed a comparative study of the use of synthetic materials and heterogenous blood vessels in experimental animals. His observations indicate that a nylon filter fabric and a braided nylon treated with formic acid and silicon are very satisfactory substitutes for blood vessels. Through studies such as these it may even be possible to show that such synthetic materials are superior to preserved homografts. At the very least, they will help alleviate the great demand for preserved material.

CORNEA

Small bits of debris that become lodged in the cornea of the eye can cause scar tissue to form, which may result in the loss of sight. Corneal opacity can be overcome only by replacing the damaged cornea. As the supply of living and preserved corneas is limited, studies of plastic or other types of artificial corneas must be encouraged. ONR's contribution to investigations of this problem stems from its support of the work of Dr. W Stone, Jr., of the Massachusetts Eye and Ear Infirmary. The technique being developed by Dr. Stone consists of removing the damaged cornea and implanting a plastic "artificial" cornea in its place. Although to date Dr. Stone has experimented only with animals, the results have been excellent. As can be seen in the photograph on the lower half of page 18, the tissues of the eye do not grow over the central elevated portion of the disc, and the animal can see. It has been estimated that only about 1 out of every 25 blind persons could be successfully treated in this way; nevertheless, the technique holds out much promise, for these successes would number into the thousands.

CARTILAGE AND FASCIA LATA

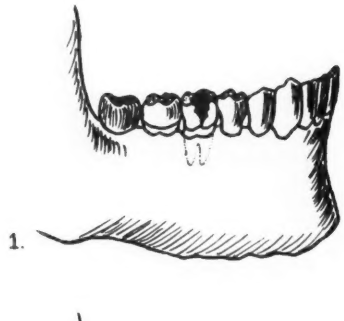
A great need exists for preserved cartilage, which is used as a supportive substance for repairing injuries that jeopardize the normal functioning of the body, such as those resulting in contour defects. Thus the substance should be made available in large quantities and be prepared for immediate use. Although experiments on animal cartilage indicate that this material can be preserved in the viable state, satisfactory methods for preserving human cartilage have not yet been developed. A step toward solving this problem is being taken by Dr. R. F. Hagerty of the Medical College of South Carolina.

Recently, preserved fascia lata "drawn" from the Navy's Tissue Bank was used successfully in the treatment of wounds sustained by 14 patients who had undergone radical surgery. By virtue of the bridge provided by this substance, the body is helped to regenerate its own supportive tissue. The work, which was done under the direction of Dr. R. K. Snyderman of the Sloan-Kettering Institute, represents an important advance in the clinical use of nonliving tissues.

TEETH

At present, the best replacements for extracted teeth are bridges, partial plates, and complete dentures. Of course, these are not quite as satisfactory as the real thing. There is hope for the future, however, because a few teeth have already been transplanted from one site to another in the same individual (see illustration on this page). In fact, "takes" of several years duration have been recorded. The stumbling block is our lack of knowledge concerning the development, mineralization, and calcification of bones and teeth. More fundamental information must be acquired before complete success in this field will be achieved. Needless to say, the development of methods for preserving and transplanting teeth would be very important both to dentistry and to tissue preservation.

Another approach to the preservation of teeth stems from improved techniques for root canal therapy and pulpotomy. Entirely too many teeth whose pulpous cores have decayed are condemned to extraction even though the teeth are sound in other respects. In this field, ONR supports the work of Dr. I. Schour of the University of Illinois, through which a technique for saving such teeth has been developed.



Autogenous transplantation of a tooth. (1) Decayed first molar condemned to extraction. (2) After extraction of first molar. (3) After extraction and transplantation of third molar.

ONR, in collaboration with the Bureau of Medicine and Surgery and the Navy's Tissue Bank, has taken a big step toward organizing, sponsoring, and promoting a sound program in tissue preservation and transplantation. Although the reasons set forth for the program are by no means exhaustive, they are significant. They can be summed up as follows: The present and future welfare of the most valuable resource of the military services, as well as of all other organizations—their personnel—depends very much on increased research efforts in tissue preservation and transplantation. Continued application of principles already established in these fields will lead to the saving of many lives which might otherwise be lost.

NRL Scientist Awarded $10,000

An award of $20,825, the largest amount of money that has ever been given to a group of Navy employees under the Government's Incentive Awards Program, was made last month to 45 scientists at the Naval Research Laboratory for their role in improving interceptor armament control systems. The key figure in this work and the principal recipient of the award was Peter Waterman, an electronic scientist of NRL's Radar Division. He received $10,000. The remaining $10,825 was distributed among the 44 employees who worked with Mr. Waterman by rank of significance of their contributions. Ten of these employees received $700 each, the second largest amount given.

The presentations were made on May 20 at NRL by RADM Rawson Bennett, Chief of Naval Research.

Mr. Waterman earned his portion of the award for his ingenuity and for the competent technical advice he gave in directing the research and development work on the interceptor armament control systems. He and his associates were able to solve not only specific technical problems on components and circuits but they were also able to bring about a greater appreciation of aircraft fire-control equipment and pilot dynamic relationships and their importance to the successful operation of the fighter aircraft as a complete weapons system. As a result of their efforts the tactical effectiveness of airborne weapons systems, particularly those using air-to-air missiles, has been greatly improved.

The overall monetary savings attributable to this exceptional accomplishment are incalculable. However, savings which have accrued directly from the work have been estimated at $20,000,000 to the Navy alone. Moreover, the work has resulted in a better system than that which was originally planned.

Boiling Points or Melting Points?

Readers of the May issue of Research Reviews may well have wondered whether the bars in the graph on page 3 indicate boiling points or melting points, inasmuch as the caption indicates the former and the graph itself, the latter. To set the record straight--the graph contains the correct information; therefore, the caption should read, "Figure 2 - Melting points of . . ."

On the Nav

CAPT Boyce

New Special Assistant for Research Reserve

On May 31 CAPT Andrew S. Boyce, USNR, relieved CAPT James M. McCoy, USNR, as Special Assistant to the Chief of Naval Research (Research Reserve). In this capacity CDR Boyce will direct the Research Reserve Program, which is comprised of 113 companies and about 2,500 members.

CAPT Boyce, who was born in Augusta, Georgia, is a graduate of the Georgia Institute of Technology, Atlanta, Georgia. His Naval career began in 1930 when he was commissioned Ensign by the Naval Reserve Officers Training Corps at this school.

CAPT Boyce entered active Naval service in 1940 and was stationed at the Reserve Midshipmen's School at New York City as an instructor. After completing a special aeronautical engineering course at M. I. T. in 1941, he was assigned to the Naval Air Station at Norfolk, Virginia, as Assistant Assembly and Repair Officer. In 1942 he was assigned duty at sea, and for the following 3 years he served in various commands afloat. From 1942 to 1943 he served as Commanding Officer of the SC 639 and the SC 1766, and from 1943 to 1945 he was the Commanding Officer of the USS INGRAM (DE-62), during which tour he saw service in the Mediterranean and North Atlantic. In 1945 he assumed command of the APD-43 and participated in the occupation of Korea. This was his last assignment before he was released from active duty in December 1945.

While on inactive duty CAPT Boyce was active in the Reserve program, and in 1947 and 1948 served as the Commanding Officer of the Naval Reserve Battalion, Savannah, Georgia.

Upon recall to active duty in 1948 he was assigned as Reserve Training Coordinator at the Sixth Naval District. From January 1949 to January 1951 he served as Assistant Inspector Instructor at the USNTC, Detroit, Michigan. He was then assigned to 2 years of sea duty as Executive Officer of the USS TACONIC (AG-17). In March of 1953 he reported to the Office of the U. S. Naval Attache, Cairo, Egypt, as Assistant Naval Attache. He remained at that post until 1955, when he reported to the Commandant, Sixth Naval District, as Electronics Program Officer and Director of Training.

Research Reserve

LCDR Ross Receives Navy League Award

LCDR Ross

LCDR Malcolm D. Ross, USNR, a member of NRRC 5-8, Washington, D. C., has been honored by the Navy League of the United States. On May 2 that organization awarded him the Rear Admiral William S. Parsons Award for Scientific and Technical Progress. Mr. Ross, a civilian employee of ONR's Air Branch, and LCDR M. Lee Lewis, USN, of the Bureau of Aeronautics, were the initial recipients of this award.

Mr. Ross was chosen because of "his outstanding services to the Navy in the field of aeromedical research and for his contribution to science in connection with Projects STRATOLAB and RAM."

The award further states—

"In August and November 1956 LCDRs Lewis and Ross manned a balloon to make high-altitude investigations of the special properties of the upper atmosphere. The 10 August 1956 flight was in an open gondola to 40,000 feet. For 4 hours, in temperatures as low as -75° F, LCDRs Lewis and Ross photographed vapor trails at close range, made tests involved in gamma ray detection, and collected cosmic radiation data. On 8 November 1956 LCDRs Lewis and Ross made a flight in a closed gondola to 76,000 feet, higher than balloonists had ever before ascended. This flight was part of the Navy's program to study aeromedical problems of manned flight in the upper atmosphere.

"Both of these flights demanded the highest order of experience, skill, and courage. The contributions of LCDRs Lewis and Ross to high-altitude flight and aeromedical research constitute a bright page in aviation history."

The award was presented to CDR Ross by Mr. Carl G. Stockholm, President of the Navy League, at the Waldorf-Astoria Hotel in New York City in the presence of about 1,400 people. Among the distinguished guests were His Eminence Francis Cardinal Spellman, Archbishop of New York; Hon. Thomas S. Gates, Secretary of the Navy; GEN Randolph McC. Pate, USMC, Commandant of the U. S. Marine Corps; ADM William S. Halsey, Jr., USN, (Ret.); ADM Robert E. Carney, USN, (Ret.); ADM Arleigh A. Burke, USN, Chief of Naval Operations; RADM Milton E. Miles, USN, Commandant of the Third Naval District; and Commissioner Richard C. Patterson, Jr.

Capt. James M. McCoy, USNR, Returns to Civilian Life

CAPT James M. McCoy, USNR, Special Assistant to the Chief of Naval Research (Research Reserve), was relieved by CAPT Andrew S. Boyce, USNR, on 31 May 1957. CAPT McCoy returned to inactive duty at his own request. He had served more than 26 years in the Naval Reserve, more than 16 of which were on active duty. CAPT McCoy will make his home in New Orleans, Louisiana.

During his years of service, CAPT McCoy served in many capacities. He was assigned to communications duties as Assistant District Communication Officer, Eighth Naval District; Communication Officer, U. S. Naval Advanced Base and Officer-in-Charge U. S. Naval Radio Station, Bizerte, Tunisia; Officer-in-Charge, U. S. Naval Radio Station, Naples, Italy; Assistant Communication Officer, Eighth Fleet; Communication Officer, U. S. Naval Forces Mediterranean; and Executive Officer, Communication Department, and Assistant Force Communication Officer, Commander U. S. Naval Forces Far East. Another major part of the Naval service of CAPT McCoy was concerned with the Reserve Program. Among these duties were: Inspector Instructor, USNRTC, Memphis, Tennessee; Commanding Officer, Surface Battalion 8-33, Memphis, Tennessee; Officer-in-Charge, USS LCI 638 (Naval Reserve training ship); and District Reserve Electronics Program Officer of the Eighth and Twelfth Naval Districts.

The Naval service of the McCoy's is not completed, however–it has just been transferred. James H. McCoy, son of CAPT McCoy, is a midshipman at Annapolis, Class of 1960.

Research Reserve Seminars for Fiscal Year 1958

The Research Reserve seminar program for Fiscal Year 1958 was promulgated in Bureau of Naval Personnel Instruction 1571.4C. Eight seminars have been scheduled, and plans for the ninth, a West Coast seminar, may materialize at a later date.

The seminars and the convening dates are listed below.

Nuclear Science, Idaho Falls, Idaho	22 July 1957
Naval Research Laboratory, Washington, D. C.	19 Aug. 1957
Nuclear Power, Brookhaven National Laboratory, Upton, New York	9 Sept. 1957
Nuclear Science, Oak Ridge, Tennessee	25 Nov. 1957
Training Device Center, Port Washington, New York	14 April 1958
Aviation Medicine, Pensacola, Florida	12 May 1958
Research Methods, Columbus, Ohio	16 June 1958
Research Reserve Seminar, ONR, Washington, D. C.	16 June 1958

U. S. GOVERNMENT PRINTING OFFICE : 1957 O -4282

LAST MONTH WITH "VANGUARD"

Early on the morning of May 1, the 14th and last Viking rocket to be made was launched by a Naval Research Laboratory crew from the Air Force Missile Test Center at Cape Canaveral, Fla. The Viking, which carried in its nose a smaller rocket similar to the one being planned for the third stage of the launching vehicle for the scientific earth satellite, rose vertically for a short distance, tilted toward the horizon, then shot out over the Atlantic Ocean. By the time its fuel was exhausted, it had reached a velocity of about 3,500 miles per hour. It then coasted to the peak of its trajectory, about 120 miles above the ocean, where the smaller rocket was fired horizontally from it.

The purpose of the test was to check the complicated separation procedure for the third stage of the satellite launching vehicle. This rocket, which will bear the satellite, must be set spinning while it is still inside the nose of the larger second-stage rocket. Because the satellite has no guidance system of its own, continued spin following separation will be necessary to stabilize its flight. For the same reason, the position of both rockets before separation must be precisely oriented.

The flight performance of the third-stage rocket was monitored electronically by Naval Research Laboratory scientists and AFMTC personnel until its power was spent and it fell into the water.

The complete three-stage scientific earth satellite launching vehicle will be about 72 feet long, 45 inches in diameter, and will weigh about 22,000 pounds (gross). The first stage will closely resemble the Viking, but will be finless and employ a newly designed General Electric Company engine to produce a thrust of 27,000 pounds. The Viking had a thrust of 21,000 pounds. Like the Viking, both first and second stages will have gimbal-mounted engines which can be tilted to alter flight direction. Guided by an electronic system carried in the second stage, the first stage will carry the second and third to an altitude of about 36 miles, where it will burn out and be jettisoned. The same electronic system will then guide the second stage. This rocket will proceed under power to a height of about 140 miles, then coast forward for a distance of about 700 miles on a gradually ascending course. At an altitude of about 300 miles, the third stage will be aligned at the proper angle for launching and "spun up." It will then be fired from the nose of the second, much as was the rocket carried by the Viking in the May 1st test.

The first stage provides most of the energy to raise the satellite to orbital height and provides about 15 percent of the required orbital velocity of 18,000 miles per hour. The second stage supplies the rest of the energy needed to get the third stage of the satellite launching vehicle to the required altitude and about 32 percent of the orbital velocity.

Scientists calculate that after the third stage has reached the required altitude and orbital velocity, a satellite can be separated from it and made to circle the earth without further propulsive power.

In This Issue

COVER PHOTO: The Navy's big, new airship, the ZPG-2, is undocked at the Naval Air Station, South Weymouth, Mass. See article beginning on page 1 for story of its momentous flight.

RESEARCH REVIEWS reports highlights of technical progress in research by Navy laboratories and contractors and the aevelopment 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; $.15 per individual copy. Approved by Bureau of the Budget, 28 February 1955.