ARMY RESEARCH AND DEVELOPMENT

MONTHLY NEWSMAGAZINE OF THE OFFICE OF THE CHIEF, RESEARCH AND DEVELOPMENT
Vol. 9 No. 5 • May 1968 • HEADQUARTERS, DEPARTMENT OF THE ARMY • Washington, D.C.

COE Dedicates World's 1st Nuclear Power Plant Built To Serve in Any Emergency

Described as "a large block of electrical power that could be used throughout the world," the U.S. Army Barge *Sturgis*, containing the world's first floating nuclear power plant, was dedicated Apr. 26 at Fort Belvoir, Va.

Army Chief of Engineers Lt Gen William F. Cassidy said the MH–1A plant, costing about $18 million, has proved capable of providing "approximately 200 million kilowatt hours of electrical power for two years with-

(*Continued on page 3*)

Sheridan, Curd Win Pace Awards for '68

Secretary of the Army Stanley R. Resor approved the 1968 Pace Awards for outstanding achievement presented May 10 to Lt Col Stan R. Sheridan, Office of the Chief of Research and Development and Paul Curd, Office of the Comptroller of the Army.

The Pace Awards are presented annually in honor of former Secretary of the Army Frank Pace Jr. (1950–53) in recognition of outstanding achievements during the previous calendar year. One Army officer and one Department of the Army civilian (GS–13 or below) are selected.

Mr. Pace presented the 1968 awards at ceremonies in the Pentagon, Washington, D.C.

(*Continued on page 6*)

Army Outlines RDT&E Objectives to Congress In $1.662 Billion Budget Proposal for FY 1969

Army FY 1969 budgetary proposals presented to Congress for research, development, test and evaluation (RDT&E) activities request a total of $1,661.9 million, as compared with $1,571.0 million for FY 1968.

Assistant Secretary of the Army (R&D) Dr. Russell D. O'Neal and Chief of R&D Lt Gen Austin W. Betts stressed, however, in their presentations that the FY 69 proposals reflect maximum general austerity.

The increase requested is necessitated by R&D requirements for the deployment of the Sentinel System ballistic missile defense, oriented to the Chinese Communist threat, and the increasing R&D requirements for the war in Southeast Asia.

Presentations of the proposed budget before two of the four Senate and House committees involved in the review process had been completed as the *Army Research and Development Newsmagazine* went to press. Proposals for adjustments to the FY 68 program also are being considered.

More than 500 projects are involved in the FY 69 proposals, based on a detailed analysis of R&D requirements and ongoing programs in fields linked to the Army's mission.

(*Continued on page 2*)

Reservations Hint Record Army Science Conference Participation, June 18–21

Cash-in-advance registration for the sixth Army Science Conference June 18–21 at the United States Military Academy, West Point, N.Y., indicates record interest in participation, project officers report.

More than half of the available space allocations had been filled with the conference opening date still two months away. Remodeling of the historic Hotel Thayer to provide more dining and entertainment facilities, by an addition on the side overlooking the Hudson River, is near completion.

(*Continued on page 7*)

Featured in This Issue . . .

ARPA Plans Free Flight For 1-Man Jet-Belt Device

Free-flight tests of what may be the world's first one-man "jet belt" flying device are tentatively slated late in June after two years of design and testing sponsored by the Defense Department's Advanced Research Project Agency (ARPA).

(*Continued on page 6*)

Lt Col Stan R. Sheridan

Paul Curd

Testbed of Army-Bell "Jet Belt"

Army R&D Newsmagazine

Vol. 9 No. 5 • May 1968

Editor . . . . . Clarence T. Smith
Associate Editor . . . . George J. Makuta
Assistant Editor . . . . . Read Wynn

Published monthly by the Army Research Office, Office of the Chief of Research and Development, Department of the Army, Washington, D.C. 20310, in coordination with the Technical and Industrial Liaison Office, OCRD. Grateful acknowledgment is made for the valuable assistance of Technical Liaison Offices within the U.S. Army Materiel Command, U.S. Continental Army Command, Office of the Chief of Engineers, and Office of The Surgeon General. Use of funds for printing of this publication has been approved by Headquarters, Department of the Army June 6, 1967.

Purpose: To improve informal communication among all segments of the Army scientific community and other Government R&D agencies; to further understanding of Army R&D progress, problem areas and program planning; to stimulate more closely integrated and coordinated effort among Army R&D activities; to express views of leaders, as pertinent to their responsibilities, and to keep personnel informed on matters germane to their welfare and pride of service.

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Submission of Material: All articles submitted for publication must be channeled through the technical liaison or public information officer at installation or command level.

By-lined Articles: Primary responsibility for opinions of by-lined authors rests with them; their views do not necessarily reflect the official policy or position of the Department of the Army.

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Distribution on an individual name basis is restricted to members of the U.S. Army Atomic Energy and R&D Officer Special Career Programs. Members of the U.S. Army Reserve R&D Unit Program receive distribution by bulk lot sent to their individual units. Otherwise, distribution is made only to the Army installation, office or organizational element to which the requester is assigned.

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Army Outlines RDT&E Objectives to Congress

(Continued from page 1)

Despite stringent economies wherever feasible, it was emphasized that the budget has been formulated "with the objective of insuring qualitative superiority of the weapons, equipment and capabilities of the American soldier over those of any present or potential enemy."

Congress was informed that "in assessing where we should apply our resources in R&D, we are not only developing weapons to meet increasingly sophisticated enemy threats that cannot be handled by present weapons; we are also examining how we can develop weapons that will reduce manpower and materiel requirements and thereby conserve our resources."

The FY 69 budget contains funding proposals to continue efforts begun in prior years, initiate a limited amount of new work, conduct a level of basic and applied research to provide the technological base for future programs, and support calculated requirements for Southeast Asia.

Army forces in Southeast Asia are being supported with a special program, titled PROVOST, to meet requirements on an accelerated schedule; $206.2 million is requested for R&D support for Southeast Asia.

The decision to deploy the Sentinel System will require the commitment of significant RDT&E resources. The remainder of the program seeks to maintain the necessary impetus of technological development consistent with the "minimum feasible expense."

Army Chief Scientist Dr. Marvin E. Lasser and directors of three of the four directorates in the Office of the Chief of Research and Development participated in presentation to Congress, namely: Director of Army Research, Brig Gen Charles D. Y. Ostrom Jr.; Director of Developments, Col Thomas W. Mellon; and Director of Missiles and Space, Col Thomas N. Chavis.

By Lawrence Cohen
Deputy Chief, Programs and Budget Division
Office of the Chief of Research and Development

Many changes have been made in the FY 1968 program from that presented to the Congress in 1967. For this reason, a comparison of the FY 1968 program as reported in this magazine in April 1967 and the program as contained in the FY 1968 column of the FY 1969 budget is presented in Table I.

TABLE I

Comparison of FY 1968 Budget
By Budget Activity ($ in Thousands)

	FY 68 Budget	FY 68 Col of FY 69 Budget
Military sciences	165.4	153.5
Aircraft and related equipment	115.7	133.1
Missile and related equipment	706.2	658.8
Military astronautics and related equipment	11.1	8.3
Ships, small craft and related equipment	.9	.1
Ordnance, combat vehicle & related equipment	183.6	166.7
Other equipment	309.3	313.8
Program-wide management and support	78.8	79.4
Program total	1571.0	1513.7
Unobligated balance applied	−32.0	−60.3
Obligation authority	1539.0	1453.4

The obligation authority shown in the FY 68 column of the FY 69 budget is a net of a proposed transfer from the RDT&E program to other Army programs, receipt of Emergency Funds from the Office of the Secretary of Defense, and proposed supplemental funding for civilian pay act increases.

Program reductions have been compounded in some cases by the need for substantial internal reprograming to meet requirements primarily for Southeast Asia (SEA). It is important to note that the FY 68 budget identified $131 million for SEA support ($83 million specifically identified at that time as PROVOST). The FY 68 program, as it is now reported, contains over $262 million for SEA, a doubling of the effort.

The budget request for FY 69 is for $1,661.9 million. This compares to the request in FY 68 for an appropriation of $1,539.0 million, plus a carry-forward of $32.0 million, for a total program request of $1,5701.0, as shown in Table I. The FY 68 amount appropriated was $1,505.7

(Continued on page 20)

COE Dedicates World's First Floating Nuclear Power Plant

(*Continued from page 1*)

out any further major logistical support." It operates one year on a single loading of fuel and climaxes three years of development and testing.

The Army Nuclear Power Program, he said, was conceived in 1954 when Lt Gen Samuel D. Sturgis Jr. was Chief of Engineers and "thus it is most appropriate that this vessel is named for him." General Sturgis retired in 1956 after 38 years distinguished service in the Corps of Engineers.

In reviewing other historic milestones in the Corps of Engineers pioneering efforts in nuclear power plant development, General Cassidy cited the cooperative R&D activities with the U.S. Navy and Air Force.

The Army's SM–1 plant was the first nuclear power plant in the United States to furnish electrical power to a commercial power system, in April 1957. It is still producing electrical power at Fort Belvoir, Va., but its main mission is training nuclear power plant operators for all the U.S. Armed Forces.

The U.S. Navy and Air Force have been operating their power plants since 1962. The Navy's PM–3A is at McMurdo Sound in the Antarctic, where it furnishes electrical power for the station and is used also for the production of fresh water. The Air Force PM–1 plant is located near Sundance, Wyo., where it powers operation of a defense radar installation.

Requests for use of the *Sturgis* floating nuclear power plant have come from all corners of the world. General Cassidy said selection of its first overseas duty station is not expected to be announced for several weeks. "We are confident," he added, "that this deployment will further the cause of the peaceful uses of nuclear energy for the benefit of all mankind."

Capability of the *Sturgis* to be towed to sites near which the majority of the world's population lives, he explained, insures its usefulness in furnishing vital electrical energy. It may be used for temporary restoration of electrical services to those localities damaged or destroyed by either war or nature. It also may be used for "alleviation of constantly occurring power shortages" or for military installations.

General Cassidy used the dedication ceremony to commend efforts of firms and Army personnel who worked to produce the *Sturgis*. He cited Martin-Marietta Corp. as prime contractor, J. S. Henry Corp. as marine designers, Alabama Shipbuilding Co. for construction, and the Philadelphia District Engineer for supervision of construction and testing.

ARMY CHIEF OF ENGINEERS Lt Gen William F. Cassidy activates the 535th Engineer Detachment as the crew of the *Sturgis*, world's first floating nuclear power plant. Receiving the guidon is Lt Col Robert H. Shultz, CO of the 535. Looking on is SMaj Robert F. Heishman, plant superintendent.

Special acknowledgement was given to the U.S. Army Engineer Reactors Group for insuring operational readiness of the floating power plant by "their diligent and dedicated work during the past three years."

In presenting the unit guidon to Lt Col Robert H. Shultz Jr., commander of the 535th Engineer Detachment (Floating Power Plant, Nuclear), which was activated Mar. 15 as the operational unit for the Sturgis, General Cassidy stated:

Lt Col Robert H. Shultz Jr.

". . . I hereby dedicate the U.S. Army Barge *Sturgis* and the MH–1A Nuclear Power Plant to the U.S. Army's continuing efforts to apply the peaceful uses of nuclear energy to the benefit of the United States of America and to mankind all over the world."

The authorized officer strength of three for the 535th Engineer Detachment is complete, with 1st Lt Richard L. Spessard as nuclear power staff officer and liasion/technical adviser, and CWO Eugene Loibl as power plant superintendent. Sgt Maj Robert F. Heishman is plant supervisor. The authorized complement is 64 other enlisted men.

Lt Col Shultz was a major when assigned to the Army Corps of Engineers Nuclear Power Field Office at Fort Belvoir, in October 1966. The *Sturgis* plant, in a modified Liberty Ship hull, was accepted by the Army from Martin-Marietta Corp. June 23, 1967, and Maj Shultz was promoted in August 1967.

His previous assignment was with the 36th Engineer Group (Combat) in Korea, where he also served during the war years 1952–1953 with the 10th Engineers, 3d Infantry Division.

A 1952 BSME graduate of Virginia Polytechnic Institute, he received an MS degree in nuclear engineering in 1960 from North Carolina State University.

Army Scientists Study Holography for 3-D Data Storage

Fascinating possibilities of 3-dimensional color TV, libraries stored on matchbox-size crystals, automatic fingerprint recognition and other equally intriguing long-range goals are being investigated by scientists using holography.

Known as lensless photography, holography provides the first true 3-dimensional pictures. In effect, a hologram can "see" around corners. Background objects hidden behind another object can be brought into view by moving the head to one side, and the eyes must be refocused when shifted from objects in the background to those in the foreground.

Scientists are quick to point out that 3-D television and other exotic applications are a long way off, but holography as a scientific and industrial tool is a reality.

U.S. Army Missile Command R&D Directorate scientists at Redstone Arsenal, Ala., are exploring the use of holograms for data storage in three dimensions, using tiny, light-sensitive crystals.

A simple hologram uses the plane of a photographic film; in a crystal many planes are available instead of one. When a film is used, a single scene is recorded so a 3-dimensional reproduction is possible. When a crystal is used, reproductions of many thousands of different scenes are possible.

Capt James Brown, who works in the Applied Physics Branch of the Physical Sciences Laboratory, explains why. "Since the crystal has a third dimension, a lot more material is available for recording information than on a 2-dimensional film surface."

What is a hologram? The name comes from the Greek word "holo," meaning whole—literally, whole picture. Unlike a conventional photograph, a hologram is not an actual picture of an object. By itself, it appears as a meaningless blur of fringes and diffraction patterns. A hologram presents a complex pattern of light waves reflected by an object. Since each object scatters light in a particular way, a hologram captures the code pattern of a particular object, much as a tape recording imprisons a code representing sound waves.

How is an object's code pattern captured in a hologram? In simplified terms, here is what you would do to make a hologram.

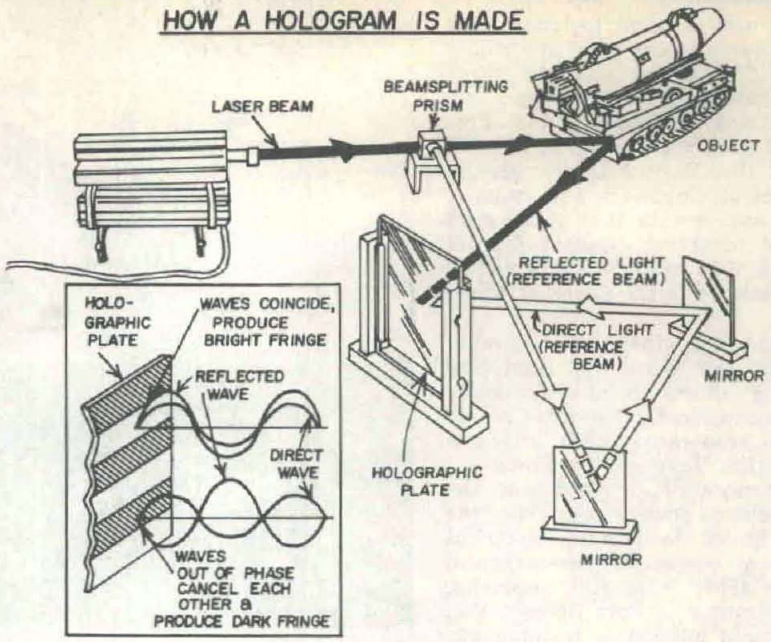
To illuminate the subject, start with a laser beam, which produces a highly disciplined beam of light. Split the beam in two, using a prism. Aim the first beam at your subject, where it is reflected onto the photographic plate. Bounce the second beam off a mirror and onto a photographic plate. This half is called the "reference" beam.

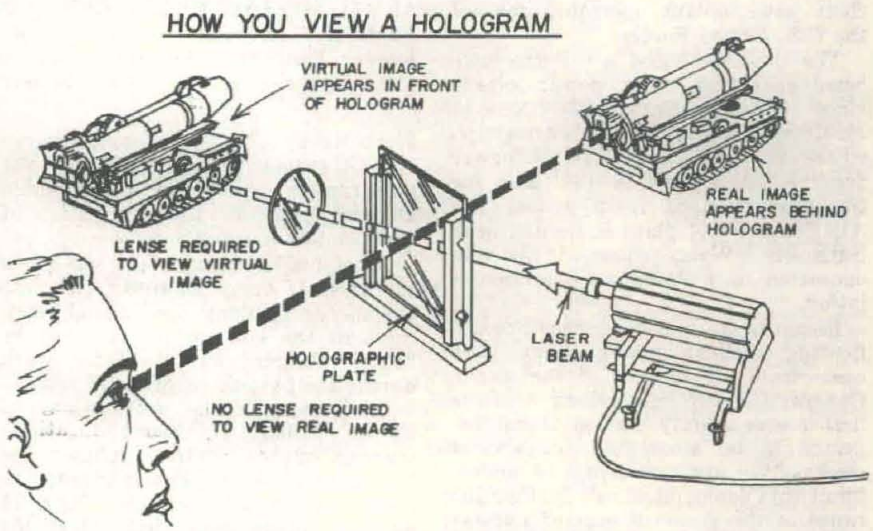
Light from the reference beam hits no obstacles on its journey to the mirror and the photographic plate. The waves of the first beam hit the subject, and are forced out of step. When the two beams hit at the film plate, they clash, forming an "interference pattern."

This pattern registers on the plate as a subvisible pattern of whorls and dots. What the plate has caught is not a conventional picture, but a recording of the light waves that cause the picture—waves from every part of the subject.

Just as a tape must be "played back" to translate recorded impressions into sound waves, a hologram must be illuminated to "reconstruct" the recorded light waves. Light is beamed on the exposed and developed plate in a way that roughly duplicates the unobstructed light beam during exposure. An observer can then see the "reconstructed" image in three dimensions, as though he were viewing the real subject through a window.

William Otto, who is also in the Applied Physics Branch of the Physical Science Laboratory, points out that "A holographic plate records an ultrafine pattern of lines—many thousands of lines per inch, far more than in ordinary photographic plates.





"This explains why it can record more information than an ordinary photograph. It also explains why holograms can be difficult to make. During exposure, the plate must remain motionless in relation to the mirror and the object being recorded. Any relative movement greater than a few millionths of an inch causes the lines to blur.

"Unless a pulsed laser is used, a rigid structure is needed to support the apparatus, which must also be insulated against vibration. A pulsed laser, which greatly increases light exposure, can record a picture in less than 30 nanoseconds—1/30 millionth of a second—which stops movement."

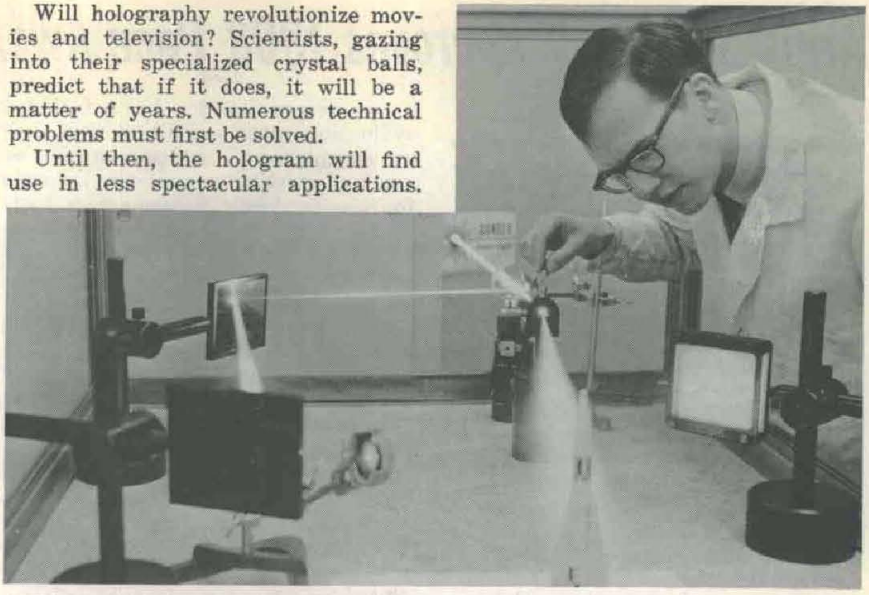
Using a special pulsed laser, other scientists have made holograms of human hands, a fan rotor at full speed, water sprays from a jet, and front-lighted smoke screens.

The first hologram was made over 20 years ago by a physicist named Dennis Gabor, but the mercury beam he used was not intense or coherent enough. With the development of the laser, the way was opened for full-scale experimentation into hologram applications.

Today, holography is used by medical researchers to explore the mysteries of blood, by manufacturing engineers to study defects in small electronic components, and by aerodynamicists to study missiles.

Will holography revolutionize movies and television? Scientists, gazing into their specialized crystal balls, predict that if it does, it will be a matter of years. Numerous technical problems must first be solved.

Until then, the hologram will find use in less spectacular applications.



SCIENTIST Capt James Brown makes adjustment to focus laser beam before making a hologram of a Hawk missile model. The hologram picture captured on the film plate at right will seem to hover in 3-dimensional space behind the plate when a laser is beamed on the developed plate. To make a hologram, the laser beam is split into two parts, as shown in illustration on page 4.

Sentinel Contract Awards $85.48 Million to 9 Firms

Sentinel System Command award of an $85,480,628 initial production contract, covering a 6-month period beginning Apr. 1, has been announced by the Department of the Army.

The contract provides for the build-up of a manufacturing capability and production of some components for use in development of the system. A longer-term extension is planned prior to termination of the contract.

Total production and deployment acquisition cost of the system is expected to be about $5 billion. Initial production will begin on electronic circuits and related items for radars and computers, many of which will be high-volume components requiring a lengthy production period.

Nine firms receiving more than $1 million in the first contract are: Western Electric Co., $28 million; McDonnell-Douglas Corp., $6.3 million; Martin Marietta Corp., $2.8 million; General Electric Corp., $1.7 million; Raytheon Corp., $19 million; Lockheed Electronics Co., $1.7 million; Motorola Corp., $5 million; Radio Corp. of America, $5 million; and Texas Instrument Corp., $5 million.

Boeing Co. Chosen to Make Sentinel Launch-Site Study

Studies of the Sentinel System antiballistic missile defense selected launching sites will be conducted by Boeing Co. on a cost-plus-fixed fee contract of $590,932, the U.S. Army Sentinel System Command at Redstone (Ala.) Arsenal has announced.

During the 14-month study, Boeing's Missile and Information Systems Division will compile site validation information from internal and outside sources. Evaluation teams will consider factors such as transportation, labor, housing, land costs, local industry and educational facilities.

The study reports will provide a basis on which the CG of the Sentinel System Command can validate a site at each Sentinel deployment location.

Brig Gen Gonseth Assumes Duties at DCA

Brig Gen Kenneth M. Gonseth will assume new duties May 15 as deputy director for Operations, Defense Communications Agency, Washington, D.C.

Since June 1966, he has served at HQ U.S. Army Electronics Command, Fort Monmouth, N.J., as deputy CG for Operations, following a year of duty with ECOM as project manager for Universal Integrated Communications/Strategic Army Communications (UNICOM/STARCOM).

From 1961 to 1965, he was assigned to the U.S. Army Communications Zone Europe (COMZEUR). He served successively as commander of the Army Signal Supply Control Agency in France, Signal officer for COMZEUR, chief of Army Systems Development Office, and chief of COMZEUR Supply and Maintenance Agency.

Brig Gen Kenneth M. Gonseth

General Gonseth was graduated in 1961 from the National War College at Fort Lesley J. McNair, Washington, D.C., after serving two years as commander of the Lexington (Ky.) Army Depot.

From 1955 to 1958, he was on the faculty and staff for the Supply Management Course at the Army Management School, Fort Lee, Va. During the Korean War, he was with General HQ of the Far Eastern Command in Japan, and later became Signal officer of the 1st Cavalry Division.

Upon his return to the United States, he was assigned to the Signal Supply Agency in Philadelphia, Pa., as assistant deputy for Procurement, and later as deputy for Industrial Mobilization.

During World War II, he served with the 6th Bomber Command, the 58th Bomber Wing, and the 20th Bomber Command. From 1945–46 he served in the Office of Air Communication at Army Air Force HQ, before entering Harvard for postgraduate work.

After receiving his MBA degree in 1948, he was assigned to the Office of the Chief Signal Officer in the Pentagon, where is served in the Procurement and Distribution Division. He received a bachelor's degree from the University of Illinois in 1939 and was commissioned in the Army Signal Corps with duty at Fort Monmouth.

Army Secretary Approves 1968 Pace Awards for Sheridan, Curd

(*Continued from page 1*)

Scheduled to leave in June for an assignment with the 4th Infantry Division in Vietnam, Col Sheridan was recognized for his work since July 15, 1965, as Army General Staff supervisor of 20 major tank and tank weapon systems R&D projects.

Responsibilities in which he distinguished himself included R&D activities on the U.S./Federal Republic of Germany Main Battle Tank (1970s), and its related equipment such as the Heavy Equipment Transporter, training devices and ancillary vehicles.

Col Sheridan also supervised such projects as the Shillelagh weapons system, General Sheridan tank system, combat engineer vehicle, combat vehicle dynamic armor, radiological armor developments, tank cannon/ammunition applied research, and armored vehicle launch bridge.

When Col Sheridan was assigned as Department of the Army R&D Staff Officer on the MBT–70 program, the U.S./FRG agreements had produced engineering and a plan for development, but no hardware. He personally assisted the U.S./FRG Program Management Board in the assignment of national responsibility by country for component development.

Unexpected technical problems experienced by the developers contributed, along with inflationary trends, to substantially increased costs. Col Sheridan was responsible for analyzing the cost increase and the preparation and staffing through the Army and the Office of the Secretary of Defense a supplemental agreement to the U.S./FRG commitment.

Serving as U.S. Army staff project officer, he assisted the MBT–70 U.S. program officer in a "complete, detailed and objective review of the joint development program, including costs, schedules and technical progress."

Col Sheridan also headed a U.S. delegation to the Federal Republic of Germany for discussions leading to a Joint MBT–70 Advanced Product Improvement Program. He participated in numerous other joint planning sessions where his technical cognizance contributed importantly to critical decisions, the nomination citing his achievements stated.

PAUL CURD received the Pace Award for his exceptional achievements as chief, Cost Model Branch and senior supervisor, Digital Computer Systems, Directorate of Cost Analysis, Office of the Comptroller of the Army.

His responsibilities have included evaluation, development, design, improvement and implementation of new and existing computerized models for use in Army Headquarters cost-effectiveness, cost-analysis and cost-research studies, and for systems analysis support of DA costing exercises.

Development of these cost models is credited in the Pace Award nomination with providing the Army and the Office of the Assistant Secretary of Defense with a computer-assisted cost model to describe the resource requirements of various existing or proposed Army divisions. He developed the mathematical equations for all cost elements for a family of computerized models.

In Calendar Year 1967, the system was made operational for the Armored, Infantry, and Infantry-Mechanized Divisions, and is scheduled to be operational for the Airmobile Division within the near future.

'Jet Belt' Flight Test Scheduled for June

(*Continued from page 1*)

ARPA mobility program manager Alexander N. Tedesco said R&D effort has been conducted under a contract awarded by the U.S. Army Aviation Materiel Command (AVCOM), St. Louis, Mo., to the Bell Aerosystems Co.

The jet-powered system is a longer-range version of the tree-jumping Bell-developed Rocket Belt that captured public fancy when it was demonstrated by the former U.S. Army Transportation Research Command in June 1961. The jet belt holds promise of enhancing individual mobility for a wide variety of military and civilian missions, Tedesco said.

A small bypass turbojet engine developed under subcontract by the Williams Research Corp. of Walled Lake, Mich., will be mated to the belt for initial tethered test flights followed by free-flight tests at the Bell Aerosystems facility. A free-flights demonstration of the jet belt is planned in the area of Washington, D.C., in July this year.

The WR–19 jet engine that is currently undergoing preliminary flight-rating tests (PFRT) at the Williams plant features a high thrust-to-weight ratio and low fuel consumption. It measures approximately one foot in diameter and two feet in length.

Thrust from the jet engine is channeled equally through two nozzles pointed downward just behind the operator's shoulders, similar to the earlier rocket device. For lift-off, the right-hand motorcycle-type grip is turned to increase thrust.

In flight the "pilot" controls his course by manipulating the thrust nozzles with arm and hand motions. By tilting the nozzles backward, he will move forward at a speed dependent upon the degree of deflection of the nozzles.

Developers say the operator will have complete freedom of flight, including reverse and sidewise flying, rotation of the vertical axis, and hover.

Ordinary kerosene-type jet fuels in wrap-around clear plastic tanks are burned by the engine. Heat from the engine is kept from radiating to the operator and fuel tanks by an intake air deflection system designed into the bypass turbojet.

The complete jet flying belt is mounted on a fiber-glass corset that puts most of the weight "comfortably" on the operator's hips.

Inventors of the new jet belt are Bell's gas turbine engineering chief, John K. Hulbert, and assistant chief engineer Wendell F. Moore.

Moore also invented the Rocket Belt, which since 1961 has achieved a 100 percent record of reliability in more than 3,000 flights throughout the world. Powered by a hydrogen-peroxide propulsion system, it has been flown up to distances of 860 feet, at speeds of more than 60 mph and to altitudes of 80 feet. The jet-belt invention was patented by Bell (No. 3,243,144) in 1966.

The new jet belt mobility system will enable man to fly over natural obstacles such as rivers, cliffs and canyons or such man-made obstacles as mine fields and barbed wire. Mine field clearing, reconnaissance, counter-guerrilla warfare, assault, perimeter guard and communications missions appears well within its capability.

Possible civilian applications include riot control, powerline and pipeline patrols, microwave tower inspections, photographic news coverage, fire inspection, rescue operations and traffic surveillance. An air-to-air and air-to-ground communications system is an integral part of the jet belt.

Reservations Indicate Record ASC Participation, June 18-21

(*Continued from page 1*)

Supporting the keynote presentation by Dr. William G. McMillan, science adviser to General William C. Westmoreland, CG, U.S. Army and U.S. Military Assistance Command Vietnam (MACV), will be an exhibit of more than 30 items of foreign military materiel used in Southeast Asia.

Deputy for Technical Operations John A. Ord, U.S. Army Foreign Science and Technology Center, Washington, D.C., is in charge of arranging the exhibit. Scale models of Soviet tanks (the T–10M, T–62, T–55 and PT–76) as well as of the Soviet 122mm Howitzer (D–30), 57mm SP antiaircraft gun (ZPU–4) and other antiaircraft and artillery weapons will be shown.

The display also will include a number of Soviet rifles, pistols, machineguns, rockets and launchers, grenades and launchers, the Australian plastic antitank mine, the French 122mm RAP round, and various items of Chinese Communist materiel.

Army Chief of Research and Development Lt Gen Austin W. Betts will make one of the major general assembly presentations when he discusses Army research and development activities, response to Vietnam needs, and some of the major problem areas.

Two major panel discussions are scheduled, one concerned with the U.S. pacification program in South Vietnam and the other with survivability and casualty evacuation. The latter panel will deal with new techniques that have dramatically increased the "save rate" of combat casualties, including the Army Medical Unit Self-Transportable (MUST) field hospital system.

Dr. Kenneth Edwin Clark, dean of the College of Arts and Sciences at the University of Rochester (N.Y.), is chairman of the pacification panel which includes Dr. Ithel de Sola Pool, Center for International Studies, Massachusetts Institute of Technology, and Dr. Michael Conley, Center for Research in the Social Sciences, American University.

Military members of the pacification panel are Brig Gen William R. Desobry, deputy director, Plans, Office of the Deputy Chief of Staff for Operations; Lt Col Thomas M. Huddleston, chief, Special Operations Division, International and Civil Affairs Directorate, Office of the Deputy Chief of Staff for Operations; and Lt Col Guy S. Melloy, Far East Branch, Politico-Military Division, DCSOPS.

The medical panel will be chaired by Brig Gen Joe Blumberg, CG of the U.S. Army Medical Research and Development Command. Other members are Brig Gen James A. Weir, CG of William Beaumont General Hospital, El Paso, Tex.; Col William D. Tigertt, commander and director of Walter Reed Army Institute of Research; and Lt Col John J. Kovaric, deputy director, WRAIR Division of Surgery.

Dr. Ralph G. H. Siu, director, Plans, Development Directorate, HQ U.S. Army Materiel Command, has accepted an invitation to be toastmaster at the banquet, but the guest speaker was indefinite at press time.

Presiding chairman of the conference will be Dr. Marvin E. Lasser, Army chief scientist, who also heads the panel of judges that will select prize-winning papers from the 96 technical presentations scheduled. Dr. Russell D. O'Neal, Assistant Secretary of the Army (R&D), will present cash awards expected to total over $3,500 and Certificates of Achievement.

Director of Army Research Brig Gen Charles D. Y. Ostrom Jr. will introduce Dr. McMillan as keynote speaker. Host for the conference is Academy Superintendent Maj Gen Donald V. Bennett.

HDL Projects Relocation to Naval Ordnance Lab Site

Proposed relocation of the U.S. Army's Harry Diamond Laboratories, known worldwide for scientific innovations of vast significance, has received Department of Defense approval—five to seven years from now and depending upon funding by Congress.

Two preliminary hearings before citizens' and planning groups were held Apr. 17–18 to explain details of the proposed move. Approval also will be required by Prince Georges and Montgomery Counties and the National Capital Planning Commissions.

Hinging upon all these obstacles to be surmounted, the Harry Diamond Laboratories (HDL) anticipate moving from the former site of the National Bureau of Standards in Washington, D.C., to much more spacious accommodations on the grounds of the Naval Ordnance Laboratory, Hillandale, Md.

The plan is to submit budgetary requirements through the Department of Defense to Congress. HDL operations currently represent a $25 to $30 million expenditure annually, involving activities of some 1,400 scientists, engineers, technicians and laboratory assistants. The proposed move is expected to be a multimillion-dollar project, including construction of buildings.

Since its establishment in 1953 as an "offshoot" of the National Bureau of Standards, which provided about 150 of the initial staff of some 300 employes, the Harry Diamond Laboratories (formerly the U.S. Army Diamond Ordnance Fuze Laboratories), have achieved recognition for numerous phenomenal discoveries. Included are many notable responses to requirements of the war in Southeast Asia.

In addition to important contributions to Army requirements in electronics and new materials, HDL is known for such far-reaching research achievements as the proximity fuze (a vitally important World War II innovation), and the principles of fluid amplification. This latter discovery is leading into multimillion-dollar-a-year industrial applications.

ARMY CHIEF OF R&D Lt Gen Austin W. Betts and Col Leslie G. Callahan, commander of the Harry Diamond Laboratories, Washington, D.C., view a model of the proposed future home of HDL. The projected relocation of HDL is scheduled five to seven years from now on the grounds of the Naval Ordnance Lab, Hillandale, Md.

ASL Constructs Laboratory 'Cell' for Advanced Laser Research

Conversion of a 70-foot section of 14-inch gas transmission pipe into a laboratory "cell" that performs "sleight of hand" with light beams for advanced laser propagation research is nearing completion at White Sands (N. Mex.) Missile Range.

Work has been performed by the U.S. Army Atmospheric Sciences Laboratory (ASL) since September 1967 and will be finished this month. Six months after construction began, Dr. Rufus Bruce reported that the first basic calibrations were performed.

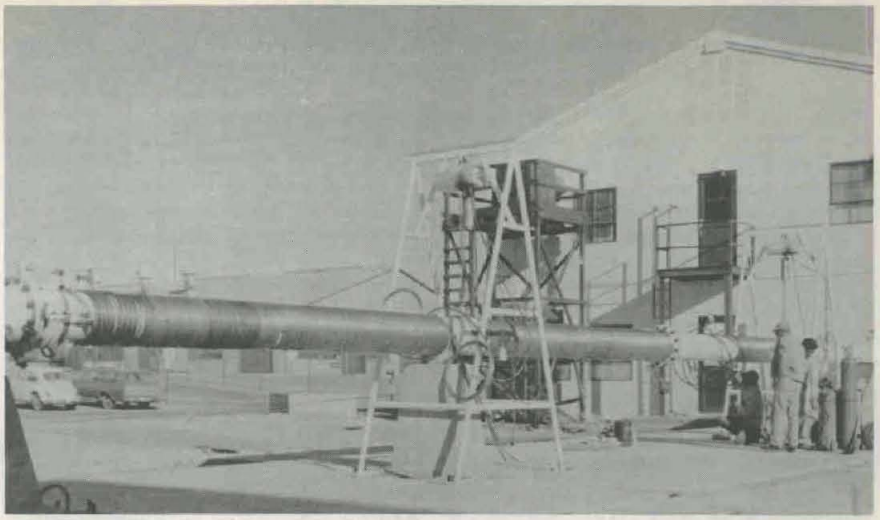
The ASL research physicist and project manager for the laser-cell lab said it will enable physicists and atmospheric scientists to make precise light measurements under controlled conditions.

A large absorption cell, a spectrometer-monochromator device and various environmental controls will be used to study the absorption of laser light under simulated atmospheres inside the laboratory cell.

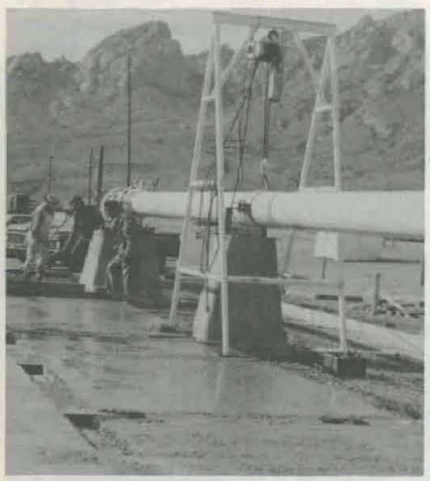
(A spectrometer measures spectral wavelengths. A monochromator is a filtering instrument used to select light of one wavelength or one color of the spectrum.)

Changing the position of three spherical mirrors allows light entering the cell to be reflected back and forth along a 20-meter path for a specified number of times before it is detected.

Adjustment of the mirrors for 99 reflections—part of the "legerdemain"—provides a mile-and-a-quarter (two kilometers) path for the light from a small helium-neon laser. This arrangement, similar to a design developed more than 25 years ago by an Army physicist, makes possible the long optical paths required for high-resolution absorption studies in a laboratory.



MORE THAN ⅔ of a mile of copper tubing is wrapped around main body of absorption cell. Water flowing through tubing controls temperature for testing.



FOUNDATION is set for a galvanized iron shelter to house the absorption cell and the environmental controls.

Coupled to the absorption cell is the combined spectrometer-monochromator device. It weighs about three tons, including frame, housing and supports.

When operated as a spectrometer, the unit samples a portion of laser light entering the cell and displays its frequency distribution. As a monochromator, it accepts the total output of a light source and selects an ultra-narrow frequency band for input to the cell.

In either mode, output from the cell is measured by a photodiode detector and compared with the input intens- and compared with the input intensity to determine the absorption characteristics of the cell's gaseous medium.

The nature of the medium is determined by a gas-handling system which injects air into the cell, maintaining it at a desired pressure and humidity level. The system can fill the cell with a variety of pure gases and with two mechanical pumps and a diffusion pump can evacuate the cell for "outgassing" or calibration.

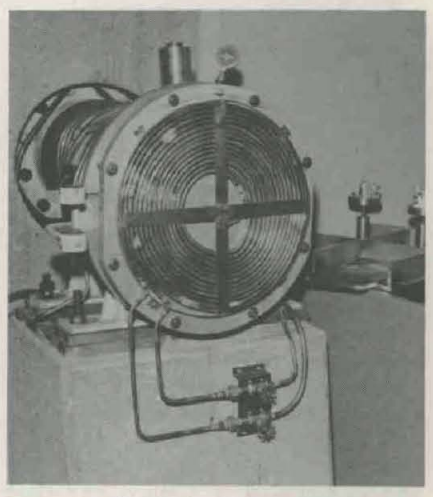
A temperature control system maintains constant temperature inside the cell by pumping a solution of water and ethylene glycol through 3,500 feet of copper tubing wrapped in consective coils around the cell wall. It is also surrounded by four inches of fiber-glass insulation.

A network of valves and tanks, coupled with an electronically actuated 2-way valve, controls the amount of fluid originating from hot or cold source tanks for circulation through the coils.

The system is designed with electronic controls to maintain cell temperature constant to 0.1° C. over the range of −48° C. to 55° C. Under manual control, higher temperatures can be attained for outgassing.

Through these environmental controls, the ASL facility can reproduce a gaseous medium with temperature, pressure and humidity equivalent to countless atmospheric conditions.

The specialized optics within the cell perform scientific magic by stretching 20 meters to 2 kilometers and shrinking vast atmospheric regimes into the volume of a 70-foot long 14-inch-diameter pipe.



TEMPERATURE control tubing is extended to cover aluminum end-plate of absorption cell at WSMR, N. Mex.

Spartan Passes Firing Tests at Kwajalein

Sentinel System development as a part of the defense against threat of a Communist Chinese antiballistic missile attack moved ahead early in April with the successful test firing of the Spartan missile from Kwajalein Test Site in the Pacific.

The 3-stage, 55-foot-long interceptor missile's performance was acclaimed by Lt Gen Alfred D. Starbird, Sentinel System manager, as a "gratifying success for the first test of the Spartan." It is the U.S. Army's biggest and most powerful missile.

Scheduled for deployment at Sentinel System sites throughout the Continental United States, the Spartan will be capable of intercepting incoming warheads at ranges of several hundred miles, outside the atmosphere of the earth.

The shorter-range Sprint missile, also being developed by the U.S. Army as a part of the Sentinel System, has been undergoing flight tests at White Sands (N. Mex.) Missile Range since late 1965. Brig Gen I. O. Drewry, CG of the Sentinel System Command, is responsible for testing of both Spartan and Sprint, and commands Kwajalein Test Site.

The Spartan test launched from Kwajalein did not carry a warhead, though external configuration and most of the components were of tactical design. The flight tested the main propulsion system as well as the missile's structural integrity, response to ground guidance, and controllability in flight.

Spartan test flights will continue from Kwajalein Island while the launching facilities for both the Spartan and Sprint are being built on nearby Meck Island, 17 miles north.

The first model of the Sentinel System's Missile Site Radar (MSR), for detection and tracking of targets as well as for guidance and tracking of the interceptor missiles in flight, also is being constructed at Meck Island.

Sentinel System R&D plans call for the MSR and the Spartan and Sprint interceptors in future tests to engage test targets launched from Vandenberg Air Base in California, 5,000 miles away.

Longer and heavier than its Nike Zeus predecessor, the Spartan is designed for greater power and longer range. Development of the Spartan was commenced in 1965 to give the Army's ballistic missile defense system a wider area coverage with each strategically located battery.

Fifteen to 20 Sentinel System sites, the Secretary of Defense stated last fall, will protect the entire nation, including Alaska and Hawaii, against the limited attacks considered possible by the Communist Chinese. The first Sentinel site in the U.S. is expected to be placed in operation early in the 1970s.

Western Electric Co. is the Army's prime contractor for the Sentinel System. Bell Telephone Laboratories are responsible for systems development and design. Thiokol Chemical Corp. is developing the solid propellant and casting the Spartan motors. McDonnell-Douglas Corp. Missile and Space Systems Division is developing the Spartan missile.

SPARTAN "FOOTPRINT" shows relative area of the United States that could be protected by the 55-foot-long missile which is being developed as a long-range interceptor for the Sentinel antiballistic missile system sites.

WAG Reviews Weapons Materials R&D for SEA

"Obtaining Optimum Effectiveness of In-House Capabilities for Weapons Materials Such as Needed in Southeast Asia" was the theme of the meeting of the Weapons Advisory Group (WAG), U.S. Army Weapons Command, Apr. 2–3.

Brig Gen William J. Durrenberger presided at the sessions at Watervliet (N.Y.) Arsenal. Top scientists drawn from industry, education and U.S. Government research and development organizations participated.

The WAG meets regularly to advise General Durrenberger on scientific and technological matters relative to the WECOM mission, which includes development of artillery, infantry and aircraft weapon systems, combat vehicles, fire control and test equipment, and associated material.

WEAPONS ADVISORY GROUP (WAG) participants at recent Watervliet Arsenal meet included Brig Gen William J. Durrenberger, CG of the U.S. Army Weapons Command; Col Arthur H. Sweeney, Watervliet CO; and WAG member, Maj Gen Chester W. Clark (USA, Ret.), vice president for Research, Research Triangle Institute, Durham, N.C., near Duke Univ.

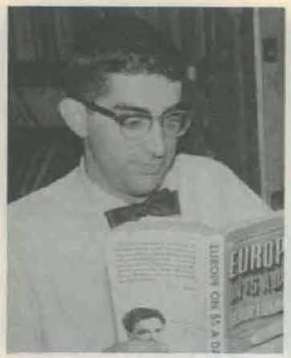
Representatives of Rock Island (Ill.) and Frankford (Pa.) Arsenals participated in discussion of heavy weapons design and development.

Col Arthur H. Sweeney Jr., Watervliet commander, reviewed current R&D activities at that installation. Maj John C. Scholz, chief, Arsenal's Benet Research and Engineering Laboratories; P. K. Rummel, chief, Development Engineering Laboratory; and Dr. Frederick W. Schmiedeshoff, chief, Research Laboratory, gave more detailed briefings.

Other presentations were made by Richard Meyer, development engineer, HQ U.S. Army Weapons Command; W. T. Abell, director of Fire Control Development and Engineering Laboratories, Frankford Arsenal; and Donald R. Wagner, chief, Advance Development and Planning Branch, WECOM.

Tours were made through Watervliet's laboratories, other R&D facilities, and manufacturing areas where the principal production program is currently for gun tubes and breech assemblies of the 175mm self-propelled gun.

Martin Goland, Southwest Research Institute, is chairman of the WAG. Other members are: Maj Gen Chester W. Clark (USA, Ret.), Research Triangle Institute, Durham, N.C.; Dr. William L. Everitt, Dean, College of Engineering, University of Illinois; James A. Reid, Phillips Petroleum Co., Bartlesville, Okla.; Herbert K. Weiss, Litton Systems Inc., Van Nuys, Calif.; Dr. Maurice J. Zucrow, emeritus professor of mechanical engineering, Purdue University; and Dr. Gordon H. Miller, Deere and Co., Moline, Ill.



Don Rubin

LeRoy T. Burrows

Richard N. Gottron

3 Army Engineers Excel in Fluid Dynamics Courses

Three civilian engineers from separate U.S. Army agencies reportedly have excelled in courses at the von Karman Institute for Fluid Dynamics in Belgium and are making significant research contributions.

Attending the NATO-sponsored postgraduate school are Leroy T. Burrows, GS–13, aerospace engineer, Army Aviation Materiel Laboratories (AVLABS), Fort Eustis, Va.; Richard N. Gottron, GS–13, mechanical engineer, Harry Diamond Laboratories (HDL), Washington, D.C.; and Don Rubin, GS–12, aerospace engineer, Army Missile Command (MICOM), Redstone Arsenal, Ala.

Institute Director Dr. Robert O. Dietz recently cited Burrows' project as one that hopefully will produce results "of immediate and significant interest to the U.S. Army gas turbine program." The research is on "The Effect of Meridional Constriction on Turbine Nozzle Performance."

The other Army students' research projects are: "Fluidic Oscillators as Temperature and Concentration Sensors" (Gottron), and "An Intensified Look at the Effect of Expansion Angles on a Turbulent Boundary Layer at M=2.70" (Rubin). All of the projects will be completed this summer.

In a letter concerning continued cooperation of the von Karman Institute with the U.S. Army, Director Dietz wrote that he was "confident that the training and experience that these men are gaining this year will result in improved performance by them when they return to their Army positions."

The letter was addressed to Dr. Ivan R. Hershner Jr., chief of the Physical and Engineering Sciences Division, Office of the Chief of Research and Development.

During the 9-month course, HDL's Gottron—the laboratories' second engineer to study at the institute—served as a "visiting professor" in fluidics. During the 1966–67 academic year, HDL physicist Joseph Kirshner established a fluidics laboratory at the institute by request. HDL already has nominated mechanical engineer John Goto for the 1968–69 session.

The Army has four spaces each year at the institute, as do the U.S. Navy and Air Force. If a space is not filled, it may be allocated to one of the other NATO nations. Institute graduates receive the equivalent of a master's degree in fluid dynamics.

This is AVLAB's third consecutive year of representation at the Belgian fluid dynamics center. Predecessors to Rubin are Donald P. Neverton (1966–67) and Clifton G. Wrestler Jr. (1965–66), aerospace engineers.

BURROWS has been employed at AVLABS since 1964. Assigned to do basic and applied research in the area of aircraft propulsion and related systems, he holds a BS degree in mechanical engineering from Virginia Polytechnic Institute (1960).

GOTTRON was named 1966 Outstanding Young Professional Engineer by the Washington (D.C.) Academy of Sciences and the District of Columbia Council of Engineering and Architectural Societies. With Wilmer Gaylord, he coauthored the $1,000 first-prize technical paper at the 1966 U.S. Army Science Conference.

Gottron is a graduate of the U.S. Military Academy and while on active duty with the Army attended Purdue University for his MS degree in engineering in 1960. He served four years in uniform at HDL, resigned his Army commission and became a research mechanical engineer at HDL in 1964.

RUBIN is in the Aerodynamics Branch of the MICOM Research and Development Laboratory. He holds BS and MS degrees in aeronautical engineering from the University of Alabama, and is the author of several well-received technical reports.

(Editor's note—The following has been excerpted from a von Karman brochure:

To be eligible for admission as a student to the von Karman Institute, the applicant must be a citizen of one of the NATO countries and must be approved by one of the delegates from his own country to AGARD (Advisory Group for Aeronautical Research and Development of NATO). Names and addresses of national delegates will be furnished when application forms are requested.

Correspondence should be addressed to Dr. Robert O. Dietz, Director, The von Karman Institute for Fluid Dynamics, 72 Chaussee de Waterloo, Rhode-Saint-Genese, Belgium.)

Jordan, 32, Promoted to Army General Counsel

General Counsel, Department of the Army, is the distinction that Robert E. Jordan has earned at age 32, after serving in an acting capacity since September 1967. His appointment was announced Mar. 25.

Graduated from Massachusetts Institute of Technology with an SB degree in 1958, he received an LLB from Harvard Law School in 1961. Graduated magna cum laude, he served as editor of the *Harvard Law Review.*

From 1961 to 1963, he served as assistant Post Judge Advocate at Edgewood Arsenal, Md. In 1963, he was assigned to the staff of the President's Committee on Equal Opportunity in the Armed Forces.

Robert E. Jordan

After a year as a special assistant for civil rights in the Office of the Assistant Secretary of Defense (Manpower), he was appointed assistant United States attorney for the District of Columbia in 1964.

From 1965 to 1967, he was executive assistant for enforcement in the Office of the Secretary of the Treasury. In May 1967, he was appointed Deputy General Counsel of the Army.

Qualified to practice in the State of Virginia and the District of Columbia, he is a member of the American Bar Association. He also is admitted to practice before the Supreme Court of the U.S. and the Court of Military Appeals.

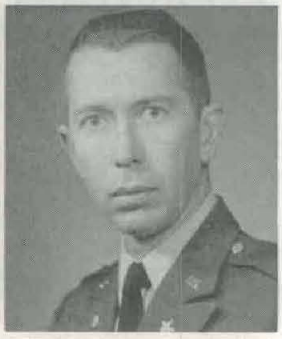
Col T. N. Chavis

Lt Col C. D. McKeown

Jack R. Merritts

Maj T. C. Young

Maj F. C. Berry Jr.



Maj J. E. Schaefer

OCRD Announces 6 Personnel Assignments

Personnel changes in the Office of the Chief of Research and Development this past month included a new assignment for Col Thomas N. Chavis and the addition of four officers and one civilian employe.

Col Chavis, who has served as deputy director, Missiles and Space, OCRD, since September 1967, succeeded Col Francis J. Pallister as director Apr. 1 when he retired from military service.

Col Chavis was assistant chief of staff (G–2), Central Army Group Europe, NATO, for a year until assigned as Assistant Director of Army Research, OCRD, and commander of the Army Research Office in April 1966. He served with the 32nd Artillery Brigade in Europe (1963–65) as executive officer and deputy brigade commander.

Following his first tour of duty in OCRD as a staff officer in the Air Defense Division (1958–60), he served two years with the Army Element, Office of the Joint Chiefs of Staff, Washington, D.C. From 1955 to 1957, he was deputy chief of staff for administration for Operations, Air Defense and Guided Missile Center, Fort Bliss, Tex.

LT COL CHARLES D. McKEOWN is the new executive officer for the Behavioral Science Research Laboratory (BESRL). He served until recently as an adviser with the II Corps in Vietnam.

He served with the 4th Infantry Division at Fort Lewis, Wash. (1961–64), with the Allied Forces Southern Europe (1958–61), and with the 2d Infantry Division, Korea (1952), and was an assistant professor of military science at Georgetown University (1954–57).

Lt Col McKeown received a BS degree in business administration from the University of Florida (1951), an MS degree in psychology from the University of Miami (1957), and graduated from the Command and General Staff College in 1965.

Among his citations and awards are the Legion of Merit, Bronze Star and Army Commendation Medal.

JACK R. MERRITTS, the new executive for administration, OCRD, has followed a career in personnel training and management with the U.S. Government since 1951.

He received a BS degree in secondary education from State Teachers College, Slippery Rock, Pa., in 1943, and an MS degree in education administration from Syracuse University in 1950.

Employed by the Air Force in Washington, D.C., and by the Navy Bureau of Aeronautics in Washington, D.C., and in Argentia, Newfoundland, he received Outstanding Performance Ratings in 1965 and 1966 and the Meritorious Civilian Service Award in 1966.

MAJ THOMAS C. YOUNG, assigned to the Systems Analysis Division, recently received an MBA degree in operations research from Tulane University. He completed the C&GSC in 1966, and served as operations officer, Office of the Dean, USMA, from 1961–64.

In 1964–65, he was an Artillery Battalion adviser, Advisory Detachment 1 in Vietnam, for which he was awarded the Cross of Gallantry with Silver Star. He received the Bronze Star in 1965 and the Army Commendation Medal in 1964.

MAJ FRED C. BERRY JR. was assigned to the Behavioral Sciences Division, Army Research Office, following a tour with the 196th Light Infantry Brigade in Vietnam.

Other assignments have included service with the technical board at the U.S. Army Infantry School, Fort Benning, Ga.; 3d Infantry, Fort Myer, Va.; 32d Infantry, Korea; and 505th Airborne Infantry, Fort Bragg.

Maj Berry completed the Armor Career Course in 1962 and was graduated from the C&GSC in 1965. He has a BA degree in mathematics from Georage Washington University (1961) and an MA degree in communications from Stanford University (1967).

He holds the Bronze Star Medal with V device, and the Army Commendation Medal with Oak Leaf Cluster.

MAJ JOHN E. SCHAEFER has been assigned to the Southeast Asia Division, following duty since June 1967 as deputy director, Security, Plans and Operations, 9th Logistical Command, and as management officer, HQ U.S. Army Support Thailand.

From 1957 to 1964 he served in artillery and ordnance officer assignments in the U.S. and Germany. A 1957 graduate of the United States Military Academy, he received an MSE degree in 1967 from Arizona State University.

ARADMAC Boosting Test Ability With New Computerized Facility

The Army Aeronautical Depot Maintenance Center (ARADMAC), Corpus Christi, Tex., will greatly increase its turbine engine testing capability when its new $1,300,000 computerized engine test cells facility is completed in mid-1968.

ARADMAC has seven working turbine engine test cells, capable of testing out at an annual rate of 4,600 engines. The addition is a 4-test-cell complex, expected to enable ARADMAC to increase its output of engines to an annual rate of 5,500 in 1969, 6,000 in 1970, and 6,500 in 1971.

ARADMAC is the Army's main overhaul and repair facility for the UH–1 helicopters from Vietnam.

Mobility Equipment R&D Center Honors Employes

Scientific, Techological and Leadership Medals for outstanding achievement for 1968 were presented May 10 at the 11th Annual Commanding Officer's Award Ceremonies, U.S. Army Mobility Equipment R&D Center (MERDC), Fort Belvoir, Va.

Army Chief Scientist Dr. Marvin E. Lasser presented the Scientific Achievement Medal to William J. Haas, 29, research electrical engineer.

Col Edwin T. O'Donnell, MERDC commander, awarded the Leadership Medal to E. Donald Hardin, 31, a principal commodity engineer. G. Edwin Burks, chairman of the Mobility Command Scientific Advisory Group, honored Robert A. Rhodes Jr., 38, with the Technological Medal.

Maj Gen Charles C. Case, CG of the Mobility Command, commended the achievements of the award winners and cited their work as exemplary of the many significant contributions to the success of Army research and development by MERDC employes in making the principal address.

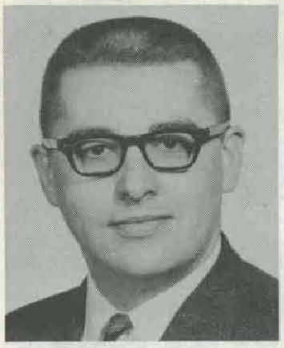
Haas gained recognition for theoretical and computational applied research studies said to have advanced physical understanding of, and computational methods for, the electromagnetic pulse environment produced by nuclear explosions under various burst conditions.

Hardin was cited as the Leadership Medal winner for his diligence, personal sacrifice and devotion to duty which not only "helped solve production problems, but, in many instances, helped correct and prevent problems before production on over $40 million worth of generators. This permitted timely delivery of a quality product to troops in the field."

Technological Achievement Medal recipient Rhodes was selected for "in-house development of the 18–5 MUMS (Mobile Utility Module System) in the short period of 11 months from concept. The 18,000 Btu, 5–kw unit provides air conditioning and heating and electrical power to the field in one package."

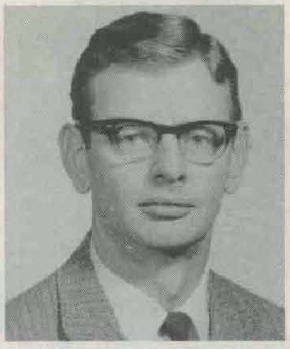
In the preliminary tests, capabilities of the MUMS unit proved so successful that the project manager for Army Area Communications Systems requested expedited completion and production for use in Southeast Asia.

Each of the winners received a commemorative wall plaque, Certificate of Achievement and a $50 cash award. Certificates of Achievement were presented also to 10 additional nominees, as follows:



William J. Haas

E. Donald Hardin



Robert A. Rhodes Jr.

Scientific Achievement: James Wallen Jr. and Maurice Pressman. Technology Medal: Rexford G. Booth, Raul Rodriguez, George F. Hartnell and Harry J. Barker. Leadership Award: John D. Grabski, Henry R. Atkinson, John H. Hopkins and Dr. Frank A. Mueller.

WILLIAM HAAS was graduated in 1961 from Purdue University with a BS degree in electrical engineering and was employed briefly in private industry until he entered military service later that year.

After completing basic training at Fort Knox, Ky., he was assigned to the Army S&E (Scientific and Engineering) Program and stationed at the Mobility Equipment Research and Development Center. He terminated military service in September 1963 and was retained as a civilian employe at the center. Meanwhile he has completed course work for a master's degree at George Washington University, Washington, D.C.

E. DONALD HARDIN was graduated in 1959 from the University of Wisconsin with a BS degree in electrical engineering. He began his Federal Civil Service career that same year with the Milwaukee (Wis.) Office of the U.S. Army Engineer District.

Transferred to the Engineer Procurement Office in Chicago in 1963, he moved two years later to the Mobility Equipment R&D Center, where he is employed in the Electrical Engineering Division.

ROBERT RHODES served 10 years in the Army (1949–59) and then attended the University of South Carolina to complete his work for a degree in mechanical engineering. After four years in private industry, he became a civilian employe of the Post Engineer Office at Fort Belvoir in 1963. In June 1966, he transferred to MERDC in the Environmental Control Division, in which he is still assigned.

Hanby Succeeds Mitchell as RIA Deputy CO

Rock Island (Ill.) Arsenal's new deputy commander is Lt Col John B. Hanby Jr., who succeeded Lt Col C. E. Mitchell, now special assistant to the commanding general, U.S. Army Weapons Command (WECOM) at Rock Island.

Since February 1967, following graduation from the Armed Forces Staff College, Lt Col Hanby had served as the first project officer for the 155mm Close-Support Artillery Weapon System. Previously he was materiel officer of the 2d Infantry Division in Korea.

Lt Col J. B. Hanby Jr.

He was aide-de-camp to the WECOM CG in 1962 and later was assistant to the director of Procurement and Production at HQ WECOM.

Lt Col Hanby received a baccalaureate degree from Pennsylvania State University in 1950 and was commissioned a second lieutenant Artillery after OCS at Fort Sill, Okla. He was an Artillery forward observer during the Korean war and a prisoner of the Communists from September 1952 to August 1953.

Transferred to the Ordnance Corps in 1955, he completed Ordnance School courses at Aberdeen (Md.) Proving Ground before assignment to Germany.

He has an MA degree in industrial management from Babson Institute (1960) and is a graduate of the Command and General Staff College.

COLED-V Computes Combat Loss-Rate in Vietnam

COLED–V, the U.S. Army's latest electronic "recruit" serving in Vietnam, will complete a year's tour in June as the first testbed for computerized data on losses of combat materiel and ammunition expenditures.

The acronym stands for Combat Loss and Expenditure Data-Vietnam. The system is considered the modern approach to warfare logistics in which "highly specific" loss-rate information is portrayed in specific time frames for analysis.

The Army Combat Developments Command (CDC), Fort Belvoir, Va., is project sponsor in cooperation with the U.S. Army Pacific (USARPAC), U.S. Army Vietnam (USARV) and U.S. Army Materiel Command (AMC).

Data-reduction processing and the analysis operation are performed under Army contract with the Research Analysis Corp., McLean, Va.

Lt Col Thomas G. Fulton of CDC heads a data-collection team of seven men from CDC, USARV and AMC stationed at Long Binh, near Saigon.

The COLED–V project calls for field commanders to use forms and newly designed data cards to record regularly their loss of equipment or use of ammunition. With this collection method, data on types of warfare and intensity of combat are clearly designated and correlated with losses and expenditures.

Information from the computer's print-outs includes:

- Ammunition losses, intentionally disposed of by our ordnance specialists, captured or destroyed by the enemy, and ammo expended in action.
- Equipment losses noted by cause —combat or noncombat; by mission, such as search and destroy; and by intensity of combat—heavy, moderate or light.
- Loss-rate factors for specific time periods and time intervals.
- Unit, time and place of loss of materiel or ammo.

When data is collected, it is possible, for example, to determine for any size unit and command the equipment losses and ammo expenditures for a particular geographical area. This can then be related to a particular type of terrain and specific combat operation.

Loss-rate tables developed through computer routines can be assembled to show loss rates versus item density; loss rates versus a man-factor (force population); loss rates by type of combat mission; and loss rates by cause of loss.

CDC officers say it is now possible "to tell the circumstances of any specific combat-type loss from the day of its entry to the date of its elimination from the Army inventory or the subsequent rebuild of the item."

Maj Raymond L. Kervahn, CDC project officer for the COLED–V development, views the volume of information as valuable for planning replacement rates, war gaming, extraction of operational data, and for reconstruction of situations and circumstances of a battle.

The data can also be used to trace weaknesses of high-loss articles and can be used as an input source for field manuals and supply bulletins.

Ultimate objective of the data-collection plan is to develop a meaningful data bank of information that can be used to form a predictive type-loss and expenditure-rate system for the kind of warfare in Vietnam.

Preliminary testing of COLED–V started Apr. 1, 1967, and will end June 30. Data collection began July 1. Results are under study by the Department of the Army.

AFRRI Starts $1.58 Million Gamma Facility

Construction of a $1,587,890 addition featuring a gamma-exposure facility has been started at the Armed Forces Radiobiology Research Institute (AFRRI) in Bethesda, Md.

The 36,000-square-foot addition will increase AFRRI's overall facility by approximately 40 percent, a major increase in the research laboratory space and exposure facilities available to the biological investigative staff.

The gamma-exposure facility will complement the AFRRI other ionizing radiation sources, which include a nuclear reactor, two linear accelerators, and two X-ray generators. The cobalt source will provide investigators with both a new source of ionizing radiation and a standard against which other radiation exposure studies can be compared.

A tri-service command of the Defense Atomic Support Agency, AFRRI conducts research on biological effects of ionizing radiation for the benefit of the military services, national welfare, and the well-being of mankind. Programs range from an analysis of radiation effects on cells and subcellular constituents to the evaluation of total physiological and behavioral response in a radiation environment.

The construction contract for the 4-floor addition was recently awarded to Industrial Engineering, Inc., of Baltimore, Md. The building will also contain offices and laboratories for radiation safety monitoring and support, and information support to include a scientific reference library, conference room and technical publications office.

PRESIDENT LYNDON B. JOHNSON sent his congratulations for more than a half-century of distinguished service when Wilfred "Bricky" Hosking retired recently from federal service at Picatinny Arsenal, N.J. In a letter to Hosking, the Chief Executive commended the director of the Industrial Services Directorate at Picatinny for leadership in the production of ammunition during World War II, the Korean War and the current Vietnam conflict. He recognized Hosking for the "development of the countless employes who have worked under your supervision and the inspiration and example they have drawn from your remarkable career." Congratulating him are Maj Gen Frank G. White, CG, Army Munitions Command, and Col Roger Ray, Picatinny Arsenal CO.

Gerace Takes Command of Natick Laboratories

Brig Gen Felix J. Gerace took command of the U.S. Army Natick (Mass.) Laboratories after serving a year as assistant chief of staff, G4, HQ Eighth U.S. Army, Korea.

General Gerace was executive officer, Office, Assistant Secretary of the Army (I&L), Washington, D.C., until he went to Korea and was earlier the commandant of the Army Logistics Management Center, Fort Lee, Va.

Other assignments have included duty as chief of the Logistics Division, Military Assistance Advisory Group, Laos, and staff officer with the Joint Chiefs of Staff, Joint Military Assistance Directorate in Washington, D.C.

During World War II, he was with the 12th U.S. Army Group in London. Later, he was CO, 543d Quartermaster Group, Europe; staff officer, American Graves Registration Command in Paris; and staff officer, HQ 15th U.S. Army Board, Germany.

In 1948 he became executive officer to the post Quartermaster at the U.S. Military Academy until 1952, when he was assigned as a logistics officer in Germany and France. In 1955 he was reassigned as special adviser on airborne matters to the Quartermaster General in Washington, D.C. He became a division chief in the Office, Deputy Chief of Staff for Logistics, in 1958.

General Gerace is a 1941 graduate of the U.S. Military Academy and earned an MBA degree at Stanford University in 1948. He also is a graduate of the Command and General Staff College, The Infantry School, Armed Forces Staff College, and the Industrial College of the Armed Forces.

Brig Gen Felix J. Gerace

Scientists Find High Winds, Interplay in Mesosphere

High-altitude studies by the U.S. Army aimed at knowledge related to improved communications capabilities have indicated some wind speeds exceeding 220 mph in the mesosphere and strong interplay between the neutral and ionospheric regions.

The interplay discovery conflicts with prevalent belief that ionospheric regions are isolated from the neutral region. It brings into focus the possibility that physical processes in the lower atmosphere may be important to the physical structure of the upper atmosphere.

Extending in altitude from 65 to 85 kilometers (41 to 53 miles), the mesosphere is that part of the earth's atmosphere extending far beyond the stratosphere. It consists of a series of constantly changing layers of heavily ionized molecules.

Meteorologists in the Atmospheric Sciences Office at White Sands (N. Mex.) Missile Range initiated a program for acquiring data from the mesosphere in 1966. The objective was to improve understanding of the circulation of the upper atmosphere and its relation to both the lower atmosphere and the ionosphere.

The WSMR program is part of the U.S. Army's overall study of the upper atmosphere and includes sponsorship and participation in the Meteorological Rocket Network. Studies are directed primarily to development of improved military communications.

In addition, the development and operation of various medium- and long-range systems for detection, tracking and interception of missiles requires data on temperature, wind and density in the upper atmosphere. Involved is the altitude regime corresponding to the stratosphere and mesosphere where reentering bodies may be identified because of changes in their movement due to atmospheric effects.

WSMR meteorologists decided that the region which indicated the greatest possibility for success in their study was the mesosphere. A comprehensive effort to collect and analyze data at this height employed a new high-velocity Loki meteorological rocket and .001-inch diameter radar reflective glass chaff as a passive wind sensor.

As this system proved both reliable and inexpensive, a series of firings was executed at Fort Greely, Alaska (lat. 65° N) in early August 1966. This experiment was designed to investigate thermal atmospheric tides in the mesopause (50 miles altitude).

The theory supporting the study was that continuous irradiation of the polar stratopause (31 miles) region in mid-summer results in elongation of the diurnal heat range. The result, it was postulated, increases the easterly circulation at these high latitudes.

Convergence of this tidal circulation causes vertical motion, resulting in greater zonal flow in the upper mesosphere than in the stratopause region where heat input occurs at middle and low altitudes, it was conjectured.

Prior to the development of this stratospheric tidal hypothesis, models of the polar stratosphere-mesosphere showed maximum flow of 30 to 40 meters per second (mps) in the lower mesosphere at high latitudes; also, that minimum temperatures were over the pole near the mesopause.

Eight wind soundings were obtained over Fort Greely in a 50-hour period. Results showed easterly winds of 10 to 20 meters per second near the stratopause, increasing to 100 mps near the mesopause. These data indicated that a new model of high-latitude mesospheric circulation was in order.

In late July 1967, additional high-velocity Loki firings were made at Fort Greely and at Thule Air Force Base, Greenland (lat. 76° N). This further study was aimed to verify earlier findings and prove that this was a recurring phenomenon.

Results again revealed easterly winds increasing with altitude in the mesosphere, reaching velocity of 80-90 mps near the mesopause over Fort Greely and velocities of 60-80 mps over Thule.

Assuming that the thermal wind relationship is valid in this region, these easterly winds increasing with height indicate warmer air toward the polar mesopause, with the coldest temperature of the earth's atmosphere occurring near 60° latitude in summer.

This initial look at the synoptic structure of the mesopause region provides a rather limited picture. Clearly a systematic synoptic study of this region is required before a comprehensive understanding of the dynamics of the atmosphere can be attained.

Understanding the dynamics at these heights will in turn lead towards applications of this knowledge for improvements in the design and development of electromagnetic propagating devices which operate from lower atmospheric levels in and through these regions.

DA Awards 273 Basic Research Grants in 1967 for $6.29 Million

Basic research grants awarded by the Department of the Army during Calendar Year 1967 totaled $6.295 million for 273 grants to 142 institutions in the United States and in foreign countries.

Taken recently from the report prepared by the Research Programs Office, U.S. Army Research Office (USARO), Office of the Chief of Research and Development, these figures show a decrease from 1966 totals of $9.651 million for 292 grants to 152 institutions.

Statistics were consolidated from reports of grants awarded by the Army Corps of Engineers, Office of The Surgeon General, Army Materiel Command, Army Research Office-Durham (N.C.), the Far East Research Office in Tokyo and the Army Research Office, Arlington, Va.

The smallest single grant of $2,326 to a U.S. institution went to the University of Burlington, Vt. The largest aggregate amount of $291,315 was for eight grants to the University of Pittsburgh (Pa.).

Foreign grants ranged from $662.40 to the Central Research Lab of the Nippon Electric Co., Kanasaki, Japan, to $145,750 for the Institute for Medical Research, Kuala Lampur, Malaysia. All other foreign grant aggregates to any one country were under $100,000.

Listed in the USARO report are grants to universities, colleges, institutes, foundations, laboratories and hospitals in the U.S., Japan, Malaysia, Australia, Canada, Thailand, Brazil, India, Argentina, Chile, Korea, Uganda, Taiwan, Indonesia, Philippines, Sabah, Sarawak, Colombia and Peru.

Other U.S. academic institutions that received grants aggregating more than $100,000 are the University of California at Los Angeles, 7 grants, $190,808; University of Chicago (Ill.), 5 grants, $205,342; Duke University (Durham, N.C.), 5 grants, $152,133; University of Illinois, Urbana, 9 grants, $284,420;

New York State University (Albany), 5 grants, $112,418; New York University (New York City), 8 grants, $220,854; University of Notre Dame (South Bend, Ind.), 3 grants, $103,395; Ohio State University (Columbus), 6 grants, $154,257; and

University of Pittsburgh (Pa.), 8 grants, $291,315; University of Southern California (Los Angeles), 5 grants, $195,011; University of Texas (Austin), 4 grants, $102,766; Washington University (St. Louis, Mo.), 3 grants, $176,397; and the University of Washington (Seattle), 4 grants, $150,422.

Book Traces Guerrilla Warfare from 1908 to Vietnam

Guerillas, a history and analysis from Napoleon's time to the 1960s, by Arthur Campbell; 344 p.p.; 12 maps; The John Day Company, New York; first American edition, Apr. 24, 1968; $6.95.

It was during the war in Spain, between 1807 and 1814, when the Spanish people, in concert with Wellington's British Army, threw off the yoke of Napoleon's military conquest, that modern guerilla warfare was conceived.

Thus Arthur Campbell, British Army lieutenant colonel and author of two previous books, concludes the introductory chapter of *Guerillas*. It is an absorbing history and analysis of this form of military operation, against which he has fought in three widely different campaigns.

Guerrilla is the Spanish word for "little war." The Spaniards applied the term to the irregular bands of warriors who fought during the French occupation. Lt Col Campbell uses the American alternate and British-preferred spelling.

The author treats the major guerrilla wars of the 19th and 20th Centuries one by one, but links the separate accounts with a series of narratives, some in the I-was-there first person. The stories vary in objectivity, but each is a gripping account of courage and cruelty, barbarity and bravery, and of extreme endeavor.

In prefatory comment, the author pins down the first guerrilla warfare to 1908. His closest approach to the war in Vietnam is treated in 60 pages, Parts I and II, Narratives 9 and 10, "Indo-China—1950 to 1954."

He explains the lack of an examination of the present war in Vietnam as follows: "I feel that this war has not yet passed into history and, although the experiences of the French and Vietminh in the Indo-China campaign between 1945 and 1954 point the way to victory over Communism in this area of operations, it is as yet too early to draw conclusions from the present day-to-day happenings in Vietnam."

Lt Col Campbell was born in an Army family and had first-hand experience in guerrilla warfare in Burma, Malaya and Cyprus among other places. At 20 he fought Pathan guerrillas in the Himalayas on the northwest frontier of India. He earned the Military Cross (1949) in Malaya fighting Communist guerrillas and went on to Greece, where his regiment secured the Athens base against Greek guerrillas. He campaigned for two years against the EOKA in Cyprus. His other books are *Jungle Green* and *The Siege*.

Government Fluidics Coordination Group Meets at HDL

Fluidics state-of-the-art information was exchanged by representatives of 35 federal agencies at the eighth semiannual meeting of the Government Fluidics Coordination Group (GFGG), Apr. 16-17, at the Harry Diamond Laboratories, Washington, D.C.

HDL research physicist Joseph M. Kirshner, Fluid Systems Branch chief, presided as chairman. Some 55 representatives of the U.S. Army, Navy, Air Force, National Aeronautics and Space Administration, and the Atomic Energy Commission participated.

Kirshner last year contributed his knowledge of fluid dynamics to the construction of a new laboratory while a student at the NATO-sponsored von Karman Institute for Fluid Dynamics in Belgium.

A major project of the GFCG is preparation of a comprehensive paper on fluidics state-of-the-art, particularly in the U.S. Government. Contributions to a draft paper were discussed as possible additions or items to be incorporated in the final work.

The coordination group was first organized early in 1964 when discussions between Harry Diamond Laboratories engineers and scientists and those of other military agencies sounded the need for coordination to exchange information and minimize duplication of effort.

Twelve agencies were represented at the first GFCG meeting July 18, 1964. Army members today represent 10 Army Materiel Command agencies and the Office of the Chief of Research and Development.

Surgeon General Dedicates $2 Million Army Hospital

Army Surgeon General (Lt Gen) Leonard D. Heaton dedicated Weed Army Hospital, a $2 million Army Medical Service complex, at recent ceremonies at Fort Irwin, Calif.

Named for Brig Gen Frank Watkins Weed, MC (1881-1945), the 41,703-square-foot, one-story building contains a surgical suite, X-ray department, laboratory, 6-chair dental facility and other adjunct and diagnostic accommodations.

Many communication systems, such as television, radio, staff paging, public address, intercommunication and dictating, have been installed for patient welfare and improved operating economy and efficiency.

General Weed's long and distinguished career was marked by success as editor of the Medical History of World War I. He served also as post surgeon and professor of military hygiene at the U.S. Military Academy, West Point, N.Y., and CO of Letterman General Hospital, San Francisco, Calif.

Major RDT&E, Procurement Contracts Total $458 Million

Army contracts of more than $1 million each awarded from Mar. 10 through Apr. 9 for research, development, test and evaluation totaled $458,901,131, as reported by the Office of the Secretary of Defense.

This total included an $85,480,628 contract awarded to Western Electric Co. in March for initial production of the Sentinel antiballistic missile (ABM). The cost-plus-fixed-fee contract was awarded by the Sentinel System Command, Huntsville, Ala. Additional details are covered in a separate article in this edition of the Newsmagazine.

Largest other single contract was $34,207,590 for 5,559 5-ton trucks to be produced by Kaiser Jeep Corp. Three contract actions totaling $19,541,588 went to AVCO Corp. for modifications or definitizations to previous letter contracts for technical nonpersonnel services, supplies, product support and improvement program for T–53 series aircraft engines.

American Hoist and Derrick Co. will get $14,459,620 for wheel-mounted 20-ton cranes for rough terrain and Hercules, Inc., is receiving a $14,361,873 contract modification for production of propellant for 2.75-inch rockets and maintenance of production facilities.

Mason and Hanger, Silas Mason Co., Inc., will load, assemble and pack medium and large caliber ammunition, components and mines for $13,695,853. AH–1G helicopters will be furnished by Bell Aerospace Corp. for $10,727,908.

Continental Motors Corp. will receive $10,079,764 for AVDS1790 engine assemblies and Bell Helicopter Division, Bell Aerospace Corp., is receiving a $9,858,430 order for rotary wing blades, parts and main blade assemblies for UH–1 helicopters.

Metal parts for 8-inch high-explosive projectiles will be manufactured by National Presto Industries for $9,855,441. Federal Cartridge Corp. will produce ammunition and maintain the Twin Cities Army Ammunition Plant (New Brighton, Minn.) for $9,844,170.

General Motors Corp. will get $9,202,622 for 105mm projectile parts and Mack Trucks, Inc., has been awarded a letter contract for $8,278,908 to produce diesel engines for 5-ton trucks.

An additional contract for $7,451,687 is going to Kaiser Jeep Corp. for 1,924 1¼-ton trucks. A $7,148,991 second increment to a 3-year contract awarded in 1966 is going to Wisconsin Motor Corp. for 10- and 20-hp military standard gasoline engines.

Eastman Kodak Co. will receive an additional $6,556,994 for manufacture of explosives and maintenance of facilities. Metal parts for 105mm cartridges will be manufactured by the Kisco Co., Inc., for $6,457,500.

Bulova Watch Co. will receive $5,196,800 for M565 mechanical time fuzes. A contract modification of $5,078,839 will go to AVCO Corp. for T–55–1–11 engine spare parts used in the CH–47 helicopter.

One prototype and five production units of a mobile instrumentation radar system will be produced by the Radio Corp. of America for $4,892,931. Bowen-McLaughlin-York Co. division of HARSCO Corp. will get $4,625,000 for retrofit of M48A1 tanks to the M48A3 configuration.

Martin-Marietta Corp. will provide ground support equipment for the Pershing missile under a $4,500,000 long-lead-time (FY 1969) contract. AVCO Corp. won a $5,499,000 facility contract to establish a second production capability for T–53 helicopter engines.

Northrop-Carolina, Inc., will receive $4,440,800 for the CS–1 riot-control agent. Artillery systems (20mm antiaircraft) will be produced by General Electric Co. for $4,092,000.

Machineguns (7.62mm, M60) with spare barrel and bipod assemblies will be produced in additional quantities by Maremont Corp. for $3,774,154. Pace Corp. will get $3,728,535 for illumination signals and Martin-Marietta Corp. will provide industrial engineering services for the Pershing 1A weapons system for $3,560,339.

XTE–250–1A transmissions with spare parts for M551 vehicles will be produced by General Motors Corp. for $3,555,525. Trainers (XM49–E3) for the Redeye missile system will cost $3,479,000 under a contract with General Dynamics Corp.

Muncie Gear Works, Inc., will receive $3,351,500 for fin and nozzle assemblies for 2.75 rockets. Modification of $3,196,006 to a contract for three months maintenance and operation services for the Integrated Wide

GCA Radar Instructor Modifies Circuit for Safety

Minor modification of the circuit of radar equipment used for military air traffic control will provide increased precision and safety in guiding military aircraft onto runways, results of tests at the U.S. Army Signal School indicate.

The improvement was proposed by Thomas J. Terrana, a member of the Signal School faculty at Fort Monmouth, N.J., who teaches repair of Ground Controlled Approach (GCA) radar equipment in the Surveillance Branch. Army-wide adoption is expected, based on test results.

INSTRUCTOR Thomas J. Terrana assists U.S. Army Signal School student in interpreting Ground Controlled Approach display of AN/TPN–8 radar.

Possibilities of modifying the circuit were investigated after he learned that field Army users of the GCA equipment indicated that greater precision capability in pinpointing the location of approaching aircraft in the runway area was desirable.

Before the change, the display on the GCA scope, which has a reconnaissance range of 10 miles with linear markers a mile apart, did not clearly define the runway approach.

With the modification, the sector embracing the runway approach area is shown by a low-density light, and a bright intensified "strobe beam" marks the exact course for runway landing. This enables greater precision in guiding the pilot.

Only four tiny diodes, costing about 50 cents each, are involved in the circuit modification. Step-by-step wiring instructions have been prepared by Terrana, who states modification of a set can be made in less than two hours.

An electronics troubleshooter for Columbia Broadcasting System before entering military service in the Korean War, Terrana joined the Army Signal School faculty in 1954 and has been teaching repair of GCA equipment since inception of the course in 1956.

Band Communications sites in Southeast Asia goes to Philco-Ford Corp.

Two other contracts of $3 million or more have been awarded to Union Carbide Corp. for dry batteries for radio sets—$3,165,525; and to Atlantic Research Corp. (exactly $3 million) for incorporation of a new design for the explosive opener assembly on a mine system.

Contracts and modifications *under $3 million* include: General Electric Co., $2,972,517, for spare parts for the XM12 armament pod and the M61A1 gun; Jackes-Evans Manufacturing Co., $2,948,990, for 7.62 mm links; AVCO Corp., $2,688,400, for a gas turbine engine component for the UH–1 aircraft; and

Union Carbide Corp., $2,627,235, for dry batteries for radio sets; Chandler-Evans, Inc., $2,512,104, for main fuel controls for UH–1 aircraft; Lehigh, Inc. (Easton, Pa.), $2,499,910, for metal parts for high-explosive warheads for 2.75-inch rockets; and

Southwest Truck Body Co., Inc. (St. Louis, Mo.), $2,497,182, for semitrailer-mounted repair shop equipment; Hughes Tool Co., $2,426,584, for rotary wing blades for OH–6A helicopters; U.S. Steel Corp., $2,422,265, for metal parts for 8-inch projectiles; and

Batesville (Ark.) Manufacturing Co., $2,395,800, for 750-pound bomb nose fuzes; Midvale-Heppenstall Co., $2,325,600 for forging alloy tubes for 175mm guns; Stewart Avionics, Inc. (Brooklyn, N.Y.), $2,237,721, for maintenance of truck-mounted shop equipment; and

Lear Siegler, Inc., $2,168,436, for artillery shell fuze components metal parts; Honeywell, Inc., $2,124,670, for multiplexers and related spare parts kits; General Instrument Corp., $2,090,000, for metal parts for bomb tail fuzes; and

Kilgore Corp., $2,048,910, for parachute illuminating flares; Sylvania Electric Products, Inc., $2 million, for reliability testing and debugging of helicopter radio sets, and Motorola, Inc., $2 million, for classified electronics equipment.

Other contracts and modifications *under $2 million* are: R. C. Can Co., $1,965,600, for fiber ammunition containers for 105mm projectiles; Raytheon Co., $1,956.460, for self-propelled Hawk missile system ground support equipment; United Ammunition Container Corp. (Philadelphia, Pa.), $1,930,320, for ammunition fiber containers for 105mm projectiles; and

Consolidated Box Co. (Tampa, Fla.), $1,915,200, for similar containers; General Motors Corp., $1,842,423, for spare parts for M551 vehicles; Olin Mathieson Chemical Corp., $1,839,178, for 81mm illuminating projectiles; and

Harrington and Richardson, Inc. (Worchester, Mass.), $1,826,016, for 7.62mm gun barrels; Norris Industries, $1,777,279, for 66mm rocket launchers; Philco-Ford Corp., $1,753,999, for Shillelagh engineering services; Hercules Engines, Inc., $1,671,596, for 10- and 20-hp gasoline engines; Eisen Bros., Inc. (Hoboken, N.J.), $1,647,550 for metal parts for 40mm high-explosive projectiles; and

Appalachian Power Co., $1,620,000, for power to support Army Ammunition Plant (Radford, Va.) production requirements; Pace Corp., $1,609,054, for surface flares (M49A1); General Motors Corp., $1,579,240, for T–63–A–5A engines; Raytheon Co., $1,549-500, RF oscillators for Hawk missile system ground equipment; and

Grand Machining Co. (Detroit, Mich.), $1,529,409, for M149 fin assemblies for the 81mm mortar; Teletype Corp., $1,500,000 for electronics equipment; Philco-Ford Corp., $1,444,118, for continued development of the XM140, 30mm automatic gun for UH–1B helicopters; and

National Union Electric Corp., $1,392,650, for metal parts for 750-pound bomb nose fuzes; Page Communications Engineers, Inc., $1,366,475, to engineer, furnish and install communication-electronic subsystems equipment in the EUCOM Command Center (70 percent in Stuttgart, Germany, and 30 percent in Washington, D.C.); and

Collins Radio Co., $1,352,789, for AN/GRC–158 radio sets; KDI Corp., $1,331,200, for metal parts for 2.75-inch rocket fuzes; Raytheon Co., $1,303,250, for metal parts for bomb fuzes; and

National Presto Industries, Inc., $1,299,734, reimbursement for facilities to manufacture metal parts for 8-inch shells (M106); Delaware Valley Armaments, Inc. (Mount Laurel, N.J.), $1,296,000, for point detonating fuzes; Colts, Inc., $1,249,132, for line item repair parts for M16 weapon family; and

Northrop Corp., $1,181,781, for 152mm canisters (XM626); Norris Industries, Inc., $1,181,650, for metal parts for 81mm mortar projectiles; Bell and Howell Co., $1,174,758, for metal parts for 81mm illuminating projectiles; General Motors Corp., $1,158,000 for production improvement program for the T–63–A–5A engine for OH–6A helicopters; and

Wells Marine (El Segundo, Calif.), $1,155,000 for parts to various components of artillery shell fuzes; Lockheed Aircraft Corp., $1,500,000, for ground support equipment for AH56A helicopters; Bell Aerospace Corp., $1,380,000, for three air-cushion vehicles; and

Cumerford Manufacturing Co., $1,343,250, for 7.62mm links (M13); Philco-Ford Corp., $1,273,500, engineering changes in Secure Voice Access System; Mine Safety Appliances Co., $1,300,000, for riot-control agent masks; Hughes Tool Co., $1,148,056, for OH6A helicopter transmission assemblies; and

Raytheon Co., $1,146,650, for 750-pound bomb tail fuzes; Borg Warner Corp., $1,116,900, for 7.62mm links (M13); General Instrument Corp., $1,113,750, for metal parts for 750-pound bomb nose fuzes; Colt's Inc., $1,081,728, for 20-round magazine assemblies for M16 weapons; and

AVCO Corp., $1,071,785, for technical publications in support of T55 and T53 series turbine aircraft engines; Watson Automotive Equipment Co. (Detroit, Mich.), $1,070,304, for 150 ambulance-autos; National Union Electric Corp., $1,052,295, for 750-pound bomb nose fuzes; and

Cummins Engine Co., $1,048,510, for 10-ton truck diesel engines; Alleghany Ludlum Steel Corp., $1,023,207, for 2,026,152 pounds of special clad steel for 7.62mm ball ammunition; and $1 million each to Philco-Ford Corp. for electronics equipment and to TRW, Inc., for classified research and development.

Okinawa Switching Center Joins AUTODIN System

The Automatic Digital Network (AUTODIN) communications system added another link recently with acceptance of the Automatic Digital Message Switching Center (ADMSC) at Fort Buckner, Okinawa.

The Okinawa ADMSC is operated by the U.S. Army Strategic Communications Command (STRATCOM) Long Lines Battalion at Futema as one of eight switching centers in the Pacific Theater.

Other centers are in Hawaii, Republic of the Philippines, Thailand, Guam, Japan and the Republic of Vietnam (2). ADMSCs are also located throughout the United States and in England, Germany and Italy.

AUTODIN is planned as a worldwide system to accept, relay and deliver data, teletypewriter and computer communications between various types and combinations of transmitting and receiving equipment. It is designed to accept, process and deliver digital data at speeds from 60 to 3,200 words per minute.

Kudos

DECORATION FOR EXCEPTIONAL CIVILIAN SERVICE. *Harry F. Vincent* was presented the Department of the Army's highest civilian award in recognition of outstanding service since 1962 as project director, Research and Development Directorate, U.S. Army Missile Command.

MICOM CG Maj Gen Charles W. Eifler presented the award at Redstone (Ala.) Arsenal ceremonies. He cited Vincent's ". . .extraordinary accomplishment in achieving balanced fiscal program and project distribution harmonizing with technical capabilities and in developing a highly skilled professional team in evaluation of air defense systems. . . ."

Vincent received the Meritorious Civilian Service Award in 1966 and has won numerous performance awards during his service at MICOM.

A graduate of Washington University (St. Louis, Mo.), he joined the former R&D Division of the former Army Rocket and Guided Missile Agency in April 1951. He assumed his present position when the Missile Command was activated in 1962 in the Army reorganization.

Nineteen awards in various categories of service were made during March and April to military and civilian personnel of the Office of the Chief of Research and Development.

MERITORIOUS CIVILIAN SERVICE AWARD. *Raymond B. Murray Jr.* received a second MCSA from Chief of R&D Lt Gen A. W. Betts for exceptional performance as program specialist in the Programs Branch, Programs and Budget Division, OCRD, from Apr. 1, 1966 to May 31, 1967. Murray has been in the OCRD since January 1961 and received his first MCSA in May 1963.

Dr. C. Jelleff Carr, chief of the Scientific Analysis Branch of the OCRD Life Sciences Division from May 1963 to June 1967, also received a second MCSA from General Betts for his outstanding service in the U. S. Army Research Office. Dr. Carr has since joined the Federation of Societies for Experimental Biology (FASEB), Bethesda, Md.

Charles M. Goddard, research chemist at the U.S. Army Natick (Mass.) Laboratories, received the MCSA for his courage and prompt action during a laboratory fire. He was cited for extinguishing the blaze which also ignited the clothing of a fellow employee. This category of the MCSA also carries a cash honorarium and the medal is inscribed "For Bravery."

EXCEPTIONAL CIVILIAN Service Award is presented to Harry F. Vincent by Maj Gen Charles W. Eifler, CG of the U.S. Army Missile Command.

LEGION OF MERIT (LOM). *Col Robert A. Smith*, assigned early this year as chief of the Technical and Industrial Liaison Office, OCRD, was cited for his contribution to the success of the U.S. advisory effort in the Republic of Vietnam from October 1966 to October 1967. He distinguished himself "by exceptionally meritorious conduct . . . as Senior Adviser, Quang Tri Province . . ."

The citation further stated that Col Smith "was instrumental in establishing close liaison with United States Marine Corps elements operating in the Province" which resulted in the establishment of a "Joint Sector Intelligence and Operations Center, then personally supervised its operations. . ."

Col Smith also holds two of the highest awards of the Republic of Vietnam—the Cross of Gallantry with Gold Star and the Medal of Honor.

Lt Col William B. Burdeshaw assigned to the Nike-X and Space Division, OCRD, since late 1966, received the LOM for his service as sector adviser, Tuyen Duc Province, Vietnam, from September 1965 to August 1966.

The citation states that he "achieved remarkable successes in combating a strong insurgent influence present in the Province . . . initiated a series of military operations which considerably reduced Viet Cong strength and effectiveness . . . continually demonstrated considered judgement, inspiring leadership and a singularly impressive grasp of the intricacies . . . in the entire spectrum of Revolutionary Development and nation-building activities. . . ."

Col Francis J. Pallister, former director of Missiles and Space Directorate, OCRD, was presented the LOM at retirement ceremonies Mar. 29. Maj Gen Robert E. Coffin, Deputy Chief of R&D, made the presentation.

Col Pallister was cited for "exceptionally meritorious service in the Office of the Chief of Research & Development from July 1964 to March 1968." Under his guidance, the citation stated, the Directorate "functioned in an outstanding manner in a wide range of areas far beyond the normal hardware developments and often served as the initial point of contact for planning in operational doctrinal matters of defense-wide concern. . . ."

Col Tyron E. Huber, Army Medical Corps, who retired May 1 after more than 30 years military service, was presented the Second Oak Leaf Cluster to the LOM by General Betts. He served as chief of the Life

MERDC Honors Senior Woman at Awards Ceremonies

Miss Catherine L. White is the senior woman in point of service at the U.S. Army Mobility Equipment Research and Development Center, Fort Belvoir, Va., and recently became one of the highest ranking woman employes.

A veteran of nearly 28 years of service at the Center, Miss White recently was promoted to management analyst officer in the Manpower/Management Science Division.

Miss White plans and executes the Center's management science programs, including organization and functional alignment, procedural analysis and development, management improvement and work simplification, reports management and work measurement.

A graduate of George Washington University, Miss White entered Civil Service in 1939 and was employed by the Civil Aeronautics Authority until 1940, when she transferred to the predecessor organization of MERDC at Fort Belvoir.

Col Edwin T. O'Donnell, commanding officer, presented Miss White with a promotion certificate at an awards ceremony.

Catherine L. White

Sciences Division, OCRD, for seven years and was a member of The Army Research Council.

Col Huber was cited for "conspicuously superior professional ability" in several areas including the Military Medical Research Program in Southeast Asia and the Malaria Research Program. He has joined the FASEB as a technical consultant.

Lt Col George F. Oliver, staff officer at HQ U.S. Army Combat Developments Command, Fort Belvoir, Va., received the first Oak Leaf Cluster to the LOM from Maj Gen William A. Becker, CDC deputy commanding general.

Sfc Lawrence W. Clements, 34-year-old specialist with the Strategic Communications Command at Fort Huachuca, Ariz., recently joined the relatively small cadre of Army officers and enlisted men who have won the Legion of Merit.

STRATCOM's CG, former Director of Army Research Maj Gen Walter E. Lotz Jr., presented the award to Sgt Clements for his work in resolving a complicated transportable communications equipment problem, for developing "accurate measurement of spurious frequency response from a billionth of a volt, and assisting in development of a more accurate measurement of envelope delay distortion."

On his own time, Clements has earned a BS degree from the University of Maryland and an MS degree from Georgia Institute of Technology, both in electrical engineering. He plans to continue study for a PhD degree.

BRONZE STAR MEDAL. *Lt Col Jay A. Hatch,* Combat Materiel Division of OCRD, received this award for heroism from General Betts. Assigned to OCRD in mid-1967, Lt Col Hatch was cited for distinguishing himself in action on 10 January 1967, while serving as commanding officer of the 2d Battalion, 12th Cavalry, during a search and destroy mission in the Republic of Vietnam.

Flying repeatedly in his command helicopter under extremely adverse weather conditions, he supported his unit with "dauntless courage" which proved a "great inspiration to his troops. . . ," the citation stated. His aircraft was downed by enemy ground fire but he ordered another and returned to the battle area.

JOINT SERVICE COMMENDATION MEDAL. *Lt Col Joseph T. Adinaro,* deputy commander of the U. S. Army Strategic Communications Command—Continental U. S., Suitland, Md., received the JSC Medal Apr. 16. He was commended for his work as chief, Transmissions System Branch of the Plans Division, Defense Communications Agency.

His planning concepts and procedures "greatly enhanced the orderly programing, funding and implementation activities of the Military Departments in the extension, expansion and modernization of the world-wide Defense Communications Agency . . . ," the citation stated in part.

ARMY COMMENDATION MEDAL, *CWO Severt L. Sundine,* U.S., Army Engineer Reactors Group at Fort Belvoir, Va., received a Third Oak Leaf Cluster to the Army Commendation Medal from Lt Col Viekko E. Jardstrom, chief of the Nuclear Power Field Office.

CWO Sundine was commended for exceptionally meritorious service from Feb. 15, 1965 to Dec. 31, 1967 as resident nuclear inspector in supervising the contractor construction and testing of the *Sturgis,* recently dedicated first floating nuclear power plant in the world.

COMMENDATION CERTIFICATES. General Betts presented Outstanding Performance Rating certificates to *Dr. Marvin E. Lasser,* Army Chief Scientist; *Mrs. Glenna B. Hester* of Dr. Lasser's office; and *Mrs. Nora L. Comer* and *Mrs. Cathleen R. Durkin,* both of the OCRD Office of Administration.

Deputy CRD (International Affairs) Brig Gen Kenneth F. Dawalt presented OPR certificates to *Miss Joyce P. Webb, Robert J. Facey* and *Alfred F. Birra,* all of the International Office.

OCRD Director of Plans and Programs Brig Gen Thurston T. Paul Jr. presented OPR certificates to *Paul V. Dobrow* and *Mrs. Mary B. O' Connor* of the OCRD Management and Evaluation Division; *Austin L. Duncan* and *Albert T. Finnell* of the Programs and Budget Division and *Mrs. Sherrie L. Collison,* Plans Division.

Four Awards Recognize Mallard Project Personnel

The Mallard Project first anniversary ceremonies Apr. 10 at Fort Monmouth, N.J., were highlighted by presentation of four awards to project personel for outstanding performance of duties.

Maj Gen Paul A. Feyereisen, U.S. program/project manager for Mallard, presented the Legion of Merit to U.S. Air Force Col David S. Woods, U.S. assistant deputy manager for Mallard. The award was in recognition of distinguished service as director of Communications-Electronics (J–6), HQ U.S. Strike Command.

Loren D. Diedrichsen, chief of the Systems Division in the Mallard Project Office, received the Meritorious Civilian Service Award for "exemplary" performance as one of the key figures in preliminary planning before international ratification of the Mallard undertaking.

Other awards were a Certificate of Appreciation to U.S. Army Capt Ariel L. Adams Jr. for "exceptional meritorious performance" as Mallard security officer, and a Certificate for Outstanding Performance to Mrs. Louise M. Pierce, a Mallard secretary.

The Mallard Project is an agreement between the U.S., Canada, Australia and the United Kingdom to develop a long-range communications system for the nations' field armies, elements of their navies, air forces and the U.S. Marine Corps.

Col David S. Woods

Loren D. Diedrichsen

Capt Ariel L. Adams Jr.

Louise M. Pierce

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million, plus $48.3 million to be recouped from prior years for a total of $1,554.0 million.

This $1,554.0 million is being reduced by a proposed transfer of $100 million to O&MA (Operations and Maintenance) funds and $127,000 in rentals to General Services Administration. The program was increased by $12.0 million reprogramed from FY 67, $39.6 million in emergency funds and a supplemental appropriation request for $8.2 million to cover the cost of the civilian pay raise. The current program being executed is for $1,513.7 million.

Table 2 compares the FY 69 budget request to the FY 68 program as it is being carried out by budget activity and Table 3 provides a comparison by program category.

TABLE 2

Summary by Budget Activity
($ in Thousands)

	FY 67	FY 68	FY 69
Military sciences	158.5	153.5	172.2
Aircraft and related equipment	115.9	133.1	100.1
Missile and related equipment	715.5	658.8	772.9
Military astronautics and related equipment	15.9	8.3	10.6
Ships, small craft and related equipment	.6	.1	.6
Ordnance, combat vehicle and related equipment	192.4	166.7	175.7
Other equipment	311.9	313.8	339.4
Program-wide management and support	80.5	79.4	90.4
Total	1591.2	1513.7	1661.9

TABLE 3

Summary by Program Category
($ in Thousands)

	FY 67	FY 68	FY 69
Research	84.2	78.5	92.1
Exploratory development	222.5	210.8	230.4
Advanced development	196.5	201.5	374.5
Engineering development	537.7	500.9	167.2
Management and support	264.2	255.2	274.1
Operational systems development	286.1	266.9	523.7
Total	1591.2	1513.7	1661.9

Table 2 is the traditional grouping of RDT&E effort, primarily commodity/industry-oriented. Table 3 represents the application of funds to the various phases of RDT&E. Another approach to analysis of the program is reflected in Table 4 and 5. In these tables, the program categorization of Table 3 is shown by the budget activities of Table 2. Tables 4 and 5 will be used as the base for discussing the FY 69 program.

Before discussing details, there is one other pertinent program segmentation that deserves mention.

About 32.7 percent of the request is devoted to Army tactical developments, programs that are essential to maintain our defense posture.

Army tactical developments include major developments of weapons systems such as the Cheyenne and Huey Cobra helicopters, tanks such as the M60A1E1 and Main Battle Tank (1970s), air-defense weapons systems such as Redeye, Vulcan/Chaparral and SAM–D, artillery, and the many items required by the fighting soldier.

New obligation authority proposed for FY 69 for this category is more than FY 68, but nearly the same as the new obligational authority for FY 67. R&D devoted to Southeast Asia has increased very markedly in the last three years and is making a significant contribution, particularly in personnel detection, night-vision devices and counter-mortar radar.

The budget allows 19.4 percent for scientific research and development of technology directed toward future systems. In order to meet our objectives of more effective weapons systems and equipment, we rely heavily on the results of research and exploratory development. The request for FY 69 is about the same as the average for the last four years.

Testing and facility operations represent 8.5 percent of the budget. Testing confirms that development items or systems will fulfill their military purpose. The essential supporting and operating costs of Army RDT&E installations and activities are also included in this segment.

National Programs account for 39.4 percent of the budget consisting of projects that are part of the overall national defense requirements. These include Ballistic Missile Defense, the operation of the White Sands and Kwajalein missile test ranges and the Deseret Test Center. The proposed increase in 1969 is due largely to the decision to deploy a defense against ballistic missiles (the Sentinel System).

The largest of these National Programs are the Sentinel System and the Nike-X Advanced Development Program, with the associated test site at Kwajalein. Sentinel and Nike-X Advanced Development constitute 73 percent of the National Programs segment, and 29 percent of the total Army RDT&E program.

The FY 69 program may be best summarized by a description of the budget activities as they appear in Table 3.

Military Sciences. This program is directed to new ideas and concepts. It finances basic research, where the goal is primarily an increase in the reservoir of fundamental knowledge adaptable to the solution of widely variant future operational requirements. As can be seen from Table 3, research has been reduced in FY 68 from the FY 67 level. In FY 69, an increase has been recommended, with the objective of restoring the program to a viable level. While there is a general increase in all areas, biological-medical sciences, behavioral and social sciences, and the University Program (THEMIS) have significant increase from FY 68.

Exploratory Development in this program is the sustained-level-of-effort type. Increases are expected in information processing, intelligence electronic warfare, surface mobility studies, materials, military personnel performance, military training leadership, defense-operations-related social analysis and biological-medical investigations.

Nuclear investigations and environmental studies will continue at reduced rates. Efforts to improve medical care continues to receive high priority. In the field of social and behavioral sciences, effort is directed to solving the age-old problem of fostering good relations between local people and foreign soldiers.

Advanced Development funding is for education and training innovations. The decrease reflects a change in funds for work on a helicopter/VTOL synthetic training system.

The Studies and Analyses Program in the Management and Support category funds contracts for essential studies in support of the Department of the Army staff and major commands. Studies and analyses assist the Army in the preparation of strategic estimates and plans, the technological forecast, and the assessment of the impact of technology on future land combat.

The program covers studies in the areas of future alternative force structure and logistic and weapon systems; also, development of concepts and the selection of specific weapon systems and organizations needed by the Army of the future.

TABLE 4

President's Budget
FY 1968 Column of FY 69 Budget ($ Millions)

	6.1 Rsch	6.2 Expl Dev	6.3 Adv Dev	6.4 Eng Dev	6.5 Mgmt & Spt	6.7 Opn Sys Dev	Total
BP 5000 Military Sciences	78.5	61.0	2.5		11.5		153.5
BP 5100 Aircraft		20.4	21.8	30.8		60.1	133.1
BP 5200 Missiles		27.4	60.9	361.7	113.5	95.3	658.8
BP 5300 Military Astronautics			8.3				8.3
BP 5400 Ships, Small Craft				.1			.1
BP 5500 Ordnance, Combat Vehicles		46.9	19.2	34.8		65.8	166.7
BP 5600 Other Equipment		55.1	88.8	73.4	51.5	45.0	313.8
BP 5700 Mgmt & Support					78.7	.7	79.4
Total	78.5	210.8	201.5	500.8	255.2	266.9	1513.7

TABLE 5

President's Budget
FY 1969 ($ Millions)

	6.1 Rsch	6.2 Expl Dev	6.3 Adv Dev	6.4 Eng Dev	6.5 Mgmt & Spt	6.7 Opn Sys Dev	Total
BP 5000 Military Sciences	92.1	67.4	1.2		11.5		172.2
BP 5100 Aircraft		25.1	19.9	29.7		25.4	100.1
BP 5200 Missiles		31.2	232.9	6.3	116.9	385.6	772.9
BP 5300 Military Astronautics			10.6				10.6
BP 5400 Ships, Small Craft				.6			.6
BP 5500 Ordnance, Combat Vehicles		47.5	24.2	44.5		59.5	175.7
BP 5600 Other Equipment		59.1	85.7	86.1	56.0	52.5	339.4
BP 5700 Mgmt & Support					89.7	.7	90.4
Total	92.1	230.3	374.5	167.2	274.1	523.7	1661.9

Aircraft and Related Equipment. Work in this activity advances the state-of-the-art in air mobility and aerial firepower. Funding for this important program is lower than FY 68, due primarily to the stage of development that the Cheyenne (AH–56A) armed helicopter has reached.

Exploratory Development continues in the area of aircraft weaponization, avionics, aeronautical research and air mobility. In this latter area there are two important items. Work will be increased in attempts to reduce the detectability of Army aircraft by design and development of countermeasures, reduction of noise levels and infrared signature suppression. Another highly important area is Reduction of Vulnerability of Army Aircraft.

Fire is the greatest killer in aircraft accidents. The Army's goal is to reduce the aircraft fire hazard by 95 percent. This effort is being pursued in two major areas; improved containment of raw fuel, and reduced volatility of fuel through development of semisolid emulsified fuels.

Most promising for fuel containment is the development of a nylon basket-weave material called ARM–021 and its self-sealing counterpart, ARM–024. This material provides a six-to-one improvement over present fuel tanks.

Since the vaporization of fuel plays such a significant part in post-crash fires and explosions, the U.S. Army Aviation Laboratories have engaged in research for less volatile fuels. Emulsified fuels can be produced by relatively simple facilities, and can be passed through the nozzle of jet engines without difficulty.

Our goal is to complete development of the ARM–021 crash-resistant fuel cells for the training UH–1 aircraft within six months, and also to develop the crash-resistant self-sealing fuel cells for Vietnam on an accelerated basis. Development and experimentation with emulsified fuels will continue in coordination with the other military services.

Advanced Development will continue at a somewhat reduced level from FY 68. Component development and test and a complete engine test are planned for the Aircraft Demonstrator Engine project. Avionics and aircraft weaponization will continue, as will work on improving rotary-wing aircraft and concept formulation of follow-on Army aircraft.

Engineering Development will remain at about the FY 68 level. Avionics systems, aircraft weaponization, engines and supporting items for air mobility are the major areas of effort. In this latter area, effort is continuing on armor protection for all the Army's helicopters.

Combat experience in Vietnam has demonstrated that the vulnerability of helicopters to ground fire has been far less than predicted. Recent statistics reveal that only one helicopter is shot down for every 6,300 combat sorties flown; only one helicopter for 23,000 combat sorties is unrecoverable. This is due, in part, to the armor kits for critical components and armored seats that have been developed for helicopters.

The interim armed helicopter, the Huey Cobra, was developed and deployed in Vietnam pending development of the Cheyenne. It was introduced into Vietnam during last August.

The internal armament subsystem of the Huey Cobra is the TAT–102A flexible turret, containing one 6-barrel, 7.62mm machinegun. The Huey Cobra can carry up to four pods of 2.75-inch rockets. Each pod has 19 tubes and a 7-tube pod is available. Two minigun pods, the XM–18, are interchangeable with two of the rocket pods. Each carries 1,500 rounds of ammunition. They are fired by the pilot, who aims the entire helicopter.

The XM–28 turret is being developed to replace the TAT–102. The XM–28 can hold two miniguns, or two 40mm grenade launchers, or one of each.

The Army is continuing development of the AH–56A Cheyenne, the most advanced design available. This program is on schedule and the first prototype was completed in April

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1967, one year after award of the development contract to Lockheed Aircraft Corp.

The first flight was completed in September 1967 and 5 of the 10 prototypes in the development program have been completed. Flight testing to date has been eminently satisfactory. The U.S. Government exercised a production option with Lockheed in January 1968 for 375 AH–56As and the first production aircraft will be delivered in September 1969.

The AH–56A Cheyenne is the fastest, most maneuverable helicopter in today's U.S. military inventory. This weapons system is a stable, all-weather, 2-place manned, compound helicopter featuring a rigid rotor, a pusher propeller and retractable gear.

It has armor protection for crew, engine and vital components. A self-contained doppler inertial navigator system provides for accurate battlefield movement without reliance on external navigation sources.

Missiles and Related Equipment. This budget category, the largest in the R&D program, finances work on surface-to-air and surface-to-surface missile systems and support equipment. It also finances the operation of two national missile ranges operated by the Army—White Sands (N. Mex.) Missile Range and Kwajalein Test Site in the Pacific.

Exploratory Development is directed to solutions of missile problems in such areas as guidance and control, aerodynamics, electronic countermeasures, launchers, vulnerability and warheading. Effort is also directed to expanding knowledge in propulsion, both propellants and motors. Plans are for propulsion effort to be restored to the FY 67 level of effort.

The content of the Advanced Development segment will change considerably in FY 69. As can be seen by comparing Tables 4 and 5, about $172 million more is requested in FY 69 than FY 68. The major increase is attributable to the Nike-X Advanced Development Program and is relatable to the Sentinel System Program.

The Sentinel System is being developed to be very effective against the light, unsophisticated attacks that the Chinese Communists are capable of launching against the United States during the mid-1970s.

If the Chinese threat increases in size and sophistication, some modification in the existing Sentinel System may be required to maintain its high degree of effectiveness. It is possible to accomplish this against the most probable Chinese improvements by quantitative means; that is, we could increase the number of Sentinel interceptors and radars. This alternative, however, could be an expensive one to implement.

A more attractive alternative is to increase Sentinel effectiveness qualitatively; that is, by introducing new components or techniques to counter the improvements in the Chinese ICBM. A major mission of the Nike-X Advanced Development Program is to investigate these possible qualitative improvements and to develop those that appear most promising.

A major item in this program is the Tactical Multifunction Array Radar, or TACMARK, under construction at Kwajalein Test Site.

Another major item in our Nike-X Advanced Development is our reentry physics research, including development of discrimination techniques. This continuing program was initiated in FY 64.

Reentry Measurements Program A was the initial stage in this effort and it was highly successful. It contributed greatly to our knowledge of reentry phenomena, and aided the development of penetration aids for our strategic offensive forces.

Reentry Measurements Program B, our current effort, began its flight series in June 1967. Funds in the amount of $165.0 million are requested for FY 69 to continue this advanced development.

Another major factor in the increased effort in Advanced Development Program relates to forward-area air defense. An increase in funding is requested for supporting research and study effort to define forward-area air defense systems for the post-1975 time frame.

SAM–D (Surface-to-Air-Missile Development) is the Army's newest program for an air-defense weapons system. The system as now conceived has evolved from the earlier concepts of the Field Army Ballistic Missile Defense System and Army Air Defense System for the 1970s.

The principal requirements that SAM–D must meet are: multiple simultaneous engagements, short-reaction time, defense against short-range ballistic missiles and a high degree of mobility.

The Army sees SAM–D as a replacement for both of the current air-defense weapons systems, Nike-Hercules and Hawk, resulting in a 50 percent saving in manpower. SAM–D, now in advanced development, could be used in both the Continental United States and overseas areas. We have built components to insure that the technology is at hand.

As a result of the Sentinel System deployment decision and the establishment of the Nike-X Advanced Development Program, the Engineering Development budget segment contains only work directed to the development of targets and ancillary equipment to be used in evaluating and testing air defense missile systems and in training air defense troops.

Management and Support provides for operation of the two national ranges. They provide missile-test facilities for the Army, Navy, Air Force and the National Aeronautics and Space Administration. The Nike-X tests discussed previously are being carried out at these two ranges.

Kwajalein has become a center for the testing for our strategic offensive and defensive missile systems. Current activities include construction of facilities at Meck and Kwajalein Islands for future testing of the Sentinel System; Nike-X Advanced Development testing at Kwajalein; Advanced Research Projects Agency reentry signature studies at Roi Namur; and strategic offensive missile tests along the mid-atoll corridor, with impacts into the lagoon.

The workload at White Sands Missile Range continues to grow in support of various missile programs such as Pershing, Sprint, Hawk, Redeye, Talos and Athena. Improved range instrumentation and the ability to conduct off-range launches enable White Sands to support these programs.

Technological advances in weaponry require equal advances in range capabilities. Both national ranges have ongoing instrumentation development programs to meet future user requirements.

Operational System Development as a budget category is further separated into Strategic Forces and General Purpose Forces. The first subcategory contains the RDT&E effort specifically directed to the Sentinel System; deployment will require $312.9 million in RDT&E funds for FY 69.

The principal components of the Sentinel System are the Perimeter Acquisition Radar (PAR), the Missile Site Radar (MSR), and the Spartan and Sprint missiles. PAR is a long-range detection radar that has the function of detecting the enemy's missiles; it can track multiple targets while continuing its search role for

new targets. As it tracks the incoming targets, it processes data to the MSR.

The MSR can track multiple targets as well as provide the command and control guidance to Spartan and Sprint interceptor missiles. For the engagement of an enemy's attacking reentry vehicles, the long-range Spartan missile will be the primary defensive missile.

In the event our early warning system is attacked and there should be leakage through the Spartan engagement, the Sprint missile, a highly responsive, accurate interceptor, will be committed around certain high-value areas to engage the enemy's reentry vehicle within the atmosphere.

Under the General Purpose Forces subcategory is funding for work on our other missile systems. Included are Nike Hercules, Hawk, Pershing, Land Combat Support Systems, Vulcan/Chaparral and Lance.

Military Astronautics and Related Equipment. The major Army project in this area is that of providing the ground environment elements of the Department of Defense Satellite Communications Program, one of the national programs.

In satellite communications, the R&D worldwide terminals of the Initial Defense Satellite Communications System became operational in 1967. FY 68 funding provided for the upgrading of the transportable terminals from 5 to 11 voice channels and for making these terminals more reliable. In addition, the Army has deployed for operational use a new, highly transportable terminal.

The Tactical Satellite Communications Program is a tri-Service effort aimed at eventually providing the tactical elements of the Army, Navy, Air Force and Marine Corps with reliable communications both within and outside the combat theater. In this program, we built five tactical terminals in-house and successfully tested them with the improved Lincoln Experimental Satellite No. 5.

During FY 68, the Army is developing for field use 18 tactical satellite terminals configured for manpack, vehicles and helicopters. FY 69 funds will provide for two super-high-frequency helicopter antennas and the communications processing equipment needed for all terminals.

Ships and Small Craft. The Army's development activity is directed toward the use of harbor tugs, lighters and amphibious cargo carriers. A portion of this effort, in coordination with the U.S. Navy, involves preparation of design criteria and a data base for future Army marine craft and amphibian requirements. Our principal development continues to be a Beach Discharge Lighter for use with Navy Roll-on-Roll-off ships. In FY 69, our RDT&E effort consists of monitoring Navy-contracted construction and testing.

Ordnance, Combat Vehicles and Related Equipment. This program provides for ground firepower delivery systems (other than missiles), munitions, weapons and vehicles. Exploratory Development will continue at about the same level as FY 68.

Effort is directed to development of components and techniques to improve effectiveness of operation and maintenance of land combat and transport vehicles, chemical/biological weapons, supporting R&D for firepower (other than missiles) in small arms, mortar, cannon, infantry antitank weapons, artillery, fuzes, fire control, ammunition, gun propellants and pyrotechnics. A project of special interest is the development of caseless ammunition and combustible cartridge cases.

Advanced Development effort is programed to increase primarily in the small arms and advanced artillery weapons and ammunition areas. Power systems and converter work will increase as will mine warfare and CB weapons.

Engineering Development also increases from FY 68, although only back to the FY 67 level. Infantry individual and supporting weapons increases due primarily to work on vehicle rapid-fire weapon systems. Field Artillery weapons remains relatively level as does Nuclear Munitions. Work continues on wheeled vehicles, mines and CB weapons. Track and Special Vehicles effort will increase primarily for a mechanized infantry combat vehicle and an armored reconnaissance scout vehicle.

Effort in the Operational Systems category shows a decline. This can be attributed to the heavy antitank weapon, TOW, having reached the engineer/service test phase, and to the status of development of the Main Battle Tank. Work on Shillelagh and the Dragon (medium antitank assault weapon) will continue at about the same level as in FY 68.

Other Equipment. This activity provides for a broad range of materiel and equipment that cannot be directly associated with previously discussed activities. It includes communications-electronics, electronic warfare, surveillance and target acquisition, night vision, mapping and geodesy, chemical/biological defensive measures, and general combat support. Testing is an important effort financed in this activity.

Exploratory Development work includes support of communications-electronics, airborne and ground surveillance and target acquisition, electronic devices, mapping and geodesy, and night vision. Work also will continue on CB (chemical-biological) defensive measures and combat support requirements.

Advanced Development efforts will continue on electric power sources, automatic data system for the field Army, surveillance and target acquisition, intelligence and electronic warfare, night vision, RADA, The Mallard Project, CB defense and malaria prophylaxis.

Engineering Development will increase substantially, including strategic, tactical and supporting communications effort, electronic warfare, surveillance and target location efforts. Training devices will be increased primarily for work on a synthetic flight-training system. General Combat Support has the largest increase, primarily for work in support of SEA.

Management and Support provides for the operation of the U.S. Army Electronic Proving Ground (Fort Huachuca, Ariz.) and for testing. The objective is to confirm the acceptability of developmental items or systems to fulfill the intended military purpose.

Operational System Development is directed to electronic warfare systems, a tactical fire-direction system (TACFIRE), and intelligence and communications.

Program-Wide Management and Support. This program provides for expenses incident to the operation of RDT&E facilities not chargeable to specific projects. This covers support of facilities and installations, management costs and special-purpose equipment.

Beginning in FY 69, a share of the expenses for major headquarters below Department of the Army level with an RDT&E mission will be charged to this program. The FY 69 program provides for the initial establishment an support of the Army Corps of Engineers Construction Engineering Research Laboratory under a lease agreement with the University of Illinois Foundation.

The FY 69 program is an austere program, even though in total funding it exceeds the FY 68 level. It makes provision for support of known requirements for SEA, and for continued support for the Ballistic Missile Defense Program. The balance of the funds will provide a bare-minimum, planned program for continued technological progress of the Army.

Counterfield Magnetic Joining Coils

By Joseph E. Kirshtein

Magnetic forming and joining operations have long been utilized in the production of various parts and assemblies. However, little information had been developed, until recently, concerning potentially damaging effects of the developed electromagnetic and sonic fields on electromechanical parts internal to tubular structures which are to be magnetically joined.

The U.S. Army Missile Command at Redstone Arsenal, Ala., has recognized the potential benefits of magnetic joining of missile sections and has sponsored a study of "Magnetic Forming Effects on Electrical Components (In Magnetic Joining of Missile Sections)."

This study was part of a continuing Manufacturing Methods and Technology Program covering the development and evaluation of new manufacturing methods and the improvement of manufacturing technology. This effort was performed under contract by Advanced Kinetics, Inc., Costa Mesa, Calif.

Parameters have been determined by this study for forecasting fields internal to missile sections to be magnetically joined. Methods also have been developed for avoiding potentially damaging effects on components and assemblies contained therein prior to the joining operation.

A substantial amount of new knowledge developed under this study is contained in the final report (Defense Documentation Center Acquisition No. 816-532). It is interesting to note the development of several counterfield coil concepts which substantially decrease fields internal to the missile structure, while maintaining the capability of accomplishing adequate joints between the missile sections.

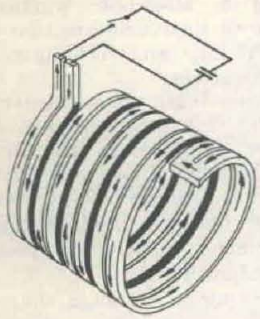


Fig. 1. Basic Multiturn Counterfield Coil

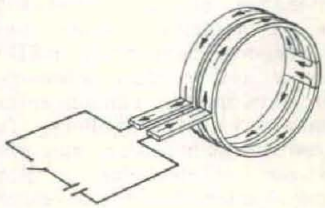


Fig. 2. Special Counterfield Coil

Basically, counterfield coils are so constructed that adjacent turns are wound in opposing directions (see Figure 1), thus developing opposing fields. This substantially weakens fields internal to the missile shell, while maintaining suitable magnetic fields immediately under the turns to interact with the tube surface current to generate the magnetic pressure necessary for the joining operation.

Two other coil concepts developed during the course of the study are adaptations of the basic counterfield coil configurations, in that they do not rely on helically wound coil constructions.

One of these configurations consists of two interconnected adjacent closed loops, with the interconnection parallel to the common axis. One power connection is made to each loop at locations diametrically opposite the interconnection points (see Figure 2).

One result is that each loop has upper and lower half current paths in opposing directions; adjacent loops have opposing current directions in their upper halves and in their lower halves.

The other adaptation of the basic counterfield coil concept consists of two half loops connected in series so that the current paths in the two segments are in opposing directions (Figure 3a).

This configuration appears to have certain advantages over another form of this concept (figure 3b), which would utilize two diametrically opposed connections on one complete loop to obtain similarly opposing current paths. The series circuitry of the preferred version assures equal currents in the two loop segments and implies a capability for separation of the coil segments to facilitate loading and alignment of tubular sections to be joined.

It is considered that counterfield coil philosophy and other data developed under this study effort will be of distinct value in missile system production. In fact, the basic information developed is presently being adapted to application in one specific missile system.

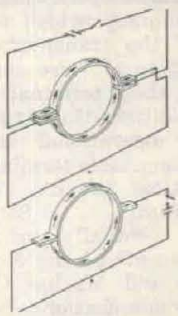


Fig. 3a and b. Special Counterfield Coils

Further, the magnetic forming and joining data necessary to this study is of such nature as to be of substantial value in a wide range of applications, not necessarily restricted to those instances where internal fields are of major concern.

Magnetic swaging coil concepts described in this article are covered in a patent application filed by Advanced Kinetics, Inc. The U.S. Government has a non-exclusive, royalty-free license under the patent application.

Employed at the U.S. Army Missile Command, Redstone Arsenal, Ala., since October 1958, Joseph E. Kirshtein is serving as the Missile Command coordinator for the U.S. Army Materiel Command Manufacturing Methods and Technology Program.

During the past five years, he has been a senior project engineer and staff consultant, concerned principally with manufacturing methods improvement and production problem resolution. He is currently the Missile Command representative on the Ad Hoc Working Group for an engineering design handbook, "Design Guidance for Producibility."

For six years he was employed at Frankford Arsenal, Philadelphia, Pa., as an engineer in the Fire Control Sub-Office, Office of the Chief of Ordnance. He worked eight years in various manufacturing fields, two years in engineering sales, and two years in warehousing-processing plant construction.

Joseph E. Kirshtein

CASSA Aims to Standardize CONUS Armies' ADP

Standardization of all computer and related electronic hardware used by the five numbered Armies in the Continental United States is the goal of the new Continental Army Command Automated Systems Support Agency (CASSA), Fort Eustis, Va.

Col Ralph J. Hanchin, CASSA commander, said that "from a financial standpoint alone, if computer systems were standardized and devised at a central point, the savings would be phenomenal."

The 4-month-old agency is charged with development and installation of standard automatic data processing systems required by management for efficient operation of Army activities. The systems will be advanced in design and will have communications capabilities.

Frank Muguira, CASSA technical director, expects installation of third-generation computers and "remote" units will begin soon at 15 Army posts throughout the United States. Present plans are to set up 20 additional computer complexes during FY 1970.

CASSA's computer configuration—the IBM 360/30—is scheduled to arrive at Fort Eustis this month. Most of the agency's immediate effort, Muguira said, will be aimed at developing computer programs, eliminating problem areas and testing the results of the CASSA complex.

Each of these computers is capable of retaining up to 370 million bits of information. With the communications system, isolated units will be able to "talk" to each other.

The CASSA staff is expected to total about 135 by June, increase to about 280 during FY 1969 and reach a peak around 400 in FY 1970.

Computer systems analysts and programers will be most numerous. A smaller segment will be "subject matter personnel" including logisticians, personnel management specialists and administrators. Other technical information specialists will translate requirements into understandable terms for the analysts.

CASSA also will be required to maintain the standard systems it develops. The computer operator training course at CASSA will enable trained operators to be proficient at any of the complexes, with minimal adaptation required for installations with slight variations.

Muguira said the major cost of operating a computer is in training and salaries and that rental of the machines is "relatively inexpensive." Because CASSA systems will be universally applicable, he explained, "we will pay for specific programing only once."

Col Hanchin said that creation of CASSA was "inevitable" because of the increasing complexity of Army organization and operations.

Commending the foresight of Continental Army Command planners to tackle the problem before it got "out of hand," he predicted that similar computer services eventually will be made available to combat units in the field. Commanders will have a wealth of timely and accurate information when they need it, he said.

Before assignment to CASSA last January, Col Hanchin was chief of Management Science and Data Systems, Army Test and Evaluation Command at Aberdeen (Md.) Proving Ground. He was also TECOM chief of staff.

Power Sources Conference Expected to Attract 1,000

More than 1,000 educational and industrial leaders will join with Department of Defense researchers of advanced power sources at the 22nd Annual Power Sources Conference, May 14–16, at Atlantic City, N.J.

The largest technical meeting in its field, the conference is sponsored by the Power Sources Division, U.S. Army Electronics Command (ECOM), Fort Monmouth, N.J., in cooperation with the Interagency Advanced Power Group. Dr. Galen R. Frysinger, ECOM Power Sources Division chief, is chairman for the conference.

On May 14, the conferees will discuss Fuel Cell Control Systems, Fuel Cell-Battery Hybrid Systems, and Battery Chargers. The second-day proceedings will cover Overcharge Protection, Iron Electrodes, and Zinc-Silver Oxide Batteries.

Areas to be covered the final day include High Energy Cathode Materials, Solid Electrolyte Batteries and Zinc-Air Batteries.

Aircraft Engine Test Cell Replacing Stands at Sharpe

An aircraft engine test cell facility under construction at Sharpe Army Depot, Lathrop, Calif., will greatly increase aircraft maintenance and repair capabilities.

The $122,000 facility will be operational before mid-1968 and will put aircraft engines through stresses and strains far greater than those encountered in actual flight, assuring combat-readiness.

Using a dummy propeller and dynamometer, the facility will be able to test many conventional (reciprocating) engines, including engines on the *Bird Dog* 0–1, the *Otter* U–1A, the *Beaver* U6, the *Seminole* U8, and H13 and H23 helicopter engines.

Relatively minor adjustments will enable the facility to test small turbine (jet) engines such as the T–63 engine on the OH–6A *Cayuse* helicopter through use of a water brake.

The depot presently checks out aircraft engines by use of portable test stands. The new facility will increase engine-testing capabilities because it is a 2-cell complex, capable of simultaneously testing two engines, even of differing types.

Perry West Jr., aircraft staff specialist in the depot's Directorate of Maintenance, described the more sophisticated testing facility as "the first step toward development of a full aeronautical depot capability at Sharpe."

Limited presently to aircraft engine repair, the depot will have engine overhaul and rebuilding capabilities when the construction project is completed.

Another benefit of the new installation is reduction of the noise level of the testing process. The noise level presently causes ear discomfort and can affect hearing. Baffling in the new facility will reduce this hearing hazard to a safe decibel level.

WECOM Assumes Function Of Enemy Materiel Disposal

Worldwide responsibility for disposal of material which has become United States property is assigned as a new function of the U.S. Army Weapons Command, Rock Island, Ill.

Effective Apr. 1, the function is assigned under provisions of a new Army Regulation titled "Disposal of Supplies and Equipment, Captured Enemy Equipment and Other Foreign Material."

Continental U.S. Army Central Activity (CACA) at Rock Island is established as a collection point for captured, confiscated or abandoned enemy equipment. A list of items will be sent to a selected group of agencies and commands on a priority list.

After 90 days, agencies will indicate the items they desire and the Weapons Command will inform CACA where to ship the equipment. The impact of the new function is not expected much before July 1. Gene Taylor is in charge of CACA and his deputy is George Mayernick.

Explosion Welding

By H. J. Addison, Jr.
J. F. Kowalick, W. W. Cavell

Explosion Welding* which has been known also as explosive bonding, is a relatively new method for joining metals and alloys. Welding with this process occurs when adjacent surfaces of appropriately positioned pieces are properly thrust together by energy from an explosive charge.

Since the introduction of high-velocity projectiles in the 1880s, various instances of unintentional welding of metallic projectiles to targets have been observed. The potential of explosion welding as a method of fabrication was not recognized, however, until the 1950s when metal blanks being explosively formed sometimes became welded to metal dies.

The process has more recently been developed to an accepted fabrication tool which is being used or considered for a number of special joining applications in the aerospace, marine, nuclear, chemical and defense industries.

The advantage of the process is its applicability to certain joining situations that cannot be more readily or economically accomplished by the conventional, established processes.

WORK AT FRANKFORD ARSENAL. Several U.S. Government and private organizations and institutions have been active in developing the process to its current status. As an Army agency, Frankford Arsenal (Philadelphia, Pa.) has made significant contributions to this technology. It is believed to be the first agency to publish information on explosion seam welding and the feasibility of ultrasonic inspection of explosively bonded joints.

In conducting this work arsenal scientists and engineers have obtained considerable data on the relationship between weld quality and basic welding parameters. Various types of explosives (Table 1) and their configurations were studied, using air, vacuum and water as transmitting mediums. Many base metals, including copper, magnesium, steel and several aluminum alloys, were spot- or seam-welded in various combinations.

More recently, studies have been underway to clad explosively the interior of gun barrels with refractory metal liners. This work has been sponsored by the U.S. Army Weapons Command to develop an integral gun barrel having increased service life in terms of corrosion and erosion resistance.

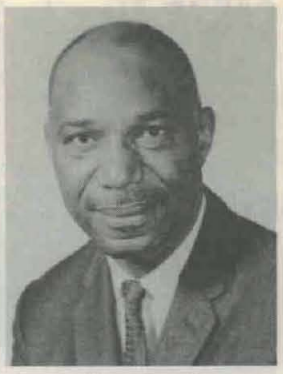
Welding refractory alloys to steel by conventional fusion welding processes has proved unsatisfactory because of the formation of brittle intermetallic phases at the weld interface. Furthermore, the requirement for a complete bond between the liner and barrel makes joining by other more common welding processes difficult if not impossible.

In contrast, the explosion welding study at Frankford has produced promising bonds under experimental conditions between refractory liners and thick-walled steel cylinders. This

**Explosion Welding is the official designation given this process by the American Welding Society.*

H. J. Addison Jr.

J. F. Kowalick



W. W. Cavell

The authors are members of the Pitman-Dunn Research Laboratories, Frankford Arsenal. Addison received a BS degree in chemical engineering from the University of Pittsburgh and has taken postgraduate courses in metallurgical engineering at the University of Pennsylvania. He has served as project engineer on many explosion welding studies, has a patent pending on the process and has authored several technical papers and reports on explosion welding.

Kowalick received BS and MS degrees in chemical engineering from Lehigh University and Drexel Institute of Technology, respectively, and is continuing graduate work at Drexel. He is currently secretary of the Explosives Components Group, JANAF Fuze Committee and is a member of the Missiles and Space Advisory Panel, Project LEX for the Engineers Joint Council.

Cavell obtained a BS degree from Virginia Union University and an MS degree from the University of Michigan and studied chemical engineering at the Graduate School of the State University of Iowa. He holds patents and has authored reports in the fields of pyrotechnics and explosives and is project leader of Frankford Arsenal's current explosive bonding program.

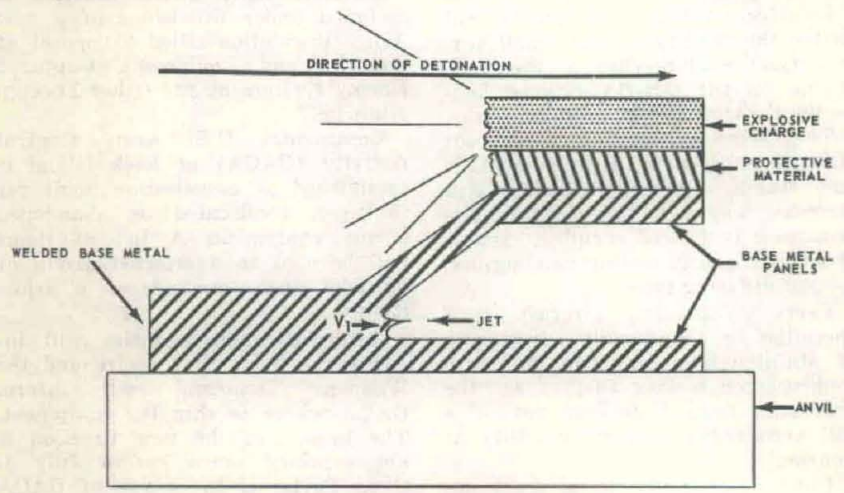


Figure 1. Jetting in Explosion Welding

work has also produced techniques for explosion seam-welding thin refractory sheet to thick steel panels. Tension-tested specimens removed from flat composites were sufficiently strong to force failure away from the weld interface through the refractory alloy.

THEORY. Two criteria must be satisfied to achieve a reliable weld with any joining process. First, the surfaces to be joined must be relatively free of surface films. Usually these films are composed of oxides, nitrides or absorbed gases, all of which can prevent successful welding. Secondly, the atoms of the materials being joined must be brought into such close contact that interatomic forces act to produce a weld.

These criteria are satisfied in explosion welding. Although several theories have been advanced to explain the bonding mechanism, most investigators agree that surface impurities are removed by a basic phenomenon known as "jetting."

During the welding operation, a jet, similar to that emitted by hollow "shaped charges" used in defeating armor, removes films from the surfaces being joined, as shown in Figure 1. High pressure (up to 4,000,000 psi) generated by the detonating explosive then propels the clean metal surfaces together to form the weld.

It has been established that in order for the jet to form without disruptive shock waves tearing the bond apart, the velocity of the point of impact along the metal surfaces (V_1 in Figure 1) should approximate, but preferably be slightly less than, the acoustic velocity of the base members. When dissimilar base metals are welded, this velocity should not exceed the lower acoustic velocity of the members.

In recent experiments, directed toward relating process parameters, Carpenter, Wittman and Carlson advanced the following relationship:

$$L \propto \frac{y\ e\ t}{d}\ a^2$$

where:

- L = Mass of explosive charge per unit area of cladding plate.
- y = Yield strength of cladding plate.
- e = Density of cladding plate.
- t = Thickness of cladding plate.
- a = Angle generated between cladding and backer plates during welding operation.
- d = Distance separating cladding plate, and backer plate initially positioned parallel to each other.

This relationship, once its limits are determined empirically, reportedly permits welding conditions to be predicted for a given explosive without resorting to elaborate instrumentation. Either "L" or "d" is readily obtained when L is plotted against the factor

$$\frac{y\ e\ t}{d}$$

Although the relationship is not dimensionally consistent, it appears that it is satisfied over an appreciable range of material properties and gap distances for a specified explosive.

In a more recent investigation by Hay and Kowalick, dimensional analysis was used to relate the same process parameters by the relationship where "E" is the elastic modulus

$$L \propto \left(\frac{y\ e\ t^2}{Ed}\right)\ a^2$$

of the base material and the other parameters are as defined previously. This relationship is dimensionally consistent and appears to satisfy available data on explosion welding.

PRACTICES. In the present state of development, certain generalizations may be drawn with respect to practices of organizations employing the explosion welding process. These practices concern welding techniques, types of welds and joints, explosive considerations, base metals and inspection techniques. A discussion of these various aspects of the process follows:

Welding Techniques. In actual practice, the bonding mechanism is usually employed through the use of two welding techniques, illustrated schematically in Figure 2. The obvious dissimilarity between the two setups is the positioning of the panels or members being welded.

In Figure 2A, the top panel is placed at an angle to the bottom panel. This angle is sometimes known as the "contact angle" and consequently the method has been called the "angular technique."

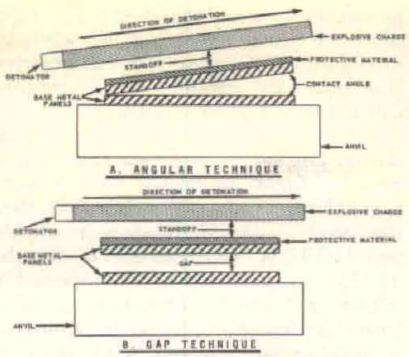


Figure 2. Explosion Welding Setups

In Figure 2B, the panels are parallel to each other and may be either in contact with each other or at a predetermined distance apart. This technique has been called the "gap technique" due to the gap or spacing between the panels.

The setups are similar in several respects. The panels are located between an explosive charge and anvil, with the bottom panel resting on the anvil. The anvil removes excess energy from the weld region, preventing the bond from being torn apart after it is formed. The distance between the explosive charge and the protective material may be called the standoff.

Most welding operations apparently are conducted when the standoff is zero or the charge is in contact with the protective material.

The purpose of the protective material, which is not necessary for some explosive charges, is to prevent pitting, fracturing or gouging of the panels. Protective materials have been made from many substances, including rubber, masking tape, wood and plastics.

Variations of the above techniques may be employed, depending on the application. The gap technique in Figure 2B, for example, lends itself with slight modification to the cladding of hollow cylinders.

To weld a liner to the interior surface of a hollow cylinder, the explosive may be placed inside the liner and a die positioned outside the cylinder. The die serves as an energy sink and aids in maintaining the exterior dimensions of the cylinder.

Conversely, the outer surface of a hollow cylinder may be clad with tubing by placing the explosive around the exterior of the tubing and a mandrel inside the cylinder to prevent it from buckling.

In these examples, an appropriate spacing (gap) would exist between the cylinder and liner or tubing. Tubing or pipe also may be joined to itself with these techniques.

Types of Welds and Joints. Essentially three types of welds have been accomplished with the explosion-welding process. These are seam welds, spot welds and wide-area welds as employed in clad composites.

The greatest application for the process, thus far, has been associated with cladding applications in which the lower member, for example a

(Continued on page 28)

Explosion Welding

(*Continued from page 27*)

steel plate, has been overlayed with a thin sheet of another alloy.

Usually the purpose of the cladding is to impart a specific property to the plate, such as wear or corrosion resistance. Explosion spot- and seam-welding have been used to a much more limited extent. At least two organizations have constructed explosion spot-welding equipment.

Frankford Arsenal and several other organizations have demonstrated that all of the basic weld joints, with the exception of the butt, can be made with the explosion-welding process. A variety of structural materials have been welded using lap, tee, corner and edge-type joints. No known butt joints have been accomplished, although a considerable amount of effort has been expended in this area.

Related Considerations. Explosion welding has been accomplished with both high-velocity (15,000–25,000 ft/sec) and medium-velocity (5,000–15,000 ft/sec) explosives. Table 1 shows some that have been used at Frankford Arsenal.

Table 1

Explosives Used in Explosion Welding Studies at Frankford Arsenal.

High Velocity	*Medium Velocity*
PETN	Low-density PETN
RDX	Nitroguanidine
EL–506A*	Dynamite
Tetryl	
Primacord**	

*Proprietary sheet explosive made by E. I. du Pont de Nemours and Co., Inc.

**Proprietary cord explosive made by Ensign Bickford Co.

High-velocity explosives generally are used with the angular technique. Medium-velocity explosives usually are employed with the gap technique. Medium-velocity explosives also are considerably less expensive—as low as 1/50th the cost of high-velocity explosives—and generally require little or no buffering.

The shape of the charge has great influence upon the geometry of the weld. At Frankford Arsenal, spot welds have been accomplished with pill-shaped charges. Seam welds, on the other hand, have been made with cord- or strip-shaped charges. Clad components have been made with explosive charges whose contour approximated the surface of the top member.

The explosives employed with this process are stable and can be handled with little danger if proper safety precautions are observed. In fact, some of them, such as low-density nitroguanidine, are so insensitive that standard commercial detonators will not directly initiate them.

When small members are explosively welded, noise, air blast and ground vibrations do not have to pose a problem, as shown by the fact that the process has been used in highly populated areas. These effects may be muffled by conducting the operation within a vacuum chamber, a reinforced room equipped with baffles or a tank or pit covered with sand or water.

Large members, however, usually must be bonded in isolated areas. Precautions must be taken to avoid severe air and ground vibrations which can be felt miles away from the explosion.

Base Metals. Many base metals have been joined by explosion welding, including iron, low-carbon steel, medium-carbon steel and alloy steels in similar and dissimilar combinations. The process has also proved suitable for joining various combinations. The process has also proved suitable for joining various combinations of aluminum, copper, beryllium, tin and magnesium alloys, as well as refractory alloys and precious metals.

Explosion welding appears to be adaptable to most metal systems except those in which the base materials have low impact resistance or low melting temperatures. Brittle metals or alloys fragment easily under impulsive loading. Alloys having low melting ranges fuze under the high pressures generated during welding.

Current investigations indicate these difficulties may be overcome with further improvements in techniques. For example, lead, a low-melting-point material, recently was bonded to steel.

Most of the work has been conducted on wrought materials although some welding has been performed with castings. Cladding materials ranging from a few mils to more than half an inch in thickness have been welded to backer materials ranging in thickness from less than one-quarter inch to 18 inches. Size of the welded assemblies has varied from small coupons to at least 7 feet x 20 feet.

Inspection. High-quality explosive welds can be assured only by using adequate testing techniques. Visual inspection is, of course, the most commonly employed nondestructive testing method and is useful for de-

AFIP Museum Adds Electron Microscope to Collection

This nation's first commercial electron microscope is a new addition in the Medical Museum of the Armed Forces Institute of Pathology (AFIP) Billings Microscope Collection, which traces evolution of the microscope from 1590 to the present.

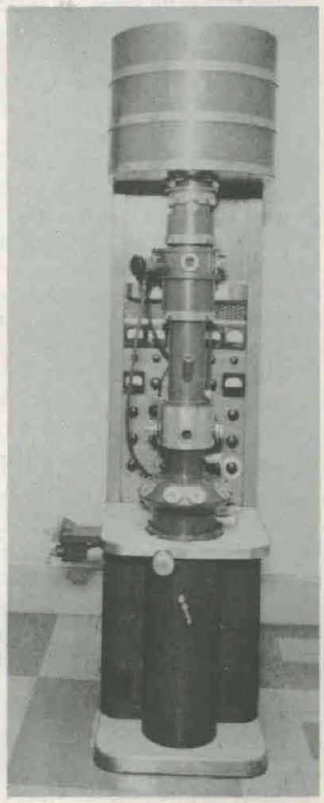
AFIP Director Capt Bruce H. Smith, MC, U.S. Navy, said modern medicine and all the life sciences depend on capabilities of various microscopes for research and that development of the electron instrument was of monumental significance.

Medical Museum curator, Capt Elgin C. Coward, MC, U.S. Navy, said the Radio Corp. of America EMB electron microscope is one of a series of recent valuable donations to the exhibit from colleges and individuals. It was produced in 1948 and was donated by Loyola University of Chicago.

"There is a growing awareness," Capt Smith said, "that the Billings Microscope Collection represents American science and that American science can make it one of the great technical displays of the world.

"This is being done on many levels, from the general practitioner who tipped us off on an antique microscope he saw in a pawnshop window to such gifts [as the EMB electron microscope] from great universities.

Believed to be the largest and most significant exhibit of its kind in the world, the Billings Microscope Collection is on display at the Medical Museum, 7th St. and Independence Ave., S.W., Washington, D.C., from 9 a.m. to 5 p.m. every day.



EMB Electron Microscope

termining whether surface cracking, gouging or warpage is present.

Ultrasonic inspection appears to be the most widely used nondestructive method for determining internal defects. It is quick, relatively inexpensive, offers no radiation hazard and can indicate defects not easily determined by radiography.

Other nondestructive test methods, such as radiography and magnetic penetrant inspection, have been used to a much more limited extent.

The most common destructive inspection methods for revealing the mechanical characteristics and soundness of joints are tensile, shear, bend and hardness tests. Other destructive methods such as metallography, impact tests, accelerated corrosion tests and electron microscopy have been used for specialized applications but are often too expensive for production.

APPLICATIONS. Explosive welding is still in its infancy and, thus far, has been used to fabricate relatively few items in production. Applications are increasing, however, and explosively welded parts and components will become more common with process development.

Flat clad plate and sheet normally are fabricated into more complex structures and configurations, seldom being employed in the as-welded condition. Serviceability of these flat products has been demonstrated in a number of applications. Explosively clad and subsequently rolled sheet metal has been used in the minting of United States composite coins. Explosive cladding has also found application in the fabrication of lined pressure vessels, retorts and tube sheets.

Explosively clad flat products are amenable to conventional fabricating operations. They have been flame-cut, sawed, sheared, ground, drilled, fusion-welded, hot- and cold-formed, and submitted to many other manufacturing operations.

Considerable effort also has been expended on the explosion welding of tubing, usually related to itself, pipe or flat components. Cladding the surfaces of bar stock and the inner or outer surface of hollow cylinders also has been accomplished.

Applications that have been reported include cladding of tubes for reactors, welding tubing to tube plates of heat exchangers, and fabricating transition joints between tubes of dissimilar metals that would otherwise be difficult to fusion weld.

The process gives promise of satisfying many future military requirements. Work is under way to line alloy steel, half cylinders with aluminum for a turbine engine application. Progress also is being made in cladding steel forgings with stainless steel to minimize the effect of salt water corrosion.

Thin refractory alloy tubing has been joined to the interior of stainless steel cylinders for reactor tubing in boilers. Heat-treated alloy steel plates are being welded to the side wall of aluminum tank wheels for wear-resistant purposes.

Another potential application for explosively clad plate is lightweight, composite vehicular armor. Armor having superior ballistic characteristics appears possible by using two or more materials with the proper combination of mechanical and physical properties.

Explosion spot-welding holds considerable interest because it shows promise for field repairs in inaccessible locations where conventional equipment cannot be transported. The technique also might serve effectively when only a few welds are required, conventional spot-welding equipment is not available, and its purchase is not warranted.

ACKNOWLEDGMENTS: The authors express their appreciation to Messrs. I. G. Betz and T. Q. Ciccone, both of the Pitman-Dunn Research Laboratories, for their helpful suggestions.

ARPA Cosponsors Mobility Testing Meeting

About 300 U.S. and foreign experts on terrain vehicles are preparing to meet June 26–27 at the Institute of Defense Analysis (IDA) near Washington, D.C., in a research symposium on "Mobility Testing."

Lt Gen William B. Bunker, deputy CG of the U.S. Army Materiel Command, will be keynote banquet speaker at the Off-Road Mobility Research Symposium jointly sponsored by the Department of Defense Advanced Research Projects Agency (ARPA), Cornell Aeronautical Laboratory and the International Society for Terrain-Vehicle Testing Systems (ISTVS).

On the program are 16 technical paper presentations, three panel discussions titled "Simulation," "Requirements," and "New Concepts," and an off-road mobility demonstration. The demonstration will be at either Fort Belvoir, Va., or Quantico (Va.) Marine Base.

Government agencies, industry, academic institutions and active members of the ISTVS in the U.S., Canada and 20 other countries have been invited on a "first come" basis. The IDA auditorium at 400 Army-Navy Drive, Arlington, Va., near the Pentagon, has a 300-seat capacity.

General sessions chairman is IDA's Dr. Alfred Jones. In charge of general arrangements is Jack Egley of Cornell's Washington area office.

Alexander N. Tedesco, ARPA mobility program manager, may be contacted by telephone for additional details: Area Code 202—OXford 57196.

Brown Succeeds Oswalt as WES Director

Direction of the U.S. Army Waterways Experiment Station (WES), Vicksburg, Miss., the major laboratory complex of the Corps of Engineers, will become the responsibility of Lt Col Levi A. Brown July 1.

Selected on the list for promotion to colonel, he has been serving as deputy director of WES since July 1967. He will succeed Col John R. Oswalt Jr., who will take command of the U.S. Army Engineer Topographic Laboratories, Fort Belvoir, Va., effective July 1.

Lt Col Levi A. Brown

A 1946 graduate of the U.S. Military Academy at West Point, Col Brown holds a master's degree in civil engineering from California Institute of Technology (1952) and a civil engineer's degree from Columbia University (1964). He is a graduate of the U.S. Army Command and General Staff College and the U.S. Army War College.

He has served two tours of duty in Japan, one in Germany and one in Vietnam. He was an engineer adviser at Vietnamese Army headquarters and a logistics plans officer in the U.S. Military Assistance Advisory Group.

Col Brown is a registered professional engineer in the states of Michigan and Mississippi, a Fellow of the American Society of Civil Engineers, and a member of the Society of American Military Engineers, National Society of Professional Engineers and the American Concrete Institute.

NATO Standardization of MERDC Filter/Coalescer Element

By LeRoy L. Stark

North Atlantic Treaty Organization (NATO) nations are phasing into their aircraft fueling systems the standardized filter/coalescer element developed at the U.S. Army Mobility Equipment R&D Center, Fort Belvoir, Va. This action follows agreements reached at a NATO conference in Wiesbaden, Germany, in September 1967.

General agreement was reached that NATO standardization of the U.S. filter/coalescer element would benefit all member nations by reducing costs, by minimizing procurement, operational and maintenance problems, and by significantly assisting in attaining the objectives of cross-servicing.

Implementation of the agreement will be on a gradual basis as it becomes economically feasible, since in Europe there are large stocks of nonstandard elements on hand which must be expended before the U.S. standard element can be fully adopted.

Immense quantities of liquid hydrocarbon fuels are required to support modern military operations, representing 60 to 70 percent of all military supply tonnage. Between the commercial supplier and the military user, this fuel is handled by a wide assortment of systems and facilities which contribute contamination in the form of dispersed water droplets, and extremely fine solid particles.

Contaminants are not tolerated by the susceptible fuel controls of modern military aircraft and ground equipment, which utilize small orifices and close tolerance sliding fits. Therefore, prior to use, all fuel must be processed by decontamination equipment, such as filter/separators.

Application of 15-gpm filter/separator in helicopter refueling operations.

Early military practice was to use commercially available filter/separators, modified as required to meet specific military requirements. Water and solids removal performance was specified, but materials, size, configuration and fabrication details were the manufacturer's option.

This procurement practice resulted in many dissimilar filter/separator models in service at U.S. military installations throughout the world. With this equipment, there was no interchangeability of components, and parts replacement problems became tremendous. Training, operation and maintenance problems with the nonstandard equipment also were unacceptable.

To alleviate the problems created by use of thousands of nonstandard filter/separators in 1958, U.S. Army Mobility Equipment R&D Center (USAMERDC) researchers undertook development of a standardized family of Army filter/separators. The initial objective was to develop a standard filter/coalescer element, which is the expendable and replaceable functioning component of every filter/separator.

Development of the elements has been successfully achieved, and five fabricators have successfully met stringent military water and solids removal performance requirements. The standard elements are 20 inches long, 3¾ inches in diameter, and are cylindrical in configuration.

Materials employed in fabrication include fiber-glass net and cloth of various densities and porosities, plastic impregnated cellulose paper, asbestos fibers, nylon, cotton, etc.

Initial cost per element was $15, but by improving fabrication techniques and developing competition among suppliers, the cost has been gradually reduced to less than $3.50 each.

Since upwards of 100,000 replacement elements are procured annually, savings of more than $1,000,000 annually are being effected. Annual savings far exceed the entire cost of the filter/separator development program.

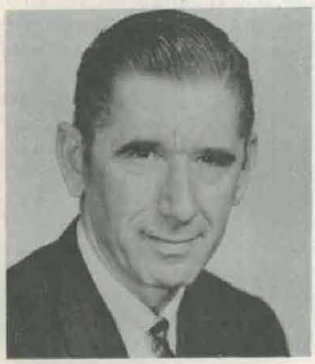
The standard USAMERDC-developed elements are utilized in the required multiples in each size of the standard family of filter/separators, consisting of the following flow rates: 15, 50, 100, 350 and 600 gpm.

Initially, it was intended that they would be a standard for Army use, with the expectation that they might also become a Department of Defense standard. This also has come to pass, and the elements are now being used in Navy and Air Force fueling equipment.

Acceptance of the filters as a NATO standard means the USAMERDC element will be used extensively in Europe, and will result in significant improvement in fuel-handling operations at NATO airfields.

LeRoy L. Stark is deputy chief of the Fuels Handling Equipment Division, Mechanical Technology Laboratory, U.S. Army Mobility Equipment Research and Development Center (MERDC), Fort Belvoir, Va.

The division is responsible for research, design, development and engineer design testing and evaluation of bulk and retail liquid hydrocarbon fuels transport and handling equipment and techniques; fuels decontamination and quality surveillance equipment for Special Forces.



Stark attended the Wisconsin School of Mines and, later, the University of Pittsburgh, where he received a BS degree in petroleum engineering in 1937. He served in the Army from 1944 to 1947, including duty at the MERDC's forerunner (ERDL) where he accepted a civilian position following his release from active duty. He received an Outstanding Performance Rating in 1967, and in 1964 earned a Special Act or Service Award for authoring a technical article.

New IER System Aids WSMR Test Missile Retrieval

Recovery of missile components test fired at White Sands (N. Mex.) Missile Range is being accomplished much more rapidly with a system called Impact Estimation for Recovery (IER), similar in principle to Ground Control Approach (GCA).

Computers operating on an inexpensive real-time, time-sharing basis all but eliminate the trial-and-error methods used formerly in locating downed components, some of which may be buried 10 feet underground.

IER accomplishes almost immediate location of spent missiles, compared to as much as six months under conventional methods, stated William A. Rice, chief of real-time operations in the White Sands Missile Range Analysis and Computation Directorate.

The computer estimates the impact point from the mission radar data. With the aid of data from a tracking radar, the computer generates visual plots and displays to guide an aircraft to the point of impact, in much the same manner as GCA assists pilots in blind landings.

Under the trial-and-error method, recovery teams had to examine camera angles, radar data and other information accumulated from numerous tracking stations dispersed throughout the 2-million-acre WSMR following impact of a missile. The most promising data, plotted on maps, provided the basis for recovery teams to be sent to suspected areas.

WSMR is the scene of 1,500 to 2,000 missile firings annually. All missiles fired must be recovered and the craters filled to avoid confusion and error in both the immediate and far future.

Debris from some components is worthless and is removed to the WSMR "missile graveyard." Many components, however, are either extremely important or valuable for research purposes.

Troubles of searchers are compounded by the fact that recovery areas often measure more than a square mile. Searchers must guess whether the spent missile made a crater, a "rabbit hole," a mound, or shattered against a boulder.

Under the old system, recovery time might vary from 10 minutes to six months, depending upon such factors as point of impact compared with the target, how long radar was locked on the missile before impact, and whether spotters observed the impact.

Maj George W. Wallace, chief of the WSMR Recovery Division, cited a case of a missile going off course and landing in Colorado, where it was found after six months of intensive searching. Operations involved both aerial reconnaissance and searchers covering the area on horseback.

IER involves the feeding of missile tracking radar data into the Analysis and Computation Directorate's direct couple system (DCS) that includes IBM 7044 and 7094 computers. Raw data are transmitted to the DCS through Kineplex data transmitters in binary form.

The DCS computer handles the input data in binary form, converting it into readable decimal figures and analyzing it at electronic speeds.

As the DCS analyzes the data, it chooses the "best" signals and returns its decisions to both printers and plotting boards. All the information is recorded for immediate playback or future reference.

In cases where radar loses contact, personnel in the Analysis and Computation Directorate mathematically simulate the missile trajectory to obtain predicted impact point via a special computer program.

With the estimated impact point instantly available, the recovery division can go into operation immediately or it can choose to delay its mission. The decision depends on circumstances such as the payload's importance, point of impact and others.

Recovery personnel also have a choice of methods in conducting the search. Survey teams can be dispatched to the area to mark the predicted impact areas. In cases of extremely important payloads, observation aircraft can be vectored, or talked, onto the impact point by use of computer-derived displays.

Vectoring helicopters to within 20 feet of the impact point appears commonplace with IER. In a test case, a pilot was vectored onto the "bulls-eye" in 11 minutes.

In a recovery operation, IER utilizes radar tracking sites on the range in the same way the initial data is recorded. Data digested and analyzed by the 7094 is instantaneously plotted on both a map and target mounted on an electronically controlled plotting board.

Initially, the aircraft is vectored on a 1:3000-feet scaled target. As it nears the indicated impact point, a flick of a switch expands the target's scale to 1:300 feet. Displays showing distance, altitude, speed and direction coupled electronically to the plotting board enable the controller to talk the pilot onto the bull's-eye in a matter of minutes.

The IER is especially effective when the missile goes off target. As Maj Wallace puts it, "That's where our real trouble begins." Radar data is fed into the computer system and the DCS makes its decisions. The best signals are plotted and the observation helicopter is on its way.

Depending upon the predicted point of impact, the helicopter conceivably can drop under the radar surveillance net. In this case, a fixed-wing aircraft is vectored onto the bull's-eye with the helicopter flying beneath it as well as the radar net. The pilot of the fixed-wing craft, in turn, vectors the helicopter to the point of impact.

Thus, the recovery task that formerly took an average of 50 to 60 hours is reduced to a matter of minutes. Using the real-time, time-sharing mode offered by the DCS, no costs are incurred for computer time, one of the most valuable items at White Sands Missile Range.

Maj Wallace cited some IER drawbacks from the standpoint of vectoring the observation aircraft onto the target, including use of radar in vectoring procedures. "Not only are radar operations expensive," he explained, "but firing schedules will in many cases necessarily interfere with this mode of recovery.

The IER system, he said, would be invaluable using the survey team method. "Whereas we have had to search for spent missiles at several different points, or suspected areas, in the past, we now have one area smaller and more reliable to search."

SCIENTIFIC CALENDAR

Symposium on Analytical Methods in Mathematical Physics, sponsored by OAR, Bloomington, Ind., June 3–6.

Conference on Atomic Physics, sponsored by ARO-D, AEC, NSF, AFOSR, ONR, New York University, International Union of Pure and Applied Physics and Brookhaven National Laboratory, N.Y.C., June 3–7.

4th Conference on Atmosphere Contamination in Confined Spaces, sponsored by AMRL, Dayton, Ohio, June 4–6.

Vacuum Metallurgy Conference, sponsored by the American Vacuum Society, Beverly Hills, Calif., June 10–13.

Annual Conference of the Society of Photographic Scientists and Engineers, sponsored by the Rome Air Development Center and SPSE, Boston, Mass., June 10–14.

21st Military Operations Research Symposium, sponsored by ONR and AFOSR, Colorado Springs, Colo., June 11–13.

Symposium on Mathematical Aspects of Optimization and Variation Methods in the Physical Sciences, sponsored by OAR, Toronto, Canada, June 11–14.

14th Conference of Army Mathematicians, sponsored by ARO–D and U.S. Army Mathematics Steering Committee, Rock Island Arsenal, Ill., June 12–13.

2d International Symposium on Multivariate Analysis, sponsored by AFARL and Wright State University, Dayton, Ohio, June 17–22.

1968 Army Science Conference sponsored by OCRD, West Point, N.Y., June 18–21.

71st Annual Meeting of the American Society for Testing and Materials, and 18th Materials Testing Exhibit, San Francisco, Calif., June 23–28.

2d Annual Computer Conference, sponsored by IEEE, Los Angeles, Calif., June 25–27.

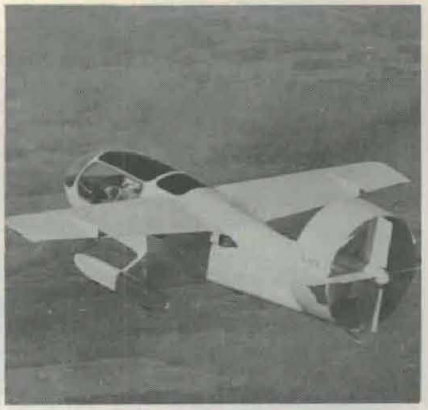
1968 Conference of the Data Processing Management Association, Washington, D.C., June 25–28.

Meeting of the Society of Nuclear Medicine, St. Louis, Mo., June 27–30.

MARVEL Project Enters New Phase

By Lt George Zuments

This is the second article 1st Lt George Zuments, 25, has contributed to the Army R&D Newsmagazine. *"Advanced Geometry Glass Fiber-Reinforced Plastic Rotor Blades" was published in the July–August 1967 edition. Since September 1966 he has been an aerospace engineer in th Rotary Wing Branch, Applied Aeronautics Division at the U.S. Army Aviation Materiel Laboratories, Fort Eustis, Va. After receiving an ROTC commission and BS and MS degrees in aerospace engineering from Georgia Institute of Technology in 1964 and 1965, he was employed as an aerospace engineer for about nine months before going on active duty with the Army in June 1966. He completed the Chemical Officers Basic Course at Fort McClellan, Ala., and earned the Parachutist Badge at the Airborne School, Fort Benning, Ga.*



XV–11A MARVEL

With a new OH–6 Cayuse engine, the experimental fiber-glass aircraft XV–11A MARVEL is expected to reach a speed of 250 mph in the latest 6-month, 30-hour flight-test program which began May 1.

The Allison T–63–A5A helicopter engine is rated at 317 hp, 67 more than the previous power plant. The additional power is needed to operate one of the unconventional features of the aircraft without sacrificing performance. The maximum speed reached in previous tests was 150 mph. This is the only university flight-vehicle research program under contract with AVLABS.

MARVEL is an acronym for Mississippi Aerophysics Research Vehicle, Extended Latitude. It is an all fiber-glass Boundary Layer Control (BLC) research aircraft, designed and built by Mississippi State University (MSU) under contract to the Army Aviation Materiel Laboratories (AVLABS), Fort Eustis, Va.

For the high-lift BLC investigation, the design includes several features never before utilized on the same aircraft. It employs suction BLC in combination with a variable-camber wing for increased lift. A shrouded propeller gives increased thrust at low airspeeds. Fiber-glass construction assures smooth aerodynamic surfaces in complex structural designs without sacrificing strength and rigidity. Certain modifications were necessary after the previous 6-month 49-hour flight-test program.

Program Objectives. Basic objectives of the XV–11A program are to investigate means of obtaining aircraft STOL (short takeoff and landing) capabilities by utilizing BLC, variable-camber wing, and a ducted propeller.

Incorporation of these three subsystems into a single design should satisfy the requisites of high lift and high thrust-to-weight ratio for STOL performance.

To utilize the high-lift potential of the variable-camber wing, a suction BLC system was designed to prevent flow separation and the resultant loss of lift at the necessary high-camber angles. It is anticipated that a 5.0 coefficient of lift will be obtained with this system.

For greater takeoff thrust, a shrouded propeller was designed. This system resulted in a 90 percent increase in static thrust over a conventional propeller with no drag penalty below 100 mph. Demonstration of the aircraft's capability to take off over a 50-foot obstacle in 200 feet is the program's ultimate goal.

Program Background. The Aerophysics Department of Mississippi State University has been engaged in high-lift and low-drag boundary-layer research since 1950.

Originally, the effort was sponsored by the U.S. Army through the Office of Naval Research. This research included the use of various gliders and L–19 and L–21 conventional aircraft. Based on this research, the Army acquired responsibility for the program in 1963 and awarded a contract for construction and flight testing of the XAZ–1 MARVELETTE.

The MARVELETTE was used as a test bed for the unconventional configuration and systems to be incorporated in the XV–11A. It utilized the fuselage, engine and slightly modified landing gear of an Anderson-Greenwood AG–14. The proposed XV–11A wing included provisions for suction BLC and camber variation. A specially constructed 66-inch diameter fiber-glass propeller shroud with articulated trailing edges provided control surfaces.

The AG–14 engine produced only 90 horsepower, 7 of which were used to drive the BLC blower system. Increased shroud weight due to fabrication, along with intricate control linkage and cable requirements, called for a ballast of 40 pounds of lead in the aircraft nose to remain within center-of-gravity limits. These factors combined to make aircraft performance extremely marginal.

The XAZ–1 proved the feasibility of the high-lift BLC, variable-camber wing and shrouded propeller, leading to a contract with MSU in 1964 for construction and flight test of the XV–11A. Actual aircraft construction was subcontracted by MSU.

Unconventional systems tested in the XAZ–1 were modified slightly before incorporation into the XV–11A. To save weight and simplify construction, cruciform control surfaces were placed within the shroud, thus eliminating the complex control horns and cables. In addition, placing the control surfaces within the high-velocity propeller slipstream increased control effectiveness at low airspeeds.

Decrease in shroud weight eliminated the need for ballast in the nose, thus increasing performance. The largest performance increase was realized by installing a 250-horsepower T63–A5 turboshaft engine as the main power plant. The BLC system and variable-camber wing did not need modification for use in the MARVEL.

A contract for preliminary flight testing was awarded in November 1965 and the XV–11A was first flown in December. Modifications based on results of the flight test were contracted for in November 1966.

Unique Features. Several methods may be used to increase aircraft STOL capability. The XV–11A uses increased lift and takeoff thrust.

Increased lift may be achieved by increasing wing camber, that is, the radius of curvature of the airfoil. At low speeds, this is effective; as speed increases, however, the highly cambered wing produces an excessive drag rise.

A compromise is to use trailing-edge flaps (single and multiple slot-

ted, for example) and leading edge devices (slots, slats and flaps).

Mechanically complex devices do increase the effective camber of the wing, but are limited to maximum lift coefficients of approximately 3.5. The XV–11A employs a relatively simple and more efficient mechanism; it bends the aft portion of the wing to change the camber.

The camber-changing mechanism consists of two load-carrying horns in each wing supporting four subspars aft of the main spar. (Fig. *1*) Taking the place of wing ribs throughout the camber-changing area, the horns rotate through journals consisting of short nylon arc blocks sliding in a "U" section.

One limiting factor on the lift attainable by a highly cambered wing is flow separation. The high camber produces retarding pressure gradients that cause boundary layer and hence flow separation. This results in a decrease or even a total loss of lift.

One method of preventing this separation, is to keep the boundary layer attached by sucking it onto the wing. On the XV–11A it is sucked through thousands of perforations in the wing upper surface. Previously, this air was ducted to the power plant and used as the engine's primary compressor air source. Flight tests proved this method unacceptable because it was not possible to maintain sufficient suction pressure at low engine speeds, particularly during the landing approach.

A suction fan powered directly by the T63–A5A power plant was designed and developed at MSU. The higher output T63–A5A replaced the T63–A5 so that the 25 hp required to drive the fan would not affect aircraft performance. Tested at 6,000 rpm, the fan provides 28 inches of water-suction pressure at a flow rate of 4,000 cubic feet of air per minute. This maintains sufficient BLC suction pressure.

In attempting to achieve the high thrust necessary for short takeoff with a conventional propeller the slipstream contracts, reducing the possible mass-flow through the propeller. This causes a substantial loss in possible thrust due to residual axial velocity in the wake.

Placing a shroud or duct around the propeller decreases the slipstream contraction, increasing the mass flow. By using this method, it has been possible to increase static thrust 90 percent over that available through a conventional open propeller.

Although the shroud increases static- and low-speed thrust, it does have greater drag at higher speeds. In the XV–11A, at speeds above 100 mph, the increased drag overcomes any thrust increase. To realize any net advantage on the installation, the shroud had to be used to replace another aircraft component.

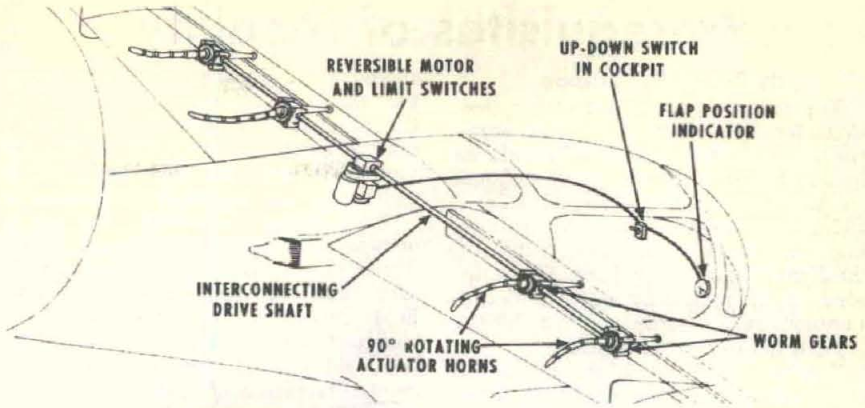


Figure 1. Camber Change System Schematic

Consequently, the elevator- and rudder-control surfaces were placed within the shroud in a cruciform configuration, providing the extra advantage of greater control power with the high-energy air flow over these surfaces at low speeds.

In designing reduced structural weight into an aircraft, the engineer must make it strong and rigid enough under load to keep distortion to a minimum. The fiber glass in a polyester resin used in the SV–11A has met these requirements and yielded some additional advantages.

The relative ease of fabrication allows the use of complex but more aerodynamically efficient shapes, such as the variable-camber wing. The inherent smoothness of the finished product assures an extremely low parasite-drag aircraft. In addition, the characteristics of the fiber glass allow easy skin or minor structural repair. Table I contains XV–11A dimensional data.

Program Accomplishments. By Nov. 30, 1967, the XV–11A had completed 49 hours in the air and proved the feasibility of its systems.

TABLE I

XV–11A Data

1.	*Gross weight*	*2600#*
	Payload	*400#*
2.	*Wing area*	*106 ft²*
	Span	*26 ft*
	Airfoil	*Modified NACA 63615*
	Aspect ratio	*6.5*
3.	*Length*	*23.25 ft*
4.	*Power loading*	*10.4#/hp*
5.	*Wing loading*	*25#/ft²*
6.	v_{max}	*150 mph (45% power)*
	v_{stall}	*30 mph*
	$c_{l max}$	*5.0*

Inadequate data on structural integrity supplied by the airframe manufacturer caused flight test restrictions to 150 mph top speed and 1.5 g-load factor. Within these restrictions, the aircraft attained 150 mph at 45 percent power and a rate of climb of 2,000 feet per minute. A takeoff ground roll of 200 feet was achieved at a lift-off speed of 40 mph.

The aircraft structure has been strengthened and the permissible flight envelope expanded to provide increased flexibility for the current flight-test program. Within the next few months the XV–11A should provide much more valuable data and information on STOL-type aircraft.

Orman Fills In as Deputy As Johnson Goes to Korea

Assignment of Col Leonard M. Orman to succeed Brig Gen Chester H. Johnson as deputy commander of the U.S. Army Weapons Command has been announced by WECOM CG Brig Gen William J. Durrenberger.

General Johnson has been assigned as assistant chief of staff, G-4, HQ Eighth U.S. Army in Seoul, Korea, after serving in WECOM one year. The editor regrets that the March edition of this publication erred in announcing his new assignment.

Col Orman will serve as acting deputy CG in addition to his duties as WECOM Research and Development director, a position he has held since July 1966. He was assigned to WECOM after serving four years as the first chief of the Defense Research Office, Latin America, in Rio de Janeiro, Brazil. Prior to that he was a special assistant to the CG of the Ordnance Special Weapons-Ammunition Command, Picatinny Arsenal, Dover, N.J.

Graduated from the U.S. Military Academy in 1940, he also has a MS degree in electronics from the University of Pennsylvania.

Prerequisites of Mobility

By Robert R. Philippe

The paths of transport are varied. Consider the contrast of the burro trails established by the Spaniards in South America, the poled dugouts on the Brahmaputra River, a sled swing to Camp Centry, Greenland, and the crush of holiday traffic on the Pennslyvania Turnpike. These are some of the means by which a "satisfactory" rate of transport (mobility) is achieved to meet a demand.

The rate at which things are moved over and across the earth is often enhanced by that which we inherit. In the case of the Brahmaputra, it can be as trivial as well-spaced pole holes in the river's clay bank. In the case of a turnpike, it could be an old canal right-of-way. To be complete, true mobility should have assessed against it a proportion of time representing these various means of mobility. If this were to be done, we would *walk* a great deal more.

With the crush of traffic on highways and in the airways, we are being made fully aware of the demands for roads and airfields. Less apparent is the inherent need in any mobility ststem to produce a balance between the vehicle and the conditions in nature which will permit it to operate. In the vast majority of cases, some modification of natural conditions is required. As we continue to push into the more remote and undeveloped areas of the world, an understanding of these inherent needs is being thrust upon us.

Relative to ground-based transport, the author prepared the 12 theses of mobility listed on page __. These serve to identify a spectrum of mobility interrelationships. Consideration of these interrelationships gave rise to Vicksburg Exercise A which took place at the Waterways Experiment Station (WES), Vicksburg, Miss., over 3 years ago. More than a score of Army scientists and engineers gathered to design a comprehensive ground mobility experiment based on these broadening thoughts, motivated in good measure by the growing demands for off-road mobility.

Underlying any approach must be the admission that *there is no single universal solution to the ground mobility problem.* Experience dictates that there is no ground vehicle, nor is there likely to be one, that will traverse the worst of natural ground conditions and still be capable of carrying a significant payload with any rapidity.

The implications broaden because any given vehicle, operating under conditions for which it was not designed, pays performance penalties—for example, a swamp buggy on a turnpike. The elements of mobility are performance (vehicle), penalties (terrain) and preparations (roads and airfields)—three Ps of mobility.

When these penalties are great enough, they are corrected by expedients or preparations, such as auxiliary carriers, trails, roads and airfields. Mobility, if it is to be achieved, results from the design of a properly balanced mobility system, the interrelated elements of which are vehicle capability, terrain conditions and corrective preparations. It is premature to believe that these relationships can be expressed in the form of equations, but it is hoped that ultimately this will be the case.

If we examine valuations of the major transport systems of the United States, we can glean some sense of the magnitude of the preparation portion of such an equation.

Valuation (in billions of dollars) of Major U.S. Transport Systems

System	Valuation Fixed Plant	Valuation Vehicles	Annual Capital Outlay Fixed Plant	Annual Capital Outlay Vehicles
Highways roads and streets	47	65	7	13
Railroads	14	21	0.3	0.6
Airlines (civil)	2	2	0.7	1.6

This indicates that for mass transportation systems satisfactory mobility is achieved when the invested value in preparations approaches the invested value in the vehicle systems. Rough checks of small but favorable systems, such as those in Greenland (Camp Tuto—Camp Century run) and Iran (The Aramco operation), do not indicate lesser proportions. Under less favorable conditions, Korea, for example, costs of preparations exceeded 10 times the cost of vehicles.

In assessing penalties introduced by terrain, we have been obsessed with identifying the limit, the "go, no-go" situation, since virtually all vehicles are beset with a lower limit of ground-strength conditions below which the vehicle cannot function. Conversely, a vehicle should be designed for a carefully selected set of limiting ground conditions because we cannot afford to design for the worst possible case.

For the design of a vehicle with universal application, the selection of suitable limiting criteria presents a double dilemma—acceptance of a no-go situation below this limit, and less ened mobility performance at all other conditions when compared with design optimized at one condition.

The worldwide distribution of soil strength, in terms of trafficability, is such that the well-known M113 (Armored Personnel Carrier) has a worldwide 22 percent probability of off-road no-go. The same vehicle, however, has a 92 percent probability of wet weather off-road no-go at Binh Hung, Vietnam, a locality which is representative of the Mekong Delta.

In view of alternatives the former may be acceptable. The latter demands preparations to gain mobility.

Thus it becomes necessary where mobility is to be achieved to place the vehicle together with the conditions on the spot to identify the extent of preparations required. On this score, much of road building and paving

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ROBERT R. PHILIPPE, chief of the Science and Technology Division, Development Directorate, U.S. Army Materiel Command (AMC), graduated as a civil engineer (1929) from the Massachusetts Institute of Technology (MIT), where he later became an assistant in the Foundations and Soil Mechanics Laboratory.

In 1934 he established the first soil mechanics laboratory for the Muskegum Project. Three years later the lab was moved to Pittsburgh, Pa., and in 1941 to Cincinnati, Ohio, where it became the Ohio River Division Laboratories. Philippe was director from 1941 until 1951 when he transferred to the Office, Chief of Engineers where he became chief of the Special Engineering Branch of R&D.

Prior to his present position, Philippe was scientific director of Environmental Research, AMC. He also was associated with the Salt Lake Crossing of the Southern Pacific Co., and the design and construction of the Karaufuli River in East Pakistan as a consultant.

Philippe has taught or lectured at MIT, Carnegie Institute of Technology, University of Illinois and George Washington University. He has authored several articles ranging from rock mechanics to photo-elasticity. He is now writing a text on transport and mobility.

experience is being brought to focus so as to identify rapidly the magnitude of the preparations required.

For the situation cited above, two and one-half days of effort by an engineer battalion would be required to establish each mile of elementary trail for the M113 at Binh Hung, provided some suitable fill material *could* be found. This could be reduced to 1.6 battalion days per mile if an 8x8 (XM410) truck was somehow modified to serve like a troop carrier as a substitute for the M113.

The vestige of exactness which filters through is deceiving, for even though we have good sense of the limit (go, no-go) our true sense of reduced performance in mobility is less and depends upon information very incomplete, at best, such as:

- *Mobility* for these purposes is defined as rate of transport, expressed in ton-miles per hour.
- *Assessment* of vehicle performance particularly as to rate of transport with ground conditions varying from bad to good.
- *Performance* characteristics of vehicles as they depend on such dimensional factors as roughness of ground, slope, obstacles and the like.

During the Vicksburg Exercise A, three vehicular test beds were designed for operation on very soft ground. The exercise is an experiment that introduces numerics within this mobility spectrum ranging from very soft to hard ground. Each test bed was designed to meet the following requirements:

- Ability to travel on soil strength of 25 Rating Cone Index (RCI) at 50 passes and on 10 RCI for a single pass with maneuvering.
- Ability to reach a speed of 5 m.p.h. in the minimum soil strength.
- Ability to transport a payload of 5,000 pounds.
- Maximum vehicle gross weight of 15,000 pounds.
- Ability to ford a 4-foot deep stream or top a 3-foot-high obstacle.

The mobility of these test beds is being measured in competition with three existing 2½-ton capacity vehicles (U.S. Army designations M134, XM410 and M113) on several approximately level courses a mile long.

These courses are selected successively to provide a variety of ground conditions, from soft to hard, and include a paved surface. Mobility, expressed in this case as ton-miles-per-hour, will be compared.

In addition to the level unobstructed course at each site, another course will be selected to evaluate dimensional factors, such as roughness, slope and vegetation. The mobility of each vehicle will be measured over this additional route.

The experiment is unique because for the first time its conduct—

- Has produced design of vehicle concepts (test beds) based upon quantified soft-ground conditions.
- Will demonstrate the validity of these design methods.
- Will measure rate of transport under known terrain conditions.
- Will quantify terrain-mobility relationships.
- Will validate obstruction-mobility relationships.
- Will fix limits from which efforts for preparation can be calculated.
- Will yield a basis for estimating the effectiveness of prefabricated roadway surfaces.
- Will make it possible to write the first comprehensive mobility equations for this limited case.
- Will provide a basis to establish cost-effectiveness techniques.
- Will give means to estimate expended effort-benefit factors in tactics and logistics.
- Will provide a more rational basis for establishing universal vehicle design requirements.

This experimental approach has the specific purpose of producing quantifiable ties between the three Ps (performance, penalties and preparations) having particular application to the off-road movement problem. In principle, this is an example of an approach which has powerful application to a wide spectrum of mobility-related problems.

Mobility Theses

Thesis A. Mass transportation systems are inexorably dependent upon the fixed preparations such as roads, rails and the like. Conversely, without such preparations the ability to transport becomes limited and in extreme instances nonexistent.

Thesis B. A satisfactory mass transportation system is achieved only when valuations of the preparations of the fixed elements of the system approach, equal or exceed the values of the moving stock.

Thesis C. Preparation is a prerequisite to mobility. The greater the mobility to be achieved, the greater is the preparation required, with no limits as yet prescribed.

Thesis D. Mobility problems at any location are influenced by the state of preparation having application to the problem at that location. In all cases where the preparation is not adequate, an evaluation of the applicable preparation is essential to the solution of the mobility problem. It is probable that the greater the preparation and the greater the competing preparations the more difficult is the process of evaluation.

Thesis E. In the case where preparations are inadequate to support a mobility concept, local conditions of terrain and environment are critical to the definition of the character and energy needed to provide the additional preparations. An analysis of these conditions in terms of the requirements for alternate solutions will often dictate the proper solution.

Thesis F. Attempts to reduce the preparation required for mobility by adding more flotation and traction to a vehicle (land or air) imposes penalties upon the vehicle which rapidly become unacceptable. If a vehicle is provided with flotation and traction devices to take care of the worst of terrain conditions, its load carrying capacity approaches zero.

Thesis G. Means are at our disposal whereby vehicle design configurations can be established to fit any given ground conditions and overall vehicle performance limitation.

Thesis H. Vehicles operating off-road suffer penalties in apparent mobility and perhaps load carrying capacities which appear to increase as the limiting ground support conditions for the vehicle are approached. An evaluation of these penalties is an ingredient necessary to the selection of an off-road mobility system.

Thesis I. To each ground condition there is a unique vehicle contact configuration best suited to that condition. Conversely, a vehicle contact configuration selected for one condition will suffer performance penalties over another unique contact configuration operating under its best suited conditions.

Thesis J. The statistical and regional distribution of ground support conditions is critical to the selection of the fewest number of limiting ground conditions for which vehicles should be designed.

Thesis K. Inherently a sufficient number of different military vehicles or vehicle groups should not be devised to operate on all possible natural ground conditions. In many instances vehicles will have performance characteristics so marginal that limited operations is all that could be supported. The creation of a satisfactory mobility system will still depend upon providing adequate preparations. Conversely consideration of the preparation necessary for adequate mobility will remain a part of the mobility problem.

Thesis L. The operational ramifications caused by changing surface mobility concepts are profound and likely to be overpowering in coming to a proper solution. This should be ever in the background of research and weighed in the light of results.

Army Views Capabilities of ETL Laser for 'Unparalleled Precision'

Long-distance measuring with surveyor's tapes, or even with the technique of radio sounding waves, might become obsolescent with development of a new laser device for the U.S. Army Engineer Topographic Laboratories (ETL), Fort Belvoir, Va.

Capabilities of the instrument for "unparalleled precision" were exhibited to a select group of Army scientists at the ETL Research Institute in Alexandria, Va., preliminary to a 2-month series of distance checks ranging from one to 50 miles, beginning Apr. 22.

Approved test locales include Fort Belvoir, an area in Hybla Valley south of Alexandria, Va., and the Blue Ridge Mountains of Virginia. Plans also are being developed for tests at a special triangulated range near San Diego, Calif.

Acting Director Dr. Desmond C. O'Connor said the Research Institute is responsible for the instrument, its evaluation and testing. Kenneth Robertson, research physicist and task leader in optics, carries out the test plans established by the institute.

The laser device was developed and built by Spectra-Physics Corp. of Mountain View, Calif., under a 1965 contract with the Office of the Chief of Engineers and was delivered in June 1967.

Developers described it as an instrument of such precision, stability and resolution that it should detect any "apparent change" of less than one-tenth of one foot caused by minute fluctuations of the earth's atmosphere, within the distance to a "corner reflector" target 30 miles away.

The purpose of the $69,000 fixed-price contract was to obtain an instrument to study the "index of refraction" of the air (variations of temperature, atmospheric pressure and humidity) which affects the velocity of light and radio beams, Robertson said.

LASER EXPERTS discuss long-distance-measuring instrument at ETL Research Institute. Dr. Robert B. Watson (left), chief of the Physics, Electronics and Mechanics Branch, Physical and Engineering Sciences Division, Army Research Office, OCRD, witnessed a demonstration during recent visit to the Institute.

LINEAR MEASURING TABLE is operated by Kenneth Robertson to test laser against a highly accurate laser interferometer. "Eye" of the laser (above Robertson's head) beams light to the mirror (far left) for short-range testing.

As preliminary tests progressed, physicists discovered that the product was definitely a case of "scientific serendipity." Much interest in the laser instrument shifted to its long-distance ranging capability which, Robertson said, "Far outclasses, in tests so far, any known light-beam generator available to Army or private surveyors."

The success Spectra-Physics had with fulfilling the Army contract requirements led the firm to commercial production of similar units. Robertson said he understands production models sell for about $80,000.

The Geodimeter, a light-beam generator manufactured in Sweden by the AGA Corp., is used extensively by general surveyors. Robertson said it is used occasionally by the Army when relatively limited range but highly accurate readings are desired.

He said this instrument is not considered an all-weather device and its range is little more than one mile in daylight. A few Geodimeter models have been modified for small lasers.

Radio-beam instruments used in Army topographic mapping include the Tellurometer, made by a South African corporation. Another microwave radio device for measuring distance is Electrotape, manufactured by the Cubic Corp. of California.

Robertson said the laser instrument "met or exceeded its design goals in all respects." In index-of-refraction tests completed at press time, the physicist listed the laser's characteristics as follows:

- Resolution: .001 foot or .3mm.
- Zero error: .001 foot or .3mm.
- Stability: less than .01 foot drift or 3mm in 24 hours.
- Maximum distortion throughout the modulation wavelength: .002 foot or .6mm.
- Oscillator frequency error: less than one part in 10 million.
- Range: depending on atmospheric conditions—daylight, 30 miles; night, 50 miles.

"Perhaps the world's finest portable distance-measuring instrument," ETLRI personnel express this opinion of the laser unit which with control unit and tripod weighs about 90 pounds and is easily transported by two men. It uses 110 volts from a conventional source or from a portable gasoline generator.

In one test, two measurements of a 3,000-foot baseline made six months apart agreed to within .002 foot, or with precision better than one part in one million. This exceeds the "known accuracy" of the velocity of light, measured in terms of a basic standard at one in one million.

By physical law, *accuracy* of this type of instrument cannot exceed the established standard of accuracy for the velocity of light. *Precision* of the laser device now being evaluated can and, in several tests, has exceeded the standard.

Robertson said the precision of the laser could be used to measure small earth movements over a period of time, such as the shifting of a hillside, or changes in any of the earth's geological faults. The "lean" of the Leaning Tower of Pisa or the sinking rate of the streets of Venice could be measured by periodic readings.

Highly refined electronically and optically, the ETL Research Institute laser is considered a most practical instrument, requiring an hour and a half to "warm up" and one-half hour to make specific distance measurements. It is estimated it would take a surveying crew with tape "weeks to perform the same task with the same accuracy."

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