(2nd page of W. Brode Dec. 15 letter)

Members of the Presidents Science Advisory Committee

John Bardeen (Physics) (Univ.)
+George Beadle (Bio) (Univ.)
-Detlev Bronk (Bio-Phys) (Un'v) MJ-12
+Harvey Brooks (Physics) (Univ)
- James B Fisk (Physics) (Industry)
Donald F. Hornig (Chem-Phys) (Univ)
+ James R. Killian (Phys-Adm) (Univ) IDA CHAIRMAN
+ Robert F. Loeb (Med.) (Univ)
+ W.K.H.Panofsky (Phys) (Univ) IDA JASON
+ E.R.Piore (Phys) (Industry)
+ E.M.Purcell (Phys) (Univ)
+ I.I.Rabi (Phys) (Univ) IDA JASON
+ G.T.Seaborg (Chem-Phys)(Univ)
John W. Tukey (Math-Phys) (Univ) IDA TRUSTEE
+ A.M.Weinberg (Phys) (Industry)
+ J.B.Wiesner (Phys) (Univ) IDA JASON
W.H.Zinn (Phys) (Industry)
+ G.B.Kistiakowsky Chem-Phys) (Univ) IDA JASON

Former members have included
- RobertBacher (Phys) (Univ) IDA TRUSTEE
+ E.H.Land (Phys) (Industry) IDA TRUSTEE
+ L.V.Berkner (Phys) (Univ-Ind) MJ-12
- W.O.Baker (Chem@Phys) (Industry) IDA TRUSTEE
+ C.P.Haskins (Phys) (Foundation)
- H.P.Robertson (Math-Phys) (Univ)
J.R.Zacharias (Phys) (Univ) IDA JASON
- Paul Weiss (Bio) (Univ)
Hans A.Bethe (Phys) (Univ)
J.H.Doolittle (Eng-Phys) (Industry) RUMORED HIGH LEVEL INVOLVEMENT
- Herbert York (Phys) (Industry) IDA TRUSTEE - JASON FOUNDER
- PAUL DOTY (CHEM) (UNIV) JASON

Note High concentration in Physics with exclusion of many important fields of science

Concentration in limited number of Universities and industries

Complete absence of career government scientists

My personal view

\+ favor Democratic philosophy
\- favor Republican philosophy

RICHMOND, VA 232
PM
26 AUG
1989

WORLD STAMP EXPO '89
WASHINGTON, DC
NOV. 17 - DEC. 3, 1989

E
Earth
Domestic USA

T. Scott Crain, Jr.
P.O. Box 11
Port Matilda, Pennsylvania 16870

William S. Steinman
15043 Rosalita Dr.
La Mirada, Calif.
90638

Dr. Eric A. Walker
8 Stuart Place
Hilton Head, South Carolina
29928

Must rept
Did Code(-1)

April 7, 1988

Dear Dr. Walker:

Sorry for not getting back with you sooner in referance to your letter to me dated Sept. 23, 1987. That letter left me completly bewildered; so I set it aside and let it go for a while.

procedures for determining draft calls and assigning enlistee and draftee duties. The Assistant Secretary of the Army for Manpower and Reserve Affairs, William K. Brehm, is quoted extensively throughout the report. "The popular jobs are the ones for which people enlist. They don't enlist for the hard-core combat skills. That is why draftees tend to populate the hard-core combat skills: 70 per cent of the infantry, armor, and artillery are draftees." Brehm, in explaining that the three-year enlistees are allowed to choose their jobs in the Army, was somewhat ruefully aware that in 1970 fewer than 3 per cent of those volunteering for service in the Army asked to serve in the infantry. "As strange as it sounds," the *National Journal* quoted Brehm as saying, "only 800 young men a month out of 200 million Americans are enlisting for combat."

It should be noted that Brehm is the Assistant Secretary of the Army for Manpower *and* Reserve Affairs. The *National Journal* quoted Director of Manpower Utilization Jonas M[illegible] to the effect that the draftee policy for the Army is formulated within the Army. Those two facts, taken in the context of the times, might indicate that, once the *National Journal* had broken the story on the draftee death rate in Vietnam, Mr. Brehm was instrumental in alerting the Administration to the need for counteracting as well as possible any latent (say, election year) criticism of Administration draftee policy.

The publication of these key draftee statistics, in conjunction with the fact that the Administration has long been aware of the class inequities of the present system, might better explain this unexpected move by the Pentagon (read: Nixon) than does a concern for economy. The possibility of the vote for 18-year-olds, coupled with Agnew's recent catering to the "workers," raises the urgency of some conciliatory gesture yet another notch. Traditionally, the sons of the upper class have filled the ranks of the Reserves and National Guard—which until now have been seen as an easy out from overseas duty—and the sons of the lower class, Agnew's "workers," have fallen to the monthly toll of the draft, and as the *National Journal* revealed, to the weekly toll of the war. □

The Military Research Network

MICHAEL KLARE

Mr. Klare, a staff member of the North American Congress on Latin America, is completing a book on counterinsurgency planning in the United States.

Opposition to university-performed military research has been a national issue since the dramatic 1968 student rebellion at Columbia University, which had been provoked, in part, by the university's sponsorship of a Pentagon think tank. Many of the campus protests, sit-ins, building occupations, strikes and bombing incidents of the past few years have been an outgrowth of the struggle against war-related research. This article examines the ways in which university life has been altered by the research priorities of the cold war, and assesses the effects of the campus movement against war research.

Until the present century, new weapons were developed by hit-or-miss experimentation, or through continuous refinement of existing devices. It is only in the past three decades that instrumentalities of warfare have emerged from organized scientific investigations, in which the talents of many researchers are pooled in the quest for novel military systems. The Manhattan Project of World War II is the prototype for all such efforts—at its peak thousands of scientists were engaged in various subtasks of the project, many without being aware of its final objective. In order to mount other large-scale research projects, the War Department found it necessary at the onset of the war to establish a network of mammoth laboratories devoted to intensive research on advanced weapons systems. Since the only reservoir of trained scientific manpower available for such work was the university community, it was inevitable that the nation's institutions of higher education be mobilized for the establishment of a military research network. Gerard Piel of *Scientific American* wrote in 1965 that during World War II,

> The universities transformed themselves into vast weapons development laboratories. Theoretical physicists became engineers, and engineers forced solutions at the frontiers of knowledge. MIT and Harvard undertook to create the strategy and tactics as well as the instruments of radar and counter-radar; from Johns Hopkins came the proximity fuse that brought the conventional high-explosive artillery shell to its peak of lethality, and Columbia, Chicago and California joined in the successful engineering and manufacture of the most fateful weapon of all.

During the war, a number of university laboratories developed into sizable institutions, employing thousands of scientists and technicians. This wartime mobilization of university resources had been undertaken on the basis of expediency, and had not been intended to outlast the war. As victory approached, however, the military services and some of the universities sought to prevent the dissolution of these installations. With the dawn of the cold war, the Pentagon found itself enjoined to "contain communism" on a front that stretched from Berlin to Seoul, and a new era of university-government cooperation commenced. The Pentagon maintained, and ultimately expanded, the military research network.

The outstanding characteristic of university warfare laboratories—the concentration of scientific personnel under conditions of relative autonomy—makes them particularly attractive to the Pentagon as performers of military research work. University research centers have grown in importance in direct proportion to the increasing value placed on the country's "technical intellectual resources" —the scientists and engineers whose investigations lie at the root of all technological advancement. The growing respect accorded these human resources can be detected in the concern expressed by many countries over the "brain drain," and in the efforts of aerospace companies to sell their technical intellectual capability rather than their technology.

Since there is a limited supply of this highly marketable commodity, the motivations, incentives and working conditions which determine the employment patterns of the technical work force are matters of great concern to Pentagon research administrators—who naturally seek to attract the best minds available to any given project. Studies of the attitudes of professional research personnel indicate that organizational incentives (opportunity for advancement into management) and material incentives (higher salaries) are not closely related to technological productivity. In contrast, professional incentives (e.g., allowing the individual a high degree of freedom and flexibility in choosing his own work assignments according to what he feels will be professionally challenging) are likely to be associated with higher levels of both professional and organizational productivity.

In one survey of work attitudes, research professionals indicated that they were highly motivated by the "opportunity to contribute to scientific knowledge" and by "association with other professionals of recognized ability," and were little stimulated by "membership in a company producing reputable goods and essential services." It is not hard to deduce from such data that universities provide the environment most likely to assure high technological productivity. In confirmation, Dr. Frederick Seitz, past president of the National Academy of Sciences, told a Senate committee in 1963:

> A certain fraction of the best minds find the type of freedom and flexibility peculiar to the university best suited for their work. In addition, the presence of many inquiring young minds in the formative period, particularly the research students, adds a particular freshness and vitality to research. I do not mean to say that excellent work is not done elsewhere. . . . What is important is that any program which does not take maximum advantage of the capability of the university will not advance in the most effective way possible.

Analysis along such lines has prompted the Defense Department to establish military research centers at selected universities, to enlist the help of university administrators in the creation of independent research organizations (as in the case of the Institute for Defense Analyses), and to offer financial inducements to universities that agree to adopt an existing facility (as when the University of Rochester undertook to administer the Center for Naval Analyses). Where direct university participation has not proven feasible, the Pentagon has created a network of para-universities—independent research organizations which boast a "campus-like environment" and adhere to the many rituals of academic life (the most famous example of this kind of institution is the RAND Corporation).

In its postwar determination to reconstitute the military research network, the Pentagon could count on the enthusiastic cooperation of many university scientists and administrators. The reasons were obvious enough—for the first time in American history, scientists and academicians had come to enjoy positions of considerable prestige and influence in Washington. Experiments that would have been prohibitively expensive before the war now enjoyed abundant government financing. Moreover, the establishment of large research organizations had freed many professors from conventional academic procedure and permitted them to pursue laboratory studies without being accountable to their colleagues in tradition-minded university departments. Some scientists—more interested in the application of their research to the "real world" of industry and national security than to the advancement of higher education—welcomed this development. In a 1967 Senate speech on "The War and Its Effects," Sen. J. William Fulbright commented that, "Disappointing though it is, the adherence of the professors [to the military-industrial complex] is not greatly surprising. No less than businessmen, workers, and politicians, professors like money and influence. Having traditionally been deprived of both, they have welcomed the contracts and consultantships offered by the Military Establishment."

For this combination of reasons, scores of semi-autonomous military research organizations were established by American universities. Some of these installations have come to enjoy a special relationship with the government as Federally Funded Research and Development Centers (FFRDCs). As such, they receive at least 70 per cent of their income from federal agencies, and work "under the direct monitorship of the government." According to National Science Foundation nomenclature, FFRDCs are "organizational units associated with universities and colleges whose creation and operation are not primarily related to the main function of the administering universities and colleges." FFRDCs receive a substantial portion of the federal research-and-development (R&D) funds available to the university community: in fiscal 1968 (the last year for which such data are available), university-administered FFRDCs received $945 million from the government, compared with the $1,416 million awarded directly to the universities for R&D activities.

Even when not recognized as FFRDCs, campus research centers can be found at most universities. In the main, these institutions work on military and space "hardware" —the mechanical equipment needed to outfit an army or launch a space vehicle. Increasingly, however, they are devoting themselves to developing "software" systems— the mathematical and analytical models used in systems analysis, operations research and related methodologies. Research centers have contributed substantially to the development of military software systems, and many of them—particularly the para-universities like RAND and IDA—have become noted for this kind of work. University social scientists, foreign area specialists and educational researchers also found it profitable to establish autonomous research centers when the R&D budgets of nonmilitary federal agencies exploded in the 1960s.

As cold-war defense appropriations soared, ambitious researchers—many of them associated with the Defense Department as consultants—could get impressive contracts from the government. Most of these went to semi-autonomous research centers like Michigan's Willow Run Laboratory and the Cornell Aeronautical Lab., which could meet the Pentagon's strict security requirements Today, some of these organizations enjoy the budget and facilities of a large university The University of California, for instance, operates the Lawrence Radiation Laboratory and the Los Alamos Scientific Laboratory—installations which have a combined staff of 11,850 scientists, technicians and support personnel, and an annual operating budget, in 1968, of $288 million (an amount that exceeds most state budgets for higher education). Many of the scientists associated with these institutions have been able to augment their incomes by setting up defense-oriented "spin-off" companies which market the products developed in university laboratories.

In fact, as one penetrates further into the military research network, the distinction between academic and nonacademic functions tends to disappear. The trustee or administrator of a university research institute is more often than not the executive of a spin-off company located in the nearby industrial park, and at the same time a consultant to the Pentagon bureau which monitors contracts in his field of research. RAND, IDA and the other independent "think-tanks" often act as middlemen in these consortia. With such a system, the government can buy top scientific talent while bypassing low civil service salaries and avoiding accountability to Congress. Defense industry corporations, whose executives often dominate the boards of trustees of the research institutes and think-tanks, gain access to classified information and have the opportunity to "evaluate objectively" the projects they are trying to sell to the government. The universities, in return for their participation in the consortia, receive for their professors large research contracts and lucrative consulting fees. Examples of this arrangement can be found in most university communities, and are especially prevalent at the large research-oriented campuses like MIT, Stanford and Johns Hopkins.

In the summer of 1965, a subcommittee of the House Committee on Government Operations held a series of hearings on "Conflicts Between the Federal Research Programs and the Nation's Goals for Higher Education." The committee subsequently issued a report to the Congress in which it was argued that, "While both research and higher education share the common goals of extending scholarship and developing the intellectual resources of the nation, *the immediate interests of one are not necessarily those of the other*." [Emphasis added.] Federal research programs, the committee explained, are designed to advance the nation's technological capabilities—particularly in the areas of defense, atomic energy and space—while goals for higher education call for as many Americans as possible—regardless of race, nationality or income—to obtain a college education. From the testimony and reports it examined, the committee concluded that, "Our Federal research programs, on the one hand, and the nation's goals for higher education, on the other, are in increasing conflict."

The first conflict, according to the committee, is the application of America's technical intellectual resources: "scientists and engineers are indispensable to research and development. They are also indispensable as teachers in the expanding higher education system. Since their numbers cannot be greatly increased over the short run, too much diversion into the one means deprivation of the other." Using National Science Foundation (NSF) figures, the committee estimated that two-thirds of all scientists and engineers engaged in R&D work were employed on federally funded projects. Since almost 90 per cent of all federal R&D funds are contributed by either the Department of Defense, the National Aeronautics and Space Administration or the Atomic Energy Commission, it is safe to assume that a majority of these scientists and engineers were committed to defense-related work. When federal R&D expenditures are rising (as, for instance, during the years 1950-65, when they grew at the rate of 15 per cent a year), this diversion of scientific manpower to military work leaves an inadequate number of qualified scientists for college teaching (particularly at the smaller colleges). R&D employment in the government sector has also created a problem that was not foreseen in the 1950s and early 1960s: when federal R&D expenditures are reduced (or maintained at an even level during a period of inflation, as has been the case for the past two years), a surplus of scientific manpower develops which cannot be easily integrated into other sectors of the economy. Since the scientists engaged in defense research tend to become specialists in narrow fields of particular interest to the military, they often lack the background that would enable them to switch into teaching or nonmilitary research activities.

The same kind of skewed priorities have developed *inside* the university. "Federal competition for scientific manpower," the committee found, "has not stopped at the gates of colleges and universities." By providing about 70 per cent of all research funds received each year by educational institutions, "the Federal government reaches within the higher education system to claim a substantial share of the working time of the college and university faculties, and a very high share of the time of science faculties." The consequences of this phenomenon are as obvious to the committee as they are to most other observers of university education: "colleges and universities have responded to Federal demands for research by channeling an increasing number of professional employees into research work, by reducing teaching time of research-performing faculty, and by offering such reductions as inducements to attract new faculty." The resultant deterioration of undergraduate education—manifest in huge lecture classes and poorly qualified teachers—has become a fact of life at every large university.

The most conspicuous result of the conflicts between federal research programs and the nation's goals for higher education is the concentration of federal funding in the institutions that Clark Kerr calls "Federal grant universities." These favored schools receive up to 85 per cent of their income from federal research funds, and up to 100 per cent of their research budget from this source. There are not many such institutions. According to fiscal 1967 figures, the top 100 recipients of federal obligations for higher education got 69 per cent ($2,278 million) of all such funds, and 88 per cent ($1,166 million) of all federal R&D funds. Fifteen universities alone captured 38 per cent ($507.9 million) of all R&D funds available directly to universities, while fifteen schools alone received 49 per cent ($447.4 million) of federal funds going to university-administered Federally Funded Research and Development Centers.

The favored status of such federal grant universities, which can in most cases be traced back to World War II, is a self-perpetuating phenomenon. The objective of federally funded research, according to the House committee, "is the most research at the least costs." Since the government is most likely to entrust its R&D funds to scientists with considerable research experience, "the objective of buying research to the exclusion of other considerations will lead inexorably to the concentration of Federal research funds at the major universities."

The concentration of federal R&D funds at a relatively few universities has meant, according to the committee,

> a similar concentration of research opportunities and incentives for scientists and engineers. Favored universities have been able to attract and keep the best scientists and graduate students. Institutions not so favored have lost many of their ablest professors, and are unable to compete on equal terms for replacements. *Thus, the Federal research programs have not only made already strong institutions stronger. They have done so partly at the expense of the weak.* [Emphasis added.]

The ability of top universities to attract the best scientists has in fact created a "brain drain" from poorer institutions—four-year colleges, junior and community colleges—and from certain sections of the country—Appalachia, the Deep South, the Plains and Mountain states. With a few exceptions, the principal recipients of federal R&D funds are in the Northeast, Middle-Atlantic, Great Lakes or Pacific Coast areas. Six states (Massachusetts, New York, Pennsylvania, Illinois, Michigan and California) received 43 per cent of all federal funds going to universities and colleges in fiscal 1967, and federal R&D expenditures at schools in these states were even more concentrated.

At this point, it is appropriate to draw some conclusions as to the effects of university-military collaboration in the postwar era. The facts presented above suggest that American colleges and universities have become divided into two camps—with the big R&D performers on one side, and those with few R&D contracts on the other. The large research-oriented universities are able to maintain their favored status by "bleeding off" the intellectual resources of less-favored schools. This process tends to perpetuate the underdeveloped condition of the "have-not" schools, which consist of women's colleges, Black colleges, four-year liberal arts colleges, state and municipal schools attended by working class and lower-middle-class youth, agricultural schools, and other non-Ph.D.-granting institutions. Such schools lack adequate equipment and facilities, are unable to attract outstanding faculty members (particularly in the sciences), and cannot offer opportunities for faculty and students to engage in advanced research projects. They cannot, in sum, provide their students with a first-rate education.

The big R&D-oriented universities are, of course, strong where the have-not schools are weak—they can boast ultra-modern facilities, star-studded faculties, multiple research opportunities. But by becoming dependent upon federal research contracts for their operating expenses, they have lost any claim they might once have enjoyed to be called "independent centers of knowledge." The patterns of cooperation between university R&D performers and federal R&D consumers tend to become self-sustaining. This is admirably summarized in this passage from the *Harvard Crimson*'s 1969 "Report on the Future of the University":

> The government, to a large degree, has created its own need for itself among the universities. It is not merely a case of the universities needing money and the government providing it; the government has built up large-scale scientific research as an almost totally new function for universities, a function that only the federal government can finance. . . .
>
> As the sale of the research product became more and more profitable to universities (especially after Sputnik, in 1957), the universities began to reorient their resources—and their own concept of their function—to be able to provide the product more easily. The universities developed a deep dependence on the government, which caused them to anticipate what the government wanted from them and brought them to believe the government's interests were the same as their own.

It is clear that by orienting its activities so as to anticipate the research needs of the government, the universities have by default neglected those areas of inquiry that might embarrass the government or threaten its prerogatives. This fact has been noted by many critics of the government-university relationship; thus, in his 1967 speech on "The War and Its Effects," Senator Fulbright commented that while federal R&D funds do make some contribution to higher education, they do so at a price:

> That price is the surrender of independence, the neglect of teaching, and the distortion of scholarship. A university which has become accustomed to the inflow of government funds is likely to emphasize activities which will attract those funds. These, unfortunately, do not include teaching undergraduates and the kind of scholarship which, though it may contribute to the sum of human knowledge and to man's understanding of himself, is not salable to the Defense Department or the CIA.

Fulbright concluded that the current wave of student unrest is due, not to inferior education but to "the student's discovery of corruption in the one place . . . which might have been supposed to be immune from the corruptions of our age."

For the past two years, student opposition to university-conducted military research has been a major issue all over the country. Efforts by student radicals to "move beyond protest" in the struggle against U.S. intervention in Vietnam led to campaigns against local manifestations of the "War Machine"—ROTC, Armed Forces recruiters, Dow Chemical Company representatives, and military research projects. As campuses became mobilized behind concrete demands—"ROTC off the Campus," "No More War Research"—symbolic protests and vigils gave way to mass civil disobedience and then to violence.

Opposition to Columbia University's membership in the Institute for Defense Analyses culminated in a strike which effectively paralyzed the school for two months. The Columbia action was followed a year later by a "spring offensive" against military research that led to sit-ins, strikes, and in some cases violent confrontations with police at many of the large research universities. Finally, the Cambodian invasion of April-May 1970 precipitated a nationwide wave of protests against war research and military ROTC training. These successive campaigns have produced a number of conspicuous realignments in the military research network. Several prominent research centers have lost their university affiliation (American University's Center for Research in Social Systems, George Washington's Human Resources Research Office, MIT's Instrumentation Laboratory, and the Stanford Research Institute), and several others have been compelled to restrict their military research activities. One may pertinently ask, however, how much has actually been accomplished by the student movement. Here follows a provisional answer to that question.

I have said that the most important military function of the university is the production and concentration in useful form of what have been called "technical intellectual resources." A 1966 Stanford Research Institute study summarized this function as follows: "The university is a major performer of defense R&D; a supplier of advisers and consultants to defense R&D agencies; a producer of the technical professional work force that is the prime production factor in the many government, nonprofit, industrial, and academic laboratories that produce defense R&D; and a provider of continuing, updating education to the defense R&D work force."

Any evaluation of the movement against war research would have to conclude that the only *measurable* achievements of the campus revolt have been confined to the *first* role identified by Stanford Research Institute, the production of defense R&D directly by the universities. Some universities have placed bans on secret research or otherwise objectionable projects (e.g., work on chemical and biological warfare), and some research institutes have been severed from their parent university. However, no limitations have been placed on any of the other defense R&D roles performed by the university. It is questionable, moreover, whether any of the actions taken by the university have had any effect on the day-to-day functioning of the military research network: nonuniversity research organizations have been found to assume responsibility for projects abandoned by the universities, and the institutes that have lost their university sponsorship are fully capable of continuing work on their own. Thus even the institutional measures adopted by the universities to divest themselves of defense R&D work will not substantially alter the composition of the military research network, the cohesion of this network, after all, depends not so much on formal arrangements as on its ability to funnel information to the Pentagon and money back to the research performers—a process that goes on unabated.

If any results have been achieved at all by the campus protest movement, they would have to be manifest in the most fundamental area of all—the attitudes and loyalties of the people who comprise the nation's technical intellectual resources. If America's outstanding scientists and engineers were persuaded to abandon military work, the military research network would be seriously impeded. And if young scientists and graduate students eschewed a career in fields closely tied to "defense technologies," the impediment would be lasting.

In a guest article in *The New York Times*, Director of Defense Research and Engineering, Dr. John S. Foster, Jr., revealed that the Pentagon is concerned by the growing alienation of young scientists from military research work. This phenomenon received national attention on March 4, 1969, when thousands of scientists participated in a one-day research strike to "protest the misuse of technology and the complicity of the scientific and technological community with the growing power and influence of the military-industrial complex." Participants in the March 4 strike at MIT heard an impassioned plea from Harvard biologist George Wald for nothing more than "a reasonable chance to live, to work out our destiny in peace and decency." Wald, a Nobel laureate, told an appreciative audience that while "our government has become preoccupied with death, with the business of killing and being killed," the business of scientists "is with life, not death." [See "Science: The Movement vs. the Establishment" by Charles Schwartz, *The Nation*, June 22.] Recognizing that these arguments endanger the morale and discipline of the troops under his command, Foster felt compelled to respond on an elevated moral plane to the anti-military campaign:

> The theme of these young people is valid—our talents and our physical resources should be directed primarily toward enhancing the quality of life. . . . Unhappily, one compelling attribute of the current era, the end of which is not in sight, is the fact and prospect of war. Security from external threat to our nation is a prerequisite, therefore, to the improvement of the quality of life. . . .

Lurking in the background, then, are the faded imperatives of the cold war; from this perspective, "Research in areas of interest to defense is not in itself immoral. But to deny others the right to pursue defense research and to find alternatives for the common defense is, in my judgment, immoral."

There is, of course, no way to determine who is being most persuasive in this struggle for the loyalties of young scientists. Nevertheless, there is some indication that the Pentagon will not, as in the past, be able to choose at random among the brightest minds in the nation when lining up staff for important research projects. Disenchantment with the military orientation of the "Science Establishment" was clearly visible at 1969 and 1970 meetings of the American Physical Society and the American Association for the Advancement of Science, where activists shattered the normally placid atmosphere of the proceedings to challenge those who unquestioningly accepted the present utilization of scientific resources. ("Our job as scientists," one protester shouted, "is to see that science resources benefit the people.") At MIT, the Science Action Coordinating Committee, sponsor of the March 4 research strike, has won a pledge from the institute's administration to seek nonmilitary financing for MIT's

M.I.T	JOHN HOPKINS	HARVARD	PRINCETON	U. of. BERKELEY
	34-26. BOARD of TRUSTEES.			
Hunsaker 33-51	TUVE 42-46	MENZEL 32-66	VON NEUMAN	OPPENHEIMER
Bush dean eng 1932-38	BRONK. 1949..	WALKER	OPPENHEIMER	TELLER.
Kissinger	HYNEK.	KISSINGER 50-57		MENZEL.
Berkner sp. projects 1950-52.	EISENHOWER.			
	BUSH - TRUSTEE			ALVAREZ
Compton				
~~[illegible]~~ Zacharias				

CARNAGIE INST.	TUFTS.	NAT'L ACAD. ENG
BUSH. 38-55	BUSH 1914-17	BUSH FOUNDERS. AWARD 1966.
BERKNER	WALKER	WALKER - one of founders V.P. 1st PRES.
TUVÉ 1946	TUVÉ.	

The Polar Watch

continued from page 120

intended targets; he was convinced that electronics could supply the necessary techniques for a nearly automatic control of the air battle.

Von Kármán was impressed by Valley's ideas. He pressed them upon the Air Force, and Valley was asked to explore the technical possibilities in a study known as ADSEC (Air Defense Systems Engineering Committee).

ADSEC was the first serious step toward the development of an electronics system for the central control of the continental air battle; out of it emerged the germinal scheme for the SAGE system. But in the face of the skepticism of the Air Force, ADSEC did not get very far with the idea of extending a warning system beyond the U.S. frontiers.

Project Charles ponders

In February, 1951, at the request of the Air Force, M.I.T. began another study of air defense under the code name Project Charles. The project gave its blessing to the SAGE system, and to allow more time for the system to come into action, it recommended strengthening the radar surveillance line along the U.S.-Canadian frontier (now called the Pine Tree System). However, Project Charles brushed past the idea of the polar warning line, if only because the technical difficulties appeared to be overwhelming. Communications in the Arctic were often "blacked out" for hours at a time by magnetic storms, which meant that critical parts of a warning system might be blotted out for long and dangerous intervals.

Further, then existing search radar did not have a vertical span of much beyond 40,000 feet—and the line could therefore be overflown by jet bombers. Nor could existing radar provide low-altitude protection beyond the horizon, which meant the line could also be underflown. Moreover, Soviet bombers could outflank the line by using the Atlantic or Pacific approach.

"How much warning?"

For all of these reasons, Project Charles concentrated its attention on the "local" air battle—i.e., the defense of the northernmost cities of the U.S. and the SAC bases.

While all this was going on, Dr. Lloyd V. Berkner, a physicist who now heads the Brookhaven Laboratory for nuclear research, was conducting for the Defense Department a civil-defense study called East River. One of Berkner's first questions had been, "How much warning can we expect?" He was told: possibly not more than ten minutes.

The more Berkner studied civil defense, the more convinced he became of the absolute necessity of a polar warning system. "Either we find a way to give ourselves four to six hours' warning," he told whoever in Washington would listen, "or we give up the idea of any kind of defense, civil or military."

Seeking support for a distant alarm system, Berkner got in touch with his scientist friends at M.I.T. Dr. Albert G. Hill, an electronics expert, had become director of the Lincoln Laboratory at M.I.T., an outgrowth of Project Charles. Berkner pressed Hill to widen the laboratory's study of air-defense weapons systems into a thoroughgoing examination of the feasibilities of an Arctic radar line. Hill agreed to make the Lincoln facilities available for a full-dress seminar to which Berkner would invite the ablest scientists he could recruit.

This was the setting of the celebrated and controversial Lincoln Summer Study of 1952—an informal and, so far as the Pentagon was concerned, a wholly unofficial, wholly unsponsored caucus of many of the nation's most eminent scientists. They concluded that an Arctic radar line had become tehcnically feasible, within acceptable costs. Two developments contributed to these conclusions. Physicists Jerrold Zacharias and Louis Smullin of M.I.T., working along one line, and Dr. Garnet A. Woonton of McGill University, working along another, had more or less simultaneously come up with ways to trigger an alarm automatically whenever a radar beam picked up an airplane. The Zacharias-Smullin technique could be applied to a rotating search radar, and Woonton's to fixed-beam equipment that could be used to cover the low-altitude gap under the longer-range search radars. The two methods in combination promised to reduce the manning requirements of the DEW Line to one-eighth of what the Air Force had thought they would be. Zacharias' contribution was a major one; it brought the various components into a full-blown and nearly automatic warning system.

Another missing piece

A third and even more striking advance had taken place in the field of communications. The Voice of America had been relaying its programs

continued page 246

to transmitters in Europe by means of short-wave radio across the Atlantic. Short-wave relay was notoriously noisy and in 1950 the State Department asked the Bureau of Standards and M.I.T. to devise a better relay.

Out of that study came a truly revolutionary development—the "forward scatter" technique. In simple terms, this utilizes the troposphere and ionosphere (layers in the earth's envelope of air) as reflectors for bouncing VHF and UHF signals beyond the horizon. Tropospheric scatter, it was established, was good over a range of 50 to 400 miles, and ionospheric at 600 to 1,200 miles. Tests in Alaska, moreover, had proved that the signals were all but impervious to atmospheric disturbances common to the Arctic. M.I.T. scientist Wiesner was sure that forward scatter would provide the reliable communications essential to a polar warning line. The Lincoln Summer Study group was profoundly impressed.

Before they finished in September, the Lincoln scientists even drew a feasible line across the Arctic, choosing locations that could be supplied by relatively cheap sea transportation during the summer months when the Arctic waters are open. They also proposed to cover the sea flanks by maintaining a continuous patrol of radar-equipped aircraft along the Atlantic and Pacific approaches.

That autumn, the Summer Study proposal went to the Pentagon, there to meet a cold reception. The Air Force was still not convinced of the value of what, at best, was only an alarm system. Berkner, however, managed to maneuver the proposition past the Air Force to President Truman. It was a bad time to do business with the White House. The Democrats had gone down in defeat in November. Nevertheless, in December, 1952, only a few weeks before his term of office expired, Truman sent a terse memorandum to the Defense Department that went substantially as follows: "Go ahead with this all out. Seventy-five million dollars has been set aside for it."

The DEW Line was among the military programs reviewed by President Eisenhower and the reconstituted National Security Council in February, 1953. Truman's "all out" order was peremptorily withdrawn. But the project, which had already been launched on a tentative basis, was allowed to go forward, starting with a prototype DEW Line consisting of seven stations, which would provide a practical test of the technical theory.

The tests began at Barter Island, just off the north coast of Alaska, in the Beaufort Sea about 350 miles east of Point Barrow. Here, during the winter, the sun remains below the horizon for seven and a half weeks; the temperature drops to -60°; and gales up to 100 miles an hour can be expected.

"Quick and dirty"

Western Electric Co. was given the contract for setting up the stations and equipping them. It subcontracted the station-building job to Puget Sound Bridge & Dredging Co., of Seattle. To Lincoln Laboratory and, specifically, to Dr. Albert Hill fell the responsibility for guiding the technical side of the project.

Hill's plan was to place three radar search stations about 150 miles apart—close enough, theoretically, for the scanning beam of one to overlap that of the next; and to space between them, at intervals of about fifty miles, four fixed-beam stations (intermediate, or "I" stations) that would cover the low-altitude interstices between. The I's were to be equipped for tropospheric scatter communication laterally along the line, as were the search stations. Two of the search stations would be auxiliary ("aux") stations. The third, at Barter Island, in the middle of the whole line, would be the main station: besides performing the search function and acting as a data-collecting center for the smaller stations on either side, the main station would have ionospheric scatter for communicating rearward—in this instance to Anchorage, 720 miles south.

In the interest of speed, Hill had decided on a "quick and dirty" conversion of equipment already in production for the military. The most difficult job was to adapt the automatic alarm features to the existing radar and this meant devising "discriminating," or "second-thought," devices, intricate gear that would not be fooled by birds, blizzards, meteors, or the aurora borealis.

There were other problems—how, for example, to keep the rotating antennae from collapsing under the weight of ice that was certain to accumulate. The first solution was to encase the structure in a rubber radome, inflated like a balloon by warm air at two pounds' pressure.

continued page 250

The Polar Watch cont.

(This radome was a flop. The winds buffeted it; leaks were chronic; and it was replaced by a plastic dome.)

By May, 1953, the essential gear was at dockside in Seattle. By July, it was being unloaded at Barter Island and at the adjoining sites along the Beaufort Sea. By September, the buildings were up at all the sites; and by February, 1954, the radar and forward-scatter systems were in full operation.

A second decision

The Barter Island experiment vindicated the fundamental technical assumptions. It was also educational. From it, for example, there evolved an ingenious new idea for polar housing: a prefabricated structural block, or module, twenty-eight feet long, sixteen wide, and ten high, made of plywood. Identical modules fastened together in a "train" of desired length would provide connecting working, living, and storage quarters; and the low and narrow frontal area, pointed into the prevailing wind, would present little lodgment for the drifting snow that otherwise overwhelms all that is stationary.

By the summer of 1954 theory and practice were demonstrably in accord, and the Air Force now swung behind the early-warning idea. The Canadians agreed to open up their geography. That summer a tentative line across the Arctic was charted from the air and sites for the stations were selected. Still the National Security Council hesitated—especially Defense Secretary Wilson, who was worried about the cost. But finally, in November of 1954, the Administration decided to go ahead with the line—as a crash operation.

Western Electric was again given the supervisory contract. This called for delivering the system in full operation to the Air Force by July, 1957. To carry out this heroic assignment, designated as Project 572, the company turned to a forty-nine-year-old communications engineer, Vernon B. Bagnall, Western Area manager for the Bell System, who had supervised the Barter Island operation and had good reason to know what he was in for.

First by air

Bagnall divided the 3,000-mile line into three segments for construction purposes; a different contractor would be put in charge of each segment, and the work would be pushed simultaneously.

By late January, 1955, Bagnall had three first-class companies lined up. Puget Sound Bridge & Dredging took on the entire Alaskan segment. Northern Construction Co., a Vancouver firm that had built Canada's northernmost hydroelectric plant near Yellowknife and a big power plant in the Yukon, was given the central segment (from the Alaskan frontier to the middle of the Boothia Peninsula—1,600 miles). The Foundation Co., of Montreal, was awarded the eastern segment (from Boothia Peninsula to Baffin Island—topographically the most difficult segment).

The Canadians were startled by the American insistence on doing the job in two seasons. Bagnall did not seem to hear their objections—that construction on this scale would take at least three, possibly four seasons—he had everything figured out. During what was left of the winter he planned to airlift pioneer construction crews to all the sites. Temporary strips scraped on the sea ice would last until the spring breakup and would take the Air Force Globemasters laden with "cats," bulldozers, and rock crushers. What couldn't be landed would be parachuted. Before the ice went out, the roads would be ready, the sites prepared, and the gravel dug for permanent runways. In summer, after the seas were open, a huge sea lift would bring the major construction equipment, including steel for the antenna towers, some of which would be 400 feet high.

The subcontractors were not so sanguine. In February, Robert Shaw, a vice president of the Foundation Co., got his first glimpse of Baffin Island, from an Air Force plane hugging the shore. On seeing that awesome glaciated land, steep cliffs plunging straight down to the frozen sea, jagged valleys buried in snow, and hardly a level place to be seen, the contractor moaned, "Shaw, you poor devil."

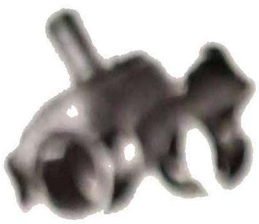
Yet the work went forward along the broad lines of Bagnall's master plan. By spring, practically all of the main and auxiliary sites, and many of the intermediate, had been established; and from half a dozen different staging bases far to the south—from Fairbanks, Edmonton, Hay River, Churchill, and Mont Joli on the St. Lawrence—several hundred aircraft, on charter from several dozen companies, together with military cargo carriers, were pouring in men and equipment.

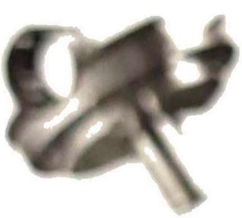
Then by sea

Now came the crucial stage of the operation—the sea lift around the

continued page 25

7





DAC. MACHINE AND TOOL CO

DACO

mber, not Sputnik or what Sputnik foreshadows—a r-armed ICBM. The DEW Line's radar can pick up, y, and track Soviet strategic bombers of the Bison ear classes over a distance of 200 miles or so, at heights ching 60,000 feet, and traveling at speeds of about les an hour. A nuclear-armed ICBM, however, soaring on its projectile trajectory to a height of about 600 would be traveling at 16,000 miles an hour or so. It be able to make the transit from the U.S.S.R. to the can hinterland in less than half an hour. On the face he DEW Line might look like money poured down an rathole.

fought on the computers

ome respects the line was a waste—but a measurable that was forced upon the U.S. by the need of fore- war and its immeasurable waste.

n the Air Force finally decided to invest in the DEW t was persuaded to do so by a fairly simple proposi- his was to foreclose, in Soviet strategic planning, the t of a cheap ride into the American air. Trevor r, former Assistant Secretary of the Air Force for h and Development and, since his resignation in 956, the Eisenhower Administration's severest critic ary research matters, was the official who bulled the ine through. Gardner had been set afire by the argu- f scientists and a group of Air Force officers who ided that the strategy of the technological power emanded something more subtle than the threat of offensive strength alone. "The game," Gardner re- vas to force the other fellow to ante up. It was agreed e couldn't stop a determined, well-led air attack. r, with a combination of an early-warning line, ef- interceptor and ground-to-air missiles, and a cen- rected air-defense system, we could make the enemy vily for his ride. That was the idea behind the DEW o force the other guy to go higher, faster, and load down with electronic countermeasure gear."

te Comrade Khrushchev's recent offhand intimation mbers are finished, Soviet military planners may be as uncertain as our own as to how soon the stra- mber will be supplanted by the strategic rocket. They obliged to make yet another massive investment in , in supersonic vehicles of the Mach 2, Mach 3 class. ous American gambit is to keep pushing up the odds Soviet bomber attack and thus dilute that ever immi- . An investment of between $30 million and $50 chiefly for more powerful radar, would fit the polar coping with supersonic bombers. Such radar, now pment, would enable the line to operate farther out, r altitudes, and with less chance of being "spoofed" onic countermeasures.

of the technicians concerned with the development trategic missiles believe that the U.S.S.R., for all its ccess, can now have a truly operational ICBM— hat is reliable, and deployed among trained squad- n the necessary ground-control gear. On the basis xperience with strategic missiles, which is already der than is generally realized, such a capability quire another three to five years of truly strenuous at estimate would push out an effective materializa- e military, as distinct from the propaganda, threat viet ICBM to 1961-63. This is not to say that the will not meanwhile make the most of the oppor- or political blackmail that their initial successes ned to them. They may even short-cut the development stage in order to produce a weapons system of frightening aspect, irrespective of the reliability and accuracy that a professional soldier, say of the Zhukov school, might demand. But the hard fact is that the Soviet strategic bomber will persist for several years more as the crucial threat; and the warning function that the DEW Line was invented to perform remains as valid as ever.

And it is not to be assumed that the line will be written off after the ICBM becomes operational. In September, General Thomas D. White, Air Force Chief of Staff, categorically stated that radars capable of picking up an intercontinental missile at ranges *out to 3,000 miles* are being developed. When the missile begins to weigh more heavily in the power equation, the DEW Line will undoubtedly undergo still another technical transformation.

With respect to the influence on strategy of defense systems like the DEW Line, Dr. Jerome B. Wiesner offers an enlightening observation. Wiesner is head of the Electronics Laboratory at M.I.T., and a member of the Scientific Advisory Committee to the President and the Defense Department. He was a prime mover in bestirring the government to rush the ICBM; and, as will be related, he had an equally active part in the DEW Line. "We seem," Wiesner says, "to be moving from a World War III to a World War IV situation. This has induced in some the belief that the U.S. has been caught short—our weapon systems have been developed for the wrong war. What these people don't seem to understand is that the weapons in place kept World War III away."

Dr. Edward Teller, who was foremost in pushing the Truman Administration into thermonuclear strategy, puts the idea this way: "World War III is being fought on the computers." By this he means that whenever Soviet strategists have gone to the computers to find out whether the Russians were now ahead of the U.S. in military strength, the computers have answered, "Not now, not yet." The DEW Line, by eliminating the possibility of full surprise, and the chance of crushing SAC on the ground, undoubtedly helps to discourage the Soviet computers.

An unsolicited letter

The DEW Line materialized out of a situation not unlike the one now precipitated by Sputnik. Then, as now, the galvanizing influence upon American thought was the revelation of a Soviet technical coup. In 1949, it was the successful test of an atomic weapon, coupled with evidence that the U.S.S.R. had made a tremendous start on long-range delivery systems, both bombers and rockets. This was the prelude of the technological contest that is now moving so rapidly into space vehicles and ballistic missiles. Then, as now, the U.S. reacted with a mixture of confusion and irresolution. No one seemed to know quite what to do next.

One of the first technicians to grasp the implications of the Soviet push into strategic air power was a young M.I.T. physicist, Dr. George E. Valley Jr., whose specialty was electronics. Valley was a junior member of the Air Force's Scientific Advisory Board. (He is now the Air Force's senior scientist.) In September, 1949, he composed a letter to his venerable chairman, Dr. Theodore von Kármán, the gist of which was that the nation must set about at once to construct an air defense against the threat of nuclear attack. It was clear to Valley that the orthodox tactics to which the Air Force was still committed had been hopelessly outmoded by the fact that a single airplane, armed with a single nuclear bomb, could shatter a great metropolis. What was needed, the physicist insisted, was a new kind of air defense for detecting and intercepting bombers short of their

continued page 245

…RANT, FREDERICK CLARK, III, museum exec., b. Ardmore, Pa., Dec. 31, 1916; s. Frederick Clark, Jr. and Cornelia Allen (Howel) D.; B.S. in Chem. Engring., Lehigh U., 1939; postgrad. Phila. Mus. Sch. Indsl. Arts, 1946-47; m. Carolyn Griscom Jones, Oct. 4, 1947; children—Carolyn M., William C., Stephen H. Engr., E.I. duPont de Nemours & Co., Inc., 1939-41; rocket engr. Bell Aircraft Corp., 1947-48; dir. engring. Naval Air Rocket Test Sta., 1948-51; cons., Washington, 1952-53; mem. sr. staff Arthur D. Little, Inc., 1954- 57; dir. Maynard Ordnance Test Sta., 1954-55; exec. asst. to dir. Avco-Everett Research Lab., 1957-59; dir. pub. and govt. relations, research and advanced devel. div. Avco Corp., Wilmington, Mass., 1959- 61; sr. rep. Bell Aerosystems Co., Washington, 1961-64; asst. dir. astronautics Nat. Air and Space Mus., Smithsonian Instn., Wash., 1964—. Participant ann. congresses Internat. Astronautical Fedn., 1951—, pres., 1953-56; mem. organizing com. Project Orbiter, 1954. Served to comdr. as naval aviator USNR, 1941-46,48-52. Registered profl. engr., D.C., Mass. Recipient spl. medal L'Assn. Pour l'Encouragement de l'Aeronautique et de l'Astronautique, 1963. Fellow Am. Astronautical Soc (chmn awards com. 1961), Am. Inst. Aeros. and Astronautics, Am Rocket Soc (pres 1953), mem Internat Acad Astronautics, Nat Space Club (gov 1961), hon fellow or mem. numerous fgn rocket and space flight socs Contbg editor Missiles and Rockets, 1956-58 Club Cosmos Contbr. to Ency Brit., Ency Americana, World Book, Funk & Wagnalls Year Book, contbr. (space terms) Am Heritage Dictionary Home 109 Grafton St Chevy Chase MD 20015 Office Nat Air and Space Mus Smithsonian Instn Washington DC 20560

GOUDSMIT, SAMUEL ABRAHAM, physicist, editor; b. The Hague, Netherlands, July 11, 1902; s. Isaac and Marianne (Gompers) G.; student U. Amsterdam; Ph.D., U. Leiden (Netherlands), 1927; D.Sc. (hon.), Case Inst. Tech., 1958, U. Chgo., 1972, Utah State U., 1972; m. Jaantje Logher, Jan. 19, 1927 (div. 1960); 1 dau., Esther Marianne; m. 2d, Irene Bejach Rothschild, 1960. Came to U.S., 1927. Faculty U. Mich., 1927, prof. physics, 1932-46; Rockefeller fellow, 1926, Guggenheim fellow, 1938; vis. prof. Harvard U., 1941; prof. physics Northwestern U., 1946-48; vis. prof. Rockefeller U., 1955—, on leave to Radiation (Radar) Lab. Mass. Inst. Tech. and Eng., 1942-46; sr. scientist Brookhaven Nat. Lab., 1948-70, editor-in-chief Am. Phys. Soc., 1951—. Detailed to War Dept. as chief sci. intelligence mission in Europe, 1944-45. Decorated Medal of Freedom, officer Order of Brit. Empire; recipient Research Corp. Sci. award, 1954; Max Planck medal German Phys. Soc., 1965. Fellow Am. Phy. Soc., Netherlands Phys. Soc., Nat. Acad. Scis., Am. Nuclear Soc.; mem. Am. Philos. Soc.; corr. Netherlands Royal Acad. Scis. Jewish religion. Author books including: Alsos, 1947. Founder Phys. Rev. Letters. Contbr. sci. articles to profl. jours. Discoverer (with G.E. Uhlenbeck) of so-called spin of Electron, 1925. Office: Brookhaven National Lab Upton NY 11973

PAGE, THORNTON LEIGH, astrophysicist; b. New Haven, Aug. 13, 1913; s. Leigh and Mary Edith Cholmondeley (Thornton) P.; B.S., Yale U., 1934; D.Phil. in Astrophysics (Rhodes scholar for Conn. 1934-37), Oxford (Eng.) U., 1938; M.A. (hon.), Wesleyan U., Middletown, Conn., 1959; D.H.C. (hon.), U. Cordoba (Argentina), 1969; m. Helen Ashbee, Aug. 28, 1938 (div. 1944); 1 dau., Tanya; m. 2d, Lou Williams, Aug. 28, 1948; children—Mary Anne, Leigh II. Chief asst. Oxford U. Obs., 1937-38; from instr. to asst. prof. astronomy U. Chgo., 1938-50; physicist Naval Ordnance Lab., 1941-43; dep. dir. Ops. Research Office, Johns Hopkins, 1950-58; prof. astronomy Wesleyan U., Middletown, 1958-71, dir. Van Vleck Obs., 1959-71; research asso. Manned Spacecraft Center, NASA, 1968-70; research asso. E.O. Hulburt Center Space Research, Naval Research Lab., Washington, 1970-76; contract astrophysicist Johnson Space Center, NASA, 1976—. Mem. for Ops. Research Soc. Am. to NRC, 1960-62; mem. research adv. com. United Aircraft Corp., 1959-72; Smithsonian research asso. Harvard Obs., 1965-67; Nat. Acad. Scis. sr. research asso., 1968-70. Served to comdr. USNR, 1943-46. Decorated Bronze Star, Legion of Merit. Fellow Royal Astron. Soc., AAAS (v.p. sect. D astronomy 1967-68), Am. Astronautical Soc.; mem. Operations Research Soc. Am. (charter, editor, council, v.p.), Astron. Soc. Pacific. Am. Assn. Physics Tchrs., Internat. Astron. Union, Am. Astron. Soc., Internat. Statis. Inst., Sigma Xi. Clubs: Cosmos (Washington); Appalachian Mountain. Author: Stars and Galaxies, 1962; Wanderers in the Sky, 1965; Neighbors of the Earth, 1965; Origin of the Solar System, 1966; Telescopes, 1966; Starlight, 1967; Evolution of Stars, 1967; Stars and Clouds of the Milky Way, 1968; Beyond the Milky Way, 1969; UFO's, A Scientific Debate, 1972; Far-UV Preliminary Science Report, Apollo 16, 1973; Space Science and Astronomy, 1976; Apollo-Soyuz Experiments in Space, 1977; S201 Catalogue of Far-UV Objects, 1977. Home: 18639 Point Lookout Dr Houston TX 77058 Office: Code SA NASA Manned Spacecraft Center Houston TX 77058

ROBERTSON, Howard Percy, scientist; b. Hoquiam, Wash., Jan. 27, 1903; s. George Duncan and Anna (McLeod) R.; B.S., U. of Wash., 1922, M.S., 1923; Ph.D., Calif. Inst. of Tech., 1925; m. Angela Turinsky, Jan. 27, 1923; children—George Duncan, Mariette. Nat. research fellow, Göttingen, Munich, Princeton U., 1925-28; asst. prof. mathematics, Calif. Inst. Tech., 1927-29; asst. prof. math. physics, Princeton U., 1928-31, asso. prof., 1931-38, prof., 1938-47; prof. math. physics, Calif. Inst. Tech., 1947—; sci. adviser Supreme Allied Comdr. Europe, 1954-56. Mem. div. I, sect. B, Nat. Defense Research Com., 1940-43; sci. liaison officer, London Mission, Office Sci. Research and Development, 1943-46; expert cons. Office sec. of War, 1944-47; director of research Weapons Systems Evaluation Group, Office Sec. Def., 1950-52. Awarded Medal for Merit, 1946. Fellow Am. Phys. Soc., Royal Astron. Soc.; mem. Am. Math. Soc., Am. Philos. Soc., Nat. Acad. Scis., Am. Astron. Soc., Edinburgh Math. Soc., Sigma Xi, Phi Beta Kappa. Club: Cosmos. Author: researches on differential geometry, theory of relativity, quantum theory, cosmology and applied mechanics. Home: 590 Auburn Av., Sierra Madre, Cal. Office: Cal. Inst. Tech., Pasadena, Cal.

VALLEY, GEORGE EDWARD, JR., educator, physicist; b. N.Y.C., Sept. 5, 1913; s. George Edward and Edith Ringold (Cummins) V.; S.B., Mass. Inst. Tech., 1935; Ph.D., U. Rochester, 1939; m. Louisa King Williams, July 19, 1941 (div. Dec. 1960); children— George Cummins, John Willaims, Katharine; m. 2d, Shea LaBonte. Optical engr. with Bausch & Lomb Optical Co., 1935-36; teaching asst. U. Rochester, 1936-39; research asso. Harvard, 1939-41, NRC fellow nuclear physics, 1940-41; project supr., sr. staff Radiation Lab., Mass. Inst. Tech., 1941-45, editorial bd. Radiation Lab. Tech. Series, 1945, successively asst. prof., asso. prof. Mass. Inst. Tech., 1946-57, prof. physics, 1957—, assisted founding Lincoln Lab., 1949, asso. dir., 1953-57, undergrad. planning prof., 1965-68. Mem. Air Force Sci. Adv. Bd., 1946-64; chmn. Air Def. System, engring. com. for Chief Staff USAF, 1950-51, chief scientist, 1957-58. Recipient U.S. Army certificate of appreciation; President's certificate of merit; Air Force Assn. Sci. award; exceptional civilian service medal, USAF, 1956, 58, 64. Fellow Am. Phys. Soc., Inst. Radio Engrs.; mem. Sigma Xi. Club: Cosmos (Washington). Author and editor books and monographs. Address: Dept Physics Mass Inst Tech Cambridge MA 02139