BOOK REVIEWS

Research via Rocket

Science with a Vengeance. How the Military Created the US Space Sciences After World War II. DAVID H. DEVORKIN. Springer-Verlag, New York, 1992. xxii, 404 pp., illus. $69.

The title of this book is at once amusing and clever, misleading and understated. The main title is a pun. From 1946 to 1952, the U.S. Army test-flew 62 V-2 rockets captured from Germany in World War II. This vehicle was the Vergeltungswaffe 2, second reprisal or vengeance weapon. Thus when scientists hitched a ride on these flights to conduct experiments in the upper atmosphere they were literally conducting science with a vengeance.

The subtitle is a thesis, one of several. It is misleading because the word "created" suggests a stronger and more conscious military influence on science than the author reveals in the book. It is understated because the book actually delivers far more than the subtitle promises.

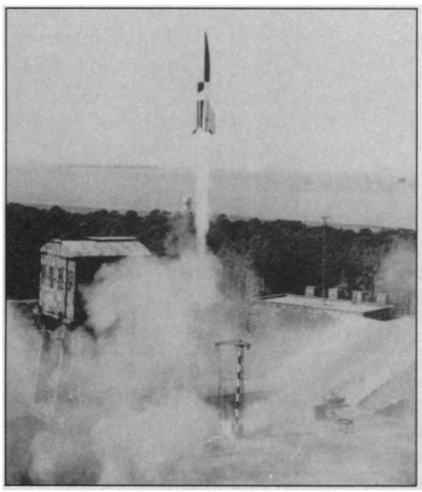
There is no doubt that the military shaped space science after World War II. Indeed, until the National Aeronautics and Space Administration was created in 1958 in response to Sputnik, the military was virtually the only institutional supporter of rocket activity in the United States. Paul Forman, Harvey Sapolsky, and others have demonstrated how the military influenced science in general after World War II. The case is even clearer in space science, where the military had a monopoly on the research equipment.

This book goes well beyond making that case. It provides in addition a detailed and meticulous case study of how experimental science has come to be practiced in the second half of the 20th century. The story has two parts. In the first half of the book, DeVorkin traces the migration of the V-2 from being an instrument of destruction in World War II Germany to being a scientific instrument in the United States. A happy collaboration of scientists such as Fritz Zwicky and military officers such as Holger Toftoy made possible in the United States what physicist Erich Regener had been unable to achieve in Germany. Forty-one scientists from 12 institutions organized the "V-2 Rocket Panel" on 16 January 1946 to plan a research program for the captured rockets. This panel, later to be called the Upper Atmosphere Rocket Research Panel, counted among its members Richard Tousey, James Van Allen, S. Fred Singer, Fred Whipple, and others. Its early leadership came from Ernst Krause of the Naval Research Laboratory.

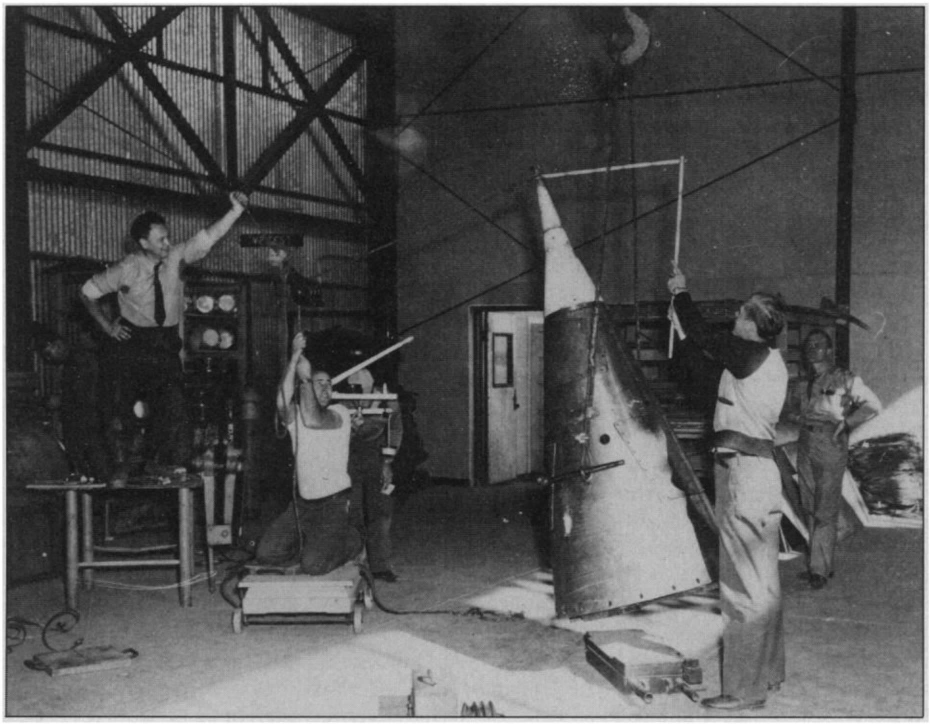
This group took their act to White Sands, New Mexico, in the summer of 1946, where they shared with their Army hosts the frustrations of learning to fly the V-2. In the second half of the book, DeVorkin chronicles the scientific achievements of the subsequent flights. He discusses the early work on photographic solar spectra, the imaging in 1952 of the Lyman Alpha emission line (the resonance line in hydrogen's ground-state spectrum), the development of new detectors for the extreme ultraviolet, the emergence of cosmic ray research, and finally the research in the upper atmosphere that was to lead to rocket-borne ionospheric studies and the next generation of research vehicles. DeVorkin's study ends with the early planning for the International Geophysical Year of 1957–58, the setting that was to give the world Sputnik and a whole new level of rocket-borne scientific research.

The conduct of this science has many dimensions beyond the role of the military that is the main focus of DeVorkin's study. Equally important was the relationship between science and technology, the way in which development of research equipment evolved with and shaped the experimental agenda. This, of course, fed the demand for funding that often brought scientists into the realm of the military. Important also was the teamwork required for this kind of research; individuals such as James Van Allen may still stand out, but successful projects flowed from many hands and a bewildering array of skills, the cast of characters ranging from rocket engineers to instrument makers to theoretical physicists. Furthermore, no atmospheric scientist prospered if his experiment failed to get off the ground. Thus, the nature of the research enterprise changed research agendas. Some scientists left the field because of delays and uncertainties; others changed their focus to take advantage of the science that was doable as opposed to the science they wanted to do. They went where the money was; looked where the rockets could go; and measured what their instruments could measure.

DeVorkin eschews conceptual models of this activity in favor of a straightforward description of the research that was done and how it was accomplished. This book is in many ways a sequel to his *Race to the Stratosphere: Manned Scientific Ballooning in America* (1989). It is a scientist's book, rich in detail and documentation but relatively inaccessible to the lay reader. The author assumes considerable familiarity with the science and technology of spectroscopy and ionospheric physics. Those conversant with these topics will find here a loving reconstruction of early space research in these fields, complete with luminaries, institutions, instruments, experiments, and results. DeVorkin knows this science, and he



Left, "The launch of a V-2 from Peenemunde, circa 1943." *Right*, "A V-2 out of control seconds after launch" from White Sands Proving Ground, New Mexico, 1946. "This is either the fateful 22 August flight of Michigan's V-2, which reached just over 100 meters altitude before spin out, or Princeton's V-2 which leveled off at about 360 meters on 14 November." [From *Science with a Vengeance*; Deutsches Museum, Munich, and U.S. Navy photograph, Ernst Krause collection, National Air and Space Museum]



American rocketeers at work, 1946. James Van Allen's "stated 'strong back, weak mind' syndrome pervaded all areas of scientific rocketry in the first five years of effort." This syndrome "is well-illustrated in this scene of Naval Research Laboratory personnel improvising to find the center of gravity of a warhead suspended in the White Sands assembly building. . . . After the warhead was weighed on the scale beneath it, it was hoisted and tilted by Ralph Havens, kneeling on another scale. Thor Bergstralh (obscured by the scale, left center background) is preparing to read the scale to determine the tension that Havens is exerting on the rope. Serge Golian (at the left on the stand) is keeping tension on the rope to keep the pulley directly above Havens. F. S. Johnson is holding a ruler to let Krause (at the right, background) read the tilt of the nosecone from the vertical, defined by the cables holding the warhead." [From *Science with a Vengeance*; U.S. Navy photograph, Ernst Krause collection, National Air and Space Museum]

has researched the story thoroughly in primary documents and oral histories.

The main themes, however, often get lost in the detail. It is not clear, for example, that the fortuitous and fleeting availability of the captured V-2s meant that these scientists "had to develop instruments and logistical systems with a vengeance reminiscent of the wartime effort" (p. 341). Surely other scientists felt a similar pinch as wartime resources dried up or were diverted in the late 1940s. Nor is it clear that these researchers exemplified "a new definition of the scientist" (p. 2), though this proposition bears comparison with experience in other fields of "big science" and team research emerging after World War II. The military is not nearly as visible or as influential in DeVorkin's account as his subtitle suggests; it is rather an arm of government that brings to mind the warning of Lionel Tiger and Robin Fox: If you have a Pentagon, you will use it and it will use you.

Still, this is an important book. It reveals how thoroughly the military has been involved in scientific and technical development since World War II. It presents a richly detailed case study of the role of technology in modern scientific research. And it demonstrates, as DeVorkin claims, the way in which external forces—social, political, economic, and technological—can shape scientific research.

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Routes to Agriculture

The Origins of Agriculture and Settled Life. RICHARD S. MACNEISH. University of Oklahoma Press, Norman, 1992. xx, 433 pp., illus. $75.

In this volume one of the best-known of contemporary American field archeologists discusses an issue of great concern to many scholars. MacNeish himself has pursued primary archeological evidence about agricultural origins in both North and South America at various periods during the past 40 years. Here he presents his conclusions about how and why village agricultural economies developed not just in the regions he knows at first hand (Mexico, Peru, and New Mexico) but in all other portions of the globe.

MacNeish begins with a brief history of theories about agricultural origins, then outlines his own formulation, which he calls the trilinear theory because it specifies three main routes (each with several variations) from hunting-collecting bands to agricultural villagers. Most of the rest of the book consists of overviews and syntheses of relevant archeological data from all the world areas for which such information has been published. These overviews are ordered according to MacNeish's categorizations of regions into domestication centers and non-centers (the latter subdivided into temperate and tropical). The evidence from each area is described with reference to the appropriate parts of the trilinear theory in order to check or test the theory. Results are often unsatisfactory because of sparsity of data, but in several areas MacNeish finds support for the essential portions of his theory and concludes that "we have moved from speculation and hypothesis toward the ideal state of scientific generalization or laws of cultural change" (p. 363).

The trilinear theory itself (best summarized in figure 10, p. 362) is a paleoecological, materialistic, subsistence-settlement system model elaborated and somewhat updated from MacNeish's writings of the 1960s and '70s about his important research in Tehuacan, Mexico. MacNeish's account of this model and the processes or conditions he envisions as fundamentally crucial (necessary) and specifically explanatory (sufficient) are likely to stimulate considerable discussion. He has been thinking about the general issue for a long time and has some interesting insights to convey.

There are major problems with the rest of the book, however. One has to do with the definition of centers and non-centers. MacNeish follows Vavilov's original description of centers as "those culture areas where a large number of plants were initially domesticated." MacNeish opposes centers to non-centers, the latter being "those areas where this did not occur" (p. 20). Thus he departs significantly from the usual definition of non-centers as provided by Jack Harlan in 1971 (*Science* **174**, 468). MacNeish's set of definitions is not only rather vague (how many domestications constitute a large number?) but is ultimately dependent upon archeobotanical information to demonstrate the occurrence and extent of domestication. That means that the classifier of regions as centers and non-centers must be thoroughly conversant with the latest results in all the world areas where paleoethnobotanical research