the admirer of the French to escape their positivism, as is revealed in his description of Newtonian ontological views as "a psychological prop" and a "heuristic aid." Nor, in view of Black's explicit rejection (in his *Lectures*, vol. 1, pp. 282–283) of attraction as a means of explaining chemical combinations, can I accept Guerlac's arguments in "The background to Dalton's atomic theory" for the importance to Cullen and Black of Newtonian force concepts.

For all one's minor objection to some of the conclusions of these papers, together they constitute an instructive and readable introduction to some of the problems of 17th- and 18th-century science and to the range and subtlety of mind of one of the major practitioners of the history of science. My only strong objection to the book is the autumnal flavor of the foreword and introduction. I must protest their implication that we are not to continue to be instructed and goaded in our research by a continuation of papers by Guerlac.

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Struggles and Success

Lunar Impact. A History of Project Ranger. R. CARGILL HALL. National Aeronautics and Space Administration, Washington, D.C., 1977 (available from the Superintendent of Documents, Washington, D.C.). xviii, 454 pp., illus. $6.25. NASA History Series. NASA SP-4210. Stock No. 033-000-00699-3.

The first close-up photographs of the lunar surface, obtained in mid-1964, opened a new era by bringing the moon into the purview of experimental science. The photographs almost to the last appeared to be unattainable. Many advanced machines had to be designed to provide them, and the difficulties encountered in the task were not only ones of engineering, but ones of management as well. This is the theme of Hall's well-researched and excitingly written history of Project Ranger, conducted by NASA and the Jet Propulsion Laboratory (JPL) of the California Institute of Technology in the years 1959 to 1965.

The design of Ranger began as the Explorer and Mercury projects attained their successes and during the Army's Pioneer and NASA's Atlas-Able programs. The stated mission of the Ranger project emphasized sending a satellite to the moon and conducting some experiments during the flight, but the question of what experiments it would do along the way and before impact gave rise to much perturbation before the first successful flight. NASA, being a civilian agency, was more susceptible than the military to outside influences, and early planning for Ranger involved many tensions. One major tension existed between the designers, who wanted a fail-safe system with redundant backup, and the experimenters, who wanted to load as much scientific apparatus as possible on the capsule, even if backup had to be sacrificed. Another tension came from the differences between the points of view of sky and planetary scientists. The former desired information about the region above the earth's surface and the latter saw the project as an opportunity to learn more about the moon and other bodies of the solar system. The two groups argued for different experiments. Compromises were designed to placate both sides. The problems multiplied when the Air Force insisted that because it developed the Atlas rocket and commanded the launch facilities it should control launches.

Other factors, too, affected decision-making, and Hall effectively integrates these into his narrative. For example, NASA, then a fledgling agency, found it desirable to oversee the early work of contractors by committee; the armed services conducted programs for research on missiles and rockets and created confusion because of inter-service rivalry; and, not least, the times were highly charged with a competitive spirit, stimulated by Sputnik, that made many conclude that the United States must reach the moon before the Soviets. For the first five Rangers these problems were not satisfactorily resolved. Consequently, designs were weak and the missions failed—at first owing to Atlas failures.

After Ranger 5 failed the program was overhauled, with great distress for JPL, which had to bear the brunt of everyone's discontent. Fortunately, by that time NASA had resolved its management difficulties, and subsequent activities were directed in a more hierarchical fashion. And along the way a new view of the space program was taken by the Kennedy administration, and manned lunar missions received first priority. These developments helped to rigidify Ranger's mission, and engineering became uppermost because of its importance in ensuring the return of information that would be valuable in making Apollo flights safe. In this way planetary scientists won a partial victory in that a few of their experiments were included. Of course, this offered the potential for a new set of tensions, but they were avoided by good management practices.

Although the increasing accomplishments of the Ranger program could not be appreciated during the stress of trying to achieve success, Hall notes that they were many and varied. Pointing to the greatest value of Ranger, he writes,

> Perhaps more than any other flight project, Ranger proved the technologies and the designs for the automatic machines NASA would use for deep space exploration: attitude stabilization on three axes, onboard computer and sequencer, directional scientific observations, midcourse trajectory and terminal maneuver capability, and steerable high-gain antenna.

In addition, Ranger scientists developed the Deep Space Network, using a two-way Doppler tracking and communication system that aided accurate trajectory computation. And, most impressive, the last three Rangers returned excellent photographs of the lunar surface made with the use of a camera developed by RCA.

Hall presents all these events in an engaging manner, and he portrays warmly the struggles with design, construction, and preparation for launch, the complete and partial failures, and the attainment of success. Hall has been careful not to let himself be deflected from his main theme by effects on the project that were generated by persons or institutions beyond NASA. There are instances, however, when some further information or slight repetition would aid the reader. The number of offices and companies involved in the project increases as the story unfolds, and their various roles are not always made clear. The central role of JPL in the story tends to minimize the contributions of others, but at the same time we receive only occasional glimpses of how work on the Ranger program affected other JPL activities. Even so, the book resembles a mystery story to which you know the ending but which you feel compelled to complete in order to learn how the obstacles were overcome.

Included in the volume are several useful appendixes of data about flights, spacecraft, experiments, schedules, finances, and lunar theory before Ranger, plus a good index. Like other NASA histories, it is profusely illustrated, including good line drawings to elaborate technical descriptions in the text.

From the works of James Killian, George Kistiakowsky, Herbert York, and Philip Morse, to name only a few, we have learned much about how policies for science developed in the executive branch. *Lunar Impact* adds another important dimension to the story by making known some of the discussions among other scientists trying to influence policymaking and by describing some of the problems faced by contractors, such as JPL, that had to implement those policies. Only a few agency histories have achieved this result.

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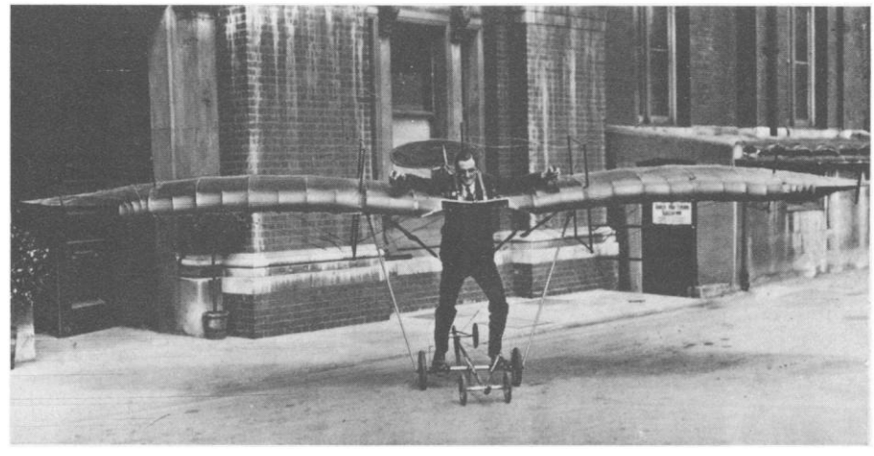
The Icarus Syndrome

The History of Man-Powered Flight. D. A. REAY. Pergamon, New York, 1977. x, 356 pp., illus. $15.

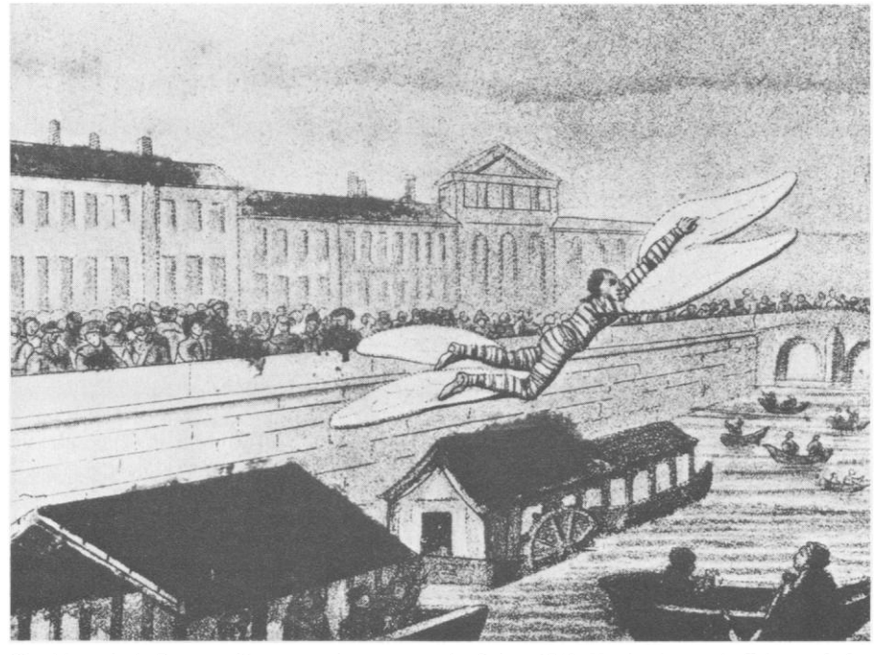
The irony of this account of the development of man-powered flight is that, although it is focused on efforts to win the Kremer Prize and properly gives accounts of the non-British as well as the substantial British contributions, the prize was won while the work was in press by the California team of MacCready and Oldershaw, who, though a hasty postscript on pp. 341–342 notes their accomplishment, are not even mentioned in the text. Yet that should be a reminder that there are still independents outside the normal academic-professional communities who may succeed in meeting a challenge because they start without preconceptions. The man-powered flight aficionados have themselves been divided into two groups—those who believe that professional benefits can accrue and those who are sportsmen. The former now argue that what is learned may be beneficial in energy-saving (if not in pulling in research funds), whereas the latter are simply intrigued by the challenge of success. MacCready, a sometime glider champion, belongs in the purist camp.

Reay, who is an engineer by profession, has long been heavily involved in Britain in the man-powered flight enterprise. And his book falls into the Gibbs-Smith tradition of examination of the minutiae of one aspect of aviation. This is not to belittle the achievement, but to make the point that what he has done is a meticulous (as far as one can tell in the face of the almost complete lack of literature in the field apart from Keith Sherwin's 1971 *Man-Powered Flight*) history of that interesting combination of dreaming and practical experiment with almost no money that is involved in studying flight at bird speeds. As Reay shows, the early designers too often had insufficient aerodynamic knowledge, for until the 1920's the knowledge simply did not exist. The take-off point was the work of the Germans in the '20's and '30's. Efforts accelerated rapidly after World War II both because of the enormous growth of technical knowledge and because of a sort of nostalgic challenge that might be labeled the "Icarus syndrome." Who has not dreamed of flying like a bird without auxiliary power?

Though the book appears, having been printed by photo-offset from typescript, to be merely a research report, it is a sound historical work and deserves a place on the shelves because it provides a survey with illustrations of the work that preceded the successful flight of



"An obscure English attempt at flight in 1920." [From Radio Times Hulton Picture Library, reproduced in *The History of Man-Powered Flight*]



The Marquis de Bacqueville attempting to cross the Seine, 1742. Having jumped off the roof of a house overlooking the riverbank, Bacqueville crashed into a passing barge and broke his legs. "Aviators were not encouraged by the words of William Cowper, who in 1783 wrote: 'If man had been intended to fly, God would have provided him with wings.' This was, of course, not the first time such a sentiment had received publicity, and it was certainly not the last." [From Radio Times Hulton Picture Library, reproduced in *The History of Man-Powered Flight*]