versations. They are varied, often delightful and witty essays. Some ideas, such as the loneliness of Earth and the need for reverence for life, have been treated as well elsewhere, for example by Loren Eiseley; other ideas are seeds for science fiction stories, here germinating as essays. Some are amusing, such as Sagan's alleged run-in with CIA spies and his advice to Stanley Kubrick on *2001*. Some are thought-provoking, for example, oxygen chauvinism, the need to get U.S. and U.S.S.R. military into space ("the more of them engaged up there, the less of them engaged down here"), and the engineer's dream of "terraforming" another planet. Pithy Saganisms abound: "I know of a sun the size of the earth—and made of diamond." Evocative line drawings and photos illustrate the book. The essays appear to be raggedly disconnected, but together they form an astronomical perspective on 20th-century Earth. The book should especially appeal to student readers and might convince a few incipient antiscience pseudointellectuals that scientists are not (always) monsters who work on H-bombs.

NASA is to be congratulated on issuing the inexpensive paperback *Life beyond Earth and the Mind of Man*. This is the record of a symposium held at Boston University in 1972. Of the three books, it is the most restricted in subject, being a speculative discussion of the social impact and mechanics of the possible discovery of alien life in the universe. Here, the mixture includes two astronomers, an anthropologist, a biologist, a physicist, and a theologian. They are all eloquent, but the short essays and question-and-answer session seem to leave several of them too cramped for space to make a coherent presentation. Nonetheless, fascinating ideas fly back and forth. The viewpoints that emerge are contradictory and sometimes unexpected. Sagan endorses a search for alien life as a character-building activity for the human race. George Wald is vaguely unhappy about the whole thing; he seems afraid the aliens will wipe us out, spiritually if not physically. Ashley Montagu is horrified; he expresses a curiously impertinent view that we, through our evil natures, will wipe out the aliens. Theologian Krister Stendahl philosophizes without clear conclusion on the advantages of realizing our small place in the scheme of things, the priority of the search, and the viciousness of frightened man. Pragmatic Philip Morrison asserts that the discovery will come in any case by radio, and pictures it as a fascinating analog to our receipt of 10,000 books of knowledge in one-way transmission through time from the Greeks, with no hope of two-way dialog. Editor Berendzen adds instructive connecting remarks. NASA has here given us proof that not only a few astronomers but a broadening spectrum of intellectuals are coming to grips with the possibility of alien life. Whether these six Americans appraise this idea realistically is entirely unknown; Montagu reminds us of the impetuous audacity of our own culture by quoting Gandhi's comment on Western civilization: "I don't think it would be such a bad idea."

It is hard to escape the idea that the more books like these there are, the more likely we are to have a civilization.

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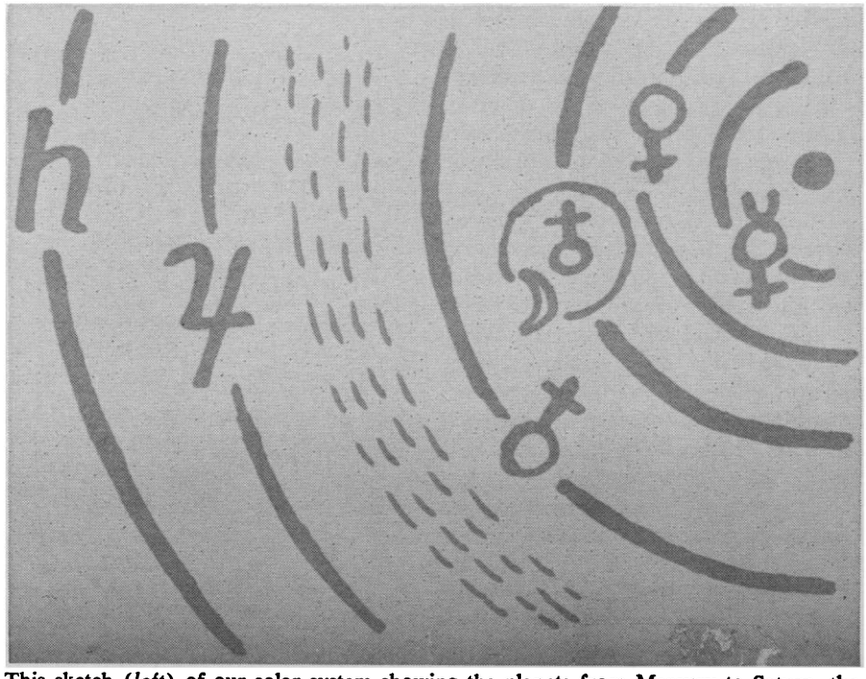
## The Further Story of Jodrell Bank

**Out of the Zenith.** Jodrell Bank, 1957–1970. BERNARD LOVELL. Harper and Row, New York, 1974. x, 256 pp., illus. + plates. $12.50.

In his new book Sir Bernard Lovell continues and expands *The Story of Jodrell Bank*, an earlier volume about the giant 250-foot radio telescope and its work, including moments of drama when he feared he was about to be jailed for a cost overrun. That fate was averted by the auspicious appearance of the Sputniks in 1957, which helped save the day. The present book, which is a melange of history, branches of radio astronomy, and practical politics, describes the work of the telescope from its beginning in 1957 until 1970, when the great bowl was turned to the zenith for modification and improvement; the title *Out of the Zenith* celebrates its emergence into a new life in November 1971 as the Mark IA.

Many current topics of radio astronomy are traced back to their recent origins, and the lines of reasoning governing the Jodrell Bank participation are displayed. We go back to the time in 1960 when Rudolf Minkowski obtained a spectrum of the visible object identified with the strong radio source Cygnus A and found it to be receding at a velocity exceeding 40 percent of the velocity of light. At that time, it



This sketch (*left*) of our solar system showing the planets from Mercury to Saturn, the moon, and the asteroid belt was transmitted in February 1964 on a frequency of 160 Mhz from the 250-foot dish at Jodrell Bank up to the NASA Echo II balloon and back down to a 50-foot dish at Gorki, U.S.S.R., where it was received (*right*). "The Russians

was the most distant object known, but if it was the second strongest radio source, what could the fainter ones be? Lovell's approach to this problem was to lead by continuous steps to the very-long-baseline interferometry which is continuing to yield rich results at the forefront of extragalactic radio astronomy and will in time have nonastronomical applications. The intervening stages were as follows. Hoyle calculated that, in an Einstein–de Sitter universe, a source having the absolute dimensions of the Cygnus source would, if it receded indefinitely, pass through a minimum apparent angular diameter of 15 seconds of arc. Henry Palmer's group therefore performed a sequence of observations, using the big dish as one element of a long-baseline interferometer, that not only promptly pushed angular resolution to 3 seconds of arc but revealed the existence of number of sources having diameters less than this. These were to come to be known as quasars. Astonishingly, when one of these sources was photographed at Palomar by Allan Sandage it not only looked like a star but varied in light output over the course of a year so that interpretation as a large, distant galaxy seemed impossible. The introduction of the method of lunar occultation on the 250-foot telescope by Cyril Hazard then took the angular resolution down to hundredths of a second of arc and helped quasar research out of this impasse by showing distinctly nonstarlike structure; meanwhile, interferometer baselines became intercontinental, involving many nations.

Pulsars became a big activity at Jodrell Bank immediately the remarkable news of their discovery was announced from Cambridge, U.K., and three chapters are devoted to them. Jodrell became very good at discovering new pulsars and at the end of 1972 was coming up fast behind Sydney University, the two observatories together accounting for three-quarters of the 84 then known. When the announcement of pulsars appeared in *Nature* in February 1968, radio astronomers were astounded, and not least by the fact that the first records had evidently been taken many months previously and kept under a dark cloak of secrecy, which, as Lovell says, was almost as much of an accomplishment as the discovery itself. Lovell defends this withholding of data up to the point where the existence and astronomical nature of the unprecedented signals were established, on the grounds that "a scientific discovery of enormous fundamental importance would have been submerged in a torrent of science fictional nonsense."

Other topics dealt with include flare stars, the radar detection of Venus, and the Mark IA radio telescope. A marvelous anecdotal chapter deals with plans for the United States to exchange greetings with the Soviet Union via the Echo balloon. Because a single hop was not feasible, NASA proposed to include Jodrell Bank in the circuit. Wonderful three-nation confusion reigned for more than three years, but the transmissions were successfully established, including facsimile transmission (see illustration). However, Lovell doubts that the Echo experiments had any useful scientific or technical consequences. He says, "Their major value was the maintenance of contact in the space field between the U.S.A. and U.S.S.R. at a most difficult period of their relations."

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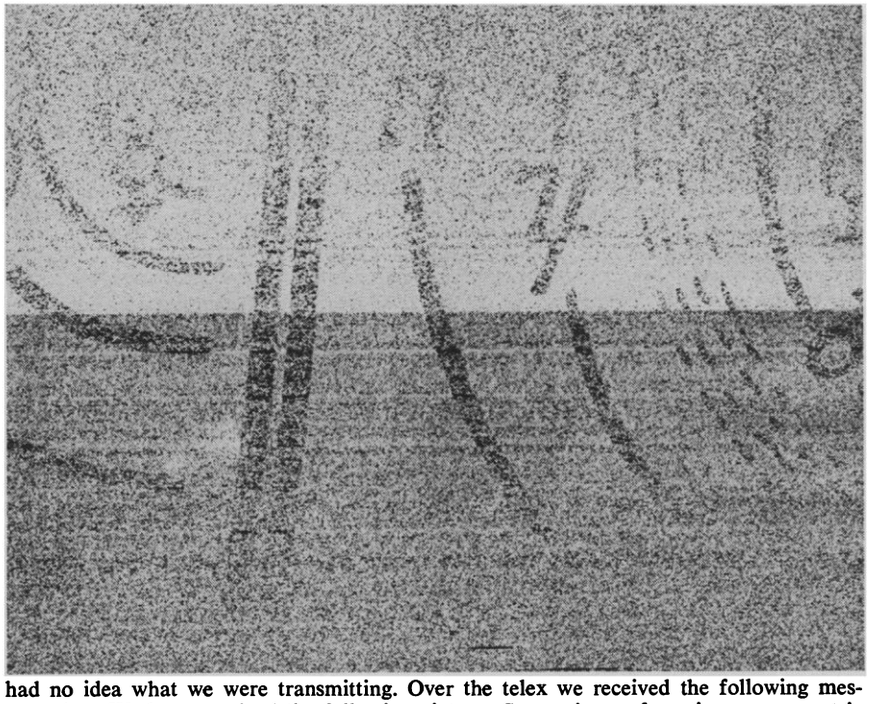

had no idea what we were transmitting. Over the telex we received the following message: '. . . We have received the following picture: Some pieces of continuous geocentric circles between them there are four dotted circles. It seems to us that we have seen on these circles the planets signs of the solar system.' " [From *Out of the Zenith*]

## Michelson

**The Master of Light.** A Biography of Albert A. Michelson. DOROTHY MICHELSON LIVINGSTON. Scribner, New York, 1973. xii, 376 pp., illus. + plates. $12.50.

It is said that scientists do not in general make good subjects for biographies, as their results are obtained methodically and logically and with little drama. They are remembered by other scientists for their works rather than for their personalities. Few of them ever challenge the establishment and even fewer of them get rich, so what benefit is there in studying their lives? This observation does not apply to Michelson (1852–1931), who from improbable beginnings rose to become in 1907 the first American to win a Nobel Prize in science, and who helped move America onto the world scene in physics.

Albert Michelson was three when his family emigrated from Poland to America, settling in Murphys, California, where his father ran an emporium for miners' supplies. His early schooling was rugged and rudimentary, but after high school he managed to obtain an appointment to the Naval Academy. After four years of training, he joined the fledgling physics department there as an instructor, and one of his first assignments was a demonstration experiment repeating Foucault's rotating-mirror measurement of the speed of light. In studying this experiment he