tragic figures of our time". (This is one of the points where the analogy between Newton and Einstein breaks down: Newton could hardly be considered in any sense as a tragic figure.) Clark develops this statement throughout the biography. If it remains not entirely convincing at the end, this does not derive from poor exposition by the author. The difficulty stems more, perhaps, from Einstein's own single-mindedness. It is hard to discern the century's great tragic hero in someone who saw the Universe as so much more important than human activities.

A. J. MEADOWS

Aspects of the Earth

Topics in Geophysics. By P. J. Smith. Pp. x+460. (Open University: Bletchley, May 1973.) £2.50.

THIS is a textbook for a short course in geophysics given by the Open University. The book does not attempt to cover the whole subject but chooses three topics as representative of different aspects.

The first is the structure and physical properties of the Earth's crust and upper mantle as determined from seismology and gravity; this represents a largely factual account about whose conclusions there is little doubt. The next topic is the heat flow from the Earth and its thermal properties. This is a subject in which a considerable range of views is possible owing to the inaccessibility of the deep interior of the Earth to temperature measurement. The third topic is earthquakes with special reference to prediction and prevention; this is a subject with engineering and social implications.

In the context of the Open University the plan of the book seems very suitable. Their short course could not cover the whole subject, except in a very superficial way, and the presentation of three contrasting topics in some detail seems a good way of providing something with a real intellectual content to students who do not intend to become professional Earth scientists. Within the three topics the author has a severe problem of choosing what to put in and what to leave out, and agreement is not to be expected. To me it seemed that in discussing the Earth's crust there was too much emphasis on gravity and too little on the mechanisms of earthquakes, the study of which has so strikingly contributed to the understanding of plate tectonics.

The figures are nearly all reproduced from papers; many of them could have been greatly improved by redrawing and some are hardly intelligible (for example, the map showing Pacific guyots and that of Japanese earthquakes).

How far the book will find an audience outside the Open University it is difficult to say. It is interesting and worth reading for a schoolboy or an undergraduate with an interest in the Earth, but have they the time to read a book that confines itself to three selected topics? I hope they have.

E. C. BULLARD

Jodrell Bank

Out of the Zenith: Jodrell Bank, 1957–1970. By Bernard Lovell. Pp. 255 (8 plates). (Oxford University: London, Melbourne and Toronto, November 1973.) £5.50.

SIR BERNARD has made the hiatus caused by conversion work on the Jodrell Bank 250-foot Mark 1 radio telescope the opportunity for an account of what he likes to call his "stewardship of that unique instrument". Since he describes not only the scientific work but also the diplomatic and managerial activities that went on behind the scenes to keep the show on the road, many interesting issues arise that can only be touched upon in a brief review.

Although for most of 1957–70 the Mark 1 was the largest fully steerable telescope in the world, it was involved directly in few of the most spectacular radio astronomical discoveries of the period—quasars, the radio source counts, pulsars. The initiative in the study of discrete sources has remained firmly with the interferometers developed in the early fifties. This is mainly because, to achieve a resolution or positional accuracy comparable with optical telescopes, radio telescopes with overall dimensions of the order of miles, rather than hundreds of feet, are needed. Indeed in one of the most successful programmes pursued at Jodrell Bank, the study of the structure of extragalactic sources, the Mark 1 dish was itself used as one arm of an interferometer, the other being a variety of much smaller aerials at ever increasing distances. By 1962, using a baseline from Jodrell Bank to Lincolnshire, Henry Palmer and his group had surpassed the best resolution obtainable with optical telescopes (1″ of arc), and by 1966 they had shown that a number of quasars have sizes smaller than a few per cent of this.

Had these studies continued throughout the sixties there could now be some structure information down to 1″ or better for all the brighter sources, a task now being undertaken by the new Cambridge 5 km interferometer (which will provide complete maps of the sources). Instead, Sir Bernard describes how he diverted Palmer and his group to what proved to be the chimaera of intercontinental baselines with the Russians as the other end of the interferometer arm. An intercontinental link was eventually achieved in 1969 with the huge Arecibo telescope in Puerto Rico, but some two years after the Canadians and Americans had been on the air.

The programmes to which a telescope like the Mark 1 is ideally suited are those pursued by the groups under R. D. Davies on the 21 cm hydrogen line (primarily the structure of our own Galaxy), under R. G. Conway on the accurate fluxes, spectra and polarisation of radio sources, and under Graham Smith on the pulsars. Curiously, Sir Bernard finds space to describe only the last of these three programmes, bowing no doubt to popular interest. Instead there is an account of what might be called 'radar games' in which the United States and the Soviet Union bounce messages of dubious goodwill to each other off the Moon, balloons and what have you, using Jodrell Bank as a sort of telephone exchange. Like the manned space programme, this was no doubt entertaining for the general public, at least on the first occasion.

Jodrell Bank has been *par excellence* a pulsar observatory and has discovered more than half the northern hemisphere pulsars known. The pulsars therefore deserve their three chapters in the book, although I frankly think that Graham Smith might profitably have been asked to contribute these chapters. Indeed, a more balanced and penetrating account of Jodrell Bank's scientific work might have been arrived at by asking Palmer, Davies, Conway and Smith each to contribute sections on their own programmes, with Sir Bernard providing those interesting glimpses of the committee men in action. That, of course, would not be Sir Bernard's style, and instead we get an account of pulsars which might have been satisfactory in 1969, but seems a bit thin on the observational side for 1973. And the only theoretical work described is Gold's now superseded 1968 model. No mention at all of Pacini's 'oblique rotator', now all the rage.

There is a chapter on Sir Bernard's own observational work on red dwarf flare stars, a topic which I found interesting and not, I think, covered in other popular books on astronomy. There is a curious sentence here, though. After describing the ultimate fate of the Sun as a white dwarf, he goes on (page 170): "However, if the star is much more massive than the Sun—at least one and a half times greater mass according to present views—it is believed that the gravitational forces during the collapse are so great that the final state will be that of a neutron star". Black hole *aficionados* (and who is not one nowadays?) will know that if the mass of a star is greater than about one and a half times the mass of the Sun, not only can it not be a neutron star but *sui generis* must become a black hole, unless it sheds some of its mass.