on air, meteors and the saltiness of the oceans. In short, he gives a general and accurate picture of how the Earth was viewed in the late eighteenth century; and he does so, moreover, within a logical framework which most writers of books about the Earth have adopted ever since.

As Goldsmith freely admits, the model for his first book was Buffon's *Histoire Naturelle*; but whereas Buffon was out to establish his theory of the Earth above all others and was quite happy to make some of the facts fit his case, Goldsmith had no axe to grind. He was concerned to be more critically objective and discriminating, and thus went beyond Buffon to Burnet, Woodward, Whiston and other sources, both acknowledged and unacknowledged. But from wherever his information came, his judgement was always on the alert and he was ever ready to discard the opinions of others, however eminent, if they were refuted by personal observation.

Goldsmith never lost sight of his intention to write not a scientific treatise but a popular account; his concern was to produce "innocent amusement for those who have nothing else to employ them, or who require a relaxation from labour". The result is a book which is both scientifically accurate (for the time), and a work of genuine literary merit written with what Jeffares (*Oliver Goldsmith,* British Council, 1959) calls "all the ease and grace we expect from Goldsmith". In seeking "to drag up the obscure and gloomy learning . . . to open inspection" rather than to publicise scientific advances or make a scientific case Goldsmith must be regarded as one of the earliest of what are now called 'science writers'.

During the following century, Goldsmith's *An History of the Earth, and Animated Nature* went into at least 23 editions, including one in Welsh. His model was copied by scores of writers during the nineteenth century. Could it be that Goldsmith's science writing and its legacy, ignored by scientific and literary historians alike, actually affected the public mind more than many of the better known purely literary works?

A night on Mount Hamilton

by John Gribbin

THE Lick Observatory on Mount Hamilton, near San Jose, has an interesting history and a fine array of telescopes which make it well worth a visit from any itinerant astronomer (or ex-astronomer) who happens to be in the neighbourhood. I was in that happy position on October 25, and my native guide, Dr John Faulkner, was also able to provide a potted history of the observatory. (For further details see the booklet *Lick Observatory,* fifteenth edition, available from the University of California, Santa Cruz.)

It seems that James Lick, who provided the finance for the building of the observatory, now rests in a tomb underneath the 36-inch refractor. He originally intended that the memorial by which the good citizens of San Francisco should remember him would be a pyramid downtown, rather larger than that of Cheops. He was dissuaded from this by a retired sea captain who pointed out the great lustre that could be brought to the name of Lick by an observatory containing the largest telescope in the world. After a costly site survey covering much of the United States (and the first of its kind) Lick and his seafaring friend were no doubt delighted to find that Mount Hamilton, in their own backyard, was as good a site as any available.

Building an observatory on the top of a mountain was an epic achievement in the 1870s. The builders did, in fact, cheat a little on Lick's bequest, since they did not feel up to the task of building a reflector bigger than the Earl of Rosse's remarkable Irish instrument. Instead they built the largest refractor in the world.

Since those days, the Lick Observatory has expanded, and so, alas, has the nearby town of San Jose. The pretty lights below the mountain and the haze from the urban environment conspire to plague the astronomers. But although there is talk of a new observatory being built in a less accessible part of California, there are no definite plans as yet.

Pride of place on the mountain today is taken by the 120-inch telescope, which the Lick observers claim to be the best light bucket in the world. The impressive array of electronic gadgets which can be attached to it makes the telescope, they claim, a better performer even than the 200-inch at Palomar, although the Lick instrument has just 36% of the collecting area of the larger telescope. But they may soon have to consider a new rival to the telescope which can get the most in-

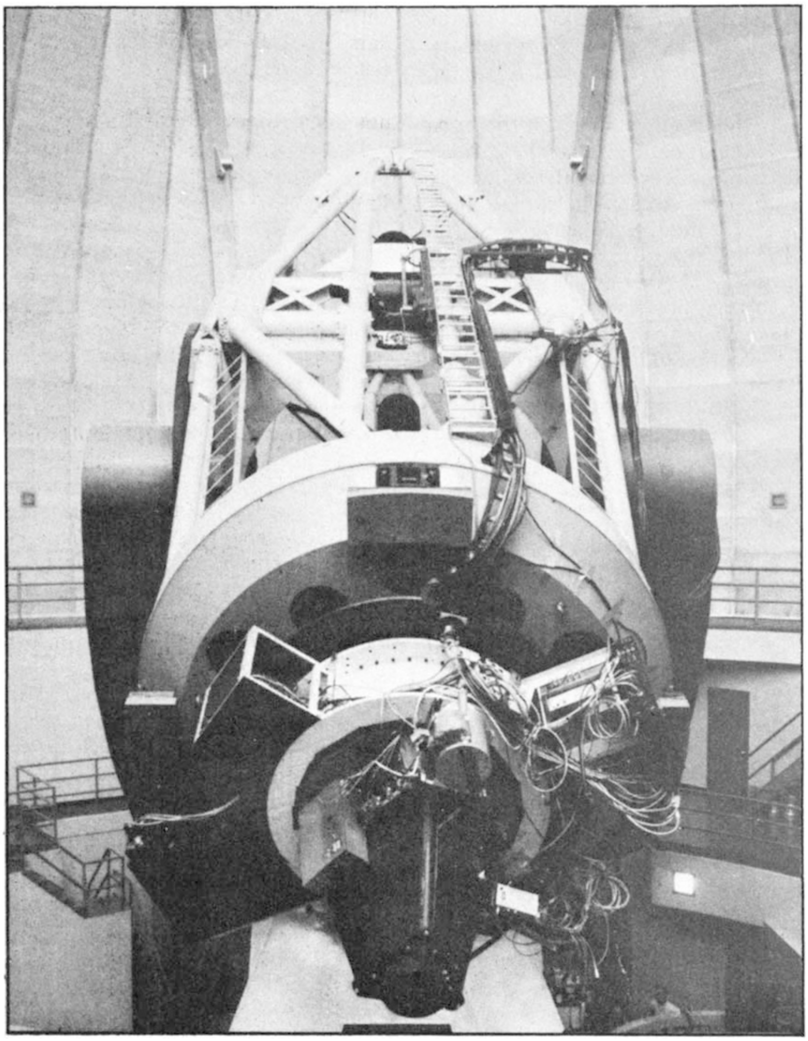

Fig. 1 The business end of the 120-inch telescope on Mount Hamilton, showing the impressive array of electronic instrumentation. (Courtesy Lick Observatory.)

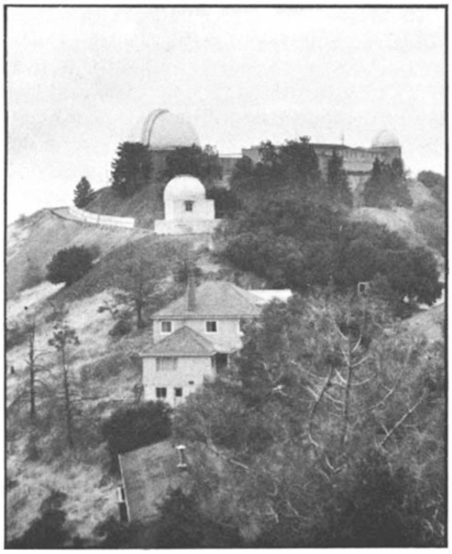

Fig. 2 "It was a dark and stormy night . . ." View of the main building of the Lick Observatory from close to the 120-inch site. The small hut in the middle ground conceals the absence of any electronic instrumentation on the Tauchmann.

formation out of the smallest number of photons—the Anglo-Australian Telescope, whose director, Jo Wampler, must have taken with him from California many of the tricks of the trade.

But the casual passer-by is not allowed even to enter the 120-inch dome, much less operate the mighty machine. For such itinerants, a slightly less sophisticated instrument with an aperture one sixth that of the big telescope is available. This instrument, the Tauchmann reflector, provided the entertainment on the night of my visit. In the words of one recent user it provides "a rickety but fun operation". The meaning of this can best be gauged from the instruction book provided to aid the unfamiliar with their observations. After explaining how to open the dome (not as easy as the uninitiated might guess) and how to set the telescope in the required direction, some handy hints are provided to explain why you may not be able to see anything. The list begins: "(1) Is telescope pointing out of dome slit?" and continues in similar vein.

Our fun was only slightly marred by the 99% cloud cover on the night of October 25. We did, briefly, see the Moon and my colleague claims that he saw Jupiter, but the observation was not confirmed. As the only observers on the mountain that night we can at least report that for once the Tauchmann achieved more than the 120-inch. Of course after a two hour drive back to Santa Cruz on the coast we found a cloudless sky, thus proving Parkinson's second theorem.

Chunky sputtering

from Robert W. Cahn

THOSE incorrigible optimists who look for salvation to the large-scale controlled release of thermonuclear fusion energy should be cheered by a conference which was held at Argonne National Laboratory near Chicago last January, under the title *Surface Effects in Controlled Thermonuclear Fusion Devices and Reactors*. The proceedings have now been published as a special volume of the *Journal of Nuclear Materials*. For perhaps the first time, a major conference took as a premise that large fusion reactors will be built well before the century is out; Klaus Zwilsky of the Division of Controlled Thermonuclear Research of the United States Atomic Energy Commission proffered a timetable which included an experimental power reactor in operation by 1984. The conference was concerned with one class of engineering problems which will arise in the design of such reactors, namely the interaction between imperfectly confined plasmas and the wall of the containing vessel, combined with more conventional radiation damage due to energetic particles, especially neutrons, impinging on the walls. Physicists and metallurgists do not lavish time and money on such difficult studies unless hard-headed engineers have concluded that the hardware is in principle feasible.

Many of the papers dealt with the effects of particles peculiar to thermonuclear reactors, such as lithium, deuterium and tritium ions, but a particularly intriguing group of papers was concerned with that familiar entity, the high-energy neutron. The neutrons impinging on a fusion reactor wall will be exceptionally energetic, and little is known concerning the effects of such super-neutrons. Kaminsky and Das (*J. nucl. Mater.*, **53**, 162; 1974) experimented with 14 MeV neutrons from an accelerator, impinging on niobium. It has long been realised that the sputtering (that is, collision-induced erosion) of the metal could gradually damage the wall, and perhaps more serious, contaminate the plasma with metal ions through the knocking-out of individual metal atoms. But something else quite unexpected happened as well. 'Chunks' of niobium often exceeding one micrometre in size and containing many millions of atoms, were emitted from the surface. Nothing remotely like this had been reported before in sputtering experiments. Kaminsky and Das discovered that the emission of chunks was much greater when the target was cold-rolled and roughly polished than when it was annealed and finely polished; though these aspects were not varied independently, the investigators were sure that internal stresses and rough surfaces each and severally promote emission of chunks (as opposed to single atoms).

A companion paper by Guinan (*ibid*,. page 171) develops the hypothesis that thermal transients engendered by collision cascades within the metal will generate shock waves which might suffice to spall off chunks. Guinan concludes that the magnitude and duration of such shock waves would not alone suffice to do the trick. But if the metal contains regions of high internal stress (for instance, at the head of a dislocation pile-up) then as Guinan shows, a shock wave can act as a trigger to release the stored internal energy, leading to the ejection of a chunk. On this hypothesis, as Karminsky and Das have found, both plastic deformation and surface roughness will foster chunk emission (though it must be admitted that the role of the second variable is not clearly explained). Unannealed cold-rolled foils, which contain macro as well as micro stresses, are particularly vulnerable. Karminsky and Das conclude that a high mirror polish on a vacuum-annealed metal, monocrystallic for choice, will render it virtually immune to chunk emission or the associated damage. It seems the phenomena resembles ordinary fatigue, very largely controlled by surface quality.

In related studies, Blewitt *et al.* (*ibid.*, page 189) failed to find chunks emitted from gold bombarded with 14 MeV neutrons, whereas Biersack, Fink and Mertens (*ibid.*, page 194) found copious chunk emission when UO_2 films were sputtered by self-generated fission fragments during neutron irradiation. Here there was a pronounced effect of foil thickness (thin foils emit more chunks), and in particular, there was a lower limit of neutron dose below which no chunks emerged. It is surprising that the many earlier experiments on fission-fragment self-sputtering had not previously uncovered this phenomenon.

The notion, which seems well supported by the experiments on niobium, of the cold-rolled metal as a sort of self-stressed microbomb from which fragments are released by neutron bombardment, is reminiscent of researches at Harwell in 1956 by Cottrell and Roberts, who discovered that the intergranular stresses engendered by uranium by the anisotropic radiation-induced growth of individual crystal grains led to creep under absurdly small applied stresses. Here, the external stress triggers off the release of internal stresses created by prolonged uranium fission. Radiation creep has come to be recognised as a