follow. One important part of the theory of subatomic particles treated in this section is the set of symmetry principles that these interactions satisfy. Davies' discussion of the basis of these principles is curiously Aristotelian, relying on the invariance properties of empty space. Although he is able to draw correct conclusions from this analysis, past experience should make us cautious about the extent to which such a style of argument can be trusted. It would be just as easy to infer Aristotle's form of inertia as Galileo's form from Davies' arguments.

The final section of *The Forces of Nature* deals with recent developments, such as the quark theory of hadrons, and the unified theories of weak and electromagnetic interactions. The discussion here is very up-to-date, and includes the discovery of the upsilon meson, and of parity non-conservation in deep inelastic electron scattering. There are also nice discussions of spontaneous symmetry breaking and of some reasons why quarks may not be observable. Once again, some things in the text are misstated, such as the mechanism by which charged pion decay occurs in the quark model.

A general stylistic objection to the book is that over and again Davies resorts to the phrase "it can be shown," or the like, a device that will probably annoy others as much as it does this reviewer. But on the whole, *The Forcers of Nature* is a considerable achievement in popular science writing. It is most likely to appeal to readers with an abstract turn of mind, who like deductive reconstructions of physical phenomena. □

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Einstein's ideals

Eugene Wigner

Albert Einstein, The Human Side: New Glimpses from His Archives. Selected and edited by Helen Dukas and Banesh Hoffman. Pp.168. (Princeton University Press: Princeton, New Jersey, and Guildford, UK, 1979.) $10; £4.95.

THE purpose of this book is to acquaint the reader with Einstein's social ideas, with his emotional life, with his convictions concerning the objectives man should strive for. And he surely abided by the ideals he put forward in his letters as well as any person could. The book is almost completely restricted to these aspects and contains hardly any information about Einstein's scientific accomplishments. It deals with what the authors call the human side.

As far as Einstein's own direct contributions to the book are concerned, these are almost completely restricted to letters which he sent out and a few which he drafted but did not send off. It does contain also two vitae — one written when he was 17, the other when he was a member of the Prussian Academy of Sciences, in Berlin at the age of 53 — and these are interesting to compare. Most of the rest of the book is due to two of his admirers: his almost life-long secretary Helen Dukas and his past friend and collaborator Banesh Hoffmann. They call themselves Selectors and Editors of the letter collection, but their contribution is actually much greater. It includes also the description of Einstein's relationship to the addressee of the letter, Einstein's attitude towards him or her, the motives leading Einstein to write the letter and the circumstances under which it was written. All this is done very clearly. They have also written a very nice introduction to the book.

Most of Einstein's letters were originally written in German and some were sent in that language. Others were drafted in German then translated into English by Einstein himself, but in some cases only the original German draft is available. In both these cases translations have been made by the Selectors and Editors, and in some cases this has been a difficult task. A particularly difficult case is that of the poems written by Einstein for inclusion in the letter. But whenever the letter's English formulation was not by Einstein himself, the German original is reproduced in the second part of the book ("German Originals", pp. 119-163). In a few cases, one must admit, the translation is less lively than the original, but it is good even in these cases.

The book does give the reader a vivid impression of the breadth of Einstein's interests, of his modesty and desire to help his fellow men and please them, of his convictions about what is good and what is evil. As to the first question, even the writer of this review, though he knew Einstein since about 1925, was not aware of all his interests. Besides all branches of physics, it also included music — his favourite composers were Bach and Mozart but he did have an affectionate regard for some of the later ones. His love of his violin was well-known to all his acquaintances. But in addition to these well-known interests, he showed great fondness towards the great philosophers of the past, and many of his letters are enlivened by philosophical remarks which give pleasure to the interested reader of the book and must have given even more pleasure to the original receipient of the letter. "The concept of a soul without a body seems to me empty". "What I see in Nature is a magnificent structure that we

can comprehend only very imperfectly, and that must fill a thinking person with a feeling of humility" (pp 39 and 40) are two such passages. But there are many, and even if one does not fully agree with them, all are refreshing. He also defended philosophy in general against its deprecators even when recognising its weakness: "Philosophy is like a mother who gave birth and endowed all other sciences" (p106) is perhaps an exaggeration but a well-meant one.

Einstein's love of poesie is also little recognised. He even wrote some poems, all of a slightly humorous nature, for his letters. About ten of these are contained in the book, and all are amusing.

Einstein's attitude towards religion is also clearly expressed in his letters. He felt — as many people do today — that its main role should be in the ethical domain, whereas its cognitive assertions should be more in the background. He also writes a good deal about the extinction of life — one must, with sadness, come to the conclusion that he enjoyed his last few years very little and considered the extinction of his life not only cognitively, but to some degree also emotionally, as a liberation from obligations.

Einstein's political convictions are also very apparent from his letters. These are, of course, generally known: he was opposed to all dictatorships, be they of the national socialistic — that is, Hitler-inspired and anti-semitic — or of communistic nature. In fact, one draft letter (pp110-112) is so vehement that it was not sent out but, according to the introduction preceding it, "must have brought him a feeling of relief".

The preceding discussion contains, of course, only a superficial review of the kind of information the reader will gain about Einstein's interests and thinking when reading this book. And the information will appear in a much more lively fashion than the foregoing summary presents it.

The book contains more than a hundred letters. To whom were they addressed? A few to his sister, Maja, a few more to his earliest physicist friends Zangger, Ehrenfest and Lanczos, but even more, about eight, to his psychiatrist friend Juliusburger. There is no letter to either of his wives or to the rest of his family. The rest of the letters are practically all answers to letters he received, each from a different person. With about half of these he had some acquaintance, the other's being written to please or comfort people he had not heard of before. Many of these letters, the writing of which was stimulated by kindness or compassion, contain passages which are truly memorable, and manifest deep insights. A few of the other letters are directed to editors of journals and about four to ministers of churches. These latter all have a strong political undertone.

It is not clear how the letters published were selected, nor is it clear how Einstein had chosen the letters to be answered. In one of his letters (p43) he praises the one which he answers as being very reasonable, in contrast to the hundreds of other letters which he was receiving, most of which, of course, he did not answer. It would also be interesting to know where and how the letters and the drafts of the letters published were found.

The English language part of the book (the first 115 pages) are arranged into 12 sections. These sections, however, have no titles and it is not clear on what basis the various letters are distributed into these sections. This has advantages if one reads the book from cover to cover — it is not easy to digest 10 philosophical letters in succession and not refreshing to read several complaints about politicians' misdeeds one after the other. But if one wants to recover a passage which one remembers vaguely, it would be good to have either a definite order of the articles in the book, or at least an index at the end of it. Similarly, the time ordering of the letters seems to be a random one. Thus, Section 6 (pp54-74) has articles dating from '33, then '51 and '53, then '27, again '33, '35, '21, and so on, ending up with one of '27. The subjects vary equally greatly, the first is political, the next a thank-you for the offer of financial help, the next refers to physics, then comes a letter to a student publication, then a praise of science in general and so it goes on. It is amusing to read all this, but a catalogue surely would be useful.

After all this criticism, let me compliment again the Selectors and Editors for the very good job they have done. It surely required not only knowledge but also devotion to the job and a true interest in the human side of Einstein. □

Eugene Wigner first met Einstein in 1925, while a student in Berlin. He had closer contact with him after 1933 when both lived in Princeton, New Jersey.

The quantum and its supporting planks

P.T. Landsberg

Black-Body Theory and the Quantum Discontinuity, 1894-1912. By T.S. Kuhn. Pp. 512. (Clarendon/Oxford University Press: Oxford and New York, 1978.) £12.

THE realisation that discontinuities (or quanta of energy) are needed for the description of microscopic phenomena represented one of the great transformations of human thought. Not that everything was believed to be continuous before that — the atomic concept of Democritus, the distinct notes of musical instruments, comets and explosions had been part of the intellectual furniture for centuries, and they certainly implied discontinuities of sorts. But they were not fundamental. Comets continued to be, when not in view; explosions could presumably be analysed into a more or less continuous sequence of chemical reactions; musical notes could be changed by altering the tension in the wire; and the constitution of atoms (if they existed, one would add in 1900) posed in any case intractable problems, for example, how could they be indivisible if they participated in the production of spectral lines? Indeed, as W.K. Clifford observed, an atom must be at least as complicated as a grand piano. Upon this placid scene, in which physics seemed to be approaching a completed structure, there floated gently (for it did not 'burst') Planck's theory of the energy density, as a function of frequency, of radiation when in thermal equilibrium with bodies at temperature T (black-body radiation). Shortly afterwards arose the problems of relativity, specific heat anomolies, etc., and so black-body radiation never lost the charisma of having been the first problem area which brought deep changes to classical physics. It did so by suggesting that an atom oscillating linearly at a frequency ν has available only discrete energies $h\nu$, $2h\nu$, . . . and so on, whereas classical theory would have allowed a continuous range of energies. Here h is the newly introduced constant of nature, now called Planck's constant.

At precisely what time and through whose pen did these discontinuities enter physics? The normal answer is that the year was 1900 and the man was Max Planck. In this scholarly study, which can boast 90 pages of notes and references, Kuhn suggests an amendment. Planck restricted the energy of N oscillators to be integral multiples of an energy unit, ε say, a type of "quantisation" already envisaged by Boltzmann in 1877, but he did not impose this constraint *on a single oscillator* until after 1906 (see p126), the year in which this requirement had been emphasised independently by Paul Ehrenfest and Einstein, "the two physicists who first recognised that Planck's black-body law could not be derived without restricting resonator energy to integral multiples of h or some equivalent non-classical step" (page ix).

In the Epilogue Kuhn discusses Planck's "second theory" of heat radiation (1911) which introduced the notion that the mean energy of an atomic oscillator goes to a constant and non-zero value at the lowest temperatures. Although this zero-point energy remained important, Planck's second theory was