

Scientific bases for understanding being

MECHANICAL MAN: THE PHYSICAL BASIS OF INTELLIGENT LIFE. By Dean E. Wooldridge. 212 pp. McGraw-Hill, New York, 1968. \$8.95

by Sanborn C. Brown

Many physicists have written extensively on the scientific bases for understanding life. Perhaps most famous of the modern physicists was Erwin Schrödinger, whose readily accessible works on this subject are contained in a book *What is Life?*, published by the Cambridge University Press in 1944. Schrödinger discussed the concept of entropy as it applied to organisms in contradistinction to entropy in the physical universe and proposed a definition of life based on its antientropic behavior. In sharp contrast to Schrödinger's approach, two years ago Walter M. Elsasser published a book through Princeton University Press entitled *Atom and Organism* in which he proposed that life is a primary phenomenon not deducible from physics or from any other scientific discipline. Diametrically opposed to this concept are the conclusions drawn by Dean E. Wooldridge, cofounder of The Ramo-Wooldridge Corp. and presently a research associate in engineering at the California Institute of Technology. Wooldridge concludes, "The properties we call lifelike that differentiate living cells from inanimate matter result directly from the nucleic acid/protein enzyme mechanisms, and a complete explanation of these mechanisms is possible in terms of the operation in inert chemical ingredients of the ordinary laws of physical science."

After a careful introduction to the chemistry of the living process and the development of single and multicellular organisms, Wooldridge discusses basic behavior mechanisms and behavior patterns in animals. This discussion leads up to his explanation of intelligence by means of the ordinary physical laws of nature. He closely parallels the behavior of the brain with that of an electronic computer. He argues that not only are computers intelligent, but that the ordinary laws of operation of the evolutionary process are a valid mechanism for their

improvement. He concludes this part of the book with: "All intelligence, whether of computer or brain, is the natural consequence of the powerful symbol-manipulating capabilities of complex switching networks and that therefore the ordinary laws of the physical scientist are adequate to account for all aspects of what we consider to be intelligent behavior."

With this statement, the author changes his approach to the subject matter in the last third of the book to discuss such human attributes as the physical sources of consciousness and the explanation of personality, free will and social attitudes based on the ordinary laws of physics. This last part of the book is considerably more speculative than the material leading up to it, but perhaps because of this reason it is more controversially stimulating. Such ideas as using a

disembodied human brain as the basic computer element in fast industrial computers and storing a man's complete conscious function (such as memory, emotional life, goals, aspirations and knowledge) on IBM cards or memory drums, so a man can be transported through time and space and then recreated, if desired, are all part of the feasibility discussion forming Wooldridge's conclusion. In justification of the full title, *Mechanical Man: The Physical Basis of Intelligent Life*, Wooldridge summarizes as follows: "We have learned how behavior, even of the kind we call intelligent, will probably be found to be completely accounted for when we have adequately developed our understanding of the properties of the complex switching networks that appear to underlie the operation of brains as well as computers. We have



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"... we can today assert that biology is indeed a branch of physical science and that man is only a complex kind of machine."
—from *Mechanical Man*

studied evidence that the subjective concomitant of thought and sensation—consciousness—is also a lawful phenomenon, with its content determined in regular and predictable fashion by the structure and electrochemical activity of the brain. We have, in short, followed the development of a strong case for concluding that the origin and properties of the human organism—physical, behavioral, mental, subjective and objective—are completely and in detail the consequence of the normal interaction of the ordinary laws and particles of physics. In such terms, man is a machine."

Waves and magnetoelasticity

ADVANCES IN APPLIED MECHANICS, Vol. 10/1. G. Kuerti, ed. 112 pp. Academic Press, New York, 1967. Paper \$4.75

by James B. Kelley

This tenth volume in the *Advances in Applied Mechanics* consists of two papers: "Wave Propagation in Real Gases" by Wilbert Lick of the California Institute of Technology and "Magneto-Elasticity and Magneto-Thermo Elasticity" by Gunadhar Paria of the Shri Govindram Seksaria Technological Institute in India. Of the two papers, Lick's is much longer and marks a continuation of work the author has been doing in this general field for the past several years.

As Lick points out in his short introduction, the analysis carried out here is somewhat more sophisticated than the usual linear acoustics theory for a uniform one-dimensional medium with the assumptions of constancy of wave form and entropy. The basic equations are those that describe the conservation of mass, mo-

In 1964 and 1965 Wooldridge received the AAAS-Westinghouse award for science writing, and he demonstrates his ability to express himself clearly and succinctly in this present volume. Whether the reader is convinced that Wooldridge has adequately proved his thesis, one is left with no doubt regarding the author's ability to present his case in an interesting and stimulating fashion.

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mentum and energy and the equations of state relating the different thermodynamic variables.

The problem worked out in detail is the following: a one-dimensional, time-dependent propagation of disturbances through a gas, semiinfinite in extent; the gas is bounded by a piston on the left and is initially in static equilibrium. For time $t > 0$, conditions on certain variables such as velocity and temperature of the piston will be changed to prescribed constant values different from their initial values. Generally, as a result, a wave is propagated to the right in the x direction; the general character of the motion is then studied. Lick calls this problem the "signalling problem."

In the four sections following the introduction, the basic equations, linear theory, structure of steady-state shock waves and the formation of a steady-state shock wave are studied. Such essential factors as viscosity and thermal conductivity, chemical reaction, mass diffusion, radiation and mag-

netohydrodynamics (idealized to some extent, to be sure) are considered in the equations. The presentation is straightforward, the assumptions realistic within the bounds of the conditions set and the solutions handled well. As can be easily imagined, the solutions of the equations are not rigorous—this would be impossible—but involve numerical methods that the author spares the reader.

No presentation of this length could be exhaustive, but Lick has done well in striking the highlights both in his paper and in the list of references of some of the more recent work done in this field. For the researcher in applied mathematics, for seminars or for a specialized graduate course, Lick's paper would be useful.

The problem discussed by Gunadhar Paria, "Magneto-Elasticity and Magneto-Thermo Elasticity," has some special interest to the reviewer because some time ago he helped develop certain nondestructive testing methods for the internal hardness of odd-shaped objects using the phenomenon of magnetostriction. As Paria points out in his introduction, the possibilities for applications of magnetoelasticity and magnetothermoelasticity in modern seismology, geophysics, acoustics, etc., are considerable. Despite the present interest being generated in the field, there is still much to be done.

The development is traditional; it begins with the elastic stress tensor for Hooke's law in an elastically isotropic solid and Maxwell's equations. The Maxwell electromagnetic stress is given in terms of the electric and magnetic field, from which Paria develops the modified Fourier law for heat conduction with terms to indicate the effect of the elastic strain and the electric current on the temperature distribution in the solid. The author points out that relatively few problems in magnetothermoelasticity have been solved, and most of those that have been solved are recent. It is interesting to note that many of those attracted to work in this field have come from outside the US, particularly from India and the Soviet Union.

The problem that Paria considers in some detail is that of magnetoelastic stresses in an infinite medium with a long cylindrical hole. The mathematical presentation is developed in some detail and the basic equations are developed for two dimensions. The solution is carried out for the purely elastic

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