do. Surely the privileged people outside of Watts need "retraining" as much as the people inside, because they have a distorted view of social reality.

It is not altogether ridiculous to say that social experimentation requires that there be no experts—or, if you wish, that everyone is an expert on some relevant aspect of planning. Indeed, one measure of performance of social planning might very well be the extent of contribution of all members of society. One of the most frustrating aspects of society today is the very little that most of us can contribute to the planning of social change; at best we have an occasional vote (often on undesirable alternatives) or an occasional letter to a representative. It would be a tragedy if all the good work of the earlier pragmatists produced a society ruled by "scientific" experts, no matter how elegant their experiments might be.

I'd feel a lot happier about the coming age of man-machine digital systems if I could more clearly understand a theory of implementation of the results of social experiment.

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Philosophical Inquiries

Delaware Seminar in the Foundations of Physics. Mario Bunge, Ed. Springer-Verlag, New York, 1967. xii + 193 pp. $9.50. Studies in the Foundations, Methodology and Philosophy of Science, vol. 1.

The most outstanding feature of this collection of essays is the diversity of their subject matter and approach. Three of the contributions (Bergmann, Bernays, Bunge) treat general questions about the nature of physical theories; two (Noll, Truesdell) present closely connected, and rather technical, discussions of the foundations of continuum mechanics; two (Grad, Jaynes) offer divergent accounts of the nature of statistical physics; two (Schiller, Margenau and Park) treat quantum mechanics, from quite different points of view; one (Post) offers a critical discussion of the physical content of the covariance principle; and another (Havas) presents a general discussion of problems arising in formulating general relativity theory.

Of the general discussions, the most substantial is Bunge's. He presents the outlines of a general account of the nature of "contemporary theoretical physics" by referring to a specific example of a physical theory—the two-component theory of the neutrino. He analyzes this theory into four components; its background (the other theories it presupposes); its form (the mathematical formalism of the theory); its content (the physical interpretations of this formalism); and finally, its evidential support. The general picture that emerges is one of a theory whose "essence" is a certain mathematical formalism which may be given various interpretations, or applied to various physical situations. The enterprise of giving such interpretations is discussed and an attempt made to distinguish this from the enterprise of producing empirical tests for the theory. A suggestion is made that the understanding of this enterprise—the semantical side of physical theorizing—may be advanced by employing the concepts and results of model theory. This appears to be a fruitful suggestion. It is regrettable that Bunge does not pursue it further in his article.

Two of the more specialized contributions are unified by a feature worth noting. Both the contribution of Jaynes and that of Margenau and Park deal extensively with the concept of subjective probability and its role in physics. It is astonishing that neither refers to *any* of the vast body of literature on subjective probability published in the last 30 years. The work of Ramsey, de Finetti, Savage, and Jeffrey has produced a theory of subjective probability quite distinct from, and superior to, the rudimentary efforts of Laplace, Keynes, and Jeffreys. In particular, the work of de Finetti has provided an account of how there can be wide intersubjective agreement about the values of certain subjective probabilities—one of the commonly mentioned difficulties in viewing physical probabilities as subjective.

This lacuna is particularly surprising and regrettable in the work of Jaynes—surprising because Jaynes is an advocate of a subjective interpretation of probabilities in physics, regrettable because it masks a very interesting problem in Jaynes's maximum-entropy principle. This is essentially a principle for choosing a prior probability distribution on the basis of data about average values of certain quantities. It is introduced by Jaynes as a postulate. From the point of view of modern subjective probability theories, an interesting question is this: Can this distribution be shown by the one on which *all* prior distributions converge in the limit of large numbers of certain kinds of experiments—the experiments which give us the data on "average values"?

The lacuna is not so surprising, but equally regrettable, in the contribution of Margenau and Park. The most glaring manifestation of it is the absence in their discussion of a distinction between the a priori or logical interpretation of probability (whose most outstanding recent proponent is Carnap) and the subjective interpretation in general. What the relation between these interpretations is may not be a closed question, but it is generally recognized not to be identity. The question of whether or not a subjective interpretation of probability in quantum mechanics is possible or fruitful is hardly illuminated by mounting objections to a quite different interpretation of probability. It is also regrettable that an alternative to the authors' account of the "seemingly miraculous" numerical agreement between subjective and objective probabilities—that of de Finetti—is not even mentioned.

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The Theory of Automata

Computation: Finite and Infinite Machines. Marvin L. Minsky. Prentice-Hall, Englewood Cliffs, N.J., 1967. xviii + 317 pp., illus. $12. Prentice-Hall Series in Automatic Computation.

A mathematical theory of computing machines (sometimes called automaton theory) was first presented by Alan Turing in 1936 (hence such machines are also often called Turing machines). Since that time there has been an extensive development of the field, although the models proposed are still very far from the current digital computers we find in so many places these days.

Minsky's *Computation: Finite and Infinite Machines* has finally brought order and sense to the mass of material that has appeared in the literature since Turing's first publication. The book has the character of simplicity that so often marks a great step forward; it uses only elementary mathematics (although in somewhat sophisticated ways) and presents the elements of the subject in a simple, sensible form. Now that he has done it, we can only wonder why the book was so long in coming.

The book begins by examining the simple model of a finite-state machine (a machine which can have only a finite number of states). After carefully defining his mathematical model and explaining some of the relationships between it and reality, Minsky proves that a finite-state machine can add arbitrarily long sequences of binary digits of two binary numbers provided the lowest-order digits are presented to the machine first, but that a finite-state machine *cannot* do the corresponding multiplication.

Neural nets and the McCulloch-Pitts models are shown to be equivalent to automata made up of simple parts and then to be equivalent to finite-state machines. Some logical systems such as Kleene's theory of regular sets are also shown to be equivalent to finite-state machines; thus the idea of finite-state machines is shown to provide a unifying view of a number of originally diverse topics.

The second part of the book treats infinite-state machines. It begins with the development of the classic Turing machine and effective computability, demonstrates the usual universal Turing machine, and passes on to the surprising limitations of effective computability, such as the unsolvability of the "halting problem" and some decision problems. Special attention is given to the interesting consequences of computable numbers.

Just as finite-state machines were shown to unify some diverse topics, so infinite-state machines are shown to be related to recursive-function theory and Post's theory of productions, and the normal-form theorem is proven. The book ends with some specially simple Turing machine models such as the four-symbol, seven-state Turing machine.

These topics, many of which were until quite recently considered to be advanced and abstruse, are treated with a commonsense attitude, a simplicity of presentation, and a style that make much of this material accessible to the "average person" interested in the field. Thus the book is a significant contribution.

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Cool Stars

Colloquium on Late-Type Stars. Trieste, June 1966. Margherita Hack, Ed. Osservatorio Astronomico, Trieste, 1967. 465 pp., illus. Paper, 10 L.

The term "late-type" is astronomical jargon for stars of low temperature. The idiom arises from a long-dead theory of stellar evolution that held that stars began their lives as objects with very high surface temperatures and then simply cooled down. To this day we call hot stars "early-type" and cool stars "late-type." The spectral sequence is similarly ordered, and the designation "early" or "late" refers to the position of the star in the sequence. More particularly, "late-type stars" refers to stars cooler than the sun, with surface temperatures ranging downward from about 5000°K, although no precise definition has ever been adopted. A number of objects are cooler than the reddest stars visible to the eye. Such objects are detected by infrared devices and are now often called "dark-brown" stars.

Cool stars are of astrophysical interest for a variety of reasons: At low temperatures, compounds form. Isotope effects in molecular bands of carbon compounds such as CN are readily observed, for example. Only from molecular spectra has it been possible to get information on stellar isotope abundances. The spectra of cool stars are very sensitive to the ratio of carbon to oxygen. Titanium oxide bands dominate the spectra of cool stars with solar composition, whereas if carbon exceeds oxygen in abundance all the oxygen disappears as carbon monoxide and carbon bands dominate the spectra. Giants and supergiants represent stars in late stages of evolution; cool representatives sometimes show remarkable abundance anomalies and even the presence of short-lived technetium. Hence these objects are of enormous interest in connection with theories of element building and stellar structure. A great advantage in their study is offered by the fact that the astrophysicist can approximate their temperatures in the laboratory.

This excellent symposium volume brings together a number of valuable papers on the spectral classification, high-dispersion spectra, chemical and isotopic composition, atmospheres, internal structures, and evolution of these remarkable stars. As mentioned above, some of them are very luminous giants and supergiants; others are dwarf stars much fainter than the sun and show no evolutionary effects, but attempts have been made to find planet-like companions among them. Perhaps the greatest value of this information-packed book is the stimulation it will certainly bring to a rising generation of physicists, chemists, and astrophysicists to engage in one of the most exciting fields in astronomy.

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The Views of a Physicist

Erwin Schrödinger. An Introduction to His Writings. William T. Scott. University of Massachusetts Press, Amherst, 1967. xvi + 175 pp. $6.50.

In his later years Erwin Schrödinger was deeply concerned that physics was cutting itself off from its historical background. He considered much in quantum mechanics, particularly the statistical interpretation of the wave function, to be a break with the scientific tradition of over two millennia. Schrödinger argued as forcefully as he could against this trend, going so far as to compare quantum jumps and virtual transitions with the circles and epicycles of medieval astronomy. But this was the same Schrödinger who had created wave mechanics in 1926 in a series of articles about which Max Born later remarked, "What is there more sublime in theoretical physics?" Schrödinger had indeed felt that same way then, being confident that his new theory "struck deep into the nature of the quantization rules" because it made atomic quantum numbers as *natural* as the number of nodes of a vibrating string. He had never liked "this damned quantum jumping," as he called it, and had found the essentially discrete and algebraic matrix mechanics to be "forbidding, not to say repulsive." He did not find in it what he prized most—an intuitive clarity.

William T. Scott has written the first book on this remarkable physicist. It is, in his own words, "a modest introduction" which deals only with some of the major themes in Schrödinger's writings and very briefly with his life. (His publisher does him a disservice by misadvertising the book as a "comprehensive study.") One of these major themes, strange in view of Schrödinger's attitude toward quantum mechanics, is the