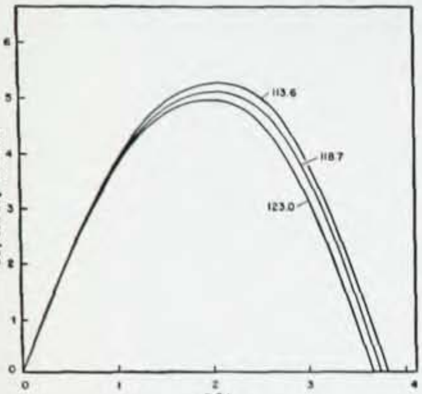

Fig. 6. Entropy difference between normal and superconducting states for tin samples of different mean atomic mass. These curves are geometrically similar figures.

namic equilibrium. As the temperature is lowered more and more of the normal fraction "condenses" to form part of the superconducting fraction. The model is set up so that x varies from zero to unity as the temperature goes from the absolute zero to the transition temperature T_c. Quite naturally therefore x is a function of the reduced temperature T/T_c.

The total electronic entropy, according to the two-fluid model, is taken to be γT, the ordinary linear term for an electron gas, multiplied by a function of x, the normal fraction. An expression of this sort will automatically exhibit the similitude feature if the function contains no hidden mass dependent parameters. In the original formulation of the two-fluid model the electronic entropy was taken to be

$$S_{s(\mathrm{el})} = \gamma T x^{\alpha}, \tag{4}$$

a form chosen because it was consistent with early exprimental data. α is an adjustment parameter, characteristic of each superconductor and empirically found to be of the order of one-half. Inasmuch as α is essentially an electronic parameter it is plausible to assume that it would be independent of isotopic mass as is γ. With this assumption Eq. (4), therefore, clearly exhibits the similitude property experimentally observed. This is a direct result of the fact that the internal parameter x depends on the *reduced* temperature, T/T_c, and is an intrinsic feature of the two-fluid model. The equation for the critical field curve which follows from (4) can be derived in a straightforward way. As would be expected, the reduced field, h, is a function of the reduced temperature, t, and the parameter, α, and consequently also exhibits the similitude feature.

In concluding this brief survey we note that the phenomenology of the isotope effect gives us an interesting insight into both the microscopic and macroscopic pictures of superconductivity. From the microscopic point of view it suggests an intimate connection between the dynamical properties of the crystal lattice and superconductivity, and the general trend of agreement with the "half-power law" of the lattice vibration theories reinforces this notion. On the macroscopic side it exhibits the similitude property inherent in the two-fluid model of a superconductor.

Books

Les Atmosphères Stellaires (in French). By Daniel Barbier. 238 pp. Flammarion, Editeur, Paris, France, 1952. 625 francs.

This excellent book is really somewhat more than the title suggests, and in fact covers quite a broad part of the domain of astrophysics. It deals in some detail with classifications of stars and spectral types, radiative equilibrium and hydrostatic effects, the absorption coefficient and the continuous spectrum, and the contours of the absorption lines in stellar spectra. It also discusses such incidental topics as molecular spectra, bright (emission) line spectra, and gaseous nebulae, and presents a good summary of students' work done in this field.

The book, well illustrated with figures and diagrams, is written on the graduate student level, or for physicists desiring to familiarize themselves with recent developments in this neighboring field. It assumes the familiar forms of mathematics and atomic physics; however, since it is not intended as a treatise to instruct the experts, the references are given by name and occasional date only. It will make excellent supplementary reading, not only in astrophysics, but also as an example of the applications of the principles of atomic physics.

The style is clear and lucid and the book is strongly recommended to all interested in this subject. As usual with French editions, the volume is uncut and has paper covers.

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Electrons and Holes in Semiconductors. With Applications to Transistor Electronics. By William Shockley. 592 pp. D. Van Nostrand Company, Inc., New York, 1950. $9.75.

"I have said it thrice: What I tell you three times is true," said the Bellman. Following this sound pedagogical precept, Shockley has organized his excellent text into three parts of increasing mathematical complexity or increasing level of abstraction: Part I, Introduction to Transistor Electronics; Part II, Descriptive Theory of Semiconductors; Part III, Quantum-Mechanical Foundations. The structure is discussed in the preface:

"In Part I, only the simplest theoretical concepts are introduced and the main emphasis is laid upon interpretation in terms of experimental results. This material is intended to be accessible to electrical engineers or undergraduate physicists with no knowledge of quantum theory or wave mechanics. It should serve as a basis for understanding the operation of transistor devices and for elementary design considerations.

"Part III, at the other extreme, is intended to show how fundamental quantum theory leads to the abstractions of holes and electrons. . . .

"Part II attempts to bridge the gap between Parts I and III by presenting the reasoning and results of Part III in pictorial and descriptive terms."

Part I treats the bulk properties of semiconductors, the transistor as a circuit element, quantitative studies of injection of holes and electrons, and the physical theory of transistors. As a useful aid to intuition, the discussion of impurity atoms and the occurrence of conduction electrons and holes is paralleled by one of mobile cars and car holes in an automobile storage garage.

Part II discusses quantum states, energy bands, Brillouin zones; velocities and currents for electrons in crystals; electrons and holes in electric and magnetic fields; distributions of quantum states in energy; Fermi-Dirac statistics for semiconductors; theory of conductivity and Hall effect; and their applications to transistor electronics. Certain consequences of a quantum mechanical treatment are assumed from the outset and are correlated with results for mechanical and electrical systems of coupled oscillators to provide a basis for the development.

Part III presents elementary quantum mechanics with circuit theory analogies, the theory of electron and hole velocities and accelerations, statistical mechanics for semiconductors, and the theory of transition probabilities for holes and electrons. The introduction to quantum mechanics is novel: after preliminary remarks on the structure and procedures of an applied mathematical theory, the writer considers the basic equations and quantities that specify the transmission line; the same formalism is then applied to a quantum mechanical system. This approach is well conceived and skillfully exploited to preserve the theme that the "important contribution which the theory makes is to provide a *conceptual framework on which to hang experimental facts. . . .*"

A great deal of pain is taken throughout to insure the usefulness of the text. Each part begins with a general bibliography and contains numerous references to the literature. The major sections commence with an introduction and outline, are internally correlated with the remainder, and are summarized at their conclusion. The numerous diagrams and graphs are easily followed and the author and subject indices are on the whole inclusive. (Shockley himself is absent from the index, either through oversight or second order sophistication.) The structure of the book, the progressive refinements and restatements, are well suited to lead the practical engineer into the complexities of the subject and to facilitate his acquiring a comprehensive background in transistor electronics.

From a physicist's viewpoint, one might prefer that the development be more deductive and not as apologetic in regard to the role of theory; however, in view of the writer's aims, this is scarcely germane. Thus: "The preparation of this book was motivated by the conviction that electronic conduction in semiconductors was about to take its place as a subject of major importance in the communications art and other branches of electrical engineering as well. Workers in transistor electronics had expressed a need for a new treatment of the physical principles in descriptive terms with special emphasis upon the features likely to be used as the basis for engineering design." The major part of the text amply fulfills this. In addition to its usefulness for engineers, however, the book will prove a valuable auxiliary for courses in solid state physics.

Transistors were invented by J. Bardeen and W. H. Brattain carrying out research under an extensive program directed by Shockley. (According to J. R. Pierce, the name, suggested by the varistor and thermistor, was supplied by J. J. Coupling.) Their work, and that of J. R. Haynes, G. L. Pearson, H. Suhl, and others, marked the new era of research in semiconductor phenomena that is chronicled by the present book. As for the future of transistor electronics—"Those who have worked intensively in the field share the author's feeling of great optimism regarding the ultimate potentialities. It appears to most of the workers that an area has been opened up comparable to the entire area of vacuum and gas discharge electronics."

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Briefly Noted

Symmetry

The brief masterpiece appearing under the foregoing title (by Hermann Weyl; 168 pp.; Princeton University Press, 1952; $3.75) is essentially a liberally illustrated printing of the author's Louis Clark Vanuxem Lectures, given at Princeton University in February 1951. "I aim," Professor Weyl remarks in his preface, "at two things: on the one hand to display the great variety of applications of the principle of symmetry in the arts, in inorganic and organic nature, on the other hand to clarify step by step the philosophico-mathematical significance of the idea of symmetry. The latter purpose makes it necessary to confront the notions and theories of symmetry and relativity, while numerous illustrations supporting the text help to accomplish the former." The photographs and drawings used in the work were chosen with great care and imagination, and the text is a rare example of brilliance and clarity, both in language and mathematical treatment.

Electrical and Magnetic Units

A report summarizing the electrical measurements made at the National Bureau of Standards and describing the experimental derivations of electrical and magnetic units (ohm, volt, farad, henry, ampere, watt, joule, gauss, and oersted) has recently been issued as a thirty-three-page NBS circular. The report also de-