reader. A certain amount of elementary mathematics is used in proving some of the statements, but in no sense can the book be called mathematical.

We find general introductions to all fields of astronomy and these are written in a fashion tending to spur the reader on to further investigation. This is admirably illustrated in the various sections dealing with controversial subjects. The author presents the factual material in an interesting style, gives the various theories equally fair treatment and then stops without thrusting his personal views to the foreground. The reader is stirred to seek further information; and it is a bit unfortunate that detailed references to the various sources are not given.

The method of treatment of the purely descriptive sections, such as those dealing with the planets, is admirable. The numerical data concerning the various objects are gathered together in tables, and these tables are placed in the body of the text and not banished to an appendix. With this material before the reader, the author is free to write his descriptions unhampered by a mass of numbers, and to point out clearly the significance of the tabular matter.

The history of astronomy has not been neglected in this text, for in nearly every chapter we find references to the pioneers in the particular field under consideration, and the dates of fundamental discoveries are indicated. The chapter dealing with the rise of the Keplerian Theory is worthy of particular mention in this respect.

The line drawings are very carefully made and chosen to explain the text in a most illuminating fashion. The star maps form a valuable feature, but it is unfortunate that, in the attempt to reduce some excellent charts to text-book dimensions, the lettering is reduced to illegibility. The photographic reproductions are splendidly done, and the subjects both new and valuable. It is very pleasing to find, in addition to the usual plate showing the circumpolar trails, plates showing the trails of equatorial stars when they are setting. Many of Professor Duncan's own plates, taken with the 100-inch, are reproduced; and the quality of these photographs is too well known to require further comment here.

It is unfortunate that such an excellently written book could not have received better treatment at the hands of those responsible for the format. The paper is much too heavy for the number of pages and style of binding, with the result that the book will not stand the treatment which it will receive in the hands of the average undergraduate. With these defects remedied, we shall have a book which will set a high standard, not only as a text for use in elementary classes in astronomy and for general reading, but also as a model for text-books in any subject.

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SPECIAL ARTICLES

ON THE ABSOLUTE ZERO OF THE CONTROLLABLE ENTROPY AND INTERNAL ENERGY OF A SUBSTANCE OR MIXTURE

THE writer read a paper on the above subject before the physics section of the meeting of the American Association for the Advancement of Science held in Philadelphia. Since the results are of a most far-reaching nature it was thought that an outline of the line of reasoning would be of interest to the readers of SCIENCE. From this outline the proof of the results could be constructed without difficulty.

The internal energy and entropy are each divided into two parts, one of which is externally controllable, and thus a function of the absolute temperature T and volume v, while the other is not. The least values these controllable quantities can have must correspond to zero values, for if they corresponded to finite quantities they would evidently not be externally controllable. If a surface is drawn corresponding to v, T, and the internal energy u as axis, using u in the general sense, the controllable internal energy is measured from the point where a plane parallel to the T and v axes touches the surface. Similarly the controllable entropy may be interpreted. The zeros of these quantities for all substances and mixtures can be shown to correspond to the condensed state at the absolute zero of temperature by means of the theorem (A) that the specific heat at constant volume is always positive, which may be said to follow from our motions of temperature and heat content, and the postulate (a) that the increase in pressure per unit increase of temperature at constant volume is not infinite, which will probably be readily admitted.

Consider first the controllable internal energy. Suppose that the substance or mixture in the condensed state at the volume v_0 and absolute zero of temperature has its volume isothermally *decreased* to v'. It can then be shown by means of the thermodynamical equation

$$\left(\frac{\partial u}{\partial v}\right)_T = T\left(\frac{\partial p}{\partial T}\right)_v - p$$

and postulate (a) that this corresponds to an increase in internal energy. U is the internal energy of the substance at the temperature T, volume v, and pressure p, and may be taken to refer to the controllable internal energy because the uncontrollable part would disappear through differentiation with respect to v. Raise the temperature to T, keeping the volume v' constant, which gives rise to an increase in the controllable internal energy according to Theorem (A), since the specific heat represents a change in the controllable energy.

Again begin with the substance at the volume v_0 and isothermal *increase* its volume to v''. No evaporation takes place since the molecules possess no motion of translation, and therefore there is no change in internal energy. Increase the temperature to T at constant volume v'', which gives rise to an increase in internal energy according to Theorem (A). Thus on passing from the condensed state at the absolute zero of temperature to any other physically possible state the controllable internal energy is increased, and that state therefore corresponds to the zero of this quantity.

Next consider the controllable entropy. Let an adiabatic on a v, T diagram pass through the zero of entropy. Take a point on the curve corresponding to the volume v_0 and temperature T. Now if we pass from this point at constant volume v_0 to the temperature $T = 0$ we arrive at the point of zero internal energy. This would evidently correspond to a decrease in entropy. But the entropy can undergo an increase only, and therefore the adiabatic must pass through the point of zero internal energy. This point may therefore also be taken as the zero of the controllable entropy.

Formulae for the controllable internal energy, entropy, free energy and potential, corresponding to any possible state of matter, may now immediately be deduced. They may be used to solve thermodynamical problems, which, as will be evident on reflection, usually involve externally controllable equilibria only. In general it will appear that by the introduction of controllable quantities a new and important aspect is given to the whole subject of thermodynamics. The results given include what is known as the third law of thermodynamics, and Nernst's theorems, besides a number of other important results may be deduced directly from it, which lack of space will not allow to be given here.

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THE WHALE-SHARK, RHINEODON TYPUS, IN THE GULF OF CALIFORNIA

THE first and last records of this giant shark in American waters are from the Gulf of California, but these last printed records are not in scientific publications and hence are lost. Furthermore, there have come to me in letters or by word of mouth four other trustworthy accounts which corroborate the printed narratives. Hence it has seemed of value to bring all this evidence together and make definite record of it.

For the earliest account of a whale shark in the Gulf of California, one must go as far back as 1865. It seems that in the year 1858 a Captain Stone had sent to the Smithsonian Institution the vertebrae and jaws of an enormous shark captured in the waters of Lower California and known therein as the "Tiburon ballenas"[1] or "whale shark." The data accompanying this material (length, twenty feet, width of head six feet, back covered with reddish spots, head truncated in front, etc.), together with the extraordinary tooth structures, left no doubt that it was the whale shark. These data and material came into the hands of Dr. Theodore N. Gill, and in 1865 he published a brief note entitled "On a New Generic Type of Sharks."[1]

Gill of course knew of the discovery of this fish by Dr. Andrew Smith in April, 1828, in Table Bay, Cape of Good Hope[2] and likewise he had undoubtedly seen Smith's figure published twenty years later. However, misled by Smith's description and Müller and Henle's[3] defective figure of the teeth, Gill, while retaining this fish in the family Rhineodontidae, differentiated it from Smith's *Rhineodon typus* and described it under the new name *Micristodus punctatus* —the spotted shark with the small teeth. There is, however, every reason to reduce this name to synonymy and identify this and all other specimens of whale sharks from the Gulf of California as *Rhineodon typus.* The writer has personally examined the teeth of the alleged *Micristodus* and has found them identical with those from a *Rhineodon* taken on the Florida coast. Furthermore, both sets of teeth agree absolutely with Gill's description—"Each tooth is recurved backwards and acutely pointed, swollen and with a heel-like projection in front rising from the base."

In the *Santa Catalina Islander* for May 27, 1925, the well-known novelist and deep sea angler, Zane Grey, has an article entitled "Fishing Virgin Seas." On page 10, he speaks of trying to capture off Cape San Lucas a whale shark estimated at over fifty feet in length. The story of this contest is told in Mr. Grey's characteristic vivid fashion in his latest angling book, "Tales of Fishing Virgin Seas."[4]

This giant shark was caught by a gaff hook fixed in its tail, and by this it towed the boat around, as is shown in the plates. Finally, after five hours of playing with its captors and towing them for miles, it dived into the depths of the sea, carrying off about 1,600 feet of rope before the hook tore out and set it free. Efforts were made to harpoon it, but the irons rebounded from its enormously thick hide and generally were so bent as to necessitate a visit to the blacksmith's forge.

[1] Proceedings Academy of Natural Sciences of Philadelphia, 1865, Vol. 17, p. 177.

[2] "Contributions to the Zoology of South Africa." *Zoological Journal,* 1829, No. 16, pp. 443–444—"Illustrations of the Zoology of South Africa," 1849, pl. xxvi, fig.

[3] "Systematische Beschreibung der Plagiostomen," 1841, pl.

[4] New York, 1925, pp. 204–216, pls. cxi and cxii.