plied to steadily sweeping substances. Thus Boltzmann's H function, which has a minimum value and closely corresponds to entropy when a gas is in thermal equilibrium, has a definite value for any steady state of a gas other than thermal equilibrium.

Entropy always increases in natural phenomena, and the notion of entropy is, perhaps, much more intimately related to the notion of time than any other physical notion whatever. The notion of entropy seems to me, indeed, to be the very foundation of the notion of time as a physical fact, although the numerical evaluation of time depends, in practice, upon the approximate realization of some of the precise ideas of mechanics.

This intimate relationship of the notions of entropy and time gives very great emphasis to the two propositions A and B in article 7 in which increase of entropy appears as measured by elapsed time.

Heretofore the idea of the increase of entropy associated with a sweeping process has been thought by the ablest writers on thermodynamics, such as Willard Gibbs, to be dependent upon the devising of a reversible process which leads to the same change of state as the given irreversible process. This is, I think, true in regard to sweeping processes in general, but it is not true in regard to steady sweeps.

The characteristic features of irreversible processes are, in my opinion, very clearly suggested by the term sweep and by the special terms simple sweep, trailing sweep and steady sweep, and I urge the adoption of these terms.

W. S. FRANKLIN.

LEHIGH UNIVERSITY.

METEOROLOGY AT THE BRITISH ASSOCIATION.

CONTRARY to custom, meteorology took foremost place at the Southport meeting of the British Association. This was largely due to the efforts of Dr. W. N. Shaw, the head of the British Meteorological Office, by whose invitation the International Meteorological Committee met with the British Association for the Advancement of Science and for the first time in England since 1876. The attendance of a majority of the members of the committee justified the innovation, and before going to Southport they were able to meet some representative British men of science at a dinner in London given by Dr. Shaw. Of the seventeen members constituting the International Meteorological Committee, the following ten were present at Southport: the president, Professor Mascart, of Paris; the secretary, Professor Hildebrandsson, of Upsala; Dr. Shaw, of London; Dr. Paulsen, of Copenhagen; Professor Mohn, of Christiania; Dr. Snellen, of Utrecht; General Rykatcheff, of St. Petersburg; Professor Pernter, of Vienna; Professor Hellmann, of Berlin; and Professor Moore of Washington. Although the United States has had a representative in the committee for twelve years, only now, for the first time, was a meeting attended by the chief of the Weather Bureau, indicating the present desire of this country to cooperate in international meteorology. Besides the above, there came for the discussion of meteorological telegraphy, Professor van Bebber from Hamburg and Captain Chaves from the Azores; and of the sub-committee for scientific aeronautics its chairman, Professor Hergesell from Strasburg, M. Teisserenc de Bort from Paris, and the writer. The sessions of the committee lasted five days and the questions considered related principally to details of administration, publication and observation. Of greater scientific interest was an apparatus, shown by Dr. Paulsen, for the collection of atmospheric electricity by the employment of radioactive salts, and a

new hair hygrometer, exhibited by Professor Pernter as superior to the psychrometer. A commission, consisting of Sir Norman Lockyer, Dr. Shaw, Professor Pernter and M. Angot, was appointed to consider the study of the relations of solar physics to meteorology, and it was decided to support the resolutions of the Royal Saxon Academy of Sciences relative to the organization of investigations in atmospheric electricity. After hearing Professor Hergesell's report on the progress in exploring the atmosphere with kites and balloons, the continuation of this work, especially its prosecution in England, was recommended, and the writer's project, to explore the atmosphere above the tropical oceans by means of kites flown from a steamship, received hearty endorsement. It was announced that the committee for scientific aeronautics would meet at St. Petersburg next August, and that the general committee would assemble at Innsbruck in September, 1905. Dr. Snellen resigned from the committee, in consequence of his retirement as director of the meteorological service of the Netherlands, and was succeeded by M. Lancaster, chief of the meteorological service of Belgium. Professor Hellmann, who had recently taken Professor von Bezold's place on the committee, agreed to codify the resolutions that had been adopted at the various meetings since the Vienna Congress of 1873.

In the Physical Section of the British Association meteorology also predominated, the chief topics discussed being the relations of solar activity to meteorology and the exploration of the upper atmosphere. Great interest was manifested in the use of kites for the latter purpose, and this was especially gratifying to the writer, who first advocated the method at the Liverpool meeting of the Association in 1896, and in consequence of the growing interest has since presented annual reports of the results obtained with kites at Blue Hill and on the Atlantic Ocean. The Physical Section was divided into two subsections, and in one of these meteorology was recognized as a distinct branch of physics. Dr. Shaw was chairman of the department of astronomy and meteorology, and it is believed that his introductory address is the first treating exclusively of meteorology which has been given before the Association for many years. The subject was 'Methods of Meteorological Investigation,' and after mentioning the good work accomplished by the several members of the committee and by others, Dr. Shaw declared that meteorology in Great Britain needed the aid of the universities. The topic of simultaneous solar and terrestrial changes was introduced by Sir Norman Lockyer's paper, in which, from a comparison of rainfall and barometric observations in India with solar prominences, the author concluded that the latter are not only the primary factors in the magnetic and atmospheric changes occurring in our sun, but that they are also the instigators of the terrestrial variations. (This paper is reprinted in SCIENCE, pp. 611–623.) Professor Hildebrandsson confirmed the general conclusions of Sir Norman as to the 'surgings' of the barometric pressure, while Professor Hellmann and Dr. Buchan corroborated the coincidence found between rainfall and sunspots, using the data for other years. Father A. L. Cortie, of Stonyhurst, spoke of the recent researches made by Father Sidgreaves, Dr. Chree and himself on the question of the relation between sun spots and terrestrial magnetism. Sir Norman Lockyer, he said, had raised the question as to whether prominences might not supply the place of sun spots in cases where a great magnetic storm was unaccompanied by sun spots. By a series of observations he had made, and by the observations of Father Fenyi,

of Kalocsa, they had come to the conclusion that in no single case could a magnetic storm be with certainty associated with any given prominence, and great disturbances had occurred without any answering swing of the needles. It was, they thought, the general disturbance of the sun and his surroundings which affected the earth's magnetism, and not any particular manifestation of spot or prominence.

The important subject of the investigation of the upper atmosphere was opened for consideration by Mr. W. H. Dines' report of the joint committee of the Association and Meteorological Society on obtaining meteorological observations with kites, which were flown from a steamer off the west coast of Scotland during the past summer. Owing to the slowness of the vessel chartered and the bad weather, the experiments were not very successful, 20 records being obtained in 38 flights, with a maximum height of only 6,000 feet. In his sixth report upon meteorological kite-flying at Blue Hill, the writer stated that during the years 1901–2 the average height reached in the 23 flights was 7,900 feet, with a maximum of 14,060 feet. Some deductions concerning the decrease of temperature in cyclones and anti-cyclones were given and the project of exploring the atmosphere in the tropics by kites flown from a steamer was explained, as is outlined in SCIENCE, Vol. XVII., pp. 178–9.

General Rykatcheff described experiments of raising kites in a calm from a Russian warship, steaming twelve knots. M. Teisserenc de Bort traced the circulation of the air around barometric depressions, as evinced by the trajectories of his balloons, and from experiences with kites in Denmark he suggested that the meteorographs carried by them should etch their records on copper, so that these might be preserved in case the instruments fell into the water. Professor Hergesell gave a résumé of the operations of the International Committee for Scientific Aeronautics since its foundation in 1896. For several years monthly ascensions of balloons have been conducted in various parts of Europe, but permanent stations, where kite flights can be made daily, are desired. A kite station was maintained during nine months in Denmark and, since the first of the year, kites, or captive balloons, have been sent up each morning from Berlin and kites less regularly from Hamburg. The monthly observations are collected by Professor Hergesell and published at the expense of the German government. The establishment of an aeronautical observatory in the British Isles would be of great importance for these studies. Professor A. Schuster insisted upon the value of the information that could be derived from kites, and although unmanned balloons can attain the greatest altitudes, he hoped that balloons carrying aeronauts would be included in the program of work, since, with them, samples of air for analysis could be collected from the high strata of the atmosphere and personal observations made of various phenomena. He considered it most important for England to take a proper part in these investigations by placing the Meteorological Office on an altogether different basis, and a discussion of the question at the present time, when so many distinguished foreigners testified as to its importance, appeared appropriate. Professor H. H. Turner expressed the same opinion and declared that he knew of no scheme more deserving of government support than is the exploration of the upper air by means of kites.

Professor Hildebrandsson announced that the discussion of the cloud observations which had been made simultaneously in various parts of the world indicated the following to be the circulation of the atmosphere at different heights: (1) Above the thermic equator and the equa-

torial calms there exists throughout the year a current from the east; (2) above the trades an anti-trade blows from the southwest in the northern hemisphere and from the northwest in the southern; (3) this anti-trade does not pass the polar limits of the trades, but deviates more and more to the right in the northern hemisphere and to the left in the southern, so as to become a current from the west over the barometric maximum of the tropics where it descends to increase the trade; (4) the regions situated at the equatorial limit of the trade join sometimes that of the trade, sometimes that of the equatorial calms, according to the season; (5) the pressure of the air diminishes gradually towards the poles, at least beyond the polar circles; (6) the upper layer of air in the temperate zones flows over the high pressures of the tropics and descends there; (7) the irregularities found at the surface of the earth, especially in the regions of the Asiatic monsoons, generally disappear at the height of the lower or intermediate clouds; (8) it is necessary to abandon completely the idea of a vertical circulation between tropics and poles, hitherto assumed, according to James Thomson and Ferrel.

In the report of the Seismological Commission, presented by Mr. J. Milne, it was inferred from the data collected that the crust of the earth was not more than forty miles thick, the interior having a very high effective rigidity and the nucleus being probably more uniform in its chemical and physical conditions than was usually supposed. The report of the Ben Nevis Observatory Committee, drawn up and read by Dr. A. Buchan, stated that funds privately subscribed would maintain the high- and low-level stations for another year, after which time the permanent support of the government was desired. It was claimed that no pair of stations in the world are so advantageously situated for meteorological investigation and forecasting. Additional papers were by Dr. Buchan on the diurnal variation of temperature in the Levant and its relation to radiation; by Dr. Paulsen on a comparison of the spectrum of nitrogen with that of the aurora; by Dr. W. J. S. Lockyer on the spectra of lightning; by Dr. H. R. Mill on some rainfall problems; by Dr. L. A. Bauer on the magnetic survey of the United States and the earth's total magnetic energy, and by the writer on audibility at Blue Hill as affected by weather conditions.

Upon the recommendation of the council of the Physical Section, the General Committee of the Association passed a resolution that it is desirable to adopt a uniform system of units in meteorology, and another resolution to the effect that the systematic investigation of the upper atmosphere by means of kites and balloons is of great importance. A further appropriation of £50 was voted to Mr. Dines for the continuation of this work with kites.

In conjunction with the meeting of the International Committee, an exhibition of meteorological apparatus, charts and photographs was organized by the Meteorological Office and Society. Many pieces of new apparatus, as well as articles of historic interest, were shown and their study was facilitated by a carefully-prepared descriptive catalogue. The meteorological telegrams received each morning at the London office were repeated to Southport, where they were charted and forecasts made by a member of the staff. These were incorporated in a weather map that was printed and distributed during the afternoon and its close agreement with the map prepared in London from the same data was surprising. It had been announced that Mr. Dines would fly his kites from a steamer at South-

port, but, unfortunately, neither the boat nor the apparatus could be brought from Scotland in time for the experiments. Professor Pernter demonstrated the formation of vortex-rings on a large scale in the open air by firing a conical cannon, such as is used in some parts of Europe to disperse hail-storms. While the efficacy of the process is doubtful, yet in the Southport experiments the smoke-rings issuing from the cannon, which was placed horizontally instead of vertically, could be both seen and heard in their passage through the air for a distance of several hundred feet.

A visit was paid by the International Committee to the Fernley Observatory in Hesketh Park, established by Mr. J. Baxendell, Sr., and now maintained by the borough of Southport. This observatory, which is one of the best equipped in Great Britain, has an auxiliary station, provided with Mr. Dines' anemometers, situated near the coast. Excursions were made to the Stonyhurst College Observatory, near Whalley, Lancashire, and also to the Physical Laboratory of the Owens College in Manchester. About sixty meteorologists sat down to their annual breakfast, in accordance with a custom inaugurated some thirty years ago. The meeting terminated on September 16 with a brilliant banquet to more than one hundred persons, which was given by the mayor of Southport, Mr. Scarisbrick, at his residence, Greaves Hall, in honor of Sir Norman Lockyer, president of the British Association and Professor Mascart, president of the International Meteorological Committee.

A. LAWRENCE ROTCH.

BLUE HILL METEOROLOGICAL OBSERVATORY,
October 30, 1903.

SCIENTIFIC BOOKS.

Manual of Advanced Optics. By C. RIGBORG MANN. Chicago, Scott, Forsemann & Co. 1902. Pp. 193.

As the author states in the preface, this manual is the basis of the advanced laboratory course in optics in the University of Chicago, and represents contributions from various instructors. Naturally, it deals rather extensively with interference and the applications of interference methods.

The opening chapter presents, in a very simple manner, the important but generally neglected theory of the limit of resolution of a telescope. Chapter II. extends this theory to the case of two slit apertures before a lens for both single and double line sources. The experimental illustrations make clear the possibility of measuring the angular size of a source and the angular distance between two line sources, but do not suggest the application of this method to astronomical problems. Reference is not made to Rayleigh's theory of, and experiments with, the central stop. The third chapter, on Fresnel's mirrors, contains diagrams, familiar to all of Professor Michelson's students, illustrating the evolution from the earlier forms of interference apparatus to the modern interferometer. The theory and experiments in this chapter and in the following one on Fresnel's biprism take up seventeen pages of the text, relatively a large part when the grating is treated in eight pages.

Chapters V. and VI. contain Michelson's theory of the interferometer and its elegant applications. The presentation is very clear and the contents complete. The gathering together of material from little-used sources bearing upon the interferometer method, probably the most powerful and yet simple method we know in accurate measurement, makes this manual a valuable one to place in the hands of a student.

The arrangement of the material in Chapters VI. and VII. is out of the ordinary. For in the earlier chapter the author deals with a very modern, complex, perhaps forced, method of analyzing an approximately homogeneous radiation, while in the later chapter he presents the well-known prism method of analyzing a spectrum. The theory of Chapter VII. follows the methods of geometrical optics. Rayleigh's simple method of obtaining the dispersive power of a prism is not given.