

an important part, during certain seasons, of all meteorological reporting services.

Some original and important experimental work along this line has been carried on by Lieut. W. F. Reed, U. S. N., aerological officer of the naval air station, Pensacola, Fla.¹ Lieut. Reed has been successful by the use of a radio receiver and direction finder to forecast the approach and movement of electrical disturbances over that particular portion of the Gulf covered by aviation operations from the Pensacola base. He has been able to detect the approach of these storms long before any local signs give warning of their approach and has been able to plot the movement of these storms, the directions from and to which they are moving, as well as their intensity. By this means he has been able to make the aviation operations from this base safer and much more successful. During the coming hurricane season it is to be hoped that this station, as well as others, may be able to carry on some extremely valuable experimental work, which in time may lead to the use of radio as a valuable aid to the hurricane-reporting service in the Gulf and Caribbean.

The field is large and there is need for considerable experimental work on the part of meteorologists acquainted and in touch with radio work. Our present forecasts of probability of the formation and approach of electrical disturbances and rather indefinite notice of their movements should in time be superseded by forecasts of a more definite nature, telling when to expect the disturbances at certain points, the direction and rate of movement, and their intensity. This type of service is at present rendered on a large scale in so far as the West Indian hurricanes are concerned, but in the case of nearly every one of these storms the position of their centers and the direction and rate of their movement is unknown for many hours, and in many cases days, by the forecasters who are charged with the task of reporting them, due to a lack of reporting stations over great

areas of the Gulf and Caribbean during the progress of the storm. On the first notice of their formation and approach most vessels strike for port. Radio equipment, in addition to the broadened program of aerological observation, tide reports, and perhaps even vessel patrols now planned by the Weather Bureau, may in time fill this gap.

AEROLOGICAL OBSERVATIONS IN THE WEST INDIES.

It is generally thought that tropical cyclones (hurricanes) move approximately in the direction and with the speed of the air in the strata at no great height above the surface. If this be true, it is very desirable to obtain observations of free-air wind conditions on all sides of hurricanes, particularly on the north and west sides. Although working under severe restrictions of funds and personnel, the Weather Bureau is undertaking a campaign of this sort for the hurricane season of 1920, July to November, inclusive. Stations are being equipped and will be operated at San Juan, P. R., and Key West, Fla., in addition to those in the Gulf States at which observations are now being made by the Weather Bureau at Groesbeck, Tex., and Leesburg, Ga.; by the Meteorological Section of the Signal Corps at Ellington Field and Kelly Field, Tex.; and by the Naval Aerological Section at Pensacola, Fla. Moreover, two new stations are being organized by the Navy at Colon and Santo Domingo. These nine stations form a network which, it is believed, will furnish information of great value in the study of these destructive storms and in forecasting their direction and rate of movement. Moreover, the observations will be taken regularly twice each day, irrespective of the occurrence of hurricanes, and will, therefore, give us data as to trades, antitrades, etc., of the utmost interest from a theoretical point of view and of inestimable benefit in their practical application. It is probable that some of the stations will be continued throughout the year and that many others will be added, if funds permit, during the next two or three years.—*W. R. Gregg.*

¹ Further details of Lieut. Reed's work will appear in a later issue of the REVIEW.

THE MEASUREMENT OF TEMPERATURE, WITH SOME REMARKS ON OTHER PHYSICAL MEASUREMENTS, AND APPLICATIONS TO METEOROLOGY.^a

By EDGAR W. WOOLARD.

INTRODUCTION—UNITS IN GENERAL.

Lord Kelvin once wrote, "When you can measure what you are speaking about and express it in numbers, you know something about it, and when you can not measure it, when you can not express it in numbers, your knowledge is of a meager and unsatisfactory kind. It may be the beginning of knowledge, but you have scarcely in your thought advanced to the stage of a science."

The general Theory of Measurements is familiar to everyone: There are five *fundamentally* different entities which physics is at present considering, viz, those the *concepts* of which are symbolized by the words *space, time, matter, electricity, and entropy*.¹ Hence, as was pointed out by Rucker,² we need five *fundamental units*

for the measurement of physical quantities; those usually chosen are the units of length, mass, time, permeability, and temperature, although better selections probably could be, and have been, made.³ However, it has been found that by arbitrarily fixing the magnitudes of the units corresponding to the three indefinables of mechanics—space, time, and matter—we are then enabled, through the Theory of Dimensions, to derive units for all other quantities. In a few cases, such as when dealing with heat and electricity, additional units which are sometimes called *secondary* fundamental units appear, but probably it is only our ignorance of the true nature of the quantities involved which prevents us from expressing these, too, in terms of the three primary fundamental units.⁴

The practical application of the above theory consists of the selection of the fundamental units, the construction of standards, and the devising of measuring instruments which may be calibrated by comparison with the standards.

^a Delivered in part before Am. Metl. Soc., Apr. 22, 1920.

¹ These five concepts, together with that of *number*, are necessary and sufficient for the complete description of the universe so far as it is at present known to us from observation: the objective universe, however, is itself composed of only matter and energy—the other indefinables are not "things," strictly speaking, but only creations of the mind, *conventional frames imposed on the universe* for convenience in study and interpretation. Cf. H. Poincaré: *Foundations of Science*; and K. Pearson: *Grammar of Science*.

² A. W. Rucker: On the suppressed dimensions of physical quantities. *Phil. Mag.*, (5), 27, 104-114, 1889.

³ See, e. g., R. C. Tolman: The measurable quantities of physics. *Phys. Rev.*, (2), 9, 237-253, 1917.

⁴ W. Watson: *Textbook of Physics*, new ed. London, 1911, pp. 5, 334; Rucker, *op. cit.*