η is the displacement, μ the angular frequency, g the acceleration due to gravity, θ the inclination of the wave-front to the wind direction, $\epsilon(\mu, \theta)$ the random phase and A (μ, θ) the amplitude of the wave of frequency μ and orientation θ.

The spectral distribution of E is not precisely known. Neumann (1953) has suggested a semi-empirical spectrum, though all do not agree with it.

Forecasting of Ocean-waves.—As long as non-linear effects can be disregarded, individual waves propagate independent of each other. Deep-water waves are highly dispersive and the wave energy is propagated with the group velocity which is half the phase velocity, g/μ.

At any point inside an area of generation of waves, the entire wave spectrum will be present, provided the fetch and the duration of the wind are long enough. The associated wave parameters like the average height, the significant height, 'sun glitter', etc., can be computed once the energy spectrum is known. At any point outside the area of generation, it is possible to estimate for any moment the range of the wave periods present, their total energy and hence the wave-parameters. Their computation is based on the relation

$$P_a da = \frac{2a}{E} e^{-a^2/E} da$$

where $P_a da$ is the probability of an amplitude between a and $a + da$, and E is the amplitude integral

$$\int_{\mu_1}^{\mu_2} [A(\mu)]^2 d\mu.$$

A few wave statistics based on the Neumann spectrum are given in Table I.

TABLE I

Wind in knots	E-value in ft.²	Range of periods in secs. From	To	Average amplitude in ft.	At least one wave in 10,000 waves is higher than
10	0·2	1·0	6·0	0·4	1·4 ft. (15 hrs.)†
20	7·7	3·0	11·1	2·5	9 ft. (30 hrs.)
30	58·7	4·7	16·7	6·8	24 ft. (45 hrs.)
40	247	6·5	21·7	14·0	50 ft. (60 hrs.)

† Represents the average time for 10,000 waves to pass a place.

MEASUREMENT OF RADIATION AND HEAT BALANCE OVER THE INDIAN OCEAN*

MISS ANNA MANI

PRECISE, quantitative measurements of the total energy transferred at the ocean-atmosphere boundary and at the top of the atmosphere are required for a study of the transformation of solar energy into kinetic, potential and chemical energy within the atmosphere. The thermal energy available to the oceans is given by :

$$Q_0 = Q_s - Q_r - Q_e - Q_t$$

where Q_s is the incoming solar radiation from the sun and sky, Q_r the solar radiation reflected from the sea surface, Q_e the latent heat of evaporation and Q_t the turbulent heat flux into the atmosphere. The thermal energy available to the atmosphere is given by :

$$Q_a = R_{ab} + Q_{ec} + Q_t$$

where R_{ab} is the energy absorbed in the atmosphere and Q_{ec} the latent heat of evaporation subsequently released through condensation. Q_{ec}, Q_t and Q_e are obtained from the determination of vertical fluxes of water vapour, heat and momentum supplemented by condensation observations. Q_s and R_{ab} are measured directly by using pyranometers and radiometers, both ground-based and airborne, supplemented by satellite observations.

The radiation balance at the surface of the earth, R, is the difference between the absorbed and outgoing radiation,

$$R = Q_s \ (1 - a) - I$$

where a is the albedo of the earth and I the effective outgoing radiation. Measurements of radiation balance and of components of heat balance over the Indian Ocean are planned during the International Indian Ocean Expedition from a network of over 70 land stations and from oceanographic ships, to be supplemented by the meteorological observations over both land and sea.

* Abstract of a talk delivered at the symposium on "Oceanographic Research and Related Topics" held at the 28th Annual Meeting of the Indian Academy of Sciences, Bombay, December 1962.