If we put $\chi(x) = x^2 + x$ in this integral, we shall obtain a perfectly correct result.

I discovered the following integral some years ago. It may have been discovered before, although I have been unable to meet with it.

$$\int_0^{\frac{n}{2}} d\theta\, \theta\, (2\cos\theta)^{m-1} \sin(m + 2r + 1)\,\theta$$

$$= \pm \frac{n}{4} \cdot \frac{1\,.\,2\,.\,3\,\ldots\,.\,r}{m\,(m+1)\,(m+2)\ldots.(m+r)}\,.$$

From this may be deduced an enormous number of results, as will be at once apparent. I will write down two of them.

$$\int_0^{\frac{n}{2}} d\theta\, \theta\, \frac{\cos 5\theta \sin\theta + (1 - x)\sin 5\theta\cos\theta}{x^2 + 2x + 2 + (x^2 + 2x)\cos 2\theta}$$

$$= n \left\{ \frac{(x+2)^2}{4x^3} \log_\epsilon \left(1 + \frac{x}{2}\right) - \frac{3x + 4}{8x^2} \right\}.$$

Now let $\Theta_r = \cos^{n-r}\theta \sin(r + 2)\,\theta.$

Then
$$\int_0^{\frac{n}{2}} \theta\, \frac{\Theta_4 - 4\alpha\Theta_3 + 6x^2\Theta_2 - 4\alpha_3\Theta_1 + \alpha^4\Theta_0}{((\alpha^2 - 2\alpha + 2) + (\alpha^2 - 2\alpha)\cos 2\theta)^4}\, d\theta$$

$$= \frac{\pi}{24} \cdot \frac{1}{8 - 4\alpha}\,.$$

The first integral was derived from the series $\frac{x^3}{1\,.\,2\,.\,3} - \frac{x^4}{2\,.\,3\,.\,4} + \ldots$, the second from $\frac{1\,.\,2\,.\,3}{1\,.\,2\,.\,3} + \frac{2\,.\,3\,.\,4}{2\,.\,3\,.\,4}\,\alpha + \ldots$

## VI. "On Meldrum's Rules for handling Ships in the Southern Indian Ocean." By Hon. RALPH ABERCROMBY, F.R. Met. Soc. Communicated by R. H. SCOTT, F.R.S. Received June 7, 1888.

(Abstract.)

The results of this paper may be summarised as follows:—

The author examines critically certain rules given by Mr. C. Meldrum for handling ships during hurricanes in the South Indian Ocean, by means both of published observations and from personal inspection of many unpublished records in the Observatory at Mauritius. The result confirms the value of Mr. Meldrum's rules; and the author then develops certain explanations, which have been partially given by Meldrum, adds slightly to the rules for handling

ships, and correlates the whole with the modern methods of meteorology.

As an example, a hurricane is taken which blew near Mauritius on February 11, 12, and 13, 1861, and the history of every ship to which the rules might apply is minutely investigated. The result, dividing Meldrum's rules shortly into three parts, is as follows :—

Rule 1. Lie to with increasing south-east wind till the barometer has fallen 6-10ths of an inch. Seven cases, rule right in every case.

Rule 2. Run to north-west when the barometer has fallen 6-10ths of an inch. Three cases, two failures, one success.

Rule 3. Lie to with increasing north-east or east wind and a falling barometer. Seven cases, rule right in every instance.

Rule 2 was exceptionally unfortunate in this case, as the path of the central vortex moved in a very uncommon and irregular manner. At the same time, in any case, it appears to be about equally hazardous to follow this rule or to remain hove to.

The following statements are then examined in detail :—

The shape of all hurricanes is usually oval, not circular. An elaborate examination is made of hurricanes on 60 different days, in 18 different tropical cyclones in various parts of the world, with the following results :—

1. Out of 60 days, cyclones were apparently circular on only four occasions, and then the materials are very scanty.

2. The shape was oval on the remaining 56 days, but the ratio of the longer and shorter diameter of the ovals very rarely exceeded 2 to 1.

3. The centres of the cyclones were usually displaced towards some one side. No rule can be laid down for the direction of displacement, and in fact the direction varies during the progress of the same cyclone. The core of a hurricane is nearly as oval as any other portion.

4. The longer diameter of the ovals may lie at any angle with reference to the path of the cyclone ; but a considerable proportion lie nearly in the same line as the direction of the path.

5. The association of wind with the oval form is such that the direction of the wind is usually more or less along the isobars, and more or less incurved. This is the almost invariable relation of wind to isobars all over the world.

From an examination of the whole it is proved conclusively that *no rule is possible for determining more than approximately the position of the central vortex of a cyclone by any observations at a single station.*

The relation of a hurricane to the south-east trade is then discussed, and it is shown that there is always what may be called "a belt of intensified trade wind" on the southern side of a cyclone, while the hurricane is moving westwards. In this belt a ship experiences increasing south-east winds and squalls of rain, with a falling barometer, but is not

within the true storm field. The difficulties and uncertainties as to handling a ship in this belt are greatly increased by the facts that the longer diameter of the oval form of the cyclones usually lies east and west, and that there is no means of telling towards which side of the oval the vortex is displaced.

The greater incurvature of the wind in rear than in front of hurricanes in the Southern Indian Ocean is next considered, and then facts are collected from other hurricane countries confirmatory of Meldrum's rules for the Mauritius.

Knipping and Doberck in the China Seas find little incurvature of the wind in front, but much in rear of typhoons.

Mr. Wilson finds in the Bay of Bengal that north-east winds prevail over many degrees of longitude to the north, *i.e.*, in front of a cyclone; and this is analogous to the belt of intensified trade so characteristic of Mauritius hurricanes.

Padre Viñez finds at Havana that the incurvature of hurricane winds is very slight in front, and very great in rear.

The author then details further researches on the nature of cyclones, which bear on the rules for handling ships.

1. Indications derived from the form and motion of clouds. It is shown that the direction of the lower clouds is usually more nearly eight points from the bearing of the vortex than the surface wind; but as the direction varies with the height of the clouds, and as this height can only be estimated, this fact is not of much value.

2. Looking at the vertical succession of wind currents in the Southern Indian Ocean, if the march of the upper clouds over the south-east trade is more from the east, then the cyclone will pass to the north of the observer; but if the upper clouds move more from the south than the surface wind, then the hurricane will pass to the south of the observer.

3. As to the form and position of clouds; so soon as the upper regions commence to be covered, the direction in which the cirrus veil is densest gives approximately the bearing of the vortex. Later on, the characteristic cloud bank of the hurricane appears, and the greatest and heaviest mass of the bank will appear sensibly in the direction of the vortex.

The irregular motion of the centre of a cyclone is next discussed, and it is shown that the centre often twists and sways about, in some cases even describing a small loop.

From all the facts relative to the nature of cyclones adduced in this paper it is shown that the attempts which have been made—

1. To estimate the track of a cyclone by projection;

2. To estimate the distance of a ship from the vortex, either by taking into account the entire absolute fall, or by noting the rate of fall, can lead to no useful result.

A series of revised rules for handling ships in hurricanes in any part of the world is given. Comparing these rules with the older ones it will be remarked—

1. That the rule for finding approximately the bearing of the vortex is slightly modified.

2. That the great rules of the "laying to" tacks remain unaltered.

3. That the greatest improvement is the recognition of the position and nature of the belt of intensified trade wind on the dangerous side of a hurricane, where a ship experiences increasing wind, without change of direction, and a falling barometer. The old idea that such conditions show that a vessel is then *necessarily* exactly on the line of advance of a hurricane is erroneous. She may, but she need not be; and under no circumstances should she run till the barometer has fallen at least 6–10ths of an inch.

4. There are certain rules which hold for all hurricanes; but every district has a special series, due to its own local peculiarities. Those for the Southern Indian Ocean are given in this paper.

## VII. "Magnetic Properties of an Impure Nickel." By J. HOPKINSON, F.R.S. Received June 9, 1888.

[PLATES 2—13.]

The sample of nickel on which these experiments were made was supposed to be fairly pure when the experiments began. A subsequent analysis, however, showed its composition to be as follows:—

| | |
|---|---|
| Nickel | 95·15 |
| Cobalt | 0·90 |
| Copper | 1·52 |
| Iron | 1·05 |
| Carbon | 1·17 |
| Sulphur | 0·08 |
| Phosphorus | minute trace |
| Loss | 0·13 |
| | 100·00 |

The experiments comprise determinations of the curve of magnetisation at various temperatures, the magnetising force being increased, that is to say, they are confined to a determination of the ascending curve of magnetisation. The temperature was always produced by enclosing the object to be tested in a double copper casing with an air space between the two shells of the casing, and by heating the casing from without by a bunsen burner. The temperature was measured by determining the electrical resistance of a coil of copper wire. The copper was first roughly tested to ascertain that its