As commonly understood, a map is primarily concerned with the land; a chart with the water, especially in its relation to navigation.

The early air maps were little more than topographic maps showing the relative position of details of the terrain. With the coming of improved aircraft and advanced methods of air navigation, however, these publications have undergone a gradual development.

The aeronautical chart of to-day can no longer be considered as merely a map — it is a navigational instrument differing in many details from an ordinary map. Features that once were considered essential have been replaced with others of greater relative importance. Certain items which should be included in a topographic map are now omitted in order not to obscure detail of more value to the navigator; other features are exaggerated beyond topographic justification because of their landmark value. Finally, the addition of the highly developed system of aids to air navigation has made the aeronautical chart exactly comparable to the nautical charts so essential for safety at sea.

Nautical charts are designed to show not only the harbours and channels, but also the complete system of lights, buoys, radio beacons, and other aids which enable the mariner to determine his position and reach his destination safely, even under conditions of poor visibility. Of at least as great importance is the charting of shoals, rocks and other obstructions. Soundings are selected so as to show the extreme variations in depth and the contour of the ocean is developed by depth curves, or shading.

In the aeronautical chart, exactly the same elements are present. The airports and established airways are shown, together with the system of beacon lights, radio range stations, and other aids which enable air pilots to determine position and safely complete scheduled flights even with zero visibility. Here, as at sea, the charting of mountain peaks and other dangers is of equal importance. Elevations take the place of soundings, and the characteristics of the floor of the "air ocean" are developed by means of contours and other conventional symbols.

The distinction that a chart is primarily connected with water areas largely disappears when we realise that the chief difference between air and water is one of density, or specific gravity. The air ocean is just as real as the water ocean, and is just as substantial at air-liner speeds as the water ocean beneath the keel of a battleship.

The aeronautical chart is in reality a navigational instrument representing the bottom of the air ocean.

Maps in general may be looked upon as containing information which is subject to little change, even over a considerable period of time. By way of contrast, the aeronautical charts include more than 2,000 airports and landing fields and some 20,000 miles of fully equipped airways. With such an extensive system of aids to air navigation it is obvious that many changes must occur; new airways are being established and old airways rebuilt with improved equipment, for more efficient operation. Changes of this nature are so numerous that new editions charting these changes are necessary at frequent intervals".

THE DEEP-WATER CIRCULATION OF THE INDIAN OCEAN

by

A. J. CLOWES and G.E.R. DEACON.

(Extract from *Nature* - London, December 14, 1935, page 936).

Until very recently, it has been generally assumed that the deep-water circulation in the Indian Ocean was very similar to that of the Atlantic; in certain features, such as the Antarctic bottom current and the Antarctic intermediate current, the close resemblance between the two oceans is still undisputed. It has, however, been suggested that the North Atlantic deep current — the highly saline deep current which MERZ and WÜST (1922) showed to flow southwards between the intermediate and bottom currents in the Atlantic Ocean — has no parallel in the southern part of the Indian Ocean.

The existence of a southward deep current of highly saline water in the Northern part of the Indian Ocean was demonstrated very clearly by SCHOTT (1926), MATTHEWS (1927) and MÖLLER (1929), and it was found to be composed of highly saline surface water sinking from the coastal regions of the Arabian Sea and the neighbouring gulfs, particularly from the Red Sea. The observations made by the *Challenger*, *Valdivia*, *Planet* and *Gauss* also showed that there was a highly saline warm deep layer in the Antarctic and sub-Antarctic regions; and since the data from the intervening part of the ocean were very scanty, it was reasonable to suppose that the warm deep layer found in the south was a continuation of the deep current which spreads southwards from the north. It was therefore assumed by L. MÖLLER (1929) that the north Indian deep current filled the deep layer in the western part of the Ocean with water of salinity more than 34.80 per mille almost as far as the Atlantic-Indian cross ridge in about 50° S.

THOMSEN (1933) has, however, used the observations made by the *Dana* (1932), and the *Willebrord Snellius* (1932) in the southern tropical and sub-tropical parts of the ocean to show that the assumption that the highly saline deep layer in the south was a continuation of the deep current in the north was, after all, not justified. He found that the north Indian Ocean deep current did not carry water with a salinity greater than 34.80 per mille south of a line from the northern end of Madagascar to Ceylon L. MÖLLER (1933) was not convinced that the new data which THOMSEN used justified at present a reversal of her former conclusions. In a later paper, THOMSEN (1935) states that at stations on a line between Ceylon and Cape Delgado he found no traces of a deep current between 2000 m. and 3000 m., but that it is possible that a rudimentary, southerly-directed current exists with a nucleus at about 800 m. in the north and about 1200 m. in the south.

Further light has been thrown upon the problem by a series of observations made by the R.R.S. *Discovery II* in her recent voyage from the Antarctic in 1935 on a line from Marion Island through the Mozambique Channel to the Gulf of Aden. The north Indian deep water is clearly distinguished at the northern end of the profile sections by its high temperature and high salinity, and low oxygen content. The salinity section shows that it has a salinity of 34.80 per mille as far as 20° S. approximately. South of this latitude there is a second body of highly saline water with a salinity of more than 34.80 per mille, but it is clear from the salinity, temperature and oxygen content that this second body of highly saline water is not merely a continuation of the north Indian deep current. It is approximately 2° C. colder and 2 c.c. per litre richer in oxygen, and is therefore derived partly from another source, plainly from an eastward current of Atlantic deep water. The existence of such a current is in fact generally agreed upon. It was inferred by MERZ and WÜST (1922) from the temperature chart for 1500 fathoms given by BUCHAN (1895) in the *Challenger* reports, and also recognised by WÜST (1926) and MÖLLER (1929).

Although there is this body of Atlantic deep-water in the southern part of the sections, our observations suggest that the north Indian deep current does not come to a sudden termination in 20° S. The oxygen distribution, especially, suggests that the north Indian deep water flows much farther south in the upper stratum of the warm deep layer, sandwiched between the Antarctic intermediate current and the Atlantic water. A chart of the oxygen distribution in the warm deep layer in the southern part of the Indian ocean, to be published in a forthcoming report by one of us (G.E.R.D), shows that south of Africa the oxygen content of the deep layer falls rapidly towards the east, indicating that the Atlantic water is joined by a southward movement of water containing less oxygen from the northern part of the Indian Ocean.

A comparison of our section with that of MÖLLER (her Mozambique section is along almost the same line as ours) suggests that the volume and salinity of the north Indian deep current are subject to large variation, probably related to the changes of salinity in the coastal regions and to the current differences brought about by the changes of the monsoon winds and variation in the south Equatorial current. The observations of the *Valdivia* and the *Ormonde* used by MÖLLER show that the deep current fills the northern part of the Ocean with water of 35.00 per mille salinity as far as 8° S. and to a depth of 2000-2500 metres, while our section shows that this isohaline is not found south of the equator or deeper than 1500 metres. A strict comparison cannot be made between THOMSEN's and our section, since his is much farther east than ours, but the volume of the deep current seems to have been less when his observations were made, since he did not find the 34.80 per mille isohaline south of a line from Ceylon to Cape Delgado (1933), whereas we found it to extend as far as 20° S.

Thus, as a result of the recent observations of the R.R.S. *Discovery II*, the extent of the southward flow of the north Indian deep current appears to be a compromise between the views of MÖLLER and THOMSEN. Oxygen observations in particular show that this current can be traced southwards as a tongue of poorly oxygenated water sandwiched between Antarctic intermediate water and an eastward current of north Atlantic deep water.

REFERENCES.

BUCHAN, A.................. "Report on Oceanic Circulation", Summary of the Scientific Results of the Voyage of H.M.S. *Challenger*, 2, map 13; 1895.

MATTHEWS, D.J............ "Temperature and Salinity Observations in the Gulf of Aden", *Nature*, 120, 512; 1927.

MERZ, A. and WÜST, G. "Die Atlantische Vertikalzirkulation", *Z. Ges. Erdk. Berl.* 1-35, 1922.

MÖLLER, L..................... "Die Zirkulation des Indischen Ozeans", *Veroff. Inst. Meeresk. Univ.* Berl. 21, 1-48; 1929.

MÖLLER, L.................... "Zur Frage der Tiefenzirkulation im Indischen Ozean", *Ann. Hydrogr.* Berl. 61, 233-236; 1933.

Van RIEL, P.M. .... "Einige ozeanographische Beobachtungen im Roten Meer, Golf von Aden und Indischen Ozean", *Ann. Hydrogr., Berl.*, 60, 401-407; 1932.

SCHMIDT, J. .... "Dana's Togt omkring Jorden 1928-1930", Köbenhavn; 1932.

SCHOTT, G................... "Die Tiefenwasserbewegungen des Indischen Ozeans", *Ann. Hydrogr., Berl.*, 12, 417-431; 1926.

THOMSEN, H................ "The Circulation of the Indian Ocean", *J. Cons. inst. Explor. Mer.*, 8, 73-79; 1933.

THOMSEN, H................ "Entstehung und Verbreitung einiger charakteristischer Wassermassen in dem Indischen und südlichen Pazifischen Ozean", *Ann. Hydrogr., Berl.*, 63, 293-305; 1935.

WÜST, G....................... "Zweiter Bericht über die ozeanographischen Untersuchungen", *Z. Ges. Erdk. Berl.*, 231-250; 1926.

THE 1910 TO 1935 SURVEY OF THE CURRENTS OF THE INDIAN OCEAN AND CHINA SEAS.

Under this heading, Mr. E. W. BARLOW of the Marine Division, Meteorological Office of the Air Ministry, London, has published in *The Marine Observer*, Vol. XII, N° 120, October 1935, page 153, a well-documented study on the currents of the Indian Ocean, the Eastern Archipelago and the China Seas south of Latitude 30° N.

The Indian Ocean differs entirely from the Atlantic and Pacific Oceans in two ways: firstly the area of the Indian Ocean north of the Equator is extremely small in comparison with other oceans, secondly the cold waters of the Arctic Ocean have no access to the Indian Ocean. Besides, the atmospheric pressures which prevail on the Indian Ocean round about the 35th parallel of southern Latitude differ from the corresponding regime in the Atlantic and Pacific Oceans.

The article describes, at the outset, the surface circulation of the Indian Ocean. Tables 1 and 2 appended to the article, give the various seasonal means (in miles per diem) in the Indian Ocean south and north of the Equator. For the circulation south of the Equator the article describes successively the various local currents such as the Agulhas Current, the Mozambique Current, the East African Current and the Counter-Equatorial Current. Two interesting diagrams with reference to them are reproduced.

The writer then turns to the study of the seasonal monsoon circulation for the periods November-January, February-April and May-October. Next he moves on to the