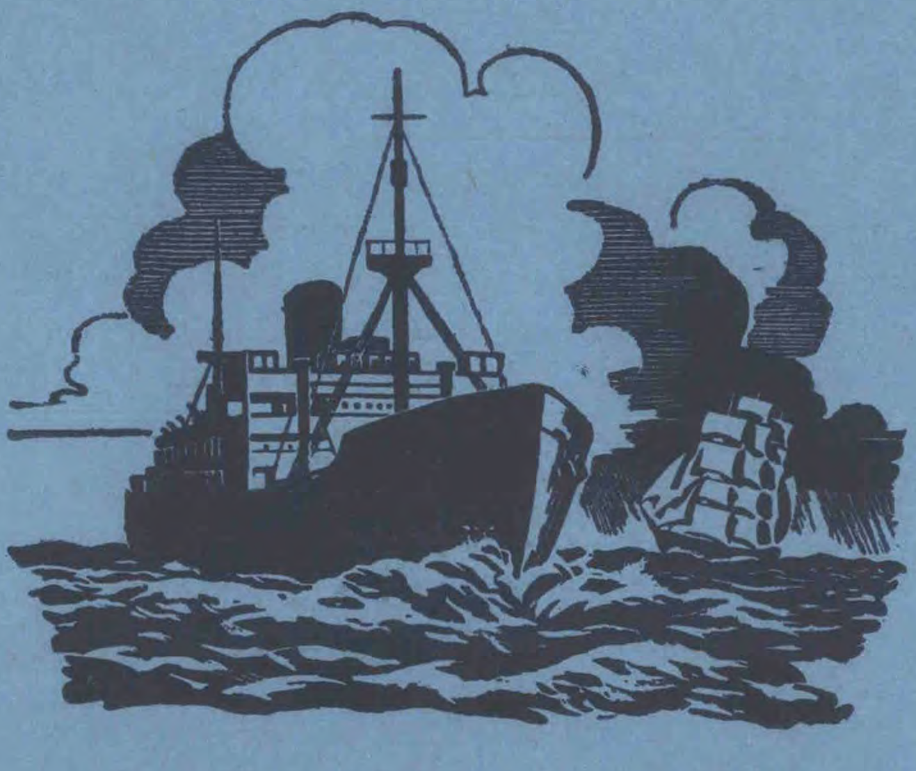
Met.O. 799

The Marine Observer

A quarterly journal of Maritime Meteorology



Volume XXXVIII No. 220

April 1968

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METEOROLOGICAL OFFICE

Ships' Code and Decode Book

(Met.O. 509) 7th Edition

The World Meteorological Organization has introduced some changes in the international meteorological codes for weather reports to and from ships. These changes, which came into effect on 1st January 1968, are incorporated in the 7th Edition of this book.

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Met.O. 799

THE MARINE OBSERVER

A QUARTERLY JOURNAL OF MARITIME METEOROLOGY PREPARED BY THE MARINE DIVISION OF THE METEOROLOGICAL OFFICE

VOL. XXXVIII **No. 220** **APRIL 1968**

CONTENTS

Letters to the Editor, and books for review, should be sent to the Editor, "The Marine Observer," Meteorological Office, Eastern Road, Bracknell, Berkshire

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Editorial

"Accordingly, everyone who uses the sea is invited to make certain observations; or, in other words, propound certain queries to Nature, and to give us a faithful statement of the replies she may make." So wrote Maury in his report about the first International Meteorological Conference in Brussels in 1853. His report goes on to say "Unless we have accurate instruments, instruments that will themselves tell the truth, it is evident that we cannot get at the real meaning of the answers that Nature may give us. An incorrect observation is not only useless of itself but, when it passes undetected among others that are correct, it becomes mischievous. . . . We are now about to turn over a new leaf in navigation, on which we may confidently expect to see recorded much information which will tend to lessen the dangers of the sea and to shorten the passage of vessels."

As a result of the Brussels Conference the international scheme for the making of voluntary meteorological observations aboard merchant ships was started and the British Meteorological Office was founded in 1855; the Selected Ship scheme as we know it today is a direct link with that Brussels Conference. Maury's words are as true today as when they were written; in fact they are probably more important because of the operational significance of meteorology nowadays, not only to shipping but to innumerable activities ashore. An erroneous observation, particularly from the ocean, because of the relative sparseness of ships compared with shore stations, can so mislead the meteorologist (or the now fashionable computer) that the accuracy of the resulting forecast is seriously impaired. In the case of a doubtful ship observation, by the time it has been plotted on the chart and the forecaster has studied it against the background of other observations, it is always difficult, for various practical reasons, for him to send a message to the ship in time enough to obtain verification of the observation. In the case of the computer, a very obvious error will be rejected and then can be investigated by a meteorologist; a doubtful observation, however, may well be used by the unsuspecting computer in preparing its forecast and, if erroneous, will adversely affect the accuracy of the result. An article of the treatment of errors by computers appeared in the April 1964 number of *The Marine Observer*.

From the beginning the Meteorological Office, in consultation with the Royal Society, took great care in heeding the advice of the 1853 Conference about accuracy of instruments. As a result, British Voluntary Observing Ships have always been supplied on loan with officially-tested instruments and consequently, provided the instruments are read carefully and corrected as necessary, the results will be very accurate, having in mind the obvious limitations due to the ship herself and her motion in the sea waves. The only major change in marine barometers has been the use of the correction slide and the recent decision to replace gradually the mercurial instruments with precision aneroids. There have only been minor changes in thermometry and the change from Fahrenheit to Celsius is nothing new; the 1853 Conference recommended Fahrenheit and Celsius scales being marked on the thermometers! It has always been difficult to get accurate sea temperatures. The 1853 Conference recommended that "the water should be taken up in a wooden bucket, as far as possible from the ship's side and placed in the shade on deck; the thermometer should then be placed in the water . . . and read whilst the bulb is in the water". This was easy enough to do aboard a sailing ship; aboard British ships of all types during the years the bucket method has always been the standard, the only difference is that the bucket material has changed from wood to canvas, to single-skinned canvas, double-skinned canvas, and finally to the existing reinforced rubber. The bucket method still seems to be the best and most accurate way of doing this job—provided, of course, that the size and speed of the ship doesn't make it impracticable, in which case the 'intake' method is the only alternative at present.

While instrumental observations merely need care, the visual observations or estimates that the marine observer has to make call for skill, experience, judgement and patience in addition to care—all of which are necessary qualities in a seaman and thus a proficient marine observer is probably a good officer as well.

Next to the barometer reading, the most important observation both to the seaman and the meteorologist is that of wind force and direction; obviously they are both related and the wind observation can often be a useful check on the pressure reading. Thanks to the Beaufort scale and its association with the appearance of the sea, the mariner has a simple and a relatively accurate method of making this observation without instruments and the experienced officer is so used to making these observations for his own purposes that errors are generally unlikely. Estimation of visibility should also cause little difficulty to a sailorman except at night-time, nor should a description of the existing and past weather.

Apart from cloud observations, probably the most difficult visual observations the mariner is asked to make are those of wave height and period. Aboard an ocean weather ship lying stopped in mid-ocean such an observation is easy, for the observer can get as close to the sea surface as he likes and take his time over it and there is no ship speed problem. It is a very different thing aboard a fast-moving ship with a high bridge and it is difficult even to give any practical advice about how best to make these observations in such a case other than to refer to the general guidance given in the *Marine Observer's Handbook.* Obviously the observer won't be able to leave the bridge very often to get on a lower deck to make the observation; one can only rely on his judgement and common sense in making it from whatever site is available to him. Wave observations have become rather important nowadays in connection with the weather routeing of ships and the naval architects' efforts to improve ship design.

Having made the observation, there is plenty of scope for error in coding it, entering it on a signal pad, transmitting it from the ship and receiving it ashore and then relaying to various authorities. It is only care on the part of all concerned that can eliminate errors of this nature.

The following incident illustrates these points. Early in December a radio weather message was received in Bracknell from a ship in the eastern North Atlantic which gave a position far away from where the ship could possibly have been. A signal was sent to the ship requesting a check and the correct position was then received; thus were the forecasters able to make full use of the observation.

On arrival in port the officer responsible for the error was kind enough to write to us a letter of apology from which we quote: "After receiving your telegram, I realized that I had placed in the latitude and longitude columns the wet- and dry-bulb temperatures for that report."

This error proves two things. Firstly, that mistakes are easily made even by the most experienced observers and that every reading needs checking; this is a point which we have mentioned in the preliminary pages of the meteorological logbook. Secondly, that every radio weather message from a ship is valued and used by the forecaster; if it were otherwise, this particular message could easily have been discarded.

Meteorologists appreciate that the making of weather observations aboard a ship is entirely a voluntary business, that it takes time and that ships' officers have many other duties to perform and that some of this meteorology may well have to be done when they come off watch. Also it is realized that as ships get larger and faster and as the number of officers aboard becomes less, due to the introduction of automation, the duties of the officer on watch become more onerous.

In an attempt to ease the job of the voluntary observing officer aboard large and fast ships, the Meteorological Office is, at the invitation of the Sugar Line, introducing some instrumental automation in one of their new bulk carriers while she is under construction. The wet- and dry-bulb readings will be made by electrical thermometers in a screen and led to a dial-type recorder in the wheel-house. The sea temperature will be measured by a 'limpet-type' electrical thermometer fastened to the skin of the ship inside one of the holds and will similarly be led to the recorder in the wheel-house. The instrument will be insulated from the hold and its principle is that the ship's steel is such a good conductor that, being located beneath the water-line, the sea-water temperature will thereby be indicated accurately. For temperature observations all the officer will need to do will be to operate a selector switch and press a button on the dial; the appropriate temperature reading will then be given direct. A precision aneroid barometer also will be fitted in the wheel-house and this will be fitted with a 'static head' to make sure that it does, in fact, indicate the outside atmospheric pressure. The possibility of providing an anemometer was considered, but there is considerable difficulty aboard any ship in finding a site which will be free from interference; the instrument would be quite expensive and would require appreciable maintenance. As the provision of an anemometer does not really ease the job of the observer very much in a moving ship because he still has to convert the readings from relative wind to true wind it was decided not to fit one. We will be very interested to see the results of the trials with the above equipment; if successful we hope to get it aboard other similar ships if and when the necessary funds become available.

C.E.N.F.

Report of Work for 1967

(MARINE BRANCH AND MARINE CLIMATOLOGY SECTION OF THE METEOROLOGICAL OFFICE: VOLUNTARY OBSERVING FLEET AND OCEAN WEATHER SHIPS)

1. Voluntary Observing Ships

At the end of the year the British Voluntary Observing Fleet was comprised as follows:

(*a*) 479 Selected Ships which are supplied with a full set of meteorological instruments on loan and which make observations in code form FM21.C every six hours and transmit them to the appropriate coastal radio station wherever their voyages take them.

(*b*) 60 Supplementary Ships, including 11 trawlers, which make less detailed observations than Selected Ships and are supplied on loan with only a barometer, air thermometer and screen. They use abbreviated code form FM22.C for their messages.

(*c*) 95 coasting ('Marid') vessels, and one lightship, which make sea-surface temperature observations in U.K. coastal waters and transmit them in a special code by W/T or R/T. When in the North Sea, the coasting ships include in their messages wind, weather and visibility observations.

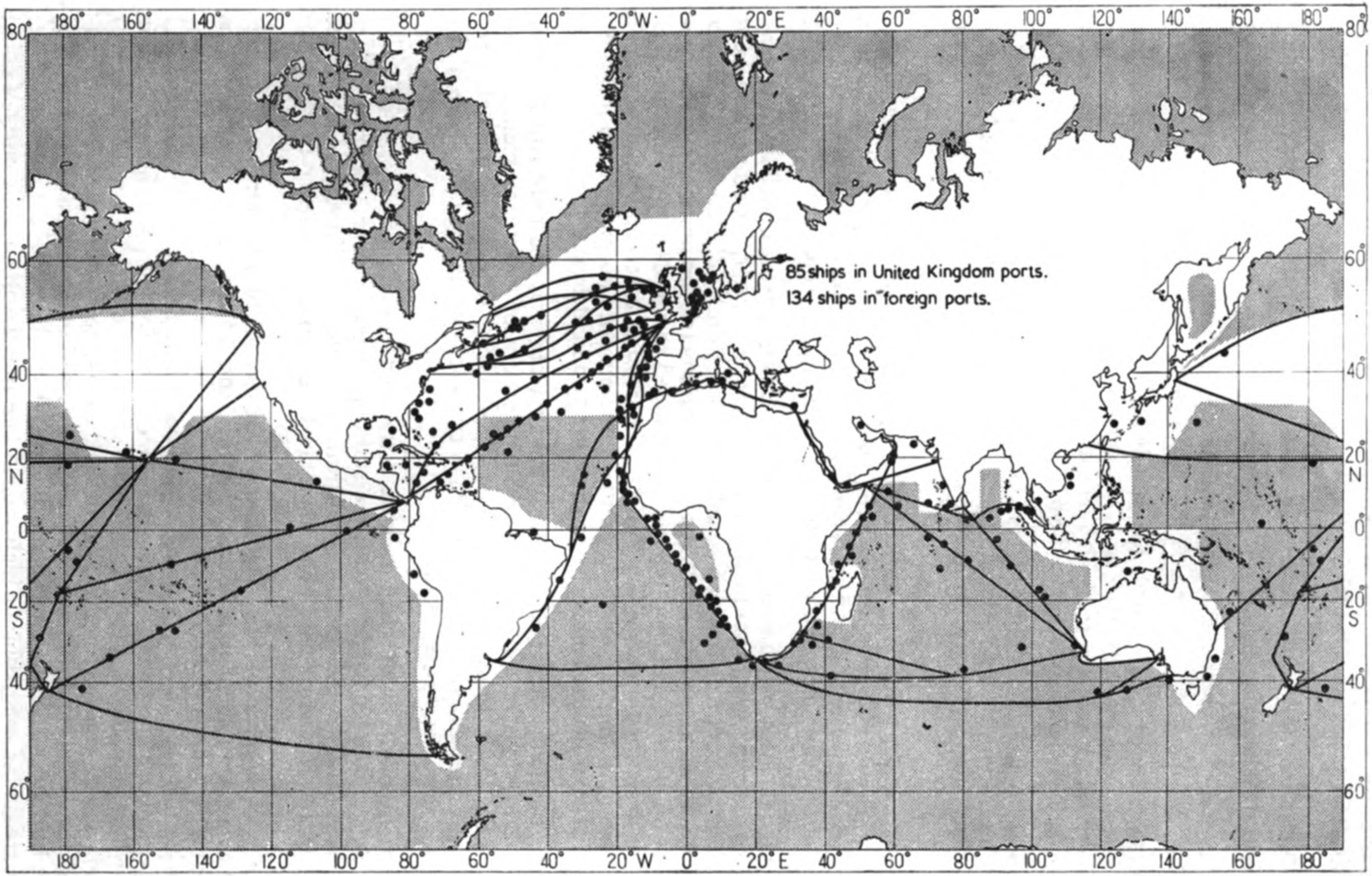
(*d*) 13 lightships which make observations of wind, waves, visibility, air and sea temperatures; 11 of these send coded reports by R/T, the other two record their observations for climatological purposes only. The *Dowsing*, *Galloper* and *Royal Sovereign* lightships report barometric pressure using the precision aneroid, and their reports are included in the BBC 5-minute weather bulletins for shipping. The *Galloper* also reports barometric tendency. The time limit imposed on BBC weather bulletins does not permit the inclusion of the barometric tendencies of the other two lightships.

(*e*) 16 trawlers which make non-instrumental observations only and transmit them by W/T or R/T using the first four groups of FM21.C, to radio stations in the U.K., Canada, Iceland, Norway or U.S.S.R. depending on the area in which they are fishing. In addition to these, 11 trawlers now figure in the Supplementary Ships' List.

(*f*) 62 Auxiliary Ships which make and transmit visual observations similar to those made by trawlers, with the addition of pressure and air temperature readings from the ships' own instruments (using the 'Shred' code). These ships do this work only when in areas where shipping is known to be sparse.

The total number of British Voluntary Observing Ships taking part in this scheme represents about 16 per cent of the world total of some 4,500 observing ships belonging to various maritime countries.

During the year 1,013 meteorological logbooks were received from Selected and Supplementary ships and 149 forms from Auxiliary ships voyaging through oceanic areas where shipping is sparse. Valuable observations and radio weather messages continued to be received from trawlers of the distant-water fishing fleet. The willingness of the owners and skippers of these ships to add our instruments to the many others in their small chartrooms is much appreciated. Trawlers' meteorological logbooks are almost invariably of a high standard despite the obvious difficulty of doing this work in the uncomfortable conditions under which they work for so much of the time when in the high latitudes.



The positions of British Selected and Supplementary Ships on 14th July 1967. The shaded areas are those in which shipping is sparse and in which Auxiliary Ships make reports.

The Port Meteorological Officers at London, Liverpool, Glasgow, Hull and Cardiff and the Merchant Navy Agents at Southampton and Newcastle, whose job it is to recruit ships for the work, equip them with the necessary instruments and to instruct the voluntary observers in their duties, have between them visited each British observing ship every three months where possible. During these visits instruments are inspected and renewed as necessary, the work is discussed with observing officers and radio officer, and newly-joined officers are instructed in their observing duties. Valuable observations have been received during the year from H.M. survey ships which tend to operate in areas where shipping is sparse. By arrangement with the Hydrographer and the Director of the Meteorology and Oceanographic Services (Naval), these ships use the same meteorological logbook as our Supplementary ships but have their own tested instruments.

The British Voluntary Observing Fleet includes ships of over 100 shipping companies as well as the research ships *Discovery*, *John Biscoe*, *Shackleton* and *Ernest Holt*. Table 1 shows the variety of trade routes on which they are engaged:

Table 1. Average numbers of British Selected and Supplementary Ships on main trade routes to and from the U.K.

Australasia	99	South America	21
Far East	79	Pacific Coast of North America	11
Persian Gulf	35	Europe	44
South Africa	33	Falkland Islands and Antarctic	2
North Atlantic	90	World-wide 'tramping'	85
West Indies	40		

The map opposite shows the positions of British voluntary observing ships in various parts of the world on 14th July 1967 (a date picked at random).

The following table gives the average daily number of radio weather messages received at the Meteorological Communications Centre at Bracknell during the year from merchant ships via GPO coastal stations.

Table 2. Daily average number of reports received direct from ships

(*a*) North Atlantic (east of 40°W and north of 35°N)	
U.K. Selected and Supplementary Ships	84
'Marid' ships (coasting vessels)	13
Foreign ships	15
Trawlers	8
Total	120
(*b*) North Sea (51° 30'N to 61°N and 4°W to 7° 30'E)	
U.K. Selected and Supplementary Ships	12
'Marid' ships (coasting vessels)	3
Trawlers	2
Total	17
(*c*) Light-vessels	55

During two typical days, one in June and one in December, the total number of reports from ships received in the Central Forecasting Office at Bracknell from various sources is shown in Table 3.

The greater freedom now allowed to the radio officer aboard a merchant ship in choosing the station through which he may clear a radio weather message has resulted in more messages being received. A random sample of observations made during the period 1st–7th June showed that out of 749 radio weather messages sent by 50 ships only 43 messages (less than 6%) had to be broadcast, the remaining 706 being cleared point-to-point to specific radio stations. The majority of merchant

Table 3. Total number of reports received at Bracknell by various sources from ships during two typical days in the year

	JUNE	*DECEMBER*
Direct reception from		
British ships in North Atlantic	112	104
Foreign ships in North Atlantic	13	19
British trawlers in North Sea	12	10
British merchant ships in North Sea	10	17
	147	150
Via other European countries		
Ships in North Atlantic	581	337
Ships in Mediterranean	61	98
Ships in North Sea	97	113
Ships off North Russia	47	41
Ships in Pacific	143	135
Ships in other waters	123	86
	1052	810
Via North America		
Ships in North Atlantic	554	342
Ships in Pacific	520	494
Ships in other waters	93	46
	1167	882

ships carry only one radio officer who generally makes strenuous efforts to clear all weather messages.

The closing of the Suez Canal in June 1967 and the consequent re-routeing round the Cape of Good Hope of all ships on the Persian Gulf, India, Far Eastern and Australian trades has improved the observational network from ships in the Indian Ocean with consequently less observations from the Red Sea and Mediterranean.

2. Ocean Weather Ships

The British Ocean Weather Ships completed 20 years in the North Atlantic during the year; the present four ships have been in operation for about 8 years and continue to give good service. These ships co-operate with French, Dutch and Norwegian vessels in maintaining four weather stations in the eastern North Atlantic while a number of other countries make financial contributions towards the cost; weather ships of the U.S. Coastguard similarly man four stations in the western Atlantic. All these ocean weather stations are constantly manned and the hourly surface and six-hourly upper-air observations (to an average height of about 65,000 feet) are transmitted by radio. In addition, scientific work carried out aboard ships include the measurement of solar radiation, sea temperature and salinity at various depths down to the sea bed, magnetic variation, deep-echo soundings and some biological work, including plankton sampling and fishing for squid. All four ships are now fitted with wave recorders.

The weather ships also provided routine navigational aids, communication facilities and air/sea rescue potential for trans-Atlantic aircraft. Frequent comprehensive air/sea rescue exercises were carried out both in harbour and at sea; RAF Coastal Command aircraft took part in some of these exercises and dropped mail to the ships in watertight containers.

During the summer months the British weather ships on stations 'India' and 'Juliett' embarked parties of Naval personnel to carry out a special series of bathythermograph soundings; during this operation some 10,000 bathythermograph and

3,000 temperature-probe soundings were taken. In connection with this exercise the ships on station 'Juliett' maintained constant visual and radar contact with an oceanographic buoy for two months, a unique experiment in mid-Atlantic. This buoy enabled special ocean current observations to be made.

3. Ice and Surface Ocean Currents

Since the transfer to the Central Forecasting Office last year of the day-to-day responsibility for sea-ice work more time has been devoted to the study of ice development. The Marine Branch retains responsibility for the production and issue of monthly ice charts.

Revision of the ocean current and sea-ice sections of six volumes of the Admiralty *Pilot* was completed during the year and the computer programming for the processing of all ocean currents data, much of which has already been put on punch cards, proceeded steadily.

4. Weather Routeing

The Marine Branch co-operated with the Central Forecasting Office in providing experimental weather routeing during September for four merchant ships on westbound passages across the Atlantic.

5. Inquiries

There was an increase in the number of marine inquiries dealt with during the year, most of which were from solicitors, shipbrokers and insurance companies. Amongst other technical questions, advice was given about various aspects of hovercraft and hydrofoil operation, cable laying in the North Sea and about the probable spread of the oil during the *Torrey Canyon* incident.

6. Publications

The changes in the ships' meteorological codes, with effect from 1st January 1968, involved a considerable amount of time and effort in the revision of new versions of Met.O.509 *Ships' Code and Decode Book*, the code cards, logbooks and related forms. Although early preparation should have ensured that final copies were available for distribution by mid-1967, printing delays caused serious embarrassment, especially to the Port Meteorological Officers and Agents.

The change in ships' codes gave us the opportunity to design a logbook especially for the Ocean Weather Ships and this has now been printed.

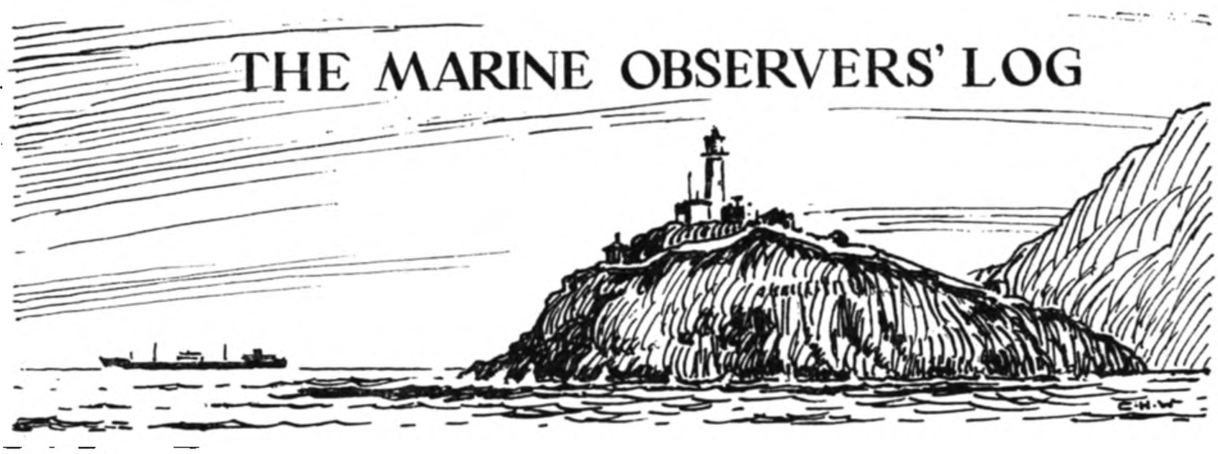
The 2nd edition of Met.O.593 *Meteorology for Mariners* and the new edition of Met.O.435 *Ocean Currents of the South Pacific* were published during the year and the preparation and printing of *The Marine Observer* continued as usual.

A new (9th) edition of Met.O.522 *Marine Observer's Handbook* is in preparation.

7. Awards to Voluntary Observing Ships

Annual awards of books were made to the master and officers of 100 Selected/Supplementary ships, 4 coasting ships making sea temperature observations and 4 non-instrumental trawlers whose work reached the required standard; barographs were awarded to four shipmasters whose long and zealous record of voluntary observing was considered as deserving special recognition.

The books selected for awards were *Cassell's English Dictionary*, *Lodestone and Evening Star* by Ian Cameron and *The University Atlas*.



April, May, June

The Marine Observers' Log is a quarterly selection of observations of interest and value. The observations are derived from the logbooks of marine observers and from individual manuscripts. Responsibility for each observation rests with the contributor.

Observing officers are reminded that preserved samples of discoloured water, luminescent water, etc. considerably enhance the value of such an observation. Port Meteorological Officers in the U.K. will supply bottles, preservative and instructions on request.

TORNADO
off Gambia

m.v. *Richmond Castle.* Captain E. Everitt. Las Palmas to South Africa. Observer, Mr. D. M. Hawker, 3rd Officer.

18th June 1967. A typical West African tornado was experienced at about 0030 GMT. An arc of very black upper cloud was seen to be approaching rapidly from the east, the wind being very light and variable in direction, and the heat oppressive. (Air temperature 79·0°F, wet bulb 76·5°.) As the cloud passed overhead the wind became E'ly, force 6 or 7, and pressure rose immediately by 3 mb. No lightning was seen and there was very little rain but, soon after the cloud had passed over, an area of very heavy rain several miles in extent was seen on the radar, moving rapidly out to sea. At 0100 approximately the sky partially cleared and the wind dropped, but by 0115 it again blew from the E at about force 5 and continued to do so. The sky in the east once more became very black. At 0200 the barometer began falling rapidly but the rate of fall decreased about 0400, the wind then being NE, force 3. Sea temp. 80°F.

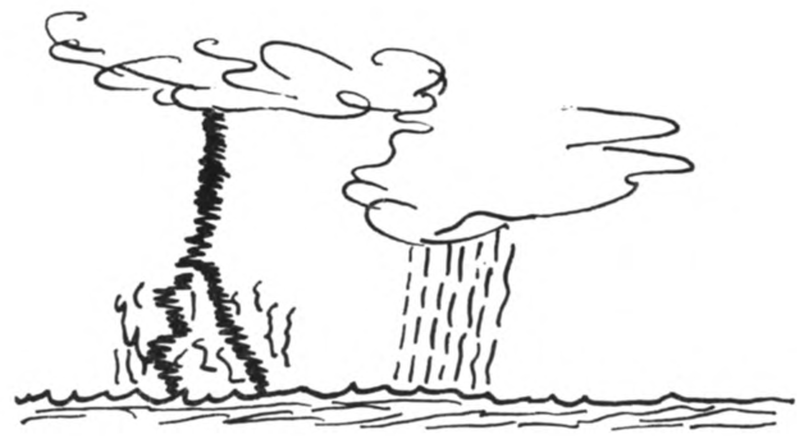
Position of ship: 13° 00'N, 17° 30'W.

Note. The account given above corresponds well with the description of a typical West African tornado given in the *Africa Pilot,* Vol I, pp. 56–58.

FORKED WATERSPOUT
South China Sea

m.v. *Flintshire.* Captain R. G. Rippon. Port Swettenham to Hong Kong. Observer, Mr. P. M. Whitworth, 4th Officer.

19th May 1967. A waterspout which divided into two branches about half-way



between the cloud base and the sea, as shown in the sketch, was seen at 0715 LMT about 10 miles off. The two parts joined together about 10 min later to form a single column, at the base of which great turbulence was observed. A shower was falling in close proximity. Air temperature 84°F, wet bulb 80·5°, sea 83·7°.

Position of ship: 14° 15′N, 112° 24′E.

Note. We wonder whether this is in reality what it appears to be. Some doubt has been expressed as to whether such a formation is dynamically possible and the idea most favoured is that there were in fact two separate spouts, the upper part of the distant spout being in the same line of sight as that of the nearer one.

LIGHTNING: MAGNETIC COMPASSES AFFECTED

Western North Atlantic Ocean

s.s. *Crofter*. Captain R. Sutcliffe. Pensacola to Newport News. Observer, Mr. R. A. Francis, 3rd Officer.

24th April 1967. At 0200 GMT the vessel entered a severe thunderstorm which radar indicated was 16 miles in radius. The forked lightning in the storm centre frequently affected the off-course alarm and the two magnetic compasses showed signs of disturbance. In the course of an hour the air temp. fell from 76°F to 70° and the wet bulb from 70° to 69°.

Position of ship: 30° 35′N, 78° 20′W.

FOG BANK

Mediterranean Sea

m.v. *Port Pirie*. Captain W. J. Williams. London to Port Said. Observers, all Officers and Apprentices.

1st May 1967. At 1345 GMT, what at first appeared to be a long bank of low cloud on the horizon turned out to be fog when a vessel 2 miles distant and just forward of our port beam was lost from view. Her topmasts reappeared above the bank and were visible most of the time, giving an approximate height to the top of the fog of 60–70 ft.

The south side of the bank had, for the most part, a clearly-defined limit though occasionally it was blurred. We ourselves were on the verge of entering the fog at 1515 and speed was reduced until 1540 when the visibility ahead improved to about 10 miles. The fog bank was judged to be about 30 miles long and lying in a 120°–300° direction. Air temp. 63°F, dew-point 57°, sea, 64·5°. Wind, light S'ly airs.

Position of ship: 36° 40′N, 13° 02′E.

Note. Our synoptic weather charts show that an extensive area of relatively high pressure covered the central and western Mediterranean on the 1st May. Winds were very light and skies were clear during the early morning, conditions favourable for the development of radiation fog. If such a fog bank had formed on the coastal belt of southern Sicily it could well have been drifted out to sea by the light NE'ly winds and been slow to disperse. The values of air temperature, dew-point and sea temperature are incompatible with the formation of true sea fog in the area through which m.v. *Port Pirie* was then passing.

CHANGES IN AIR TEMPERATURE

Mediterranean Sea

m.v. *Diomed.* Captain M. G. Thomas. Port Said to Leixões. Observers, Mr. P. R. Dew, 3rd Officer and Mr. B. Kay, Officer Cadet.

27th May 1967. At 1800 GMT, the wind direction was E'N, force 4 and the air temperature 74·1°F. By 1900 the direction had veered to S'W and gusts of force 4 or 5 were occurring.

With the change of direction the air temperature suddenly rose from 77·0°F at 1900 to 90·5° at 1935. Not long afterwards the wind backed to ESE force 3 and the temperature began to fall. The readings of the dry- and wet-bulb thermometers taken between 1900 and 2100 are given below.

TIME (GMT)	DRY (°F)	WET (°F)
1900	77·0	66·5
1935	90·5	67·0
1945	88·0	67·0
1955	88·0	67·0
2005	83·0	66·7
2015	82·5	66·7
2025	79·5	66·7
2035	78·5	66·5
2045	77·5	66·5
2100	77·5	66·5

The sea temperature by condenser intake was 65° throughout. Vessel's speed, 16·5 kt.

Position of ship at 1900: 37° 15'N, 4° 32'E.

s.s. *City of Manchester.* Captain G. R. Jackson. Port Said to Avonmouth. Observer, Mr. T. F. Weale, Jnr. 2nd Officer.

27th May 1967. When the vessel was approximately 35 miles north of Cape Carbon the following changes in wind and air temperature were observed.

GMT

2000: Wind E, force 2. Ten min later it fell to calm.

2015: Sudden squall of cool W'ly wind, force 5.

2020: Wind died away to light airs. Air temperature fell from 71°F to 67°.

2130: Wind increased to W'S, force 4–5. Within 5 min the temperature rose from 67° to 88°.

2145: Wind W'S, force 6. Temperature now 96°. This extremely hot, dry wind continued at force 5–6 for 20–25 min. Visibility was not impaired but sand or dust could be felt stinging the eyes and throat. No deposits seen on the vessel.

2230: Wind backed slowly to SW, force 2–3. Temperature 87°.

Position of ship at 2100: 37° 18'N, 5° 18'E.

Note. Our synoptic weather chart for 1800 GMT on 27th May shows that large Cu were reported in the Algiers area and Cb elsewhere further to the eastward. Their presence indicates the possibility of the occurrence of squally winds which could come from almost any direction in view of the lightness of the pressure gradient. The sudden rise in temperature occurred when the wind blew strongly from the land, bringing in the high air temperatures of the desert. In spite of a light sea breeze the air temperature at Algiers was 88°F at 1800 but inland it must have been several degrees higher. At noon at Algiers it was 104°.

UNUSUAL CURRENT SET

East Pacific Ocean

m.v. *Ruahine*. Captain R. G. Hollingdale. Balboa to Papeete. Observer, Mr. J. Gibbard, Senior 3rd Officer.

18th–20th April 1967. Instead of the usual favourable currents experienced in this area the vessel encountered adverse or E'ly sets between 0124 GMT on the 18th (0° 44'N, 104° 48'W) and 0212 on the 20th (3° 48'S, 117° 43'W). The four current observations made in this period gave the following results:

034° 1·8 miles over 11 hours
066° 34·0 miles over 13 hours
073° 15·2 miles over 11 hours
146° 3·6 miles over 13 hours

All positions were obtained from stellar observations. Before the period referred to, the set was:

285° 7·8 miles over 13 hours
239° 21·1 miles over 12 hours

Note. The ocean current atlas (Met.O.435) confirms there is a probability of equatorial counter-currents over the track of m.v. *Ruahine*. It is very useful to record the occurrence of these unusual sets.

CURRENT RIP

Indian Ocean

s.s. *Royal Arrow*. Captain V. W. B. Davies. Port Elizabeth to Arabian Gulf. Observer, Mr. A. Aitchison, 3rd Officer.

27th June 1967. At 0900 GMT the vessel encountered a current rip causing turbulence in the surrounding sea in a belt 2–3 cables wide, which extended from the horizon in a semicircle between 300° and 120°. As the vessel entered the rip she yawed about to such an extent that she had to be put on hand steering and took 35° of helm in both directions before steadying up. The course was 030°. Wind SW, force 3–4.

Position of ship: 3° 57'N, 51° 06'E.

Note. The phenomenon observed by s.s. *Royal Arrow* was associated with the very large area of complex vertical exchanges within the sea that occur off the East African coast between Madagascar and Socotra with the onset of the SW monsoon.

CURRENT RIP: LARGE SEA TEMPERATURE CHANGE

East of Galápagos Islands

m.v. *Rangitoto*. Captain H. N. Lawson. Balboa to Papeete. Observers, Mr. M. J. Jackson, 2nd Officer and Mr. P. Murdoch, Quartermaster.

12th June 1967. The vessel, travelling on a course of 237° at 17 kt, passed through a current rip at 1145 GMT. The automatic pilot was in use and the ship swung violently off to port. Hand steering was immediately engaged and it was found necessary to use large amounts of helm for about three min as the vessel traversed the rip.

This showed as a very marked zig-zag line running approximately in an E–W direction as far as the eye could see, the surface of the water along the line of the rip being very disturbed. Sea temperatures, taken by bucket, were 78·1°F before entering the rip and 71·2° on the other side of it. Air temp. 70°. Wind S, force 2–3.
Position of ship: 1° 34′N, 88° 17′W.

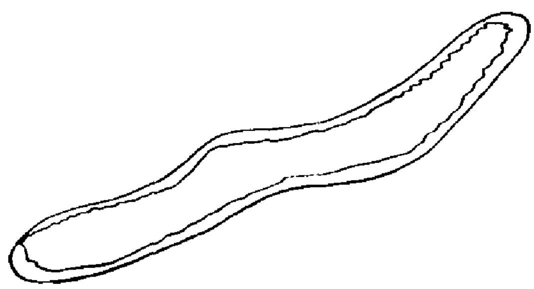
Note. This report is from a location in which vertical exchanges within the sea are frequently observed. It is where the Peru current flows into the zone of equatorial counter-currents.

JELLYFISH

Indian Ocean

s.s. *Mahseer.* Captain A. B. Davis. Aden to Gan Island. Observer, Mr. A. H. Lord, 3rd Officer.

30th May 1967. At 0500 GMT a large jelly-like object was sighted about 6 ft below the sea surface. It was 4–4½ ft long and 6–9 inches wide. The outside edge was a



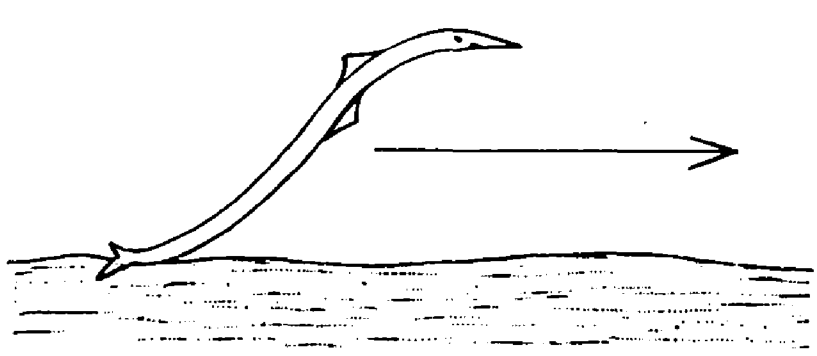
pink colour while the inside was almost transparent, with a tinge of pink. The general appearance is shown in the accompanying sketch. Sea temp. 84°F.
Position of ship: 6° 31′N, 59° 11′E.

FISH

Indian Ocean

s.s. *Mahseer.* Captain A. B. Davis. Gan Island to Madras. Observers, the Master and Mr. K. J. G. Bell, 2nd Officer.

6th June 1967. At 0200 GMT, as the vessel was leaving Gan Channel, numerous fish of the type shown in the sketch leapt from the water and propelled themselves along by flicking the sea surface with their tails, covering in this way a distance of about 70–100 ft. They were about 3 ft long, with a sharp head and a narrow body. Sea temp. 84°F. Wind calm and sea smooth.
Position of ship: 0° 18′S, 73° 30′E.



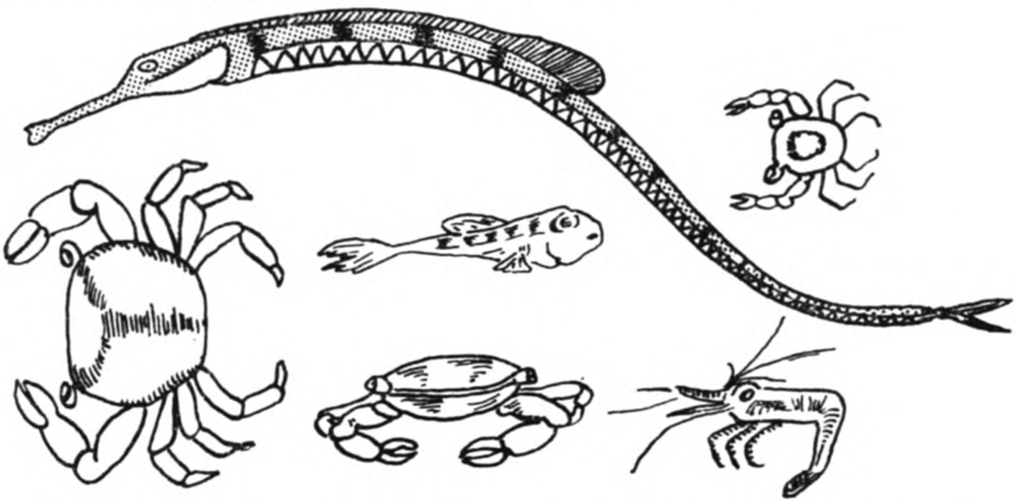
Note. Mr. P. J. Whitehead of the Department of Zoology, Natural History Museum, comments:
"This is a saury (*Scombresox sp.*) well known for their habit of skittering along the surface on their tails."

MARINE LIFE IN GULF-WEED
North Atlantic Ocean

m.v. *Crystal Gem*. Captain D. Patrickson. London to Belize. Observers, Mr. E. G. Winsor, 2nd Officer and Mr. B. Kernaghan, 3rd Officer.

28th June 1967. While the vessel was stopped during the afternoon, the opportunity was taken to collect samples of gulf-weed. They were found to contain the specimens of marine life shown in the accompanying sketch. [The pipefish is shown life-size, the others approximately life-size.] In the absence of formalin the specimens were preserved in surgical spirit but this, unfortunately, was rather unsuccessful as they became somewhat discoloured.

Position of ship: 25° 40′N, 62° 34′W.



Note. Mr. Alwyne Wheeler of the Department of Zoology, Natural History Museum, comments:

"The fish forwarded is a species of pipefish, *Syngnathus pelagicus L*, often found with floating Sargassum weed and recorded from many parts of the North Atlantic and the Mediterranean.

"My colleague, Dr. A. L. Rice of the Crustacea Section, has asked me to include the following notes on the crustacea you sent:

" 'The Sargassum crab, *Planes minutus* (Linnaeus), Swimming crab, *Portunus sayi* (Gibbes), shrimps, *Latreutes fucorum* (Fabr.), *Leander tennicornis* (Say)—all these species are fairly commonly found in association with Sargassum weed. They are therefore not at all rare but we are very pleased to have these specimens which are in very good condition.'

"To this I would add my own thanks for the specimens of pipefish which will be incorporated into the collection of fishes."

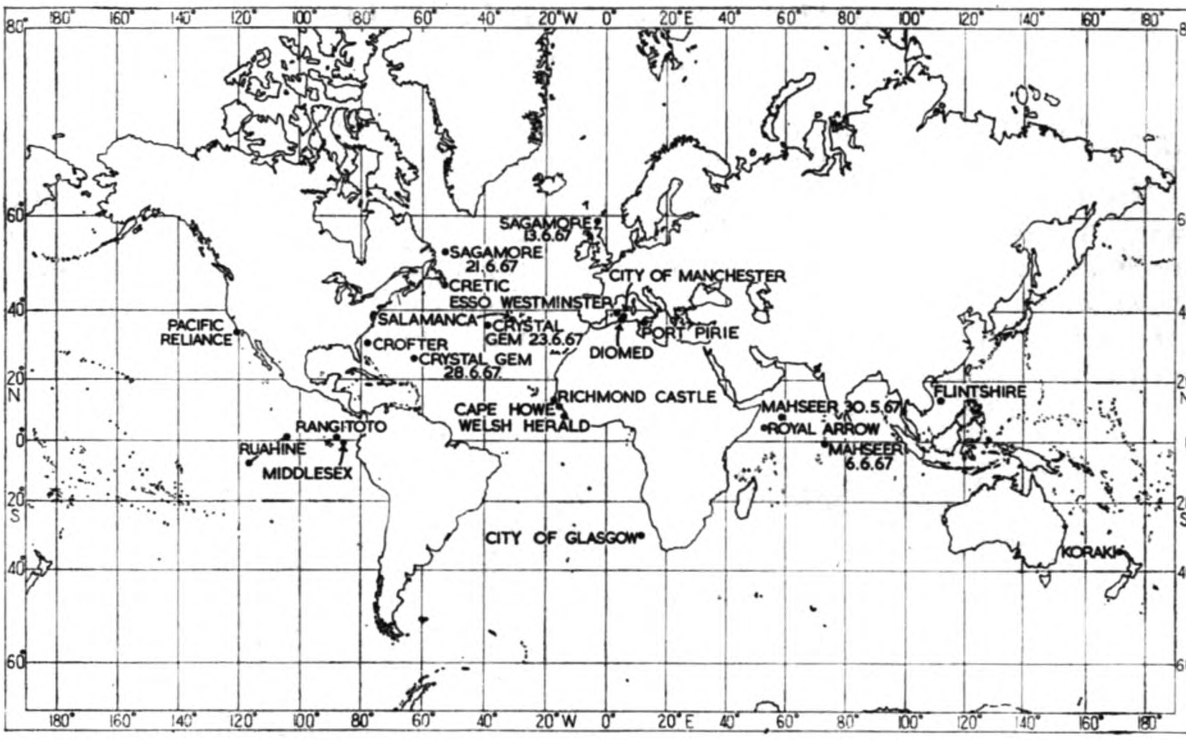
Note 2. It was a good idea to use surgical spirit in the absence of formalin; the latter can be obtained from any Port Meteorological Officer in the U.K.

TURTLES AND OTHER MARINE LIFE
Eastern Pacific Ocean

m.v. *Middlesex*. Captain K. Mayhew. Napier to Balboa. Observers, Mr. A. D. Welsh, 2nd Officer and Mr. P. M. Swan, 3rd Officer.

12th February 1967. During the day a number of turtles (at least 100) were observed, apparently having a rest on the surface. On occasions birds were seen perched on the turtles' backs. These were thought to be cormorants, large and black with white neck and a long, slender bill. Also observed during the day were two large swordfish which swam towards the ship and lay off at about 40 ft, two bottle-nosed whales about 20 ft in length, a small shark and innumerable flying fish. Sea temp. at 1800 GMT: 79·8°F. Wind ENE, force 2.

Position of ship at 1800: 00° 01′S, 86° 00′W.



Position of ships whose reports appear in "*The Marine Observers' Log*".

Note. Dr. L. D. Brongersma, Director of the Natural History Museum, Leiden, comments: "This information about turtles seen between the Galápagos Islands and the South American mainland is very interesting though it is impossible to say what species they were. For centuries the Galápagos have been known to have nesting beaches visited by turtles. In 1923 hundreds of turtles were seen in that part of the ocean 'floating lazily with the current and covering over a mile of sea surface'.

"Aggregations of turtles have been reported from the eastern Pacific on numerous occasions. About 35 turtles were seen within 100 ft of the m.v. *Port Lincoln* at 6° 57'S, 80° 35'W on 20th May 1965 but most of the observations were made further to the north, off the coast of Central America. On 28th November 1945 large numbers were seen about 50 miles off the coast of the Mexican state of Guerrero, at 15° 57'N, 99° 46'W. Three were captured and identified as Olive Ridleys (*Lepidochelys olivacea*).

"When in the open sea, turtles will feed on planktonic organisms such as jellyfish, salpae, pelagic snails, etc. During the day this plankton may move down to about 180 fathoms, to come to the surface at night. It may well be that lack of food during the day makes the turtles inactive and they just float around, and that at night they become more active when the food supply comes to the surface. This may explain why so often large numbers of turtles are seen floating idly on the surface. One observation of large numbers of turtles actively swimming in one direction suggests that they were migrating to or from the nesting beaches.

"Further observations on such aggregations of turtles would be welcome, especially if some kind of description (size, colour) of the turtle can be given, together with information about their behaviour (drifting or swimming and in which direction). From talks I had with ships' officers, turtles seem to be so common in the eastern Pacific that the observations are not recorded and this is to be regretted because much valuable information becomes lost in this way."

TURTLES

North Atlantic Ocean

m.v. *Salamanca*. Captain D. Houghton. London to Kingston (Jamaica). Observers, Mr. P. Creber, 2nd Officer and Mr. M. Neal, 3rd Officer.

10th April 1967. Between 1100 and 1300 GMT about seven or eight turtles were seen. The largest was about 12 inches long (length of shell) and the smallest 8 inches;

some seemed to be an orange-red colour while others were grey-green. Sea temp. 66°F. No wind.

Position of ship at 1200: 37° 12'N, 30° 18'W.

Note. Dr. L. D. Brongersma comments:

"The orange-red turtles were without any doubt Loggerheads (*Caretta caretta*). Judging by the colour, the grey-green turtles may have been Kemp's Ridleys (*Lepidochelys kempi*), a species that breeds on the western shore of the Gulf of Mexico, and specimens of which wander through the Florida Strait into the Atlantic Ocean. It has been found along the east coast of North America northwards to Nova Scotia, but also in the eastern Atlantic in British, Irish, and Dutch waters, as well as in the Azores and near Madeira. Therefore, it is to be expected that occasionally Kemp's Ridleys will be observed in the open ocean. However, there is one snag. From personal experience (in the waters north of the Azores) I know that some Loggerheads have the shell covered with a film of fine, green algae, and this may give them a greyish or greenish appearance. Thus, although the grey-green colour mentioned in the report would point to these turtles being Kemp's Ridleys the possibility cannot be excluded altogether that they may have been Loggerheads with a covering of algae.

"Very little is known about the growth of Loggerheads and nothing about that of Kemp's Ridleys. Loggerheads with the shell 8 inches long may have been between 1 and 1½ years old; those with the shell 12 inches long may have been about 2 years old.

"The record is of especial interest as it is from a part of the ocean from which no previous records are known to me."

South of Cape Race

m.v. *Cretic.* Captain V. H. Vizer. Montreal to English Channel. Observers, Mr. M. Lindsay, Chief Officer and Mr. M. D. Williams, 4th Officer.

10th June 1967. A turtle was seen swimming with the ship for about 2 min at 0920 GMT. It had a pale yellow shell with olive-green markings and a white neck. The length overall was judged to be about 18 inches. Such a sighting is thought to be rather remarkable in these waters. Wind SSE, force 4, waves, 2–3 ft high. Sea temp. 48°F.

Position of ship: 45° 49'N, 53° 09'W.

Note. Dr. L. D. Brongersma comments:

"The information about a turtle sighted in 45° 49'N, 53° 09'W is of great interest as turtle records from the area are very scarce. I am afraid that I cannot give a definite opinion upon the species that was observed. Recent experience has shown me that the Loggerhead (*Caretta caretta*), of which the young and half-grown are usually reddish-brown, may appear to be pale yellow under certain circumstances. Judging by what is known about the occurrence of turtles in northern waters it is most likely that the observed turtle was a young Loggerhead, with Kemp's Ridley (*Lepidochelys kempi*) as a second possibility."

ABNORMAL REFRACTION

off Mallorca

s.s. *Esso Westminster.* Captain J. G. Ridley. Leghorn to Hamburg. Observer, Mr. P. Q. Rees, 3rd Officer.

1st April 1967. At 0740 GMT an inverted image of the town of Puerto Petro was observed below the horizon line. It was seen immediately after leaving a heavy shower and passing into an area of bright sunlight and excellent visibility. By 0745 the mirage had completely disappeared. The cloud in the shower area consisted of large Cu and Sc; in the clear area there were small Cu. Air temp. 47°F, sea 56°. Wind NE, force 3–4.

Position of ship: 39° 08'N, 3° 30'E.

Note. When the sea is warmer than the air, as in the present case, the air at and near to the surface becomes warmer than the air higher up and therefore optically less refracting. In such circumstances a ray of light from a distant object—in this instance the town—tends to follow a path which takes it at first downwards towards the surface. It then diverges away from the surface, the change of direction of the light ray giving rise to the inverted image seen below the horizon line. The effect is analogous to that produced by the lens in a camera when it throws an inverted image on the film.

Santa Barbara Channel

s.s. *Pacific Reliance.* Captain C. G. Killick. Balboa to Los Angeles. Observers, Mr. C. Townsley, 2nd Officer and Mr. M. Cory, 3rd Officer.

15th May 1967. When the vessel was between 15 and 18 miles off Concepcion Point at about 0830 GMT, on a course of 285°, the light on the Point appeared to be double, the refracted image being approximately 12′ of arc above the true light. A number of other lights on shore showed the same peculiarity. An apartment block was observed through binoculars to have an inverted image above it and all white lights appeared to be either bright green or orange. Air temp. 61·5°F, wet bulb 54·5°, sea 60°. Wind N'ly, force 1–2.

By 0940 GMT all lights were the normal colour again. Air temp. now 57·0°, wet bulb 54·0°. Wind NW, force 3. Earlier, Anacapa Light (277 ft) was observed at a distance of 35 miles.

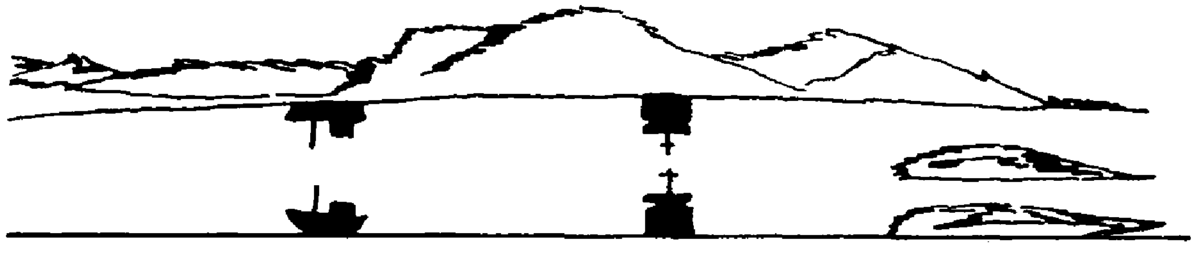
Position of ship at 0940: 34° 21′N, 120° 28′W.

Pentland Firth

m.v. *Sagamore.* Captain W. F. Swann. Ijmuiden to Seven Islands. Observers, Mr. W. P. K. Basham, Chief Officer and Mr. J. Currie, 3rd Officer.

13th June 1967. During the afternoon, while passing through the Pentland Firth, abnormal refraction was observed, causing a variety of images to be seen, an example of which is shown in the accompanying sketch. Smoke from the funnels of nearby trawlers rose to a height of about 50 ft above the sea and then flattened out into horizontal lines. Air temp. 55°F, wet bulb 53·5°, sea 53·5°.

Position of ship at 1800: 58° 42′N, 3° 10′W.



Note. At noon on the 13th an anticyclone covered the British Isles and adjacent sea areas. In this situation it is normal to find that the air temperature in the lowest layers of the atmosphere increases with height or, in other words, there is an inversion of temperature. The presence of the smoke layer is a visual indication that an inversion existed up to the estimated height of about 50 ft. When the sea is colder than the air, conditions are favourable for the type of mirage shown in the sketch. The rays of light from the distant vessel followed at first a shallow upward curve away from the surface and afterwards a shallow downward path to the observers' eyes. The variations in the curvature of the light rays caused their paths to cross, thereby producing the inverted image.

The double light seen on Concepcion Point and the inverted image of the apartment block seen by the observers aboard s.s. *Pacific Reliance* are due to generally similar causes. The change in colour of the lights from the normal white to green and red is due to the absorption and refraction of the white light on its way through the atmosphere. As a result only the green and red rays are left.

approaching Belle Isle

m.v. *Sagamore*. Captain W. F. Swann. Ijmuiden to Seven Islands. Observer, Mr J. Currie, 3rd Officer.

21st June 1967. At 0100 GMT when the vessel was 50 miles from Belle Isle, the North-East Point light was seen with the naked eye. The normal range of this light is 17 miles. The sky was cloudless and visibility excellent. Air temp. 38°F, wet bulb 37·5°, sea 38°. Although all the temperature readings were nearly the same no fog was encountered during the approach to, or passage through the Belle Isle Strait.

Position of ship at 0000: 52° 42'N, 53° 36'W.

Note. On the 21st June a large anticyclone covered Eastern Canada and the adjacent Western North Atlantic. In such circumstances an inversion of temperature may be expected, i.e. the air temperature over the region increases with height throughout the first few hundred feet above the surface, the air being warmer than the sea. This is a situation in which objects become visible at unusually great distances since the rays of light from them tend to follow the earth's curvature instead of diverging from it, as is more commonly the case.

No fog was encountered because the sea temperature was sufficiently high to prevent the air from cooling to its dew-point.

MOON—ABNORMAL REFRACTION

off Guinea

m.v. *Cape Howe*. Captain A. McLeod. Glasgow to Monrovia. Observers, the Master and Mr. J. Purdon, 3rd Officer.

13th April 1967. At 2130 GMT, the moon (age 4 days) appeared to have two crescents. The real crescent was bright while the false one was dull and lay just above it. This abnormal appearance persisted for 7 min. No cloud was visible but there was a halo round the moon. A light dust haze restricted visibility to about 10 miles. Air temp. 72°F, wet bulb 70°. Wind NNW, force 3.

Position of ship: 10° 38'N, 16° 52'W.

Note. A rather similar report was published in *The Marine Observer*, January 1967. When rays of light from the moon pass through layers of temperature discontinuity the effects of refraction produce one or more images of the crescent.

VENUS—COLOUR CHANGES

off S.W. Africa

m.v. *City of Glasgow*. Captain R. K. Walker. United Kingdom to Cape Town. Observer, Mr. M. Allen, Jnr. 2nd Officer.

15th June 1967. On a cloudless night, at about 1925 GMT, Venus was observed setting. At an altitude of approximately 5° the colour began to alternate between red and green, the intensity becoming greater as the elevation of the planet decreased. At the moment of setting there was a vivid green flash in the shape of a triangle. Visibility was extremely good, hills only 300 ft high having been seen during the morning at a distance of 40 miles, when the vessel was 50 miles south of Lüderitz Bay. Air temp. 58°F, wet bulb 55°, sea 59°. Wind SE, force 2.

Position of ship: 30° 00'S, 16° 00'E.

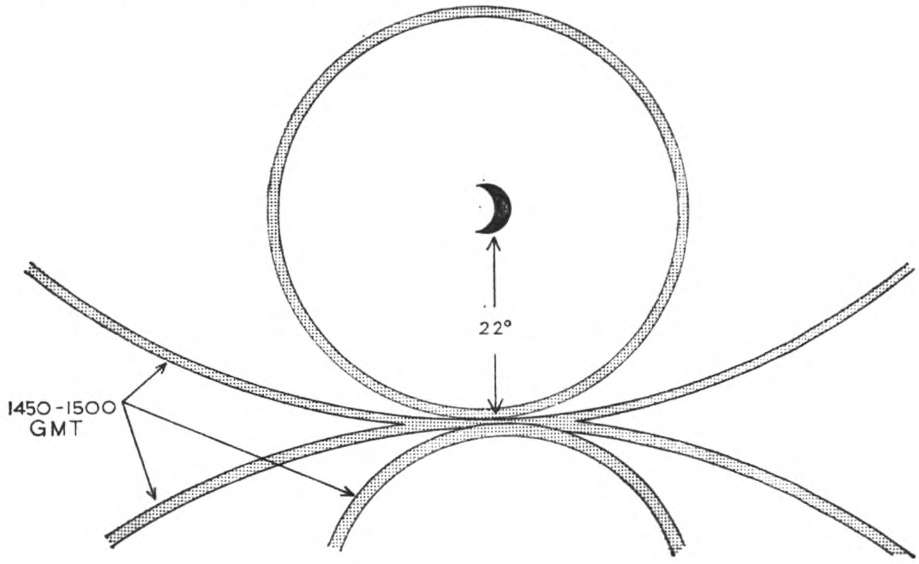
Note. The alternation in colour between red and green as Venus approaches the horizon is a well-known occurrence. The rays of white light from the planet have an increasingly long distance to traverse through the atmosphere as the elevation decreases, reaching a maximum at the moment of setting. The light is absorbed and scattered and only the red and blue-green rays are left, the green being above the red and therefore the last colour to be seen as the planet passes below the horizon.

LUNAR HALO COMPLEX
New Zealand waters

m.v. *Koraki*. Captain H. C. Townend. Tauranga to Melbourne. Observer, Mr. M. J. C. Orr, 2nd Officer.

28th May 1967. The 22° halo was first seen at 1415 GMT when the moon was at an approximate altitude of 60° and bore 090°. At 1450 the tangential arcs appeared, weak at first but gradually gaining in intensity in the next 10 min. The complex, shown in the accompanying diagram, remained visible for about 20 min, after which time only the 22° halo was seen. A thin layer of Cs to As was present and also some Cu. Air temp. 61·7°F, wet bulb 58·8°, sea 61·5°. Wind, light airs.

Position of ship: 34° 34′S, 171° 42′E.



Note. We are pleased to publish this interesting observation from a New Zealand Selected Ship.

ABNORMAL RADIO RECEPTION
off Freetown

m.v. *Welsh Herald*. Captain A. C. H. Allerston. Monrovia to Glasgow. Observers, the Master, Mr. K. G. Horrocks, Radio Officer and Mr. C. C. Davidson, 3rd Officer.

12th April 1967. At 2100 GMT the Dakar pilots were heard very clearly on VHF at a distance of 380 miles, on a Marconi 'Argonaut' set, the normal range of which is 25 miles. After watch, Radio Caroline also was clearly heard on the medium wave band. Visibility over 30 miles. No low cloud.

Position of ship: 8° 50′N, 15° 10′W.

GREEN FLASH
North Atlantic Ocean

m.v. *Crystal Gem*. Captain D. Patrickson. London to Belize. Observers, the Master and Mr. W. Cowan, Chief Officer.

23rd June 1967. At sunset, three narrow bands of cloud lay across the sun's disc. As the upper limb of the sun sank past the upper edge of each band there was a distinct pale emerald-green flash and, finally, a brilliant green flash as the top of the sun's disc disappeared below the horizon. Each of the four flashes was separate and distinct. Air temp. 70°F, wet bulb 62·2°.

Position of ship: 35° 26′N, 39° 26′W.

Note. The green flash is caused by the unequal refraction of light of different colours when the sun's elevation is very low. Green, blue and violet fringes occur on the upper limb and red on the lower limb. The fringes of light on the upper limb cannot normally be seen, due to the intensity of the sunlight, until the greater part of the disc has passed below the horizon, or, as in the present case, has been partially obscured by cloud banks.

AURORA

The following notes have been received from Mrs. Mary Hallissey of the Aurora Survey:

"From the Balfour Stewart Auroral Laboratory in the University of Edinburgh we acknowledge with thanks the auroral observations made in British ships, as listed below, for the period April–June 1967.

"The outstandingly active period of these months, in fact of the whole year, started around midday U.T. on 25th May, reached a peak around midnight of 25th–26th May, but continued at a fairly high level until the end of the month.

"On 25th–26th May coronal forms were overhead in central England and Washington, D.C., and at similar latitudes over the Atlantic (well illustrated by a detailed sketch from an observer in m.v. *Sagamore*). m.v. *Redcar* reported that all short-wave frequencies were unsuitable for reception from distant stations throughout the night. Observations were made in a Dutch ship in latitude 31° in western Atlantic.

"From m.v. *Port Pirie* we had a welcome report of the same display from the southern hemisphere, describing a red glow seen from a position in the Australian Bight. Red colouration was also reported by some northern observers; this is characteristic of large-scale displays and has been seen very infrequently since the last solar maximum. Due to the extensive coverage, a comprehensive report of the display was of value in the analysis of the cosmic event and VLF emissions which was prepared in Norway."

DATE (1967)	SHIP	GEOGRAPHIC POSITION	Λ	Φ	I	TIME (GMT)	FORMS
9th Apr.	*Weather Adviser*	60°30'N 29°34'W	060	69	+75	0150	V
22nd	*Weather Adviser*	62°09'N 32°42'W	060	70	+76	0450–0530	N
24th	*Weather Reporter*	59°02'N 19°18'W	070	65	+72	0220–0315	RA
1st May	*Weather Adviser*	62°10'N 32°59'W	060	70	+76	0250–0315	RB, RR
2nd	*Weather Monitor*	58°00'N 15°25'W	070	63	+72	0100–0300	N
3rd	*Weather Adviser*	62°09'N 33°17'W	060	70	+76	0100–0400	HB, RB, RA, P
	Weather Reporter	58°56'N 19°10'W	070	65	+72	2345–0001	HA
4th	*Weather Adviser*	61°10'N 29°30'W	060	69	+75	0100	N
	Weather Monitor	61°20'N 29°40'W	060	69	+75	0245–0310	RA, RB
5th	*Weather Monitor*	61°55'N 32°50'W	060	70	+76	0100–0120	HA, RB
8th	*Weather Reporter*	58°50'N 19°32'W	070	65	+72	0300	P
25th	*Redcar*	47°00'N 45°00'W	030	57	+70	sunset–sunrise	RA, RR
	Port Pirie	35°28'S 125°56'E	200	−47	−68	2300–2330	N
	Media	Off S. Ireland	080	56	+67	2325–2355	RB, RR
	Romanic	48°06'N 05°14'W	080	52	+65	2345–0001	P
26th	*Sagamore*	46°44'N 47°16'W	030	57	+71	0015–0230	HA, RR

KEY: Λ = geomagnetic longitude; Φ = geomagnetic latitude; I = inclination; HA = homogeneous arc; HB = homogeneous band; RA = rayed arc; RB = rayed band; R(R) = ray(s); P = patch; V = veil; N = unidentified auroral form.

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Canada's New Weather Ships—the World's Most Modern

(This article has been specially provided for *The Marine Observer* by the Department of Transport, Canada, through the courtesy of Mr. Gordon W. Stead, Assistant Deputy Minister, Marine.)

Streaking through the sky, 30,000 feet above the Pacific Ocean and far above a floor of sun-swept cloud, a jet liner heads for Japan.

A crew member works with quiet concentration at his instruments and notes with satisfaction that the aircraft is right on course. He has just checked the data received from Ocean Station 'Papa', 860 n. miles out at sea west of Vancouver.

The station, a storm-ravaged 10-mile-square of ocean, presents a picture quite different from that in the jet's serene crew compartment. One of the Canadian Coast Guard's new weather ships—she could be either CCGS *Vancouver* or CCGS *Quadra*—is slowly bucking against a howling gale, trying to maintain the position from which she serves as a navigational check-point for other shipping and for trans-Pacific aviation. Aboard her, scientists and technicians, all well schooled to working in what is regarded as one of the world's worst weather areas, are going about their tasks just as though they were snug ashore, sending out an almost endless flow of weather, navigational and oceanographic data to a waiting world.

The two weather ships operate from the Canadian Department of Transport's district marine base at Victoria, British Columbia. They were specifically designed for the highly-specialized tasks they perform (*see* photograph opposite page 76). Built at a total cost of nearly $24 million, they are fitted with the most modern instrumentation. They are equipped with the patent McMullen Flume-type anti-rolling system and bow-jet steering for control at low speeds and are designed on the basis of extensive model tests, to provide a stable working platform for scientific research.[1]

The vessel's hulls are of welded steel construction and the superstructures are of aluminium. Much attention was given in the planning to the elimination of vibration that might affect delicate instruments. As a result, the ships are twin-screw, steam turbo-electric powered. The superstructures were designed so as to minimize abnormal wind turbulence that would adversely affect the operation of weather recording equipment.

The ships were designed by G. T. R. Campbell and Company, naval architects, of Montreal, to the requirements of and supervised by the Department of Transport Shipbuilding Branch, the Meteorological Branch and the Telecommunications and Electronics Branch. Also consulted in the planning were the Department of Energy, Mines and Resources, and the Pacific Oceanographic Group of the Fisheries Research Board of Canada at Nanaimo, B.C., in view of their interests in the fields of hydrography and oceanography.

They were built at the yard of Burrard Dry Dock Co. Ltd., North Vancouver, *Vancouver* entering service in April 1967 and *Quadra* in October. They replaced the old Canadian Coast Guard weather ships, two ex-frigates, CCGS *St. Catharines* and CCGS *Stonetown* and the old standby ship, *St. Stephen.*

CCGS *Vancouver* and CCGS *Quadra* are the largest ships in the Canadian Coast Guard fleet, being 404 feet 3 inches long overall and 50 feet in breadth. They have a loaded displacement of 5,605 tons, a range at 14 knots of 8,400 n. miles plus 2,000 miles reserve, and a top speed of 18 knots. The last-mentioned statistic becomes important when the ships are called upon, as are all Canadian Coast Guard vessels, to take part in search and rescue operations.

Each vessel is at sea for a period of seven weeks, comprised of one week sailing to and from station and six weeks on station.

In each ship the propulsion machinery consists of two oil-fired 'D'-type water-tube boilers supplying steam to two turbo-propulsion alternators, each of 2,900 kW. These in turn supply alternating current to two propulsion motors, each developing 3,750 s.h.p. through two propellers turning at 185 r.p.m. Operation of the machinery is from a common control room and remote-control stations located in the wheel-house and on the bridge wings.

Each ship normally has a maximum complement of 100. These include: 6 meteorological staff, under a chief meteorological officer; 11 telecommunications staff, under a chief telecommunications officer; and 2 to 5 oceanographers—depending on the availability of personnel, under a chief oceanographer.

The vessels are equipped with helicopter-landing platforms, from which helicopters, to be attached to the ships in the future, will be able to operate in a variety of scientific undertakings that are now in the planning stages.

Practically all members have single accommodation, senior officers having attached bathrooms. Unlicensed personnel each have a desk, table, table lamp and berth in their cabins.

The ships are equipped with officer's and petty officer's lounges, a recreational room, a cinema and a hobby shop. Recreation and hobbies consist of movies twice a week, woodworking, leather work, the weaving of rugs, ship modelling and other crafts. Some of the crew members paint, others study and the Victoria Public Library supplies a large number of books. Many a thesis has been written on the weather ships by budding oceanographic students. Card playing is quite popular.

Unusual appearance

Most notable feature of the ships, to the casual observer, is the great radar dome towering high above each. The dome houses a new type of balloon-tracking radar capable of automatically tracking meteorological balloons up to a height of 100,000 feet, of detecting storms as far away as 200 n. miles and of keeping track of aircraft within a radius of 200 miles.

For many years, meteorological information has been collected on a volunteer basis by merchant ships travelling the world's sea lanes and reported to meteorological stations ashore for use in preparing forecasts. Events of World War II and the rapid development of international aviation routes after the war made it apparent that a more precise source of such information was needed, in addition to that provided by the merchant ships. In particular, aircraft need upper-air data, which are of importance to high altitude operations.

Canada was committed as a member of the International Civil Aviation Organization (ICAO) to operate jointly with the United States one station on the Atlantic Ocean and one station on the Pacific Ocean. Between 1947 and 1950 Canada operated one vessel on an alternating basis on Station 'Baker' on the north Atlantic. This arrangement was not very satisfactory economically and, as a result, Canada took over the complete operation of Station 'Papa' on the north Pacific in lieu of her previous commitment. The weather ships (ex Royal Canadian Naval frigates) *Stonetown* and *St. Catharines* were put into service on Station 'Papa' commencing 1st December 1950.

These ships continued to man the station, located at 50°N, 145°W, until they were replaced by CCGS *Vancouver* and CCGS *Quadra*.

Surface Weather Programme

Both of the new ships are manned and instrumented for 3-hourly surface meteorological observations and 6-hourly upper-air soundings. Three anemometers are available for measuring the surface wind. Two of these are located at either end of the catwalk atop the forward mast. These sites provide excellent exposure for apparent winds less than about 140° off either bow. The readings of the windward anemometer are, of course, used in practice. The third anemometer, mounted on a mast over the helicopter hangar aft, is used only on the relatively infrequent occasions when the apparent wind is less than about 40° from the stern.

Each anemometer has its own direction and speed readouts in the meteorological office, with repeaters in the wheel-house and oceanographic laboratories. The pressure instruments consist of two precision aneroid barometers, a marine mercury barometer, and a three-day marine barograph. The mercury barometer serves as a standard instrument against which the operational aneroids can be compared. One of the aneroids is selected as the 'official' barometer for each patrol. The sling psychrometer is the standard temperature measuring device on all Canadian voluntary observing ships and it is also used on the new Ocean Weather Ships for the official observations.

Four Stevenson screens are mounted on the wheelhouse top for comparison and experimental purposes. The official sea-surface temperatures are measured by means of the standard rubber sea-temperature bucket, although a 'Rustrak' sea-temperature recorder is also available. The sensing element of this recorder is located in a loop about 12 feet below the water-line. After two patrols of CCGS *Vancouver*, the greatest difference between bucket and recorder readings has been only 0·4 degC.

A cloud searchlight and alidade system measures the cloud height for night observations, but the necessarily short baseline precludes accurate measurements above about 1,000 feet. In daylight, the cloud height for the 1800 and 0000 GMT observations is determined by timing the ascent of the rawinsonde balloon.

Each ship is equipped with the British National Institute of Oceanography's Muirhead wave recorder. This permanent sophisticated piece of hardware has taken much of the estimation out of determining wave heights and periods.

There can still be a bit of occasional estimation, however, as the crew of CCGS *Quadra* found out during a hurricane on 1st December 1967. The needle on the wind velocity was forced beyond the highest marked limit, 100 m.p.h., and the wave recorder indicator went past its highest marked limit, 60 feet, during the storm.

Investigations into the best method of measuring rainfall on board ship have interested several nations, including Canada, in the past. The new weather ships carry four rain-gauges mounted in different locations aboard the ship to test the effect of various exposures on the amount of rainfall caught. Two gauges are located high on the catwalk atop the forward mast, the catch of one gauge being collected through a plastic tube in a container at deck level. Other gauges are mounted on the boat deck forward and on the helicopter hangar top.

Since Station 'Papa' has been occupied by Canadian ocean weather ships, except for a few very short periods, since 1st December 1950, a few words on various aspects of the weather at this point in the north-eastern Pacific Ocean over the past 17 years may be of interest. The warmest month, which is not really very warm, seems to be August with a mean temperature of 55·8°F, followed closely by September with 55·6°. The coolest month appears to be March (40·5°), followed by February (41·2°), January and April (each 41·5°). Temperatures rarely exceed 60° (only 0.3 per cent of all observations) or fall below 32° (0·2 per cent of all observations).

Wind speeds average 20 knots or more from October through March, November having the highest average wind speed of 25 knots. The highest sustained wind speed on record was the 100 m.p.h. reading already mentioned. Although a month-by-month analysis of wave heights has not yet been worked out, high waves, in excess of 20 feet, are infrequent, occurring on the average of only 3·4 per cent of the observations in the course of a year. Low visibilities of less than 2 n. miles seem to occur most frequently in August (about 28 per cent of the observations) and least frequently in October (about 2 per cent of the observations).

(Opposite page 76)

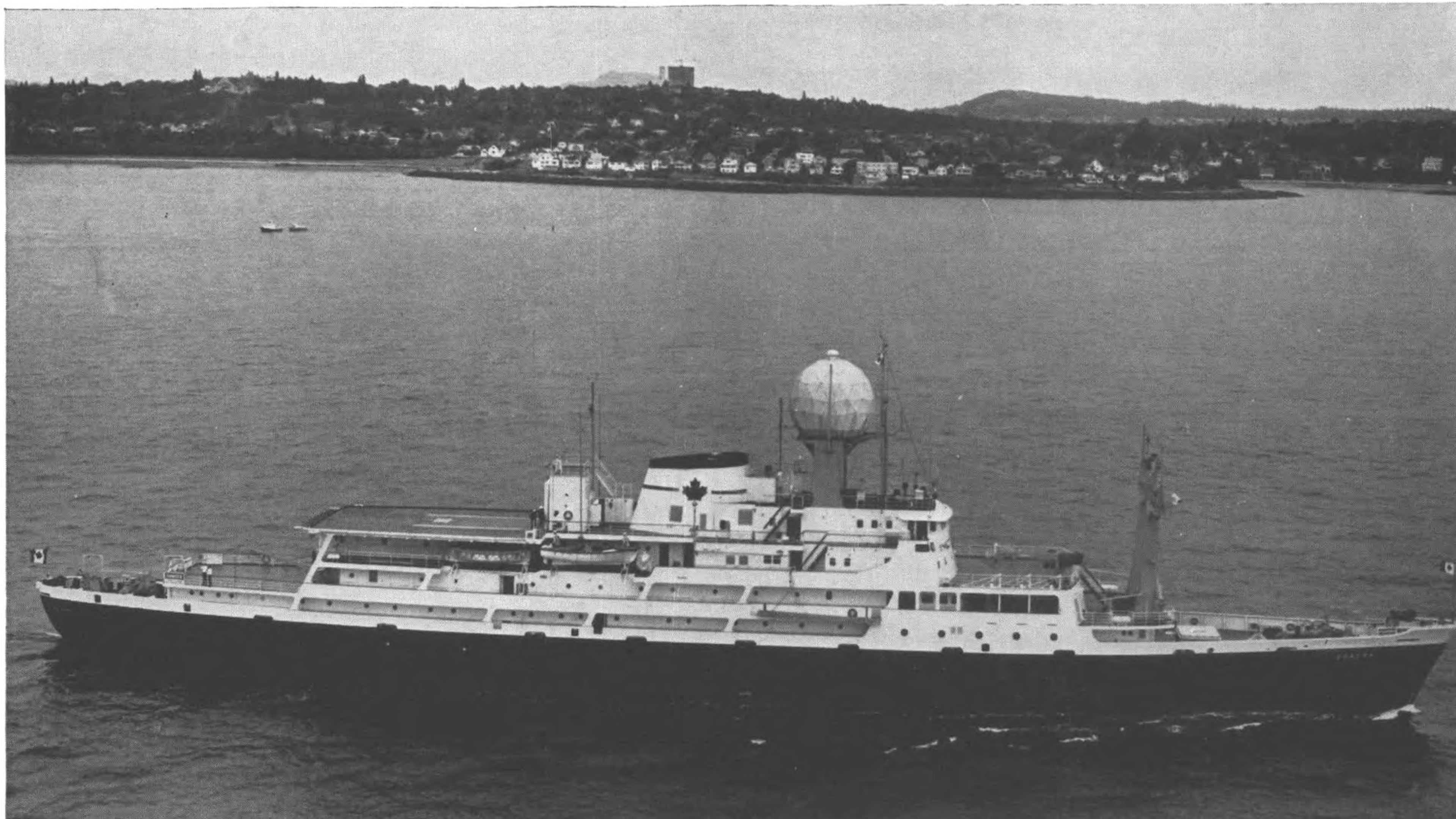

Photo by courtesy of the Department of Transport, Canada

CCGS *Quadra*, one of the new Canadian Weather Ships (*see* page 74).

(*Opposite page 77*)

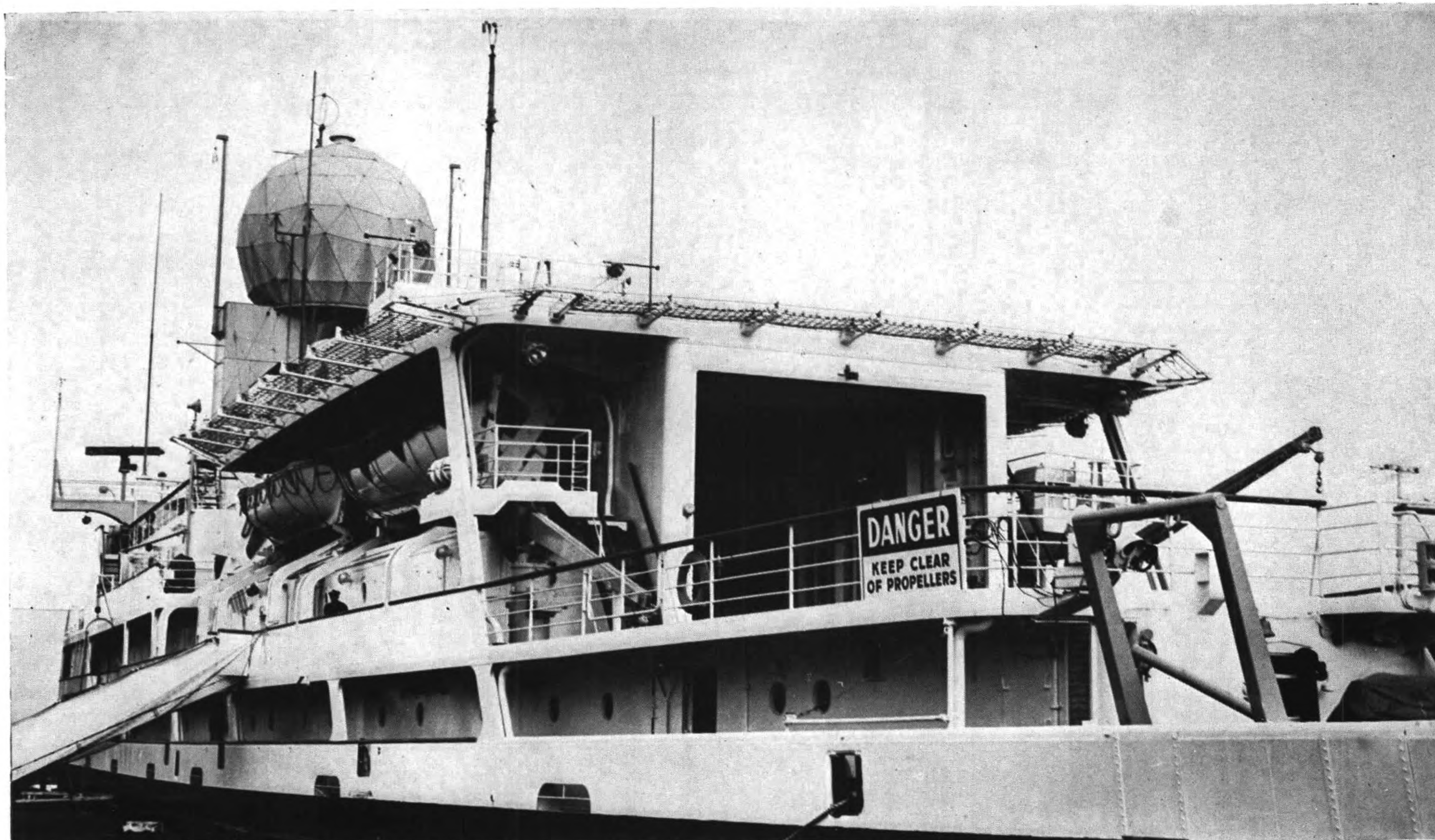

Photo by courtesy of the Department of Transport, Canada

The meteorological balloon shelter on board the new Canadian Weather Ship CCGS *Vancouver* (*see* page 77).

Upper Air Programme

CCGS *Vancouver* and CCGS *Quadra* have the most modern facilities for a complete programme of upper-air observations.

A balloon-inflation shelter has been designed to accommodate aerological balloons which are capable of reaching an altitude of 100,000 feet or higher. When inflated with helium these balloons measure 8 feet in horizontal diameter and attain a height of 12 feet. The balloon-inflation shelter and release deck comprise an appreciable portion of the ship's operational facilities (*see* photograph opposite page 77). Each ship carries around 200 cylinders (57,000 cu. ft) of helium gas. These are stowed below decks and connected by a manifold system in order that a supply of gas will always be available through a reduction valve in the balloon-inflation shelter.

Four upper-air or rawinsonde ascents are made daily at regular 6-hour intervals. The balloon carries aloft a radiosonde instrument which measures the temperature, pressure and relative humidity of the air and transmits this information by radio transmitter to a ground receiver.

The balloon also carries aloft a special target which is followed by a stabilized radar system to obtain speed and direction of the winds at any desired altitudes. The balloon rises until it bursts, usually at a height of about 100,000 feet, thus terminating the upper-air sounding. No effort is made to recover the airborne equipment, which falls into the sea a hundred miles or so away from the ship, depending upon the velocity of the upper winds.

It was decided not to make any major changes in the radio ground-receiving equipment for the new weather ships since the existing receptor units were functioning quite satisfactorily. The frequency of transmission is 107 mc/s with provision for switching to any one of four dipole antennae situated at strategic locations to obtain a clear signal path from the airborne radiosonde. The signals are received as variations in audio frequency from 0 to 200 c/s and are printed out automatically on a recorder chart.

Each ship carries a complete dual set of ground-receiving equipment with additional component spare parts to minimize the possibility of a missing observation due to equipment failure.

Special Radar Unit

The balloon-tracking radar on these new ships is perhaps the most advanced equipment of this type in the world. It was designed and engineered by the Sperry Gyroscope Co. of New York and is designated as 'Wind Finding Radar SP6504'. The antenna itself is housed in a spherical plastic shelter comprising the highest component of the ship.

The radar is capable of automatically tracking the balloon and computing the wind directions and speeds every six seconds with a print-out of time, slant range, azimuth, elevation, target height, wind direction and wind speed. It is necessarily completely stabilized with regard to the ship's motions. In addition to the wind-finding functions, it is capable of weather surveillance operation, thus considerably enhancing the surface weather observations with the weather radar reports (*see* photograph opposite page 92).

The meteorological complements on each of the new weather ships have been increased to six men, in order that the improved facilities could be utilized to the fullest extent. The official daily meteorological programme has accordingly been expanded to include:

(*a*) four complete upper-air observations at 0000, 0600, 1200 and 1800 GMT;
(*b*) four main surface synoptic reports at 0000, 0600, 1200 and 1800 GMT;
(*c*) four intermediate surface synoptic reports at 0300, 0900, 1500 and 2100 GMT;
(*d*) four weather radar (SD) reports at 0300, 0900, 1500 and 2100 GMT.

Atmospheric Radiation Measurements

Measurements of atmospheric radiation have been made for some time aboard the ships maintaining Ocean Station 'Papa'. However, with the introduction of the new ships, a somewhat more elaborate installation of radiation sensors has been devised. The short-wave radiation of the sun (about 0·2 to 4 microns wave-length) is registered by an instrument called a Kipp solarimeter which is located at about 85 feet above the water-line on a platform on the ship's foremast. The instrument is provided with a gimballed mounting.

A new feature of these ships is the addition of instruments to measure the net flux of the short-wave solar radiation and the long-wave radiation from the sea surface (4 to about 100 microns wave-length). When in use these instruments, called net pyrradiometers, are suspended over the sea on the end of 6-foot booms, one on either side of the ship at a height of about 24 feet above the water-line. In each instrument one of a pair of thermopiles faces downward to receive the long-wave radiation from the sea surface and the other faces upward to the sky. A specially-designed universal joint fitting is used to carry the instrument at the boom end in order to overcome the effect of the ship's movements. In rough weather the booms are hinged inboard and lashed down on the promenade deck.

Each of the three radiation instruments transmits its data to a separate chart recorder where they appear as a continuous pen trace. In addition each recorder is fitted with an integration and print-out device which prints the digital equivalent of the summation of the chart record at one-hour intervals on a paper tape.

Oceanographic Studies

In the realm of oceanography, the weather-oceanographic vessels are making an increasingly important contribution, the most extensive series of observations to date having been made at Station 'Papa'. *Vancouver* and *Quadra* are fitted with the latest types of equipment available, housed in spacious laboratory areas. The physical oceanographic studies are concerned with the variability of properties in the ocean, its thermal structure, internal wave action, large-scale air-sea interaction and related subjects. It has been found that, far from being a scientifically uninteresting area, the north-east Pacific Ocean undergoes physical processes upon which science has just begun to touch.

Every seven weeks two oceanographic technicians conduct studies along 'Line P', the route from the weather ship's Victoria base to Station 'Papa'. The physical and chemical properties and structure of the water are observed as serial depths to 400, 1,200 and 4,000 metres depths in sequence, at 12 stations.

On station, daily observations are made: temperature, salinity (water bottle salinometer), dissolved oxygen (Winkler) phosphates and silicates (DU photocolorimeter) from 0 to 400 metres (twice weekly); 0 to 1,200 metres (twice); 0 to 4,000 metres (once); phytoplankton, chlorophyll-a, 48-hour productivity (three times) and zooplankton to 400 metres (three times).

During each seven-week patrol, samples of surface and deep water are taken for radioactivity, to be analysed at Scripps Institute, La Jolla, California. Once during each patrol, physical properties are observed in a series of stations in a square, 110 miles on each side, around Ocean Station 'Papa'. New equipment and procedures (expendable bathythermograph, electronic conductivity-temperature-depth devices, ocean buoys, etc.) are tested as required.

Both ships' companies observe a bathythermogram every four hours on Station 'Papa' and 'Line P', and report by radio to base.

Biological oceanographic studies have been under way since 1956, including studies governing the living resources of the north-eastern Pacific. Research concerning the relationship between the ocean's production of drifting microscopic plants (phytoplankton) and its production of fish are of major importance to the salmon fishery of the North American west coast, and to British Columbia in particular.

Investigators from the Pacific Oceanographic Group have been the biggest users of the data, but many scientists from other countries, in particular the United States, Japan and Russia, have examined it intensively. An important user in the United States has been the United States Naval Post-graduate School at Monterey, California.

Information compiled aboard the weather-oceanographic vessels is being utilized in the classrooms of many universities offering courses in oceanography in Canada, the U.S. and Japan. It also has been used as a basis, by some international bodies, to determine whether certain proposed studies should or should not be pursued, the experience gained at Station 'Papa' having provided a yardstick by which the possible magnitude of other such undertakings can be measured.

Using meteorological and oceanographic data collected during an 11-year period at Station 'Papa', a detailed study of the exchange of heat energy between the ocean and the atmosphere has been made. The various aspects of air-sea interaction are of vital importance to weather forecasting, both short and long range, to fisheries studies and to maritime defence, particularly in relation to anti-submarine warfare.

Research conducted aboard the weather-oceanographic ships has shown that the complex interactions between the factors that control biological production, such as sunlight, mixing processes, ocean currents and nutrient chemicals in the north-east Pacific are quite different from those in the Atlantic Ocean.

Aids to Navigation

Because the vessels are commonly referred to as 'weather ships', one of their most important functions, that of navigational aid to ships and aircraft, tends to be overlooked. They are fitted with Long Range Aid to Navigation (LORAN) equipment and thus can establish their own positions accurately at all times.

A 400-watt radio beacon transmits constantly, on medium frequency, a four-letter group indicating the station and its position, based on the grid system of two-letter co-ordinates. This facility enables any ship or aircraft fitted with direction-finding equipment to obtain a line of position with fairly high accuracy at ranges of several hundred miles. Ships and aircraft at closer range (14 miles for surface ships, 200 miles for aircraft) can, on request, be given their precise position by means of radar. On an average 'on station' patrol, more than 500 aircraft are furnished not only with their position, but also their true course and speed and weather conditions at their altitude.

The ships also serve as important communications relays between other vessels with less powerful radio equipment and shore radio stations.

Specifications for the impressive array of electronic equipment aboard the weather ships were drawn up by the Telecommunications and Electronics Branch of the Department of Transport and branch engineers and technicians attend to maintenance and operation.

Each vessel is equipped with facsimile radio-receiving equipment, by means of which weather maps can be received from the mainland. Each has a radio room and a communications and electronic equipment centre. The radio facilities include positive air-ground, ship-to-ship, and ship-to-shore equipment, each having a 1 kW transmitter capable of single side-band, double side-band and continuous wave (CW) operations.

There are additional automatic transmitters for air-ground and ship-to-ship communication.

On the bridge of each vessel are single side-band H/F radio telephones, VHF F.M. and VHF A.M. radio telephones. There is an automatic telephone exchange and an intercommunication system for within-ship use, backed up by a sound-power batteryless telephone system.

The navigational radar is remoted to the chart room, to provide simultaneous radar presentation on the bridge and in the chart room. High frequency direction-finding equipment is provided and is particularly useful in search and rescue work. The latter is also capable of medium-frequency operation, for navigation purposes.

There is a dual gyro installation on each ship for both navigation and for provision of stabilization information for the balloon-tracking radar. The ships also have electro-magnetic speed logs.

There are three sets of portable emergency communications equipment for use in lifeboats, as well as portable VHF F.M. radio-telephone units for use in workboats or otherwise as needed.

An amateur radio 'ham' room is provided on each vessel for the use of radio hobbyists among the crew and is equipped with a 1 kW single side-band transmitter.

There is one other crew activity that is a mixture of research and off-hours pleasure. They are provided with fishing equipment and, on bringing in a catch, they record the species, its stomach content and other information that is later passed on to fisheries research experts. They also keep a log of sightings of sea birds and marine animals such as whales, seals and dolphins. These records are also sent to appropriate government departments, to add to man's knowledge of the world around him.

REFERENCE

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551.509.313

Numerical Weather Prediction

BY F. H. BUSHBY, B.SC., A.R.C.S.

(Assistant Director (Forecasting Research), Meteorological Office)

Forecasting in most meteorological offices is done in two stages. The first stage is the prediction of the large-scale pressure patterns such as anticyclones and depressions. Before the advent of computers this was done by the application of knowledge gained from many years of experience, and the skilful use of a few qualitative rules based on a necessarily limited scientific approach. Nowadays, more and more National Meteorological Offices are using electronic computers to calculate forecast pressure fields by solving complicated sets of partial differential equations. The second stage in the preparation of a forecast is the inference of the weather from the predicted pressure patterns. This stage is still normally done by the forecaster, but more complicated mathematical models are being developed which will enable the calculations to be extended to forecast some aspects of weather, such as rainfall. A mathematical model can be defined as a set of equations which approximate to the behaviour of the atmosphere.

The first attempt at numerical forecasting was made by L. F. Richardson at the end of World War I. This was a remarkable feat, at least a generation before its time. It was doomed to failure because of inadequate data, lack of computing facilities and unsuitable finite difference schemes. However, a group at the National Center for Atmospheric Research, Boulder, Colorado is now developing a model based almost completely on Richardson's formulation of the problem, and this is a clear indication of his insight. After Richardson's ill-fated attempt, the subject lay dormant until it was revised by Professor J. G. Charney at the end of World War II. Since then, considerable research has been done in many countries, including our own.

The first computer used by the British Meteorological Office was LEO I, which was built by J. Lyons & Co. Research was subsequently carried out on two Ferranti computers at Manchester University, and eventually a Mercury computer was purchased by the Meteorological Office. This enabled the research effort to be stepped up and it became apparent that the numerical forecasting of isobaric charts, both at mean sea level and at upper levels in the atmosphere, would be of operational value. An English Electric KDF 9 computer (some 20 times faster than Mercury) was therefore purchased for the Office, and forecast charts are now produced twice daily for operational use.

In order to solve the very complicated mathematical equations which describe the behaviour of the atmosphere, it is necessary that they should be considerably simplified. Nowadays, with much faster and larger computers than hitherto, it is possible to represent the atmosphere more realistically than in the early days of numerical forecasting. Even with the fastest computers now available, many approximations still have to be made in order to complete the calculations in time to be of use to a forecaster.

One of the main approximations used in all the early models (except Richardson's) was the geostrophic approximation. This simplifies the problem because the wind at any stage of the forecast can be derived from the pressure field. Thus one has only to forecast changes in pressure, from which one can deduce changes in wind, instead of forecasting independently changes in both wind and pressure. Models which use this or similar approximations are known as 'quasi-geostrophic' models and their success is attributable to their ability to predict the behaviour of vorticity patterns moderately well.

Vorticity is a measure of the local spin of a fluid about an axis perpendicular to the motion. If the motion is horizontal, the only component of vorticity will be about a vertical axis. Vorticity is a difficult concept to be grasped by the layman and can best be demonstrated by considering a paddle-wheel with long arms floating with its axis vertical, in a current. Any spin of this wheel about its own axis is a measure of the vorticity of the current. If the current is flowing from west to east and the speed of the current is gradually decreasing from south to north, the paddle-wheel will float eastwards, but the southernmost arm will always be moving faster than the northernmost arm, thus causing the paddle-wheel to rotate. In the atmosphere, this effect is most marked on either side of a belt of strong winds. If the current is rotating about a fixed point with constant angular velocity, then the paddle-wheel will move in a circle back to its original position, but the arm furthest away from the centre of rotation will move faster than the arm nearest it, and the paddle-wheel will have rotated once about its own axis by the time it returns to its original position. This occurs in the atmosphere when the air is flowing round anticyclones, depressions, troughs and ridges, etc.

Vorticity about a vertical axis in the atmosphere can be expressed in terms of the horizontal variations of wind. Since the geostrophic approximation expresses the wind in terms of pressure, one can calculate the vorticity field from the pressure field. If one ignores the effect of horizontal variations of temperature, reasonable approximation is that the vorticity field is only changed by horizontal advection, i.e. the vorticity is blown into a new position by the wind. Thus, given a pressure field and making the above approximations, we can compute both the wind and vorticity fields, and calculate what the new vorticity field will be at some future instant of time. Given the new vorticity field, one has to solve a differential equation in order to obtain a new pressure pattern. If one is making a forecast, mathematical limitations impose a condition that one cannot proceed in steps of more than about ½ hour, so one has to repeat this process 48 times to produce a 24-hour forecast. A reasonable approximation to the behaviour of the large-scale pressure patterns at about 15,000 feet above m.s.l. can be obtained in this way and the first numerical forecasts were aimed solely at computing forecast pressure patterns at that level by this technique.

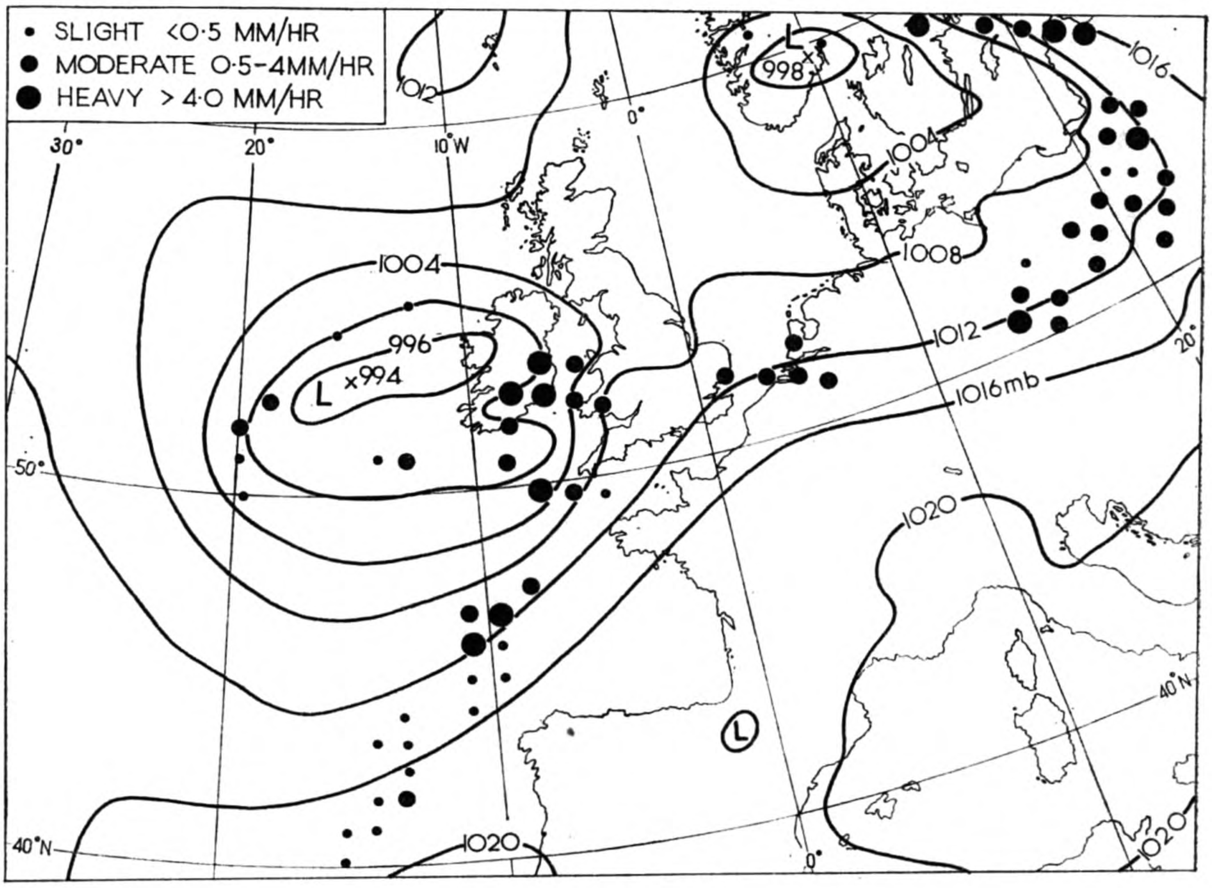

Fig. 1. The 24-hour forecast of rain pattern and surface isobars for 0000 GMT on 13th July 1965.

In practice it is convenient to use contour charts rather than isobaric charts. In this context a contour chart is one on which the lines join places where the height above m.s.l. of a given pressure surface is the same. The system of equations which has to be solved is more easily expressed in terms of contour heights than pressures.

The next development was the formulation of models which relate to more than one level in the atmosphere. In these multi-level models it is necessary to consider both interaction between the levels and thermal effects. The difference in height of two pressure surfaces, called the thickness of the intervening layer, is proportional to the mean temperature of that layer. In any multi-level model it is possible to write down equations which say how thicknesses will change because of advection, adiabatic cooling and heating, and non-adiabatic effects such as the warming of cold air masses over warm seas. In this way, thermal effects are included in the model. It is also possible to include other effects such as those due to mountains and friction. The model used for the operational forecasts at Bracknell is a three-level quasi-geostrophic model similar to that described above.

Current research at Bracknell makes use of a much more sophisticated mathematical model of the atmosphere, and the geostrophic approximation is no longer used. The presence of water vapour in the air is taken into account and the formation of clouds and rain are predicted. The latent heat effects of condensation and evaporation which are included in the new model are important factors connected with the deepening of depressions, and are likely to lead to improved predictions of the behaviour of the large-scale pressure systems.

The state of the atmosphere at any given time is represented by values of temperature, pressure, wind and humidity at points in a three-dimensional network. In order to deal with the relatively small-scale motions associated with rainfall it is

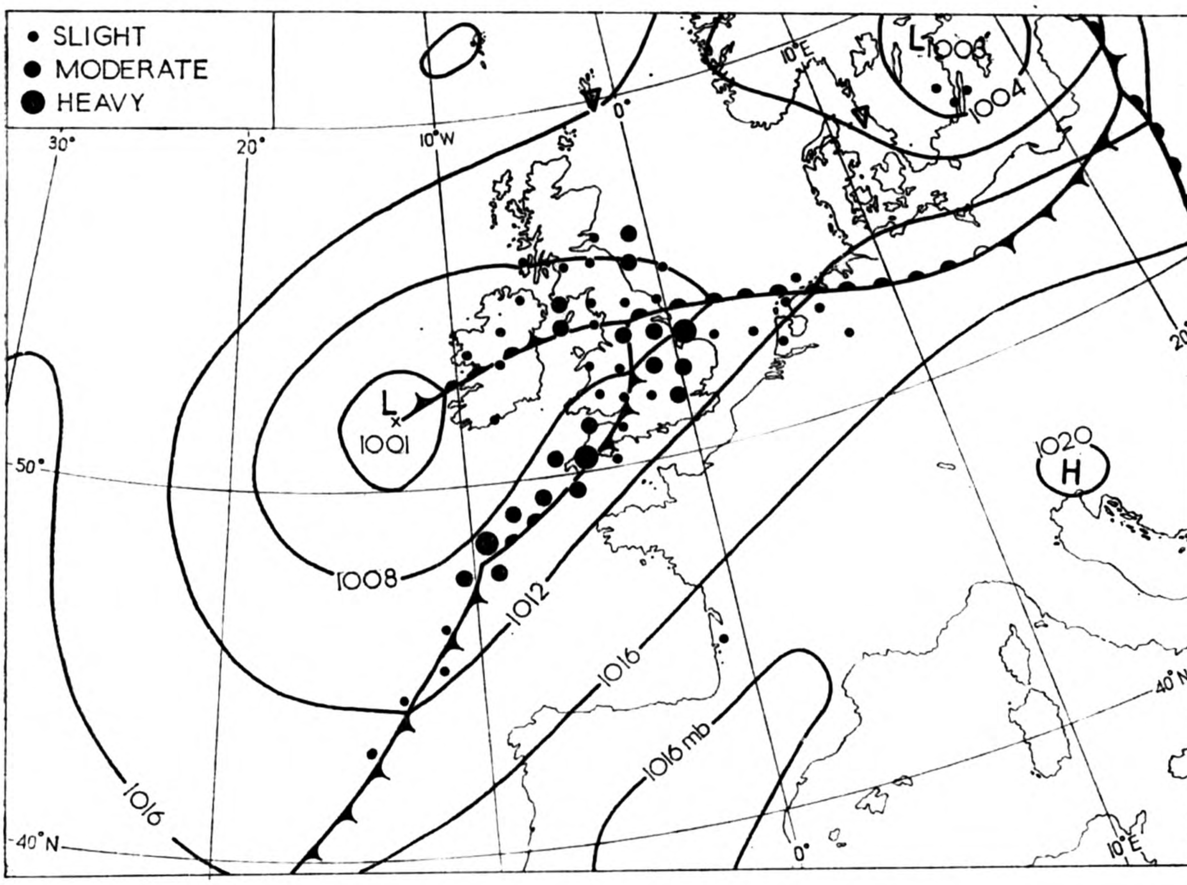

Fig. 2. The actual rain pattern and surface isobars at 0000 GMT on 13th July 1965.

necessary to use a much closer network of points than in the current operational model. Predictions are therefore made for hundreds of points about 25 miles apart. Similarly we use ten levels of altitude, about 4,000 feet apart, whereas the previous model used only three levels. The nature of the equations is such that we can only proceed in time steps of 90 seconds. Thus to produce a 24-hour forecast the equations have to be solved 960 times and a computer has to carry out six thousand million instructions. The calculations have been performed on the Science Research Council's Atlas computer at Chilton, one of the largest and fastest computers available in this country, but even so it takes 8 hours to produce a 24-hour forecast. This time does not include the initial processing of the data, nor its analysis to get the starting values of pressure, wind, temperature and humidity on our three-dimensional network of points. The amount of calculation is so great that it will not be possible to introduce this model into routine forecasting until a computer is available which is 20 to 30 times as fast as Atlas.

Fig. 1 shows an example of a 24-hour forecast of rainfall and the associated pressure pattern. The actual weather map is shown in Fig. 2 for comparison although the rainfall over the SW Approaches and the Bay of Biscay has had to be estimated in places where there were no ship observations. The results obtained so far show reasonable agreement between predicted and actual rainfall. However, it must be emphasized that this model is still in the research stage and much remains to be done before these latest models can be incorporated into routine daily use.

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North Sea Drilling Operations—Wind and Wave Problems*

By J. H. Brazell, M.Sc.
(formerly in charge of the London Weather Centre and now Assistant Director (Climatological Services), Meteorological Office)

At the London Weather Centre we have been forecasting the weather for oil and gas exploration in the North Sea for about two years. During this time we have been continually developing our service in the light of our experience, and as a result of consultation with the oil companies concerned. The forecasts which we issue for the operations cover all the weather elements, but I shall confine myself here to the two most important factors—wind and waves.

Wind-generated waves

We know that the action of the wind on the sea produces a train or group of waves of different amplitudes and periods, and that these waves travel along together at slightly different speeds. This means, of course, that they are continually getting into and out of step with each other, so that a train or group of waves presents some very large waves with some rather quieter water in between them. The factor which we are mainly concerned with is the height of the wave measured from trough to crest. Wave height depends on wind speed and, the fetch and duration of the wind. The effects of fetch and duration are interrelated, as in Fig. 1.

Suppose we have a stretch of calm sea bounded by the coastline A B. Let us assume that a wind with constant speed W and a constant direction—which is at right angles to the coastline—suddenly starts to blow over the whole sea area under consideration. At the point G_0 near the coast the waves run to leeward as soon as they are formed, i.e. the waves near the coast never increase in size. Consider the position near point G_1; the waves start with a size appropriate to the wind speed, but they run to leeward and are replaced by waves which first started at the neighbouring area to windward. When these waves reach G_1, they will be a little larger since they have received some extra energy from the wind.

This process will go on with the waves gradually increasing in size until eventually at a time t_1 the waves originally generated at G_0 reach G_1; after this, the waves at G_1 will not increase further however long the wind blows. Thus at time t_1 the waves in the windward zone G_0G_1 increase in height as one gets further from the coast, but have ceased to increase with time, i.e. the wave height depends only on fetch of the wind. However, at time t_1 the waves in the leeward zone G_1H are all the same size, but they can still increase with time, i.e. the wave height depends only on the duration of the wind.

Similar arguments apply to positions G_2G_3 at later times t_2t_3. In other words, we can regard the point G as moving down-wind with the group velocity of the waves. If we plot the wave heights at $G_1G_2G_3$ (where $t_1t_2t_3$ are 3, 6, 9 hours) against fetch and duration, we have a diagram similar to the one shown. Thus, if the fetch is x_4 and the wind duration is only 6 hours, G_4 is in the leeward zone and the wave height will be less than the value given by G_4; it will be given by point Z. If the fetch is x_2 and the duration is 12 hours, G_2 is in the windward zone and the wave height is also given by point Z.

This is a simple example of the type of graph which can be used for forecasting wave heights. If we know the wind speed and the fetch and duration of the wind, we proceed along the curve appropriate to the wind speed, until we meet either the

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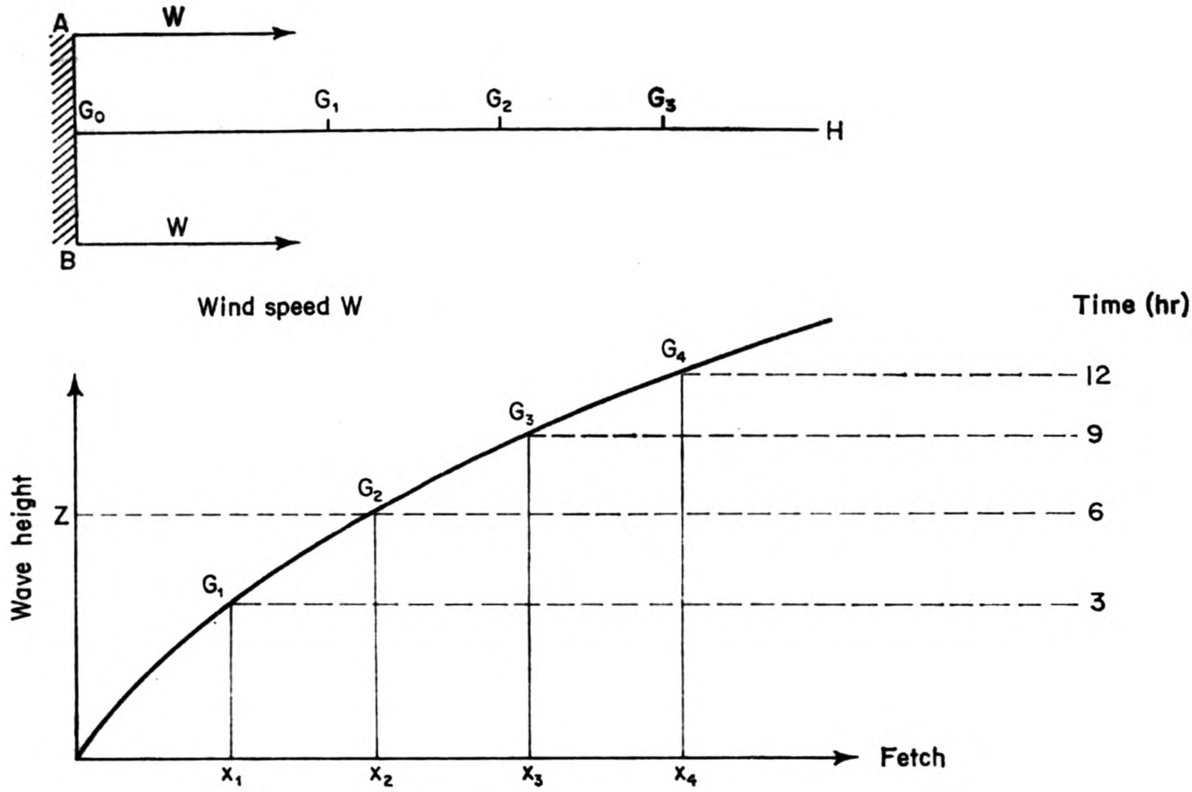

Fig. 1. Wave height, wind speed, fetch and duration.

fetch line or duration line—whichever we meet first—and that point gives us the wave height.

The graphic method used for forecasting wave heights and periods was developed by Darbyshire and Draper of the National Institute of Oceanography. It is based on wave data recorded by the Morecambe Bay lightship (53° 55′N, 3° 29′W) in the Irish Sea during the year November 1956 to November 1957 and by the Smith's Knoll lightship (52° 43′N, 2° 18′E) in the North Sea during the year commencing March 1959. Since the two sets of data gave results which were consistent with each other, they were grouped together to produce wave prediction graphs which can be regarded as applicable to waters in the vicinity of the British Isles with a mean depth of about 100–150 feet. The data consisted of an almost continuous series of wave records of 10–15 minutes duration (about 100–150 waves) taken at 2-hour intervals.

Definitions:

- Hm Maximum wave height in a typical wave record of 10–15 minutes.
- Hs Significant wave height. Mean height of the highest one-third of the waves on the record.
- Ts Significant period. Mean period of the highest one-third waves on the record.

Hm and the significant wave period Ts were measured for each record and the appropriate wind data were extracted from weather charts. From this information Darbyshire and Draper produced graphs which can be used to forecast Hm maximum wave height and Ts significant wave period.

The graph relating wave height to wind speed, duration and fetch is given at Fig. 2. To use the graph, we draw a horizontal line from the appropriate wind speed to the point where this line meets either the duration or fetch line, stopping at whichever is reached first. This point gives Hm the forecast maximum wave height. The forecast value of Hs, the significant wave height, is obtained from the equation $Hm = 1{\cdot}60\ Hs$.

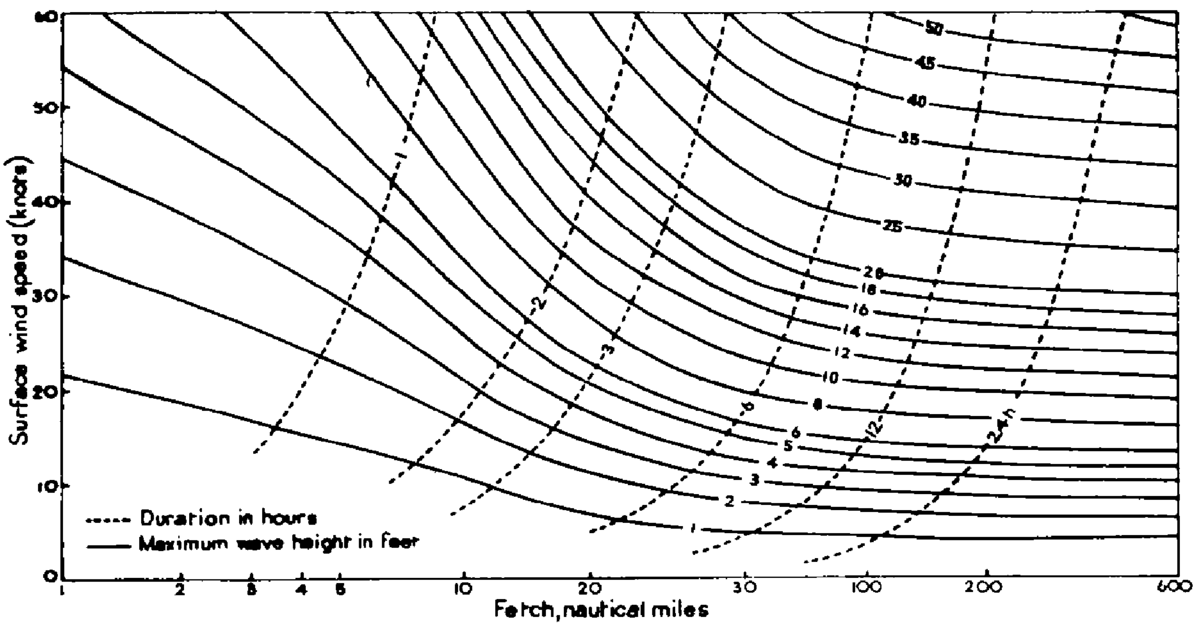

Fig. 2. Wave height related to wind speed, duration and fetch.

The Morecambe Bay and Smith's Knoll data included very few reports of winds over 35 knots and wave heights of over 30 feet were not recorded at either lightship, so the top part of Fig. 2 (and Fig. 3) was completed by extrapolation. However, during the last 2 years we have received many reports of wave heights of 25–40 feet from the various oil rigs operating in the North Sea. With one exception, these reports agreed with the graph given in Fig. 2. There were good grounds for assuming that the exception was a poor observation. The graph relating wave period to wind speed, duration and fetch is given at Fig. 3, which is used in the same way as Fig. 2.

Knowing the wind speed, duration and fetch, and making due allowance for changes in these parameters, we can use Figs. 2 and 3 to forecast:

Maximum wave height during forecast period.
Significant wave height.
Significant wave period.

The forecast maximum wave height is based on wave records of 10–15 minutes duration made every 2 hours and the value obtained can be regarded as reasonably accurate under normal conditions. However, during a gale or storm lasting, say, 6–48 hours, the chance of a lot of component waves getting into step to produce a really big wave is very much greater than it is in a wave record of 10–15 minutes duration. The determination of the height of this wave is complex, but in practice we obtain the most probable height of the highest wave in the storm by multiplying the maximum wave height by a factor which depends on the duration of the storm.

Fetch is defined as the distance over which the wind blows. The three factors wind speed, fetch, and duration are obtained from a study of the latest actual charts and the forecast weather charts for 12, 24 and 48 hours ahead. A high-speed computer is now used in the preparation of the forecast weather charts, but the accuracy of the forecast decreases as the period increases. Accuracy is greater in a static or slow-moving situation than it is in a fast-moving situation. In the latter case, a relatively small error in forecasting the position of a fast-moving depression can make all the difference between an accurate and an inaccurate forecast.

Swell

Swell is defined as waves which are no longer under the influence of the wind which produced them, either because the wind has died out or because the waves

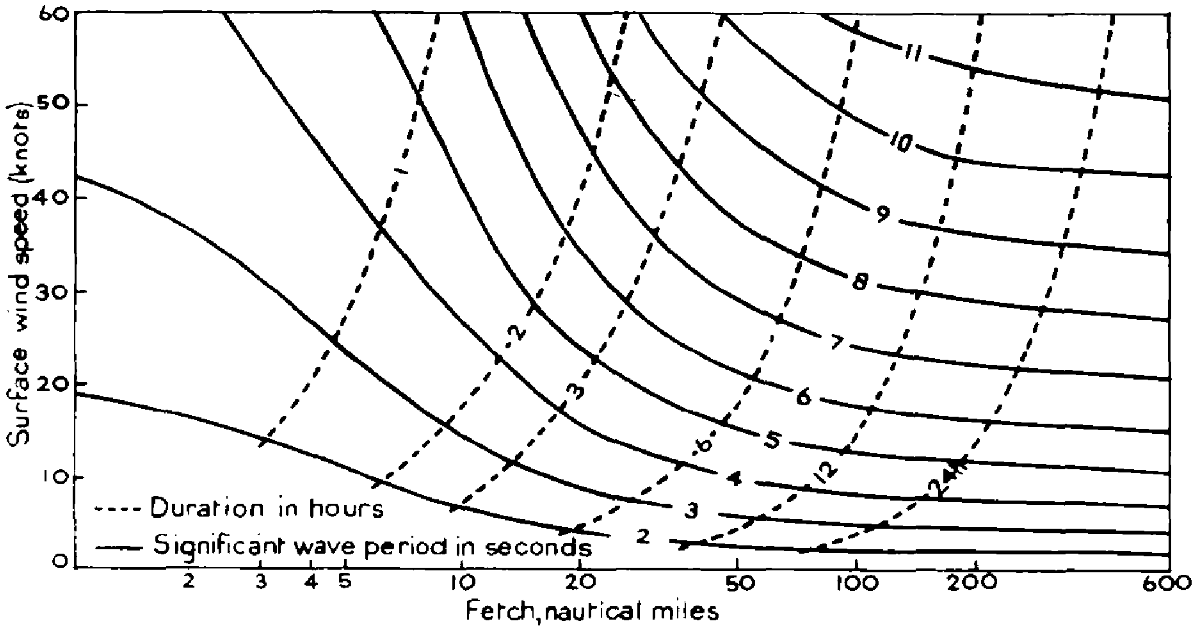

Fig. 3. Wave period related to wind speed, duration and fetch.

have left the generating area. In the open sea the rate of loss of energy is small unless a strong wind blows against the waves. Swell can, therefore, travel a considerable distance before it becomes too low to become noticeable. However, the amount of swell recorded at Smith's Knoll was negligible and it does not appear to present a great problem in the southern North Sea because long swell would be damped out by friction between the waves and the sea bottom in the comparatively shallow water. Over the northern North Sea—water depth about 400 feet—swell would be a problem, especially when it comes from the north. There is no simple graphic method of estimating it and forecasts will have to be based on studies of the wind field and observations of swell. When it enters an area where waves are being generated, the two waves combine in a complex manner. For practical purposes, the combined height H of two waves of height h_1 and h_2 is given by:

$$H=\sqrt{h_1^2+h_2^2}$$

Fifty-year storm

The probable extreme values of wind speed and wave height which will occur in the North Sea during a period of 50 years have been evaluated by various people, and the term '50-year storm' has come into use. In this context, it is interesting to consider the storm of 31st January 1953, which is almost certainly the most severe experienced over the western and central parts of the North Sea during the present century. The depression, which formed just north of the Azores on 29th January, intensified and moved in a north-easterly direction. It reached the extreme north of Scotland by 0600 GMT on 31st January, as shown in Fig. 4. Its subsequent path is shown in Figs. 5 and 6. An advancing and intensifying anticyclone helped to increase the northerly pressure gradient immediately behind the depression. In Orkney the mean wind at about 500 feet above mean sea level reached about 80 knots with gusts to 100 knots, and force 12—with gusts to 88 knots—was recorded at Aberdeen. By 1800 GMT, there was a long belt with geostrophic wind averaging about 120 knots over a substantial part of the North Sea; this would be equivalent to a surface wind of about 70 knots or more. Such conditions are more likely to be associated with the '100-year storm' than the '50-year storm'.

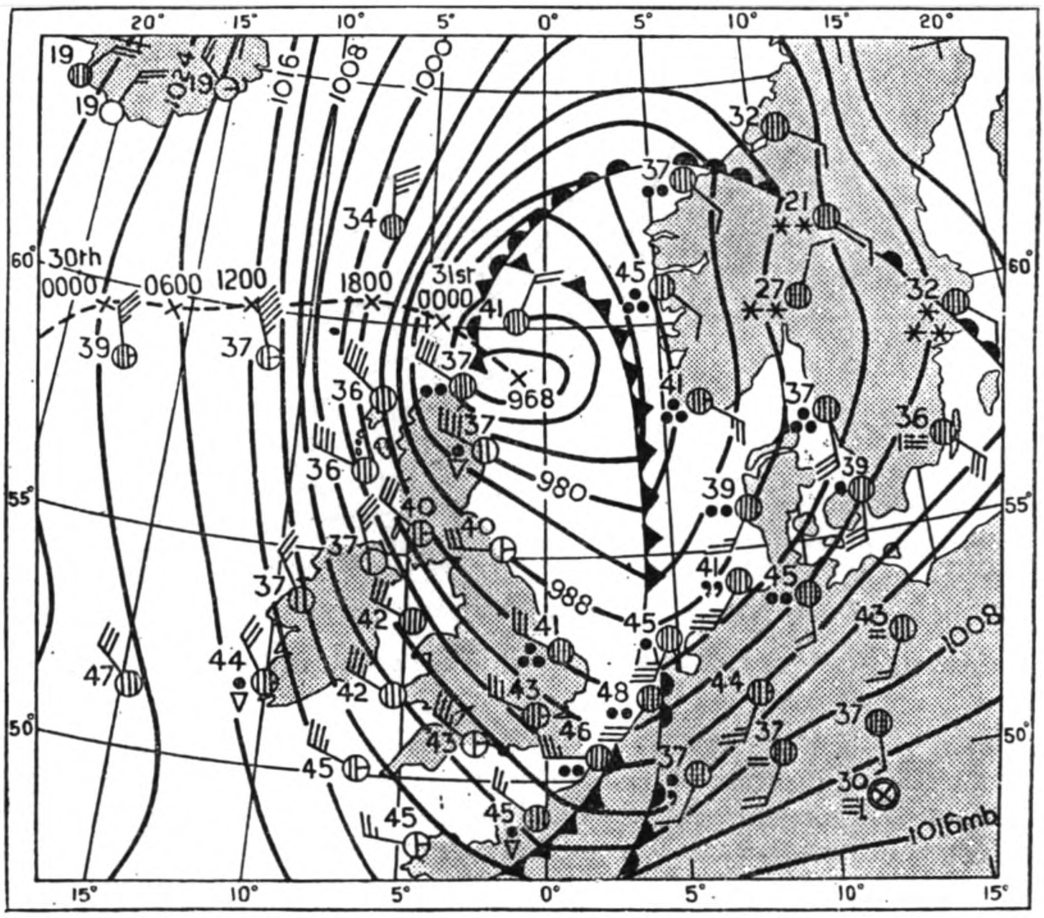

Fig. 4. Synoptic chart, 0600 GMT, 31st January 1953.

Forecast verification

To verify the accuracy of the forecasts of wave heights we plot graphs comparing observations made by the oil rigs with the forecast values of significant and maximum wave heights. Since the observations are made at set times they should, on most occasions, agree with the significant wave height rather than the maximum wave height. Figs. 7 and 8 are the graphs for the rig *Endeavour* during the periods January–March and April–June 1966. Agreement between the forecast significant wave height and the observed wave height is reasonably good. There were only a few occasions when the observed value exceeded the forecast maximum height. The graphs show that the technique used for forecasting wave heights works quite well, and investigation of the relatively few major errors, such as the forecasts for 28th March and 9th April 1966, show that they are mainly due to mistakes in forecasting the wind strength or estimating the wind fetch. Such mistakes may result from relatively small errors in forecasting the path taken by a depression.

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2. DARBYSHIRE, Mollie, and DRAPER, L. *Engineering*, 5th April 1963, 195, pp. 482–484.
3. DOUGLAS, C. K. M. Gale of January 31, 1953. *Met. Mag., London*, 82, 1953, pp. 97–102.

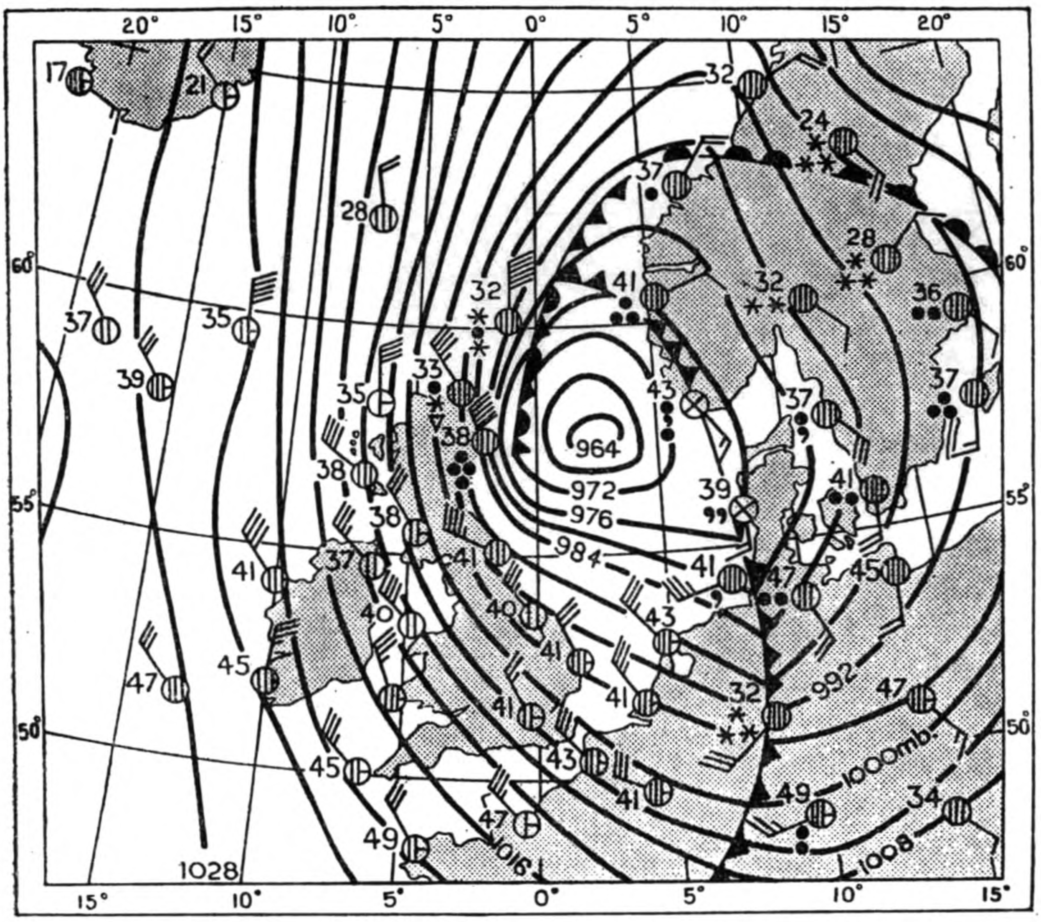


Fig. 5. Synoptic chart, 1200 GMT, 31st January 1953.

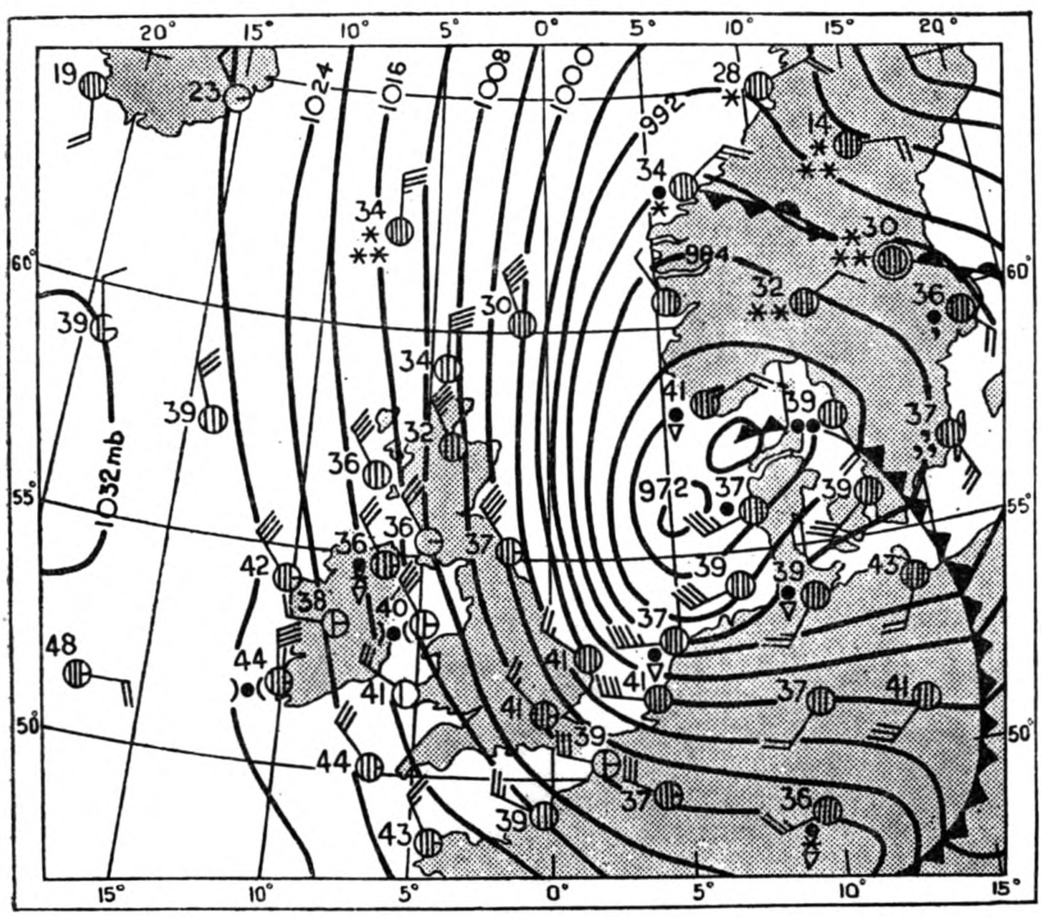


Fig. 6. Synoptic chart, 1800 GMT, 31st January 1953.

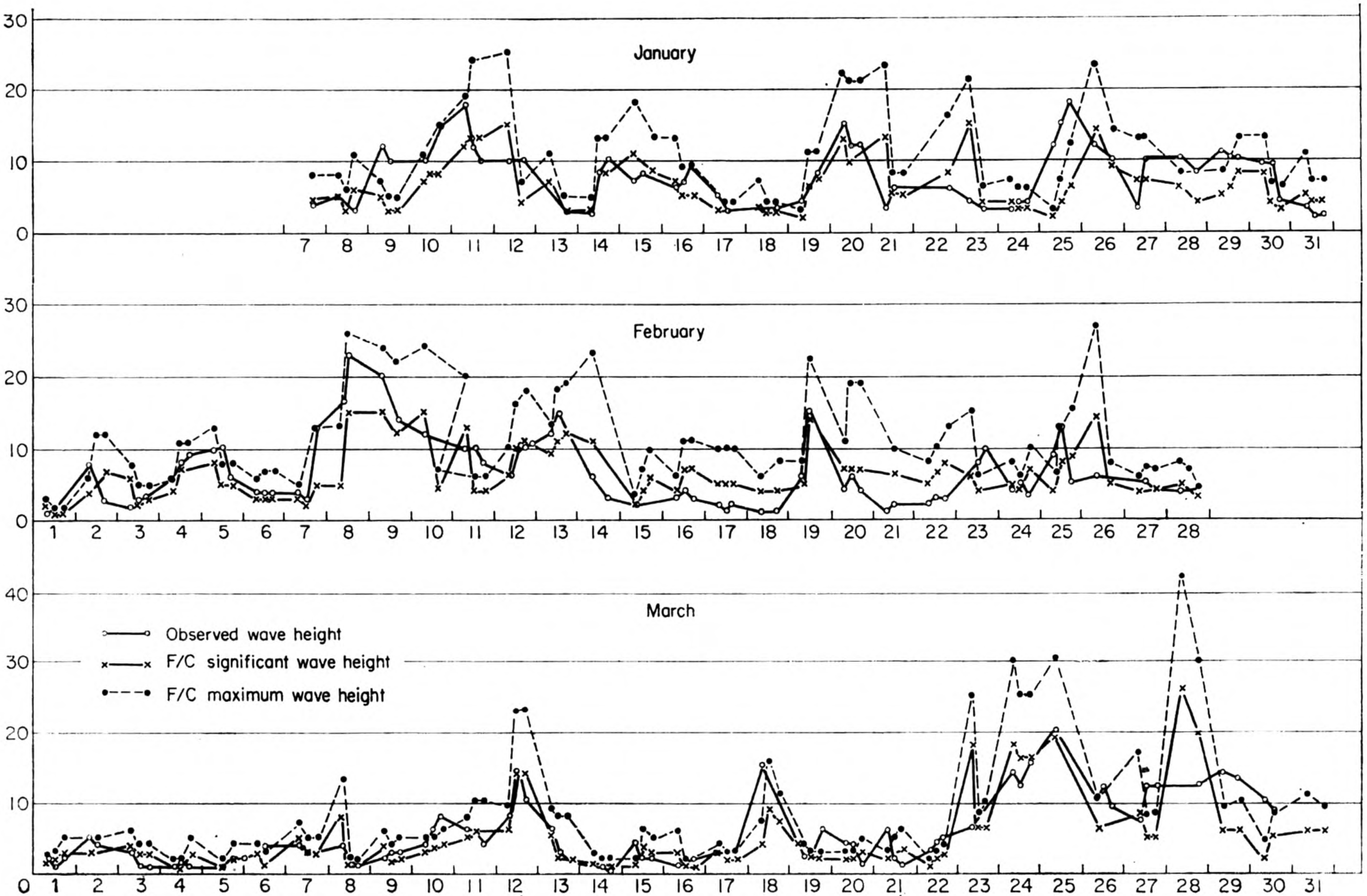


Fig. 7. Comparison of forecast and observed wave height (1966) at Endeavour, 54° 22′N, 00° 05′W.

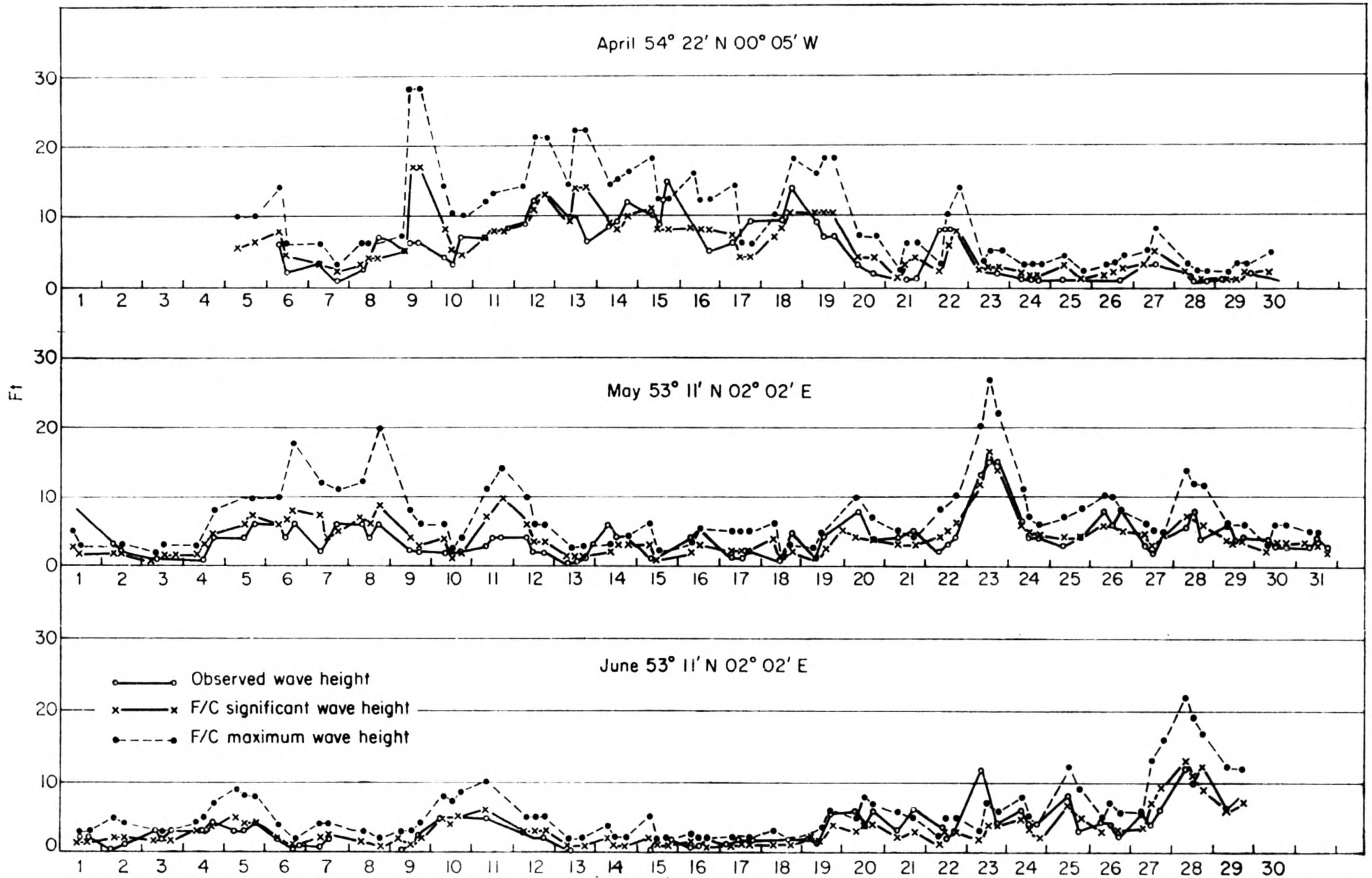


Fig. 8. Comparison of forecast and observed wave height (1966) at Endeavour.

A CENTURY OF VOLUNTARY OBSERVING—THE NEW ZEALAND SHIPPING CO. LTD.

Our annual pictorial series of ships of one ownership covering a century of voluntary observing for us is continued opposite page 93 with pictures of three observing ships belonging to the joint New Zealand Shipping Company and Federal Lines.

Our association with them goes right back to 31st March 1855 when our Agent in London put a set of meteorological instruments aboard Money Wigram's *Kent*. She was a full-rigged ship of 879 gross tons, built in London in 1853 and is the subject of our first picture as she lay at anchor off Gravesend on 21st May 1871. The first meteorological logbook from her of which we have a record covered the period August 1857 to March 1858, a voyage from London to Melbourne via the Cape and home round the Horn.

In those years, more than a century ago, we had also on our Voluntary Observing List three other of Wigram's sailing vessels: *Sussex* (recruited 10th October 1856), *Suffolk* (11th February 1858) and *Lincoln* (18th December 1858), whilst the first observing ship to bear a New Zealand Shipping Company name was the steamer *Ruahine* which 'signed on' in London on 10th August 1867.

Our second picture is of the *Ruapehu*. She was a steamer of 7,885 gross tons, built in 1901 by W. Denny of Dumbarton. She had a long and honourable career in our Voluntary Observing Fleet for her first meteorological logbook which covered the period 4th November 1904 to 27th February 1905, a voyage to New Zealand via the Cape and home round the Horn, was received here on 3rd March 1905 whilst her last book, which covered the period 20th December 1930 to 17th April 1931, a voyage from U.K. to New Zealand via Panama and return, came in just 26 years later, on 21st April 1931. We have no reliable list of awards which were made before the first publication of *The Marine Observer* in 1924 but the *Ruapehu* appears in eight successive annual lists which were published from that time until she left the Fleet.

Our third picture is of the Company's latest observing ship, the *Tongariro*. She is a motor ship of 8,233 gross tons, built in 1967 by Bartram & Sons Ltd. of Sunderland. Under the command of Captain J. D. Bennett, she joined the Voluntary Observing Fleet in London on 16th May 1967 and her first meteorological logbook was received here on 29th September 1967.

From the days of the *Kent*, when the Meteorological Office itself was a very young organization, this Company's name has seldom, if ever, been absent from our registers. Today we have 29 of their ships in our Voluntary Observing Fleet and the standard of their observations is reflected in the annual lists of awards; we would like to take this opportunity of paying tribute to the services which the masters and officers of so many ships have voluntarily given us for well over a century.

We are indebted also to the Company's publicity department for the loan of the photographs here reproduced.

L. B. P.

NOTES ON ICE CONDITIONS IN AREAS ADJACENT TO THE NORTH ATLANTIC OCEAN FROM OCTOBER TO DECEMBER 1967

October

The atmospheric circulation was exceptionally vigorous, resulting in many places in an almost complete reversal of the temperature distribution of the previous months. The north of Canada, for example, became relatively warm for the first time in months.

Canadian Arctic Archipelago. Light variable winds with a slight preponderance of westerlies drew warmer air into the southern part of the area and temperatures rose locally to as much as 6 degc above normal. The freezing season which had been well ahead fell back and by the end of the month was nearly a week behindhand. Although there was the usual 10/10 cover round the northern islands, there was less than the normal amount or thickness of ice over such waters as the Amundsen and Coronation Gulfs in the south.

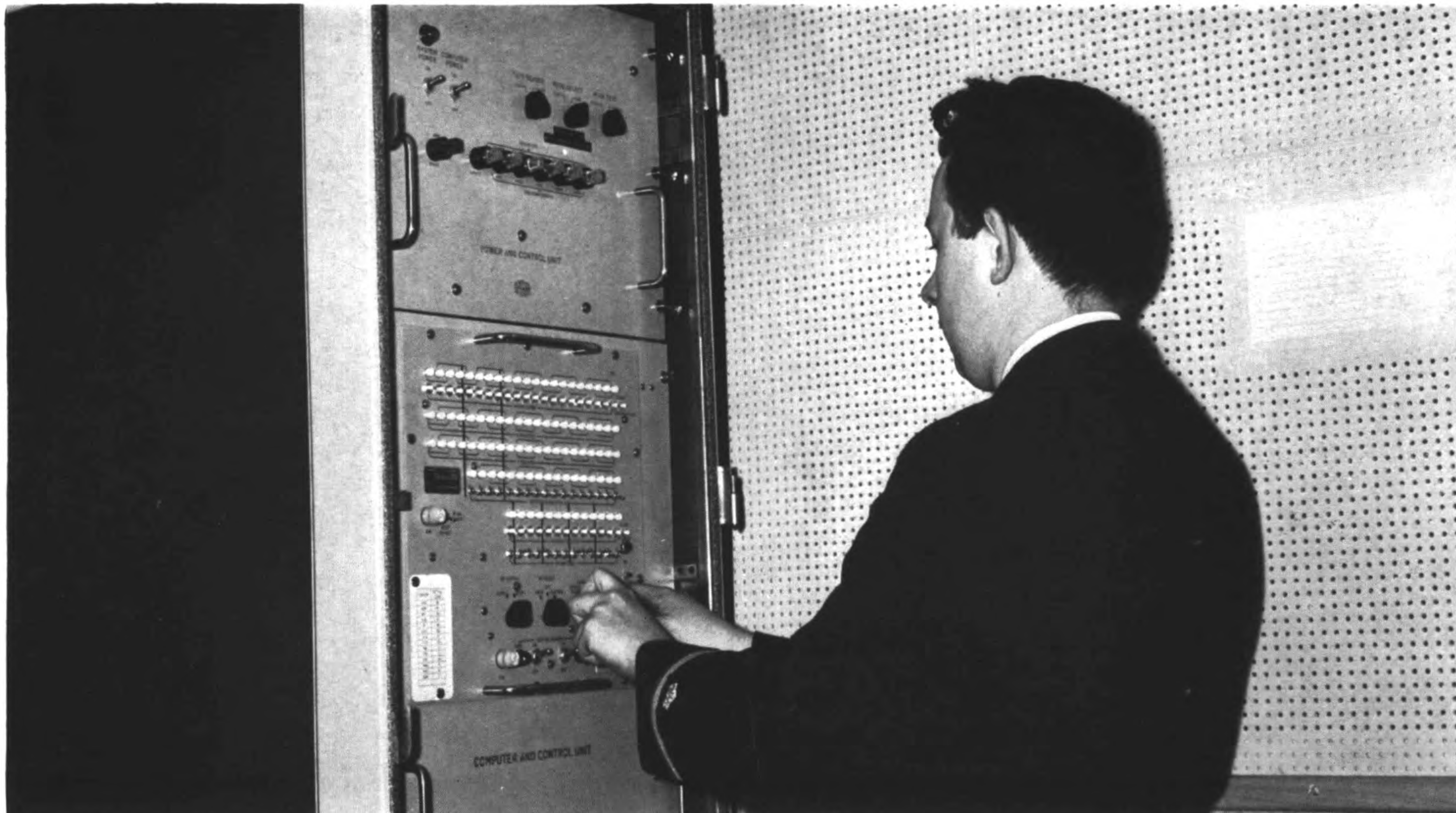


Photo by courtesy of the Department of Transport, Canada

The weather radar computer aboard CCGS *Vancouver* (*see* page 77).

(*Opposite page 93*)

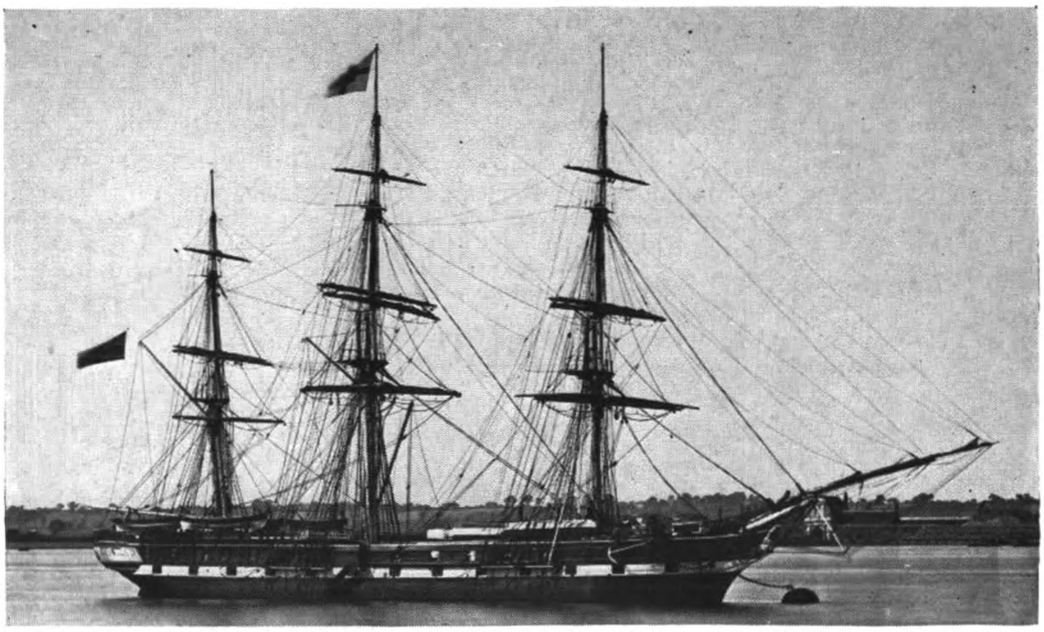
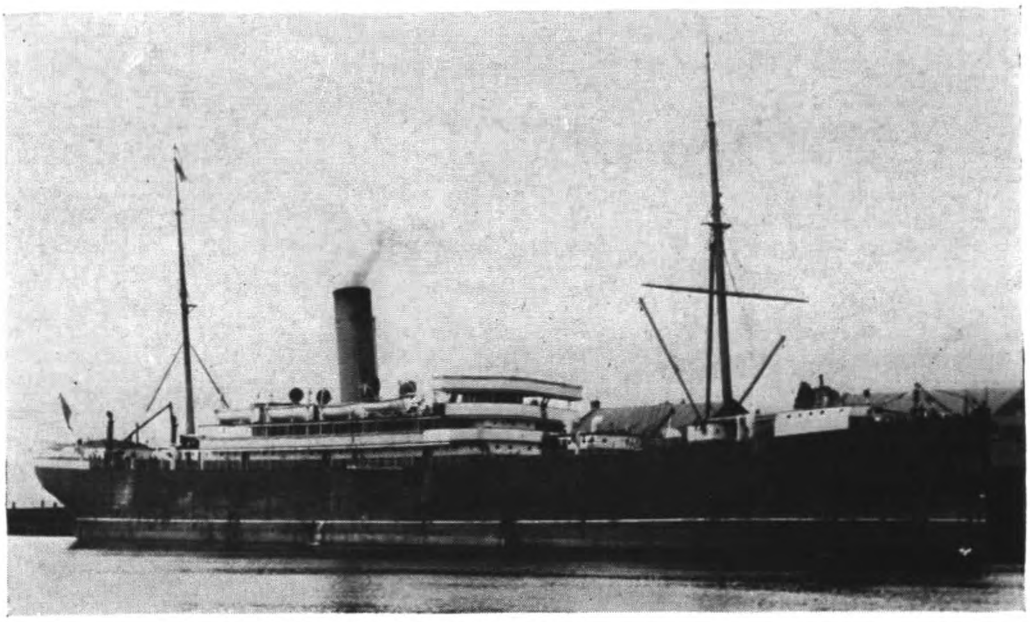
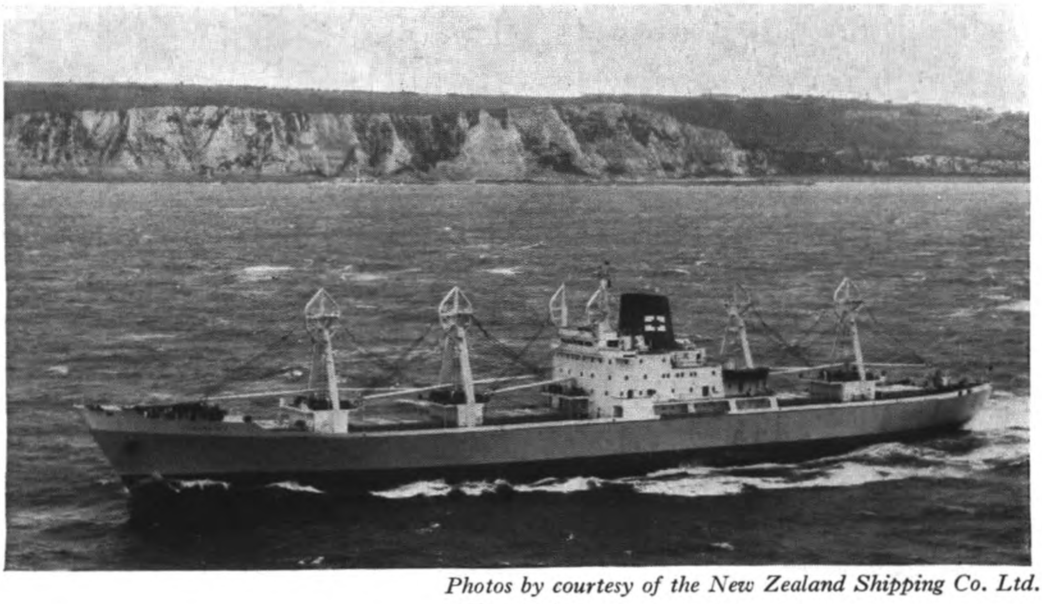


Photo by courtesy of the Trustees, National Maritime Museum

Kent



Ruapehu



Photos by courtesy of the New Zealand Shipping Co. Ltd.

Tongariro

THREE SHIPS OWNED BY THE NEW ZEALAND SHIPPING CO. LTD. (*see* page 92).

Table 1. Icebergs sighted by aircraft and merchant ships within latitudes 40°N–65°N and longitudes 40°W–65°W

(This does not include growlers or radar targets)

Limits of Latitude and Longitude		Degrees North and West											
		66	64	62	60	58	56	54	52	50	48	46	44
Number of bergs reported south of limit	Oct.	>84	>84	>76	>12	1	0	0	0	0	0	0	0
	Nov.	25	25	22	4	0	0	0	0	0	0	0	0
	Dec.	Incomplete Data											
	Total	—	—	—	—	—	—	—	—	—	—	—	—
Number of bergs reported east of limit	Oct.	>84	>84	>84	>84	>84	>84	>84	>83	>74	>55	>11	>8
	Nov.	25	25	25	25	25	25	25	24	13	11	9	2
	Dec.	Incomplete Data											
	Total	—	—	—	—	—	—	—	—	—	—	—	—
Extreme southern limit	Oct.	57° 00′N, 59° 24′W on 17.10.67											
	Nov.	59° 30′N, 44° 36′W on 5.11.67											
	Dec.	Incomplete Data											
Extreme eastern limit	Oct.	60° 00′N, 42° 48′W on 12.10.67											
	Nov.	59° 36′N, 43° 24′W on 5.11.67											
	Dec.	Incomplete Data											

> ('greater than') has been inserted where there is some doubt as to the actual number of icebergs at some of the sightings, but the true value is probably greater than the value given.
Extreme limits during the 3-month period are underlined.

Baffin Bay. Mainly northerly winds kept air temperatures a few degrees below average so that cooling was about a week or so ahead, this being aided by the subnormal temperature of the sea. In the extreme north and also along the Greenland coast north of 70°N ice was forming rapidly, especially in Smith Sound and Kane Basin where there was 9/10 cover.

Foxe Basin. Apart from a short spell of southerlies which temporarily raised the temperature in the middle of the month, northerly winds prevailed with resulting temperatures up to 3 degC on the low side. There was much more ice than normal, freezing being nearly a fortnight in advance, ice covering the whole area.

Hudson Bay. Winds blew from every quadrant except south-east and temperatures fluctuated 3 or 4 degC either side of normal. In the south there was still no ice but in the north-west some formed along the coasts while in the north-east floes from Foxe Basin drifted as far south as 63°N.

Hudson Strait. Here again there was an influx of ice from Foxe Basin but penetration was not great since the water at the eastern end of the strait remained warm, its temperature being 2 degC higher than normal. Winds were variable, as were air temperatures.

Davis Strait. Predominantly northerly winds resulted in subnormal air temperatures and, except for the area near Cape Chidley, cooler than normal sea. The season had not advanced enough, however, for ice to form.

Labrador Sea. Moderate north-westerly winds tended to back to westerly and air temperatures, at first low, tended to rise to as much as 4 degC above normal. Sea temperature was variable, there being patches where it was 2 degC cooler than normal but others where it was 2 degC warmer. There was no sea ice and icebergs were very scarce.

Great Bank and South Newfoundland Sea. Westerly winds blew throughout and, apart from a short cool period in the middle of the month, the air was generally 2 to 4 degC warmer than usual. Sea continued to be exceptionally warm, temperatures in places being as much as 5 degC higher than normal. There was, of course, no ice.

River and Gulf of St. Lawrence. Westerly winds helped to maintain temperatures, both of air and water, 2 to 3 degC higher than normal. It was far too early for freezing.

Greenland Sea. Much stronger than usual north-north-easterly winds, blowing approximately parallel to the east coast of Greenland, had the expected effect of lowering temperatures well below normal levels. In some places, particularly to the west of Jan Mayen, the air was 4 degC cooler than usual and, except in the extreme south where there was a positive anomaly, sea temperatures were 2 to 3 degC below average. Over much of this area ice amounts were greater than usual, the edge between Iceland and Jan Mayen being 50 miles further out than normal. Near Jan Mayen itself the ice extended up to 100 miles beyond the usual October limit.

Table 2. Baltic Ice Summary: October–December 1967

No ice was reported at the following stations during the period: Keil, Tonning, Husum, Emden, Lubeck, Gluckstadt, Bremerhaven, Flensburg, Stettin, Tallin, Visby, Aarhus, Copenhagen, Oslo, Kristiansandfjord.

No ice was reported at any of the stations during October and November.

Station	December								
	Length of Season		Ice Days			Navigation Conditions			Accumulated Degree Days
	A	B	C	D	E	F	G	H	I
Leningrad	7	31	25	25	0	4	21	0	324
Riga	12	31	10	3	2	7	0	0	198
Pyarnu	11	31	21	21	0	0	21	0	238
Viborg	8	31	24	24	0	4	20	0	—
Gdansk	0	0	0	0	0	0	0	0	45
Klaipeda	12	31	14	0	0	0	0	0	136
Ventspils	12	31	16	0	0	0	0	0	—
Helsinki	13	31	16	9	0	15	0	0	335
Mariehamn	0	0	0	0	0	0	0	0	166
W. Norrskar	24	27	4	0	0	2	0	0	—
Turku	13	31	15	9	0	9	0	0	312
Mantyluoto	21	31	11	1	0	5	0	0	—
Vaasa	9	31	23	23	0	14	9	0	396
Oulu	4	31	28	24	0	6	21	0	—
Roytaa	4	31	21	6	7	11	8	0	—
Lulea	6	31	26	21	0	13	13	0	479
Bredskar	11	31	19	6	0	13	0	0	—
Alnosund	12	31	20	12	0	20	0	0	241
Stockholm	12	31	18	11	0	18	0	0	168
Kalmar	20	31	6	0	0	6	0	0	83
Visby	0	0	0	0	0	0	0	0	73
Göteborg	0	0	0	0	0	0	0	0	63
Skellefte	12	31	20	20	0	6	13	0	—

CODE:

A First day ice reported.
B Last day ice reported.
C No. of days that ice was reported.
D No. of days continuous land-fast ice.
E No. of days of pack-ice.
F No. of days dangerous to navigation, but assistance not required.
G No. of days assistance required.
H No. of days closed to navigation.
I Accumulated degree-days of air temperature (°C) where known.*

* These figures give a rough measure of the first probability of the formation of sea ice, and later the progress of the growth and its thickness. They are derived from daily averages of temperature (00+06+12+18 GMT) and are the sum of the number of degrees Celsius below zero experienced each day during the period of sustained frost.

Spitsbergen. Persistent north-easterlies lowered the air temperature 2 to 4 degC below normal. The sea which initially had been about 2 degC warmer than usual cooled down rather rapidly and was probably colder than average by the end of the month. Nevertheless ice amounts to the west remained on the low side. There was, however, evidence that south of Spitsbergen freezing was ahead of normal.

Barents Sea. North of 75°N north-easterlies lowered the air temperature to about 4 degC below average. There were few reports of sea-surface temperatures but such as were available suggested that they were extremely variable. Ice was in excess, by as much as 100 miles, to the south of Franz Josef Land. South of the 75th parallel winds were variable and air temperatures also fluctuated but, on balance, were 3 to 4 degC higher than usual. The sea also was warmer, in the extreme south by 4 degC. Under these conditions there was, naturally, no ice.

White Sea. In this area, too, it was warmer than usual with a moderate west-south-westerly airstream being maintained. There was no sign of ice.

Baltic. The abnormally warm conditions of September, under the influence of moderate to strong south-westerly winds, continued throughout October, the overall positive temperature anomaly being about 3 degc on the surface and at depth.

NOVEMBER

Scandinavia and European Siberia enjoyed a mild south-westerly airflow but the winds over the Greenland Sea were stronger than usual with a more than usually marked northerly component.

Canadian Arctic Archipelago. Winds, generally light, were very variable in direction so that surface temperatures oscillated widely over a range extending from 6 degc above to 9 degc below normal. The overall effect was such that the ice covering all the surrounding waters consolidated and thickened.

Baffin Bay. There was considerable variability in the winds but for the early part of the month those with an easterly component predominated. Generally the air was much colder than usual with negative anomalies being as much as 8 degc in the north and west of the area. For a short period in the middle of the month, however, the temperature along the Greenland coast at about 73°N was slightly above average. Ice was greatly in excess of normal.

Foxe Basin. Northerlies, sometimes moderate in strength, blew steadily and contributed to an accelerated fall of temperature to about 9 degc below that expected at the end of November. There was, of course, a complete cover of close pack.

Hudson Bay. North of 60°N winds were generally from the north-east quadrant. Temperatures were extremely variable but, in spite of being sub-normal for a period in the middle of the month, were generally slightly on the high side for the time of year. Ice formed fairly rapidly but in the north-west no faster than usual. South of 60°N north-westerlies prevailed, and temperatures varied roughly as further north but generally were rather higher than normal so that ice development was noticeably behindhand.

Hudson Strait. Variable winds brought in warmer air from the east and south-east but much cooler than usual from the west where was felt the influence of the outflow of ice from the Foxe Basin noted in October. The overall ice situation, except in the extreme west where there was an excess, was probably about normal.

Labrador Sea. Persistent south-westerlies helped to keep air temperatures well above average, at one time by about 6 degc, but sea temperature was extremely variable. There were, indeed, in spite of the wind direction, signs of the Labrador current once again running more strongly with the result that, in places, the sea surface was 3 degc cooler than average. In the last part of the month ice began to develop in some coastal areas.

Great Bank. South-westerlies blew during the month and the air was much warmer than usual throughout. The extreme positive anomaly in sea-surface temperature continued over the whole area except for a small area near Belle Isle. In some places, probably due to the northwards displacement of the Gulf Stream 'wall', the water was between 5 and 9 degc warmer than usual. No ice, of course, was reported.

South Newfoundland Sea. Mainly southerly winds resulted in both air and sea being several degrees warmer than average.

River and Gulf of St. Lawrence. Again a preponderance of westerlies and air temperatures generally above normal. In spite of this, however, there were signs of the river water becoming cooler rather rapidly while the Gulf, although mostly warmer than usual, was relatively cool along its northern shores.

Greenland Sea. As already mentioned, the climatic north-north-easterlies were much stronger than usual except south of 65°N where, in the latter half of the month, light south-westerlies developed. Apart from this latter area, where at the end of the period it became warmer than normal, the whole of the Greenland Sea experienced unusual cold both in the water and in the air above. Negative anomalies in the air temperature ranged from −1 degc to as much as −7 degc, while those in the sea, where reported, lay between −2 and −4 degc. Under these circumstances ice amounts were greatly in excess of normal, the edge of the pack being between 60 and 150 miles further out than usual in the extreme north and even more, up to 250 miles, further south in the Jan Mayen area. There is some evidence that this was the greatest extent in any November since 1876. At about 67°N the limit of open pack, 70 miles further out than the normal, reached to within 10 to 20 miles of the north-west coast of Iceland. Quite exceptionally for the time of year pack extended southwards along the shore to Cape Farewell and even beyond.

Spitsbergen. In the north moderate to strong north-easterlies persisted, air temperatures were at times 7 degC and the sea about 1 degC below average. There were few reports from the ice fields but it seemed that south and south-east of Spitsbergen the pack stretched out 60 miles beyond the normal limit. Immediately to the south-west of the territory a moderately warm south-westerly airstream somewhat reduced the amount of ice, but further west the Greenland pack encroached into the area.

Barents Sea. Winds, sometimes strong but very variable in direction, caused the air temperature to oscillate quite violently. In the north, at times, it was 6 degC below normal while further south, especially along the west coast of Novaya Zemlya and off the Siberian shore, temperatures were as much as 13 degC above. Ice was in excess to the south-east of Spitsbergen but elsewhere markedly deficient. There was a small amount of ice along the Chesha Bay and Pechora Gulf coasts. Generally speaking, the onset of winter was about a month late.

White Sea. Here again winter was late with strong south-westerly winds lasting most of the month and temperatures being about 6 degC higher than usual. In the very shallow water near the coasts some ice formed but much less than normal.

Baltic. This sea enjoyed mild conditions, the south-westerlies which blew most of the time raising air temperatures 6 degC above average in the Gulf of Bothnia and Gulf of Finland. Further south the anomaly was about 3 degC. Throughout the area sea temperatures, both on the surface and below, were 2 degC on the warm side. The formation of ice was, in consequence, very much delayed. Only in the extreme north of the Gulf of Bothnia, indeed, was any reported at all and this was very thin and tended to melt.

December

The main change in the situation was the transfer of the main low pressure area from the Norwegian Sea to the south-east Barents Sea, which, combined with rising pressure over Greenland, increased the flow of ice from the Arctic to the Greenland and Barents Sea and accelerated ice growth in these areas and also in the Baltic.

The rise of pressure over Greenland cut off the supply of cold air to eastern Canada for a time, retarding the ice season in many areas.

Canadian Arctic Archipelago. The area remained ice-covered, as is usual at this time of year. Air temperatures varied considerably with a remarkably mild spell about mid-month when they were up to 12 degC above normal.

Baffin Bay. With a cold spell at the beginning of the month the ice cover became complete rather earlier than normal. Very mild weather during the remainder of the month failed to change the situation.

Foxe Basin. During the month air temperatures were about normal but very variable. The area remained totally ice-covered.

Hudson Bay and Strait. The remaining areas of open water in the Hudson Strait and the southern part of the Bay were soon covered over and, with below-normal temperatures in the Strait, ice conditions were in advance of normal. Over the month as a whole, however, temperatures were above normal and ice thicknesses in the south of the Bay particularly were probably low for the time of year.

Davis Strait. The month as a whole was rather warm but ice conditions remained worse than normal.

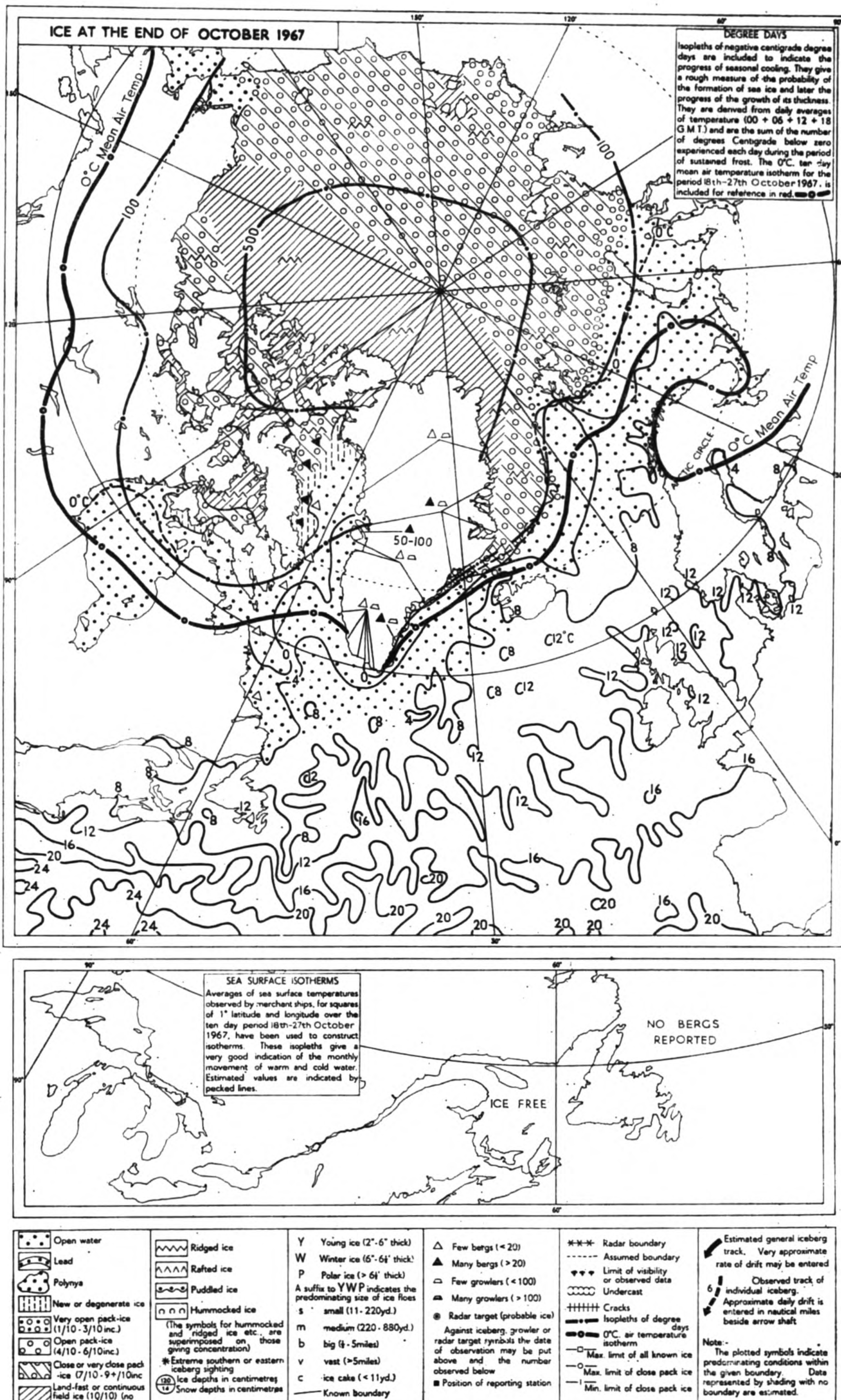
Labrador Sea. Winds were mostly light between north-east and north-west and, with rather mild weather for most of the month, there was less ice than normal.'

Great Bank and South Newfoundland Sea. There was no ice in the area and air and sea temperatures were both above normal with sea temperatures up to 7 degC above normal locally.

River and Gulf of St. Lawrence. Ice began forming in the river and along coasts in the Gulf early in the month but because of above-normal temperatures there was generally slightly less ice than usual.

Greenland Sea. Winds were mainly between north and east and moderate or strong except near South Greenland where the flow was lighter and more from the north-west. With these winds assisting the southward flow of ice and persistent cold weather causing more ice formation the ice situation continued to worsen with pack-ice coming very close to north-west Iceland. To the north of Jan Mayen the ice was more than 200 miles east of its normal position.

Spitsbergen. Moderate north-east winds and temperatures as much as 10 degC below normal brought the ice 60 miles south of Bear Island, unusually far south for the time of year.


ICE AT THE END OF OCTOBER 1967
DEGREE DAYS
Isopleths of negative centigrade degree days are included to indicate the progress of seasonal cooling. They give a rough measure of the probability of the formation of sea ice and later the progress of the growth of its thickness. They are derived from daily averages of temperature (00 + 06 + 12 + 18 G.M.T.) and are the sum of the number of degrees Centigrade below zero experienced each day during the period of sustained frost. The 0°C. ten day mean air temperature isotherm for the period 18th–27th October 1967, is included for reference in red.
0°C Mean Air Temp.
ARCTIC CIRCLE
500
100
50-100
SEA SURFACE ISOTHERMS
Averages of sea surface temperatures observed by merchant ships, for squares of 1° latitude and longitude over the ten day period 18th–27th October 1967, have been used to construct isotherms. These isopleths give a very good indication of the monthly movement of warm and cold water. Estimated values are indicated by pecked lines.
NO BERGS REPORTED
ICE FREE
Open water
Lead
Polynya
New or degenerate ice
Very open pack-ice (1/10 - 3/10 inc.)
Open pack-ice (4/10 - 6/10 inc.)
Close or very close pack-ice (7/10 - 9+/10 inc
Land-fast or continuous field ice (10/10) (no open water)
Ridged ice
Rafted ice
Puddled ice
Hummocked ice
(The symbols for hummocked and ridged ice etc., are superimposed on those giving concentration)
Extreme southern or eastern iceberg sighting
120 Ice depths in centimetres
14 Snow depths in centimetres
Y Young ice (2"-6" thick)
W Winter ice (6"-6½' thick)
P Polar ice (> 6½' thick)
A suffix to YWP indicates the predominating size of ice floes
s small (11-220yd.)
m medium (220-880yd.)
b big (½-5miles)
v vast (>5miles)
c ice cake (< 11yd.)
Known boundary
Few bergs (< 20)
Many bergs (> 20)
Few growlers (< 100)
Many growlers (> 100)
Radar target (probable ice)
Against iceberg, growler or radar target symbols the date of observation may be put above and the number observed below
Position of reporting station
Radar boundary
Assumed boundary
Limit of visibility or observed data
Undercast
Cracks
Isopleths of degree days
0°C. air temperature isotherm
Max. limit of all known ice
Max. limit of close pack ice
Min. limit of close pack ice
Estimated general iceberg track. Very approximate rate of drift may be entered
Observed track of individual iceberg. Approximate daily drift is entered in nautical miles beside arrow shaft
Note:- The plotted symbols indicate predominating conditions within the given boundary. Data represented by shading with no boundary are estimated.

Barents Sea. After a very mild start to the month colder weather spread from the north-west and there was a rapid increase of ice in the north, due to north-east winds, which brought the ice much further south than normal.

White Sea. At the beginning of the month the ice conditions were better than normal but with temperatures as much as 12 degC below normal the ice increased rapidly.

Baltic. Initially, freezing was about a fortnight behindhand but temperatures fell rapidly to as much as 17 degC below normal and by the end of the month the Bay of Bothnia was covered with pack-ice.

North Sea. Persistent north-west winds brought cool weather to the area but no ice was reported and sea temperatures near Norway remained 2 to 3 degC above normal.

N. B. M. & G. P. D.

Note. The notes in this article are based on information plotted on ice charts similar to the map shown overleaf but on a much larger scale (39 in × 27 in). These charts are published at ten-day intervals and are available at the price of reproduction on application to the Director General, Meteorological Office (Met.O.1), Eastern Road, Bracknell, Berks. Alternatively, they may be seen at any Port Meteorological Office or Merchant Navy Agency. Up-to-date ice charts are broadcast daily by facsimile.

Book Reviews

Vinland Voyage, by J. R. L. Anderson. 8¾ in × 6 in, pp. 278, *illus.*, Eyre and Spottiswoode (Publishers) Ltd., 11 New Fetter Lane, London E.C.4, 1967. Price: 45*s*.

The possibility of the existence of European colonies in America long before the voyages of Columbus has, for many years, been the subject of much research. The Icelandic sagas give apparently factual accounts but these are oral history only and nothing seems to have been written down until long after the event. The announcement by Yale University in 1965 of the discovery of a map showing a recognizable outline of the American coast drawn many years before Columbus and referring to a Norse colony which they had named Vinland gave a new stimulus to interest in the sagas and legends. The biggest question which they left unanswered was: Where was Vinland?

Sponsored by his newspaper, John Anderson, Assistant Editor and Yachting Editor of the *Guardian*, led an expedition in the summer of 1966 in the 44-foot cutter *Griffin* with the object of rediscovering America by the old Norse route via Iceland and Greenland and, if possible, finding out where Vinland actually was. *Vinland Voyage* is the story of that expedition.

With five companions, Anderson sailed from Dover on 27th April 1966 and took his final U.K. departure from Scarborough on 2nd May. Trouble with the rudder caused the *Griffin* to spend four days in the Faeroe Islands which was no part of the original plan but which nevertheless gave opportunities of going further into the economic background of the westward Norse expansion in the generations before the expansion from Iceland to Greenland and so on to North America. On 17th May she arrived in Reykjavik and left three days later; this was substantially the beginning of the effort to retrace the voyages of Bjarni and Leif Eiriksson. On Sunday, 22nd May she was about 100 miles NE of the *Weather Adviser* (Captain H. Sobey) on station 'Alfa' in 62°N, 33°W and, over the R/T, arranged to call the following day. Captain Sobey provided a relief crew for the *Griffin* whilst all six adventurers were taken aboard and entertained to hot baths and hot food. Mr. Anderson makes some very kind references to the *Weather Adviser*, particularly to the catering side.

And so on to Greenland and the hazards of an abnormal ice year. But Frederikshaab was safely reached on 30th May and the last leg towards Vinland commenced three days later. This final and longest passage was perhaps the most hazardous and yet the most interesting of them all. Hazardous because of the three days when *Griffin* was virtually trapped in the ice and the six days when she was fog-bound. ("We were back with Bjarni and his crew, sharing in a strangely intimate way their ordeal of 'many days' in fog. For our task of trying to reconstruct Bjarni's and Leif's voyages we could not have been granted a more providential physical demonstration of the conditions which brought Europeans to North America for the first time in recorded history. It was the same sea and the same fog. And we knew no more than Bjarni did when the fog would lift.") And interesting because it brought the added zest of trying to settle the actual location of Vinland; Labrador, Newfoundland, Nova Scotia or New England. The journey ended with the landing at Martha's Vineyard on 27th June 1966.

"What did we achieve?" writes the author. "I do not claim to have 'discovered' or 'proved' anything . . . I cannot say that Bjarni *did* sight the coast of Nova Scotia or that Leif Eiriksson *did* go ashore on Martha's Vineyard. But after the practical experience of our voyage, I can say that I think it *almost certain* that these things happened . . . I cannot say that I have *proved* that Newfoundland was *not* Vinland, but I do say that this location seems now so improbable that it ought to be ruled out." Matching his own navigational experience and the topography of his landfalls against the evidence given in the sagas, the author makes it clear that he would settle for Martha's Vineyard on Nantucket Sound as being the original site. But, as he writes in his final paragraph, "All human history is a jigsaw puzzle; one man may find a small piece that fits here, but the pattern cannot emerge until many men have found and fitted many pieces".

Before she sailed from Dover, we had equipped the *Griffin* as a Supplementary Ship and a very full meteorological logbook was kept throughout the voyage; of particular value was the sea-ice information which she gave us. Thanks to the powerful, though compact, radio installation which she carried on this voyage, regular radio weather messages were sent in turn to the various meteorological services through whose area of responsibility she passed, whilst every day she was in radio touch with her sponsors at home.

The task of blending a 20th century maritime adventure with a 10th century legend and maintaining the balance between the two, so that one will stimulate interest in the other, is no light one but Mr. Anderson has done this admirably. Indeed, *Vinland Voyage* well deserves its place in the bibliography relating to the Norse discovery and settlement of North America.

L. B. P.

Quarterly Surface Current Charts of the South Pacific Ocean (Met.O.435), Meteorological Office, London. 19¾ in × 16¾ in, pp. 25, H.M. Stationery Office, London. 2nd edition, 1967. Price: 92*s.* 6*d.*

No hesitation whatsoever is needed by way of opening comments on this new work which supersedes its much less handy (35 × 24 in) predecessor of 1938. Not only are the charts of this new atlas of superb clarity; the 'Explanation of the Charts' given on the first page is admirable on two important counts: in telling the intended user just how the various quarterly charts (showing predominant direction and average rates, vector means and current roses) were compiled and how best use may be made of them and which to choose for different purposes. The clear explanation faithfully reflects the detailed and painstaking discussions held in past years between marine meteorologists, master mariners, oceanographers and others who, between them, had useful ideas to promulgate and a sound appreciation of user value.

We particularly like the clearly-stated method used for drawing the streamline charts and recall the careful thought given to this problem in days when there was so much concern for the safety of ditched aviators. These streamline charts now made available in this and other similar atlases not only take one's thoughts back to the renowned silk handkerchief charts of wartime; they immediately suggest themselves as ideal material for the improvement of No. 5216 in the waterproof-wrapped half dozen Ship's Boats' Charts of Admiralty package N.P.255.

An obvious thing to do was to compare, for the areas and the two seasons in common, the details of these new streamline charts and those of the pair of 'Stream Drift Charts of the World' published (and republished at intervals) on the backs of U.S.H.O. Pilot Charts. As to overall current directions they agree well, but the new ones have the advantage of including indications of current speed in nautical miles per day. It will not be surprising that comments made on this new atlas by an oceanographer are much directed to these streamline charts which are claimed (and rightly so) to be "of value for oceanographical purposes", and the reviewer's eye was immediately caught by the currents portrayed off the NW coast of Australia in the streamline chart for June, July and August. This is a very unusual sort of picture indeed to find in charts based upon ship-set data, but the powerful offset from the land portrayed there is entirely in keeping with the transports of surface circulation computed by the scientists of the NAGA Expedition of 1959–1961, and accords excellently with the existence there of the copious upwelling marked on the NAGA charts for the season in question. With the passage of the years, more and more interest in ocean currents is coming to be displayed by 'biogeographers' who raise questions on the possibility of across-ocean drift of various components of the marine fauna and flora—and these new streamline charts will be a good tool to their hands.

It may be wrong but is quite understandable that the reviewer should have devoted his space so largely to the scientist interest of the content of the atlas, but to have done so is no more than a fully-deserved tribute. We accept the opinions expressed as to the derivation of surface current from wind for they accord with the views most widely held. As to the navigational value of the atlas: this is in keeping with that of the other up-to-date publications from the same source devoted to regions less far from Britain and it is cheering to see that data logged by British ships, both merchant and naval, in distant waters over the near-century 1854–1952 have sufficed for the production of a work in which the Marine Branch of the Meteorological Office can justly take pride.

It is not to be doubted that, given care in following the instructions contained in the Explanation which prefaces the atlas, its charts will give as much service to the mariner as they have given interest to an oceanographer, and many will join with him in applauding the sensible retention of nautical miles per day as the unit of current speed.

J. N. C.

Notice to Mariners

WEATHER FORECASTS FOR SHIPPING FROM DJIBOUTI

It has been agreed by the WMO Permanent Representative of France that in future the weather forecasts for shipping broadcast from Djibouti (TXZ) in French will be repeated in English now that a weather forecast in English is no longer broadcast from Aden.

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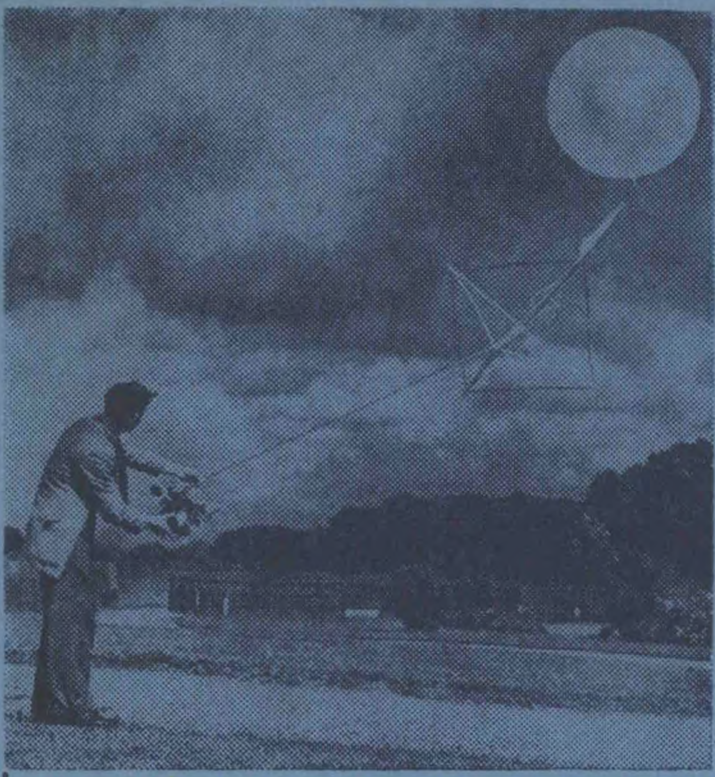
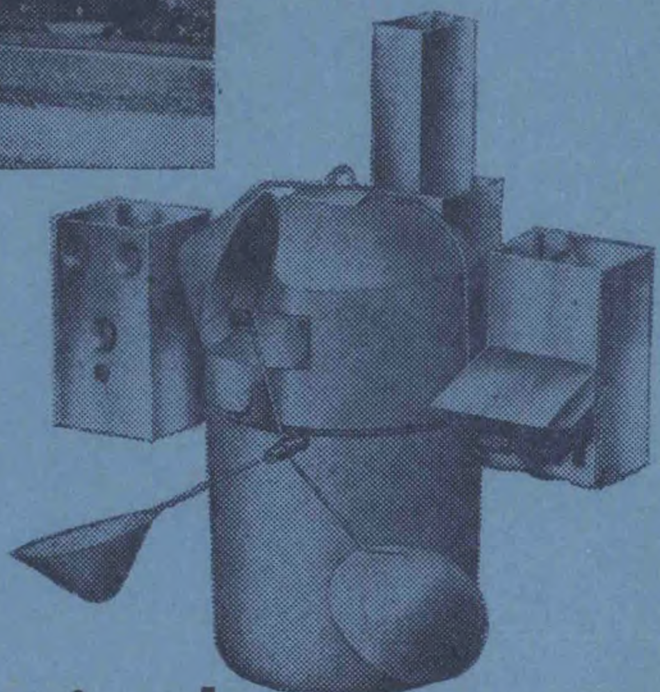
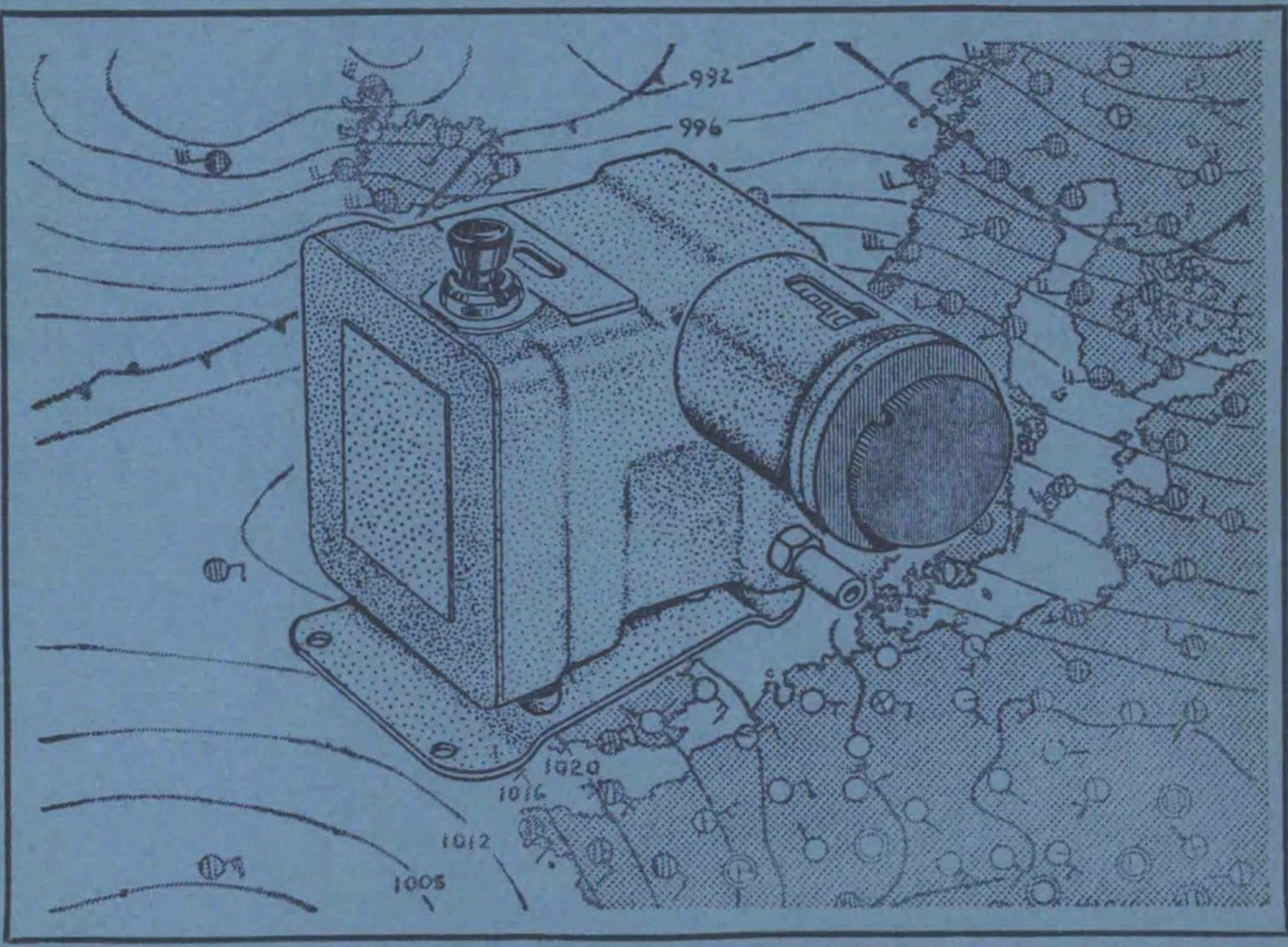




MECHANISM PRECISION ANEROID BAROMETERS WITH DIGITAL READOUT FACILITATE WEATHER REPORTING



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