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THE MARINE OBSERVER

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

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TABLE OF PRINCIPAL 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

In *Cassell's English Dictionary* the verb 'communicate' is defined as "to impart, to give a share of, to transmit, to reveal, to share, to hold intercourse, to confer by speech or writing, to be connected . . .". It is thus a verb of some versatility.

It seems reasonable to suppose that the means of communication employed by prehistoric man was that of his nearest comparison in the animal world—the ape or the gorilla. As the mind of *Homo sapiens* developed he solved the problem of the closer-range intercourse by means of speech, drawing and writing. For distant communication it seems that it was only the African who had the wit and ingenuity to use drums which proved themselves so efficient and versatile that they are still in use today; our forefathers, like the North American Indians, seem to have been content in the early days with smoke beacons, or by messages delivered by homing pigeon or messengers on horseback from which has evolved the international postal system of today. Then there was the gradual evolution of signal flags, distant shapes of various form, the semaphore, the sound signal and the Morse lamp—all of which have stood the test of time. The magic of electricity, aided by many many miles of essential wire cable, extended our communication range by means of the telephone and the telegraph. And what a debt the world of communications owes to Signor Marconi and his co-workers who opened up the wonderful world of wireless, girdling the world as it now does with wireless telegraphy, wireless telephony, television and facsimile, assisted in the first place by the Heaviside layer and latterly, in some instances, by the communications satellites.

In all forms of human and animal activity there is not much doubt about the important part that communications play—the thump of the rabbit's hind legs or the excited screech of the blackbird to warn of danger, the hand signals of the cricket umpire, the neon lights at Piccadilly Circus, the top mark on a buoy and the sound of Big Ben on the BBC programme are but a few homely examples.

The revision of the International Code of Signals for use at sea, which has been completed recently by the Maritime Safety Committee of IMCO, reminds us how essential efficient communications are at sea, particularly in emergency. This revised code which is 'intended to cater primarily for situations related essentially to safety of navigation and persons' and is suitable for transmission by all means of communication including radio-telephone and radio-telegraphy, is very much simpler than the existing international code; it is expected to come into force in January 1968. The revised code contains only single-letter signals, two-letter signals supplemented when necessary by a numeral and, for medical purposes only, three-letter signals. It is much shorter than the existing code and should be easy to use. Its meteorological section is adequate and practical and includes the provision of very brief reports of actual and forecast weather, the latter being related to the MAFOR code. The revised International Code of Signals is only intended for use when there are language difficulties or on occasions when, for example, flags have to be used because it is impossible to communicate by radio or by lamp. Nobody at sea can be sure that he will not, at some time, be called upon to use flag signals or a Morse lamp in emergency, no matter how comprehensive the radio equipment is in his ship. We only need to go back to the last war to remember how necessary flag signals were in convoy and how quickly and efficiently the officers in merchant ships dealt with them with practice. And the new code recognises, rightly enough, the value of sound and visual signals of various types in emergency.

Governments of maritime countries have been in the throes of preparing for the World Administrative Radio Conference for the Maritime Mobile Service which was held at Geneva, under the auspices of the International Telecommunications Union (ITU), in September 1967. The technique of telecommunications is moving very fast nowadays and the questions discussed at that Conference included the use aboard ship of single side-band technique, H/F radio-telephone, radio-teletype, facsimile apparatus and selective calling devices whereby certain ships or groups of ships can be alerted in emergency. Other questions for discussion included communication by satellite, satellite navigation, the hours of service of ship radio stations and the frequencies to be used for radio transmissions from automatic buoys (meteorological and oceanographic). These ITU Conferences take place at rare intervals, so this was an important occasion.

In no sphere of activity are efficient communications more important than in meteorology. Unless the meteorologist can collect observations speedily and accurately from a large number of observing stations scattered all over his hemisphere, he cannot make an adequate weather map and hence cannot forecast the weather with any accuracy. Now that the high-speed electronic computer has come so much into the meteorological picture, it is more than ever important that there should be the smallest possible time-lag between making the observations and transmitting the coded weather message and that the data be accurate when they are received ashore, because the advantages to be gained from the rapidity with which the computer can digest the information and present it in a suitable form for plotting on a weather map will be nullified unless it can be fed with the observations soon after they have been made. Meteorological communication networks are unique because they need to arrange not only for the initial reception of the data but their dissemination on a very wide international scale. So many data have to be handled nowadays on these networks that high-speed radio-teletype has to be employed as well as a fast landline teleprinter network. In addition to this, means have to be provided for reception of satellite pictures of cloud cover, ice cover, etc. and for the dissemination of these and of weather maps by facsimile via landline and radio.

Meteorological observations from ships present unique telecommunication problems. Apart from those which are transmitted by radio telephone from coasting vessels, almost all radio weather messages from ships are transmitted by hand Morse and, as most ships only carry one radio officer, the times of transmission are governed by his hours of watch. When received at a coastal radio station ashore the messages are immediately retransmitted to a meteorological centre by landline teleprinter and are then rebroadcast by radio-teletype with a minimum of delay as part of a collective message for use by the meteorologists of other countries. It is fairly obvious that, with the best will in the world, transmission reception errors are likely to creep in to ships' coded messages transmitted, as they are, by different systems and subject to more than one retransmission. If and when radio-teletype comes into use aboard merchant ships, the risk of this kind of error may become eliminated—particularly if the radio-teletype is fitted with an error-correcting device. Another possible alternative is the use of facsimile for message transmission from ship to shore; this eliminates errors as the original message can be transmitted as written and experiments with this method are being carried out now in the British Weather Ships. The main synoptic weather maps used for forecasting are, by international agreement, those based on the observations made at 0000, 0600, 1200 and 1800 GMT. The World Meteorological Organization, realizing that it is impracticable to make major changes in the hours of watch of radio officers aboard ship, has made adjustments to the times that certain observations can be made so as to fit in with the radio officers' watches in order to get as wide a spread of observations as possible. In all parts of the world, ships' radio weather messages can be transmitted up to four hours after the time of observation if this fits in with the radio officer's watch hours; in areas where shipping is very sparse such reports are welcomed as much as 12 hours after the time of observation. These late observations are better than none at all; they are often very valuable as a check on other observations in a particular area when a difficult meteorological situation has developed. It is obvious that all of these late observations are of somewhat limited value in so far as the computer is concerned; usually human intervention would be needed to insert them in weather maps and to interpret them.

The scheme recently introduced by WMO to facilitate the transmission of radio weather messages from ships also gives the radio officer much freedom of choice as to the radio station to which he can transmit his weather messages; this should tend to eliminate the frustration of having to take a long time to clear a message and thus ease his task appreciably. A study of meteorological logbooks shows that aboard the majority of British voluntary observing ships considerable effort is made to transmit as many observations as possible and that the WMO scheme referred to above is proving helpful; the achievement of this implies harmonious co-operation between the deck and radio department.

C.E.N.F.

October, November, December

The Marine Observer's 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.

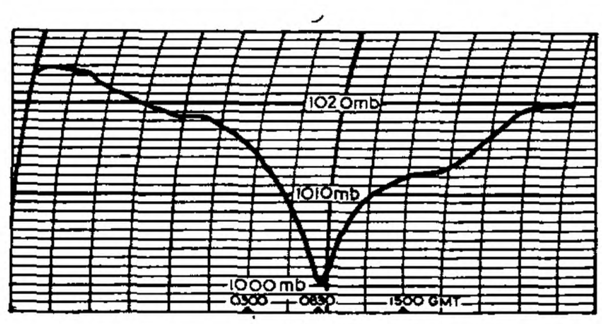
It sometimes happens that we are unable to offer an explanation for phenomena reported. In such cases we shall be very glad to hear from any reader who can put forward an authoritative or a possible explanation, which could be published in this journal. We should also be glad to hear from any reader who has witnessed a similar phenomenon in the past, but which has not previously been communicated to us.

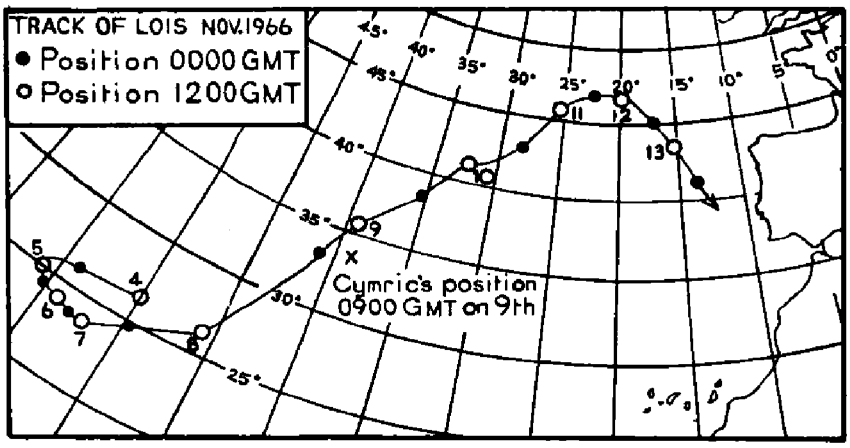
HURRICANE 'LOIS'

North Atlantic Ocean

m.v. *Cymric*. Captain C. R. Downes. Liverpool to Willemstad.

9th November 1966. At about 0830 GMT the vessel was not very far from the centre of Hurricane Lois. The wind, blowing at force 10–11, veered quickly at that time from SSE to SW and the barometer, which had fallen 10 mb in the previous 3 hours,





began to rise equally rapidly. Torrential rain showers fell between 0800 and 0900. The sea was confused with waves of up to about 40 ft in height.

Position of ship at 0900: 33° 51′N, 38° 40′W.

Note. Dr. G. P. Cressman, Director of the U.S. Weather Bureau, forwarded the following comments from their National Hurricane Center in Miami, Florida:

"Observations from m.v. *Cymric* for 1200 and 1800 GMT, 9th November 1966, were received. The 1200 GMT report was particularly useful since the vessel was only 2° latitude south of the center of Hurricane Lois.

"Please convey to the Captain and Officers of the *Cymric* our appreciation for these very timely and accurate reports."

Note. 2. Lois was discovered as a tropical storm on 6th November near 24°N, 54°W and reached hurricane intensity the following day. As it moved NE'ward at about 10 kt the maximum winds increased to 75 kt by the 8th, with gales extending 100 miles from its centre. The hurricane continued on its NE'ly course and had accelerated to 23 kt as it passed within about 55 n. miles of *Cymric* on 9th November.

ROUGH WEATHER

Port Étienne

m.v. *Welsh Herald.* Captain J. G. Tunnicliffe. In port. Observer, Mr. C. C. Davidson, 3rd Officer.

28th November 1966. While singling-up the vessel for sailing, between 0325 and 0345 GMT, the wind quickly increased from ENE force 4–5 to force 7–8, making it impossible to leave the berth. By 0900 the wind was ENE force 8–9 and it continued to blow at this strength until 2230. Sand was found all over the vessel which was pitching and rolling alongside and shipping spray. There was a very rough sea and a moderate short swell. According to the pilot M. Cirot, this happens only about once each year when the wind direction changes from N or NNE to ENE, across the desert.

Position of vessel: 20° 54′N, 17° 02′W.

Note. This is an interesting report; the more so because this is a region where weather reports are scarce and about which very little has been written. This would seem to have been a 'harmattan' gale. Gales are infrequent at Port Étienne and those that do occur are more often N'ly. According to a French source, the average frequency of NE'ly winds exceeding 30 kt is only 1% in November.

In this region the winds are largely governed by the pressure gradient between the Azores anticyclone and the Central African low. The resulting winds are predominantly NE'ly (locally N'ly on the coast) and, at sea, constitute the familiar NE Trades. To the north of Port Étienne the general orientation of the African coast is NE and SW, so that NE'ly winds blow along these coasts and, for the most part, retain their trade-wind characteristics. Southward of Port Étienne the coastline runs more north and south. Consequently, NE'ly winds on the more southern coasts blow from the interior and have a long land track across the desert. It is these hot, dry and dusty NE'ly winds which are termed 'harmattan'. The latter seldom reaches the coast, from Port Étienne northward, but does so increasingly further south.

Usually it is the maritime trade-wind stream which affects Port Étienne but on this occasion the boundary was pushed back to seaward by an unusual development of the continental harmattan with its accompaniment of desert dust.

UNUSUAL TURBULENCE

off Western Australia

m.v. *Centaur*.

15th December 1966. Between 1100 and 1600 GMT the vessel passed through an area of unusual turbulence in which the wind direction and force, temperature and humidity fluctuated every few minutes, as shown in the accompanying table. Between 1145 and 1215 GMT there was an exceptional amount of radio interference as though an electrical storm was taking place locally. Speed of vessel 16 kt. Course 142°.

Position of ship at 1100: 29° 30'S, 113° 35'E.

TIME GMT	WIND		AIR TEMP. °F		R.H. %	PRESSURE	REMARKS
	DIRECTION	FORCE	DRY	WET		mb	
1100	E'ly	—	—	—	—	—	Wind backed quickly from WSW.
1130	—	—	81·0	—	—	—	
1140	—	—	83·0	63·0	28	1014·6	
1145	S'ly	4–5	—	—	—	—	Wind veered quickly from E.
1150	—	—	82·0	65·0	37	—	
1155	S'E	—	82·0	64·0	34	1013·9	
1200	—	—	83·2	63·8	29	1014·6	
1210	S'E	—	79·8	65·2	43	—	
1220	—	—	78·5	66·0	49	—	Cloud 7/8 C_L9.
1225	—	—	77·8	66·5	53	1015·2	
1230	S'W	4–5	—	—	—	—	Light rain.
1250	—	—	74·2	67·0	68	1015·6	Rain stopped.
1305	S'E	5	76·1	65·6	55	—	
1315	SSW	4	77·7	64·9	47	—	
1330	SW'W	3	77·0	66·3	55	1016·9	
1400	Var.	2	75·6	68·9	70	1016·6	Cloud beginning to break up.
1430	SE	5	75·0	67·0	65	1015·9	
1440	SE	5–6	77·2	64·0	46	1015·6	Wind gusting to force 7 every few minutes; temperature and humidity fluctuating with wind. (1440–1515)
1445	SE	6	78·8	63·9	40	—	
1450	SE'S	7	77·8	65·0	47	—	
1500	SE'E	5	77·7	65·0	47	1016·6	
1515	SE'S	5	76·2	66·2	57	—	
1530	SE'S	4	74·7	67·3	66	1016·6	
1600	SE'S	4–5	74·5	66·8	65	—	Steady.

Note. We are pleased to publish this interesting and very thorough observation from an Australian Selected Ship.

Note 2. The Regional Director, Bureau of Meteorology, Western Australia, comments:

"This observation of unusual turbulence on 15th December 1966 is most interesting. On that day a low pressure trough extended south along the coast from the Port Hedland–Marble Bar area. In this trough there was considerable vertical motion as evidenced by the cumuliform clouds observed, the radio interference and the lightning. An old frontal boundary, with which was associated no obvious activity, extended through the trough and NW'ward into the Indian Ocean with cold frontal characteristics. The turbulence was associated with the ship's passage in the trough centre and through the cold front."

EXCEPTIONAL VISIBILITY

English Channel

m.v. *Apollo*. Captain G. V. Barnes. Rotterdam to Plymouth. Observer, Mr. W. C. Sommerfield, Chief Officer.

11th November 1966. At 1915 GMT when 7 miles E's of Start Point, the loom of the Lizard Point light was seen at a distance of 71 miles. Air temp. 53°F, wet bulb 51·5°. Sea 58°. Cloud 8/8 Sc.

Position of ship: 50° 11'N, 3° 26'W.

Note. The apparent distance of the horizon is usually reduced when the air is at a lower temperature than the sea immediately beneath it. On this occasion, however, in spite of the recent passage of a weak warm front over the area, there was a shallow temperature inversion in the air sufficient to create anomalous refraction by which the range would be extended. The direct beam of the Lizard Point light would normally have been visible at just over 20 n. miles. Undoubtedly the 8/8 Sc acted as a reflector by which the light loom was seen at a much greater distance.

SAND DEVILS

Suez Canal

s.s. *Oronsay*. Captain E. Cowen. Port Said to Aden. Observer, Mr. C. E. Burnell-Jones, 4th Officer.

18th October 1966. At 1200 LMT when the vessel was passing through the Suez Canal a sand devil was seen. It resembled dark smoke when first observed, but closer approach showed clouds of sand in the form of a column swirling upwards in an anticlockwise direction. The column was about 1,000 ft high and ended in the vicinity of a single, dark, towering cumulus cloud. The base of the column was about 60 ft across at first, but it increased to about 100 ft by 1210 and then started to decrease again. At 1215 the column of sand thinned and divided into two sections about 200 ft apart; a few minutes later the sand dispersed. Several small swirling clouds of sand were seen at 1220 but they lasted for a few minutes only.

El Tina Signal Station was passed to starboard at 1224. Air temp. 80°F, wet bulb 70°. Wind SSE, force 2. Cloud, 2/8 C_L1.

Position of ship: 31° 05'N, 32° 19'E.

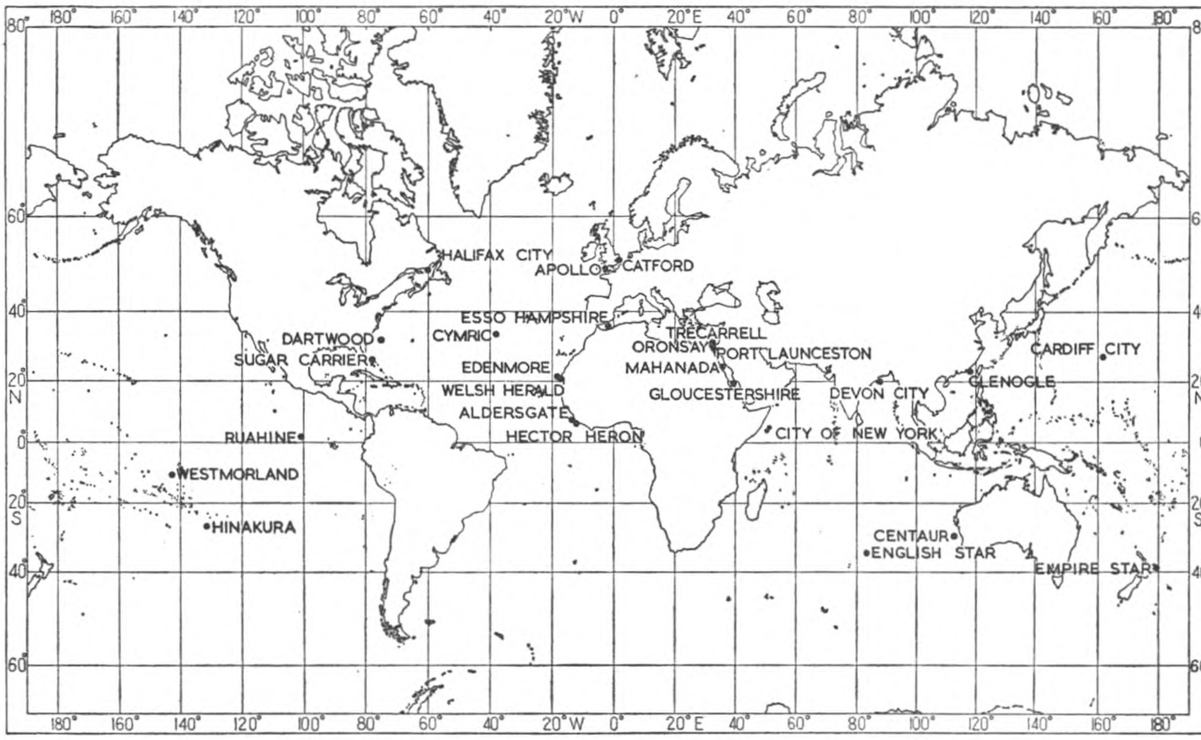
SANDSTORM

Suez Canal

m.v. *Port Launceston*. Captain G. Carling. At anchor. Observer, Mr. D. J. Morton, 3rd Officer.

8th November 1966. The vessel was at anchor 1·7 miles from the land, in the Great Bitter Lake, when at 1110 GMT dust was observed building up over the shore. At 1115 the sandstorm began to move quickly across the Lake and in a matter of 2 or 3 min the vessel was in smog-like conditions. The wind, which previously had been no more than light airs, increased to force 5 from a W'ly direction; by 1121 it was N'ly, force 8. A low, then moderate swell developed, moving from about NW. At the height of the storm visibility was reduced to 300 yd but only a very slight amount of sand was felt at the ship, not nearly as much as might have been expected from the appearance of the sky. By 1200 the sandstorm had cleared the area, almost as quickly as it had arrived. As the storm approached, clouds of type C_L2 and C_H9 were seen. The air temp. was 85°F and the wet bulb 78°.

Position of ship: 30° 22'N, 32° 20'E.



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

CURRENT RIP

Red Sea

s.s. *Mahanada*. Captain A. P. Briggs. Djibouti to Suez. Observers, Mr. B. H. Bennion, 2nd Officer and Mr. M. R. N. James, 3rd Officer.

17th December 1966. A current rip was observed at 1120 GMT lying in a direction 239°–059° from horizon to horizon. As the vessel passed through the line of disturbance the vessel's head swung 11° off course, to port, in 40 sec. Wind NW'W, force 4. Course 329°.

Position of ship: 24° 08'N, 36° 21' E.

EXCEPTIONALLY STEEP WAVE

Gulf of St. Lawrence

m.v. *Halifax City*. Captain E. Irish. Avonmouth to Montreal.

20th October 1966. When off Cape Whittle at about 2310 GMT, the vessel was rolling heavily in a very rough sea and a short steep swell, the wind being SE, force 8–9. At 2325 an extremely steep wave was encountered far in excess of what was being experienced, which caused the vessel to be thrown about and roll in excess of 47° each way. Course was altered from 268° to 180° and speed reduced until conditions enabled the voyage to be continued with the wind and sea aft.

Position of ship: 50° 05'N, 60° 00'W.

Several weeks later, while working the Great Lakes, our agency at one port mentioned that an underwater land slip, or tremor, had occurred at about the same time in the vicinity of Cape Whittle.

Note. There is no record at Kew Observatory, Richmond, Surrey, of any seismological disturbance having occurred in the area referred to. The outsize wave encountered would most probably have been caused by several waves, having different periods and heights, getting 'into step' and thus producing a wave of abnormal dimensions. It is possible that the period of the wave may have coincided with the natural period of roll of the vessel, thus causing her to roll more heavily.

LINE OF DEMARCATION

Eastern Pacific Ocean

m.v. *Ruahine*. Captain R. G. Hollingdale. Balboa to Papeete. Observer Mr. R. Laycock, 2nd Officer.

28th November 1966. A line of demarcation between two currents was observed at 1252 GMT lying in a direction 130°–310°. Sea temperature observations, when using a rubber bucket, gave readings of 77·6°F to the east of the line, while only 400 yd further towards the west the temperature dropped to 66·2°. Wind s'ly, force 3. 8/8 C_L5.

Position of ship: 1° 28'N, 100° 23' W.

Note. Although the demarcation line between the west-flowing, relatively cool South Equatorial Current and the east-flowing, warmer Equatorial Counter-current usually lies parallel to the equator and rather further north than *Ruahine's* position, meanderings could easily account for the orientation here reported. Sea surface temperatures in this locality inevitably cover a fairly wide range but a difference of 11·4°F is quite exceptional.

BAT

off Sierra Leone

m.v. *Aldersgate*. Captain P. L. Hopkins. Antwerp to Monrovia. Observer, Mr. I. Stoppard, 3rd Officer.

7th December 1966. At about 0800 GMT, when the vessel was about 65 miles from the nearest land, a creature resembling a bat landed on the vessel and was caught by one of the crew. On measurement the wings were found to have a total span of 27 inches. The body was about 7 inches long, ending in two points and was covered with fur of a medium-brown shade. The fur itself was infested with numerous small red spiders. The head was large, with big round protruding eyes, similar to a bush baby's, which seemed to have little vision in the daylight. The ears were long and pointed and the snout, which was also long, had a square-shaped end. When the creature's mouth was forced open the teeth were seen to be white, extremely long and sharp, and they pierced the thick fireproof cloth in which it was being held. After examination it was released and flew off but it did not go beyond 200 yd from the vessel, staying in the air for some 10 hours and not landing until Monrovia was reached. In flight it was extremely agile, with very swift movements, diving towards the sea and generally behaving like a normal sea bird. Wind calm.

Position of ship: 7° 16'N, 13° 32'W.

Note. Mr. R. W. Hayman of the Mammal Section, Natural History Museum comments:

"The description indicates that the animal was likely to have been one of the two larger species of West African fruit bats. The probability is that it was a specimen of the Hammer-headed Fruit Bat, *Hypsignathus monstrosus*. The description of the squarish snout, the medium-brown fur and the size all fit, although adult males of the species can reach an even larger size, up to three feet overall wing span and a body length of up to ten inches.

"The only other West African fruit bat reaching the dimensions given is the Straw-coloured Fruit Bat, *Eidolon helvum*, but in this species the snout could hardly be described as square-shaped and the body colour is a rather conspicuous strawy-yellow, with large naked black flanks limiting the fur on the back to a narrow band. This species has once been recorded 150 miles from land off West Africa. There appears to be no published record of the Hammer-headed Fruit Bat occurring at sea, but since its habitat on land includes coastal mangrove swamp there is the possibility that an occasional individual might wander or be blown off course. Both these bats are strong fliers and are accustomed to seasonal migrations in search of the tropical fruits on which they live and *Eidolon helvum*, in particular, is often seen flying from the mainland to off-shore islands from the Cameroons to Sierra Leone.

"If the captain or any member of the crew who actually handled the bat were able to call here we could show him these two species and perhaps arrive at a more definite identification from the skins available here.

"A remarkable feature of the observation is the length of the sustained flight within sight of the ship after release for 10 hours until port was reached. This is probably greatly in excess of the duration required in the terrestrial seasonal migrations of any of these fruit bats.

"Further observations of this kind from ships at sea off West Africa would be most interesting as reports of this kind for fruit bats are very few indeed. On the other hand, some of the small insectivorous bats, particularly in the New World, are well known to make annual long migrations from North to South America, often involving long sea flights, and there are many reports of these bats turning up in Bermuda or on ships hundreds of miles from the nearest land at such times."

SWIMMING CRABS

Somalia waters

s.s. *City of New York.* Captain R. H. Broadbent, Mombasa to Djibouti.

22nd October 1966. At 1315 GMT numerous small brown crabs, varying in size from about 1½ to 3½ inches across the shell, were sighted swimming on the sea surface up to a distance of about a mile from the ship, judging by the ripples which they caused. On the average the separation between individual crabs was around 3 or 4 ft. So far as could be determined there was a general movement of the whole body towards the south or southwest, and there was no change in the density of distribution right up to 1440 when darkness prevented further observation.

Sea temp. 81°F. Wind NE, light airs. Sea smooth with long, low NE swell. Current approx. 050° at 2 kt.

Position of ship at 1315: 3° 56'N, 48° 17'E.

Position of ship at 1440: 4° 18'N, 48° 30'E.

Note. Dr. A. L. Rice, of the Department of Zoology, Natural History Museum, comments:

"This observation is very similar to an earlier one made from m.v. *Herefordshire,* Colombo towards Aden, on 21st October 1963 in the same general area (10° 43'N, 59° 26'E). In neither of these reported cases were specimens of the crabs caught, so that it is impossible to say what they were with any certainty.

"However, during the International Indian Ocean Expedition, similar sightings of swimming crabs were made from the research vessel *Anton Bruun* in the extreme western Indian Ocean. The crabs were seen on three successive evenings (1st–3rd November 1964) in the area 5°–10°S, 41°–44°E and a number of specimens were collected. They turned out to be Portunid swimming crabs *Charybdis (Goniohellenus) edwardsi* Leene and Buitendijk, and in size and colour quite closely agree with the *Herefordshire* and *City of New York* reports.

"As their common name suggests, the family to which *C.edwardsi* belongs are adapted for swimming although they normally spend most of their time on the sea bottom. Prior to the *Anton Bruun* report only one species of the family, *polybius henslowi* Leach, was known to swarm. Very little is known about the biology of these oceanic crabs but it is suggested that swarming may be a response to the temporary presence of food in the upper layers or, alternatively, connected with the reproductive cycle, as in the famous palolo worm of the Pacific. It is interesting that these three records from the western Indian Ocean were all in late October or early November, indicating perhaps that whatever causes the swarming behaviour occurs at the same time each year!

"Many thanks for the information, we would welcome any further records you may come across."

WHALE UNDER ATTACK

off Cape Blanco

m.v. *Edenmore.* Captain A. L. Wiles. Monrovia to Cardiff. Observers, the Master, Mr. J. S. Rutherford, Chief Officer and Mr. J. W. Rimmington, 2nd Officer.

15th November 1966. A disturbance was noticed on the starboard bow and on closer inspection was seen to be caused by creatures jumping out of the water. They were black, with white stripes on their sides. (The writer usually knew them as 'Blackfish' but has also heard them called 'orca', 'grampus' or even 'thresher'). On approaching to within about 2 miles of the scene, a big whale was found to be in the centre of the disturbance and a considerable amount of blood was seen on the surface of the water; there was apparently a large wound in the whale's side. Five fins were seen at one time but the total number of assailants involved was unknown. One of the attackers was seen to leap clear of the water and land on the whale's head.

Position of ship: 21° 32′N, 17° 54′W.

Note. Dr. F. C. Fraser of the Department of Zoology, Natural History Museum, comments:

"The incident described suggests to me that the animals attacking the whale were *Orcinus orca* (the Killer or Grampus). The noticeable dorsal fin, the black and white pigmentation, the aggressiveness of the attack, all point to the Killer. I have not heard of the name 'thresher' being applied to this species. Its normal application is to a species of shark with a very long dorsal lobe on the tail, brownish grey on the back, somewhat lighter ventrally but definitely not contrasting black and white. The thresher is a fish-eater, its prey being small fish such as herring. The Blackfish (=pilot whale or ca'ing whale) has a much greater preponderance of black in its body colour than the Killer, also the Blackfish head is much more globose, the 'forehead' bulging out above the upper jaw whilst that of the Killer, although rounded, is altogether much lower and less prominent. I am glad to have seen Chief Officer Rutherford's letter which is a useful addition to information about *Orcinus orca.*"

FLOATING 'ISLAND'

off Sierra Leone

m.v. *Hector Heron.* Captain S. Hay. Bonny to Hamburg.

13th November 1966. A floating 'island' about 50 yd × 30 yd was passed at 1145 GMT. It consisted entirely of grass and rushes and had the appearance of having been broken off from the land, although no soil could be seen adhering to it. A great number of sea birds were on the 'island'.

Position of ship: 6° 46′N, 12° 55′W.

Note. Dr. T. J. Hart of the National Institute of Oceanography comments:

"The formation of such rafts is quite frequent on the estuarine parts of tropical rivers (notably the Amazon) where, however, onshore winds tend to keep them confined to the river reaches at most seasons. There are ample lagoon and estuarine stretches inside Sherbro Is. (7° 30′N, 12° 40′W) for a source of such a raft and ebb tides of up to 2½ kt would help one over the bar. Then seasonal factors would affect the rate of drift. November falls just within the period of the second or 'little' rains on that coast and also within the so-called 'tornado' season, a term which is used in West Africa to denote a seasonal recurrence of heavy line squalls that may reach some 40 kt and an almost 24-hourly frequency. These blow off the land from the north, frequently extending quite far out into the Gulf of Guinea.

"Sea birds will gladly avail themselves of any resting place furnished by flotsam (when large enough) and certain fishes etc. tend to congregate round the same."

GULF WEED

Bahama Islands

m.v. *Sugar Carrier.* Captain J. R. Cassidy. Sydney (Cape Breton Is.) to Tampico. Observer, Mr. W. Brothers, 2nd Officer.

9th October 1966. Between 1930 and 2015, when in the Northwest Providence Channel, the vessel passed from deep blue water into an area of much lighter blue estimated to be 13 miles long by 6 miles wide. Inside the light patch very little of what is commonly known as gulf-weed was seen, whereas outside it the weed was abundant. As far as could be seen, the patch of lighter water was almost completely enclosed by a belt of weed varying from approximately 4 ft to 20 ft in width.

The mean of three sea-temperature readings taken by rubber bucket while passing through the lighter blue water was 85·3°F; readings taken in the deep blue water gave a mean of 82·7°. Wind NE'E, force 2–3. 3/8 C_L1 and C_M1. Course 273°. Speed 15 kt.

Position of ship at 1800: 26° 00′N, 78° 00′W.

LUMINESCENCE

Bay of Bengal

m.v. *Devon City*. Captain M. J. Higgins. Madras to Calcutta. Observer, Mr. J. J. Kalnins, 2nd Officer.

29th November 1966, 2200 GMT. No luminescence at all had been observed in the sea this night. However, when the log-line, which had been handed about 5 hours previously and was now nearly dry, was moved in the darkness of the wheelhouse it sparkled with minute specks of bright green light and continued to do so until completely dry. Even when examined under a magnifying glass no trace could be found of the particles emitting the light. They were certainly not activated by any kind of artificial light. Sea temp. 80°F.

Position of ship: 20° 00′N, 87° 30′E.

Taiwan Strait

m.v. *Glenogle*. Captain W. J. Moore, D.S.C., R.D. Moji to Hong Kong.

16th December 1966. Luminescence was observed intermittently over a distance of 40 miles, weak from 1300 to 1400 GMT and bright from 1400 to 1530. Isolated intense bright green discrete spots were observed near the surface within 60 ft of the hull, glowing vividly for 1–2 sec, apparently stimulated by disturbance of the water by the hull and by the wind. Samples were taken which glowed when agitated; formalin abolished the effect. Wind NNE, force 5. Moderate sea, low swell, overcast and very dark.

Position of ship: 23° 20′N, 117° 45′E.

Note. Dr. T. J. Hart, who analysed this sample at the National Institute of Oceanography, reports the presence of parts of two large dinoflagellates both known to possess the power of luminescing: *Noctiluca miliaris* and a species of *pyrocystis*, probably *p. lunula*.

Note 2. Dr. R. H. Kay of the University Laboratory of Physiology, Oxford, writes:

"An interesting aspect of movement stimulation of these little jellyfish-like creatures is that their average density is very close to that of the sea water itself; the relative motion between the animal and the water must be very small. Therefore they are either extraordinarily sensitive to water flow across their bodies or extraordinarily sensitve to small accelerations, presumably detected by the different densities of parts of their structure, though the whole has about the density of water."

New Zealand waters

m.v. *Empire Star*. Captain G. G. King. Lyttelton to Panama. Observers, Mr. P. A. Heathcote, 3rd Officer and Mr. P. Lielle, lookout.

23rd December 1966. Marked luminescence was seen from about 1345–1445 GMT in the bow wave and in the breaking crests of waves where the accommodation lighting shone on them. It consisted of small specks giving off a greenish-white light, but occasionally larger objects about 6–8 inches in size were observed. One small object landed on the foredeck when the vessel shipped a large amount of spray. It glowed brightly and seemed to do so even more each time when spray came aboard. The lookout was sent down to retrieve it and when brought up to the bridge it still gave off a faint glow. The specimen, which resembled a shrimp, was put into a glass of water to see if this would revive it, and thereafter it glowed dully for 2 or 3 min before fading out altogether. Next day it was put into a small bottle containing methylated spirits in an attempt to preserve it, no formalin being available. Sea temp. 64°F. Wind NNE, force 5. Heavy NE swell. Sky overcast.

Position of ship: 41° 47′S, 178° 10′E.

ABNORMAL REFRACTION

North Sea

m.v. *Catford*. Captain E. Clarke, M.B.E. Sunderland to London. Observer, Mr. L. Thompson, 2nd Officer.

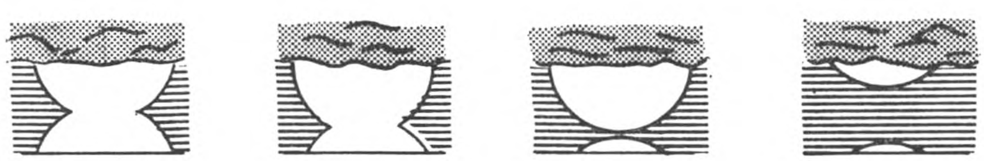
23rd October 1966. When off Orford Ness at 0530 GMT the effects of abnormal refraction were observed, lights beyond 7 miles' range appearing double, with a false light below the true light. Air temp. 49·8°F, sea 57·4°. Visibility very good. Wind w'ly, force 3. Cloud 6/8 Sc.

Position of ship: 52° 05'N, 1°40'E.

Note. A shallow depression had moved steadily across southern England and the North Sea during the night and at the time of this observation was centred near Heligoland. Behind this a cold airstream resulted in the air temp. being lowered to several degrees below that of the sea. The consequent abnormal refraction produced a mirage, the reflected image being seen *below* the real object.

off Port Said

m.v. *Trecarrell*. Captain R. B. Oliver. At anchor. Observer, Mr. J. Double, Chief Officer.



12th December 1966. As the sun rose, conditions of abnormal refraction caused it to undergo in 1½ min the changes of appearance shown in the accompanying diagrams.

Position of ship: 31° 17'N, 32° 19'E.

BROCKEN SPECTRE

Mediterranean Sea

s.s. *Esso Hampshire*. Captain L. H. Grey. Sidon to Fawley. Observers, the Master, Mr. G. G. Cunningham, 3rd Officer and Mr. W. Saunders, A.B.

21st October 1966. Between 0945 and 1015 GMT, while the vessel was proceeding through moderate to thick fog, the observers standing on the starboard wing of the bridge noticed that their shadows were cast on the fog by the sun, which was towards the SE. The shadows were encircled by a white bow which showed faintly the colours of the spectrum. Air temp. 61·5°F, sea 60·0°. Wind w'ly, force 1.

Position of ship: 36° 35'N, 2° 19'W.

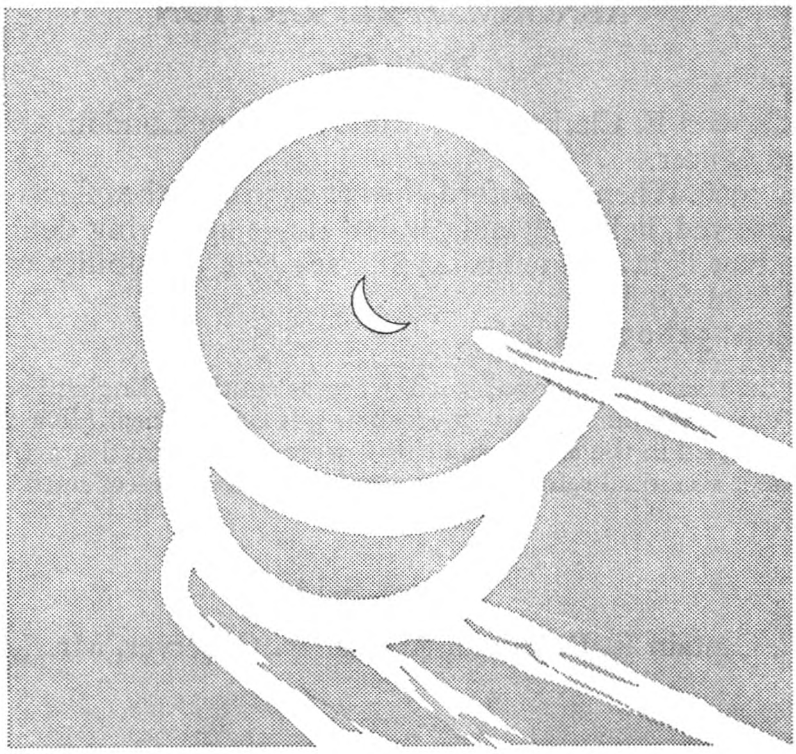
Note. This phenomenon is associated with great density of very fine drops in the fog and, behind the observers, of high intensity of the sunlight. The Brocken Spectre, as it is called from first being noted on the Brocken Mountain in Germany, is more common at sea in Arctic regions (where the sun is naturally at a low altitude) than in middle latitudes.

LUNAR HALO COMPLEX

South Indian Ocean

m.v. *English Star*. Captain G. Seaye. Beira to Melbourne. Observers, Mr. P. G. Hoiles, 3rd Officer and Mr. P. Holtby, 4th Officer.

20th October 1966. At 1340 GMT the halo complex shown in the diagram was observed. It was of the 22½° radius type and whitish in colour, as were the other



parts of the complex which were visible for 20 min. The halo proper was seen for an hour.

Position of ship: 37° 34′S, 83° 30′E.

CREPUSCULAR RAYS

Red Sea

m.v. *Gloucestershire.* Captain L. H. Sheldrake. Aden to Suez.

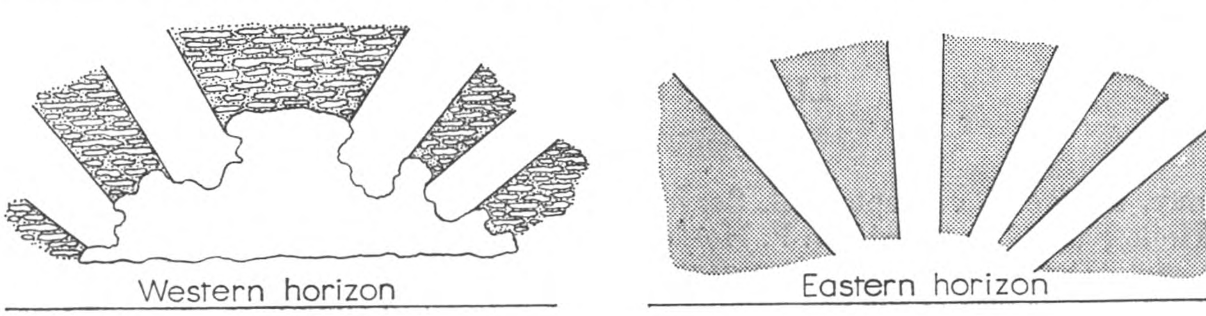
17th October 1966. At 1500 GMT, shortly after sunset, crepuscular rays were observed radiating from the setting sun and converging on the opposite horizon, but none was seen overhead. The sunset was golden red in colour, while the rays in the west were bright red and purple-blue. In the east the rays were dark red and purple, with quite well-defined edges, but there was no definite point of convergence. The cloud consisted of lenticular Ac or Ci in ill-defined patches. The sun bore 260° on setting and the rays reached an altitude of about 60°, extending from the northern horizon to 45° above the southern horizon. Visibility was excellent.

Position of ship: 19° 45′N, 39° 05′E.

South Pacific Ocean

m.v. *Westmorland.* Captain A. C. Davies. Balboa to Noumea. Observers, Mr. I. Thomson, 2nd Officer and Mr. M. G. Bishop, 3rd Officer.

12th December 1966, 0345–0405 GMT. At sunset an interesting light effect from the sun's rays was observed. The sun, setting behind a large Cb cloud, sent rays of



light which illuminated the Ac (C_M3) from the observers' zenith to a point just above the eastern horizon in remarkably distinct bands of light and shade, as shown in the accompanying sketches. Air temp. 78·5°F, wet bulb 75·5°. Visibility excellent.

Position of ship: 9° 58'S, 142° 46'W.

GREEN MOON

at Swanage

The following observation was made by Mr. K. G. Thomas, 2nd Officer, *Esso Exeter*, while on leave in Swanage.

18th December 1966. During my leave I was walking along the High Street at Swanage, Dorset just at or after sunset (about 1630 GMT). The setting sun was obscured from my view by buildings and rising ground, which also prevented my seeing any part of the horizon. There was some Ci and Cs or As in the sky which was perhaps 3/8 or 4/8 covered; I cannot be exact about this because I had no comprehensive view of the sky. In the sky to the west and south-west the clouds were red-tinted and I was suddenly astonished to see that the moon, which came into my field of vision from behind a church tower and bore about S'W, was bright green. It was plainly visible through a patch of Cs which was tinged with pink, but which was very much less than the cloud in the sky to the west. I was with my mother at the time and we both witnessed the green colouration which lasted for perhaps 30 sec. Thereafter it diminished and although we thought we recognized a green tint for a further minute or so, this may have been because we were looking for it. The patch of Cs between us and the moon was apparently without motion during the observation.

Note. Dr. D. J. K. O'Connell, S.J., Director of the Vatican Observatory, comments:

"Reports such as that of Mr. Thomas, as a ship's officer a careful and experienced observer, are always valuable. The length of time that the green colour persisted is, I think, sufficient indication that it was not an after-effect of seeing the red sun or red clouds."

Dr. O'Connell forwarded the observation to Professor M. Minnaert, former Director of the Utrecht Observatory, who comments:

"The report about the observation of a green moon is, in my opinion, a very clear example of colour contrast. The observer was only able to see the portion of the sky which showed a pronounced red-pinkish colouration. The rather quick disappearance of the contrast green may be due to an adaptation of the eye to the surrounding colour."

When forwarding Professor Minnaert's comments, Dr. O'Connell remarked that "these phenomena are often not at all easy to explain fully".

METEOR SHOWER

North Pacific Ocean

m.v. *Cardiff City*. Captain A. B. Parkhouse. Pascagoula to Moji. Observer, Mr. P. D. Haworth, 2nd Officer.

17th November 1966. Between 1300 and 1700 GMT meteors were frequently seen, but none remained visible for more than 2 sec, or was of any exceptional brilliance or colour. The average magnitudes varied between those of the stars Regulus and Rigel. When the tracks were produced backwards nearly all the meteors seemed to originate from an area between the stars Dubhe, Merak, Phecda and Megreg of the constellation Ursa Major.

Position of ship at 1500: 27° 10'N, 161° 15'E.

South Pacific Ocean

m.v. *Hinakura*. Captain N. L. Warren. Auckland to Balboa. Observer, Mr. C. J. Brownings, 2nd Officer.

17th November 1966. Between 1030 and 1300 GMT intense meteor activity was observed ahead of the ship.

At first only about one meteor was seen at any particular moment, but the number gradually increased to about six at a time up to 1130 GMT when the sky became 'alive' with a very intense shower which continued for about 45 min. The numbers thereafter gradually decreased until about 1300 when the last one was seen. Cloud, 1/8 C_M6.

Position of ship at noon: 25° 18′S, 131° 48′W.

Western North Atlantic Ocean

m.v. *Dartwood*. Captain J. Elliott. Newport News to Mobile. Observer, Mr. W. F. R. Whiting, 2nd Officer.

17th November 1966. At 0751 GMT a brilliant meteor came into sight to the south of Sirius, travelling westwards. It left a long reddish trail and exploded with a brilliant flash about 10° above the horizon on a bearing of 220° from the ship. A white flash was seen at 0809, bearing 230° from the ship about 7° above the horizon, but cloud made it impossible to see whether there was a trail or not. Two trails were seen at 0831 and 0832 about 30°–40° above the SW horizon but cloud prevented a more complete observation. Ship's course 189°.

Position of ship at 0751: 32° 01′N, 75° 48′W.

AURORA

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

"Listed below are visual auroral observations made by observers in British ships during October–December 1966. There are also six reports which arrived too late to be included in the previous issue. Again some welcome new names appear in the list, of which we specially mention the Canadian observing ship *Sunprincess*. The data are charted at the Balfour Stewart Auroral Laboratory in the University of Edinburgh and we ask all those concerned in making and passing on the written and sketched details to accept grateful thanks for their help.

"The reports from observers in ships are read with much pleasure at the B.S.A.L. The majority of reports from other sources are now in abbreviated symbolic style which enables those with very limited time to observe, aircraft personnel for instance, to record briefly but accurately the essential information. But to read that the aurora "had taken on a definite form like a light green curtain blown in a gentle breeze", or to extract the information conveyed by a carefully drawn sketch, is to be reminded that an auroral display is a fascinating and awe-inspiring spectacle.

"There were no outstanding displays during this period, but the reports fit into the pattern of geomagnetic activity/auroral appearance/latitude relationship. Solar activity increased steadily during 1966 and the graph outline shows clearly how well chosen were the Quiet Sun Years of 1964–65. We are now becoming aware of a fairly rapid build-up towards the next solar maximum."

Date (1966)	Ship	Geographic Position	Λ	Φ	I	Time (GMT)	Forms
4th Sep.	*Colina*	45°15′N 74°13′W	360	57	+75	0045–0314	HB,RB,RR,P,V,N
15th	*Redcar*	54°35′N 44°17′W	030	64	+73	2300–0314	HA,HB,RB,RR,P
19th	*Sunprincess*	46°45′N 71°20′W	360	61	+75	0330–0530	HA,RB,N
	Manchester Freighter	50°00′N 61°40′W	010	61	+75	0400–0515	HA,HB,RA,RB
20th	*Essex*	53°18′N 51°06′W	020	64	+74	2330–0200	RB,RR,N
27th	*Manchester Freighter*	48°30′N 69°00′W	360	60	+75	0250–0305	HB,RB
4th Oct.	*King City*	49°30′N 62°00′W	010	61	+75	0100–0340	HA,HB,RA,RR
						0810–0820	HB,RA,RR,P
	British Workman	58°53′N 00°35′E	090	61	+72	2013–2045	RR,P
	Weather Adviser	52°43′N 20°13′W	060	59	+69	2335	RB
5th	*Weather Reporter*	59°04′N 18°57′W	070	65	+72	2200–2215	HA
9th	*Mabel Warwick*	51°20′N 57°00′W	020	63	+75	2320–0010	HA,RA,N
18th	*Mabel Warwick*	65°00′N 05°00′E	100	66	+75	1730–2300	HA,HB,RB,N
20th	*St. Giles*	70°24′N 11°21′E	110	69	+77	1725–2100	HA,RB,P,N,
26th	*Catford*	52°00′N 01°33′E	080	54	+67	0100–0115	N
29th	*St. Giles*	74°10′N 17°30′E	120	71	+79	2000–2030	HA,RB
7th Nov.	*Weather Surveyor*	59°00′N 18°55′W	070	65	+72	2150–0500	HA,N
8th	*King City*	52°20′N 53°00′W	020	63	+74	0400	HA,HB,RA,RB,P
	Franconia	50°00′N 60°30′W	010	62	+75	0420–0715	HA,HB,RR,N
	Weather Surveyor	59°05′N 18°50′W	070	65	+72	2350	N
9th	*Weather Surveyor*	59°05′N 19°05′W	070	65	+72	0450–0600	N
10th	*Weather Surveyor*	59°00′N 19°00′W	070	65	+72	0050	HB
12th	*Weather Surveyor*	58°55′N 19°30′W	070	65	+72	0250	HB
		59°00′N 19°10′W	070	65	+72	2350–0100	N
13th	*Weather Surveyor*	58°55′N 19°00′W	070	65	+72	2150	HB
15th	*Weather Surveyor*	59°10′N 19°50′W	070	65	+72	2350	N
16th	*Weather Surveyor*	59°10′N 19°50′W	070	65	+72	0150–0350	N
19th	*Weather Surveyor*	58°30′N 17°25′W	070	65	+72	1950–2100	N
5th Dec.	*Weather Adviser*	59°08′N 19°02′W	070	65	+72	0115	RR
	Weather Adviser	59°02′N 19°15′W	070	65	+72	1950, 2345, 0145	N
	Rathlin Head	51°22′N 56°50′W	020	62	+75	2135–2330	HA,RR,N
10th	*Weather Adviser*	58°57′N 18°47′W	070	65	+72	2150	N
13th	*Weather Monitor*	58°25′N 17°00′W	070	64	+72	0500	N
14th	*St. Giles*	60°05′N 02°25′E	090	62	+73	1745–2400	RB,P
	Weather Monitor	59°05′N 19°05′W	070	65	+72	1900–2300	RA,N
	Catford	54°17′N 00°12′E	090	57	+68	2100–2250	RR,N
15th	*Weather Surveyor*	52°40′N 19°35′W	060	59	+69	0350	N
16th	*St. Giles*	69°50′N 17°20′E	120	68	+76	2115–2210	RB,P
18th	*Weather Monitor*	58°55′N 19°05′W	070	65	+72	2100	N
26th	*St. Giles*	71°27′N 24°10′E	120	68	+78	1829–1840	HB,RB

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.

551.507.2:551.508.824

The Meteorological Buoy Programme of the U.S. Navy

By CAPTAIN R. E. MOTTERN, U.S.N., E. F. CORWIN and A. F. PYLE
(Meteorological Division, Naval Air Systems Command, Department of the Navy, U.S.A.)

Introduction

Obtaining adequate meteorological and oceanographic information from the ocean areas of the world presents a serious problem. Synoptic weather observations and sea conditions are considered adequate only along major shipping routes. The quality of these observations is known to vary widely with the observers and ships that obtain them. To analyse and forecast environmental conditions successfully, it is necessary to know what changes are occurring in the atmosphere at all places and at all times. The use of numerical analysis and prediction by EDP (Electronic Data Processing) has become operational on a hemispherical basis during the past ten years. However, these methods are handicapped by inadequate spacing of observations and large areas of practically no information. The U.S. Navy is concentrating on methods of predicting the meteorological and oceanographic conditions at the air-sea interface, and computer techniques are being applied to these problems at the Fleet Numerical Weather Facility, Monterey, California.

The development of automatic weather buoys for the U.S. Navy began during the second world war under the joint sponsorship of the Navy Bureau of Aeronautics and the Navy Bureau of Ships for use primarily in coastal waters. The first ones developed were of the free-floating type.[1] It soon became apparent that it was not always possible to know the exact location of the free-floating type, so development work commenced on a moored boat-type automatic weather station constructed of aluminium alloy and other non-magnetic materials. This boat-type automatic weather station was anchored subsequently by a deep-water slack-line mooring in 1,875 fathoms of water. To approximately halve the cost of the relatively large boat-type station (20 feet long, 10 foot beam and hull depth approximately 9 feet), a toroid weather buoy 8 feet in diameter has been developed. In addition, a small boat-type weather buoy with dimensions approximately one-half those of the larger boat-type station has also been developed. Both the toroid buoy and the smaller boat-type station have transistorized electronic components and will be equipped with a command sub-system. With these three types of anchored environmental buoys, regional networks can be formed in the Atlantic, Pacific or Indian Oceans where practically no environmental information is now being obtained.

The U.S. Navy's general-purpose tactical weather buoy can be air-dropped to obtain short-term meteorological conditions for a specified area. This buoy was developed from an earlier model known as the 'grasshopper-type' weather station, which was parachuted from aircraft for use on land, and was successfully used in the Antarctic. By using some of the better features from the 'grasshopper' and a free-floating weather buoy known as the 'hurricane monitoring buoy' the current developmental model of the tactical weather buoy has evolved.

NOMAD (Navy Oceanographic Meteorological Automatic Device)

The larger U.S. Navy boat-type automatic weather station, AN/SMT-1 was named NOMAD. After preliminary tests of the developmental model in the Chesapeake Bay, a more powerful radio transmitter was installed to prepare the NOMAD station for deep-sea evaluations where transmission distances could be up to 1,000 n. miles.[2]

The NOMAD automatic weather station has two masts, a large flashing beacon, a buoy-type bell, a whip antenna fastened to one of the masts, but uniquely reinforced at the base to prevent damage due to flexing caused by wind, and a railing (*see* photograph opposite page 180). Sensing devices for temperature and wind are fabricated to form the top section of the instrument mast. Sensors for pressure and sea-water temperature are located separately. In addition, wind generators are fastened to the support frame for the flashing beacon. According to Corwin, *et.al.*,[3] considerable research and development effort went into the solution of providing a stable mooring for the selected location: 25° 00'N and 90° 00'W, or approximately at the centre of the Gulf of Mexico. Here the depth is 1,875 fathoms, presenting a formidable task to provide a safe mooring at this particular location. The Woods Hole Oceanographic Institution helped the U.S. Navy solve this problem. The final solution to the anchoring problem is shown overleaf. By using 10,000 feet of semi-buoyant ¾-inch polypropolene cable ending with 225 feet of first ¾-inch and then 1¼-inch chain connected to a 500-pound mushroom anchor, the main problem of dead weight on the buoy at the surface was almost eliminated. If only chain were used for anchoring the maximum anchoring depth would be 600 fathoms, so the buoyancy from the polypropolene cable would relieve the load on the buoy platform and allow the NOMAD to be located in the deep ocean with successful anchoring depths of 2,000 fathoms or more.

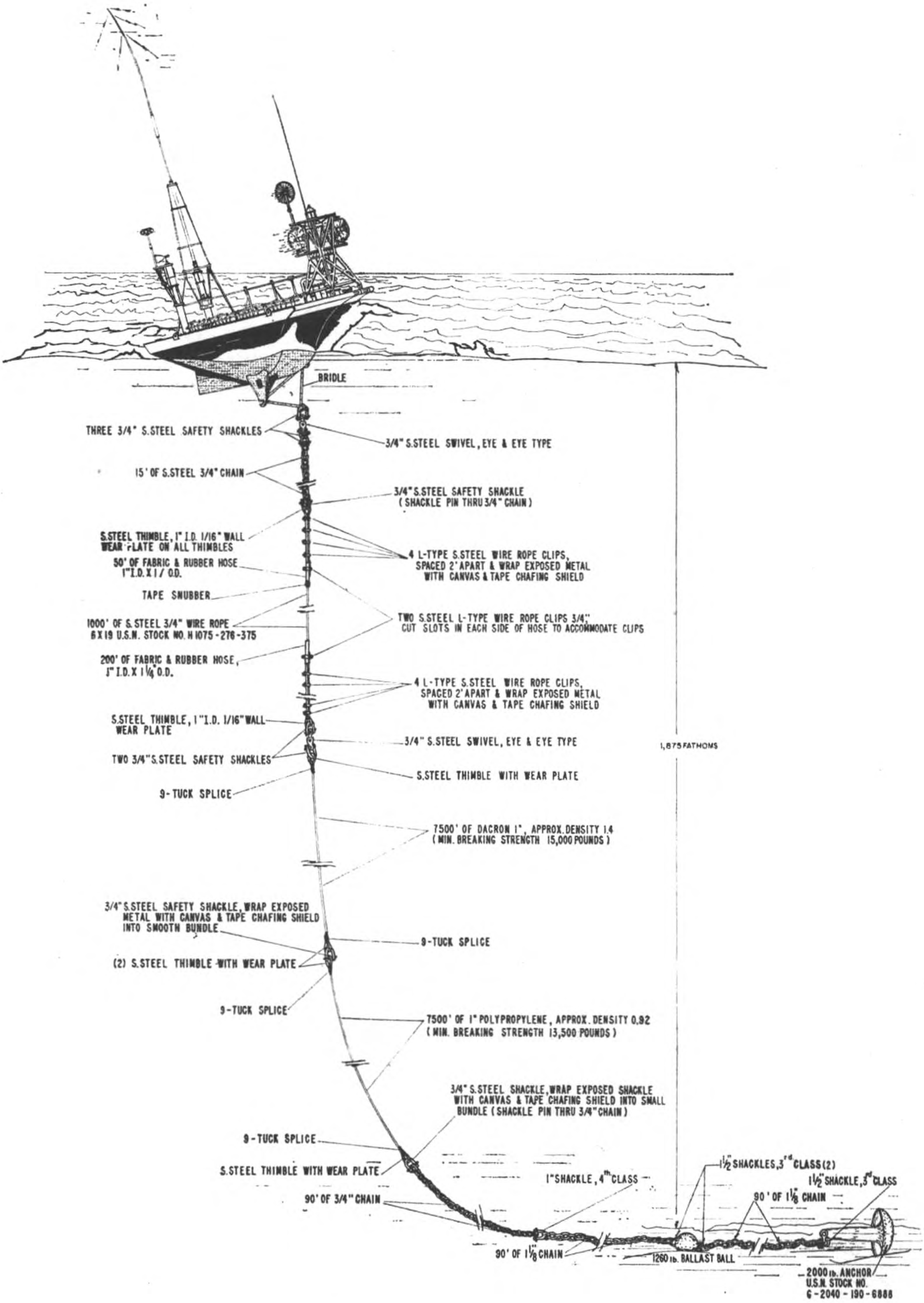
The NOMAD automatic weather station transmits normally on a 6-hourly schedule. During periods of high winds a storm sensor becomes operative, so for winds of 22 knots (± 2·0 knots), or above, the automatic station reports on an hourly schedule. The data transmitted is atmospheric pressure (± 1·0 mb accuracy), air-temperature (± 0·5°C accuracy), sea-water temperature (± 0·5°C accuracy), wind speed (± 2·0 knots accuracy) and wind direction (± 5·0° accuracy). Underwater temperatures and pressures to 1,000 foot depths have been measured and transmitted experimentally to shore receiving stations. A sea-state measuring device has been tested and is now being re-engineered for greater reliability and longer life. The objective of the NOMAD station is to provide a deep-ocean meteorological/oceanographic measuring device, which will operate for at least one year without maintenance.

Nuclear-powered NOMAD

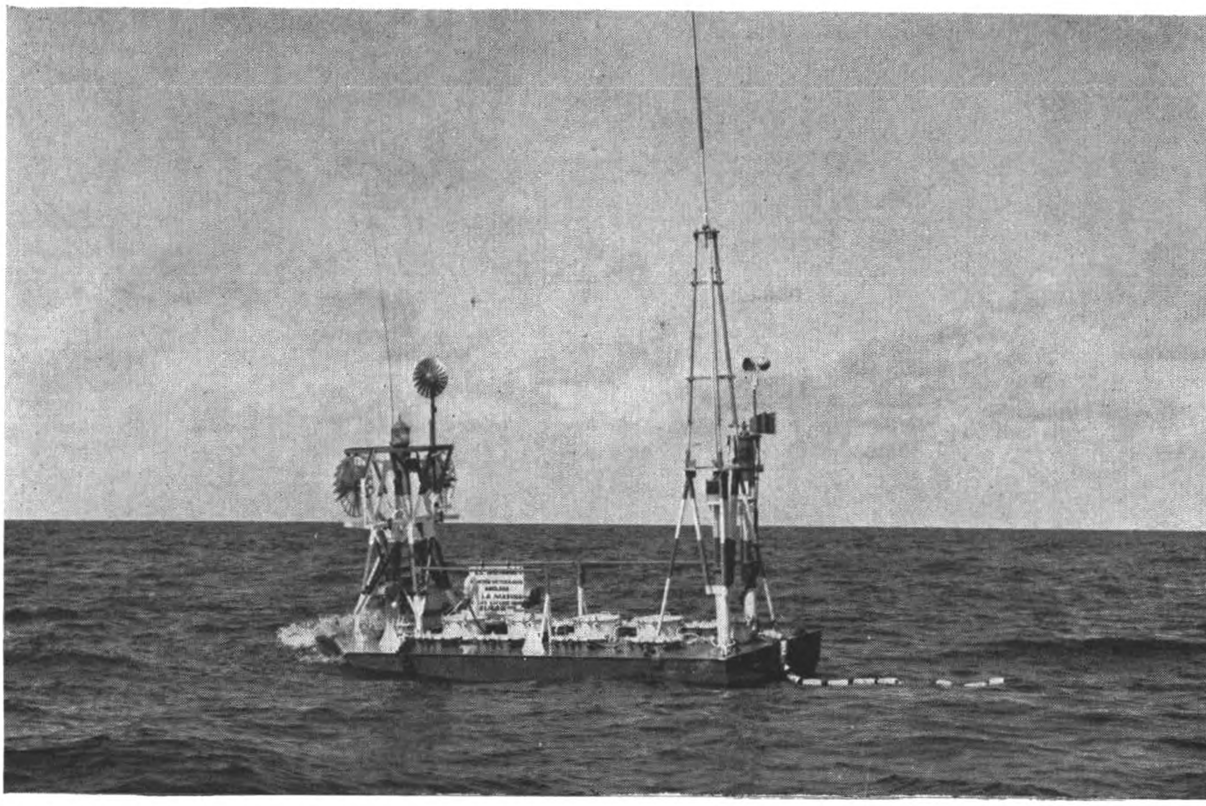
During the last week of January 1964 a nuclear-powered NOMAD was anchored in the central Gulf of Mexico at 25° 00'N, 90° 00'W (*see* photograph opposite page 180). This modified version of the NOMAD, with a 60-watt nuclear power supply, designated SNAP-7D, was starting a long evaluation for reliability, accuracy, and adaptability to adverse environmental conditions. After three years it is still reporting on schedule. The objective is to service the electronic components and the nuclear power-supply only once a year. With a few minor changes, such as more reliable relays, improved high-voltage insulators, etc., the objective will be reached.

The nuclear-powered NOMAD in the Gulf of Mexico had to live up to the reputation acquired by the original battery-powered NOMAD, at this same location. The original NOMAD made history when it became the first deep-sea weather buoy to be anchored successfully in approximately 2,000 fathoms of water and remain anchored over long periods of time. From the Gulf location, the earlier weather buoy detected and reported on Hurricane Ethel in 1960, and the same buoy reported weather information and sea-surface temperatures, hourly, throughout the passage of Hurricane Carla in 1961. Hurricane Carla, considered one of the most violent hurricanes to hit the Texas coast during the 20th century, passed directly over the NOMAD station before heading toward the Texas coastline.

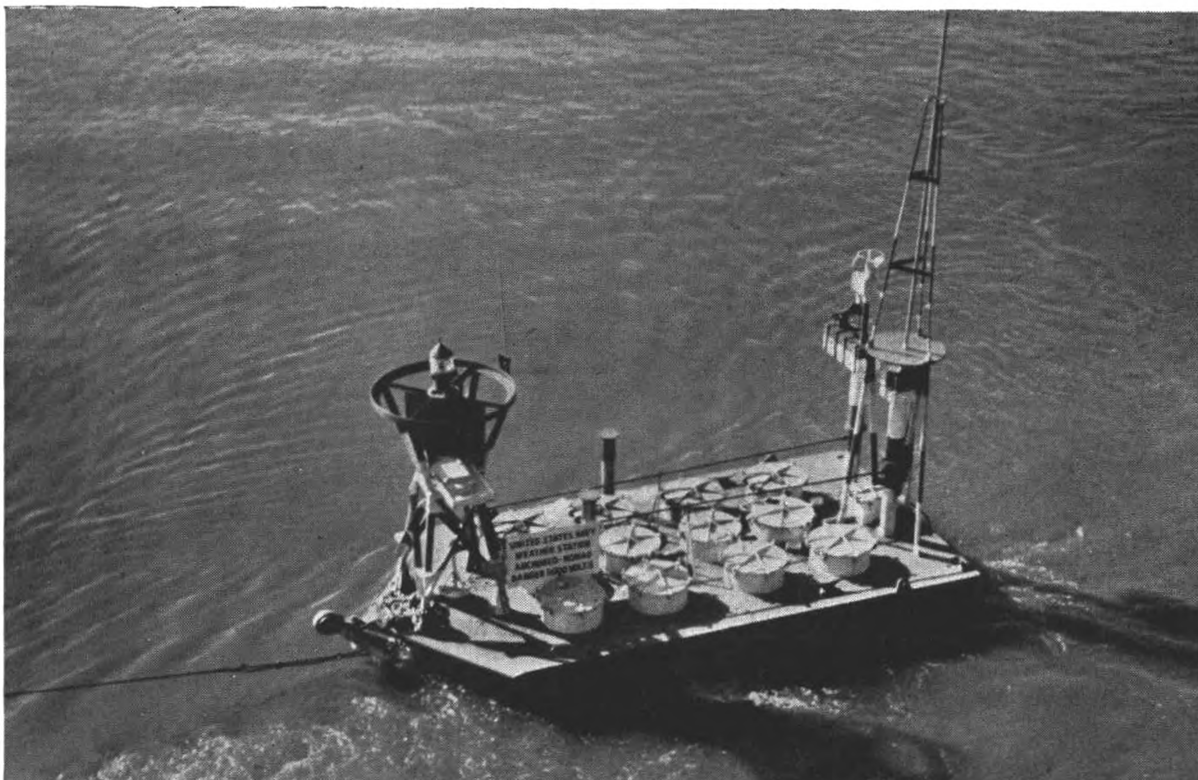
The development work, to combine the automatic weather buoy and the SNAP-7D power system, began over seven years ago. The Atomic Energy Commission and their contractor, the Martin-Marietta Company of Baltimore, Maryland, developed the SNAP-7D system, a radio-isotope-fuelled thermoelectric generator, to meet the requirements of automatic weather and oceanographic stations of the NOMAD type. This would allow mooring for long periods of time at deep-ocean locations. The SNAP-7D generator is 34 inches high, 22 inches in diameter, and weighs 4,600 pounds. It is fuelled with approximately 20 pounds (225,000 curies) of encapsulated strontium-90 titanate. A special high-strength, corrosion-resistant metal, Hastelloy C, encases the 14 fuel capsules, forming a seal designed to last 500 years—a period in



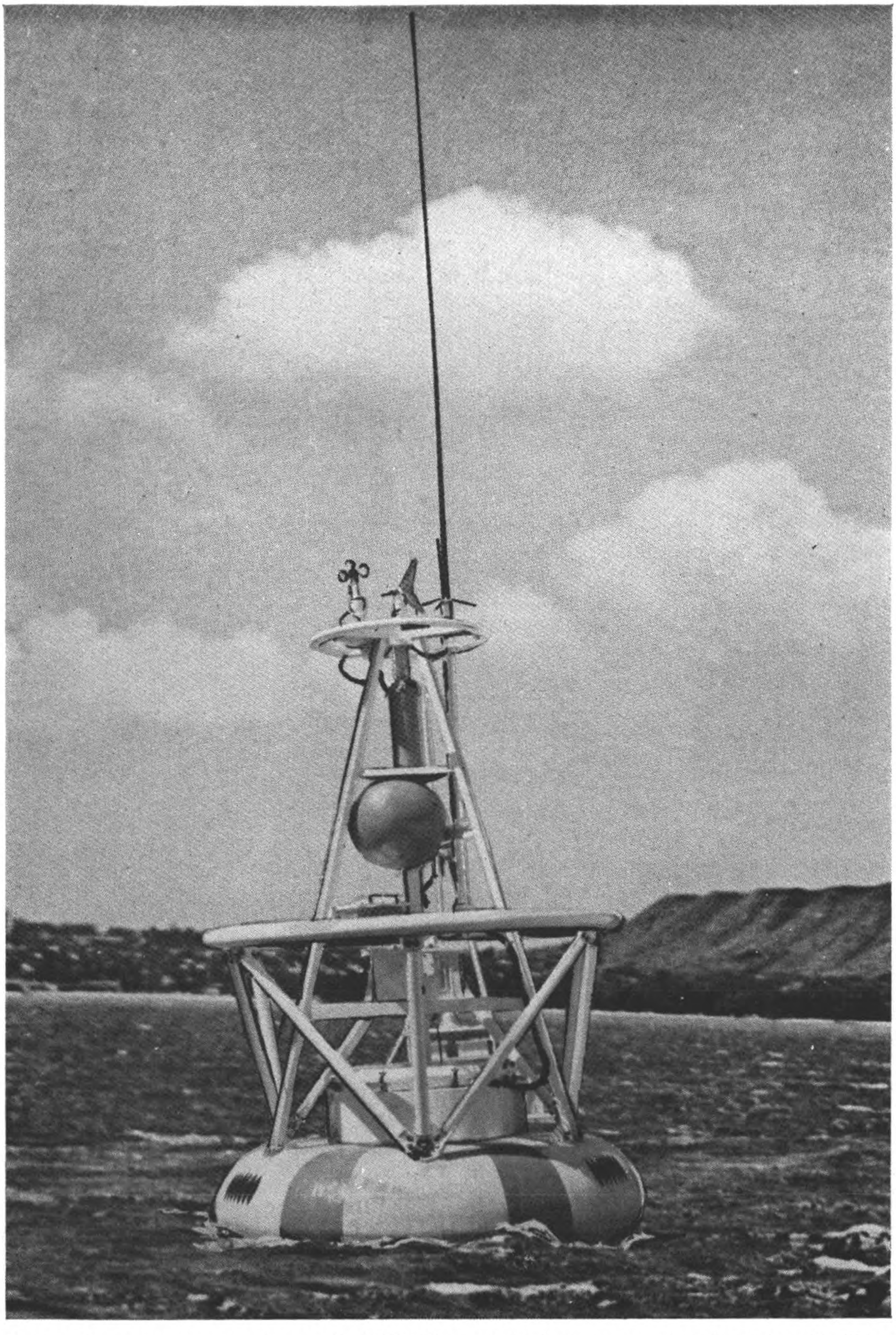
Deep-water anchorage for the NOMAD automatic weather station.



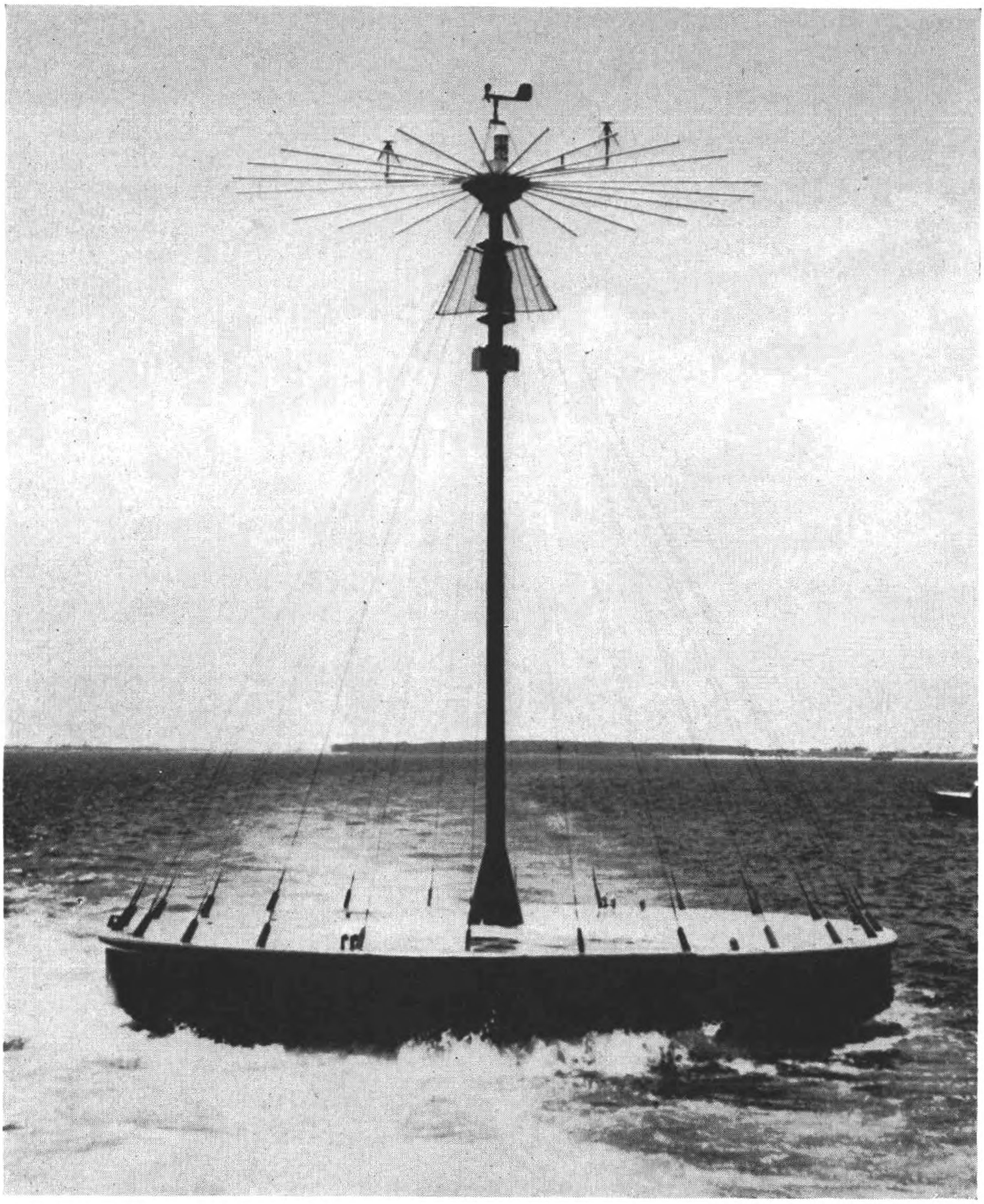
NOMAD automatic weather station anchored in the centre of the Gulf of Mexico. Note the appendage which floats the sea-water temperature sensor astern to minimize the thermal influence of the hull (*see* page 178).



The first nuclear-powered version of NOMAD being towed to the centre of the Gulf of Mexico. Absence of wind chargers on the forward mast eliminates the possibility of turbulent flow at the after-mast wind sensor (*see* page 179).

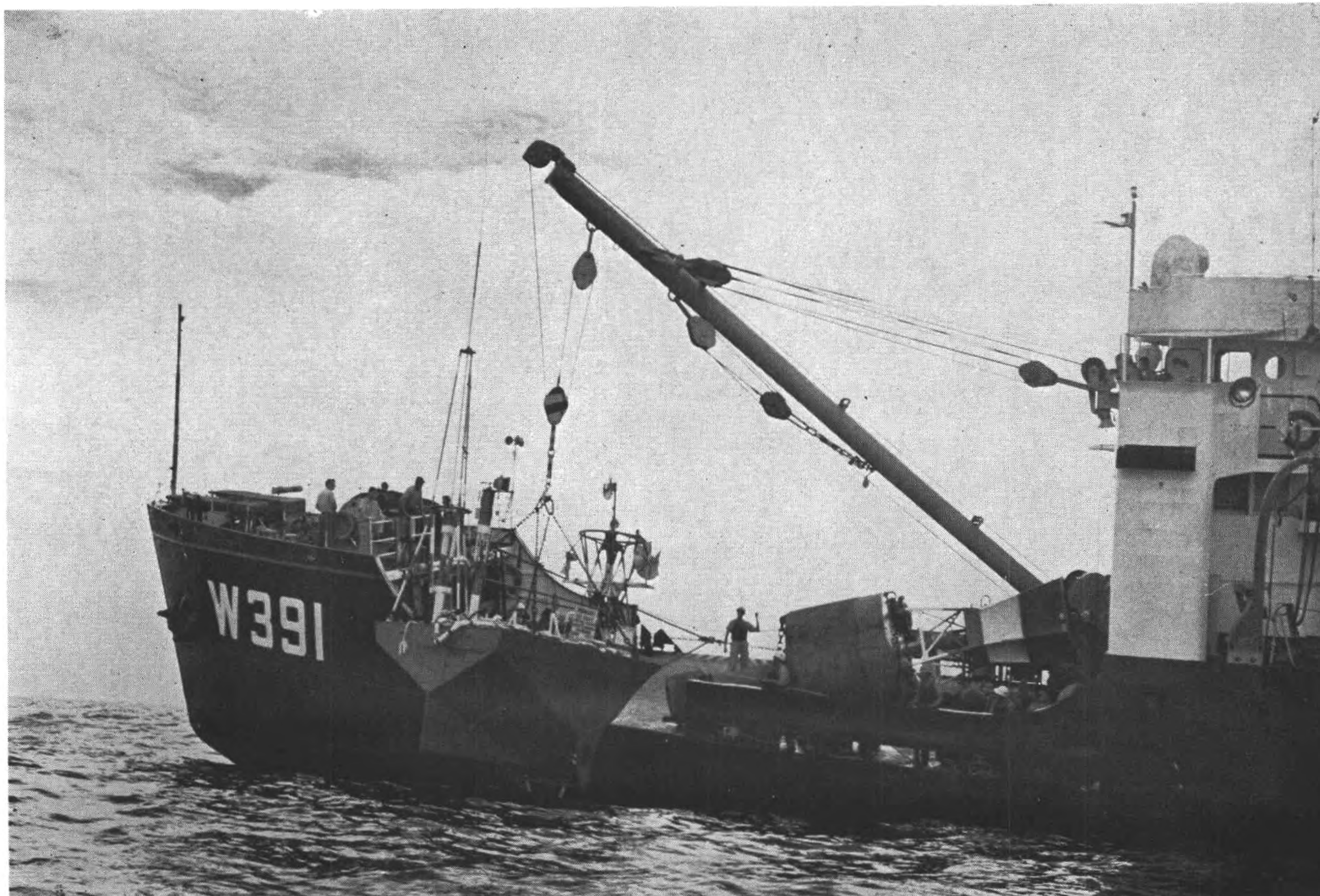


A secondary-type weather buoy, the TOROID, which is cheaper and easier to handle. These qualities make it attractive as a 'gap-filler' in buoy networks (*see* page 181).



The MONSTER oceanographic research buoy being towed to an evaluation site off the Florida coast (*see* page 182).

(*Opposite page* 181)



The NOMAD being lifted aboard for repair. The marker buoy (shown on deck) will remain on station until another weather buoy is substituted (*see* page 185).

which the radioactivity will have decayed to a fraction of the original amount. Heat from the fuel is converted into electricity through 120 thermocouples which surround the fuel. This electrical power is controlled to provide the main NOMAD weather station battery pack with a constant charge.

The combination of the automatic weather station and the SNAP-7D generator will provide the Navy with an unattended weather buoy, which has the capability to report meteorological information from remote deep-sea locations for a period of a year or more. Before the SNAP-7D generator was developed the station used lead-acid batteries. This necessitated servicing every six months. The SNAP-7D device is engineered for servicing approximately every 2 years and has an estimated life of 10 years. It is anticipated that servicing of the electronic components of the NOMAD weather station can now be accomplished only once a year.

Because the weather station regularly transmits its data for 2 minutes and 20 seconds every three hours, batteries are used to store the electricity produced continuously by the generator. Power from the generator is also used to light a navigation beacon to alert passing ships. NOMAD is designed to provide the key weather buoy for any network of buoys which may be used over large oceans areas.

Miniature NOMAD

A small-scale NOMAD weather buoy has been developed by the National Bureau of Standards and the Naval Avionics Facility Indianapolis for the Naval Air Systems Command. This automatic weather station is patterned after the large-scale NOMAD but its dimensions have been halved, so the volume has been cut down to an eighth of the original. The National Bureau of Standards provided the stainless steel hull, superstructure and general design, while the Naval Avionics Facility Indianapolis provided the transistorized electronics and the meteorological sensors for this miniature NOMAD. This small-scale weather buoy is being developed to become a secondary-type buoy for meteorological and oceanographic buoy networks. If it is found that this small-scale buoy has the ability to transmit over distances as great as the large-scale NOMAD, and its reliability is equal to that of the other NOMAD, it is believed that this automatic weather station can be produced in quantities for approximately one-half the cost of the larger automatic weather station.

The miniature NOMAD transmits on command either from an aircraft or from a land-based transmitter; or, by clock timing, to a shore receiving station, on two assigned frequencies. One frequency is used for daytime transmission and the other for night-time. The buoy transmits every three hours the following meteorological and oceanographic data: (*a*) atmospheric pressure, (*b*) air temperature, (*c*) sea-water temperature, (*d*) wind speed, and (*e*) wind direction. The miniature NOMAD will eventually be provided with an underwater thermistor cable for measuring temperature and pressure from the surface to a 1,000-foot depth. This underwater information will be transmitted by cable to the buoy proper, placed on magnetic tape and then transmitted to a shore receiving station at the time of transmission of the surface meteorological information. No processing of data will be accomplished by the buoy.

The miniature NOMAD is powered with nickel-cadmium batteries and receives auxiliary power from two wind-charging devices which have been evaulated on the large-scale NOMAD.

TOROID Weather Buoy

The TOROID weather buoy is an ocean automatic weather station housed in a 'doughnut-shaped' hull, with an 8-foot diameter (*see* photograph following page 180). The 'hole' in the doughnut has been filled in with the battery compartment. The TOROID transmits meteorological information at either 6-hourly or 3-hourly intervals; or when interrogated from either an aircraft or shore-based transmitting station operating on a frequency of 9009·5 kc/s.

The buoy hull is constructed of styrofoam-filled glass fibre material. It is modular in construction and is divided into the following components: (*a*) buoy structure, (*b*) night-identification light, (*c*) meteorological sensors, and (*d*) electronic equipment group. The meteorological sensors consist of an anemometer, wind vane, air-temperature element, sea-water temperature element, an aneroid barometer operating an internal 2,000-ohm potentiometer, and a compass-element for the wind direction measurement, which converts magnetic-heading into a resistance value. The electronic equipment group consists of a radar-beacon transmitter, antenna and junction box, radar reflector, radio transmitter-receiver, sequential timer, code generator, and a battery power-supply arranged in a compartment at the centre of the TOROID. The batteries supply sufficient power to operate the station, unattended, for a period of one year. The cells have a small rate of self-discharge and are equipped with leak-proof vent-valves.

The buoy structure, with the antenna, is 25 feet high. The components of the buoy include the hull, superstructure and counterweight support tripod. An opening in the hull is required for the placement of the sea-water temperature sensor. The hull also contains a compartment for the battery pack. The counterweight is constructed so as to provide a means for attaching a mooring cable. On the superstructure are mounted the radar-reflector, navigation light, junction box, transmitter-receiver unit, antenna and antenna mount, beacon transmitter, anemometer, wind-direction sensor, and an air-temperature sensor.

The navigation light has a life expectancy of one year over a temperature range of 0 to 120°F, at a repetition rate of two flashes, one second apart, and an off time of 18 seconds. The power output of the flash lamp per flash is 0·36 watt-seconds, with a light output of over 16,000 peak horizontal candle-power. The average lamp life is 10^7 flashes. A photocell has been designed so that the flash is activated at very low-light levels, with the photocell shutter open. The shutter is adjustable, thus allowing activation at the light-level desired. This permits the navigation lamp to be in an 'off' condition during the daylight hours. The flash rate is fixed at one flash per second. The flash cycle is controlled by adjusting two potentiometers located on the underside of the electronics assembly. The number of flashes per cycle is adjustable from one to a maximum of ten. The unit will work satisfactorily, but with a diminishing light output, until the battery power decreases to approximately 8 volts from the original battery voltage of 12 volts.

The TOROID weather buoy is designed to be used in a meteorological/oceanographic buoy network, but is considered to be a secondary-type buoy to the large NOMAD automatic weather station. These TOROID buoys are expected to be comparable in cost to the miniature NOMAD weather buoy.

MONSTER Buoy

The MONSTER Buoy[4] was developed by the Convair Division of the General Dynamics Corporation for the Office of Naval Research (*see* photograph following page 180). It is primarily an oceanographic research buoy, but it has been included in this article because it has the capability of measuring and transmitting surface meteorological information, in addition to the oceanographic data.

The buoy hull is disc-shaped, 40 feet in diameter and 7½ feet thick, with the lower four feet of the hull tapered inward at an angle of about 60 degrees. Mounted on the hull is a 40-foot mast which acts as a snorkel for the engine-generators and supports the discone radio antenna.

Electrical power is supplied by two 4-cycle engine-generators, utilized alternately for charging a nickel-cadmium battery bank. Propane is used for fuel in the engine and the generator is 1 kW, 28 volts d.c. The electrical system is designed for 200 watts continuous power output.

The radio transmitter, for telemetering, operates on command from a shore station. It is planned that three to four frequencies between 3 and 30 mc/s will be available and that this will give sufficient flexibility for reliable radio transmission at all times.

The data system will handle 100 scientific channels. These will be sampled once an hour and the data stored in two memories. The short-term memory will be used for the telemetering of data to shore and will report all of the data collected during the past 24 hours each time it is queried from the shore station. This will occur every 6 hours. The long-term memory will store all of the data collected during one year of unattended operation at sea.

The data will be telemetered in binary bits as a pulse-code modulated signal on a frequency-shift-keyed subcarrier. The radio equipment will be single sideband with 100-watts average power.

TACTICAL Weather Buoy

The TACTICAL weather buoy is a general-purpose free-floating meteorological buoy. The TACTICAL buoy is being developed with solid-state electronics circuitry, so it can be air-dropped from aircraft to obtain meteorological information where none is otherwise available. Several of these small free-floating buoys can be parachuted into the sea to cover the immediate weather situation in an area of interest.

The original design for this buoy was developed by the Naval Research Laboratory and several drop-tests were performed from aircraft. During these original tests some damage was sustained upon water entry, but the components were redesigned and successful delivery from aircraft was then accomplished. The tests indicated that parachute delivery of the buoy can be accomplished if the aircraft speed, when released, is reduced to approximately 150 knots. Since this release speed prevents deployment with faster aircraft, the electronics circuitry is now being redesigned by the Naval Avionics Facility Indianapolis in order to have all components provided with solid-state circuits.

For obtaining surface meteorological information, i.e. air pressure, air temperature, sea-water temperature, wind speed and wind direction, from an area where none is available, the parachute TACTICAL weather buoy can be delivered and placed at the desired location by aircraft in a relatively short interval of time.

Buoy Networks

The growth of networks of fixed meteorological observing stations over ocean areas will undoubtedly parallel the arrangement into networks of synoptic stations over continental areas. Individual stations can provide information representative of only a small area when compared with the large area from which data are desired. Many of the considerations for a land station network can be ignored in planning for the marine counterpart; some constraints, however, are greater. There is no concern for optimum topographic location at the sea surface, but it may be of concern on the ocean floor. However, no compromise of sensor location will result from a slightly different location on the ocean surface. There are no hills or valleys, or airport runway complexes, to be avoided. One section of the ocean surface is as good as any other. There are exceptions, of course, such as the proximity to land, ocean currents and shipping lanes.

In general, freedom from the usual constraints found on land in the selection of data points makes possible an exact grid for computer utilization of the observations. This approach is equally valid for the acquisition of raw data as well as the verification of processed data. Equal grid spacing does not preclude a network of greater density, in or near areas of greater interest, or more relaxed spacing in areas of casual concern. For example, the basic network could be supplemented during periods of greater tropical storm activity by halving the grid spacing in areas of incipient cyclogenesis. The supplementary network need not be composed of buoy types identical to those in the basic grid, but the intermediate units must act in concert with the primary station.

The operating capability of single meteorological buoy stations over extended periods has been demonstrated many times, but efficient use of the radio-frequency spectrum, timeliness of synoptic data, and economic considerations, require a rapid, error-free, on-demand response when several buoys are to be integrated to form an operating network. A plan for arraying several buoy types into a network configuration is being implemented with these basic concepts as the reference frame.

The two platforms considered for the network are the full-size boat-type NOMAD and the TOROID. Three NOMAD buoys and two TOROID buoys will be arrayed in a X-shaped configuration with the centre of the arrangement at 25°N, 90°W in the Central Gulf of Mexico. The Gulf array will serve as a control network, because of the length of experience with buoys at this location. Two NOMADs will be anchored approximately 30 miles away from the NOMAD in the centre of the array on a north-west/south-east line. Two TOROIDs will be in the north-east and south-west corners of the network at the same distance from the centre point. At a later date, some miniature NOMADs will replace or augment, the TOROIDs by extending the network toward the north.

To avoid bias in the communications test of the network, three methods of transmitting the data ashore will be utilized. The control buoy (centre point) and the NOMAD at the south-east point will transmit in international Morse code by CW similar to the method employed in all developmental models. The TOROID located at the north-east point will also transmit in serialized Morse code, but at a faster rate. A new communications technique, Multiple Access Discrete Address (MADA), will be evaluated aboard the north-west NOMAD station and the south-west TOROID buoy. In addition, the latter will transmit in frequency shift keying (f.s.k.) mode.

All transmissions will be received in a mobile van, so that the distance from the buoys can be varied. All MADA and f.s.k. buoys will be capable of semi-automatic interrogation, while the CW transmissions will be clock-controlled. If the test proves the feasibility of the communications sub-systems employed, a computer-controlled automatic interrogation system will be implemented to acquire environmental data. The Federal Communications Commission network will continue to monitor the central buoy and serve as an independent check in the control of the test.

One of the options in communicating with a buoy network is the relatively simple method which will be evaluated in the Gulf of Mexico. Other possibilities, however, include the concept of a 'mother-buoy' or manned weather ship, which could replace the central buoy by a floating command and control station. This station could then interrogate and receive replies from all the weather buoys in the network and act as a collection and forwarding centre. Aboard ship, this communications rôle could be accomplished, but 'aboard-a-buoy' this function might require a power-supply and electronics circuitry that are beyond design limitations at the present time.

Satellite interrogation systems have been highly publicized as meeting all the data-handling requirements necessary to support a successful buoy network. While the buoy-to-satellite communications seem feasible from an engineering viewpoint, realization of this capability has not been fully demonstrated. Several United States projects have been planned to show that the weather buoys and a synchronous satellite system are compatible for communication purposes. One deterrent to these projects has been the high cost of the combined systems. If a reasonable synchronous satellite system lifetime of 2 to 3 years is assumed, the cost of this system versus the direct buoy-to-shore high frequency system approximates 35 to 1. (This ratio does not take into account the cost of the platforms in either system.) At this ratio the annual operating cost of the satellite system is greater than the acquistion cost of a complete 300-unit buoy system. When the buoy system is doubled to incorporate about 600 buoys, the satellite will be used more efficiently and result in a reduced cost ratio of approximately 8 to 1. This ratio can be reduced further by utilizing other satellite capabilities, i.e. cloud photographs, infra-red data, etc., or other communications users, so that the cost can be spread over several systems, rather than be wholly subsidized by the buoy system. Even with these considerations, the satellite communications system appears to be 'gold-plated', and not a panacea for weather and oceanographic data transmission, because, at least in the northern hemisphere, all oceanic areas are within range of high-frequency radio communications shore stations.

The photograph opposite page 181 shows the NOMAD weather buoy being retrieved from the Central Gulf of Mexico location. The logistic support, being furnished by a Coast Guard buoy-tender, must be given prime consideration in any future implementation of a large-scale buoy-network.

A definitive study of United States buoy requirements for meteorological and oceanographic data is now being conducted by the Coast Guard. Results will be published late in 1967 and will determine the future direction and level of effort in meteorological and oceanographic buoy development. The long history of the U.S. Navy's work in this area is contributing materially to the comprehensive study.

The views expressed by the authors are their own and do not necessarily represent those of the U.S. Department of the Navy or the U.S. Department of Defense.

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Incidence of Ice in the Approaches to North America during the Decade 1956–1965

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Introduction

In an earlier article Tunnell[1] discussed the distribution of sea-ice during the ten years immediately following the second world war as reported over the main ocean routes to the east coast of North America which is the area surveyed by the International Ice Patrol of the United States Coast Guard whose annual *Bulletins* have provided the statistics for this survey. It is now possible to extend the study over another decade, the period 1956–1965, and to examine, in the light of up-to-date information, some of the conclusions previously reached.

The same generally-accepted yardstick, namely the number of icebergs moving south of 48°N in the vicinity of the Great Bank, is again taken as a measure of the severity, or otherwise, of the season but one slight modification has been made in the details presented in graph (*a*) of Fig. 1. Whereas the earlier diagram showed the eastern limits reached only by the southernmost bergs, the plots in the present case are of the extreme easterly position of any bergs drifting south of 48°N—a wider criterion.

The southward and eastward movement of icebergs

Although there have been more icebergs reported in this last decade than in the previous one (an annual average of 267 as against 197), the average numbers fall well below those for the longer period 1913–1965 (358). Recently there has been, however, far greater variability in their incidence and it now seems probable that the tendency, noted by Tunnell, for high and low iceberg-years to be grouped together no longer holds. Contrasts such as those between the years 1957, 1958 and 1959 when the counts were respectively 931, 1 and 693 had not been recorded earlier. It is tempting to offer some explanation of this phenomenon.

The theory that oceanographical factors which determine the number of icebergs drifting south in any year tend to persist over several years is probably still true. There must therefore be some additonal parameters which can affect the totals and, in the extreme case, turn a potentially heavy year into a light one. Abnormally strong winds north of the Great Bank itself, for example, can cause many icebergs to be driven aground in the relatively shallow water along the Labrador and eastern Newfoundland coastlines. Such was the case in 1961, when in the early part of the year, the ice situation appeared to be particularly threatening. A change of wind to strong easterly or north-easterly late in March forced most of the bergs inshore and very few were left to endanger the shipping lanes. On the other hand, the large numbers in 1957 and 1959 were undoubtedly partly augmented by bergs which had been unduly held up north during the previous seasons.

It is interesting to note the high correlation between the southerly and easterly movement of the bergs, the close similarity between graphs (*a*) and (*b*) of Fig. 1 illustrating this point very clearly. It is further demonstrated in Fig. 2. Also, as might be expected, there is some, but not a very close connection between the number of bergs and the degree of southerly movement. This is shown in Fig. 3 (*a*), the similar relationship between the numbers and easterly movement being displayed in Fig. 3 (*b*).

In the earlier article typical tracks of icebergs in 1953, a light year, were traced. In the present account some during a heavy season, 1959, are depicted (Fig. 4).

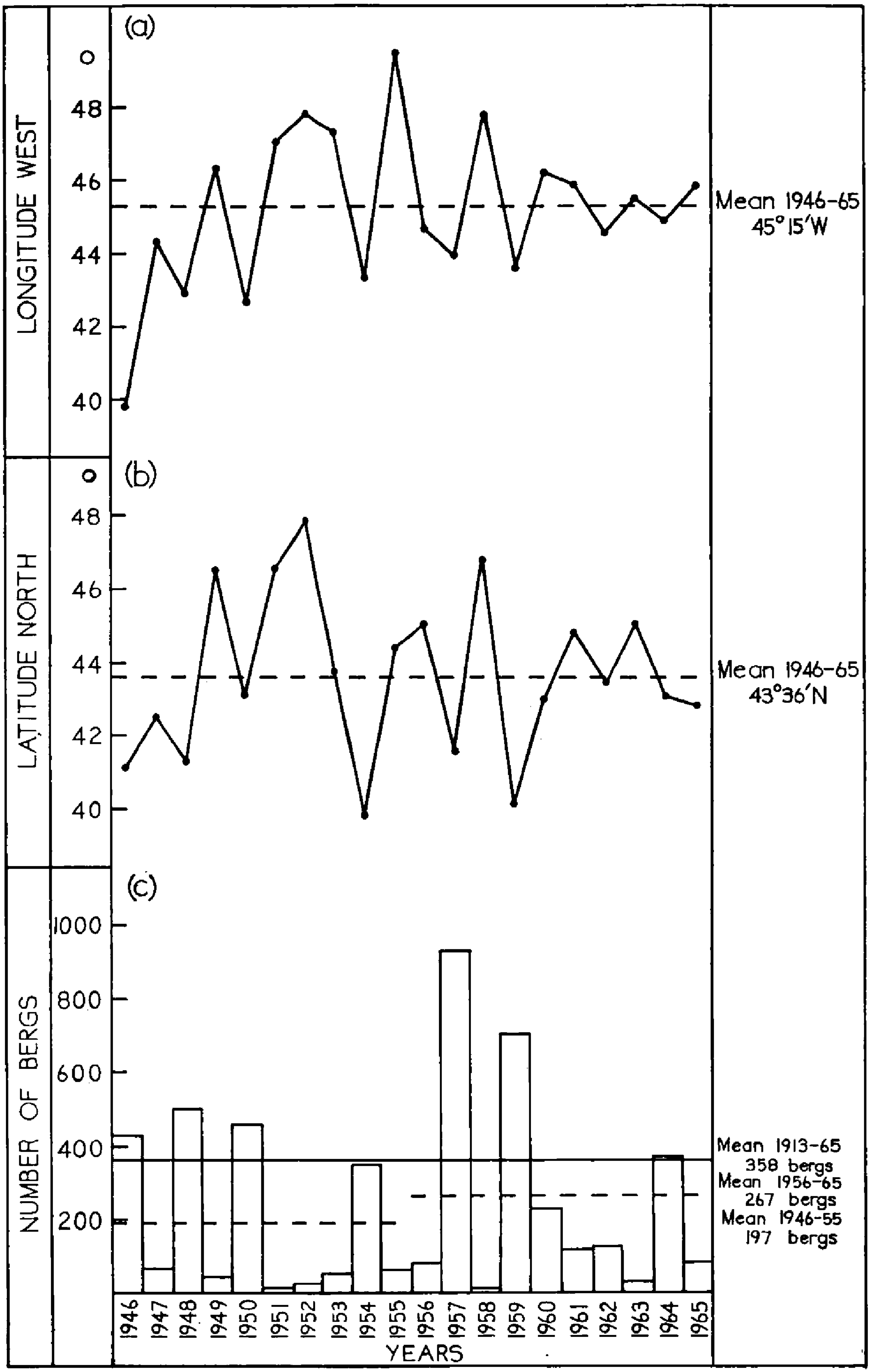


Fig. 1. Numbers and extreme positions of icebergs drifting south of latitude 48°N.

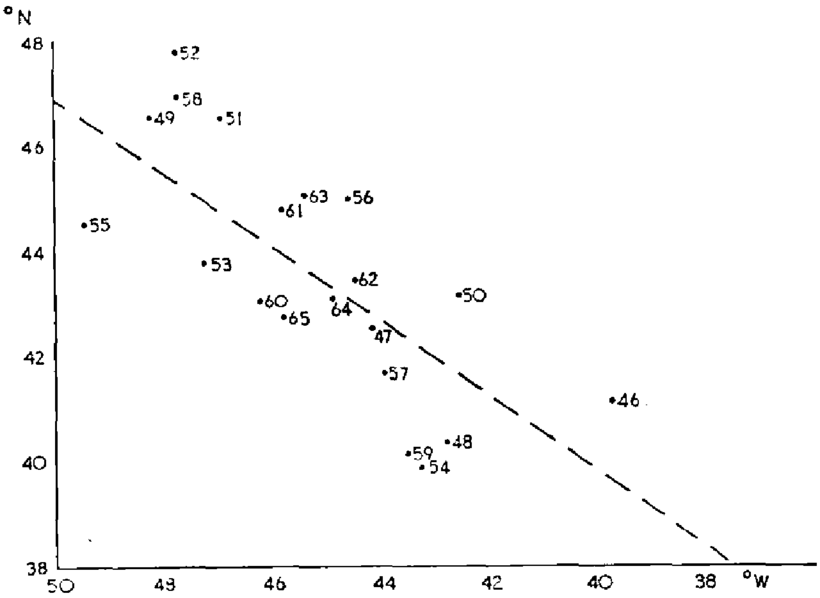
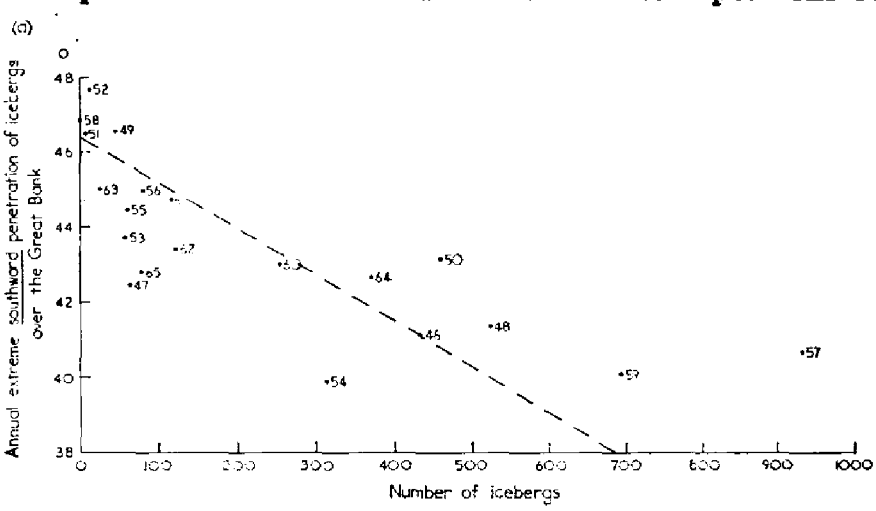


Fig. 2. Relationship between extreme southern and eastern positions of icebergs.



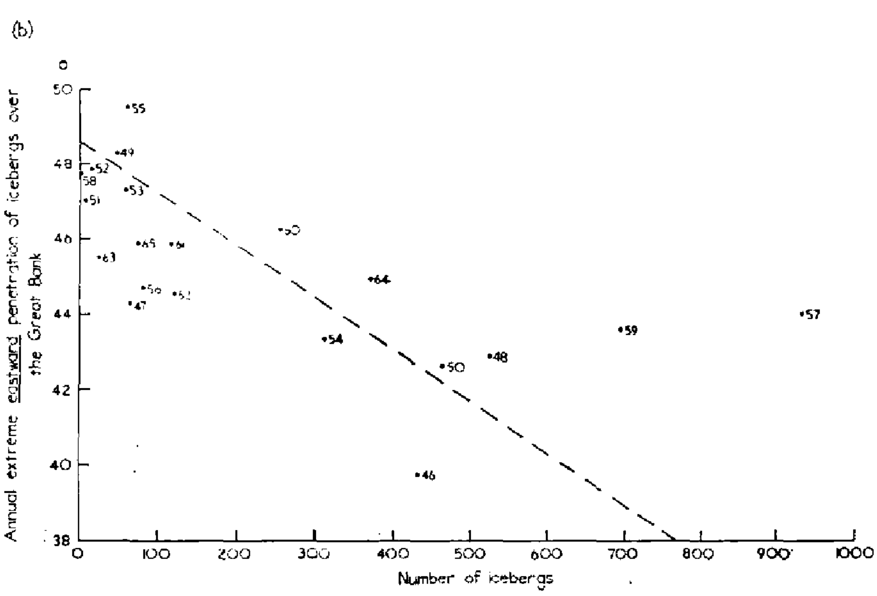


Fig. 3. The annual extreme penetration of icebergs (a) southward and (b) eastward.

The tendency for many bergs to follow the 100-fathom contour lines round the Great Bank for part of their journey is again apparent but there is, nevertheless, one marked difference between the two years. In 1953 the general curvature of the tracks was clockwise but in 1959 the reverse was the case, most turns being anti-clockwise.

(Opposite page 188)

Official U.S. Coastguard Photo

A petroleum incendiary bomblet in an iceberg 450 ft long, 150 ft high above the water, off Virgin Rocks in the Grand Banks of Newfoundland, leaving a trail of smoke as it burns a crater in the ice (*see* page 189).

(*Opposite page* 189)

The presentation of barographs at Bracknell on 2nd February 1967; left to right (front row): Captain C. H. Percy, Mrs. R. White, Dr. B. J. Mason and Captain J. S. Moate (*see* page 199).

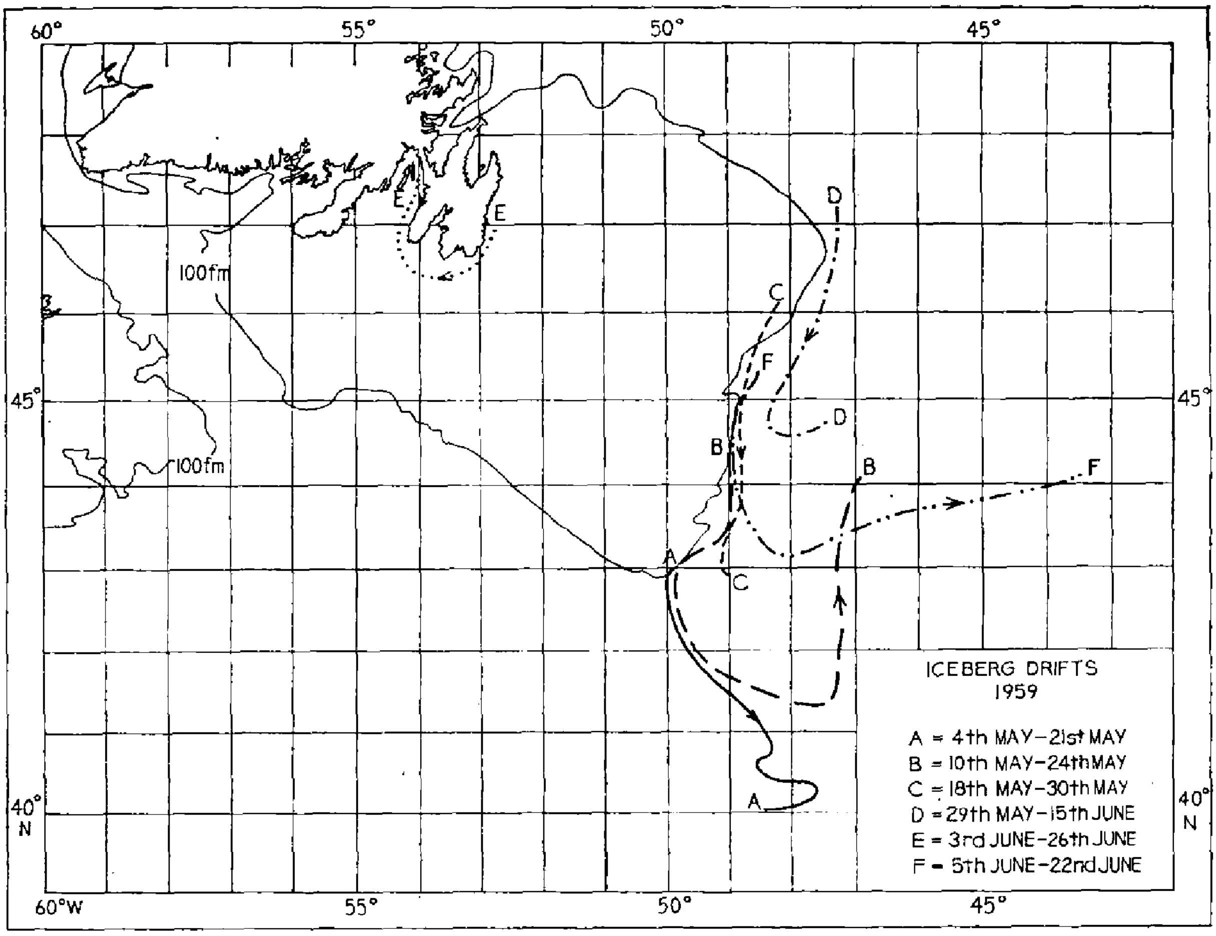


Fig. 4. Six typical iceberg tracks in 1959.

As has been mentioned already, 1959 was one of the heavier ice years. It was, by chance, also noteworthy for the large-scale experiments on iceberg demolition conducted under the auspices of the International Ice Patrol. As far back as 1916, and on several subsequent occasions, attempts had been made to destroy bergs but with discouraging results. This was hardly surprising in view of the enormous heat energy necessary for any useful effect. In 1959 determined attacks on selected bergs were again launched, this time from an Albatross amphibian aircraft at a height of 1,000 ft—a carefully calculated altitude. Ten canisters, each of 700 lb weight (containing numbers of small bomblets filled with powdered magnesium and thickened gasoline) and ten weighing 975 lb each (holding thermate) were dropped and were so well aimed that all struck their target (*see* photograph opposite page 188). Some, however, bounced off! Although the bombs made their mark there was no significant disintegration of the bergs but nevertheless it is likely that experiments will continue.

Fig. 5 shows in map form the extreme limits reached by icebergs in each of the last two decades, together with those for the longer period 1920–1945. (It should be recognised that the reliability of plots is now far greater than in earlier years because of the increase in ice surveillance by aircraft.) In view of the fact that there were rather more bergs, on the average, during the last decade than in the previous one it might be expected that the area delineated by the 1956–1965 boundary would be greater than of 1946–1955, but this is not so. The reason may be, of course, that excessive penetration of bergs southward or eastward is only on a relatively narrow front. This, in turn, may be due to the interaction of the south-flowing Labrador currents with the Gulf Stream directed towards the north-east and east, especially when both are comparatively strong with a large temperature gradient along the 'wall' between them.

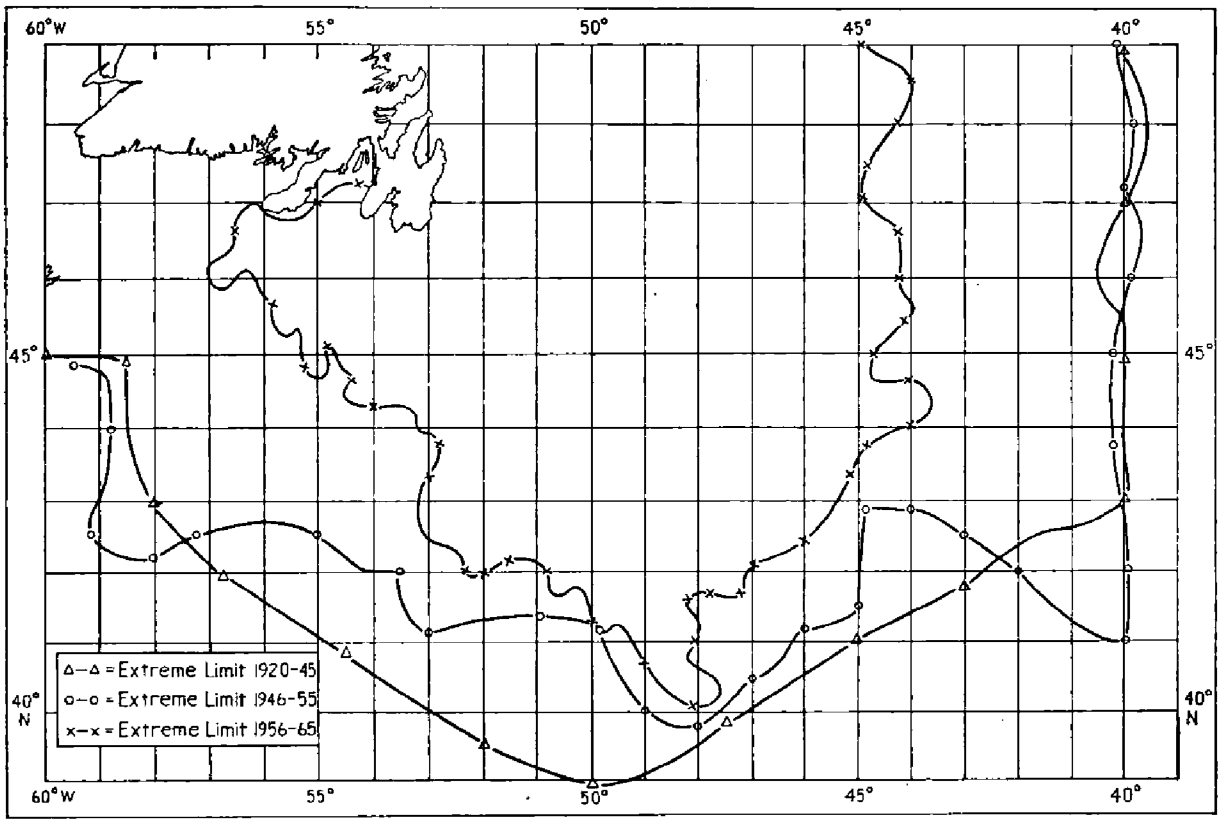


Fig. 5. Limits of observed locations of icebergs, 1920–65.

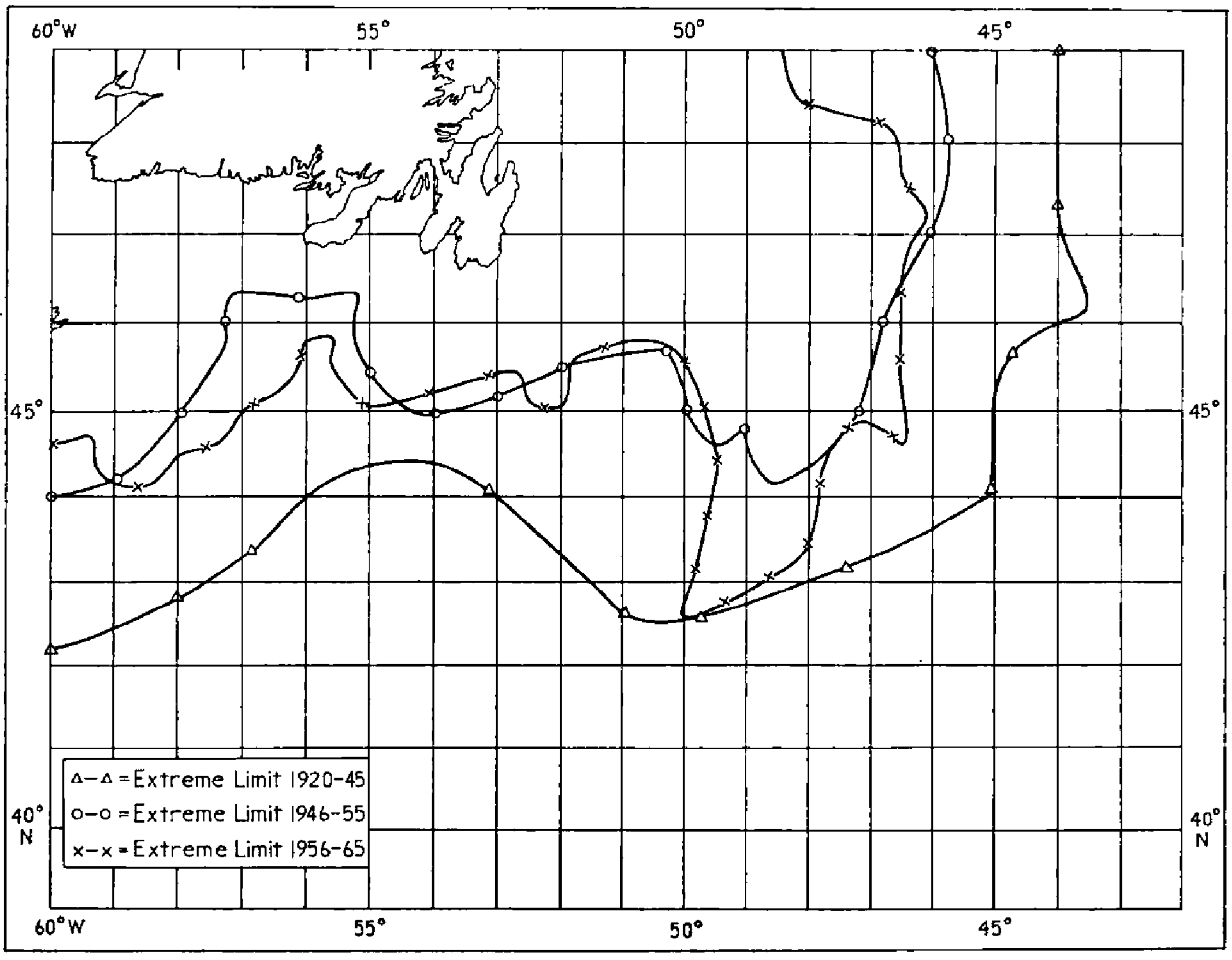


Fig. 6. Extreme limits of pack-ice, 1920–65.

The southward and eastward drift of pack-ice

Fig. 6 shows the limits of pack-ice during the same three periods as in Fig. 5. It will be observed that, over the last two decades at least, there has been a far closer connection between the areas covered by pack than is the case with icebergs. The reason for this probably lies in the well-known fact that the formation and movement of pack-ice is more intimately linked with surface weather than is the far-away

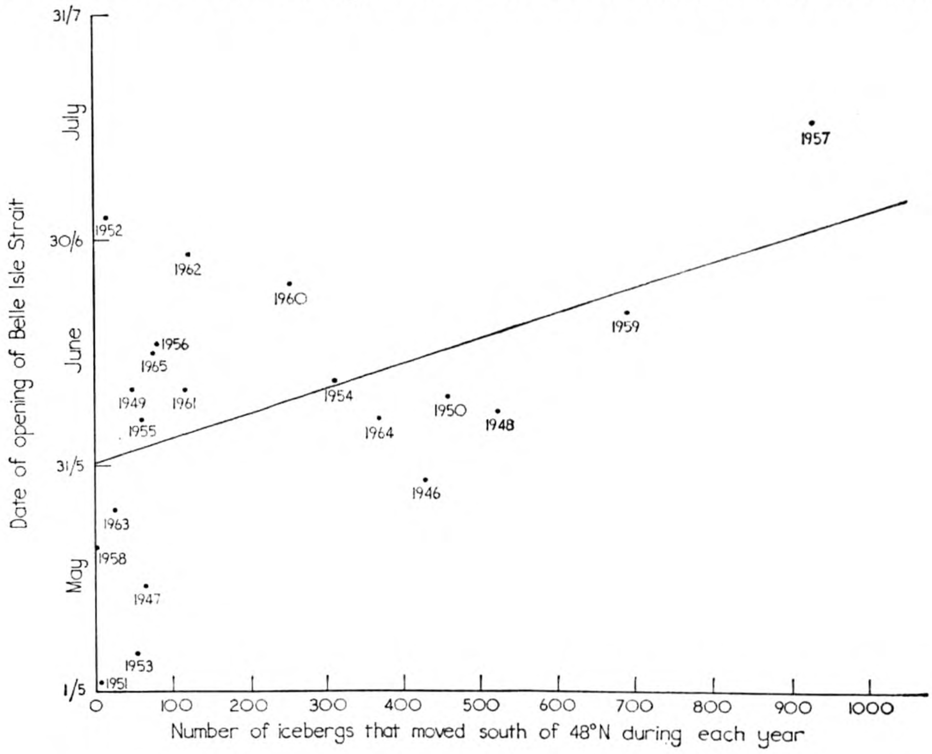


Fig. 7. The dates of opening the Belle Isle Strait with the yearly total of icebergs observed south of 48°N.

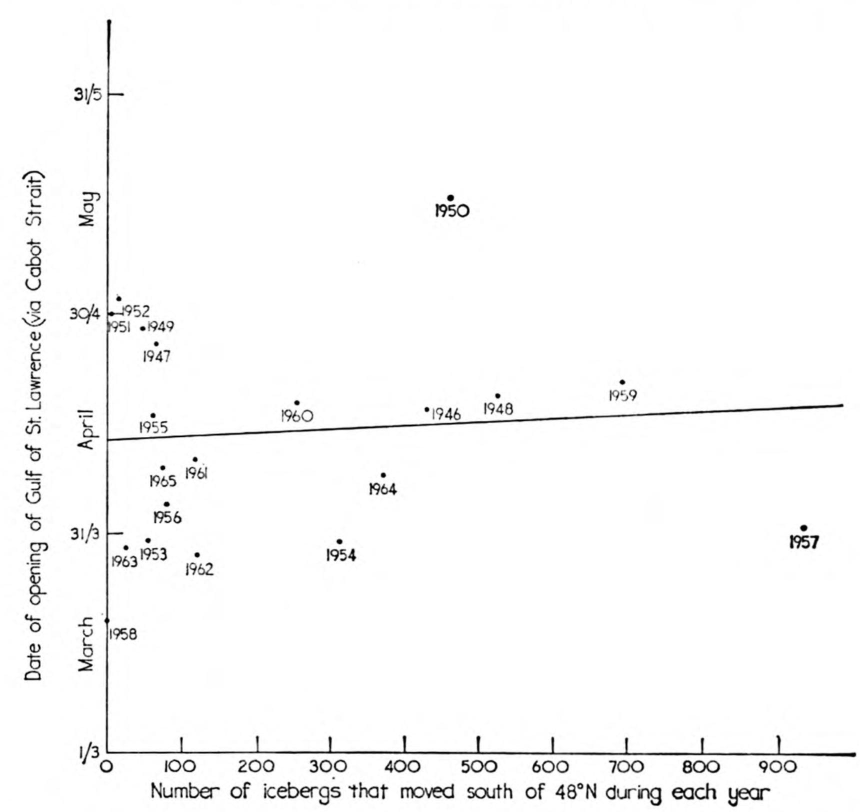


Fig. 8. The dates of opening the Gulf of St. Lawrence with the yearly total of icebergs observed south of 48°N.

calving and subsequent drifting of icebergs whose greater draught makes their mobility more dependent on currents, both wind and density invoked.

Recent studies on ice development also make it clear that, contrary to what was accepted previously, much of the pack-ice encumbering the coasts of Labrador and Newfoundland is of local origin although some will have drifted south from the Canadian Arctic Archipelago, the Baffin Bay and Hudson Strait.

Ice in the Gulf of St. Lawrence and the Belle Isle Strait

With the commercial importance of the knowledge of ice conditions in the two main approaches to the St. Lawrence River and Seaway in mind it would be of great advantage to derive, for forecasting purposes, some connection between their dates of opening and the standard parameter, the number of bergs drifting south of 48°N.

In the case of Belle Isle Strait it seems clear that, generally speaking, the greater the number of bergs the later the clearance of pack, the years 1957, 1958 and 1959, for example, illustrating the point. On the other hand Fig. 8 shows that there is only small dependence of the opening date of the Cabot Strait on the berg count, the correlation being so low as to be non-significant.

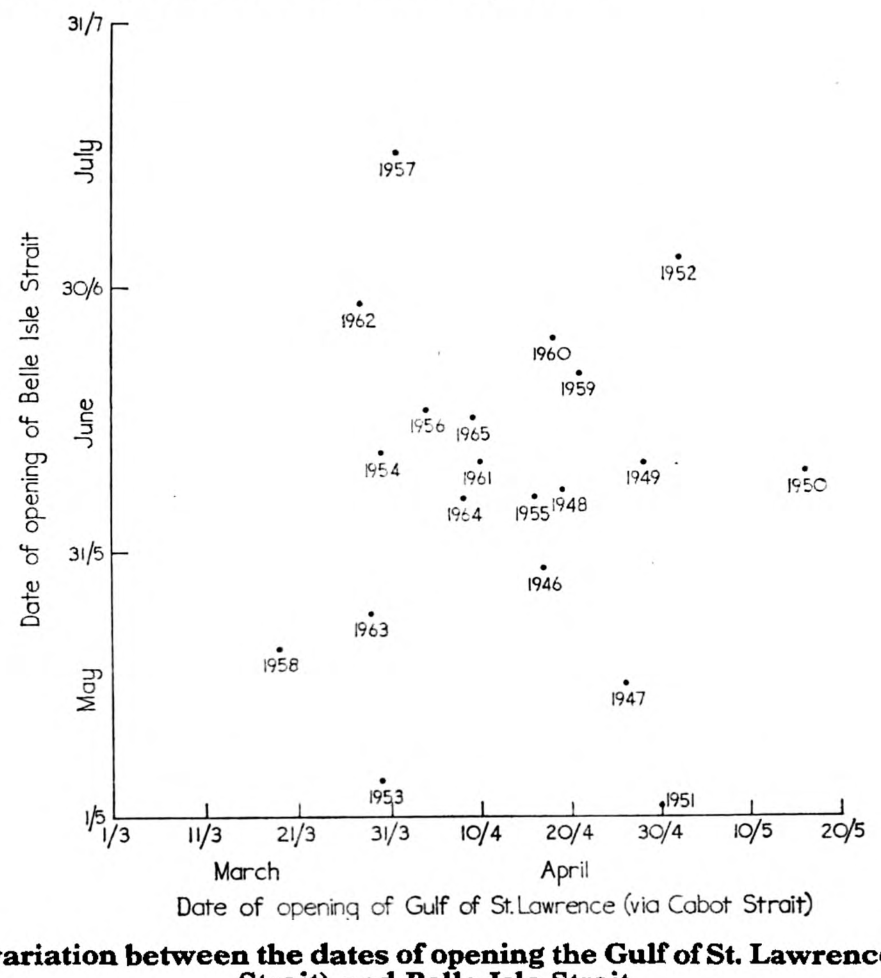


Fig. 9. The variation between the dates of opening the Gulf of St. Lawrence (via Cabot Strait) and Belle Isle Strait.

As can be seen from Fig. 9, where the scatter is so great that no attempt has been made to fit a curve, there is little connection between the opening dates of the two Straits. This makes it all the more desirable that day-to-day attention be directed on the state of the ice in both channels into the St. Lawrence. The delays caused by a premature attempt to enter through the Belle Isle Strait can be, economically, quite serious.

REFERENCE

1. TUNNELL, G. A. Incidence of ice in the approaches to North America during the decade 1946–1955. *Mar. Obsr, London*, **31**, No. 192, 1961, pp. 78–85.

TECHNOLOGY OF THE SEA AND SEA-BED

From the many papers read at the April 1967 conference, two were chosen for publication in *The Marine Observer* as being of obvious interest to its readers. By kind permission of the United Kingdom Atomic Energy Authority, the organizers of the conference, Dr. G. D. Robinson's paper was published in the July 1967 number and Mr. A. J. Lee's paper is reproduced below. The full proceedings of the conference will be published in *Technology of the Sea and Sea-bed* (A.E.R.E. R 5500) by Her Majesty's Stationery Office, price £5.

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Monitoring the Ocean

By A. J. Lee
(Fisheries Laboratory, Lowestoft)

Introduction

The study of the water masses and currents of the deep oceans and of the shelf seas along their margins has applications of economic importance. Fisheries scientists have shown that the distribution, abundance, growth and age at first maturity of commercially important species are governed by sea temperature and that this, in its turn, depends to a considerable extent on the ocean currents. Marked year to year fluctuations occur in the degree of survival of fish eggs and larvae and there is strong evidence pointing to one cause of these as being the fluctuations in the physical and biological environments brought about by the variability of the oceanic circulation. Improved knowledge of the oceanic circulation could therefore lead to our better understanding the causes of variations in fish abundance and ultimately to their prediction.

The atmosphere and the oceans are intimately connected as part of an open thermodynamic system controlling our climatic environment. Our present knowledge of the ocean leads us to believe that oceanic weather might be as varied and complex as the weather of the atmosphere. Because these two forms of weather are coupled, the prediction of atmospheric behaviour, particularly on a scale longer than a few days, might therefore be improved by our having firstly a better knowledge of the physical processes operating in the sea, and secondly the ability to monitor the oceanic environment.

Similarly, the prediction of the storm surges, which can cause enormous damage in the coastal areas surrounding shallow seas like the North Sea, can be improved by our having an improved knowledge of the meteorological, tidal and other oceanographic forces involved in their generation. The same applies in the field of marine pollution: the prediction of the effects of the disposal into the sea of obnoxious wastes, which may damage fisheries, cause hazards to health, lead to loss of amenities and hinder maritime activities, requires a knowledge of current systems and eddy diffusion, and of their response to meteorological forces. Again, the study of sediment transport along the sea bed, a subject of great importance to harbour authorities, coastal engineers and to companies operating drilling rigs at sea, requires a knowledge of current systems.

Until the last few years the study of the oceanic environment and the possibility of monitoring it have been seriously handicapped by the lack of any suitable instrumentation for (*a*) measuring directly the currents and (*b*) obtaining the temperature, salinity and current fields in sufficient detail in space and time. A general picture of the oceanic circulation has been built up from the observed set and drift of ships between successive fixes, the drift tracks of floating objects, water mass analysis and calculations of the geostrophic current. But the number of actual current measurements in the deep ocean are very few and, as a result, oceanographers are like meteorologists working without any surface and upper air wind data. The chief difficulty in making current measurements in the deep ocean lies in providing suitable moored platforms for carrying the current meters over long periods of time: in the shelf seas the same difficulty exists, although this has on occasions been partially overcome by the use of light-vessels. Similarly, a general picture of the temperature and salinity fields in the sea has been obtained from water-bottle observations along lines of stations across the oceans, but many of these lines have been worked on a 'once and for all' basis. The only long-time series of observations that exist relate to the surface layers and have been obtained by the use of merchant ships, light-vessels and weather ships.

Recent Developments in Oceanographic Instrumentation

In the last few years the application of electronic engineering to oceanography has made available instruments that make good these deficiencies in the oceanographer's armoury. Firstly, improved drifting devices have become available for measuring currents: these include transponding buoys for surface measurements and Swallow floats and parachute drogues for determining currents at depth. Improved navigational aids have allowed surface currents to be obtained more accurately from a drifting ship, and the use of direct reading current meters from such a vessel in order to determine current shear has allowed vertical current profiles to be determined in the deep ocean. Now, yet other instruments are becoming available. These are of two types:

(*a*) Parameter-versus-Distance recorders that allow parameters to be recorded continuously (*i*) at various depths between the surface and 200 m over great distances across the ocean by ships under way, e.g. undulating oceanographic recorders and thermistor chains, (*ii*) between the surface and depths as great as 6000 m at fixed points, e.g. temperature-salinity-depth recorders and expendable bathythermographs.

(*b*) Parameter-versus-Time recorders that allow parameters to be monitored over a long period of time at various depths in a network of moored buoys, e.g. recording current meters of the type shown opposite p. 196.

All these instruments are expensive, but they are readily available in the U.S.A. and to a large extent in the Federal Republic of Germany. A British firm is now manufacturing one of them (the recording current meter with provision for the recording of temperature and other parameters). This firm is also developing an undulating oceanographic recorder to monitor zooplankton and relevant physical parameters such as temperature and salinity, in collaboration with the Oceanographic Laboratory, Edinburgh, and has also established links with U.S. manufacturers which enable it to supply expendable bathythermograph systems and a temperature-salinity-depth recording system.

British firms in general seem to be reluctant to manufacture oceanographic equipment. The home market seems to be too small for them to be sure of selling enough equipment to break even with their research and development costs. Some small firms will produce a few copies of equipment developed in an oceanographic or a fisheries laboratory and others are prepared to develop equipment if given a substantial development fee. U.K. laboratories have an outstandingly good record as far as the design and development of novel oceanographic equipment is concerned, but the speed of advance of the research is now so fast that a fair amount of buying of equipment instead of making it oneself is inevitable. If laboratories in the U.K. could agree on standard instruments for particular lines of research, then it might be possible to guarantee sufficient sales to stimulate firms into going into production of the equipment in question.

Proposed U.K. Studies of the Oceanic Circulation

Of the new instruments which are becoming available, the moored buoy array would seem likely to make a particularly great impact on marine science. For the first time it appears to be possible to obtain synoptic pictures of the current and temperature fields in a particular sea area and to study the variations of current and temperature in time and space: the oceanographer is at last placed in a position where he has a network of observing stations like that of the meteorologist.

The recording instruments themselves are basically simple in their principles. Current speed is measured by means of a propeller, a Savonius rotor or a pendulum; current direction by means of a magnetic compass; and temperature by means of a thermistor. Recording is on magnetic tape or cine film, the former having a distinct advantage as far as data-processing is concerned. Sampling frequencies and in-sea cycles vary. As an example, there is a recording current meter which has a storage capacity for 55,200 measurements giving an in-sea cycle of up to 80 days, depending on the number of parameters to be measured and the sampling frequency selected.

As far as the British civil research field is concerned, moored buoy networks are being or will be developed by the National Institute of Oceanography, by the fisheries laboratories at Lowestoft and Aberdeen, and at Liverpool by the Tidal Institute and the University Department of Oceanography. The operation of these networks will on occasion call for the use of such Parameter-versus-Distance recorders as temperature-salinity depth recorders, expendable bathythermographs, thermistor chains and undulating oceanographic recorders in order to fill in the picture between the fixed sampling points in the array. Further, while the moored network will determine the oceanic circulation in an Eulerian form in that the velocity past fixed geographical points is measured as a function of time and depth, it might be desired at times to use such instruments as transponding buoys and Swallow floats in order to determine the Lagrangian form of the motion as well, i.e. to plot trajectories at several depths with respect to time.

The National Institute of Oceanography is developing a mooring system suitable for use in deep water, and expects to begin using it for current meter observations in June 1967. Two main uses of these buoys are envisaged:

(1) intensive observations of some features of strong currents, e.g. flow through the Faroe Bank Channel;
(2) long-term studies of variability of currents in mid-ocean in various time and space scales. Previous observations have demonstrated the presence of a wide spectrum of variable currents. Much of the kinetic energy seems to be in long-period fluctuations (with time scales of a few weeks and length scales of a few tens of miles). Theoretical work has shown that planetary waves in this scale can be generated by moving wind systems, but the available observations are too meagre for the waves to be identified or related to the winds. The proposed long-term buoy programme should provide suitable observations. At the same time, it may be expected that useful information will be gained on internal waves and tides.

It is proposed to start with a very limited array, perhaps three buoys at a spacing of a few kilometres for a few months, increasing in scale and duration as experience is gained. A relatively small-scale array of the kind proposed would make a suitable framework within which to attempt observations of diffusion in deep water, an important part of the general circulation which is at present poorly understood.

It is hoped that these observations can be integrated, as much as possible, with any air-sea interaction programme that is developed for a mid-ocean area and that within a few years it will be possible to cover an area 100 km square in sufficient detail for significant budgeting of mass and heat.

The Fisheries Laboratory, Lowestoft, has already started to use moored buoy networks in the shelf seas around the U.K. and it is aiming to have a capability of mooring an array of 14 stations in seas like the North Sea, Irish Sea and Norwegian Sea by mid-1967. The Marine Laboratory, Aberdeen, is also beginning to develop an array for use in the Faroe-Shetland Channel and the northern North Sea. The objectives of these two laboratories are twofold. The first is to be able to provide such information about the physical, chemical and biological environments as is necessary for progress to be made towards the solution of such major fisheries problems as:

(*a*) the investigation of the relative importance of the parts played by environmental factors (e.g. temperature and salinity), on the one hand, and of the size of the adult fish stock, on the other, in determining the number of recruits entering a fishery each year;

(*b*) the behaviour of fish in relation to currents and other environmental stimuli and to fishing gear;

(*c*) the pollution of the sea, particularly of fishing grounds and of the inshore nursery areas inhabited by commercial species of fish in their first two years of life.

The second is to obtain such an observational knowledge of the circulations in shelf seas as will lead to an understanding of the mechanisms which maintain them. This is necessary if environmental prediction and prediction of fish abundance, as influenced by the marine environment, are ever to be achieved. It is also necessary in order to be able to foresee the oceanographic and fisheries consequences of actions which will change the marine environment, e.g. the stopping of the freshwater discharge of major estuaries in order to conserve freshwater supplies.

Compared with the difficulties and expense of observing tidal stream speeds and directions at sea, the recording of sea level at coastal stations is a relatively simple and cheap process. As a result, research in the field of tides and storm surges has, of necessity, depended mainly on the coastal observations. To verify, describe in greater detail and extend our knowledge of these natural phenomena requires current measurements at sea. At the Liverpool Tidal Institute various models are now in the course of development which attempt to reproduce the dynamical response of whole seas to meteorological, tidal and other oceanographic forces, from a knowledge of the basic hydrodynamical equations. The application and evaluation of such techniques require observations of the depth structure of currents at strategic points in British waters during both calm and stormy weather and the institute is moving towards the use of moored buoy arrays in order to obtain it.

The Department of Oceanography, University of Liverpool, hopes over the next five years to use moored current meters in coastal waters in order to investigate the tidal currents and residual circulation in relation to density effects and the wind system. In addition these meters might be used to investigate advection effects in heat budget studies in a particular area. An array of 3–4 buoys, each supporting several current meters, would be used for periods up to four weeks. The department also envisages using moored current meters in the deep ocean in connection with studies of the temperature and salinity structure of the upper part of the water column, including the effects of internal waves.

The possibility of using moored current meter networks has also attracted the attention of:

(*a*) scientists studying sedimentation processes in shallow seas;

(*b*) hydrographic offices needing information on tidal streams for navigational purposes;

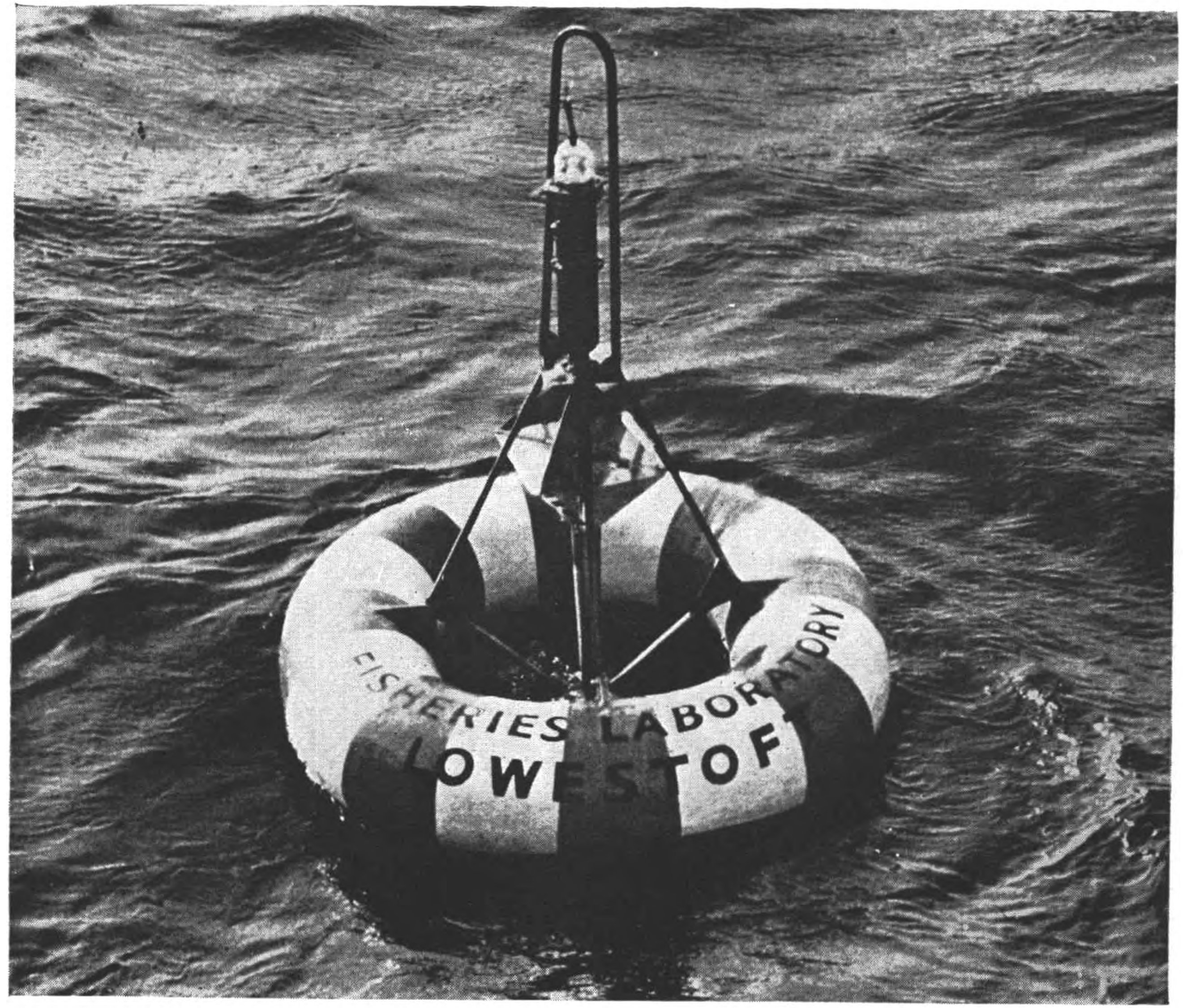
(*c*) coastal engineers, especially those concerned with laying outfall pipes;

(*d*) oil companies drilling wells and laying pipes in the North Sea.

Proposed U.K. Studies of the Marine Environment

The proposed arrays of moored ocean data stations are designed to add to our knowledge of the oceanic circulation. Changes in that circulation help to bring about changes in the temperature and salinity fields and in biological distributions and processes. One type of biological distribution, that of zooplankton in the seas around Britain and in the North Atlantic Ocean, has for some years been obtained through

(*Opposite page* 196)



A toroidal buoy of the type frequently used to mark moored recording current meters, etc. The fibreglass skin is packed with plastic foam and is painted with fluorescent red and yellow stripes. The buoy carries a radar reflector and a flashing light (*see* page 194).

(Opposite page 197)

Photograph by courtesy of The Journal of Commerce

Captain Haddock receiving his barograph from Captain A. D. White aboard the *Carrigan Head* at Liverpool on 16th March 1967 (*see* page 199).

the Continuous Plankton Recorder survey conducted by the Oceanographic Laboratory, Edinburgh. This laboratory is engaged in the study of the mechanisms which control the abundance and distribution of the plankton, and the full development of this programme is impeded by the fact that its present plankton recorder samples at one depth only (10 m) and by the shortage of physical data on a comparable temporal and spatial scale. The laboratory proposes that the Continuous Plankton Recorder technique be expanded into a general oceanographic survey, incorporating the study of physical variables as well as the plankton, and to extend the vertical range of sampling. In this way quasi-synoptic physical and biological pictures of sea areas could be obtained. A towed instrument is now being developed which is designed to undulate in the vertical plane as it is towed by ships at normal steaming speeds; it is hoped that the range of undulation can be extended to cover the upper 100 m of the sea. The preliminary trials encourage the belief that it should be possible to design an undulating instrument, incorporating an improved version of the Continuous Plankton Recorder together with transducers and a magnetic tape recording system for physical variables. The ideal set of parameters would be temperature, salinity, radiant energy, chlorophyll and a measure of total zooplankton. Some of these are available or could be acquired by modification of existing sensors. Others will require a special programme of research and instrument design.

An Estimate of the Cost of the Proposed Studies

The new oceanographic instrumentation that is now becoming available is expensive. The 14-buoy array being constructed by the Lowestoft laboratory will cost £50,000. Taking this as a basis, the arrays required to carry out all the current meter work envisaged in this paper will probably cost about £150,000. It is estimated that the equipment necessary to carry out the undulating oceanographic recorder project of the Edinburgh laboratory will cost about £200,000. These two costs taken together approximate to the cost of building a small research vessel, e.g. the Lowestoft laboratory's *Corella* (136 ft overall), at present building, will cost £300,000, excluding the cost of scientific equipment. The cost of maintenance of the Lowestoft array is estimated at £5,000 per annum, including the replacement of equipment lost at sea. The equivalent cost for the undulating oceanographic recorders is estimated as being £15,000 per annum higher than that for the Edinburgh laboratory's existing continuous plankton recorders. The total additional maintenance costs brought about by the introduction of the new instruments are therefore estimated as being about £30,000 per annum. This can be compared with the estimated running costs of *Corella*, namely £50,000 per annum, although it must be remembered that some of these will be concerned with the laying and recovery of arrays. But an attractive feature of the moored array lies in the fact that a single moored buoy carrying current meters and other instruments can be regarded as equivalent to a research vessel as far as data collection goes. Thus a moored array can obtain data that it is otherwise impossible to collect without using a large fleet of vessels, no matter whether it is deployed in the deep ocean or shallow coastal waters. Similarly, a fleet of merchant vessels towing oceanographic recorders virtually becomes a fleet of research vessels. Viewed in this light the cost of moving to the monitoring of the ocean and to the study of oceanic physical processes causing variability in time and space compares very favourably with the cost of mounting an expedition on classical lines merely to determine the general oceanographic features of an area.

Physical oceanographic work at sea is made more expensive by the fact that periodic losses of equipment occur. Wires can break and let some thousand pounds' worth of instruments fall to the sea bed. The first U.S. experiments with moored current meters were marred by the loss of 50 per cent of the meters and by failures in a number of those that did survive. Equipment left moored in the sea is subject to attack by the sea-water itself, currents, waves, fish, ships and thieves. Oceanographic equipment has to be used in a hostile environment and it must be designed to meet the three Rs—ruggedness, reliability and reproducibility. But no matter how well designed and made the instruments and no matter how much care is put into their use, the risk of loss always remains.

Prevention of loss of moored ocean data stations, particularly in shelf seas where fishing takes place, has many aspects. On the one hand, the mooring system has to be sufficiently rugged to withstand storms and high seas and has to be designed so that it cannot easily be removed by fishermen. On the other hand, it must not be a hazard to shipping and must be capable of being moored and recovered from vessels down to about 90 ft in length. Further, in shallow seas one has to choose between a pop-up system and one employing a surface marker buoy. The former has the advantage of being out of the reach of the weather, out of the way of shipping and of not being capable of deliberate removal by ships other than that which laid it. It has the disadvantage that it can foul trawls and so antagonize fishermen.

Second Generation Anchored Ocean Data Stations

The moored arrays envisaged at this time by U.K. laboratories are intended to store data only and not to telemeter them to a shore station or a ship. One is again faced with a choice. If one merely stores the data, the loss of a station means the loss of all the data collected as well as of the instrumentation: against this a telemetry system ensures that at least some data are obtained even if the station is lost and it also provides a check on the well-being of the array, but it does involve one in risking the loss of equipment which is much more expensive than that which merely records. At this point in time most oceanographers are faced with no urgency in obtaining their data as they require them only for research purposes: there has therefore been no firm demand for telemetry. Should, however, the results of their researches lead to a requirement to monitor the ocean for prediction purposes in such a way as to make it essential to have the data in the shore laboratory for analysis within a few hours of its collection, then telemetry will become necessary and a second generation of ocean data stations will come into being.

A major difficulty will be to find suitable frequencies for buoy-shore telemetry purposes. If the moored array is to be close to the shore, then a band in the VHF or UHF portion of the spectrum would be suitable. If, however, it is eventually required to obtain data from an ocean-wide array which is at distances from shore stations varying between 100 and 3,000 km, then it would seem as if the H/F (4–22 mc/s) region will have to be used. This will make high data-transmission rates impossible owing to the vagaries of propagation and to multipath problems. Further, as the transmitters on the buoys will be of low power and the command stations of high power, specified timing of commands agreed on an international basis will eventually be required in order to prevent mutual interference. The Intergovernmental Oceanographic Commission has this whole problem under review and is collaborating with the World Meteorological Organization in presenting a case for the allocation of H/F bands for telemetry from moored buoy arrays to the World Administrative Radio Conference for the Maritime Mobile Service due to be held in Geneva in September 1967.

The present indications are, however, that the second generation of ocean data stations are not likely to come into operational use in less than 5–10 years from now. There is every reason to hope that by that time communications with them will be through a satellite. This will obviate using H/F telemetry, but there seems to be little likelihood of being able to avoid its use in the interim period if one wishes to carry out experimental telemetry from small-scale arrays within a few hundreds of miles from the shore. Such experimental work will call for a consideration of aerial design and of the power supply for the transmitter and, once these are known, of the buoy and its mooring. All this has been done in the U.S.A., and also in Norway under a NATO contract, and telemetering buoys are actually in operation in the deep ocean off the coasts of these countries on an experimental basis. Within the U.K. little progress has as yet been made.

PRESENTATION OF BAROGRAPHS

One of the more pleasant breaks in the routine of our lives here in Bracknell comes with the annual visit of the shipmasters who are to be presented with a barograph for their long and zealous voluntary observing at sea for us.

The 1966 awards, to Captain W. A. Haddock, O.B.E., of the Head Line, Captain J. S. Moate of the Port Line, Captain G. H. Percy of the Cairn Line and Captain R. White, D.S.C. of the Blue Star Line, were announced in the October 1966 number of *The Marine Observer* and, though we indulged in our perennial hope that the four shipmasters might be brought together in one place at one time, last-minute adjustments in the current voyages of Captain Haddock and Captain White once again made this impossible.

The party that assembled here on 2nd February 1967 to take a glass of sherry with the Director-General, Dr. B. J. Mason, F.R.S., and senior officers of the Meteorological Office was therefore smaller than we had hoped but nevertheless made a most enjoyable nautical occasion. Captain Percy and his wife had come down from the Tyne, Captain Moate and his wife had travelled from his Yorkshire home and was joined here by Captain T. S. Paton, Marine Superintendent of the Port Line. Mrs. White had bravely come from Margate to represent her husband in what is substantially a man's world and to receive his barograph on his behalf, being joined here by Captain H. D. Windle, Assistant Marine Superintendent of the Blue Star Line, and Mr. R. McCaw, their Assistant Manager.

In making the presentations, Dr. Mason stressed the enormous value which ships' observations had always been to the Meteorological Office; one could visualize great advances being made in the meteorological coverage of the world now that meteorological satellites, meteorological rockets and unmanned automatic observing stations were a reality, whilst the computer and vastly improved communication systems were undoubtedly making their mark in the technique of forecasting. But one could never visualize a situation in which the surface observation from a ship at sea would be redundant.

Captain White, whose personal record of voluntary observing went back to 1932, was the first Blue Star Line shipmaster to receive a special award whilst Captain Percy, who had been a voluntary observer since 1948 was likewise the first shipmaster in the Cairn Line to have his service thus recognized. The ships of both these companies were comparative newcomers to the voluntary observing fleet, the record of the Blue Star Line dating from 1923 when a meteorological logbook was received here from the *Ionic Star* and that of the Cairn Line from 1937 when the *Cairnesk* sent in her first returns. On the other hand, Captain Moate, whose own record started in 1928, came from a company with which the Meteorological Office had been associated for almost its entire life, for it was in 1854 that the *United Kingdom*, a full-rigged ship operated by one of their constituent companies, first started observing.

As is customary on these occasions, each captain's personal record card, kept up-to-date in the Marine Branch from the time that his first meteorological returns were received, was on view together with his own maiden meteorological logbook; afterwards the party took luncheon with the Director-General and subsequently made a tour of the office.

The presentation to Captain Haddock had to wait until he brought the *Carrigan Head* into Liverpool on his last voyage before retirement. On 16th March 1967, Captain A. D. White, Deputy Marine Superintendent of the Meteorological Office, made the presentation aboard the ship on behalf of the Director-General, the ceremony being attended also by Mr. Davis, the Liverpool Manager of the Head Line and his Assistant, the Chief Engineer and Chief Officer of the ship and Captain Radley, the Port Meteorological Officer in Liverpool. In making the presentation, Captain White mentioned that Captain Haddock, whose record of voluntary observing went back to 1929 when he sent us a meteorological logbook from the *Lord*

Antrim, was the first Head Line shipmaster to receive a special award. The company's record of voluntary observing went back to 1903 when their *Lord Roberts* was equipped as an observing ship and since then, on their permanent trade across the North Atlantic, their ship's observations have always been of great value to us.

After the presentation was made the party was very hospitably entertained to luncheon aboard the ship.

Photographs of the presentations are shown opposite pp. 189 and 197.

L. B. P.

Presentation of barograph in Hong Kong

On 19th June 1967 a barograph was presented in Hong Kong to Captain R. E. Brooks of m.v. *Anking* for services to marine meteorology. The presentation was made by Mr. G. J. Bell, Director of the Royal Observatory, and the ceremony was attended Mr. H. J. C. Browne, Chairman of Directors of Messrs. Butterfield and Swire Ltd., Mr. K. Milburn, Director of Marine in Hong Kong, Captain O. L. Work, Manager of Holts Wharf, and Captain L. King, Marine Superintendent of the China Navigation Co. Ltd.

Captain Brooks has served both as an observing officer and as master in ships of the China Navigation Co. Ltd., and has traded in China Seas and Western Pacific from the Gulf of Po Hai to Japan, Fiji, New Zealand and Australia. He has given most valuable services to marine meteorology and to the weather forecasting and storm-warning centres in these widespread areas. Hong Kong has benefited more than other centres because Captain Brooks has served in Hong Kong voluntary observing ships and it has been to the Royal Observatory that the many meteorological logs, to which he contributed as an observing officer, were returned.

The Excellent Award scheme was not introduced in Hong Kong until 1960, the year in which Captain Brooks was made master of the s.s. *Hupeh*, so he had no opportunity to qualify for an award during the seven years he served as an observing officer. However, 4 meteorological logbooks returned from ships in which he was master have been classified as 'excellent'. It is gratifying, therefore, to have had this opportunity of showing appreciation for the very valuable assistance received from voluntary observers by making this presentation to a master who has served in Hong Kong voluntary observing ships as both observing officer and master for the comparatively short period of 14 years. It is hoped he will continue in this service for many years to come.

W. P. G.

NOTES ON ICE CONDITIONS IN AREAS ADJACENT TO THE NORTH ATLANTIC OCEAN FROM APRIL TO JUNE 1967

April

The improvement in temperature which occurred over eastern Canada towards the end of last month was short-lived and an outbreak of cold air soon moved in again from the north-west. Temperatures in the east remained above average.

Canadian Arctic Archipelago. Temperatures here were mostly below normal but warmer air spread into the western area late in the month. Ice cover remained almost complete, which is normal for the time of the year.

Baffin Bay. Early in the month the winds were south-easterly, closing the leads along Baffin Island, and temperatures were above normal. There then followed a change in wind direction to north or north-west with below-normal temperatures and no more changes in ice conditions were seen.

Hudson Bay, Foxe Basin and Hudson Strait. This month brought a return to colder weather and northerly winds. Leads, opened by the wind, appeared off Hall Beach, Coral Harbour, and along the south-eastern shore off Hudson Bay where the wind was from the north-east.

Davis Strait. The month began with near-normal temperatures and south-westerly winds, but conditions soon returned to those which have prevailed for most of the winter, with winds becoming northerly and temperatures falling below normal. These conditions produced little change in the ice situation with the unusually large area of ice being maintained.

Labrador Sea and Great Bank. Although air temperatures were lower than normal throughout the month the ice decreased considerably due to north-easterly winds during the latter part of the month. In spite of the cold winter, ice conditions were lighter than average and sea temperatures were 1 to 2°C above normal off Labrador. Numbers of icebergs, although many more than in the last couple of years, remained less than normal.

South Newfoundland Sea. The month was cool, with north-east winds, and small amounts of ice continued to drift through the Cabot Strait.

Gulf of St. Lawrence. The ice cover decreased steadily and the northern half of the Gulf was ice-free by the end of the month apart from pack ice drifting in through the Belle Isle Strait. As temperatures remained below normal the area of ice remaining in the southern half of the Gulf was larger than usual.

River St. Lawrence. During the month the ice cleared from the river although the break-up was somewhat delayed by the persistent cold weather.

Greenland Sea. During the early part of the month temperatures ranged from normal in the south to 8°C above normal in the north with south-westerly winds throughout. During the rest of the month, however, winds were north or north-east and temperatures averaged 3 to 4°C below normal. North of Jan Mayen amounts of ice were slightly below normal and to the south of the Denmark Strait there was also less ice than normal, but between these two areas there was much more ice than usual with some of it being not far from the north coast of Iceland. As winds to the north and north-east of Iceland tended to be north-westerly the ice continued to increase and spread eastwards. South of Iceland sea temperatures fell below normal and were about 1°C below normal at O.W.S. 'Alpha'.

Spitsbergen (Svalbard). Temperatures began above normal but soon fell below normal as winds changed from southerly to north-easterly. During the warm spell ice decreased but for the rest of the month there was little change. There continued to be rather less ice than normal.

Barents Sea. In the north, ice retreated at first due to warm southerly winds and was further north than normal, but a change to a more northerly direction brought the ice southwards to near its normal limit. In the south, warm westerlies continued to reduce the amount of ice and conditions were up to six weeks ahead of normal.

White Sea. Warm south-westerly winds persisted and the sea was mostly open water by the end of the period.

Baltic. A return to near normal temperatures slowed the break-up a little but by the end of the month the Gulf of Finland was almost free of ice. Sea temperatures were above normal.

North Sea. Ice-free.

May

During the month pressure was abnormally high between Nova Zemlya and north-eastern Greenland and relatively low over the Canadian Arctic Archipelago. This resulted in the Arctic, especially that sector just north of Greenland, being warmer than usual, extensions of this pattern occurring further south.

Canadian Arctic Archipelago. With winds oscillating rather wildly air temperatures fluctuated and ranged from about 6°C above normal to generally 5°C below, although round Banks Island it was even cooler than this. Ice coverage, however, remained roughly average.

Baffin Bay. Predominantly southerly winds kept the air on the warm side but, nevertheless, the amount of ice differed little from normal.

Hudson Bay. A mainly north-westerly airstream caused temperatures to be about 2°C lower than usual but ice was normal with perhaps rather wide leads along the north-west coast near Chesterfield.

Foxe Basin. Temperatures, some 5°C below normal at the beginning of the month, rose under the influence of steady south-easterlies, to several degrees above, later dropping back a little. Nevertheless ice covered the Basin as usual.

Hudson Strait. South to south-easterly winds maintained temperatures slightly above average with the result that the ice broke into open pack rather ahead of schedule, particularly in Ungava Bay.

Davis Strait. With mainly southerly winds air temperatures were a couple of degrees above normal; the sea, except in the area round the entrance to the Hudson Strait, also being a little warmer than usual. The month started with ice being slightly in excess but thawing proceeded briskly and average conditions were reached by the end of the period.

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	42
Number of bergs reported south of limit	April	>711	>680	>672	>652	>650	>628	>600	>600	>598	>478	54	0	0
	May	>885	>885	>885	>885	>885	>885	>885	>884	>869	>672	>45	>7	0
	June	>961	>961	>958	>948	>899	>797	>733	>652	>526	>302	7	0	0
	Total	>2557	>2526	>2515	>2485	>2434	>2310	>2218	>2136	>1993	>1452	>106	>7	0
Number of bergs reported east of limit	April	>711	>711	>687	>669	>650	>629	598	313	122	16	0	0	0
	May	>885	>885	>885	>885	>885	>885	>857	>317	>135	>79	13	3	3
	June	>961	>961	>945	>851	>786	>723	>553	>233	>120	64	11	1	0
	Total	>2557	>2557	>2517	>2405	>2321	>2237	>2008	>863	>377	>159	24	4	3
Extreme southern limit	April	44° 31′N, 50° 07′W on 22.4.67												
	May	42° 44′N, 49° 15′W on 11.5.67												
	June	44° 31′N, 46° 25′W on 12.6.67												
Extreme eastern limit	April	46° 26′N, 46° 53′W on 26.4.67												
	May	47° 06′N, 41° 48′W on 25.5.67												
	June	48° 25′N, 43° 11′W on 23.6.67												

> ('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.

Table 2. Baltic Ice Summary: April–June 1967

Notice was reported at the following stations during the period: Riga, Stettin, Gdansk, Klaipeda, Ventspils, Tallin Mariehamn, Turku, Mantyluoto, Alnosund, Stockholm, Kalmar, Visby, Göteborg, Kiel, Tönning, Husum, Emden, Lübeck, Gluckstadt, Bremerhaven, Flensburg, Aarhus, Copenhagen, Oslo, Kristiansundfjord.

No ice was reported at any of the stations during June

Station	April									May								
	Length of Season		Ice Days			Navigation Conditions			Accumulated Degree Days	Length of Season		Ice Days			Navigation Conditions			Accumulated Degree Days
	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
Leningrad ..	1	16	8	0	8	1	0	0	767	0	0	0	0	0	0	0	0	440
Pyarnu ..	1	18	14	4	10	2	12	0	428	0	0	0	0	0	0	0	0	79
Viborg ..	1	17	17	17	0	1	17	0	—	0	0	0	0	0	0	0	0	—
Helsinki ..	1	11	11	0	0	9	0	0	545	0	0	0	0	0	0	0	0	244
W. Norrskar	1	30	30	6	16	19	10	0	—	1	4	4	0	4	0	0	0	—
Vaasa ..	1	10	10	10	0	0	19	0	631	0	0	0	0	0	0	0	0	384
Oulu ..	1	30	30	30	0	0	15	15	—	1	9	7	0	1	0	9	0	—
Roytaa ..	1	30	30	30	0	0	0	30	—	1	26	25	23	2	2	0	23	—
Lulea ..	1	30	30	30	0	0	7	23	992	1	15	15	10	5	2	8	0	822
Bredskar ..	1	25	25	25	0	2	18	1	—	0	0	0	0	0	0	0	0	—
Skellefteå ..	1	28	28	28	0	0	12	16	—	10	11	2	0	2	0	0	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 the degrees Celsius below zero experienced each day during the period of sustained frost.

Labrador Sea. South-westerly winds at the beginning of the month gave way to north-westerlies, air temperatures falling from about 2°C above to 5°C below average. The sea, however, apart from a small area just south of Cape Chidley, remained on the warm side and so ice amounts were much less than usual, the area south of Hamilton Inlet being, exceptionally, quite clear.

Great Bank. With a steady south-south-westerly airstream temperature of the air rose, except in the extreme north, to 3°C above average as did also that of the sea. The only pack, in Notre Dame Bay, was very open, while the iceberg count was somewhat lower than usual.

South Newfoundland Sea. The wind was mainly southerly and in the east of the area both air and sea temperatures were, in consequence, higher than normal. Curiously, though, near the Nova Scotia coast, air and sea were significantly cooler than usual. There was no ice apart from bergs.

River and Gulf of St. Lawrence. Winds were variable and light but rather cold weather lasted on through May, at the end of which temperatures were at least 2°C below normal. The water, too, was on the chilly side. Ice in the river itself had cleared by the beginning of the month but there was still rather more pack than usual in the Gulf, especially just north of Prince Edward Island.

Greenland Sea. The situation was rather confused in this area. Winds were variable but north of 65°N blew mainly from a northerly direction. The air was slightly on the warm side. Water temperatures were relatively high to the north-east and extreme south-west, low in the north and south-east and variable both in the Denmark Strait and in the area just north of Iceland. North of 75°N the ice, excessive in amount at first, tended to melt along the edge which, by the end of the month, was well inside its average position, in places by as much as 100 miles. Further south this picture was reversed with the pack extending as much as 100 miles east of its normal limit. Just north of Iceland, in fact, the eastward spread of the pack was the greatest for many years. It was thought, however, that the ice was fairly thin and not likely to last. Along the south-east coast of Greenland there was also more ice than usual though this was melting fast, if irregularly, by the end of the period.

Spitsbergen. (Svalbard). North-westerly winds gradually veered to south-easterly and air temperatures rose from a level about 1°C below to 1°C above normal. Sea temperatures were abnormally high, in the area to the south-west of Spitsbergen, by as much as 5°C. Consequently there was a marked ice deficit.

Barents Sea. As in the Spitsbergen area, winds veered from north-westerly to easterly but the air was generally about a degree cooler than usual although the sea was mostly relatively warm. In the north there was still a slight excess of ice but along the Russian coast clearance of the pack was well ahead of schedule, as in the previous month.

White Sea. Light variable winds and roughly average temperatures made little difference to the situation in which the ice cleared early in the month, perhaps six weeks earlier than usual. All White Sea ports were clear by 3rd May.

Baltic. South-east winds raised the temperature from 2°C below average to 2°C above and the residual ice in the north of the Gulf of Bothnia was quickly breaking up. Only small amounts of very open pack remained by the end of the month.

JUNE

An exceptionally intense anticyclone centred near the New Siberian Islands, in conjunction with pressures significantly below normal south of Spitsbergen and over Hudson Bay, combined to make the Arctic warmer and north-east Canada cooler than usual.

Canadian Arctic Archipelago. Mainly north-north-westerly winds kept temperatures well on the low side so there was little departure from the normal 10/10 fast-ice over most of the area. Lancaster Sound, however, had mostly very open pack.

Baffin Bay. In contrast with the previous area, the winds, although very variable, had a general tendency to blow from the east or even south-east. At the beginning of the month temperatures were about normal but they fell steadily, finishing two degrees below normal. Ice cover, especially in the north (Smith Sound area) and in the east along the coast of Greenland, was on the whole greater than usual, such leads as there were being narrower than would be expected at this time of the year.

Foxe Basin. Mainly northerly winds kept temperatures two or three degrees below average so that the amount of ice remained normal or more. There was, however, an opening to clear water over a small area near Fury and Hecla Strait, probably due to the wind.

Hudson Bay. As may be inferred from the introduction, winds over Hudson Bay were extremely variable but there was a slight tendency for those from a westerly direction to predominate. Temperatures, originally on the high side, fell to 2°C below normal. On the west side of the Bay there was a deficiency of ice, north-west of the line from Port Nelson to Coats Island even having completely open water, but on the east there was rather more ice than usual. However the southern half of James Bay was ice-free.

Hudson Strait. North-westerly winds backed steadily to south-westerly but temperatures remained slightly on the low side. Ice cover was normal except in Ungava Bay which was, exceptionally, almost clear.

Davis Strait. Conditions here varied greatly from side to side. In the west there were mainly westerly winds, lowish air temperature but the sea slightly warmer than usual. Ice was less extensive than usual with very little near Cape Chidley. On the Greenland side, however, winds were variable and the air was cool, as was also the sea. Ice amounts were roughly normal except in the south where there was a definite excess.

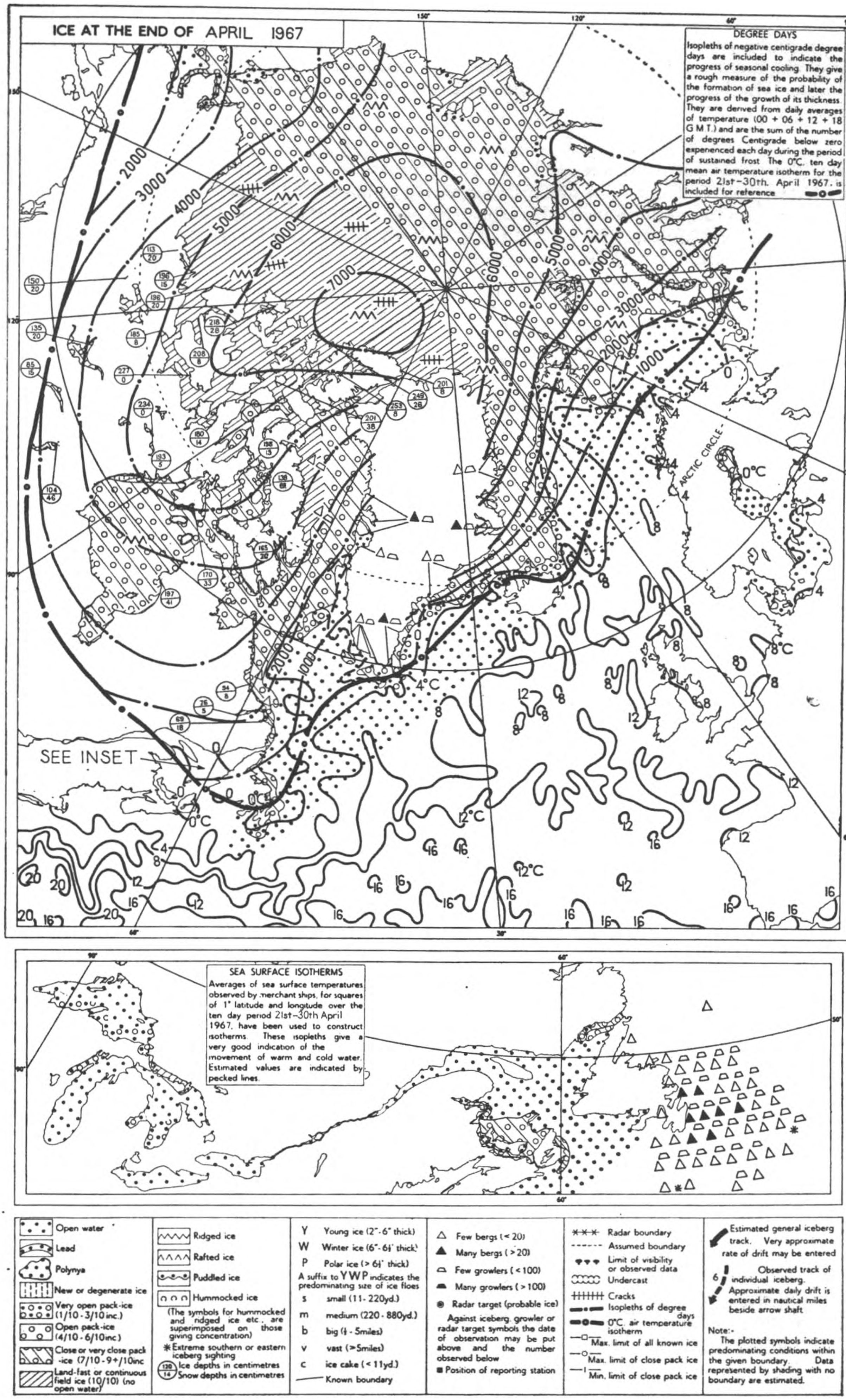
Labrador Sea. North-westerly winds here backed to south-westerly and air temperatures fell from about 1°C above normal to as much as 3°C below. Near the coast the sea in a narrow belt was very warm—up by 4°C above normal—but further out it was slightly on the cool side. There was, exceptionally, practically no field ice and icebergs were fewer than usual.

Great Bank and South Newfoundland Sea. Westerly winds had the effect of cooling the air from a temperature 2°C above normal to 2°C below but the sea, at least near the coasts, remained abnormally warm. Further out, it is true, the sea was cooler than usual. Apart from icebergs which tended to melt rather quickly there was no ice.

Greenland Sea. North of 70°N light easterly winds gradually became northerly and air temperatures dropped from near normal to a degree or so below. In spite of this, however, it appeared that sea temperatures were on the high side with the natural result that the eastern edge of the ice-field receded. There were also extensive shore leads, particularly in the extreme north. Further south the winds, although mainly light north-easterly, at times blew strongly from the west. The air was somewhat cool as was also the sea. Ice amounts, therefore, were greater than usual, particularly in the area just north-west of Iceland and near Cape Farewell.

Spitsbergen (Svalbard). Yet another warm month with both air and sea temperatures being three to four degrees above the seasonal average. The ice edge to the west of Spitsbergen receded well beyond its normal position.

Barents Sea. Over most of this area extremely variable winds, often moderate to strong, caused fluctuations in both air and sea temperatures from about four degrees higher than to one to two degrees lower than normal. The ice-fields were slightly reduced in area but the


ICE AT THE END OF APRIL 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 21st–30th. April 1967. is included for reference
SEE INSET
ARCTIC CIRCLE
SEA SURFACE ISOTHERMS
Averages of sea surface temperatures observed by merchant ships, for squares of 1° latitude and longitude over the ten day period 21st–30th April 1967, have been used to construct isotherms. These isopleths give a very good indication of the movement of warm and cold water. Estimated values are indicated by pecked lines.
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
Ice depths in centimetres
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.

concentration greater than usual. In the Novaya Zemlya area the temperatures over the second half of the month were well above average and the ice deficit was well marked.

Baltic. The last remaining ice in the extreme north of the Gulf of Bothnia cleared on 5th June.

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.

SPECIAL LONG-SERVICE AWARDS

Annual awards have always been a feature of our voluntary observing scheme but after the second world war it was decided that there should also be four special awards, made for a combination of long service and quality of records. These awards, inscribed barographs, were first made in 1948 and this is thus the 20th year in which they have been given.

The minimum qualification for a special award is fixed at 15 years in which meteorological records bearing the officer's name, either as an observing officer or as master, have been received, including of course the year previous to that in which the award is made. Service in ships which are not Observing Ships, service in a rank which does not participate in the work, time ashore for certificates and periods of lay-up are some of the things which preclude these 15 years from being continuous and it is by no means unknown for them to be spread over 40 years or more. But when an officer's first meteorological logbook is received a personal card is started for him and throughout his observing service all his meteorological logbooks and the character awarded to them are recorded on his card, no matter how many or how long the interruptions in his observing career may be.

Every year the cards of all masters and officers with the required 15 or more years' voluntary service are put under close scrutiny. A mathematical formula which considers their actual number of years' service and the character awarded to each of their meteorological logbooks or forms effectively places them in an order of merit and the first four are nominated for a special award.

This year there were 75 such cards; the formula was applied to each one of them and the Director-General of the Meteorological Office is pleased to award inscribed barographs to the following:

1. CAPTAIN K. BARNETT, R.D. (New Zealand Shipping Co. Ltd.), who sent us his first meteorological logbook in 1937 when he was in the *Rangitane*. In 18 years he has sent us 31 meteorological logbooks of which all but two were classed 'excellent'.
2. CAPTAIN N. F. FITCH, M.B.E. (Bibby Line), who first observed for us in the *Pareora* of the Federal Line in 1927. In 21 years he has sent us 55 meteorological logbooks of which 24 received the 'excellent' classification.
3. CAPTAIN C. P. ROBINSON (New Zealand Shipping Co. Ltd.), who sent us his first meteorological logbook in 1946 when he was in the *Tongariro*; subsequently he sent us, in 17 years, 29 meteorological logbooks of which 27 were classed 'excellent'.
4. CAPTAIN W. F. T. DAN (New Zealand Shipping Co. Ltd.), whose first meteorological logbook came here from the *Paparoa* in 1948; he has 18 years of voluntary observing to his credit and has sent us 24 meteorological logbooks of which 19 have been classed 'excellent'.

We congratulate these four shipmasters on this recognition of their valuable voluntary service over many years. They will be personally notified of the award and of the arrangements which will be made for its presentation.

An account of the presentation of the previous year's special awards, including one made by the Director of the Hong Kong Meteorological Service to a shipmaster in the Hong Kong Voluntary Observing Fleet, appears on page 199 of this issue.

L. B. P.

Book Reviews

The Astronomical and Mathematical Foundations of Geography, by Charles H. Cotter, B.Sc. 8¾ in × 5¾ in, pp. 244, *illus.*, Hollis & Carter Ltd., 9 Bow Street, London, W.C.2, 1966. Price: 35*s*.

Charles Cotter, Extra Master, is Senior Lecturer in the Department of Maritime Studies at the Welsh College of Advanced Technology, Cardiff. In the foreword to this book he tells us that it is addressed primarily to sixth form students and fifth year undergraduates reading geography; there is little doubt that mariners will also, as he suggests, find it a useful book for background material. As with his earlier books, the author is economical with words and in this small book of some 240 pages he manages to condense an enormous amount of information, supplemented by numerous geometrical drawings, about this fascinating subject.

The first chapter, which deals with the size and shape of the earth, includes a wealth of historical notes and gives an elementary and easily-understood summary of the subject with a minimum of mathematics. Chapter 2 begins with mathematical principles of the sphere and moves on to the more difficult subject of the ellipsoid, while the 26 pages of chapter 3 manage to summarize the essentials of plane and spherical trigonometry. Chapter 4 deals with the nautical mile and the problems of sailing on the Earth—rhumb-line sailing, plane sailing, the Mercator chart, middle-latitude sailing and great-circle sailing, together with the pertinent formulae. The dozen pages of chapter 5 explain the Earth's orbit and the seasons and provides the opportunity for such important characters as the Celestial Pole and the first point of Aries to appear on the scene. In chapter 6, entitled 'The Earth's Rotation . . .', the measurement of time and the problems of finding latitude and longitude by astronomical means are described. Marine readers may find it disappointing that the familiar 'stereographic projection in the plane of the observer's rational horizon' is not the main feature of some of the diagrams; its elements are incorporated in a somewhat more graphic form of presentation. Plotting of position lines is briefly explained.

Chapter 7 gives an elementary summary of the various methods used by the professional surveyor. The final chapter, which is the longest in the book, describes no less than 55 different map projections. Finally there is a selected list of books on the subject for further reading.

Obviously in such a small book there is not much detail, but it should prove useful for ready reference or as an *aide-mémoire* for the navigator or for the student of geography.

C. E. N. F.

Progress in Oceanography, Vol. 1, edited by M. Sears. 9¼ in × 6¼ in, pp. viii+383, *illus.*, Pergamon Press Ltd., Headington Hall, Oxford, 1963. Price: 100*s*.

This is the first volume of a series designed to keep oceanographers, and others interested in the sea, conversant with recent research. These are serious publications and in no sense popular, being primarily intended for the research student.

This volume contains five articles all of which are of considerable substance. They cover the geology of the sea shore, atmospheric electricity, biological seawater populations, sea chemistry, and the last gives a further but detailed physical examination of the Gulf Stream.

The first article, by E. Seibold of the University of Kiel, is a study of the transport of coastal sands in the Baltic and North Sea adjacent to Kiel.

The geology of the structure of the sea shore above and below the sea surface is described. The movement and evolution of geological features have been studied with modern techniques including aerial photography, mechanical sampling of the sea bed and acoustics. The long- and short-term effects of wind and current are described.

The second article, by P. C. Blanchard of the Woods Hole Oceanographic Institution, is of considerable interest to meteorologists and deals with the electrification of the atmosphere by the projection of bubbles from the tops of sea waves.

Laboratory studies have been made observing mechanical and electrical processes when bubbles of varying sizes are projected from small tubes or water surfaces. Ingenious equipment has been used including the Millikan continuous diffusion cloud chamber to reproduce natural processes in the laboratory.

The laboratory experiments and field data resulted in the conclusion that the greatest sources of particles that pass into the atmosphere from the sea are the bubbles emitted at the tops of waves. Of these the greatest amount of electric charge is passed to the atmosphere by droplets formed from the neck of water that links the bubble to the sea at the time of its emission. This amounts to an average current of 160 amperes from all the seas of the world.

The third article concerning suspended organic matter in seawater is by T. R. Parsons of the Fisheries Research Board of Canada.

Dr. R. A. Cox of the National Institute of Oceanography provides the fourth article. This reviews the subject of oceanic salinity, including definitions and chemical and electrical methods of measurement. The very accurate and rapid electrical methods of measuring salinity have made it necessary to depart from classical methods of measuring salinity indirectly, in which the salt content was deduced from the concentration of chlorine.

The last article, by F. C. Fuglister of Woods Hole Oceanographic Institution, mainly describes the results of a close survey of water masses and flow patterns of the Gulf Stream. Impressive experimental evidence is given of large circulations and meanderings in the stream of maximum velocity. The water mass discontinuity, i.e. between warm Atlantic water and that of northerly origin adjacent to the coast and south of the Grand Banks, appears to have properties analogous to an atmospheric polar front.

This whole volume is splendidly produced and is most suitable for a reference library. The material is very well set out with clear tables and diagrams, and excellent monochrome photographs.

G. A. T.

The Changing Climate: Selected Papers, by H. H. Lamb. 9½ in × 6¼ in, pp. 236, *illus.*, Methuen & Co. Ltd., 11 New Fetter Lane, London, W.C.4, 1966. Price: 45*s*.

One only needs to be mildly interested in climatology and history to derive some pleasure and benefit from this fascinating book which deals with climatic changes and their effects on man during the period 4000 B.C. to the present day. The book is nothing more than a convenient collection of papers written by Mr. Lamb during the years 1959 to 1964, six of them having been published in different scientific journals and two of them being hitherto unpublished lectures.

Mr. Lamb is an indefatigable worker and he must have done an enormous amount of research in preparing these papers, which contain no less than 270 references!

The book is not lacking in its direct interest to the mariner; one of the papers is entirely devoted to the rôle of atmosphere and oceans in relation to climatic changes and the growth of ice sheets on land and there are numerous references in the other papers to the significance of sea-ice cover and of ocean currents in climatic change. As most of the papers deal with the northern hemisphere, the Gulf Stream and North Atlantic drift play a prominent part. (One of the illustrations of ice cover off Greenland was prepared in the Marine Branch of the Meteorological Office.) There are, nevertheless, several references to Antarctic ice cover and its effect on the world's climatic changes and vice versa.

How does one know what the climate was in 4000 B.C. or, for example, during the Middle Ages? The author explains briefly how such evidence is collected—from a study of fossils, marine fauna, evidence of past vegetation and bog growth for the earlier period and, for the latter period, largely from narrative accounts and illustrations, aided by visible evidence of glacier growth and of past vegetation. A particularly interesting paper is devoted to evidence, from a radio-carbon study of tree trunks found in a bog in north-west Scotland, that these tree trunks grew between 2700 and at latest at about 2200 B.C. and that the site of these trees belongs to the latter period of the main post-glacial warm epoch. Subsequent evidence seems to indicate that no trees have grown in that area since about 2000 B.C.

An obvious question is 'What is the value of these investigations?' In the final paper the author attempts to answer this question. He shows, for example, that one would not gain useful evidence of climatic change from a study of sea temperatures in the Thames at present because of the artificial rise in temperature there, due to industrial effluent. He illustrates and gives various tables showing actual climatic trends and variations and points out that false impressions of the trend of winter conditions and hence immunity from severe weather encourage easy-going customs —"ranging from injudicious plumbing . . . to . . . wearing of brief underwear". It might be that if those responsible for our gas and electric supplies had read this book we would have been spared the discomfort which occurred during the cold spell in the winter of 1964/65.

It seems that the more we can know about climatic change in the past the more we can plan for the future.

Each of these papers is illustrated with adequate maps, tables and graphs and there are three photographs—one showing the terraces of an English medieval vineyard as they appear today. In the Appendices are tables indicating the summer wetness/dryness, and winter mildness/severity, for every 10-year period from 1100 to 1959.

C. E. N. F.

Personalities

OBITUARY.—We regret to record the death on 1st May 1967 of CAPTAIN W. K. TADMAN, Master of the *Rialto*.

William Kilvington Tadman was born on the 13th February 1912, commenced his sea service as an apprentice in 1928 with Ellerman Bucknall & City Line and stayed with them for 8 years. He joined Ellerman Wilson Line on 21st April 1936 as 3rd Mate and remained with them until joining the Royal Naval Reserve in 1939.

During the war he served on convoy escort duties, returning to Ellerman Wilson Line on 17th February 1946. He was promoted to Chief Officer of the *Rinaldo* in January 1947 and to his first command, the *Spero*, in April 1952. He was later in command of the *Empire Wansbeck* which was engaged in trooping service between Harwich and the Hook of Holland.

Captain Tadman's association with the Meteorological Office goes back to 1935 and since that time he sent in 15 meteorological logbooks.

We offer our sympathy to his widow, son, and two daughters.

E. R. P.

RETIREMENT.—CAPTAIN E. A. BRUCE, O.B.E. retired last April after 34 years' service with the Scottish Home Department and the Department of Agriculture and Fisheries for Scotland.

Captain Bruce was born in Edinburgh in 1902 and it was from the port of that city, Leith, where most of his departures were made.

After completing his education aboard the *Worcester*, Bruce served his apprenticeship with Messrs. J. Hardie & Company of Glasgow aboard the renowned barque *Archibald Russell.* On obtaining his 2nd Mate's certificate he joined the s.s. *Elphinston* as 2nd Mate subsequently serving in the Ben Line and Cairn Line. He passed for Master in 1929 and joined the Fishery Board for Scotland (later to come under the Scottish Home Department) in 1933.

As an officer in the R.N.R. he joined the Royal Navy at the outbreak of the second world war and was appointed command of H.M.S. *Gillian* in 1940. On cessation of hostilities he rejoined the Scottish Home Department's Ships as Chief Officer and in 1949 was promoted to command the Fishery Cruiser *Brenda*, transferring to Research Ships in 1948.

Captain Bruce has given many years of excellent service to the Meteorological Office. His first meteorological logbook was received from F.R.S. *Explorer* in 1938; since that year he has sent 21 meteorological logbooks to the Meteorological Office, 19 of which have been classed as excellent, and he has received Excellent Awards every year between 1958 and 1967 (10 in all).

The photograph of his ship F.R.S. *Explorer* was published in the July 1960 number of *The Marine Observer* and she has been included three times in the short list of the best observing ships.

Whilst regretting the loss of such a valuable Voluntary Observer we wish Captain Bruce an enjoyable well-earned retirement.

R. R.

RETIREMENT.—CAPTAIN F. R. NEIL, Senior Master of the Bristol City Line fleet, has now retired owing to ill health after 44 years of service at sea, 39 of which have been with the Bristol City Line.

Frederick Reginald Neil first went to sea as an apprentice with the Clan Line in 1923 and, after obtaining his 2nd Mate's certificate, served as a Junior Officer with that company, joining the Bristol City Line as 3rd Officer in 1928.

He obtained his Master's certificate in 1934 and was first appointed to command in the *Boston City* in August 1942. He remained in command of various Bristol City Line ships for 25 years until his retirement and has been Senior Master of their fleet since August 1963.

During the second world war Captain Neil served mainly on the North Atlantic trade; he was on one occasion Commodore of a large ocean convoy from Halifax, Nova Scotia to the U.K. and he served as coastal Commodore on several occasions on both sides of the Atlantic. He received letters of commendation from the Admiralty and from the Naval Control at Halifax, N.S. for this work. He was awarded the Coronation medal in 1953. Captain Neil's association with the Meteorological Office commenced in 1952 when he was Master of the *New York City*. Since then, 30 completed logbooks have been received from ships under his command, all of which were assessed as 'excellent'. He received Excellent Awards in 1958, 1959, 1960, 1961, 1963 and 1967.

We sincerely hope that he will soon be restored to good health and we wish him many years of happiness in his retirement.

F. G. C. J.

RETIREMENT.—CAPTAIN R. J. N. NICHOLAS, R.D., R.N.R. retired on 31st March 1967 after 40 years at sea, 35 of which were spent with the Cunard Line.

Richard John Nolan Nicholas made his first voyage to sea as a midshipman in the

Brittania of the Anchor Line of Glasgow in 1926. He passed for 2nd Mate in 1930 and Master in 1937.

Joining the Cunard Line in 1931, his first appointment was 3rd Officer of the *Bactria*; his first command was the *Andria* in 1954. He subsequently commanded the *Assyria, Alsatia, Saxonia, Sylvania, Brittanic, Franconia* on her maiden voyage and *Carinthia* which was his last command. Captain Nicholas also served as Staff Captain of both Queen liners and the *Mauretania* and *Caronia*. Both his father and grandfather were also Cunard Line shipmasters.

As an officer of the permanent Royal Naval Reserve, which he had joined as a midshipman in 1928, he spent the war years on North Atlantic escort duties and, latterly, in H.M.S. *Howe* of the Pacific Fleet where he was mentioned in dispatches.

As a Captain R.N.R. he was appointed A.D.C. to H.M. The Queen in 1963–64; he retired from the R.N.R. in 1965.

Captain Nicholas's association with the Meteorological Office dates back to 1937 when he was serving as 3rd Officer in the *Berengaria;* in 12 years of voluntary observing he sent in 21 logbooks, 13 of which were classed 'excellent'; he received an Excellent Award in 1961.

We wish him health and happiness in his retirement.

J. R. R.

RETIREMENT.—MR. C. J. A. MILLS, who was Senior Scientific Assistant under Mr. Matheson, the Port Meteorological Officer in London, retired in June this year.

Mr. Mills joined the Meteorological Office in 1937 and, as is customary in this Office, had served as a meteorologist in various parts of the world and at RAF stations and elsewhere in the United Kingdom before being appointed to London Docks.

Writing about his retirement, Mr. Mills says: "During my 12 years' service in London Docks I have seen many changes, both in ships and personnel—new entrants, promotions and retirements—and now I am retiring myself. The work was hard but I enjoyed it and it gave me great pleasure to visit so many ships and to meet so many ships' officers. I would like to express my appreciation to all concerned for the courtesy that was shown to me and the assistance given to me by so many people, both afloat and ashore, in carrying out my duties in the docks."

We wish him health and happiness in his retirement.

C. E. N. F.

Notice to Mariners

ADEN—CESSATION OF SHIPPING FORECASTS BY BRITISH AUTHORITIES

Due to the impending transfer of political authority in Aden the British forecasts for shipping, which were broadcast from Aden (ZNR), have been discontinued since 31st August 1967. The intentions of the new authority are unknown.

The area officially allocated to Aden is covered by Karachi (ASK) and Djibouti (TXZ). Full details of weather information broadcast from these stations is given in *Admiralty List of Radio Signals*, Vol. III. The forecasts from Djibouti are at present broadcast in French only but it is hoped arrangements can be made to have them repeated in English in accordance with WMO procedure.

Radio weather messages from ships may be sent to any of the stations in Ceylon, India, Pakistan or French Somaliland listed in Part IV of the *Marine Observer's Guide.*

Notices to Marine Observers

SPECIAL REMINDER NOTICE

All voluntary observers are reminded that the revised code (see *The Marine Observer*, January 1967), shown below, comes into force on 1st January 1968.

99	=	Indicator figures for ship's report.
$L_aL_aL_a$	=	Latitude (as before).
Q_c	=	Quadrant of the globe.
$L_oL_oL_oL_o$	=	Longitude (now includes hundreds figure).
YY	=	Day of the month (GMT).
GG	=	Time (as before).
i_w	=	Wind speed indicator.
Nddff VVwwW PPPTT $N_hC_LhC_MC_H$	}	As before.
D_sv_sapp	=	As before (except for new Table for v_s).
$(0T_sT_sT_dT_d)$	=	As before.
$(2I_sE_sE_sR_s)$	=	As before.
(3	=	Indicator figure for wave groups.
P_wP_w	=	Period of sea waves, in seconds
$H_wH_w)$	=	Height of sea waves in units of ½ metres.
$(d_wd_w$	=	Direction from which swell waves are coming.
P_w	=	Period of swell waves.
$H_wH_w)$	=	Height of swell waves in units of ½ metres.
(ICE c_2 $KD_ire)$	}	As before.

Only those groups which are to be used in British voluntary observing ships are included above (e.g. the special supplementary sea temperature group, which is not to be used to begin with, is not shown).

If the new instructions and the yellow logbooks have not been received aboard any ship by 1st January, her observing officers should continue to report in the present code until they receive the new publications.

RAIN IN THE SOUTH-WEST APPROACHES—APPEAL FOR SPECIAL OBSERVATIONS

The Cloud Physics Branch of the Meteorological Office is initiating an ambitious programme of research into the fundamental processes responsible for precipitation in warm-frontal conditions. One of the most important parameters to be measured is the pattern of vertical motion associated with the front and so, in order to avoid complications introduced by land masses, the initial experiments are to be centred on the Scilly Isles. It is planned to obtain data on the vertical motions by two methods. The first is by means of a doppler radar from which information on a scale of 10 km can be obtained by studying the doppler shift of frequency of the radar pulse due to reflection from the moving raindrops. The second method is on the scale of motion over a 100 km square along the sides of which very accurate horizontal winds will be obtained by using high-precision tracking radar in conjunction with special radar targets dropped from aircraft. From these measurements it is hoped to be able to deduce the variations of vertical velocities in warm-frontal cloud and to relate these to the rate of rainfall.

The most crucial factor determining the suitability of a front for investigation will be the extent and intensity of the rainfall ahead of it and it is here that we would like assistance from ships in the SW Approaches. The routine meteorological reports received from ships, together with satellite pictures, will be of considerable help in determining the position and movement of a front, but will not give enough detailed information on the extent of the rainfall. Therefore on a number of occasions from October to December 1967 additional reports about rain will be requested from ships in the appropriate specified area—by means of a special message originating from the Meteorological Office at Bracknell. The information requested will be for an immediate report on whether it is raining or not and, if it is raining, with what intensity, e.g. slight, moderate or heavy. The position and time of the observation will also be required, of course.

The whole success of these experiments could well depend on the number of special reports received in reply to our requests.

NAUTICAL OFFICERS AND AGENTS OF THE MARINE BRANCH OF THE METEOROLOGICAL OFFICE, GREAT BRITAIN

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Captain A. D. White, R.D., Lt.-Cdr. R.N.R., Deputy Marine Superintendent. (Telephone: Bracknell 20242, ext. 543.)

Lieut.-Commander L. B. Philpott, D.S.C., R.D., R.N.R., Nautical Officer. (Telephone: Bracknell 20242, ext. 461.)

Mersey.—Lieut.-Commander E. R. Pullan, R.D., R.N.R., Port Meteorological Officer, Room 709, Royal Liver Building, Liverpool 3. (Telephone: Central 6565.)

Thames.—Mr. J. C. Matheson, Master Mariner, Port Meteorological Officer, Movement Control Building, South Side, Victoria Dock, London, E.16. (Telephone: 01-476-3931.)

Bristol Channel.—Captain F. G. C. Jones, Port Meteorological Officer, 2 Bute Crescent, Cardiff. (Telephone: Cardiff 21423).

Humber.—(*Name to be announced later*) Port Meteorological Officer, c/o Principal Officer, Board of Trade, Trinity House Yard, Hull. (Telephone: Hull 36813.)

Clyde.—Captain R. Reid, Port Meteorological Officer, 118 Waterloo Street, Glasgow, C.2. (Telephone: Glasgow City 4379.)

Forth.—All enquiries to Captain Reid above.

Tyne.—Captain C. J. D. Sutherland, Merchant Navy Agent, c/o F. B. West & Co., Custom House Chambers, Quayside, Newcastle upon Tyne. (Telephone: Newcastle 23203.)

Southampton.—Mr. J. W. E. Thwaites, Master Mariner, Merchant Navy Agent, Southampton Weather Centre, 160 High Street below Bar, Southampton. (Telephone: Southampton 20632.)

INDEX TO VOLUME XXXVII, 1967

[*Subjects of* Book Reviews, Editorials, Notices to Marine Observers, Notices to Mariners, Photographs, *and persons named in* Retirement *and* Obituary *notices, are indexed under these general headings.*]

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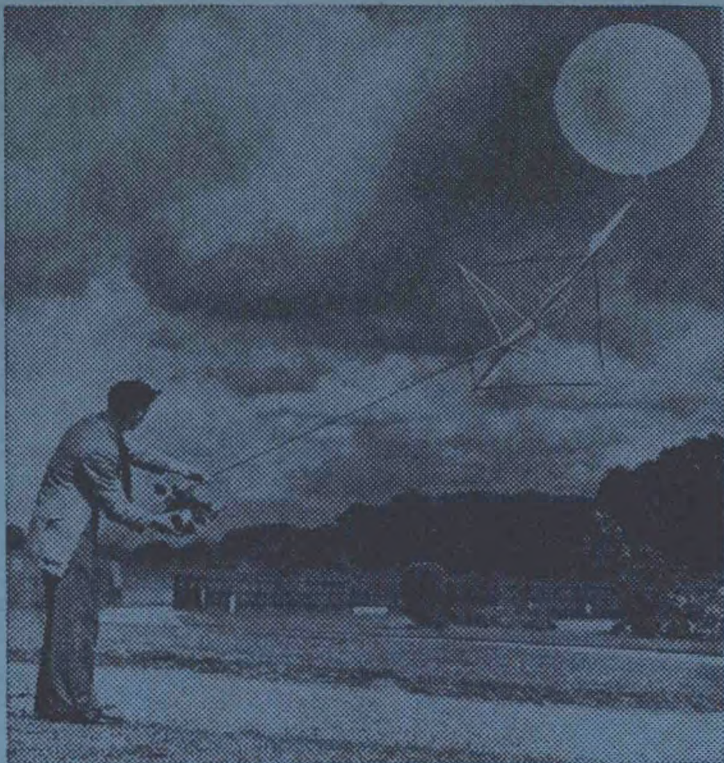

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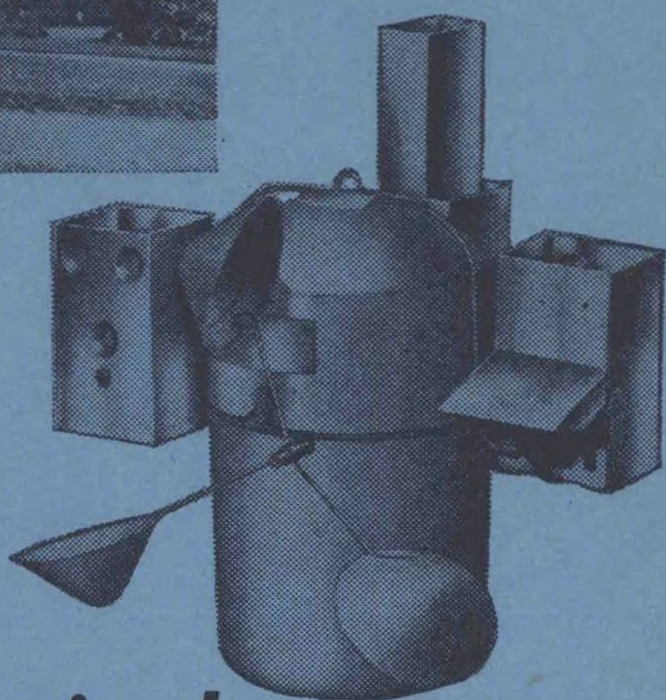

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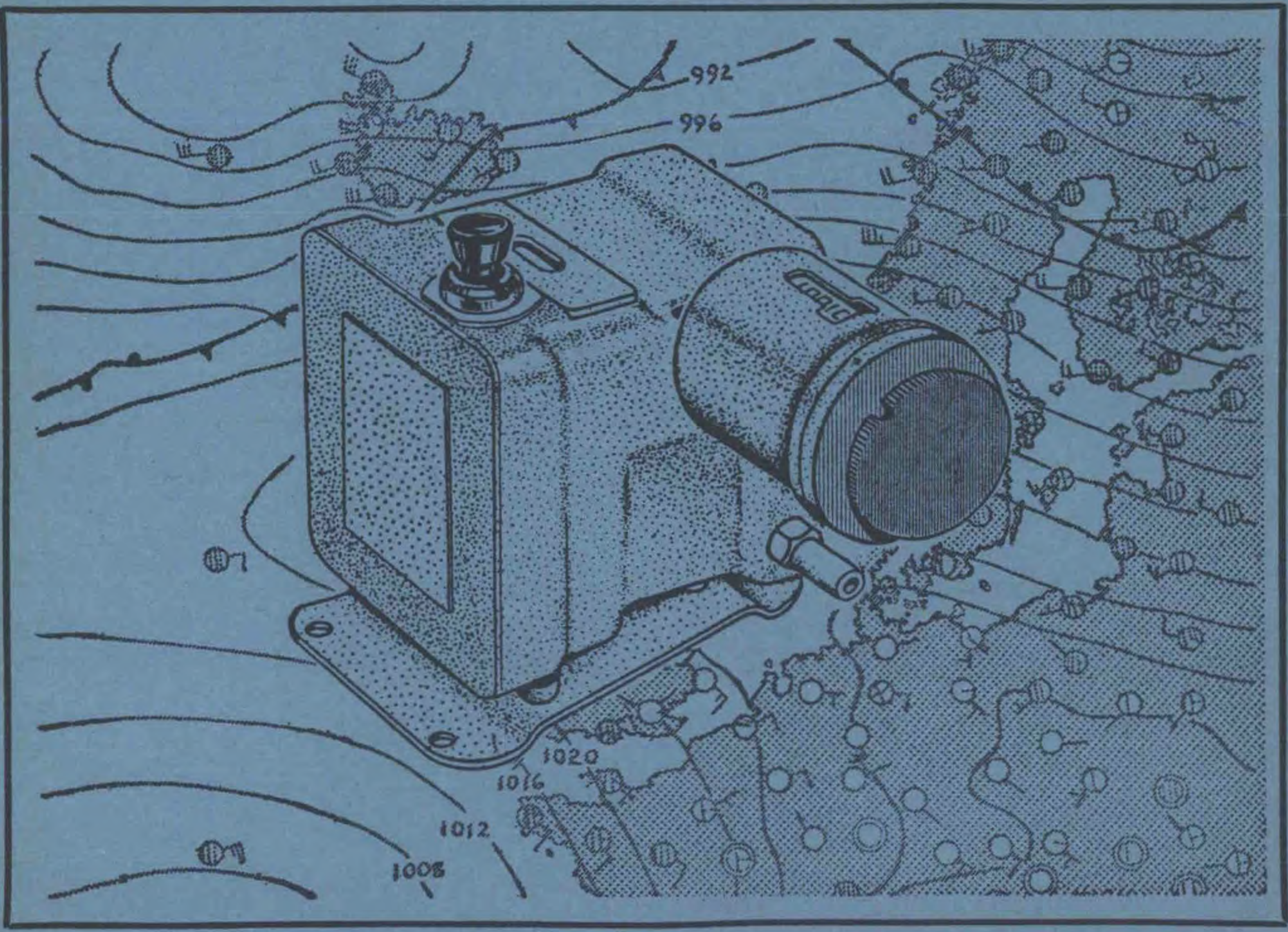

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