M.O. 667

The Marine Observer

A quarterly journal of Maritime Meteorology

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January 1960

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THE
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prepared by the Marine Division of the
Meteorological Office

Vol. XXX

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M.O. 667 AIR MINISTRY

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VOL. XXX **No. 187** **JANUARY 1960**

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Editorial

The International Union of Marine Insurance, which is 85 years old, held its annual conference in London in September 1959. Some of the discussions at that conference, which are reported in *The Policy Insurance Weekly*, highlight the big part that weather conditions play in this world of marine insurance—a world with which the masters and officers of ships, and indeed everybody in the shipping industry, are intimately concerned. The interest which underwriters show in the weather at sea is illustrated by the fact that Lloyds take the trouble to phone the Meteorological Office daily for coded weather reports from ships in the eastern Atlantic, which are thus made available in " the Room " and when space permits are published in *Lloyd's List*. Ice reports are also made available to Lloyds by teleprinter. The casualty lists and law reports from the Admiralty Division, as published in *Lloyd's List*, contain frequent reminders of the relationship—often an unhappy one—between weather conditions and the underwriters.

Weather problems connected with the navigation of the recently extended St. Lawrence Seaway including " fog and rain in the summer with an early freeze up, ice and snow in November and December " figured prominently in the discussions at this insurance conference. "Although the seaway engineers had done an excellent job in overcoming the hazards of geography, they could not control the weather." The inference was that additional rates would need to be maintained on both cargo and hull of ships trading in that area. With reference to the lower St. Lawrence, the hazards of late sailings from Montreal or Quebec were mentioned, one of the factors being the difficulty of salvage if a ship found herself in trouble on the way out. " It was not wise to be influenced by unseasonal balmy weather in late November or early December—good weather can change rapidly as was seen in November 1958."

On the general question of weather at sea there was some discussion about " weather routing " with its consequent saving of heavy weather damage to cargo and hull, more passenger comfort and less time on voyage. This procedure has long been practised by civil aircraft—but its application to shipping is more complicated for the meteorologist since the ship is affected not only by the wind but by the waves—which depend upon wind force, direction and fetch. (This is a question which has been under active discussion by the Commission for Maritime Meteorology and, as stated in earlier numbers of *The Marine Observer*, has been tried out operationally with apparently some success by the U.S.A. authorities.) It was almost inevitable that the use of radar at sea came under fire at the conference and that there was criticism about the improper use of this aid by ships' officers leading to unnecessary collisions. The conference hoped that the next Safety at Sea Convention would take some positive action about this problem and that the Convention will not " confine itself to face-saving manoeuvres "!

The proper loading of grain shipments, which is another subject to be dealt with at the forthcoming Safety at Sea Convention, was also discussed as it is obviously a question of great interest to underwriters. Its meteorological significance is obvious; if there were no bad weather or rough seas, no shifting boards would be needed. Even today it is not unknown for a ship loaded with a grain cargo to get into trouble in heavy weather.

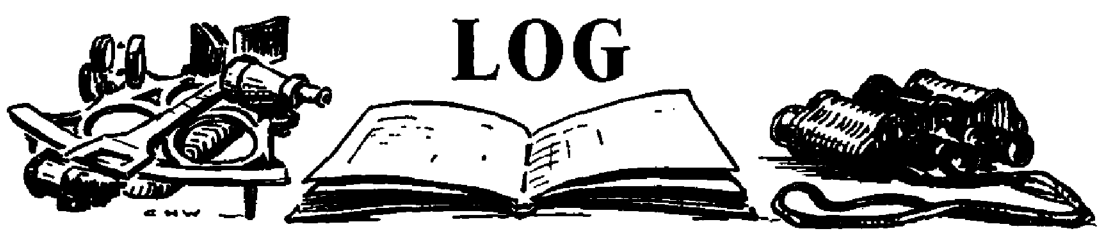
Many insurance aspects other than marine are intimately affected by meteorological conditions. It is evident that road transport casualties and their consequent claims are more prevalent in bad weather; and then there are the domestic examples of burst pipes in frosty weather. Damage by such causes as flooding due to violent and prolonged rainfall is usually covered by insurance, but certain very exceptional meteorological hazards may well be classified as "Acts of God" and thus be excluded from a policy. On the more spectacular side, insurance against hurricane damage is customary in parts of the United States and other countries affected by these storms. All of this goes to show that those engaged in the insurance business need to be meteorologically minded.

The obvious aim of the shipmaster is to bring his ship and her cargo safely to her terminal port, irrespective of whether it is insured or not. In order to assist him in this job, the various meteorological services of the world issue radio weather bulletins in all oceans, and almost every copy of the weekly *Admiralty Notices to Mariners* contains some addition or amendment to these notices. For example, recent additions have included details of storm warnings issued by eight radio stations in the Great Lakes and a very comprehensive R/T hurricane warning service in the Caribbean area. Similarly, the meteorological authorities of all countries provide the best possible warning service of meteorological dangers for various interests ashore; meteorologists cannot control the weather but they can at least anticipate trouble. Thus, in the United Kingdom we have special fog and flood warnings. In countries which are visited by tropical storms, elaborate warning systems are in force, but, as the Japanese typhoon casualties during the autumn of 1959 show, heavy loss of life can still occur despite these warnings. The efforts that man can make seem rather puny when nature decides to " get rough ".

On behalf of the Director-General and staff of the Meteorological Office we extend to all our readers best wishes for their health and happiness throughout 1960.

C. E. N. F.

THE MARINE OBSERVERS' LOG



January, February, March

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

CURRENT RIP

North Atlantic Ocean

S.S. *Cortona*. Captain A. L. Hunter. Santa Cruz to Buenos Aires. Observer, Mr. R. S. McLundie, 2nd officer.

9th March, 1959. At 1530 G.M.T. the vessel passed through a strong current rip. It was approximately ¼ mile broad and stretched in a 080°–260° direction for as far as the eye could see. The direction of the waves at the time was 200° (true) but in the apparent current rip the water appeared to break in a 270° direction on the average, though its choppiness made this difficult to ascertain.

Position of ship: 09° 15′N., 25° 05′W. Course 203° (true), speed 16 kt. Wind NNE., 5 kt.

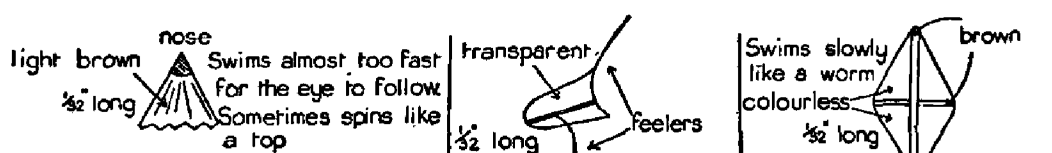
Note. This is probably a current rip caused by the discontinuity between the North Atlantic equatorial current and its countercurrent. Current rips are frequently reported between the equatorial currents and their countercurrents, indicating that the discontinuity of the flow between these currents is a fundamental characteristic of the circulation of the oceans.

DISCOLOURED WATER

Entrance to Persian Gulf

S.S. *Esso Canterbury*. Captain S. R. Rance. Fao to Suez. Observers, Mr. R. A. Harvey, 2nd officer and Mr. B. Meyer, Cadet.

10th March, 1959. At 1030 G.M.T. the vessel passed through a line of intense wine-coloured water 100 yd wide, extending in a direction 090°–270°. At the time the wind was N'W, 12 kt, sea slight and sea temperature 70°F. A line of foam, as from a whale track, crossed the band of discoloured water, while two 18-in. sea snakes and many jelly fish were floating in the vicinity. Several dozen floating dead locusts, some coloured pink or grey but mostly yellow, and one flying pink locust, were seen. A number of birds were in the area but they did not appear to be feeding.



1st Specimen (top view) | 2nd Specimen (side view) | 3rd Specimen (top view)

For the next hour the sea had a faint rusty colour with an occasional patch of more certain colouring. Water samples were taken and they contained living organisms as shown in the sketches (in order of prevalence).

The vessel had passed into clear water by 1230 G.M.T.

Ship's position: 26° 15'N., 56° 45'E.

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

"I am sorry I cannot make any better guess than Pteropods from the *Esso Canterbury* sketches from the Gulf of Oman, but I am passing them to some of my more zoological colleagues. They must be zooplankton from the speed of movement but zooplankton includes examples of more than half the groups in the animal kingdom. If that is right, the actual colour of the water was probably due to other organisms too small to be seen with the naked eye. If only they had 'pickled' a sample for us."

Indian Ocean

M.V. *Avonmoor*. Captain F. Lamb. Calcutta to South Australia. Observers, Mr. R. E. Gatiss, 2nd officer and Mr. C. B. Nicholas, 3rd officer.

2nd March, 1959. Shortly after the 0600 G.M.T. observation was recorded the slight breeze ceased and the sea took on a glassy appearance. The vessel was observed to be surrounded by what looked like a slight sand deposit of a fine mossy texture which was only visible because of the calm sea. It was more noticeable in some parts than in others and at one time seemed to be lying in lines along the direction of the previous wind (SE'S, force 1).

Small pieces of weed and sticks were occasionally seen. Just under the surface was a jellyfish, 3 to 4 in. in diameter. It had numerous small "feelers" around which was swimming a shrimp-like fish approximately 2 in. long. Both were of a reddish-orange colour. A small crab was also seen swimming quickly towards the vessel and very near to the surface. It was about 3 in. in diameter, and a deeper shade of the same colour.

A shoal of fish, each about 3 to 5 in. long, was observed at about 2 ft below the surface. They appeared to be of a bluish-grey colour but one was noticed to be steel-blue with thick black vertical stripes. They were disturbed by the vessel and dived out of sight. Several creatures which looked like bubbles were also seen, skimming haphazardly over the surface of the water, usually away from the vessel.

At 1225 S.A.T. the vessel passed through a dense patch of discoloration where the " mossy sand " was in fist-sized lumps. In the middle of the patch was a white-edged, greyish green, irregular strip looking like scum and about 2½ ft wide. The lumps readily disintegrated in the bow wave, which was quickly discoloured as if by red sand. This dense patch was about 400 ft long and a smaller, similar patch was encountered 5 min later. Throughout the encounters the discoloration went down to a depth of at least 4 ft. It gradually got more sparse and at 1500 no trace was visible. Unsuccessful attempts were made to take samples.

The nearest land was Simalur Island, which bore NE'N, distant 56 miles at noon, and Nias Island which bore E'S, distant 120 miles. The island of Sumatra lay behind these islands and its nearest point was 145 miles away.

Position of ship: 01° 49'N., 95° 19'E.

Note 1. Dr. T. J. Hart, of the National Institute of Oceanography, comments:

" This sounds like a plankton concentration of some sort. The red and sandy texture mentioned sounds like a *Trichodesmium* bloom but there was obviously much flotsam and animal plankton about also. The small striped fish could have been young pilot fish, which have the habit of living around large (and dangerous) jellyfish, the which however do not seem to molest them."

Note 2. Mr. G. A. Tunnell of the Marine Division, Meteorological Office, recently visited Dr. Hart at the National Institute of Oceanography and discussed with him biological reports published in the " Marine Observers' Log ". Dr. Hart informed him that he has indexed five years of ships' discoloured water reports and is making a special study of this phenomenon; he is emphatic about the need for samples. Port Meteorological Officers would be glad to supply sample bottles and preservatives to any voluntary observing ship.

RADIO FADE-OUT

Arabian Sea

S.S. *British Sailor*. Captain R. C. D. Flamsteed. Bandar Mashur to Suez. Observers, the Master, Mr. W. Sharkey, Radio officer and Mr. M. J. Hooper, 3rd officer.

5th March, 1959. At 0604 G.M.T., on frequencies 8, 12, 17 and 22 mc/s, an instant fade-out of radio signals was experienced but 500 kc/s was not affected. At 0621 Asmara local station could only be heard on 17 mc/s. At 0634 Colombo was faintly heard on 17 mc/s. The conditions on 17 and 22 mc/s were slowly improving and at 0639 the European stations were returning to normal but there was no improvement on 8 and 12 mc/s. At 0700 contact was established with Colombo on 17 mc/s and weather observations were cleared and at this time 8 and 12 mc/s were rapidly returning to normal. At 0710 the conditions were normal on all frequencies.

During this period two apparently small sunspots were observed at 200° clockwise and 1/6th of the diameter from the edge of the sun. There was no change in these sunspots when radio propagation came back to normal.

Position of ship: 16° 53'N., 54° 42'E.

Note. Mr. G. O. Evans, of the Post Office Engineering Department, comments:

" Dellinger fade-outs of the type experienced by S.S. *British Sailor* between 0604 G.M.T. and 0710 G.M.T. on 5th March were also reported by receiving stations in Hong Kong and Singapore and occurred between 0602 G.M.T. and 0650 G.M.T. No similar fade-outs were reported by receiving stations in the United Kingdom during this period.

" Dellinger fade-outs are caused in the sunlit region of the earth by a sudden increase in the ultra-violet radiation emitted by the sun. The fade-out reported by S.S. *British Sailor* was probably associated with the large sunspot, of area 800 millionths of the sun's visible hemisphere, which was visible between 1st and 14th March.

" Frequencies of the order of 22 mc/s returned back to normal before frequencies of the order 8–12 mc/s because attenuation of H.F. signals due to absorption in the lower ionospheric layers decreases with increase in frequency.

" Due to the proximity of the ship to NKA Asmara local station it was possible to receive signals on 17 mc/s via the ground wave which is unaffected by atmospheric conditions."

South Indian Ocean

M.V. *Eastern City*. Captain I. Williams. Bunbury W.A. to Rotterdam.

29th March, 1959, between 0800 and 0815 G.M.T., the radio officer, Mr. E. Willocks, reported a radio fade-out on all H.F. bands between 8 mc/s and 22 mc/s. Normal reception was obtained after 15 min. This was corroborated by M.V. *Leeds City* in position 29° 12′S., 95° 31′E.

During the above period two sunspots were observed at the position of 6 o'clock on a clock face.

Position of ship: 29° 52′S., 98° 32′E.

Note. Mr. G. O. Evans, of the Post Office Engineering Department, comments:

" Radio fade-outs of the type experienced by the *Eastern City* between 0800 and 0815 G.M.T. on 29th March, 1959, were also reported by receiving stations in the United Kingdom as having affected all eastern circuits between 0750 and 0850. Similar fade-outs were also reported by Singapore as having affected a few of its incoming circuits between 0750 and 0820.

" This Dellinger fade-out was associated with three large sunspots which were visible on 29th March, 1959."

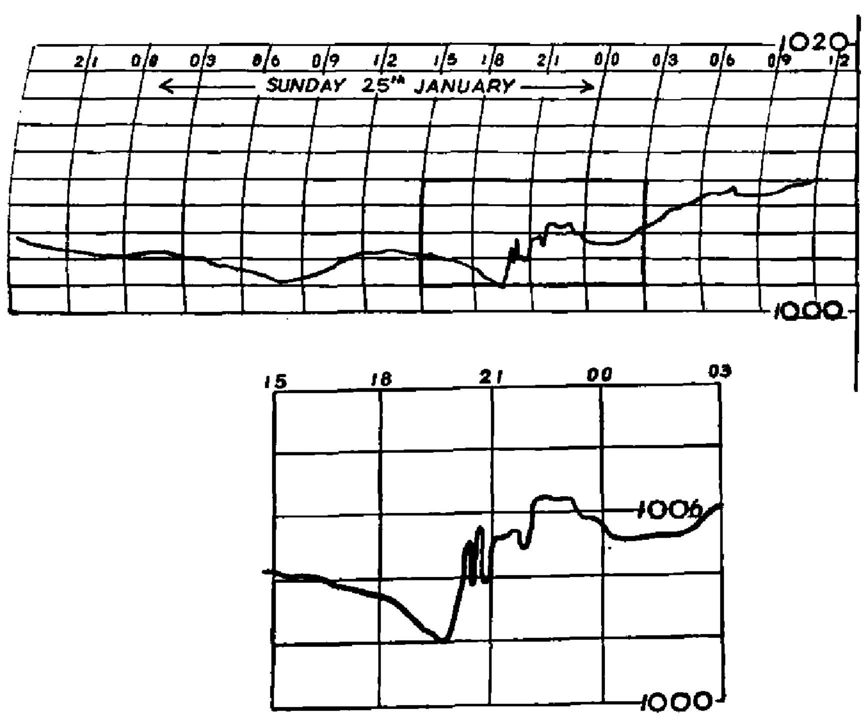
PAMPERO

Rio de la Plata Estuary

S.S. *Hemiglypta*. Captain S. A. Greenaway. At Chico Bank Anchorage. Observers, the Master and Mr. M. T. John, Chief officer.

21st January, 1959. Since late on 21st the atmosphere had been growing oppressive and by 23rd the temperature was in the upper 80's. Previously the sky had been cloudless; now there were dense cirrus patches. The air was thick with insect life, chiefly butterflies and moths.

At 1800 G.M.T. on 25th a roll of cumulonimbus cloud was seen, stretching about 10 to 12 miles on each side of its centre, which was to the SW. By 1900 G.M.T. the Cb covered the sky and the wind was force 7 to 8 from WSW. The wind backed to



SSW. as the squall approached and then to SE. immediately after it passed, finally settling in the S. again by 2030 G.M.T. It gusted to force 10 at times. It quickly raised waves about 4 ft high and the swell remained for several hours. It was impossible to differentiate between rain and spray, for at times the scud was not above 100 ft. With the onset of the rain the temperature fell to 66°F (which was also the dew point). The rain fell for about $\frac{3}{4}$-hour. Half-way through the heavy rain, clear crystals of hail fell. They were perfectly formed and the largest was nearly $\frac{3}{8}$ in. in diameter. Before sunset a fiery sun appeared in a gap at the horizon of about 4°. To complete the phenomena already experienced, a most perfectly formed double rainbow was observed, of brilliant colouring which faded gradually with the setting of the sun.

Position of ship: 34° 19′S., 57° 25′W.

Note. This is an interesting and characteristic report of the Pampero. The wind frequently rises to a maximum in the frontal squall, then dies off following the passage of the latter and later increases again as the main flow of cold southerly air sets in. It is thought rare for the wind to back to SE. following the squall.

The diagrams give the variations in barometric pressure during the passage of the Pampero. The sharp rise in pressure is typical of a line squall; in this case, however, it was followed by two further complete pressure oscillations.

The Pampero is, in general, more common in the southern winter but this statement needs qualification. The word is commonly used in two different senses. The ‘ Pampero sucio ’ or dirty Pampero is applied to the squall, usually from between W. and S., which accompanies the cold frontal passage and which is usually associated with heavy rain. The ‘ Pampero limpio ’ or clean Pampero is the term applied to the strong wind, usually from between SW. and S., which sets in after the frontal passage and may blow for two or three days, accompanied by relatively clear skies. This latter wind is more common, and strongest in winter, but the former tends to be most violent in the southern summer.

ST. ELMO'S FIRE

North Atlantic Ocean

S.S. *Imperial St. Lawrence.* Observer, Mr. E. J. Samson, 3rd officer.

18th February, 1959. At 0645 lightning was observed to the E., and a line squall lying N. and S., the length of which was 30 miles and 6 miles to the E. (radar observation). By 0700 the squall was over the ship accompanied by heavy rain, thunder and lightning. By 0730 it had moved 8 miles to the W. and was now lying in a NW.–SE. direction. By 0745 it had again moved back over the ship with heavy rain, thunder and lightning. At 0800 the rain cleared and the squall was now moving rapidly eastward.

During the passing of the line squall the wind was from all directions, never staying in one direction more than 1 or 2 min, with velocities of 0 to force 7. At 0815 the line squall was 10 miles eastward. It was not raining on the ship, but squall clouds showed all around the radar.

The ship's main aerial suddenly became illuminated with St. Elmo's Fire. Tops of standards on monkey island and T.V. antenna looked like a Christmas tree. The main aerial appeared to be lit with small greenish bulbs set about 4 or 5 in. apart and flickering continuously. The condition lasted about 3 min, then rain started and the display disappeared.

Position of ship: 31° 33′N., 67° 12′W.

Note. This observation was received from the Director of the Canadian Meteorological Branch.

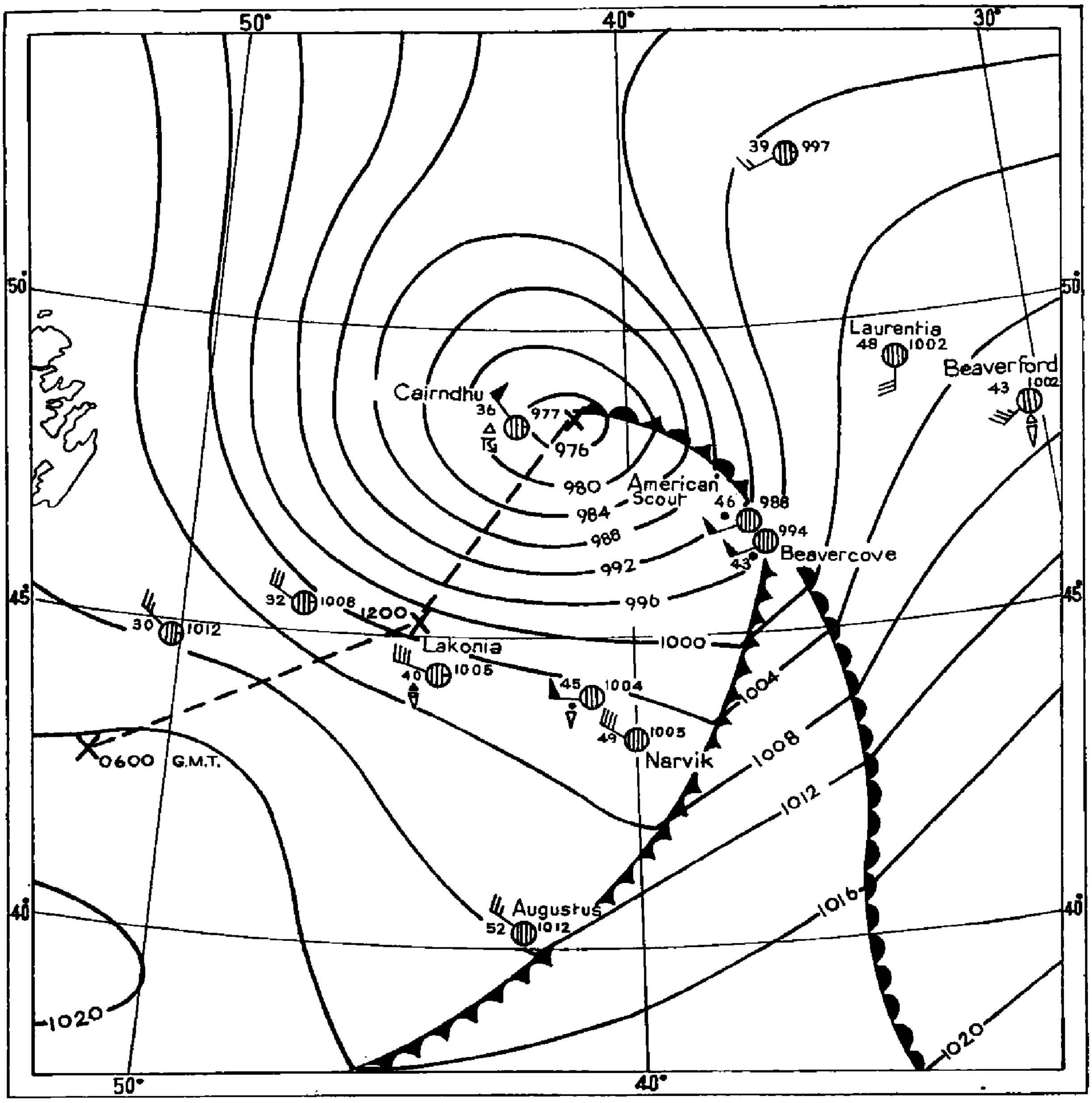
St. Elmo's Fire is not infrequently observed at sea during squalls and thunderstorms. The above is a typical example. It may appear as a brush discharge of radiating streamers several inches long, or as luminous globes, a number of which are seen along the aerial. At other times a structureless glow envelops an elongated object, such as a mast or an aerial. St. Elmo's fire is usually bluish or greenish in colour, but a violet glow has been reported and sometimes the colour is pure white.

QUICKLY-FORMED DEPRESSION

North Atlantic Ocean

S.S. *Beavercove*. Captain N. W. Duck. St. John (New Brunswick) to Le Havre. Observers, officers of the watch.

27th March, 1959. While moving at 16 kt on a course of 072° (true), the barometer was falling steeply. Visibility was between ½ and 3 miles, the wind s., force



27th March, 1959, 1800 G.M.T.

9 to 10, and there was a high sea and a heavy swell. The weather was overcast with continuous rain between frequent fierce heavy rain squalls. At 1729 G.M.T. the rain became very heavy and visibility poor and the wind suddenly increased to force 12 and veered to w's, but settled to wsw., force 10, while the barometer rose steeply; by 1810 it had ceased raining, the visibility was 5 miles, the wind sw., force 10, and the barometer was again falling steeply.

Position of ship at 1729: 46° 27′N., 37° 11′W.

Note. The depression concerned is the low B whose movement is described in the article "Two Atlantic storms of March 1959" (see page 21). In the same depression, S.S. *Cairndhu* experienced, at 1705 G.M.T. on 27th March, an intense thunderstorm with severe lightning and torrential rain. On course 228°, speed 12½ kt, she experienced a pressure fall of 6 mb an hour between about 1500 and 1800. After a brief clearance, from 1800 to 1815, there was further heavy rain, with snow flurries. The wind rapidly veered to NNW. and increased to force 10. The pressure began to rise as rapidly as it had fallen. Sea and swell were very steep and confused. Visibility was reduced to 50 yd by the sea spray and heavy snow. The diagram shows the position of the *Beavercove* and other vessels in relation to the depression and its frontal system. Some six hours later S.S. *Laurentia* (position also plotted in the diagram) was to experience a line squall at 0005 G.M.T. followed by a second at 0100 on 28th. Subsequently, *Beavercove* experienced force 10 or 11 winds from between WSW. and W. up to 29th when her noon position was 48° 48′N., 22° 00′W.

CLOUD

North Atlantic Ocean

M.V. *Runswick*. Port Arthur, Texas, to Birkenhead.

22nd March, 1958. The same cloud was taken in sequence over a period of 30 min, 1430–1500 G.M.T. (see Figs. 1–3, opposite page 20). This cloud was observed as C_L2, but later developed into a perfect anvil giving the appearance of C_L9 (Fig. 4). Frequent passing showers were observed at station throughout, but none during the hours the photographs were taken. The cloud was still visible at 1600, the anvil still predominating. Dry bulb 53°F, sea 54°. Bar. 1001 mb, rising steadily. Wind 170°, force 6, steady.

Position of ship: 50° 12′N., 13° 40′W.

Note. These photographs show clearly the transition from cumulus (C_L2) to cumulonimbus (C_L9). One of the cumulus cloud domes has developed into a magnificent anvil. The contrast between the sharp outlines of the cloud in the first photograph, and the fibrous character of the anvil in the last photograph, brings out the essential difference between cumulus and cumulonimbus cloud.

SHIP-MADE CUMULUS

Indian Ocean

S.S. *Himalaya*. Captain H. C. Shinn. Adelaide to Colombo. Observers, Mr. A. R. Turner, Chief officer and Mr. R. E. L. Webb, 3rd officer.

4th January, 1959. At about 1600 S.M.T. a small white cumulus cloud was seen directly over the bridge. It developed until it was about 300 ft in diameter at the base. At this stage part of the cloud broke away and slowly disappeared, a new cloud forming directly over the funnel and joining with the remains of the former cloud. This breaking away and the forming of more cloud continued until about 1715, some two hours before sunset. Since the speed and direction of the wind were the same as that of the ship, there seems to be no doubt that the hot air rising from the funnel was responsible for the cloud formation. The cloud eventually disappeared at about 1735. Some small cumulus was present in the sky but the base of the " ship's cloud " seemed to be at a rather lower level than those of the natural cloud formation. Air temp. 80°F, wet bulb 70°. Wind SE., force 5. Ship's course 320°, 21 kt.

Position of ship: 23° 31′S., 104° 32′E.

Note. This ship was in air which had neutral stability. Heat transmitted from the ship to the air was sufficient to form warm, buoyant, rising bubbles of air. The air was also sufficiently moist for cloud to form in the way cumulus cloud forms over land. The humidity of the air recorded from observations of the wet and dry-bulb temperatures was however surprisingly low.

SEA SMOKE

North Atlantic Ocean

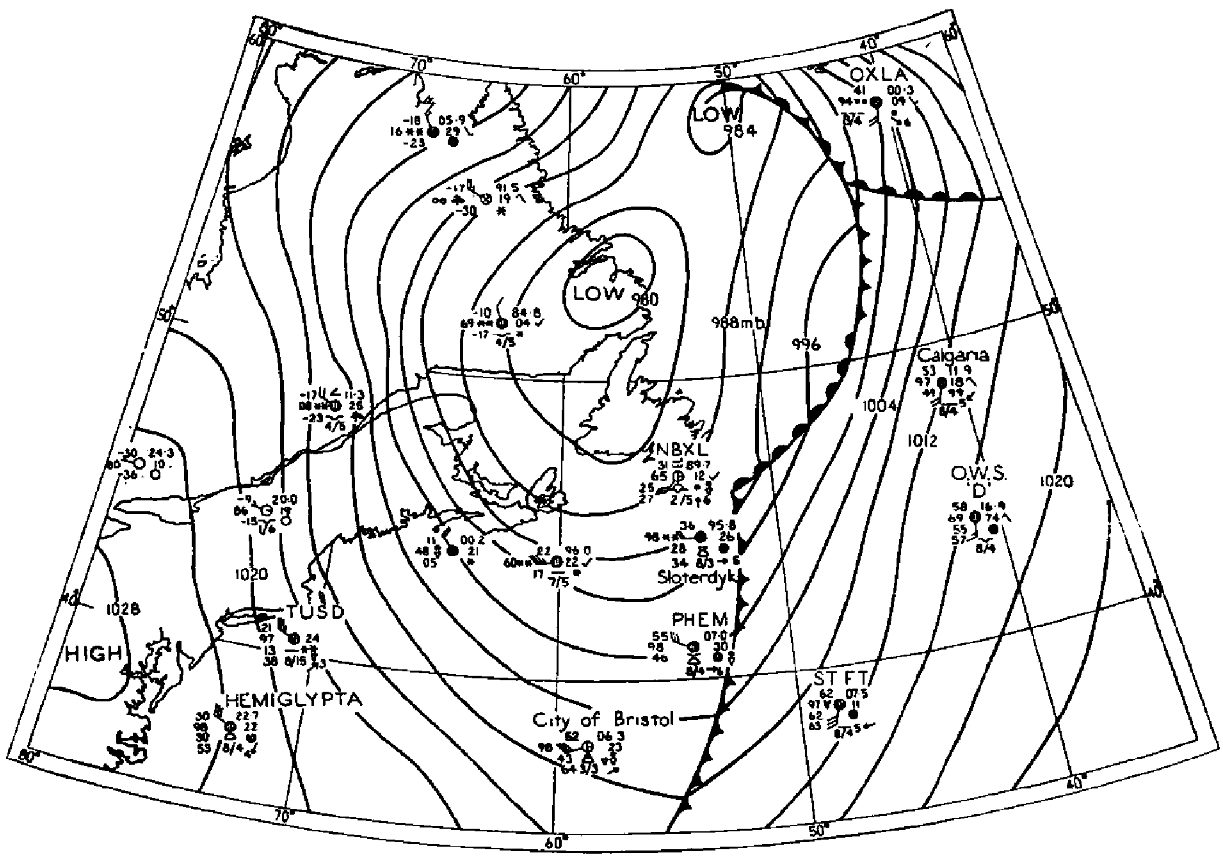
S.S. *Torr Head*. Captain S. J. Stark. Liverpool to Baltimore. Observers, the Master and Mr. J. J. Gomez, Chief officer.

1st February, 1959. Extensive sea smoke was observed at 2030 G.M.T. At the time the air temperature was 40°F and sea temperature 65°. The sky was overcast, general visibility ¼ mile and a light drizzle falling.

Ship's position: 39° 40′N., 60° 17′W.

Note. This is an interesting example of sea smoke but which occurred considerably further east than that described very fully below.

S.S. *Hemiglypta.* Captain S. A. Greenaway. New York to Curaçao. Observers, the Master, Mr. J. M. Connolly, 2nd officer and Mr. W. R. Smith, 3rd officer.



20th February, 1959, 1200 G.M.T.

20th February, 1959. At 1415 G.M.T. there was observed, across the southern horizon, a "hedge" of shallow sea smoke from which there occasionally arose columns, some like Roman candles which were spinning, some like bushes. It was particularly striking the way the sporadic sun-beams between the clouds played on these columns. A "moisture shimmer" was clearly seen in the air around the ship just before it entered the sea smoke. (At 1300 the air temp. was 31°F, sea 53° and the wind NNW., force 6.)

The vessel entered the smoke at 1430. The air temperature was not immediately changed but the sea temperature rose quickly at the demarcation line to 66°F. The smoke steamed from the sea surface as far as the eye could see. It rose to heights varying from 3 to 10 ft, with frequent turbulent columns rising to over 50 ft.

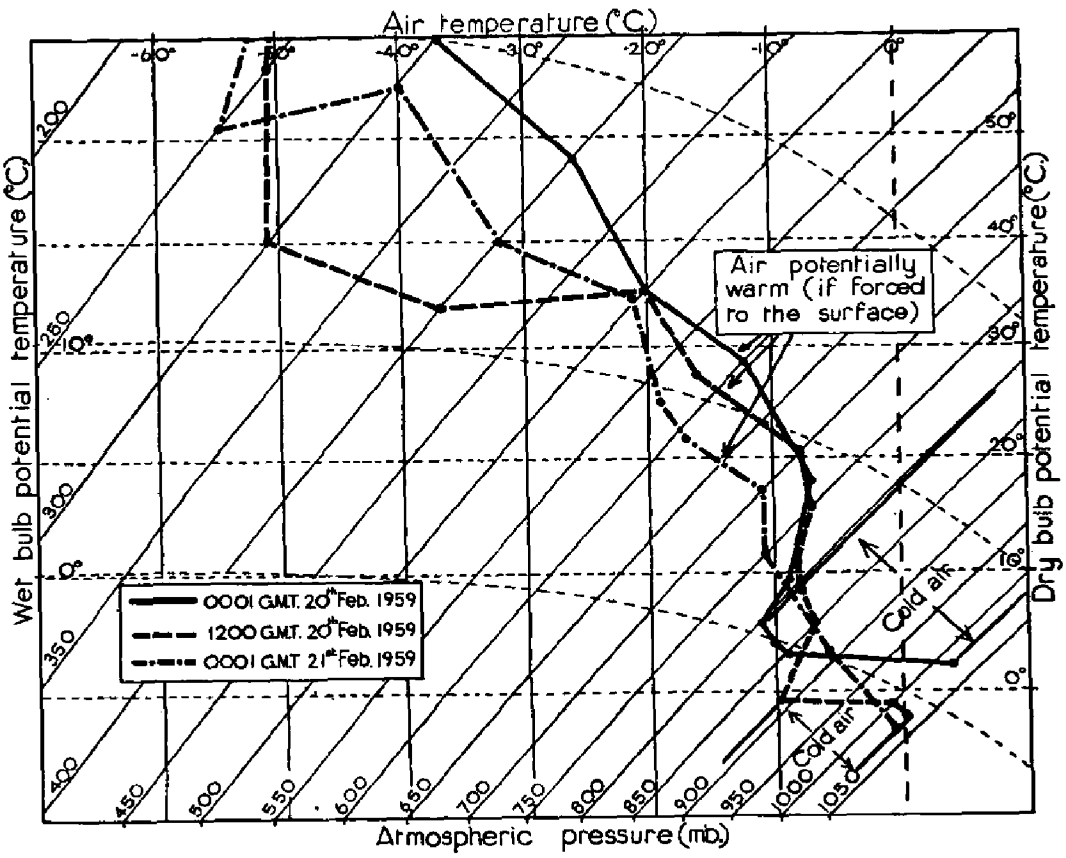
By 1600 the sea temperature was 71°F, and the air temperature 35°, the wind, still NNW., was force 5. The clouds, which earlier were large cumulus, were changing to cumulonimbus. Beneath them small waterspout "tails" formed frequently and then the sea smoke below showed vigorous turbulence. The visibility now was 3 to 5 miles. Of vessels passing close, only the superstructure was visible; later they appeared to be floating on clouds, suggesting strong refraction.

At 1645, when the air temperature was 37°F and the sea temperature 74°, the wind increased to force 5–6, increasing the "steaming" so that at times eddies of smoke blew over the vessel at heights of 40–50 ft, the flurrying snow thickened and larger waterspouts would now form quickly and last 3 or 4 min—sometimes part of the tail would break away and be blown by the wind into a peculiar S-shape.

At 1800 the wind began to back to WNW., and for a while the visibility was reduced by the sea smoke and the snow flurries, at times to only 50 yd. By 1830 the snow had changed to sleet (the air temperature was 38°F). By 1940 the sea smoke had produced a stratus cloud, which had been at about 150 ft at 1900 and was now somewhat higher, while the sea smoke itself had an average height of 10 ft. The air temp. was now 40°F, wet bulb 36°, sea 74° and visibility 9 miles.

Position of ship: 36° 50′N., 72° 27′W.

Note. This is an interesting account with photographs (one is reproduced opposite page 21) of conditions experienced by S.S. *Hemiglypta* off the coast of the United States when an intensely cold air current passed over the boundary in the sea between the cold water of the Labrador current and the warm water of the Gulf Stream. A glance at the synoptic chart (page 12) shows that *Hemiglypta* was on the western edge of a cold Arctic stream flowing directly from north-western Greenland, with a cold continental anticyclone over North America to the west.



Tephigram (upper air diagram) for Hatteras (see *Note*).

The meteorological office at London Airport has supplied us with upper air ascents made at Hatteras (35° 15′N., 75° 40′W.) plotted on a tephigram. [The tephigram is described in the *Admiralty Weather Manual* (Chapter 21, page 433) and is mentioned in *Meteorology for Mariners* (page 13). It is a special diagram for plotting upper air data. It has a horizontal temperature scale while lines of equal pressure are at an obtuse angle with the temperature scale. The temperature of a deep homogeneous but unsaturated atmosphere would follow the broken straight horizontal lines (dry adiabatic) in the diagram, while a similar but saturated deep layer would follow the broken curved lines (wet adiabatic).]

Actual upper air temperature observations are plotted on this diagram for three consecutive ascents and indicate that the cold air was several thousands of feet thick at Hatteras, but the effect of the subsidence in the cold continental anticyclone is clearly evident in the relatively warmer air aloft. It can also be seen that, as the depression causing the flow of Arctic air moved away towards the east, the warming subsidence spread down to lower layers. At the position of *Hemiglypta* the depth of cold air would have been greater than shown on the ascents, while further to the east, where some ships reported thunder, the depth of cold air would have been even greater. The higher temperatures aloft associated with subsidence and intense night radiation cooling in the lowest layers are typical of continental polar air. True Arctic air is usually cold aloft as well as at the surface.

This observation is of particular interest because the sudden change in air–sea temperature difference has accelerated the diffusion of heat and water vapour, and intensified atmospheric instability. It gives one a glimpse of the processes which form warm tropical air masses and which must frequently lead to tropical storms when they occur at low latitudes.

LOCUSTS

Vicinity of Canary Isles

S.S. *Argentina Star*. Captain E. R. Pearce, O.B.E. Tenerife to Recife. Observer, Mr. M. B. Foster, 3rd officer.

17th October, 1958. At dawn, after leaving Tenerife, a number of locusts were found aboard. Their colour varied from bright pinkish red to a pale pink. For several hours, up to early afternoon, large numbers of locusts were seen in the water near the ship, several being still alive.

S.S. *Calabar*. Captain P. M. Ralston. Freetown to Funchal.

17th October, 1958, 0800 to 1500 G.M.T. A number of locusts landed on board ship and hundreds were observed to be dead in the sea. Wind N., force 3, from 0800 to 1300; veered to NE., force 3, at 1300; backed to N'W, force 2, at 2130.

Position of ship at noon: 25° 02'N., 16° 47'W.

Note 1. Miss Z. Waloff, of the Anti-Locust Research Centre, comments on the two above observations:

" These records coincide to within a couple of days with the date of the heavy invasion of the Canaries in October 1954—when some desert locusts flew as far as the British Isles." [See page 207 of the October 1955 number of this journal.]

Note 2. Locusts were reported on the same date by M.V. *Richmond Castle*, from a position within 120 miles of both the above observations (as published on page 174 of the October 1958 number).

MARINE LIFE

South Pacific Ocean

M.V. *Armagh*. Captain T. Hastings. Bluff, N.Z., to Panama. Observers, the Master and Mr. W. Wright, 3rd officer.

23rd March, 1959, at 1100 ship's time. Pieces of whitish-yellow matter were seen floating, apparently a few inches below the surface. These objects were irregular in shape and varied in size from that of a football to that of a wheelbarrow. They were widely dispersed across the sea and only visible one at a time. In the area were whales and small white-grey sea birds. Pieces of drifting seaweed were seen occasionally.

Position of ship: 45° 40'S., 165° 13'W.

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

" This is very difficult to guess at and quite impossible to identify from the description. Large jellyfish can give such an appearance, sometimes exceeding the lower size limit stated but none as large as a wheelbarrow. The white-grey birds might be whale birds."

PHOSPHORESCENCE

North Atlantic Ocean

M.V. *Corinaldo*. Captain J. L. McQueen. La Plata to Rotterdam. Observer, Mr. J. MacDonald, 2nd officer.

15th March, 1959, at 0250 G.M.T. Two bright phosphorescent lights were seen.

They appeared to be raised above the surface of the water and an area of about 3 ft in diameter was lit by their glow. Several Portuguese men o' war had been seen during the day and it was as if two of them had had their sails illuminated; the light was a definite green, being almost emerald.

Position of ship: 19° 00'N., 20° 34'W.

Gulf of Oman

S.S. *British Sailor.* Captain R. C. D. Flamsteed. Thames Haven to Bandar Mashur. Observers, Mr. W. J. Guy, extra Chief officer, Mr. M. J. Hooper, 3rd officer and Mr. R. Haigh, Apprentice.

24th February, 1959, between 1730 and 2400 ship's time. Passed through areas of vivid blue/green phosphorescence. It was visible only in the bow wave and wake and when the sea was disturbed by fish. Samples of the water were taken and very small organisms, not unlike transparent jellyfish, were observed.

Position of ship: 23° 50'N., 58° 45'E.

Arabian Sea

M.V. *British Purpose.* Captain T. R. L. Tanner. Chittagong to Abadan. Observer, Mr. D. C. Williams, 2nd officer.

3rd March, 1959, at 2000 G.M.T. The vessel was passing through normal phosphorescence only visible in her own wash. This brilliance slowly increased and at about 2100 the sea all round the ship began to sparkle. This effect was due to thousands of little momentary splashes of phosphorescence close to the ship, which appeared to be caused by the rapid movement of small fish or other creatures, as some splashes of light had short tails but each was visible for only an instant. At any one time there were thousands of them visible and this persisted until well after 2400. By 2145 they had attained a brilliance difficult to believe, almost like burning magnesium, also the vessel's bow wave was dazzling and by its light it was possible to read. At 2155 the vessel crossed a single band of phosphorescence. This was visible for at least a mile, lying in an E.–W. direction and varying in width from 50 to 100 ft. It was very dull compared with the other illuminations, with a steady, even glow. As the vessel passed through it, the bow wave did not vary in brilliance at all. Soon after this the general brilliance began to decrease very slowly. The moon, in its last quarter, rose at 2230. At 2300 the bow wave of another vessel proceeding in the opposite direction could be clearly seen at over 7 miles with binoculars. At 2345 a light NW. breeze sprang up and the moon became quite bright but this in no way affected the general display. Small waves formed but did not break. Prior to this, apart from the vessel's wash, there had been absolutely no movement of the sea surface.

The sample of sea water taken, when placed in an enamel bucket and agitated, glowed brilliantly and each independent speck of phosphorescence could be seen. Traces of phosphorescence were visible in the sample for two days. Unfortunately the bottle containing it was subsequently smashed.

Position of ship at 2200: 21° 28'N., 61° 18'E.

South Pacific Ocean

M.V. *Rangitane.* Captain R. G. Rees. Wellington to Balboa. Observers, Mr. G. MacIver, 2nd officer, Mr. J. C. Whittington, 3rd officer, Mr. D. C. Marvis, Supernumerary 3rd officer and Mr. J. Jackson, 4th officer.

15th February, 1959, 1000–1600 G.M.T. On the night of 14th–15th February a large number of phosphorescent objects were seen, which under the light of the long-range Aldis lamp appeared to be cylindrical, 5 to 9 in. in length, and a light brown or grey in colour. They emitted a very bright greenish light and often they were arranged in irregular clusters. With the aid of the lamp it was estimated that only about a tenth of the objects glowed. Some ceased to shine after being subjected to the bright light while others, of no apparent difference in structure, continued to glow. At first they were thought to be some form of fish, but no movement through the water was observed. Sea temp. 65°F. Wind SE'E, force 4–5. Sea moderate.

Position of ship: 40° 30′S., 172° 54′W.

ABNORMAL REFRACTION

Bass Strait

S.S. *Paparoa.* Captain D. A. G. Dickens. Aden to Melbourne. Observers, Mr. A. C. Anson, 2nd officer, Mr. A. Hill, 3rd officer and Mr. F. Wilson, Chief radio officer.

14th March, 1959, 0200 G.M.T. Whilst in the vicinity of Portland, Victoria,

mirages were observed as illustrated in the sketches. The images of the land appeared at approximately 5° above the horizon. The atmosphere at the time of observation was clear, the air temperature 67°F, relative humidity 90%, sea temperature 64°, wind light and variable.

Ship's position: 38° 46′S., 142° 27′E.

Marguerite Bay, Antarctica

R.R.S. *John Biscoe.* Captain W. Johnston. Ship ice-bound. Observer, Mr. B. G. Turner, 3rd officer.

7th and 8th March, 1959. On both mornings, which were almost cloudless, with temperature 18°–20°F, sea temperature 29°F, and excellent visibility tempered by a faint haze over distant mountains and out to sea, the following phenomenon was observed. Beginning about 0730 local time, becoming most pronounced by 0930 and fading away completely by 1110, mirages occurred. From Horseshoe Is. in the E. to about SSE., the lower ridges of the mountains were distorted, increasingly so southwards, into a wavy pattern. From SSE. to S. the lower ridges were obscured by a grey haze in which appeared many inverted icebergs, both 'tabular' and 'pinnacle', some with their peaks reaching the horizon, others quite clear of it, whilst many of the comparatively close real bergs were very distorted. From S. to about SSW., where the mirage faded out, was an extremely realistic, though slightly shimmering, mirage of ice-cliffs, which became increasingly distorted and unrealistic as they faded to westward. It was impossible to determine whether the ice-cliff mirage also was inverted.

Above the haze and mirage the mountains of Alexander I Land (80–90 miles away) and Fallières Coast (40–70 miles away) stood out, slightly hazily but free of distortion. When the lower haze and mirage had " lifted " the distant mountains were no more nor less clear than before, but there was no sign of land or of ice-cliffs behind where the mirage ice-cliffs had been. (*See* diagram opposite.)

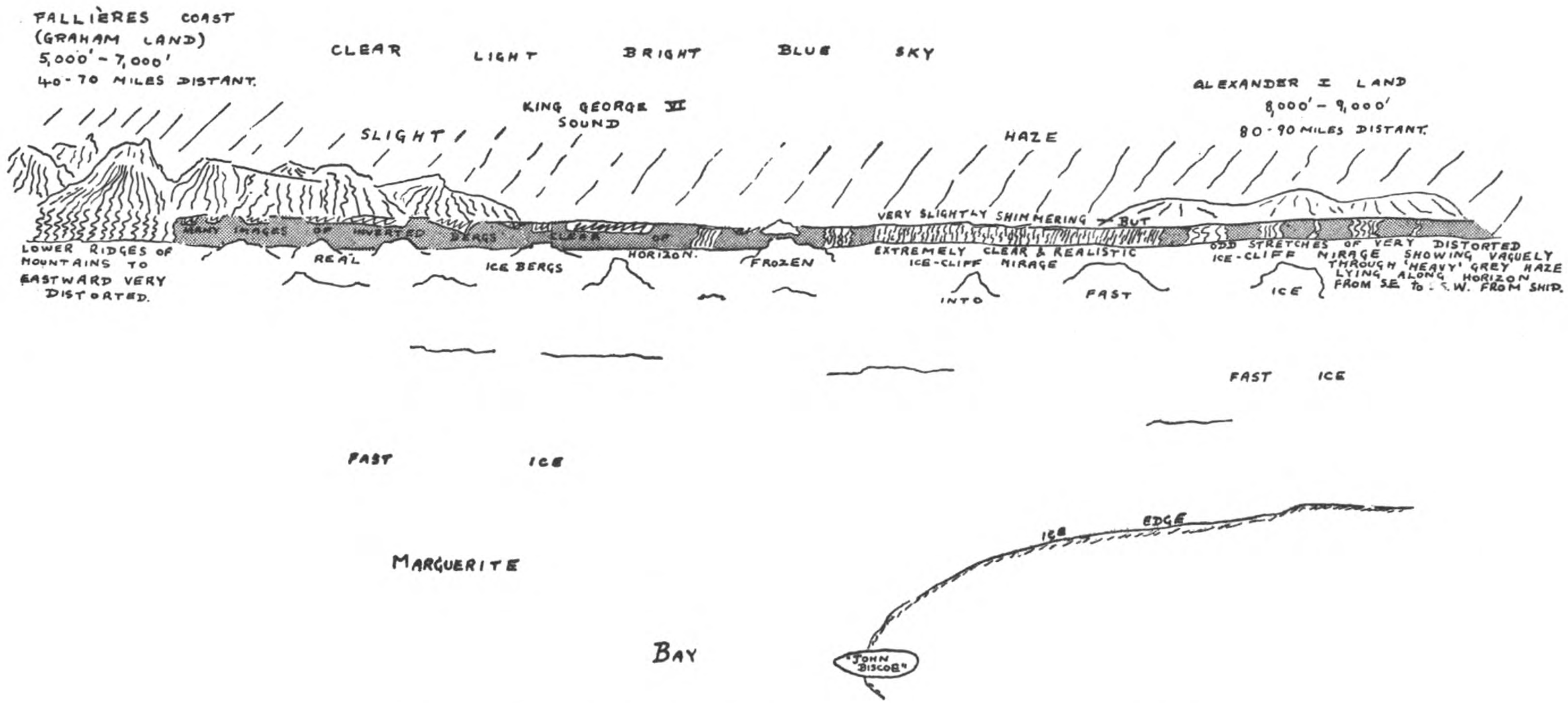
Ship's position: 67° 54′S., 68° 27′W.

RAINBOW

North Sea

S.S. *Borodino.* Captain A. T. Jardine. Aarhus to Hull. Observer, Mr. R. L. Cole, 3rd officer.

4th January, 1959. At 1017 G.M.T. a shower causing a partial rainbow was seen



Abnormal refraction as observed from R.R.S. *John Biscoe* (see page 16).

moving from NW. As it approached the ship rapidly, the bow increased to a semicircle and a secondary bow was also seen, green being the predominant colour. As the shower passed overhead the primary extended to form a complete circle which touched the ship's sides: the secondary bow was semicircular. Both faded out after 2 min.

Altitude of sun, 20°. Bearing, 150°. Air temp., 39°F.

Position of ship: 54° 57′N., 2° 47′E.

Note. This interesting sequence of events was due to the motion of the rain area from a considerable distance away to very near the observer.

South Pacific Ocean

M.V. *Suffolk*. Captain C. P. Robinson. Port Chalmers to Balboa. Observer, Mr. R. Jordan, 2nd officer.

16th March, 1959. From the bridge, eye-height 50 ft above the sea, a brilliant rainbow was observed. It appeared to be flat over the surface of the sea and was practically a complete circle, the ship's side cutting off a small segment. The radius of the inner edge of the bow was about 500 ft. A light drizzle was falling at the time, the wind a gentle breeze from WSW. The sun's altitude was 40° and the phenomenon was visible for about 5 min.

Position of ship: 26° 48′S., 115° 53′W.

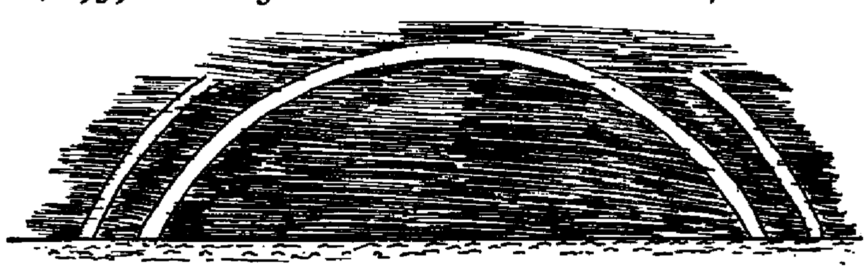
Note. This phenomenon is due to the close proximity to the observer of the rain particles reflecting the sunlight.

DOUBLE LUNAR RAINBOW

Tasman Sea

S.S. *Paparoa*. Captain D. A. G. Dickens. Observers, Mr. M. A. Hill, 3rd officer and Mr. F. Wilson, Chief radio officer.

17th March, 1959. At 1230 G.M.T. a clear lunar rainbow, whitish in colour, was



observed. Rain was approaching from the SW., the moon's bearing was approximately 300°(T) and its altitude 7°. The bow was approximately a complete semicircle, reaching an altitude of 25° and extending from 070° to 140° at its extremities. After about 2 or 3 min a secondary bow was observed about 5° outside the first one. This also was whitish in colour, and to the naked eye barely visible. It was incomplete, the extremities being visible to an altitude of approximately 20°.

Ship's position: 36° 03′S., 150° 40′E.

Note. A double lunar rainbow is a very rare phenomenon. The observer is to be congratulated for observing the dimensions of the two bows.

FALSE SUNRISE

Indian Ocean

S.S. *Canton*. Captain G. K. Fox. London to Hong Kong. Observer, Mr. J. W. Perry, 4th officer.

16th March, 1959. At 0130 G.M.T. the sea appeared a bright silver colour,

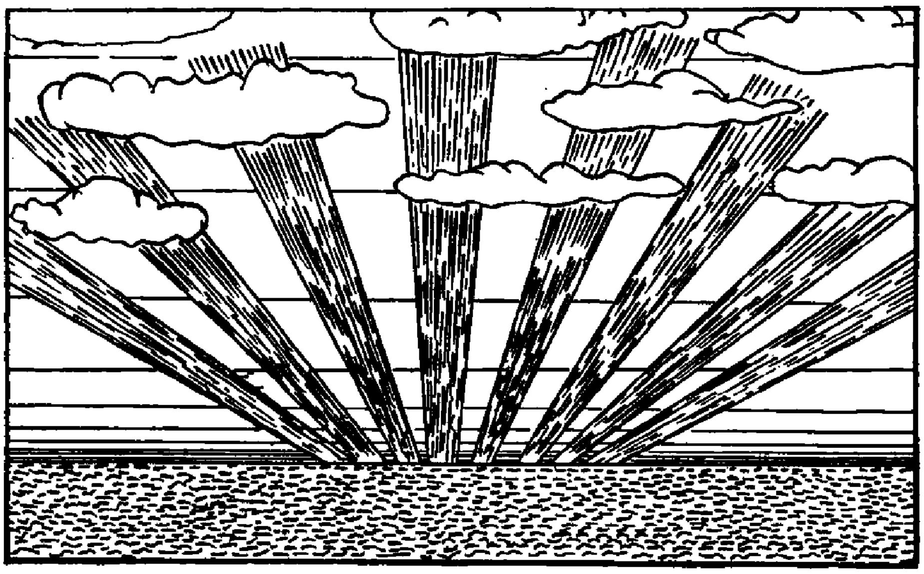
with a clear cut horizon. A light purple colour effect was observed at the horizon.
Ship's position at 0000 G.M.T.: 14° 54'N., 53° 18'E.

ANTI-SOLAR RAYS

North Atlantic Ocean

S.S. *Loch Ryan.* Captain W. S. Thomas. Cristobal to Rotterdam. Observers, Mr. F. G. Nickson, 3rd officer and the watch.

29th January, 1959, at 2055 G.M.T. Before sunset, when the sun was 7° above the



horizon, bearing 246°, several bands showing a darker colour than the sky, which was rose pink, were observed to be radiating from a point just below the horizon diametrically opposite to the sun (see sketch). As the sun set, the pink colouring gradually faded and the bands disappeared. Air temp. 73°F, sea 73°. Visibility excellent. 2/8 Cu.

Position of ship: 28° 40'N., 47° 51'W.

Note. The darker sections of the sky are probably associated with the shadow of the earth thrown by the sun on to the earth's atmosphere. (See *Marine Observer's Handbook*, page 77.)

IRIDESCENT CLOUD

Indian Ocean

S.S. *Nestor.* Captain A. McDonald. Aden to Fremantle. Observer, Mr. K. W. Jack, 3rd officer.

11th January, 1959. At 0700 G.M.T., when the sun's altitude was 71°, there appeared a band of vivid colouring on a high horizontal layer of Ac to the S. at an altitude of 25°. The band, 46° removed from the sun, covered an arc of 45° and was approximately 2° in width. The predominant colours were red and green, with a pale purple showing quite strongly between the two. The phenomenon lasted for 10 to 15 min. The sky was 4/8 covered, Cu, Ac, and Ci being the predominant types.

Position of ship: 02° 21'S., 71° 52'E.

SCINTILLATION OF VENUS

Indian Ocean

S.S. *Nestor.* Captain A. McDonald. Aden to Fremantle. Observers, Mr. J. C. Ray, Chief officer and Mr. I. B. Hunter, 4th officer.

16th January, 1959. Between 1300 and 1308 G.M.T. a spectroscopic scintillation of Venus was observed. The phenomenon commenced with Venus at an altitude of 3° and continued till it set at 1308 G.M.T. Its bearing on setting was 248°. During the 8-min period the colours seen varied from blood red to emerald green. The air temperature was 73°F, the wet bulb 65° and the sea temperature 74°.

Position of ship: 23° 13′S., 101° 35′E.

Note. See note on the observation given below from S.S. *Orontes* describing green flash at the setting of Venus.

GREEN FLASH AT SETTING OF VENUS

Indian Ocean

S.S. *Orontes.* Captain S. Ayles, R.D. Fremantle to Colombo.

19th January, 1959. At 1303 G.M.T. Venus was observed at an altitude of 1° 13′, over a very well defined horizon, to turn blood red. It retained this colour, fluctuating in brightness between magnitude −4·0 and −1·0 until its lower limb made contact with the horizon. At this moment the planet, whose magnitude was then approximately −3·0, turned a bright emerald green and disappeared. At 1200: air temp. 77·6°F, wet bulb 70·6°, sea 80°; wind SE'ly, force 3; visibility excellent; sea slight.

Position of ship: 15° 54′S., 100° 30′E.

Note. The phenomenon described here is closely related to the green flash of the sun at sunset. It is however very special because of the purity and regular succession of the colours of the spectrum, indicating horizontal and vertical uniformity in atmospheric gradients of temperature and humidity.

South Pacific Ocean

S.S. *Tongariro.* Captain I. Batley. Balboa to Auckland. Observers, Mr. B. Baggott, Chief officer and Mr. R. Bayliss, 4th officer.

26th February, 1959. The vicinity of Venus was completely clear of cloud. The planet commenced to scintillate when about 3° above the horizon and rapidly changed colour from blue to red to green. When it began to set it appeared enlarged and white. As it dipped its lower limb, at 0645 G.M.T., there was quite an intense green flash which lasted about 1½ sec before disappearing.

Position of ship: 31° 19′S., 163° 28′W.

Note. Venus at this time appears to have provided a number of ships with interesting optical phenomena. See for example reports from S.S. *Orontes* and S.S. *Nestor.*

AURORA

North Atlantic Ocean

S.S. *Beaverglen.* Captain W. J. P. Roberts. St. John to London. Observer, Mr. R. P. Wilman, 4th officer.

9th January, 1959, at 0005 G.M.T. Aurora observed in the N. in the form of curtains. From 310° to 010° it was bright. From 310° to 305° and from 010° to 020° it gradually faded away to nothing. It was bluey-green in colour and reached a maximum altitude of 4°, bearing 350°.

At 0010 it gradually faded until it just lit the sky in the N., not unlike the appearance of the sky at midnight in this latitude during June.

At 0030 G.M.T. it was very faint and was only just lighting the sky slightly in the N., and gradually diminished until it was virtually non-existent at 0600.

Position of ship: 49° 57′N., 24° 36′W.

Australian Waters

S.S. *Clan Robertson.* Captain C. M. Powell. Port Pirie to Sydney. Observers, the Master and Mr. D. C. Stobbart, 2nd officer.

9th January, 1959. At 1830 G.M.T. a very bright display of aurora was observed.

(*Opposite page 20*)

Photos by Mr. J. Conn, 2nd officer

Fig. 1.

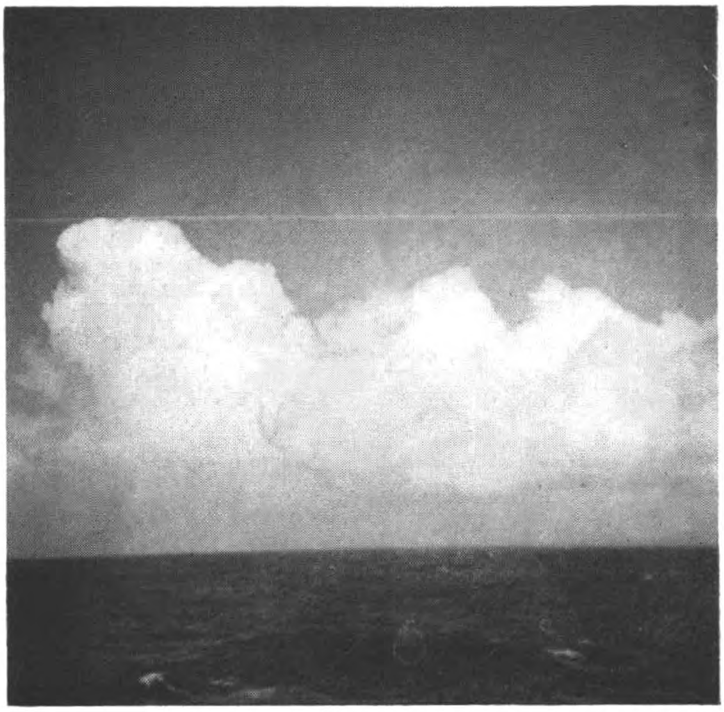


Fig. 2.

Fig. 3.

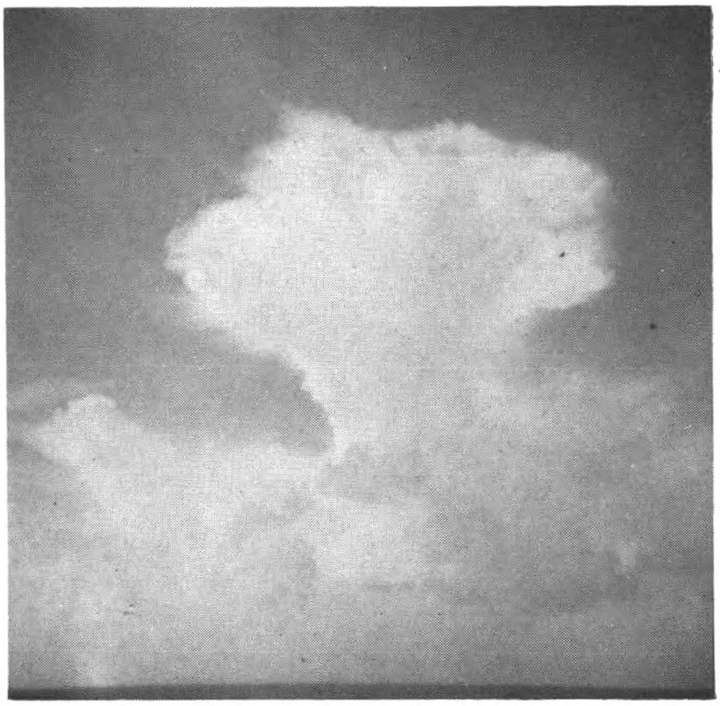
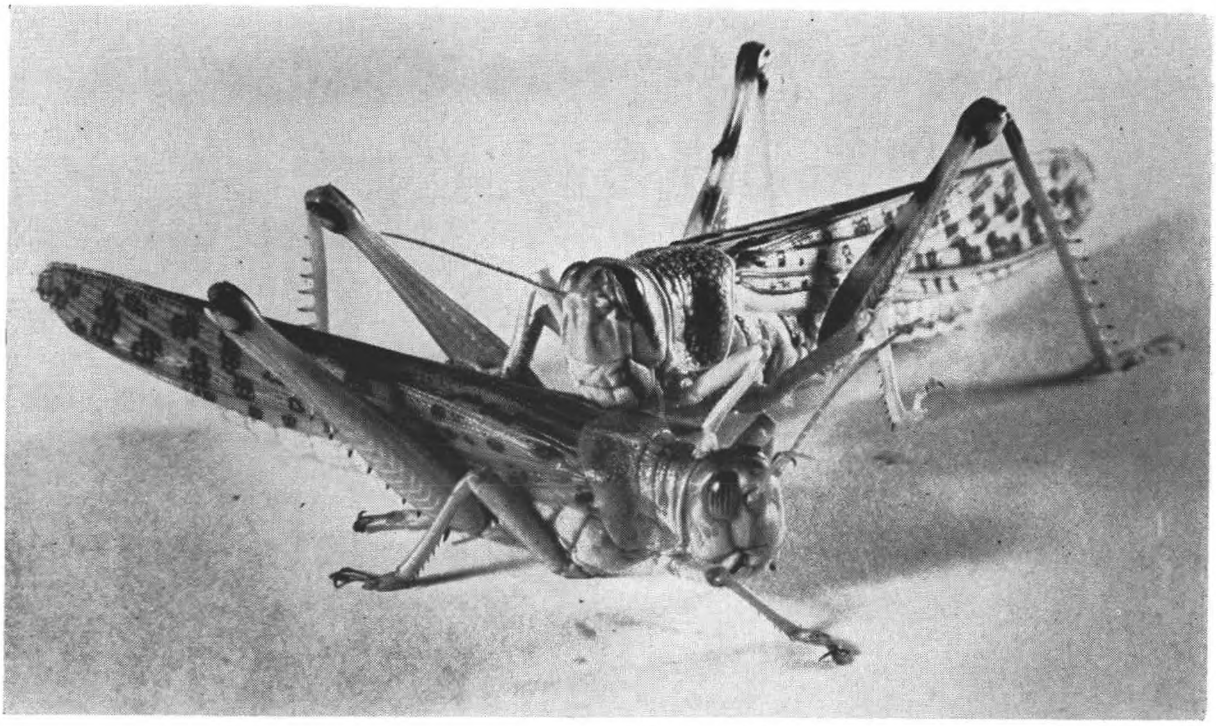


Fig. 4

Cloud observed from M.V. *Runswick* (see page 11).

(*Opposite page 21*)



Central Office of Information photo (Crown Copyright)

Specimens of Desert Locust *Schistocerca gregaria* Forsk. (see page 40).

Photo by S. A. Greenaway

Sea smoke observed from S.S. *Hemiglypta* (see page 12).

It commenced with a bright red circular glow bearing 170°, which became more intense and extended from 140° to 230° with maximum altitude of 40°. The area was covered with very sharply defined beams of vertical light. The phenomenon lasted for about 20 min during which time the colour changed from red to pink and finally, before fading, to a light greenish colour.

Position of ship (approx.): 39° 00'S., 146° 48'E.

METEOR

North Atlantic Ocean

S.S. *Tongariro*. Captain I. Batley. Milford Haven to Curaçao. Observer, Mr. R. G. Williams, 3rd officer.

3rd February, 1959, at 0219 G.M.T. A most brilliant meteor was observed which fell from almost overhead to 20° above the horizon. The starting point was Procyon, bearing 130° and altitude 75°, and the finishing point was near to Canopus, the meteor bearing 175°, altitude 20°. It appeared to hover at its starting position and then fall rapidly, giving the impression of a star-shell. It had a bluish-white colour while falling and then turned green before disintegrating into several smaller pieces, which soon vanished within a few more degrees of fall. The magnitude was far greater than that of the moon and bathed the ship and the sea in a blue glare. No stars were visible during its fall, which lasted approximately 3 sec. The bluish-white trail persisted for about 5 sec.

Position of ship: 15° 11'N., 66° 03'W.

Note. Mr. H. B. Ridley, Director of the Meteor Section of the British Astronomical Association, comments:

"There is no doubt that the meteor was exceptionally brilliant, and it is almost certain that one of the size implied would survive its passage through the atmosphere and arrive at sea-level as a meteorite. Since the ship was some 300 miles from the mainland it is likely that any material that fell landed in the sea—that unfortunately is the fate of most of the meteorites that encounter the earth. I have no other report of the meteor from which a true path could be deduced by comparison with the report received, nor does the date correspond with any known meteor stream; but these big meteors are usually sporadic. I have made a check to eliminate the possibility that the object may have been a piece of earth-launched hardware re-entering the atmosphere, but there was no reported descent on that date."

Two Atlantic Storms of March 1959

By F. E. LUMB, M.SC.
(Marine Division, Meteorological Office)

During the winter a favourite breeding ground of deep Atlantic depressions is the region between Bermuda and the eastern seaboard of the U.S.A. These wave depressions usually move quickly ENE. during the first 24 hours of their existence, but subsequently slow down, eventually finishing up as large, deep, slow-moving lows. Their tracks after passing to the South of Newfoundland vary considerably and the problem facing the forecaster is to decide whether the depression is likely to keep moving ENE. across the Atlantic to the vicinity of the British Isles or whether it is likely to turn on a more northerly track towards the Faeroes or Iceland, or even towards Greenland. For the main trans-Atlantic shipping lanes the amount of northward turning from an undisturbed ENE. track is very important. A deep low which advances towards the British Isles will give much more prolonged gales along the main shipping lanes than one which turns away towards the north.

As an example, we shall consider two intense depressions (A and B) of March 1959. Fig. 1 shows the track of each, and the depth of the centre in millibars every twelve hours over a period of 72 hours. Low A first appeared as a recognisable cyclonic centre in 39°N., 55°W., at 0001 G.M.T. on 19th. It moved ENE. in

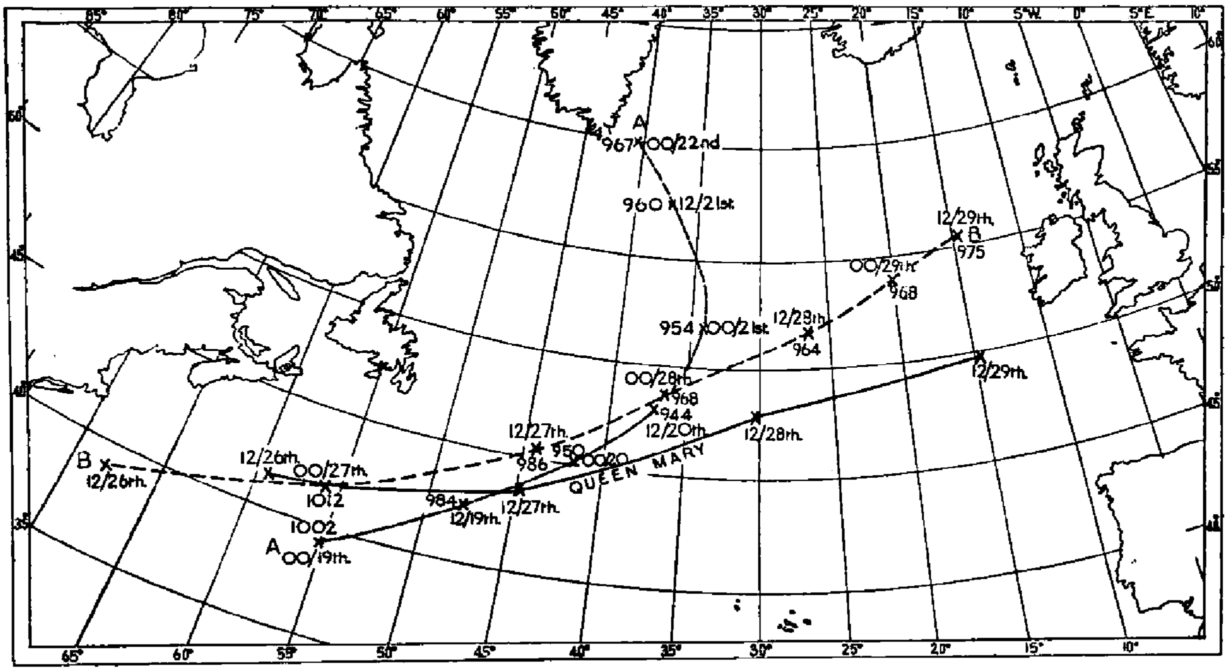


Fig. 1.
Depressions A and B of March 1959.

the next 24 hours, then turned sharply towards the north, and later NNW. to reach a position just off Cape Farewell at 0001 G.M.T. on 22nd. When at its maximum intensity on 20th the pressure at the centre had fallen to 944 mb. Low B first appeared as a small wave on a trailing cold front in 39°N., 68°W., at 1200 G.M.T. on 26th. It subsequently moved rapidly ENE. across the Atlantic, reaching a position about 300 nautical miles west of Scotland by 1200 G.M.T. on 29th. Pressure at the centre fell to 964 mb on 28th. Fig. 2 shows low A at its most intense (at 1200 G.M.T. on 20th). Fig. 3 shows low B at its most intense (at 1200 G.M.T. on 28th). In both cases there were several ships reporting winds of 50 kt or more close to the centre in the SE. and SW. quadrants. It is evident that east-bound ships would be exposed to gales for a much longer period with low B (which moved close to the north of and approximately parallel to the main shipping lane east of 45°W.) than with low A (which moved away northwards). Low B was responsible for the gales which the *Queen Mary* experienced during most of her homeward passage from New York.* The track of the liner in relation to that of low B is shown in Fig. 1. During 26th, the deepening low rapidly overtook the *Queen Mary*. By noon on 27th, the ship was just to the south of the centre of low B and was experiencing " a westerly storm, high seas and very heavy swell ". Thereafter low B and the *Queen Mary* both travelled at about the same speed along tracks which diverged only slowly, thus keeping the ship continually in the region of storm winds (force 10 or 11), to the south of the centre of the depression.

In order to explain the differences in the behaviour of the two depressions we shall examine the pattern of upper air flow over the North Atlantic at the time when each was in its very early stage of development off the eastern seaboard of the U.S.A. Fig. 4 shows the contours of the 500 mb pressure level (about 18,000 ft) at 0001 G.M.T. on 19th. The relation between the upper winds and the contour

* According to *The Times*, low B " caused the liner *Queen Mary* to roll 22 degrees one way and 11 degrees the other ". The Captain reported that " except for this one roll, stabilizers kept the ship remarkably steady ". The Marine Superintendent of the Cunard Company informs us that " the stabilizers are very efficient, but occasionally when the ship is travelling at high speed, and the swell becomes shorter, the stabilizers react to the first swell that moves the ship, and whilst they are still in the 'action' position for that swell, the next wave or swell hits the ship before the stabilizers are in a position to deal with it; hence the occasional roll. This is most likely to happen as the ship approaches the coast of Ireland where the swell becomes shorter ".

lines is very similar to that between surface winds and surface isobars; upper winds circulate counterclockwise round an upper low and clockwise round an upper high. There is an upper high just to the west of the British Isles and an upper low near Baffin Bay. Between these two systems there is a belt of very strong upper winds shown clearly by the crowding of the contours. The wind direction aloft is WSW. from off the eastern seaboard of the U.S.A. as far as 40°W., where there is a sharp change to SSW. The belt of strong SSW. winds extends from mid-Atlantic to north of Iceland. At Bermuda the upper wind was 250° 72 kt, at ocean weather ship " C " (52° 45′N., 35° 30′W.) it was 200° 90 kt. As mentioned in the article " The use of Upper Air Charts in Forecasting ", on page 27, the movement of existing pressure systems is determined primarily by the upper flow. It is a well established fact that a young wave depression will move in the direction of the strong upper winds overlying the centre, and since the general pattern of upper wind flow changes only slowly with time, this relationship can be used to forecast the movement of the new depression for a period of one or two days ahead. Allowance has to be made for the interaction between the deepening depressions and the upper winds, for as the low deepens it distorts the upper wind flow over it and this results in the track of the low deviating somewhat to the left of the " tramline " track which unmodified steering would give.

Comparing Figs. 1 and 4, we see that steering by the upper winds (with an allowance for slight deviation to the left) gives a good approximation to the true track until the depression reached the latitude of 55°N., i.e. for a period of 48 hours after the time of the upper air chart. The existence of the belt of strong SSW. upper winds over the mid-Atlantic at 0001 G.M.T. on 19th was a clear indication that the low would turn away towards the north, and not advance towards the British Isles.

Fig. 5 is the upper air contour chart for 1200 G.M.T. on 26th, when the incipient low B was in position 39°N., 68°W. Comparing Figs. 4 and 5, we see at once that the upper flow was very different on 26th from that on 19th. The upper high west of the British Isles had disappeared, and there was an upper low centred to south-west of Iceland. There was a belt of strong W. to WSW. winds extending from Nova Scotia across the Atlantic to the British Isles, and the steering influence of these upper winds would have acted strongly to keep the centre moving along an E. to ENE. track. Comparing Figs. 1 and 5, we see that the application of the steering principle (with allowance for some slight deviation to the left across the contours) again gives a good estimate of the track of low B for the next 48 hours, and indicates that it would advance across the Atlantic towards the British Isles.

It is clear that charts of the upper air flow at 500 mb can be of great assistance in forecasting the behaviour of frontal depressions. Also, they are essential as the basis on which to prepare forecast upper air charts required for the planning of trans-Atlantic flights. With the pattern of upper winds shown in Fig. 5 it is obvious that on a flight from London to New York at 18,000 feet along a great circle or a rhumb-line, strong head winds would be encountered over most of the route. A track further north, just to the north of the centre of the upper low south-west of Iceland, would be preferable. Though longer in distance than a great circle it would lead to a saving of time in flight.

The basic information necessary for the construction of these upper air charts over the North Atlantic is supplied by the radar and radio-sonde measurements made on board the ocean weather ships. However, the ocean weather ships give only a skeleton network of upper air observations. In order to draw the belts of strong upper winds accurately, a detailed knowledge of the positions of the centres of the lows and highs at the surface is required; also a correct analysis of the frontal structure of the lows. Ahead of active warm fronts and to the rear of active cold fronts the wind increases very rapidly with height and in direction it tends to become parallel to the fronts, so that the belts of strong upper winds are orientated approximately parallel to the main fronts as drawn on the surface synoptic charts.

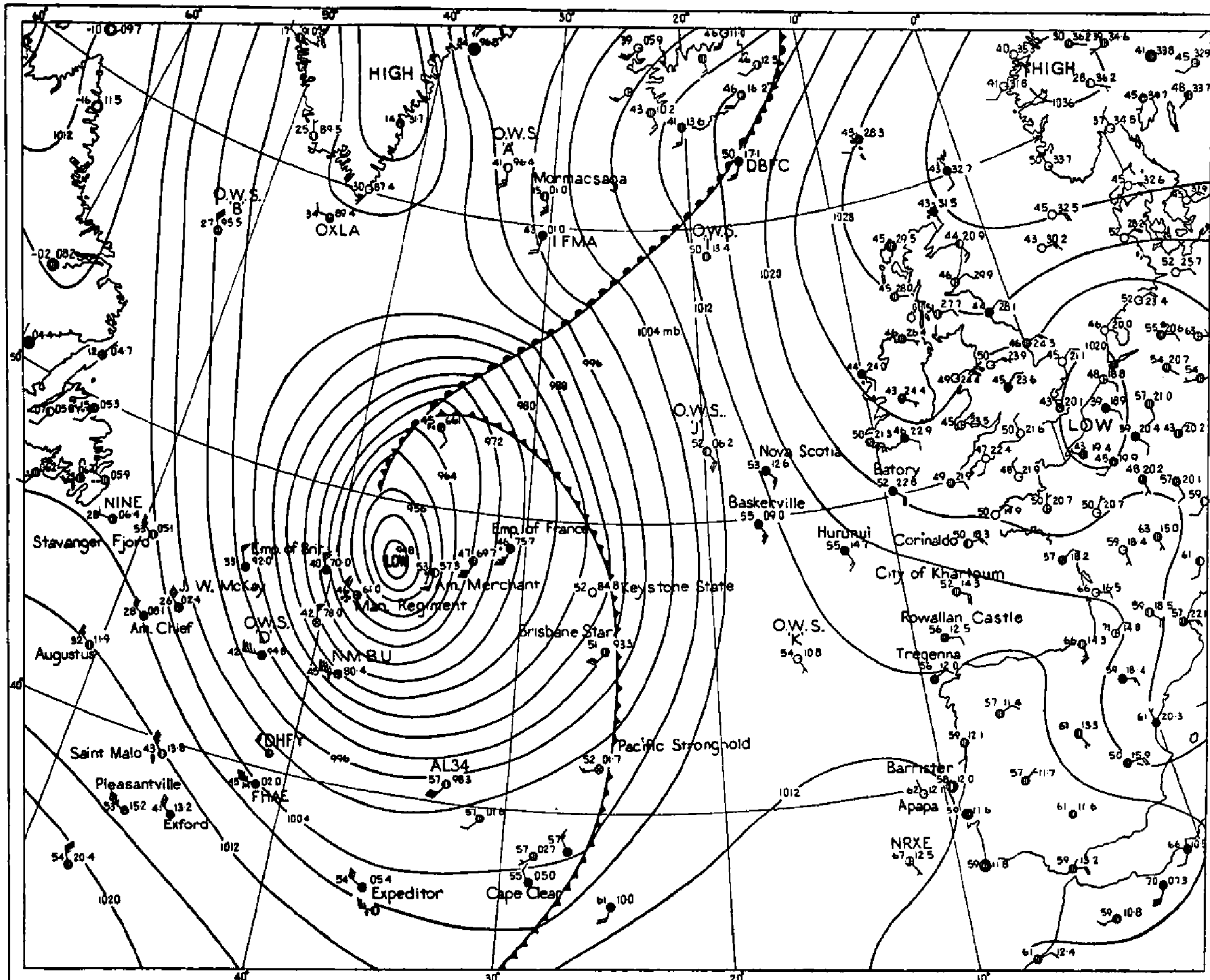


Fig. 2.

Synoptic chart for 1200 G.M.T. on 20th March, 1959. (See Addendum on page 52.)

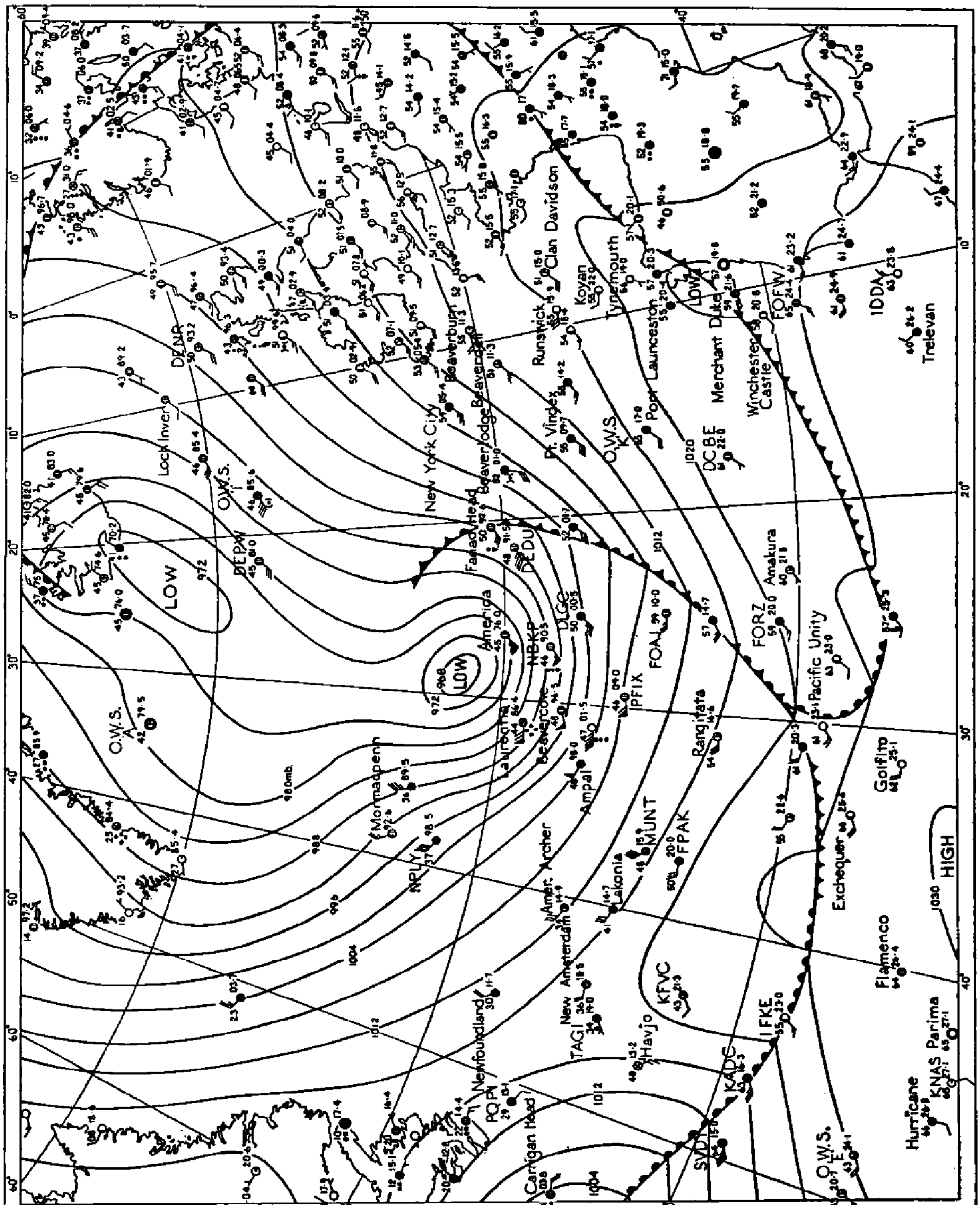


Fig. 3.

Synoptic chart for 1200 G.M.T. on 28th March, 1959.

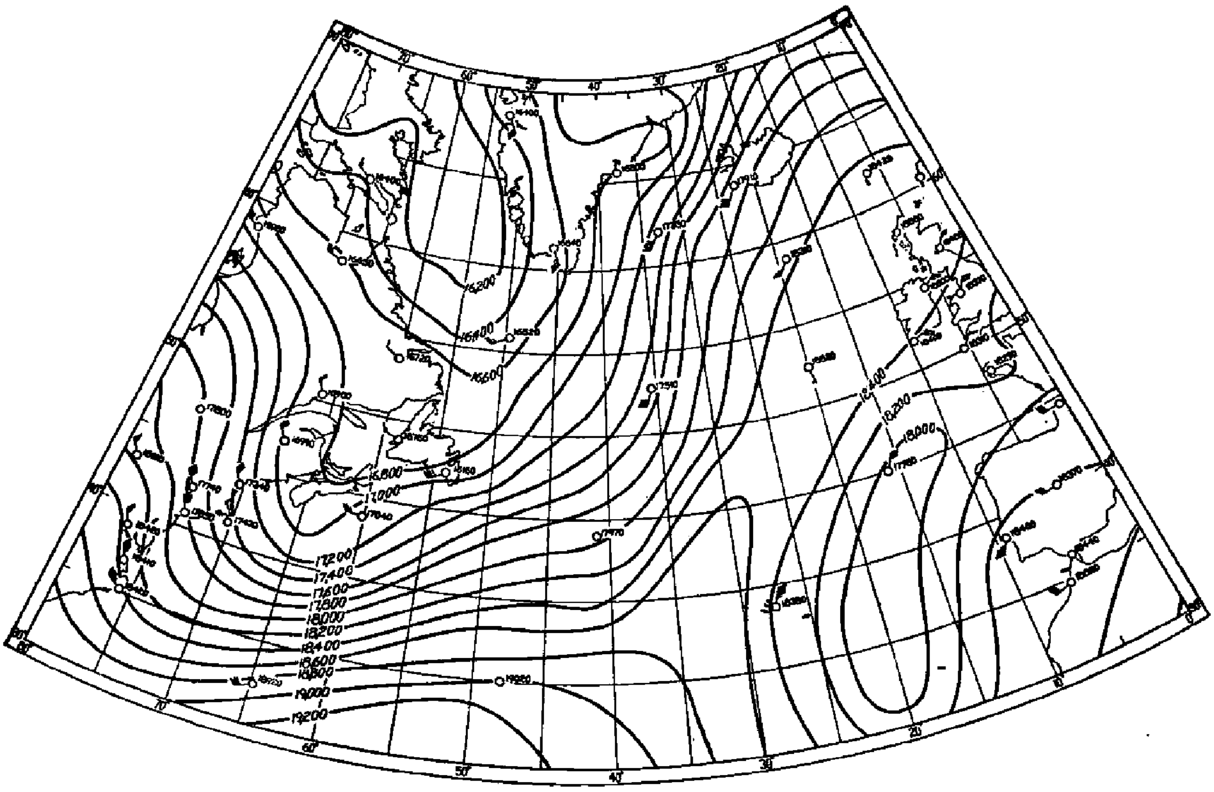


Fig. 4.
Contours of the 500 mb pressure level at 0001 G.M.T. on 19th March, 1959.

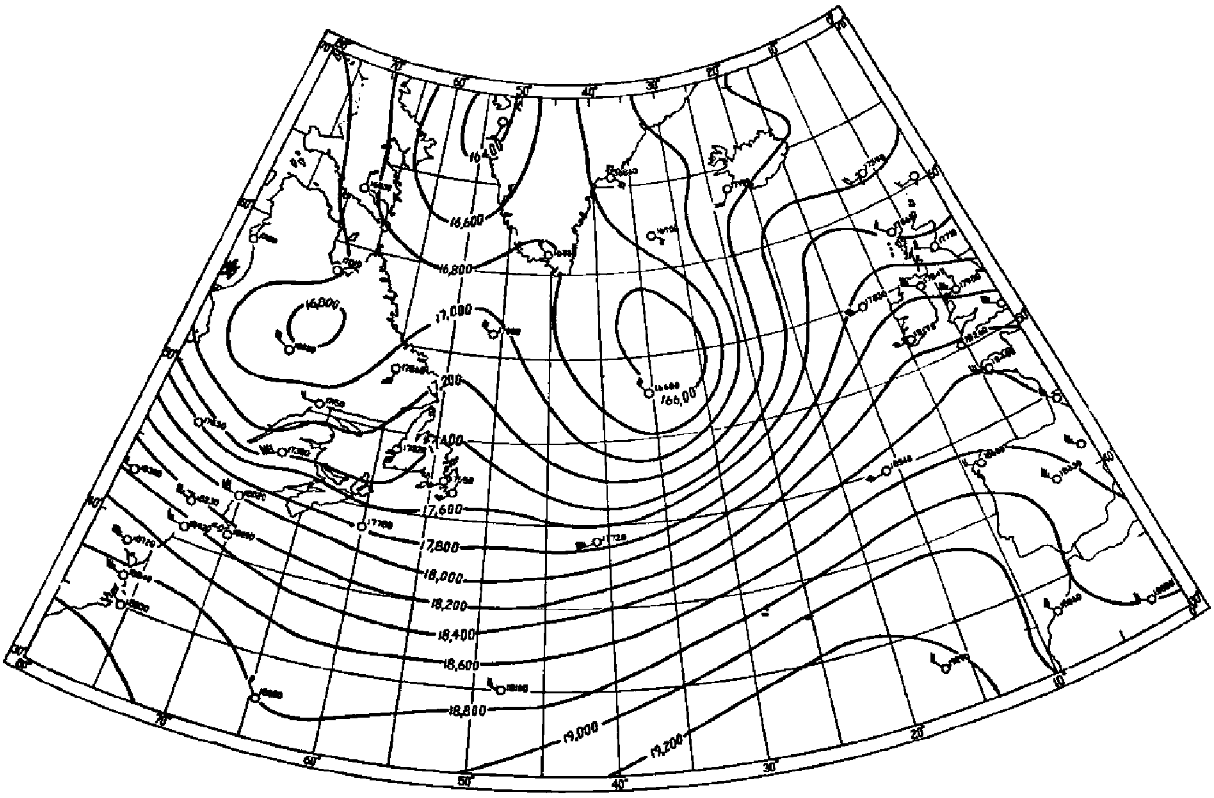


Fig. 5.
Contours of the 500 mb pressure level at 1200 G.M.T. on 26th March, 1959.

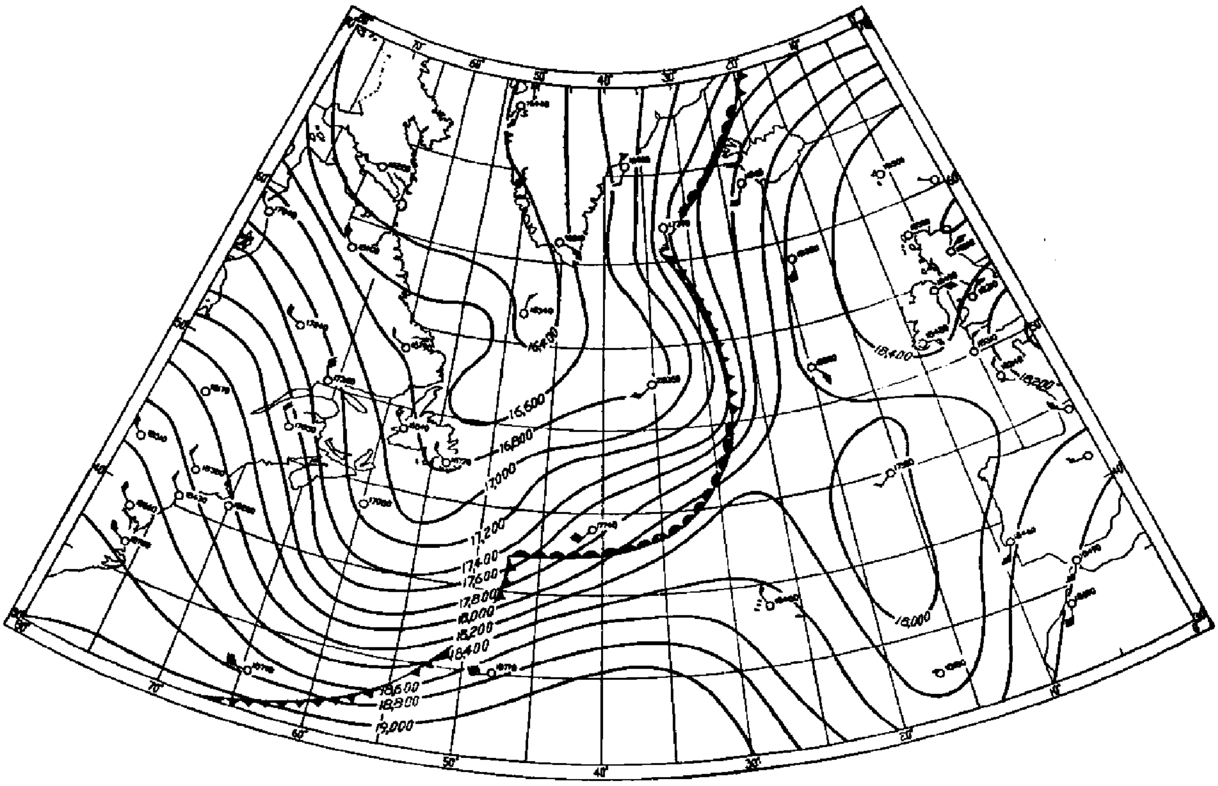


Fig. 6.
Contours of the 500 mb pressure level at 1200 G.M.T. on 19th March, 1959.

This relationship is illustrated in Fig. 6, which shows the contours of the 500 mb pressure level at 1200 G.M.T. on 19th March, 1959. The surface fronts have been drawn on this chart. The strong upper wind belt on the Atlantic is seen to be approximately parallel to the main polar front (except near the tips of the frontal waves where it is parallel to the warm sector isobars).

By a graphical technique which combines into one consistent whole the sum total of information provided by the surface isobars, the frontal systems, the upper air observations and the known relationship between fronts and change of wind with height, the forecasters are able to make the best possible use of all surface and upper air data in constructing their upper air charts at several standard levels up to 100 mb (approximately 50,000 ft). Since the forecaster relies primarily on weather reports from ships for fixing the positions of depressions and anticyclones and for the correct frontal analysis over the Atlantic, it is evident that weather reports from voluntary observing ships are essential, not only for the drawing of surface synoptic charts which have always been, and still are, the most powerful weapon in the forecaster's armoury, but also for the accurate drawing of the upper air charts which, as explained in the article below and illustrated in this article by two relatively simple examples during March 1959, have now become indispensable to every up-to-date major weather forecasting office.

The Use of Upper Air Charts in Forecasting

By C. J. Boyden, B.A.
(Assistant Director of Central Forecasting, Meteorological Office)

A few months ago when a ship's captain was being shown the work of the forecast room at Dunstable he made the remark, " When I see the latest surface chart I have a pretty fair idea of where the depressions will go and what is going to happen in the next twenty-four hours." To some degree this is of course true. Before the war the professional forecaster worked largely from surface charts: his upper air knowledge over the British Isles was obtained from pilot balloon ascents, the occasional nephoscope observation and from temperature soundings by one or two meteorological aircraft. Today his basic tool in forecasting surface pressure changes is the upper air analysis over an extensive area.

A hundred years or so ago bad weather came to be associated with low surface pressure, and isobars were regarded as not much more than boundary lines for weather systems. Abercromby developed a system of forecasting on this basis, and rules for movement of pressure systems evolved only slowly from familiarity with surface charts, supplemented later by a small number of upper air observations. Nowadays the forecaster's day-to-day study of the atmosphere is fairly completely three-dimensional. The aim of this article is to explain in a general way why this approach is necessary. A general explanation is a simplification of the problem and in meteorology this is never far removed from over-simplification, and half-truths cannot be entirely avoided. The reader should remember, too, that an improvement in the accuracy of forecasts has rarely been attained without increasingly complex methods.

Pressure at sea level is no more than a measure of the weight of air in a vertical column extending the whole way up through the atmosphere. The existence of a depression means that there is a shortage of air somewhere aloft or that the air above is comparatively warm and therefore light. The air near the ground moves towards the centre of the depression—nature's attempt to make good the deficiency—and the accumulation of air near the centre and along the fronts is forced upwards and thereby cooled to produce cloud and rain. In the anticyclone everything works in the opposite direction.

In forecasting for more than a few hours ahead it is not enough to work from existing trends on the surface chart. The problem is to estimate where the next depression will form, whether an existing system will deepen or fill, whether it will accelerate or slow down, and so on. All these happenings result from air at some high level being excavated from one place and deposited elsewhere. The problem is to decide when and where this transfer is likely to happen and on how big a scale. One is reminded of the modern method of getting a picture of the profile of sea waves by making a continuous recording of the pressure variations measured by an instrument on the sea bed. These readings, after certain corrections have been made, measure the varying depth of water above the instrument. The forecaster's problem is analogous to having to forecast the waves in order to forecast the pressure changes under the water—and moreover in water which must be supposed to have a very variable density.

The excavation of air referred to is known as divergence, and when a surface depression forms it is usually the result of divergence in the upper half of the troposphere. The immediate outcome is a pressure fall in the lower half followed by an inrush (or convergence) of air at lower levels. Not so much air flows in as flows out, so we are left with a net deficiency of surface pressure and our depression makes its appearance on sea-level charts. Clearly then it is to the upper half of the troposphere that we look for the first link in this chain of events. Why does this divergence take place?

But first a word is necessary about the mapping of the upper air. Radiosonde and radar wind observations from land stations and from ocean weather ships are the basis on which charts are drawn for levels up to far into the stratosphere. These charts are drawn not at fixed heights but for standard pressure levels. Two of the most useful are where the pressure is 500 mb (about 18,000 ft in temperate latitudes) and where it is 300 mb (about 30,000 ft). These isobaric surfaces are nearly horizontal but they show hills and valleys (corresponding to anticyclones and depressions) and these are indicated by the contours of the height above sea level. Contours have much the same properties as the more familiar isobars: the wind blows along them with a speed proportional to their closeness, and an upper air chart (see Fig. 4) looks much like a surface chart except that there are fewer closed circulations. So when the word "contour" is used the reader

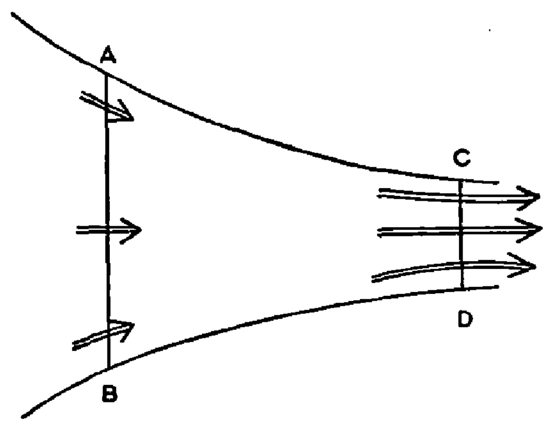


Fig. 1.
Geostrophic flow, with no convergence or divergence.

unfamiliar with upper air charts can substitute " isobar " without fear of confusion.

Except very close to the ground the wind speed which " matches " a certain spacing of isobars can be found fairly accurately from the distance between them. This is the geostrophic wind and is measured with a geostrophic wind scale. Fig. 1 shows a pair of converging isobars (assumed stationary), the wind being represented by arrows whose length is proportional to the speed. If the wind is geostrophic the amount of air slowly crossing AB in a certain time is exactly the same as the amount moving fast across CD. In other words there is no divergence, the amount of air within the area ABDC being unchanged. The movement is like that of a crowd of people passing through the barrier on to a railway platform. They approach it slowly, shoulder to shoulder, and finally pass through quite quickly and still packed tightly.

An interesting thing about the atmosphere is that all movements and developments of pressure systems occur because the wind does *not* quite match the pressure gradient, that is to say because it is not precisely geostrophic and there *is* divergence. Flow which is slightly across isobars or contours is the cause of our constantly varying weather. A few examples will illustrate how these deviations can come about.

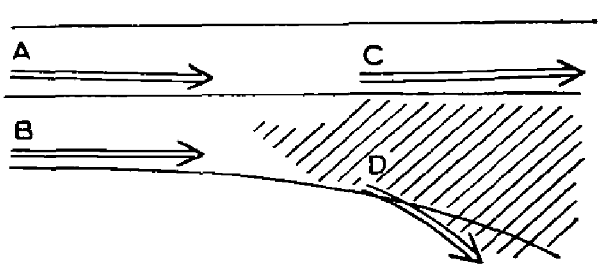


Fig. 2.
Divergence (from the shaded area) as the air slows down.

Fig. 2 represents contours (supposed stationary) giving a steady west wind at A and B, the speed being represented by the length of the arrow. The air at A moves on to C and beyond, keeping the same speed because the contour spacing is uniform. On the other hand, when the air from B reaches D it is travelling too fast for the weakening pressure gradient. The pressure gradient can no longer control it as it did when the air was at B so the airstream turns off to the right of the contour and there is a deficiency of air in the shaded region. The extent of such divergence depends on the magnitude of the change of wind, so it is often large near jet streams, those channels of very strong wind often found near the tropopause. The effect of this divergence alone (and there are other factors) is to cause a drop of pressure at lower levels. Notice that it is essential to this argument that the air should move through the contour pattern and this commonly happens in the upper atmosphere.

To avoid confusion between what is illustrated in Fig. 1 and Fig. 2, it should be made clear that Fig. 1 shows a hypothetical situation in which the wind is at all times balanced by the pressure gradient, whereas Fig. 2 shows more nearly what actually happens in the atmosphere.

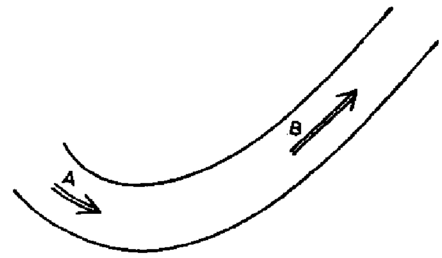


Fig. 3.
The flow of air round a trough of low pressure.

Fig. 3 illustrates another way in which divergence often occurs. The contours are curved cyclonically in the area of A and gradually straighten out by the time B is reached. Suppose the wind to blow along the contours at all points and the contours to be the same distance apart everywhere. Then the wind speed is lowest at A because there the curvature is greatest (gradient wind is less than geostrophic*) and it gradually increases to become geostrophic at B. Thus the region from A to B is one of divergence in the upper air because not enough air goes in the curved end of the " pipe " to supply what goes out at the straight end. Again pressure tends to fall at lower levels and this is the main reason why a depression commonly forms on the east side of an upper air trough and existing

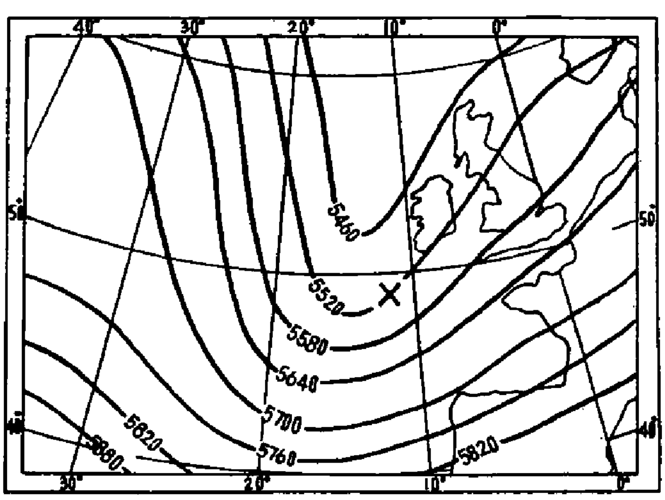


Fig. 4.
The 500 mb chart of 1500 G.M.T. on 28th July, 1956. At 1200 G.M.T., on the same day, a surface depression was deepening at the place marked by the cross.

depressions often deepen when they arrive there. An example of this which many may remember is the depression of 29th July, 1956, which deepened rapidly off our southwest approaches. Fig. 4 shows that at 1500 G.M.T. the previous day the depression, whose position (near 50°N., 10°W.) is marked by a cross on the 500 mb chart, lay in a favourable position for deepening, being on the east side of the upper trough, though the development to the extent shown by Fig. 5 was quite exceptional.

Apart from the development of new systems the movement of existing ones is also determined primarily by the upper flow. To put the argument rather crudely, the mechanism which has removed air from above where we now have a surface depression will move the general upper stream to show our surface depression in another place on the next chart. Such rules as that of the movement of a depression

* See *Meteorology for Mariners*, page 30.

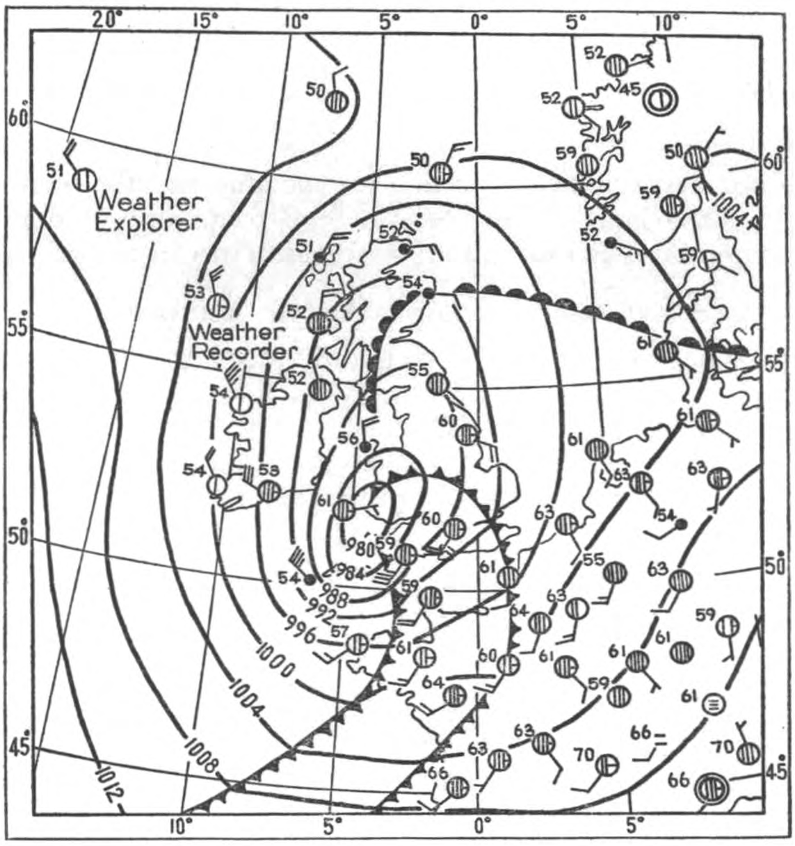


Fig. 5.
The intense depression of 29th July, 1956, as seen on the 0600 G.M.T. chart.

in the direction of the warm sector of isobars apply simply because the upper flow over the central parts of such a depression is in the same general direction as the warm air movement at the ground.

These examples give an over-simplified picture mainly because what happens at a single upper level only partly determines surface development. A vital additional factor is the distribution of temperature in the lower troposphere. Nevertheless, principles such as those described above are of first importance, though a major difficulty of applying them is that of assessing how effective a particular feature of the pattern will be in inducing developments. The forecaster reaches his conclusions from a qualitative estimate of the relative importance of different factors and a development may take place sooner or later than he expects or the conditions favouring development may become more or less pronounced as time goes on. The qualitative judgement will eventually be superseded by the precise calculations of the electronic computer (one is installed in the research laboratory of the Meteorological Office, Dunstable) but the complexity of the atmosphere must remain the overriding limitation to precise forecasting.

In conclusion one must draw attention to the fact that all that has been described shows no more than the kind of influence an upper air chart has on surface developments. But this is only part of the problem, because we have yet to forecast the upper air chart. This is done largely by applying the laws of fluid motion to the upper atmosphere but also by considering how the flow there will be distorted by the very surface developments we are trying to forecast! This situation is not so paradoxical as it may seem. It is indeed characteristic of forecasting that it has always been a compromise between a number of opposing lines of reasoning and interacting developments.

NOTES ON ICE CONDITIONS IN AREAS ADJACENT TO THE NORTH ATLANTIC OCEAN

At end of July 1959

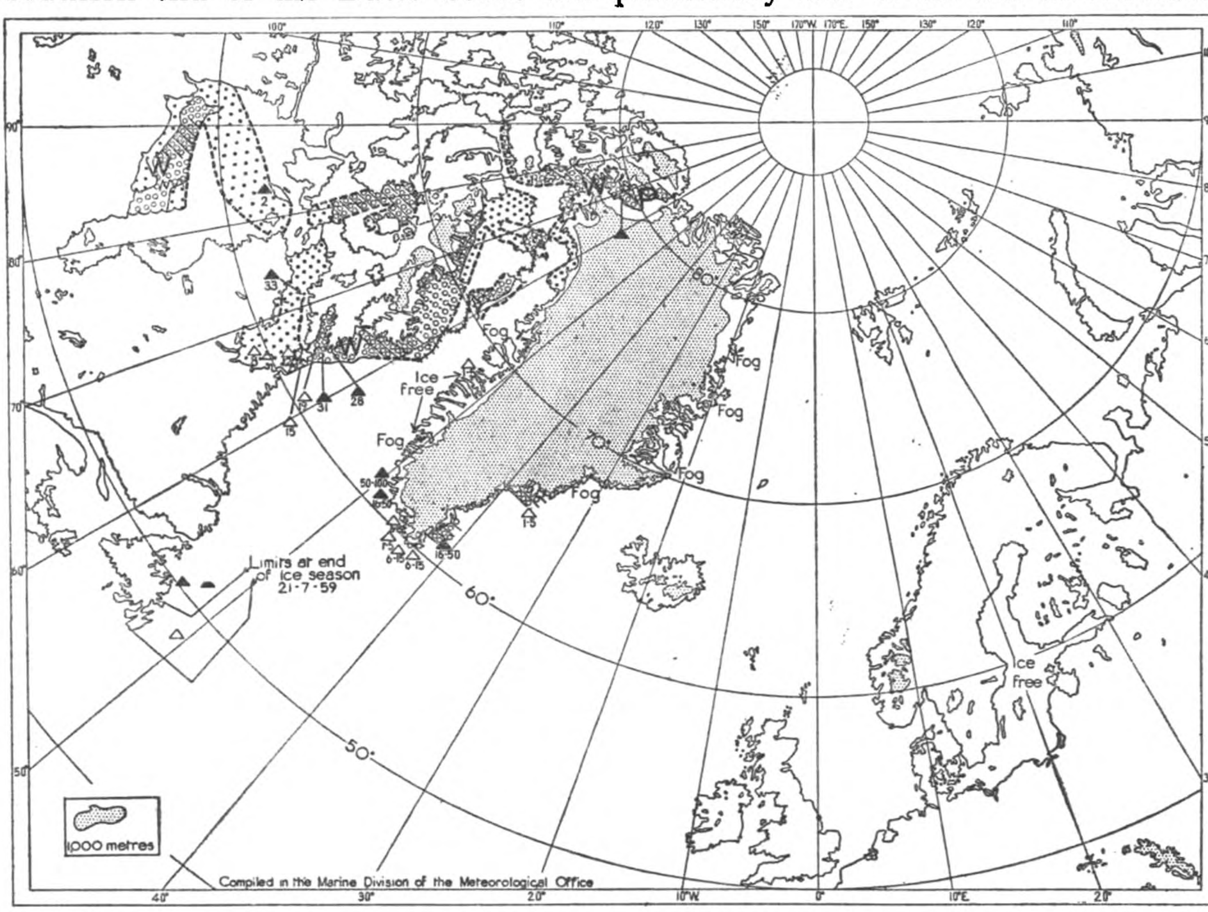
Relevant Weather Factors

There was nothing spectacular concerning the weather in July 1959 likely to create any abnormal ice situations. There was a high frequency of depressions at the southern end of the Davis Strait and off south-eastern Greenland.

Baffin Bay, Davis Strait and Canadian Arctic Archipelago

Amounts of pack-ice appeared to be generally lower than normal and less thick. Pack-ice appeared to be concentrated mainly on the western side of the open sea area about the latitude of the Arctic Circle.

There were considerable amounts of pack-ice in and around the islands of the Canadian Arctic Archipelago but this is quite usual for this time of the year. The southern end of the Davis Strait was particularly free of ice but considerable



Distribution of sea ice at end of July 1959.

KEY

- Open water
- New or degenerate ice
- Very open pack-ice [1/10-3/10 inc.]
- Open pack-ice [4/10-6/10 inc.]
- Close pack-ice [7/10-9/10 inc.]
- Land-fast or 'field-ice' [10/10] [no open water]
- Ridged ice
- Hummocked ice
- Lead
- Polynya
- Y Young ice [2"-6" thick]
- W Winter ice [6"-6½' thick]
- P Polar ice [>6½' thick]
- — Known boundary
- Radar boundary
- ----Assumed boundary
- --- Limit of observed data
- Undercast
- Few bergs [< 20]
- Many bergs [> 20]
- Few growlers [< 100]
- Many growlers [> 100]

concentrations of pack-ice still remained on the western side of Davis Strait and Baffin Bay north of the Arctic Circle.

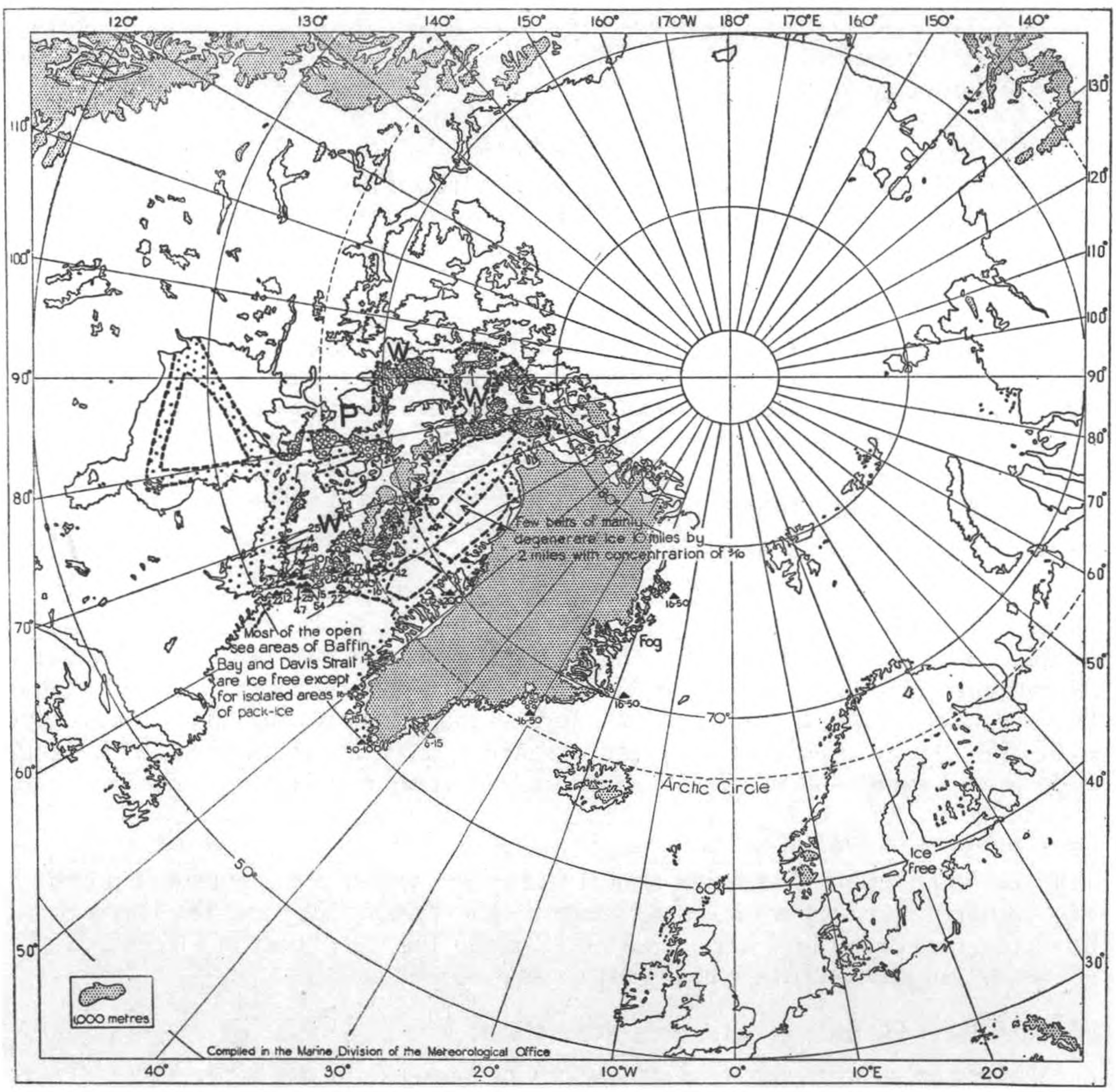
Few icebergs were reported off north-western Greenland but there were considerable concentrations of bergs off south-western Greenland and off south-eastern Baffin Island.

Hudson Bay, Hudson Strait and Foxe Basin

Large concentrations of pack-ice were reported in the south-eastern quarter of Hudson Bay and over Foxe Basin. Relatively small numbers of icebergs were reported at the eastern entrance to Hudson Strait with an isolated concentration of 33 bergs on the north side of the Strait towards 70°w.

Eastern Greenland

Much fog was reported all along the east Greenland coast north of the Arctic Circle and the reporting of ice was very difficult. However, reports indicated that the whole of the coast of eastern Greenland had less than normal fast- and pack-ice. Moderate concentrations of icebergs were reported off south-eastern Greenland.



Distribution of sea ice at end of August 1959. (Key as for July map.)

At end of August 1959

Relevant Weather Factors

The lower atmosphere was generally warmer than normal over the Arctic basin during August and over eastern Canada and western Europe, but over Greenland and the Canadian Archipelago it was cooler than normal. There were many depressions over southern Davis Strait and off southern Greenland.

Canadian Arctic Archipelago

There were still large amounts of pack-ice remaining during August but with increasing amounts of open water probably associated with much movement of pack-ice.

Baffin Bay

A great deal of the pack-ice in the open sea appears to have dispersed during August or have drifted southwards. Large concentrations of icebergs were reported on each side of the Bay but few bergs were reported to the east side north of 75°N.

Davis Strait

The Davis Strait appeared to be almost clear of pack-ice by the end of August, but very large concentrations of icebergs were reported at each side of the Strait, particularly off Baffin Island, at the entrance to Hudson Strait and off the north-east coast of Labrador.

Hudson Bay, Hudson Strait and Foxe Basin

Hudson Bay and Strait were reported almost free of pack-ice but there were large areas of open pack-ice in Foxe Basin. There were large concentrations of icebergs at the entrance to Hudson Strait and along the north side of the Strait east of 70°W.

Eastern Greenland

There were reports from eastern Greenland of close pack-ice north of 75°N. and open pack-ice off south-eastern Greenland, but amounts were well below normal. There were large concentrations of icebergs reported all along this coast and all were probably moving south-westwards.

At end of September 1959

Relevant Weather Factors

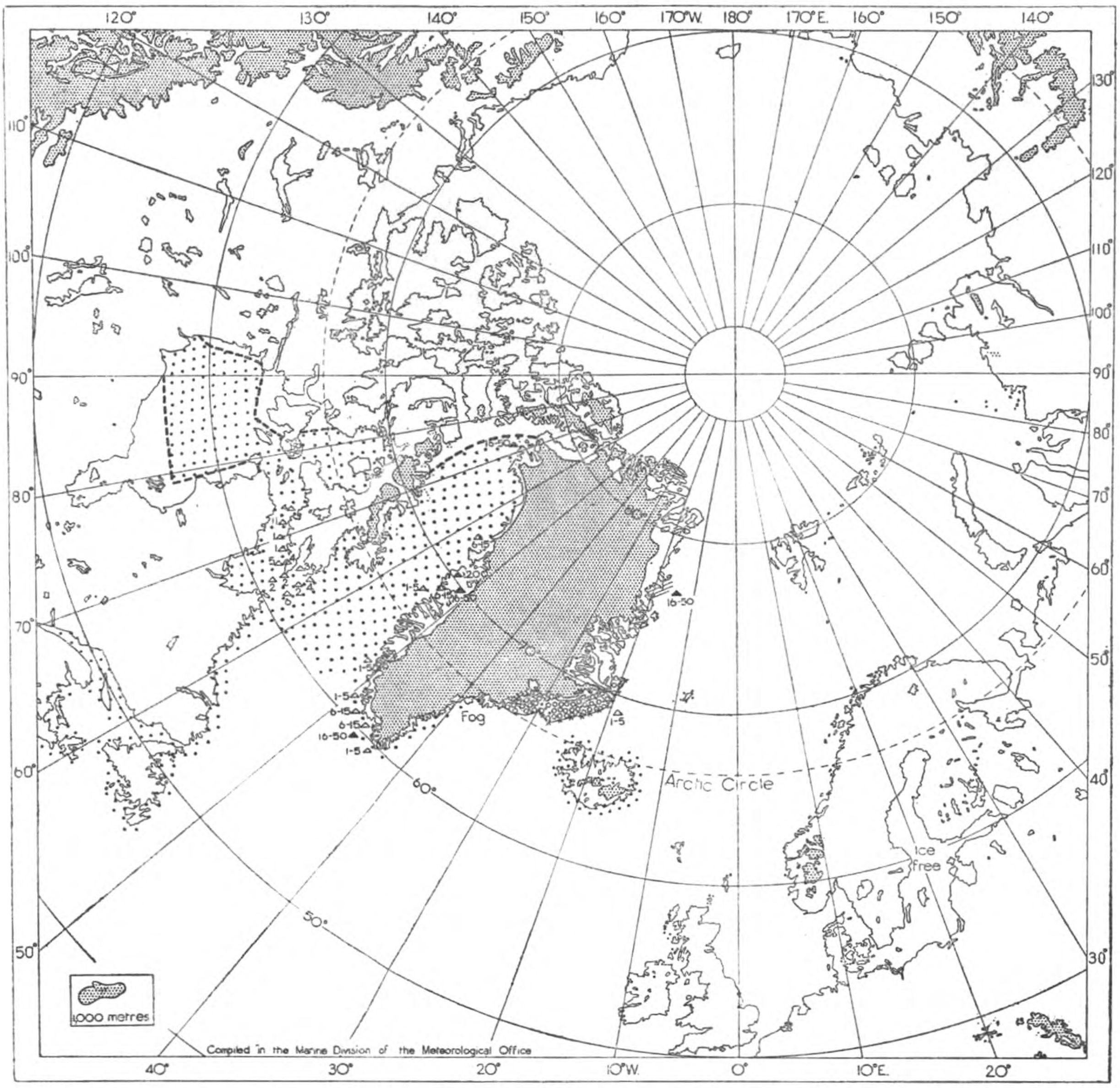
There were again during this month frequent depressions over the southern Davis Strait and off Greenland from Cape Farewell to Spitsbergen, but anticyclones became more frequent in the latter half of the month off north-eastern Greenland. Abnormally cold air appears to have moved from the Arctic over Baffin Bay, Davis Strait and the Canadian Arctic and southern Greenland. There was some indication that areas adjacent and east of Spitsbergen (i.e. well north-east of Iceland) experienced somewhat warmer than normal moist air masses.

Baffin Bay and Davis Strait

These were reported as being almost free of ice, which is normal for September. Few icebergs were reported on the western side of Baffin Bay and the Davis Strait but large concentrations were reported all along the west coast of Greenland and moderate numbers off the south-west coast of Greenland.

Hudson Bay, Hudson Strait and Foxe Basin

All these areas were reported almost free of pack-ice during September. There were, however, small concentrations of icebergs along the north side of Hudson



Distribution of sea ice at end of September 1959. (Key as for July map.)

Strait east of 75°w. It appears that this area was perhaps slightly freer of ice than usual.

Off Eastern Greenland

Large concentrations of icebergs and land-fast field-ice were reported along the coast of north-east Greenland south of 80°N., while extensive areas of open and close pack-ice associated with small concentrations of icebergs were reported off the coast between 65° and 70°N. Coastal areas south of the Arctic Circle were apparently free of field-ice although fog hampered ice observations in these areas. This again appears to be a month of lower than normal concentrations of field-ice along all the eastern Greenland coast.

G. A. T.

An Unusual Indicator of Convection

By W. G. Harper

(Mr. Harper is in the Meteorological Office, and this article is based on a paper he read at the Seventh Weather Radar Conference at Miami in 1958 when he was working at East Hill, near Dunstable.)

Introduction

There is increasing recognition in Europe that widespread displays on PPI of the weak point-target echoes known as ' angels ' are caused by birds, especially by birds on migration (e.g. [1,2]). It has been shown that this type of echo in south-east England has all the characteristics of bird-flight.[3] But there are other types of echo, of assumed meteorological origin, which await adequate explanation. Elder[4] in America has published evidence of expanding rings of echo which he suggests may be due to gravity waves. Closely-similar rings recorded here however have been positively identified as originating at the site of large roosts of birds,[5] and the rate of expansion of the rings is consistent with bird-flight.

There is now evidence that a third class of ' angel '-type echoes, in the form of lines and irregular arcs, which have been recorded only in summer, and which have the unusual characteristic for ' angels ' of drifting roughly with the wind, is also caused by birds.

Instrumental Details

The Meteorological Office radar research station at East Hill has been in operation since 1947 for study of the development and movement of precipitation systems, e.g., frontal precipitation, showers and thunderstorms, and is equipped with three 10-cm radars and one 3-cm radar.

The two high-power 10-cm radars* which are referred to in this article suffer to some extent from wartime anonymity, and are known only as a PPI Type 14 and RHI (range-height indicator) Type 13. Both have output powers of 500 kW and use 2-microsecond pulses. The third 10-cm radar* (Meteorological Office 10-cm wind-finding radar, Type 1, based on the war-time A.A. No. 3, Mk. 2) which is of lower power, does not have a PPI, but gives A-scope presentations of range (coarse and fine), bearing and elevation on separate cathode-ray tubes.

The centres of the radar aerials at East Hill are only about 15 ft above the ground, but the site is an open one. There is appreciable obstruction in one sector only, to the south, where the Chiltern Hills prevent some of the more distant storms being seen. Permanent radar watch is not maintained.

The high-power 10-cm radars are better than the 3-cm radar for the detection of ' angels '; phenomena which have caused considerable difficulty at times on airfield-control radars. It was while studying ' angels ', at that time thought to be meteorological phenomena, that the realisation came to the operators that they were following the movements of birds.

Radar appearance

(*a*) Lines of Echo

An example of lines of echo on PPI* is shown in Fig. 1, to the east and south-east of the heavy permanent echoes. They are usually quite weak, are typically spaced several miles apart, and lie up-and-downwind, never across-wind. They may be up to 5 to 10 miles in length, occasionally more, e.g. the line arrowed. They can sometimes be echoes which drift with the wind, but show slight irregularities of

* 10-cm PPI, P_t 500 kW, θ $1\frac{1}{4}°$, ϕ 6°, A_e 3·4 m²
10-cm RHI, P_t 500 kW, θ $7\frac{1}{2}°$, ϕ $1\frac{1}{2}°$, A_e 2·6 m²
10-cm GL3, P_t 250 kW, θ 6°, ϕ 6°, A_e 0·7 m²
where P_t = transmitted power (peak pulse power)
θ = beamwidth in azimuth to half-power points
ϕ = beamwidth in elevation to half-power points
A_e = effective area of antenna

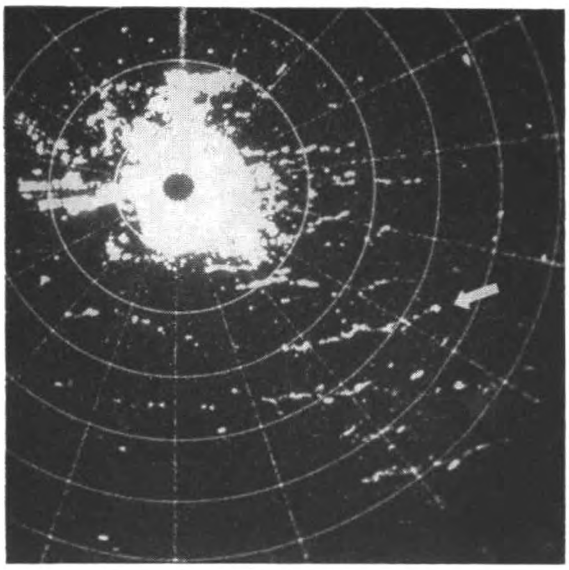
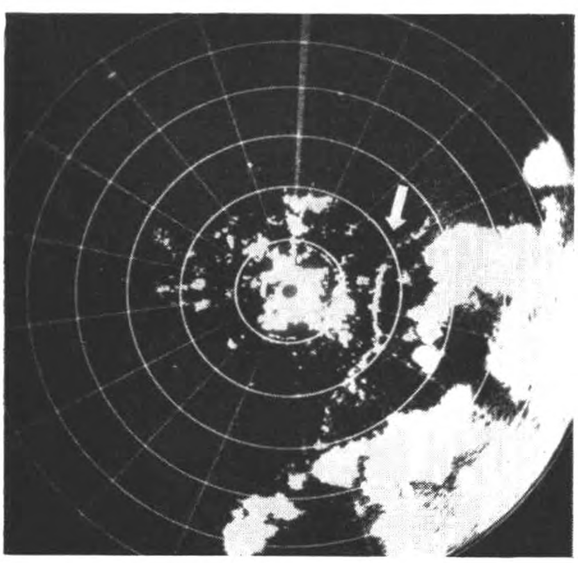
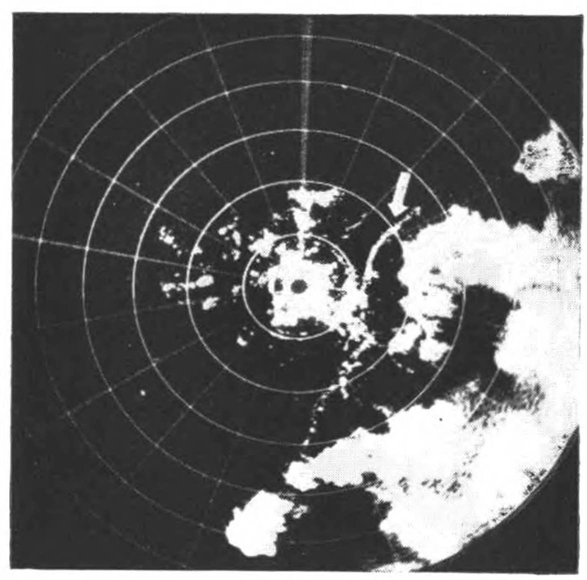


FIG. 1.

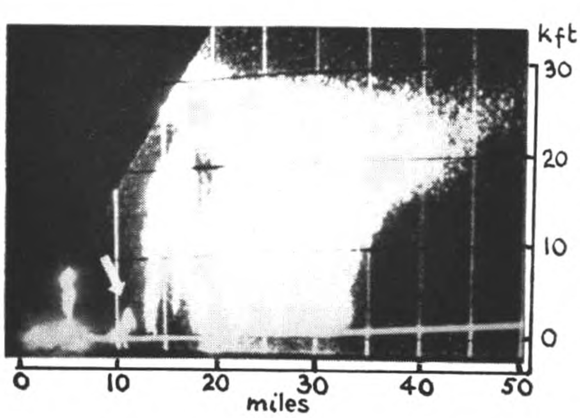
Lines of ' angels ' on 10-cm PPI to the south-east of heavy permanent echoes at 1210 G.M.T. on 12th July, 1956. Range circles are at 5-mile intervals, and the radial azimuth lines at 20-degree intervals. The lines of ' angels ' lie roughly up-and-downwind.



(a)



(b)



(c)

FIG. 2.

An intense arc of echo roughly parallel to the edge of a Cb mass, on 11th July, 1955, at 1703 (a) and 1711 G.M.T. (b), showing drift of arc and precipitation with the wind. The RHI at 1654 on azimuth 100° (c) shows the arc as a short, sloping column.

(Opposite page 37)

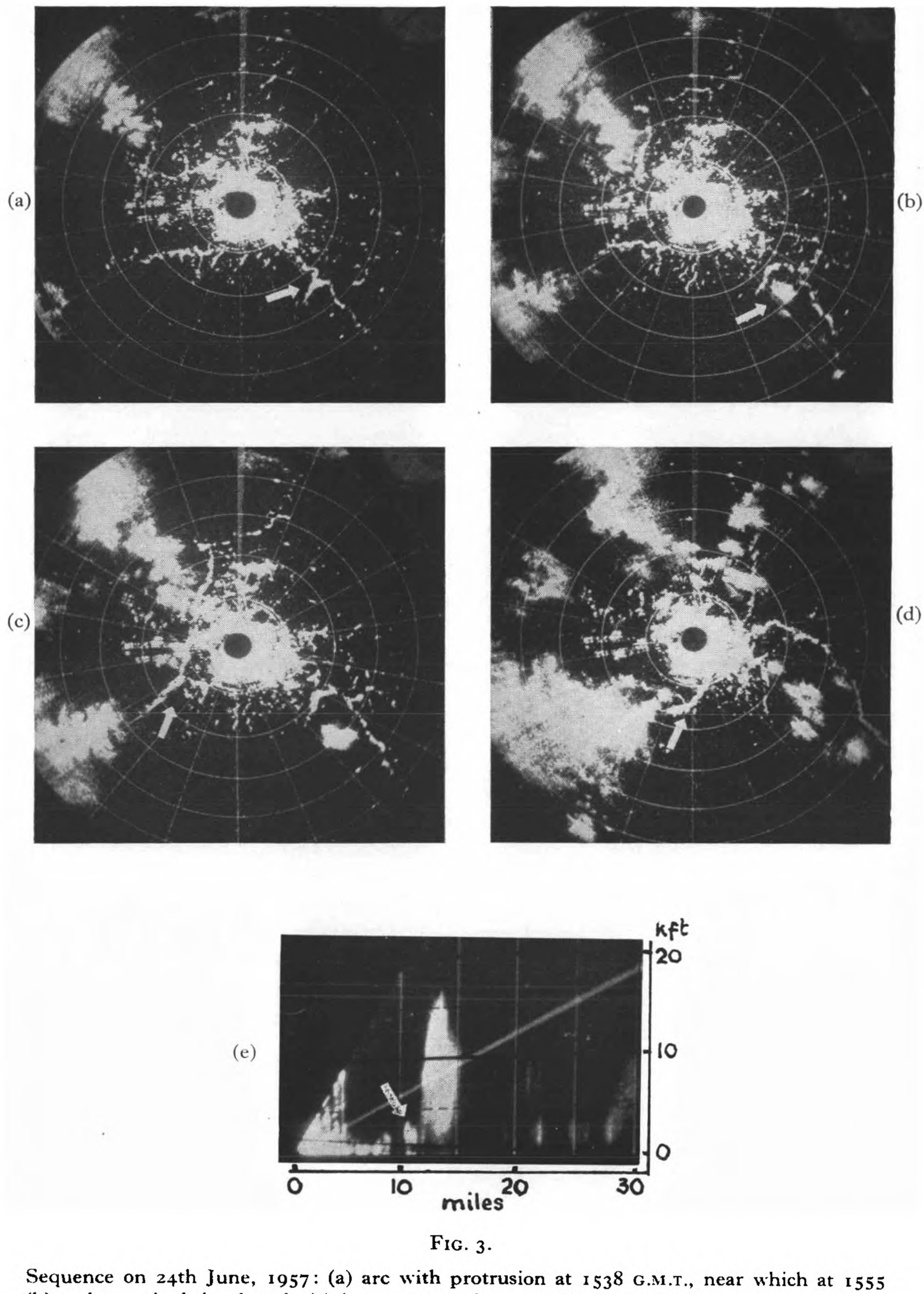


FIG. 3.

Sequence on 24th June, 1957: (a) arc with protrusion at 1538 G.M.T., near which at 1555 (b) a shower had developed; (e) is a cross-section on azimuth 135° at 1553 through these. A new arc developed by 1605 (c), which has passed directly over the station by 1641 (d).

motion and of appearance and disappearance. The range height indicator (RHI)* shows that the individual 'angels' are usually below 2,000 ft, but are sometimes as high as 5,000 ft or more. They occur almost exclusively in fine and warm weather in summer.

From co-ordinated double-theodolite and radar measurements in 1956 a clear association was established between lines of 'angels' and lines of small cumulus clouds,[6] the 'angels' occurring either isolated or in irregular columns, at levels up to the cloud base. Explanation was attempted in terms of refractive effects associated with rising thermals or bubbles of heated air.

(*b*) IRREGULAR ARCS OF ECHO

At the other extreme are intense arcs and curved lines of echo, not always continuous, but sometimes as much as 15 to 20 miles in length, occasionally seeming to lie parallel to the edges of cumulonimbus shower echoes, but separated from them by a few miles. Such an arc is arrowed in Fig. 2a. Eight minutes later both the storms and the arc had drifted about 2 miles towards the station (Fig. 2b). The RHI (Fig. 2c) cuts through this rain area, and the arc appears as a sloping column up to 3,500 ft, a level in reasonable agreement with reported cloud bases. It can be seen that on the more distant upwind side of the storm mass there were mature cumulonimbus clouds with anvil echo to 30,000 ft, and that the newer growth was on the western (downwind) side, evidenced by hard-edged echoes on PPI, and clear separation into columns on RHI. The precipitation columns have an appreciable slope caused by wind shear, and it is significant that the 'angel' column shows a similar effect of shear.

Some displays of these summertime 'angels' have characteristics intermediate between the parallel lines of echo and the more intense arcs, and it is suggested that they have basically the same origin. Occasionally they are recorded as irregular scattered blobs of echo drifting with the wind on PPI, and at times as assemblies of point-target echoes on the RHI at various levels in the first few thousand feet above the ground, in roughly vertical or sloping columns. When recorded only on the RHI we have referred to these as 'stacked angels'.

Evidence of avian origin

Suspicion that these manifestations were caused by birds was aroused early in 1957, for we were by that time convinced that most fast-moving point-target 'angel' echoes were caused by birds on migration. The first lines of echo of the summer 1957 were seen on 21st May, with scattered stratocumulus, and on 22nd May, when there was practically no cloud in the East Hill area. On both days semi-coherent echoes of the kind we have come to associate with 'angels' were received on the 10-cm wind-finding radar, type 1.* No other echoes were detected which could have corresponded to the lines of echo on PPI, and their computed heights, between 600 and 1,600 ft above the ground, were in the same range as the RHI heights. Of 37 targets followed by the radio operators on these two days, 31 were resolved as birds by telescope fixed to the radar aerial and not under the control of the observer. Some were held for only short periods before the signal became distorted by permanent echoes; others were held in the field of view for several minutes. The writer acted as observer for much of the time, and all the birds seen by him were swifts. A few were single swifts, but most were pairs, diving and wheeling in and out of the telescopic field, passing and repassing each other every 20 to 40 seconds in what was almost certainly feeding flight. This fits well with our 1956 observation that lines of echo on PPI define rows of thermals (not reaching the condensation level on 22nd), in which the insect food of the swifts was being convected.

* See footnote on page 36.

Evidence that the intense arcs of echo can be caused by birds had to await the passage of an arc over the station. This happened on 24th June, 1957. At 1538 (Fig. 3a) there was an area of showers to the west and north-west, and an irregular arc lying to the south of the station, remarkable for the strange protrusion of echo 12 miles south-east. A shower may already have been developing here above the PPI beam, for by 1555 (Fig. 3b) the shower had reached the ground, and it is seen that the ' angel ' echo partly encircles the shower. The RHI photograph (Fig. 3e) shows the shower reaching 16,000 ft and the arc on its near side with its top around 3,000 ft. The east–west arc by this time was breaking up, but already a new arc can be seen just ahead of the shower area to the north-west of the station. By 1605 (Fig. 3c) this was well defined, lying roughly NNE.–SSW., and it moved over the station, being still clearly identifiable at 1641 (Fig. 3d). Birds were first seen in the radar telescope at 1618, and as the strong echo was followed in towards the station increasing numbers were seen against a dark background of cloud, until at its maximum at 1632 I estimated that there were more than a hundred birds in the 5° field of the telescope. They were definitely swifts, in erratic feeding flight. The 10-cm wind-finding radar, Type 1, defined the height of the maximum echo at this time as 1,350 ft, but the slant range of the selected echo was 3,300 ft because of its angular elevation of 24°. Against the background of heavy cloud it was difficult to detect any birds by eye. The passage of the echo was coincident with the passage of a line of heavy cloud, but no shower fell at the station at this time. Fig. 3d shows, however, that many new showers had developed by 1641.

I am now convinced that our 1956 observations of the association of lines of ' angels ' with cumulus cloud-streets[6] were also the detection of swifts. We recorded for example that individual ' angels ' on RHI, after rising perhaps 1,000 to 1,500 ft over several minutes, were seen to descend. This seems inconceivable in convective bubbles, but becomes readily explicable in terms of birds breaking away from a thermal before reaching cloud base.

Correlation with habits of swifts

Some of the echoes described may be caused by other species of birds flying in the area, such as swallows and martins, even by gulls, which are seen at times at considerable heights, but it seems probable that the swift (*Apus apus*) is the main species responsible. It is a widespread summer visitor throughout Europe, is very powerful on the wind despite its relatively small size, and has been observed from aircraft migrating at heights up to 7,000 ft.

The following points are taken from an extensive study of swifts made by Lack[7]:

(i) British-breeding swifts arrive on migration in early May, and the young and adults depart from late July to mid-August. They are remarkably regular in these habits. The many swifts seen in England in late August and September are thought to be birds moving south from Scandinavia.

(ii) The most intensive aerial activity of swifts is in July when the young are in the nest, and then feeding goes on continuously throughout daylight hours in good weather. The insects taken by swifts for their young are formed into food-balls in the throat, and Lack records that on a very favourable day a single pair of swifts brought 42 of these to the nestlings, which he estimates contained 20,000 insects. This was in addition to their own food requirements, and gives an indication of their aerial activity.

(iii) The nestling swift can when necessary survive for days without food, and the parents often make no feeding flights in bad weather.

(iv) The generally held view expressed by Lack is that swifts usually feed from 20 to 100 ft above the ground, but he records that on fine and still days they often circle up to several hundred and occasionally to several thousand feet. He does not state whether they are seriously feeding at such times.

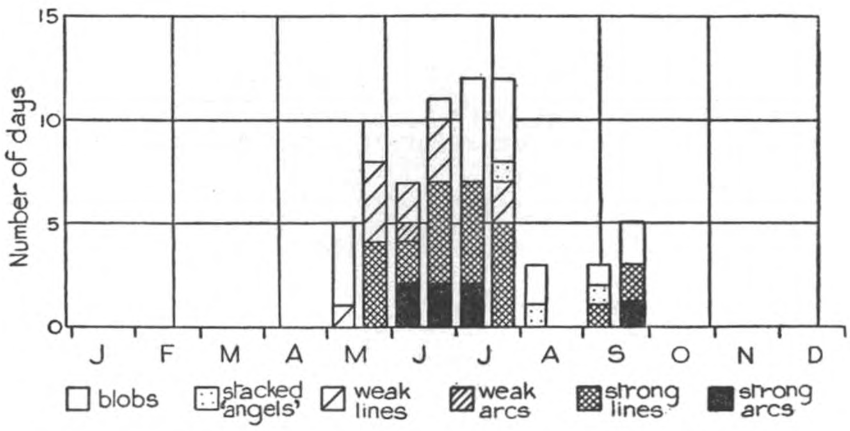


Fig. 4.

Seasonal distribution of summertime 'angels' by half months with division into types of display. (Records on 68 days in the years 1952 and 1957.)

Analysis of the seasonal distribution of records of summertime 'angels' in the years 1952 and 1957* (Fig. 4) does not conflict with these movements and habits. There were no 'angel' occurrences of the types we have described outside the period May to September (and only one such record in other years, a line of 'angel'-type echo lying up-and-downwind on 5th March, 1954). The maximum of occurrences is a broad one, spreading throughout late June and July, and there is a minimum in August. Of the eight cases recorded in September, two are known to have been caused by flocks of soaring swallows, not swifts. The two years of records may not be fully representative of the seasonal distribution, since the equipment was not operated at weekends, and was occasionally out of action for maintenance. When allowance is made for these non-operational days, the 24 occurrences in July are found to represent an average of more than one day in two. This suggests that flight to considerable altitudes (probably a necessary condition for detection by radar) must be a common feature of the activity of swifts.

In general, summertime 'angels' develop during the morning, and fade out by the afternoon or early evening, in agreement with convection activity and with the feeding habits of swifts. We have no proof that lines and arcs of echo do not recur at night, for the radar is not in operation then.

The apparent liking of swifts for the edges of rainstorms and thunderstorms, and the inference that this is not a rare occurrence, have not, as far as we are aware, been described before. The movements are definitely not those of birds escaping from the storm. It is of interest therefore that the swift is known in parts of Europe as the "thunder swallow".[7]

Discussion

Patterns of great meteorological interest are suggested by the lines and arcs of echo, but further study will be needed to assess their importance to our understanding of convective processes. The length and degree of continuity of some of these lines and arcs is quite surprising. It seems fairly certain that they define the positions of thermals, at one extreme not reaching the condensation level, at the other associated with clouds in which showers are forming, and that the swifts act as indicators of a stage of convection not otherwise detectable by radar of this power.

Rather similar arcs of echo have been reported by Leach[8] from 10- and 23-cm PPI radars in America, ahead of vigorous convective belts of precipitation. He has

* In the intervening years few observations of the kind were made, and it seemed better to exclude them.

called them " thin bands ". They were usually a few miles ahead of the precipitation and up to 5 miles in width, but in appearance bear a distinct family resemblance to our arcs, with occasional cusp-shaped sectors roughly parallel to the edges of the precipation cells. He offered explanation in terms of refractive-index-type ' angels ' or precipitate-sized particles held in suspension by turbulence, but we think that explanation in terms of birds deserves careful consideration. Analogy with our lines of echo may also be seen in the ' convective angels ' of Chmela & Armstrong.[9]

REFERENCES

1 SUTTER, E. Radar-beobachtungen uber den Verlauf des nachtlichen Vogelzuges. *Rev. suisse Zool.*, **64**, 1957, p. 294.

2 TEDD, J. G. and LACK, D. The detection of bird migration by high-power radar. *Proc. Roy. Soc., London*, Series B, **149**, 1958, p. 503.

3 HARPER, W. G. ' Angels ' on centimetric radars caused by birds. *Nature, London*, **180**, 1957, p. 847.

4 ELDER, F. C. Some persistent ' ring ' angels on high-powered radar. Proc. Sixth Weather Radar Conf., Cambridge, Mass., 1957.

5 HARPER, W. G. Roosting movements of birds and migration departures from roosts as seen by radar. *Ibis, London*, **101**, 1959, p. 201.

6 HARPER, W. G., LUDLAM, F. H. and SAUNDERS, P. M. Radar echoes from cumulus clouds. Proc. Sixth Weather Radar Conf., Cambridge, Mass., 1957.

7 LACK, D. Swifts in a tower. Methuen, London, 1956.

8 LEACH, W. Observed characteristics of convective cell bands. Proc. Sixth Weather Radar Conf., Cambridge, Mass., 1957.

9 CHMELA, A. C. and ARMSTRONG, G. M. Observations of ' angels ' beneath convective clouds. Proc. Fifth Weather Radar Conf., Asbury Park, N.J., 1955.

Some Notes on the Desert Locust and on its Occurrence at Sea

By Z. WALOFF, M.SC.

(Anti-Locust Research Centre, London)

Following the appeals by the Anti-Locust Research Centre, London, for information on locust swarms seen at sea,* numerous records of such swarms have been reaching the Centre from the Desert Locust Survey in Nairobi, which receives signals from ships, and through the good offices of the Marine Division of the Meteorological Office, which sends us extracts from ships' logbooks on locusts and the corresponding weather. The ships' reports have added to our knowledge of swarm movements, and have often helped in the assessment of the current plague situations; they also raised some interesting problems relating to locust migrations. An attempt is made in this note to outline some results of recent investigations on the Desert Locust, and to indicate how the understanding of their migrations might be helped by further observations made at sea.

Most of the recent ships' reports have been concerned with the Desert Locust, a major plague of which has been in progress, almost without intermission, since 1941. An adult Desert Locust† is about 2½ inches long, with a wing-span of about 5 inches, and is rosy-red or brownish-red when immature and bright yellow when ready to breed. The females lay clusters of 50 to 100 eggs in moist soil; in favourable conditions these develop in about a fortnight, and the wingless " hoppers " which hatch out of them grow for four to five weeks and moult five times before they reach the winged adult stage. In the gregarious or swarming phase the adults

* *The Marine Observer* in 1951, Vol. 2 , no. 151, p. 61 and in 1955, Vol. 25, no. 168, p. 118.
† See photograph opposite p. 21.

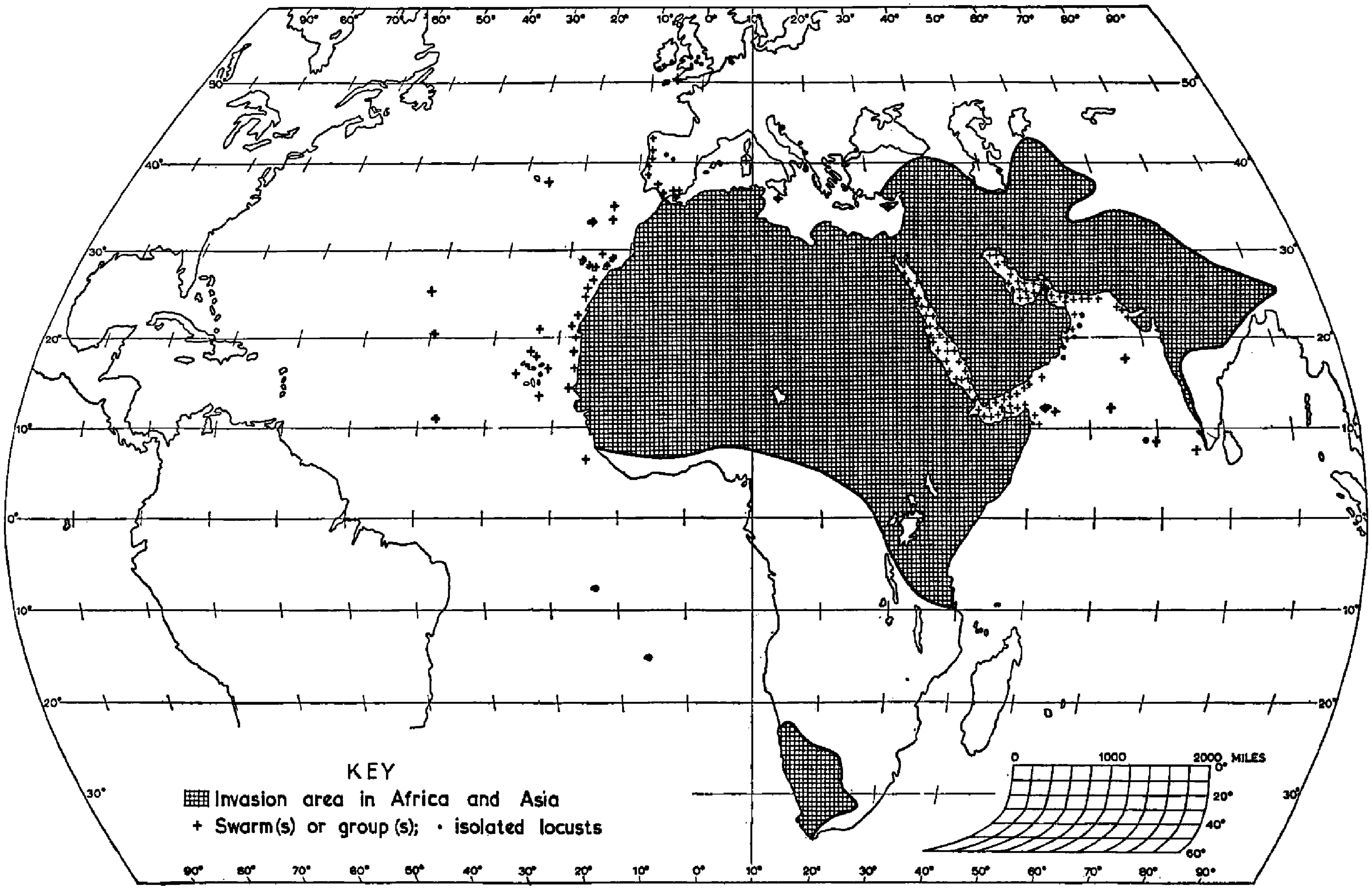


Fig. 1. Distribution of the Desert Locust.

form swarms which may vary in size from a few acres to more than a hundred square miles. The swarms usually roost by night and fly by day, when the height above ground to which they rise varies with the weather; in the absence of active convection they fly in sheet-like " stratiform " formations within less than a hundred feet above the ground, while in conditions of vigorous convection large swarms become " cumuliform " and may rise to great heights, with locusts flying at all levels between the ground and several thousand feet above it.[1] In spite of such effects of atmospheric turbulence, the swarms flying over land usually remain fully cohesive, with the locusts turning back into the swarm when they fly, or are blown, beyond its perimeter.[2]

Although the pastoral and agricultural people of the Middle East and Northern Africa have suffered depredations by the Desert Locust from earliest times, it is only recently that the range of its migrations and the extent of the invasion area have become known. The assembling together of all the swarm and breeding records was begun about thirty years ago, and the Anti-Locust Research Centre now receives regular monthly or weekly reports from all the territories invaded by this species. The scores of thousands of individual records received each year are systematically plotted and analysed, and have provided information on the seasonal distributions and movements of swarms, the location of the breeding areas, and the relative liability to invasions of different parts of the area.

The total area over which the Desert Locust has been recorded on land is illustrated in Fig. 1, which also shows the positions at which they have been seen in active flight on open seas, or coming to shore or flying out to sea. In Africa and Asia the invasion area covers more than 11 million square miles, and includes over sixty different territories; in Europe, Desert Locusts have occasionally reached the Mediterranean area and the British Isles.

The areas over which the Desert Locust is known to breed do not extend to Europe and occupy less than 50 per cent of the total invasion area. Over most of the latter the climate is dry, and unsuitable for breeding except during the rains, and breeding is restricted to the rainy seasons. Since these occur at different times of the year in different parts of the invasion area, most of the breeding areas can be grouped into two main zones: one, running from north-west Africa through the Middle East to Pakistan, in which locusts breed on the cyclonic spring rains, and the other, extending across Africa south of the Sahara from Senegal to the Red Sea, and eastwards through southern Arabia to Pakistan and India, in which breeding takes place in the second half of the year during the rains associated with the Intertropical Convergence Zone.

The young swarms originating in the seasonal breeding areas fly out of them on fledging and migrate towards the areas where they will breed in the following season. Thus there is seasonal exchange during the plagues between e.g. the areas to north and south of the Sahara, or between Arabia and African territories on the one hand and Arabia and India on the other. The outstanding characteristic of most of these movements is their great range; it is now known that Desert Locust swarms rarely breed close to their place of origin, and often traverse anything from 1000 to 3000 miles in a single generation. Many of the seasonal movements have been found to be in agreement with prevailing seasonal winds, and to change with them[3]; the directly downwind displacement of flying swarms has been demonstrated by means of aircraft observations on their hour-to-hour trajectories,[4] while the analysis of swarm distributions and migrations in relation to synoptic situations has led to the formulation of an illuminating hypothesis that swarms move towards and with the areas of convergent airflow.[5] Practical use is made of the accruing knowledge of the seasonal movements and breeding of the Desert Locust in the preparation of monthly forecasts of probable plague developments which are issued by the Centre, together with summaries of current situations, to all the countries subject to invasions. Since 1958 this branch of the Centre's activities has been designated the " International Desert Locust

Information Service ", and has been sponsored and partly financed by the Food and Agriculture Organisation of the United Nations.

Turning now to the records of Desert Locusts at sea, it will be clear from Fig. 1 that swarms often fly over the narrow seas around the Arabian Peninsula which lie across, or along, the main migration tracks; the frequency with which Desert Locusts fly in from the sea in this area is reflected in their Persian name of the " Sea Locusts ", and in the belief held in Arabia that they originate in the stomachs of whales.

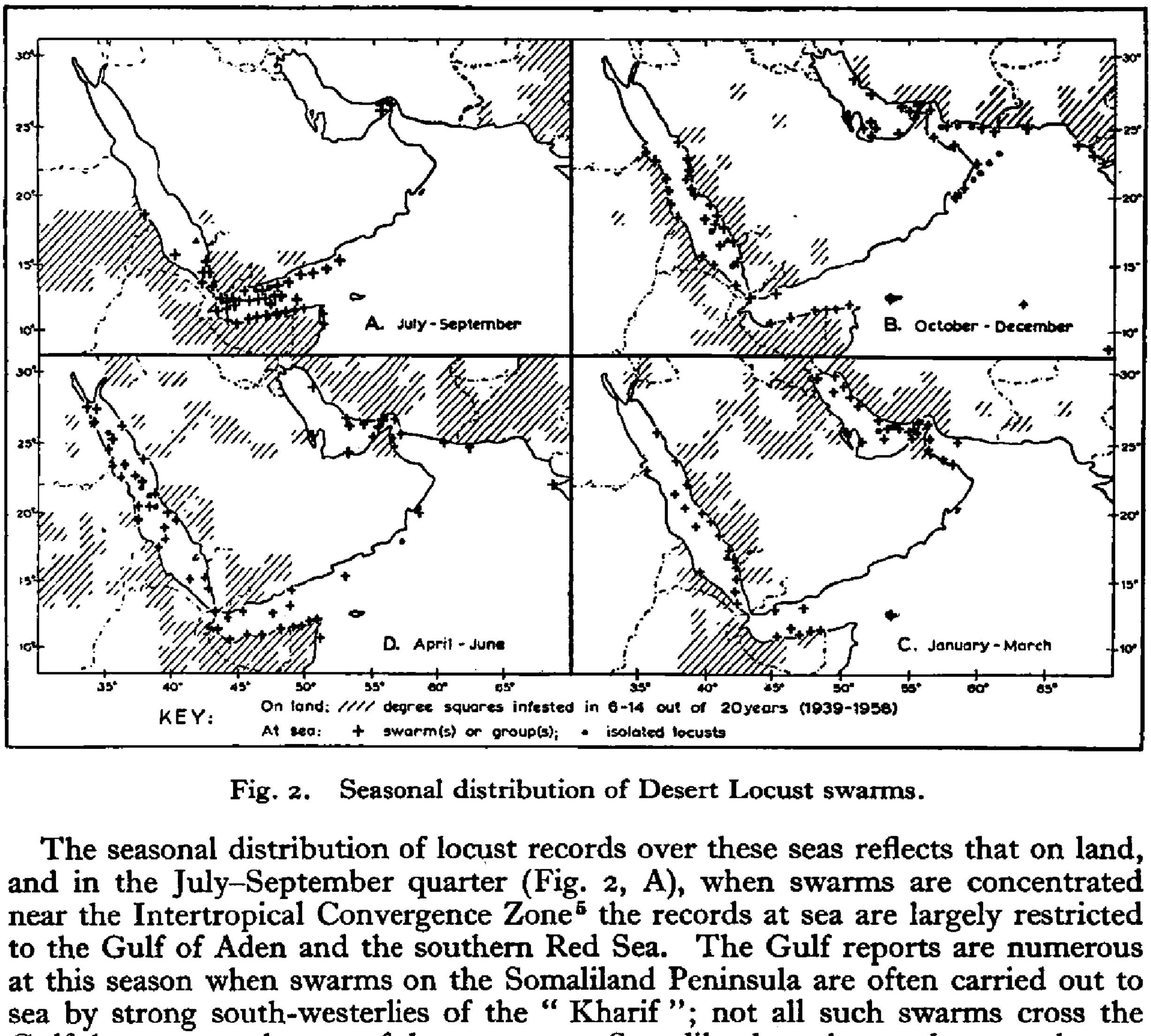


Fig. 2. Seasonal distribution of Desert Locust swarms.

The seasonal distribution of locust records over these seas reflects that on land, and in the July–September quarter (Fig. 2, A), when swarms are concentrated near the Intertropical Convergence Zone[5] the records at sea are largely restricted to the Gulf of Aden and the southern Red Sea. The Gulf reports are numerous at this season when swarms on the Somaliland Peninsula are often carried out to sea by strong south-westerlies of the " Kharif "; not all such swarms cross the Gulf, however, and some of them return to Somaliland on the on-shore sea-breeze developing in the afternoon.[6]

In the autumn and winter (Fig. 2, B and C) the Red Sea and the Gulfs are crossed by swarms originating in Africa and India and moving to the spring breeding areas in the Middle East, and in the spring and early summer (Fig. 2, D) by young spring swarms on their way to the summer areas. During these migrations the ships' reports of swarms signalled to Desloc Nairobi are sometimes the first intimations of an impending invasion, and are thus of help in planning the control operations. In addition, ships' reports of swarms or weather sometimes provide the only means of tracing swarm movements, particularly in areas where there is a dearth of land observations of either. For example, the examination of ships' weather reports in the western Arabian Sea for the period preceding a locust invasion of Socotra and north-eastern Somali Peninsula which occurred in mid-November 1952, demonstrated that the swarms arrived there down the north-easterly winds from southern Arabia, which had been reached by swarms from India at an earlier date.[7]

In view of the occurrence of such migrations, the complete absence to date of locust records from the western Arabian Sea south of 10°N. is puzzling, and the reports of any flights of locusts seen there would be of special interest. Another area with a surprising lack of locust reports, and from which they would be greatly appreciated, is the Mediterranean Sea.

In contrast to these areas, Desert Locusts are not infrequently seen flying over the eastern Atlantic, and have been recorded on many Atlantic Islands. The collection of the British Museum contains single specimens of the Desert Locust caught on St. Helena and Ascension Islands; these might have flown there from South Africa—or possibly have reached these islands on ships. Further north, groups of locusts or swarms have been reported, on various occasions, reaching the Cape Verde Islands, the Canaries, Madeira and the Azores, and there are several ships' reports of swarms encountered off the shores of Mauritania and Rio de Oro, and three records of groups of Desert Locusts landing on ships in mid-Atlantic, at distances of 1400 to 1500 miles from the African shores.* The majority of these records refer to October or November—i.e., to the period when swarms originating south of the Sahara are on the move towards north-western Africa, and may be carried out to sea by off-shore winds. The known incursions into western Europe have occurred at the same season, and on the two occasions which have been analysed, involved long flights over the Atlantic. Thus in October 1945 some swarms which had been blown out to sea by the off-shore winds in southern Morocco on 11th, reached Portugal with a strong southerly wind on 12th.[8] The other case occurred in October 1954, when following a period of off-shore winds from north-west Africa, numerous swarms appeared on the Canary Islands in the early hours of 15th. At the same time strong southerly winds were blowing over the eastern Atlantic, associated with a frontal zone crossing the British Isles; by the evening of 15th groups of flying locusts were seen from ships as far north as the latitude of Gibraltar, and on 17th, following a night in which the southerlies reached gale force at sea, some live locusts were picked up in the Scilly Isles and off the coast of Tramore in southern Ireland.[9]

While the distances traversed during these flights were not exceptional for the Desert Locust, they differed from the more usual long-range movements in their speed and particularly in the durations of continuous flight apparently involved. The long-range overland movements are usually spread over weeks, with swarms moving in a " rolling " manner—i.e., with individual locusts resettling and often feeding underneath the moving swarm, and the whole swarm traversing some 10 to 100 miles during the daily flight of 8 to 10 hours. In contrast to such behaviour, the estimated duration of the Morocco–Portugal, and the Canaries–British Isles flights were, respectively, about 24 and 60 hours. The latter figure appears greatly in excess of the probable possible duration of continuous flapping flight, which has been found to depend, among other things, on the reserves of fat in the locusts, the break-down of which provides them with the energy for flight. The amount of fat utilised in every hour of active flight has been estimated by laboratory studies[10] and the mean fat content of the fattest batch of swarming locusts so far sampled in the field would not have enabled them to fly continuously for very much more than some fifteen hours, though individual locusts may have differed considerably in this respect.

The way in which the very long flights over the sea are achieved is thus not clearly understood. Sustained flight for several hours in strong wind must often enable the swarms to cross the narrow seas around Arabia, though even here it is clear from frequent reports of floating locusts that they must often perish in large numbers during such flights. A favourable factor in this area might be the

* On S.S. *Harrisburg* at 25° 28′N., 41°33′ W. on 2.11.1865; the barque *Robert Scrafton* at 20° 50′N., 39° 28′W. on 7.10.1916; and H.M.S. *Manco* at 11°N. and between 37° and 38°W. on 29.10.1916.

numerous small islands dotting the Red Sea and Persian Gulf and providing locusts with resting places during their flights; another relevant factor might be the convective currents developing in some circumstances over the warm seas, and possibly enabling locusts to maintain height while gliding, as they often do during migrations over land.

An interesting possibility, and one which could perhaps help to explain some of the longer flights over the sea, might be temporary settling by the fliers on floating masses formed by their less fortunate fellows. This was said to have happened when swarms from Africa were invading Teneriffe in 1649,[11] but this old observation has never been verified. The formation of dense floating patches and drifts of locusts has, however, been mentioned in the ships' reports (notably in the Atlantic in October 1954); in parenthesis it might be added that since starving locusts are known to feed on other locusts, such floats, when formed by the still living insects, might enable them both to rest and to feed. It is very much hoped therefore, that in addition to the details which they have been entering in their logbooks on meeting locusts, marine observers will in future note particularly whether any fliers are seen alighting on, or taking off from, patches of locusts floating on the sea.

REFERENCES

[1] RAINEY, R. C. Some observations on flying locusts and atmospheric turbulence in eastern Africa. *Quart. J. R. met. Soc., London,* **84,** 1958, pp. 334–354.

[2] WALOFF, Z. The behaviour of locusts in migrating swarms. (Abs.) *Proc. Xth int. Congr. Ent., Montreal,* 1956, Vol. 2, 1958, pp. 567–569.

[3] WALOFF, Z. Seasonal breeding and migrations of the Desert Locust (*Schistocerca gregaria* Forskål) in eastern Africa. *Anti-Locust Mem., London,* No. 1, 1946.

[4] RAINEY, R. C. and SAYER, H. J. Some recent developments in the use of aircraft against flying locust swarms. *Nature, London,* **172,** 1953, pp. 224–228.

[5] RAINEY, R. C. Weather and the movements of locust swarms: a new hypothesis. *Nature, London,* **168,** 1951, pp. 1057–1060.

[6] RAINEY, R. C. and WALOFF, Z. Desert Locust migrations and synoptic meteorology in the Gulf of Aden area. *J. Anim. Ecol., Oxford,* **17,** 1948, pp. 101–112.

[7] POPOV, G. The Desert Locust (*Schistocerca gregaria* Forskål) in the island of Socotra. *J. Anim. Ecol., Oxford,* **28,** 1959, pp. 89–95.

[8] WALOFF, Z. A long-range migration of the Desert Locust from southern Morocco to Portugal, with an analysis of concurrent weather conditions. *Proc. R. ent. Soc., London,* (A), **21,** 1946, pp. 81–84.

[9] RAINEY, R. C. [Recent arrival of Desert Locusts in the British Isles] *Proc. R. ent. Soc., London,* (C), **19,** 1954, pp. 45–46.

[10] WEIS-FOGH, T. Fat combustion and metabolic rate of flying locusts (*Schistocerca gregaria* Forskål). *Phil. Trans., London,* (B), **237,** 1952, pp. 1–36.

[11] SLOANE, H. A Voyage to the Islands Madera, Barbados, Nieves, S. Christophers and Jamaica. 2 vols., London, 1707–1725.

PRESENTATION OF BAROGRAPHS

On 7th October, 1959, aboard the *Wellington,* headquarters ship of the Honourable Company of Master Mariners, Dr. J. M. Stagg, Director of Services of the Meteorological Office, presented barographs on behalf of the Director-General to three of the four shipmasters to whom the awards were notified in the last number of *The Marine Observer.* They were Captain H. N. Lawson, Captain F. Pover and Captain N. A. Thomas, all of the New Zealand Shipping Company. The fourth recipient, Captain L. J. Hopkins of the Shaw Savill Line, was at sea on this date and his barograph will be presented to him later.

This little ceremony was attended by several members of the Honourable Company, and representatives of the New Zealand Shipping Company and of the Meteorological Office. Sir Frederick Bowhill, Immediate Past Master, presided, and in introducing Dr. Stagg he mentioned how happy he was that ceremonies of this nature, so closely linked with the sea and the weather, should take place aboard the *Wellington.*

Before making the presentations, Dr. Stagg pointed out that despite modern scientific knowledge, it was often impracticable for the meteorologist to explain the vagaries of weather even in retrospect. He referred to the wet summer of 1958, when it was not infrequently asserted in the press and elsewhere that nuclear explosions were largely responsible for the bad weather. The Meteorological Office had consistently refused to subscribe to this idea, but its assurance that there was no scientific backing for such a belief was not helped by the fact that in the summer of 1959, which had long periods of continuous sunshine and a minimum of rain, there were no nuclear explosions, a fact which many people were not slow to observe.

The truth was that the complexity of the atmosphere and the number of factors that contributed to any one weather situation were so great that it became almost a matter of chance what kind of situation developed, and whether it was followed by a similar or different type of weather; almost a matter of chance, but not quite. Meteorologists would be defeatists if they believed that it was. They are examining all possible factors to see which are the dominant ones, and at the moment much attention is being given to the interchange of energy between the oceans and the atmosphere. Information from the oceans was particularly valuable because of the enormous effects they had upon the weather, and this was where the work of the voluntary observer at sea came in.

In presenting the barographs, Dr. Stagg thanked the recipients, not only for the meteorological work which they themselves had done when they were young officers, but also for the encouragement they were giving to the officers who were continuing this work today.

L. B. P.

AUSTRALIAN EXCELLENCE AWARD

The following information has been received from Mr. L. J. Dwyer, Director of Meteorology for Australia

Following the practice of previous years, the Australian Bureau of Meteorology has this year selected M.V. *Gorgon*, owners Messrs. Alfred Holt and Co., as the recipient of the Excellence Award as a recognition of the regularity and high standard maintained in carrying out the duties of a Selected Ship. The form of award again consisted of a suitably inscribed painting of an Australian scene together with a framed citation. The radio officer was presented with a book of Australian prose.

M.V. *Gorgon* plies between Western Australia and Singapore and reports from that vessel, allied with reports from other World Fleet Selected Ships, have on occasions been of inestimable value, especially during the cyclone season on the north-west coast of Australia. These reports also become doubly valuable when consideration is taken of overseas air routes from Australia to South Africa via Cocos Island, Australia–Djakarta and Australia–Singapore, where the sparsity of reports due to diverging shipping lanes creates quite a problem.

It is a matter of considerable gratification that the co-operation accorded by Selected Ships of all nations is still increasing. The number of reports received are increasing in a much greater proportion than increased fleet numbers would suggest.

A REPLY TO MANY LETTERS

As most of our readers know, we write each summer to the captains, principal observing officers and senior radio officers of the 100 ships whose meteorological logbooks were considered the best for the preceding year, telling them that they have merited Excellent Awards. It is always a pleasure to receive their replies, since it is not often that we in the Marine Division at Harrow can have personal contact with the captains and officers of the Voluntary Observing Fleet.

On reading through these replies, the one thing that stands out most is the evidence of the excellent teamwork which lies behind their successful observing. One captain wrote " the credit must go to my observing officers, who these days with the minimum of prodding become keen and efficient observing officers "; from an observing officer of one of the ' top ten ' ships we had a reminder that without the assistance of his fellow officers the job could never have been done; another observing officer, in referring to his particular ' team ', said, " We are all on different ships at the time of writing, but I feel sure that we are all doing our best wherever we are and will continue to do our best to help in this splendid service "; one radio officer mentioned that although he did not know the theory of meteorology too well, he found it all very interesting, and often had discussions with the observing officer on the subject; a radio officer of one of the ' top ten ' ships wrote, " We really organised ourselves into a team to get the most accurate and fastest reports away to the various ' Selected Stations '."

Many writers made a point of mentioning how interesting and useful they find their meteorological work. One observing officer said he really felt that " of all the paper work that seems to assume such a degree of importance these days, this is the only one that we seafarers get such an obvious amount of benefit from ". A captain affirmed that, " I personally have found much pleasure and satisfaction in being able, even in a small way, to contribute to such a worthy and indeed, indispensable work for the benefit of all sections of the public." Other observing officers said how useful their knowledge of meteorology was when they came to prepare for their masters' and mates' examinations.

We take this opportunity of thanking our correspondents for their interesting and encouraging letters, and of their expressions of good intentions for the future. We also wish to thank them for their help this year in completing their record forms, and putting in block capitals the addresses to which they wanted the awards sent—small things, perhaps, but much appreciated by those responsible for the despatch of the parcels.

M. V. R.

Book Review

Oceanography and Marine Biology, by H. Barnes. 8¾ in. × 5¾ in. pp. 218. *Illus.* George Allen & Unwin, Ltd., London, 1959. 35s.

The relationship between meteorology and oceanography is necessarily a close one; the truth of this was emphasised by Sverdrup in his *Oceanography for Meteorologists* and Maury has graphically dealt with the subject in his *Sailing Directions* published in 1858. The oceans occupy three-quarters of the world's surface and if there were no oceans it seems that there could be no aqueous vapour in our atmosphere and thus no rain. The beneficial effect which the oceans have in modifying world climate is enormous, and most depressions are born in an oceanic area. One of the more important basic problems now being studied—and this was given a lot of prominence during the I.G.Y.—is that of the interchange of energy between ocean and atmosphere. Students of meteorology, and of marine meteorology in particular, need therefore to be interested in the general subject of oceanography—not only at the surface, but in the depths.

In the introduction to *Oceanography and Marine Biology*, the author reminds us that oceanography is a cosmopolitan activity, embracing physics and applied mathematics (the study of the sea as a fluid in motion); geology (the study of sediment and rocks under the ocean); chemistry (the study of the chemical composition of the water sediments or living material); biology (the study of the living creatures of the oceans); and meteorology (the study of what happens at the air/sea boundary).

The meteorologist, in his study of the weather, is for ever trying to explore further into the atmosphere to try and find out more of its mysteries. In order to get information from great heights he has used balloons and aircraft and, more recently, rockets and artificial satellites. In *Oceanography and Marine Biology* the author sets out to tell us something of the complicated task that the oceanographer has in trying to get information about the physics and biology of the oceans at various depths and the large variety of ingenious and surprising instruments and apparatus which he has to use for this purpose.

The book is divided into four parts: Part 1 is entitled " Sampling the living organisms "; Part 2, " The use of sound waves "; Part 3, " Some properties of the water itself "; and Part 4, " Photography and television ".

Part 1 describes the methods and apparatus which the oceanographer uses to get samples of various forms of life ranging from plankton to relatively large fish, either from the surface waters or from the depths. Some of the apparatus described seems reminiscent of Heath Robinson or Emmett—but most of it appears to give effective results. The title of this part of the book is perhaps a little misleading, because it also deals with the complicated business of obtaining cores in order to study the composition of the sediment at the bottom of the ocean. Some of the coring instruments produce small samples of the upper layers of the deposit in order to study habits of burrowing animals—whereas other instruments can get cores of many feet in depth, from a study of which climatological and geological conditions of hundreds of thousands of years ago can be studied. Among the instruments for studying conditions near the surface, the " continuous plankton recorder " as used on behalf of the Ministry of Agriculture and Fisheries aboard the British ocean weather ships and aboard certain merchant ships, is discussed. The author not only describes the various instruments in use and their method of working but explains the scientific and economic reasons for making the observations. Here, as in other parts of the book, he reminds us that meteorology (temperature variation, sunlight intensity and rough weather) plays its part in the effect that it has upon conditions in the ocean itself and consequently upon various aspects of oceanography.

The oceanographical use of synoptic maps for showing distribution of fish population at various depths is mentioned.

In Part 2 the use of the echo sounder for various forms of oceanographical research is discussed.

Some interesting drawings and photographs are shown of bottom topography. The author then goes on to discuss the use of the echo sounder for the location of fish shoals, both for economic and scientific purposes, and he also discusses the mysteries of the famous deep scattering layer, the reason for which is not yet entirely solved. He gives some interesting details about underwater noises made by various inhabitants of the oceans, for example, the whistling noise made by whales and the snapping noise by shrimps in the Pacific. The author makes little mention of the use of explosives associated with " acoustic " buoys which has been rather widely used in association with research ships for studying the composition of the sea bed itself but perhaps that is outside the realm of oceanography.

In Part 3 details are given of the various instruments used by the oceanographer to obtain readings of the temperature and chemical composition of the water, at the surface and at great depths. The Lumby surface sampler, as towed from the British ocean weather ships when on passage to and from stations and from certain merchant ships in order to obtain temperatures in association with water samples near the surface, is among the instruments described. In this part of the book, a description is also given of various methods used by oceanographers to get detailed information about ocean currents at various depths. Even the humble drift bottle finds its place here. But most of this apparatus described implies that the ship or instruments needs to be anchored in order to get the result. A notable exception is the geomagnetic electrokinetograph, which measures water currents by their electromagnetic effect. Two special electrodes are towed astern of the ship and the potential differences between the electrodes due to water motion at right angles to the ship's course are measured, and some rather complicated subsequent calculations enable the surface current to be derived. This apparatus has been used with some success aboard oceanographical research ships.

In this section it seems a pity that no mention is made of the observations of surface currents of the oceans which have been regularly made for so many years aboard merchant ships and naval vessels of all nations, from which the Ocean Current Atlases have been compiled.

Part 4 is largely devoted to the use of aerial photography for studying bottom contours and wave formation in relatively shallow water, the use of underwater photography and the most recent innovation of under-water television in order to study the behaviour of various inhabitants of the ocean as well as bottom topography, etc.

The book is profusely illustrated with diagrams and photographs.

C. E. N. F.

Personalities

RETIREMENT.—CAPTAIN H. C. LARGE completed his last voyage with the Blue Funnel Line when the *Perseus* docked in Liverpool on 9th October last, and retired in December after nearly 34 years with the company.

Henry Charles Large first went to sea in 1916, serving his apprenticeship with the Furness Line, his first ship being the *Lexington*. He remained with this company until he obtained his Master's certificate in December 1925 when he joined the Blue Funnel Line, his first appointment being 3rd mate of the *Antenor*.

Passing through the usual grades, Captain Large was appointed to his first command, the *Glenogle*, in 1943. He subsequently commanded *Samjack*, *Glenapp*, *Menetheus*, *Bellerophon*, *Eumaeus* and *Perseus*.

During the 1939–45 war, whilst Chief officer of *Cyclops*, he was in the Narvik area during the intensive bombing, when only three ships survived the convoy. Later he was twice sunk by enemy aircraft, in the *Aeneas* in the Channel in 1940, and in the *Clytoneus* in 1941 in the North Atlantic.

Captain Large's record with the Meteorological Office dates back to 1929 when serving in *Theseus*. He has been observing for 12 years, in which period he has sent in 29 logbooks, 24 of which have been classed " excellent ". Captain Large received excellent awards in 1953, 1954, 1955 and 1958.

Captain Large is not severing his connection with the sea entirely, however, as he has been asked by the Shipping Federation to instruct on lifeboats to future seamen. We wish him health and happiness in his retirement from the sea, and success in his new appointment.

J. R. R.

OBITUARY.—Almost every deck officer who was at sea before 1939 is familiar with the name of CAPTAIN WILLIAM ELLERY—for he occupied the position of Principal Examiner of Masters and Mates from 1922 to 1939, when he retired. We regret to report Captain Ellery's death at Bridlington at the age of 85.

Captain Ellery served his time in the Brocklebank Line of sailing ships; he served over ten years in sail. He transferred to Brocklebank steam ships in 1900, his first command being the *Ameer*. He was in command for about six years, and joined the Board of Trade as an Examiner of Masters and Mates in 1910 and worked in that capacity at Hull, Aberdeen and Glasgow prior to his appointment as Principal Examiner.

When he was at sea Captain Ellery did some work as a voluntary observer for the Meteorological Office, between 1906 and 1908. Later, between 1925 and 1939, he was a member of the Meteorological Committee.

There is also a record in this office of Captain Ellery's father having been a voluntary observer in 1888 and 1889, when he was in the *Majestic* and *Holkar*.

C. E. N. F.

Notice to Marine Observers

METEOROLOGICAL NAVIGATION

In July 1959 we published the text of the first lecture on this subject given at Hamburg in 1956. It was hoped to continue the series in the present number, but lack of space has made it necessary to postpone this until the April number.

Fleet Lists

In the January 1959 number it was notified that the full fleet lists would only appear once a year (each July). Corrections to the 1959 fleet list are printed below.

HONG KONG (Information dated 5.10.59)

The following have been recruited as Selected Ships:

Name of Vessel	Captain	Observing Officers	Senior Radio Officer	Owners/Managers
Johore Bahru	J. L. Baines	U. C. de Burgh, Lo Man Shu, Ho Ying Hon.	Wong Ting Choy	Great Southern Steamship Co., Ltd.
Kweichow ..	A. Watson	R. A. Taylor, J. M. Wigham, J. F. Reilly.	J. P. Asome	China Navigation Co., Ltd.
Mui Hock ..	T. Hanson	O. Antonsen, A. Lervik.	Chan Suk Sze	Karsten Larssen & Co. (H.K.), Ltd.

The following ship has been deleted: *Yunnan*.

INDIA (Information dated 12.10.59)

The following have been recruited as Supplementary Ships:

Indian Strength (India S.S. Co., Ltd.)
Jalamudra (Scindia S.N. Co., Ltd.)
Jalapushpa (Scindia S.N. Co., Ltd.)

The following ships have been deleted: *Jalakrishna, Jalayamuna*.

MALAYA (Information dated 2.10.59)

The list of ships is the same as that published in the July 1959 number of *The Marine Observer*.

NEW ZEALAND (Information dated October 1959)

The following have been recruited as Selected Ships:

City of Auckland (Ellerman and Bucknall S.S. Co., Ltd.)
*Katea** (Union S.S. Co. of New Zealand, Ltd.)
*Koraki** (Union S.S. Co. of New Zealand, Ltd.)
*Waikare** (Union S.S. Co. of New Zealand, Ltd.)

The following ship has been deleted: *Kopua*.

* Formerly a Supplementary Ship.

GREAT BRITAIN (Information dated 13.10.59)

The following have been recruited as Selected Ships:

Name of Vessel	Date of Recruitment	Captain	Observing Officers	Senior Radio Officer	Owners/Managers
Alva Bay	16.7.59	K. Jones	T. Milles	—	Alva S.S. Co., Ltd.
Amber	30.4.59	T. Barry	J. McKinlay, W. Balmer	—	Gem Line, Ltd.
Araluen	31.3.59	R. Willcocks	P. Butcher, J. McWilliams, M. Dixon	J. McKernan	Trinder Anderson &Co., Ltd.
Bamburgh Castle	17.8.59	M. Doherty	A. K. Magrath, E. Rae, R. Johnson	D. Alder	W. A. Souter & Co., Ltd.
Bankura	11.9.59	D. C. Murison	R. Noel, H. B. Chambers, R. J. Mayor	R. A. Jacobs	British India S.N. Co., Ltd.
Birmingham City	27.4.59	F. R. Neil	T. Chappell, J. Eames, D. M. Wilton	A. Pilkington	Bristol City Line, Ltd.
British General	29.4.59	W. O. Armstrong	J. G. Harrison, J. A. Potter, R. Haworth	K. C. Mackay	British Tanker Co., Ltd.
Bulimba	8.4.59	W. E. Davies	M. C. S. Ranson, D. P. Whitton, N. K. Fogaley	J. D. G. S. Gallagher	British India S.N. Co., Ltd.
City of Melbourne	4.9.59	W. Nimmo	W. McGregor, H. Swinney, J. Swift	D. Sinclair	Ellerman Lines, Ltd.
Columbia Star	25.3.59	M. Bremberg	A. E. Jacobs, J. C. Farmer, E. C. Smith	P. Enrico	Blue Star Line, Ltd.
Edenmoor	4.9.59	N. Coubrough	M. Greig, A. Dyason, B. Wallace, —. Bradley	—	Furness Withy & Co., Ltd.
Farsistan	2.6.59	R. Connacher	I. L. C. Thomas, W. Mackenzie, R. C. Beck	K. Ducher	F. C. Strick & Co., Ltd.
Galway	14.8.59	E. J. Ridout	J. F. Holder, H. G. Chafer	—	Avenue S.S. Co., Ltd.
Glenpark	27.8.59	D. McKelvin	J. Johnstone, H. McDonald	M. J. Southern	J. & J. Denholm, Ltd.
Manchester Faith	12.6.59	J. L. McLaren	C. Spense, D. Gregson, T. V. Hancock	W. McPherson	Manchester Liners, Ltd.
*Meta**	21.8.59	A. D. McNab	T. A. Stewart, A. Wood, J. McLeod	A. Cherry	Glen & Co., Ltd.
Port Jackson	1.4.59	H. B. Conby	J. D. Cartmell, M. J. Davis, R. J. E. Clarkson	A. Harris	Port Line, Ltd.
Rushpool	8.6.59	C. Dixon	K. Harper, O. S. Ashcroft, J. E. Foreman	—	Sir R. Ropner & Co., Ltd.
Shropshire	6.4.59	H. B. Peate	J. Horn, F. Gurney, J. Beckett	R. Ferry	Bibby Bros. & Co.
Thelma	23.4.59	R. MacLachlan	J. McColl, J. Clarkson, I. Wallace	G. Glass	Glen & Co., Ltd.
Thistlemuir	15.5.59	L. H. Williams	R. E. Harvey, J. Piggott	—	Albyn Line, Ltd.
Umgazi	24.3.59	R. B. Linsley	G. R. Cooper, J. L. Catterall, A. C. Lamaletie, R. J. R. Rowe	W. Docherty	Bullard King & Co., Ltd.
Umgeni	21.5.59	R. R. Baxter	J. A. E. Lyon, M. T. Graham, I. W. Bannet	A. R. Cox	Bullard King & Co., Ltd.
Umzinto	13.4.59	F. H. S. Petherbridge	D. Stobbart, D. L'Estrange, C. Woomble	N. Birnie	Bullard King & Co., Ltd.
Welsh City	17.4.59	T. W. Piton-Davies	P. J. Harry, J. Vaughan, P. L. Lewis	A. S. Ferguson	Sir William Reardon Smith & Sons, Ltd.
*Zena**	26.6.59	L. W. Loose	A. Stoddart, A. Fotheringham, W. Steven	P. M. Driscoll	Glen & Co., Ltd.

* Formerly recruited as a coasting vessel (Marid Ship).

The following have been recruited as Supplementary Ships:

Anno	30.7.59	J. C. Cowie	R. Vickery	—	Mitchell & Rae, Ltd.
British Reliance	1.6.59	A. J. Lawson	L. Stevens, J. Clark, C. Lewis	J. O'Brien	B.P. Tanker Co., Ltd.
Garlinge	11.6.59	A. L. Wood	D. Rose, C. Ferguson, W. L. Jones	A. J. Morgan	Constants, Ltd.
Hawkinge	21.7.59	T. J. Lloyd	A. Ivanov, S. Williams, E. Livermore	R. H. Head	Constants, Ltd.
Lambtonian	12.6.59	W. Judge	T. E. Halliday, E. W. Welch, A. F. Slater	W. Dobbie	Stephenson Clark, Ltd.
Sandhoe	12.8.59	J. Gillen	J. Telford, W. Waugh, W. Fulthorpe	—	Sharp S.S. Co., Ltd.
Tana	9.7.59	D. S. Archibald	J. Nicholson, R. Hare	—	Chr. Salvesen & Co.

The following coasting vessels (Marid Ships) have been recruited:

Name of Vessel	Captain	Owners/Managers
Adriatic Coast	W. W. Lucas	Coast Lines, Ltd.
Princess Margaret	J. F. D. Hey	British Transport Commission
Starling	H. T. Griffith	General S.N. Co., Ltd.

GREAT BRITAIN (cont.)

The following skippers have been added to the Trawler Fleet List:

Skipper	Trawler Owners/Managers
L. Abbey	Kingston Steam Trawling Co., Ltd.
F. Bilton	Hudson Bros. Trawlers, Ltd.
P. Booth	Northern Trawlers, Ltd.
W. Fletcher	Lord Line, Ltd.
N. Fulstow	Kingston Steam Trawling Co., Ltd.
M. Hough	Thomas Hamling & Co., Ltd.
F. Lewis	Kingston Steam Trawling Co., Ltd.
H. Hart	Kingston Steam Trawling Co., Ltd.
P. May	Thomas Hamling & Co., Ltd.
F. Patterson	Northern Trawlers, Ltd.
A. Salter	Thomas Hamling & Co., Ltd.
J. Stones	Lord Line, Ltd.
W. Wood	Boyd Line, Ltd.

The following ships have been deleted: *Australind, Avonmoor, Baron Murray, Beecher Island, Blyth, Borthwick, British Purpose, California Star, City of Lichfield, City of Portsmouth, Clan Forbes, Clan Macrae, Clan Robertson, Cormain, Debrett, Edenfield, Empire Gaelic, Eskcliffe, Fresno City, Greenbatt, Hebble, Hilary, King William, Kohistan, Lanarkshire, Linguist, Melrose, Mirror, Montreal City, Nicania, Ocean Layer, Oilfield, Oronsay, Pacuare, Port Macquarie, Saxon Star, Southern Coast, Suffolk, Tarantia, Theliconus, Thule, Trevince, Tweed, Yarmouth Trader.*

PAKISTAN (Information dated 1.10.59)

The following has been added to the Selected and Supplementary Ships:

Fatehabad (Call Sign AQEM) (Pakistan S.N. Co., Ltd.).

The following have been recruited as Auxiliary Ships:

Name of Vessel	Call Sign	Owners
Al-Ahmadi	AQLB	Muhammadi S.S. Co., Ltd.
Chittagong City	AQEL	Chittagong Steam Corporation, Ltd.
Feronia	AQLF	East and West S.S. Co.
Iqbalbaksh	AQLE	United Oriental S.S. Co., Ltd.
Jehangirabad	AQEN	Pakistan S.N. Co., Ltd.
Mansoor	AQLA	East Bengal S.S. Co., Ltd.
Ocean Ensign	AQBZ	Trans-Oceanic S.S. Co., Ltd.
Pakistan Promoter	AQLC	Karachi S.N. Co., Ltd.
Safina-e-Barkat	AQLI	Pan-Islamic S.S. Co., Ltd.
Safina-e-Jamhooriyat	AQLD	Pan-Islamic S.S. Co., Ltd.

ADDENDUM

Though all ships' observations are plotted on the large chart at the Central Forecast Office, the reduction in the size of the chart to fit the pages of *The Marine Observer* has precluded us from plotting any more than a few of the ships' reports in Fig. 2 on page 24. We particularly regret the omission of a report from S.S. *Beaverlake*, Captain J. Soame, Rotterdam to St. John N.B., one of the first ships to send us a narrative of this storm.

At the time of the chart, *Beaverlake* was hove-to in 45°48′N., 40°32′W., in a wind from 310° estimated at 68 kt. Barometer 980.1 mb, air temp. 42°F.

METEOROLOGICAL OFFICE

Climatological and Sea-Surface Current Charts of the North Atlantic

(M.O. 615)

This new publication, which has been prepared in the Marine Division of the Meteorological Office, consists of monthly charts of meteorological and ocean current data covering the North Atlantic. The contents are based on the data contained in *Monthly Meteorological Charts of the Atlantic* (M.O. 483) and *Quarterly Surface Current Charts of the Atlantic* (M.O. 466), which were compiled from observations made aboard British voluntary observing ships between 1855 and 1939. Printed on a single sheet, 23 in. × 39 in., the new charts show wind-roses, ocean currents, ice limits, main shipping tracks, and, on small insets, mean air and sea temperatures, barometric pressure, visibility, and frequencies of gales and hurricanes. To avoid confusion between the various elements, three colours are used.

The advantage of these new charts to the navigator is that they combine on one sheet as much useful meteorological information as possible, together with the information about predominant surface currents, instead of having a separate chart for each element, as is done in the detailed climatological atlases.

Price 36s. the set (by post 37s. 2d.)
or, in folder, 37s. (by post 38s. 2d.)

Obtainable from
HER MAJESTY'S STATIONERY OFFICE
at the addresses on title page or through any bookseller

Meteorological Office (Marine Division) Atlases

The following are published by the Marine Division of the Meteorological Office and may be purchased from the bookshops of Her Majesty's Stationery Office at any of the addresses on the title page. Copies are available for reference by shipmasters and shipowners in the offices of Port Meteorological Officers.

Meteorological Atlases

Monthly Meteorological Charts of the Atlantic Ocean. M.O.483, 1948. (60°S–70°N, 80°W–40°E) 180*s.* (post 3*s.* 3*d.*)

Monthly Meteorological Charts of the Western Pacific. M.O.484, 1956. (60°S–60°N, 100°E–155°W) (16¾″×23¾″) 105*s.* (post 2*s.* 9*d.*)

Monthly Meteorological Charts of the Eastern Pacific. M.O.518, 1956. (60°S–60°N, 160°W–60°W) (17½″×24½″) 147*s.* (post 3*s.* 3*d.*)

Monthly Meteorological Charts of the Indian Ocean. M.O.519, 1952. (50°S–30°N, 20°W–120°W) (16½″×22½″) *Reprinting*

The above four atlases contain monthly charts of wind, barometric pressure, air and sea temperature, and all meteorological elements including some typical tracks of tropical revolving storms.

Monthly Sea Surface Temperatures and Surface Current Circulation of the Japan Sea and Adjacent Waters. M.O.M.447, 1944. (20°N–47°N, 110°E–150°E) (20″×17″) 7*s.* 6*d.* (post 9*d.*)

Monthly Sea Surface Temperatures of Australian and New Zealand Waters. M.O.516, 1949. (50°S–10°S, 100°E–180°) (19¾″×12¼″) 10*s.* (post 7*d.*)

Monthly Sea Surface Temperature of the North Atlantic. M.O.527, 1949. (30°N–68°N, 80°W–15°E) (19¾″×12¼″) 10*s.* (post 7*d.*)

Monthly Meteorological Charts and Sea Surface Current Chart of the Greenland and Barents Seas. M.O.575. (60°N–80°N, 30°W–120°E) 126*s.* (post 2*s.*)
This atlas contains a generalised surface current chart for the area and monthly charts of wind, barometric pressure, air and sea temperature, and all meteorological elements.

Current Atlases

Currents of the Indian Ocean. M.O.392, 1939. (50°S–30°N, 20°E–140°E) (30″×20″) 10*s.* (post 7*d.*)

South Pacific Ocean Currents. M.O.435, 1938. (60°S–0°, 140°E–70°W) (22″×34″) 12*s.* 6*d.* (post 1*s.*)
The above two atlases contain quarterly "current arrow" and "current rose" charts.

Quarterly Surface Current Charts of the Atlantic Ocean. M.O.466, 1957. (60°S–70°N, 80°W–20°E) (22½″×18″) 32*s.* 6*d.* (post 1*s.* 6*d.*)

Quarterly Surface Current Charts of the Western North Pacific Ocean with monthly chartlets of the China Seas. M.O.485, 1949. (0°–60°N, 98°E–160°W) (21″×16″) 25*s.* (post 11*d.*)
The above two atlases contain current rose charts, predominant current charts, and vector mean current charts.

Ice Atlases

Monthly Ice Charts of the Arctic Seas. M.O.M.390a, 1944. (60°N–80°N, 80°W–110°E) (12″×7″) 3*s.* 6*d.* (post 5*d.*)
Polar ice, mean limits of sea ice, extreme limits of sea ice, extreme limits of bergs.

Monthly Ice Charts of Western North Atlantic. M.O.478, 1944. (37°N–53°N, 72°W–35°W) (12″×7½″) 4*s.* (post 7*d.*)
Mean limits of pack, extreme limits of pack, mean limits of bergs, extreme limits of bergs.

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