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ROYAL OBSERVATORY, HONG KONG

TECHNICAL NOTE NO. 67

WATERSPOUTS NEAR HONG KONG

By

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SUMMARY

Waterspout statistics for the years 1959 to 1982 within 250 nautical miles of Hong Kong are presented and analysed. The formation, life-cycle and structure of waterspouts are described. The factors responsible for the damaging effects of waterspouts are provided. A summary of forecasting hints for use by forecasters is finally given.

CONTENTS

	page
SUMMARY	iii
FIGURES	vi
TABLES	ix
INTRODUCTION	1
STATISTICS OF WATERSPOUTS NEAR HONG KONG	2
FORMATION, LIFE-CYCLE AND STRUCTURE OF WATERSPOUTS	4
WATERSPOUT REPORTS AND FORECASTING HINTS	7
ACKNOWLEDGEMENT	9
REFERENCES	10

CONTENTS

	page
SUMMARY	iii
FIGURES	vi
TABLES	ix
INTRODUCTION	1
STATISTICS OF WATERSPOUTS NEAR HONG KONG	2
FORMATION, LIFE-CYCLE AND STRUCTURE OF WATERSPOUTS	4
WATERSPOUT REPORTS AND FORECASTING HINTS	7
ACKNOWLEDGEMENT	9
REFERENCES	10

FIGURES

	page
1. Waterspout observed on 29 August 1952 off Cape Rachado (Sequence No. 1)	23
2. Waterspout observed on 29 August 1952 (Sequence No. 2)	23
3. Waterspout observed on 29 August 1952 (Sequence No. 3)	24
4. Waterspout observed on 29 August 1952 (Sequence No. 4)	24
5. Waterspout observed on 16 July 1968 off Palawan (Sequence No. 1)	25
6. Waterspout observed on 16 July 1968 (Sequence No. 2)	25
7. Waterspout observed on 16 July 1968 (Sequence No. 3)	26
8. Radar picture at 0700 GMT on 16 July 1968 taken on board S.S. Ho Sang (Rings at 5 nautical mile intervals)	26
9. Funnel cloud observed on 16 July 1968	27
10. Waterspout (A) observed on 22 February 1969 in the South China Sea	27
11. Waterspout (B) observed on 22 February 1969	27
12. Waterspout observed on 26 April 1969 in the South China Sea (Sequence No. 1)	28
13. Waterspout observed on 26 April 1969 (Sequence No. 2)	28
14. Waterspout observed on 26 April 1969 (Sequence No. 3)	28
15. Waterspout observed on 19 September 1959 over Hong Kong waters	29
16. Waterspout observed on 30 September 1973 in Lung Ha Wan (Sequence No. 1)	29
17. Waterspout observed on 30 September 1973 (Sequence No. 2)	30
18. Waterspout observed on 30 September 1973 (Sequence No. 3)	30

FIGURES (CONTINUED)

	page
19. Waterspout observed on 30 September 1973 (Sequence No. 4)	30
20. Waterspout observed on 30 September 1973 (Sequence No. 5)	31
21. Waterspout observed on 11 May 1975 in West Lamma Channel	31
22. Waterspout observed on 6 August 1975 off Tai O	31
23. Double spouts observed on 11 July 1978 off Lung Kwu Chau (Sequence No. 1)	32
24. Waterspout observed on 11 July 1978 (Sequence No. 2)	32
25. Geographical distribution of waterspouts/funnel clouds sighted in or near Hong Kong	33
26. Monthly distribution of days with waterspouts (based on 24 waterspout-days in 1959-82)	34
27. Diurnal variation of occurrence of waterspouts (based on 26 reports in 1959-1982)	35
28. Tephigrams for waterspout occurrences on 19 September 1959, 4 June 1972, 21 July 1972 and 30 September 1973	36
29. Tephigrams for waterspout occurrences on 11 May 1975, 19 June 1975, 29 June 1975, 6 August 1975 and 20 June 1976	37
30. Tephigrams for waterspout occurrences on 21 May 1977, 26 June 1978, 27 June 1978 and 11 July 1978	38
31. Tephigrams for waterspout occurrences on 15 September 1978, 18 October 1980, 27 June 1981 and 18 August 1982	39
32. Weather chart for 0200 HKT 19 September 1959	40
33. Weather chart for 0200 HKT 25 May 1965	41
34. Weather chart for 0200 HKT 16 July 1968	42
35. Weather chart for 0200 HKT 18 September 1970	43
36. Weather chart for 0200 HKT 4 June 1972	44
37. Weather chart for 0200 HKT 21 July 1972	45

FIGURES (CONTINUED)

	page
38. Weather chart for 0200 HKT 30 September 1973	46
39. Weather chart for 0200 HKT 11 May 1975	47
40. Weather chart for 0200 HKT 19 June 1975	48
41. Weather chart for 0200 HKT 29 June 1975	49
42. Weather chart for 0200 HKT 6 August 1975	50
43. Weather chart for 0200 HKT 20 June 1976	51
44. Weather chart for 0200 HKT 21 May 1977	52
45. Weather chart for 0200 HKT 28 April 1978	53
46. Weather chart for 0200 HKT 26 June 1978	54
47. Weather chart for 0200 HKT 27 June 1978	55
48. Weather chart for 0200 HKT 11 July 1978	56
49. Weather chart for 0200 HKT 15 September 1978	57
50. Weather chart for 0200 HKT 18 October 1980	58
51. Weather chart for 0200 HKT 19 March 1981	59
52. Weather chart for 0200 HKT 10 May 1981	60
53. Weather chart for 0200 HKT 27 June 1981	61
54. Weather chart for 0200 HKT 13 August 1982	62
55. Weather chart for 0200 HKT 18 August 1982	63
56. Radar picture at 0701 GMT on 27 June 1978	64
57. Radar picture at 0717 GMT on 27 June 1978	65
58. Radar picture at 0732 GMT on 27 June 1978	66
59. Radar picture at 0748 GMT on 27 June 1978	67
60. Radar picture at 0803 GMT on 27 June 1978	68
61. Estimated tracks of waterspouts reported on 27 June 1978	69
62. Radar picture at 0100 GMT on 28 April 1978	70
63. Radar picture at 0800 GMT on 15 September 1978	70
64. RHI radar picture at 0738 GMT on 15 September 1978	71
65. Radar picture at 1104 GMT on 13 August 1982	71

TABLES

	page
1. WATERSPOUTS (INCLUDING FUNNEL CLOUDS) SIGHTED WITHIN 250 NAUTICAL MILES OF HONG KONG OVER THE SEA DURING 1959-82	11
2. HONG KONG 0000 GMT RADIOSONDE DATA NEAREST TO THE TIMES OF OCCURRENCE OF THE WATERSPOUTS OR FUNNEL CLOUDS	13
3. ESTIMATED SURFACE CONDITIONS DURING THE OCCURRENCE OF THE WATERSPOUTS OR FUNNEL CLOUDS	22

1. INTRODUCTION

A waterspout is an intense columnar vortex of small horizontal extent which occurs over a body of water, usually containing a rotating funnel cloud extending from the base of a cumulus congestus cloud or cumulonimbus to a water surface. When a tornado which developed overland moves over water, the associated funnel cloud can also be termed a waterspout.

Waterspouts are known to exist in many parts of the world, for example, in the lower Florida Keys (Golden 1973, 1977), the Bahamas (Peterson 1978), the Mediterranean (Gordon 1951), the coastal waters of Japan (Fujita et al 1972), the English Channel (Stevens 1976), the Hawaiian Islands (Schroeder 1977), the China Seas, the Indian Ocean and Australian waters. Voluntary Observing Ships recruited by the Royal Observatory, Hong Kong had reported a number of waterspouts in the South China Sea and the Malacca Strait.

As illustrations, six waterspout events reported by Hong Kong Voluntary Observing Ships S.S. Pakhoi, Jagjiwan, Ho Sang, Eastern Maid and Asianjade on 29 August 1952, 26 December 1965, 16 July 1968, 22 February 1969/26 April 1969 and 20 July 1981 respectively will be described in Section 2, together with statistics of waterspouts known to have existed within 250 nautical miles of Hong Kong. In Section 3, the formation, life-cycle and structure of the waterspouts will be described. The detection and forecasting of waterspouts will be further discussed in Section 4.

Hong Kong Time (GMT + 8) is used in this publication unless otherwise specified.

2. STATISTICS OF WATERSPOUTS NEAR HONG KONG

Firstly, six waterspout events reported by Hong Kong Voluntary Observing Ships are described.

Figures 1-4 taken by Captain G.T.M. Ramsay of the S.S. Pakhoi show a time sequence of a waterspout which developed over the Malacca Strait 10 nautical miles north of Cape Rachado on 29 August 1952. The spout was well-organized and lengthy but bent as a result of vertical wind shear. The surface spray and the confused sea at the base of the spout were clearly visible.

On 26 December 1965, S.S. Jagjiwan sighted a waterspout off the coast of southern Vietnam near 8.2N 109.5E. It formed at 0500 GMT and reached maximum intensity at 0520 GMT, moving eastwards. At 0540 GMT, it dissipated. The vessel encountered heavy showers immediately after the event.

Captain R.G. Macdonald of the S.S. Ho Sang reported a detailed account of a waterspout (Figures 5-7) and another funnel cloud (Figures 8-9) off the Philippine island Palawan near 11.8N 119.4E on 16 July 1968. The waterspout developed from a large cumulonimbus at 0554 GMT on port bow at a distance of 19 nautical miles. It reached maturity at 0600 GMT with a diameter of about 10 m. At 0606 GMT, the spout commenced retracting and by 0610 GMT had completely dissipated. The wind at 0600 GMT was 150 degrees 10 knots, the air temperature 29.5°C, the wet bulb temperature 26.6°C, the sea surface temperature 30.5°C, the pressure 1009.0 mbar and the cloud base at 600 m. At 0700 GMT, another cumulonimbus was detected by radar at about 8 nautical miles on port beam (Figure 8). At this time, although no well-defined hook-echo could be seen on radar, there were definite signs of a sharp curvature developing at bearing 295 degrees. By 0726 GMT, a funnel cloud had formed (Figure 9). Although the sea below was disturbed at one time, this funnel cloud never descended far enough to reach the surface. At 0734 GMT, it dissipated.

S.S. Eastern Maid documented the simultaneous occurrence of several waterspouts over the South China Sea near 13.9N 118.2E on 22 February 1969 during the period between 0355 and 0435 GMT. Captain R.G. Macdonald reported that at about 0400 GMT, the vessel passed between spout "A" (Figure 10) and another spout 3 nautical miles southward. Then spout "B" (Figure 11) was observed forming astern. As it grew, the water spray reached about 12 m high. The wind at 0400 GMT was 060 degrees 13 knots, the air temperature 28.0°C, the wet-bulb temperature 24.1°C, the sea surface temperature 27.0°C, the pressure 1011.7 mbar and the cloud base at about 630 m. This same vessel reported the sighting of multiple spouts again in the South China Sea near 14.6N 118.0E at 0124 GMT on 26 April 1969. The development of one of the waterspouts sighted is shown in Figures 12-14. In Figure 14, the spout had developed a hollow structure within and the spray reached a maximum of 27 m. At 0145 GMT, the vessel passed through its base, at which time the spout had already retracted from the surface but the spray height was still up to 7 m and gusts were 30 knots.

S.S. Asiajade observed a narrow waterspout at 0800 GMT on 20 July 1981 in the South China Sea off the west coast of Luzon near 14.7N 120.0E.

Table 1 shows a summary of the waterspouts (including funnel clouds which did not descend far enough to reach the water surface) known to have existed within 250 nautical miles of Hong Kong during the years 1959 to 1982. These statistics therefore do not include those waterspouts reported by fishermen or ships in the South China Sea beyond Hong Kong's weather radar range. Waterspout statistics are very much biased by population distribution, shipping routes, flight paths and people's awareness of the phenomenon and their willingness to report. Photographs showing waterspouts occurring in or near Hong Kong are given in Figures 15-24.

Data previous to 1959 were extremely scanty and incomplete. The only record known to the author is a waterspout sighted off Cape d'Aguilar on 29 September 1930 when a typhoon was centred about 200 nautical miles southwest of Hong Kong.

Table 1 shows that the number of waterspouts sighted in or near Hong Kong could be as high as 8 per year (occurring on as many as 5 days), such as in the case of 1978.

Figure 25 shows the geographical distribution of the occurrence of waterspouts. It appears that there are no preferential geographical locations over which they occur.

A histogram depicting the monthly distribution of waterspout occurrence is shown in Figure 26. It is obvious that they occur mainly during the rainy season from May to September when the sea surface temperature, air temperature and moisture content are sufficiently high. The maximum frequency of waterspout-days occurs in June.

The diurnal variation of the occurrence of individual waterspouts is shown in Figure 27. The frequency of occurrence attains its maximum in the morning between 00 and 01 GMT when the showery activity associated with the summer monsoon attains its maximum. There is also a secondary peak shortly after local noon between 05 and 06 GMT when the surface air temperature reaches its highest value. There were very few (only one) nocturnal occurrences reported, despite that they could sometimes be illuminated by moonlight or the phosphorescence emitted by sea organisms drawn into the sea spray.

3. FORMATION, LIFE-CYCLE AND STRUCTURE OF WATERSPOUTS

In order to understand the mechanism for the formation of waterspouts, it would be necessary to study the prevailing surface and upper-air meteorological conditions. Table 2 shows the Hong Kong 00 GMT radiosonde ascents nearest to the times of occurrence of those waterspouts that formed within or very close to Hong Kong territorial waters. (Note : A fixed time was deliberately chosen so that the data could be used for comparative and composite studies. 00 GMT was used because 70 per cent of the waterspouts occurred within 6 hours of 00 GMT.)

Using the data from Table 2 and 3, the tephigrams for the upper-air ascents up to 500 mbar have been plotted. They are shown in Figures 28-31. (It should be noted that the ascents were made at King's Park which is overland and more than 60 m above mean sea-level. Thus the low-level temperature-dew point profiles were not necessarily the same as those near the sea surface. Also the ascents could have changed if the time of occurrence of the waterspout was not near 00GMT). In all the cases, the lower atmosphere was convectively unstable and any parcel of air near the sea surface would be lifted by virtue of the buoyancy and cumulus congestus clouds or even cumulonimbi would form. Under these conditions, any positive vorticity that might be present would be intensified and the rotation of constituent meso-cyclones (composed of one or more cumulus congestus or cumulonimbus clouds) in the weather system would be enhanced. Because of the liberation of latent heat in the condensation process and hence the warming in the cumulus area, the pressure immediately underneath a meso-cyclone becomes lower than that of the surroundings. Moist air spiralling in adiabatically at low levels becomes cooled as a result of the pressure reduction and a rotating funnel composed of water droplets formed by condensation develops. Usually a single waterspout is found under a meso-cyclone but sometimes multiple spouts occur under one parent. Vortex splitting is in fact a nonlinear boundary-induced instability (Jischke and Parang 1974). When the swirl ratio (which is the ratio of tangential speed to vertical speed) reaches a certain critical value, the single vortex system becomes dynamically unstable as its torque exceeds the angular momentum supplied. It would then split into double, triple or multiple vortices. The waterspouts observed on 27 June 1978 and 11 July 1978 are good examples of such multiple vortices.

Golden (1974b) has shown that the following five scales of atmospheric motion are involved in the formation of waterspouts: funnel, spiral, cumulus, cloud-line and synoptic scales. The diameter of a funnel is about 3 to 150 m. The spiral scale which marks the size of the low-level inflow varies from 150 m to 1 km. The cumulus scale (1 to 10 km) and cloud-line scale (10 to 200 km) of motion are detectable by radar and high resolution satellite imageries. The synoptic scale structure and pattern can be studied by the use of weather charts.

Figures 32-55 are the surface charts at 18 GMT on the days of occurrence of the waterspouts. It can be seen that out of the twenty-four waterspout occasions, the major system that provided synoptic scale vorticity was the trough of low pressure. There were also three cases in which tropical cyclones were involved and two in which cyclonic summer monsoonal flow was held responsible.

Ludlam (1980) made a distinction between the intense waterspouts with heavy weather and the relatively harmless fair-weather waterspouts which develop from cumulus clouds. Based on the descriptions of waterspout events in Table 1 and the corresponding weather charts (Figures 32-55), it is found that about half of the waterspouts that occurred in or near Hong Kong belong to the fair-weather type while the other half are intense ones.

The life-cycle of a triple-spout system that occurred on 27 June 1978 will now be described. The system had been thoroughly investigated by C.Y. Lam of the Royal Observatory Hong Kong and the following is an excerpt from his report :

" On 27 June 1978, a phenomenon, which eyewitnesses described as a 'whirlwind', crossed the cableway of the Ocean Park at about 4.07 p.m. (0807 GMT). The rope was dislodged from the rope catcher at trestle No. 12 and one cablecar got entangled in the trestle. The sunshade cap of another cablecar 40 m away was removed during the event.

From 8.00 a.m. onwards, frequent showers affected various parts of Hong Kong. A radar photograph taken at 3.01 p.m. showed the distribution of showers within 30 nautical miles of Hong Kong (Figure 56). Between 3.01 p.m. and 3.32 p.m., three showers originally situated about 20 nautical miles southeast of the radar site (Tate's Cairn) merged into a line structure typical of a squall-line (Figures 57-58). This development was indicative of the intensification of the system.

At about 3.30 p.m. a waterspout was observed to form about 2 nautical miles south of the Satellite Earth Station at Stanley. This waterspout moved north and landed near one of the satellite reception aerials at around 3.50 p.m. (Figure 59) and then probably dissipated. However, other sighting reports suggested that another waterspout moved from Bluff Point northwestward to Chung Hom Kok and then crossed Chung Hom Wan to Tau Chau and beyond at around 4.00 p.m. Several eyewitnesses claimed that the cablecars had already stopped operating while this waterspout was still over water outside Repulse Bay. Therefore, this was not the waterspout that affected the Ocean Park. A third waterspout which affected the ropeway was observed by several Ocean Park employees a few minutes after 4.00 p.m. just off the coast (about 200-300 m) east of the ropeway (Figure 60). Based on eyewitness descriptions, the waterspout was at its dissipating stage. It disappeared within 15 seconds after reaching the coast. The diameter of the visible part of the first waterspout was estimated to be about 150 m. For the other two waterspouts, the diameters were estimated to be about 10 m or more. It appeared that at least three waterspouts were present between 3.30 p.m. and 4.05 p.m. Their estimated tracks are shown in Figure 61. "

The line structure shown in Figures 57-58 is the parent meso-cyclone from which the triple spouts developed.

This report, the observations in Table 1 and the descriptions given in Section 2 on waterspouts reported by the Hong Kong Voluntary Observing Ships have confirmed that the life-cycle of waterspouts in this part of the world is very much similar to that found by Golden (1974a) over the U.S. East and Gulf coasts. Golden showed that waterspouts have a characteristic life-cycle consisting of five discrete but overlapping stages : 1) the dark spot, a prominent light-coloured disc on the sea surface surrounded by a dark patch, diffuse on its outer edges, which represents a complete vortex column from cloud base to sea surface; 2) the spiral pattern, the primary growth phase of the waterspout, characterised by alternating dark- and light-coloured surface bands around the dark spot; 3) the spray ring (incipient spray vortex), concentrated around the dark spot, with a lengthening funnel above; 4) the mature waterspout (spray vortex), the stage of maximum overall organization and intensity; and 5) the decay stage, when waterspout dissipation (often abrupt) is initiated by cool downdrafts from a nearby developing rain shower. It should be noted, however, that not all waterspouts would go through all the five stages.

Data from Tables 1, 2 and 3 indicate that the average life-span of waterspouts near Hong Kong is about 10 minutes, the shortest lasting about 1 minute and the longest 35 minutes. The length of the spout varies from about 60 to 340 m. The sea surface temperature is probably $\geq 19^{\circ}\text{C}$, the air temperature $\geq 20^{\circ}\text{C}$ and the surface mixing ratio ≥ 14 g/kg. Thunderstorms sometimes accompany waterspout occurrence and the frequency of such events is about 25 per cent.

Unlike tornadoes which are usually associated with baroclinic synoptic-scale disturbances with strong vertical wind shear, waterspouts are, more often than not, found in weak quasi-barotropic disturbances with weak vertical wind shear (see upper-air wind data in Table 2). Because of the small size of the spout, the wind around it obeys the cyclostrophic relationship. In U.S. waterspouts, maximum tangential winds of 85 m/s have been measured by photogrammetric techniques (Golden 1977). The rotation of the wind is normally cyclonic but Leverson et al (1977) had identified a few anticyclonic waterspouts. They also found, based on aircraft measurements, that waterspouts are warm-cored with central temperature exceeding that of the environment by about 0.3°C . The pressure deficit is about 1-10 mbar and upward velocity at the periphery of the warm core is of the order of 5-10 m/s.

4. WATERSPOUT REPORTS AND FORECASTING HINTS

Waterspouts can cause casualties and damage. The waterspout that occurred on 28 April 1978 killed five people off Macau and that on 27 June 1978 at the Ocean Park caused the dislodgement of a cablecar rope and a sunshine cap of a nearby cablecar. The one on 10 May 1981 sank 27 boats near 21N 111E and killed 52 fishermen with 11 missing. Although the waterspout on 18 August 1982 did not cause any casualties, it lifted at least 14 containers (2 tons each) and blew away part of a rooftop, a temporary structure and some glass windows, posing a hazardous threat to human life and property.

The damaging effects of waterspouts are mainly due to the following : (1) gale, storm or hurricane force tangential winds and severe gusts; (2) 5-10 m/s upward velocity, followed by a downdraft of almost equal intensity after the passage of the spout (the time separation depends on the size of the warm core and the speed of movement of the waterspout); (3) suction caused by the pressure deficit; (4) deluge of water brought by the spout; (5) rough seas; and (6) the occasional thunderstorm activity (including lightning and chance of hail).

Nowadays with more and more people engaging in yachting and fishing, in low-level flying, in off-shore engineering and various other kinds of coastal activities, there is a greater need for people to be aware of the possible occurrence of waterspouts and their damaging effects. In order to mitigate damage caused by waterspouts, detection must be reliable, reporting promptly made, warning timely issued and disseminated, and precautions and response instantly taken.

The weather radar has been cited as a useful tool for detecting waterspouts which should give characteristic echoes in the shape of hooks or crescents (this unfortunately is not a sufficient condition). The doppler radar is even more suited for the purpose because the low-level circulation can be detected as well. Figures 58-60, 62-63 and 65 are all PPI radar photographs taken close to the times of occurrence of waterspouts. Figure 64 is a RHI picture depicting the cross-section of the parent cumulonimbus which gave rise to the waterspout at Tsim Bei Tsui on 15 September 1978. Although some curvature can be seen on the waterspout-bearing echoes, it is in general very difficult to correctly identify the signature for waterspout formation or to locate exactly where a waterspout actually is.

Visual observation therefore remains the best and most reliable method in identifying and locating waterspouts and in this connection any sighting by anyone anytime should immediately be reported to the Central Forecasting Office of the Royal Observatory (Tel. 3-7329472). Details, including the time, location, its life-span, estimated length and tilt of the spout, the extent of the disturbed sea and height of the sea sprays, any damage caused, the movement of the whole system, whether the rotation of the winds is cyclonic or anticyclonic and whether there are any accompanying thunderstorms would be extremely valuable. One should note that a spiral pattern with a dark spot on the sea surface could signify the presence of a waterspout although the funnel cloud does not extend to the water surface. With these reports, the duty forecaster would then be in a position to relate the information to the radar, satellite and other observations to produce warnings to the public.

In this technical note, a number of conditions favourable for the formation and development of waterspouts have been discussed. For ease of reference, the following is a summary of the useful hints for the forecaster :

- 1) Occur mainly from May to September with a peak in June ;
- 2) Diurnal maxima at 00-01 GMT and 05-06 GMT ;
- 3) Lower atmosphere convectively unstable ;
- 4) Presence of cumulus congestus or cumulonimbus clouds, detectable by radar ;
- 5) Presence of synoptic scale vorticity, e.g. trough, tropical cyclone, cyclonic summer monsoonal flow ;
- 6) Sea surface temperature $\geq 19^{\circ}\text{C}$;
- 7) Air temperature $\geq 20^{\circ}\text{C}$;
- 8) Mixing ratio of surface air ≥ 14 g/kg ;
- 9) Presence of hook- or crescent-shaped signatures on the radar.

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TABLE 1. WATERSPOUTS (INCLUDING FUNNEL CLOUDS) SIGHTED WITHIN 250
NAUTICAL MILES OF HONG KONG OVER THE SEA DURING 1959-1982

Case	Date (Local)	Type*	Location	Description	Report by
1)	19 Sep 59	W	Hong Kong waters	0930 GMT. Fig. 15	J.W. Devonshire
2)	25 May 65	W	Macau waters	2335 GMT; lasted 3-4 min.; greyish- black; slanting towards N; moving N; sea spray severe; heavy rain afterwards	Newspaper
3)	16 Jul 68	FC	19.1 N 113.6 E	0520 GMT	S.S. Straat- magelhaven (PHTW)
4)	18 Sep 70	FC	Haikou waters	0756 GMT; lasted 7 min.; thundery showers	Chinese Cloud Atlas 1972
5)	04 Jun 72	W	Big Wave Bay	0530 GMT; lasted 3-5 min.; turmoil at sea 7 m diameter; cloud base 60 m; violent squally showers; developed 200 m offshore & moved N, landed & dissipated.	M.J. Durr & Irving
6)	21 Jul 72	FC	Between Soko Is. & Shek Kwu Chau	0030-0100 GMT; cloud base 270 m; sea disturbed; moved NE; heavy showers afterwards	Royal Hong Kong Auxiliary Air Force
7)	30 Sep 73	W	Lung Ha Wan	Daytime; Figs. 16-20	Kitt
8)	11 May 75	W	West Lamma Channel	0330 GMT; lasted 15 min.; moved NE; Fig. 21	HKU Sociology Dept. & newspaper
9)	19 Jun 75	W	3 miles south of Tathong	2330 GMT; moved NW	Civil aircraft
10)	29 Jun 75	W	10 miles north of Tai O	0524 GMT	Tai O Station
11)	06 Aug 75	W	10 miles NW of Tai O	0510 GMT. Fig. 22	Tai O Station

* W = Waterspout, FC = Funnel Cloud

TABLE 1. (CONTINUED)

Case	Date (Local)	Type*	Location	Description	Report by
12)	20 Jun 76	FC	West Lamma Channel	0530 GMT; lasted 5 min.	P.C.W. Fung
13)	21 May 77	W	Hau Hoi Wan	0225 GMT; lasted 1 min; thunderstorm	Chow
14)	28 Apr 78	W	10 miles east of Macau	0045 GMT; thunderstorm; a 15 m x 5 m boat lifted 6 m up killing 5 people; waves 2.5 m.	Newspaper
15)	26 Jun 78	FC	Off Cape d'Aguilar	0030 GMT	W.K. Chan
16)	27 Jun 78	W	a) South of Stanley Peninsula b) Between Bluff Point & Tau Chau c) Ocean Park	0730-0805 GMT; triple spouts; damage to Ocean Park cablecar and rope	C.Y. Lam consolidating eyewitnesses' reports
17)	11 Jul 78	W	Lung Kwu Chau	0000 GMT; lasted 15 min; diameter 20 m; moved NNE; double spouts; Figs. 23-24	K.L. Liu
18)	15 Sep 78	W	Tsim Bei Tsui	0740 GMT; lasted 2 min; thunderstorm	Sergeant Ho
19)	18 Oct 80	W	Soko Is.	0430 GMT	W.T. Warden
20)	19 Mar 81	FC	8 km SE of Cheung Chau	0331 GMT; lasted 4 min; thunderstorm; cloud base 340 m. (Hail occurred that day at 0935 GMT & 1343 GMT)	K.L. Chi (Cheung Chau Met. Station)
21)	10 May 81	W	21 N 111 E	2000 GMT; 27 boats sunk; 52 fishermen killed & 11 missing; thunderstorm	Newspaper
22)	27 Jun 81	FC	West Lamma Channel	0040 GMT; lasted 5 min; moving NE	A. Campbell
23)	13 Aug 82	W	NW of Macau	1025 GMT; lasted 35 min.	S.S. Omma (HXMB)
24)	18 Aug 82	W	Nam Wan, Tsing Yi Is.	2315 GMT; lasted 5 min; lifted at least 14 containers (2 tons each); part of rooftop & a temporary structure blown away; glass window blown outwards.	Y. Lo, P.W. Mok & P.L. Chan

* W = Waterspout, FC = Funnel Cloud

Note : This table does not include the tornado event on 2 June 1982 which killed 2 persons and injured 5 at Yuen Long because it did not move into the sea. Hong Kong Time is defined in this paper as GMT + 8

TABLE 2. HONG KONG 0000 GMT RADIOSONDE DATA NEAREST TO THE TIMES OF OCCURRENCE OF THE WATERSPOUTS OR FUNNEL CLOUDS

Case	Date	Surface Wind (deg/kn)	Φ (gpm)	T (°C)	T _d (°C)	1000 mbar RH (%)	r (g/kg)	wind (deg/kn)
1	19/9/59	260/02	80	26	23	83	18.0	300/03
5	04/6/72	100/08	57	-	-	-	-	-
6	21/7/72	270/04	13	-	-	-	-	-
7	30/9/73	240/01	119	25.8	23.3	86	18.41	296/02
8	11/5/75	060/02	75	26.1	25.6	97	21.22	220/04
9	19/6/75	120/06	75	26.4	25.7	96	21.35	153/10
10	29/6/75	260/01	75	24.9	24.2	96	19.46	277/06
11	06/8/75	270/02	22	-	-	-	-	-
12	20/6/76	Calm	48	-	-	-	-	-
13	21/5/77	Calm	75	28.7	26.1	86	21.88	227/03
15	26/6/78	110/09	4	-	-	-	-	-
16	27/6/78	090/18	66	26.5	24.1	87	19.34	090/18
17	11/7/78	240/04	75	28.3	26.1	88	21.88	240/04
18	15/9/78	070/02	84	27.4	23.6	80	18.75	070/02
19	18/10/80	Calm	128	25.5	22.6	84	17.62	341/03
20	19/3/81	Nil ascent						
22	27/6/81	230/07	84	27.7	23.9	80	18.9	231/07
24	18/8/82	110/07	55	-	-	-	-	-

Note : The 25/5/1965, 16/7/1968, 18/9/1970, 28/4/1978, 10/5/1982 and 13/8/1982 waterspouts/funnel clouds occurred outside Hong Kong Territory and the corresponding radiosonde data at Hong Kong have not been included.

TABLE 2. (CONTINUED)

Case	Φ	T	950 mbar				wind	Φ	900 mbar				wind
			T_d	RH	r	T_d			RH	r			
1	530	24	21	82	16.8	304/05	1000	21	17	82	13.7	308/06	
5	505	23.2	21.3	89	17.2	131/12	975	19.2	17.5	90	14.19	159/15	
6	464	25.0	21.1	79	16.91	275/06	938	22.2	17.3	74	14.01	248/12	
7	570	21.7	20.2	91	15.97	308/02	1041	21.3	15.8	71	12.70	049/06	
8	528	23.1	22.4	96	18.34	206/10	999	20.1	18.4	90	15.03	202/15	
9	529	23.9	23.4	97	19.53	164/13	1003	21.4	21.1	99	17.97	188/21	
10	526	23.1	22.9	99	18.93	212/08	999	21.3	19.9	92	16.55	190/12	
11	474	24.7	21.6	83	17.45	244/11	949	22.6	19.4	82	16.03	239/12	
12	496	25.0	22.9	88	18.93	167/03	972	23.5	17.3	68	14.01	155/06	
13	531	25.3	19.7	71	15.47	204/02	1005	21.9	14.0	61	11.29	201/09	
15	452	23.6	23.3	98	19.41	156/15	925	20.5	20.2	98	16.37	158/25	
16	519	23.9	22.7	93	18.69	129/27	992	21.4	17.8	80	14.47	143/37	
17	530	23.8	23.1	96	19.17	258/08	1004	22.7	18.3	76	14.94	244/10	
18	538	24.1	22.4	90	18.35	030/04	1012	22.7	19.7	83	16.34	054/09	
19	579	22.2	20.5	90	16.28	031/03	1048	18.8	18.0	95	14.65	068/05	
20	Nil ascent												
22	538	23.6	20.7	84	16.3	228/13	1007	20.9	17.1	79	13.9	219/18	
24	506	23.3	23.2	99	19.4	170/18	981	21.2	21.2	100	18.0	177/20	

TABLE 2. (CONTINUED)

Case	Φ	T	850 mbar				Φ	T	800 mbar			
			T_d	RH	r	wind			T_d	RH	r	wind
1	1500	18	15	83	12.8	307/04	2010	14	13	89	11.9	300/09
5	1465	16.0	12.7	81	10.97	162/21	1980	14.0	11.0	82	10.41	174/21
6	1434	19.1	14.8	76	12.61	246/10	1955	17.1	14.0	82	12.72	243/07
7	1536	19.2	13.4	69	11.50	051/11	2056	16.8	10.8	67	10.13	064/09
8	1491	17.0	14.8	87	12.61	207/15	2007	13.8	10.2	79	9.86	198/17
9	1499	18.8	18.3	97	15.84	188/24	2020	17.0	14.8	87	13.41	187/26
10	1495	19.4	16.1	81	13.73	198/18	2016	16.6	11.7	73	10.91	200/19
11	1446	20.1	15.9	77	13.55	217/11	1969	18.0	12.2	69	11.29	221/14
12	1469	19.6	14.2	71	12.12	146/07	1991	18.3	13.2	72	12.06	140/06
13	1500	19.8	11.0	57	9.79	209/14	2020	17.6	-0.6	29	4.60	217/15
15	1419	17.3	16.8	97	14.37	168/34	1936	14.6	12.1	85	11.21	169/33
16	1486	17.9	15.9	88	13.55	159/39	2003	14.2	12.4	89	11.44	167/39
17	1500	19.4	10.9	58	9.72	232/05	2020	17.0	1.0	34	5.17	181/05
18	1508	18.0	16.3	90	13.91	086/14	2027	16.0	14.5	91	13.15	093/17
19	1540	18.1	15.0	82	12.78	086/03	2057	13.8	10.4	80	10.00	076/03
20	Nil ascent											
22	1499	18.1	12.3	69	10.8	213/19	2018	15.4	8.2	62	8.7	212/19
24	1473	17.4	15.1	86	13.0	181/24	1992	15.2	13.4	90	12.1	184/23

TABLE 2. (CONTINUED)

Case	Φ	T	700 mbar				$\bar{P}$	T	600 mbar			
			T_d	RH	r	wind			T_d	RH	r	wind
1	3130	9	5	75	7.9	196/04	4400	1	1	83	6.0	175/01
5	3098	8.4	4.6	77	7.65	-	4359	1.7	-1.5	79	5.74	-
6	3086	11.4	4.6	63	7.65	240/04	4364	6.2	-3.7	49	4.87	284/07
7	3184	11.0	4.0	62	7.33	022/03	4456	4.1	-3.9	56	4.80	074/06
8	3129	10.7	7.6	81	9.44	233/24	4398	2.5	1.0	90	6.90	243/31
9	3156	13.3	9.6	78	10.83	184/31	4440	6.2	2.5	77	7.69	192/25
10	3144	10.6	7.5	81	9.38	207/15	4417	4.1	2.9	92	7.92	218/26
11	3104	12.6	6.2	65	8.56	226/11	4386	7.1	-5.3	41	4.31	187/02
12	3126	13.2	-1.5	36	4.92	091/03	4405	5.7	-8.2	36	3.45	128/05
13	3145	10.1	-3.9	37	4.11	225/17	4412	3.8	-8.9	39	3.26	212/17
15	3060	10.6	7.1	79	9.12	142/30	4336	5.2	3.2	87	8.09	131/33
16	3124	9.3	3.1	92	9.77	181/38	4392	3.0	2.0	93	7.42	208/27
17	3146	11.0	-4.6	33	3.90	139/08	4422	6.7-11.9	25	2.57	049/06	
18	3154	10.4	3.9	64	7.28	118/02	4421	2.9-15.7	24	1.88	020/14	
19	3175	9.0	1.9	61	6.31	233/07	4433	0.1	-3.6	76	4.91	265/16
20	Nil ascent											
22	3143	11.5	-3.0	36	4.4	227/15	4412	3.9	-7.5	43	3.7	239/11
24	3115	10.0	6.2	77	8.6	192/23	4380	1.3	-0.3	89	5.3	-

TABLE 2. (CONTINUED)

Case	$\bar{\Phi}$	T	500 mbar			wind	$\bar{\Phi}$	400 mbar			RH	r	wind
			T _d	RH	r			T	T _d				
1	5860	-5	-10	68	4.6	148/01	7580	-16	-27		37	1.1	116/04
5	5809	-6.4	-8.1	88	4.17	-	7525	-15.8	-19.7		72	2.01	-
6	5831	-4.4	-11.4	58	3.21	291/10	7555	-14.9	-27.0		35	1.05	214/03
7	5916	-4.7	-10.7	63	3.40	046/09	7640	-14.7	-26.5		36	1.10	092/08
8	5857	-4.2	-6.5	84	4.72	294/24	7584	-14.8	-17.2		82	2.49	285/27
9	5915	-2.1	-4.4	84	5.55	197/19	7658	-12.0	-16.9		67	2.55	197/14
10	5886	-2.5	-3.6	92	5.90	218/13	7626	-12.6	-14.6		85	3.09	144/04
11	5861	-1.9	-15.3	35	2.33	112/05	7598	-13.2	-27.9		28	0.97	075/18
12	5866	-5.6	-17.4	39	1.96	345/10	7587	-14.6	-16.4		86	2.66	067/11
13	5869	-4.8	-28.3	14	0.75	227/21	7591	-14.5	-35.5		15	0.47	233/17
15	5813	-0.5	-8.7	54	3.98	116/31	7553	-14.0	-30.7		23	0.74	103/33
16	5855	-3.7	-4.4	95	5.55	238/17	7586	-14.3	-16.7		82	2.60	175/09
17	5894	-2.5	-23.6	18	1.14	062/09	7627	-13.9	135.0		15	0.49	054/11
18	5881	-2.7	-27.4	13	0.81	047/13	7610	-14.8	-32.8		20	0.61	062/16
19	5874	-8.0	-15.2	56	2.35	246/18	7576	-17.9	-30.0		34	0.79	261/21
20	Nil ascent												
22	5866	-5.7	-19.4	33	1.6	198/04	7581	-15.7	-34.2		19	0.52	058/05
24	5837	-3.4	-3.9	96	5.9	-	7578	-12.1	-13.2		92	3.5	-

TABLE 2. (CONTINUED)

Case	$\bar{z}$	T	350 mbar T_d	RH	r	wind	$\bar{z}$	T	300 mbar T_d	RH	r	wind
1	8580	-23	-	-	-	060/08	9690	-30	-	-	-	065/16
5	8519	-22.6	-26.1	73	1.30	-	9633	-30.5	-34.1	71	0.71	-
6	8554	-20.8	-34.6	28	0.58	334/03	9677	-28.2	-40.4	30	0.38	013/05
7	8637	-22.1	-36.5	26	0.48	078/06	9752	-30.4	-44.1	25	0.26	074/23
8	8535	-20.2	-22.2	84	1.85	284/30	9709	-28.7	-31.3	78	0.94	291/16
9	8668	-18.4	-27.7	44	1.13	110/10	9801	-26.1	-40.3	25	0.38	121/12
10	8633	-19.6	-21.5	85	1.97	020/03	9761	-27.5	-31.2	71	0.94	022/05
11	8603	-19.5	-32.4	31	0.72	077/21	9732	-26.6	-37.8	34	0.49	030/27
12	8586	-21.5	-24.0	80	1.58	081/11	9705	-29.3	-32.3	75	0.85	068/09
13	8592	-20.0	-49.9	5	0.11	222/28	9715	-28.6	-49.9	5	0.13	227/26
15	8554	-20.4	-38.1	19	0.41	100/33	9679	-27.6	-42.0	24	0.32	097/30
16	8588	-20.4	-23.7	75	1.62	247/11	9713	-27.8	-38.3	36	0.47	020/09
17	8626	-21.7	-42.8	13	0.25	066/13	9742	-30.3	-46.5	19	0.20	062/19
18	8606	-22.1	-39.0	20	0.37	054/27	9722	-30.1	-45.9	20	0.21	048/21
19	8562	-24.3	-30.8	55	0.84	275/18	9669	-31.7	-35.2	71	0.64	274/22
20	Nil ascent											
22	8575	-22.5	-38.5	22	0.39	050/09	9687	-29.3	-45.8	19	0.21	064/14
24	8539	-18.6	-20.3	86	2.2	-	9719	-26.9	-29.2	81	1.2	-

TABLE 2. (CONTINUED)

Case	250 mbar			200 mbar			175 mbar		
	Φ	T	wind	Φ	T	wind	Φ	T	wind
1	10970	-39	064/18	12460	-51	070/18	13330	-57	063/16
5	10904	-39.7	-	12391	-51.5	-	13244	-53.6	-
6	10966	-35.4	293/04	12486	-45.9	005/07	13362	-52.6	052/15
7	11023	-40.0	062/28	12509	-51.7	074/28	13362	-58.3	072/33
8	10987	-39.0	267/18	12482	-49.8	260/23	13343	-56.0	263/25
9	11095	-35.5	105/12	12606	-48.4	073/13	13472	-54.9	348/07
10	11045	-38.0	019/05	12543	-50.0	061/18	13404	-56.2	055/32
11	11022	-36.7	098/18	12529	-48.4	087/17	13395	-55.0	067/35
12	10981	-39.1	067/12	12470	-51.7	067/20	13322	-59.0	065/27
13	10994	-38.7	227/20	12486	-51.1	210/18	13340	-58.7	202/18
15	10964	-37.5	070/24	12460	-51.1	054/25	13315	-58.1	067/39
16	10995	-38.6	030/10	12482	-52.6	080/14	13330	-60.3	125/10
17	11013	-39.9	067/29	12501	-51.0	059/42	13357	-57.4	063/42
18	10994	-40.0	315/06	12477	-52.4	313/10	13326	-59.6	287/07
19	10934	-41.0	241/25	12414	-52.4	255/25	13264	-59.3	251/27
20	Nil ascent								
22	10967	-37.9	065/25	12463	-49.8	067/44	13319	-57.4	053/43
24	11007	-37.1	358/17	12510	-51.2	358/20	13364	-58.6	005/29

TABLE 2. (CONTINUED)

Case	$\bar{P}$	150 mbar T	wind	$\bar{P}$	125 mbar T	wind	$\bar{P}$	100 mbar T	wind
1	14 270	-66	090/16	15370	-75	105/16	16630	-80	095/10
5	14199	-64.8	-	15293	-71.8	-	16588	-78.3	-
6	14340	-60.3	084/21	15453	-69.3	082/27	16752	-79.4	080/37
7	14318	-64.4	067/28	15414	-71.4	065/29	16716	-76.6	069/24
8	14308	-62.9	236/22	15412	-69.8	249/07	16717	-77.3	032/12
9	14441	-62.1	305/09	15546	-70.4	063/17	16853	-76.0	067/20
10	14368	-62.9	062/42	15471	-70.4	062/45	16777	-76.4	064/57
11	14363	-62.4	061/50	15465	-71.0	059/50	16766	-77.1	078/53
12	14274	-65.4	058/24	15370	-70.6	074/29	16680	-74.8	076/44
13	14294	-65.1	228/13	15388	-71.6	246/13	16686	-77.5	167/06
15	14269	-65.8	066/57	15353	-74.6	061/48	16634	-79.7	065/43
16	14275	-67.6	068/12	15359	-72.7	075/23	16650	-78.5	070/27
17	14315	-64.5	057/53	15408	-72.6	056/55	16704	-77.0	062/49
18	14272	-67.6	297/02	15347	-76.1	064/07	16630	-77.7	091/17
19	14212	-67.0	262/33	15297	-73.1	261/27	16595	-76.0	266/20
20	Nil ascent								
22	14274	-65.5	034/44	15359	-72.9	047/37	16649	-77.4	080/42
24	14314	-65.6	032/46	15406	-71.0	054/46	16716	-72.4	062/28

TABLE 2. (CONTINUED)

Case	Φ	90 mbar T	wind	Φ	80 mbar T	wind	Φ	70 mbar T	wind
1	17230	-80	099/15	17890	-80	078/14	18650	-79	072/14
5	17186	-80.5	-	17849	-81.2	-	18602	-80.3	-
6	17348	-80.9	084/44	18021	-75.3	081/46	18802	-71.5	097/37
7	17320	-78.1	074/15	17990	-79.9	059/16	18755	-75.1	063/22
8	17323	-76.0	359/05	18002	-76.9	340/05	18775	-74.0	048/10
9	17459	-77.8	071/25	18133	-77.5	079/31	18910	-71.7	098/29
10	17382	-77.9	074/55	18063	-73.7	083/46	18857	-66.6	088/40
11	17374	-74.9	090/50	18073	-66.2	092/39	18882	-66.4	076/28
12	17296	-72.6	081/45	17998	-67.0	079/40	18809	-64.4	083/36
13	17290	-77.1	131/09	17967	-76.6	088/12	18744	-72.5	087/18
15	17230	-80.5	071/46	17893	-81.3	076/42	18657	-74.5	082/50
16	17252	-77.8	070/34	17926	-77.7	075/42	18702	-72.0	074/54
17	17309	-77.0	070/53	17994	-72.4	077/49	18785	-69.2	080/42
18	17235	-76.2	083/22	17917	-74.7	083/30	18701	-70.9	075/37
19	17205	-75.1	264/16	17895	-71.4	265/09	18687	-69.7	020/02
20	Nil ascent								
22	-	-	-	17915	-78.8	077/40	18692	-70.4	067/29
24	17333	-73.7	061/30	18030	-69.0	075/30	18835	-66.3	085/27

TABLE 3. ESTIMATED SURFACE CONDITIONS DURING THE
OCCURRENCE OF THE WATERSPOUTS OR FUNNEL CLOUDS

Case	Date(Local)	Temp. (°C)	Dew Pt. (°C)	Mixing Ratio (g/kg)	Pressure (mbar)	Sea Temp. (°C)	Wind (point/kn)
1	19 Sep 59	23	25	20.2	1007.3	26.6	SE/10
2	25 May 65	27	25	20.2	1005.0	---	S/10
3	16 Jul 68	30	28	24.2	1010.0	23.5	SE/05
5	04 Jun 72	24	23	17.9	1005.7	25.9	SE/08
6	21 Jul 72	28	25	20.2	1002.2	27.8	SW/05
8	11 May 75	26	25	20.2	1009.8	26.0	SE/08
9	19 Jun 75	26	25	20.2	1008.6	26.3	SE/10
10	29 Jun 75	26	25	20.2	1007.0	27.5	SW/05
11	06 Aug 75	31	28	24.3	1002.4	26.5	SW/08
12	20 Jun 76	33	28	24.2	1006.0	26.5	SE/05
13	21 May 77	31	28	24.2	1009.0	26.7	W/20
14	23 Apr 78	23	22	16.9	1007.2	---	N/08
15	26 Jun 78	27	26	21.7	999.8	27.3	SE/24
16	27 Jun 78	27	26	21.7	1007.8	26.6	SE/20
17	11 Jul 78	28	25	20.2	1008.6	23.2	W/03
18	15 Sep 78	31	25	20.2	1003.7	23.8	N/05
19	18 Oct 80	31	25	20.0	1014.4	27.3	SE/02
20	19 Mar 81	20	19	14.0	1008.8	19.0	NW/18
21	10 May 81	27	25	20.2	1005.0	---	SE/08
22	27 Jun 81	30	26	21.7	1010.0	23.0	SW/12
23	13 Aug 82	30	25	20.2	1003.4	---	SE/05
24	18 Aug 82	24	24	29.1	1006.2	25.2	NE/03

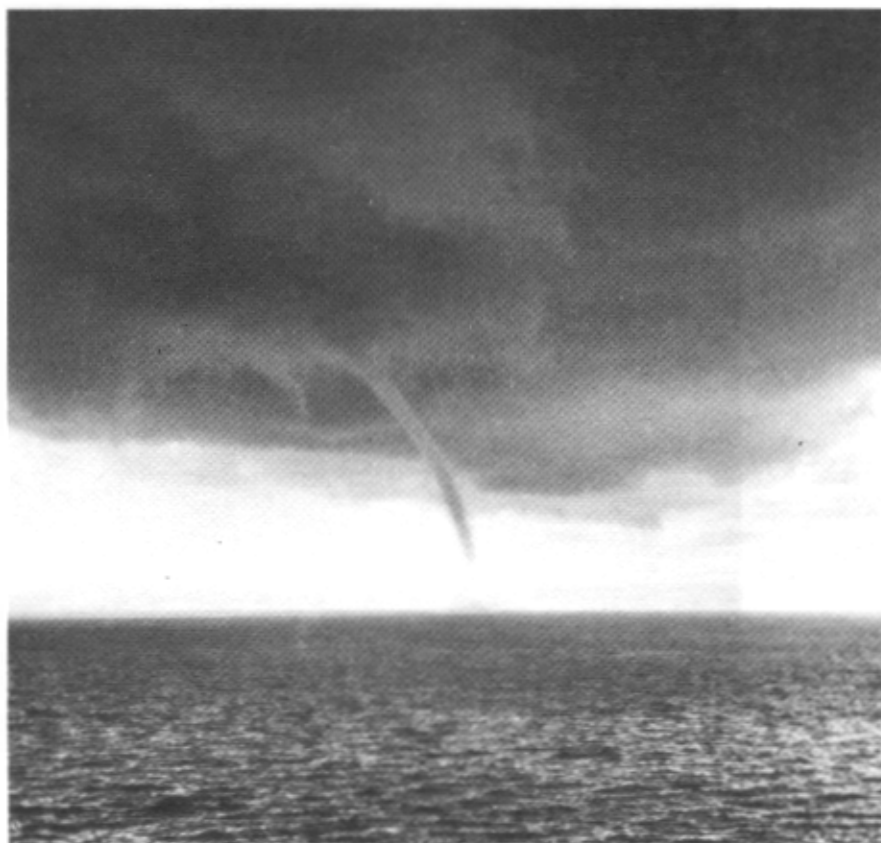


Fig. 1. Waterspout observed on 29 August 1952 off Cape Rachado (Sequence No.1) (Photo supplied by Captain G.T.M. Ramsay of S.S. Pakhoi).



Fig. 2. Waterspout observed on 29 August 1952 (Sequence No.2) (Photo supplied by Captain G.T.M. Ramsay of S.S. Pakhoi).

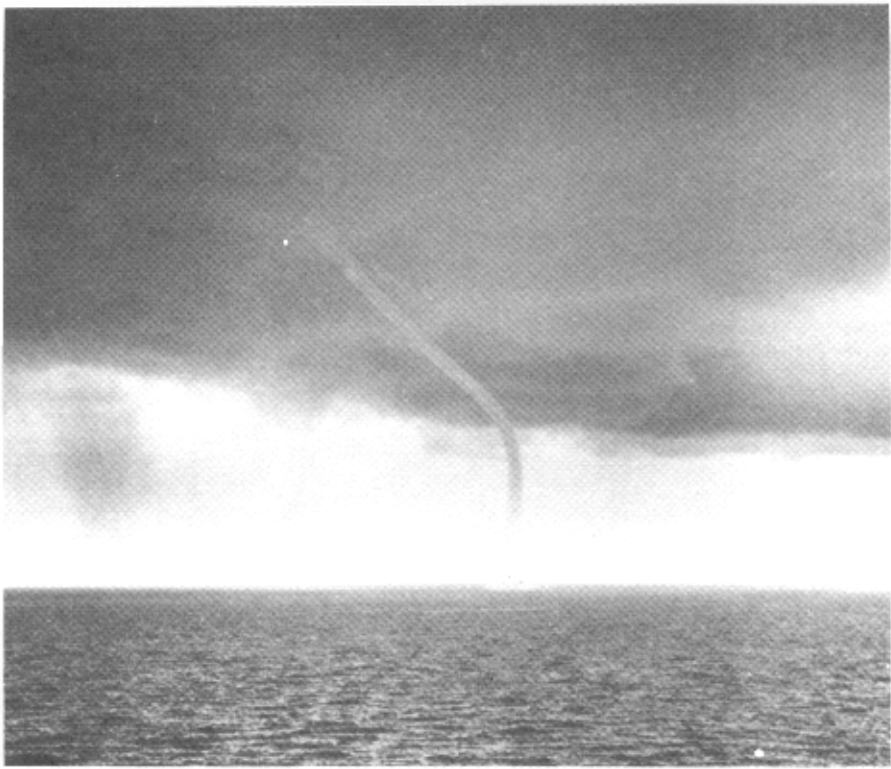


Fig. 3 Waterspout observed on 29 August 1952 (Sequence No.3)
(Photo supplied by Captain G.T.M. Ramsay of S.S. Pakhoi).

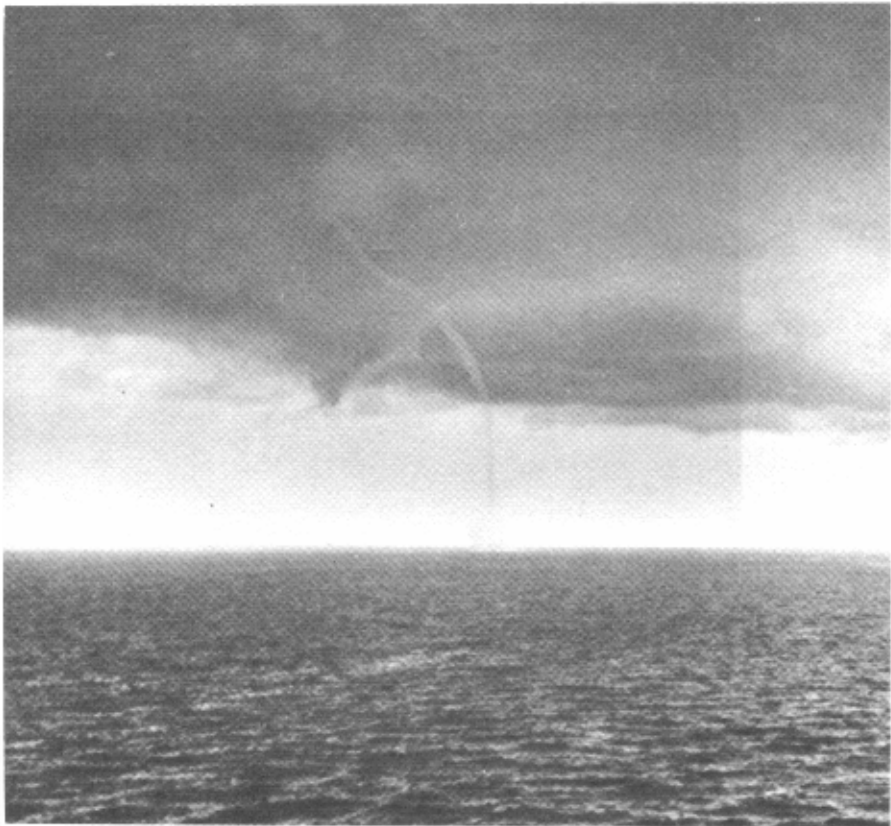


Fig. 4 Waterspout observed on 29 August 1952 (Sequence No.4)
(Photo supplied by Captain G.T.M. Ramsay of S.S. Pakhoi).

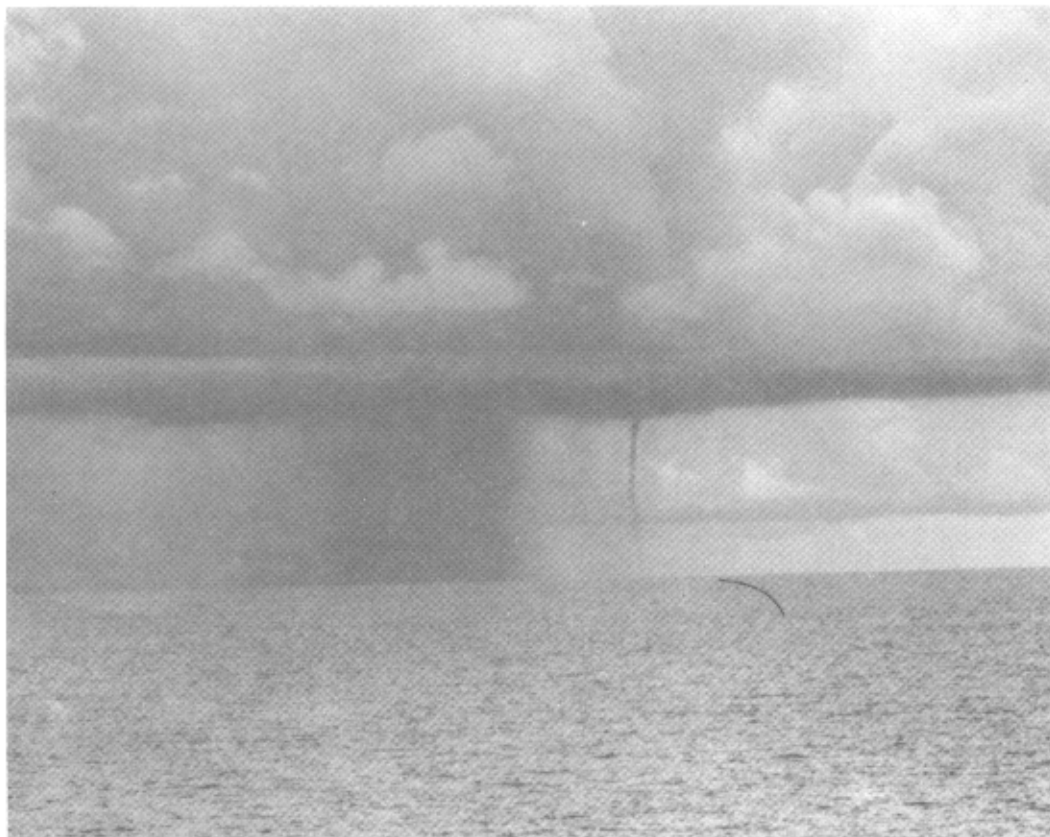


Fig. 5 Waterspout observed on 16 July 1968 off Palawan (Sequence No.1) (Photo supplied by Captain R.G. Macdonald of S.S. Ho Sang).



Fig. 6. Waterspout observed on 16 July 1968 (Sequence No.2) (Photo supplied by Captain R.G. Macdonald of S.S. Ho Sang).

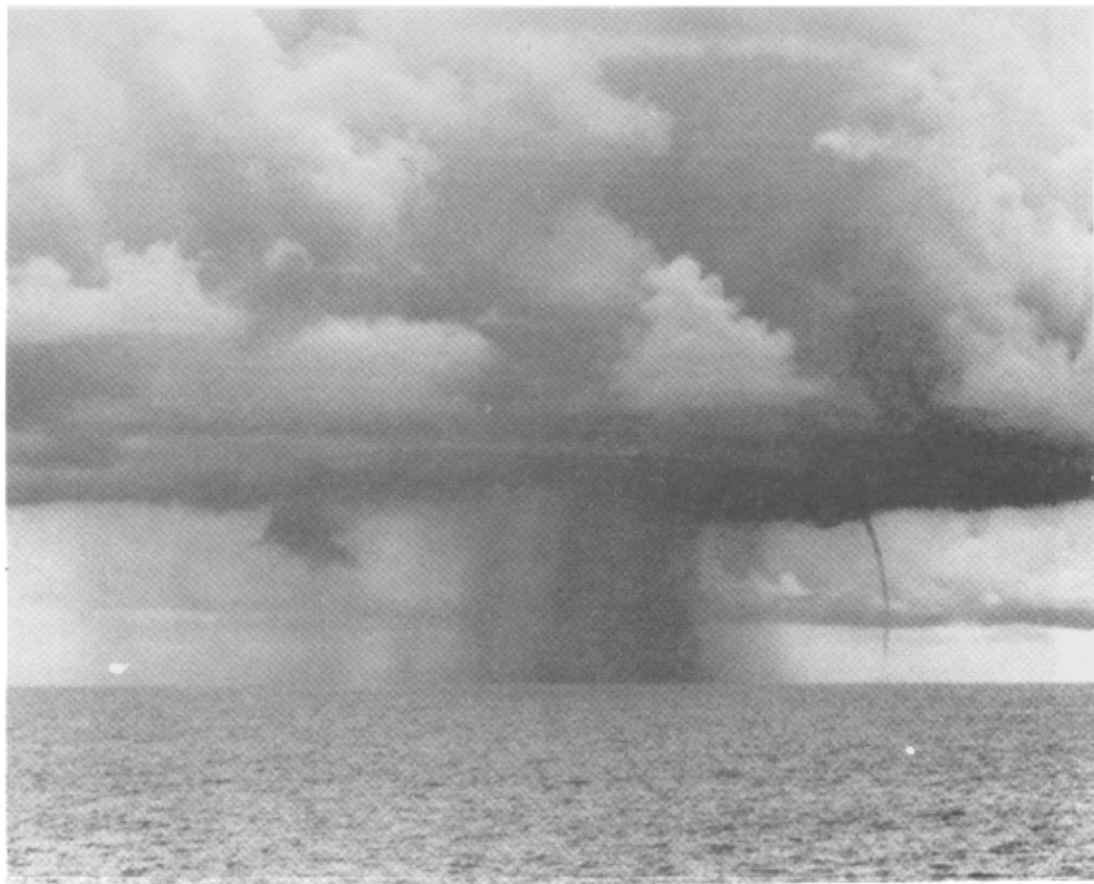


Fig. 7. Waterspout observed on 16 July 1968 (Sequence No.3)
(Photo supplied by Captain R.G. Macdonald of S.S.
Ho Sang).

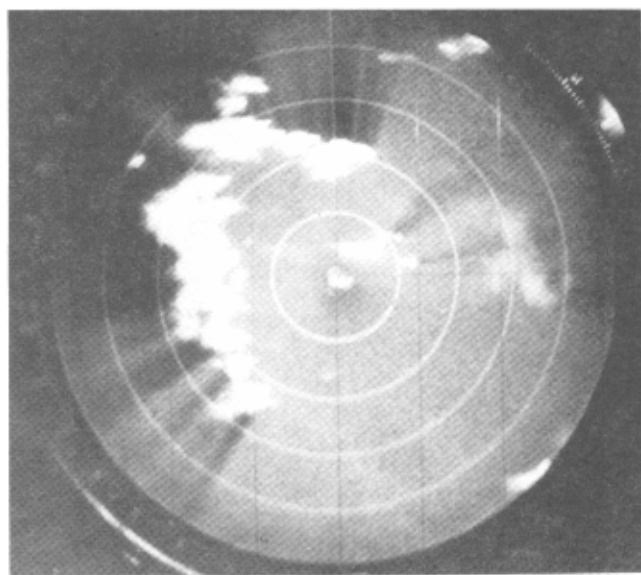


Fig. 8. Radar picture at 0700 GMT on 16 July 1968 taken on
board S.S. Ho Sang (Rings at 5 nautical mile
intervals).

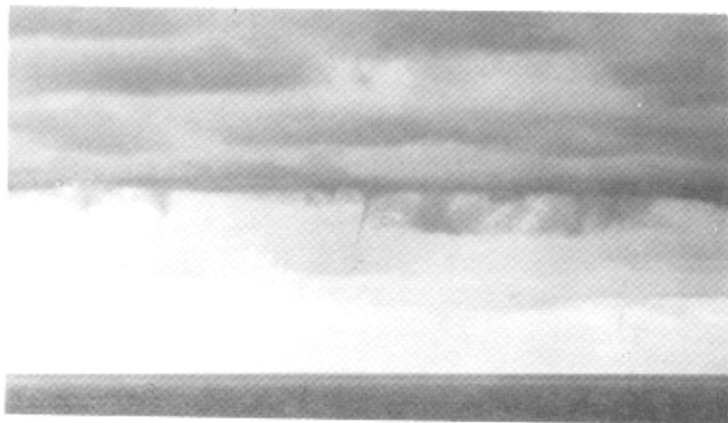


Fig. 9. Funnel cloud observed on 16 July 1968 (Photo supplied by Captain R.G. Macdonald of S.S. Ho Sang).



Fig. 10. Waterspout (A) observed on 22 February 1969 in the South China Sea (Photo supplied by Captain R.G. Macdonald of S.S. Eastern Maid).



Fig. 11. Waterspout (B) observed on 22 February 1969 (Photo supplied by Captain R.G. Macdonald of S.S. Eastern Maid).



Fig. 12. Waterspout observed on 26 April 1969 in the South China Sea (Sequence No.1) (Photo supplied by Captain R.G. Macdonald of S.S. Eastern Maid).



Fig. 13. Waterspout observed on 26 April 1969 (Sequence No.2) (Photo supplied by Captain R.G. Macdonald of S.S. Eastern Maid).



Fig. 14. Waterspout observed on 26 April 1969 (Sequence No.3) (Photo supplied by Captain R.G. Macdonald of S.S. Eastern Maid).



Fig. 15. Waterspout observed on 19 September 1959 over Hong Kong waters (Photo supplied by South China Morning Post).



Fig. 16. Waterspout observed on 30 September 1973 in Lung Ha Wan (Sequence No.1) (Photo supplied by Mr. Kitt).

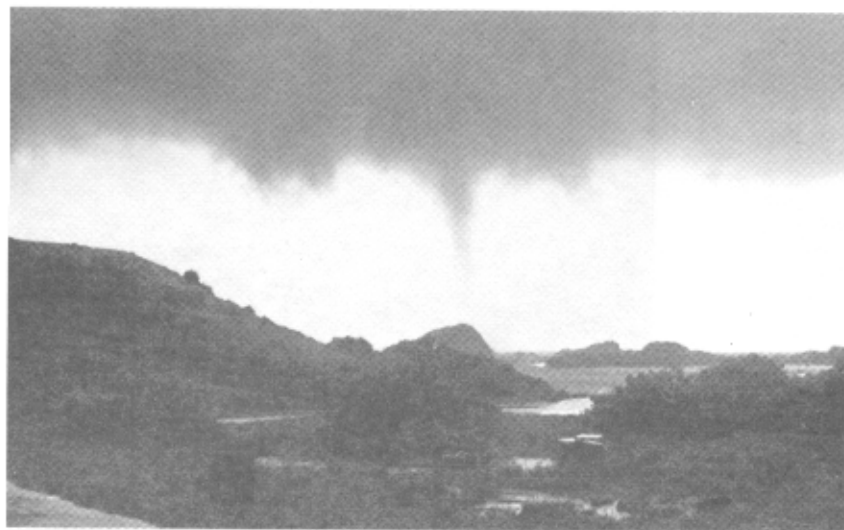


Fig. 17. Waterspout observed on 30 September 1973 (Sequence No.2) (Photo supplied by Mr. Kitt).



Fig. 18. Waterspout observed on 30 September 1973 (Sequence No.3) (Photo supplied by Mr. Kitt).

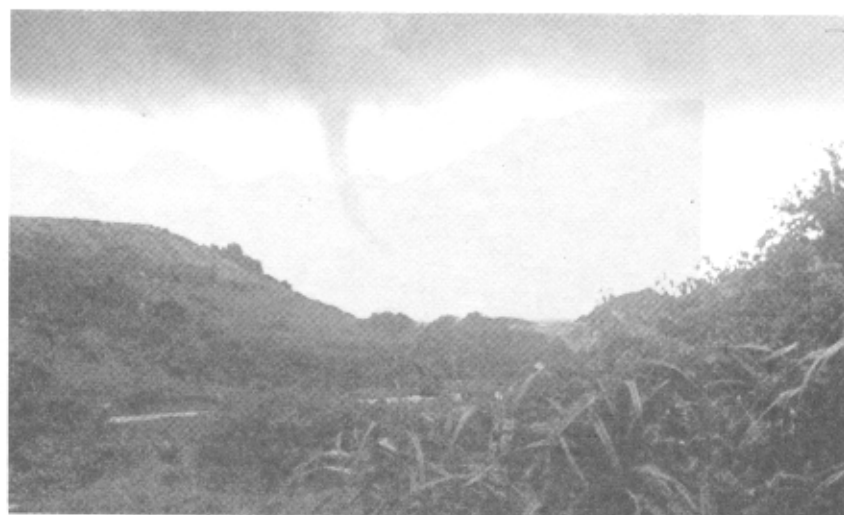


Fig. 19. Waterspout observed on 30 September 1973 (Sequence No.4) (Photo supplied by Mr. Kitt).



Fig. 20. Waterspout observed on 30 September 1973 (Sequence No.5) (Photo supplied by Mr. Kitt).

Fig. 21. Waterspout observed on 11 May 1975 in West Lamma Channel (Photo supplied by HKU Sociology Department).



Fig. 22. Waterspout observed on 6 August 1975 off Tai O (Photo supplied by Tai O Station).



Fig. 23. Double spouts observed on 11 July 1978 off Lung Kwu Chau (Sequence No.1) (Photo supplied by Mr. K.L. Liu).



Fig. 24. Waterspout observed on 11 July 1978 (Sequence No.2) (Photo supplied by Mr. K.L. Liu).

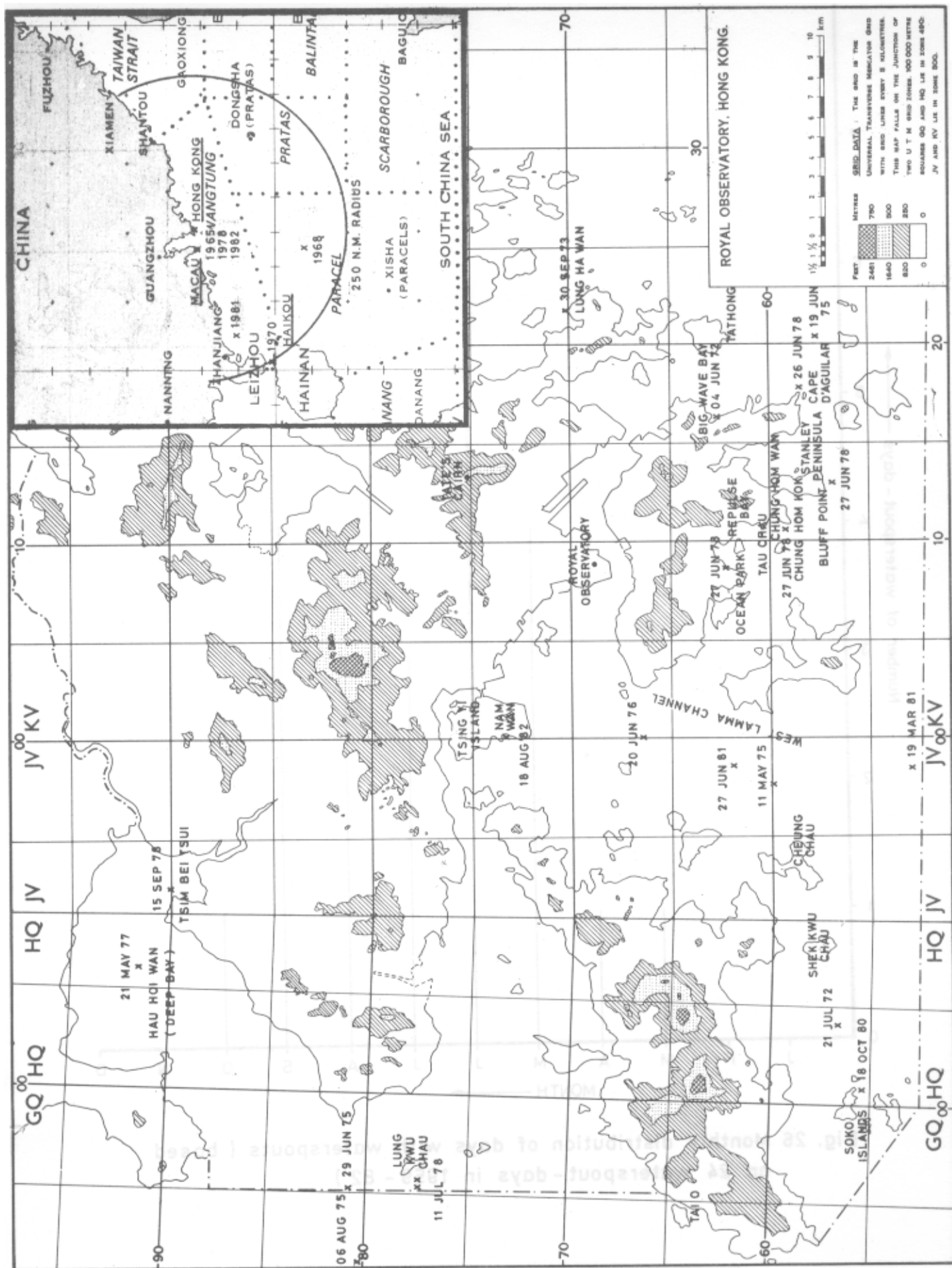


Fig. 25 Geographical distribution of waterspouts / funnel clouds sighted in or near Hong Kong

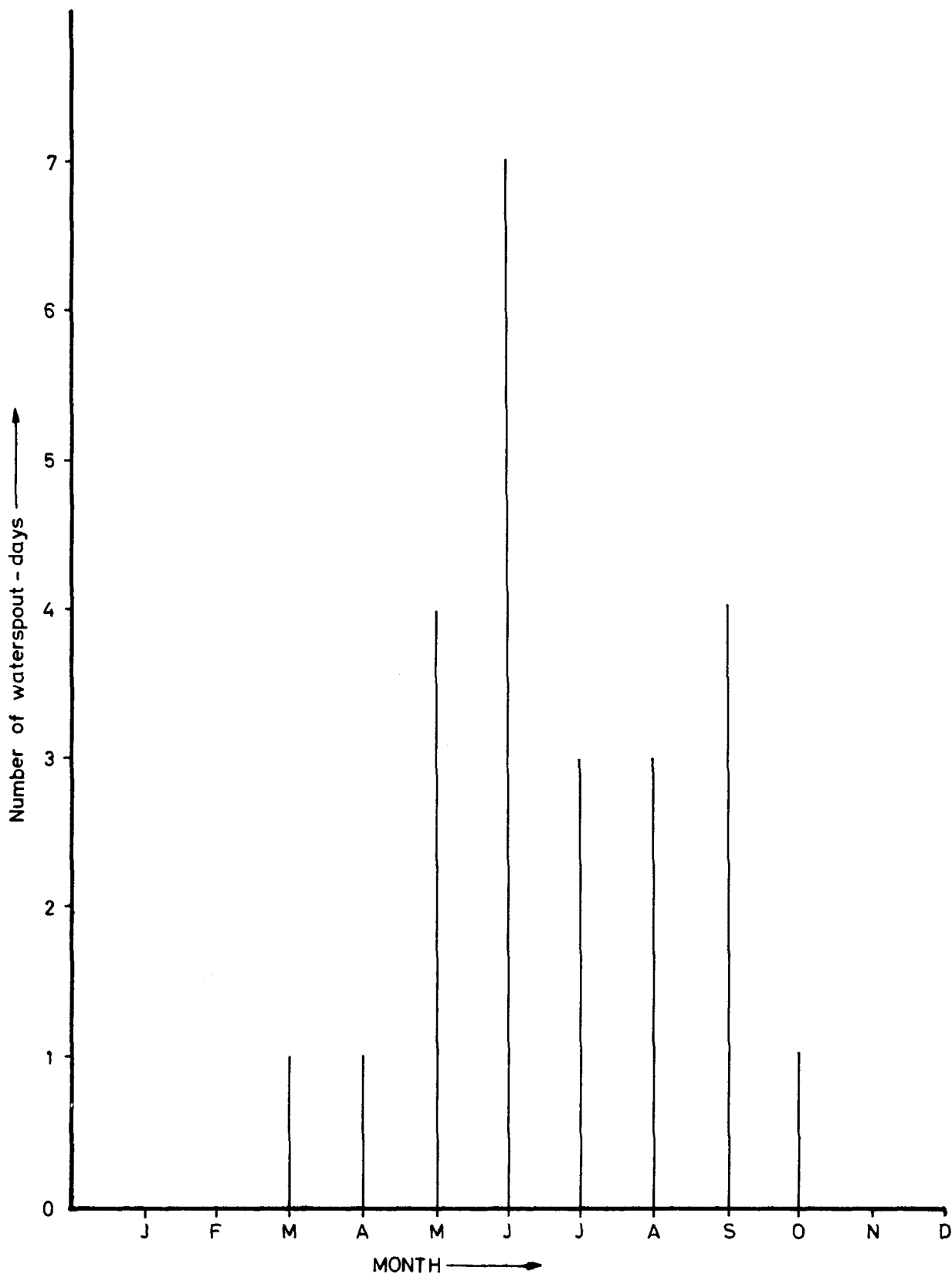


Fig. 26 Monthly distribution of days with waterspouts (based on 24 waterspout - days in 1959 - 82)

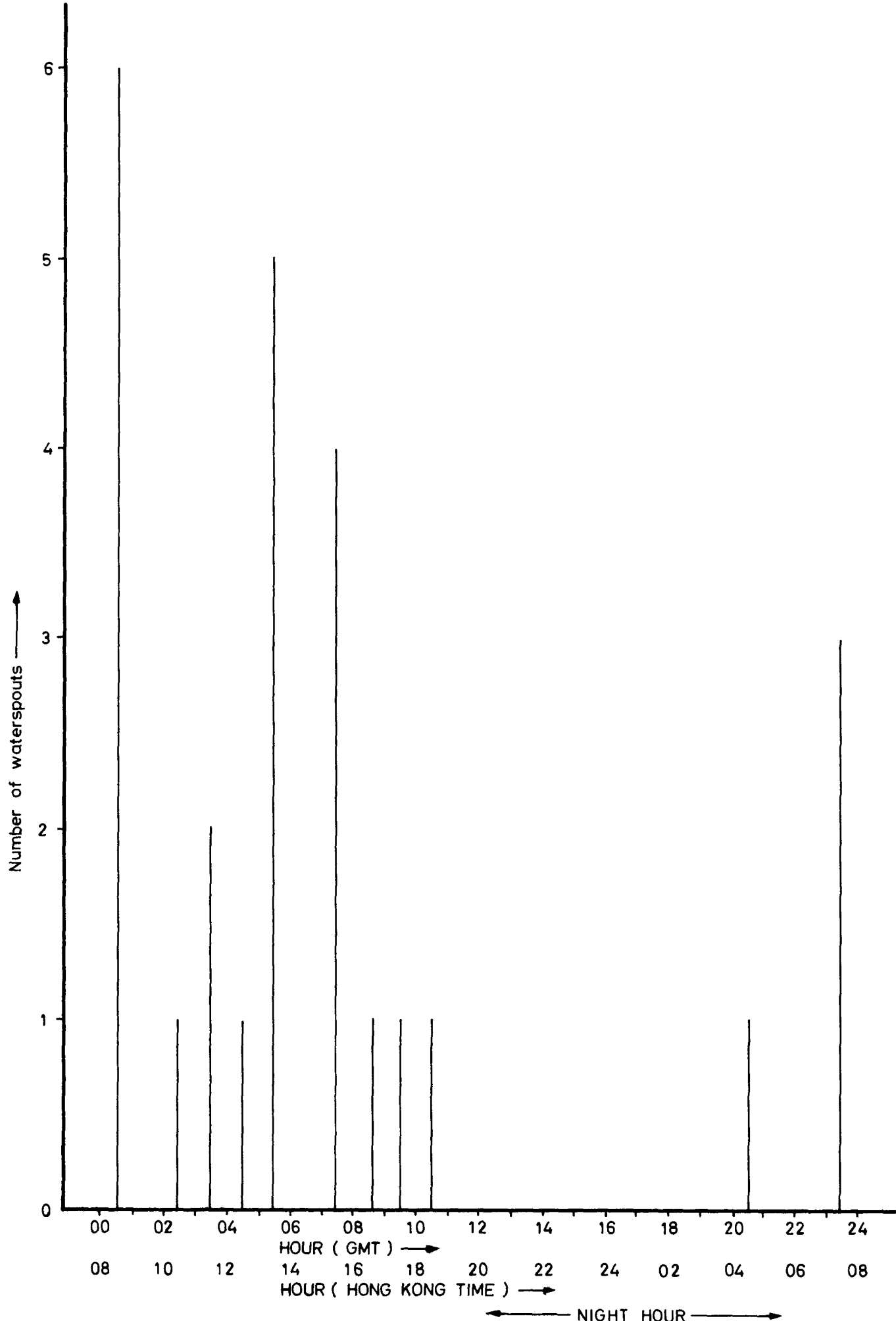
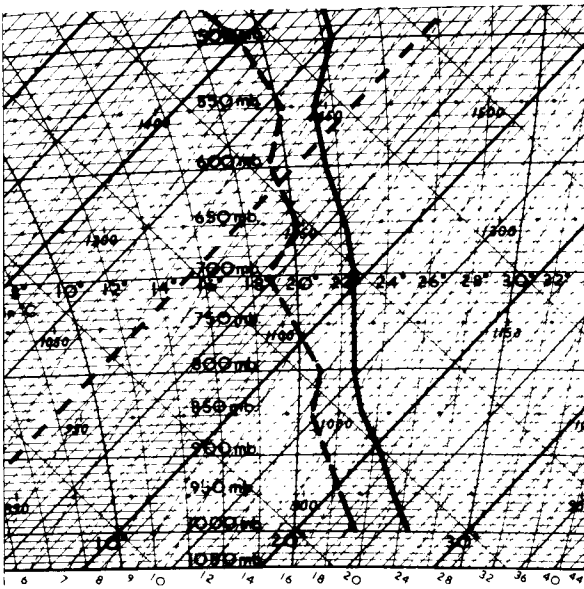
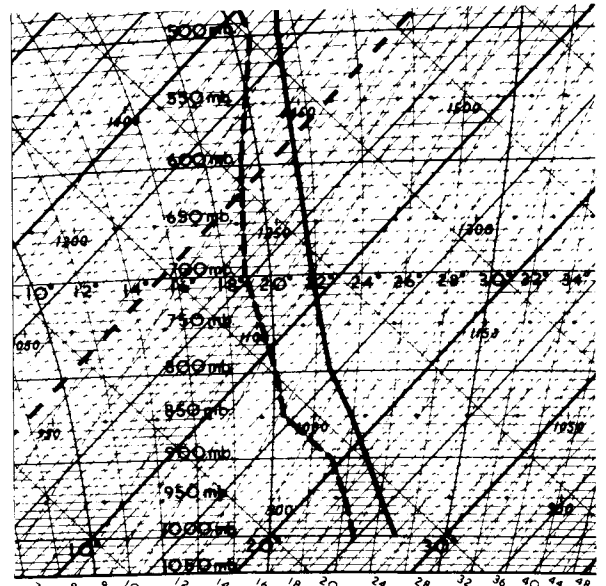


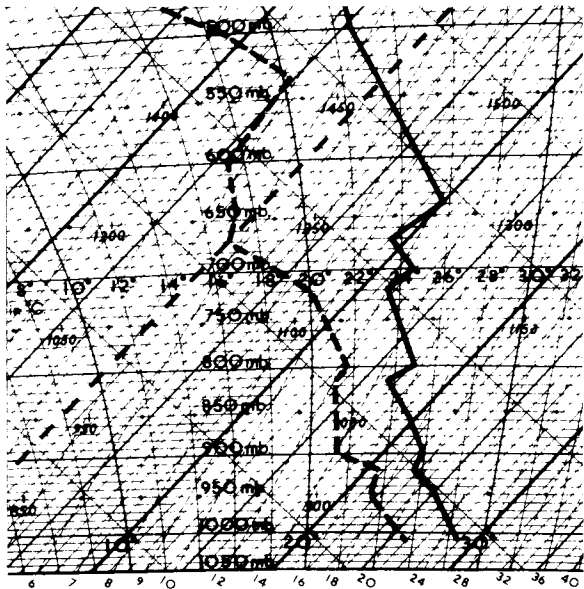
Fig. 27 Diurnal variation of occurrence of waterspouts
(based on 26 reports in 1959 - 1982)



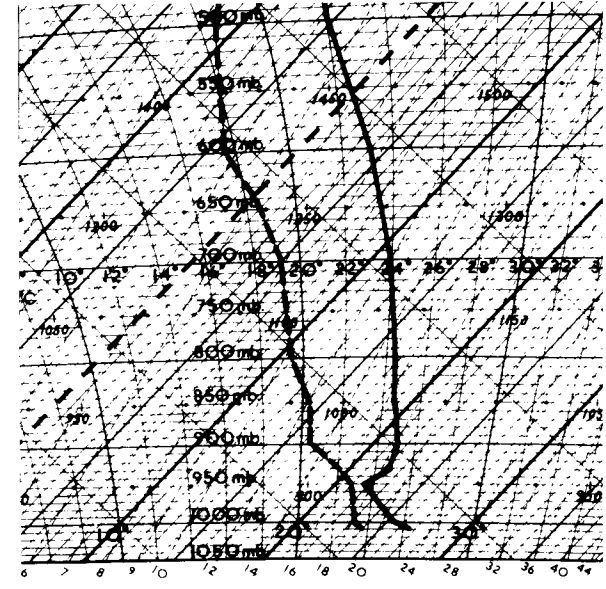
00 GMT 19 SEPTEMBER 1959 CASE 1



00 GMT 4 JUNE 1972 CASE 5

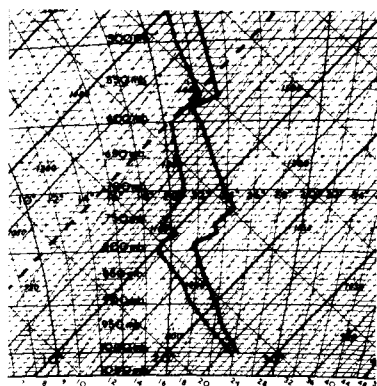


00 GMT 21 JULY 1972 CASE 6

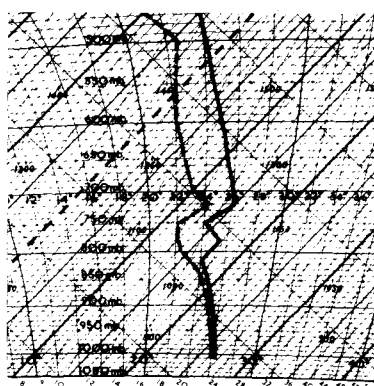


00 GMT 30 SEPTEMBER 1973 CASE 7

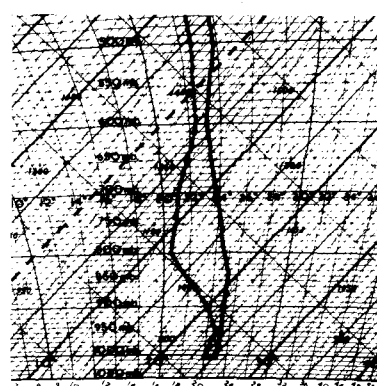
Fig. 28. Tephigrams for waterspout occurrences on 19 September 1959, 4 June 1972, 21 July 1972 and 30 September 1973.



00 GMT 11 MAY 1975 CASE 8



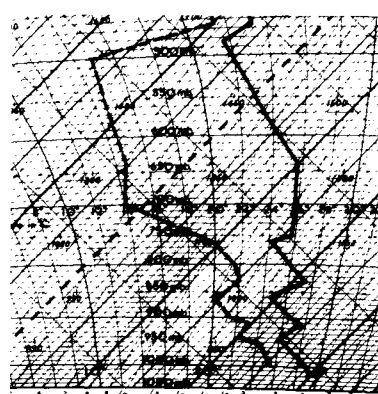
00 GMT 19 JUNE 1975 CASE 9



00 GMT 29 JUNE 1975 CASE 10



00 GMT 6 AUGUST 1975 CASE 11

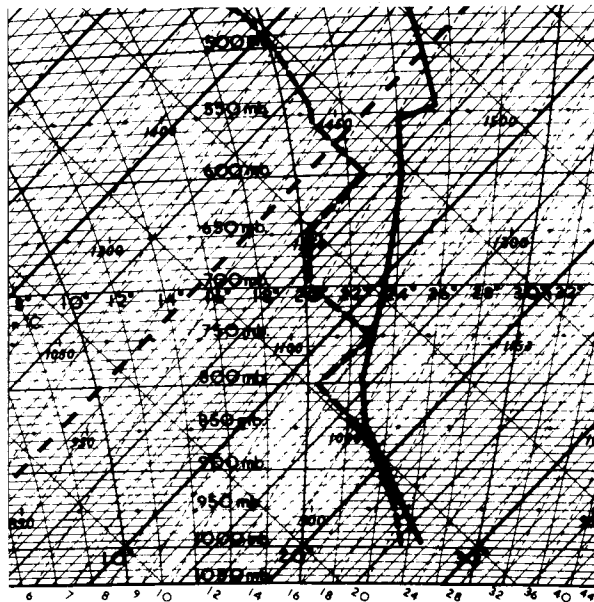


00 GMT 20 JUNE 1976 CASE 12

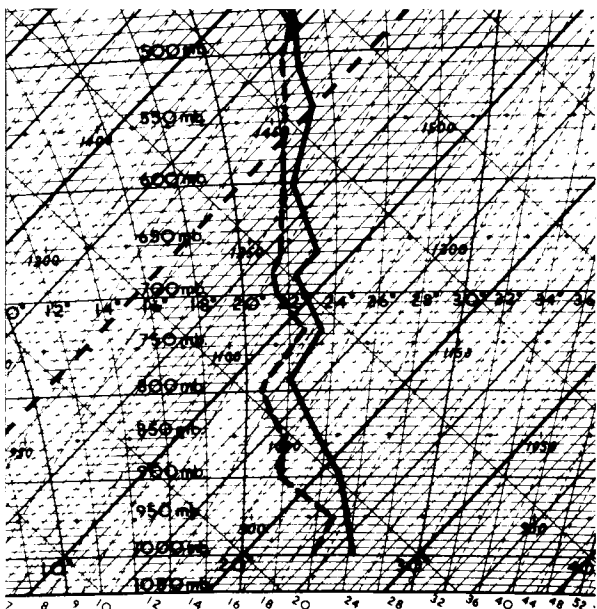
Fig. 29. Tephigrams for waterspout occurrences on 11 May 1975, 19 June 1975, 29 June 1975, 6 August 1975 and 20 June 1976.



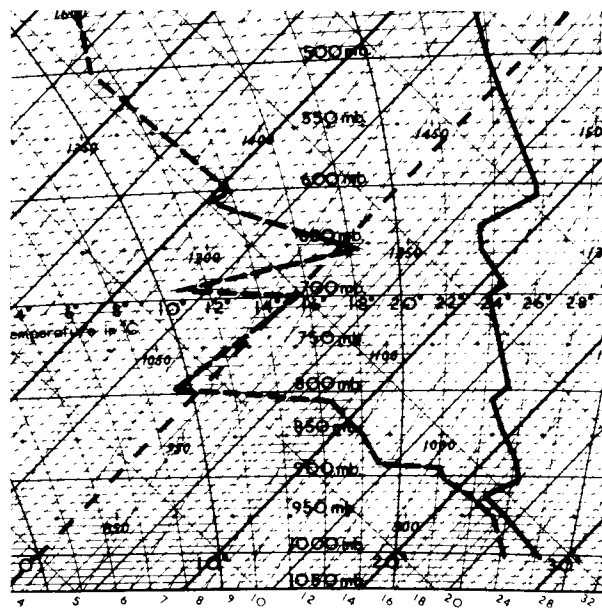
00 GMT 21 MAY 1977 CASE 13



00 GMT 26 JUNE 1978 CASE 15

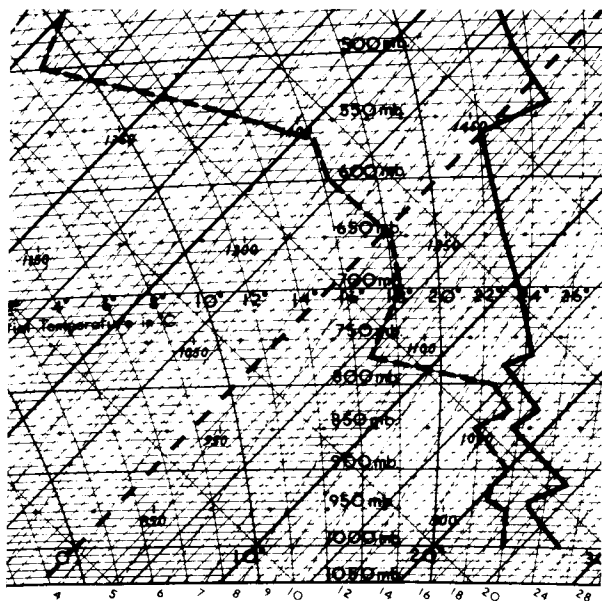


00 GMT 27 JUNE 1978 CASE 16

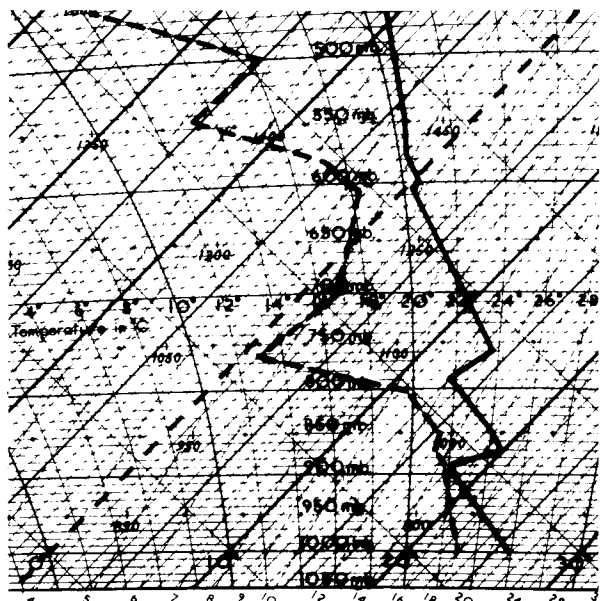


00 GMT 11 JULY 1978 CASE 17

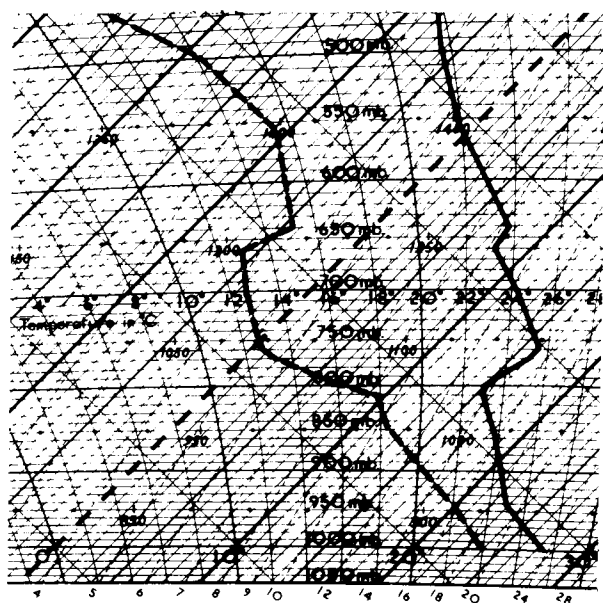
Fig. 30. Tephigrams for waterspout occurrences on 21 May 1977, 26 June 1978, 27 June 1978 and 11 July 1978.



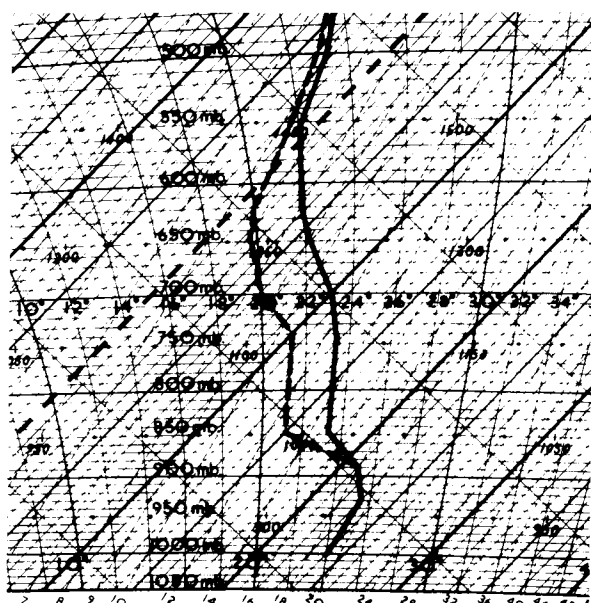
00 GMT 15 SEPTEMBER 1978 CASE 18



00 GMT 18 OCTOBER 1980 CASE 19



00 GMT 27 JUNE 1981 CASE 22



00 GMT 18 AUGUST 1982 CASE 24

Fig. 31. Tephigrams for waterspout occurrences on 15 September 1978, 18 October 1980, 27 June 1981 and 18 August 1982.

(R08) Fig.32 ROYAL OBSERVATORY, HONG KONG.
 WEATHER CHART FOR **0200** HRS. H. K. ST. T. **19 SEPTEMBER 1959**

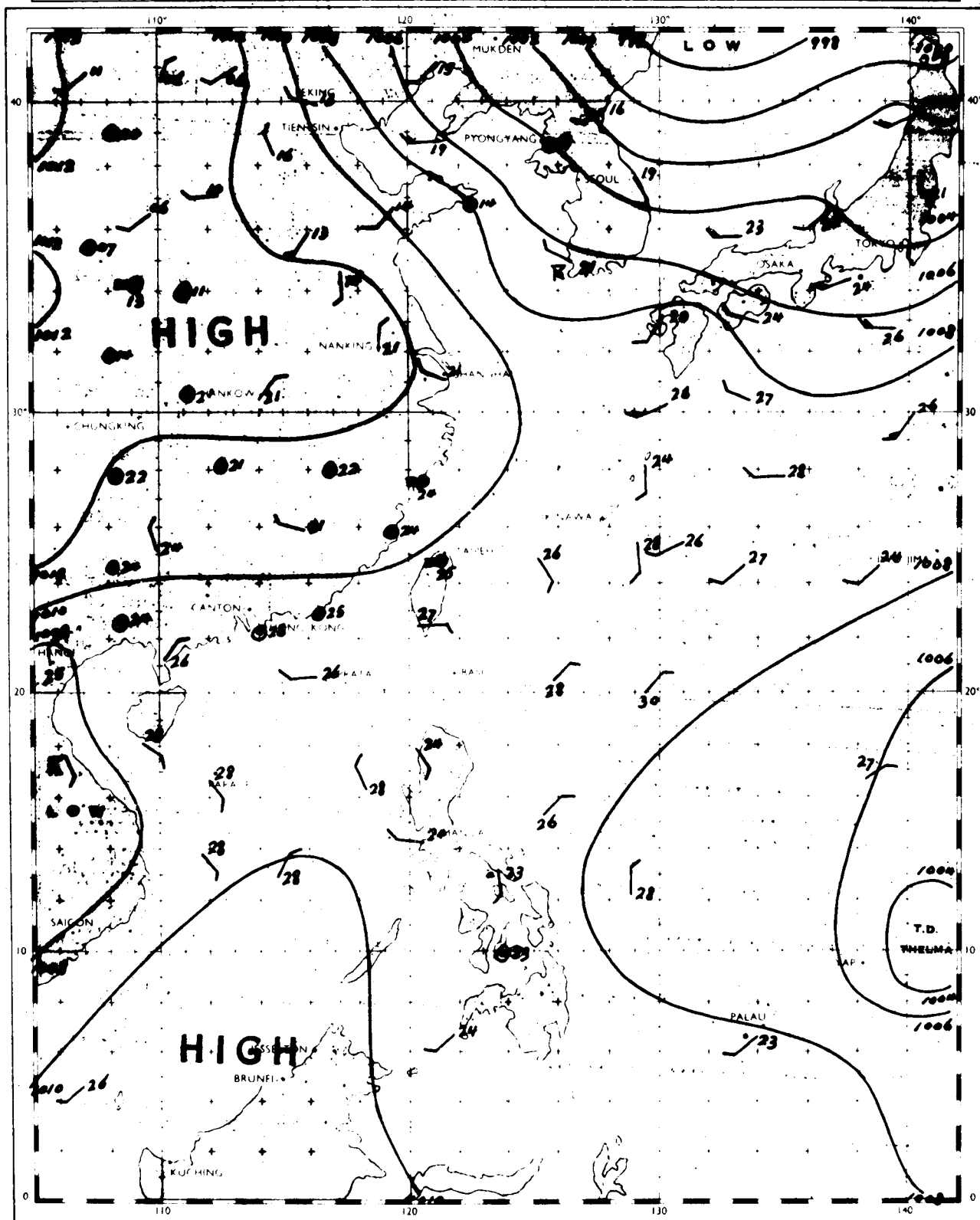
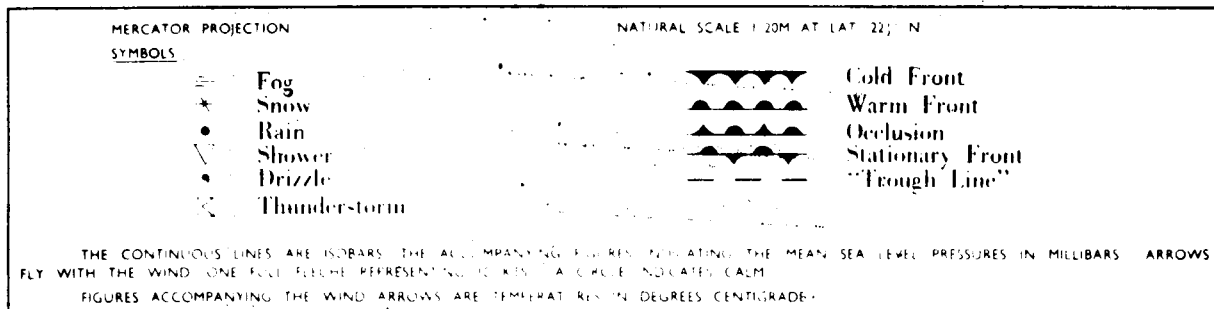


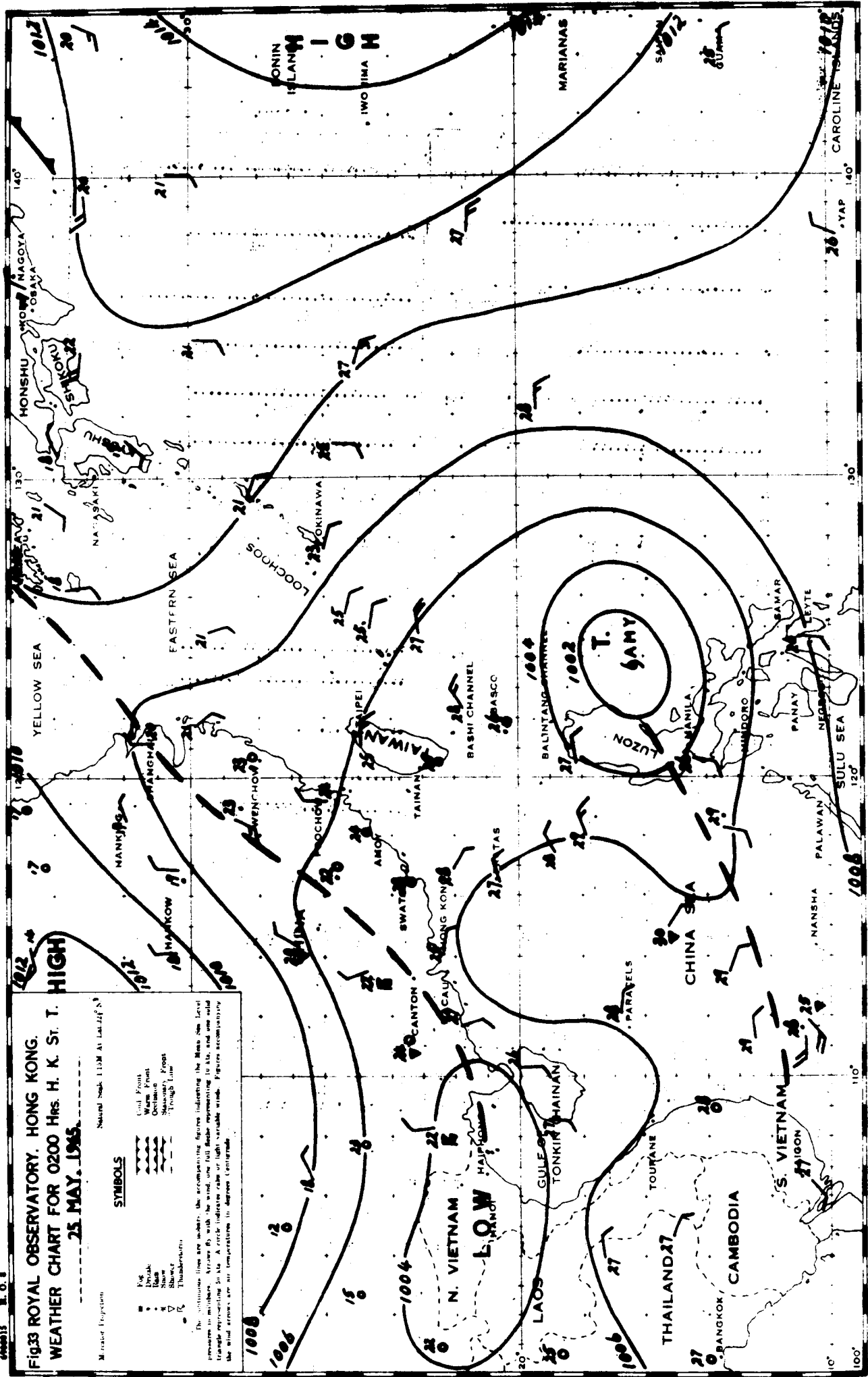
FIG.33 ROYAL OBSERVATORY, HONG KONG.
WEATHER CHART FOR 0200 Hrs. H. K. St. T.
25 MAY. 1965.

Map Projection
Natural Scale 1:100,000 AS LAM-225-53

SYMBOLS

• Fog	— Cold Front
• Drizzle	— Warm Front
• Rain	— Occluded Front
• Snow	— Squall Line
• Shower	— Trough Line
• Thunderstorm	

The isobars (lines of equal pressure) are indicated by the Mean Sea Level pressure in millibars. Arrows show the wind direction and speed in knots, and are solid triangles representing 50 kts. A circle indicates rain or light variable winds. Figures accompanying the wind arrows are air temperatures in degrees Centigrade.



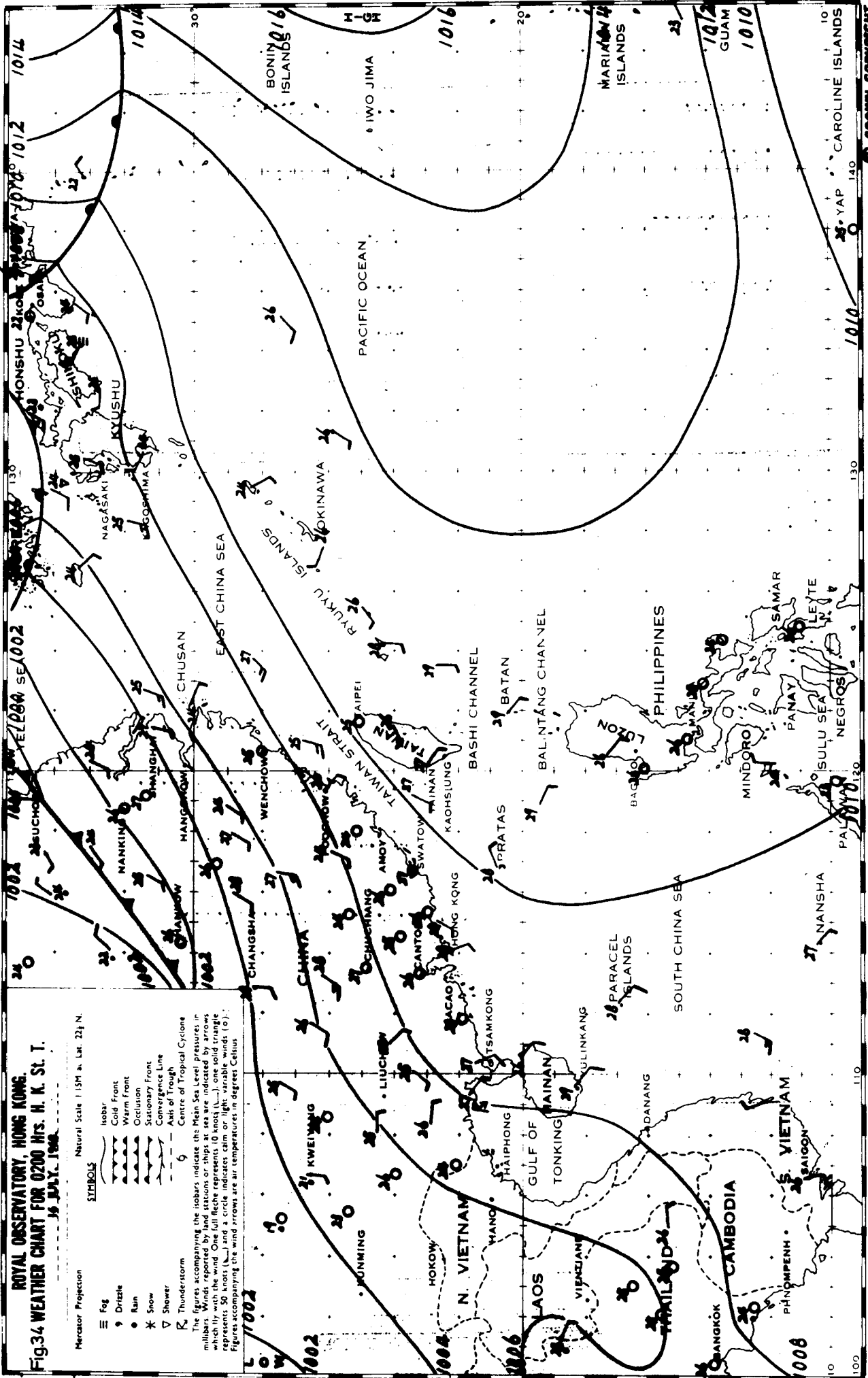
ROYAL OBSERVATORY, HONG KONG.
Fig.34 WEATHER CHART FOR 0200 Hrs. H. K. St. I.
16 MAY. 1966

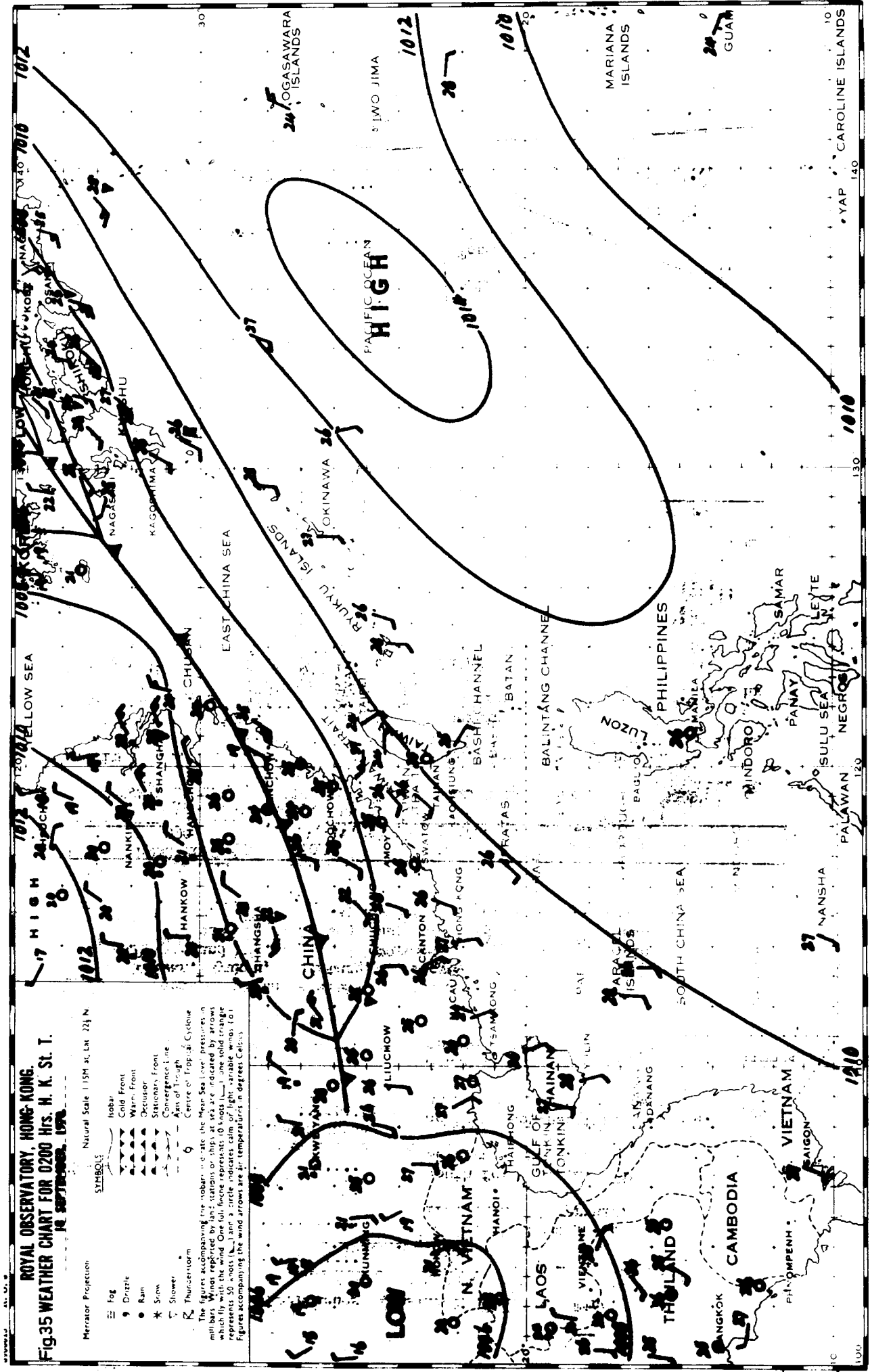
Mercaior Projection Natural Scale 1:5M at Lat. 22° N.

SYMBOLS

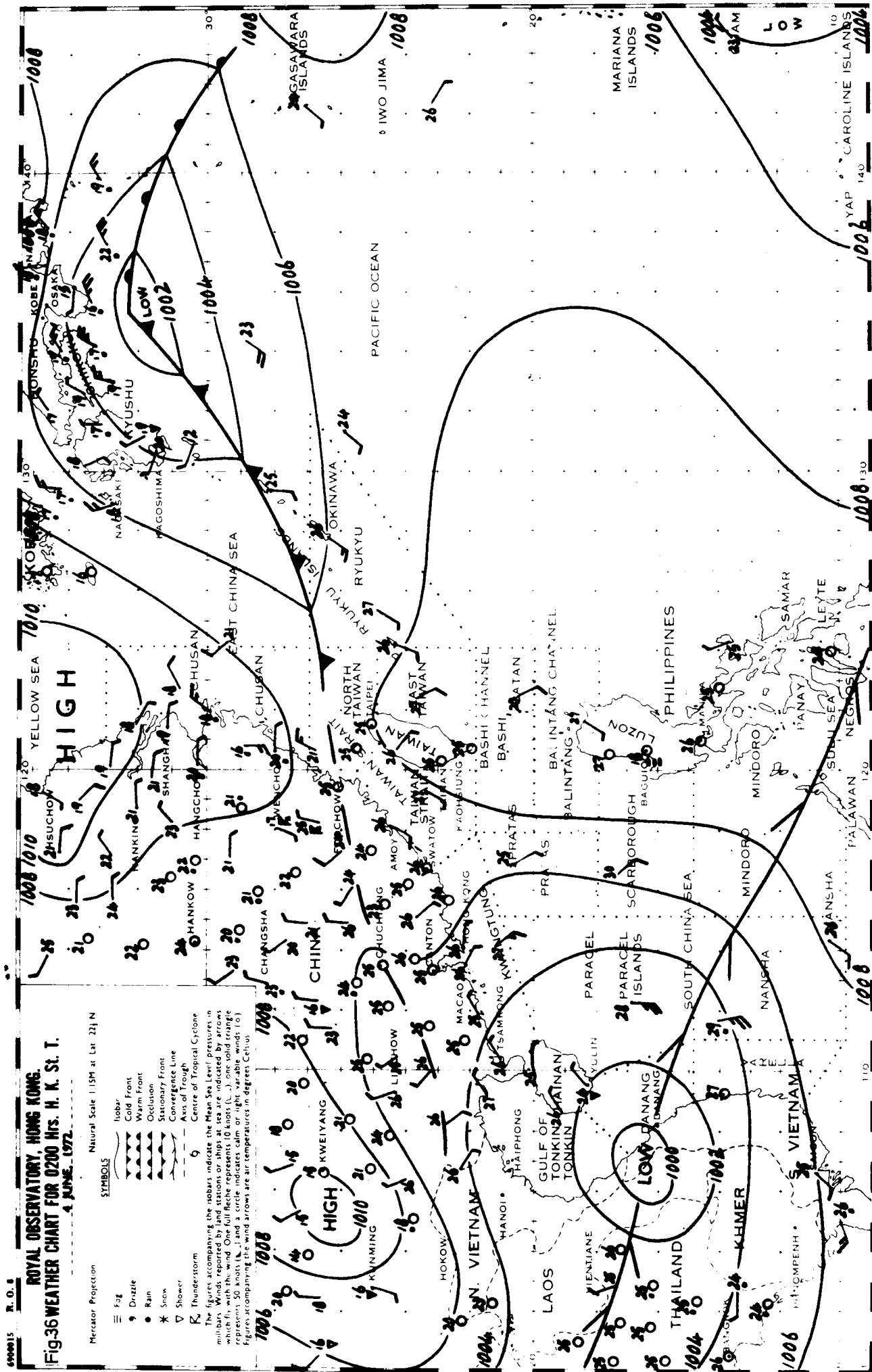
- Fog
- Drizzle
- Rain
- Snow
- Shower
- Thunder-storm
- Isobar
- Cold Front
- Warm Front
- Occlusion
- Stationary Front
- Convergence Line
- Axis of Trough
- Centre of Tropical Cyclone

The figures accompanying the isobars indicate the Mean Sea Level pressures in millibars. Winds reported by land stations or ships at sea are indicated by arrows. The length of the arrow represents the speed in knots. A circle indicates calm or light variable winds (0-10). Figures accompanying the wind arrows are air temperatures in degrees Celsius.





ROYAL OBSERVATORY, HONG KONG.
Fig.36 WEATHER CHART FOR 0200 Hrs. H. K. St. T.

[illegible]

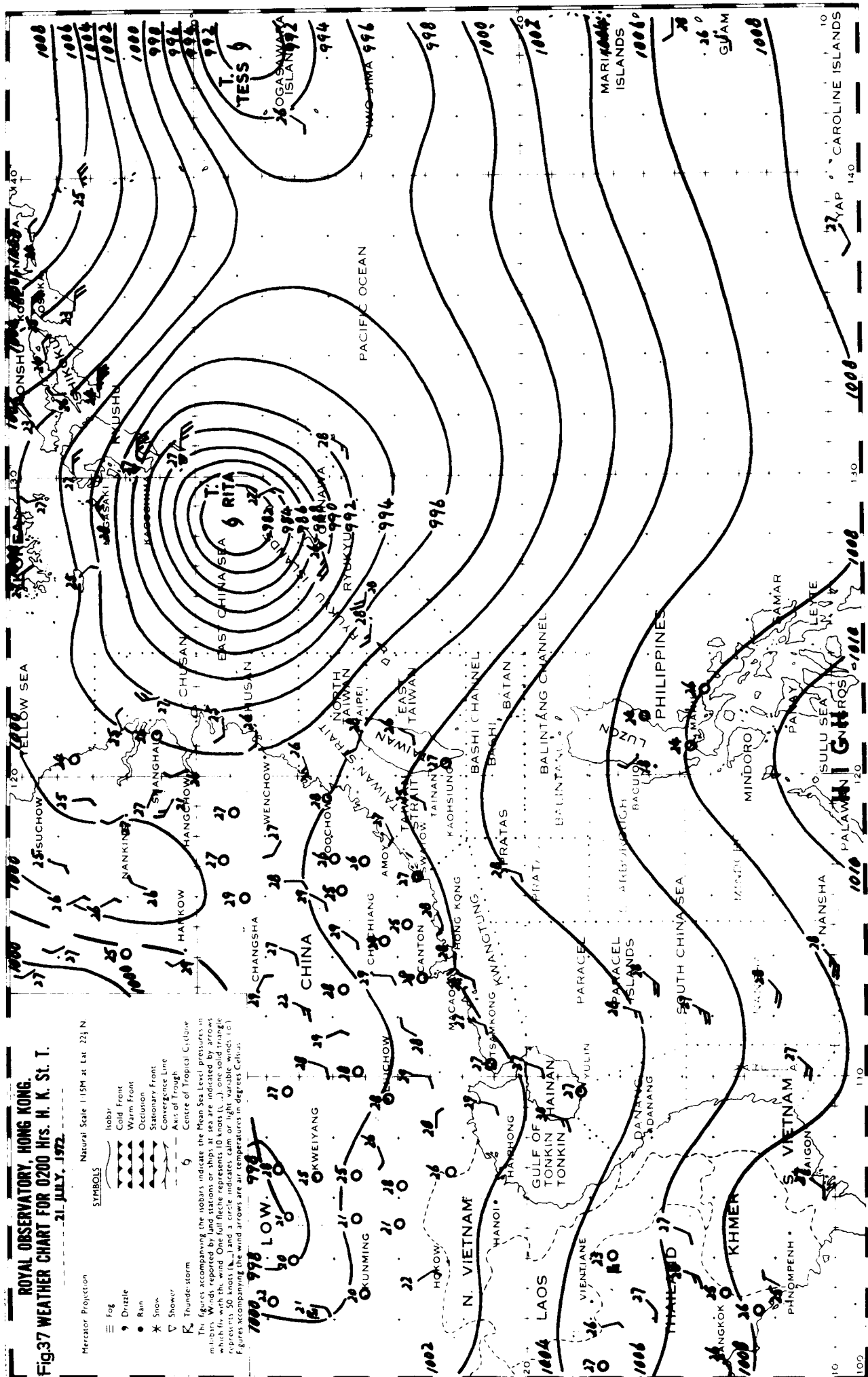
ROYAL OBSERVATORY, HONG KONG.
Fig.37 WEATHER CHART FOR 0200 Hrs. H. K. St. T.
21 JULY, 1972.

Merator Projection Natural Scale 1:5M at Lat 22° N

SYMBOLS

- Fog
- Drizzle
- Rain
- Snow
- Shower
- Thunder-storm
- Isobar
- Cold Front
- Warm Front
- Occlusion
- Stationary Front
- Convergence Line
- Axis of Trough
- Centre of Tropical Cyclone

The figures accompanying the isobars indicate the Mean Sea Level pressures in millibars, with the wind direction and speed indicated by arrows. One full fleche represents 10 knots (5.1) one solid triangle represents 50 knots (14.8) and a circle indicates calm or light variable winds (1.6). Figures accompanying the wind arrows are air temperatures in degrees Celsius.



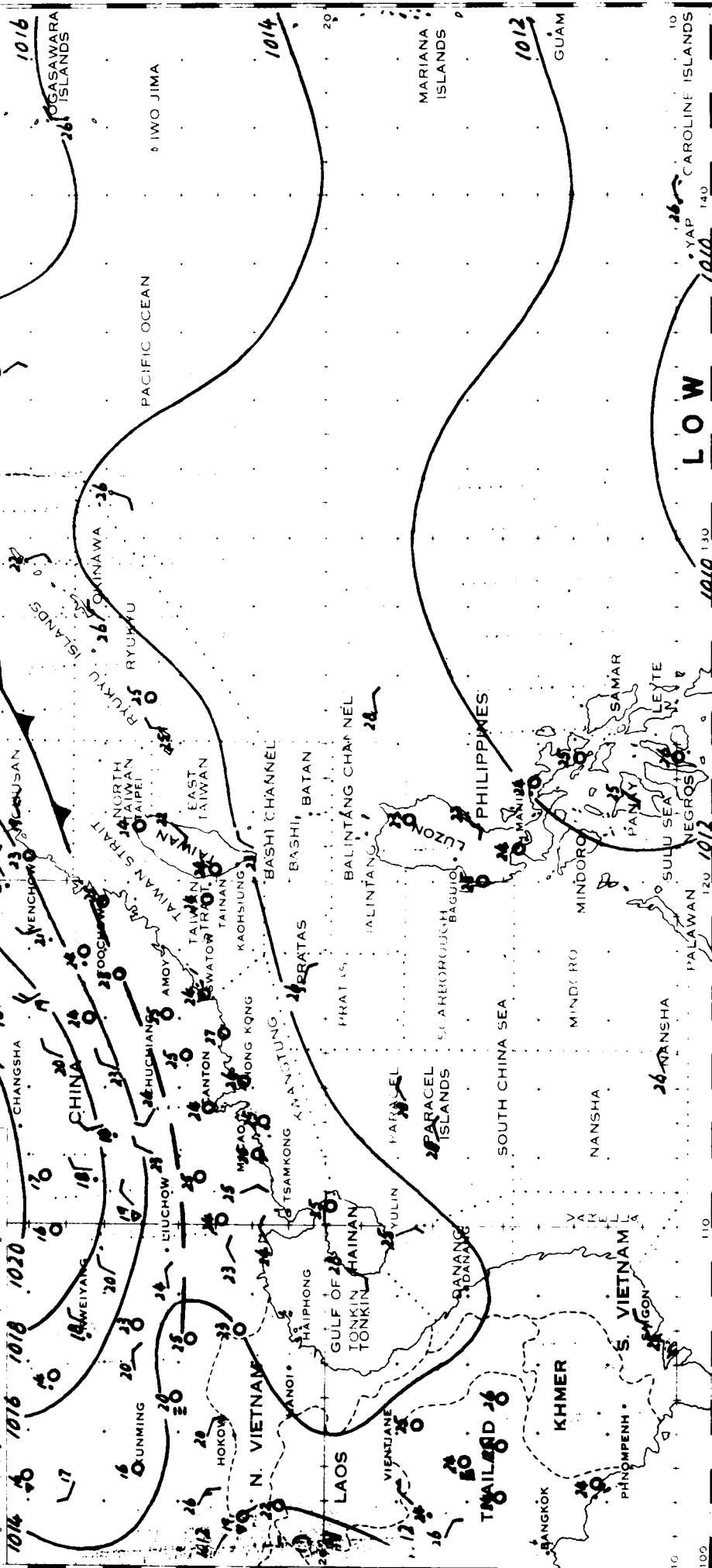
ROYAL OBSERVATORY, HONG KONG. Fig.38 WEATHER CHART FOR 0700 Hrs. H. K. ST. T. 30 SEPTEMBER, 1973.

Merator Projection Natural Scale 1:15M at Lat 22° N

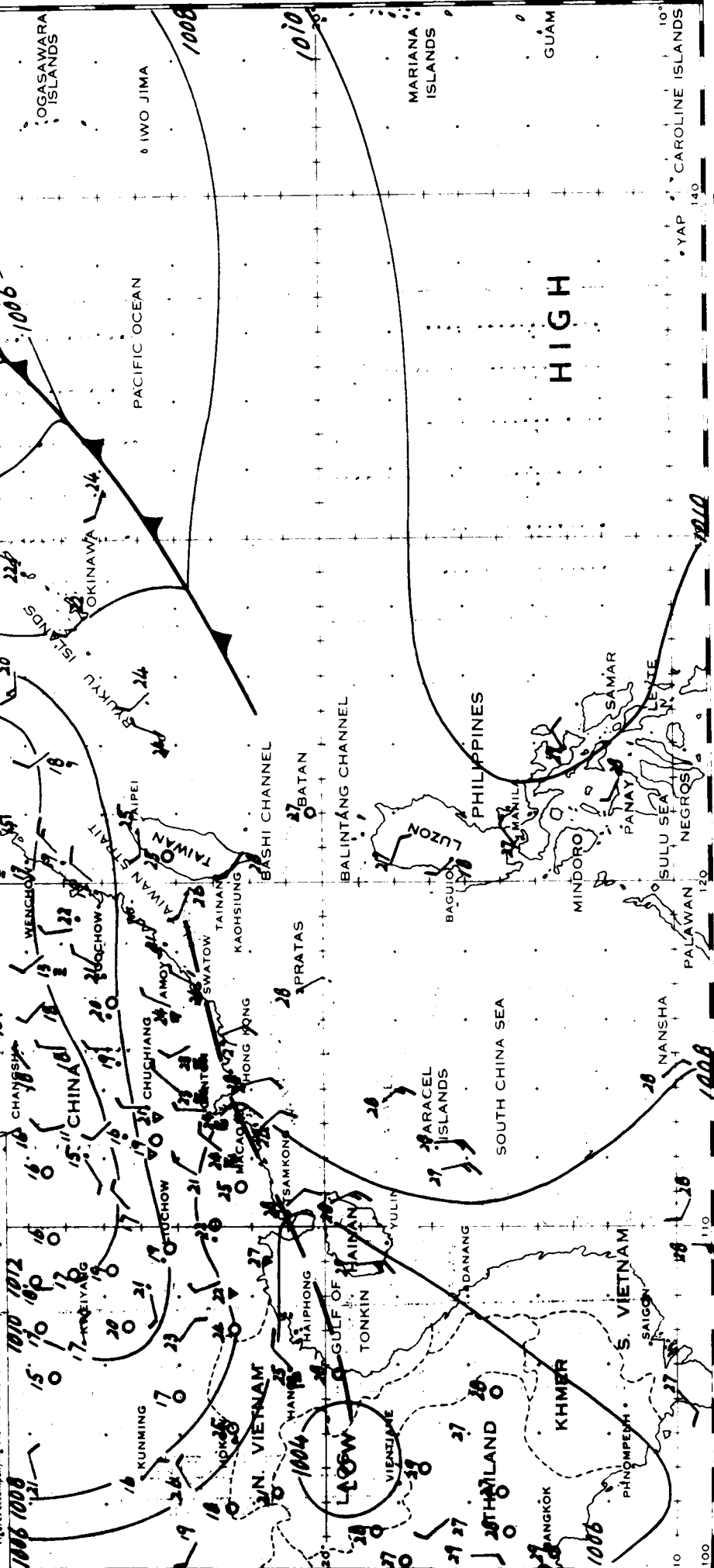
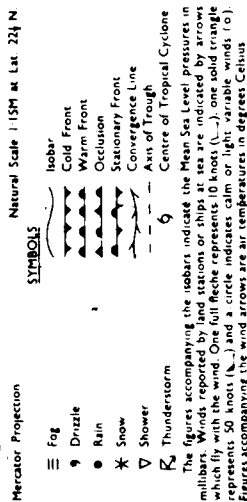
SYMBOLS

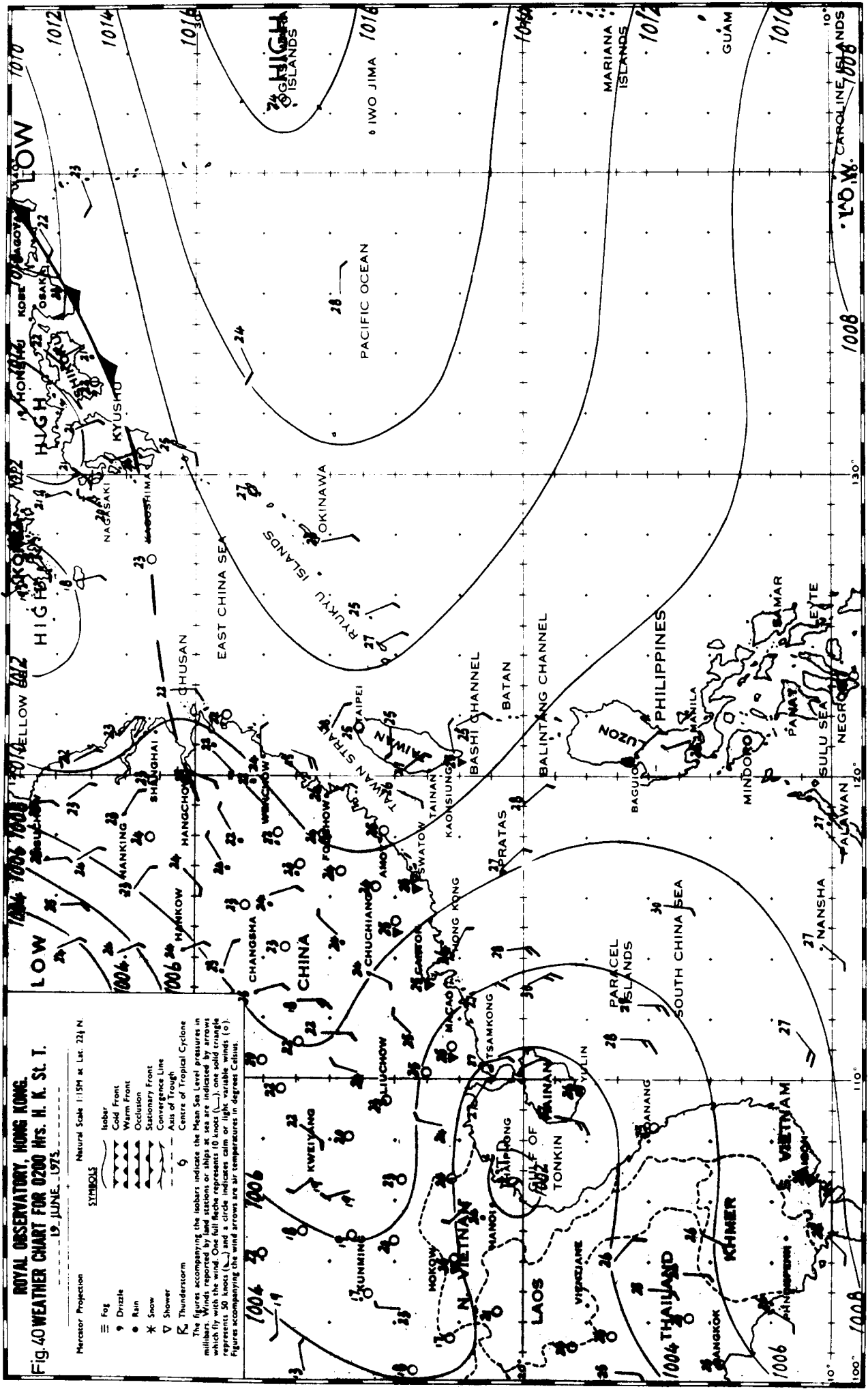
- Fog
- Drizzle
- Rain
- Snow
- Shower
- Thunderstorm
- Isobar
- Cold Front
- Warm Front
- Occlusion
- Stationary Front
- Convergence Line
- Ax of Trough
- Centre of Tropical Cyclone

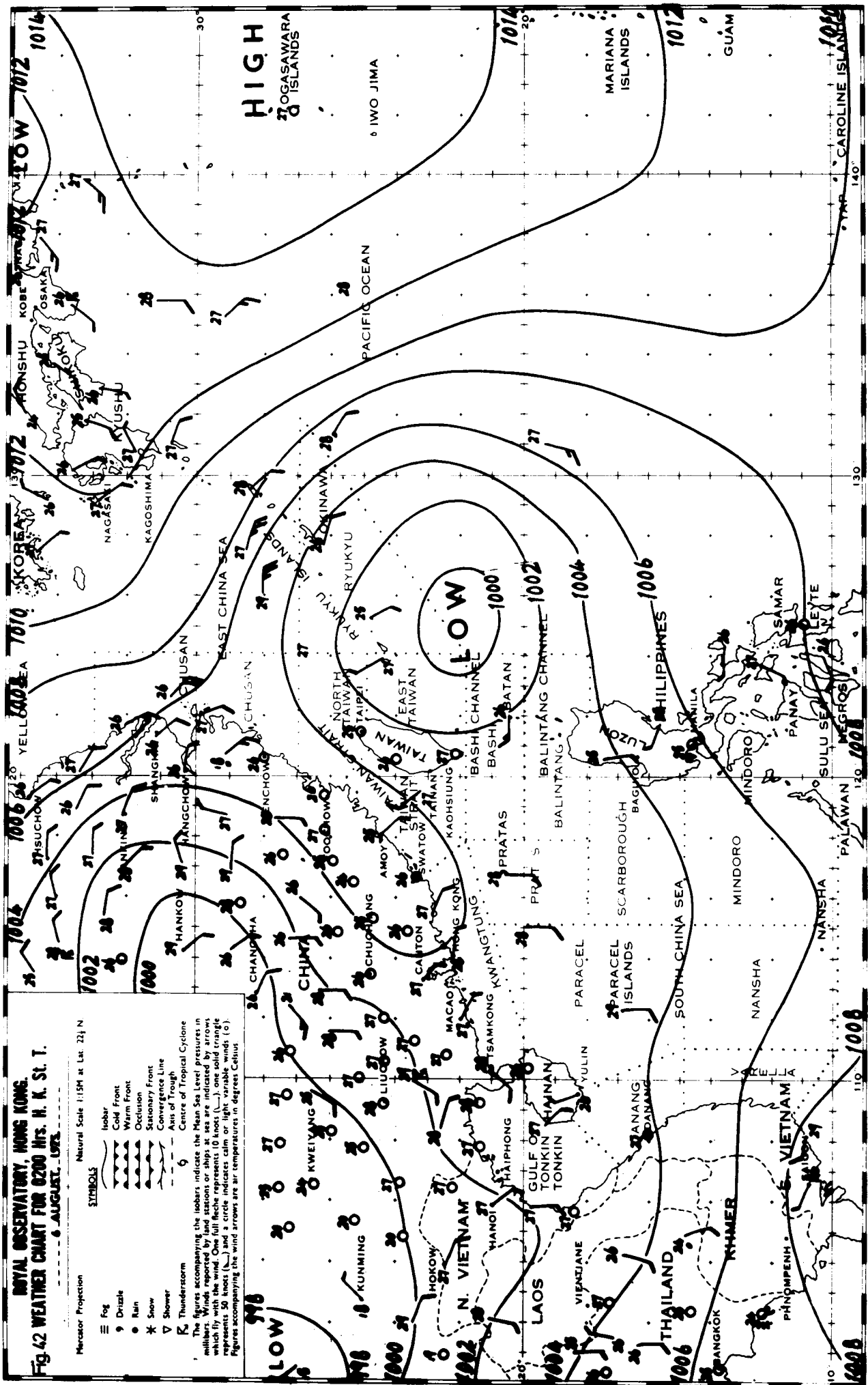
The figures accompanying the isobars indicate the Mean Sea Level pressures in millibars. The figures accompanying the fronts indicate the wind speed in knots (kts) which fly with the wind. One full fleche represents 10 knots (kts). One solid triangle represents 50 knots (kts) and a circle indicates calm or light variable winds (0-10). Figures accompanying the wind arrows are air temperatures in degrees Celsius.



ROYAL OBSERVATORY, HONG KONG.
Fig. 39 WEATHER CHART FOR 0200 Hrs. H. K. ST. T.
11 MAY, 1975.





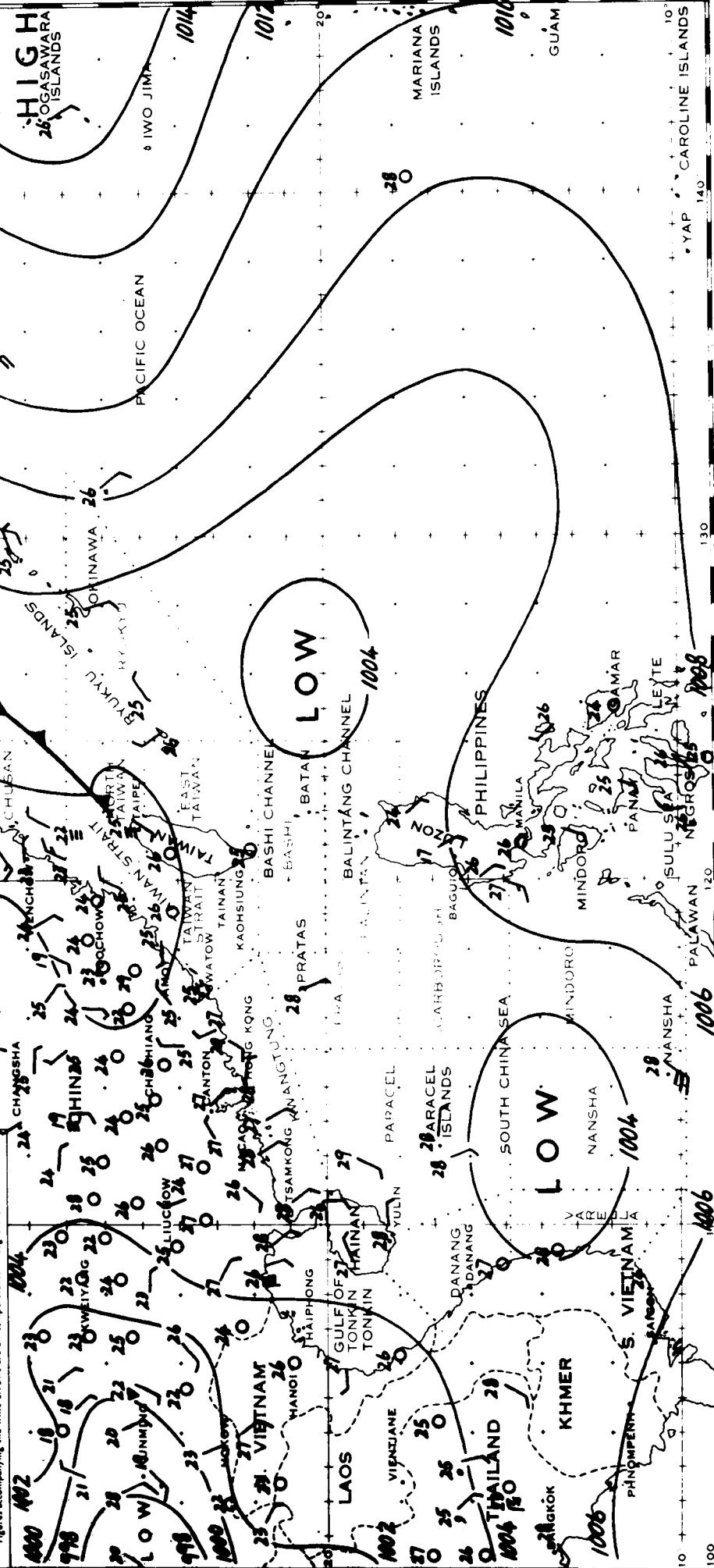
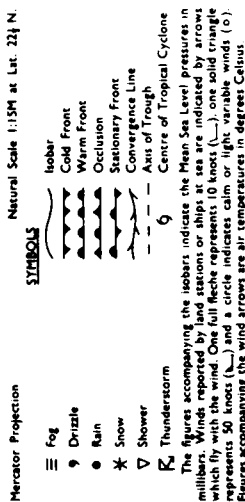


ROYAL OBSERVATORY, HONG KONG.
 Fig. 42 WEATHER CHART FOR 0200 Hrs. H. K. ST. T.
 6 AUGUST, 1975.

ROYAL OBSERVATORY, HONG KONG.

Fig.43 WEATHER CHART FOR 0200 Hrs. H. K. St. I.

20 JUNE 1978.



ROYAL OBSERVATORY, HONG KONG.

Mercator Projection

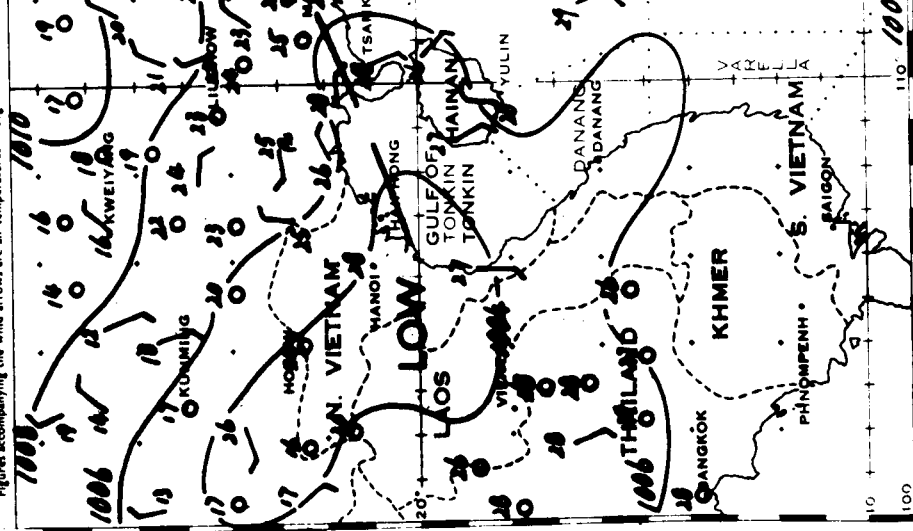
SYMBOLS

Natural Scale 1:5M at Lat. 22½°

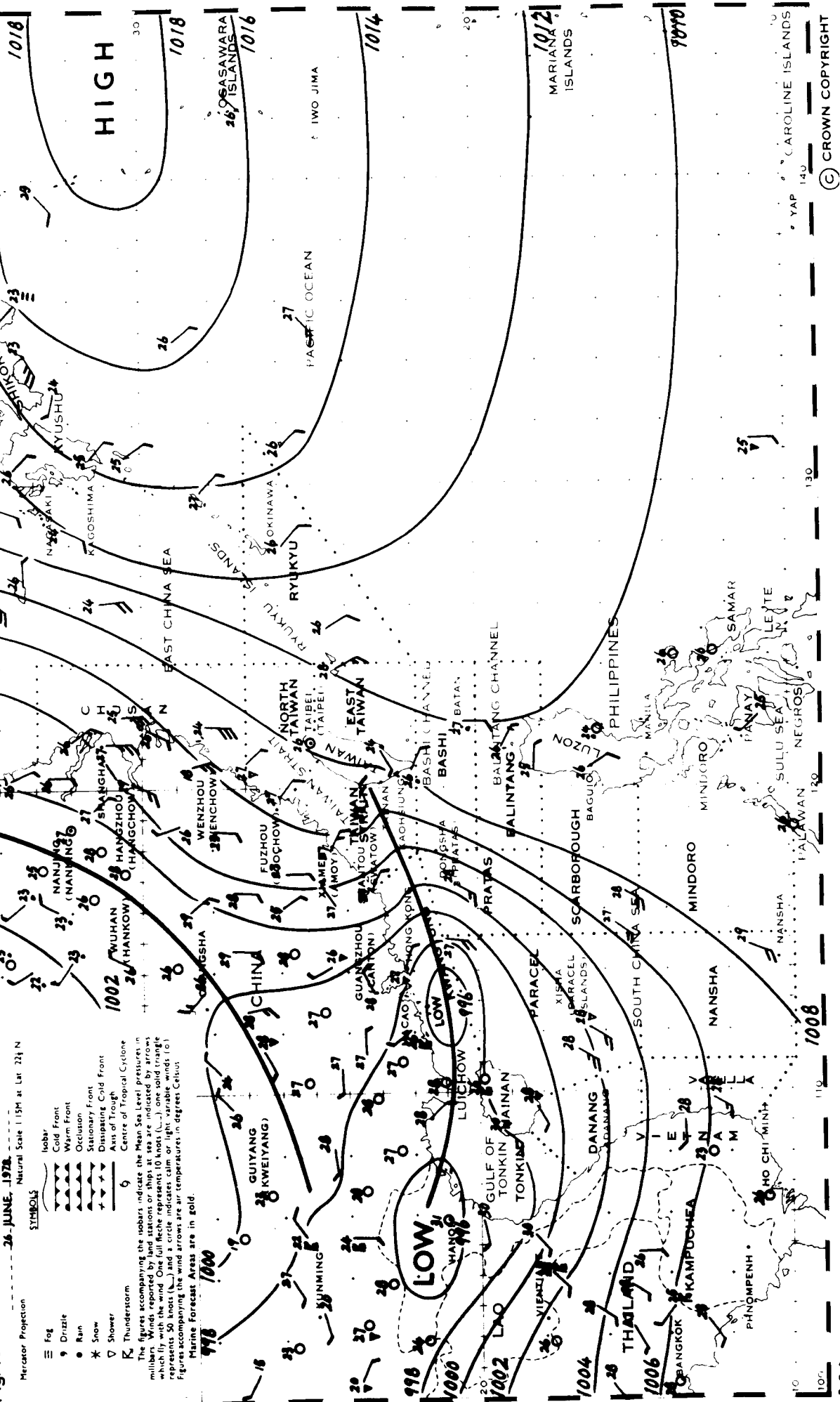
Isober
Cold Front
Warm Front
Occlusion
Stationary Front
Convergence Line
Axis of Trough
Centre of Tropical Cyclone

Fog
Drizzle
Rain
Snow
Shower
Thunderstorm

The figures accompanying the isobars indicate the Mean Sea Level pressures in millibars. Winds reported by land stations or ships are indicated by arrows which fit with the wind full force indicator. The number indicates calm or light variable winds ($\circ$) represents 50 knots (Δ). Wind arrows show air temperatures in degrees Celsius.



ROYAL OBSERVATORY, HONG KONG.
Fig. 46 WEATHER CHART FOR 0200 Hrs. H. K. T.



ROYAL OBSERVATORY, HONG KONG.

Fig. 47 WEATHER CHART FOR 0200 Hrs. H. K. T.

27 JUNE, 1978

Mercaator Projection Natural Scale 1:15M at Lat 22½ N

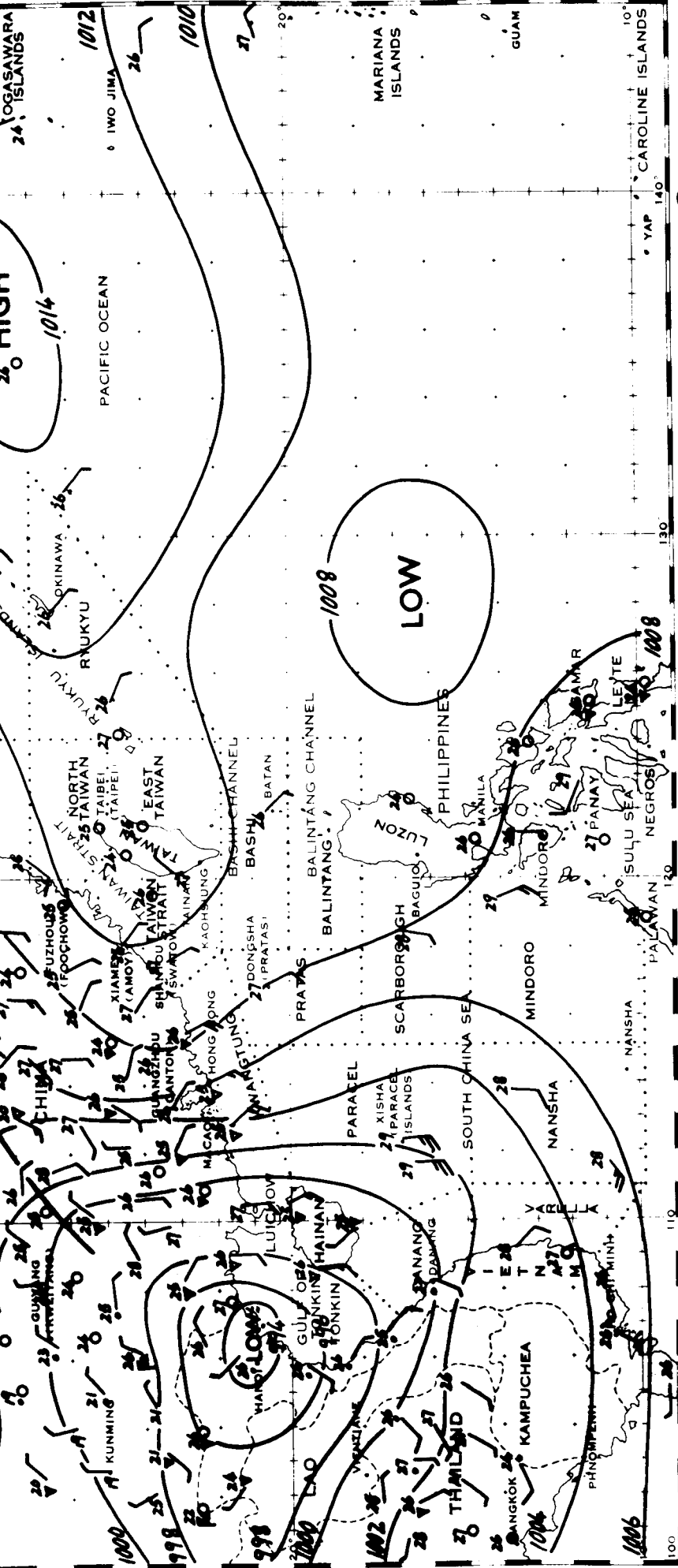
SYMBOLS

- ☁ Fog
- ☂ Cold Front
- ☃ Warm Front
- ☄ Occlusion
- ★ Rain
- ☆ Stationary Front
- ☇ Drizzle
- ☈ Snow
- ☉ Shower
- ☊ Thunderstorm
- ☋ Axis of Trough
- ☌ Centre of Tropical Cyclone

The figures accompanying the isobars indicate the Mean Sea Level pressures in millibars. Winds reported by land stations or ships at sea are indicated by the arrows. The wind speed is indicated by the number of the arrow, which is the wind speed in knots. The wind direction is indicated by the arrow pointing towards the station. The wind speed is indicated by the number of the arrow, which is the wind speed in knots. The wind direction is indicated by the arrow pointing towards the station.

Figures accompanying the wind arrows are air temperatures in degrees Celsius.

Marine Forecast Areas are in gold.



ROYAL OBSERVATORY, HONG KONG.

Fig.48 WEATHER CHART FOR 0200 Hrs. H. K. T.

11 JULY 1978

Mercaator Projection

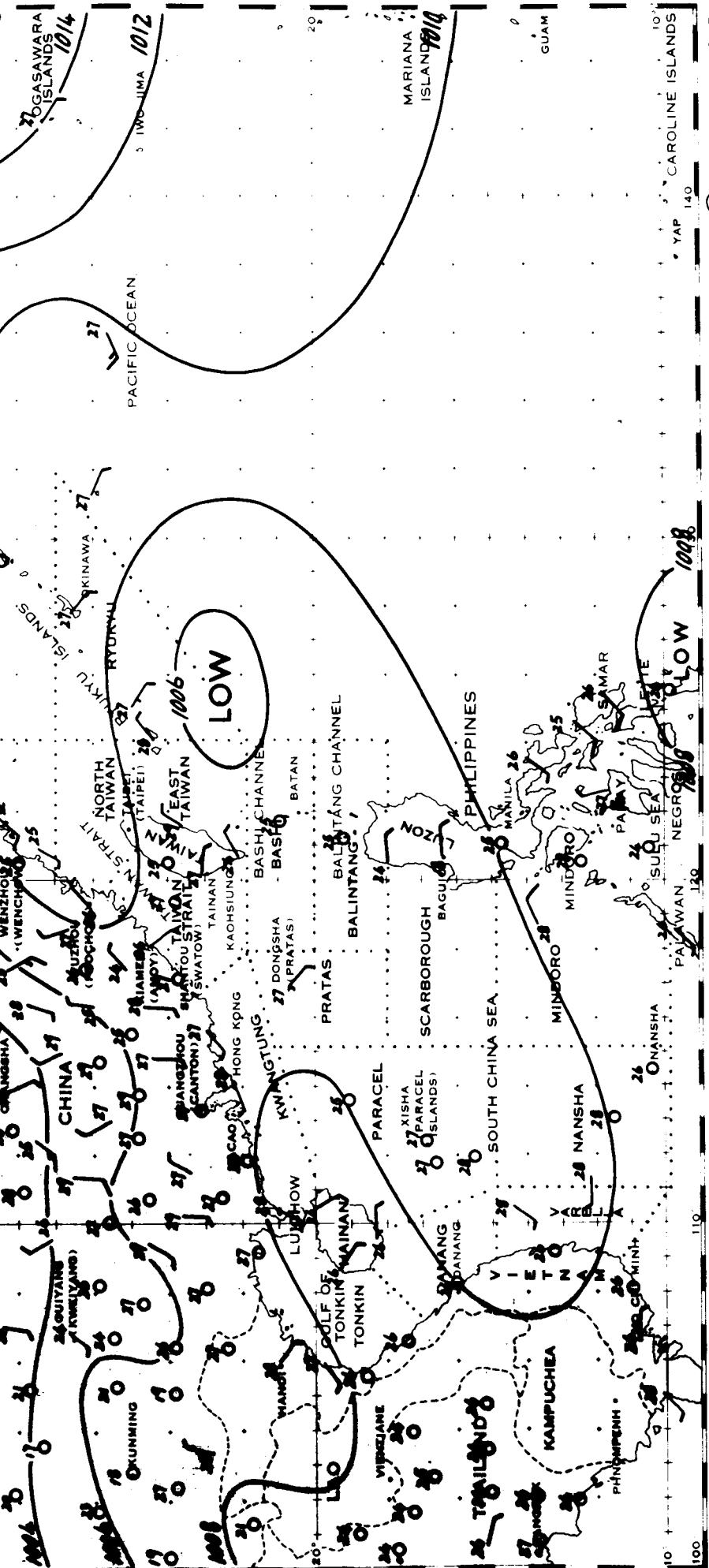
Natural Scale 1:15M at Lat. 22° N

SYMBOLS

- ☉ Fog
- ☉ Drizzle
- ☉ Rain
- ☉ Snow
- ☉ Thunderstorm
- ☉ Cold Front
- ☉ Warm Front
- ☉ Occlusion
- ☉ Stationary Front
- ☉ Disappearing Cold Front
- ☉ Axis of Trough
- ☉ Centre of Tropical Cyclone

The figures accompanying the isobars indicate the Mean Sea Level pressures in millibars. The figures accompanying the wind arrows indicate the wind speed in knots. One full circle represents 10 knots (—), one solid triangle represents 50 knots (▲) and a circle indicates calm or light variable winds (○). Figures accompanying the wind arrows are air temperatures in degrees Celsius.

Marine Forecast Areas are in gold.



ROYAL OBSERVATORY, HONG KONG.

Fig. 49 WEATHER CHART FOR 0200 HRS. H. K. T.

15 SEPTEMBER, 1979.

Mercator Projection

Natural Scale 1:15M at Lat 22° N

SYMBOLS

- Fog
- Drizzle
- Rain
- Snow
- Shower
- Thunderstorm
- Cold Front
- Warm Front
- Occlusion
- Stationary Front
- Dissipating Cold Front
- Axis of Trough
- Centre of Tropical Cyclone

The figures accompanying the isobars indicate the Mean Sea Level pressures in millibars reported by the stations indicated by the dots. The figures in the circles indicate the surface wind speeds in knots (knots) and the direction of the wind. The figures in the triangles indicate the direction of the wind. The figures in the squares indicate the direction of the wind. The figures in the diamonds indicate the direction of the wind. The figures in the circles indicate the direction of the wind. The figures in the triangles indicate the direction of the wind. The figures in the squares indicate the direction of the wind. The figures in the diamonds indicate the direction of the wind.

Marine Forecast Areas are in gold.

Figures accompanying the wind arrows are air temperatures in degrees Celsius.

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ROYAL OBSERVATORY, HONG KONG

Fig. 51 WEATHER CHART FOR 0200 HONG KONG TIME

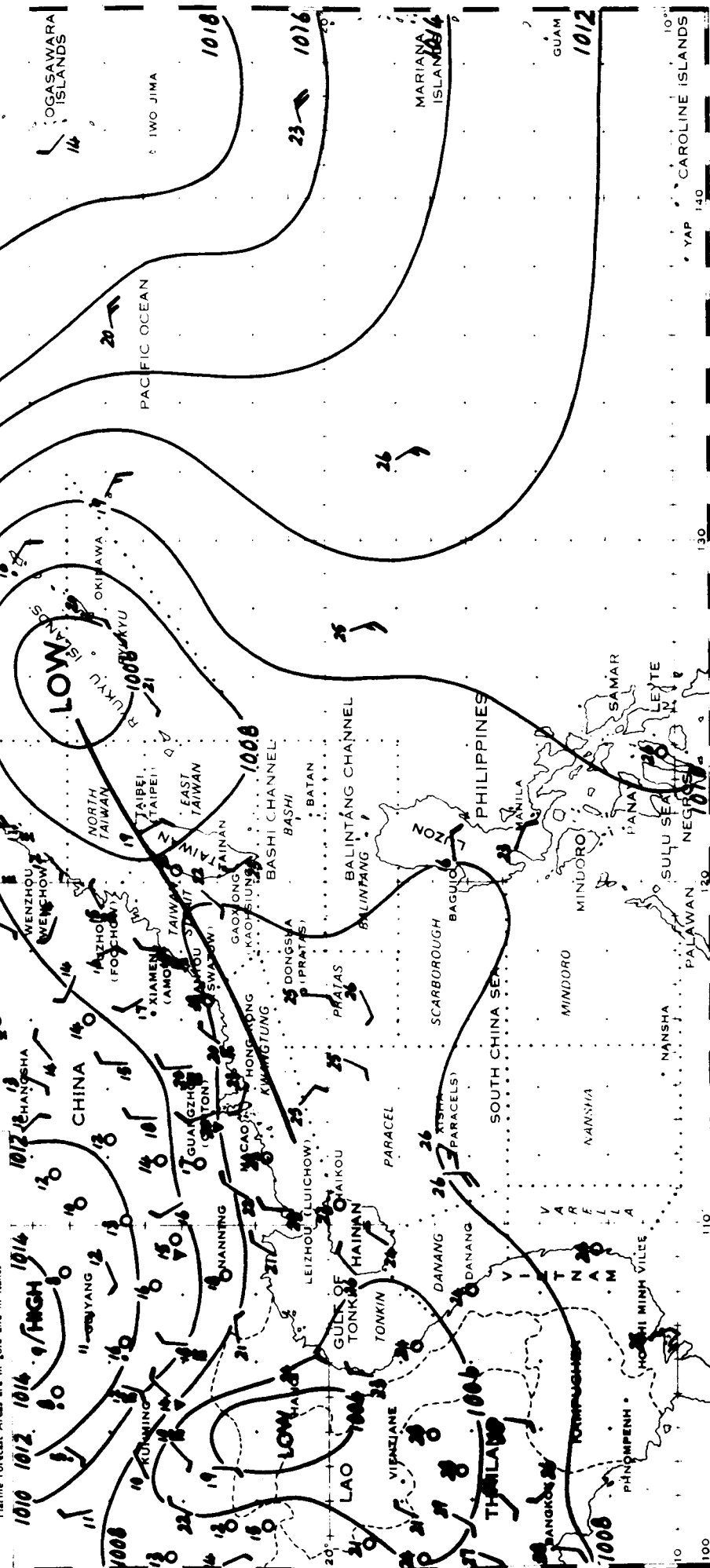
Natural Scale 1:15M at Lat 22½ N

Mercator Projection

SYMBOLS

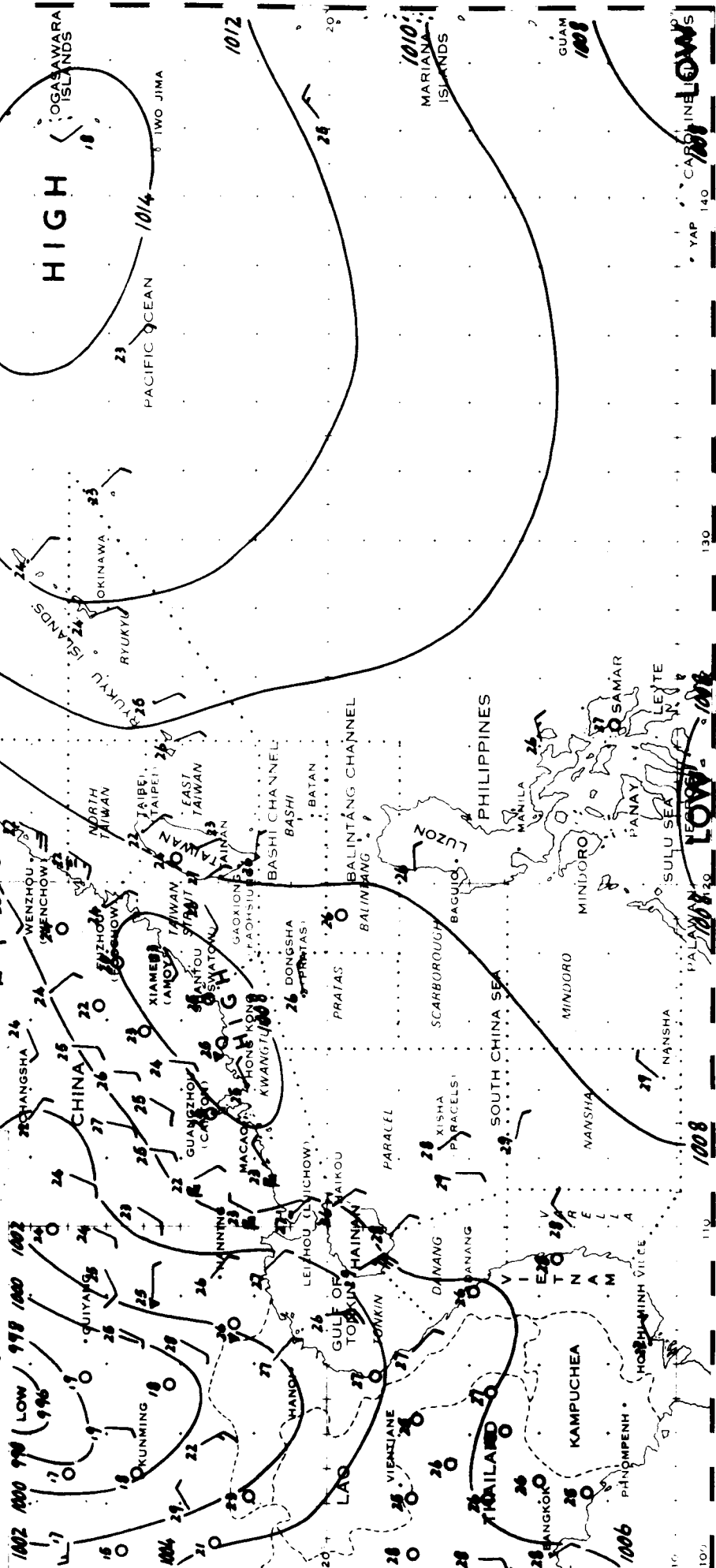
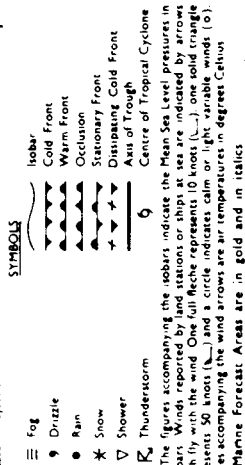
- Fog
- Drizzle
- Rain
- Snow
- Shower
- Thunderstorm
- Centre of Tropical Cyclone
- Isobar
- Cold Front
- Warm Front
- Occlusion
- Stationary Front
- Disappearing Cold Front
- Axis of Trough

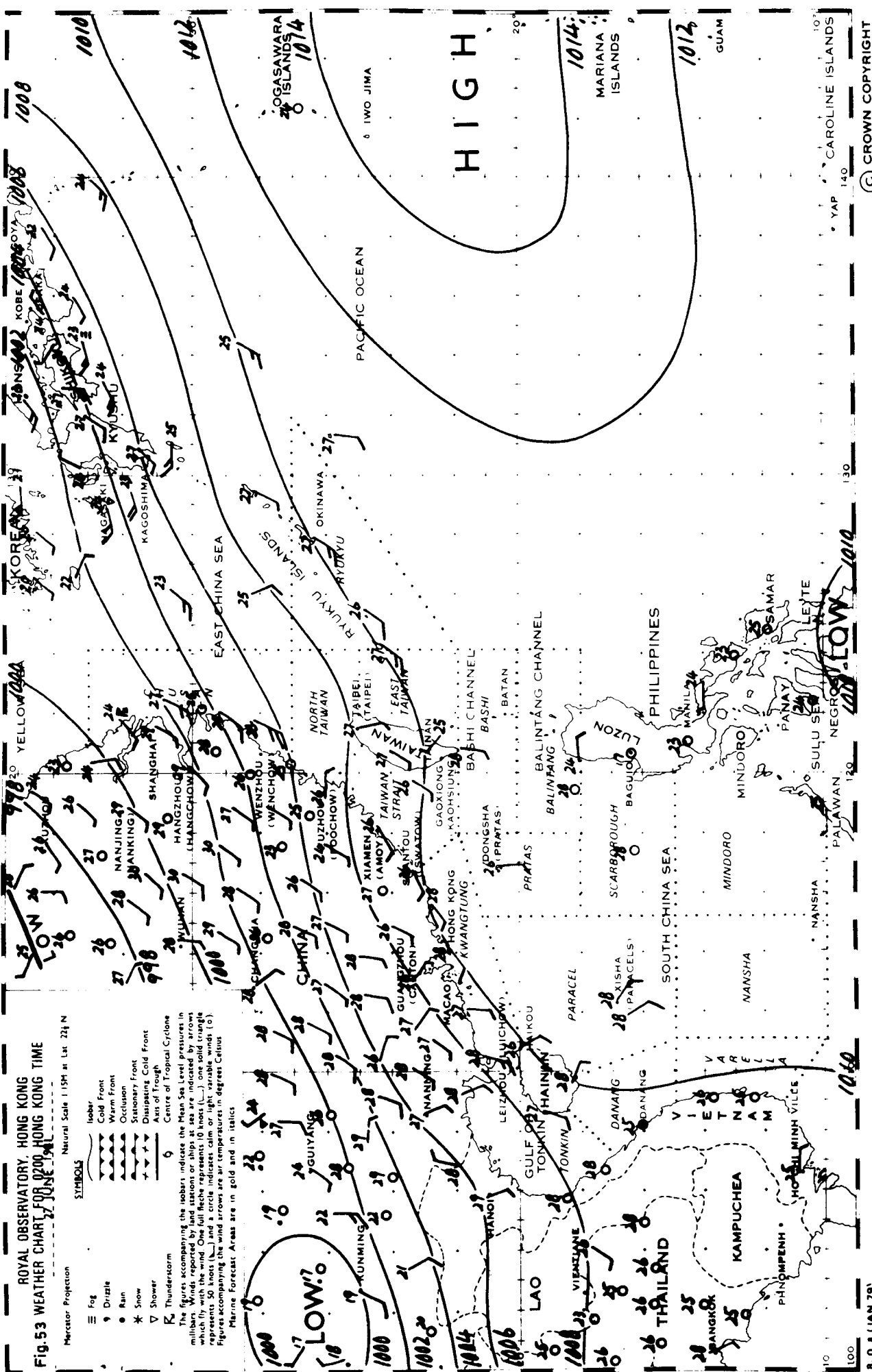
The figures accompanying the isobars indicate the Mean Sea Level pressures in millibars reported by land stations or ships at sea as indicated by arrows which fly with the wind. One full fleche represents 10 knots (—) one solid triangle represents 50 knots (—) and a circle indicates calm or light variable winds. (6) Figures accompanying the wind arrows are air temperatures in degrees Celsius. Marine Forecast Areas are in italics.

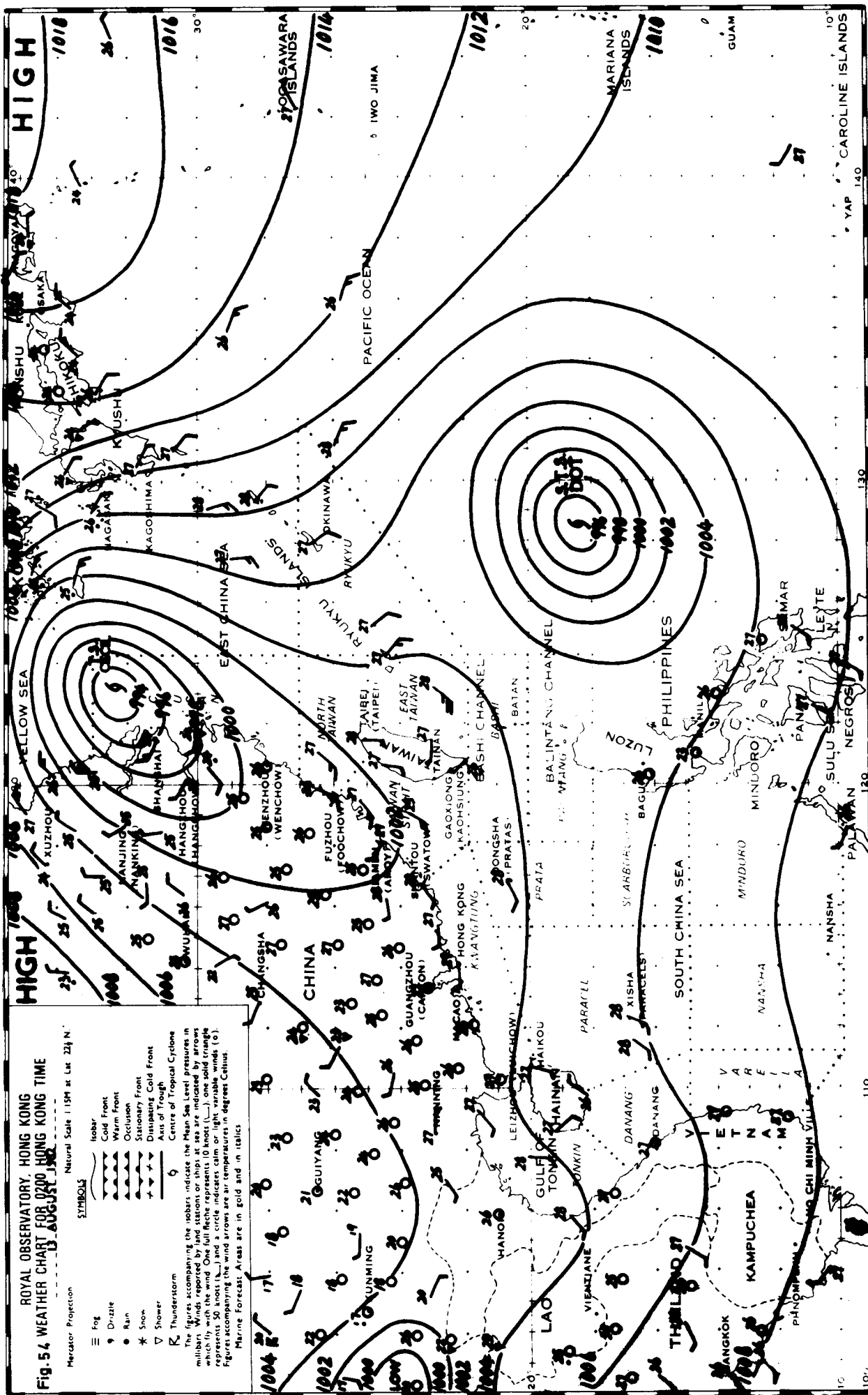


ROYAL OBSERVATORY, HONG KONG
Fig. 52 WEATHER CHART FOR 0200 HONG KONG TIME
10 MAY 1954

Mercator Projection Natural Scale 1:5M at Lat 22°N







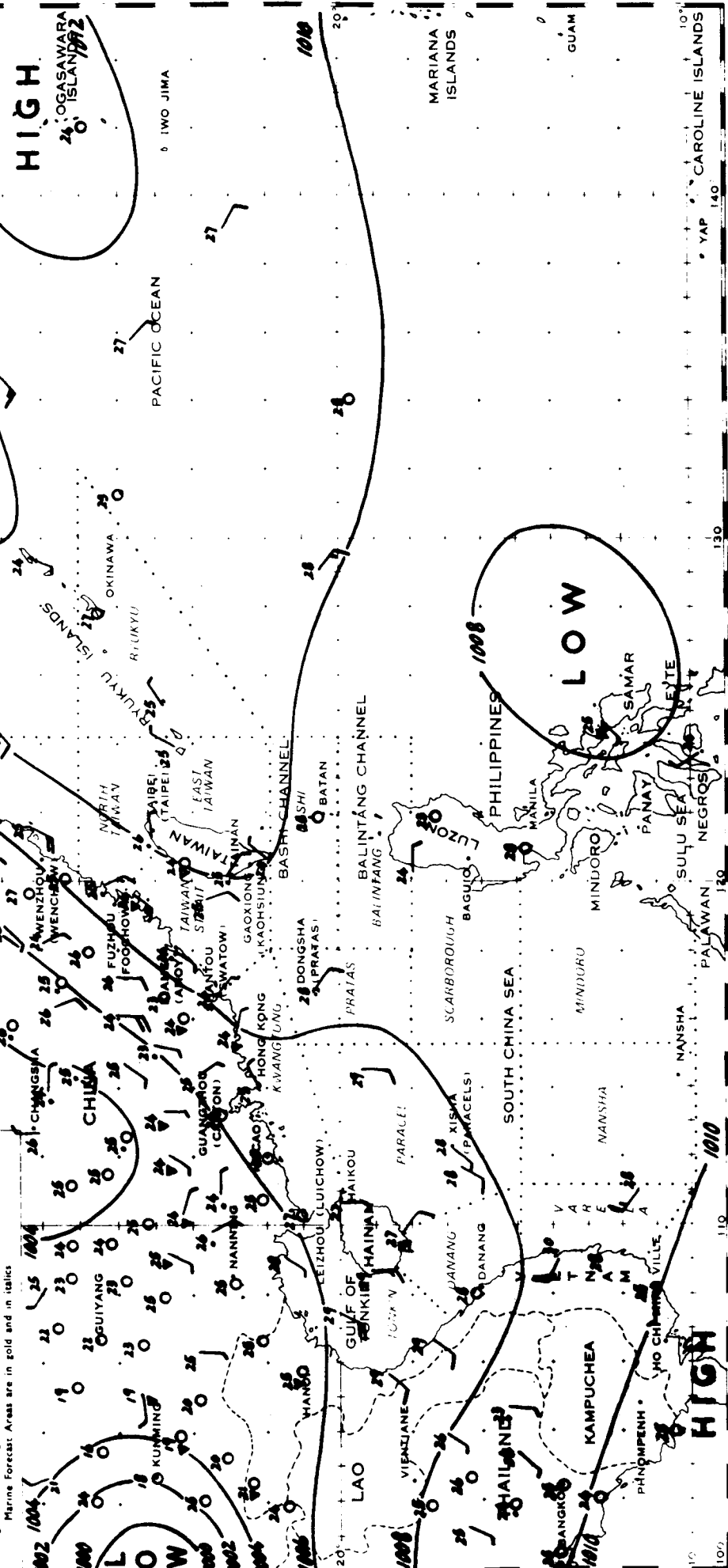
ROYAL OBSERVATORY, HONG KONG Fig. 55 WEATHER CHART FOR 0200 HONG KONG TIME 18 AUGUST 1972

Mercator Projection Natural Scale 1:15M at Lat. 22° N

SYMBOLS

- ☉ Fog
- ☂ Drizzle
- ☔ Rain
- ❄ Snow
- ☁ Thunderstorm
- Isobar
- Cold Front
- Warm Front
- Occlusion
- Stationary Front
- Disappearing Cold Front
- Axis of Trough
- ☉ Centre of Tropical Cyclone

The figures accompanying the isobars indicate the Mean Sea Level pressures in millibars. Winds reported by land stations or ships at sea are indicated by arrows which fly with the wind. One full fleche represents 10 knots (—) one solid triangle represents 50 knots (—) and a circle indicates speeds in excess of 100 knots (—). Figures accompanying the wind arrows and air temperatures in degrees Celsius. Marine Forecast Areas are in gold and in italics.



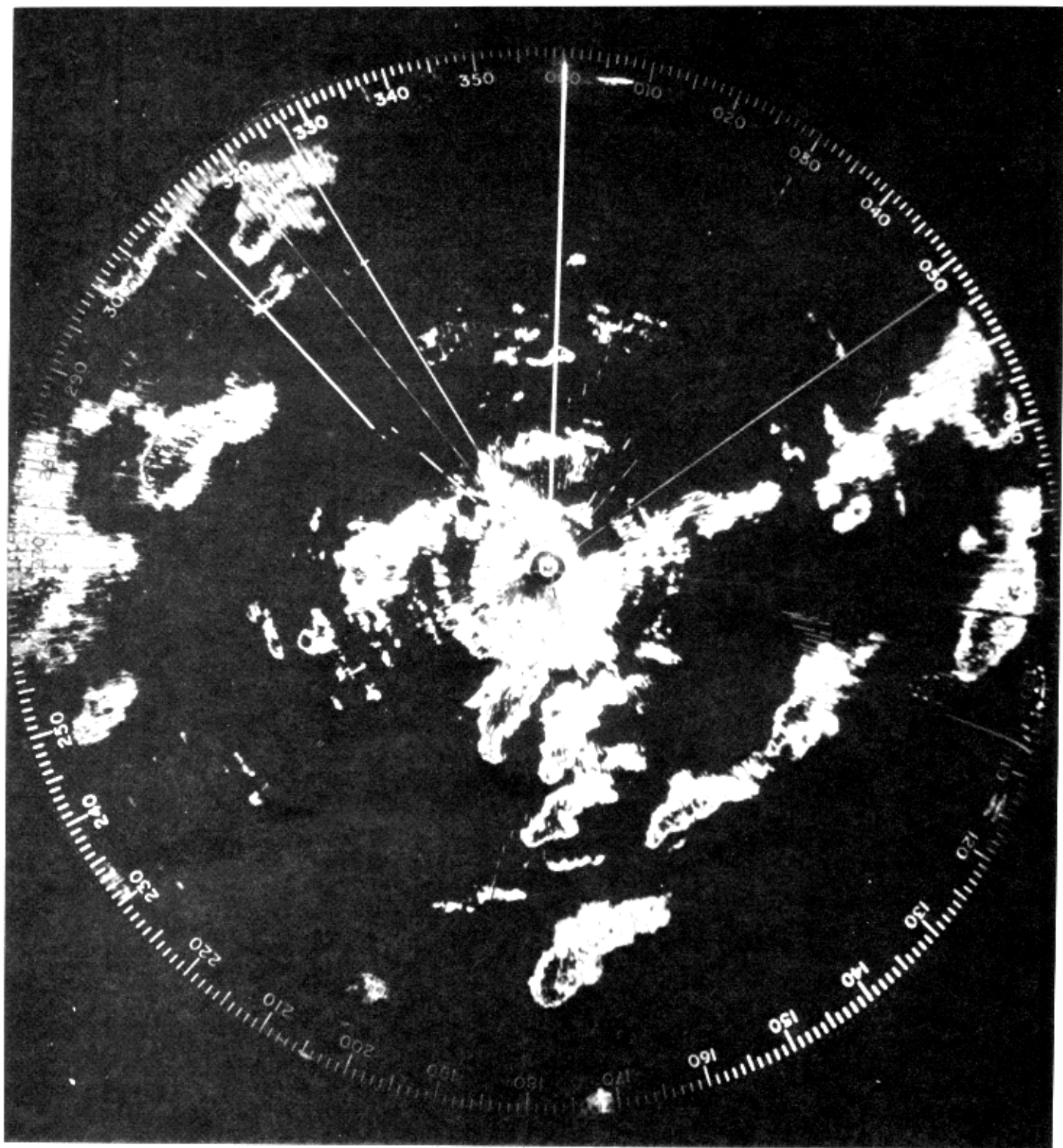


Fig. 56. Radar picture at 0701 GMT on 27 June 1978
(Centre: Tate's Cairn, Range 30 nautical miles,
Elevation 0 degree, Isoecho on).

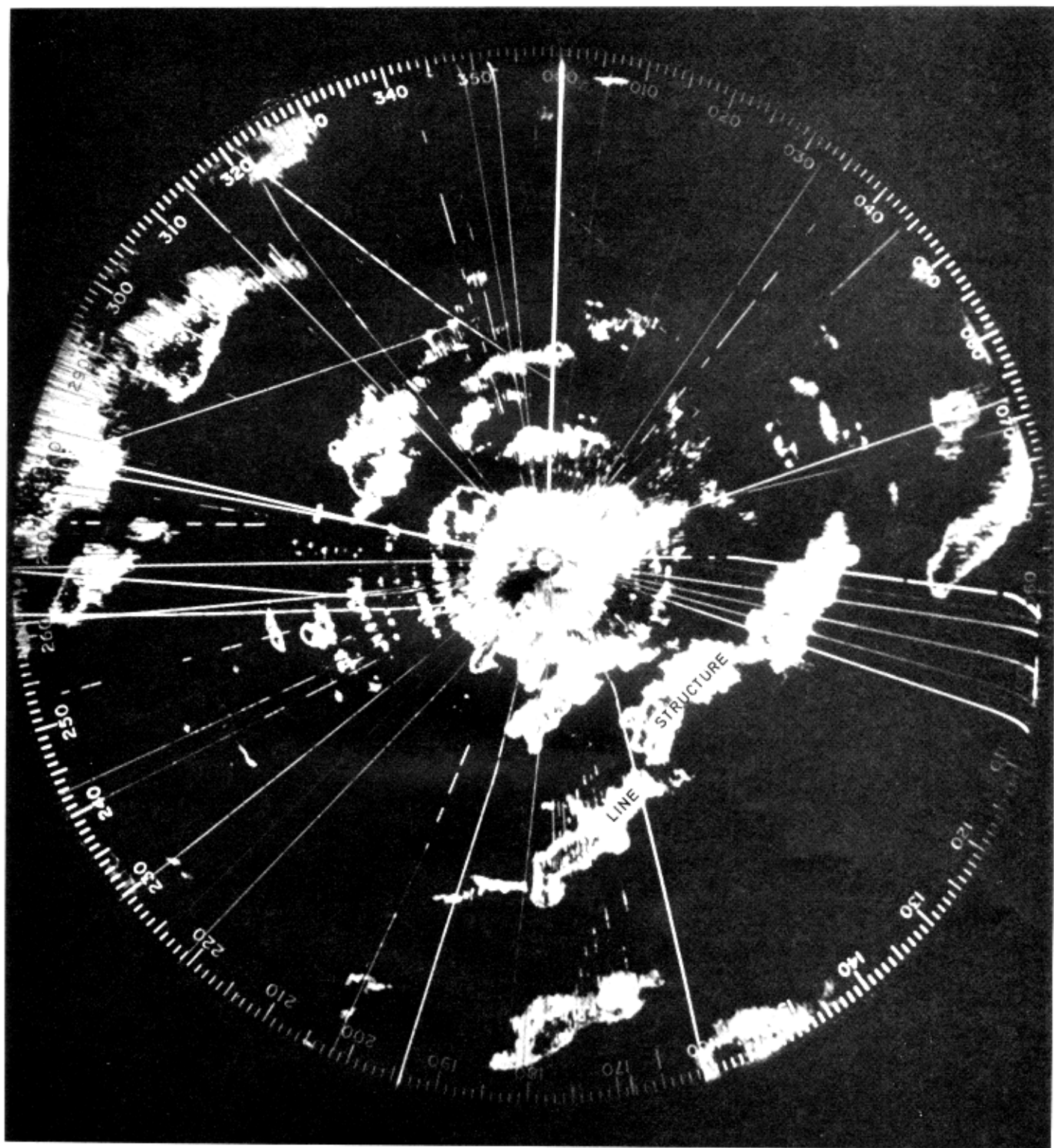


Fig. 57. Radar picture at 0717 GMT on 27 June 1978
(Centre: Tate's Cairn, Range 30 nautical miles,
Elevation 0 degree, Isoecho on).

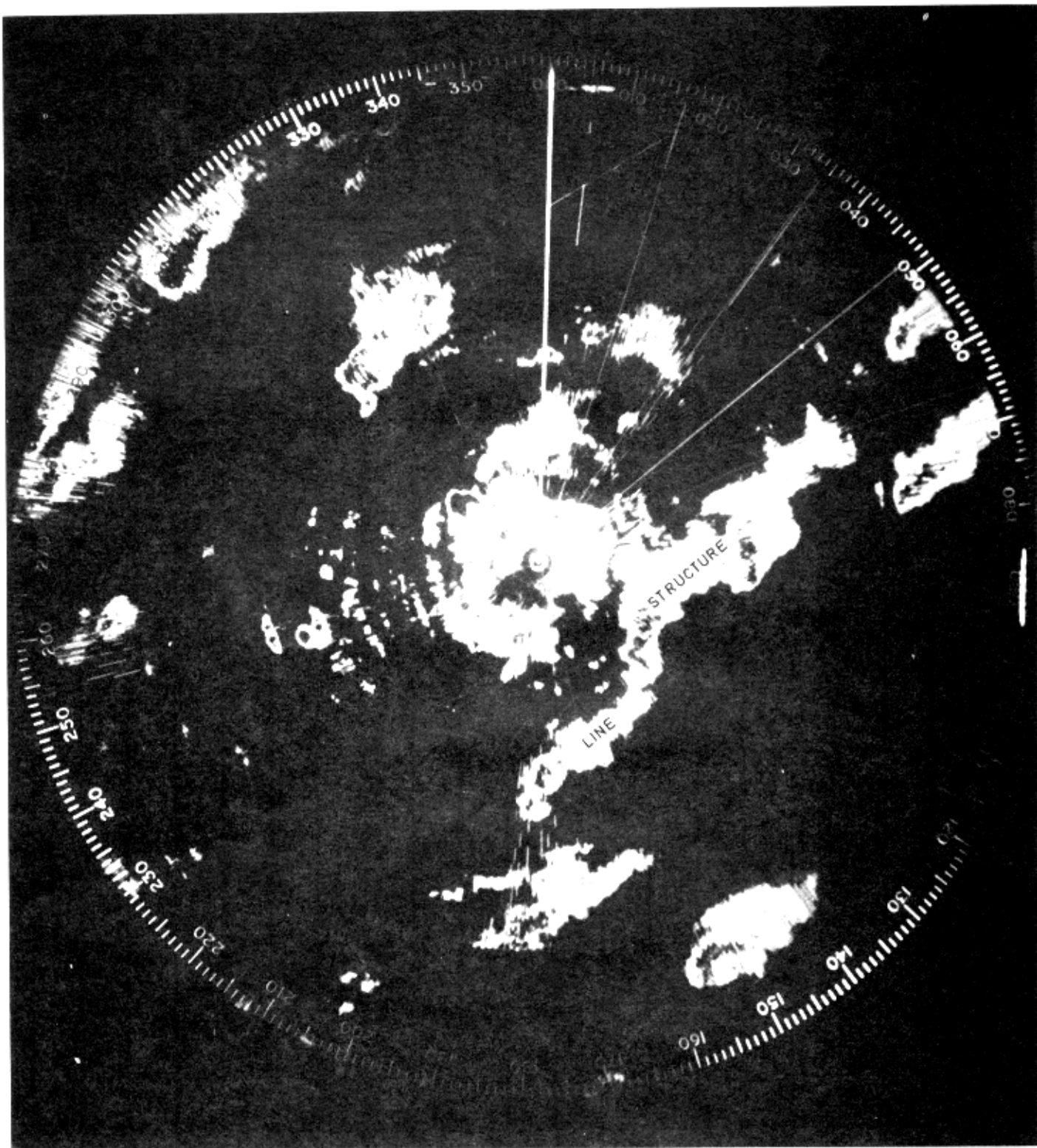


Fig. 58. Radar picture at 0732 GMT on 27 June 1978
(Centre: Tate's Cairn, Range 30 nautical miles,
Elevation 0 degree, Isoecho on).

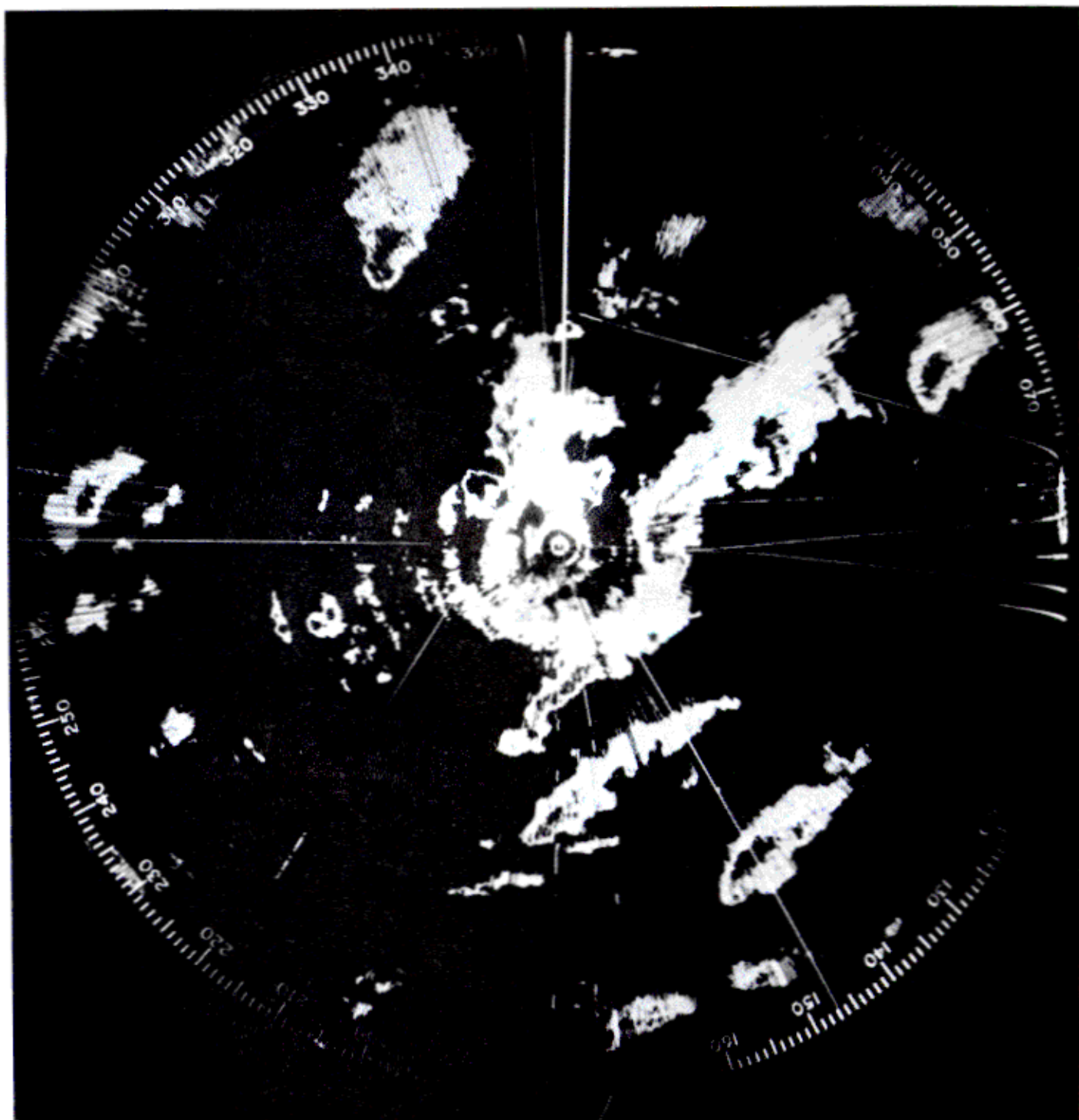


Fig. 59. Radar picture at 0748 GMT on 27 June 1978
(Centre: Tate's Cairn, Range 30 nautical miles,
Elevation 0 degree, Isoecho on).

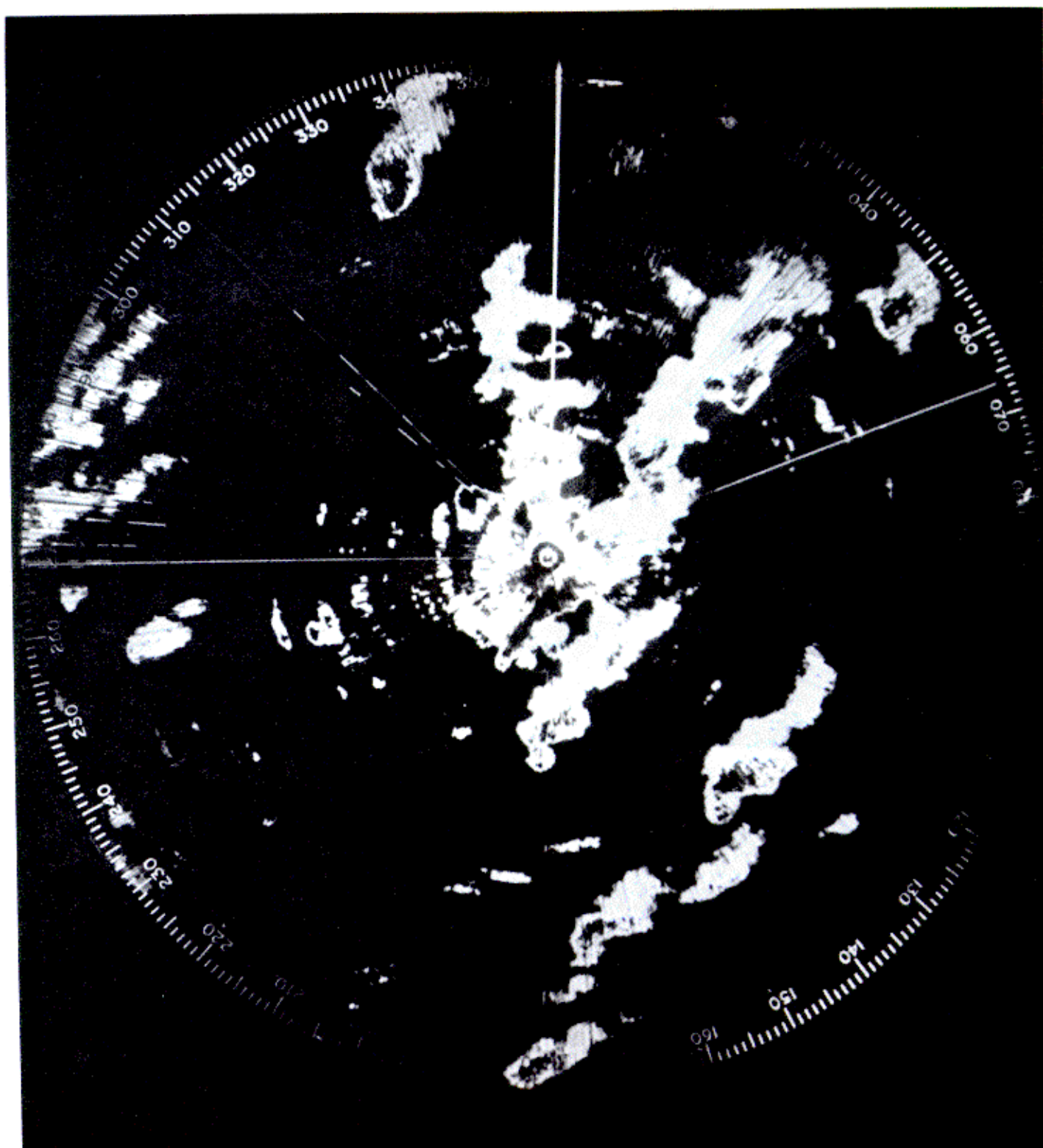


Fig. 60. Radar picture at 0803 GMT on 27 June 1978
(Centre: Tate's Cairn, Range 30 nautical miles,
Elevation 0 degree, Isoecho on).

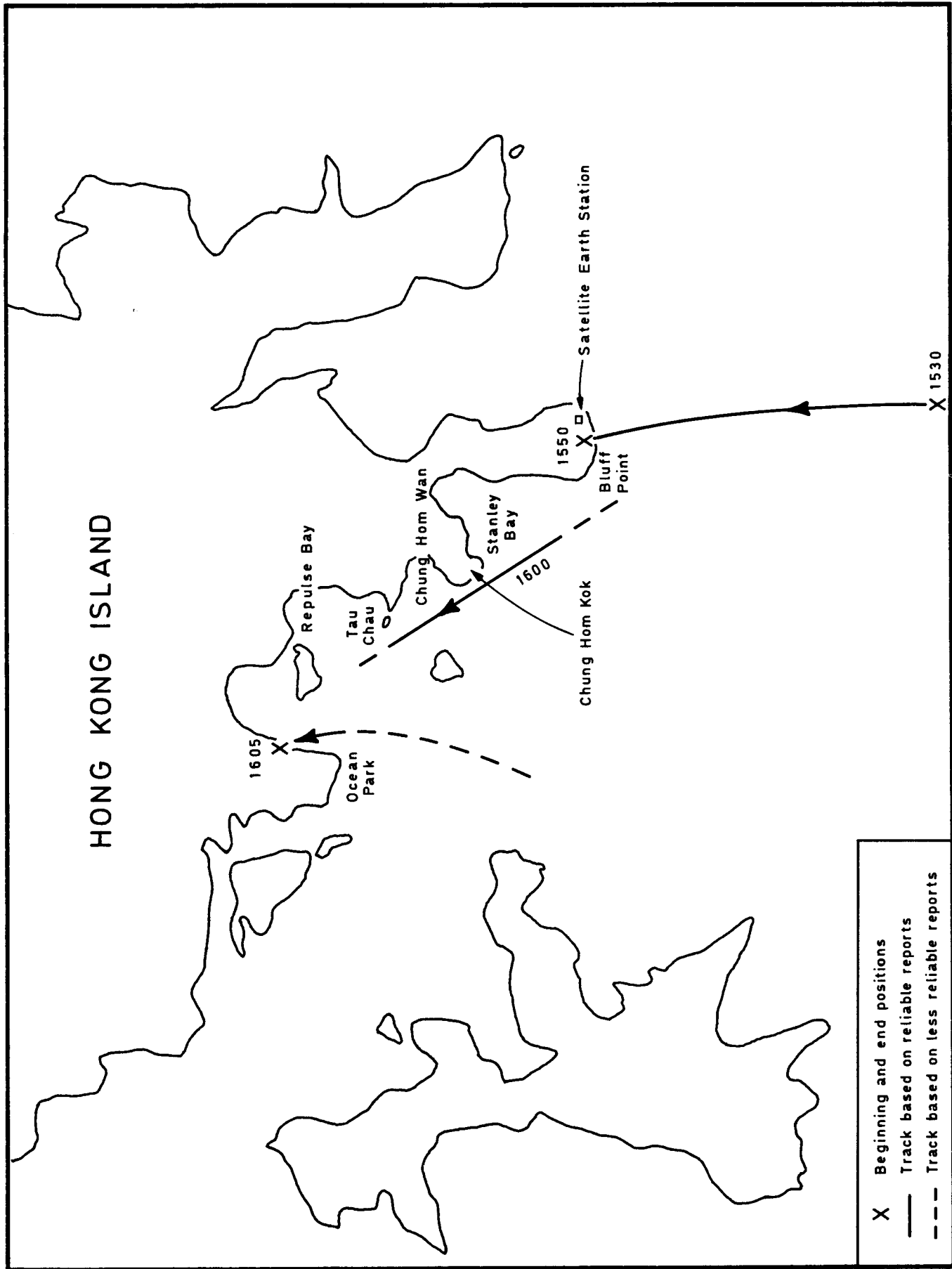


Fig. 61. Estimated tracks of waterspouts reported on 27 June 1978

Fig. 62. Radar picture at
0100 GMT on
28 April 1978
(Centre: Tate's
Cairn, Range 120
nautical miles,
Elevation 2 de-
grees, Isoecho on)
Waterspout about
30 n.m. west of
radar station.

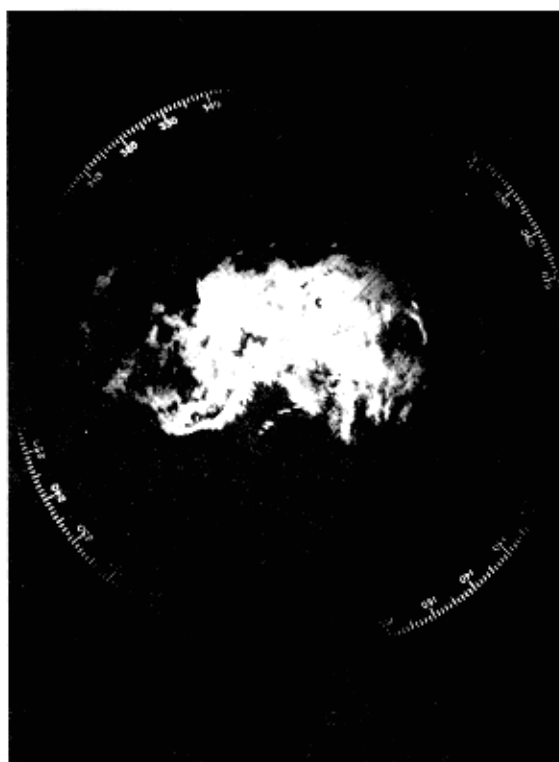
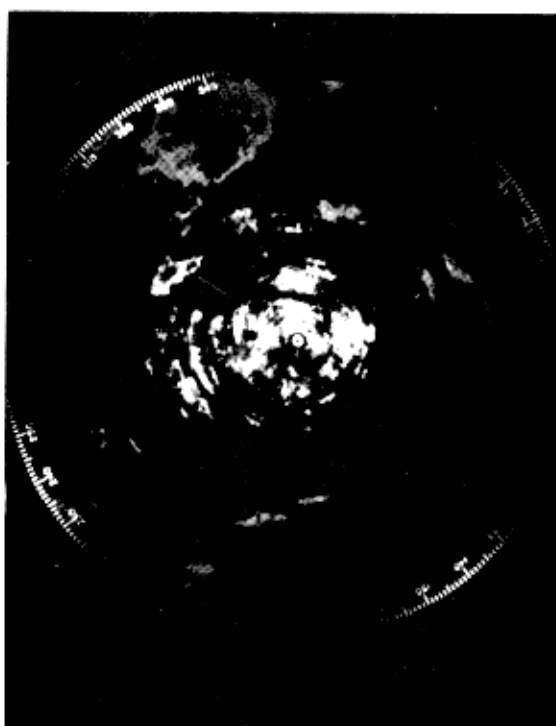


Fig. 63. Radar picture at
0800 GMT on
15 September 1978
(Centre: Tate's
Cairn, Range 30
nautical miles,
Elevation 2 de-
grees, swept gain
on, 0 dB).
Waterspout near
Tsim Bei Tsui
about 15 n.m.
northwest of radar
station.



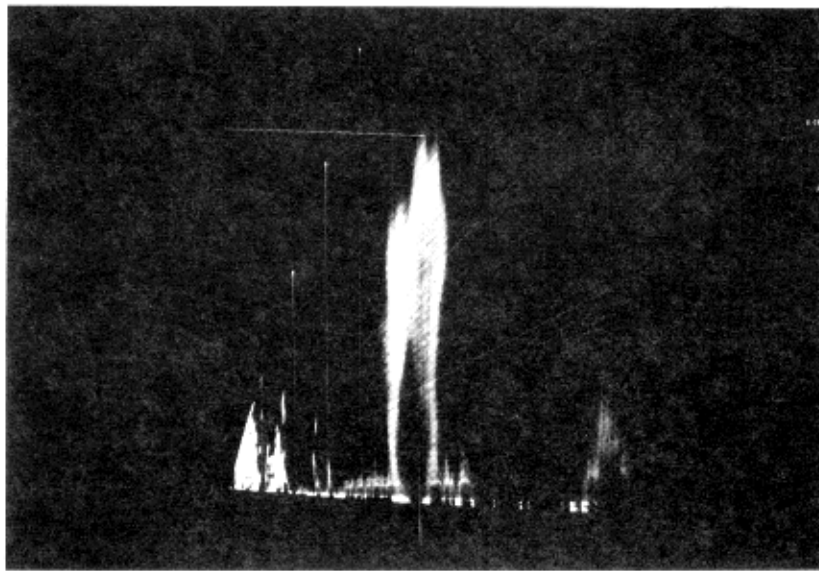


Fig. 64. RHI radar picture at 0738 GMT on 15 September 1978
(Centre: Tate's Cairn, Range 60 nautical miles,
Azimuth 350 degrees, height of echo 53500 feet)
Waterspout near Tsim Bei Tsui.

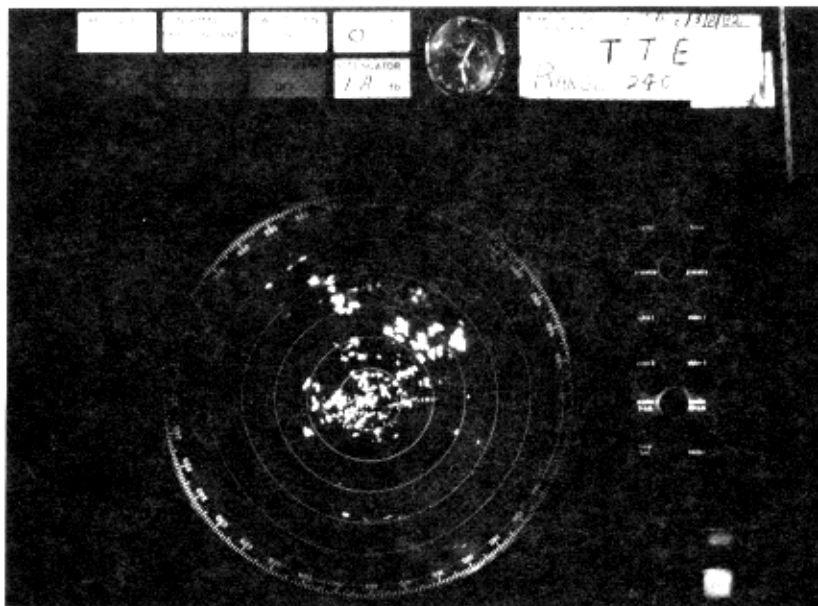


Fig. 65. Radar picture at 1104 GMT on 13 August 1982
(Centre: Tate's Cairn, Range 240 nautical miles,
Elevation 0 degree, 0 dB).
Waterspout about 40 n.m. west of radar station.