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ROYAL OBSERVATORY, HONG KONG

Technical Note No. 46

WIND SHEAR AT HONG KONG INTERNATIONAL AIRPORT IN FOUR SQUALLY SHOWER SITUATIONS

by

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1. INTRODUCTION

Wind shear in a particular direction is the change in the wind vector, or a component of the wind vector, in that direction. Normally, interest is confined to the changes in the horizontal component of the wind vector. For the purpose of this paper, we are mainly concerned with wind shear along the flight path of aircraft approaching the airport.

When an aeroplane approaches an airport and encounters a suddenly decreasing head wind, the inertia of the aeroplane will, for a short time, maintain the ground speed, but the air speed will be reduced. Reduced air speed means reduced lift and therefore the rate of descent will increase. Extra power is needed quickly in order to regain lost height and to bring the aeroplane back onto the correct glide path. Unfortunately, heavy jet aircraft require appreciable time to accelerate so that there is a danger of undershooting the runway. An increasing tail wind has the same effect as a decreasing head wind. On the other hand, an instantaneously increasing head wind or decreasing tail wind can create a danger of overshooting the runway (Reference 1).

It will be seen that wind shear along the descent and climb paths in the approaches to an airport therefore pose a serious hazard to aircraft. However, if pilot is warned in advance, he can adjust his approach path or approach speed so that the danger of a missed approach is reduced.

In order to study wind shear conditions in the vicinity of Hong Kong International Airport, a programme was designed in August 1976 to collect wind data from aircraft arriving at and departing from the airport from the height of 1000 feet to touchdown together with any turbulence reports. In addition, three sets of new anemometers were being installed at Yau Yat Chuen, Kowloon Tsai Hill and Lei Yue Mun (Figure 1). These anemometers, coupled with the other two sets on the runway, i.e. the SE and the NW anemometers, will enable an assessment to be made of the wind shear along the glide path for landing or climb-out path for both runways - 31 and 13. When these anemometers are ready for use, the data obtained from them will be processed by a micro-computer. Relevant information will then be displayed in the Air Traffic Control Office for onward transmission to pilots.

Squally showers were experienced in Hong Kong on 26 and 27 June, 1978. They occurred quite frequently during these two days. Some of them affected all four anemometers, i.e. the SE, the NW, Kowloon Tsai Hill and Yau Yat Chuen. The last two anemometers had already been installed for the Wind Shear Project. Four of the most severe showers have been selected and studied. This report shows the wind shear experienced during these four squally showers and indicates that some of the values are significant for the safe operation of aircraft landing and take-off.

2. SYNOPTIC SITUATIONS

A tropical depression developed to the east of the Balintang Channel on 23 June and intensified into a tropical storm, named Rose. After crossing the Luzon Strait, it split into two vortices in the upper air, particularly at the 850-mbar level. One vortex moved northwards across Taiwan together with the dissipating tropical cyclone at the surface, while the other vortex moved west-northwest across the northern part of the South China Sea and eventually dissipated on 27 June over southwest China to the north of the Gulf of Tonkin. On 26 June, a trough of low pressure developed at the surface across the northern part of the South China Sea while one of the upper vortices was centred to the southwest of Hong Kong (Figure 2). This enhanced the summer monsoon over the coastal areas of south China. The strong summer monsoon lasted throughout the next day (Figure 3). In Hong Kong, the Strong Monsoon Signal was hoisted for about 34 hours between 6.50 p.m. on 26 June and 5.00 a.m. on 28 June. Water-spouts were sighted off the coast of southern Hong Kong Island between 3.30 p.m. and 4.05 p.m. on 27 June and affected the operation of the cablecars of the Ocean Park (Reference 2).

The Rawin ascents made on 26 June showed strong southeast winds from the surface all the way up to the 9-km level (Figure 4). Winds remained strong on 27 June but veered to southerly or south-southwesterly. Winds of 36 knots from the southeast were recorded on 26 June at the 900-m level and 47 knots from the south on 27 June at the 4500-m level. The Tephigrams on 26 and 27 June showed that the atmosphere was humid and unstable (Figures 5 and 6).

Radar pictures were available on 27 June, but unfortunately not on 26 June. Figures 7 through 10 are four radar photographs taken on 27 June at approximately 15 minutes intervals, showing a series of rain echoes affecting Hong Kong. The centre of these radar photographs was Tate's Cairn with range circles 5 nautical miles apart. The isoecho facility was switched on so that the dark bands inside the rain echoes represents the areas of heaviest rainfall surrounded by brighter areas of less heavy rainfall. The Airport is about 2.5 nautical miles south-southwest of Tate's Cairn and the position of the runway has been marked on the radar pictures.

Figure 7 is an off-centre photograph, taken at 4.03 p.m. when showers were affecting the Airport. A band of dark echoes was approaching the Airport and heavy squally showers reached the Airport three minutes after this photograph was taken. Two other bands of rain echoes were between 5 and 10 nautical miles and between 17 and 25 nautical miles south of Tate's Cairn. Figure 8 was taken at 4.19 p.m. The shower activity near the Airport had decreased. The first band of echoes had moved inside the 5 nautical miles ring, and the second band was between the 15 and 20 nautical miles rings. Figure 9 was taken at 4.34 p.m. when the heavy showers had just passed the Airport. The leading edge of the second band had moved close to the 10 nautical miles ring. In Figure 10, which was taken at 4.50 p.m., these rain echoes had moved 5 nautical miles closer. There was no rainfall on the Airport at that time, but showers started about five minutes later and lasted until 6.10 p.m.

Rain echoes in Figures 7 through 10 were lying from southwest to northeast and were moving in a generally northerly direction at a speed of about 20 knots.

Warnings of significant wind shear and moderate turbulence in the approaches of Hong Kong International Airport were issued by the Aviation Forecasters and included in the METAR on 26 and 27 June.

3. WINDS RECORDED

Wind measuring sensors used for the Project are the combined cup generator and vane system, British Meteorological Office pattern Mk 4. The voltage values from these sensors at the anemometer site, which are proportional to the wind direction and speed, are converted into frequencies before they are transmitted through land lines to the Airport. These signals are then processed at the Airport Meteorological Office by a micro-computer to produce 2-minute mean winds, their longitudinal components along the flight path and their cross-wind components, together with the maximum gusts.

On 26 June, the violent squally shower occurred after 9 a.m. At 9.30 a.m., winds recorded on the SE anemometer in the Airport were from the southeast with a mean speed around 20 knots (Figure 11). At 9.42 a.m., the squalls reached the SE anemometer with the maximum gust up to 35 knots. Six minutes later, the NW anemometer was affected and a maximum gust of 42 knots was recorded (Figure 12). Almost at the same time, a maximum gust of 33 knots was recorded at Kowloon Tsai Hill (Figure 13). Eight minutes later at 9.56 a.m., the squally shower reached Yau Yat Chuen and a maximum gust of 28 knots was recorded (Figure 14). During these squally showers, winds generally shifted from southeasterly to southerly. A maximum wind direction shift of 55° was recorded at the SE anemometer.

Anemometers at the Royal Observatory Headquarters and King's Park Meteorological Station were also affected. Unfortunately, as the anemometer at Lei Yue Mun had not been installed at this time, no wind information is therefore available there. Table 1 shows the 2-minute mean winds and maximum gusts recorded at the four anemometers between 0928 H and 1000 H (H indicates Hours Hong Kong Time) during this squally shower.

Also on 26 June, another violent squally shower occurred in the afternoon just after 5 p.m. At 5.22 p.m. winds at the SE anemometer were 12 knots from the southeast. Winds suddenly increased to 23 knots at 5.26 p.m. and a maximum gust of 39 knots was recorded at 5.30 p.m. (Figure 11). A maximum gust of 33 knots was recorded at the NW anemometer four minutes later (Figure 12) and 32 knots at the Kowloon Tsai Hill anemometer another two minutes later (Figure 13). The storm seems to have weakened after passing Kowloon Tsai Hill as only a slight increase of wind speed was recorded at Yau Yat Chuen (Figure 14). Table 2 shows the 2-minute mean winds and maximum gusts recorded at four stations between 1720 H and 1750 H during this squally shower.

Several violent showers also occurred on 27 June. Table 3 shows the 2-minute mean winds recorded at four stations in the afternoon between 1552 H and 1612 H and also between 1638 H and 1714 H on 27 June (Figures 15 to 18).

TABLE 1. WINDS RECORDED IN THE MORNING OF 26 JUNE, 1978

2-minute Period (H)	SE Direction (degrees)	SE Speed (knots)	NW Direction (degrees)	NW Speed (knots)	KLT Direction (degrees)	KLT Speed (knots)	YYC Direction (degrees)	YYC Speed (knots)
0928-0930	135	19	155	10	150	9	130	11
0930-0932	135	21	155	11	150	12	130	11
0932-0934	130	21	150	11	150	11	135	12
0934-0936	135	21	150	12	145	11	140	12
0936-0938	145	21	150	12	145	11	140	12
0938-0940	140	21	150	10	140	12	140	16
0940-0942	140	25(35)	145	10	135	13	135	14
0942-0944	140	27(37)	140	9	135	12	140	10
0944-0946	140	27	145	18	135	16	150	8
0946-0948	150	26(36)	160	29(42)	140	21(33)	150	9
0948-0950	160	27(37)	180	19(29)	140	25	160	10
0950-0952	165	27(37)	180	18	140	20	140	10
0952-0954	180	24	185	16	170	17	160	11
0954-0956	185	19	185	14	180	15	155	18(28)
0956-0958	170	18	185	10	170	13	155	16
0958-1000	160	18	180	9	180	11	160	13

Note : All winds are 2-minute means except those in brackets which represent maximum gusts.

TABLE 2. WINDS RECORDED IN THE AFTERNOON OF 26 JUNE, 1978

2-minute Period (H)	SE		NW		KLT		YYC	
	Direction (degrees)	Speed (knots)	Direction (degrees)	Speed (knots)	Direction (degrees)	Speed (knots)	Direction (degrees)	Speed (knots)
1720-1722	145	12	140	11	135	9.5	120	7
1722-1724	140	14	140	11	135	9.5	120	7
1724-1726	140	23	140	13	140	8	115	7
1726-1728	140	26	130	14	140	9	110	7.5
1728-1730	135	29(39)	145	17	145	9	110	7.5
1730-1732	135	31	150	19	135	16	105	7
1732-1734	140	31	150	20(33)	130	16	105	8
1734-1736	140	30	150	24	135	20(32)	110	11
1736-1738	140	29	150	19	135	22	110	13
1738-1740	140	28	150	18	135	20	120	14
1740-1742	135	28	150	18	135	19	130	17
1742-1744	140	28	150	17	135	20	130	15
1744-1746	140	28	150	17	135	21	130	12
1746-1748	135	28	150	19(33)	135	21	130	10
1748-1750	135	28	150	19	135	21	130	11

Note : All winds are 2-minute means except those in brackets which represent maximum gusts.

TABLE 3. WINDS RECORDED ON 27 JUNE, 1978

2-minute Period (H)	SE		NW		KLT		YYC	
	Direction (degrees)	Speed (knots)	Direction (degrees)	Speed (knots)	Direction (degrees)	Speed (knots)	Direction (degrees)	Speed (knots)
1552-1554	130	11	120	9	125	8	120	5
1554-1556	130	11	125	10	110	8	130	7
1556-1558	135	14(24)	120	11	120	9	125	7
1558-1600	150	18(28)	130	12	120	10	110	8
1600-1602	170	15	140	12	120	11	100	8
1602-1604	190	11	140	13	125	11	100	8
1604-1606	210	6	140	22(32)	125	15(25)	090	14
1606-1608	360	7	060	22(32)	125	23	100	14(24)
1608-1610	060	7	350	12	120	19	110	14(24)
1610-1612	070	8	120	6	085	11	120	11
1638-1640	140	18	135	6	170	8	180	7
1640-1642	140	16	130	6	195	7	120	9
1642-1644	130	14	130	7	160	7	125	9
1644-1646	125	14	130	10	130	6	130	10
1646-1648	125	13	125	12	110	6	115	10
1648-1650	125	13	120	13	120	7	110	7
1650-1652	125	14	125	14	120	7	100	9
1652-1654	125	16	130	13	110	8	090	9
1654-1656	125	18	130	13	110	10	095	11
1656-1658	125	23(33)	130	13	110	8	100	10
1658-1700	120	22	125	15(25)	120	7	100	10
1700-1702	120	21	120	19	125	12	105	11
1702-1704	115	20	115	18	130	12	105	11
1704-1706	115	19	110	16	130	13	105	12
1706-1708	115	20	110	18	120	15(25)	110	15
1708-1710	110	15	105	18	120	17	105	16
1710-1712	100	13	100	16	110	12	105	16
1712-1714	095	14	100	12	110	8	105	12

Note : All winds are 2-minute means except those in brackets which represent maximum gusts.

4. WIND SHEAR

During a meeting of the Airport Wind Shear Committee in July 1978, the following decisions were made :-

(a) The Air Traffic Control Officers should be informed of the sinking and lifting effects affecting aircraft departing from or approaching the runway due to wind shear.

(b) Use will be made of winds recorded at Yau Yat Chuen and at the NW anemometer for approach on Runway 13 or departure on Runway 31.

(c) For approach on Runway 31 or departure on Runway 13, winds measured at Lei Yue Mun and at the SE anemometer will be used.

(d) A difference of 8 knots or more per 100 feet of height in the components of 2-minute mean winds along the flight path, i.e. the longitudinal components between the two anemometers can be considered as significant shear.

Since no anemometer had been installed at Lei Yue Mun at this time, it is not possible to compute the wind shear between the SE and the Lei Yue Mun anemometers for approach on Runway 31 or departure on Runway 13. However, wind shear on the runway between the SE and the NW anemometers has been computed. For the approach on Runway 13 or the departure on Runway 31, use has been made of the winds recorded at Yau Yat Chuen and at the NW anemometer as specified by the Wind Shear Committee.

The aircraft approach flight path above Yau Yat Chuen has a true orientation of 087°, and the true orientation of Runway 13 is 134°. The flight path in the vicinity of Kowloon Tsai Hill is a curved one. The point on the path nearest to the anemometer has a tangent with true orientation of 107°.

Longitudinal components along the flight path and cross wind components of winds presented in Tables 1, 2 and 3 are shown in Tables 4, 5 and 6.

To indicate the directions of the wind components, the following sign convention has been adopted in Tables 4, 5 and 6 :

Component	SE and NW		Kowloon Tsai Hill		Yau Yat Chuen	
	"+" sign	"-" sign	"+" sign	"-" sign	"+" sign	"-" sign
Longitudinal	134°	314°	107°	287°	087°	267°
Cross Wind	224°	044°	197°	017°	177°	357°

TABLE 4. LONGITUDINAL AND CROSS FLIGHT PATH COMPONENTS OF WINDS RECORDED IN THE MORNING OF 26 JUNE, 1978

2-minute Period (H)	SE		NW		KLT		YYC	
	Longi (knots)	Cross (knots)	Longi (knots)	Cross (knots)	Longi (knots)	Cross (knots)	Longi (knots)	Cross (knots)
0928-0930	19.0	0.3	9.3	3.6	6.6	6.1	8.0	7.5
0930-0932	21.0	0.4	10.3	3.9	8.8	8.2	8.0	7.5
0932-0934	20.9	-1.5	10.6	3.0	8.0	7.5	8.0	8.9
0934-0936	21.0	0.4	11.5	3.3	8.7	6.8	7.2	9.6
0936-0938	20.6	4.0	11.5	3.3	8.7	6.8	7.2	9.6
0938-0940	20.9	2.2	9.6	2.8	10.1	6.5	9.6	12.8
0940-0942	24.9(34.8)	2.6(3.7)	9.8	1.9	11.5	6.1	9.4	10.4
0942-0944	26.9(36.8)	2.8(3.9)	9.0	0.9	10.6	5.6	6.0	8.0
0944-0946	26.9	2.8	17.7	3.4	14.1	7.5	3.6	7.1
0946-0948	25.0(34.6)	7.2(9.9)	26.1(37.7)	12.7(18.4)	17.6(27.7)	11.4(18.0)	4.1	8.0
0948-0950	24.3(33.3)	11.8(16.2)	13.2(20.1)	13.7(20.9)	21.0	13.6	2.9	9.6
0950-0952	23.1(31.7)	13.9(19.1)	12.5	12.9	16.8	10.9	6.0	8.0
0952-0954	16.7	17.3	10.1	12.4	7.7	15.1	3.2	10.5
0954-0956	12.0	14.8	8.8	10.9	4.4	14.3	6.7(10.5)	16.7(26.0)
0956-0958	14.6	10.6	6.3	7.8	5.9	11.6	6.0	14.8
0958-1000	16.2	7.9	6.3	6.5	3.2	10.5	3.8	12.4

Note : (1) Figures in brackets represent the components of maximum gusts.

(2) Figures without prefix indicate a "+" sign.

TABLE 5. LONGITUDINAL AND CROSS FLIGHT PATH COMPONENTS OF WINDS RECORDED IN THE AFTERNOON OF 26 JUNE, 1978

2-minute Period (H)	SE		NW		KLT		YYC	
	Longi (knots)	Cross (knots)	Longi (knots)	Cross (knots)	Longi (knots)	Cross (knots)	Longi (knots)	Cross (knots)
1720-1722	11.8	2.3	10.9	1.1	8.4	4.5	5.9	3.8
1722-1724	13.9	1.5	10.9	1.1	8.4	4.5	5.9	3.8
1724-1726	22.9	2.4	12.9	1.4	6.7	4.4	6.2	3.3
1726-1728	25.9	2.7	14.0	-1.0	7.5	4.9	6.9	2.9
1728-1730	29.0(39.0)	0.5(0.7)	16.7	3.2	7.1	5.5	6.9	2.9
1730-1732	31.0	0.5	18.3	5.2	14.1	7.5	6.7	2.2
1732-1734	30.8	3.2	19.2(31.7)	5.5(9.1)	14.7	6.3	7.6	2.5
1734-1736	29.8	3.1	23.1	6.6	17.7(28.3)	9.4(15.0)	10.1	4.3
1736-1738	28.8	3.0	18.3	5.2	19.4	10.3	12.0	5.1
1738-1740	27.8	2.9	17.3	5.0	17.7	9.4	11.7	7.6
1740-1742	28.0	0.5	17.3	5.0	16.8	8.9	12.4	11.6
1742-1744	27.8	2.9	16.3	4.7	17.7	9.4	11.0	10.2
1744-1746	27.8	2.9	16.3	4.7	18.5	9.9	8.8	8.2
1746-1748	28.0	0.5	18.3(31.7)	5.2(9.1)	18.5	9.9	7.3	6.8
1748-1750	28.0	0.5	18.3	5.2	18.5	9.9	8.0	7.5

Note : (1) Figures in brackets represent the components of maximum gusts.

(2) Figures without prefix indicate a "+" sign.

TABLE 6. LONGITUDINAL AND CROSS FLIGHT PATH COMPONENTS OF WINDS RECORDED ON 27 JUNE, 1978

2-minute Period (H)	SE		NW		KLT		YYC	
	Longi (knots)	Cross (knots)	Longi (knots)	Cross (knots)	Longi (knots)	Cross (knots)	Longi (knots)	Cross (knots)
1552-1554	11.0	-0.8	8.7	-2.2	7.6	2.5	4.2	2.7
1554-1556	11.0	-0.8	9.9	-1.6	8.0	0.4	5.1	4.8
1556-1558	14.0(24.0)	0.2(0.4)	10.7	-2.7	8.8	2.0	5.5	4.3
1558-1600	17.3(26.9)	5.0(7.7)	12.0	-0.8	9.7	2.2	7.4	3.1
1600-1602	12.1	8.8	11.9	1.3	10.7	2.5	7.8	1.8
1602-1604	6.2	9.1	12.9	1.4	10.5	3.4	7.8	1.8
1604-1606	1.5	5.8	21.9(31.8)	2.3(3.3)	14.3(23.8)	4.6(7.7)	14.0	0.7
1606-1608	-4.9	-5.0	6.1(8.8)	-21.1(-30.8)	21.9	7.1	13.6(23.4)	3.1(5.4)
1608-1610	1.9	-6.7	-9.7	-7.1	18.5	4.3	12.9(22.1)	5.5(9.4)
1610-1612	3.5	-7.2	5.8	-1.5	10.2	-4.1	9.2	6.0
1638-1640	17.9	1.9	6.0	0.1	3.6	7.1	-0.4	7.0
1640-1642	15.9	1.7	6.0	-0.4	0.2	7.0	7.5	4.9
1642-1644	14.0	-1.0	7.0	-0.5	4.2	5.6	7.1	5.5
1644-1646	13.8	-2.2	10.0	-0.7	5.5	2.3	7.3	6.8
1646-1648	12.8	-2.0	11.9	-1.9	6.0	0.3	8.8	4.7
1648-1650	12.8	-2.0	12.6	-3.1	6.8	1.6	6.4	2.7
1650-1652	13.8	-2.2	13.8	-2.2	6.8	1.6	8.8	2.0
1652-1654	15.8	-2.5	13.0	-0.9	8.0	0.4	9.0	0.5
1654-1656	17.8	-2.8	13.0	-0.9	10.0	0.5	10.9	1.5
1656-1658	22.7(32.6)	-3.6(-5.2)	13.0	-0.9	8.0	0.4	9.7	2.2
1658-1700	21.3	-5.3	14.8(24.7)	-2.3(-3.9)	6.8	1.6	9.7	2.2
1700-1702	20.4	-5.1	18.4	-4.6	11.4	3.7	10.5	3.4
1702-1704	18.9	-6.5	17.0	-5.9	11.0	4.7	10.5	3.4
1704-1706	18.0	-6.2	14.6	-6.5	12.0	5.1	11.4	3.7
1706-1708	18.9	-6.5	16.4	-7.3	14.6(24.4)	3.4(5.6)	13.8	5.9
1708-1710	13.7	-6.1	15.7	-8.7	16.6	3.8	15.2	4.9
1710-1712	10.8	-7.3	13.3	-8.9	12.0	0.6	15.2	4.9
1712-1714	10.9	-8.8	9.9	-6.7	8.0	0.4	11.4	3.7

Note : (1) Figures in brackets represent the components of maximum gusts.
(2) Figures without prefix indicate a "+" sign.

Tables 7, 8 and 9 show the wind shear during the four squally showers. The first column in these tables was obtained by subtracting the longitudinal component of the wind at the NW anemometer from the same component of the wind at the SE anemometer. The result is the longitudinal component of the wind shear between the two anemometers. The second column was obtained by subtracting the longitudinal component of the wind at Yau Yat Chuen from the same component of the wind at the NW anemometer, representing the longitudinal component of the wind shear between the NW and the Yau Yat Chuen anemometers.

With the above sign convention and procedure of subtraction, it can be seen that :

(a) Wind Shear between the Two Ends of the Runway

(i) For NW-bound aircraft :

"+" sign means that the tail winds are decreasing, or the head winds are increasing;

"-" sign means that the tail winds are increasing, or the head winds are decreasing.

(ii) For SE-bound aircraft :

"+" sign means that the head winds are increasing, or the tail winds are decreasing;

"-" sign means that the head winds are decreasing, or the tail winds are increasing.

(b) Wind Shear between the NW and the Yau Yat Chuen anemometers

(i) For approach on Runway 13 :

"+" sign means that the head winds are increasing, or the tail winds are decreasing;

"-" sign means that the head winds are decreasing, or the tail winds are increasing.

(ii) For departure on Runway 31 :

"+" sign means that the tail winds are decreasing, or the head winds are increasing;

"-" sign means that the tail winds are increasing, or the head winds are decreasing.

When head winds are increasing or tail winds are decreasing, the shear will cause lifting effects and will result in the aircraft having an initial tendency to overfly the flight path. Sinking effects are caused by decreasing head winds or increasing tail winds and result in the aircraft having an initial tendency to underfly the flight path (References 3 and 4).

TABLE 7. WIND SHEAR EXPERIENCED DURING THE SQUALLY SHOWER IN THE MORNING OF 26 JUNE, 1978

2-minute Period (H)	Between SE and NW (knots)	Between NW and YYC (knots)
0928 - 0930	9.7	1.3
0930 - 0932	10.7	2.3
0932 - 0934	10.3	2.6
0934 - 0936	9.5	4.3
0936 - 0938	9.1	4.3
0938 - 0940	11.3	0
0940 - 0942	15.1	0.4
0942 - 0944	17.9	3.0
0944 - 0946	9.2	14.1 *
0946 - 0948	-1.1	22.0 *
0948 - 0950	11.1	10.3
0950 - 0952	10.6	6.5
0952 - 0954	6.6	6.9
0954 - 0956	3.2	2.1
0956 - 0958	8.3	0.3
0958 - 1000	9.9	2.5

Note : (1) Figures with * indicate that the wind shear is significant.

(2) Figures without prefix mean that they are of "+" sign.

TABLE 8. WIND SHEAR EXPERIENCED DURING THE SQUALLY SHOWER IN THE AFTERNOON OF 26 JUNE, 1978

2-minute Period (H)	Between SE and NW (knots)	Between NW and YYC (knots)
1720 - 1722	0.9	5.0
1722 - 1724	3.0	5.0
1724 - 1726	10.0	6.7
1726 - 1728	11.9	7.1
1728 - 1730	12.3	9.8
1730 - 1732	12.7	11.6
1732 - 1734	11.6	11.6
1734 - 1736	6.7	13.0 *
1736 - 1738	10.5	6.3
1738 - 1740	10.5	5.6
1740 - 1742	10.7	4.9
1742 - 1744	11.5	5.3
1744 - 1746	11.5	7.5
1746 - 1748	9.7	11.0
1748 - 1750	9.7	10.3

Note : (1) Figures with * indicate that the wind shear is significant.

(2) Figures without prefix mean that they are of "+" sign.

TABLE 9. WIND SHEAR EXPERIENCED DURING THE SQUALLY SHOWERS ON 27 JUNE, 1978

2-minute Period (H)	Between SE and NW (knots)	Between NW and YYC (knots)
1552 - 1554	2.3	4.5
1554 - 1556	1.1	4.8
1556 - 1558	3.3	5.2
1558 - 1600	5.3	4.6
1600 - 1602	0.2	4.1
1602 - 1604	-6.7	5.1
1604 - 1606	-20.4	7.9
1606 - 1608	-11.0	-7.5
1608 - 1610	11.6	-22.6 *
1610 - 1612	-2.3	-3.4
1638 - 1640	11.9	6.4
1640 - 1642	9.9	-1.5
1642 - 1644	7.0	-0.1
1644 - 1646	3.8	2.7
1646 - 1648	0.9	3.1
1648 - 1650	0.2	6.2
1650 - 1652	0	5.0
1652 - 1654	2.8	4.0
1654 - 1656	4.8	2.1
1656 - 1658	9.7	3.3
1658 - 1700	6.5	5.1
1700 - 1702	2.0	7.9
1702 - 1704	1.9	6.5
1704 - 1706	3.4	3.2
1706 - 1708	2.5	2.6
1708 - 1710	-2.0	0.5
1710 - 1712	-2.5	-1.9
1712 - 1714	1.0	-1.5

Note : (1) Figures with * indicate that the wind shear is significant.

(2) Figures without prefix mean that they are of "+" sign.

It is therefore seen that if the sign convention and procedures of subtraction mentioned above are observed, the "+" shear between the two ends of the runway always causes "lifting" effects and the "-" shear always causes "sinking" effects, no matter whether the airplane is NW-bound or SE-bound. Likewise, the "+" shear between the NW and the Yau Yat Chuen anemometer always causes "lifting" effects and the "-" shear always causes "sinking" effects, no matter whether it is for approach on Runway 13 or for departure on Runway 31. This simplifies the manipulation of the micro-computer and avoids the possibility of misinterpreting the results.

The heights of the anemometers are :

Yau Yat Chuen	64.0 m (210 feet) above MSL
Kowloon Tsai Hill	105.5 m (346 feet) above MSL
SE	16.4 m (54 feet) above MSL
NW	14.2 m (47 feet) above MSL

There is a height difference of 163 feet between the NW and the Yau Yat Chuen anemometers, and wind shear between them greater than 13 knots in the longitudinal components is considered as significant. These occasions are marked with an asterisk * in Tables 7, 8 and 9.

Tables 7, 8 and 9 indicate that there were significant lifting wind shears between the NW and the Yau Yat Chuen anemometers from 0944 H to 0948 H and from 1734 H to 1736 H on 26 June, and significant sinking shears from 1608 H to 1610 H on 27 June.

No criterion for significant horizontal wind shear between the SE and the NW anemometers has yet been recommended by the Wind Shear Committee. However, abnormal wind shear between them will affect the initial climb out speed (V_2), the decision speed (V_1) and the approach speed of the aircraft and thus affect the operation of aircraft during landing and take-off.

Table 7 indicates that there were frequent lifting shears of 10 knots or more between the two ends of the runway from 0930 H to 0952 H on 26 June. In Table 8 lifting wind shears of more than 10 knots were even more frequent from 1724 H to 1746 H on 26 June. In Table 9, there were sinking shears of more than 20 knots from 1604 H to 1606 H and of more than 10 knots from 1606 H to 1608 H, together with two occasions of lifting shear of more than 10 knots.

5. CONCLUSIONS

During the squally showers on 26 and 27 June, 1978, there were significant lifting shears and also significant sinking shears between the NW and the Yau Yat Chuen anemometers for approach on Runway 13 or for departure on Runway 31.

Unfortunately, no anemometer had been installed at Lei Yue Mun at this time, it is therefore not possible to study the wind shear conditions between Lei Yue Mun and the SE anemometer for approach on Runway 31 or departure on Runway 13 during these squally showers.

However, there were frequent wind shear of more than 10 knots between the SE and the NW anemometers. This would certainly affect the operation of aircraft during landing or take-off.

Two other facts are noteworthy :

(1) Frequent maximum gusts of more than 35 knots occurred from 0940 H to 0952 H for 12 minutes at the SE anemometer on 26 June (Table 1).

(2) Cross wind component of more than 20 knots in the 2-minute mean winds (or more than 30 knots in maximum gusts) occurred at the NW anemometer after 1606 H on 27 June (Table 6).

These two phenomena, i.e. high maximum gusts and large cross wind components, which would affect the operation of aircraft during landing and take-off, deserve full attention.

A recommendation has been made in this report on the sign convention and algebraic procedures for handling wind components and for evaluating wind shear in order to facilitate the interpretation of the micro-computer output.

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2.	Lam, C.Y.	1978	Reports on the Waterspout Event on 27 June 1978, Royal Observatory.
3.	Civil Aviation Authority, U.K.	1977	The Causes and Effects of Wind Shear, Aeronautical Information Circular, U.K. 39/1977, AIS.
4.	International Federation Airline Pilot Association	1976	Guidance Material for the Recognition and Reporting of Low Level Wind Shear, I.F.A.L.P.A. Attachment E.

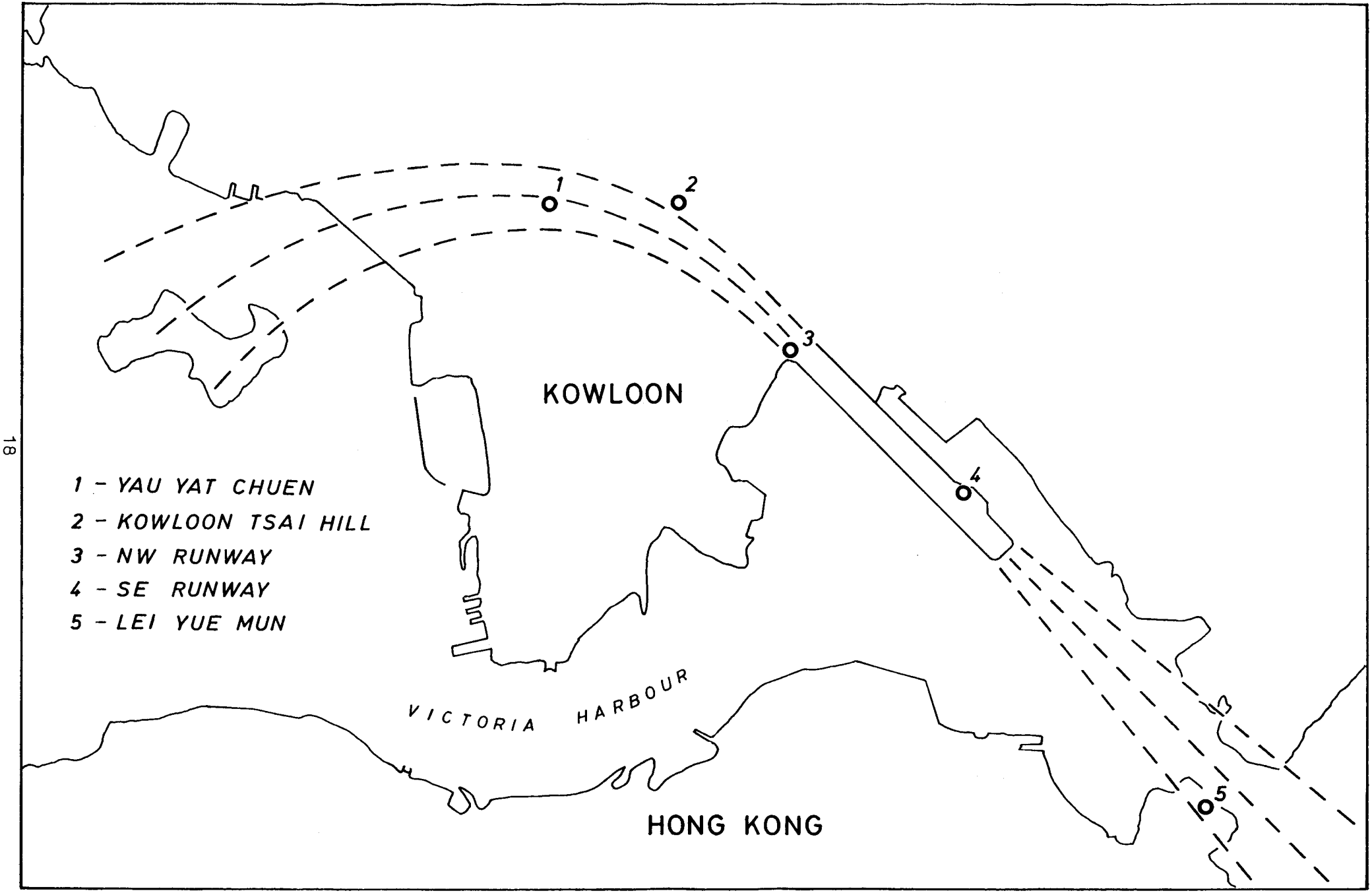

FIGURE 1 ANEMOMETER SITES FOR WIND SHEAR STUDY

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

26 JUNE, 1978.

Mercator Projection — Natural Scale 1:15M at Lat. 22½ N.

SYMBOLS

- Fog
- Drizzle
- Rain
- Snow
- Shower
- Thunderstorm
- Isobar
- 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. 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 calm or light variable winds (○). Figures accompanying the wind arrows are air temperatures in degrees Celsius.

Marine Forecast Areas are in gold.

HIGH

LOW

LOW

LOW

YELLOW SEA

EAST CHINA SEA

SOUTH CHINA SEA

PACIFIC OCEAN

CHINA

THAILAND

LAO

KAMPUCHEA

VIETNAM

PHILIPPINES

NANJING (NANKING)

SHANGHAI

WUHAN (HANKOW)

HANGZHOU (HANGCHOW)

WENZHOU (WENCHOW)

FUZHOU (FOOCHOW)

XIAMEN (AMOY)

GUANGZHOU (CANTON)

SHANTOU (SWATOW)

HONG KONG

MACAO

GUIYANG (KWEIYANG)

KUNMING

HANOI

LUICHOW

VIENTIANE

DANANG

PHNOMPENH

HO CHI MINH

BANGKOK

MANILA

BAGUIO

TAIBEI (TAIPEI)

TAINAN

KAOHSIUNG

HONSHU

KOBE

NAGOYA

OSAKA

SHIKOKU

KYUSHU

NAGASAKI

KAGOSHIMA

OKINAWA

RYUKYU ISLANDS

OGASAWARA ISLANDS

IWO JIMA

MARIANA ISLANDS

GUAM

TAIWAN STRAIT

NORTH TAIWAN

EAST TAIWAN

BASHI CHANNEL

BASHI

BATAN

BALINTANG CHANNEL

BALINTANG

LUZON

MINDORO

SAMAR

LEYTE

PANAY

SULU SEA

PALAWAN

NANSHA

PRATAS

DONGSHA (PRATAS)

PARACEL

XISHA (PARACEL ISLANDS)

SCARBOROUGH

GULF OF TONKIN

HAINAN

TONKIN

RYUKYU

MINDORO

NANSHA

FIGURE 2 WEATHER CHART FOR 0200 H 26 JUNE 1978

R. O. 8

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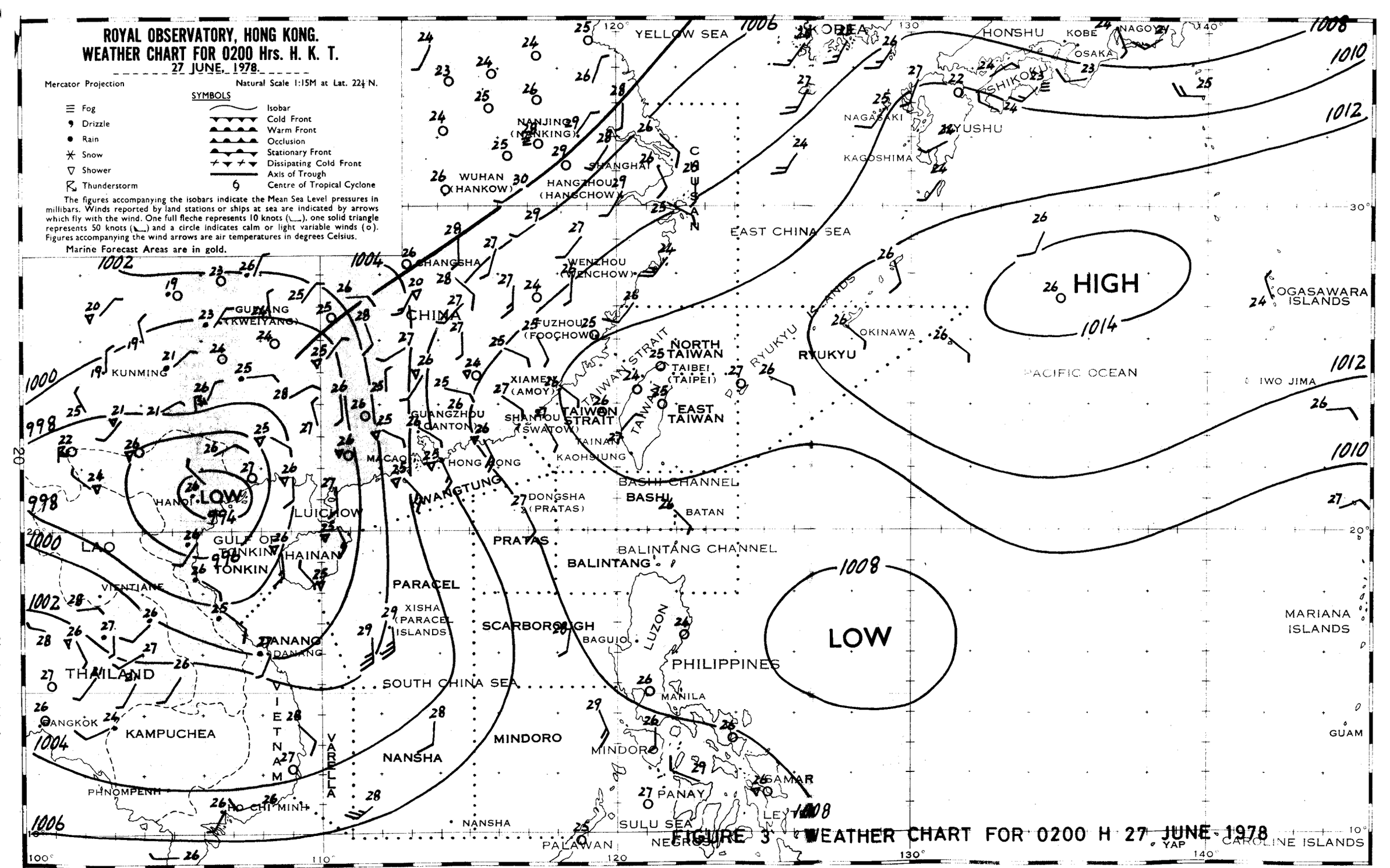

FIGURE 3 WEATHER CHART FOR 0200 H 27 JUNE 1978

R. O. 8

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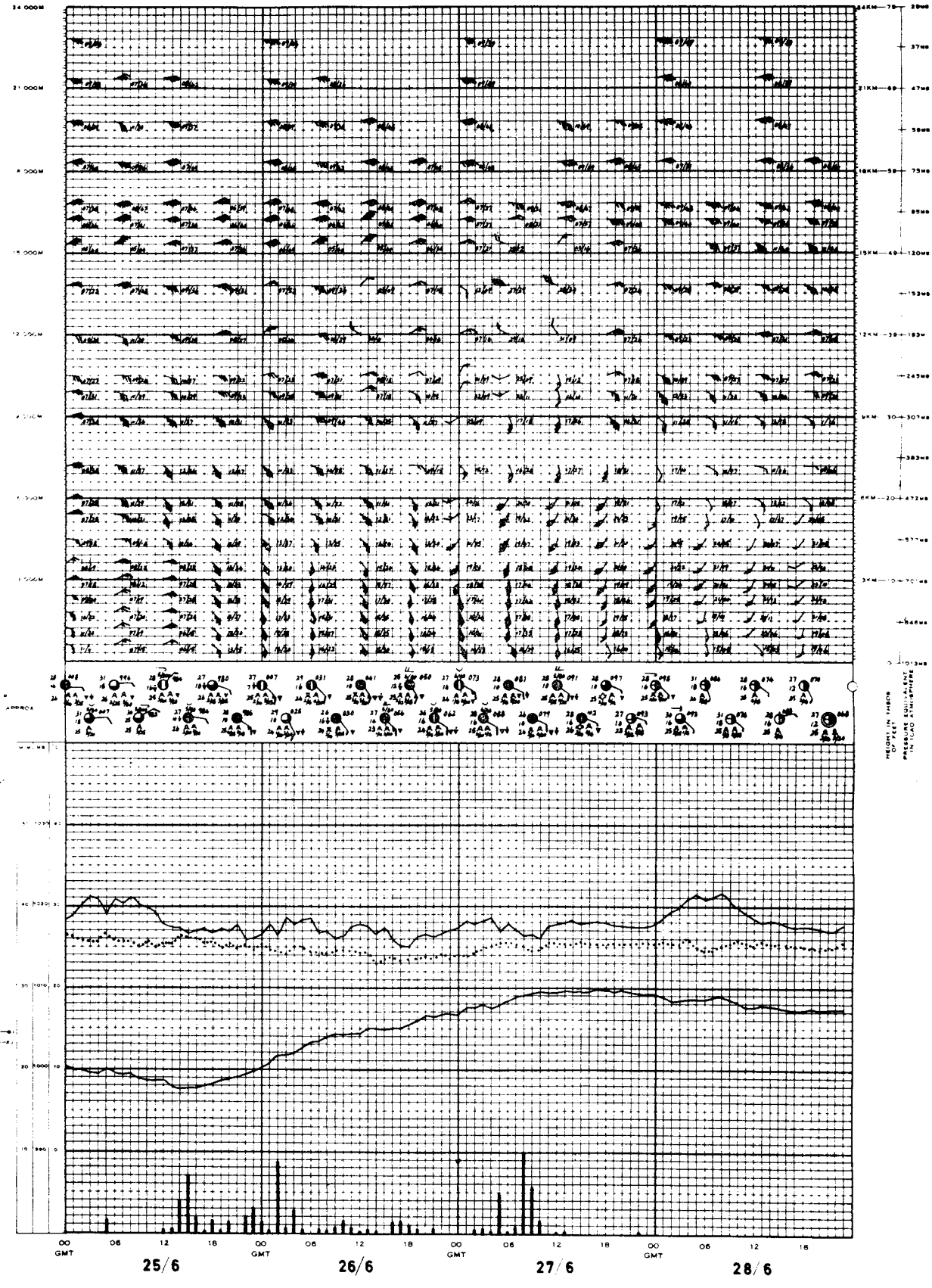

FIGURE 4 TIME CROSS SECTION AT THE ROYAL OBSERVATORY ON 25-28 JUNE, 1978

TEPHIGRAM

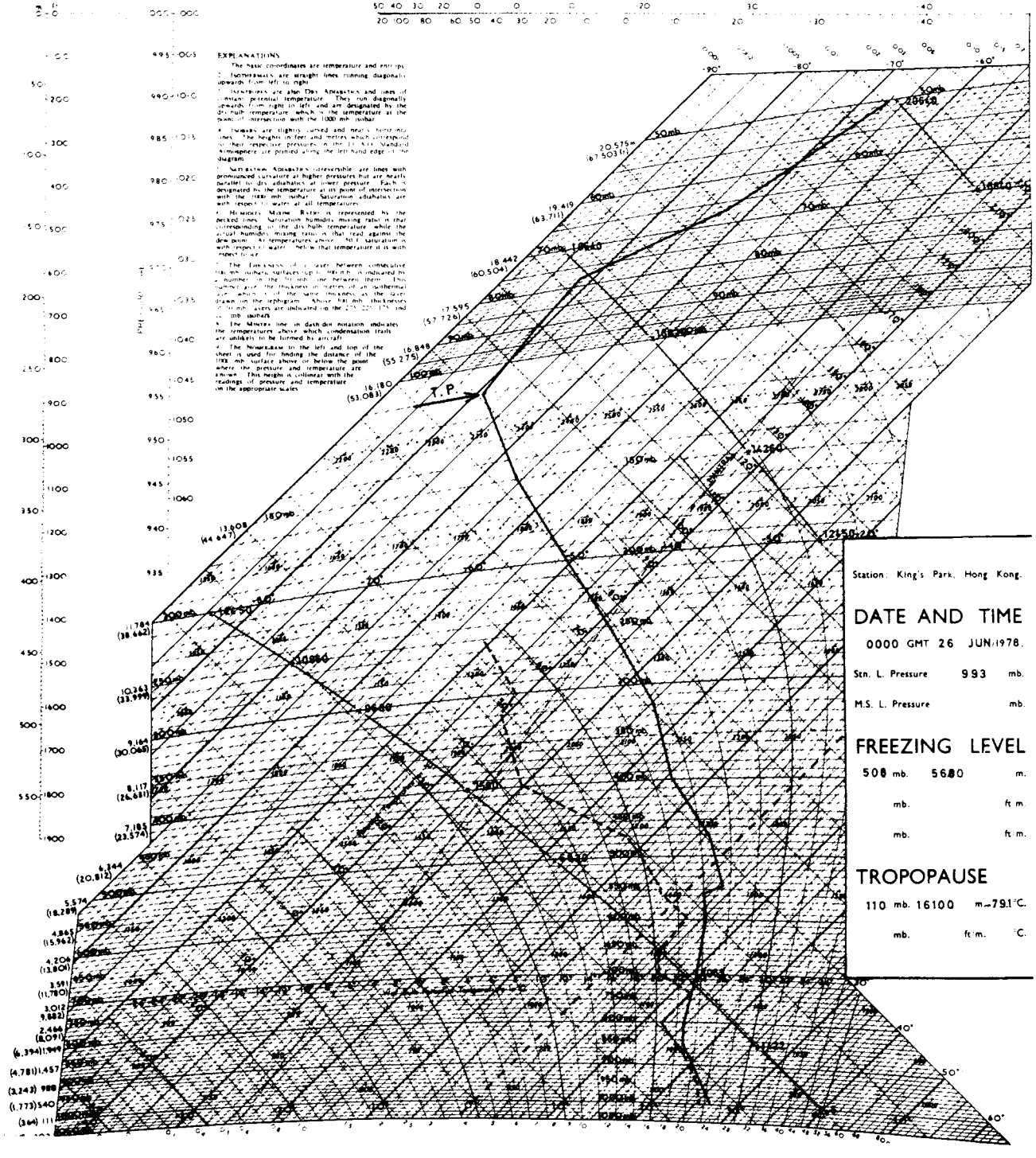

FIGURE 5 TEPHIGRAM FOR 0000 GMT 26 JUNE 1978 AT KING'S PARK

TEPHIGRAM

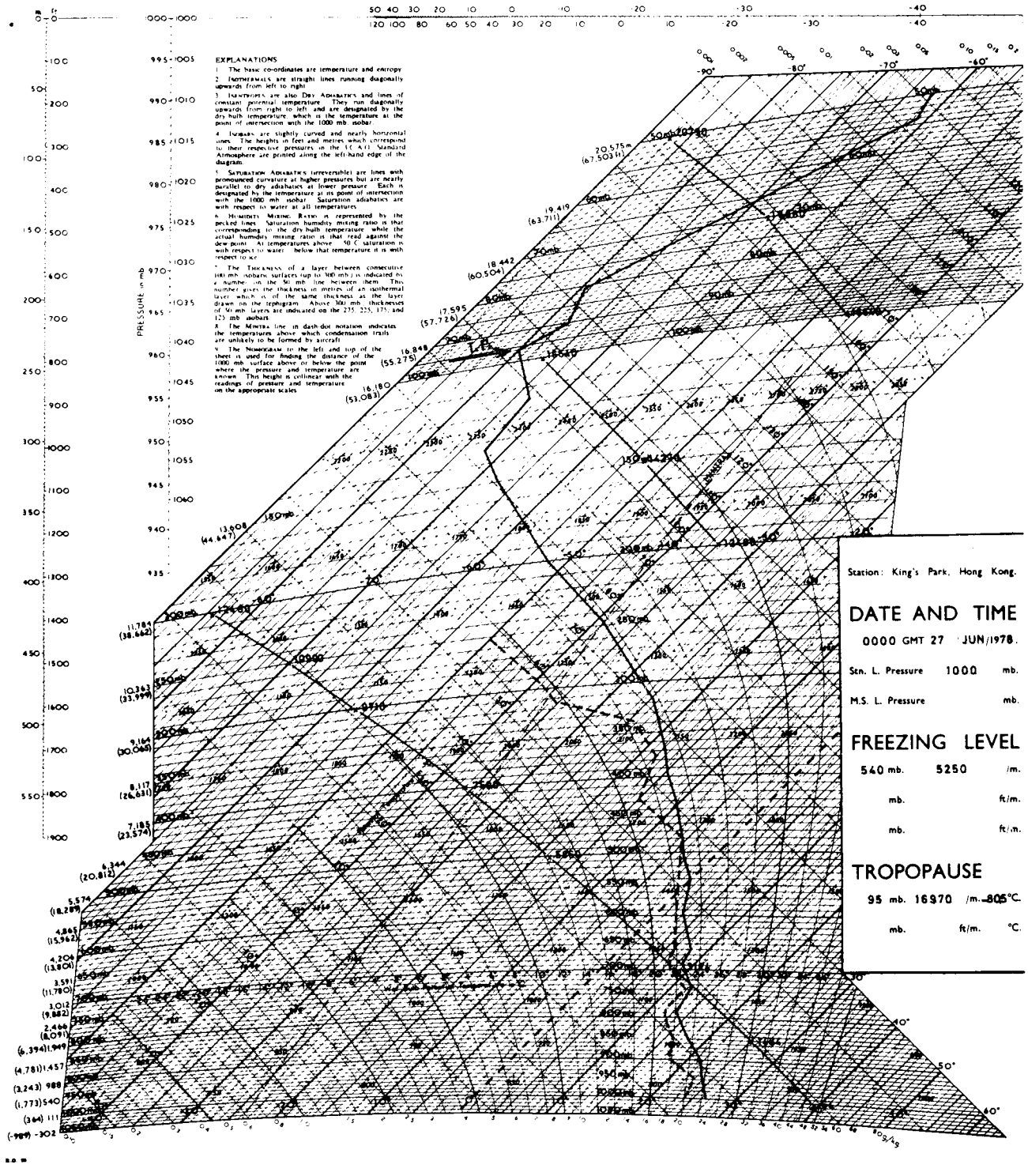

FIGURE 6 TEPHIGRAM FOR 0000 GMT 27 JUNE 1978 AT KING'S PARK

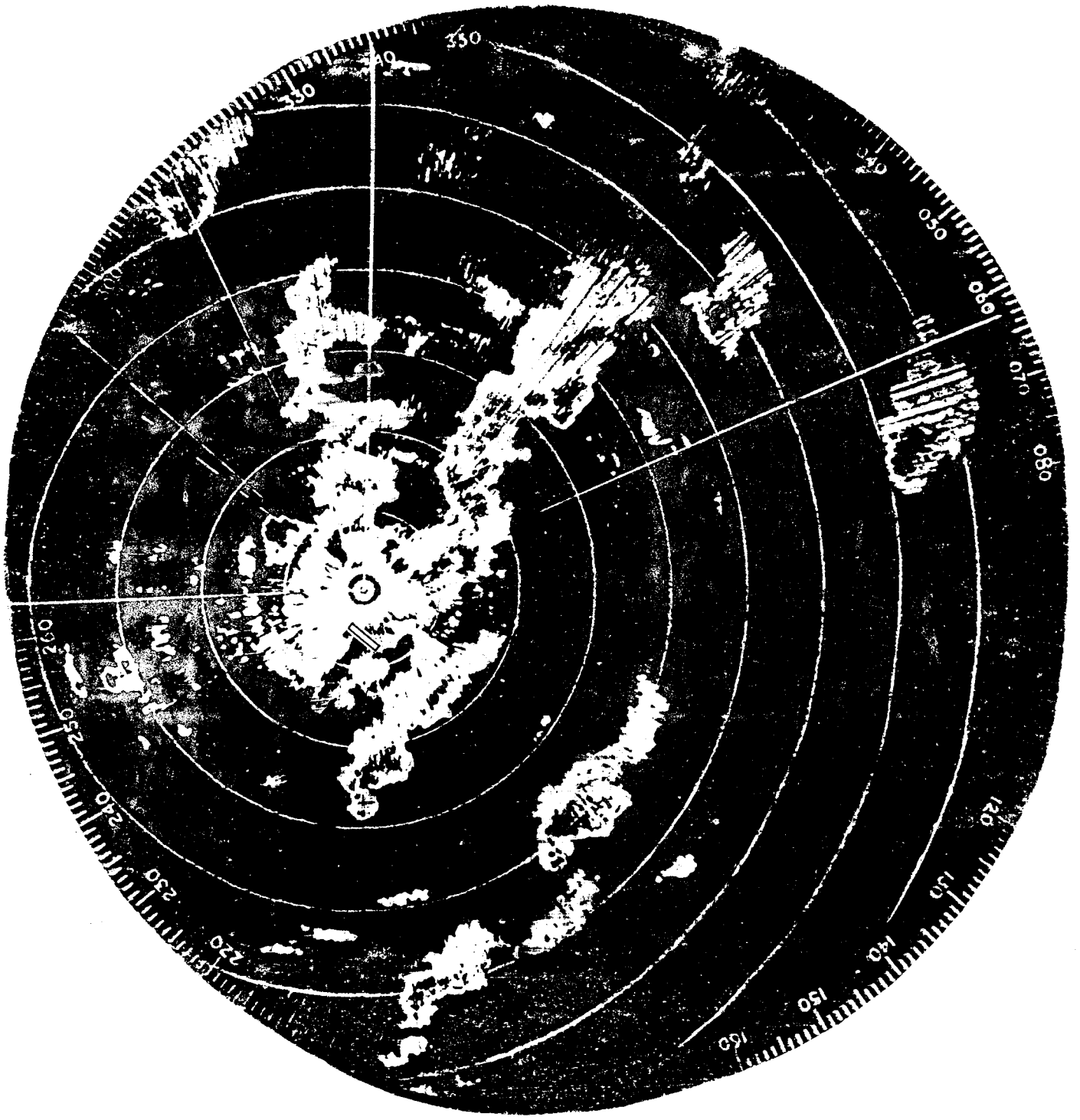

FIGURE 7 RADAR PHOTOGRAPH TAKEN AT 1603 H 27 JUNE 1978

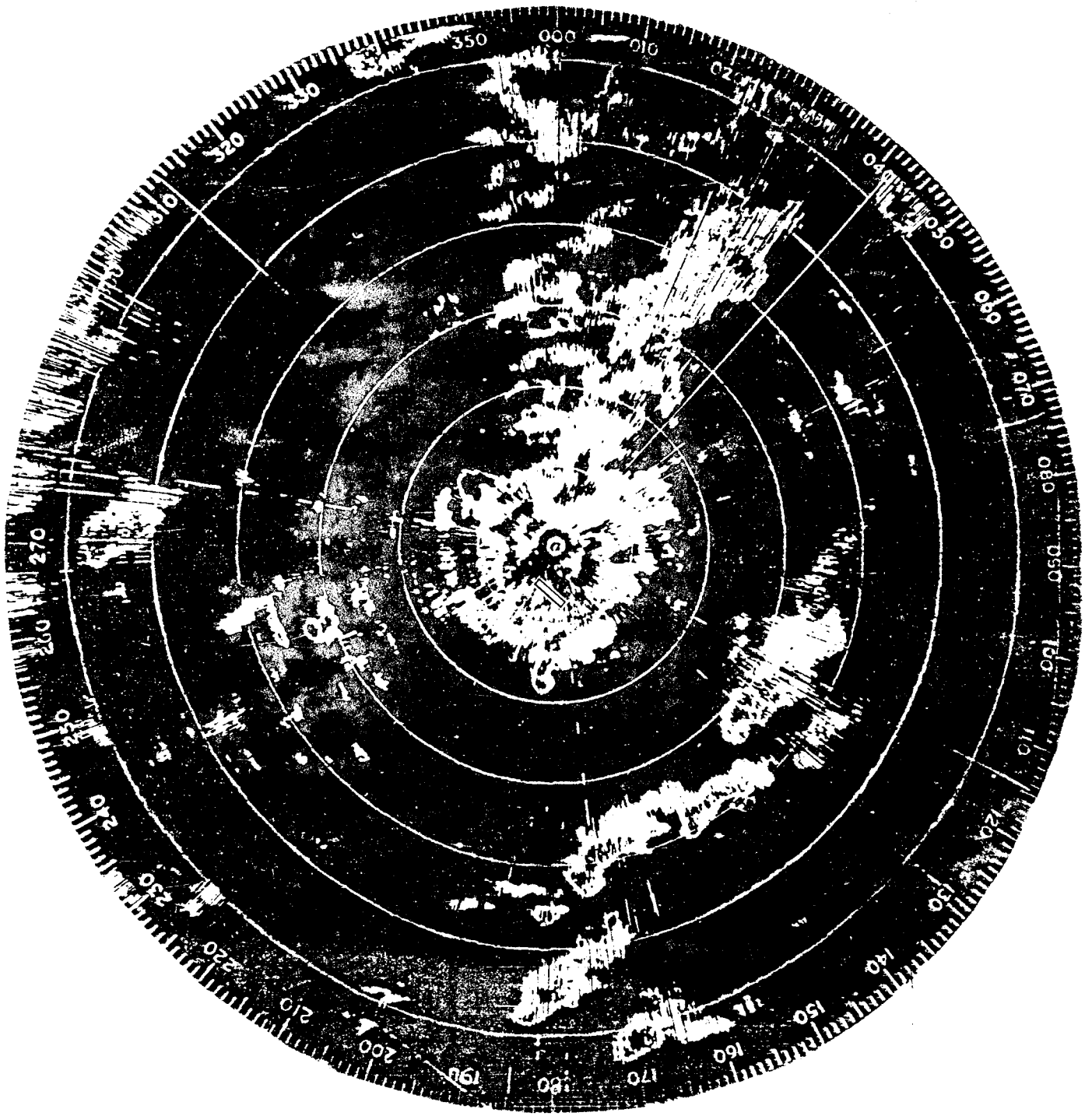

FIGURE 8 RADAR PHOTOGRAPH TAKEN AT 1619 H 27 JUNE 1978

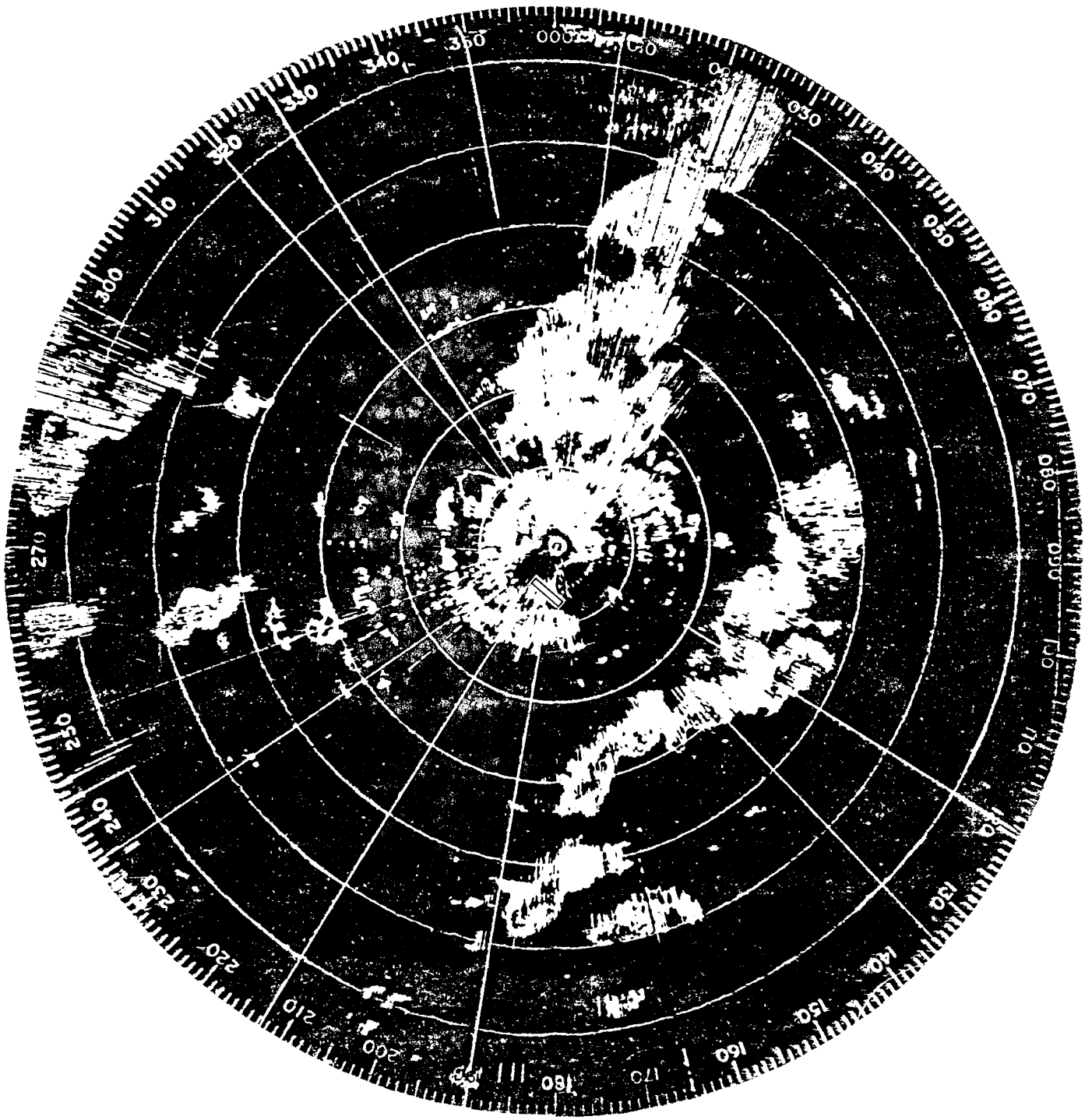

FIGURE 9 RADAR PHOTOGRAPH TAKEN AT 1634 H 27 JUNE 1978

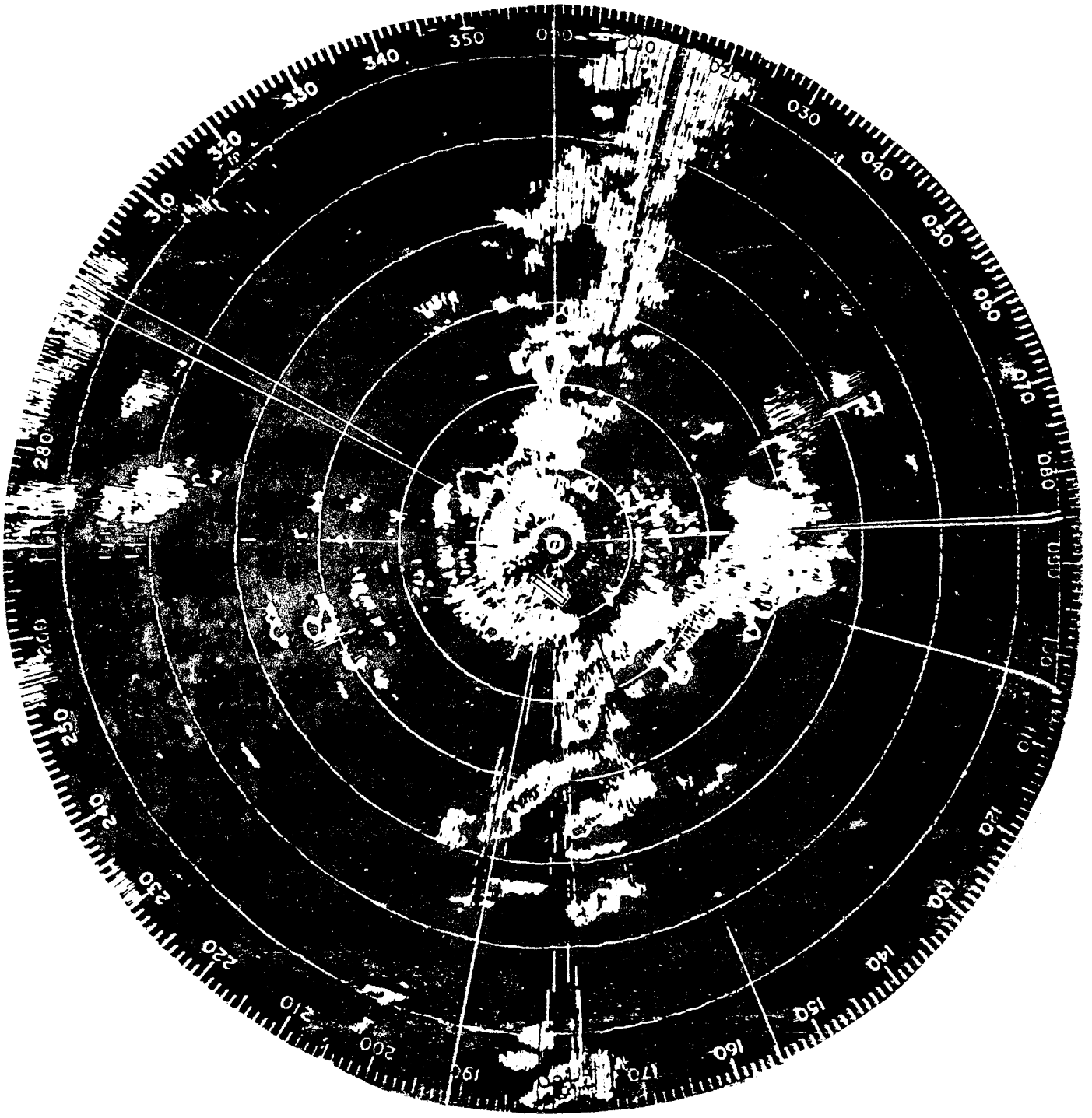

FIGURE 10 RADAR PHOTOGRAPH TAKEN AT 1650 H 27 JUNE 1978

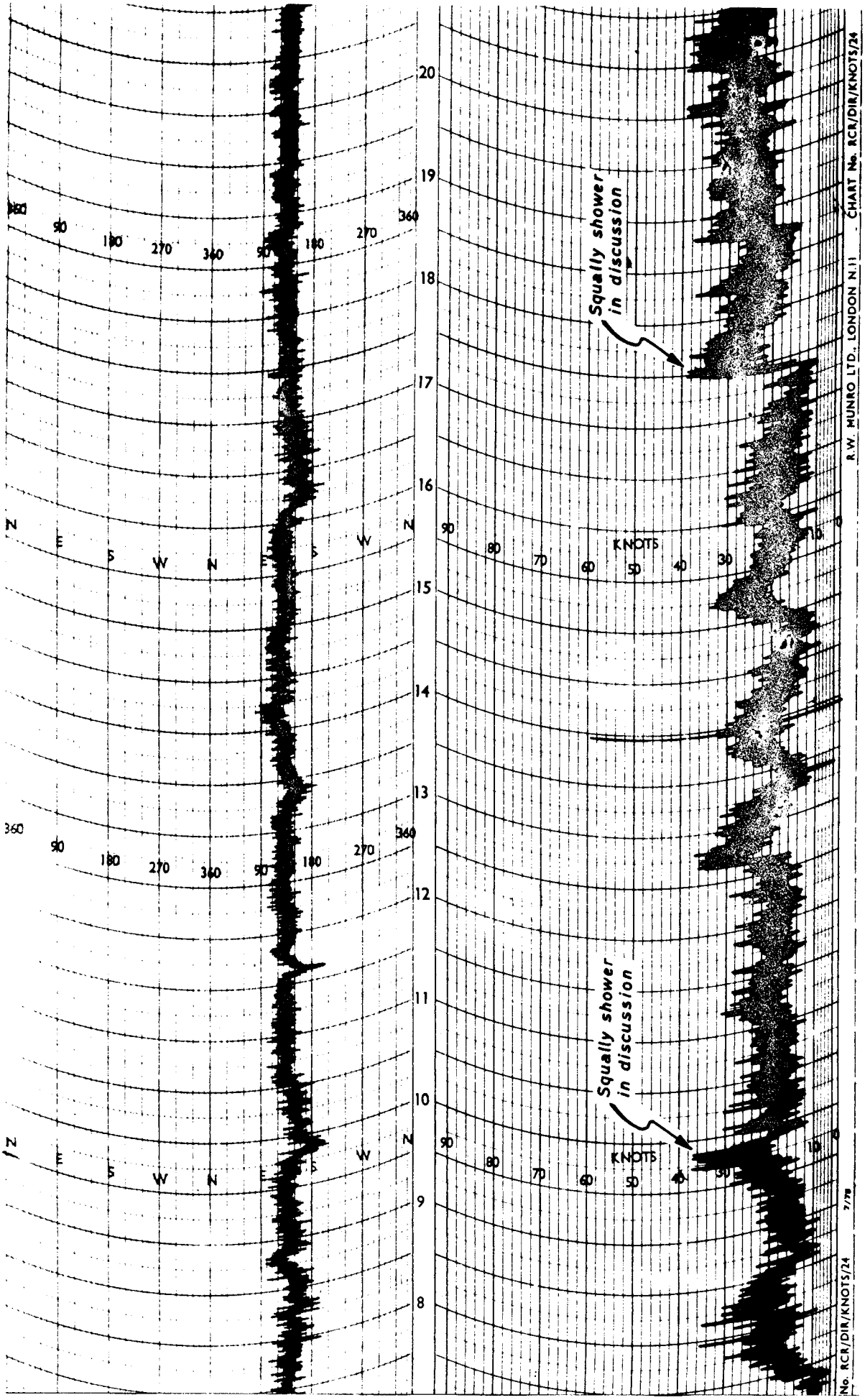

FIGURE 11 ANEMOGRAM ON 26 JUNE 1978 AT THE SE END OF THE RUNWAY

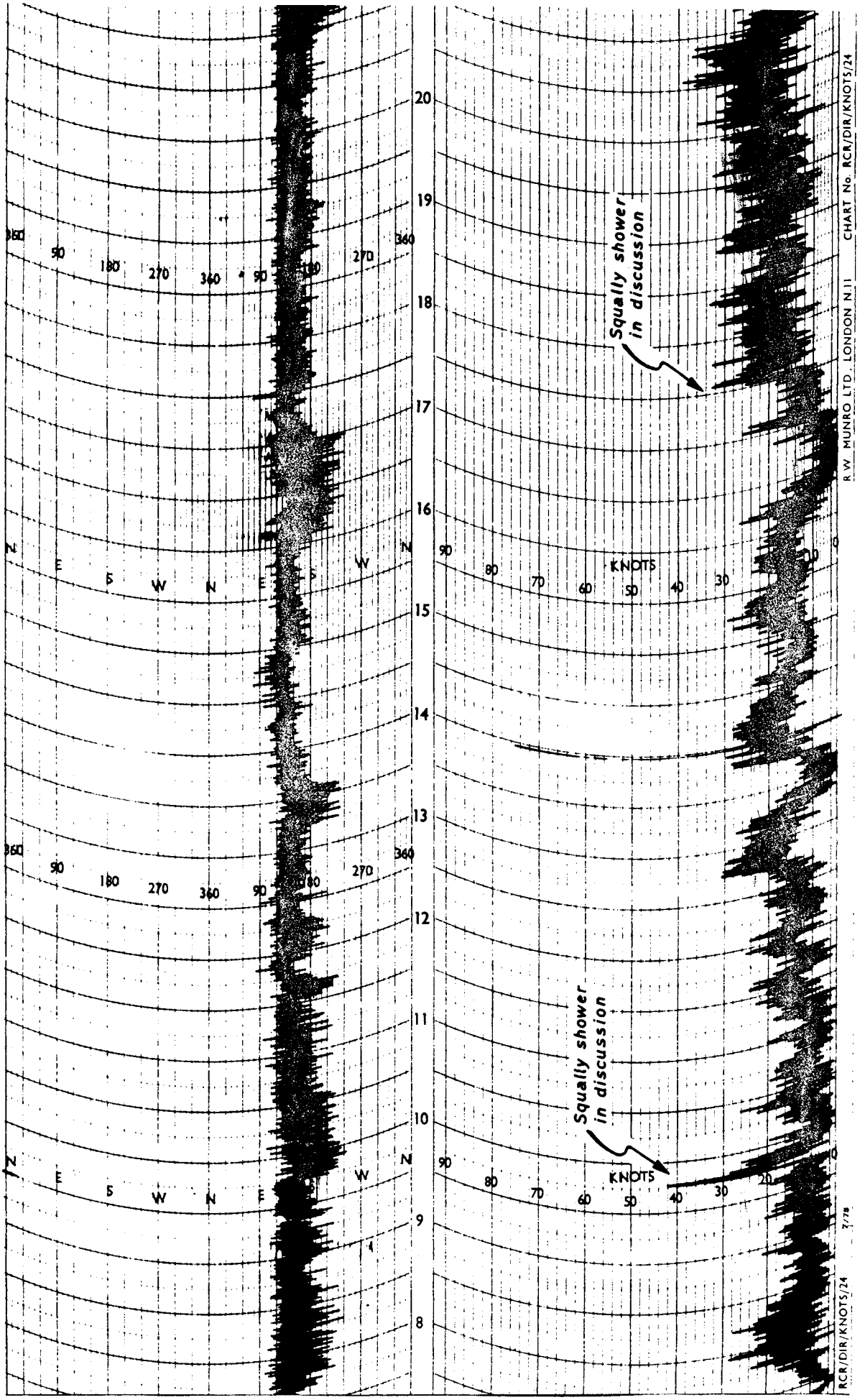

FIGURE 12 ANEMOGRAM ON 26 JUNE 1978 AT THE NW END OF THE RUNWAY

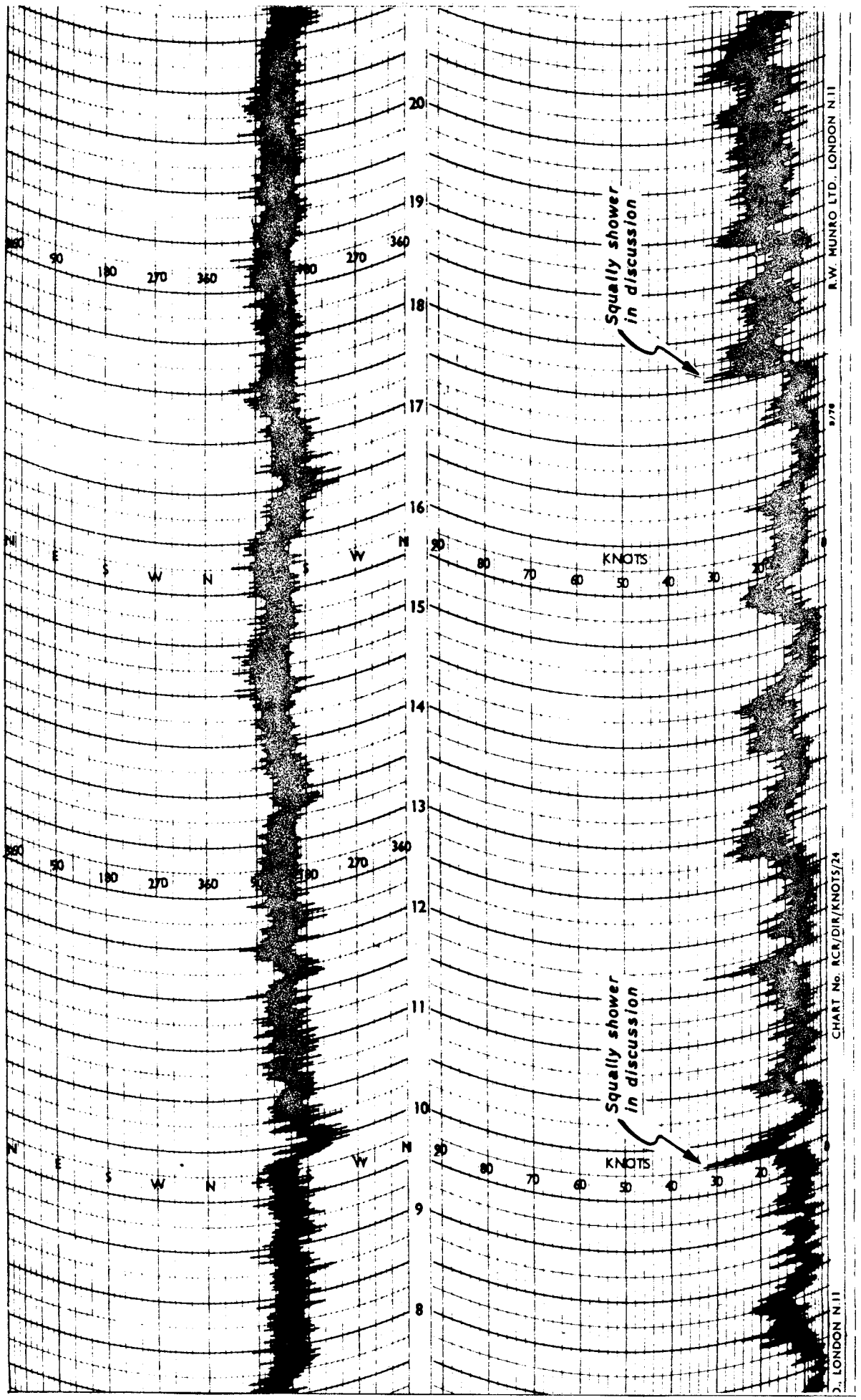

FIGURE 13 ANEMOGRAM ON 26 JUNE 1978 AT KOWLOON TSAI HILL

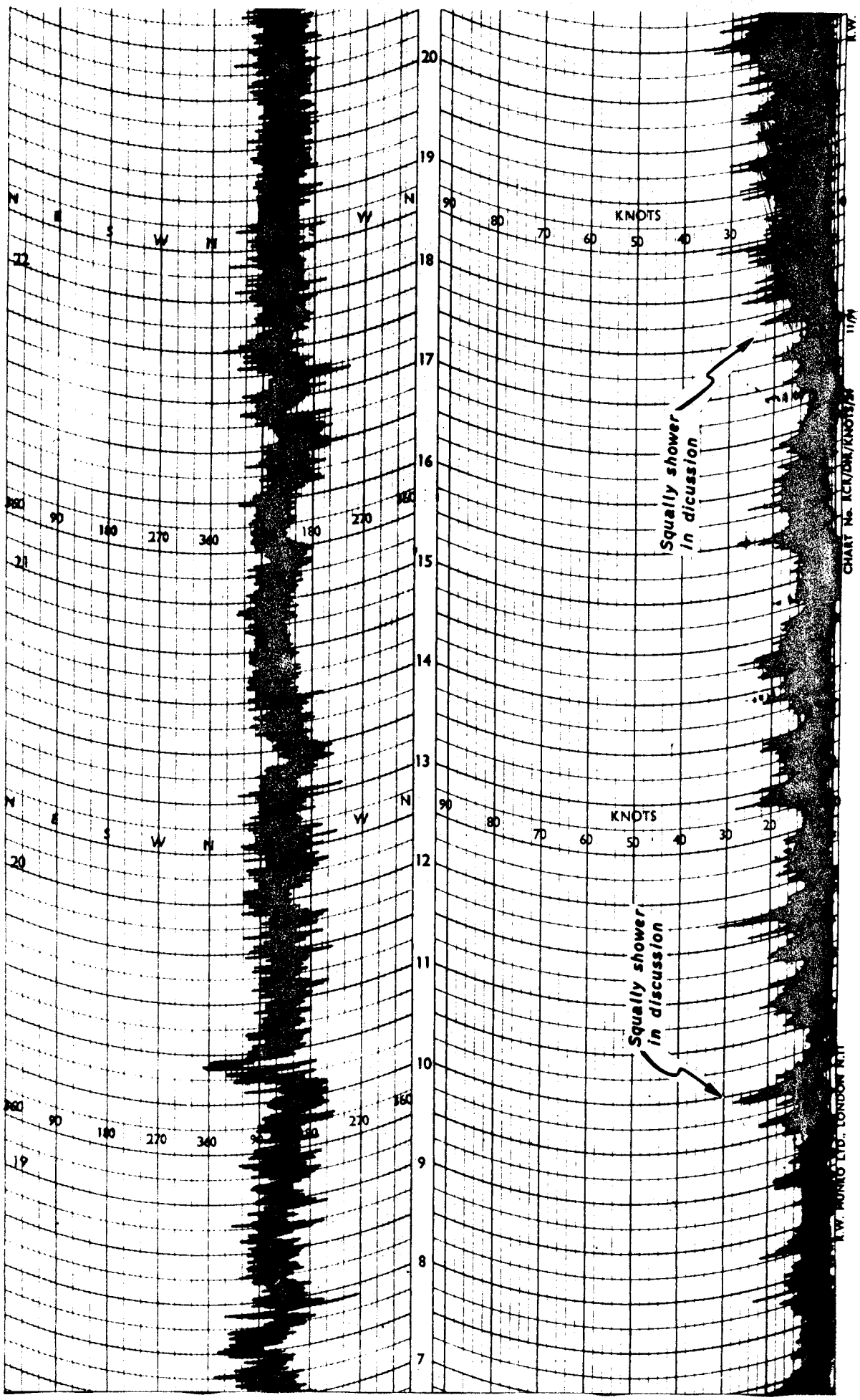

FIGURE 14 ANEMOGRAM ON 26 JUNE 1978 AT YAU YAT CHUEN

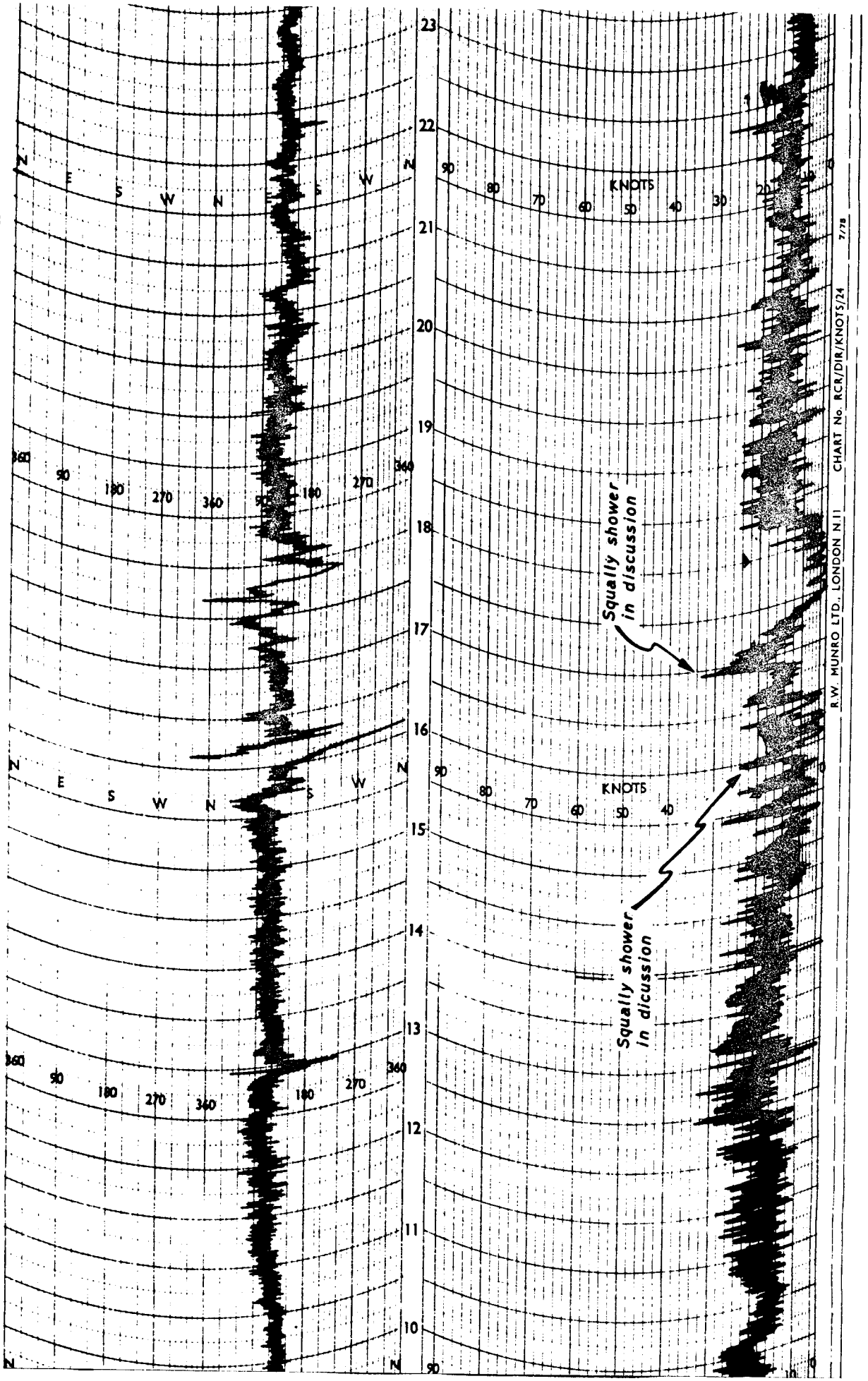

FIGURE 15 ANEMOGRAM ON 27 JUNE 1978 AT THE SE END OF THE RUNWAY

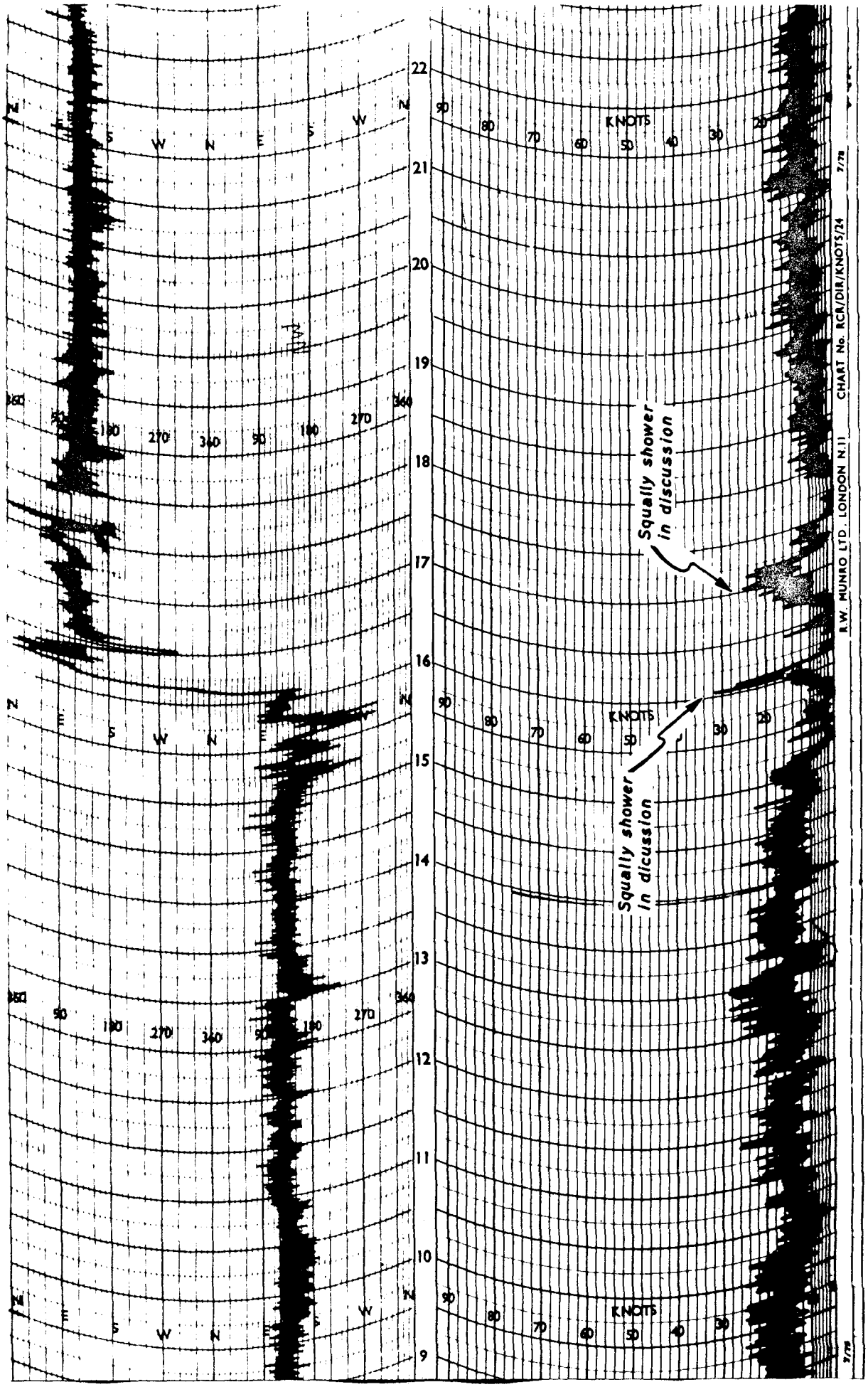

FIGURE 16 ANEMOGRAM ON 27 JUNE 1978 AT NW END OF THE RUNWAY

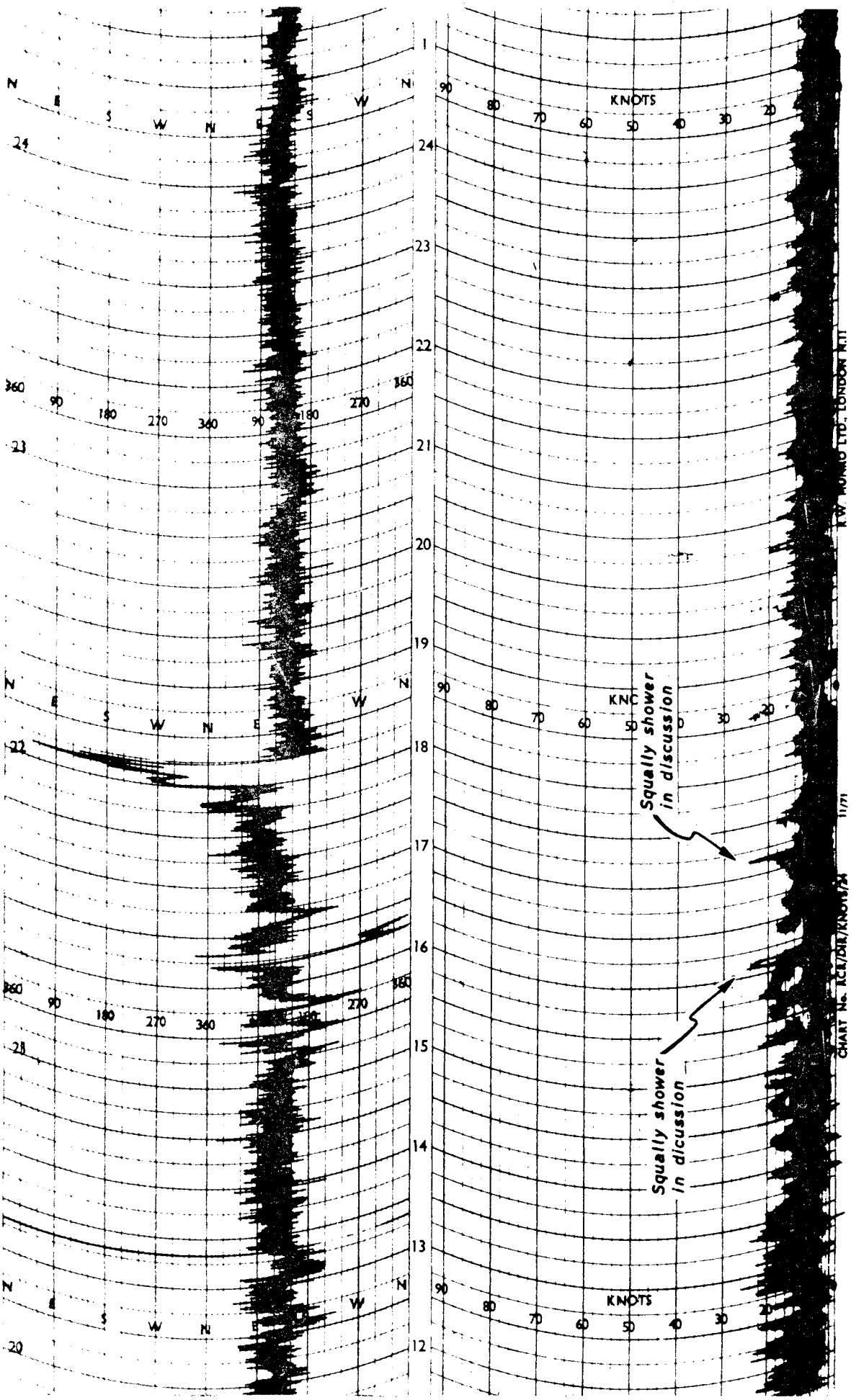

FIGURE 17 ANEMOGRAM ON 27 JUNE 1978 AT KOWLOON TSAI HILL

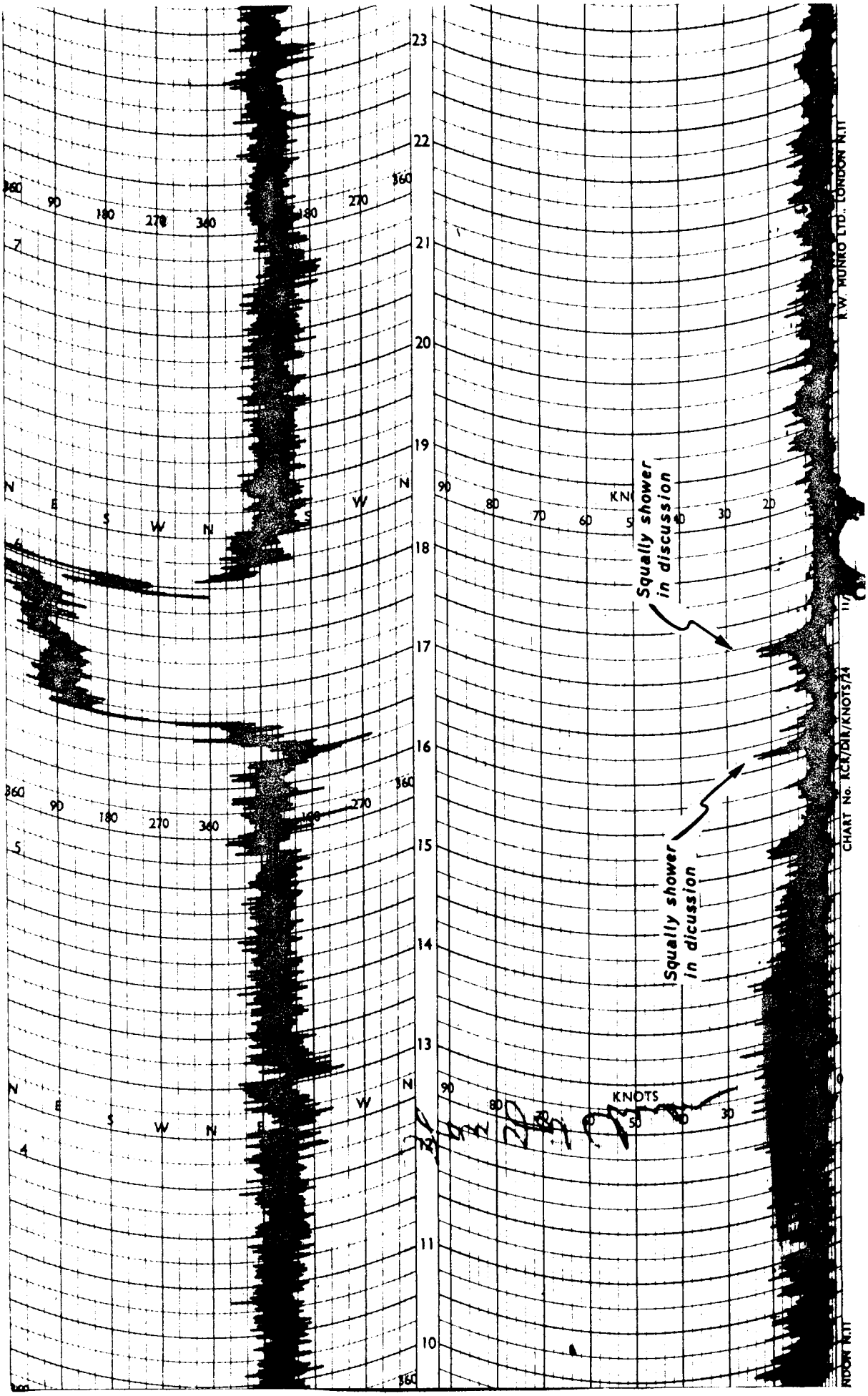

FIGURE 18 ANEMOGRAM ON 27 JUNE 1978 AT YAU YAT CHUEN