UPPER WIND FREQUENCIES AT THE ARGENTINE ISLANDS, GRAHAM LAND, 1954–58

By BRIAN D. GILES

IN a previous paper (Giles, 1963) vector mean winds, scalar mean speeds, constancy and standard vector deviation were computed for the period 1 January 1954 to 31 December 1958. This paper presents frequency distributions of the upper wind observations for the same period. Analysis was made of 444 radio-sonde and pilot balloon flights. Tables I to V give

TABLE I. UPPER WIND FREQUENCIES FOR THE WHOLE PERIOD, 1954–58

Height (ft.)	*Speed* (kt.)	*Direction* Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	*Mean Scalar* (kt.)
Surface	0– 9	194	14	7	7	10	11	19	38	30	8	6	1	2	347	
	10–19		11	4	3	1	5	4	39	8	9	3	1	0	88	
	20–39		2	1	1	0	1	1	0	0	0	1	1	1	9	
	Total	194	27	12	11	11	17	24	77	38	17	10	3	3	444	4·3
2,000	0– 9	10	22	34	19	6	24	24	39	60	21	10	10	14	293	
(900 mb.)	10–19		5	13	3	2	5	5	22	40	3	2	3	1	104	
	20–49		3	7	2	0	1	1	1	4	3	1	1	1	25	
	Total	10	30	54	24	8	30	30	62	104	27	13	14	16	422	8·1
4,000	0– 9	7	17	25	25	18	22	18	35	39	15	9	10	7	247	
(850 mb.)	10–19		13	14	11	1	11	5	14	40	5	3	2	3	122	
	20–29		4	7	2	1	2	3	4	22	3	1	4	0	53	
	30–49		3	1	0	0	0	0	0	3	1	2	0	0	10	
	Total	7	37	47	38	20	35	26	53	104	24	15	16	10	432	10·6
6,000	0– 9	5	12	9	21	5	16	8	23	23	10	11	5	6	154	
	10–19		4	16	9	5	5	4	14	32	10	6	6	5	116	
	20–29		5	3	3	0	2	3	2	17	6	4	2	4	51	
	30–39		3	1	0	0	1	0	2	10	3	1	0	0	21	
	40–49		1	0	0	0	0	0	0	2	1	1	0	0	5	
	Total	5	25	29	33	10	24	15	41	84	30	23	13	15	347	13·1
8,000	0– 9	3	7	8	11	6	8	11	14	14	12	11	7	5	117	
	10–19		6	7	13	7	1	7	16	19	12	9	2	5	104	
	20–29		4	5	3	2	1	2	7	11	13	2	5	3	58	
	30–39		3	0	0	0	0	3	2	9	8	3	1	1	30	
	40–49		1	0	0	0	1	0	1	3	2	0	0	0	8	
	Total	3	21	20	27	15	11	23	40	56	47	25	15	14	317	15·3
10,000	0– 9	1	6	7	6	10	8	12	12	9	9	8	6	7	101	
(650 mb.)	10–19		6	8	6	8	5	12	12	18	19	8	9	8	119	
	20–29		3	3	2	1	2	3	6	14	8	3	4	4	53	
	30–39		1	0	0	2	1	2	8	13	6	5	1	0	39	
	40–59		0	1	0	0	1	0	4	4	4	0	1	0	15	
	Total	1	16	19	14	21	17	29	42	58	46	24	21	19	327	16·9
12,000	0– 9	1	3	5	4	4	5	4	3	6	4	5	4	0	48	
(600 mb.)	10–19		6	4	4	3	5	10	8	7	13	3	7	6	76	
	20–29		2	0	1	1	4	3	6	12	11	2	6	1	49	
	30–39		0	0	0	0	0	3	4	5	11	2	1	0	26	
	40–59		0	2	0	1	0	1	4	7	1	2	1	0	19	
	Total	1	11	11	9	9	14	21	25	37	40	14	19	7	218	19·5
14,000	0– 9	1	2	4	5	6	5	7	1	9	6	8	1	3	58	
(550 mb.)	10–19		5	2	4	3	1	8	3	9	11	3	9	6	64	
	20–29		5	1	0	0	4	5	4	11	15	1	2	3	51	
	30–39		0	0	0	0	1	2	2	9	3	0	2	0	19	
	40–49		0	0	0	2	0	0	3	4	1	1	1	0	12	

TABLE I (*continued*)

Height (ft.)	*Speed* (kt.)	*Direction* Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	*Mean Scalar* (kt.)
	50–79		0	1	0	0	0	0	2	4	2	0	0	0	9	
	Total	1	12	8	9	11	11	22	15	46	38	13	15	12	213	19·9
16,000	0– 9	0	3	0	3	2	5	6	7	3	6	4	3	1	43	
(500 mb.)	10–19		6	1	4	2	5	5	8	7	9	9	8	9	73	
	20–29		2	3	4	0	5	5	7	13	17	5	7	5	73	
	30–39		0	0	0	0	1	3	3	9	10	1	2	0	29	
	40–49		0	0	0	1	1	1	2	6	3	2	1	0	17	
	50–79		0	2	0	0	0	2	3	4	3	1	0	0	15	
	Total	0	11	6	11	5	17	22	30	42	48	22	21	15	250	22·5
20,000	0– 9	0	2	2	1	1	3	4	1	5	3	3	5	1	31	
(450 mb.)	10–19		2	1	4	2	2	0	4	2	1	4	5	3	30	
	20–29		2	0	1	3	3	4	2	5	6	5	0	3	34	
	30–39		1	0	0	0	1	6	3	6	8	3	2	2	32	
	40–49		0	0	0	2	0	1	2	4	1	0	1	0	11	
	50–79		0	0	0	0	0	0	3	3	5	1	0	0	12	
	Total	0	7	3	6	8	9	15	15	25	24	16	13	9	150	25·4
23,000	0– 9	0	1	0	1	1	4	1	2	5	4	2	5	2	28	
(400 mb.)	10–19		3	3	4	2	0	1	5	10	7	5	7	5	52	
	20–29		5	2	1	1	2	6	8	9	6	6	3	1	50	
	30–39		0	3	2	1	2	6	4	6	12	5	4	2	47	
	40–49		1	0	0	1	1	0	1	6	6	2	1	0	19	
	50–59		0	0	0	0	0	1	3	4	4	1	1	0	14	
	60–109		0	1	0	0	0	1	3	5	3	1	0	0	14	
	Total	0	10	9	8	6	9	16	26	45	42	22	21	10	224	28·4
27,000	0– 9	0	0	1	1	0	3	2	3	3	3	4	0	4	24	
(300 mb.)	10–19		5	2	1	2	1	4	6	3	9	6	8	4	51	
	20–29		4	0	1	2	1	5	4	7	6	8	2	5	45	
	30–39		0	2	1	0	1	4	7	7	9	3	3	1	38	
	40–49		1	0	0	1	2	5	1	2	9	3	0	1	25	
	50–59		0	0	0	1	2	2	1	6	7	3	2	0	24	
	60–69		0	0	0	0	0	1	3	3	2	1	1	0	11	
	70–139		0	1	0	0	1	1	2	2	3	0	0	0	10	
	Total	0	10	6	4	6	11	24	27	33	48	28	16	15	228	31·9
30,000	0– 9	0	0	1	0	0	4	1	1	6	6	2	0	3	24	
(250 mb.)	10–19		2	2	1	2	1	1	5	2	6	10	7	2	41	
	20–29		1	1	1	2	1	3	5	9	3	5	6	4	41	
	30–39		0	0	1	0	3	2	5	4	11	5	1	3	35	
	40–49		0	1	0	0	0	8	1	1	9	3	0	1	24	
	50–59		0	0	0	0	1	1	1	3	6	1	0	0	13	
	60–69		0	0	0	0	0	0	4	1	0	0	1	0	6	
	70–79		0	0	0	0	0	0	0	3	1	0	2	0	6	
	80–139		0	0	0	0	1	1	1	1	2	0	0	0	6	
	Total	0	3	5	3	4	11	17	23	30	44	26	17	13	196	31·4
35,000	0– 9	0	1	2	1	0	0	3	3	5	2	7	1	3	28	
(200 mb.)	10–19		2	0	1	1	3	2	6	7	15	8	5	1	51	
	20–29		0	0	2	0	2	3	4	4	7	4	7	4	37	
	30–39		0	0	0	0	2	2	1	4	7	7	2	1	26	
	40–49		0	1	0	0	0	3	4	5	5	3	0	1	22	
	50–59		0	0	0	0	1	0	1	0	4	1	1	0	8	
	60–69		0	0	0	0	0	1	2	3	5	0	1	0	12	
	70–99		0	0	0	0	0	0	1	2	2	0	1	0	6	
	Total	0	3	3	4	1	8	14	22	30	47	30	18	10	190	28·4
40,000	0– 9	0	1	0	3	1	0	1	0	1	4	2	0	2	15	
(170 mb.)	10–19		0	0	0	0	3	1	4	6	10	4	3	0	31	
	20–29		0	0	0	1	0	4	3	6	6	5	5	1	31	
	30–39		0	0	0	0	1	1	0	2	4	3	0	0	11	
	40–49		0	0	0	0	0	0	2	2	4	2	1	2	13	
	50–59		0	0	0	0	0	1	0	0	5	0	1	1	8	
	60–69		0	0	0	0	0	0	0	1	3	0	0	0	4	

TABLE I (*continued*)

Height (ft.)	*Speed* (kt.)	Direction														*Mean Scalar* (kt.)
		Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	
	70–89		0	0	0	0	0	0	1	4	1	0	0	0	6	
	Total	0	1	0	3	2	4	8	10	22	37	16	10	6	119	28·6
50,000	0– 9	0	0	0	1	0	3	2	0	5	4	5	3	0	23	
(100 mb.)	10–19		1	2	0	1	3	3	5	4	5	2	3	1	30	
	20–29		0	0	0	0	0	3	2	2	9	4	3	1	24	
	30–39		0	0	0	0	0	1	0	4	6	6	3	0	20	
	40–49		0	0	0	0	1	0	1	0	5	4	0	0	11	
	50–59		0	0	0	0	0	0	0	3	4	3	3	0	13	
	60–69		0	0	0	0	0	0	1	0	0	1	2	0	4	
	70–79		0	0	0	0	0	0	0	0	2	0	2	0	4	
	80–89		0	0	0	0	0	0	0	2	2	0	0	0	4	
	90–169		0	0	0	0	0	0	0	0	1	0	2	0	3	
	Total	0	1	2	1	1	7	9	9	20	38	25	21	2	136	31·6
60,000	0– 9	0	0	0	0	0	1	1	5	2	0	0	1	2	12	
(70–60 mb.)	10–19		0	0	1	4	2	5	2	2	2	0	0	0	18	
	20–29		0	0	0	0	0	4	0	2	3	1	2	0	12	
	30–39		0	0	0	0	0	0	0	0	3	3	0	1	7	
	40–49		0	0	0	0	0	0	0	0	3	0	1	0	4	
	50–59		0	0	0	0	0	0	2	0	1	2	1	0	6	
	60–99		0	0	0	0	0	0	0	0	4	2	3	0	9	
	Total	0	0	0	1	4	3	10	9	6	16	8	8	3	68	31·1
70,000	0– 9	0	0	1	0	1	0	1	1	0	0	0	1	0	5	
(45 mb.)	10–19		0	0	0	0	4	3	1	1	0	1	0	0	10	
	20–29		0	0	0	0	1	3	0	0	1	0	0	0	5	
	30–39		0	0	0	0	0	2	0	0	2	0	0	0	4	
	40–49		0	0	0	0	0	0	0	0	2	1	0	0	3	
	50–179		0	0	0	0	0	0	1	0	2	1	1	0	5	
	Total	0	0	1	0	1	5	9	3	1	7	3	2	0	32	31·8
80,000	0– 9	0	0	0	0	1	3	2	0	1	0	0	0	0	7	
	10–19		1	0	0	0	5	0	0	1	0	0	0	0	7	
	20–29		0	0	0	1	2	0	0	0	1	0	0	0	4	
	30–69		0	0	0	0	0	0	0	0	2	3	0	0	5	
	Total	0	1	0	0	2	10	2	0	2	3	3	0	0	23	21·9

TABLE II. UPPER WIND FREQUENCIES FOR SUMMERS, 1954–58

Height (ft.)	*Speed* (kt.)	Direction														*Mean Scalar* (kt.)
		Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	
Surface	0– 9	60	4	2	3	1	2	4	12	8	4	3	0	1	104	
	10–19		4	1	0	0	1	2	6	2	1	1	1	0	19	
	20–39		1	0	0	0	0	1	0	0	0	1	0	0	3	
	Total	60	9	3	3	1	3	7	18	10	5	5	1	1	126	4·0
2,000	0– 9	4	5	10	6	1	11	8	13	20	7	2	5	4	96	
	10–19		2	3	1	0	2	0	0	3	0	0	1	0	12	
	20–29		0	1	0	0	1	1	0	0	0	0	1	0	4	
	Total	4	7	14	7	1	14	9	13	23	7	2	7	4	112	6·2
4,000	0– 9	3	6	14	8	7	11	9	15	11	4	1	2	0	91	
	10–19		1	4	5	0	2	1	2	7	1	0	0	1	24	
	20–29		1	2	0	1	1	1	0	2	0	0	1	0	9	
	Total	3	8	20	13	8	14	11	17	20	5	1	3	1	124	8·1
6,000	0– 9	2	5	4	9	3	10	6	11	11	2	3	2	2	70	
	10–19		1	4	3	2	4	2	1	7	2	0	0	0	26	
	20–29		2	1	0	0	1	0	0	3	1	1	0	1	10	
	Total	2	8	9	12	5	15	8	12	21	5	4	2	3	106	9·2

TABLE II (*continued*)

Height (ft.)	*Speed* (kt.)	*Direction* Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	*Mean Scalar* (kt.)
8,000	0– 9	2	3	1	5	6	4	4	10	8	6	4	3	2	58	
	10–19		1	3	5	1	1	4	3	6	1	0	0	1	26	
	20–39		2	1	0	0	1	0	1	1	6	0	0	1	13	
	Total	2	6	5	10	7	6	8	14	15	13	4	3	4	97	10·7
10,000	0– 9	1	2	2	2	4	4	6	8	4	4	2	4	1	44	
	10–19		1	1	2	3	1	5	5	7	5	2	0	1	33	
	20–39		0	1	0	1	2	0	2	3	2	0	0	2	13	
	Total	1	3	4	4	8	7	11	15	14	11	4	4	4	90	11·7
12,000	0– 9	1	1	0	3	0	1	2	0	4	1	2	2	0	17	
	10–19		2	0	2	2	1	6	3	4	5	3	2	1	31	
	20–29		0	0	0	1	1	1	3	4	0	0	1	0	11	
	30–49		0	1	0	0	0	0	1	0	2	0	0	0	4	
	Total	1	3	1	5	3	3	9	7	12	8	5	5	1	63	14·6
14,000	0– 9	1	0	1	2	2	2	3	1	5	1	4	0	0	22	
	10–19		1	0	2	1	0	2	2	3	6	0	3	0	20	
	20–29		0	0	0	0	2	3	0	3	1	0	0	0	9	
	30–49		0	0	0	0	0	0	2	2	1	0	0	0	5	
	Total	1	1	1	4	3	4	8	5	13	9	4	3	0	56	15·3
16,000	0– 9	0	0	0	1	0	2	0	2	3	2	1	1	1	13	
	10–19		1	1	1	2	0	2	6	3	5	3	3	1	28	
	20–29		0	1	0	0	0	0	2	4	5	0	0	0	12	
	30–59		0	1	0	0	0	1	1	4	2	0	0	0	9	
	Total	0	1	3	2	2	2	3	11	14	14	4	4	2	62	17·7
20,000	0– 9	0	1	1	0	0	2	1	0	2	2	2	2	0	13	
	10–19		0	0	3	1	1	0	1	1	1	3	0	0	11	
	20–29		0	0	0	1	0	2	1	2	3	1	0	0	10	
	30–39		0	0	0	0	1	1	1	1	3	0	0	0	7	
	40–69		0	0	0	1	0	1	1	1	2	0	0	0	6	
	Total	0	1	1	3	3	4	5	4	7	11	6	2	0	47	21·9
23,000	0– 9	0	0	0	0	0	1	0	1	2	3	1	1	1	10	
	10–19		2	0	2	0	0	0	2	0	4	2	2	1	15	
	20–29		0	1	0	0	0	1	4	3	4	1	2	0	16	
	30–39		0	1	0	0	0	1	2	1	5	1	0	0	11	
	40–79		0	1	0	0	0	0	1	3	2	0	0	0	7	
	Total	0	2	3	2	0	1	2	10	9	18	5	5	2	59	23·8
27,000	0– 9	0	0	1	0	0	1	1	1	0	1	1	0	3	9	
	10–19		4	0	0	1	0	1	1	0	5	5	2	0	19	
	20–29		2	0	1	0	0	2	2	0	4	3	1	1	16	
	30–39		0	1	0	0	1	1	3	3	3	0	0	1	13	
	40–49		0	0	0	0	1	2	1	1	6	1	0	0	12	
	50–59		0	0	0	0	1	0	0	1	2	0	0	0	4	
	60–89		0	1	0	0	1	1	1	0	0	0	0	0	4	
	Total	0	6	3	1	1	5	8	9	5	21	10	3	5	77	28·3
30,000	0– 9	0	0	1	0	0	2	0	0	2	3	2	0	1	11	
	10–19		2	1	1	1	0	1	1	2	2	5	3	1	20	
	20–29		0	1	0	1	0	1	4	3	1	2	3	0	16	
	30–39		0	0	0	0	2	1	3	1	6	1	0	0	14	
	40–49		0	1	0	0	0	1	0	1	3	1	0	0	7	
	50–89		0	0	0	0	2	0	2	0	0	0	0	0	4	
	Total	0	2	4	1	2	6	4	10	9	15	11	6	2	72	25·0
35,000	0– 9	0	1	1	1	0	0	0	1	2	2	5	1	3	17	
	10–19		1	0	1	0	3	1	3	4	8	3	2	1	27	
	20–29		0	0	0	0	1	0	3	3	4	2	1	0	14	
	30–69		0	1	0	0	2	1	1	0	2	3	0	0	10	
	Total	0	2	2	2	0	6	2	8	9	16	13	4	4	68	18·6

TABLE II (*continued*)

Height (ft.)	*Speed* (kt.)	*Direction* Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	*Mean Scalar* (kt.)
40,000	0– 9	0	1	0	2	1	0	0	0	1	3	1	0	1	10	
	10–19		0	0	0	0	2	1	3	3	6	3	2	0	20	
	20–29		0	0	0	0	0	3	1	3	1	2	1	0	11	
	30–59		0	0	0	0	0	2	1	0	1	0	0	0	4	
	Total	0	1	0	2	1	2	6	5	7	11	6	3	1	45	17·3
50,000	0– 9	0	0	0	0	0	3	2	0	4	4	4	3	0	20	
	10–19		1	2	0	1	2	1	4	4	3	0	2	1	21	
	20–29		0	0	0	0	0	3	2	1	2	1	2	0	11	
	30–39		0	0	0	0	0	1	0	1	0	0	0	0	2	
	Total	0	1	2	0	1	5	7	6	10	9	5	7	1	54	13·7
60,000	0– 9	0	0	0	0	0	1	1	5	2	0	0	1	1	11	
	10–19		0	0	1	4	1	4	2	2	2	0	0	0	16	
	20–29		0	0	0	0	0	4	0	1	0	0	2	0	7	
	Total	0	0	0	1	4	2	9	7	5	2	0	3	1	34	13·4
70,000	0– 9	0	0	1	0	1	0	1	1	0	0	0	1	0	5	
	10–19		0	0	0	0	3	3	1	0	0	0	0	0	7	
	20–39		0	0	0	0	1	4	0	0	0	0	0	0	5	
	Total	0	0	1	0	1	4	8	2	0	0	0	1	0	17	16·1
80,000	0– 9	0	0	0	0	1	2	2	0	0	0	0	0	0	5	
	10–19		1	0	0	0	3	0	0	0	0	0	0	0	4	
	20–29		0	0	0	1	2	0	0	0	0	0	0	0	3	
	Total	0	1	0	0	2	7	2	0	0	0	0	0	0	12	13·4

TABLE III. UPPER WIND FREQUENCIES FOR AUTUMNS, 1954–58

Height (ft.)	*Speed* (kt.)	*Direction* Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	*Mean Scalar* (kt.)
Surface	0– 9	33	1	0	0	3	0	4	3	3	1	1	0	0	49	
	10–19		1	1	2	0	3	0	5	0	1	1	0	0	14	
	Total	33	2	1	2	3	3	4	8	3	2	2	0	0	63	3·8
2,000	0– 9	0	4	4	3	1	2	5	8	9	1	4	0	0	41	
	10–19		0	1	0	0	2	1	4	2	0	1	1	1	13	
	20–49		0	0	1	0	0	0	0	2	1	0	0	0	4	
	Total	0	4	5	4	1	4	6	12	13	2	5	1	1	58	7·9
4,000	0– 9	1	1	5	3	3	6	0	5	6	2	3	1	2	38	
	10–19		1	0	1	0	0	2	3	7	0	1	0	0	15	
	20–29		0	1	1	0	0	1	0	2	1	0	2	0	8	
	30–39		0	0	0	0	0	0	0	1	0	1	0	0	2	
	Total	1	2	6	5	3	6	3	8	16	3	5	3	2	63	10·1
6,000	0– 9	0	1	4	2	1	2	0	4	4	2	5	0	0	25	
	10–19		1	3	0	1	0	1	0	6	2	0	1	1	16	
	20–29		0	0	2	0	0	2	0	4	2	0	1	1	12	
	30–39		0	0	0	0	0	0	1	0	0	0	0	0	1	
	Total	0	2	7	4	2	2	3	5	14	6	5	2	2	54	12·5
8,000	0– 9	0	2	2	2	0	1	2	1	1	0	1	1	0	13	
	10–19		1	1	2	2	0	1	4	3	3	4	0	0	21	
	20–29		0	2	1	0	0	0	0	1	2	0	2	0	8	
	30–49		0	0	0	0	1	1	1	5	0	0	0	0	8	
	Total	0	3	5	5	2	2	4	6	10	5	5	3	0	50	16·7
10,000	0– 9	0	2	3	1	1	1	1	0	2	1	1	1	1	15	
	10–19		1	1	0	1	2	3	1	3	4	1	1	1	19	
	20–29		0	0	2	0	0	0	0	3	3	0	1	0	9	

TABLE III (*continued*)

Height (ft.)	*Speed* (kt.)	*Direction* Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	*Mean Scalar* (kt.)
	30–49		0	0	0	0	1	1	2	1	1	0	0	0	6	
	Total	0	3	4	3	2	4	5	3	9	9	2	3	2	49	16·5
12,000	0– 9	0	1	1	0	0	1	0	1	0	0	1	1	0	6	
	10–19		1	0	0	0	0	1	2	0	2	0	0	1	7	
	20–29		0	0	1	0	1	1	0	3	2	0	1	0	9	
	30–59		0	0	0	0	0	1	2	2	2	0	1	0	8	
	Total	0	2	1	1	0	2	3	5	5	6	1	3	1	30	21·7
14,000	0– 9	0	2	0	1	1	0	1	0	2	1	0	0	1	9	
	10–19		1	0	0	1	0	1	0	2	2	0	0	1	8	
	20–29		0	0	0	0	0	1	0	1	2	0	0	0	4	
	30–59		0	0	0	0	1	0	1	2	0	0	1	0	5	
	Total	0	3	0	1	2	1	3	1	7	5	0	1	2	26	17·2
16,000	0– 9	0	1	0	1	0	0	0	1	0	1	1	1	0	6	
	10–19		1	0	0	0	3	2	1	0	2	0	1	1	11	
	20–29		0	0	1	0	1	0	0	3	1	3	0	0	9	
	30–39		0	0	0	0	1	1	0	1	1	0	1	0	5	
	40–69		0	0	0	0	0	1	1	2	1	1	0	0	6	
	Total	0	2	0	2	0	5	4	3	6	6	5	3	1	37	23·0
20,000	0– 9	0	0	1	0	1	0	0	0	1	0	0	0	0	3	
	10–19		0	0	0	0	1	0	0	0	0	0	0	0	1	
	20–29		0	0	1	2	0	0	0	1	0	0	0	1	5	
	30–39		0	0	0	0	0	2	0	1	1	0	0	0	4	
	40–69		0	0	0	0	0	0	1	2	0	0	0	0	3	
	Total	0	0	1	1	3	1	2	1	5	1	0	0	1	16	27·3
23,000	0– 9	0	0	0	0	0	1	0	0	2	0	0	0	0	3	
	10–19		0	0	0	1	0	0	1	1	2	1	0	0	6	
	20–29		1	0	1	1	1	2	0	0	0	2	0	0	8	
	30–39		0	0	1	0	1	1	2	1	2	1	0	0	9	
	40–49		1	0	0	0	0	0	0	0	1	0	0	0	2	
	50–59		0	0	0	0	0	0	1	1	0	0	0	0	2	
	60–69		0	0	0	0	0	0	0	1	0	1	0	0	2	
	70–99		0	0	0	0	0	1	0	0	1	0	0	0	2	
	Total	0	2	0	2	2	3	4	4	6	6	5	0	0	34	31·9
27,000	0– 9	0	0	0	0	0	0	0	1	1	0	0	0	0	2	
	10–19		1	2	0	1	0	0	1	1	0	1	2	1	10	
	20–29		0	0	0	1	0	2	1	0	1	1	0	0	6	
	30–39		0	0	0	0	0	1	0	1	1	1	1	0	5	
	40–49		1	0	0	0	1	0	0	1	1	0	0	0	4	
	50–59		0	0	0	0	0	0	0	1	1	0	0	0	2	
	60–69		0	0	0	0	0	0	2	1	0	1	0	0	4	
	70–139		0	0	0	0	0	1	0	1	0	0	0	0	2	
	Total	0	2	2	0	2	1	4	5	7	4	4	3	1	35	35·4
30,000	0– 9	0	0	0	0	0	0	0	1	0	0	0	0	0	1	
	10–19		0	1	0	0	0	0	1	0	0	0	1	0	3	
	20–29		0	0	1	1	1	1	0	0	1	2	1	1	9	
	30–39		0	0	0	0	0	0	0	2	1	2	0	1	6	
	40–49		0	0	0	0	0	1	0	0	1	0	0	0	2	
	50–129		0	0	0	0	0	1	2	2	0	0	0	0	5	
	Total	0	0	1	1	1	1	3	4	4	3	4	2	2	26	36·6
35,000	0– 9	0	0	0	0	0	0	0	2	2	0	0	0	0	4	
	10–19		1	0	0	1	0	0	1	1	1	2	0	0	7	
	20–29		0	0	0	0	0	1	0	0	1	0	1	3	6	
	30–39		0	0	0	0	0	0	0	2	1	3	0	0	6	
	40–49		0	0	0	0	0	1	0	1	0	0	0	0	2	
	50–89		0	0	0	0	0	1	0	2	0	1	0	0	4	
	Total	0	1	0	0	1	0	3	3	8	3	6	1	3	29	29·3

TABLE III (*continued*)

Height (ft.)	*Speed* (kt.)	Direction														*Mean Scalar* (kt.)
		Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	
40,000	0– 9	0	0	0	0	0	0	0	0	0	0	1	0	1	2	
	10–19		0	0	0	0	0	0	0	1	1	0	0	0	2	
	20–29		0	0	0	1	0	0	0	0	1	0	1	1	4	
	30–79		0	0	0	0	0	0	0	1	2	1	0	0	4	
	Total	0	0	0	0	1	0	0	0	2	4	2	1	2	12	27·7
50,000	0– 9	0	0	0	0	0	0	0	0	1	0	1	0	0	2	
	10–19		0	0	0	0	0	1	0	0	0	2	0	0	3	
	20–29		0	0	0	0	0	0	0	0	1	2	0	1	4	
	30–39		0	0	0	0	0	0	0	0	1	3	1	0	5	
	40–59		0	0	0	0	0	0	0	0	1	2	0	0	3	
	Total	0	0	0	0	0	0	1	0	1	3	10	1	1	17	27·6
60,000	0–19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	20–29		0	0	0	0	0	0	0	0	2	1	0	0	3	
	30–39		0	0	0	0	0	0	0	0	1	1	0	1	3	
	40–59		0	0	0	0	0	0	0	0	1	1	1	0	3	
	Total	0	0	0	0	0	0	0	0	0	4	3	1	1	9	37·8

TABLE IV. UPPER WIND FREQUENCIES FOR WINTERS, 1954–58

Height (ft.)	*Speed* (kt.)	Direction														*Mean Scalar* (kt.)
		Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	
Surface	0– 9	56	3	2	0	2	5	4	14	9	0	1	0	0	96	
	10–19		2	2	1	1	1	2	13	3	2	1	0	0	28	
	20–29		0	1	0	0	1	0	0	0	0	0	0	0	2	
	Total	56	5	5	1	3	7	6	27	12	2	2	0	0	126	4·3
2,000	0– 9	2	6	12	4	2	6	4	10	15	8	2	3	2	76	
	10–19		2	3	2	1	0	2	11	19	1	1	0	0	42	
	20–39		3	3	0	0	0	0	0	2	0	0	0	0	8	
	Total	2	11	18	6	3	6	6	21	36	9	3	3	2	126	9·0
4,000	0– 9	1	3	3	3	1	2	7	10	13	4	2	3	3	55	
	10–19		7	7	3	0	7	1	5	12	3	1	1	1	48	
	20–29		2	0	0	0	0	0	3	8	2	1	0	0	16	
	30–49		2	1	0	0	0	0	0	1	0	0	0	0	4	
	Total	1	14	11	6	1	9	8	18	34	9	4	4	4	123	12·4
6,000	0– 9	1	1	0	0	0	1	2	4	2	3	1	2	2	19	
	10–19		2	3	3	2	1	1	7	13	2	2	2	2	40	
	20–29		2	2	1	0	1	0	1	5	1	0	1	1	15	
	30–49		2	0	0	0	0	0	1	6	1	1	0	0	11	
	Total	1	7	5	4	2	3	3	13	26	7	4	5	5	85	16·5
8,000	0– 9	0	1	1	0	0	0	2	2	2	1	3	0	1	13	
	10–19		2	1	2	3	0	1	5	5	3	2	2	2	28	
	20–29		1	1	1	1	0	2	5	5	1	0	0	2	19	
	30–49		2	0	0	0	0	1	1	4	3	0	1	0	12	
	Total	0	6	3	3	4	0	6	13	16	8	5	3	5	72	18·6
10,000	0– 9	0	2	0	1	2	1	3	3	1	0	1	1	0	15	
	10–19		2	2	2	2	1	4	4	7	3	3	5	3	38	
	20–29		1	1	0	0	1	3	3	7	2	0	1	0	19	
	30–39		0	0	0	1	0	1	4	3	1	1	1	0	12	
	40–59		0	1	0	0	0	0	2	2	0	0	1	0	6	
	Total	0	5	4	3	5	3	11	16	20	6	5	9	3	90	19·6
12,000	0– 9	0	1	2	0	1	1	0	1	1	1	0	0	0	8	
	10–19		1	1	1	1	3	3	3	2	3	0	2	1	21	
	20–29		0	0	0	0	2	1	2	3	4	1	2	0	15	

TABLE IV (*continued*)

Height (ft.)	*Speed* (kt.)	Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	*Mean Scalar* (kt.)
			Direction													
	30–39		0	0	0	0	0	2	1	1	0	1	0	0	5	
	40–59		0	1	0	1	0	0	0	2	0	0	1	0	5	
	Total	0	2	4	1	3	6	6	7	9	8	2	5	1	54	20·6
14,000	0– 9	0	0	2	0	2	0	2	0	1	2	2	1	1	13	
	10–19		2	0	0	0	1	4	0	3	0	2	1	2	15	
	20–29		0	1	0	0	1	1	2	5	4	0	1	2	17	
	30–39		0	0	0	0	0	2	1	5	1	0	1	0	10	
	40–79		0	1	0	1	0	0	1	3	0	0	0	0	6	
	Total	0	2	4	0	3	2	9	4	17	7	4	4	5	61	22·8
16,000	0– 9	0	1	0	1	2	2	0	1	0	1	1	1	0	10	
	10–19		2	0	1	0	2	0	1	3	2	2	2	2	17	
	20–29		1	1	1	0	3	4	3	3	4	0	3	0	23	
	30–39		0	0	0	0	0	1	2	4	3	0	0	0	10	
	40–49		0	0	0	0	1	1	0	1	0	0	1	0	4	
	50–69		0	1	0	0	0	0	0	1	0	1	0	0	3	
	Total	0	4	2	3	2	8	6	7	12	10	4	7	2	67	23·5
20,000	0– 9	0	1	0	0	0	1	0	0	0	0	0	3	1	6	
	10–19		1	0	0	1	0	0	0	1	0	1	1	0	5	
	20–29		1	0	0	0	2	2	0	1	0	1	0	1	8	
	30–39		0	0	0	0	0	2	1	2	3	1	1	0	10	
	40–49		0	0	0	0	0	0	1	0	0	0	1	0	2	
	Total	0	3	0	0	1	3	4	2	4	3	3	6	2	31	24·2
23,000	0– 9	0	0	0	1	1	0	0	0	0	0	0	4	1	7	
	10–19		1	1	1	1	0	0	0	3	0	1	2	1	11	
	20–29		1	1	0	0	1	2	3	4	0	2	0	0	14	
	30–39		0	1	1	0	1	3	0	3	2	0	1	0	12	
	40–49		0	0	0	0	1	0	1	3	3	1	0	0	9	
	50–69		0	0	0	0	0	0	1	1	0	0	0	0	2	
	Total	0	2	3	3	2	3	5	5	14	5	4	7	2	55	27·3
27,000	0– 9	0	0	0	0	0	0	0	0	0	1	2	0	0	3	
	10–19		0	0	1	0	1	2	2	0	1	0	3	1	11	
	20–29		0	0	0	1	1	1	1	4	0	1	0	0	9	
	30–39		0	0	1	0	0	2	3	2	2	1	1	0	12	
	40–49		0	0	0	0	0	1	0	0	0	0	0	0	1	
	50–59		0	0	0	0	1	1	1	2	2	1	1	0	9	
	Total	0	0	0	2	1	3	7	7	8	6	5	5	1	45	29·3
30,000	0– 9	0	0	0	0	0	0	0	0	1	1	0	0	2	4	
	10–19		0	0	0	1	0	0	2	0	2	3	3	0	11	
	20–29		0	0	0	0	0	1	0	2	0	1	0	0	4	
	30–39		0	0	1	0	1	1	2	0	2	0	0	0	7	
	40–49		0	0	0	0	0	4	0	0	3	0	0	0	7	
	50–79		0	0	0	0	0	0	0	2	2	0	1	0	5	
	Total	0	0	0	1	1	1	6	4	5	10	4	4	2	38	29·8
35,000	0– 9	0	0	1	0	0	0	1	0	0	0	2	0	0	4	
	10–19		0	0	0	0	0	0	1	0	3	2	0	0	6	
	20–29		0	0	1	0	1	0	0	1	0	2	3	0	8	
	30–39		0	0	0	0	1	2	1	0	5	0	0	0	9	
	40–49		0	0	0	0	0	1	2	2	3	0	0	0	8	
	50–69		0	0	0	0	0	0	1	0	2	0	1	0	4	
	Total	0	0	1	1	0	2	4	5	3	13	6	4	0	39	29·8
40,000	0– 9	0	0	0	1	0	0	0	0	0	1	0	0	0	2	
	10–19		0	0	0	0	0	0	0	1	1	1	0	0	3	
	20–29		0	0	0	0	0	0	1	1	2	3	1	0	8	
	30–39		0	0	0	0	1	0	0	0	2	0	0	0	3	
	40–49		0	0	0	0	0	0	0	1	2	0	0	0	3	
	50–59		0	0	0	0	0	0	0	0	2	0	1	0	3	

TABLE IV (*continued*)

Height (ft.)	*Speed* (kt.)	Direction														*Mean Scalar* (kt.)
		Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	
	60–69		0	0	0	0	0	0	0	1	1	0	0	0	2	
	Total	0	0	0	1	0	1	0	1	4	11	4	2	0	24	32·5
50,000	0– 9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	10–19		0	0	0	0	0	0	1	0	1	0	0	0	2	
	20–29		0	0	0	0	0	0	0	1	0	1	0	0	2	
	30–39		0	0	0	0	0	0	0	2	1	1	0	0	4	
	40–49		0	0	0	0	1	0	0	0	2	1	0	0	4	
	50–59		0	0	0	0	0	0	0	1	2	2	1	0	6	
	60–69		0	0	0	0	0	0	1	0	0	1	1	0	3	
	70–169		0	0	0	0	0	0	0	0	2	0	1	0	3	
	Total	0	0	0	0	0	1	0	2	4	8	6	3	0	24	51·0

TABLE V. UPPER WIND FREQUENCIES FOR SPRINGS, 1954–58

Height (ft.)	*Speed* (kt.)	Direction														*Mean Scalar* (kt.)
		Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	
Surface	0– 9	41	6	2	4	3	4	7	8	7	1	1	1	0	85	
	10–19		4	0	0	0	0	0	15	3	3	0	0	0	25	
	20–29		1	0	1	0	0	0	0	0	0	0	1	1	4	
	Total	41	11	2	5	3	4	7	23	10	4	1	2	1	114	5·0
2,000	0– 9	3	7	6	6	2	4	7	7	13	4	2	1	8	70	
	10–19		1	6	0	1	1	2	7	12	2	0	1	0	33	
	20–39		0	3	1	0	0	0	1	0	1	1	0	1	8	
	Total	3	8	15	7	3	5	9	15	25	7	3	2	9	111	9·1
4,000	0– 9	1	6	3	9	7	2	1	4	6	5	3	4	2	53	
	10–19		4	2	2	1	2	1	4	13	0	1	1	1	32	
	20–29		1	4	1	0	1	1	1	9	0	0	1	0	19	
	30–39		1	0	0	0	0	0	0	1	1	1	0	0	4	
	Total	1	12	9	12	8	5	3	9	29	6	5	6	3	108	11·9
6,000	0– 9	0	4	1	9	1	2	0	4	4	3	2	0	2	32	
	10–19		0	6	3	0	0	0	5	4	4	4	3	2	31	
	20–29		1	0	0	0	0	1	0	4	2	3	0	1	12	
	30–39		2	1	0	0	1	0	0	4	2	1	0	0	11	
	40–49		0	0	0	0	0	0	0	1	1	0	0	0	2	
	Total	0	7	8	12	1	3	1	9	17	12	10	3	5	88	15·2
8,000	0– 9	0	1	4	4	0	1	1	1	3	4	2	1	2	24	
	10–19		2	2	4	1	0	1	4	2	4	3	0	2	25	
	20–29		2	1	1	1	0	0	0	3	6	2	3	0	19	
	30–39		1	0	0	0	0	1	0	2	4	3	0	1	12	
	40–49		0	0	0	0	0	0	0	1	1	0	0	0	2	
	Total	0	6	7	9	2	1	3	5	11	19	10	4	5	82	17·6
10,000	0– 9	0	0	1	1	2	2	2	1	2	4	4	0	5	24	
	10–19		2	4	2	2	1	0	2	0	4	2	2	2	23	
	20–29		2	1	0	0	0	0	2	1	3	3	2	2	16	
	30–39		1	0	0	1	0	0	1	5	2	4	0	0	14	
	40–59		0	0	0	0	0	0	1	2	4	0	0	0	7	
	Total	0	5	6	3	5	3	2	7	10	17	13	4	9	84	19·7
12,000	0– 9	0	0	1	0	2	2	2	1	1	2	2	1	0	14	
	10–19		2	3	1	0	1	0	0	1	2	0	2	2	14	
	20–29		2	0	0	0	0	0	1	1	3	1	2	1	11	
	30–39		0	0	0	0	0	0	2	0	6	1	0	0	9	
	40–59		0	0	0	0	0	1	1	4	1	2	0	0	9	
	Total	0	4	4	1	2	3	3	5	7	14	6	5	3	57	21·9

TABLE V (*continued*)

Height (ft.)	*Speed* (kt.)	Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	*Mean Scalar* (kt.)
							Direction									
14,000	0– 9	0	0	0	2	0	2	1	0	1	1	2	0	1	10	
	10–19		1	2	2	1	0	1	1	1	3	0	4	3	19	
	20–29		5	0	0	0	1	0	2	1	6	1	1	1	18	
	30–39		0	0	0	0	0	0	0	0	1	0	0	0	1	
	40–49		0	0	0	1	0	0	2	2	1	1	1	0	8	
	50–59		0	0	0	0	0	0	0	1	1	0	0	0	2	
	Total	0	6	2	4	2	3	2	5	6	13	4	6	5	58	21·8
16,000	0– 9	0	0	0	0	0	1	5	2	0	1	1	0	0	10	
	10–19		2	0	2	0	0	1	0	1	0	3	2	5	16	
	20–29		1	1	2	0	1	1	2	3	5	2	3	5	26	
	30–39		0	0	0	0	0	0	0	0	4	1	1	0	6	
	40–49		0	0	0	1	0	0	0	3	1	1	0	0	6	
	50–59		0	0	0	0	0	1	0	3	1	0	0	0	5	
	60–69		0	0	0	0	0	0	2	0	1	0	0	0	3	
	Total	0	3	1	4	1	2	8	6	10	13	8	6	10	72	25·0
20,000	0– 9	0	0	0	1	0	0	2	0	2	0	1	0	0	6	
	10–19		0	1	1	0	0	0	3	0	0	0	3	3	11	
	20–29		1	0	0	0	1	0	1	1	3	2	0	1	10	
	30–39		1	0	0	0	0	1	0	2	1	1	1	2	9	
	40–49		0	0	0	1	0	0	0	2	1	0	0	0	4	
	50–79		0	0	0	0	0	0	1	1	1	1	0	0	4	
	Total	0	2	1	2	1	1	3	5	8	6	5	4	6	44	27·2
23,000	0– 9	0	1	0	0	0	2	1	0	1	1	1	0	0	7	
	10–19		0	1	1	0	0	1	2	4	1	1	2	3	16	
	20–29		3	0	0	0	0	1	1	2	2	0	1	1	11	
	30–39		0	1	0	1	0	1	0	0	3	2	3	2	13	
	40–49		0	0	0	1	0	0	0	1	1	1	1	0	5	
	50–59		0	0	0	0	0	1	0	3	3	1	1	0	9	
	60–89		0	0	0	0	0	0	1	2	0	0	0	0	3	
	Total	0	4	2	1	2	2	5	4	13	11	6	8	6	64	29·7
27,000	0– 9	0	0	0	0	0	2	1	1	2	1	1	0	1	9	
	10–19		0	0	0	0	0	1	1	1	3	0	1	2	9	
	20–29		2	0	0	0	0	0	0	2	1	1	1	4	11	
	30–39		0	1	0	0	0	0	1	0	3	0	1	0	6	
	40–49		0	0	0	1	0	2	0	0	2	2	0	1	8	
	50–59		0	0	0	1	0	1	0	2	2	2	1	0	9	
	60–69		0	0	0	0	0	0	0	1	2	0	1	0	4	
	70–109		0	0	0	0	0	0	1	1	1	0	0	0	3	
	Total	0	2	1	0	2	2	5	4	9	15	6	5	8	59	34·3
30,000	0– 9	0	0	0	0	0	2	1	0	3	2	0	0	0	8	
	10–19		0	0	0	0	0	0	0	0	2	2	0	1	5	
	20–29		1	0	0	0	0	0	1	3	0	0	2	3	10	
	30–39		0	0	0	0	0	0	0	0	1	1	1	2	5	
	40–49		0	0	0	0	0	2	1	0	2	2	0	1	8	
	50–59		0	0	0	0	0	1	0	1	4	1	0	0	7	
	60–69		0	0	0	0	0	0	0	0	0	0	1	0	1	
	70–79		0	0	0	0	0	0	0	2	1	0	1	0	4	
	80–119		0	0	0	0	0	0	1	0	0	0	0	0	1	
	Total	0	1	0	0	0	2	4	3	9	12	6	5	7	49	35·6
35,000	0– 9	0	0	0	0	0	0	2	0	1	0	0	0	0	3	
	10–19		0	0	0	0	0	0	1	2	3	1	3	0	10	
	20–29		0	0	1	0	0	1	1	0	2	0	2	1	8	
	30–39		0	0	0	0	0	0	0	1	0	1	2	1	5	
	40–49		0	0	0	0	0	0	1	2	0	2	0	1	6	
	50–59		0	0	0	0	0	0	0	0	3	0	0	0	3	
	60–69		0	0	0	0	0	0	0	1	4	0	1	0	6	
	70–99		0	0	0	0	0	0	1	1	0	0	1	0	3	
	Total	0	0	0	1	0	0	3	4	8	12	4	9	3	44	37·1

TABLE V (*continued*)

Height (ft.)	*Speed* (kt.)	*Direction* Calm	36	03	06	09	12	15	18	21	24	27	30	33	Total	*Mean Scalar* (kt.)
40,000	0– 9	0	0	0	0	0	0	1	0	0	0	0	0	0	1	
	10–19		0	0	0	0	0	0	1	1	2	0	1	0	5	
	20–29		0	0	0	0	0	0	1	1	2	0	2	0	6	
	30–39		0	0	0	0	0	0	0	2	1	2	0	0	5	
	40–49		0	0	0	0	0	0	0	1	0	1	1	2	5	
	50–59		0	0	0	0	0	0	0	0	3	0	0	1	4	
	60–89		0	0	0	0	0	0	1	2	1	0	0	0	4	
	Total	0	0	0	0	0	0	1	3	7	9	3	4	3	30	38·1
50,000	0– 9	0	0	0	1	0	0	0	0	0	0	0	0	0	1	
	10–19		0	0	0	0	0	0	0	0	1	0	1	0	2	
	20–29		0	0	0	0	0	0	0	0	5	0	1	0	6	
	30–39		0	0	0	0	0	0	0	1	3	2	2	0	8	
	40–49		0	0	0	0	0	0	0	0	1	1	0	0	2	
	50–59		0	0	0	0	0	0	0	1	2	0	2	0	5	
	60–69		0	0	0	0	0	0	0	0	0	0	1	0	1	
	70–79		0	0	0	0	0	0	0	0	2	0	1	0	3	
	80–89		0	0	0	0	0	0	0	2	1	0	0	0	3	
	90–119		0	0	0	0	0	0	0	0	0	0	2	0	2	
	Total	0	0	0	1	0	0	0	0	4	15	3	10	0	33	47·8
60,000	0– 9	0	0	0	0	0	0	0	0	0	0	0	0	1	1	
	10–29		0	0	0	0	0	0	0	0	0	0	0	0	0	
	30–39		0	0	0	0	0	0	0	0	1	2	0	0	3	
	40–49		0	0	0	0	0	0	0	0	3	0	0	0	3	
	50–59		0	0	0	0	0	0	0	0	0	1	1	0	2	
	60–69		0	0	0	0	0	0	0	0	2	0	0	0	2	
	70–79		0	0	0	0	0	0	0	0	0	0	0	0	0	
	80–89		0	0	0	0	0	0	0	0	0	0	2	0	2	
	90–99		0	0	0	0	0	0	0	0	2	0	0	0	2	
	Total	0	0	0	0	0	0	0	0	0	8	3	3	1	15	56·1

frequencies of direction in twelve 30° sectors and frequencies of speed at the specified knot intervals; mean scalar speed is also given. The frequency tables are for the following heights: surface, 2, 4, 6, 8, 10, 12, 14, 16, 20, 23, 27, 30, 35, 40, 50, 60, 70, 80×10^3 ft.* The frequencies are not expressed per mille but as the actual number of observations. Similar tables are given by Van Rooy (1957) for the period December 1951 to February 1956 at five pressure levels for summer and winter seasons, but these cover less than 200 observations and give frequencies of speed intervals at only two of the levels. The *Falkland Islands and Dependencies Meteorological Service Annual Meteorological Tables*, 1954 to 1958, give frequency tables of the radio-sonde flights for the five years under discussion and only annual frequencies were published in 1957 and 1958.

DISCUSSION

1. *Frequencies of wind speed*

Fig. 1 shows histograms of wind-speed frequency for all the years combined. Up to 8,000 ft. most observations are in the first decile (0–9 kt.) and there are no observations of speeds above 49 kt. Between 10,000 and 16,000 ft. most observations occur in the 10–19 and 20–29 kt. groups, while in the layer from 10,000 ft. to the tropopause (30,960 ft.) there is an almost equal frequency in the 30–39 kt. group. Observations of speeds up to 80 kt. occur below 20,000 ft. and to 100+ kt. at 23,000, 27,000 and 30,000 ft. Above the latter height the frequency distribution becomes rather widespread and while most observations are found between 10 and 29 kt. there remain a considerable number at the higher speeds.

Similar diagrams for the four seasons are given in Fig. 2. In all seasons most observations

* All of the observations reported in this paper were made in English units and they have not been converted into metric units which are now generally used.

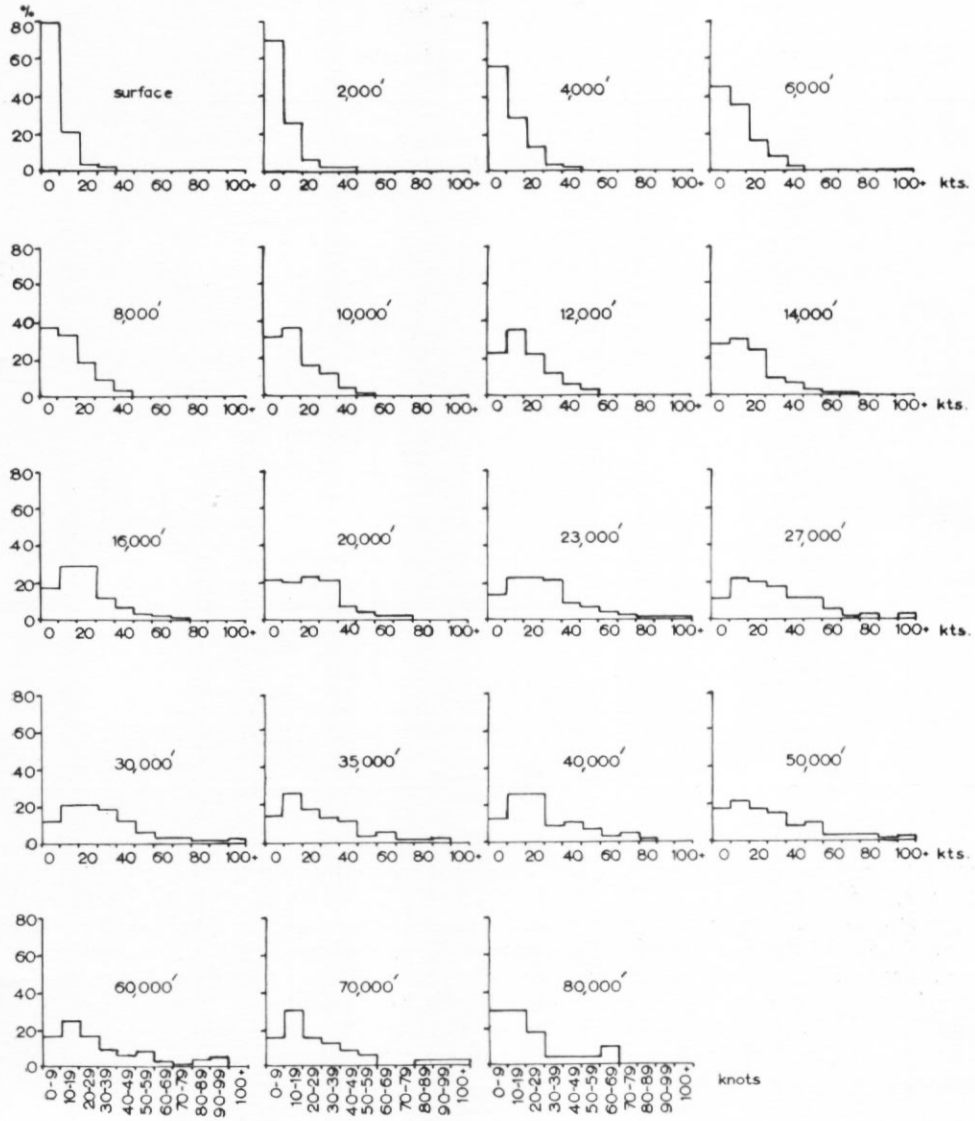

Fig. 1. Annual percentage frequency of wind speeds.

are below 10 kt. in the first 4,000 ft. but above this height the seasons differ. The majority of the wind speeds in summer remain below 20 kt. up to 16,000 ft., whereas in the other seasons stronger winds occur. Maximum frequencies are in the 10–30 kt. range in autumn and winter, while in spring this pattern does not appear until 14,000 ft. Between 20,000 and 30,000 ft. all seasons show that most winds are between 10 and 40 kt. with the higher speeds appearing in autumn and spring. Above 30,000 ft. the summer pattern of fairly light winds is again at variance with the remaining seasons which have most observations in the stronger speed groups as height increases.

A comparison of the seasonal and annual histograms shows in general that the lighter winds are a result of the summer observations while the stronger winds are, in the main,

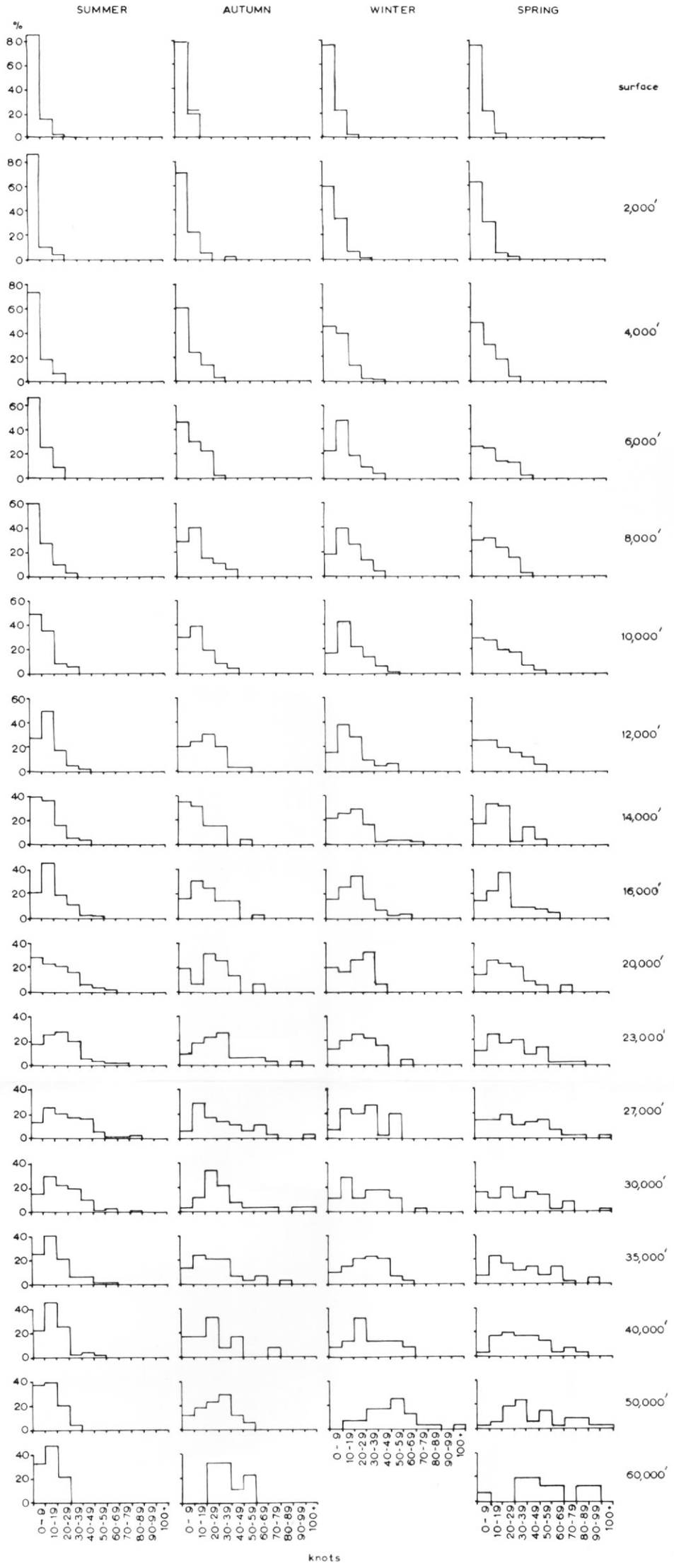

Fig. 2. Seasonal percentage frequency of wind speeds.

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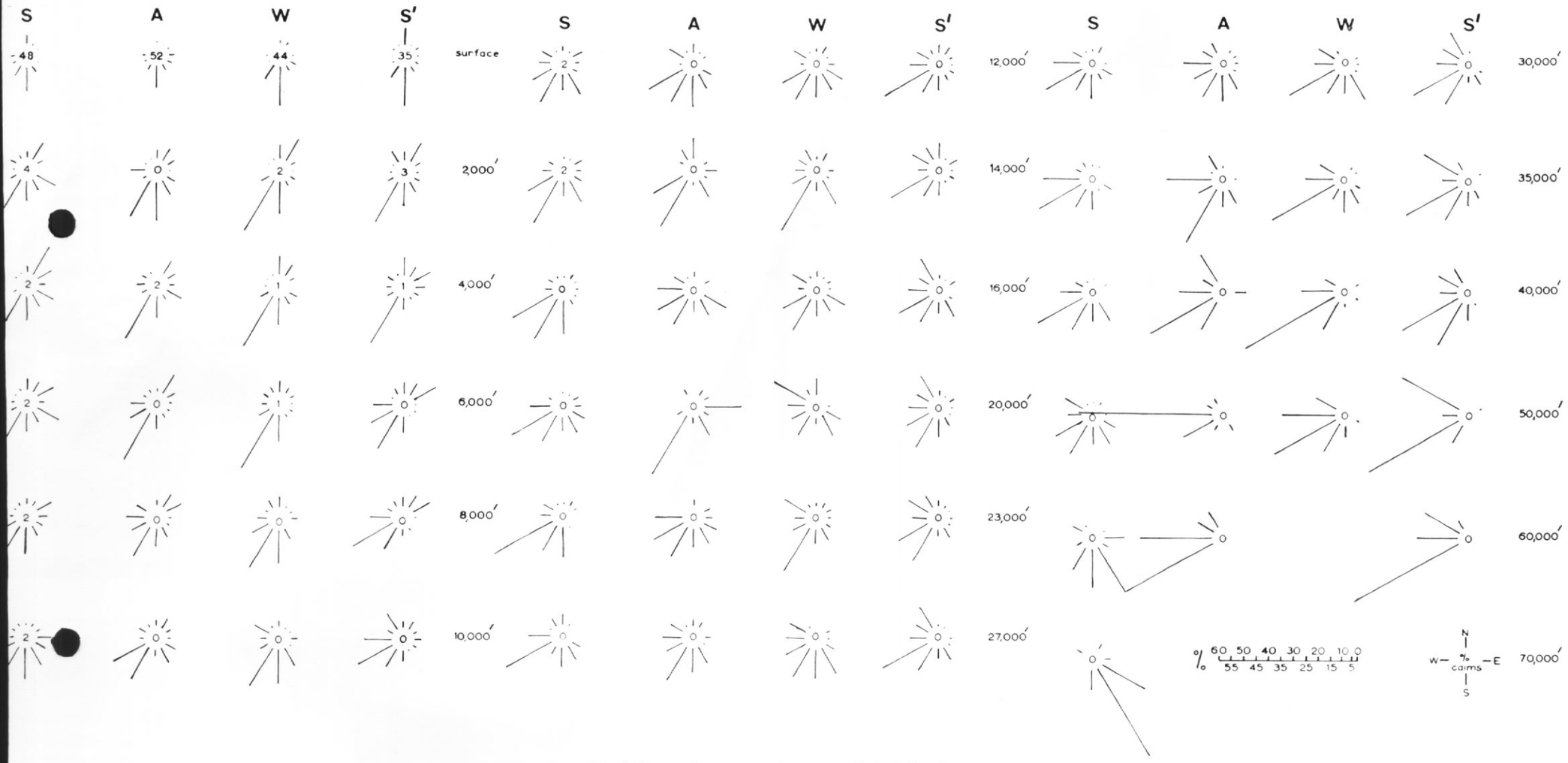

Fig. 5. Seasonal percentage frequency of wind direction.

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due to the autumn and winter observations. Highest wind speeds are reported at 27,000 and 30,000 ft. in summer, autumn and spring, but at 50,000 ft. in winter.

If one considers the speed ranges in which various percentages of the speed observations appear, a better idea is obtained of the importance of higher speeds in winter and spring. Fig. 3 shows the speed intervals in which the lowest 25, 50 and 75 per cent of the observations

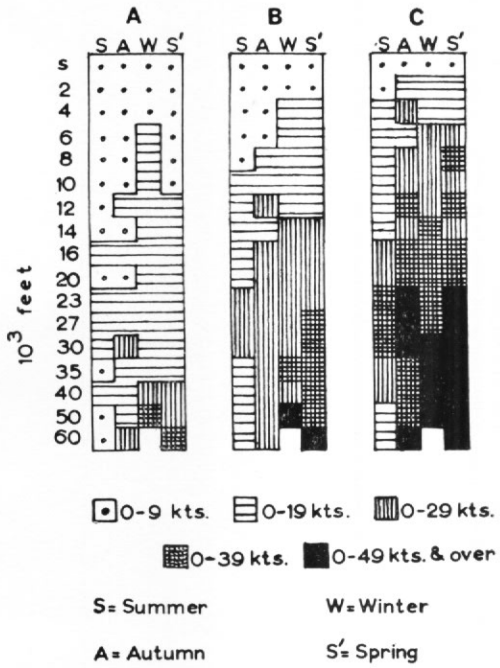

Fig. 3. Vertical cross-section of the various percentages of wind speeds.

occur. In all seasons except winter the first 25 per cent (Fig. 3A) are in the 0–9 kt. group up to 10,000 ft. and at most other heights they are in the 0–19 kt. group. Above 35,000 ft. greater wind speeds occur in winter and spring, while in summer the 0–9 kt. group re-appears. The first 50 per cent of the observations (Fig. 3B) are naturally in higher speed groups. The 0–29 kt. group appears at 14,000 ft. in winter and spring and at 16,000 ft. in autumn, but it is only found at 23,000 to 30,000 ft. in summer. Higher speeds occur near the tropopause level especially in spring and continue above this height. Fig. 3C shows the first 75 per cent of the observations. The main points of interest are the relatively low speeds in summer at all heights and the higher speeds during the rest of the year, particularly in spring. Again, the area just below the tropopause has the greatest speed groups except in winter when they tend to be above the tropopause.

2. *Frequencies of wind direction*

Wind roses giving the annual percentage frequency of wind direction in the twelve sectors are shown in Fig. 4. The number of calms is negligible above the surface and none are reported above 23,000 ft. At the surface there are two major directions—north and south; above they veer to south-west and less markedly to north-east. The latter tends to disappear around 8,000 ft. and at higher levels most winds come from the south-west. Between 12,000 and 60,000 ft. there is a secondary maximum in the north-west sector, but both of these directions are replaced by south-east and east winds at 70,000+ ft.

In Fig. 5 wind roses are presented for the seasons. They show a substantial difference in the directions recorded in each season. South-west is the major direction in all seasons

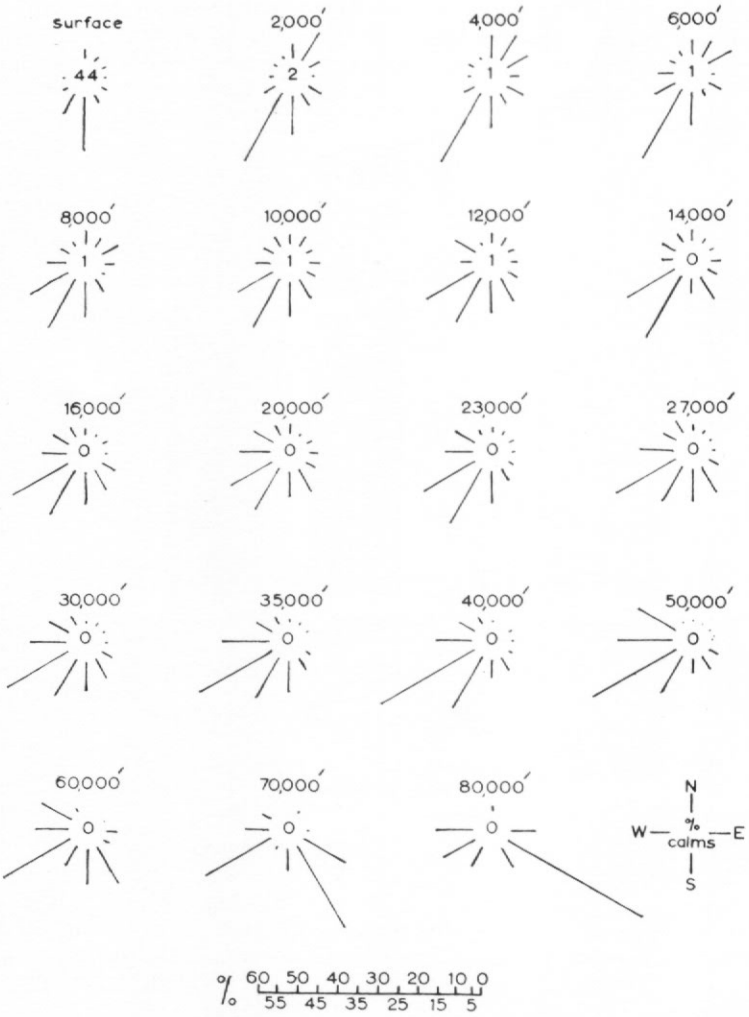

Fig. 4. Annual percentage frequency of wind direction.

between 2,000 and 40,000 ft. with a secondary direction of north-east up to 8,000 ft. However, from 12,000 to 40,000 ft. the secondary direction is south-east or south in summer and autumn, but north-west or north in winter and spring. Above 40,000 ft. south-east is most common in summer, but west and south-west in the other seasons. It is interesting to note the difference between the wind roses in autumn and winter at 20,000 and 30,000 ft. Whereas in autumn the major direction changes from south-west to west and south, in winter the main north-west direction is replaced by south-west. During spring there is a marked increase in the importance of northerly winds at and above 16,000 ft.

A vertical cross-section of directions with isopleths of percentage of observations is given in Fig. 6 (calms are excluded). In all seasons the 20 per cent isopleth is in the 210° and 240° sectors up to 40,000 ft. Above this height it backs to south-east (120° to 180° sectors) in summer, but veers to the west (240° and 270° sectors) in the other seasons. However, it is not continuous, showing that at some heights these directions are not so frequent as expected. In summer the 20 per cent isopleth appears between 14,000 and 40,000 ft. with an "outlier" at 2,000 ft. and is continuous again above 50,000 ft. It forms a series of small "hills" in autumn.

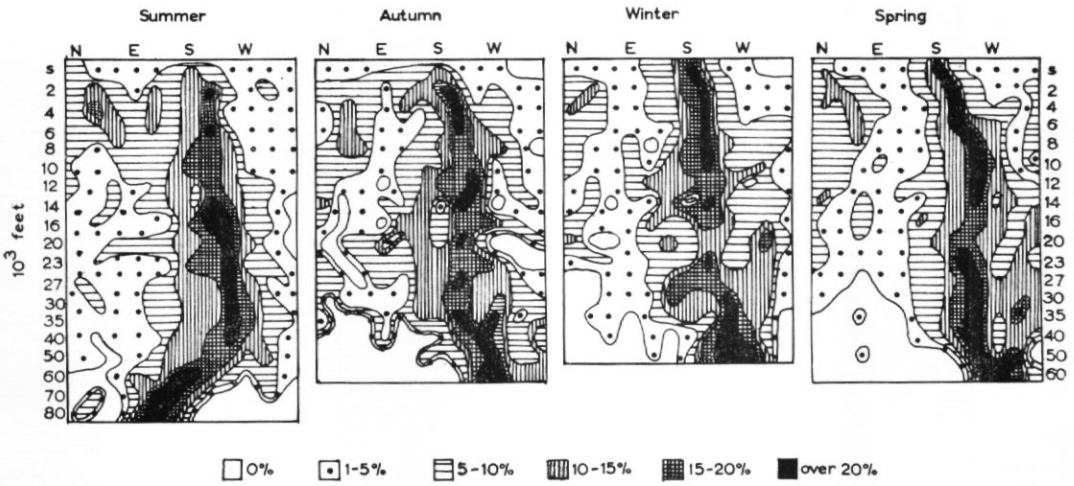

Fig. 6. Vertical cross-section of percentage frequencies of wind direction.

In winter it stretches from the surface to 10,000 ft. and, apart from outliers at 14,000 and 23,000 ft., re-appears at 30,000 ft. Finally, in spring it is interrupted only at 16,000 and 20,000 ft.

The 5 per cent isopleth shows the less favoured directions. In all seasons these are:

i. 240° to 330° up to 4,000 ft. in winter and spring, and up to 10,000 ft. in summer and autumn;
ii. 330° to 120° at all heights in winter and spring, above 4,000 ft. in autumn and above 10,000 ft. in summer.

The 360° and 030° sectors have an increased frequency at all seasons up to about 8,000 ft. and this is marked by the appearance of the closed 10 per cent isopleth in this part of the diagram. It is most marked in summer and autumn when it extends eastwards to include the 060° and 090° sectors.

3. *Considerations of frequencies of combined speed and direction*

Rosini (1948) has pointed out that because the wind is a vector it is a difficult element to portray without splitting it into the separate scalar components of direction and speed. One way of combining speed and direction is by using the normal frequency surface. Brooks and Carruthers (1953) have explained how frequencies can be represented in three dimensions by a stereogram. In the case of winds, such a stereogram would consist of a series of concentric circles (representing speeds) divided into sectors (representing directions) thus forming a series of cells. On these cells columns can be erected, the heights of which show the number of observations for each speed group in each sector. A histogram becomes a frequency curve by increasing the total number of observations and decreasing the frequency steps. Similarly, a stereogram becomes a frequency surface. The isopleths or contours of a frequency surface show frequency per unit area which can be termed "frequency density". Frequency density is obtained by finding the areas in sq. kt. of the sectors using the formula

$$\pi r^2 \alpha / 360,$$

where α is the number of degrees in each sector and r is the radius of each concentric circle in knots. A factor is obtained by dividing the unit area (chosen arbitrarily) by the areas of the other sectors and this is used to multiply the frequency in each sector to give the density per unit area.

Annual frequency surfaces for the various heights are given in Fig. 7. In all cases calms have been distributed equally between all sectors in the 0–9 kt. speed group. The number of

observations and the vector mean wind are included. The diagrams show that from the surface to 6,000 ft. winds are most frequent from the south and south-west, but the isopleths form a narrow irregular ellipse from south-west to north-east, suggesting that the latter direction is equally important at least up to 20 kt. The contours become more circular at 8,000 and 10,000 ft. thus showing a more normal distribution, although south-west is still favoured. Between 12,000 and 40,000 ft. the patterns become more complicated and less circular. There are sometimes two or more areas of high frequency which show a combination of two frequency distributions. Up to 23,000 ft. these high frequencies are between north-west to south-west and east to south-east in the 0–10 kt. range. The areas of high frequency at 30,000 and 40,000 ft. have backed to south-west and north-east and increased slightly in speed. As height increases they back even more until at 80,000 ft. the higher frequency is south-east at 10–19 kt.

Similar diagrams were drawn for each of the four seasons and a selection of these is shown in Fig. 8. At 2,000 ft. there are two cells of high frequency in all seasons except winter when they are replaced by a narrow ellipse. In summer and winter the main winds are 210° and 030° with speeds up to 9 kt. while in autumn and spring the speed remains the same, but the directions back slightly to 180° and 360°. At 10,000 ft. the seasonal patterns have changed. Again, winter differs from the other seasons in that the winds tend to be stronger and from north-west and south, whereas in the other seasons the winds are lighter and from roughly the same directions as at 2,000 ft. Frequency densities in summer are much higher than in the other seasons, although the number of observations is similar in winter and almost the same as in spring. This means that winds are more persistent in both speed and direction in summer compared with the other seasons. At 16,000 ft. winds are most persistent in spring (150°, 0–9 kt.) and least persistent in autumn. During the winter winds are easterly of 0–9 kt., while in summer they are south to south-west and stronger (10–19 kt.). The 23,000 ft. diagrams show a similarity between summer and autumn, the former having stronger south-west winds. In winter, winds are most persistent from 300° at 0–9 kt., while in spring they are from 120° at 0–9 kt. The mean height of the tropopause is near 30,000 ft. and at this level frequency densities are lowest in autumn. Of the other seasons, summer has greatest frequency in the 240°, 10–19 kt. segment, winter in the 330°, 0–9 kt. segment, and spring in the 210°, 0–9 kt. segment. Comparatively large frequencies at the greater speeds are found in winter (150°, 40–49 kt.) and spring (240°, 50–59 kt.). Finally, at 50,000 ft. only summer has any considerable frequency density and this is at low speeds and is fairly circular in form. During the rest of the year greatest frequencies can be said to be south-west and west at 20–40 kt.

Conclusions

This paper attempts to amplify the results obtained in an earlier one (Giles, 1963). Mean winds and their associated statistics can only give a limited picture because the extent of deviations is omitted. A consideration of frequencies shows the directions and speeds of winds.

The seasonal frequencies of wind indicate a general similarity on the one hand between summer and autumn and, on the other, between winter and spring. The decrease in the importance of easterly and south-easterly winds up to 10,000 ft. from summer, through autumn and winter to spring is complemented by an increase in speed from the other directions, particularly south and south-west. Similarly, above 20,000 ft. there is an increase in wind speeds and the direction veers to west and north-west.

The isopleths of frequency density are an efficient measure of the persistence of the wind both in direction and speed. The higher the frequency density, the more persistent the winds and, conversely, the lower densities show that these winds do not occur very often. The general decrease in the value of the isopleths as height increases shows that the winds have a more normal distribution. However, at no level do the results indicate a true circular distribution; to do so the isopleths would be concentric circles centred on the vector mean wind. When the annual diagrams are considered the vector mean wind lies inside the largest isopleth at all levels except the surface, 16,000, 20,000, 27,000, 30,000 and 60,000+ ft. In the seasonal diagrams (up to 50,000 ft.) the vector mean wind is enclosed by the largest isopleth at six levels in summer (8, 10, 12, 16, 23 and 50×10^3 ft.), nine levels in autumn

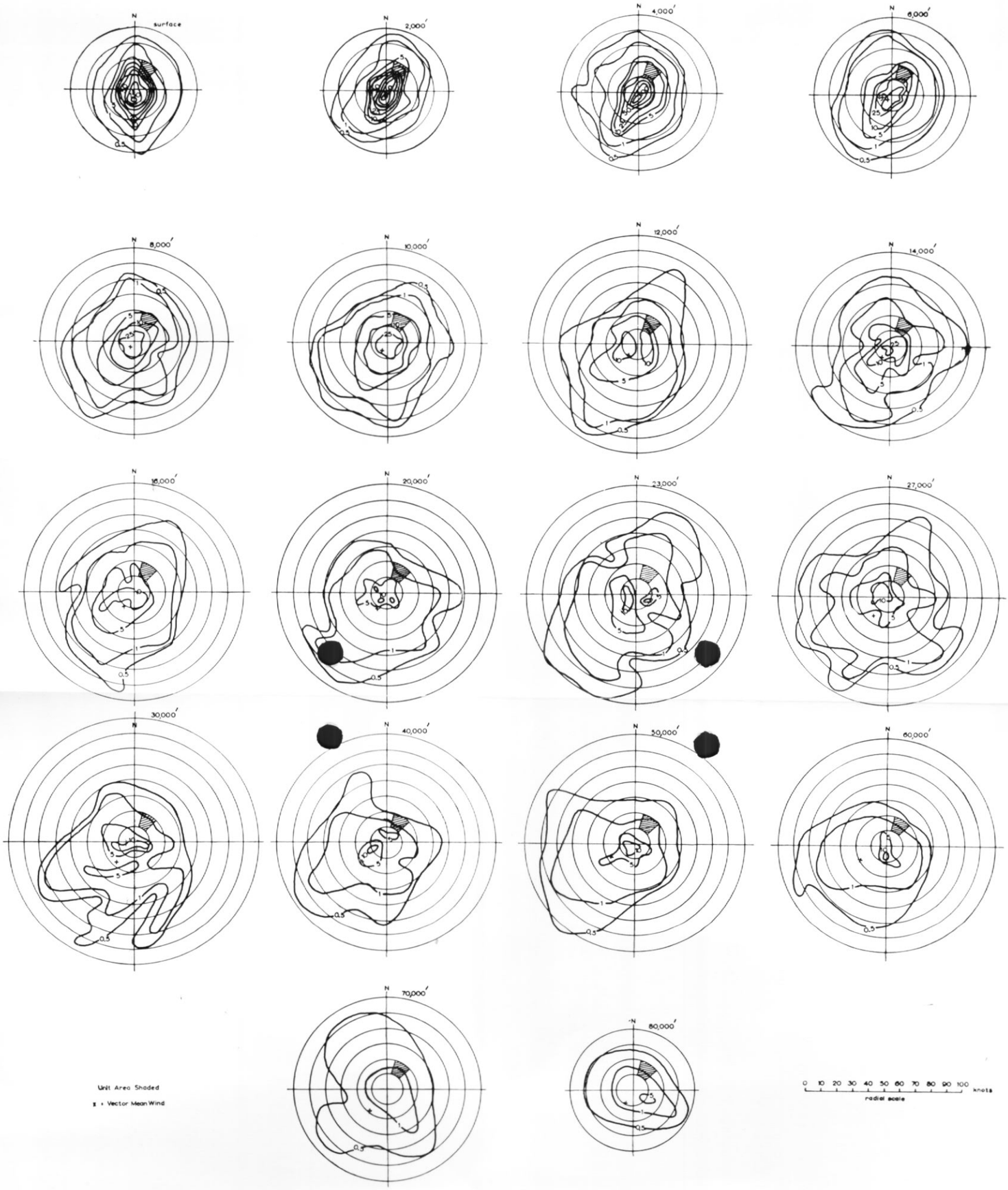

Fig. 7. Annual frequency surfaces.

[face page 54]

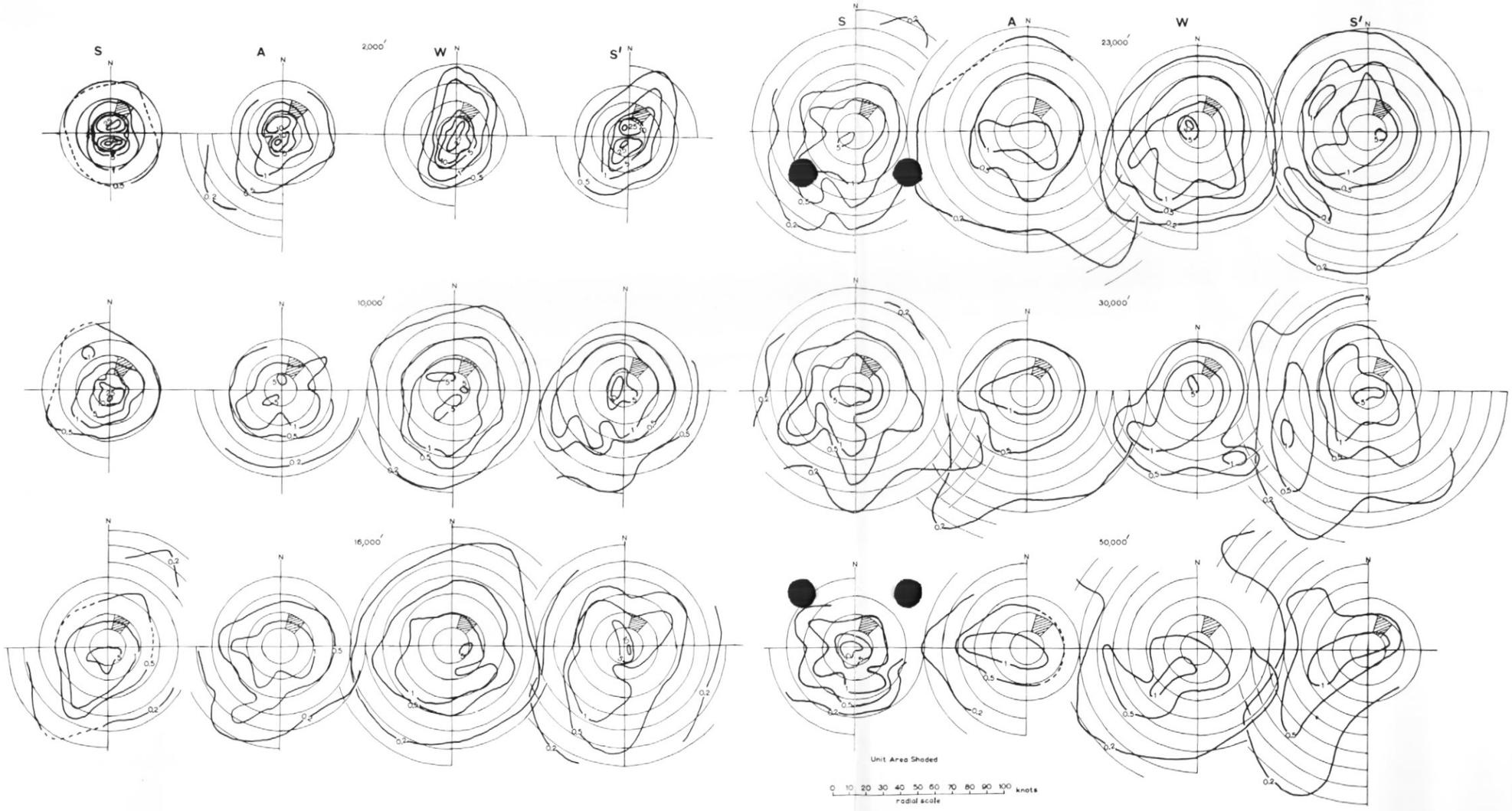

Fig. 8. Seasonal frequency surfaces.

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(surface, 4, 6, 10, 12, 14, 16, 20 and 50×10^3 ft.), six levels in winter (surface, 2, 4, 8, 10 and 40×10^3 ft.), and only four levels in spring (surface, 8, 10 and 40×10^3 ft.).

MS. received 24 April 1964

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