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Bermuda Meteorological Office

Technical Note No. 6

The Humidity of the Air in Bermuda

By

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CONTENTS

1. INTRODUCTION

Of all the elements which enter into climate, humidity is probably the most important in its effect on human comfort although its influences on our senses depends on the temperature and wind.

There would be general agreement that Humidity refers to moisture in the air but there is often misunderstanding of the terms used to describe the state of humidity as it is a rather complicated subject. The air is a mixture of gases one of which is water vapour, and in considering humidity we are concerned only with this vapour present as an integral part of the air mixture and not with the other water which is sometimes present as liquid or solid in the form of rain, hail or snow.

Of all the constituents of the air at the earth's surface water vapour is the only one whose amount shows appreciable variations from day to day and even hour to hour at a given place. In Bermuda the highest water vapour content on record is about 8 times the smallest. In the British Isles there is a range of about 20 times between the highest and lowest while in the centre of some of the continents where very low temperatures occur in winter the corresponding water content is so low that the summer values are several hundred times as great.

It is the purpose of this paper to summarise the humidity data which has been recorded since the official meteorological service was opened in 1932.

2. MODES OF EXPRESSING HUMIDITY

There is not, unfortunately, one single mode of expressing humidity which meets all needs and the data in this paper is presented in the 5 most usual forms. These are 1. Relative Humidity, 2. Wet Bulb Temperature, 3. Vapour Pressure 4. Dew Point and 5. Moisture Content.

The pressure of the air is made up of the sum of the separate pressures exerted by the various gases and the water vapour exerts its share which in Bermuda is usually from 1-3% of the total. This is called the vapour pressure and is measured in the same units as the pressure.

At any temperature there is a maximum amount of water vapour which the air can contain and this amount increases with temperature. Thus in a room ten feet in each dimension there can be a maximum of approximately half pound of water vapour at 45° F., one pound at 70° F., and two pounds at 85° F. The air can contain any smaller amounts than these and the comparison of the actual amount to the maximum which could be contained at the temperature is known as the Relative Humidity. This is usually expressed as a percentage. Thus if the air in the room contains one-half pound of water vapour its relative Humidity would be 100% at 45° F, 50% at 70° F., and 25% at 85° F. When the air contains the maximum possible and the Relative Humidity is 100% it is said to be saturated.

If we now consider our room containing one pound of water vapour at 85° F., the Relative Humidity will be 50%. If the air is cooled the Relative

Humidity will increase until when 70° F. is reached the air will contain the maximum possible for the temperature and the Relative Humidity will be 100%. If the air is cooled any more there will be more water vapour than the air can contain and consequently some of it will condense on the walls. The temperature at which this occurs, 70° F., is called the Dew Point of the air.

The Moisture Content is the actual mass of water vapour present in a specified volume of air. In this paper the value is given in grams per cubic metre, a figure which owing to the relation between metric and English units is also, to a close approximation, the value in ounces per 1,000 cubic feet.

3. THE METHOD OF MEASURING HUMIDITY

The usual method of measuring humidity depends on the well known fact that a wet body is cooled as the water evaporates. This cooling occurs because a definite amount of heat is needed to convert any mass of water into vapour and when water evaporates it absorbs the necessary heat from its immediate surroundings. The rate at which water evaporates depends on the degree of saturation of the air, the drier the air the more rapid the rate of evaporation and consequently the greater the cooling effect

The rate of cooling is determined by taking two identical thermometers and fitting a muslin sleeve round the bulb of one with a wick leading to a water reservoir. As soon as the cloth is wetted the recorded temperature begins to fall until after a few minutes it reaches a steady value at which the heat being absorbed from the bulb by the water is replaced by conduction from the rest of the thermometer which in turn is obtaining heat from the air. This steady temperature is known as the Wet Bulb temperature and the difference between the wet bulb and the similar thermometer without a wet sheath is the depression of the wet bulb.

For many purposes the wet bulb temperature is an adequate measure of the humidity and it has the great advantage of being read directly from the instrument whereas some calculation is necessary to derive the humidity in the other forms. Tables are available which were drawn up as a result of a large number of experiments in which the actual mass of water vapour was determined by weighing and the simultaneous readings of dry and wet bulb were observed. Hence the Relative Humidity, Vapour Pressure, Dew Point and Moisture Content may be deduced from the tables when the values of dry and wet bulb temperatures are known.

The tables used in Bermuda are the standard ones of the British Meteorological Service.

4. HOW HUMIDITY AFFECTS OUR SENSES

Mankind is conscious of humidity because the amount of water vapour in the air has a great effect on the loss of heat from the body. Even when we lie still the body mechanism generates a certain amount of heat, and the amount of heat generated increases rapidly with strenuous activity. This must be dissipated if the body temperature is to remain steady.

The mechanism by which this heat loss is achieved is complicated but the main processes are direct radiation and conduction to the air from the skin and loss by evaporation of water in the lungs and from the skin. When activity is high the loss by evaporation is much the most important process. Even when a normal person is lying at rest a quart of water is evaporated daily, partly in the lungs but the larger part by insensible perspiration from the skin. When the

rate of activity is increased and more heat has to be dissipated the sweat glands function and more water is spread on the skin. The amount evaporated can be ten times as great as under conditions of rest.

When the Relative Humidity is low, this moisture evaporates from the skin as rapidly as it comes through the pores, thus removing heat from the skin and the body temperature is controlled. Under these conditions the skin temperature can be 4° or 5° cooler than the interior of the body. If, however, the air is saturated the water cannot evaporate and accumulates on the skin giving the characteristic feeling of discomfort and as heat is not lost the body temperature will rise. Even when the air is not saturated the layer of air next to the skin can become quickly saturated if we remain still and evaporation will stop with resultant discomfort. If then the air layer next to the skin is continually changed by a fan or moving through the air, evaporation can continue and we are comfortable again.

In all cases it is the degree of saturation of the air which primarily determines the rate of evaporation and hence the Relative Humidity is the index which is most significant.

In summer when temperatures are around 80°F. we prefer a low Relative Humidity because it enables heat to be lost readily but in the coldest days of winter when the temperature is 50°F. we wish to conserve body heat and in these conditions a low humidity makes the cold feel more intense and we are more comfortable with a higher humidity which reduces evaporation.

5. OBSERVATION SITES

The data which is discussed in this paper was taken mainly at two sites, Fort George and Hamilton, but reference is made also to Belmont, Darrell's Island and Prospect.

The Fort George site was the main meteorological office from 1932 to 1941 and the instrument enclosure is on the South West slope of Fort George hill with the thermometers at an altitude of 169 feet above M.S.L. The instrument enclosure was originally surrounded by cedar trees which were kept cut to about 8 feet in height and provided considerable protection. These trees were infested by insects in the war years but little effect was noticed up to the end of 1947. However, defoliation proceeded at an increasing rate in 1948, most trees died early in 1949 and the entire plantation was dead by 1950. The exposure thus became more open during this time and this may be the reason why the lowest monthly means since 1932 have almost all been recorded in 1949, 1950 and 1951.

Observations were made at 8 a.m., 3 p.m. and 8 p.m. until 1st January, 1937, since when the times have been 8 a.m., 2 p.m. and 8 p.m. A hair hygrometer was in use for much of the time and from its records corrections have been deducted to give the 24 hour means from the three daily observations. Bermuda standard time is approximately 19 minutes fast on local mean time.

The Hamilton site is on the roof of the former Hamilton Hotel in which the meteorological office is now housed. The thermometer screen is mounted on a plat form which is freely exposed above the ridges of the roof and the thermometers are 92 feet above ground level and 131 feet above M.S.L. Hourly observationhave been made here since August, 1947 except for a few periods when the office was closed for several hours at night. On these occasions the hourly values were deduced from a mercury in steel recording hygrograph with bulbs in another screen on the roof platform.

The Belmont observations were taken in the grounds of the Belmont Manor Hotel in Warwick. The thermometer screen was on open ground 100 yards

South of the hotel, to the East side of the main entrance drive where the land had a small slope to the South West. The site was slightly below the hill crest and protected from the North, North East and East, by hotel buildings, one of which, Manor Cottage housed the meteorological office during the 3-year period September, 1941 to August, 1944. Observations were made at three hourly intervals.

The Darrell's Island site was on a small peninsula at the South East point of the Island. The thermometers were approximately 15 feet above M.S.L. and little more than 50 feet from the water in most directions. Observations were taken hourly during the 20 months the site was in use.

6. ANNUAL MEAN HUMIDITY

Table 1 gives the annual mean humidities at Fort George over the period and the highest and lowest annual means observed. Comparison with values for the United Kingdom shows that the annual mean Relative Humidity of 76.9% in Bermuda is slightly less than that in Great Britain where typical averages are:— London 79.2%, Glasgow 80.5% and Falmouth 82.5%. The absolute water vapour content in Bermuda of 14 ounces per 1,000 cubic feet is, however, almost twice as great as in Britain. At London at Kew Observatory, the mean vapour

		Average	Highest 1936	Lowest 1952
Relative Humidity	Percentage	76.9	79.7	71.9
Dew Point	Degree Fahrenheit	62.8	63.8	61.2
Vapour Pressure	Millibar	19.6	20.3	18.5
Wet Bulb	Degree Fahrenheit	65.8	66.3	65.0
Moisture Content	Ounces/1000 cu. ft.	14.4	15.1	13.6

TABLE 1. Annual Mean Humidities. Fort George.

pressure is only 9.9 millibars and moisture content 7.4 ounces per 1,000 cubic feet while the mean Dew Point of 43.5°F. is nearly 20° F. below that in Bermuda. These differences reflect the inadequacy of Relative Humidity alone as an index of humidity because of its dependence on the temperature. The mean temperature is about 20° F. higher in Bermuda than in London and consequently the much higher water content in Bermuda gives much the same Relative Humidity as in London.

At Washington, D.C., with a continental climate the mean Relative Humidity of 65.9% is less than in Bermuda while the mean Dew Point is very close to that in London being 19°F. lower than in Bermuda.

7. MONTHLY MEAN RELATIVE HUMIDITY

The Mean Relative Humidity each month at Fort George is given in Table 2. The table gives the means at the 3 hours of observation, 8 a.m., 2 p.m. and 8 p.m. and the mean for 24 hours as determined from these three and the diurnal variation.

The Relative Humidity is lowest in February with 72.6% and highest in June with 81.8%. The minimum is not sharply marked and from November to March the average values are not very different from that in February. The summer maximum, however, is quite sharp with a steep rise through April and May to the June maximum followed by a slower fall through July to November..

	Average at			Monthly 24 Hour Mean				
	08	14	20	Average	Highest		Lowest	
January	77.4	69.6	77.1	75.4	82.0	1947	67.7	1953
February	74.5	67.1	75.2	72.6	78.4	1936	65.8	1952
March	75.5	67.9	77.4	74.5	79.6	1934	64.3	1951
April	76.9	68.2	79.9	76.5	83.7	1934	71.3	1950
May	79.2	71.8	84.0	79.9	83.7	1937	73.2	1952
June	81.4	74.2	85.7	81.8	86.9	1936 1944	77.0	1939
July	78.5	70.6	83.7	79.7	84.2	1946	72.8	1950
August	78.0	69.0	82.1	78.4	85.9	1935	72.7	1952
September	78.2	70.9	81.8	78.3	82.0	1935	72.4	1952
October	77.9	71.3	79.7	77.0	82.4	1943	72.6	1949
November	75.0	68.9	76.6	74.3	81.3	1935	63.7	1952
December	75.0	69.3	76.0	73.7	78.7	1944	64.1	1952
Year	77.3	69.9	79.9	76.9	79.7	1936	71.9	1952

TABLE 2. Monthly Mean Relative Humidities. Fort George

Figure 1 gives the monthly mean values of Relative Humidity, Wet Bulb temperature, Dew Point and Moisture content for Fort George and also the mean Air Temperature for the same period. The Relative Humidity is discussed here and the other modes in later sections.

It will be noticed that the lowest Relative Humidities occur at the season of lowest temperatures but the highest Relative Humidities come in June, whereas highest temperatures are in August.

There is considerable variation in a given month from year to year, with the smallest range of 9.6% from 82.0% to 72.4% in September and the greatest of 17.6% from 81.3% to 63.7% in November.

No month from April to October has ever had an average under 70% and all months except February, March and December have had averages over 80%.

The lowest monthly mean of 63.7% was in November, 1952 and June had the highest mean of 86.9% in both 1936 and 1944. The lowest mean in June of 77.0% is appreciably higher than the lowest in any other month. It is to be

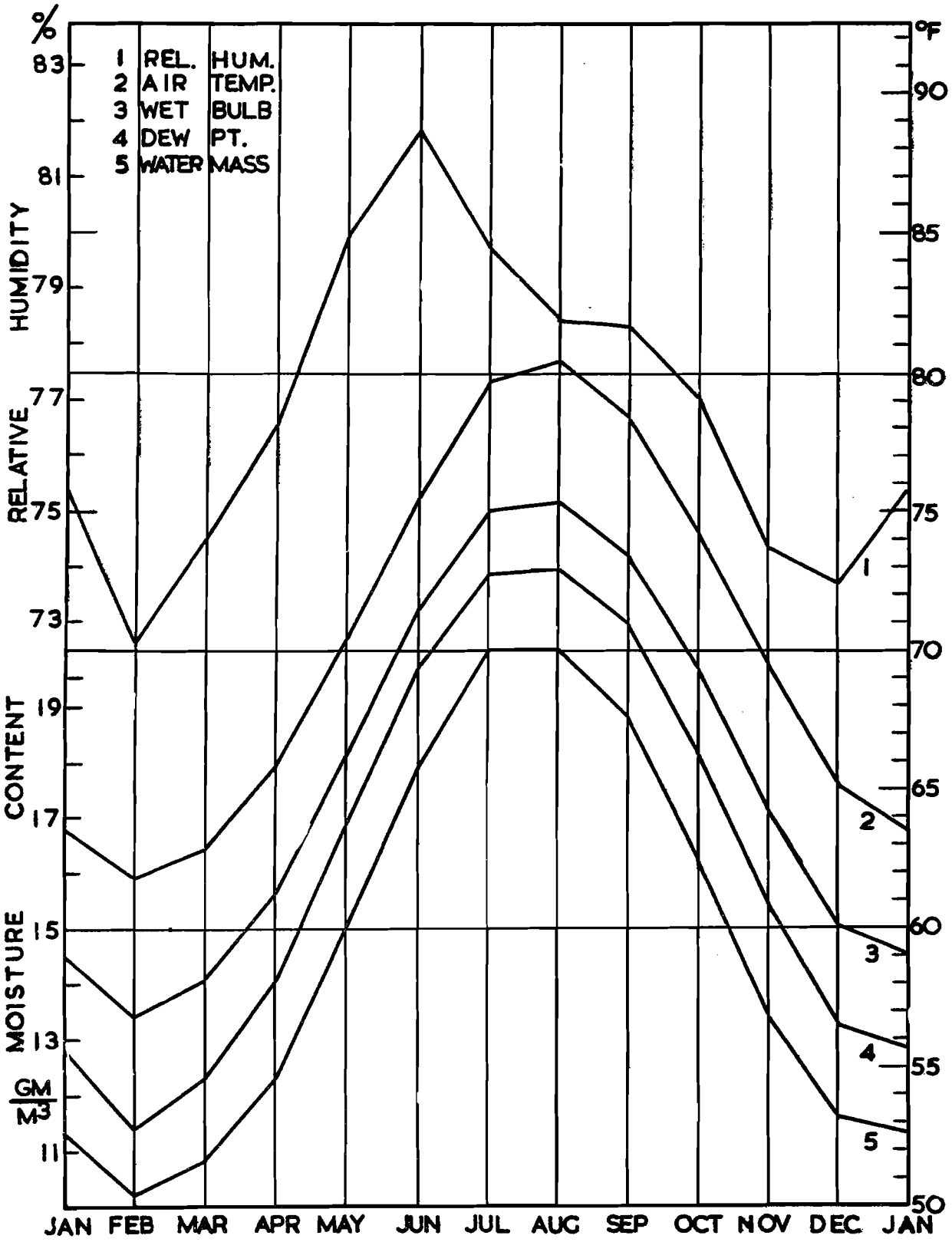

FIG. 1. Mean Humidity in each month of year at Fort George.

noted that except for June the lowest value for each month has been recorded since 1949 which may be due in part to the change in site at Fort George.

During the winter half year, monthly means are 10-12% lower in Bermuda than in Great Britain but in summer values fall appreciably in Britain while they rise in Bermuda so that in June, Relative Humidity is 10% higher in Bermuda than in London and 5% higher than in Glasgow but almost exactly the same in Bermuda and Falmouth.

8. MONTHLY EXTREMES OF RELATIVE HUMIDITY

Relative Humidity varies greatly about the means given in Table 2 and a range of 40% is common in any month.

Saturated air giving a Relative Humidity of 100% has been observed in every month of the year and except for July, 1950, when the maximum was 92% the Relative Humidity has risen to at least 95% sometime every month. However, the air over the land in Bermuda is usually unsaturated, even though the ocean is so close, for the motion of the air does not allow evaporation to saturate more than a thin layer close to the water surface. The very high

	FORT GEORGE			HAMILTON			BELMONT	DARRELLS'
	Average Lowest observed in month	Absolute Lowest		Average Lowest observed in month	Absolute Lowest		Absolute Lowest	Absolute Lowest
January	49.8	44	1935 36, 52	43.7	41	1/49	48	47
February	47.7	42	1938 1950	41.0	39	12/49 24/51	46	45
March	48.0	41	1951	40.7	37	9/53	45	46
April	48.6	40	1939	42.0	40	18/50 15/53	45	45
May	52.1	43	1950	46.8	42	21/48	49	51
June	56.9	46	1939	58.5	47	10/49	51	52
July	58.0	51	1939	57.5	51	26/49	62	64
August	57.5	46	1949	54.2	46	27/49 7/51	47	60
September	54.3	46	1952	50.7	42	22/47	48	55
October	51.5	44	1952	44.8	41	15/48 31/52	49	47
November	50.5	43	1952	42.3	39	24/39	43	50
December	49.4	42	1951	41.7	38	12/48	43	47

TABLE 3. Lowest Relative Humidity observed at any hour.

values occur most frequently on nights when there is little wind and a considerable fall in temperature.

Lowest values on the other hand are found with high daytime temperatures, especially after there has been an inflow of dry northern air.

The fluctuations often take place rapidly so that observations made only three times a day are likely to miss many of the extremes. This point is shown clearly by Table 3 which gives the lowest readings observed in each month from the 24 daily observations at Hamilton over 6 years and also from the 3 daily observations at Fort George over 21 years.

Except in June and July the average lowest is much lower in the 24-hour Hamilton records and only in June where 46% was observed at Fort George as against 47% at Hamilton was a lower absolute minimum recorded at Fort George.

The lowest humidity which has been observed is 37% which has occurred in March and December while February and November have also had readings below 40%. July has not had a Relative Humidity observed below 51% but every other month has had 46% or less.

On the average Relative Humidity falls below 45% sometime in each month from October to April but remains above 50% from June to September with the usual lowest in June and July just below 60%.

9. DAILY MAXIMUM RELATIVE HUMIDITY

For data on the frequency with which different values of Relative Humidity occur we have to rely on the Hamilton hourly observations and summaries are given in Tables 4 and 5 and Figs. 2 and 3.

Table 4 gives the average number of days in each month on which the highest Relative Humidity lay in each 5% range while Fig. 2 gives the percentage of days on which the Highest Relative Humidity was equal to or above 65%, 70% etc.

Percentage	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
50-54.9									0.2			0.2	0.3
55-59.9	0.2	0.2	0.3	0.2					0.2	0.2	0.8		2
60-64.9	0.7	0.8	3.0	1.0	0.3				0.2	0.7	1.3	1.8	10
65-69.9	2.8	2.8	2.2	1.8	1.0		0.2	0.3	1.0	1.2	2.3	3.3	19
70-74.9	3.2	2.3	2.5	1.8	1.3	0.8		1.0	1.0	2.5	3.2	3.0	23
75-79.9	3.3	2.8	3.0	2.7	1.3	1.2	1.0	1.7	1.8	2.7	2.5	2.7	27
80-84.9	2.5	3.3	3.3	2.3	1.3	0.8	6.7	6.0	4.8	4.0	3.8	3.8	43
85-89.9	6.0	3.2	3.5	3.2	3.2	2.8	10.8	10.5	8.3	6.2	4.0	5.0	67
90-94.9	4.3	5.3	4.2	6.2	7.0	9.0	7.2	7.7	7.0	6.7	4.2	4.7	73
95-100	8.0	7.5	9.0	10.8	15.5	15.3	5.2	3.8	5.5	7.0	7.8	6.5	102

TABLE 4. Average number of days per month on which the highest hourly Relative Humidity was in the limits stated. Hamilton.

It is seen that except for one occasion each in September and December the Relative Humidity reaches at least 55% every day. A value of 70% occurs on more than 4 days out of 5 every month and with a very few exceptions on every day in June, July and August.

A value of 80% occurs on 2 days out of 3 in each month and on more than 9 days out of 10 in June, July and August.

A value of 90% is observed on 4 days out of 5 in June and on more than 1/3 of the days in every month.

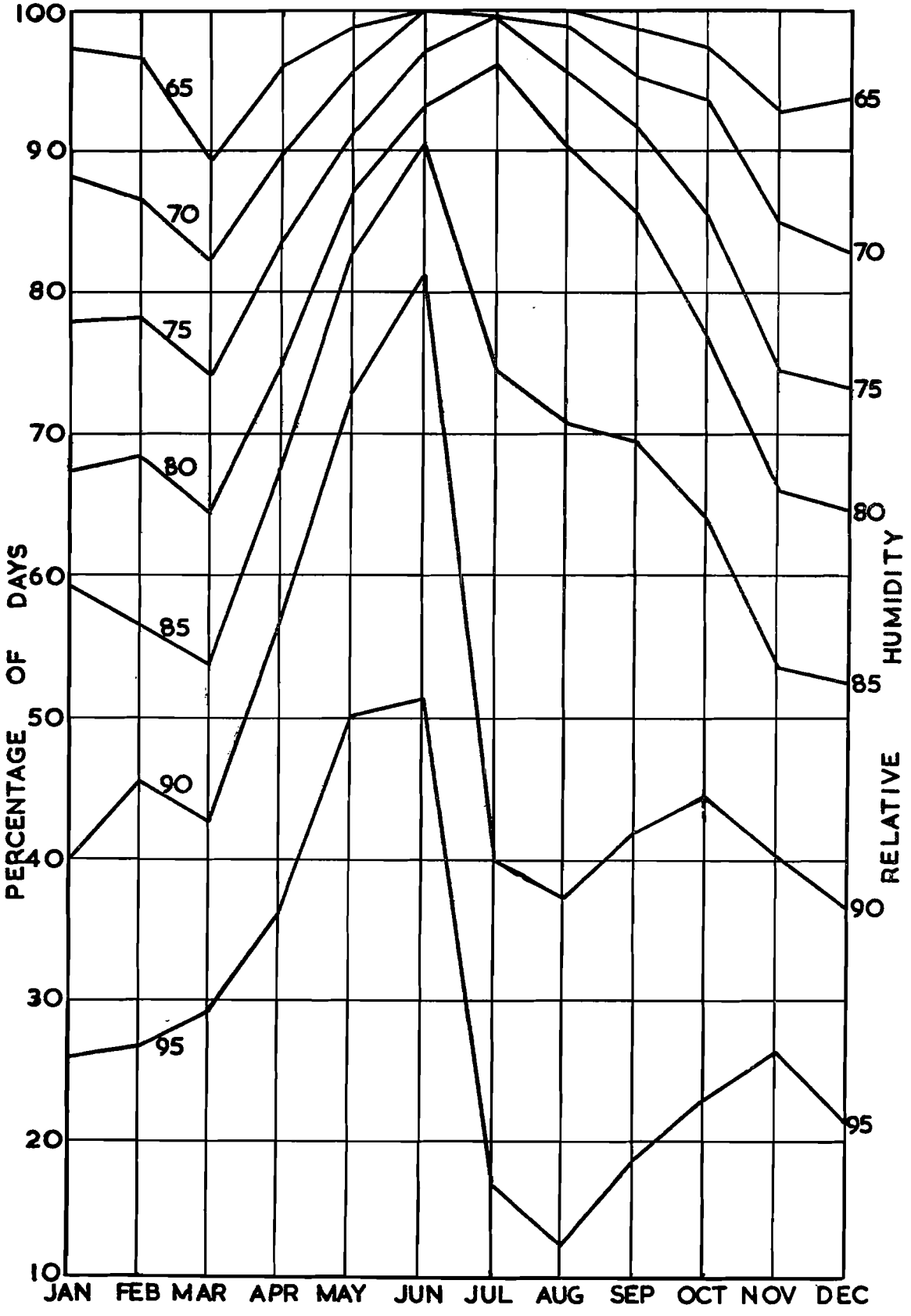

FIG. 2. Percentage of days each month on which highest Relative Humidity rose to values stated or higher. — Hamilton.

In May and June a Relative Humidity of 95% or more is observed on more than half the days.

It is noted that the days with 85% and upward increase rapidly from a minimum in winter to a maximum in June but there is a sharp fall in July so that July and August have less days with 95% than any other month. July and August have, however, a greater percentage of days with Relative Humidity reaching 80%.

10. DAILY MINIMUM RELATIVE HUMIDITY

Table 5 and Fig. 3 give data regarding the frequency of days with low values of Relative Humidity at Hamilton and show the same annual variations as in section 9. The greatest frequency of days with minimum humidity, 65% and above, occurs in June with much lower frequencies in July and August but July has a slightly higher frequency than June of days with minimum Relative Humidity of 60% and less.

It is seen that on 1 day in April and 3 days in each May and June the Relative Humidity does not fall below 85% but in other months this occurs rarely while in August the Relative Humidity falls below 80% every day.

Percentage	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
35-39.9		0.3	0.5								0.2		1
40-44.9	1.0	1.7	2.7	2.0	0.2				0.3	0.7	2.0	1.5	12
45-49.9	5.2	3.7	5.8	4.7	1.9	0.2		0.5	0.3	2.0	3.8	6.7	35
50-54.9	4.8	7.0	5.3	2.5	1.7	0.3	0.3	0.3	1.5	3.5	4.3	4.8	37
55-59.9	5.3	4.8	5.7	3.2	3.2	1.3	1.2	1.9	2.8	4.3	4.2	5.8	44
60-64.9	5.3	2.3	2.2	3.3	2.5	1.9	7.8	7.0	5.7	4.2	3.7	3.8	50
65-69.9	3.7	3.2	2.5	3.3	2.8	3.8	8.8	12.7	6.7	3.5	4.7	4.0	50
70-74.9	1.3	2.3	2.3	3.9	5.0	5.0	7.5	6.3	8.2	6.8	2.8	1.2	53
75-79.9	1.7	1.5	1.7	3.0	6.7	8.3	4.0	2.3	3.5	3.3	3.0	1.8	41
80-84.9	2.0	1.2	1.9	3.0	4.3	6.2	1.0		0.8	2.3	0.7	0.7	24
85-89.9	0.7	0.3	0.2	1.0	2.3	2.7	0.2			0.3	0.5	0.7	9
90-94.9			0.3	0.2	0.3	0.3	0.2		0.2		0.2		2
95-100					0.2								0.2

TABLE 5. Average number of days per month on which the lowest hourly Relative Humidity was in the limits stated. Hamilton.

The Relative Humidity falls below 70% on more than 4 days out of 5 from December to March, but the proportion decreases to only 1 day out of 4 in June.

A minimum of 60% is observed in 3 days out of 5 in December, February and March and the frequency ranges from a maximum of 2 days out of 3 in March to a minimum of less than 1 day out of 10 in June, July and August.

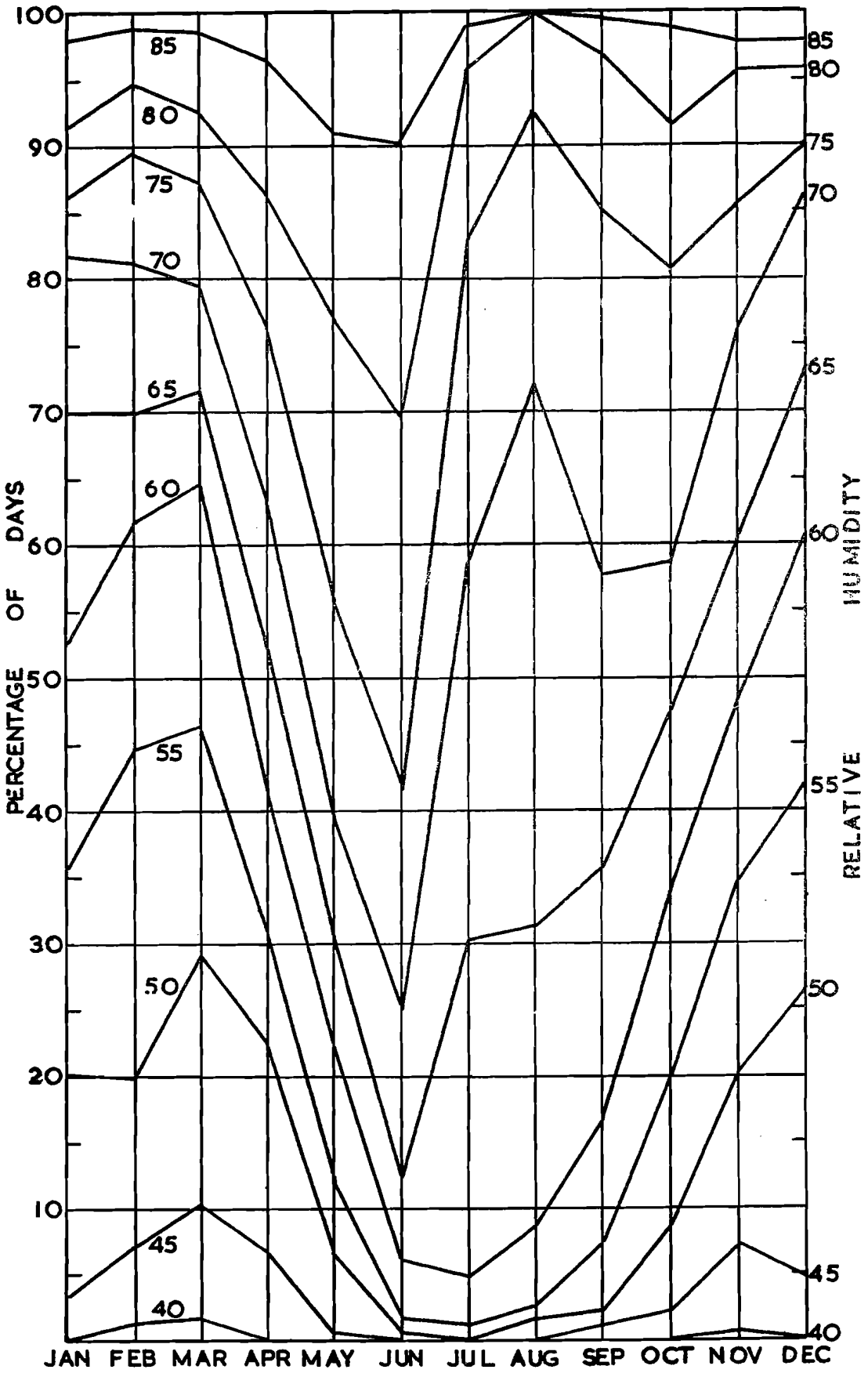

FIG. 3. Percentage of days each month on which lowest Relative Humidity fell to values stated or lower. — Hamilton.

Values fall to 50% on more than 1 day in 4 in March and 1 day in 5 from November to April but on less than 1 day per month from June to September and Relative Humidity has not been recorded as low as 50% in July

Relative Humidity has fallen below 40% once in every two years in February and March and once in the whole six years in November.

11. NUMBER OF HOURS IN EACH RANGE OF RELATIVE HUMIDITY

Table 6 gives the average number of hours in each month with Relative Humidity in the 5% ranges from 35% to 100%. The same data given as percentage of days per month is plotted in Fig. 4 and the months are placed in 4 groups according to the most frequent range.

It is seen that in February and March, the most common Relative Humidity is 55-60% which occurs about 15% of the time, there being a rapid increase in occurrence from almost zero hours with 40-45% and a gradual decrease in frequency to 95-100% which occurs in only 1 hour out of 20. In the second group, November, December and January, the most common Relative Humidity is near 65% with 14½% of hours between 60-65% in December and 12½ to 15% of hours between 65-70% in November and January respectively. The peak is very flat in November and December. All three months rise from near zero frequency of 40-45% Relative Humidity to the highest frequency and show a

Percentage	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
35-39.9		0.3	0.5								0.2	0.2	1.2
40-44.9	2.0	2.8	5.0	4.8	0.2				1.5	2.0	4.7	3.8	27
45-49.9	15	19	31	21	4.5	0.2		1.5	3.7	7.5	23	23	149
50-54.9	51	55	76	43	19	1.5	0.8	2.8	9.8	24	50	57	390
55-59.9	82	95	113	62	31	6.3	4.5	12	25	47	81	102	661
60-64.9	99	95	89	67	41	18	30	31	39	71	78	107	765
65-69.9	112	84	80	64	49	30	74	86	70	74	89	100	912
70-74.9	85	66	65	70	59	49	121	135	114	97	89	80	1029
75-79.9	75	61	63	75	79	95	154	171	150	105	83	70	1181
80-84.9	75	59	63	77	105	111	170	176	146	115	68	65	1231
85-89.9	65	63	57	89	123	161	113	92	95	111	77	67	1113
90-94.9	52	53	63	90	132	169	57	29	65	63	49	44	844
95-100	32	25	37	58	102	79	20	7.5	21	28	29	25	463

TABLE 6. Average number of hours per month and year with Relative Humidity in ranges given. Hamilton.

slow decline with higher Relative Humidity with the lowest frequency of about 4% from 95-100%. The curves are similar to those for February and March but with the greatest frequency at a higher value of Relative Humidity.

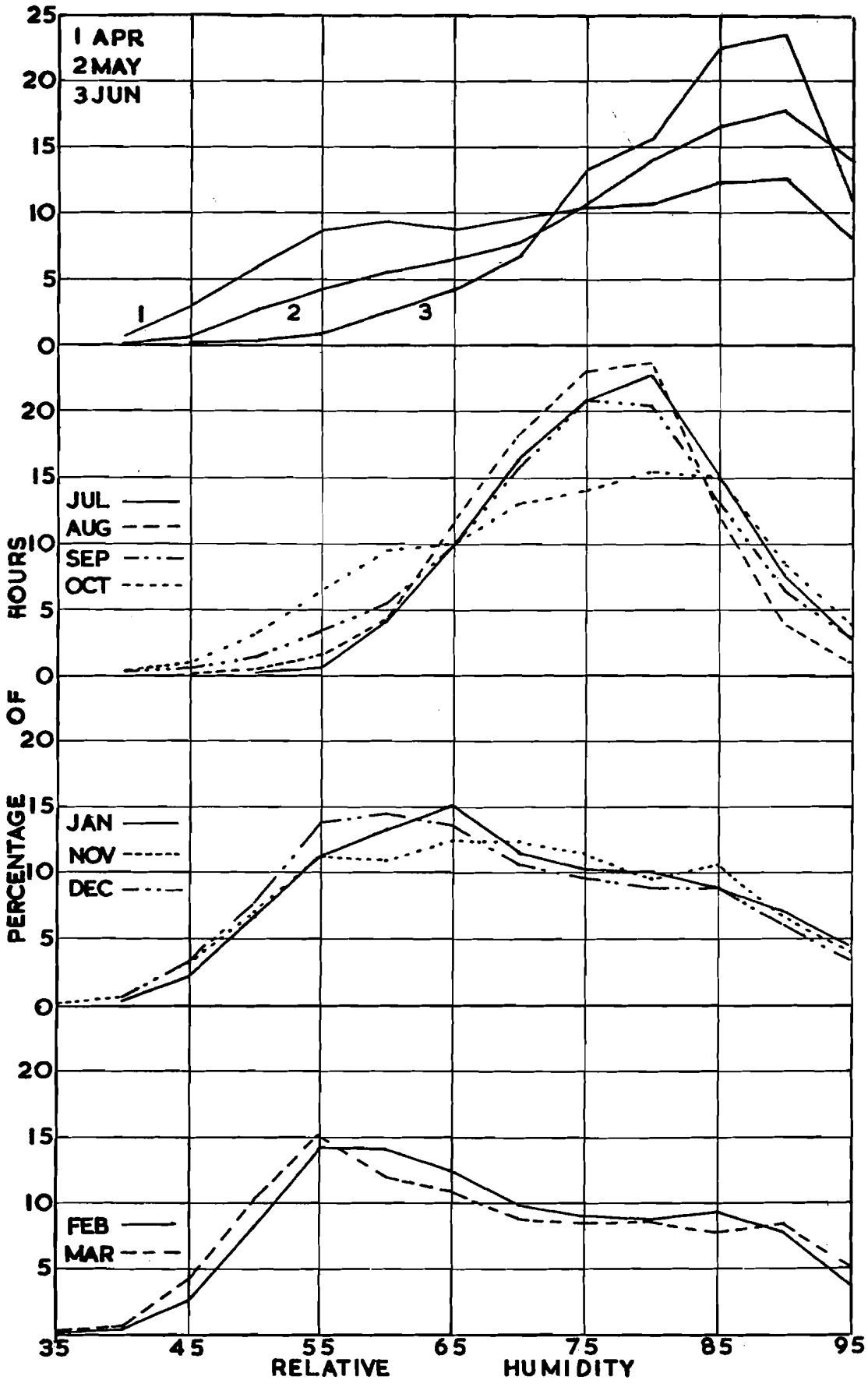

FIG. 4. Percentage of hours each month in which Relative Humidity was 35-39.9%, 40-44.9%, etc. — Hamilton.

In the next group, July, August and September, are very similar and October is classed with them because all four have their most frequent Relative Humidity 80-85%. October has, however, greater frequency of Relative Humidity below 65% and above 90%, its curve showing a much flatter peak than the other three months.

In July, August and September more than two-fifths of all hours have Relative Humidity from 75-85% and the curves show relatively little skew with steady rises from almost zero hours of 45-50% to the maximum frequency followed by falls to a frequency of only 1 or 2 hours per hundred with 95-100% Relative Humidity.

In the top group in Fig. 4 are April, May and June in each of which the most frequent Relative Humidity is 90-95%. June has a much sharper peak than the other two and almost half the hours in the month have Relative Humidity between 85% and 95%. April has about half this number in this high range and a corresponding greater percentage of hours with values below 75% than do May and June.

In each case the curves are very skew, in the reverse way to February and March, with a gradual rise from near zero in the 40-45% range to the 90-95% maximum followed by a sharp fall in the 95-100% range.

Fig. 5 shows the distribution of Relative Humidity by giving the values reached or exceeded in from 2% to 98% of hours each month. It is seen that the curves show a marked peak in June and a much smaller one about October. In the highest 20% of hours the Relative Humidity is close in May and June with July appreciably less. As the percentage of hours is increased, the June peak becomes more marked with lower values in May but July rising nearer to the June value. It is noticeable that in the most humid 10% of hours, a lower Relative Humidity is observed in August than any other month and even in the most humid 20% of hours only December has a lower Relative Humidity than August.

12. DIURNAL VARIATION OF RELATIVE HUMIDITY

As was shown earlier Relative Humidity is a ratio between the amount of water vapour present in the air and the maximum amount which the air could contain at the existing temperature.

The general humidity of the air mass over Bermuda at any time depends on its history and mainly on the length of time it has been over the ocean and the changes of temperature to which it has been subjected. Normally only a thin layer close to the water surface is saturated and the air over the adjacent land has a Relative Humidity well below 100%. When the air temperature

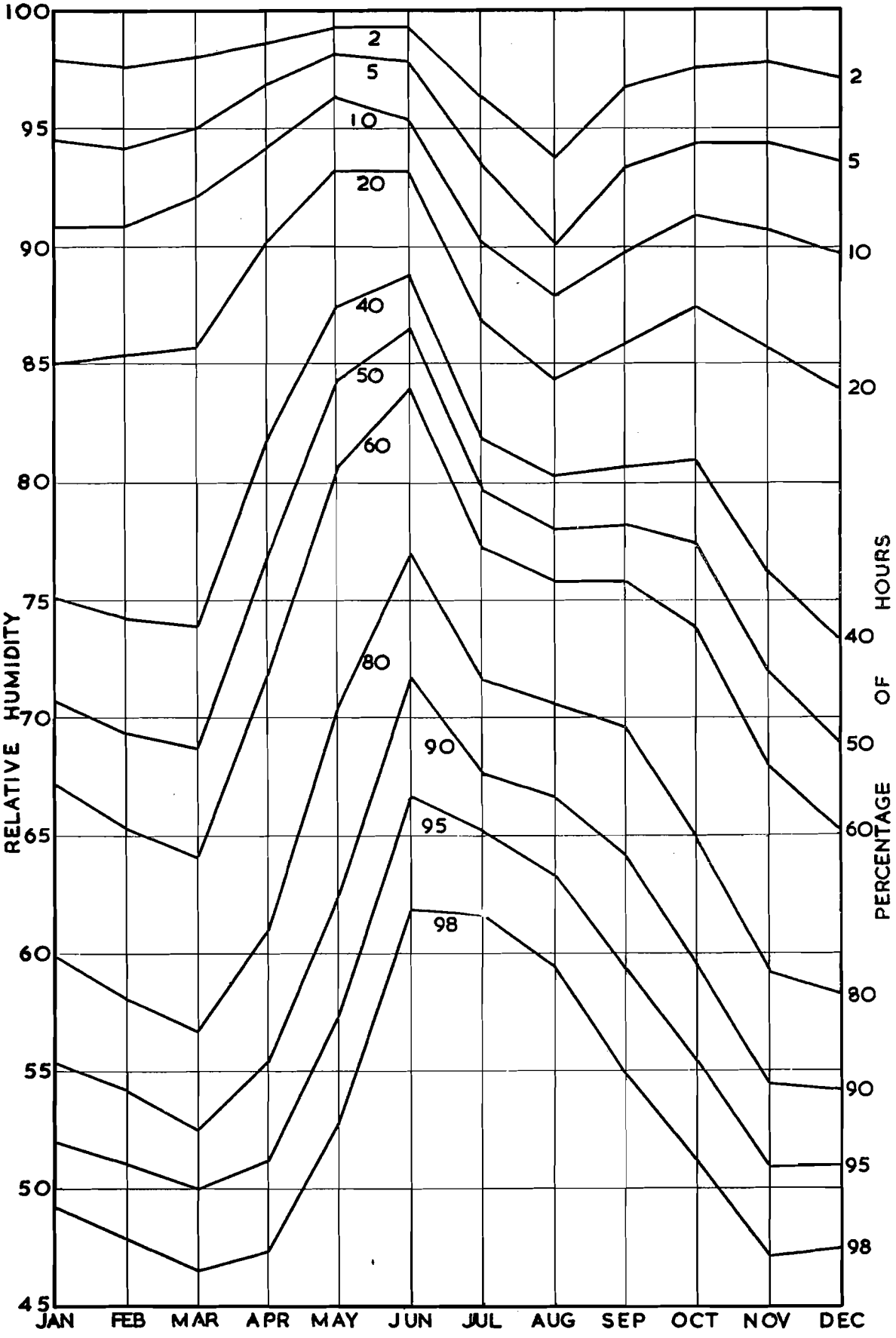

FIG. 5. Values of Relative Humidity reached or exceeded in 2, 5, 10, etc. per cent of hours each month. — Hamilton.

Hour	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year
00	2.2	2.2	2.1	3.7	4.1	4.4	4.7	4.6	3.1	3.3	1.9	1.2	3.2
01	2.5	3.0	2.7	4.2	4.2	4.6	5.2	4.4	3.8	2.9	2.1	1.6	3.4
02	3.1	2.6	2.4	4.4	4.2	4.8	5.2	5.0	4.0	2.9	2.0	1.6	3.5
03	2.7	3.4	2.1	4.1	4.3	4.9	5.5	5.1	4.5	3.1	1.9	2.2	3.6
04	1.9	2.9	2.4	3.9	4.5	5.0	5.8	5.0	4.4	2.9	1.8	2.1	3.5
05	2.2	2.8	2.3	3.8	4.5	5.1	5.9	4.9	4.5	2.8	2.2	1.7	3.6
06	2.1	2.7	2.1	4.0	3.9	4.6	5.4	4.8	4.2	3.0	2.4	1.8	3.4
07	2.1	2.6	2.2	2.3	1.9	2.6	2.5	2.4	2.8	2.5	1.7	1.9	3.3
08	1.7	1.6	0.9	-0.1	-0.1	0.3	-0.1	-0.2	0.5	0.2	0.4	1.0	0.5
09	0.1	-0.2	-1.3	-1.9	-2.4	-2.2	-2.7	-2.3	-2.3	-2.4	-1.8	-1.0	-1.7
10	-2.3	-2.0	-2.5	-4.3	-4.1	-3.6	-4.4	-4.2	-3.9	-3.7	-3.8	-2.6	-3.5
11	-4.3	-3.3	-3.5	-5.5	-5.1	-5.0	-5.5	-5.8	-5.1	-4.6	-4.6	-3.8	-4.9
12	-4.4	-4.6	-4.1	-6.1	-6.1	-6.2	-6.2	-6.0	-5.6	-5.3	-4.8	-3.9	-5.3
13	-4.8	-5.1	-4.6	-6.1	-6.3	-6.9	-6.7	-6.5	-6.3	-5.4	-4.8	-4.1	-5.6
14	-4.7	-5.3	-4.5	-6.3	-6.5	-6.8	-7.2	-7.0	-6.3	-5.2	-4.2	-3.6	-5.6
15	-4.6	-5.0	-4.8	-6.0	-5.8	-6.6	-6.7	-6.7	-6.1	-4.7	-3.8	-3.3	-5.3
16	-3.8	-3.6	-3 0	-4.8	-4.8	-5.6	-6.0	-5.6	-4.7	-4.0	-2.3	-2.1	-4.2
17	-2.2	-1.8	-1.6	-3.1	-3.3	-4.2	-5.0	-3.7	-2.6	-1.7	-0.2	-0.1	-2.5
18	0.5	0.3	0.2	-0.9	-1.7	-2.4	-3.5	-2.3	-0.4	0.9	1.4	1.6	-0.5
19	1.2	1.0	1.5	1.3	0.8	0.5	-0.8	0.6	1.5	2.2	2.1	1.8	1.1
20	1.4	1.4	2.2	2.5	2.9	2.4	2.1	2.1	2.1	2.4	2.6	1.7	2.1
21	1.9	1.8	2.4	3.3	3.5	3.4	3.4	3.4	2.6	2.8	2.4	2.1	2.7
22	2.2	1.4	2.1	3.7	3.6	3.7	4.3	3.6	2.9	3.1	2.5	1.9	2.9
23	2.0	1.4	2.0	3.6	4.1	3.8	4.8	3.8	2.9	2.9	2.1	1.3	2.9
24	2.4	1.4	2.5	4.0	4.3	4.2	4.6	4.6	2.9	3.3	1.8	1.3	3.1

TABLE 7. Diurnal Variation of Relative Humidity at Hamilton. Table gives the departure of average at each hour from the monthly mean.

rises during the day although there is some evaporation and the water vapour content increases this increase is not usually sufficient to maintain the previously existing degree of saturation and the Relative Humidity falls. As temperature falls in the evening the Relative Humidity increases again.

To determine this diurnal variation. observations at each hour are required and the longest series of these is the 6 years at Hamilton. Table 7 gives for each month the average departure at each hour from the days mean. It is seen that the lowest reading occurs in the early afternoon at 1 or 2 p.m. with a fairly sharp peak and the highest is in the early monring, being shortly before sunrise in the summer but earlier in the night in winter. In all months Relative Humidity remains fairly steady for a large part of the night. The daily range is greatest in summer and lowest in winter with 12-13% variation in summer and 6-7% in winter.

The relationship between Relative Humidity and temperature is shown in Fig. 6 which gives the mean hourly values of Relative Humidity in February and June, the months which have respectively the lowest and highest mean Relative

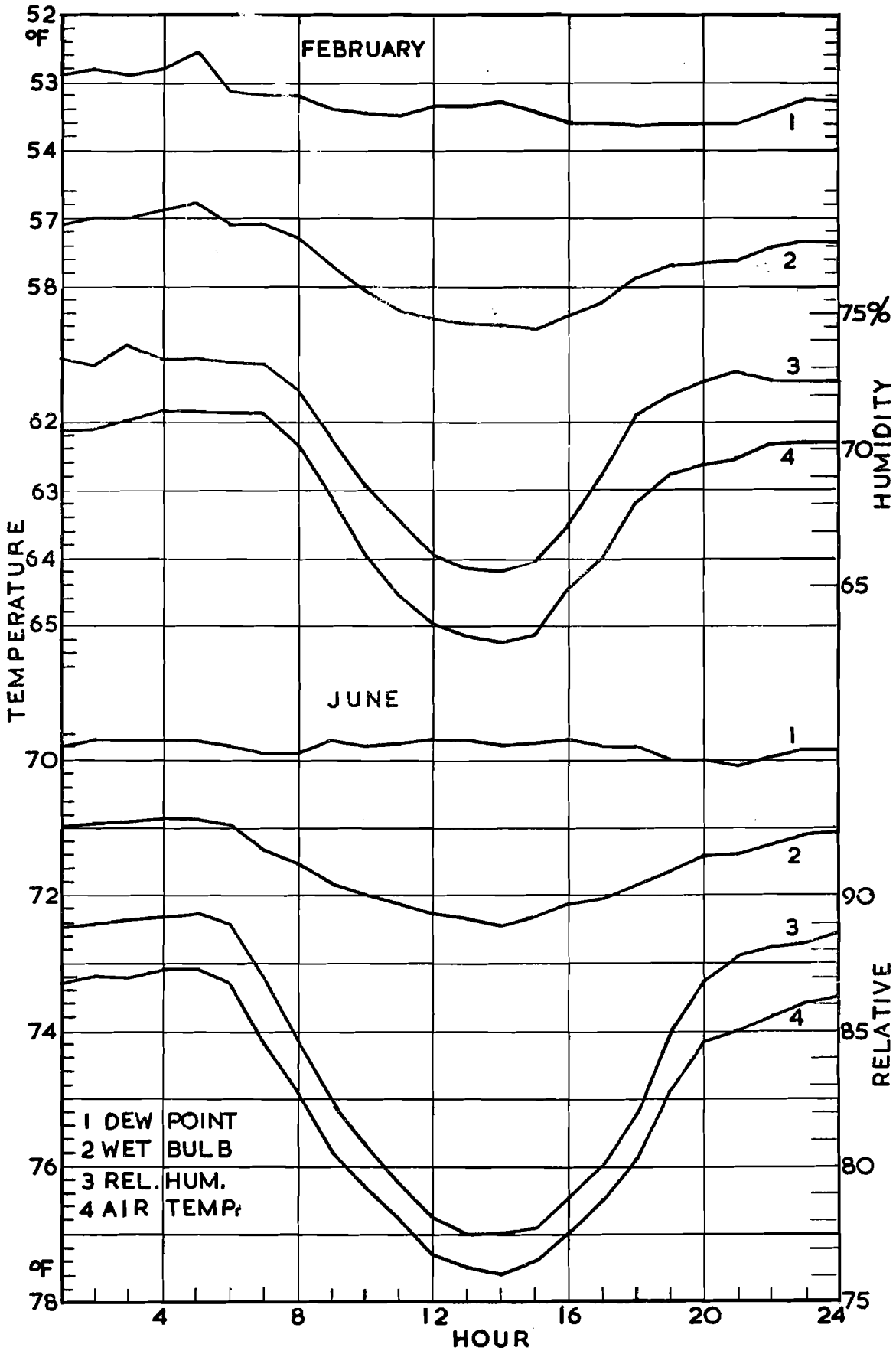

FIG. 6. Diurnal variation of Humidity in February and June at Hamilton.

Humidities. The hourly values of Air Temperature, Wet Bulb and Dew Point are also given being plotted with scale reversed from Relative Humidity.

It is seen how closely the air temperature and Relative Humidity agree with high humidity and low temperature in the early morning and low humidity and high temperature in the early afternoon.

The figure shows also how the wet bulb temperature and Dew Point move in step with the air temperature but with a diurnal change of less than half that of air temperature.

Because of this close dependence on temperature the Relative Humidity can vary considerably within short distances when there are differences in location which make for greater daily variation of temperature at one site than another.

This is shown in Fig. 7 which shows by months the average highest and average lowest daily values as departures from the daily mean at the 4 sites for which the data is available.

It is seen that the variation is least on Darrell's Island where the closeness of the ocean kept temperature variations smaller and greatest at Belmont which was the most enclosed location. The variation is also less at Hamilton Roof site than at Fort George. Fig. 8 summarises in one diagram the data on mean values and diurnal variation already given for Hamilton. It shows clearly how the overall mean range is from about 65% to 90% and shows the marked maximum in June with the two minima in March and December.

13. MONTHLY MEAN WET BULB TEMPERATURE

The average wet bulb readings each month at Fort George are given in Table 8. The values given for 08,14 and 20 hours are direct averages of the observed readings and the mean 24 hour values were calculated from the mean 24 hour temperatures and relative humidities.

	Average at			24 Hour Mean
	08	14	20	
January	58.3	60.6	58.2	59.0
February	56.0	58.8	56.3	56.8
March	57.7	60.1	57.3	58.1
April	61.1	63.3	60.2	61.2
May	66.5	68.5	65.2	66.2
June	71.7	73.4	70.7	71.5
July	74.9	76.7	74.1	74.9
August	75.2	77.3	74.3	75.3
September	73.3	75.6	73.4	73.4
October	69.2	71.3	68.4	69.2
November	64.0	65.9	63.5	64.2
December	59.7	61.8	59.7	60.1

TABLE 8. Average Wet Bulb Temperature — Fort George at 08, 14, 20 and 24 hour mean computed from Temperature and Relative Humidity.

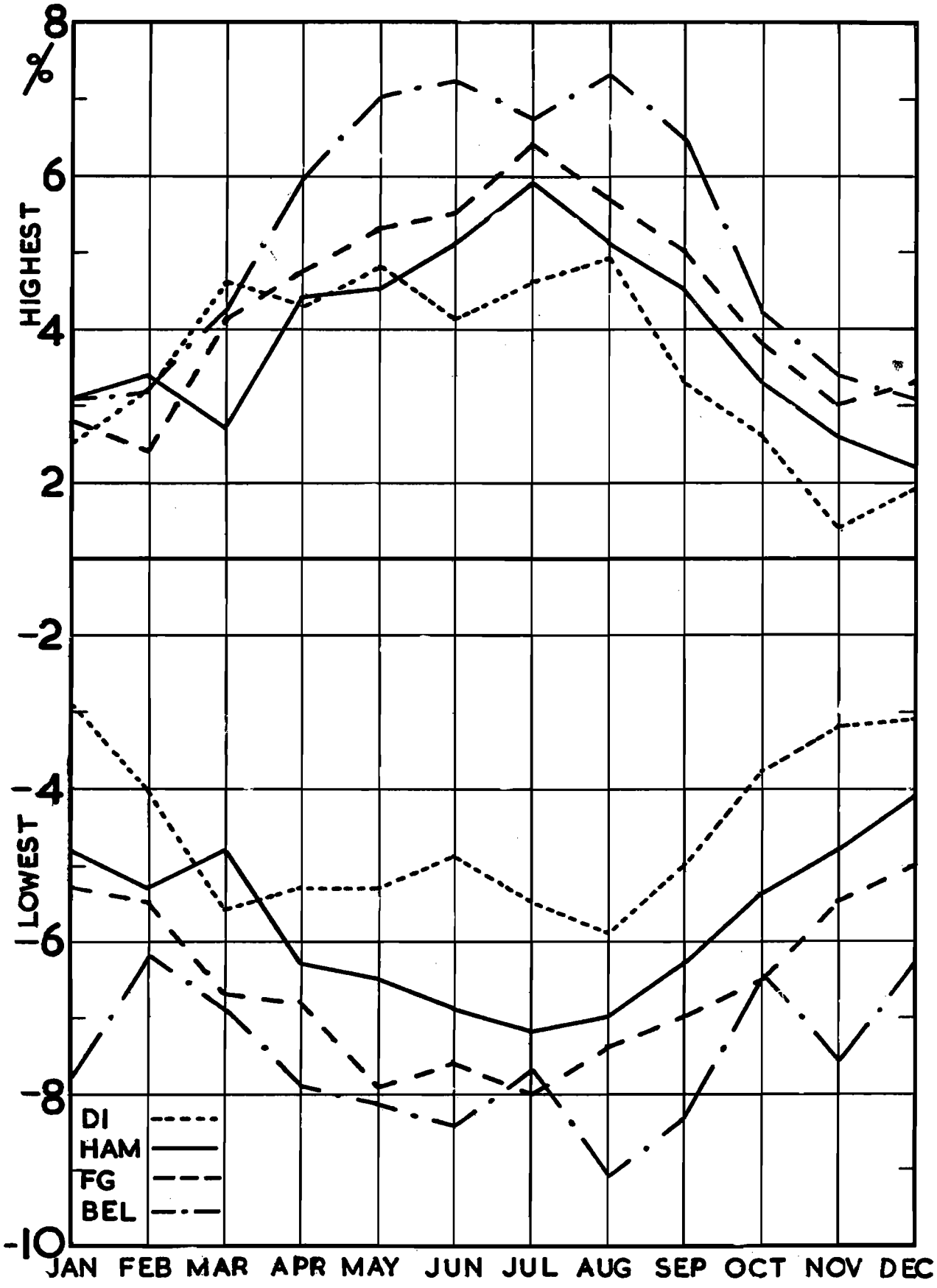

FIG. 7 Departure from daily mean of (a) average daily highest and (b) average daily lowest Relative Humidity at each station.

The annual variation is similar to that of temperature with the lowest mean of 56.8°F. in February and the highest of 75.3°F. in August. The mean is below 60°F. in January, February and March and above 70°F. in June, July, August and September with 75°F. in both July and August.

These values are 22°F. higher than in London in winter and 17°F. in summer, but Washington, D.C., which has a mean over 25°F. lower than Bermuda in winter is only 6°F. lower in summer.

14. HIGHEST WET BULB TEMPERATURE OBSERVED IN EACH MONTH

Table 9 gives the highest wet bulb readings observed at any hour at each site since 1932. Values observed at Prospect prior to this are given in appendix 3 but there is reason to doubt the validity of these extreme Prospect readings and they have therefore been omitted from Table 9. The table shows that

	Fort George	Hamilton	Belmont	Darrell's	All Sites	Date
January	70.0	69.3	70.7	70.5	70.7	4/42
Februarv	68.7	68.4	68.3	68.0	68.7	13/41
March	68.0	69.0	70.2	69.0	70.2	20/44
April	73.5	70.5	72.8	72.6	73.5	27/37
May	76.2	73.8	74.5	74.2	76.2	29/34
June	79.4	77.2	78.8	77.8	79.4	19/44
July	81.8	79.1	81.7	78.5	81.8	28/37
August	82.0	80.0	81.9	79.6	82.0	20/37
September	83.5	79.0	84.6	80.5	84.6	7/41
October	79.0	77.9	80.7	78.0	80.7	9/41
November	76.0	74.8	78.0	74.3	78.0	3/41
December	72.1	73.2	72.8	70.8	73.2	10/48
Year	83.5	80.0	84.6	80.5	84.6	7/9/41

TABLE 9. Highest Wet Bulb Temperature observed at any hour.

each month except February has had a wet bulb over 70°F. and the 4 months, July to October, have each had over 80°F. The highest at any time was 84.6°F. observed at 2 p.m. on the 7th September, 1941, at Belmont. The air temperature was 86.0°F. with a Relative Humidity of 94% and a Dew Point of 84.1°F., the latter being the highest Dew Point on record. The wind at the time was WNW. 8 m.p.h. and the sky was half covered with cloud.

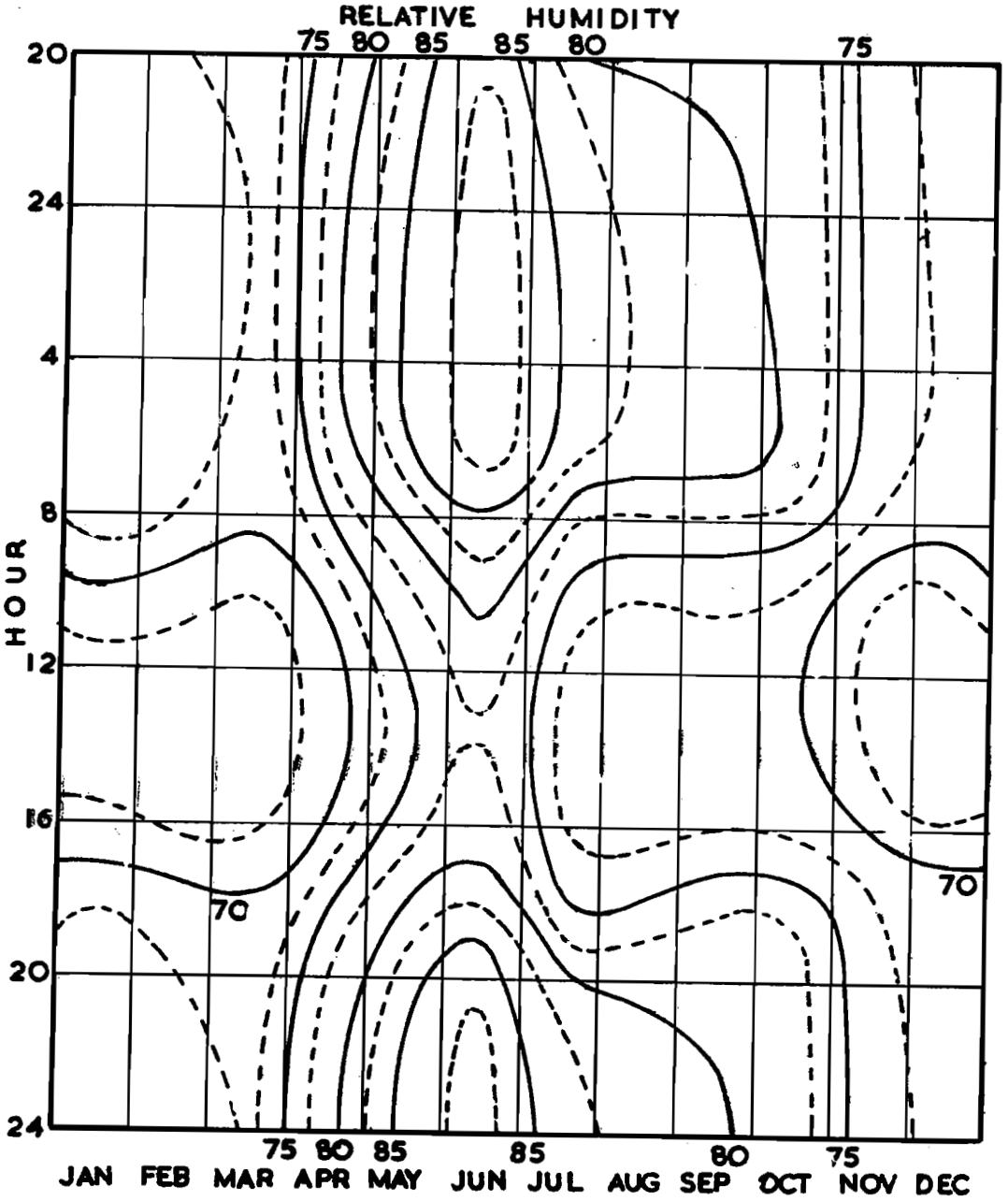

FIG. 8. Average Relative Humidity at Hamilton at each hour of the year.

15. LOWEST WET BULB TEMPERATURE OBSERVED IN EACH MONTH

Table 10 gives the lowest Wet Bulb Temperatures which have been observed at any hour at each site since 1932. Values below 60°F. have not been observed in July or August, nor below 55°F. in the 5 months June to October. Wet bulbs below 40°F. have not been observed at any time, the lowest readings being 41.0°F.

	Fort George	Hamilton	Belmont	Darrell's	All Sites	Date
January	46.6	46.0	47.0	47.8	46.0	12/48
February	41.6	42.3	44.6	45.7	41.6	24/36
March	46.2	41.0	45.1	50.7	41.0	6/48
April	47.9	48.8	46.0	51.0	46.0	4/42
May	52.5	53.7	51.5	57.2	51.5	7/43
June	58.8	59.9	60.3	60.4	58.8	7/39
July	64.1	62.0	62.8	72.4	62.0	11/48
August	64.8	63.2	61.9	72.5	61.9	29/44
September	58.0	58.5	61.0	64.6	58.0	17/48
October	55.2	55.6	59.2	56.4	55.2	26/35
November	52.4	51.0	51.0	53.9	51.0	23/49
December	48.1	44.2	43.8	49.3	43.8	18/42
Year	41.6	41.0	43.8	45.7	41.0	6/3/48

TABLE 10. Lowest Wet Bulb Temperature observed at any hour.

in March and 41.6°F. in February. The extreme 41.0°F. was observed in Hamilton at 6 a.m. on the 6th March, 1948. A northerly gale was blowing at the time with rain squalls. The dry bulb was 48.0°F. which gave a Dew Point of 30.2°F., Vapour Pressure 5.7 millibars, and Relative Humidity of 50%.

16. DAILY MEAN WET BULB

Table 11 gives for Hamilton the average number of days per month in which the mean wet bulb lies in each two degree range, while Fig. 9 gives the percentage of days in which the mean wet bulb has values of 45,50°F. etc., or above.

There is a larger range of daily mean in winter than in summer with the greatest range from 43°F. to 68°F. in March and the smallest in August from 66°F. to 79°F. The highest values in winter just overlap the lowest in summer. There was only one day (March) with a mean wet bulb below 45°F. and only few from December to March with less than 50°F. There is a rapid increase in the lower limit from March to July with no means below 50°F. in April, 55°F. in May, 61°F. in June or 65°F. in July. August has none below 66°F. and then

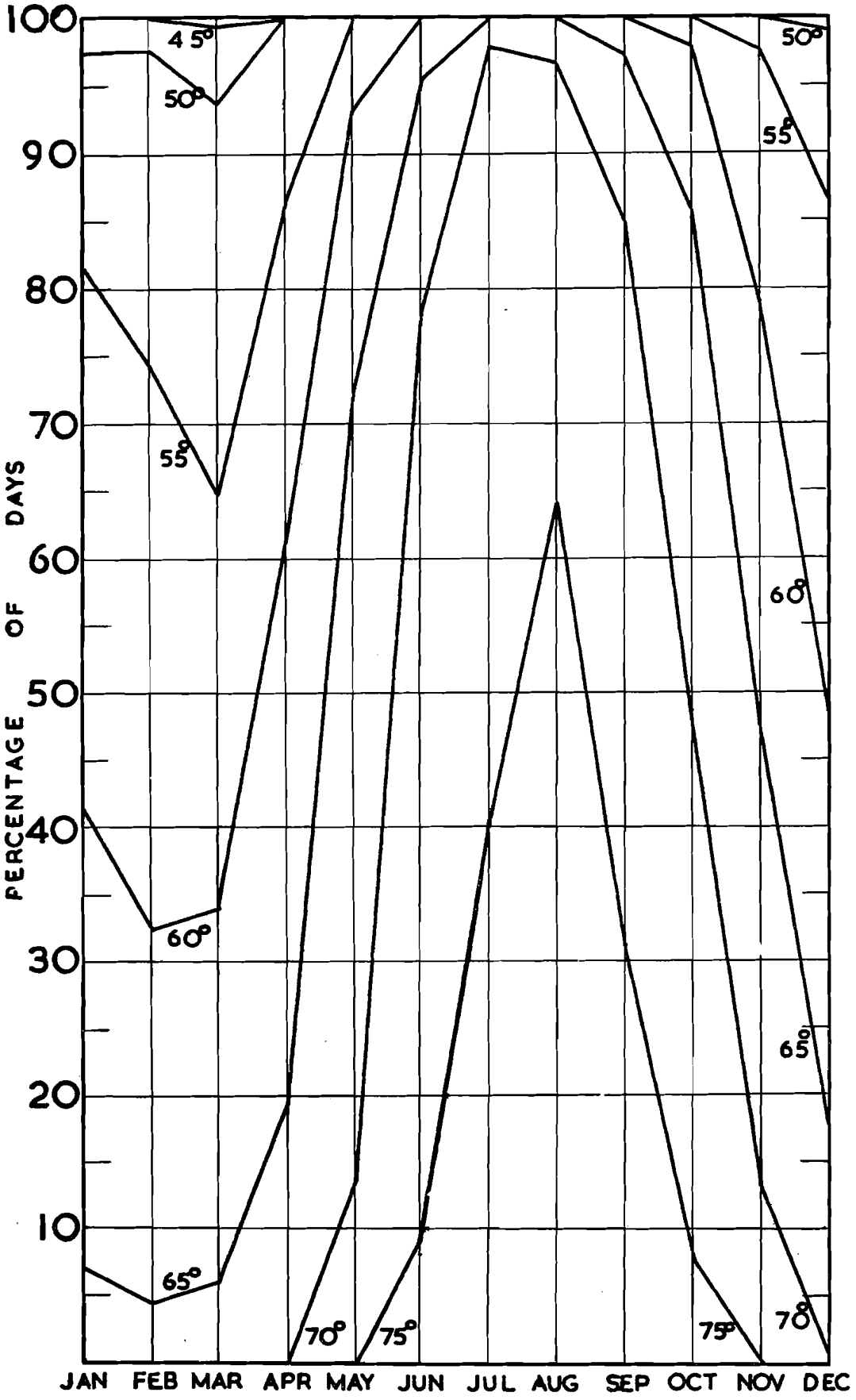

FIG. 9. Percentage of days each month with mean Wet Bulb Temperature at value given or above. — Hamilton.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
43-43.9			0.2									
44-45.9		0.2										
46-47.9		0.2	0.4									0.2
48-49.9	0.9	0.4	1.5									0.2
50-51.9	1.0	2.2	4.2	1.0								0.5
52-53.9	2.9	2.9	2.5	1.8							0.7	1.5
54-55.9	3.5	3.6	4.0	2.9	0.3						0.7	3.1
56-57.9	4.5	6.4	4.0	2.4	0.6						2.0	6.0
58-59.9	5.5	3.7	3.9	3.6	1.2					0.6	3.2	4.8
60-61.9	5.2	3.5	3.7	4.0	2.0	0.2			0.2	0.8	2.8	3.2
62-63.9	4.4	3.4	3.2	6.2	3.0	1.0			0.2	1.5	4.6	4.7
64-65.9	2.2	1.9	2.6	4.0	2.8	0.7	0.2		0.8	3.7	4,1	3.7
66-67.9	1.2	0.5	1.2	3.8	7.5	1.2	0.5	0.2	0.4	5.4	3.5	2.0
68-69.9				0.5	9.3	3.4		0.8	3.2	4.2	4.7	1.0
70-71.9					4.0	8.2	0.7	0.8	3.3	4.2	3.0	0.2
72-73.9					0.2	8.8	9.0	3.3	8.0	6.1	0.9	
74-75.9						6.3	15.5	16.5	9.5	4.1		
76-77.9						0.3	4.7	9.2	4.5	0.5		
78-78.9							0.5	0.2				

TABLE 11. Average number of days per month with mean wet bulb temperature in limits given. Hamilton.

there are falls to 61°F. in September, 58°F. in October, 52°F. in November and 47°F. in December.

From June to September there are very few days with means below 65°F. and in these months and in October there are a number of days above 75°F. with the greatest frequency in August where nearly 2 days out of 3 have mean wet bulbs above 75°F.

17. DAILY MAXIMUM WET BULB

Fig. 10 gives the frequency of days each month on which the highest hourly wet bulb rose to given values. It is seen that readings of 65°F. are recorded at all seasons of the year, on one quarter of the days in winter and on almost every day in summer.

Values of 80°F. are observed only in July and August about once in three years but 75°F. occurs on occasion from June to October with the greatest frequency in August where it is reached on 9 days out of 10.

Values of 55°F. are reached every day from May to October and on 4 days out of 5 in March which has the lowest values.

A wet bulb of 50°F. is reached every day except about once in three years in February and March.

18. DAILY MINIMUM WET BULB

Fig. 11 gives for each month the frequency of days on which the wet bulb fell to the values given or lower.

The figure shows that the wet bulb falls below 75°F. on every day from November to May and even in August on 4 days out of 5. It falls below 65°F. on occasions in every month although in July and August it happens only once in 3 or 5 years.

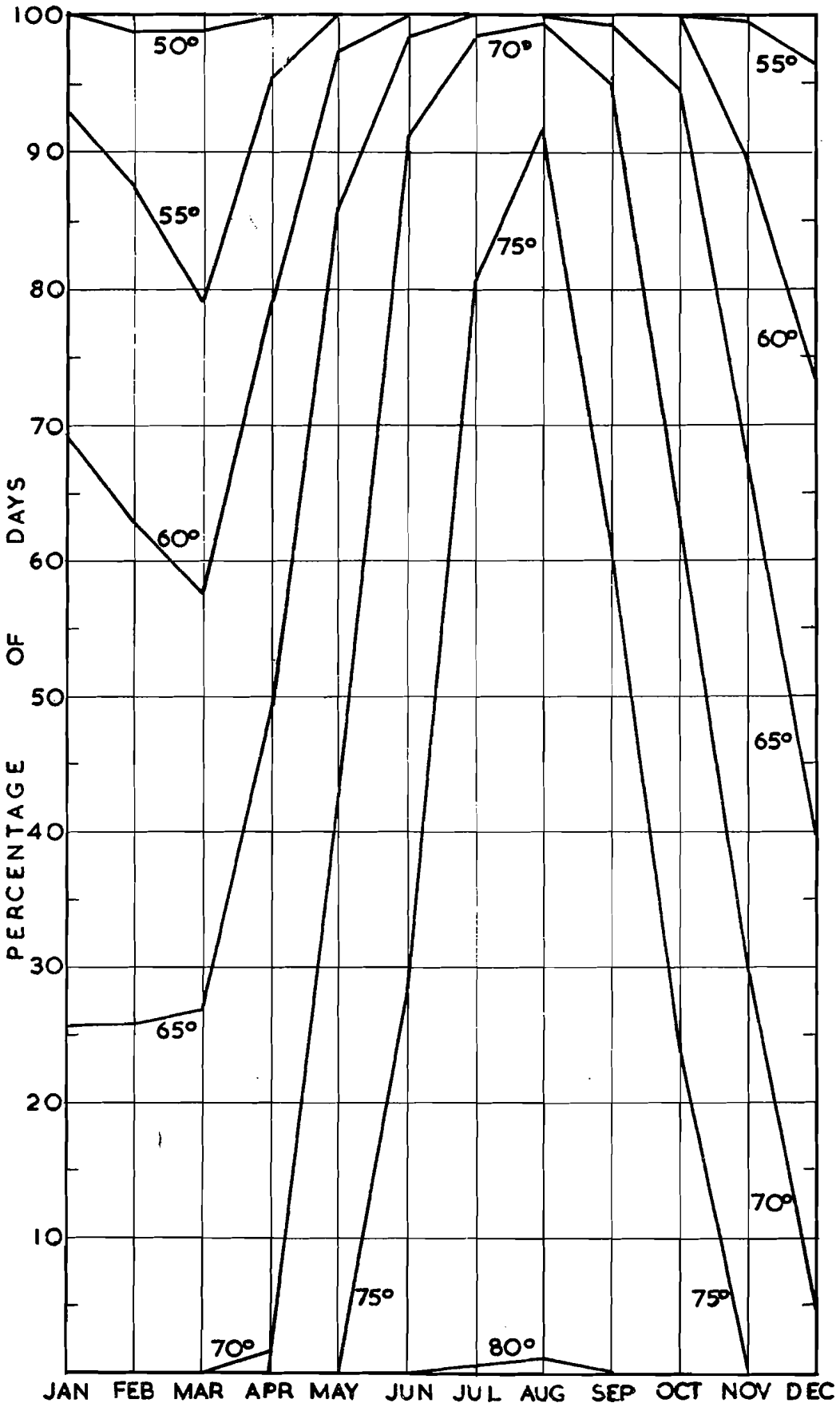

FIG. 10. Percentage of days each month on which highest wet bulb temperature rose to value given or higher. — Hamilton.

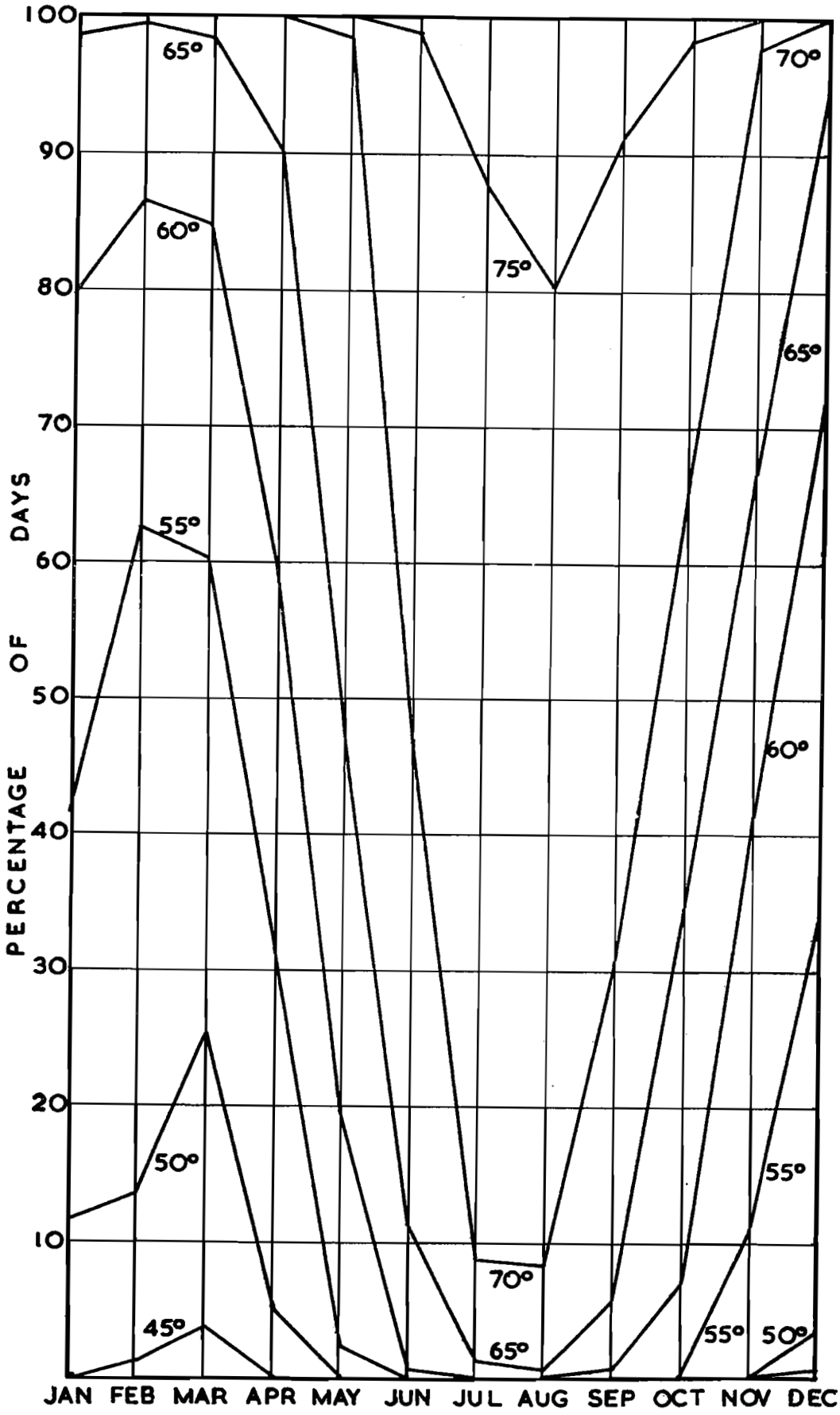

FIG. 11. Percentage of days each month on which lowest wet bulb temperature fell to value given or lower. — Hamilton.

did so on one-third of the days from December to April and occurred on 3 days out of 5 in February and March.

Wet bulb does not fall below 45°F. except on one day per month in March and once in 3 or 4 years in December and February.

19. HOURLY VALUES OF WET BULB

Table 12 gives the average number of hours each month with the wet bulb in each two degree range while in Fig. 12 a series of curves give the values of wet bulb reached in from 2% to 98% of the hours each month.

Degrees	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
41- .			0.2									
42- .		0.2	0.2									
43- .		1.0	3.2									
44- .		0.7	3.8									0.3
45- .		1.0	2.5									0.8
46- .	0.7	2.7	4.7									0.7
47- .	3.8	3.8	8.0									0.3
48- .	7.5	8.3	15	0.7								3.2
49- .	17	12	25	3.3								3.8
50- .	16	20	42	13								7.2
51- .	19	35	45	15							2.7	11
52- .	21	38	44	22							4.7	18
53- .	31	46	42	27	0.5						5.2	28
54- .	41	44	43	31	4.0						11	38
55- .	54	49	43	28	3.0					0.2	12	47
56- .	61	44	44	31	8.2					0.8	30	52
57- .	49	43	39	36	9.5					4.3	29	55
58- .	52	47	35	29	17				0.2	6.5	37	59
59- .	57	47	33	43	22	0.2			0.5	6.2	40	44
60- .	54	40	45	41	25	2.5			1.5	9.5	35	56
61- .	54	35	32	50	28	5.2			1.3	13	38	41
62- .	45	30	35	54	25	9.5	0.3		2.3	18	35	40
63- .	50	36	40	56	32	10	1.0	0.5	5.0	26	38	46
64- .	35	37	40	57	41	11	0.5	0.7	6.7	35	43	41
65- .	30	31	36	46	43	12	1.8	1.3	6.5	50	49	45
66- .	27	20	24	45	60	13	5.5	3.0	11	56	46	32
67- .	15	7.2	15	50	76	17	4.7	3.3	18	51	46	33
68- .	4.7	0.8	3.2	31	104	30	3.5	5.5	23	47	57	21
69- .	1.2		0.2	9.8	106	56	6.0	8.2	33	52	51	13
70- .				2.0	87	84	7.3	9.8	37	55	43	4.0
71- .					38	88	29	20	53	51	34	2.3
72- .					10	101	60	37	79	54	23	1.0
73- .					3.8	96	115	64	91	74	7.7	0.2
74- .						94	175	115	107	61	1.5	
75- .						70	158	195	109	44	•	
76- .						18	112	165	74	21		
77- .						1.7	45	85	47	5.7		
78- .							18	25	13			
79- .							1.5	4.5	0.7			
80- .								0.2				

TABLE 12. Average number of hours per month with Wet Bulb Temperature in range from value given to 0.9 degrees higher. Hamilton.

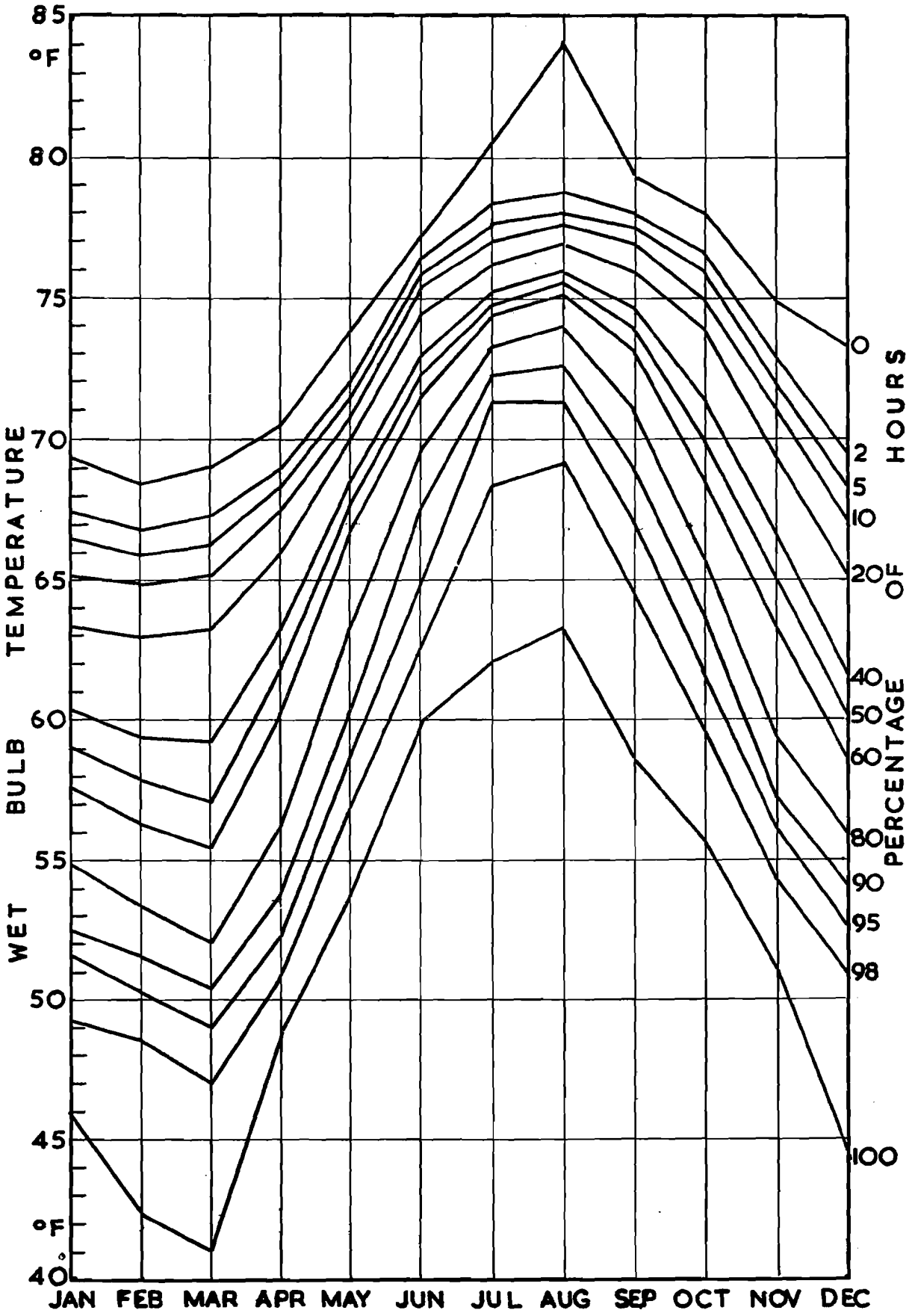

FIG. 12. Values of Wet Bulb Temperature reached or exceeded in 2, 5, 10, etc. per cent of hours each month. — Hamilton.

Both table and graph show that in summer there is a much greater concentration in a few values than in winter. Thus the central 20% of hours have a range of 3.8°F. in March from 55.4°F. to 59.2°F. but in July and August the range is only 0.8°F. from 74.4°F. to 75.2°F. and 75.1°F. to 75.9°F. respectively. In July and August 560 hours or approximately 78% of the time the wet bulb lies within 4°,73°-77° in July and 74°-78° in August, while in August half the hours lie in the two degree range from 75°-77°F. In March the central 50% of hours cover a range of 9°,50°-59°F. and the middle 80% a range of 15° from 50°-65°F.

20. MONTHLY MEAN VAPOUR PRESSURE AND DEW POINT

As any Dew Point has an exactly equivalent Vapour Pressure the two are considered together. Table 13 gives the average Vapour Pressure and Dew Point each month over the period at Fort George. The Vapour Pressure in

	VAPOUR PRESSURE				DEW POINT			
	Average at			24	Average at			24
	08	14	20	Hour Mean	08	14	20	Hour Mean
January	14.9	15.5	14.8	15.1	55.2	56.2	55.0	55.6
February	13.4	14.2	13.6	13.6	52.3	53.8	52.7	52.7
March	14.4	15.0	14.3	14.5	54.3	55.4	54.2	54.5
April	16.5	17.0	16.2	16.5	57.9	58.8	57.5	58.0
May	20.4	21.1	19.9	20.2	64.0	64.9	63.3	63.7
June	24.8	25.5	24.4	24.6	69.7	70.5	69.2	69.4
July	27.4	28.2	27.2	27.5	72.6	73.5	72.4	72.7
August	27.6	28.6	27.2	27.7	72.8	73.9	72.4	72.9
September	25.9	27.1	25.4	25.9	70.9	72.3	70.3	70.9
October	22.3	23.3	21.9	22.2	66.5	67.8	66.0	66.4
November	18.2	18.9	18.0	18.2	60.7	61.8	60.4	60.8
December	15.5	16.2	15.6	15.6	56.3	57.5	56.4	56.5

TABLE 13. Average Vapour Pressure and Dew Point at 08, 14 and 20 and 24 hour means at Fort George. Millibars and Degrees Fahrenheit.

summer is more than twice that in winter with the lowest monthly average of 3.6 millibars and 52.7°F. Dew Point in February and highest of 27.7 millibars and 72.9°F. Dew Point in August. The average in July is very close to that in August and September also averages over 25 millibars and 70°F. Dew Point while June is only slightly less. The average Dew Point is below 60°F. in the

5 winter months, December to April, and below 55°F. in February and March with Vapour Pressure below 15 millibars.

21. HIGHEST AND LOWEST VAPOUR PRESSURE AND DEW POINT OBSERVED IN EACH MONTH

The extremes observed at each separate station are given in Tables 14 and 15. It is seen that Vapour Pressure of 23 millibars (D.P. 68°F.) or more has been observed every month of the year, while in each of the 4 months, June to September, over 33 millibars (D.P. 78°F.) has occurred with the highest of 40 millibars (D.P. 84°F.) in September.

	Highest Vapour Pressure observed at:—				Highest at All Stations		
	Ft. George	Hamilton	Belmont	Darrell's	Vapour Pressure	Dew Point	Date
January	24.1	23.7	25.0	24.6	25.0	69.9	5/42
February	23.6	23.4	22.6	22.6	23.6	68.2	13/41
March	23.2	23.6	24.3	23.4	24.3	69.1	21/44
April	26.7	24.8	26.0	26.0	26.7	71.8	27/37
May	29.1	27.9	27.8	26.9	29.1	74.4	29/34
June	33.1	31.1	31.7	31.7	33.1	78.3	19/44
July	33.9	32.9	35.7	31.7	35.7	80.6	23/42
August	33.7	33.3	34.7	32.8	34.7	79.7	3/42
September	36.8	32.3	40.0	33.9	40.0	84.1	7/41
October	31.7	31.2	35.5	31.7	35.5	80.4	7/41
November	29.6	28.0	32.4	27.8	32.4	77.6	3/41
December	25.3	27.2	26.9	25.1	27.2	72.4	10/48

TABLE 14. Highest Vapour Pressure and Dew Point observed at any hour. Millibars and Degrees Fahrenheit.

This occurred at Belmont with a temperature of 86.0°F. and the highest recorded wet bulb of 84.6°F. at 2 p.m. on the 7th September, 1941. At the other extreme we see in Table 15 that Vapour Pressure below 15 millibars (D.P. 55°F.) has not been observed in July and August while less than 8 millibars (D.P. 38°F.) has been recorded in every month from November to April, with the lowest of 5.2 millibars (D.P. 28.5°F.) on February 24th, 1936, at Fort George.

22. DAILY MAXIMUM VAPOUR PRESSURE AND DEW POINT

Fig. 13 gives the percentage of days in each month on which the daily maximum Vapour Pressure reached specified values at Hamilton. The figure shows that in August a Vapour Pressure of 20 millibars is reached every day,

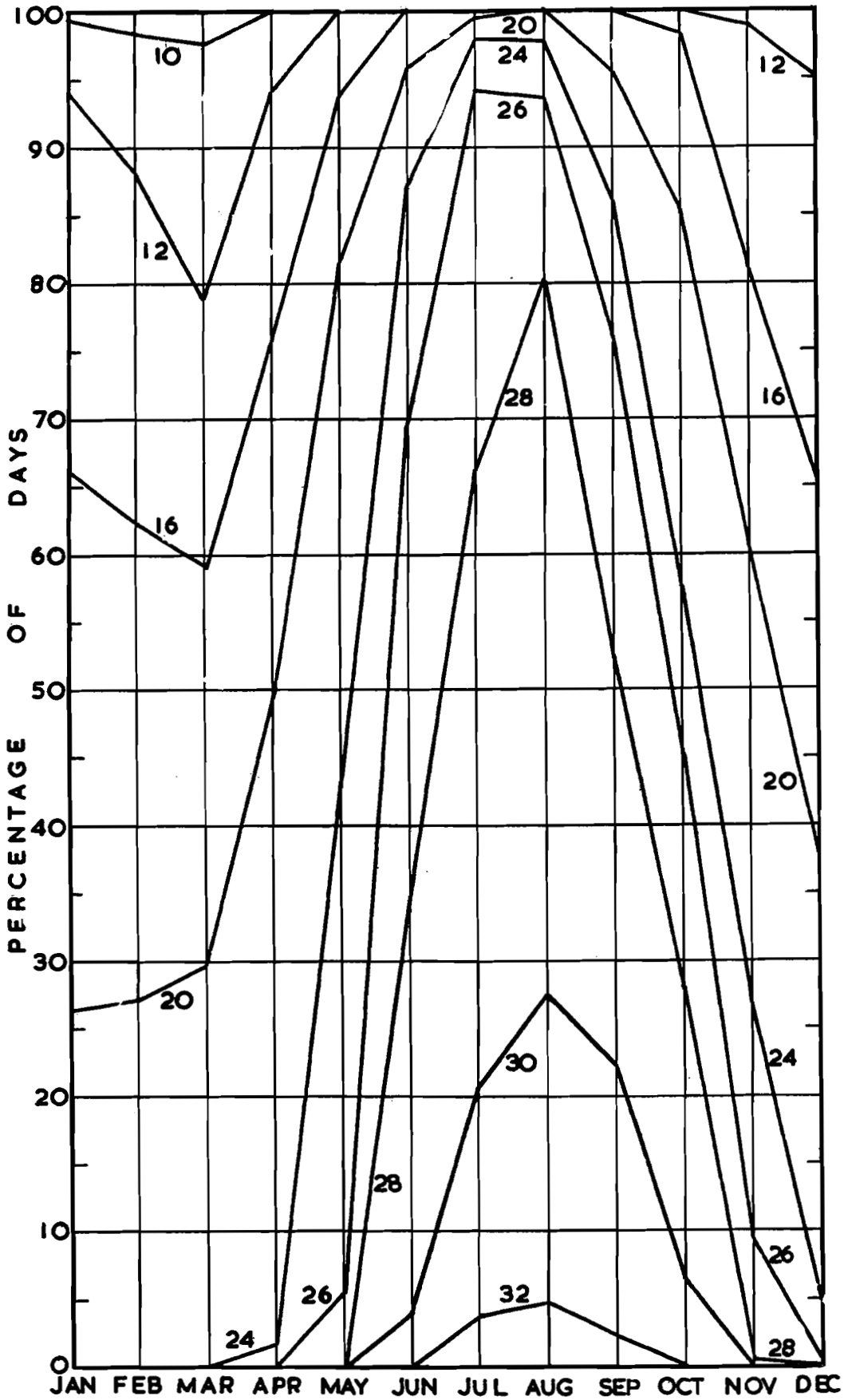

FIG. 13. Percentage of days each month on which highest vapour pressure rose to value given or higher in millibars. — Hamilton.

	Lowest Vapour Pressure observed at:—				Lowest at All Stations		
	Ft. George	Hamilton	Belmont	Darrell's	Vapour Pressure	Dew Point	Date
January	7.3	6.6	8.1	7.8	6.6	34.0	12/48
February	5.2	6.2	7.2	6.7	5.2	28.5	24/36
March	6.4	5.4	7.2	8.8	5.4	29.1	9/53
April	7.8	7.1	8.1	8.8	7.1	35.4	10/50
May	9.5	10.1	11.0	11.9	9.5	43.1	9/50
June	12.9	13.0	14.8	14.3	12.9	51.2	7/39
July	17.3	15.1	19.0	24.3	15.1	55.6	11/48
August	16.5	15.4	15.3	22.6	15.3	55.8	28/44
September	12.2	12.1	13.3	15.9	12.1	49.6	17/48
October	10.6	9.9	14.3	11.4	9.9	44.1	31/52
November	9.6	7.9	10.2	9.8	7.9	38.3	23/49
December	7.0	6.1	6.9	8.8	6.1	31.9	27/48

TABLE 15. Lowest Vapour Pressure and Dew Point observed at any hour. Millibars and Degrees Fahrenheit.

24 millibars every day except once in three years, 26 millibars on all but 2 days a month, 28 millibars on 4 days out of 5, 30 millibars on 1 day in 4 and 32 millibars on 1 or 2 days per month. In July and September the frequencies are only a little less than in August.

In March Vapour Pressure rises to 10 millibars on all but 1 day a month, reaches 12 millibars on 4 days out of 5,16 millibars on 3 days out of 5, 20 millibars on 1 day in 4 and does not reach 24 millibars on any day. In January and February Vapour Pressures up to 16 millibars occur more frequently than in March but the frequency of 20 and 24 millibars is about the same in all three months.

23. DAILY MINIMUM VAPOUR PRESSURE AND DEW POINT

Fig. 14 gives the percentage of days in each month on which the minimum Vapour Pressure observed was in specified values at Hamilton.

The figure shows that the Vapour Pressure falls below 28 millibars every day in the seven months, November to May, and even in July and August on 9 days out of 10.

At the other extreme a Vapour Pressure of 8 millibars has not been observed in the six months, May to October, and at its greatest frequency in March it occurs only on 1 day in 6.

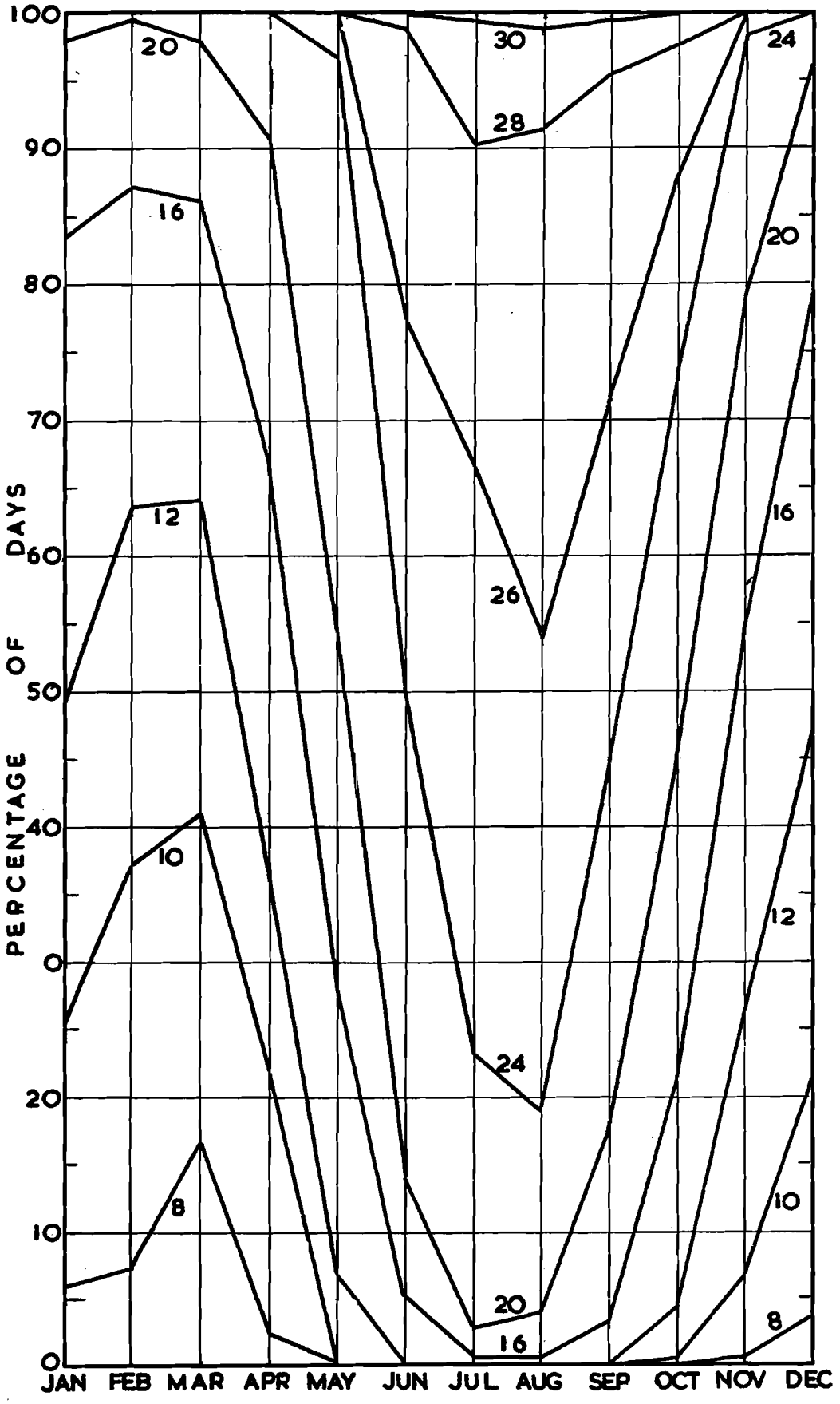

FIG. 14. Percentage of days each month on which lowest vapour pressure fell to value given or lower in millibars. — Hamilton.

At the height of the summer the Vapour Pressure fell to 16 millibars only once in the 6 years, to 20 millibars about once a month, to 24 millibars on one day in five and to 26 millibars on more than half the days.

In winter the Vapour Pressure falls below 20 millibars every day except once in 2 or 3 years. Less than 16 millibars occurs on nearly 9 days out of 10, 12 millibars on 3 days out of 5 and 10 millibars on 2 days out of 5.

24. FREQUENCY OF HOURS WITH GIVEN VAPOUR PRESSURE

Table 16 gives the average number of hours per month with the Vapour Pressure in each millibar range while Fig. 15 gives the average percentage of hours. In Fig. 15 the months are plotted in 5 groups which show similar characteristics.

In February and March which are the lowest point of winter the greatest frequency is of 9 to 10 millibars which occur about 10% of the time. There is a steep fall to near zero frequency for 5 millibars on the one side and a more gradual fall to 24 millibars on the other.

Millibars	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
5.0-			0.5									
6.0-	0.5	1	5									0.7
7.0-	4	8	21	1							0.2	4
8.0-	27	25	53	13							4	10
9.0-	40	57	76	29						0.2	8	30
10.0-	47	79	75	47	3					0.8	21	52
11.0-	61	70	67	55	12					6	39	72
12.0-	77	61	60	41	19				0.5	8	42	77
13.0-	80	50	51	37	23	0.7			2	11	50	67
14.0-	72	55	41	37	26	3			3	14	57	61
15.0-	60	50	43	45	30	10	0.5	0.5	5	24	47	51
16.0-	49	44	46	60	30	8	1	2	9	28	39	53
17.0-	53	38	41	59	32	14	1	3	8	37	39	47
18.0-	57	37	38	64	41	12	5	3	11	52	41	53
19.0-	44	45	48	47	39	10	3	3	15	53	54	39
20.0-	35	37	37	55	53	20	4	5	23	46	49	43
21.0-	21	16	29	49	74	30	6	7	29	51	39	38
22.0-	15	7	10	53	95	37	8	11	36	45	51	25
23.0-	3	0.8	2	24	117	55	17	17	36	50	47	14
24.0-				2	103	85	48	30	58	49	47	4
25.0-					39	95	105	50	84	48	29	3
26.0-					8	120	149	110	95	70	12	0.2
27.0-					1	94	154	165	111	60	4	0.2
28.0-						93	109	169	91	53	0.2	
29.0-						27	71	102	57	25		
30.0-						4	36	42	33	8		
31.0-						0.2	23	17	13	0.2		
32.0-							3	4	1			
33.0-								0.2				

TABLE 16. Average number of hours per month with Vapour Pressure at Hamilton in limits from values stated to 0.9 millibars higher.

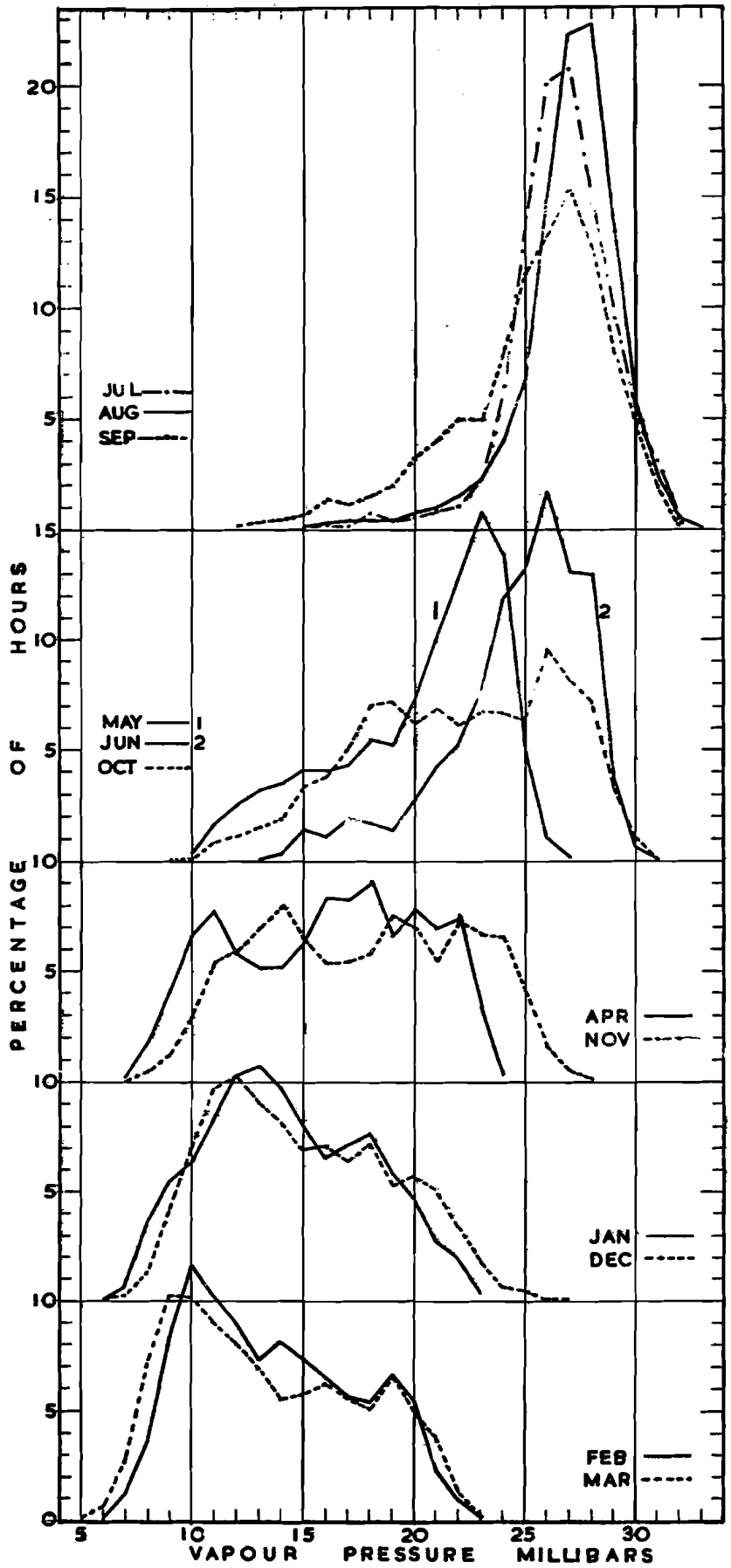

FIG. 15. Percentage of hours each month with vapour pressure from 5-5.9, 6-6.9 millibars, etc. — Hamilton.

December and January show a similar distribution but the maximum lies about 12 and 13 millibars and the extremes are slightly higher than in February and March.

April and November are transition months where the winter distribution is changing to the summer type and conversely. There is no well marked maximum and values from 11 to 23 millibars are about equally frequent, each occurring in 6 to 8% of the hours. There are sharp decreases in frequency at each end giving a total range from 7 to 28 millibars in November and 7 to 24 millibars in April.

The remaining months all show a distribution the reverse of that in winter. There is a maximum frequency in high values of Vapour Pressure with a rapid fall to the highest Vapour Pressure observed and a much more gradual decrease to the lowest. At the height of summer, in July and August, a large percentage of hours have Vapour Pressure in a very limited range. Almost half the hours in August have Vapour Pressure between 27.0 and 28.9 millibars while three-quarters of the hours in both July and August are included in a range of 4 millibars.

June and September have a similar distribution to July and August but the peak of frequency is not so marked with the greatest frequency of 15 to 16% of occasions at 26 and 27 millibars respectively.

October has its maximum frequency at 26 millibars with 9% of the hours but the maximum is not sharp and each interval from 18 to 28 millibars occurs in about 7% of the hours so that October shows perhaps most similarity to April and November.

May is rather an isolated month with a fairly sharp maximum frequency of 15% of hours at 23 millibars the slope being similar to June and September but the peak an appreciably lower value than these other two months.

Fig. 16 gives the frequency distribution by curves which show the values of Vapour Pressure and Dew Point reached or exceeded in 2, 5, 10, 20, etc. per cent of the hours in each month. The curves show that in July and August 98% of hours have Vapour Pressure of 20 millibars or above while only 2% have 31 millibars or above. In March 98% have 7 millibars or above and 2% have 22 millibars or above. The curves show that while the lowest values are more frequent in March than other winter months the top 40% of hours has slightly higher values in March than in February.

25. MOISTURE CONTENT OF THE AIR

Table 17 gives the average moisture content at Fort George calculated from the Daily 24 hour Mean Vapour Pressure and temperature for each month. The values as calculated are in grams per cubic metre but owing to the relation between the English and metric units it so happens that one gram per cubic metre is closely equivalent to one ounce per 1000 cubic feet.

We see that there is twice as much water vapour in the air in summer as in winter with a range from 10 ounces per 1,000 cu. ft. in February to 20 ounces in July and August. From June to October the average is over one pound.

There has been over one pound on individual occasions in every month of the year and a content of over 20 ounces has been observed in each month from May to November with the greatest of 26.2 ounces in September.

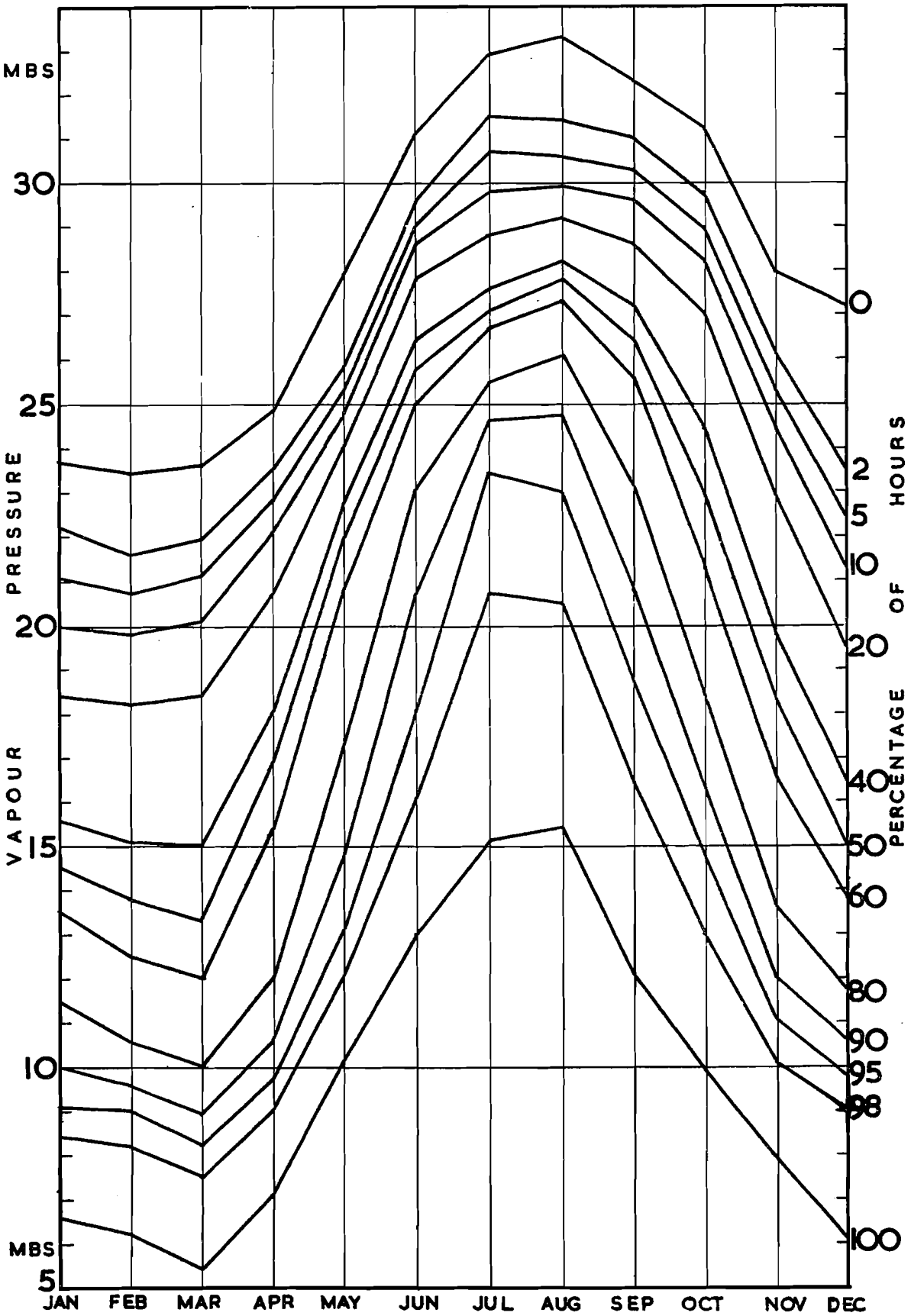

FIG. 16. Values of Vapour Pressure reached or exceeded in 2, 5, 10, etc. per cent of hours each month. — Hamilton.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Monthly Mean.....	11.3	10.2	10.8	12.3	15.0	17.9	20.0	20.0	18.8	16.2	13.4	11.6
Highest observed.....	17.8	17.0	17.2	19.4	20.9	23.8	24.1	23.9	26.2	22.8	21.5	18.6
Lowest observed.....	5.5	4.1	4.8	5.9	7.1	9.5	12.7	9.9	9.0	7.9	7.2	5.3

TABLE 17. Moisture content in grams per cubic metre and ounces per 1000 cu. ft. at Fort George.

A content of less than 8 ounces per 1,000 cu. ft. has been observed in each month from October to May with less than 5 ounces in February and March. The lowest content recorded is 4.1 ounces per 1,000 cu.ft. on 24th February, 1936. In July the lowest content is 12.7 ounces, more than the average winter value.

All these values are high by comparison with England where the water vapour content at each season is about half that in Bermuda. Thus although the average Relative Humidity of 75% in January in Bermuda is 10% less than that in London there is more than twice as much water vapour in Bermuda with 11.3 ounces per 1000 cubic feet compared with 5.3 in London. Similarly in July there are 20 ounces in Bermuda and only 10.6 in London.

26. VARIATION OF HUMIDITY WITH WIND DIRECTION

Table 18 gives the wind directions which have, on the average, the highest and lowest relative humidity and Dew Point. The table is based on 8 a.m. observations at Fort George during the last five years and gives the average values from the particular directions.

In general highest humidities occur with winds between South East and South West and lowest with North East to North West. The greatest differences with wind direction are in March where the Northerly wind has a Dew Point 14°F. and a Relative Humidity 19% less than the Southerly.

	Relative Humidity			Dew Point		
	Highest	Lowest	Difference	Highest	Lowest	Difference
January.....	S 79	N 67	12	S 58	N 50	8
February.....	S 79	W 66	13	S 58	NW 45	13
March.....	S, SW 80	N 61	19	S 59	N 45	14
April.....	S 81	N 64	17	S 62	NW 50	12
May.....	SE, S 82	N 66	16	S 67	N 56	11
June.....	SE 87	N 69	18	SW 70	N, NE 64	6
July.....	S 79	NE 66	13	N, E, S 72	NE 67	5
August.....	SW 78	NE 68	10	S, SW, W 73	NE 68	5
September.....	SW 79	N 72	7	SE, S 72	N 66	6
October.....	W 83	NW 68	15	S 71	NW 60	11
November.....	S 84	N 65	19	SE, S 66	N, NW 55	11
December.....	S 80	NW 62	18	S 61	NW 50	11

TABLE 18. Wind Directions which give the highest and lowest Relative Humidities and Dew Point and average humidities at these directions at 8 a.m. 1948-1953 at Fort George.

September shows the smallest differences with only 6°F. in Dew Point and 7% in Relative Humidity between the extremes.

In July and August there is very little variation of Dew Point with wind direction except for the small drop with North East wind. The largest differences are in February, March and April where there is 12-14°F. between the Dew Points with Southerly and with Northerly or North Westerly winds.

The wind with the highest Relative Humidity is Southerly from November to May and also in July while the lowest Relative Humidity is with Northerly winds in 7 months and in no month is the Relative Humidity with Northerly much above the lowest for the month.

The summer months do not show the steady high values of Relative Humidity over a wide band of wind directions as is the case with Dew Point. In June the Relative Humidity rises to a sharp maximum with South East winds and has an almost equally sharp minimum with Northerly. From March to June and October to December there is a difference of at least 15% Relative Humidity between the wettest and driest winds in each month.

27. COMPARISON OF FORT GEORGE AND HAMILTON

Table 19 compares the two stations at which most of the observations discussed in this paper were taken. It gives the differences Hamilton minus Fort George of the average Relative Humidity and Dew Point for each of the three hours of observation at Fort George over the six-year period when both stations were in operation.

	Relative Humidity				Dew Point			
	0800	1400	2000	Mean	0800	1400	2000	Mean
January	−0.4	+0.3	+0.2	0.0	+0.8	−0.1	+1.3	+0.7
February	−0.6	−0.2	+0.2	−0.2	+0.9	−0.4	+1.4	+0.6
March	−0.7	+0.7	+0.4	+0.1	+0.7	−0.4	+1.4	+0.6
April	+1.7	+2.0	+1.3	+1.7	+1.0	−0.2	+1.7	+0.8
May	+3.2	+3.9	+3.0	+3.4	+1.0	+0.2	+2.3	+1.2
June	+4.0	+3.3	+2.7	+3.3	+1.1	0.0	+1.8	+1.0
July	+3.1	+2.7	+0.3	+2.0	+0.8	−0.5	+1.3	+0.5
August	+1.7	+1.4	+0.1	+1.1	+0.5	−0.5	+1.3	+0.4
September	+1.3	+1.4	−1.0	+0.6	+0.5	−0.8	+0.9	+0.2
October	−0.6	−0.4	−0.4	−0.5	+0.2	−1.2	+1.1	+0.1
November	−0.8	−0.4	−0.3	−0.5	+0.4	−0.6	+1.0	+0.3
December	−0.5	−0.7	−0.7	−0.6	+0.8	−0.2	+1.0	+0.5

TABLE 19. Comparison of Fort George and Hamilton, September, 1947-August, 1953. Figures give the difference, Hamilton average minus Fort George average.

In all months the mean Dew Point is higher at Hamilton but the differences are small and reach one degree in only two months, May and June. Hamilton is usually the higher at both 8 a.m. and 8 p.m., the difference being larger at 8 p.m. but at 2 p.m. Hamilton has slightly lower values than Fort George, except in May and June.

In the case of Relative Humidity there is very close agreement in January, February and March. Values rise more in Hamilton than Fort George in April and May and the five months April to August each show a difference of at least one per cent with over 3% in May and June. The difference decreases in September, changes sign in October and in the last three months of the year the Relative Humidity is higher at Fort George but only by less than one per cent.

It is seen therefore that with regard to absolute water vapour content, as indicated by the Dew Point, observations at the two stations are in close agreement.

The stations are also closely comparable in regard to Relative Humidity from September to March and only in early summer are noticeable differences at all likely.

I have to thank my wife and Mr. S. G. Hirst for assistance in extracting and checking the data on which this note is based.

Meteorological Office,
Hamilton,
Bermuda.
February, 1954.

APPENDIX 1

Monthly Mean Relative Humidity — Fort George

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Years Mean
1932				80.7	79.7	84.3	82.1	79.5	69.1	74.1	78.6	75.2	
1933	78.6	73.2	73.6	77.7	80.2	81.1	81.1	84.6	80.5	77.3	73.9	76.2	78.2
1934	80.0	74.4	79.6	83.7	83.5	80.6	81.4	82.1	79.5	76.2	72.0	73.6	78.9
1935	73.4	77.6	75.0	76.8	81.3	81.6	82.1	85.9	82.0	80.5	81.3	72.2	79.2
1936	77.2	78.4	76.3	80.3	82.6	86.9	81.6	78.5	81.7	79.9	75.4	77.5	79.7
1937	81.1	73.8	77.9	78.2	83.7	83.9	80.6	76.4	81.7	74.4	72.0	77.8	78.5
1938	79.7	74.0	75.5	79.3	82.2	83.3	82.6	75.8	80.6	78.3	77.8	72.9	78.5
1939	72.0	70.9	77.0	77.2	79.5	77.0	80.7	79.0	78.7	75.9	73.8	72.2	76.2
1940	71.5	71.5	74.7	72.3	83.2	81.5	80.7	75.9	79.5	77.4	72.5	78.4	76.6
1941	73.8	75.7	73.0	75.1	77.2	81.7	76.1	79.4	76.0	72.7	79.7	72.6	76.1
1942	76.6	73.1	73.6	75.2	82.2	84.2	83.0	77.1	79.4	81.5	73.6	73.2	77.7
1943	79.0	73.5	77.4	77.3	78.4	78.9	77.5	81.3	81.1	82.4	73.8	76.5	78.1
1944	75.2	75.8	79.4	76.9	80.0	86.9	84.1	77.5	78.0	72.7	72.1	78.7	78.1
1945	74.6	72.6	78.0	80.1	75.8	79.8	76.7	76.6	78.9	78.9	74.8	72.9	76.6
1946	77.4	68.9	78.0	74.0	81.5	77.6	84.2	82.2	78.7	77.5	72.9	75.6	77.4
1947	82.0	69.9	73.0	78.3	79.4	85.1	77.5	77.9	76.1	77.3	74.6	74.5	77.1
1948	77.4	74.4	78.1	74.7	83.2	83.3	80.8	80.9	77.8	76.9	79.8	74.6	78.5
1949	72.9	74.3	72.3	73.9	78.3	79.6	75.6	76.1	78.6	72.6	72.6	69.4	74.7
1950	72.3	68.3	70.1	71.3	77.1	80.3	72.8	75.3	77.8	77.2	70.4	69.3	73.5
1951	71.1	70.0	64.3	72.4	79.9	79.0	78.6	73.9	76.1	75.3	74.1	71.3	73.
1952	69.0	65.8	70.5	75.4	73.2	81.4	76.7	72.7	72.4	77.4	63.7	64.1	71.9
1953	67.7	69.1	66.5	72.4	76.3	81.4	76.0	76.7	77.2	73.7	68.6	71.2	73.1

APPENDIX 2

Mean Relative Humidity — Belmont Manor — 1941-1944

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0200	81.2	76.0	80.5	83.6	87.0	91.4	89.2	87.4	90.2	86.2	82.3	78.8
0500	80.6	75.4	78.9	83.6	87.9	91.7	89.2	88.0	89.6	86.3	83.4	77.6
0800	80.2	76.1	76.6	77.1	78.6	82.4	80.8	78.5	82.5	82.7	82.6	77.6
1100	72.5	70.2	70.4	70.7	73.9	77.8	76.4	73.4	77.4	76.6	73.4	70.2
1400	70.8	67.8	70.3	70.4	72.8	76.1	75.0	71.6	75.5	76.0	72.9	69.9
1700	76.2	71.6	74.1	72.9	74.7	78.4	75.9	74.3	78.8	80.0	78.2	74.0
2000	80.6	76.8	80.3	81.6	85.0	86.9	86.0	85.2	86.9	84.3	82.7	77.7
2300	80.6	76.8	80.7	83.0	87.0	90.7	88.3	87.5	89.5	85.5	82.5	78.8

APPENDIX 3

Extreme Observations at Prospect Camp, 1891-1932, Except for 1921

Observations of humidity were made at Prospect Camp from 1891 to 1932 but it has not been possible to check the readings and computations.

However, the extreme values in the records have been extracted and the individual calculations checked. These extremes are given in the table below.

	WET BULB				RELATIVE HUMIDITY		VAPOUR PRESSURE				DEW POINT	
	Max.	Year	Min.	Year	Min.	Year	Max.	Year	Min.	Year	Max.	Min.
January	75.8	1930	43.0	1904	46	1925	30.0	1930	7.3	1892	75	36
February	73.5	1932	45.0	1923	35	1923	27.9	1932	5.5	1923	73	29
March	71.9	1932	45.0	1926	41	1910	26.3	1932	7.3	1893	71	36
April	75.7	1914	47.3	1906	41	1910	29.9	1914	7.4	1922	75	36
May	79.4	1929	50.3	1920	43	1920	33.6	1929	8.9	1897	79	41
June	82.6	1928	56.6	1902	52	1926	37.4	1928	12.1	1902	82	49
July	86.4	1931	62.6	1919	59	1900	42.1	1931	15.8	1919	86	57
August	86.4	1931	64.0	1925	50	1927	41.5	1930	16.9	1925	85	59
September	88.7	1931	60.6	1923	53	1920	45.0	1931	14.1	1923	88	54
October	83.6	1929	55.7	1909	50	1922 1923	38.0	1929	11.5	1909	83	48
November	78.2	1929	50.1	1928	46	1922	32.4	1929	8.9	1898	78	41
December	74.9	1929	47.7	1925	42	1924	28.7	1929	7.5	1924	74	37

It will be seen that in all months the highest values are above those given in Table 10 for other stations and the differences are in some cases considerable especially in the summer months. It is thought that these high values are unreliable because:—

(a) The records show that the apparently competent observer who was at the station for some years left early in 1929 and the records are unsigned after the latter part of the year. For 10 months of the year the highest observations in the record were taken by this new observer between 1929 and 1932.

(b) On many days in this period especially in the summer when there has been no indication of rain or frontal activity the recorded figures give a higher Relative Humidity in mid-afternoon than at morning or evening.

This was the case on 25th September, 1931, when the wet bulb of 88.7°F. was recorded at 3 p.m. giving with the dry bulb of 91.6°F. a vapour pressure of 45 millibars and a Relative Humidity of 89%. At 8 a.m. on that day the air temperature was 83.0°F., the wet bulb was 79.8°F., vapour pressure 33 millibars and the Relative Humidity 86%.

The change in vapour pressure is much greater than normal and the change in Relative Humidity is of opposite sign to the normal diurnal variation. There is nothing in the other elements to suggest any change of air mass.

Evaporation is rapid in summer and it is necessary to fill the wet bulb water container almost daily. It is possible that this was done at the afternoon reading at Prospect and the observer did not wait a sufficient time after wetting the bulb before taking his readings. The water being at air temperature would therefore give an unduly high reading on the wet bulb.

APPENDIX 4

Dew Point Equivalents in Degrees Fahrenheit of Vapour Pressures in Millibars and Inches

Mbs.	Ins.	DP	Mbs.	Ins.	DP	Mbs.	Ins.	DP	Mbs.	Ins.	DP
5	.148	27.3	15	.443	55.4	25	.738	69.9	35	1.033	80.0
6	.178	31.5	16	.473	57.2	26	.768	71.1	36	1.063	80.9
7	.207	35.1	17	.502	58.9	27	.797	72.2	37	1.093	81.7
8	.236	38.7	18	.531	60.5	28	.827	73.3	38	1.122	82.5
9	.266	41.6	19	.561	62.0	29	.856	74.3	39	1.152	83.3
10	.295	44.5	20	.591	63.4	30	.886	75.3	40	1.181	84.1
11	.325	47.0	21	.620	64.8	31	.915	76.3	41	1.211	84.9
12	.354	49.3	22	.650	66.2	32	.945	77.3	42	1.240	85.6
13	.384	51.5	23	.679	67.5	33	.974	78.2	43	1.270	86.4
14	.413	53.5	24	.709	68.7	34	1.004	79.1	44	1.300	87.1

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