ROYAL OBSERVATORY, HONG KONG.

TECHNICAL NOTES NO. 5.

UPPER WINDS DETERMINED BY RADAR 1949 TO 1951.

JANUARY, 1953.

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INTRODUCTION.

Since December, 1949, balloon-borne radar reflectors have been released from the Royal Observatory daily at 8 a.m. local time (2300 G.M.T. in summer, 0000 G.M.T. in winter), and tracked by radar for the purpose of determining the winds in the upper atmosphere. Upper winds were previously determined at the Observatory by pilot balloon and single theodolite; this method has three disadvantages:-

(1) The balloon cannot be followed on cloudy days.

(2) With increase in height fewer and fewer cases of strong winds are found owing to the disappearance of the balloon in the distance.

(3) The necessary assumption of the constant rate of ascent of the balloon gives rise to errors in the computed winds which may occasionally be large.

A balloon carrying a suitable reflector can be followed by 10 cm. radar, however, through all but the heaviest of rain clouds and to greater distances than is possible by theodolite. It is only above the 30,000' level that the balloon, on occasions of exceptionally strong winds, passes out of range of the radar set. Furthermore, it is no longer necessary to assume a constant rate of ascent since the height of the balloon is readily determined from the radar observations.

Previous wind-roses for Hong Kong were prepared from winds found by pilot balloon and single theodolite during the 11 years, 1921-32; it follows that these wind-roses are not representative of local conditions in so far as they exclude occasions of strong winds in the upper levels and winds prevailing on cloudy days. It was desirable, therefore, that more representative wind-roses should be prepared from the radar wind observations as soon as possible; to this end provisional roses have been prepared from the results of the first 2 years soundings, December, 1949, to November, 1951. These will be revised when a longer run of soundings becomes available. It is interesting to note that for levels above 14,000ft. more winds have been found in 2 years of radar observations than were obtained in 11 years by pilot balloon.

METHOD OF OBSERVATION.

An Umbrawin Sucal Mesh tetrahedral corner reflector of 4'6" hypotenuse was attached to the radio-sonde balloon which was filled with hydrogen to give a rate of ascent of approximately 1,200 ft/m. The target was located and followed by an Army radar set, to a range limit of 36,000 yds. Readings of the angle of elevation of the target from the radar set were taken at minute intervals. Readings of bearing (azimuth) and slant range were taken at ten and five seconds before and after the minute respectively. The two readings of bearing and of range were meaned to get a close approximation to the true value of these parameters at the minute. This procedure was adopted because it is impossible for one observer to read three continuously moving pointers simultaneously.

From the three parameters-slant range, angle of elevation and angle of azimuth - the plan position of the balloon at minute intervals was calculated and plotted on a radial co-ordinate chart; the track was then smoothed if necessary to remove random errors.

Winds at given heights are required for the preparation of wind-roses. The time at which the balloon reached a given height was determined from the time/height curve obtained from the radio-sonde readings. / On the few occasions when the radio-sonde was not flown with a radar target, the height of the balloon was calculated from the slant range and angle of elevation.

Mean winds were next found, over two or three minute intervals (approx. 2,400ft. or 3,600ft.) such that the mid-points in time were most nearly the instants at which the balloon attained the required heights.

On Sundays and Public Holidays, the radar set was not available, but the radio-sonde balloon was followed as far as possible by theodolite. The height of the balloon was determined from the radio-sonde data, and this height was used in the computation of the winds. These radio-sonde/theodolite winds have been incorporated in the wind-roses.

With a slant range of 36,000 yds and a rate of ascent of 1,200ft/min. it should be possible to follow the balloon to a height of 30,000ft if the average wind is less than 41 knots. During the two years of soundings the balloon was blown out of range before attaining 30,000ft on three occasions only. On two of these soundings, the rate of ascent was below normal; and on the third ocaasion (June 20th, 1951) the balloon was blown out of range at a height of 25,000' when the average wind to this height was 58 knots. During the months December to April inclusive, approximately 10% of the balloons are carried out of radar range at heights between 30,000ft and 38,000ft.

WIND-ROSES.

Monthly wind-roses have been drawn for eleven heights between 1,000' and 38,000', the actual values were chosen so as to be directly comparable as far as possible with earlier Hong Kong wind-roses. The form of the roses is the same as those appearing in the "Upper Winds of Hong Kong" (1) also reproduced in "Meteorological Information for Aviation Purposes, 1948" (2).

The speed ranges given in earlier publications in Beaufort force have been retained, using the equivalent in knots. The upper limit of Beaufort Force 6 has been taken as 27 knots.

DETAILED WIND-ROSES FOR 15,000, 22,000 and 30,000 ft.

For the information of airline operators, winds greater than 27 knots at the levels 15,000, 22,000 and 30,000 feet have been further analysed with regard to wind speed; 27 roses have been printed with the additional speed ranges 28-49, 50-69, 70-89 and greater than 90 knots and in addition the maximum wind speed observed during the two years is shown in printed figures against the appropriate compass point on each rose. Roses for June, July and August have not been prepared since only on one occasion (June 20th, 1951) was a wind greater than 49 knots observed, and that was attributed to a tropical storm some 300 miles to the WSW of the Colony.

It can be seen that, from May to September inclusive, winds greater than 49 knots are seldom encountered. It must be remembered, however, that typhoon or tropical storm winds during this period are mostly excluded from the records by the practice of dismantling the radar set when local storm warnings are hoisted.

During the winter months the upper W'lies blow with great regularity and increase in strength with height up to 30,000 ft. Detailed roses for heights above 30,000 ft. were not prepared, for the observations are non-representative at these heights owing to the fact that balloons were blown out of range on occasions of strong winds. The upper W'lies are strongest during the months January, February and March and above 15,000 ft. seldom have a speed of less than 27 knots during these months.

SOME COMPARISONS BETWEEN THE RADAR WIND AND PILOT BALLOON ROSES.

The advantage of the radar wind-roses over those obtained from pilot balloon ascents is demonstrated by the larger number of observations above 14,000ft. Furthermore, these observations are fully representative to 38,000ft during the summer months and to 30,000ft in the winter. The radar wind-roses show a greater percentage of strong winds at higher levels than is shown by the pilot balloon roses because of the limited range of visual tracking.

On account of the extreme cloudiness usually experienced in April, and the consequent restriction on pilot balloon ascents, it has previously been impossible to prepare wind-roses for heights above 10,000' for this month. It can be seen, however, that the radar wind-roses for April show no abnormalities; westerly components are first found at about 4,000ft and above that height the westerlies increase steadily in speed. It is interesting to observe that westerlies as strong as 27 knots do not appear in the pilot balloon roses for 10,000ft, but that 45% of the radar winds were greater than 27 knots at this height. Similarly at 7,000ft, 22% of the radar winds were stronger than 27 knots. This suggests that in April, with strong upper westerlies, the cloud base and amount are frequently such as to preclude following a balloon visually above 5,000ft.

The prevailing wind during June, July and August in the lower levels is southwesterly; this is shown much more clearly by the radar wind-roses than by the pilot balloon roses. For instance the winds at 3,000ft coming from the three points WSW, SW, or SSW during June, July and August are 38%, 47% and 52% of the total respectively, whereas from pilot balloon winds the percentages are 25, 30 and 20.

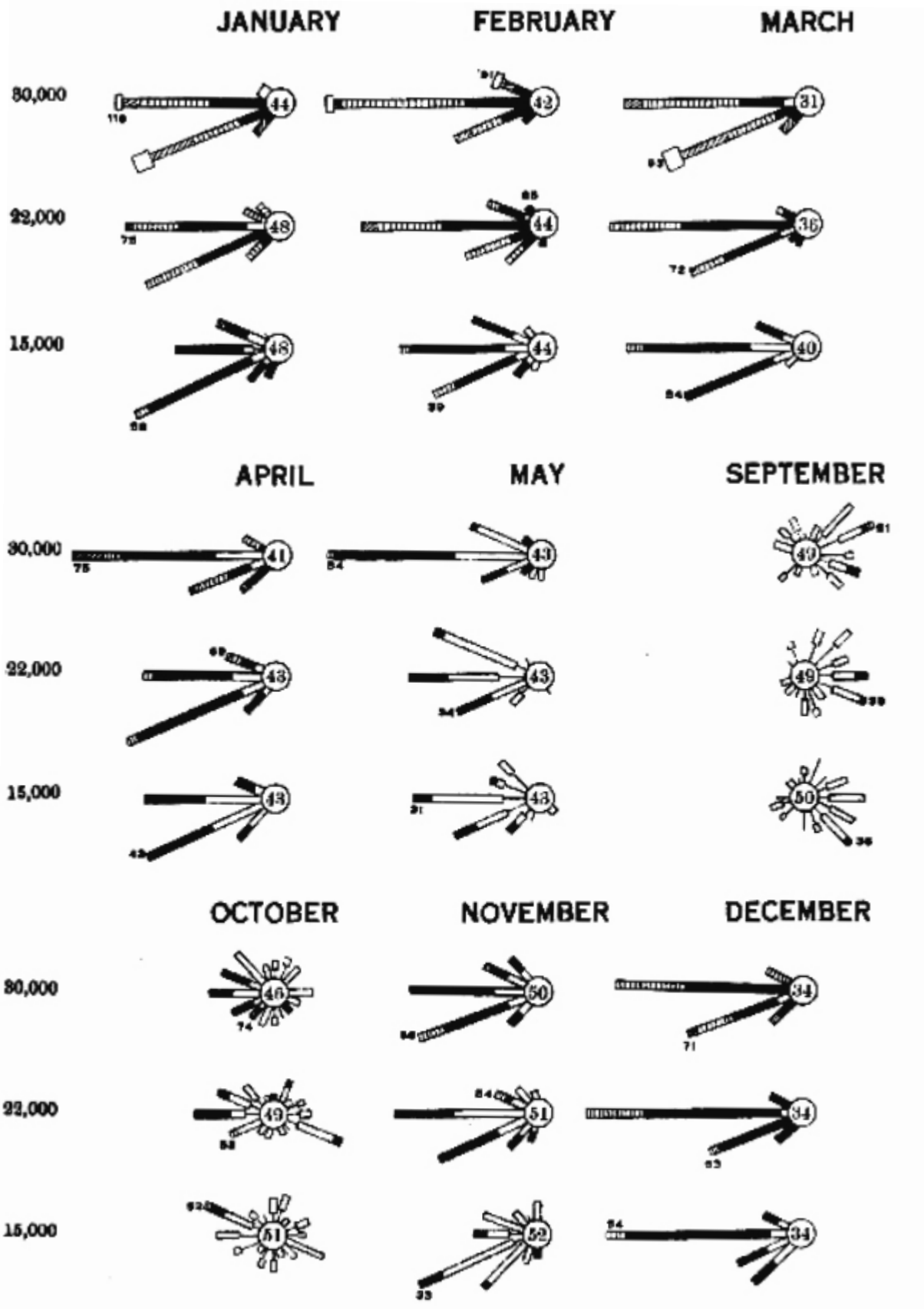
The radar wind-roses show that the upper easterlies of mid-summer are first found at 34,000ft and above in June, and that they extend downwards to 22,000ft during July and August. The older roses however, showed easterlies as the prevailing winds at 16,000ft and above as early as June. This suggests that the cloud conditions usually associated with westerly winds in June make it difficult to follow balloons visually to great heights, thereby giving undue weight to the observed easterly winds.

G.J. BELL.
LUK HUNG KWAI.
1st January, 1953.

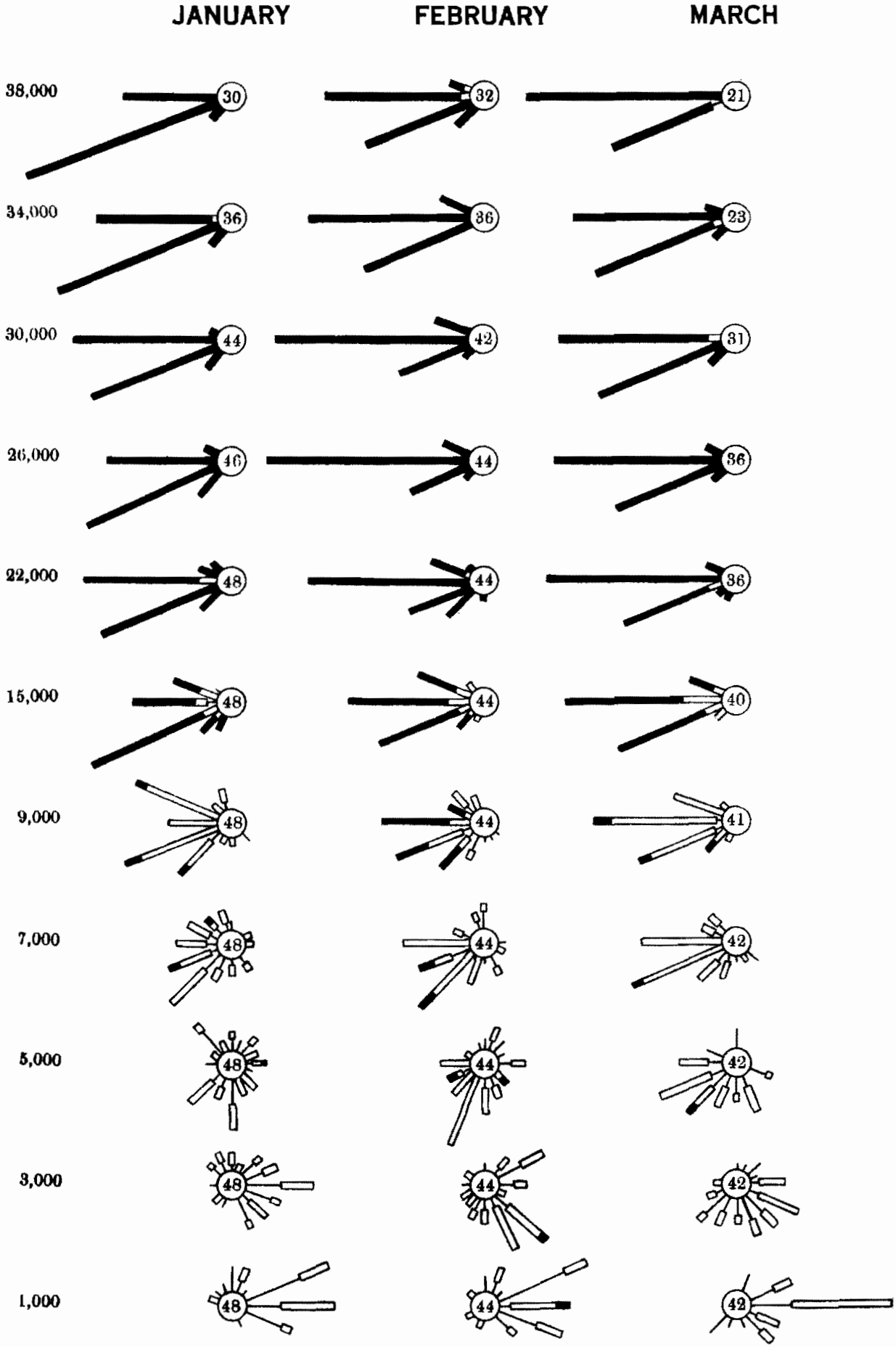
References.

(1) The Upper Winds of Hong Kong, G.S.P. Heywood, Royal Observatory, Hong Kong, 1933.

(2) Meteorological Information for Aviation Purposes, Royal Observatory, Hong Kong, 1948.



THE GREATEST OBSERVED WIND SPEED IS MARKED IN FIGURES AGAINST THE CORRESPONDING COMPASS POINT ON EACH WIND ROSE.


JANUARY
FEBRUARY
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5,000
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SCALE —
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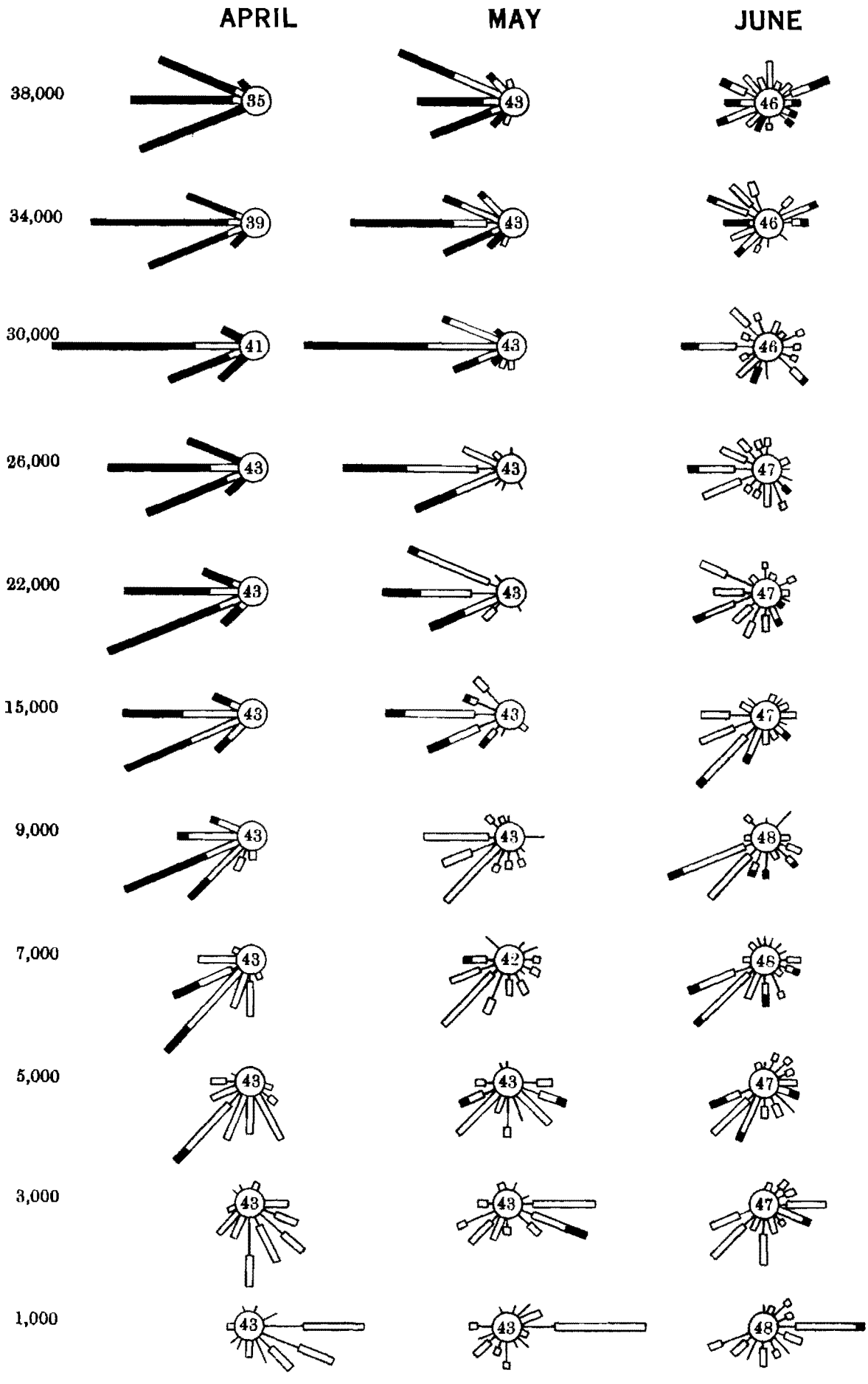
11–27
>27
PERCENTAGE FREQUENCY
SPEED IN KNOTS
NUMER OF OBSERVATIONS
ENTERED IN CIRCLE.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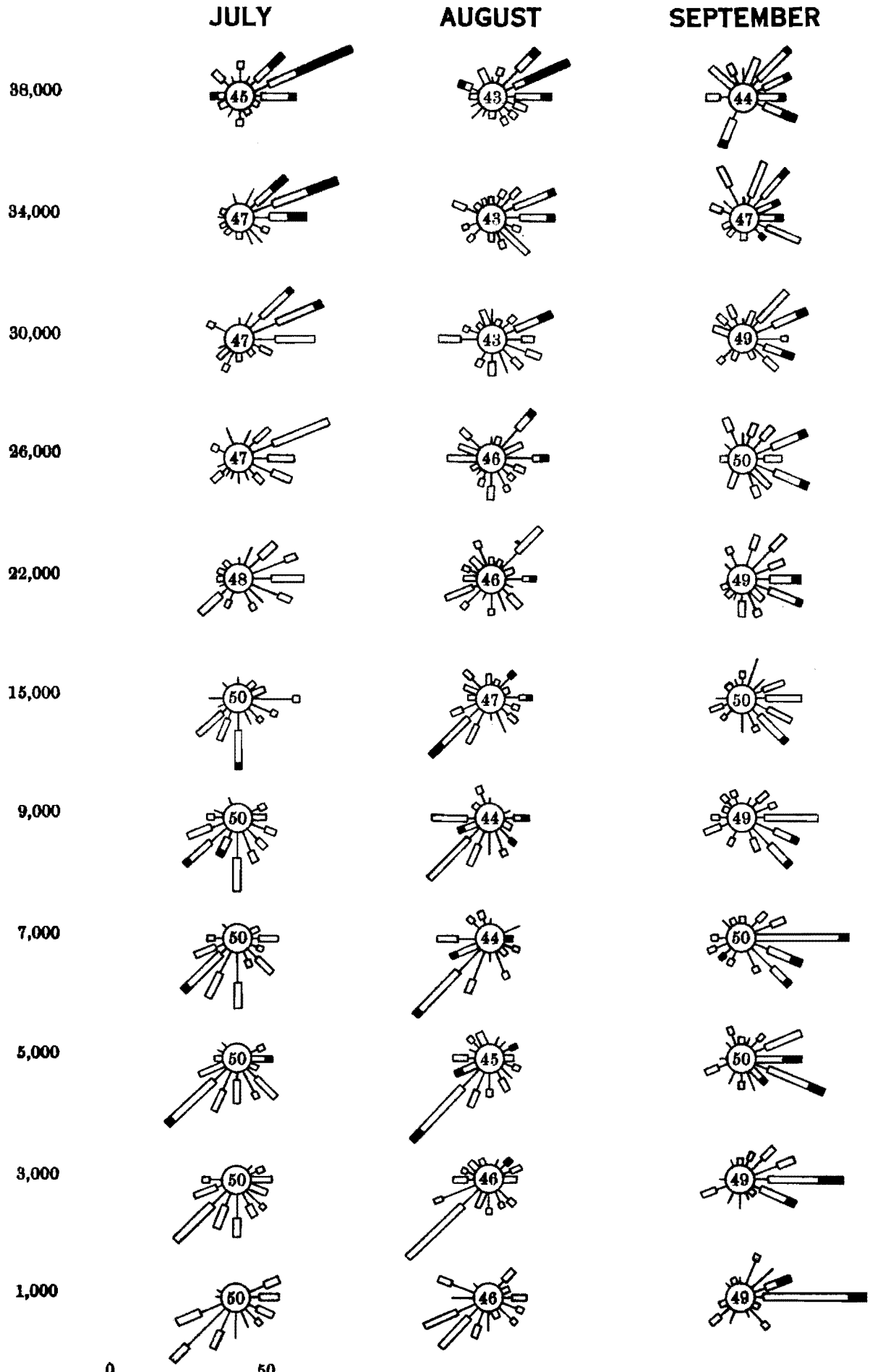
PERCENTAGE FREQUENCY
SPEED IN KNOTS
NUMER OF OBSERVATIONS
ENTERED IN CIRCLE.


JULY
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SCALE —
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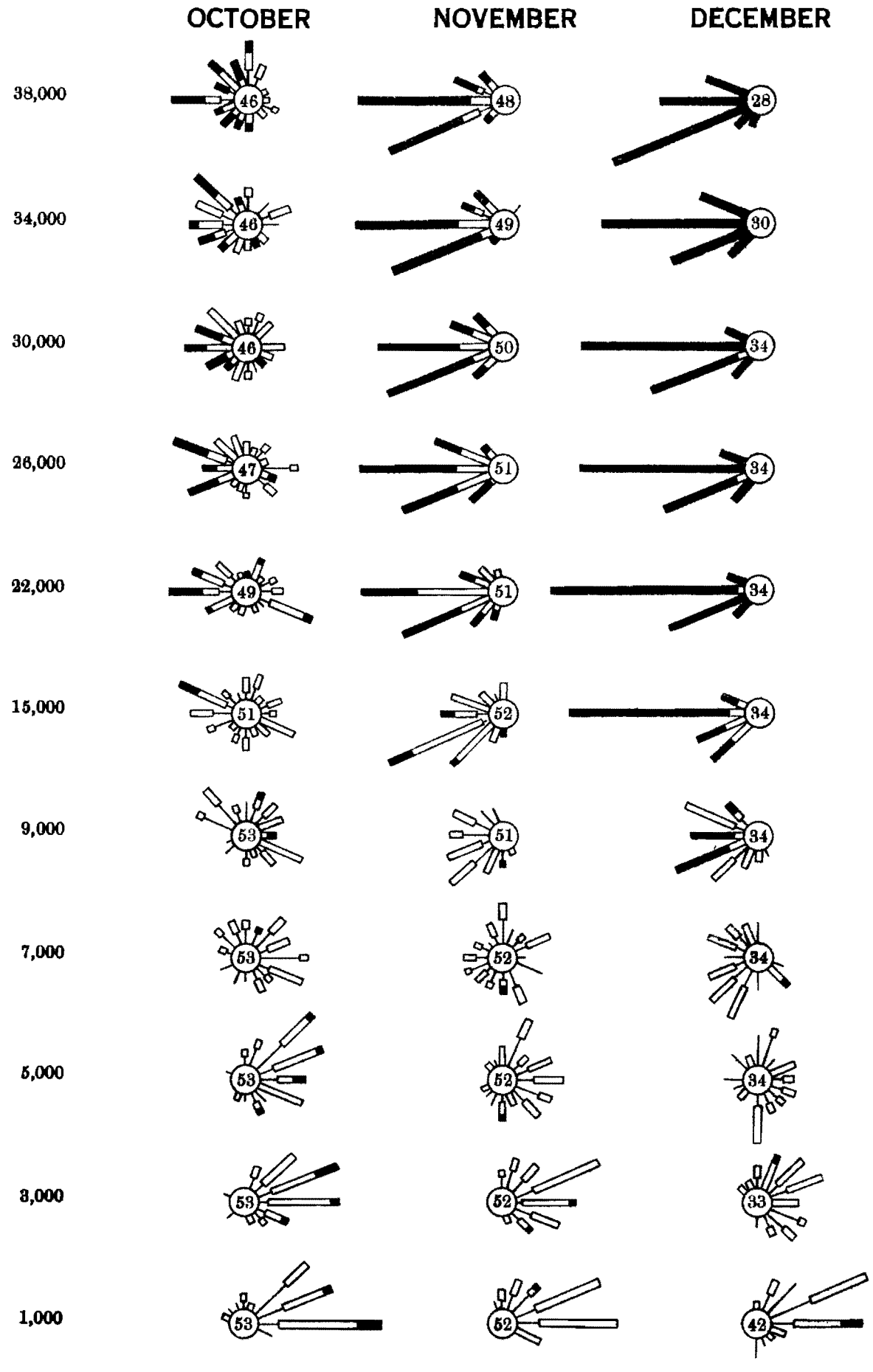
PERCENTAGE FREQUENCY
SPEED IN KNOTS
NUMER OF OBSERVATIONS
ENTERED IN CIRCLE.


OCTOBER
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DECEMBER
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SCALE –
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1–10 11–27 >27
PERCENTAGE FREQUENCY
SPEED IN KNOTS
NUMER OF OBSERVATIONS
ENTERED IN CIRCLE.