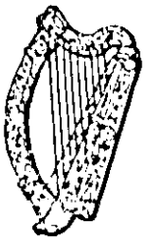
DEPARTMENT OF TRANSPORT AND POWER
METEOROLOGICAL SERVICE



A MAGNETIC SURVEY OF IRELAND FOR EPOCH 1959.5

BY

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NOTE: To simplify reproduction, the letter y has been used throughout the text to signify γ.

A MAGNETIC SURVEY OF IRELAND FOR EPOCH 1959.5

1. Introduction

A detailed magnetic survey of a country, even as small as Ireland, is a major operation, involving considerable organisation, time and expense. The result is that such surveys are not made as frequently as is desirable. To overcome this difficulty, the Irish Meteorological Service decided to set up a limited number of Magnetic Survey stations, which would provide an observation network, conforming closely to that recommended by the IAGA Committee No. 5 on World Magnetic Survey, and at which magnetic survey observations could be conveniently made at frequent intervals.

Advantage was taken of the fact that the Meteorological Service already had under its control a network of synoptic reporting stations which are well situated for the purpose in mind, and that an officer of the Service on inspection duty visits these stations at regular intervals. Accordingly, during an inspection tour of the reporting stations in 1958, one of us (Mr. J. Byrne) selected sites for the Magnetic Survey observations close to or within the grounds of each of the eleven synoptic stations, and these together with Valentia Observatory form the survey network of twelve stations, which are listed in Table 1.

During the next inspection tour of synoptic stations in 1959 the necessary magnetic equipment (see para. 4 below) was carried and the survey completed.

2. Selection and Marking of Sites

The exact site of each observing station was chosen so as to be free from all possible disturbing magnetic influences, could be expected to remain free from such influences in the foreseeable future and at which a suitable permanent reference object or "azimuth mark" was available for the Declination observations. Figs. 7 - 17 show the positions of the sites with reference to their surroundings and the meteorological station.

The chosen site was marked by means of a concrete slab, buried about 18 in. below the surface of the ground. A small hole in the centre of the slab was used to provide an exact location.

A full description of the location of this concrete slab, including measured distances from well defined reference points, was prepared so as to facilitate discovery on all future occasions. Discovery was also facilitated by means of a wooden peg driven into the ground so that its top was level with the surface and vertically over the hole in the slab.

3. Procedure

The survey was completed during the period June 2nd to July 2nd, 1959.

The tour began at the control station - Valentia Observatory - where control observations were made with each of the instruments. All eleven outstations were then visited and the tour ended at the starting point, where control observations were again made with each of the instruments. This schedule allowed about two days at each station, during which time at least two and generally three or four sets of observations were completed with each instrument.

4. Instruments used

The instruments used for the magnetic observations were as follows:

(a) Declination and Horizontal Intensity ..... QHM No. 186
(b) Vertical Intensity ..... HMZ No. 112

A second QHM (No. 184) was also carried, but the suspension of this instrument broke early in the survey, so the tour was completed with one QHM only. However, this did not affect the survey as the two QHM's were carried mainly to provide for such a contingency.

A full description of the QHM instrument and its use for Horizontal intensity measurements is given in [1]. A description of the method used for measuring Declination with this instrument is given in [2].

A full description of the HMZ instrument and its use for Vertical intensity observations is given in [3].

Other equipment, carried on the survey, consisted of a Wild surveyor's theodolite (kindly lent to the Meteorological Service by the Irish Ordnance Survey) for azimuth determinations, two accurately rated pocket watches and two stop watches, and finally a rectangular tent, specially designed for magnetic field work.

5. Azimuth Measurements

To define the azimuth for Declination observations, reference objects were chosen which it was considered would remain permanent and in clear view from the site for magnetic observations in the foreseeable future. The method used for the determination of azimuths was a variation of that described in pages 56 - 59 of [4]. The Wild theodolite lent by Irish Ordnance Survey was used for the observations. At some stations the azimuths of the reference objects were not determined during the actual survey tour, due to the sun not being visible. In such cases the necessary observations were carried out during a subsequent visit to the stations concerned.

6. Control Centre

The control centre, to which all the survey observations were referred and at which continuous records were available to provide instantaneous deviations from the mean values at each particular time of observation, was Valentia Observatory.

The magnetic recording equipment available at this station consists of:

(a) a standard La Cour 15 mm recorder, with a set of La Cour H, D, and Z Variometers.

(b) a La Cour 180 mm (Quick-Run) recorder with a second set of La Cour H, D and Z variometers.

A full description of these instruments and the recorders will be found in [5], [6] and [7], while a description of the site and the absolute and variometer huts will be found in [8].

The instruments used for base line determinations during 1959 were:

Declination and Horizontal Intensity....Ruska Obs. Magnetometer No.5917
Vertical Intensity.....EMZ No. 66.

7. Calibration of the Survey Instruments

The magnetic instruments used during the survey (para. 4 above), form part of the equipment, which is used regularly at Valentia Observatory, in addition to the base line instruments, referred to in para. 6 above. A regular comparison is therefore available, showing the agreement between the data as observed by the survey instruments and the Valentia base line instruments. The following table shows the error in the survey instruments with reference to the corresponding Variometer base line instrument at the beginning and at the end of the survey tour.

Element	Survey Instrument	Correction to reduce to the value, given by base line instrument	
		At beginning of Survey Tour	At end of Survey Tour
Declination	QHM No.186	+ 3.0	0.0
Horizontal Intensity	QHM No.186	+ 2.2y	+ 3.0y
Vertical Intensity	EMZ No.112	+ 1.0y	- 3.0y

The Valentia base line instruments have also been compared with other observatory standards as follows:

EMZ No.66: This instrument has been compared annually with the Dye Coil, originally installed at Abinger and now installed at Hartland Magnetic Station. In January, 1959, the result of this comparison showed that the EMZ No.66 was giving results, which were 5.4y higher than the Hartland Dye Coil. The constant of EMZ No.66 was therefore adjusted to bring the results into agreement with the Dye Coil values.
In February, 1960, EMZ No.66 was again compared with the Hartland Dye Coil and the result showed that the EMZ was reading only 0.5y higher than the Dye Coil. Thus, during the period of the survey, the Valentia base line standard for Z may be taken as being in agreement with the Hartland standard.

Ruska Observatory Magnetometer:

During the period 19/6/59 to 2/10/59, this instrument was compared with three QHM instruments, received from Copenhagen and used as travelling standards by the Committee on Comparison of Magnetic Standards of the IAGA.
The mean difference between the results obtained with the Ruska Magnetometer and those obtained by the three QHM travelling standards were as follows:

Ruska - QHM No. 90	=	+ 1.2 Gamma
" QHM No. 91	=	+ 0.6 "
" QHM No. 92	=	+ 0.9 "

As these three QHM's were calibrated at Rude Skov Observatory, immediately prior to dispatch to Valentia, the values obtained with them may be taken as representing the Rude Skov Standard.

8. Reduction of the Observations

The values, obtained by the survey instruments, were first of all corrected to agree with the Valentia base line instruments, using the mean of the differences as found at the beginning and at the end of the survey tour. (See para. 7 above). For each individual time of observation at the survey station, the value of the instantaneous deviation of the magnetic element from the base line value was computed from the Valentia magnetograms for the corresponding local time. Combining this instantaneous deviation with the base line value, gave the Valentia value (E_v) for the same local time as the survey value E_s.

The Annual Mean Value (for all days) for 1959 (E_m) was computed from the hourly means values, tabulated from the magnetograms.

The value for the survey station reduced to epoch 1959.5 was then obtained from the equation:

$$\text{Element for Survey Station at 1959.5} = E_s - E_v + E_m .$$

This method of reduction does not allow for the changes in the diurnal variation with latitude, but in a small country like Ireland, the error so involved is small. A check on the magnitude of this error was obtained by making at least two observations and generally three or four for each element, on different days and at different times. The result of this check showed that even though the instantaneous deviations in the elements, as recorded at Valentia, varied over quite a wide range, the mean errors in the reduced values for the survey stations were quite small. The actual values were as follows:-

(a) For the four stations in the Northern half of the country (Malin Head, Belmullet, Clones and Claremorris)

Declination	- mean error	$= \pm 1'.0$
Horizontal Intensity	" "	$= \pm 4.3$ y
Vertical Intensity	" "	$= \pm 3.0$ y

(b) For the seven stations in the Southern half of the country

Declination	- mean error	$= \pm 0'.9$
Horizontal Intensity	" "	$= \pm 3.5$ y
Vertical Intensity	" "	$= \pm 5.3$ y

9. Normal Values of the Elements.

For the purpose of comparison with a more detailed survey made for epoch 1950.5 [9], the equation for each of the elements, as a function of the latitude and longitude of the station, was computed. Each of the elements may be represented by an equation in the form:

$$E = A(\varphi - 50) + B(\lambda - 5) + C$$

where λ is the longitude West and φ the latitude North in degrees and A, B and C are constants.

Using the method of least squares, the equations obtained were:

$$D^{o} = 0.343(\varphi - 50) + 0.584(\lambda - 5) + 9.776 \quad \ldots\ldots\ldots(1)$$

$$H^{y} = -459.6(\varphi - 50) - 10.5(\lambda - 5) + 19118 \quad \ldots\ldots\ldots(2)$$

$$Z^{y} = 472.5(\varphi - 50) + 62.8(\lambda - 5) + 42950 \quad \ldots\ldots\ldots(3)$$

In the case of Declination, which is measured positive towards the West, the value obtained for Birr was obviously much too low in comparison with the four stations Shannon Airport, Claremorris, Mullingar and Kilkenny, which form an area of which Birr is the approximate centre. The value obtained for Birr, therefore, was not used in the computation of the normal equation for Declination, nor in drawing the true isogonals in Fig. 1.

These three equations give the normal values of the magnetic elements and the isogonals and isodynamic lines, derived from them are shown on Figs. 1 - 3.

Similar equations for the 1950 Survey given in [9] were:-

$$D^o = 0.248\ (\phi - 50) + 0.535\ (\lambda - 5) + 11.21 \quad \ldots\ldots\ldots (4)$$

$$H^\gamma = -472\ (\phi - 50) - 47.8\ (\lambda - 5) + 19011 \quad \ldots\ldots\ldots\ldots (5)$$

$$Z^\gamma = 448\ (\phi - 50) + 65\ (\lambda - 5) + 42909 \quad \ldots\ldots\ldots\ldots (6)$$

For comparison purposes, the isogonal and isodynamic lines, derived from both sets of equations have been drawn in Figs. 4 - 6.

In the case of all three elements, the agreement is as close as could be expected, considering that the form of the equations is so dependent on the values obtained at the individual stations, where local anomalies are likely to exist, and in no case was a station, used in the 1950 survey, re-occupied during the 1959 survey.

10. Anomalies

The values of the elements, observed at each of the stations, are given in Table 2. Also, given in this table, are the normal values for each station, as computed from equations (1) - (3) above. The differences between the observed and calculated (normal) values are given in the third column of the table. These differences are generally considered as measures of the "anomalies" at the stations, but this is only in a very general way, as they depend so much on the fit of the equations.

The values of these so called "anomalies" have been plotted in Figs. 1 - 3, the value appropriate to each station having been plotted to the right of the station circle, and the observed value to the left of the station circle. The true inclines, which take account of these anomalies, have been drawn on Figs. 1 - 3.

11. Comparison of Normal Values for 1959 and 1950

In Table 3 are given the normal values of the three elements for the 1950 survey, as computed from equations (4)-(6) for each of the stations used during the 1959 survey. The changes in the normal values for each

element, during the nine years, have also been tabulated in Table 3. From those changes, the following may be deduced:

(a) Declination has decreased by an average of 59.3 over the whole country. The rate of decrease was greatest in the South and decreased to the North and West. The equation for the change can be obtained by subtracting equations (1) and (4), giving a result:

$$D_{1959} - D_{1950} = 0.095(\phi - 50) + 0.049(\lambda - 5) - 1.444 \ldots\ldots (7)$$

For Valentia Observatory, the computed change for the nine years gives a decrease of 60!2. The actual change, based on the annual mean values at this station, was a decrease of 62!6.

(b) Horizontal Intensity increased by an average of 260y over the whole country, the rate of increase being greatest in the West and North and least in the East and South. The equation for the change can be obtained from equations (2) and (5), giving:

$$H_{1959} - H_{1950} = 12.4\ (\phi - 50) + 37.3\ (\lambda - 5) + 107 \ldots\ldots (8)$$

For Valentia Observatory, the computed change for the nine years gives an increase of 327 gamma. The actual change, based on the annual mean values for the station shows an increase of 301y.

(c) Vertical Intensity increased by an average of 113y over the whole country. The rate of change increased from South to North. The equation for the change can be obtained from equations (3) and (6) and gives:-

$$Z_{1959} - Z_{1950} = 24.5\ (\phi - 50) - 2.2\ (\lambda - 5) + 41 \ldots\ldots\ldots (9)$$

For Valentia Observatory, the computed change for the nine years gives an increase of 76y. The actual change, based on the annual mean values at the station, shows an increase of 10y. The agreement in this case is not as good as for the other two elements, probably in part due to the fact that prior to 1954 the only Vertical Intensity data available for Valentia was computed from Horizontal Intensity and the Dip as measured by means of a dip circle.

It must be remembered, however, that equations (7), (8) and (9) are unlikely to prove very reliable, if applied outside the survey area, as in a survey of this type, confined to a very narrow range of ϕ and λ, the coefficients of ϕ and λ depend very much on the form of the equation used and the local anomalies at the individual stations, and as previously stated, in no case was any station of the 1950 survey re-occupied for the 1959 survey.

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[6] Communications Magnetiques No. 11
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[8] Magnetic Observations at Valentia Observatory 1954.
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[9] Geophysical Memoirs No. 4
The Magnetic Survey of Ireland for the Epoch 1950.5. By Thomas Murphy.
(Published by Dublin Institute for Advanced Studies, School of Cosmic Physics)

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Table 1 Location of Stations used during the Survey

Station	Geographic Co-ordinates		Geomagnetic Co-ordinates	
	Latitude (N)	Longitude (W)	Latitude (N)	Longitude (E)
Malin Head	55° 22'	07° 20'	59°.3	78°.7
Belmullet	54° 14'	10° 00'	58°.8	75°.1
Clones	54° 11'	07° 14'	58°.2	78°.0
Claremorris	53° 43'	09° 00'	58°.1	75°.9
Mullingar	53° 31'	07° 21'	57°.6	77°.5
Baldonnel	53° 18'	06° 26'	57°.2	78°.3
Birr	53° 05'	07° 54'	57°.3	76°.6
Shannon Airport	52° 42'	08° 56'	57°.1	75°.3
Kilkenny	52° 40'	07° 16'	56°.8	77°.0
Rosslare	52° 15'	06° 20'	56°.2	77°.8
Valentia	51° 56'	10° 15'	56°.6	73°.5
Roches Point	51° 48'	08° 15'	56°.1	75°.5

Table 2 Observed and computed values of the Magnetic Elements

Station	DECLINATION			HORIZONTAL INTENSITY			VERTICAL INTENSITY		
	Observed (O)	Calculated (C)	(O) - (C)	Observed (O)	Calculated (C)	(O) - (C)	Observed (O)	Calculated (C)	(O) - (C)
	° '	° '	'	γ	γ	γ	γ	γ	γ
Malin Head	12 40.8	12 58.1	- 17.3	16661	16626	35	45687	45633	54
Belmullet	14 25.4	14 08.2	17.2	17019	17122	-103	45209	45262	-53
Clones	12 38.3	12 30.1	08.2	17148	17174	-26	44944	45065	-121
Cl..morris	13 12.6	13 22.7	- 10.1	17359	17366	-7	45072	44959	113
Mullingar	12 28.1	12 20.7	07.4	17529	17476	53	44764	44761	3
Baldonnel	11 49.3	11 44.0	05.3	17644	17587	57	44550	44599	-49
Birr	12 06.8	12 31.0	- 24.2	17643	17672	-29	44632	44587	45
Shannon Airport	12 54.7	12 59.2	- 04.5	17873	17836	37	44452	44472	-20
Kilkenny	12 03.8	12 00.5	03.3	17892	17867	25	44310	44354	-44
Rosslare	11 15.4	11 18.9	- 03.5	17976	18070	-94	44204	44096	108
Valentia	13 22.9	13 29.6	- 06.7	18252	18176	76	44215	44191	24
Roches Point	12 18.1	12 16.9	01.2	18232	18257	-25	43929	44004	-75

Table 3 Computed values of the Elements for 1959 and 1950 Surveys

Station	DECLINATION 1959	DECLINATION 1950	DECLINATION Change 1959-1950	HORIZONTAL INTENSITY 1959	HORIZONTAL INTENSITY 1950	HORIZONTAL INTENSITY Change 1959-1950	VERTICAL INTENSITY 1959	VERTICAL INTENSITY 1950	VERTICAL INTENSITY Change 1959-1950
	° '	° '	° '	γ	γ	γ	γ	γ	γ
Malin Head	12° 58.1	13° 47.3	° -49.2	16626	16365	261	45633	45466	167
Belmullet	14 08.2	14 56.0	-47.8	17122	16775	347	45262	45129	133
Clones	12 30.1	13 26.4	-56.3	17174	16931	243	45065	44927	138
Claremorris	13 22.7	14 16.4	-53.7	17366	17064	302	44959	44836	123
Mullingar	12 20.7	13 20.4	-59.7	17476	17237	239	44761	44639	122
Baldonnel	11 44.0	12 47.4	-1 03.4	17587	17385	202	44599	44480	119
Birr	12 31.0	13 31.6	-1 00.6	17672	17419	253	44587	44477	110
Shannon Airport	12 59.2	13 58.9	-59.7	17836	17549	287	44472	44374	098
Kilkenny	12 00.5	13 05.2	-1 04.7	17867	17642	225	44354	44253	101
Rosslare	11 18.9	12 28.8	-1 09.9	18070	17885	185	44096	44003	093
Valentia	13 29.6	14 29.8	-1 00.2	18176	17849	327	44191	44115	076
Roches Point	12 16.9	13 23.8	-1 06.9	18257	18006	251	44004	43927	077

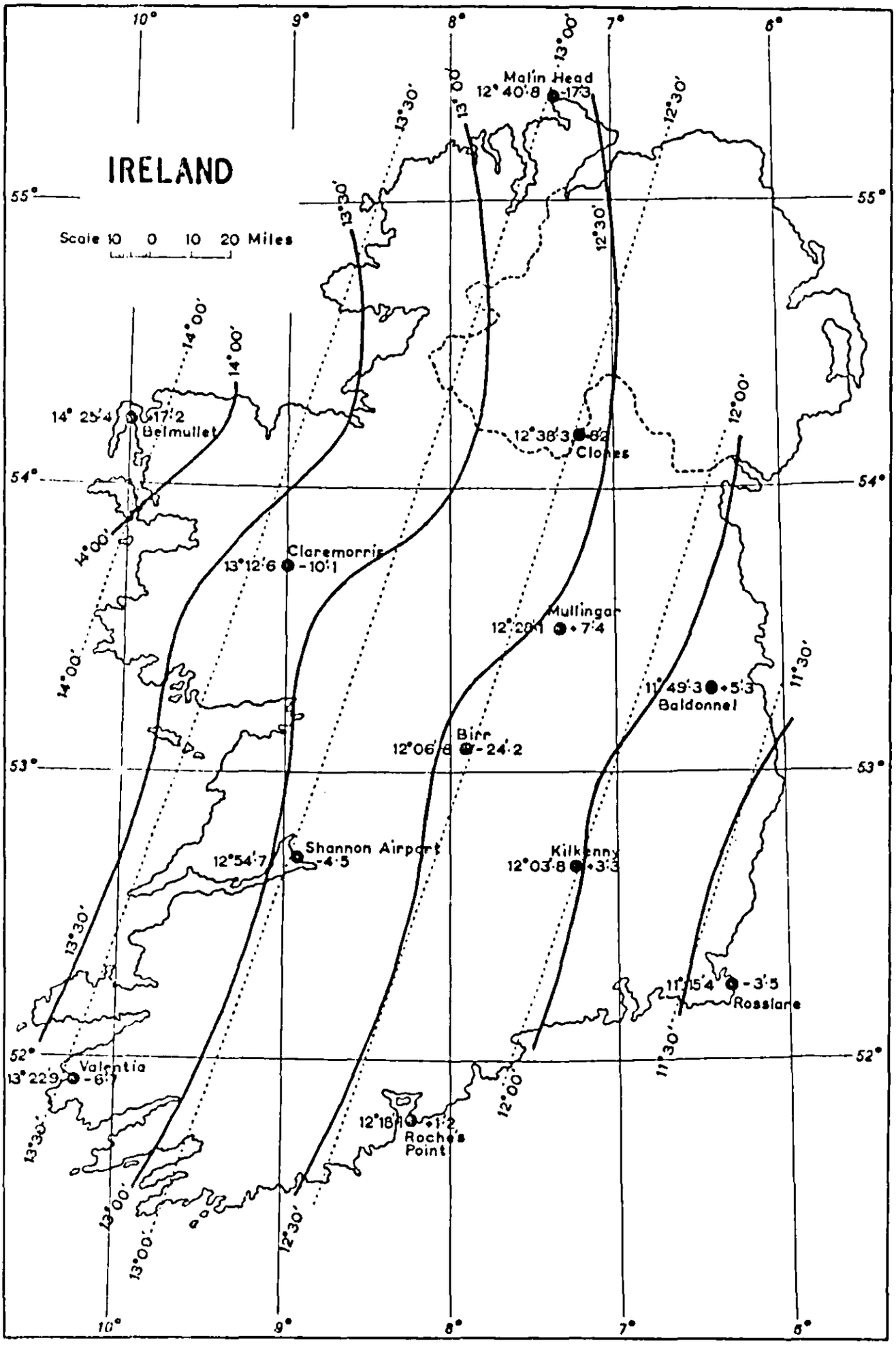

Fig. 1. Declination (West).

——— True Isogonals. ..... Computed Isogonals.

Observed value of Declination is given on left of each station circle.
Computed "Anomaly" is given on right of each station circle.

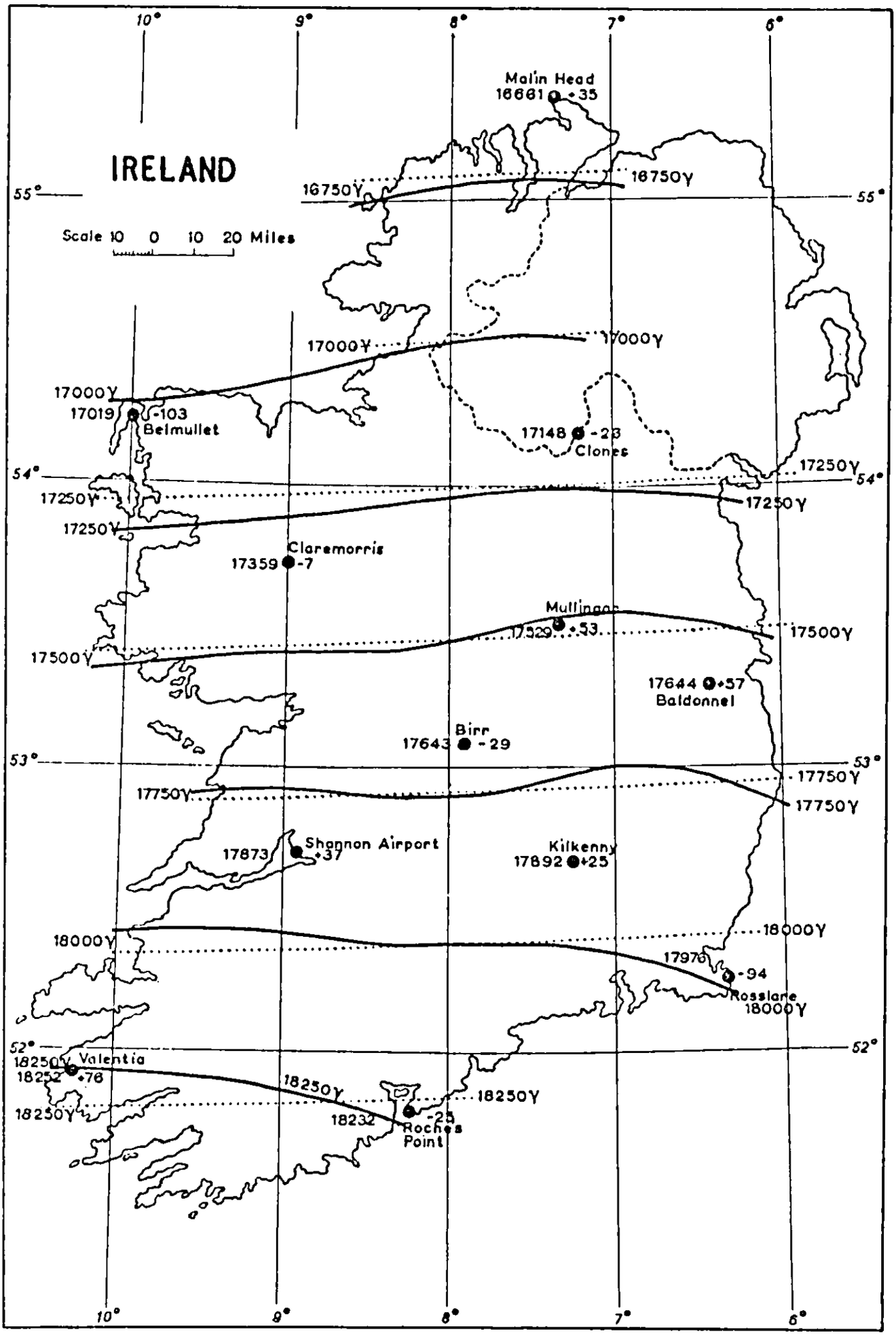

Fig. 2. Horizontal Intensity.

——— True Isodynamics. ····· Computed Isodynamics.

Observed value of Horizontal Intensity is given on left of each station circle.

Computed "Anomaly" is given on right of each station circle.

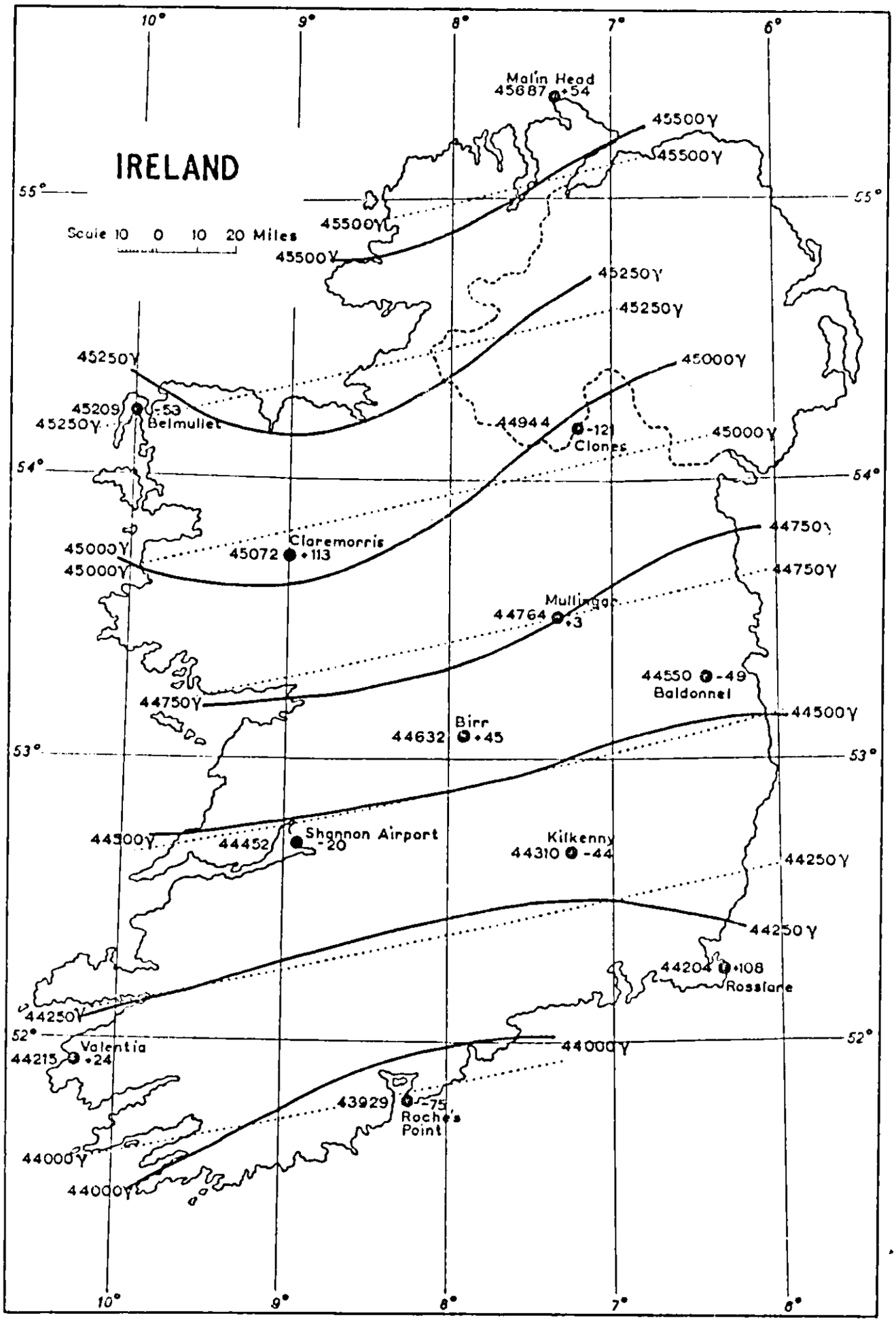

Fig. 3. Vertical Intensity.

——————— True Isodynamics. ..... Computed Isodynamics.

Observed value of Vertical Intensity is given on left of each station circle.
Computed "Anomaly" is given on right of each station circle.

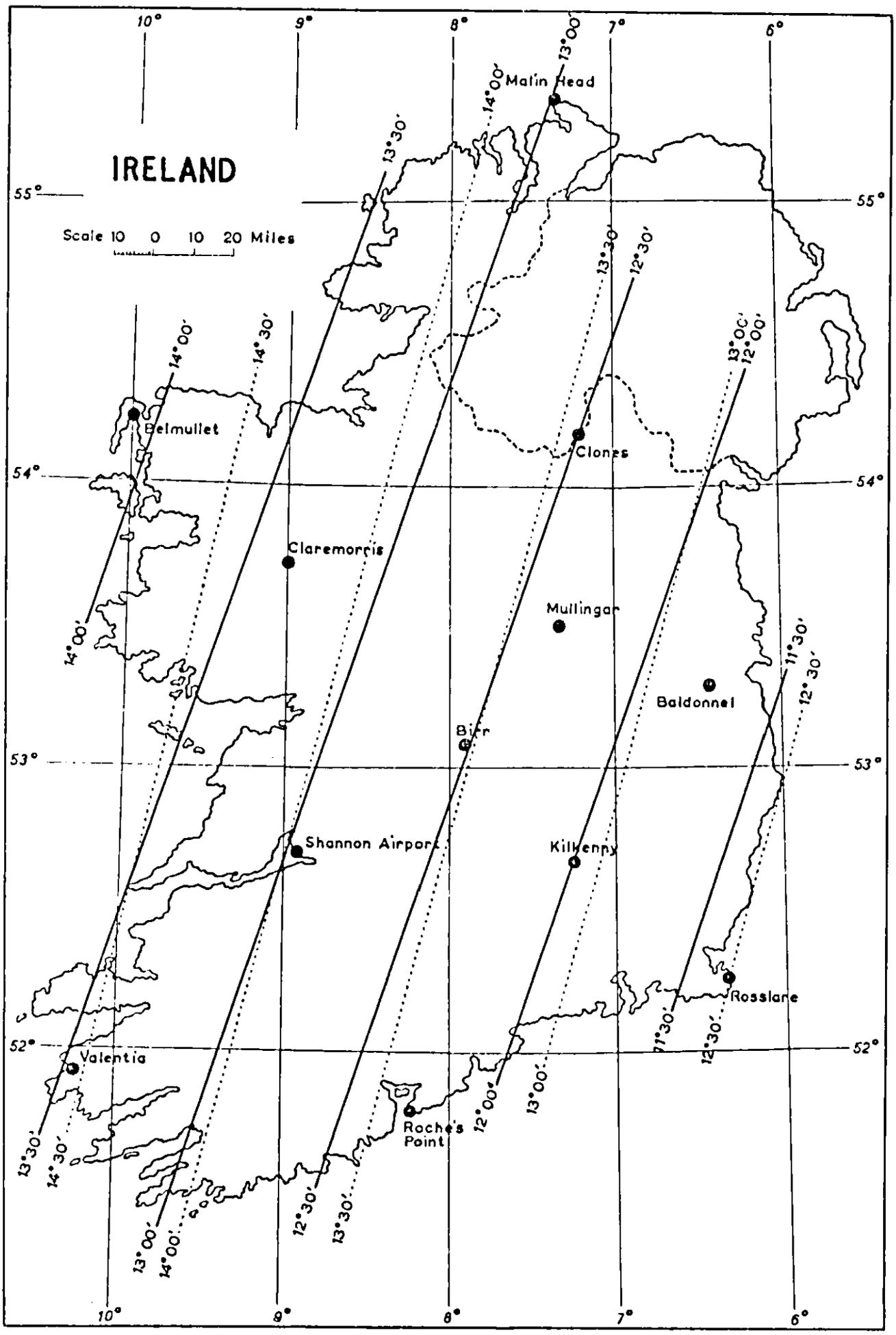

Fig. 4. Declination (West).

——— Computed Isogonals for 1959.5

····· Computed Isogonals for 1950.5

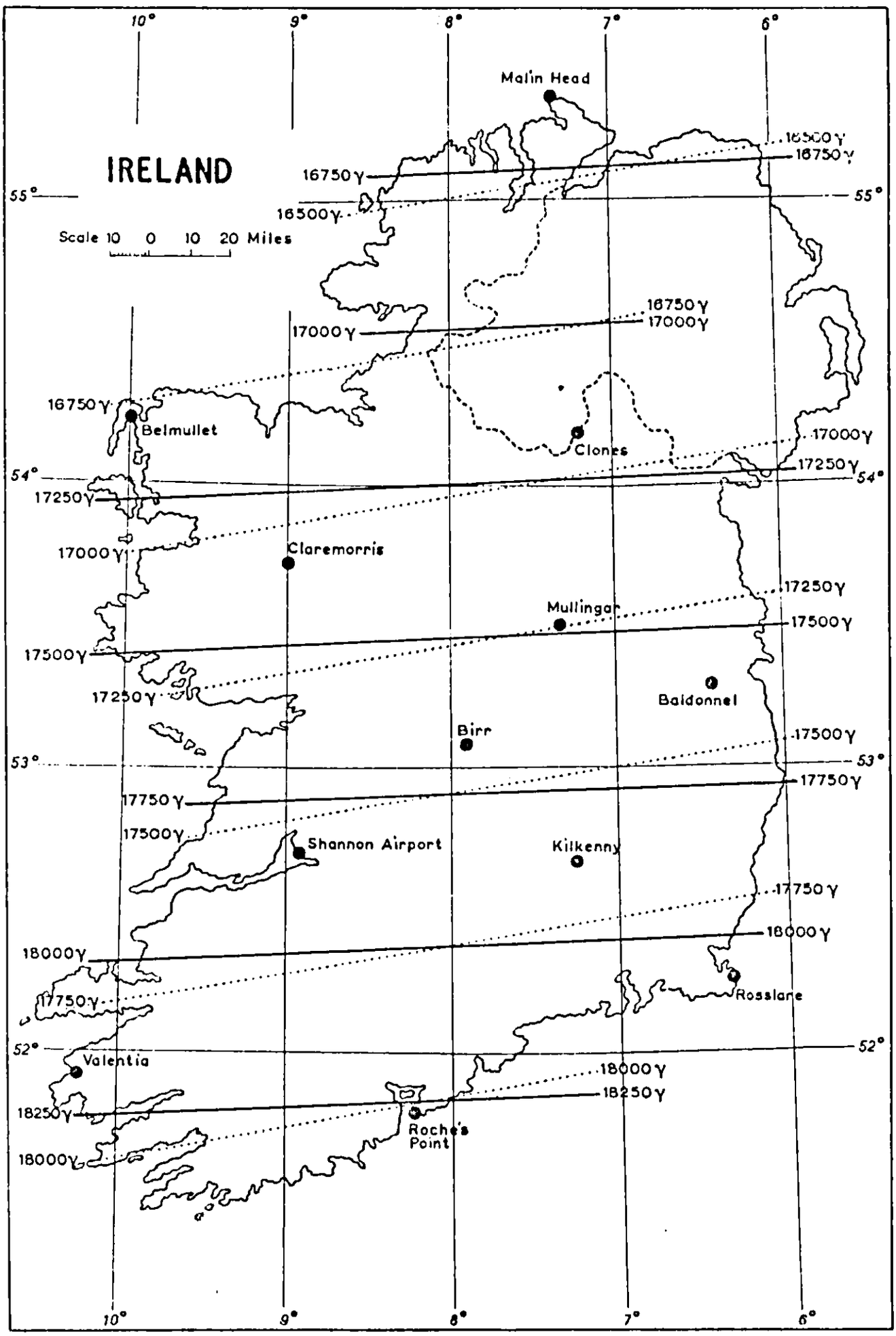

Fig. 5. Horizontal Intensity.

——— Computed Isodynamics. for 1959.5

..... Computed Isodynamics for 1950.5

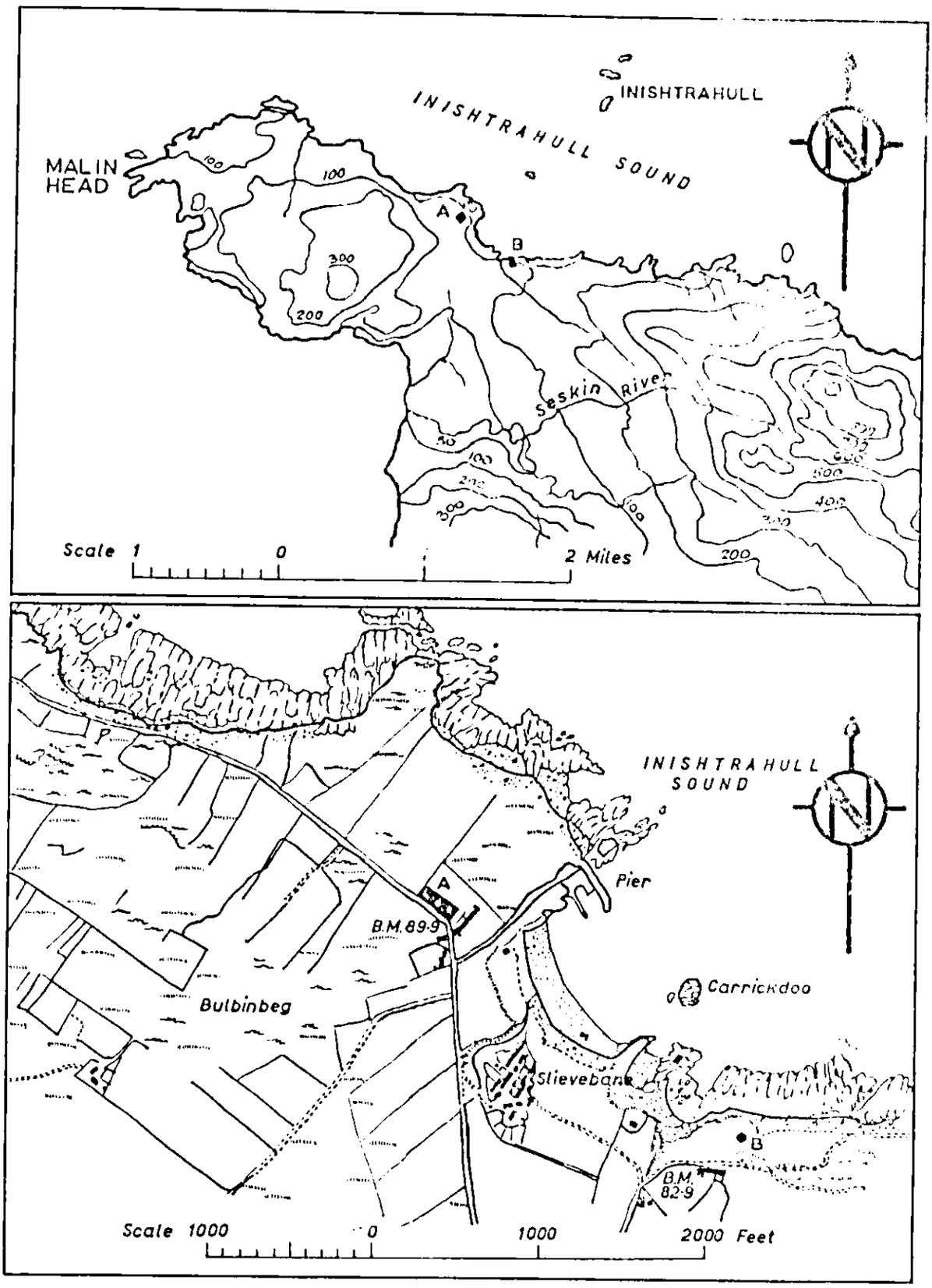

Fig. 7. Malin Head and surroundings.
(heights are given in feet above Irish Ordnance Datum)
A indicates site of Meteorological Station.
B indicates site of Magnetic Station.

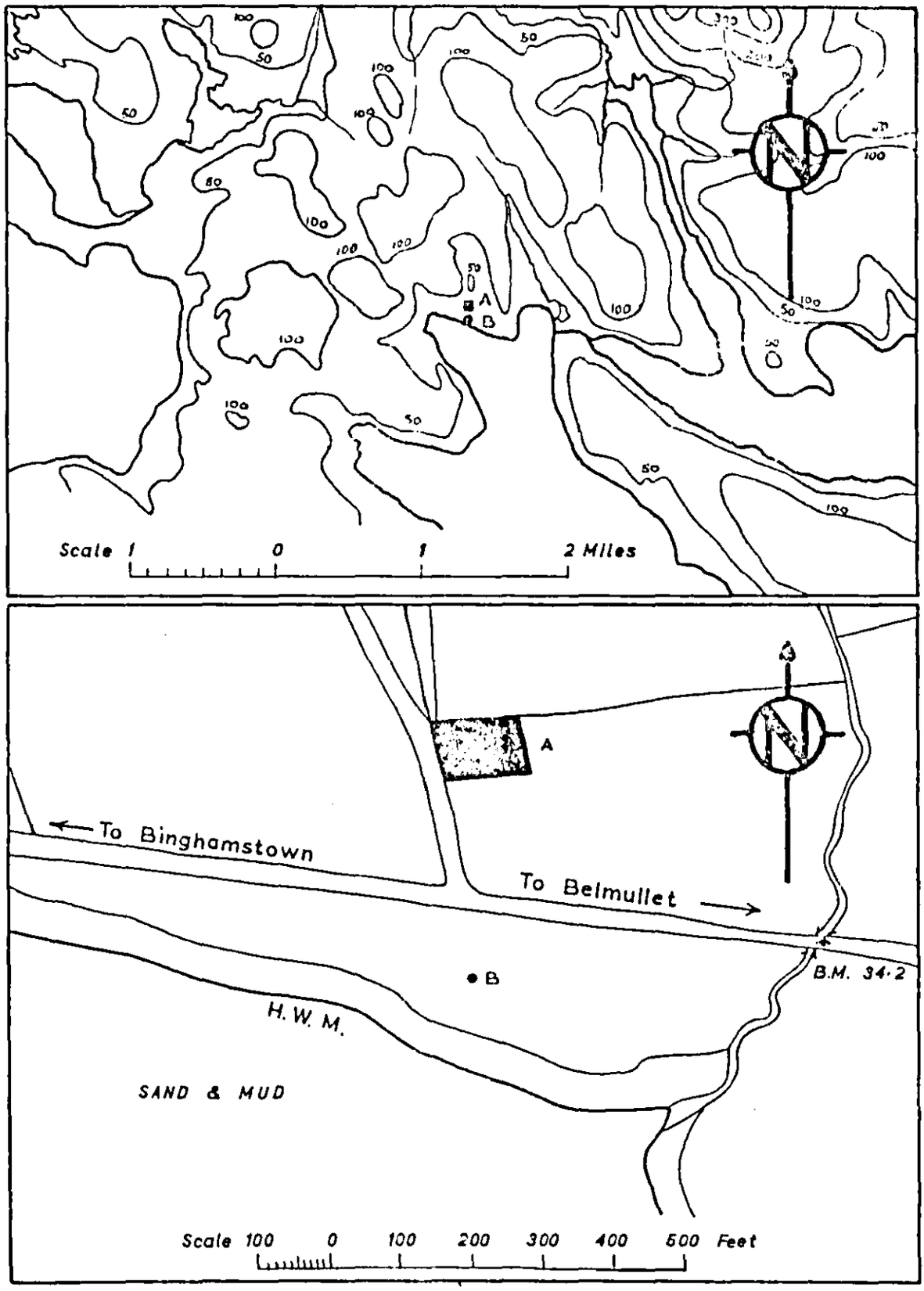

Fig. 8. Belmullet and surroundings.

(heights are given in feet above Irish Ordnance Datum)

A Indicates site of Meteorological Station.

B indicates site of Magnetic Station.

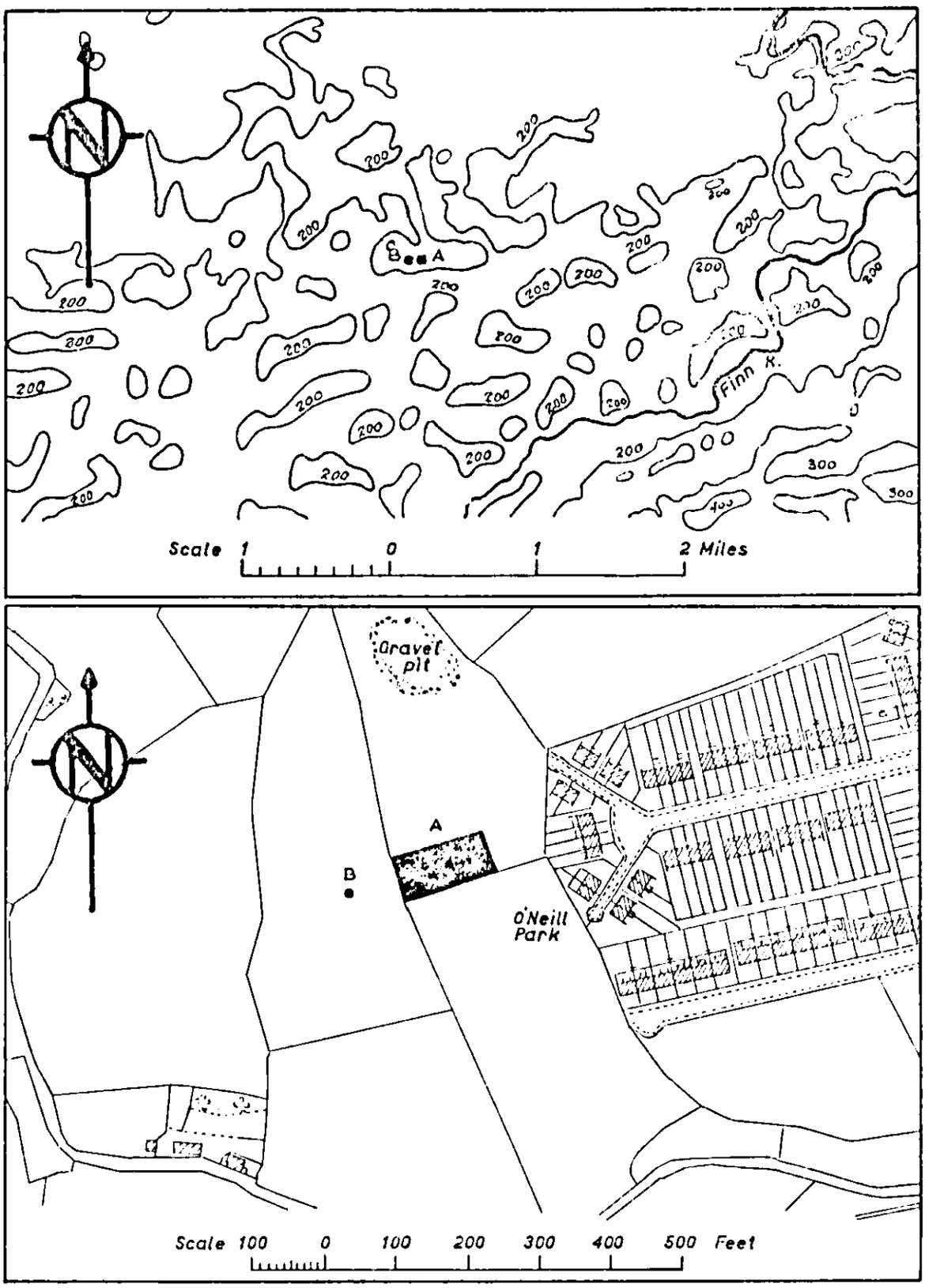

Fig. 9. Clones and surroundings.

(heights are given in feet above Irish Ordnance Datum)

A indicates site of Meteorological Station.

B indicates site of Magnetic Station.

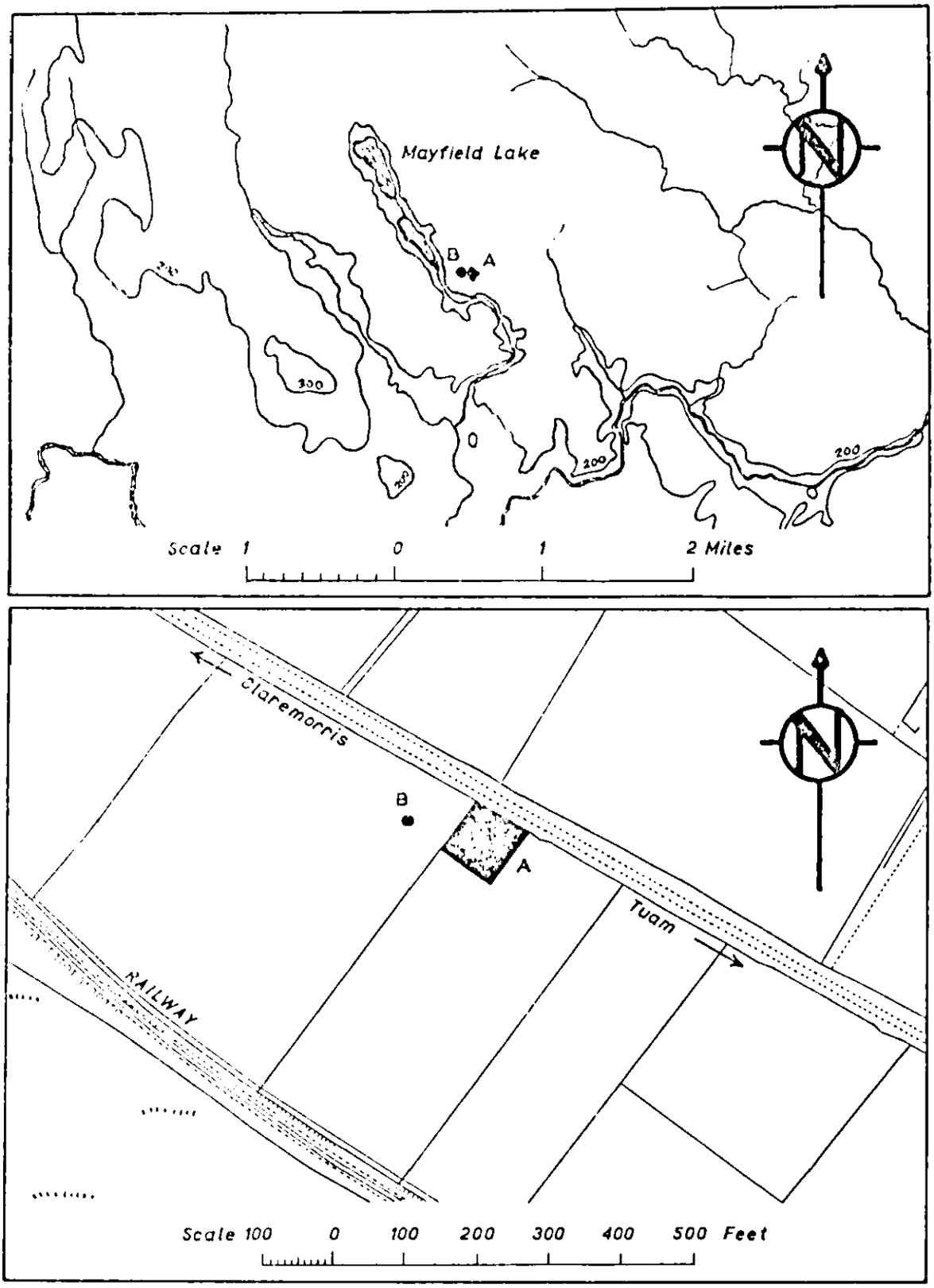

Fig. 10 Claremorris and surroundings.

(heights are given in feet above Irish Ordnance Datum)

A indicates site of Meteorological Station.

B indicates site of Magnetic Station.

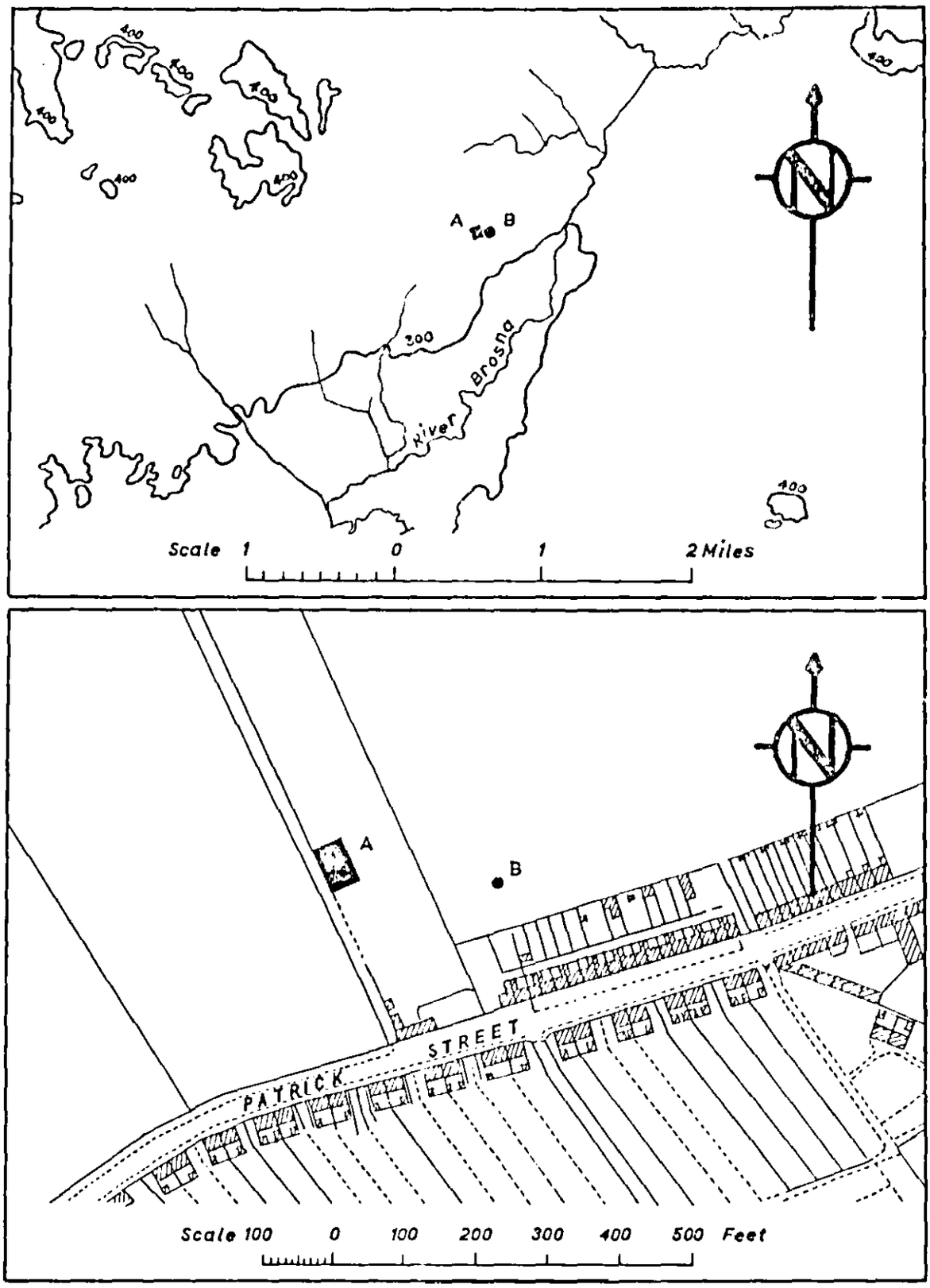

Fig. 11 Mullingar and surroundings.

(heights are given in feet above Irish Ordnance Datum)

A indicates site of Meteorological Station.

B indicates site of Magnetic Station.

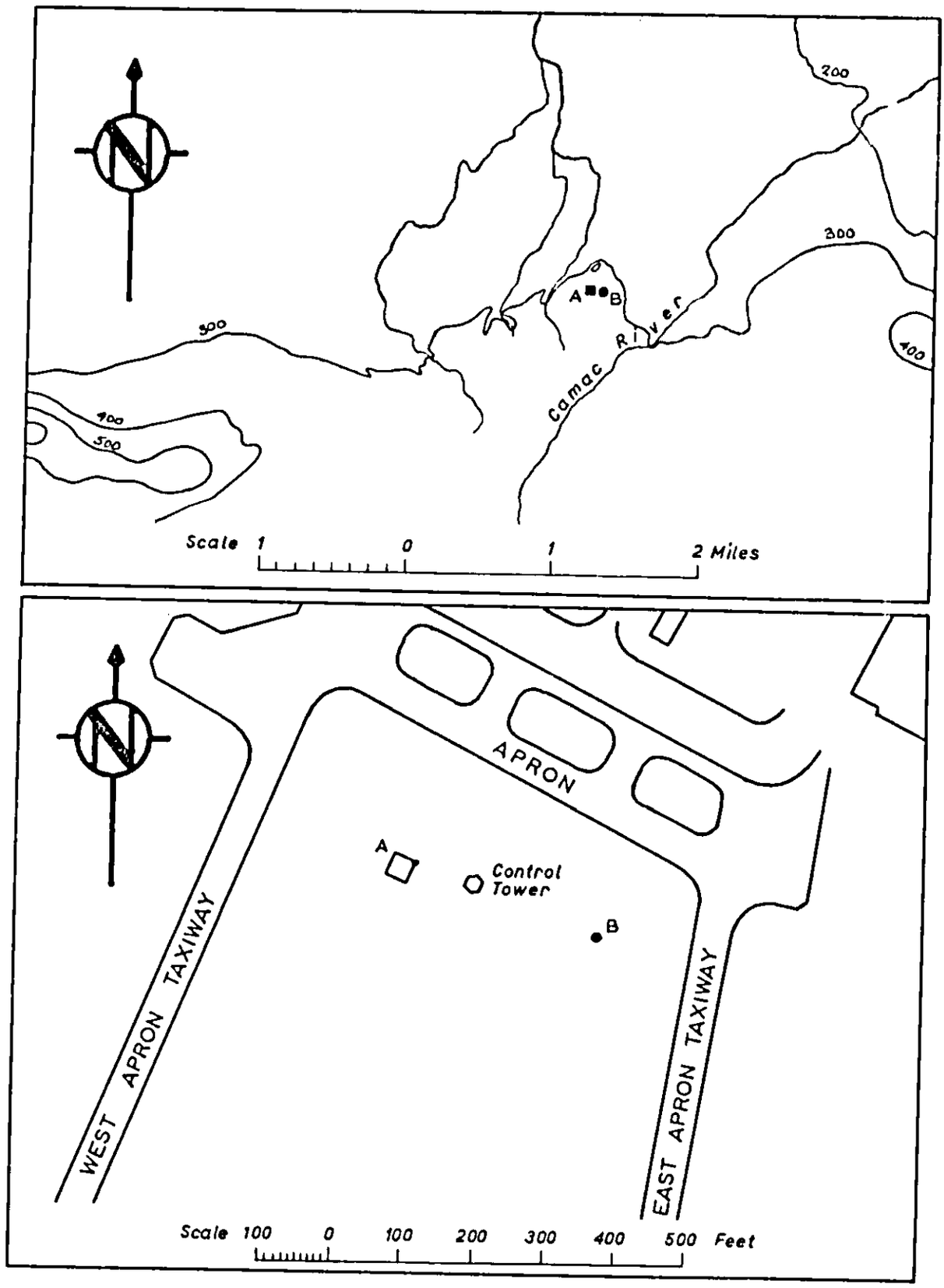

Fig. 12 Baldonnel and surroundings.
(heights are given in feet above Irish Ordnance Datum)
A indicates site of Meteorological Instrument Enclosure.
B indicates site of Magnetic Station.

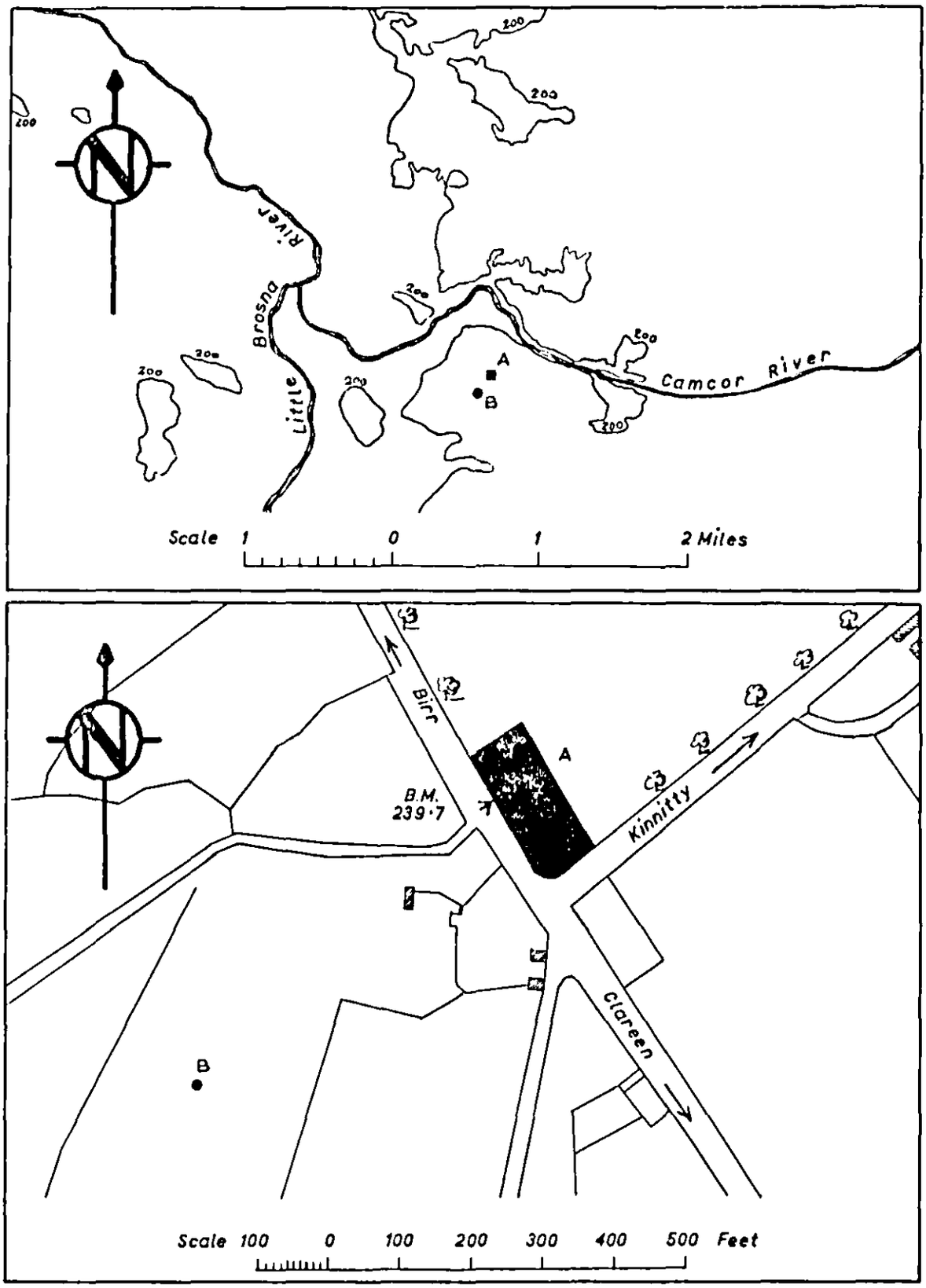

Fig. 13 Birr and surroundings.

(heights are given in feet above Irish Ordnance Datum)

A indicates site of Meteorological Station.

B indicates site of Magnetic Station.

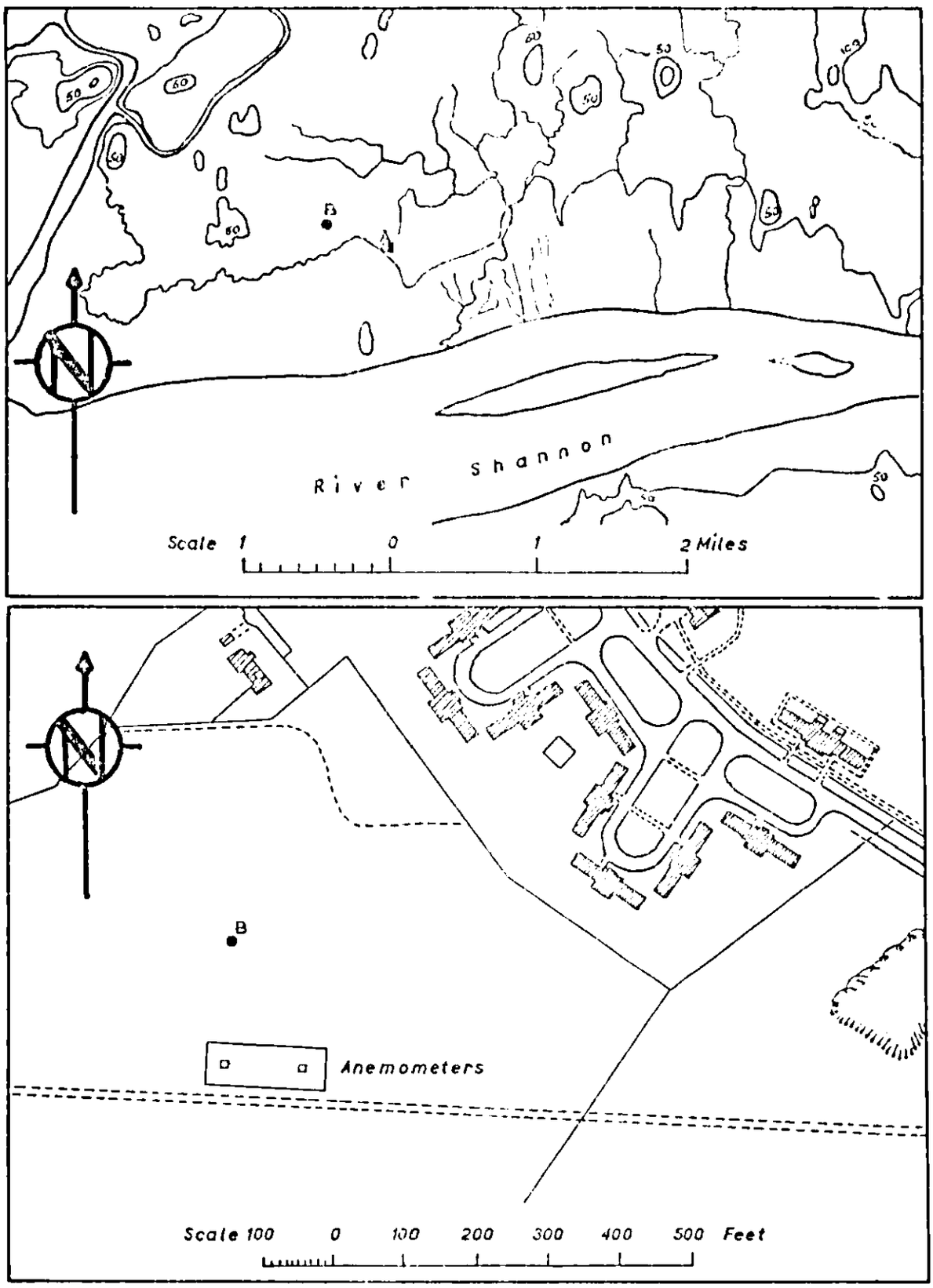

Fig. 14 Shannon Airport and surroundings.

(heights are given in feet above Irish Ordnance Datum)

A indicates site of Meteorological Instrument Enclosure.
B indicates site of Magnetic Station.

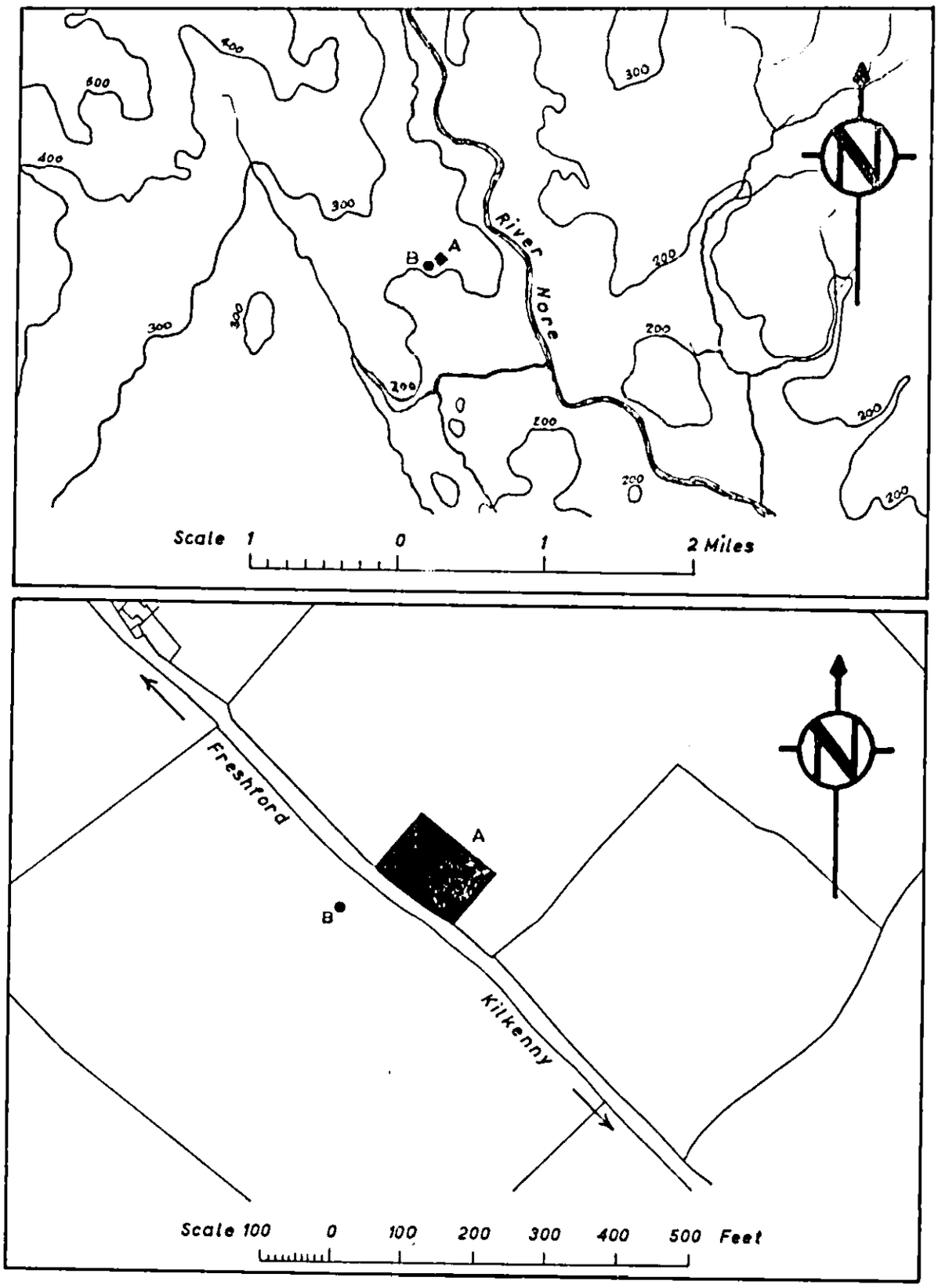

Fig. 15 Kilkenny and surroundings.

(heights are given in feet above Irish Ordnance Datum)

A indicates site of Meteorological Station.

B indicates site of Magnetic Station.

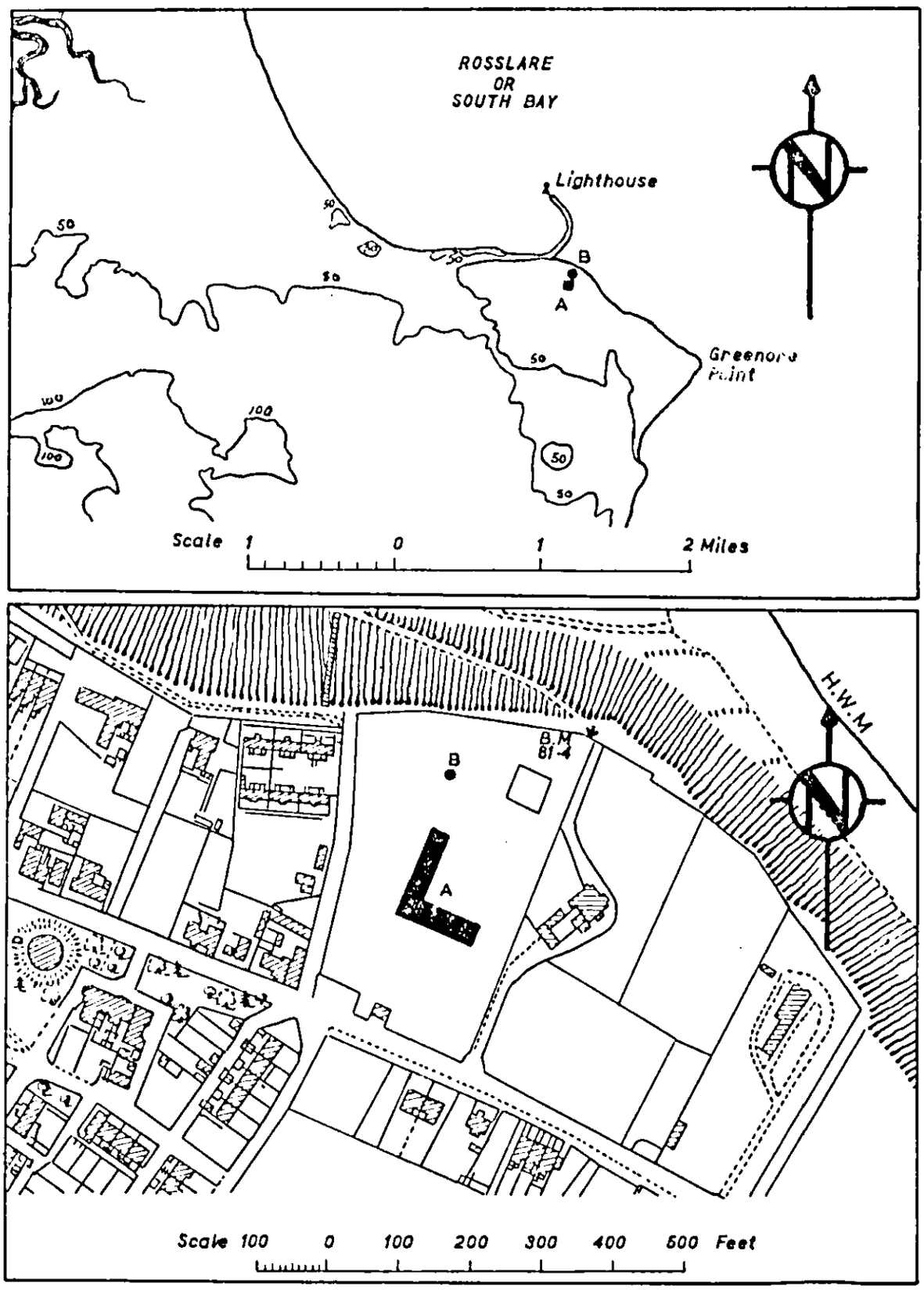

Fig. 16 Rosslare and surroundings.

(heights are given in feet above Irish Ordnance Datum)

A indicates site of Meteorological Office.
B indicates site of Magnetic Station.

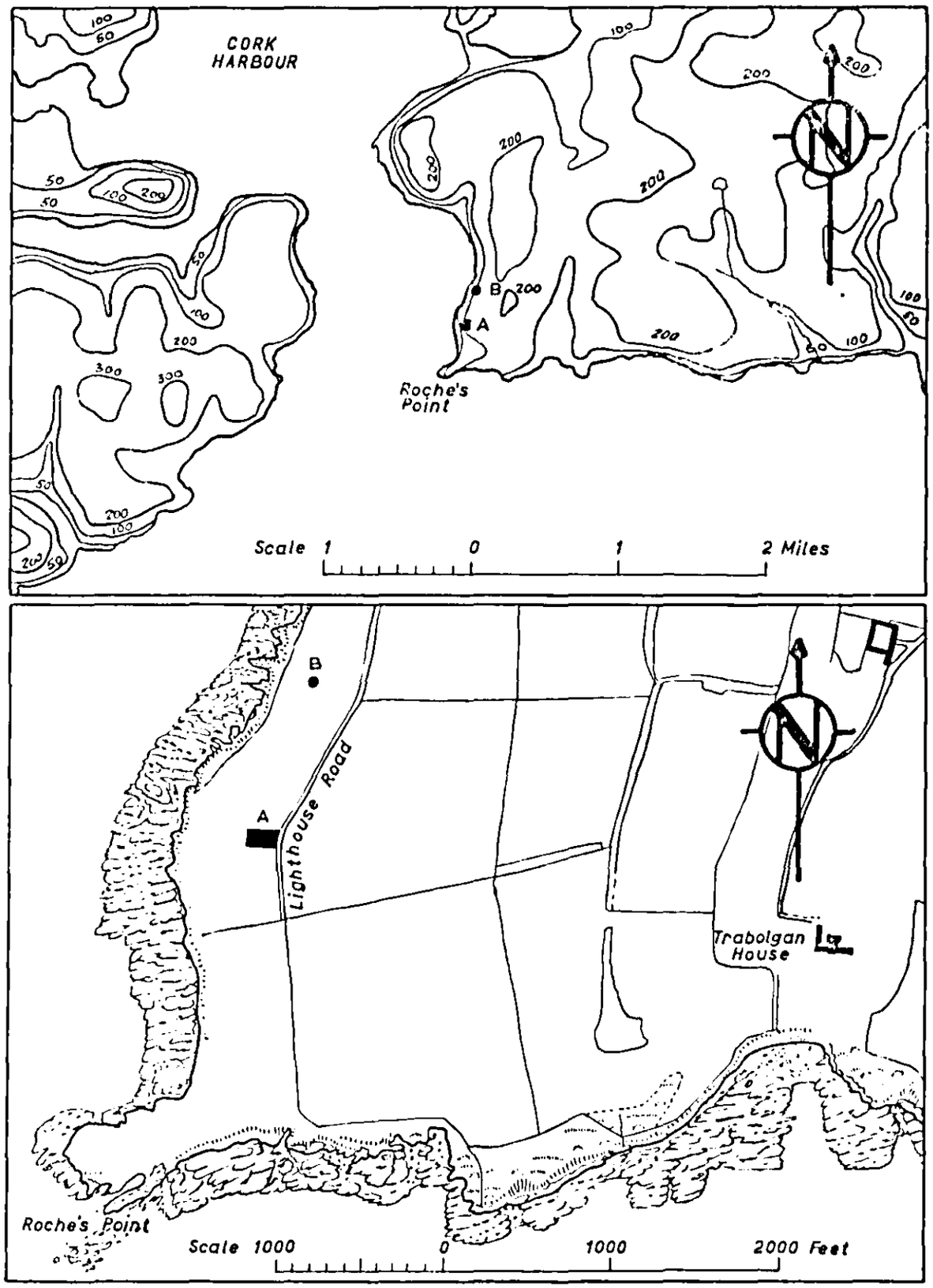

Fig. 17 Roche's Point and surroundings.

(heights are given in feet above Irish Ordnance Datum)

A Indicates site of Meteorological Station.

B indicates site of Magnetic Station.