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A meteorological study of July to October 1588: the Spanish Armada storms

K.S. Douglas, H.H. Lamb and C. Loader

1978

Climatic Research Unit
School of Environmental Sciences
University of East Anglia

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A Meteorological Study of July to October 1588: The Spanish Armada Storms.



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Cover Picture

On the cover is reproduced the commemorative medal issued by Queen Elizabeth of England after the Armada events. The inscription "Flavit et dissipati sunt" means "It blew and they were scattered".

The reproduction was made possible by courtesy of the National Maritime Museum, Greenwich.

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A METEOROLOGICAL STUDY OF JULY TO OCTOBER 1588:

THE SPANISH ARMADA STORMS

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GENERAL SUMMARY

The importance of the wind and weather sequence in the high summer and early autumn of 1588 to the history of the Armada's voyage, its ability to carry out its task and the heavy losses of ships it suffered, is briefly considered. This account is mainly concerned with establishing the facts of that weather sequence and a meteorological analysis of how it developed. One result of the analysis is to reveal that there seem to have been several spells of fine anticyclonic weather in England and (particularly) in central Europe, unlike conditions just farther west over the ocean, which were repeatedly stormy even as far south as the latitude of Portugal and the Azores, and to the north, where it must have been a notably cold summer in comparison with most modern experience. (Perhaps 1962 would provide an analogy as regards the latter aspect.) Most meteorological interest attaches to the sequence as a sample daily circulation pattern analysis of a summer during the Little Ice Age period, when Arctic sea ice and the glaciers in Europe were in an advanced state and usually advancing. It is also possible to include a quantitative assessment of some aspects of the wind circulation strength developed.

INTRODUCTION

The importance of the weather to the course of the voyage of the Spanish Armada has been acknowledged by all historians. All the vessels participating on both sides were powered by the wind*, and therefore its strength and direction would give advantage to one side or the other depending on the course to be sailed. Then the effect of the wind in driving the Armada into the North Sea and preventing its return to attempt the planned junction with Parma never fails to receive its due at the hands of all commentators.

But what of the actual weather in terms of individual depressions and anticyclones, the controlling airstreams and warm and cold fronts? Is it possible to discover the sequence of weather development and of these individual systems during the period July–October 1588 when the voyage was taking place? Scattered throughout the many contemporary documents are numerous references to wind and rain, calms and fogs, which one of us (K.S. DOUGLAS) whose primary interest is history collected together in the hope that they would provide enough data for tentative meteorological interpretations to be arrived at. The reports were marshalled in the tabulated form here presented, and a synoptic weather map series for 34 separate epochs between 22 July and 26 October 1588 (all dates converted to the modern Gregorian or New Style calendar) was first compiled and analyzed in consultation with Mr S.G. ASTON of the Meteorological Office, Aldergrove Airport and Mr S.J.G. PARTINGTON of the Meteorological Office, Belfast, whose help is gratefully acknowledged. This map series was then presented to the next author (H.H. LAMB) for further study. The series has very great meteorological and climatological interest as the most detailed sequence of almost daily weather maps so far available for such an early date. It is, moreover, the first such sample available of a summer within the main period of the Little Ice Age, when the Arctic sea ice and the European glaciers were both in advanced positions compared with modern times.**

Fortunately, a test of the meteorological analysis of the preliminary map series was possible. Unknown to those who had taken part in the first analysis, daily observations of wind and weather throughout the period were made at Uranienborg on the island Hven ($55^{o}55'$N $12^{o}45'$E) in the Sound between Denmark and Sweden by the Danish astronomer TYCHO BRAHE (LA COUR 1876). These were next entered on the maps with the result shown in the following table:

* There were a few vessels with oars, but the galleys dropped out of the Armada before reaching the Channel; the galleasses were dependent upon their sails, the oars being of significance only in calm conditions; and the pataches were communications boats only and played no part in the fighting.

** The situation in regard to the ice may prove to be comparable with the 1780s, the decade for which Mr J.A. KINGTON is producing a complete daily sequence of weather maps in the Climatic Research Unit. However, the 1580s were incontestably within the main period of ice advance.

Table 1. Number of days on which the preliminary synoptic meteorological analysis fitted or did not fit TYCHO BRAHE's observations of the weather in Denmark.

Implied the right wind direction over Denmark, within $\pm$ 20° of arc approximately and weather character appears reasonable.	Would be right in these reports if adjusted for a position error of a major front, trough, ridge etc. by not more than 250 km.*	Gave no indication at all regarding winds or weather over Denmark or the Sound.	Gave a quite wrong pattern over the Danish area.
18 cases 56%	5 cases 16%	3 cases 9%	6 cases 19%

* Essentially the same 250 km criterion (150 English miles) was formerly used in the British Meteorological Office in assessing 24-hour forecast weather maps as reliable in the time of C.K.M. DOUGLAS as chief forecaster in the Second World War.

It seems fair to conclude from the total of the cases in the two left-hand columns that the preliminary analysis gave a reliable indication of the general weather pattern over the eastern North Sea area – at or somewhat beyond the limit of the observations used and in an area which the analysts had not systematically attempted to cover – at least 72% of the time.

The synoptic analysis of the map series was therefore repeated by H.H. LAMB after adding the Danish observations to the maps and with the greatest care for continuity of the development and movement of the systems shown. There seems no reasonable doubt that the circulation patterns presented on the resulting maps as here published must be substantially more reliable within the region spanned by the observations used than the 72% figure achieved over the Danish area (beyond the fringe of the observations) on the preliminary maps. Reliability of these "second-approximation" maps, according to the criteria defined by the two left-hand columns of Table 1, is accordingly thought to be over 90% within the limits of the region for which observations are entered and between 70 and 90% in the remainder of the region covered by the analysis.

THE METEOROLOGICAL ANALYSIS

The final synoptic weather maps are presented in figs. 1 to 34, and the weather reports used are tabulated in the long table (Table 5) at the end of this text.

The successive positions of the low pressure centres from 22nd July to 1st October 1588 extracted from these charts are mapped in figs. 35 to 40, and the total populations of low and of high pressure centres during the period are seen in figs. 41 to 44. The period has been divided up into sections within which there was some approach to constancy of the broad-scale wind circulation pattern or *Grosswetterlage.*

It has been found possible to derive from these maps a classification of the LAMB synoptic weather (wind circulation pattern) type prevailing over the British Isles (50-60°N 10°W-2°E) each day from 22nd July to 10 October 1588. This is fully comparable with the classification published for every day from 1861 to the present time (LAMB 1972a, *Climatic Research Unit* 1972–5, 1976–). The daily classification for July to October 1588 is given in Table 2, and the frequencies of each wind circulation pattern over the British Isles are seen in Table 3. The full definitions of the types (W = Westerly, NW = Northwesterly etc ....., A = Anticyclonic, C = Cyclonic, and – means Unclassifiable) are given in (LAMB 1972a, b).

It turns out – no doubt unexpectedly for many people who have considered the well known aspects of the history of the Armada – that during this period the British Isles experienced two and a half times as many Anticyclonic as Cyclonic days. But in the sea areas where the ships of the Armada were the proportions of Cyclonic and Anticyclonic days were approximately reversed. This was possible because the wind circulation patterns during the period were characterized by blocking, i.e. by slow-moving (quasi-stationary) centres of cyclonic and of anticyclonic dominance in the latitudes of the British Isles and Northern Europe. The frequency of the Westerly type (in which the experience of different places within the middle latitudes zone is most alike) was low, equivalent to a total of about 55 to 60 days in a complete year. In this respect the closest analogies in the periods for which the daily weather type classification is available are in the 1780s and in the 1960s and 1970s (KINGTON 1975a, b, LAMB 1977).

Two further aspects which may readily be deduced seem likely to be common features of the Little Ice Age climate, despite the implication that there was a good deal of fair, or fine, anticyclonic weather in England and farther east in Europe during the period surveyed in these maps:

(1) Repeatedly, prominence of an anticyclone over the polar seas seems required to explain the evident blocking of the progress of depressions travelling towards the Arctic (e.g. in late July and from 21st August on into early September) or halts the northward travelling fronts over Scandinavia. It apparently produces situations with incipient frontal waves and wave depressions travelling east along a cold front which tends to move south over Denmark (e.g. 6–7th and 9–11th August and again after 25th August) as well as Northerly wind outbreaks penetrating farther south about 19th August and in late September-early October.

(2) A necessary corollary of this is that the ocean currents from the north, the East Greenland Current bringing polar water (and ice) southwards toward Iceland must have been more vigorous than is usual nowadays during much of this period. It was probably therefore also colder than is at all common in twentieth century summers. (We shall refer to this again in the next paragraphs.) Also, when this happens, as it did in 1888 and in April–May 1968 and 1969, the East Greenland Current sends a branch known as the East Iceland Current to reach part of the broad channel between Iceland and Scotland and Norway. In these circumstances water with surface temperatures as low as 2 to 3°C may approach (and possibly reach) the Faeroe Islands and the ocean near 60–62°N farther west. This may account for some of the Armada's reports of sea fogs.

Finally. C. LOADER of the Climatic Research Unit examined the speeds of movement of the low pressure centres which can be identified on the maps. These day-to-day movements carry implications about the wind-speeds prevailing in the jetstreams aloft and also the surface winds in the warm sectors of the depressions. Such relationships were investigated by W.J. van BEBBER in the last century and by PALMÉN (1928) in a paper which still provides the firmest basis* for the deductions which follow.

* The work seems to have been repeated by H.D. HOYLE (1955) in the British Meteorological Office in the 1950s but the results were not published in a form applicable to the present investigation and HOYLE's data are no longer available. An attempt by Mr C. LOADER to repeat the study with modern charts and radar upper wind measurements in the Climatic Research Unit could not be carried very far for lack of sufficiently large-scale and frequent-interval charts for the position measurements. PALMEN's investigation came to be regarded as the standard work on the subject of such relationships.

Table 2. British Isles daily weather type classification July–October 1588

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
July																						CE	CN	N	–	CNE	CNE	N	N	C	C
August	N	A	A	A	AW	W	CW	NW	ASW	SW	SW	CSW	C	SW	SW	W	CW	N	AN	A	CE	SE	SE	S	ASE	S	A	–	A	A	AE
September	AE	A	A	A	A	A	A	A	A	A	A	AS	S	CSW	W	S	SW	SW	SW	CSW	W	W	A	CSW	SW	CSW	S	C	CN	N	
October	N	AN	A	A	A	A	A	A	–	C																					

Table 3. British Isles Daily Weather Type Frequencies.

22nd July to 10th October 1588.

	W	NW	N	E	S	A	C	–
				Percentages				
July (10 days)	0	0	42	12	0	0	36	10
August	20	3	8	7	19	30	9	3
September	21	0	5	2	23	40	9	0
October (10 days)	0	0	15	0	0	65	10	10
Totals (81 days)	15	1	12	5	16	34	13	4

In the investigations of rates of movement of surface features it proved necessary to treat separately

(i) open frontal waves

(ii) young (warm-sector) cyclones up to the early stages of occlusion

(iii) occluded cyclones.

The last-named tend to be centred right outside the path of the strongest upper wind flow, i.e. away to the cold side of the jetstream. Systems in the middle category (ii) are generally centred closer to the upper wind-stream core, but are often associated with developing curvature of the upper flow. The open frontal waves are quite commonly close to a straight jetstream aloft and, as a class, therefore tend to move fastest. (The open frontal waves tend to be slightly to the warm side of the jetstream axis.)

Results of PALMÉN's investigations showed:

(i) The speed V_f of advance of an open frontal wave increases with the gradient wind speed v_G in the warm sector and the surface temperature contrast ΔT_o at the front in such a way that

$$V_f = 4.2 + 0.7v_G + 3.0\sqrt{\Delta T_o}$$

where speeds are in m/sec and temperatures in ^oC.

The speed of displacement of the wave is generally greater than the surface wind measured in the warm air over land, often by 50 to 80%. This implies, however, that V_f may be typically just 75 to 90% of the wind speeds observed in the warm air over the open sea.

(ii) The speed V_y of a young cyclone, typically less than that of an open frontal wave, is best given by

$$V_y = 0.8 + 0.6v_G + 2.6\sqrt{\Delta T_o}$$

This turns out to be on average about half the gradient wind speed v_G given by the surface isobars in the warm sector. It is typically a great deal less than the wind speed observable over the Low at cirrus cloud levels, which we may now take as jetstream level. CHROMOW (1942) takes the wind at cirrus levels as about twice the geostrophic wind at near-surface level, which implies that the speed of the cirrus v_{Ci} is given by

$$v_{Ci} \approx 4V_y$$

The measurement data were most abundant for lows in this category, and therefore the results in these cases should be the most reliable. Although the investigation which Mr LOADER was able to conduct with the chart material and observations at his disposal showed more scatter than might have been obtained with a more adequate map series, his result confirmed this last equation as closely as the data permitted.

(iii) The speed of old occluded cyclones V_o decreases rapidly as the system ages, unless a fresh cold or warm airstream is drawn into the circulation, effectively rejuvenating the system. No rule connecting V_o to v_G or v_{js} could be derived.

Table 4 lists the 24-hour movements of all the lows in each category between 22nd July and 1st October 1588 which could be measured and the equivalent wind speeds implied by the expressions above.

Table 4. 24-hour Movements of Cyclones (low pressure centres) and Frontal Waves and corresponding Wind Speeds

July – September 1588

Dates	*Identification of feature on the maps*	*Category: FW=frontal wave YC=young cyclone OC= occluded cyclone*	*Measured 24-hour Advance km*	*Equivalent average Speed m/sec*	*Implied Wind Speeds* (a) *surface wind in warm air over the sea m/sec* (in round figures)	(b) *jet-stream m/sec*
22–25 July	Low a	OC	240	2.8		
25–26 July	b	YC	1000	11.7	13 to 15.5	47
26–27 July	b	YC	750	8.6	9.5 to 11.5	35
27–28 July	b	YC–OC	850	9.7	10.5 to 13	40
28–31 July	b	OC	340	4.4		
28/29–30/31 July	c	FW–YC	850	9.7	10.5 to 13	40
30/31 July–1 Aug.	c	YC	800	9.2	10 to 12.5	37
28/29–30/31 July	d	YC	750	8.6	9.5 to 11.5	35
30/31 July–1 Aug.	d	YC	900	10.5	11.5 to 14	42
6/7–8 August	e	YC–OC	900	10.5	11.5 to 14	42
8–9 August	e	OC	850	9.7		
8–9 August	e'	FW	1700	19.7	22 to 26	80
8–9 August	f	YC	850	9.7	10.5 to 13	40
9–11 August	f	YC	300	3.5	4 to 5	14
11–13 August	g	YC	1300	15.0	16.5 to 20	60
13–16 August	h	YC–OC	700	8.1	9 to 11	32
16–18/19 August	h	OC	660	7.7	8.5 to 10.5	30
16–18/19 August	i	YC	900	10.5	11.5 to 14	42
16–18/19 August	j	FW–YC	1300	15.0	16.5 to 20	60
25–28 August	l	OC rejuvenated?	850	9.7	10.5 to 13	40
24–25 August	m	FW–YC	1400	16.1	18 to 21.5	65
25–28 August	n	YC	380	4.4	5 to 6	17
28 Aug.–1 Sept.	o	OC	350	4.2		
1–2/3 September	n+o	OC rejuvenated?	1000	11.7	13 to 15.5	47
2/3–6 September	p+q	YC–OC	700	8.1	9 to 11	32
6–8 September	s	YC?	500	5.8	6.5 to 8	23
8–10 September	s	YC rejuvenated?	900	10.5	11.5 to 14	42
13–16 September	t	YC–OC	800	9.2	10 to 12.5	37
13–16 September	u	FW–YC	1450	16.7	18.5 to 22.5	67
16–18 September	v	YC	1050	12.2	13.5 to 16.5	50
18–21 September	w	YC–OC	500	5.8	6.5 to 8	23
21–23 September	w	OC rejuvenated?	750	8.6	9.5 to 11.5	35
21–23 September	y	FW–YC	1200	13.9	15.5 to 18.5	55
23–26 September	a	YC–OC	600	6.9	7.5 to 9	27
26–28 September	d	YC	1000	11.7	13 to 15.5	47
28 Sept.–1 Oct.	c+d	YC–OC	over 600	over 6.9		

There is no ground for surprise in the fact that we sometimes derive different values of jetstream (or surface wind) strength from our measurements of the movements of different cyclonic features or frontal waves on the same dates. They are related to different parts of the map and of the upper wind-stream.

This table indicates that there were jetstreams on 6 occasions reaching or exceeding 55 m/sec (200 km/hr) during these months, the strongest (on 8–9 August 1588) being about 80 m/sec (288 km/hr or 155 knots). Three other times in August jetstream strengths more than three quarters of this value are indicated, and we derived again in mid September a speed of 67 m/sec (240 km/hr or 130 knots). The strongest mean surface winds in the warm air are estimated to have reached between 22 and 26 m/sec (80–94 km/hr or 43 to 51 knots): the greatest speeds in gusts and squalls near the cold fronts and in troughs in the cold air may have been over 50% stronger than this.

Although there is some margin of error or uncertainty attaching to the figures derived in this way, and this margin cannot be precisely gauged, it is unlikely that our one or two samples of moving surface weather systems controlled by the jetstreams of July–September 1588 register the effect of precisely the strongest part of the upper wind flow. It may be concluded therefore that winds of at least the strengths mentioned above occurred at some point within the wind circulation over the area analyzed.

This is believed to be the first opportunity to glimpse the strength of the individual wind circulation systems at such an early date and during the Little Ice Age climate.

The repeated occurrence of jetstreams of the strengths noted could probably not be matched in July–September in modern experience (up to 1976) over the region studied.* It was presumably related to a very strong thermal gradient over the region associated with the anomalous forward (60 to 63°N?) limit of the polar water in the ocean surface, transported south by a vigorous East Greenland and East Iceland Current.

In the summer of 1586, in mid June, and possibly (but with inadequate reporting of longitudes) again in 1587, expeditions under the command of Captain John DAVIS, exploring for a North-West Passage to Asia and the Moluccas, had found the Denmark Strait between Iceland and Greenland blocked by ice at latitude 66°N (*Richard HAKLUYT: Voyages and discoveries* (1598–1600)). In June 1586 the East Greenland ice also extended south to latitude 57°N near 47°W, south of Cape Farewell. Little or no ice was found, however, at those latitudes in the Labrador Current. Although no reports for 1588 in those sea areas are known to the authors, it seems likely from the analysis here presented that the situation was quite similar to these reports of the two preceding years.

It should not be concluded that such wind conditions as here derived in the analysis of 1588 could not occur in the present century, since the polar water with surface temperatures about 3°C was observed in the East Iceland Current advancing to near the Faeroe Islands briefly in the late spring of 1968.

* As far as can be estimated from the sample upper wind statistics kindly supplied by the Meteorological Office, the winds at jetstream level in July–September 1588 on at least the six occasions mentioned exceeded the maximum winds observed in the corresponding months in the years 1961–70 over northern Britain, in one case by up to 50%. And from the more limited sample of years 1949–55, for which the statistics have been mapped (*Upper winds over the world*, Parts I and II, by H. HEASTIE AND P.M. STEPHENSON, Geophysical Memoirs No. 103, H.M.S.O. for Met. Office, London 1960 and *Ibid*, Part III by G.B. TUCKER, Geophys. Mem. No. 105, H.M.S.O. for Met. Office, 1960.) over the whole area of our study, the same six occasions in the one season in 1588 indicated winds close to or somewhat beyond the probable limit of the modern distribution of upper wind strengths for those months.

ON THE WEATHER REPORTS AND THE MAPS

The weather reports used in the analysis are given in Table 5.

The authors wish to express their thanks to Professor P. RUSSELL-GEBBETT, Head of the Department of Spanish at Queen's University, Belfast who devoted much time to deriving an accurate translation of Aramburu's log and other Spanish documents which provided much of the data.

The documentary sources used are given in a separate list of references at the end of this paper.

The meteorological situation analysis is given in figs. 1—44 together with the ships' positions. Conventional weather map symbols are used in the fairly standardized reports for each day made by TYCHO BRAHE on the at-that-time Danish island Hven in Øresund (The Sound).

FURTHER INFERENCES FROM THE MAP ANALYSIS

1–5 August:	A slow-moving anticyclone centred near the ships in the Channel clearly followed the final cold front of the previous depression sequence.
6–7 August and 11–13 August:	Prominence of the polar anticyclone in this sector is implied by the failure of the frontal zone and the activity (disturbances) on it to clear beyond the Danish Sound. Ultimately the wind there goes round to a northerly point.
18–19 August:	The changes of wind strength and direction in the area near the Shetland Islands may be explained by small "polar lows" developing in the thermally unstable northerly airstream.
21 August:	Low 1, near the south of Ireland, seems to be moving northwestwards.
25 August:	The frontal patterns shown on the edges of this map can only be generalized indications of the type of activity going on in those regions and the probable linkages between successive disturbances.
	The southward displacement of the anticyclone over Denmark may be explained by cyclonic situations and frontal activity beginning to press southwards over Scandinavia.
28 August:	The Armada ships may have been blown farther west than shown at times during this last week of August, when some winds from easterly points were experienced.
	The small low which broke away as a warm-front wave and travelled eastsoutheastwards across Scotland implies that there was a strong frontal zone/jet stream, held almost stationary at that point by renewed prominence of the polar anticyclone. This is confirmed by the Danish observations.
1 September:	Continental warm air is streaming out over the Atlantic as far as the Armada and beyond, as a southeasterly wind, with sea mist forming.
18 September:	Low w, appearing for the first time in the area analyzed, already has the character of a deep cyclone centred near 45–48°N and may have originated as a tropical storm.
	Having now come rather near the rear of Low v, it is poised to draw in fresh Arctic cold air to its rear side. The sequel was the severest gale that the ships experienced.
1–4 October:	The disturbance which affected Denmark on the 3rd and 4th probably came from the northwest.

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2) Letter from the Duke of Medina Sidonia to King Philip.

30th July, 1588 – CSPS 1587 – 1603 No. 358.

3) Statement of Purser Pedro Coco Calderon of the events which happened to the Royal Armada etc.

24th September, 1588 – CSPS 1587 – 1603 No. 439.

4) Letter from Jorge Manrique to the King.

11th August, 1588 – CSPS 1587 – 1603 No. 383.

5) Advices from Rouen.

11th August, 1588 – CSPS 1587 – 1603 No. 385.

6) The Duke of Medina Sidonia's Diary.

21st August, 1588 – CSPS 1587 – 1603 No. 402.

7) Relation of the Occurences on the Spanish Armada given when the galleass "Zuñiga" entered the port of Havre de Grâce.

4th October, 1588 – CSPS 1587 – 1603 No. 449.

8) English State Papers relating to the Defeat of the Spanish Armada – Laughton.

9) Anon. Italian relation of events.

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10) Log of Captain Marcos de Aramburu on the Ship San Juan of Castile. 25th August – 14th October, 1588.

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11) Letter from the Duke of Medina Sidonia to the King.

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12) Letter from Pedro de Igueldo to Bernardino de Mendoza, Spanish Ambassador in Paris – written from Havre de Grâce.

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17) Relation of Mr. Henry Duke (including an account of the wreck of the galleass Girona).

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TABLE 5 WEATHER REPORTS AND INTERPRETATIONS

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Friday, 22nd July	Corunna	The Duke of Medina Sidonia	*Reports*	Light SW wind in the morning following strong WNW winds the day before. The Armada left port but at 2 o'clock in the afternoon it fell dead calm.
	Hven, Danish Sound	Tycho Brahe		Observations by Tycho Brahe on the island of Hven in the Danish Sound near Copenhagen: wind SE. Weather dark and clear (= variable cloud).
Saturday, 23rd July	Corunna	The Duke of Medina Sidonia		It stayed calm until 3.00 a.m. the next morning when a land breeze sprang up growing to brisk SE as the day advanced. By 6.00 p.m. the Armada had doubled Cape Ortegal with the wind in the South.
	Danish Sound	Tycho Brahe		Wind SE, dark, sometimes rain.
			Interpretation	The rear side of a low pressure area had given the ships off northwest Spain strong WNW winds on 20–21 July. This seems to have been followed by a sharp ridge of high pressure, giving calm conditions around the time of this map (fig. 1), followed in turn by winds from SE and S as the ridge passed on ahead of the ships.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Sunday, 24th July	South Biscay	The Duke	*Reports*	Wind continued Southerly and South-Westerly.
	Danish Sound	Tycho Brahe		Wind SE fairly strong. Clear. Thunder and lightning in the night.
Monday, 25th July	Biscay	Calderon The Duke		A strong wind sprang up and the Armada continued on its course. We proceeded on our voyage in excellent weather — no better weather could have been desired.
	Hven, Danish Sound	Tycho Brahe		Wind S, stormy. Rain at first in the morning. Towards evening rain again. At night still and clear.
			Interpretation	The ridge of high pressure continued to move east or north-east, followed by another Atlantic low. As the fronts of the low approached the ships, the wind strengthened probably at first from about S and later from SW.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Tuesday, 26th July	North Biscay 48°N	The Duke	*Reports*	On Tuesday at dawn we had a dead calm with a very dense fog and the Armada made no way until midday when a wind from the North sprang up and we set an easterly course. . . . . I ordered the fleet to tack to the west. . . .in the NNW winds and constant heavy squalls the whole day and following night we made but little way. . . .after nightfall the weather became thick with very heavy rain.
	Hven, Danish Sound	Tycho Brahe		Wind S light. Variable cloud. Towards midday a quick rain.
			Interpretation	The interval of dead calm and dense fog suggests the central region of a depression passing over, or close to, the ships: also rather cold sea – the unusual wind patterns, frequently blowing from the lands north and east of the ships' position may have produced some upwelling. The wind soon changed to N'ly as the centre moved away, probably northeastwards, and deepened. The thick weather and heavy rain at night are attributed to a trough – possibly the back-bent occlusion – moving South at the rear of the depression.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Wednesday, 27th July	Off Brittany	The Duke	*Reports*	It blew a full gale with very heavy rain squalls and the sea was so heavy that all the sailors agreed that they had never seen its equal in July. Not only did the waves mount to the skies but some seas broke clean over the ships and the whole of the stern gallery of Diego Flores' flagship was carried away. We were on watch all night full of anxiety. . . .it was the most cruel night ever seen.
	Hven, Danish Sound	Tycho Brahe		Wind E. Fairly threatening. Dark. In the night it became a strong storm and dashing rain, just after midnight.
			Interpretation	The wind direction was not reported by the ships, but it seems reasonable to deduce that the depression of the day before was deepening as it moved on northeastwards, leaving the Armada in very strong winds from between NW and W.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Thursday, 28th July	At the entrance to the English Channel	The Duke (part from his diary, part from his letter of 30 July).	*Reports*	The day broke clear and sunny the wind and sea being more moderate. All day we sailed with a Westerly wind the sea being much calmer than previously, the breeze however being light and with little appearance of freshening.
	Hven, Danish Sound	Tycho Brahe		Wind S. Stormy. Clear, in the afternoon cloudy.
Friday, 29th July	Off Scilly Isles	The Duke (part from his diary, part from his letter of 30 July).		Friday dawned fine but hazy clearing as the day advanced. We continued to sail with a Westerly wind until midday when I ordered the sun to be taken. We found ourselves in 50°N. At 4 o'clock in the afternoon whilst still sailing with a Westerly wind the weather being clear we sighted land at the Lizard.
	Danish Sound	Tycho Brahe		Wind SW. Cloud variable, sometimes raining.
			Interpretation	The low pressure area experienced by the ships in the previous days seems to have moved away by the 28th far enough for some ridge development at the mouth of the Channel in the cold air. By the next day, the hazy conditions reported suggest the return of warmer air from the S or from France, the crest of the ridge of high pressure having passed east of the ships.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Saturday, 30th July	Off Cornwall (Falmouth)	The Duke	*Reports*	In the afternoon some ships were sighted but as the weather was thick and rainy they could not be counted. Ensign Juan Gil went ashore in a rowing boat in the afternoon and returned at night (so it must have been reasonably calm probably mizzle).*
	Hven, Danish Sound	Tycho Brahe		Wind S light. Clear, afternoon cloudy, sometimes rain.
Sunday, 31st July	Off Plymouth	Calderon		At 2.00 a.m. the moon came out, the enemy set sail and gained the wind of us (i.e. wind in the west). At midday the Duke took advantage of the fresh Westerly wind to continue on his voyage.
		The Duke		The day broke with the wind changed to WNW in Plymouth Roads. By 4 o'clock in the afternoon the wind and the sea had risen to the extent that the Duke could not get a line on board the damaged San Salvador of Don Pedro de Valdez to put her in tow. During the night the wind and sea rose considerably.
	Danish Sound	Tycho Brahe		Wind NE light. Cloudy. Afternoon rain, which lasted all day and all through the night.
			Interpretation	The thick weather on the afternoon of the 30th is attributed to a warm front. By 2 a.m. 31st the moon was out, possibly thanks to a clearance in the warm sector. During the skirmish later that morning the wind came round WNW, presumably with the cold front of the depression, followed by increasing wind and rough seas.
				* The word "mizzle" in common use at the time of these reports, and throughout the following 100–150 years, is still used in Ireland. It corresponds to the modern English "drizzle"

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Monday 1st August	Off Devon Coast	Zuñiga	*Reports*	The main authorities, the Duke, Calderon and English sources, make no mention of weather on Monday 1st August. The Armada progressed eastwards followed by the English fleet so it can be assumed that the wind was generally Westerly and since there was a lot of communication with other vessels by way of pataches etc., it was probably light to moderate in character.
				The Zuñiga report (a highly unreliable document in several points) states that after nightfall on 1st August the wind fell calm and the Armada got separated in all directions.
	Danish Sound	Tycho Brahe		Wind NE. Rain most of the day and night.
Tuesday 2nd August	Off Portland	Calderon		The day dawned with an Easterly wind, the enemy's fleet being consequently to leeward of us, but the wind being light and the enemy's ships swifter than ours we were unable to give them chase. At 10 o'clock in the morning the wind shifted to the South which enabled the enemy to gain the wind.
		The Duke		Tuesday, 2nd August broke fine the enemy's fleet being to leeward (i.e. wind Easterly). . . .
		Zuñiga		. . . .A land breeze sprang up. . . .
	Danish Sound	Tycho Brahe		Wind W. Rain the first part of the day, then dry, but cloudy.
			Interpretation	On the 1st the low pressure system of the day before had moved away from the area. There followed a period of settled weather which lasted 4 to 5 days, a duration quite characteristic of the life of a slow-moving anticyclone cell.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Wednesday 3rd August	Off Isle of Wight	Calderon	*Reports*	. . . .the wind then fell light and the enemy fearing the galleasses remained two leagues from our Armada. . . .
		Zuñiga		. . . .the weather fell calm again that day.
	Danish Sound	Tycho Brahe		Wind S light, later N, then calm. Variable cloud.
Thursday, 4th August	Off Isle of Wight	The Duke		. . . .gives plenty of description of the action but little of the weather. From the use of the terms leeward and windward we can deduce that the weather was calm or light Westerly.
		Calderon		On Thursday 4th the weather was calm, later it freshened a little and a skirmish began. (About midday). . . .the weather being fair the Duke proceeded on his voyage.
	Danish Sound	Tycho Brahe		Wind N. Clear sky.
Friday, 5th August	Off Sussex Coast	The Duke		On Friday 5th the wind fell calm before dawn, the enemy always being on our rear and we remained motionless all day. At sunset a breeze sprang up and the Armada again got under way on the voyage towards Calais.
	Danish Sound	Tycho Brahe		Wind N light. Clear. Later and at night dark with Southerly wind.
			Interpretation	An anticyclone seems to dominate the area of the Channel during these days, giving fair, settled weather and light winds. By the 5th, a light to moderate general breeze from the West may be deduced as the high-pressure centre began to drift away south of the area.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Saturday, 6th August	Off French Coast at Boulogne	The Duke	*Reports*	At daybreak the two fleets were close together and sailed on without exchanging shots until 10.00 a.m. our Armada having the wind astern (i.e. S/Westerly).
		Calderon		On Saturday 6th the wind was blowing from the South-West, the weather being heavy with showers. The intention of the Duke was to anchor abreast of Calais with the wind astern. At night the weather fell light.
	Danish Sound	Tycho Brahe		Rain, then dry. Afternoon rain again.
Sunday, 7th August	Off Calais	Calderon		On Sunday 7th the weather was calm until 5 o'clock in the morning when it freshened with showers.
				At midnight the enemy set adrift eight fire ships with their sails set and the tide (?current?) in their favour.
		Zuñiga		During the night the wind and tide were favourable to the enemy and in the second watch they let loose eight fire ships.
	Danish Sound	Tycho Brahe		Wind W. Cloudy. Then at night stormy E wind and rain.
			Interpretation	The anticyclone seems to have moved away southeastwards and winds over the Channel area were freshening from the SW, or SSW, except under the lee of the land at night. The showers on the 7th may have accompanied the passage of the fronts of the depression and the wind direction then veered to W and later NW.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Monday, 8th August	Off Gravelines	The Duke	*Reports*	At dawn the Duke saw that his Armada was far ahead and went to collect them to bring them back to their previous position.* The wind freshened from NW, which is on shore, and the English fleet of 136 sail with the wind and tide in its favour was over-hauling us with great speed. . . .As the night was falling the sea was very heavy. . . .the wind was blowing from NW towards the land and the pilots told him he would be forced either to run up into the North Sea or wreck all the Armada on the shoals.
		Calderon		We sailed between Dover and Calais in the direction of Norway with a WNW wind. . . .At sunset a heavy sea arose driving us towards the banks.
		Zuñiga		At 4 o'clock in the afternoon the wind freshened greatly to the enemy's advantage.
	Danish Sound	Tycho Brahe		Wind SE, stormy. Rain. In the afternoon clear with light W wind, also at night.
			Interpretation	The frontal wave shown on the map is suggested by some report of an interval of light to moderate SW wind during the night of the 7th but it soon passed and the wind freshened from NW during the 8th. The heavy seas later suggest a long fetch of the windstream over the North Sea, the depression centre having presumably crossed Scotland and begun to move away northeastwards.
				* These sentences are from the Duke's own report although he refers to himself in the third person.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Tuesday, 9th August	Off Zeeland	The Duke	*Reports*	At 2 o'clock in the morning the wind blew so strongly that although our flagship was brought up as close to the wind as possible she began to fall off to leeward towards the Zeeland coast. At daybreak the NW wind fell somewhat and we discovered the English fleet of 109 ships rather over half a league astern. . . . It was going to be impossible to save a single ship of the Armada as they must inevitably be driven by the NW wind on to the banks of Zeeland. From this desperate peril we were saved by the wind shifting by God's mercy to the SW and the Armada was then able to steer a northerly course. The wind from the SSW kept increasing in violence and we continued to get further out to sea.
		Calderon		There appeared to be no hope for the Armada as either she must fall into the hands of the enemy or run on the banks. . . .But God succoured us as He always does and changed the wind in our favour so that we got free of the banks and left the enemy behind. We sailed on all day under a light sail.
	Danish Sound	Tycho Brahe		Cloudy, light rain. Afternoon clear with W wind. At night strong storm.
			Interpretation	"The miraculous change of wind" here reported marks the passage eastwards of the sharp ridge of high pressure indicated on the maps of the 8th and 9th ahead of the advancing Low f.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Wednesday, 10th August	Southern North Sea	The Duke	*Reports*	The Armada was under way with a fresh SW wind and heavy sea. In the afternoon the violence of the wind abated.
		Calderon		We sailed on towards Norway with the wind astern.
	Danish Sound	Tycho Brahe		Wind W variable cloud.
Thursday, 11th August	North Sea Lat 54°N	The Duke		We kept under way with the same fresh wind.
	Danish Sound	Tycho Brahe		Wind SW, hard storm, later W. Cloudy, at night rain.
Friday, 12th August	Lat 55°N off a shoal on the German Coast	The Duke		We have continued sailing with the same wind.
		Seymour, Wynter & Palmer (written in the Downs aboard the Rainbow with the wind WSW).		At 3 o'clock in the afternoon the fleet (i.e. English fleet) was off Yarmouth, the wind was SouthEast, an indifferent wind to go north or south. The Armada made their way North and by West since when the wind has been SSW and WSW, blowing for the most part astern. The weather has been such that no man hath been able to look upon the coast of Flanders this 7 or 8 days past (i.e. sea mist).
				This long foul weather past may breed a late summer the wind being Westerly.
	Danish Sound	Tycho Brahe		Wind W. Cloud variable, at night rain.
			Interpretation	The winds experienced by the ships of the Armada between the Strait of Dover – Flanders coast region and the northern North Sea blew continuously from about S or SW for four days, indicating that the anticyclone had become nearly stationary over the continent while the lows were being steered northeastwards over the Atlantic. The thick visibility reported indicates the passage of warm air over the cool sea.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Saturday, 13th August	In the North Sea	Capt. Fenner in the Nonpareil	*Reports*	About 10 o'clock in the morning the wind came up at North-West. Stayed at NW till 14th when it came up at SW and especially at night continued a very great gale at SW forcing him to ride out at sea.
	Danish Sound	Tycho Brahe		Rain, NE wind till midday, then SE, dry.
Sunday, 14th August	In the North Sea	Seymour, Wynter & Palmer		A great storm at WSW.
		Anon Italian CSPS No. 424		On the night of 14th a great tempest arose, which lasted 40 hours.
	Danish Sound	Tycho Brahe		Wind Southerly, cloud variable.
Monday, 15th August	In the North Sea	Sir F. Drake		A great storm considering the time of year.
	In the North Sea	Calderon		. . . .from 13th–18th we experienced squalls, rain and fogs with heavy sea and it was impossible to distinguish one ship from another.
	Danish Sound	Tycho Brahe		Wind SE, later W. Clear. Towards evening rain.
			Interpretation	The change of wind to NW about 10 o'clock on the 13th presumably marked the passage of cold front and of the depression centre away to the east of the ships. The Southwesterly storm that followed was clearly produced by the approach of another depression from the Atlantic, evidently a very vigorous one for August and presumably with a very low central pressure, since the anticyclone can no longer have been anywhere near.
			NOTE	The following notes may be relevant to the vigour of this mid August storm and possibly also to the great storm of 21 September 1588: The explorer Captain John Davis, operating near Iceland and southern Greenland in the two previous years, had reported the passage of Denmark Strait between Iceland and Greenland blocked by ice in late June 1586 and that he could not go north of 57°N in the longitude of Cape Farewell (44°W). In 1587 the ice situation was almost equally excessive in comparison with any year in the twentieth century. If this applied in the summer of 1588 also, it would provide a possibility of development of a strong frontal zone and jet stream.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION
			From Tuesday, 16th August till Thursday, 18th August there are no reports apart from Calderon's general remarks about squalls, rain, fogs and heavy seas.
Tuesday, 16th August	Danish Sound	Tycho Brahe	*Reports* Hard wind from SSE. Dark, sometimes raining. At night very heavy rain.
Wednesday, 17th August	Danish Sound	Tycho Brahe	Wind SW rain.
Thursday, 18th August	Danish Sound	Tycho Brahe	Dark. Rain till midday. Wind W, towards evening NW.
Friday, 19th August	off NE Scotland	Calderon	. . . .tried to get supplies of medicines to the "San Marcos" but was prevented by the rough sea.
	Danish Sound	Tycho Brahe	Wind light, Northerly, clear.
Saturday, 20th August	off NE Scotland	Calderon	The weather being very heavy we lost sight of Juan Martinez de Recalde and all the ships that followed him. . . . we continued on our voyage alone through squalls and fogs.
	off NE Scotland	The Duke	We have now doubled the last of the Scottish Islands to the north and we have set our course with a NE wind for Spain.
	at Harwich	Drake	The wind off Harwich was southerly light.
	Danish Sound	Tycho Brahe	Wind light, Easterly, clear.
			Interpretation The great storm depression approaching on the 15th evidently made rather slow progress from the 16th to the 19th, during which time the variations of weather noted were such as might be produced by successive frontal wave depressions maintaining the activity of the cyclonic system and causing troughs of low pressure to extend south from the main Low centre and pass generally eastward. The continuance of high seas off northern Scotland to the 20th suggests a direct northerly airstream from the Norwegian Sea followed the depression, and a meridional ridge of high pressure temporarily linking the subtropical and Arctic anticyclones came east from the Atlantic. The light Southerly wind off Essex on the 20th is interpreted as a coastal breeze near the crest of the ridge of high pressure extending from the Arctic.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION
Sunday, 21st August	Off Northern Scotland	Zuñiga	*Reports* On 21st we saw the extreme point of Ireland (more probably the Hebrides). The wind then freshened from the South and the Armada stood out to sea for the next 15 days reaching as high as 63½°N on 8th September (50 miles from Iceland).
	Danish Sound	Tycho Brahe	SE breeze. Fine and clear.
Monday, 22nd August	Danish Sound	Tycho Brahe	Clear the whole day, then cloudy, wind NEasterly, with some rain.
Tuesday, 23rd August	Danish Sound	Tycho Brahe	Light Northerly breeze, clear.
			Monday and Tuesday 22nd and 23rd August – No Reports from the ships.
Wednesday, 24th August	58½°N	Calderon	From 24th August to the 4th September we sailed without knowing whither through constant storms, fogs and squalls.
	Danish Sound	Tycho Brahe	Light Northerly wind, clear.
			Interpretation The long sequence of unsettled weather and generally Southerly winds off northwest Scotland must indicate that the eastward passage of Lows from the Atlantic was blocked in the latitude of the British Isles and at times even farther north.
			No fronts seem to have produced any major change of wind direction at the ships, though the strength of the S'ly windstream varied.
			(From 25th August the log of Captain Marcos de Aramburu gives more detailed information.)

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Thursday, 25th August	59°N NW of the Hebrides	Aramburu	*Reports*	. . . it was getting dark the wind was SEasterly and just before nightfall it became misty. We sailed with two mainsails during the night as the wind was fresh and all the other ships were on the same sail. The night was very misty and we saw neither ship nor lantern.
	Danish Sound	Tycho Brahe		Calm. Clear but misty, later cloudy.
Friday, 26th August	off Hebrides	Aramburu		The morning of 26th it was still foggy, our main foresail was damaged and we were forced to repair it. Since it was raining and it took a lot of work we were delayed until about 1 o'clock after midday. In the afternoon we saw the Flagship with some other ships on our prow to the SouthWest and somewhat to windward (i.e. wind probably now SW or WSW).
Friday 26th August– 27th August	Danish Sound	Tycho Brahe		Cloudy, sometimes raining.
			Interpretation	The changes of wind direction and weather reported on the night of 24th–25th August probably mark the passage of a warm front north over the ships and also that the central regions of the cyclonic activity (tips of the warm sectors) were coming nearer than before. By the 27th the wind direction became more changeable and some cyclonic activity (warm front waves ?) evidently began to break away to the east quite near the latitude where the ships were.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Saturday, 27th August	Off Hebrides	Aramburu	*Reports*	During the night, about the fifth watch, the wind changed to South, the South-West and even as far as NNEast. I gave orders to set course to the SSW. At dawn we saw some ships to the west to windward (i.e. wind W). At nightfall the wind was Westerly as it had been all day. From dusk right through the night we pressed on with both mainsails changing course to SSE close to the wind which was the best we could do (i.e. wind changed to SW forcing them off their SSW course).
Sunday, 28th August	Still off Hebrides	Aramburu		The morning was overcast and dark but we held the same course until nightfall (South ¼ to SE). When night fell the wind began to drop and passed through SW to the South. We steered West ¼ SW at midnight.
	Danish Sound	Tycho Brahe		Westerly breeze. Variable cloud, sometimes raining.
			Interpretation	The erratic changes of the wind direction in the area where the ships were indicates the passage of a cyclonic centre (or centres) quite close. This is interpreted on the map as a warm front wave development. The sequence of weather observations from Denmark from this time onward indicate that the front in that sector was held farther south by prominence of a ridge from a polar anticyclone and wave activity passing east or eastsoutheast along the front, presumably steered by a WNW'ly jet stream. Farther south over the British Isles and central Europe the situation was probably not much changed.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Monday, 29th August	58°N West of Hebrides	Aramburu	*Reports*	At dawn on the 29th the wind began to freshen from the South with heavy seas, mists and rain. We continued on the same course (west ¼ SW) with the mainsails lowered until night and all through the night until dawn on 30th.
	Danish Sound	Tycho Brahe		Wind light SW. Rain sometimes clear.
Tuesday, 30th August	West of Hebrides	Aramburu		On the morning of the 30th the wind dropped but with a very heavy shower as the wind died and the sea moderated. All the rest of the day the wind stayed light NE and with clouds building up from the SW.
	Danish Sound	Tycho Brahe		Cloudy, sometimes raining.
			Interpretation	The ships off the Hebrides experienced a calm interval on the night of the 28–29th August. After that a front approached from the South, and renewed cyclonic activity made itself felt over the Atlantic. The wind variations between S and NE indicate a sequence of frontal waves probably travelling northwestwards over the Atlantic and intervening ridges of higher pressure affecting the area about the ships. The prominence of the polar anticyclone explains the wind directions in that area as well as over Denmark, a front, initially with some wave activity travelling southeastwards, being held effectively stationary from Scotland to the German Bight.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Wednesday, 31st August	Off Hebrides	Aramburu	*Reports*	A wind sprang up from the South and we steered WSW until 4 o'clock in the afternoon when the wind moved round ESE.
	Danish Sound	Tycho Brahe		Cloudy, sometimes raining.
Thursday, 1st September	Off Hebrides	Aramburu		On the afternoon of 1st September we sailed SW, the sea was rough, the wind SE and there was a lot of sea mist.
	Danish Sound	Tycho Brahe		Wind light Northerly. Cloudy. In the evening soft rain.
Friday, 2nd September	Danish Sound	Tycho Brahe		Wind NE, fairly clear.
	Off Hebrides	Aramburu		On the morning of the 2nd September the ship Trinidad appeared three ship lengths of our stern but because of the sea mist we lost sight of her again almost at once. . . .In the afternoon we sighted her sailing from NE about a league away as the mist had cleared somewhat. Presently a gentle wind sprang up from SE. We were steering SW¼S with seas running from SSE. Then two hours after dark the wind veered through South round to NW very strong and stayed like that till dawn on the 3rd when it became calm until the afternoon.
Saturday, 3rd September	Off Hebrides 56½°N.	Aramburu		
	58°N	The Duke (letter of 3rd Sept)		Since 21st August we have had on four separate nights heavy gales with strong head winds, thick fogs and rain. By God's mercy yesterday at noon the wind shifted to the West somewhat more in our favour. (This weather did not reach Aramburu until 2 hours after dark.) The wind has now veered to WNW with a more favourable appearance, but the winds on this coast are always more tempestuous than elsewhere and are so prevalent from the South that there is no certainty of a continuance of the present fair weather.
	Danish Sound	Tycho Brahe		Wind light E, clear. Afternoon cloudy.
			Interpretation	At first the general Southeasterly wind current continued over the region in which the ships were, the sea mist indicating that the air was warm before coming over the sea. During the 2nd September a decisive change is registered by the wind shifting right round to NW and becoming strong: clearly a deepening depression broke through to the east on a new track.
				The change of weather on the evening of the 2nd had reached the Duke at 58°N at noon but did not reach Aramburu at 56½°N until
				2 hours after dark. The cyclonic centre seems to have been well to the north of the ships, as the winds continued about NW and WNW through the 3rd September.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Sunday, 4th September	Danish Sound	Tycho Brahe	*Reports*	NE breeze. Cloudy all day and night.
Monday, 5th September	Still 56½°N West of Hebrides	Aramburu		We continued on the same course until night with the wind moderating.
	At Dover	English State Papers Laughton Vol II pp. 161		. . . .became foggy.
	Danish Sound	Tycho Brahe		NE breeze. Soft rain the first part of the day, then cloudy but dry.
Tuesday, 6th September	Still 56½°N West of Hebrides	Aramburu		We ran before the wind from WSW¼W with heavy seas and strong wind until 2 o'clock in the afternoon when we had a heavy shower. At once the seas moderated and the wind moved round to WNW, the sea continued to moderate and we sailed SSE.
	Danish Sound	Tycho Brahe		Wind NE light. Cloudy. Towards midday rain, then dry.
			Interpretation	A mobile Westerly cyclonic sequence continued to affect the region of the northeast Atlantic where the ships were, with passing warm sectors and fronts and mostly strong winds and seas, while England enjoyed quiet, somewhat autumnal, anticyclonic weather.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Wednesday, 7th September	Still 56½°N Off Hebrides	Aramburu	*Reports*	On the 7th we continued on the same course with the same wind (i.e. WNW), we were able to take an accurate reading and found we were in 56½°N. At four o'clock in the afternoon the wind changed to SW with a gentle sea.
	Danish Sound	Tycho Brahe		Northerly breeze, clear.
Thursday, 8th September	55°N, off North West Ireland	Aramburu		The day dawned with the wind and the sea the same as the previous afternoon. The latitude was taken at 55°N and we were sailing on a bearing SE¼S.
	Danish Sound	Tycho Brahe		Wind NW clear, misty. Towards evening cloudy.
			Interpretation	Lighter winds in the region of the ships indicate that the area of influence of the anticyclone over the British Isles was spreading. The changes of wind direction mean, however, that the ships were still affected by the variations associated with passage of cylonic activity and intervening ridges of high pressure around the fringe of the anti-cyclone.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Friday, 9th September	54°N due west of Co Mayo	Aramburu	*Reports*	I took the latitude at 54°N, 100 leagues from the land of Ireland (he was actually much closer to Ireland, probably less than 100 miles) running with a moderate SW wind easing gradually, the course SE¼S.
	At Portsmouth and in the Channel	English State Papers Laughton Vol II, pp. 196		The wind had been blowing very high from the NW preventing them going to France [to attack the Santa Ana in Le Havre]. (Presumably this means on 6th and 7th or earlier because on 9th they actually did cross to Le Havre.) The date of this NW wind is not at all clear, certainly during the 9th and 10th the descriptions of the fighting at Le Havre and the use of small boats to recover the damaged Santa Ana imply that the wind was light on those days.
	Danish Sound	Tycho Brahe		Wind N, cloudy. Humid. Clear at night.
Saturday, 10th September	West of Ireland	Aramburu		We continued on the same course with a light wind and did not take a latitude reading.
	Danish Sound	Tycho Brahe		Wind N, light, clear.
			Interpretation	An anticyclonic situation with fair weather and light winds dominant over the British Isles and surrounding sea areas.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Sunday, 11th September	Off Co. Kerry	Aramburu	*Reports*	On 11th 2 hours before dawn we sighted land. We were on a fresh SW wind steering SE, the weather was misty and we did not see it till we were only one league from it. Some of us thought it was the Islands of Drasey and others the Isles of Quelmes. The pilot was of the opinion it was the islands Bull & Cow (Bull & Calf) eight leagues from the Cape (Clear). We turned out to sea with a SSW wind and at 4 o'clock in the afternoon the wind began to freshen and the seas to rise.
	Danish Sound	Tycho Brahe		Still. Lovely and clear the whole day.
Monday, 12th September	Off SW Ireland	Aramburu		On 12th we kept on heading out to sea with the same wind and sea conditions and at 5 o'clock in the afternoon it began to blow from the South with great strength, which by the night had become a very heavy storm with very rough seas and sea mist. The ship Trinidad had joined us, it had both sails furled; from midnight onwards we were unable to see it although we showed our lantern signal.
	Danish Sound	Tycho Brahe		Still. Cloudy. Clear in the evening.
Tuesday, 13th September	Off SW Ireland	Aramburu		On 13th at dawn the wind veered NW and the seas began to go down, we steered S¼SE.
	Danish Sound	Tycho Brahe		Wind S, light. Cloudy.
			Interpretation	The anticyclone of the previous days over the British Isles clearly moves away eastwards, allowing strengthening S'ly winds to encroach ahead of the fronts of an Atlantic Low (t), probably coming from the southwest. This depression passed quickly. The wind at the ships veered NW and dropped as the cold front passed, a situation likely to be followed by at least some minor wave activity (Low u) on the front.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
	Le Havre	Pedro de Igueldo (letter to Mendoza 17 September)	*Reports*	His letter of 17th September describes events at Le Havre after the English attack on the Santa Ana on 9th and 10th. Each event is not precisely dated but after 12th he says. . . .after lightening the ship all we could with the intention of getting her into the harbour at the spring tides tomorrow a great gale arose and as these roads are unsheltered the cables broke at nightfall and the ship drifted ashore near the castle of the town. (No wind direction is given but Le Havre roads are south of the town so the ship drifting ashore is consistent with Aramburu's Southerly gale off SW Ireland on the night of 12th/13th.)
Wednesday, 14th September	Off SW Ireland	Aramburu		We continued on the same course (S¼SE) with the same wind (NW).
	Danish Sound	Tycho Brahe		Hard Westerly wind. Cloudy, towards midday rain. At night clear.
Thursday, 15th September	Off SW Ireland	Aramburu		On 15th we continued heading south on a Westerly wind. (Two hours before dawn Aramburu was joined by the flagship of Juan Martinez de Recalde who had some experience of the coast of Co. Kerry. After tacking back and forth to try to get clear of the land the Westerly wind eventually drove them in shore and they found shelter in the lee of Blasket Island at the tip of the Dingle Peninsula.)
	Danish Sound	Tycho Brahe		Westerly breeze. Clear. Afternoon rain.
			Interpretation	Igueldo's letter confirms that the S'ly gale encountered off Ireland on 12–13th continued to advance eastwards ahead of the fronts of the depression, until it affected the eastern part of the Channel and the French ports. In the rear of the depression the winds ultimately became W'ly and quite strong.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Friday, 16th September	Blasket Sound	Aramburu	*Reports*	Unfortunately Aramburu having found shelter at Blasket Sound ceased in his log to give detailed accounts of the weather, and did not in fact make a specific reference to it again until 21st September. On 16th he and Recalde exchanged anchors and supplies so it must have been possible to put out small boats. On 17th they sent a long boat over to the mainland "but they found nothing except wild cliffs beaten by the seas", presumably it was still blowing a considerable wind. On 18th, 19th and 20th he said "we remained in this port without being able to sail." The way out of Blasket Sound is either westwards to the north of Gt Blasket Island or southwards between the island and the mainland. If they were unable to get out of the port the implication is therefore that the wind was Southerly or South-Westerly.
	Co. Clare	Zuñiga		Farther north the Zuñiga was off the coast of Co. Clare, their report says, "on the morning of 15th the wind changed to the west and we resumed our voyage. In the evening the wind blew heavily from the South again and we found ourselves between two points on the Irish coast neither of which we could get round on any tack for want of a rudder. We saw we were in great danger and in order not to be driven aground in the strong wind we followed the creek and by God's grace, found shelter not far from a tower held for the enemy. Here we remained 8 days until 23rd when we got out with the wind astern."
				Farther north again a report in the Irish State Papers refers to "3 great ships seen on the coast of Sligo which cast anchor in the Bay of Sligo". On one of these ships was a Captain Francisco de Cuellar who later gave an account of his adventures. In it he states. . . . "not being able to weather Cape Clear (actually the tip of Mayo at Eagle Island) in Ireland on account of the severe storm which arose on the bow we were forced to make for land with these three ships and to anchor more than half a league from the shore where we remained for four days". This ties in closely to the Southerly wind experienced by the Zuñiga on the night of 15th/16th September.
	Danish Sound	Tycho Brahe		Still [and presumably later] gentle N'ly. Clear.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Saturday, 17th September	Danish Sound	Tycho Brahe	*Reports*	S breeze. Clear.
Sunday, 18th September	45°N in Biscay about 100 miles from north coast of Spain	The Duke Letter to the King, 23rd September		I wrote to your Majesty from the Gulf sending an account of events up to that time. Subsequently the weather became so bad that the ships were all scattered only 60 standing by me. (Probably the Southerly gales of 12th/13th and 15th/16th.) They followed me until 18th when a great storm overtook us in latitude 45°N, and we all expected to perish. I was left with only 11 ships and with them when the weather abated I continued on my course to Cape Finnesterre with a Westerly wind.
	Danish Sound	Tycho Brahe		Wind S, stormy. Cloud variable.
Monday, 19th September	Danish Sound	Tycho Brahe		SE breeze. Fairly clear, later cloudy.
Tuesday, 20th September	Danish Sound	Tycho Brahe		SE breeze, later SW storm. Cloudy.
			Interpretation	There was an interval of lighter winds on the west coast of Ireland on 15–16th between Lows t + u and v, the next main centre in the sequence. The quiet interval seems to have been in a sharpening ridge of high pressure in which the anticyclone marked j formed and later passed over Denmark. The fact that the strongest winds over the next few days, as from the 13th onwards, continued to be from the South suggests that the Atlantic cyclonic centres continued tracking from about SW to NE and that the barometric pressure continued high over central Europe.
				The ships' logs between 16 and 20th September give little specific information except that the winds in the west of Ireland continued generally strong and that on the 18th the Duke of Medina Sidonia experienced a further severe gale in the southern part of the Bay of Biscay: this is clear evidence of yet another storm cyclone (Low w) in the sequence and that the centres were approaching the British Isles from far to the southwest. This one may have originated as a tropical storm.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Wednesday, 21st September	West Coast of Ireland	Aramburu	*Reports*	(At Blasket Sound) On the 21st in the morning it began to blow from the West with the most terrible fury. It was bright and with little rain. (Recalde's ship dragged anchor and struck Aramburu's.) At midday the Santa Maria de la Rosa came in by another entrance to the NW. Coming in he fired a piece as if asking for help. All her sails hung in pieces except for the foremast mainsail. She managed to come to a stop with one anchor which was all she had and with the tide entering from SE she was held steady for a while. At 2 o'clock in the afternoon the tide turned and she began to swing in her anchor and dragged down the Sound. We were also dragged not two cables length from her. She struck a submerged rock in the South entrance and went down right away with everyone on board, not a soul was saved. The same afternoon at 4 o'clock the San Juan commanded by Fernando Horra came in, her mainmast gone, and as she came in her main foresail ripped to pieces. She dropped anchor and stopped. With the fierce weather we were not able to hail her nor give her any assistance.
	Danish Sound	Tycho Brahe		Southerly storm. Cloudy, sometimes raining. At night sometimes slashing rain, SW wind.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
	Streedagh Strand off Sligo	Capt. Cuellar	*Reports*	On the fifth day there sprang up so great a storm on our beam with a sea up to the heavens so that the cables could not hold nor the sails serve us and we were driven ashore with all three ships upon a beach covered with fine sand, shut in on one side and the other by great rocks. Such a thing was never seen for within the space of an hour all three ships were broken in pieces so that there did not escape three hundred men. . . . . (later) and at that time which would be about nine o'clock in the evening the wind was calm and the sea subsiding.
	Blacksod Bay, Co. Mayo	Irish State Papers		(The long account of events in Co. Mayo chronicled in two different reports by Edward Whyte, clerk to the council of Connaught, gives the date of the great gale as Tuesday 10th September O.S. He is, however, shaky on dates in other passages and I am inclined to prefer Aramburu's date of Wednesday 21st September N.S.) Upon Tuesday 10th/20th September there blew a most extreme and cruel storm the like whereof hath not been heard a long time which put us in very good hope that many of the ships should be beaten up and cast away upon the rocks as it happily came out afterwards according to our expectation. (Indeed it did. Apart from the descriptions above at least seven other great Armada ships and probably more were destroyed by this great gale. As such it was the biggest single cause of losses in the whole course of the Armada voyage, bigger than that caused by the English gunfire at Gravelines, or the contrary weather off the northwest of Scotland.)

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION
	43½°N Off Santander	The Duke	*Reports* We ran down to 43½°N and on 21st at two o'clock we sighted land. The wind then fell calm and one of the little caravels which had ridden out the storm with her head to windward cried out we were off Santander. There was no wind and the strong currents were carrying us on to the land. Next morning a strong Southwester came up preventing the ship from entering Santander and obliging her to run for Laredo (i.e. 22nd September). *Interpretation* The great W'ly storm winds on the west coast of Ireland on 21st September can confidently be attributed to the same cyclonic system which the Duke encountered as an already severe storm in southern Biscay on the 18th (see depression tracks chart and note the consistency of its progress). There is some analogy with the progress of hurricane "Debbie" on a similar track on 16th September 1961, when there was much damage in the west of Ireland. Both storms may have originated as Atlantic tropical cyclones, this being near the peak date for such systems entering higher latitudes on recurving tracks which carry them far to the northeast. By 21st September 1588 Low w had probably been rejuvenated and deepened by drawing in Arctic cold air in its rear. The mention of Aramburu's log of "little rain" probably means that the (occluded ?) front of Low w passed quickly in the strong winds and perhaps during the night.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Thursday, 22nd September	Blasket Sound	Aramburu	*Reports*	Calmer conditions in the morning – Fernando Horra sent over a chalup to let Aramburu and Recalde know what he needed. – In the evening the weather was favourable to leave Blasket but he did not sail.
	Blacksod Bay Co. Mayo	Irish State Papers		The Nuestra Señora de Begoña left Blacksod Bay with a favourable wind, leaving behind the Rata which had been wrecked in the great gale of the 21st and the Duquesa Santa Ana which was still safely at anchor.
	Danish Sound	Tycho Brahe		Wind light SW, clear. At night cloudy, stronger wind.
Friday, 23rd September	Co. Clare	Zuñiga		(see their report of 16 September). . . "Here we remained 8 days until 23rd when we got out with the wind astern.
	Blasket Sound	Aramburu		On the morning of 23rd we sailed on a light Easterly wind but as we left harbour we had hardly gone two cables when the wind fell calm. The current began to drive us on to the island so that in a short time we would have been lost, when the wind picked up again and we were able to continue sailing as far as the rocky islets to the North of us. Again the wind dropped and the tide which was coming in kept moving us towards the land to the north. We cast anchor before nightfall with only one cable which was all we had and one hour after dark the wind began to blow from the SE and the ship began to drag towards the islands which are so rocky that no one sailing on them could be saved. We swung round on the cable and lifting the anchor we set sail commending ourselves to our Lord as we had no idea whether there was a way out, the night was so dark and cloudy, but we had to take the risk. First we tried to make our way out to windward of the rocky islets but were prevented by the currents which rather would have carried us to destruction. We turned and tried again for an opening between the islands. The wind was becoming fresh with rough sea, a lot of cloud and heavy rain. Thanks to our Lady in whom we put our trust we managed to get out this time and sailing all through the night to the west we found that by morning we were 8 leagues from land.
	Danish Sound	Tycho Brahe		Wind NE, cloudy. Afternoon and all night through rain.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Saturday, 24th September	Off SW Ireland	Aramburu	*Reports*	On the 24th three hours after daybreak a great storm sprang up from the SE with heavy rain and rough seas. Thank God it lasted only two hours. We feathered our sails and lay to. Almost at once the wind veered Westerly with big seas . . . . It was not possible to set sails until the afternoon when with a moderate wind we did manage to do so. Next day at dawn we found ourselves off the entrance to the anchorage we had just left, 3 leagues out to sea and making no headway.
	Off Co. Mayo	Irish State Papers		(Don Alonso de Leyva set sail in the Duquesa from Blacksod Bay). . . . and by all likelihood he is cast away for the wind fell contrary immediately after her departure and became very stormy and foul weather as not possible he could escape except his ship were most strong and good.
	Danish Sound	Tycho Brahe		Moist, rainy weather; then in the afternoon dry, hard SW wind.
			Interpretation	Winds became lighter and apparently Northerly after the great storm on the 21st, enabling the Begoña to set sail from Blacksod Bay and head south, while Aramburu prepared to depart from Blasket Sound. The ridge of high pressure over the British Isles between Low w and the approach of another depression from the southwest on 24th September, produced a light E'ly breeze for a time on 23rd–early 24th before the wind freshened from about SE and strengthened to gale. When the cold front of this new depression (Low a) passed the ships on the 24th, the wind veered sharply to W and blew Aramburu back to the entrance to Blasket Sound, while Don Alonso was driven northeast and ship-wrecked again on the coast of Donegal.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Sunday, 25th September	Off SW Ireland	Aramburu	*Reports*	During the morning of 25th the wind began to back South-Easterly and Southerly. We set course to the west to take advantage of the wind and double the Cape of Drasey. We sailed that day and all night till by next morning we reckoned we were 10 leagues out to sea.
	Danish Sound	Tycho Brahe		Wind W, stormy. Cloud variable. At night clear: northern lights.
Monday, 26th September	Off SW Ireland	Aramburu		On the morning of the 26th the wind came round to WSW and SW strong with rough seas moving us along at good speed, the course was SSE and sometimes SE¼S until we judged we had doubled the Cape of Drasey and were North-South from it 14 leagues.
	Danish Sound	Tycho Brahe		Wind S, stormy. Lovely and clear the first part of the day. Afternoon cloudy with two rain showers.
Tuesday, 27th September	Danish Sound	Tycho Brahe		W breeze. Cloud variable.
			Interpretation	The backing of the wind to SE and S on the morning of the 25th shows the approach of the warm front of another low pressure system. Lack of mention of any rain probably means that it passed in the night of 25–26th. By the morning of the 26th the wind had veered Westerly and become stronger and with heavy seas, perhaps marking the rear side of the complex cyclonic system (Lows a, b, c) shown on the map for the 26th.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Wednesday, 28th September	South of Ireland	Aramburu	*Reports*	On the morning of the 28th the wind came round Southerly and SSWesterly. We changed course to West and WNW. At midnight such a great gale blew up from the North-West and with such violent seas and rain, that our fore mainsail ripped to pieces, nothing was left of it. We lowered the mainsail but were not able to take it in. . . .
	At the entrance to the English Channel	Zuñiga		On the 28th we were driven by a furious gale in the direction of the English Channel. On 29th two guns were thrown overboard. During this time the Zuñiga ran according to the pilot 112 leagues and was now inside the Channel in great trouble for lack of food of any sort*. * The Zuñiga went on up the Channel and found shelter in Le Havre where she remained until July 1589.
	Danish Sound	Tycho Brahe		Wind SSE fairly stiff. Cloudy, humid.
Thursday, 29th September	South of Ireland	Aramburu		From the morning of 29th the wind gradually dropped and because of the heavy seas we carried on sailing to the South until the afternoon when we were able to fix up an old main foresail which we had made ready. The night was quite calm with not much wind and until morning we steered SE¼East.
	Danish Sound	Tycho Brahe		SW breeze, in the afternoon still. Cloudy.
			Interpretation	It is clear that yet another depression passed over the ships on the 28th, maintaining the sequence which had continued at approximately 2-day intervals since the 12th. This time, however, when the centre had passed, the wind direction stayed at NW to N for several days. The NW'ly wind was at first very violent and the cold air outbreak seems to have been followed by the formation of an anticyclone and some days of a fairer spell of weather.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Friday, 30th September	Off Brittany	Aramburu	*Reports*	We carried on with the task of repairing the ship. It remained calm until dark when the wind came up at NW light and stayed the whole night. (Diurnal breezes of the S coast of Brittany affecting the variations experienced by the Ship?)
	Danish Sound	Tycho Brahe		NW breeze. Cloudy, raining.
Saturday, 1st October	48¼°N off Brittany	Aramburu		. . . . on 1st October we sailed in like manner. At midday a reading of the sun showed 48¼°N (the sky was therefore at least partly clear).
	Danish Sound	Tycho Brahe		Wind NW light rain the first part of the day, afterwards dry.
Sunday, 2nd October to Friday, 7th October	Biscay	Aramburu		From 2nd to 7th October we continued sailing in reasonable weather and on the 8th at dawn we sighted land – the Cap de Penas off Torres (43°34'N 5°41'W).
Sunday, 2nd October	Danish Sound	Tycho Brahe		Wind NW light, cloudy. Sometimes moist. Afternoon clear, still.
Monday, 3rd October	Danish Sound	Tycho Brahe		Wind S storm. Rain. Afternoon wind N and dry. At night still, but towards daybreak stormy S wind.
Tuesday, 4th October	Danish Sound	Tycho Brahe		Wind S stormy, rain most of the day. At night clear.
Wednesday 5th October	Danish Sound	Tycho Brahe		Hard W wind. Clear. At night cloudy.
Thursday, 6th October	Danish Sound	Tycho Brahe		Squally SW wind. Cloudy, towards midday rain. Afterwards variable cloud, hard storm from SW.
Friday, 7th October	Danish Sound	Tycho Brahe		Hard SW wind, cloudy, at times rain.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Saturday, 8th October	Biscay, Coast of Spain	Aramburu	*Reports*	A fresh Easterly wind came up and we sailed on it till the next morning.
	Danish Sound	Tycho Brahe		Wind WSW fairly strong. Clear most of the day and night.
Sunday, 9th October	Biscay, Coast of Spain	Aramburu		On 9th the wind veered Westerly and since it was our intention to make for Corunna we headed towards land until we sighted Rivadeo. The wind kept getting stronger and presently it veered NW fresh. We stood out to sea that night.
	Danish Sound	Tycho Brahe		Wind S Storm. Fairly clear. Later cloudy and humid.
Monday, 10th October	Biscay, Coast of Spain	Aramburu		On the 10th a great Westerly gale developed, which damaged our main topsail, the main foresail and broke the shrouds of the main mast on the port side. This was during the night and at dawn we hove to to refit the main mast.
	Danish Sound	Tycho Brahe		Wind SSE stormy, later SW stormy. Cloudy, towards midday rain.
Tuesday, 11th October	Biscay, Coast of Spain	Aramburu		On 11th we headed back towards the land and sighted Los Arrocles, 14 leagues from Santander.
	Danish Sound	Tycho Brahe		SSE light breeze, cloudy. At night rain.
Wednesday, 12th October	Biscay, Coast of Spain	Aramburu		On the 12th we ran the whole day on a fresh wind making for Santander (obviously a Westerly wind). At nightfall it became calm and we turned out to sea.
	Danish Sound	Tycho Brahe		Wind SE light. Cloudy; raining. Towards evening and in the night some clear periods.
Thursday, 13th October	Biscay, Coast of Spain	Aramburu		On the 13th we found ourselves off Santona but were unable to sail because of the bad state we were in. At 3 o'clock in the afternoon the wind came round fresh SE without rough seas, and two hours after nightfall we arrived and anchored at the entrance to Santander.
	Danish Sound	Tycho Brahe		Wind NW light. Towards evening SE. Fairly clear most of the day and night. Northern lights at night, but not high in the sky.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Friday, 14th October	Santander	Aramburu	*Reports*	On the morning of 14th we entered port and anchored in safety for which we give thanks to God and for finding in port the Flagship and a good portion of the Armada.
	Danish Sound	Tycho Brahe		Wind SW light, cloudy.
Saturday, 15th October	Danish Sound	Tycho Brahe		Wind SE, cloudy.
Sunday, 16th October	Danish Sound	Tycho Brahe		Wind S, light. Cloudy.
Monday, 17th October	Danish Sound	Tycho Brahe		Wind S, cloudy. At night rain.
Tuesday, 18th October	Danish Sound	Tycho Brahe		Wind S. Cloudy and humid. At night fairly clear.
Wednesday, 19th October	Danish Sound	Tycho Brahe		Wind SE. Red clouds spreading. Afternoon clear.
Thursday, 20th October	Danish Sound	Tycho Brahe		Wind SE. Cloudy. Towards midday rain. Then dry.
Friday, 21st October	Danish Sound	Tycho Brahe		Wind SE light. Cloudy, but some clear periods.
Saturday, 22nd October	Danish Sound	Tycho Brahe		SE breeze, cloudy.
Sunday, 23rd October	Danish Sound	Tycho Brahe		S breeze, cloudy. At night clear periods.
Monday, 24th October	Danish Sound	Tycho Brahe		Moderate SE breeze. Variable cloud. At night [possibly meaning the night before, i.e. early hours of the 24th] northern lights.
Tuesday, 25th October	Danish Sound	Tycho Brahe		SE breeze, cloudy.
			Interpretation	The anticyclone of 29th September to 8th October finally gave way to another sequence of unsettled weather ushered in by an Atlantic cyclone which approached the British Isles again from the southwest. After the initial E wind the direction became mostly Westerly in the Bay of Biscay and Spanish coast region.

DATE	POSITION	AUTHORITY	REPORTS AND INTERPRETATION	
Wednesday, 26th October	Northern Ireland	Irish State Papers	*Reports*	After being at anchor in the shelter of Killybegs Harbour, Co. Donegal for six weeks, the galleass Girona of the Spanish Armada set sail on Wednesday 26th October with Don Alonso de Leyva on board to make for the "out isles" of Scotland. After rounding Malin Head she was caught in a North-Westerly squall, and driven on to the rocks at Giant's Causeway.
	Danish Sound	Tycho Brahe		Hard W wind. Variable cloud.
Thursday, 27th October	Danish Sound	Tycho Brahe		Wind N light, clear.
Friday, 28th October	Danish Sound	Tycho Brahe		Wind NE, cloudy.
Saturday, 29th October	Danish Sound	Tycho Brahe		Still. Clear. At night cloudy.
Sunday, 30th October	Danish Sound	Tycho Brahe		Hard Easterly wind. Cloudy. At night rain.
Monday, 31st October	Danish Sound	Tycho Brahe		Wind NE. Clear. At night cloudy, SE wind.
			Interpretation	The s/s Girona left the shelter of Killybegs harbour after six weeks of strong winds and gales from between S and NW. It seems likely that she waited for a moderate SE'ly sailing breeze. This was followed by a sharp veer of the wind to NW, presumably as a sharp occluding frontal trough passed along the north coast of Ireland. The ship's rudder was damaged and, being unable to sail close to the wind, she was driven on the rocks of the north coast near 6½°W.

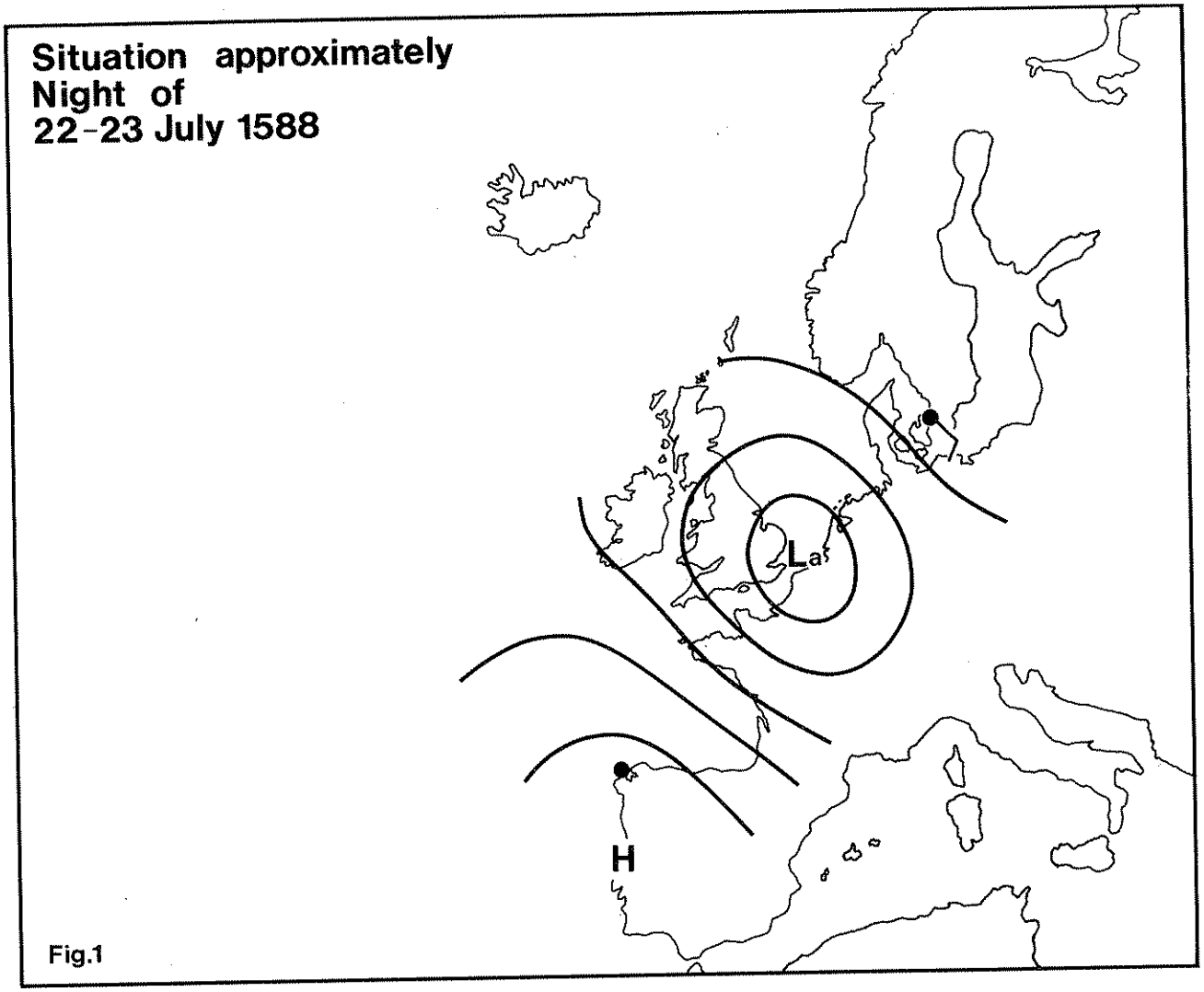

Situation approximately
Night of
22-23 July 1588
Laf
H

Fig.1

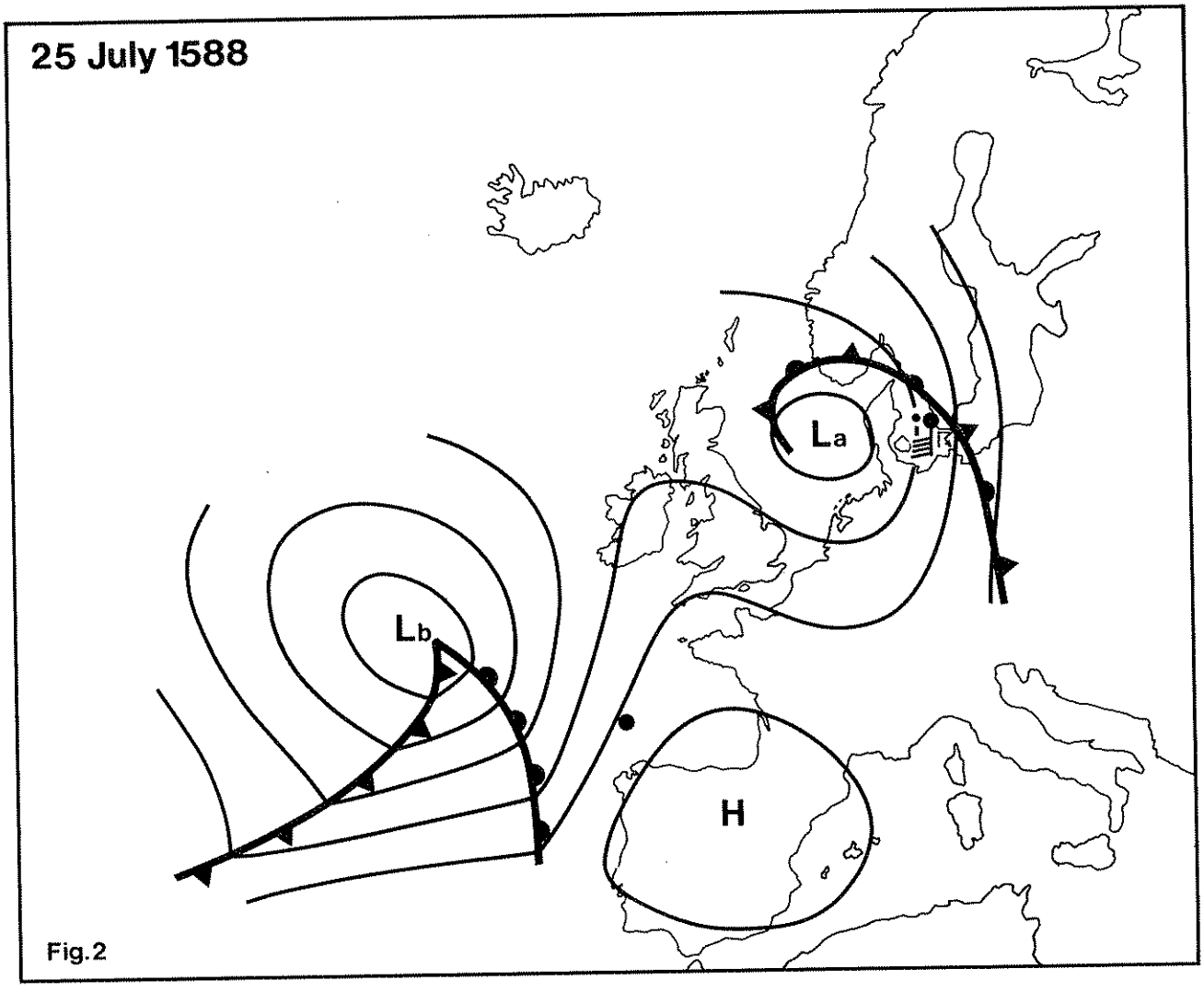

25 July 1588
La
Lb
H

Fig.2

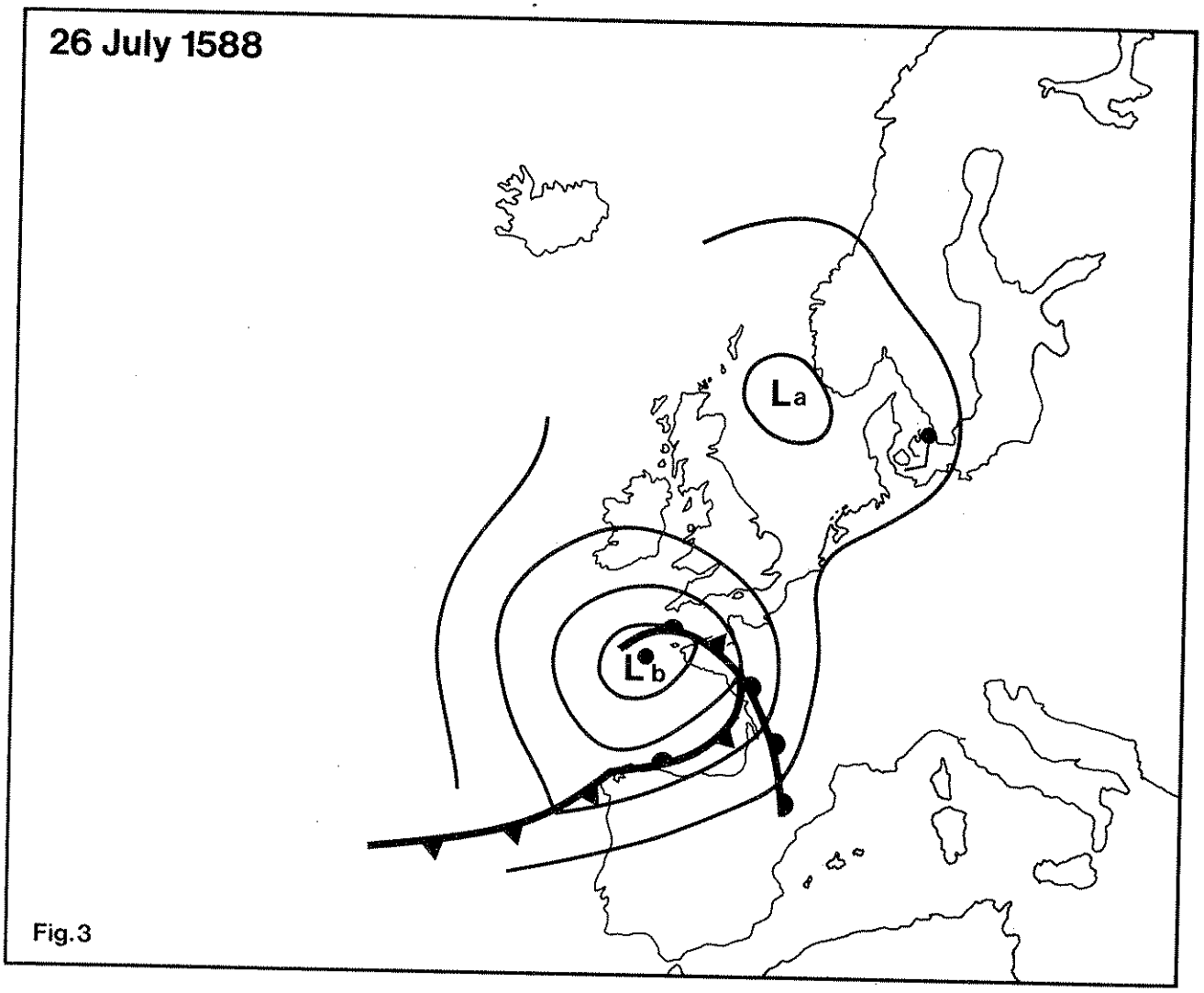


Fig.3

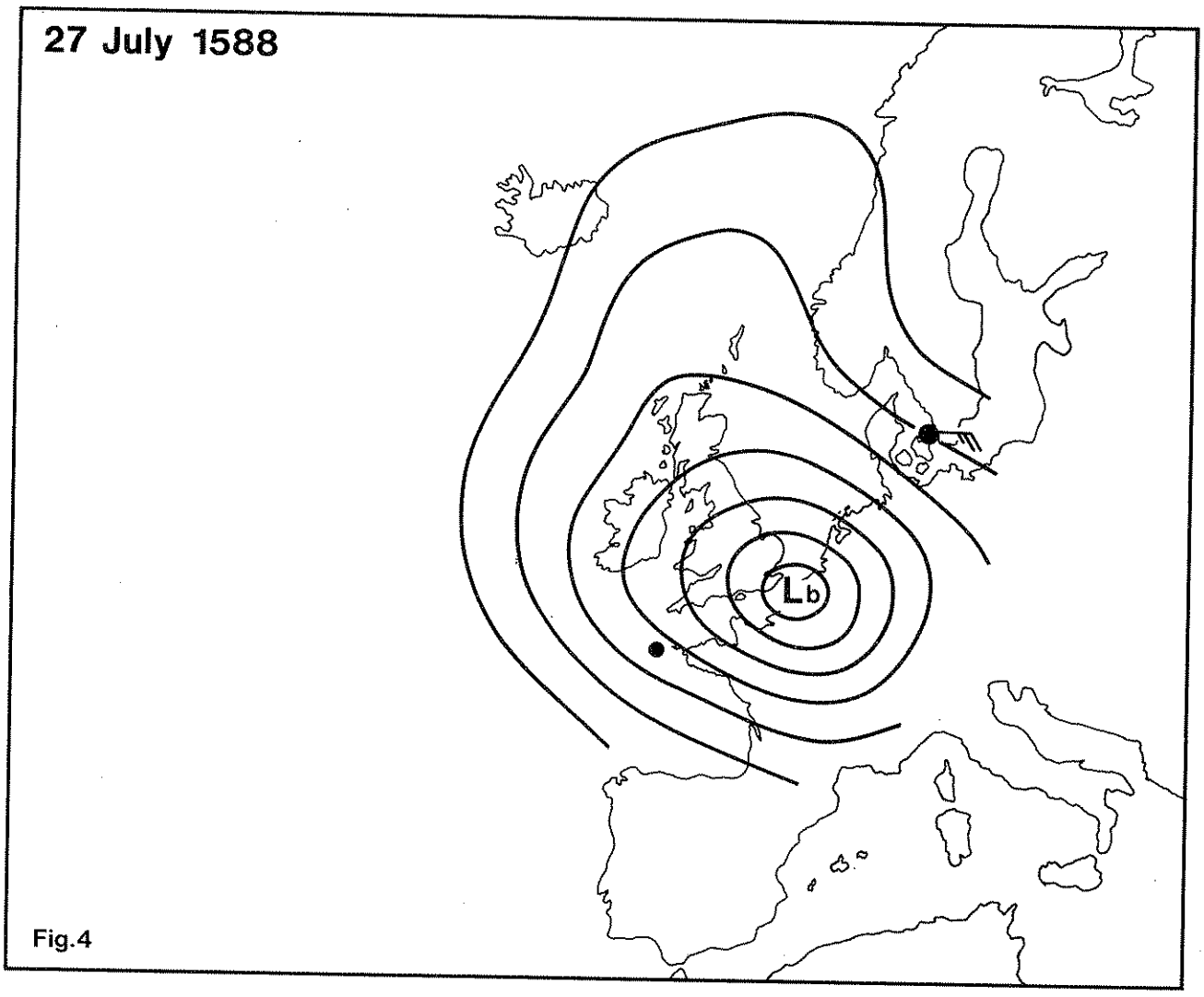


Fig.4

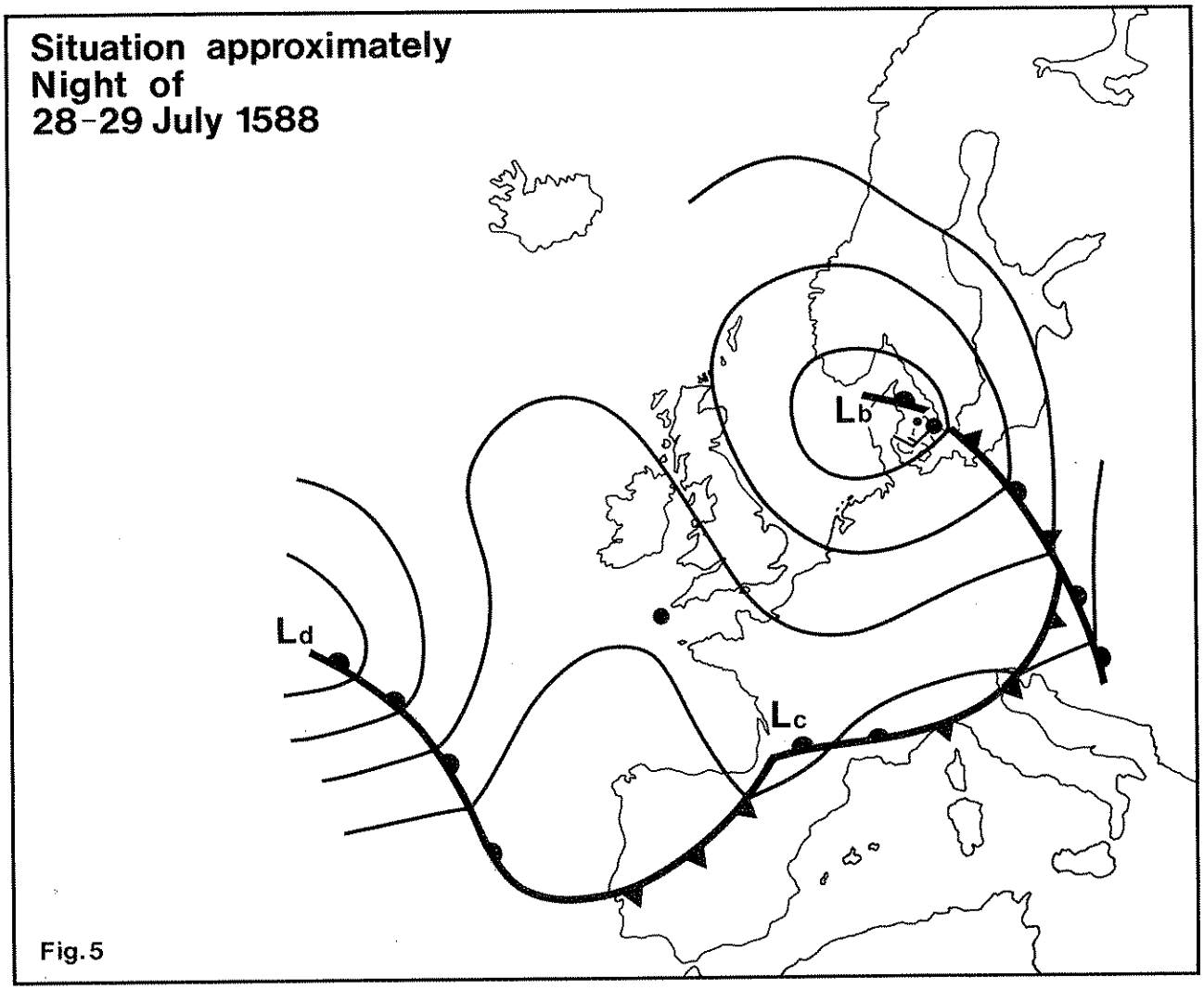

Situation approximately
Night of
28-29 July 1588
Lb
Ld
Lc

Fig. 5

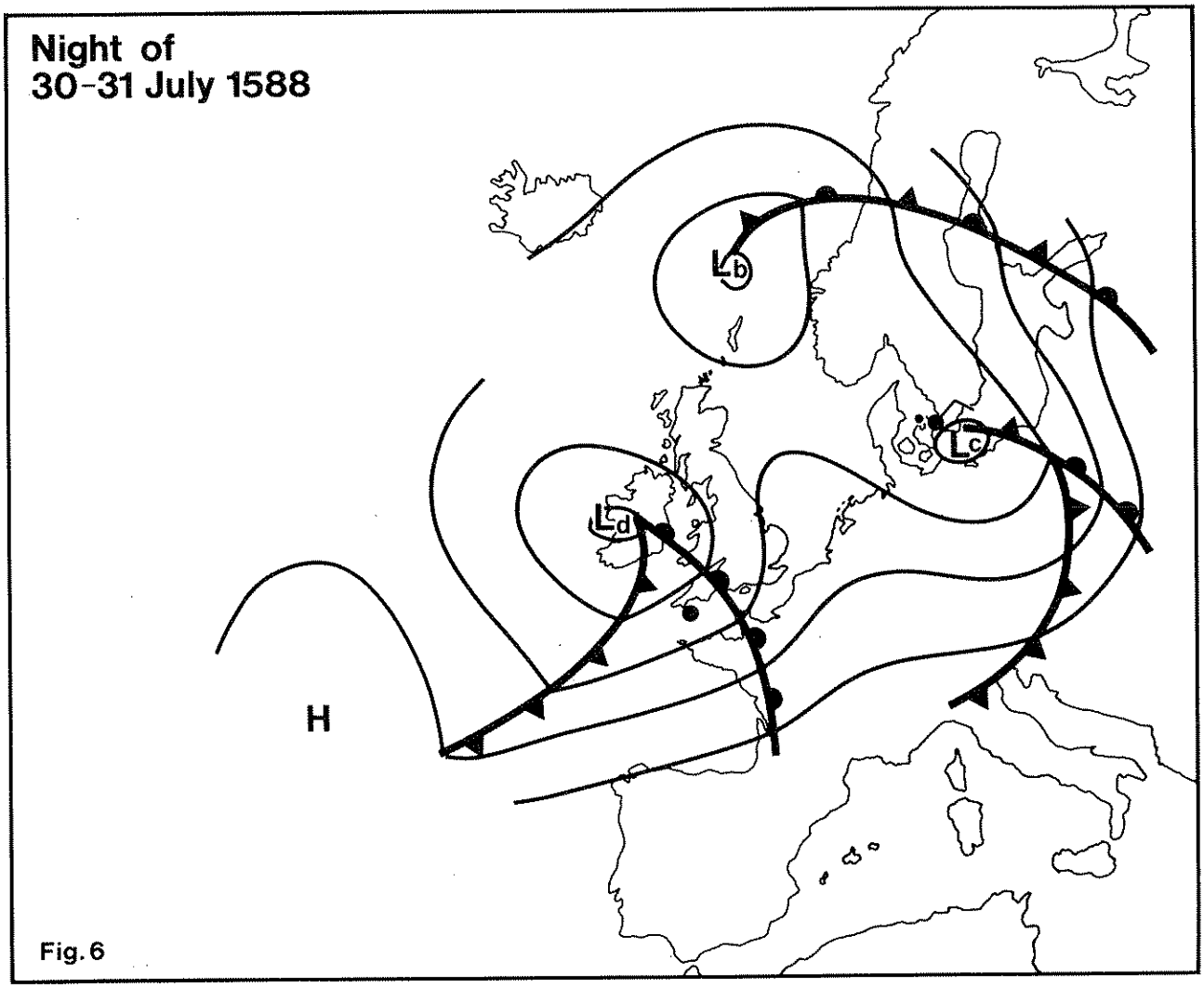

Night of
30-31 July 1588
Lb
Lc
Ld
H

Fig. 6

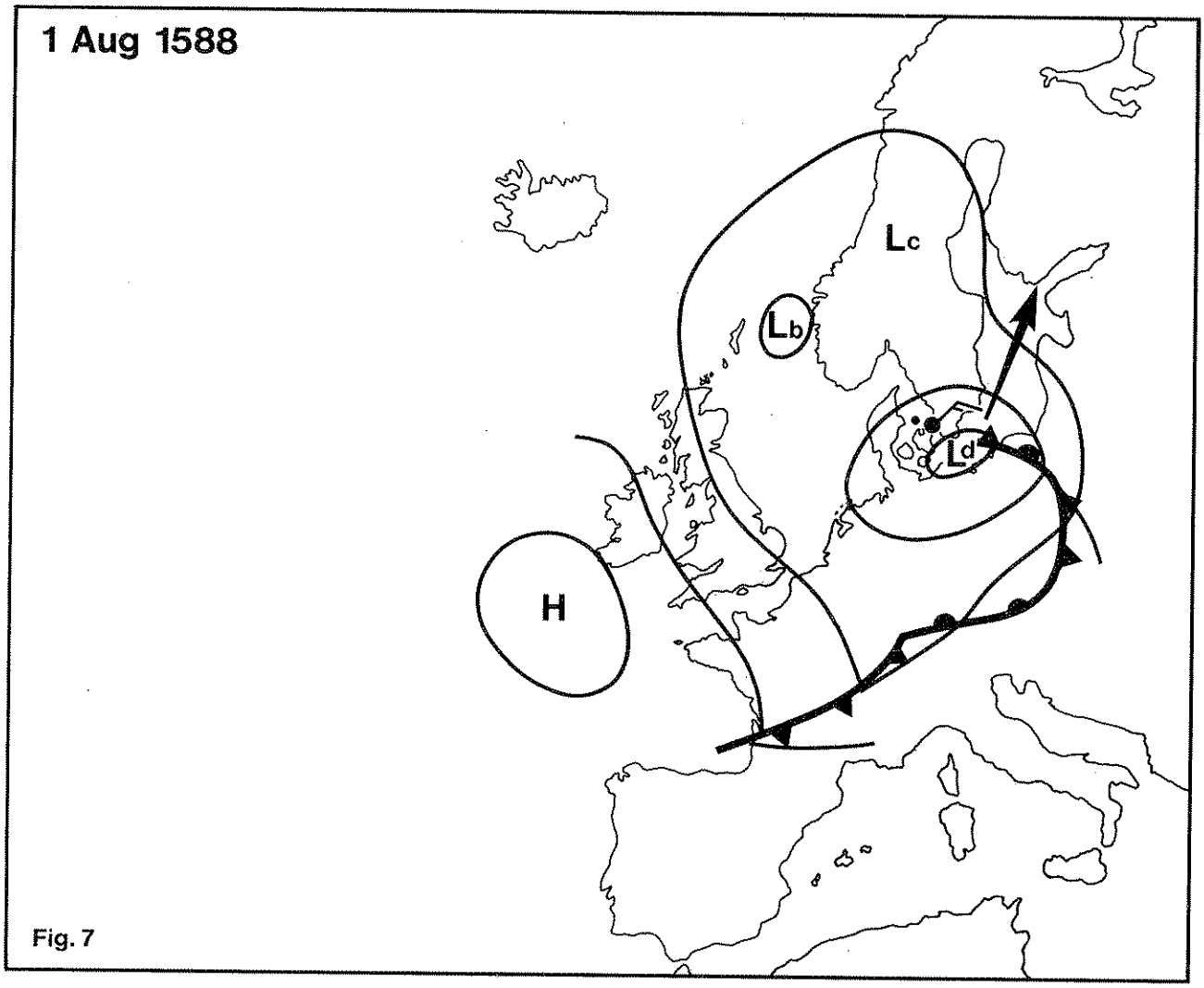


Fig. 7

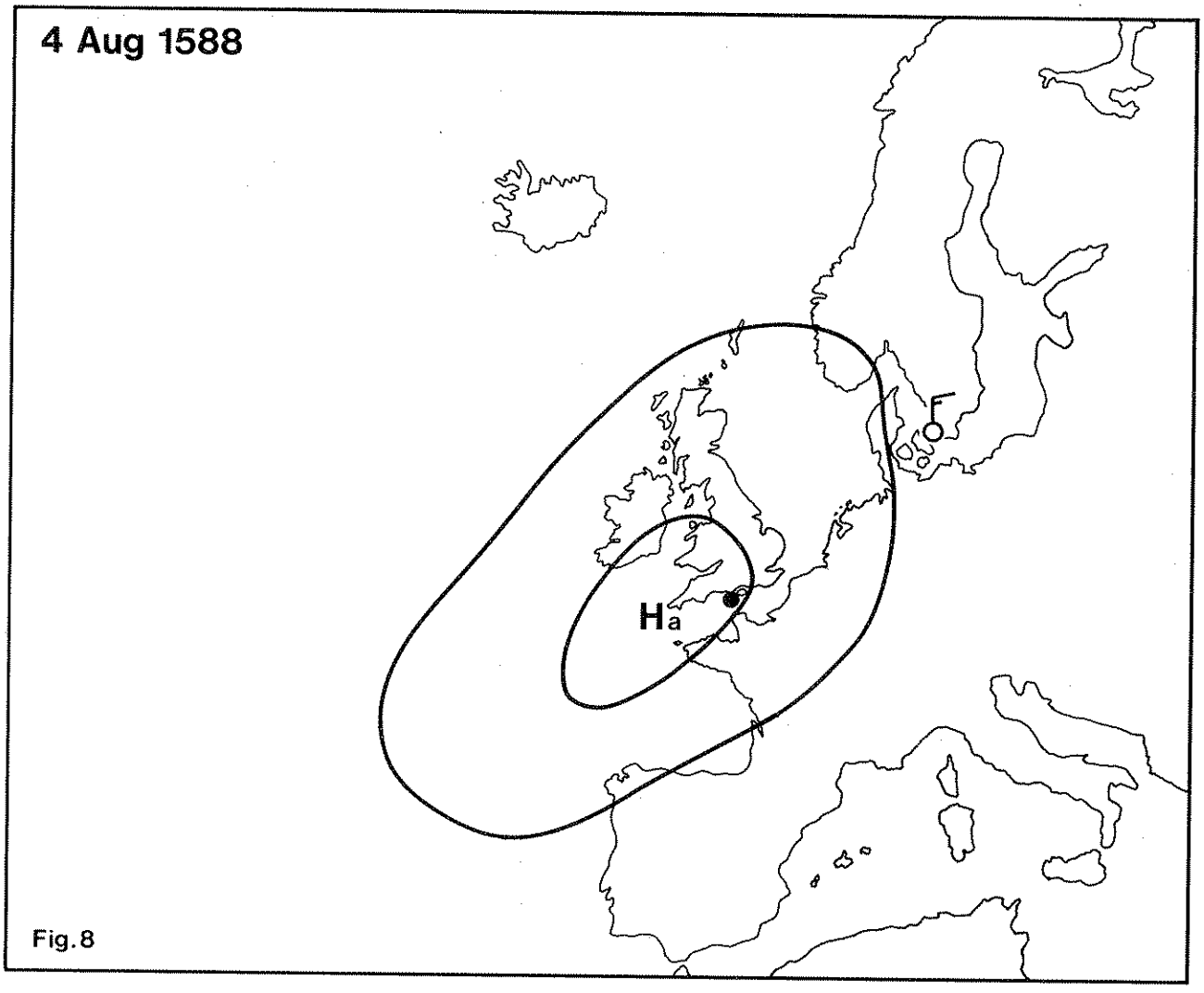


Fig. 8

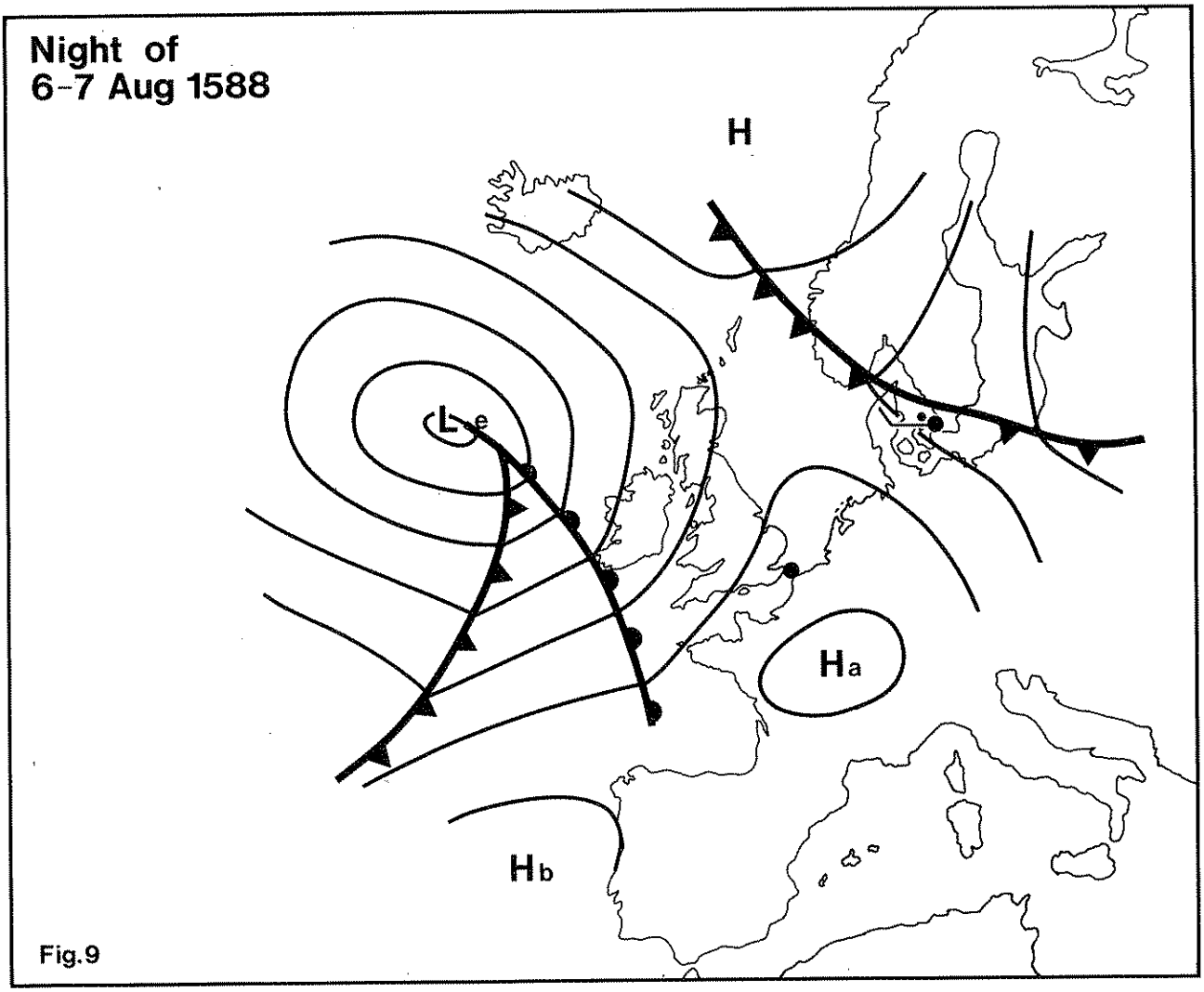


Fig.9

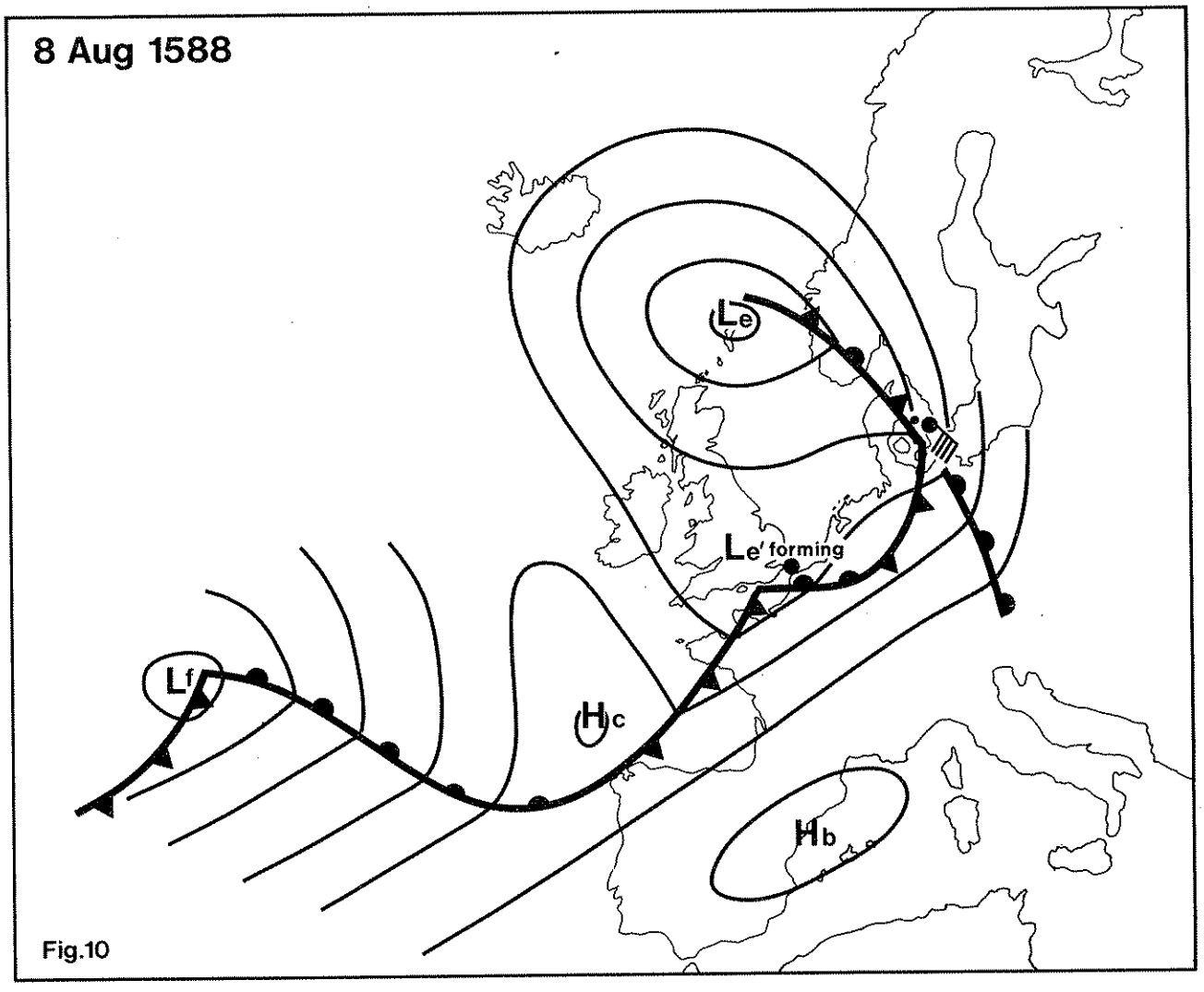


Fig.10

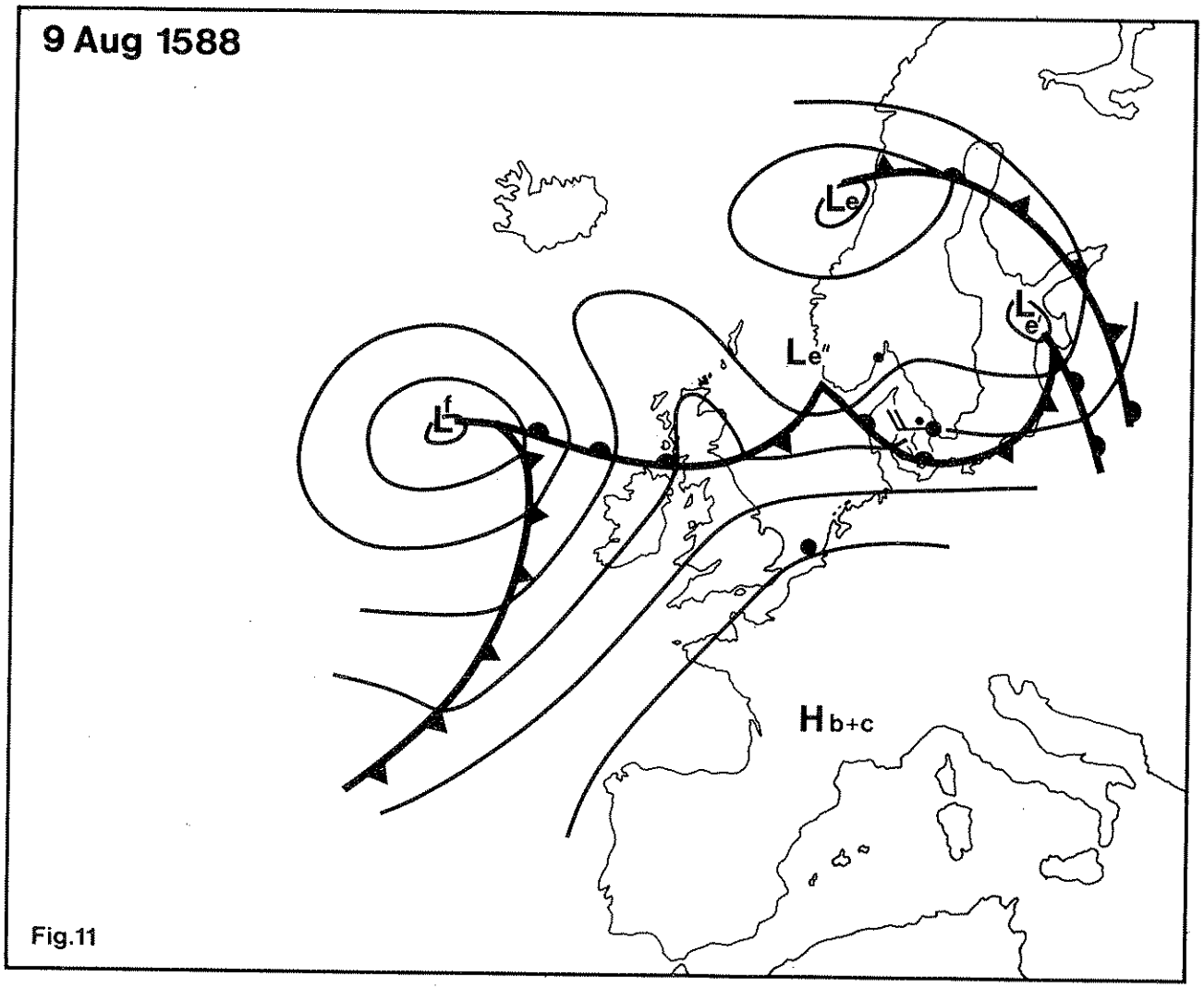


Fig.11

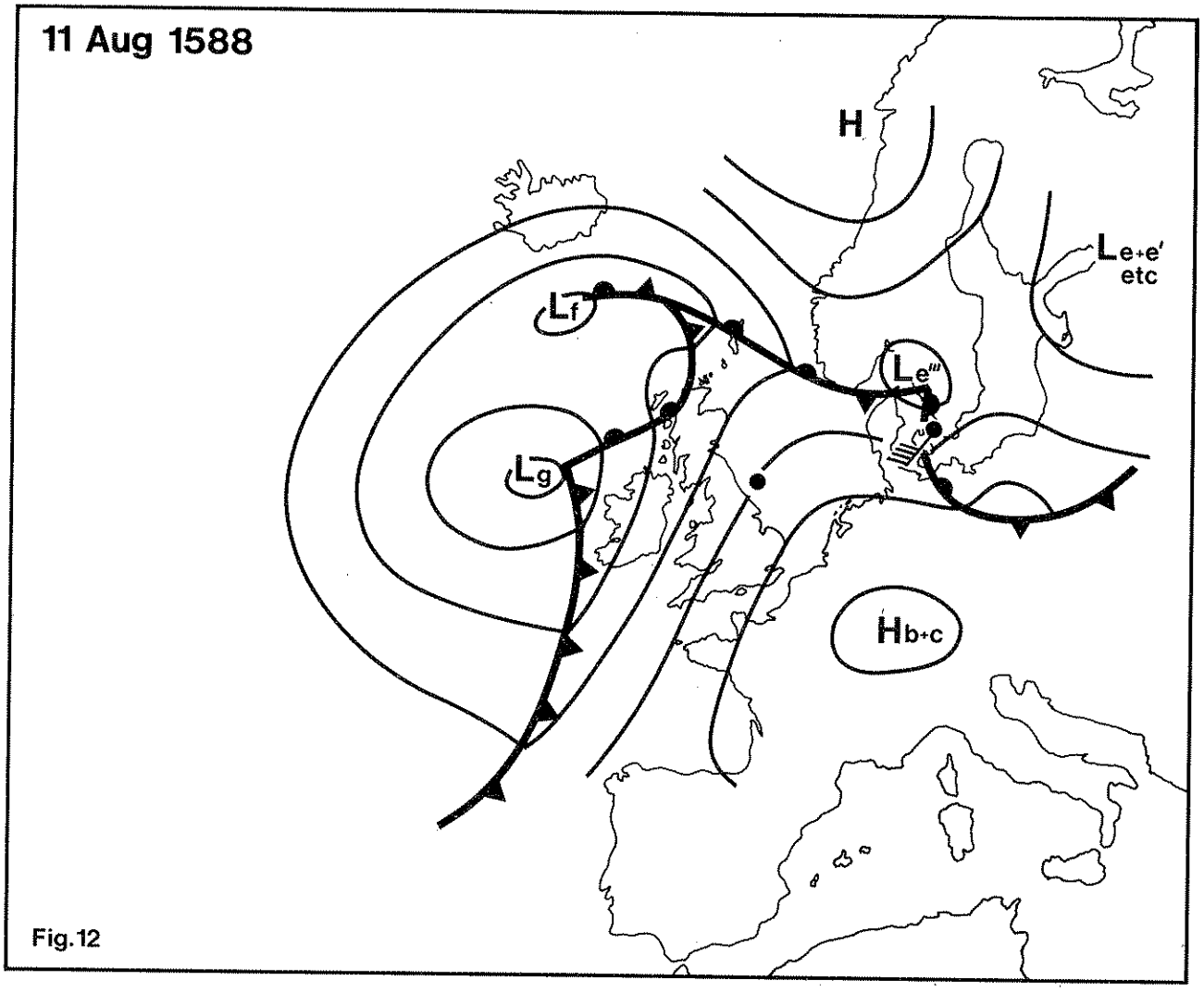


Fig.12

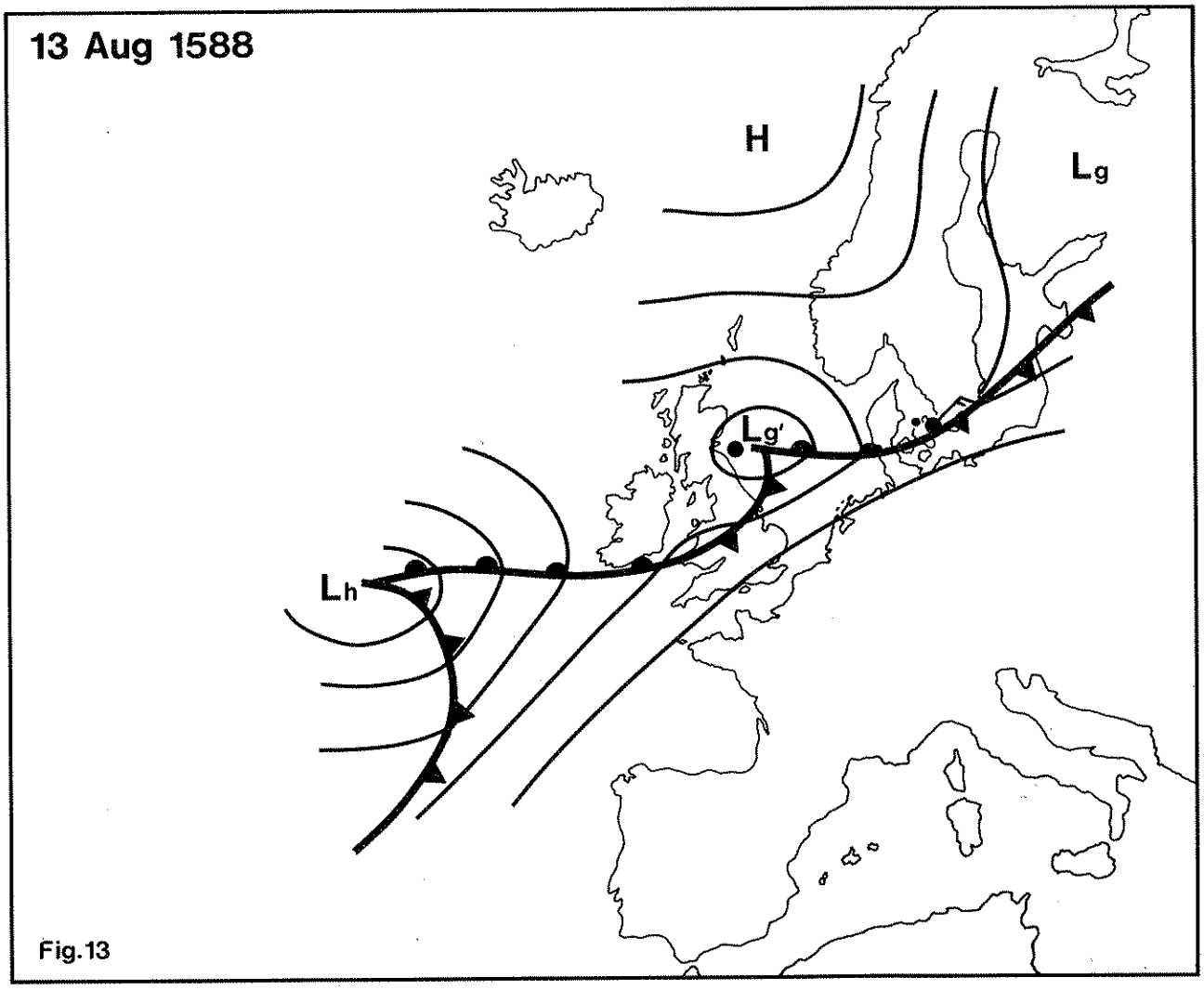


Fig.13

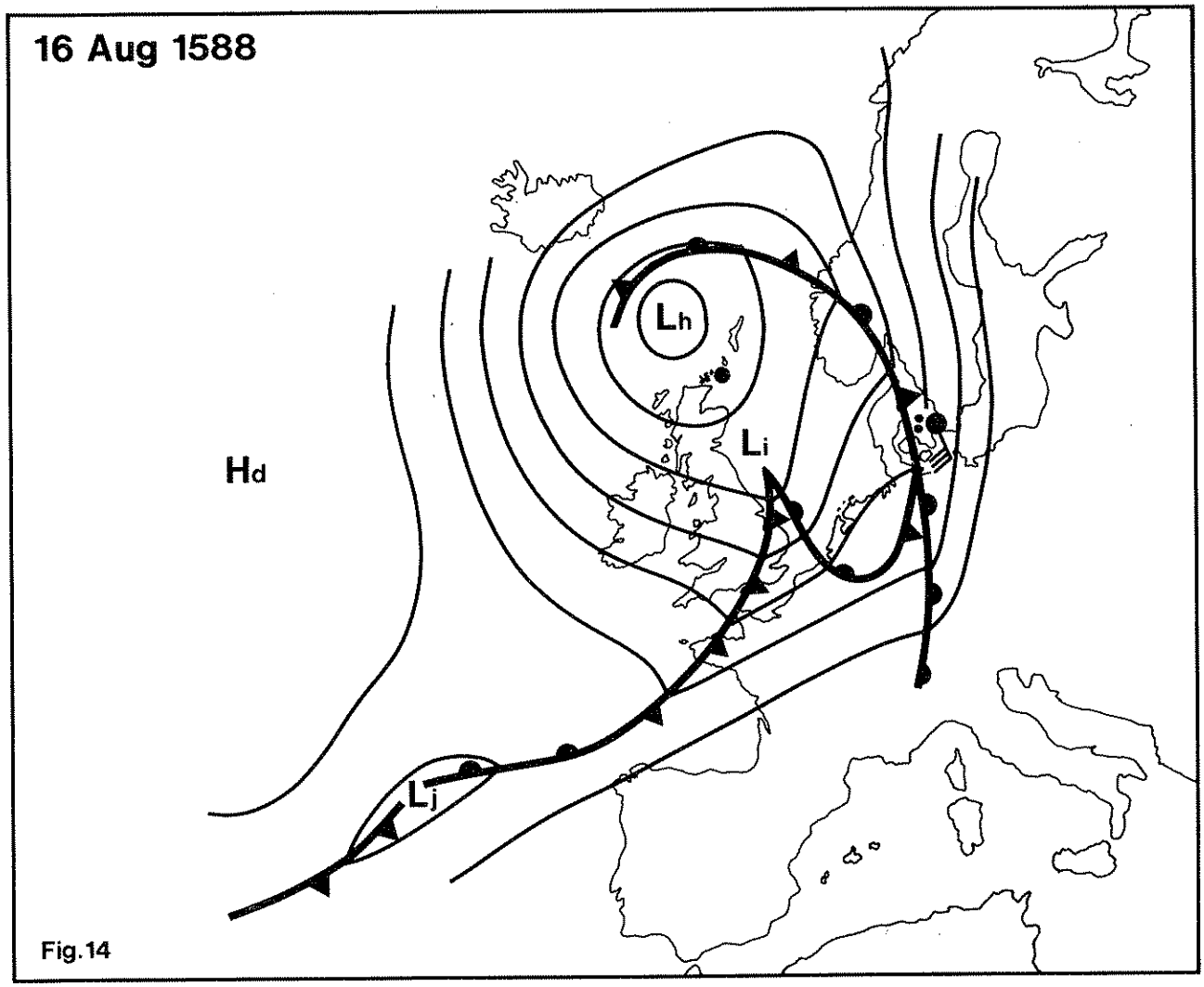


Fig.14

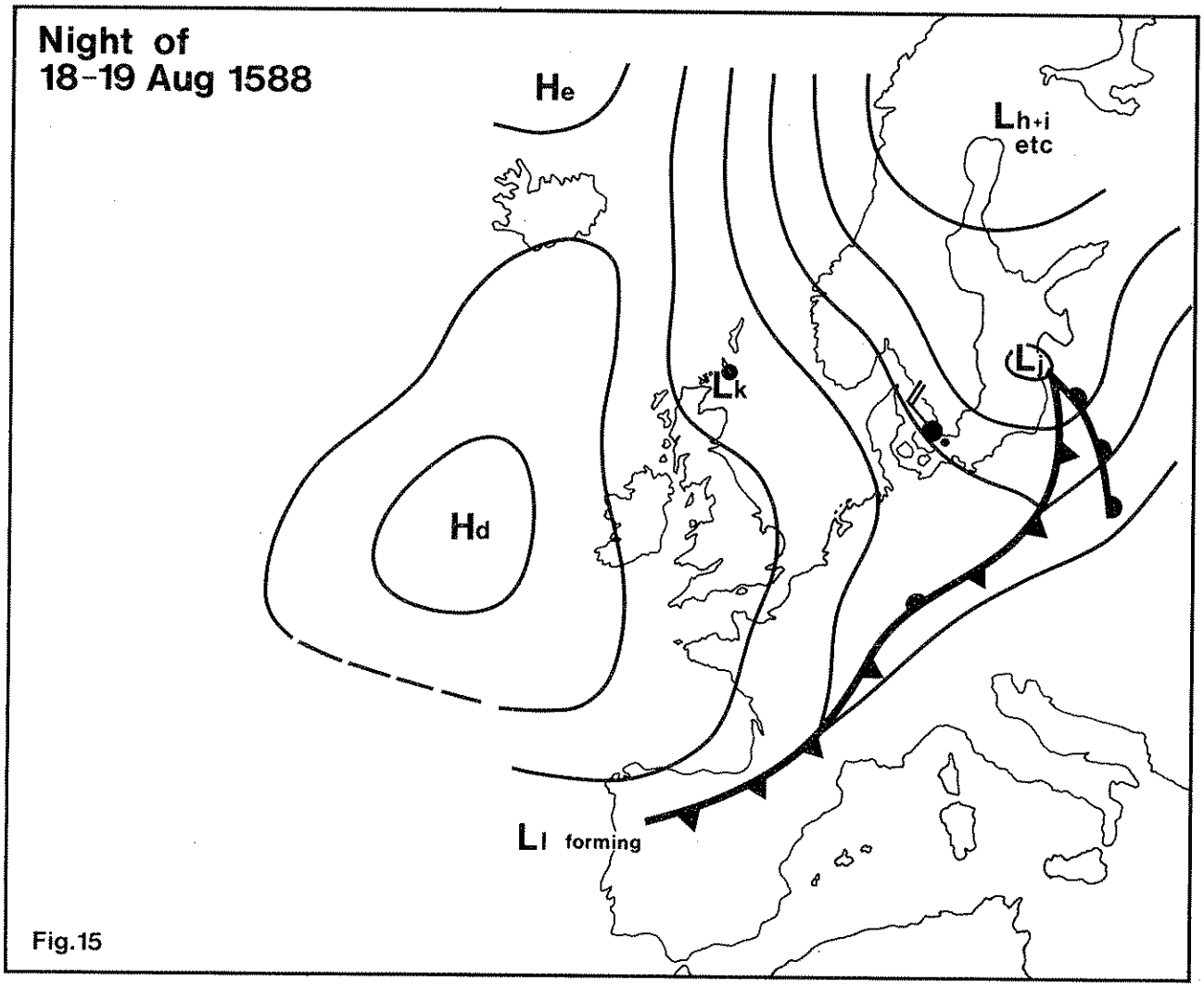

Night of
18–19 Aug 1588
He
Lh+i
etc
Lj
Lk
Hd
Ll forming

Fig.15

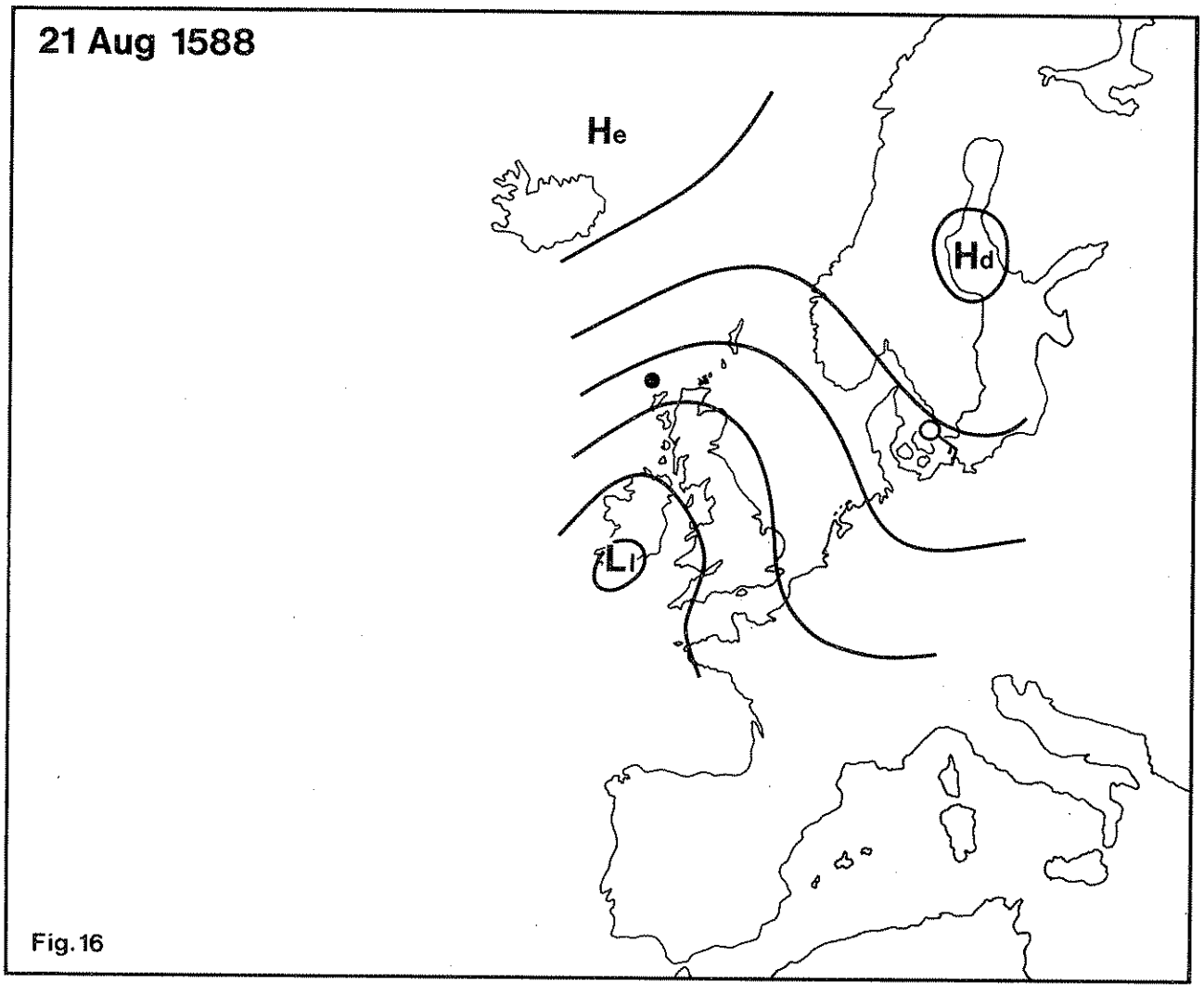

21 Aug 1588
He
Hd
Ll

Fig.16

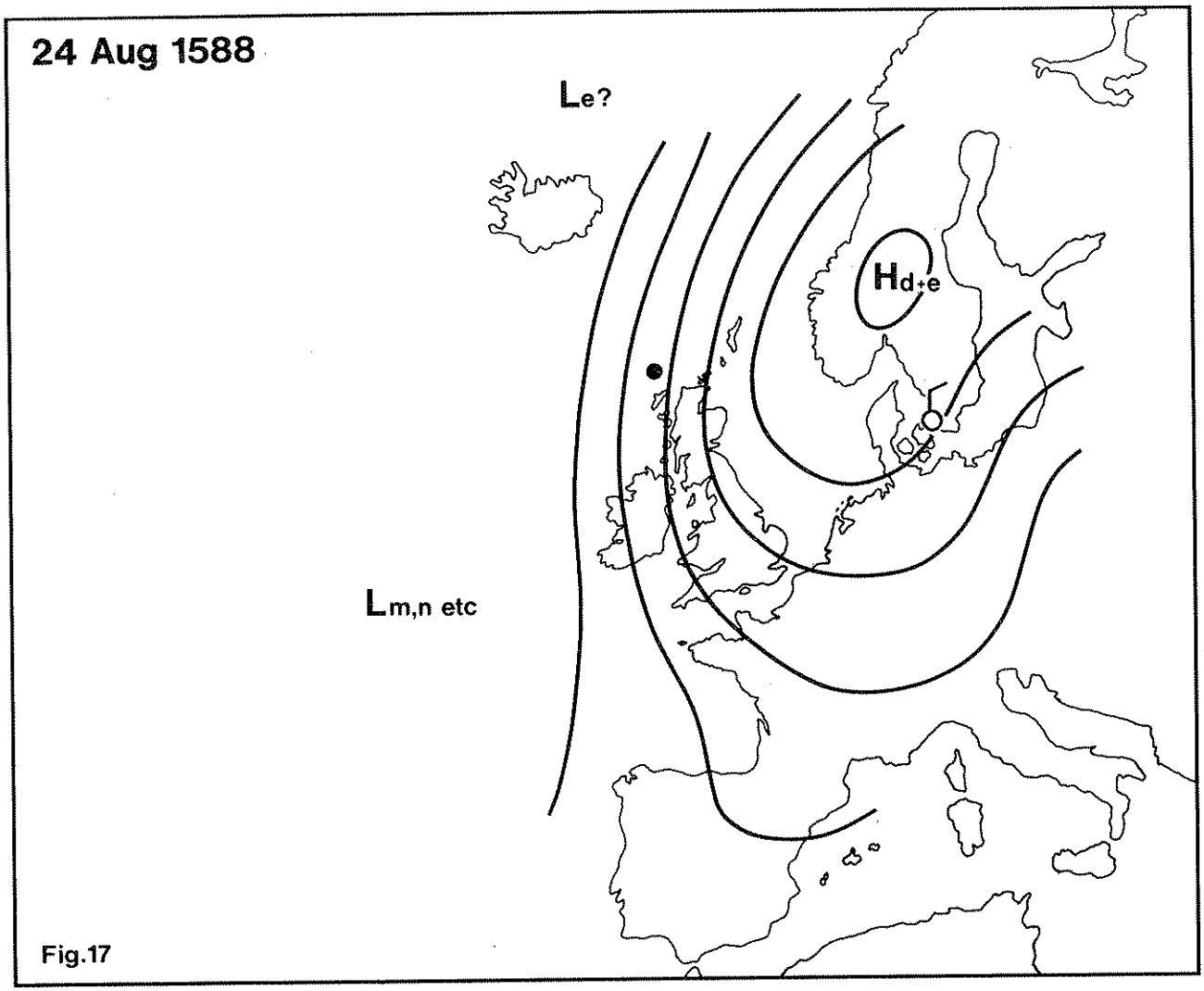


Fig.17

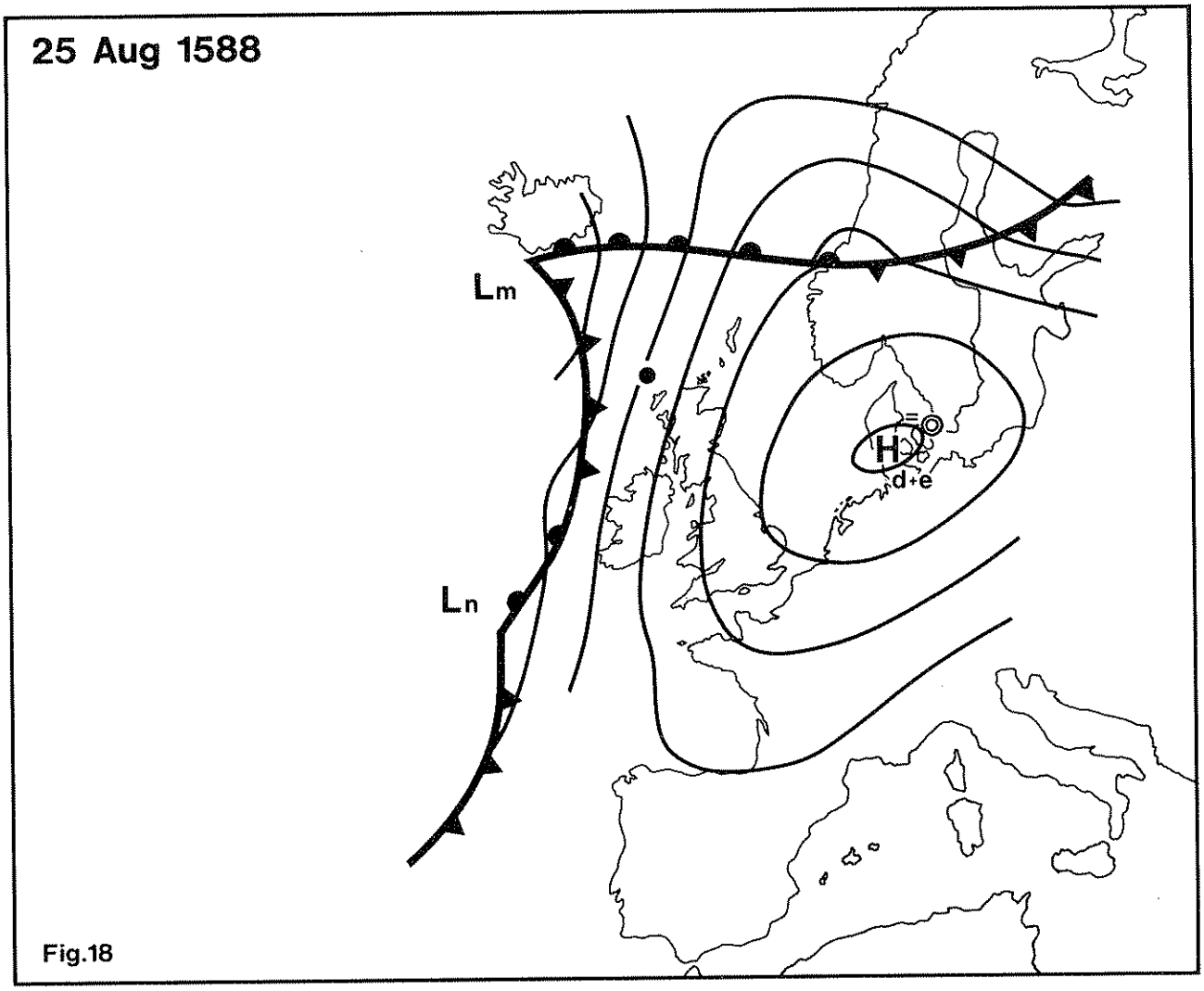


Fig.18

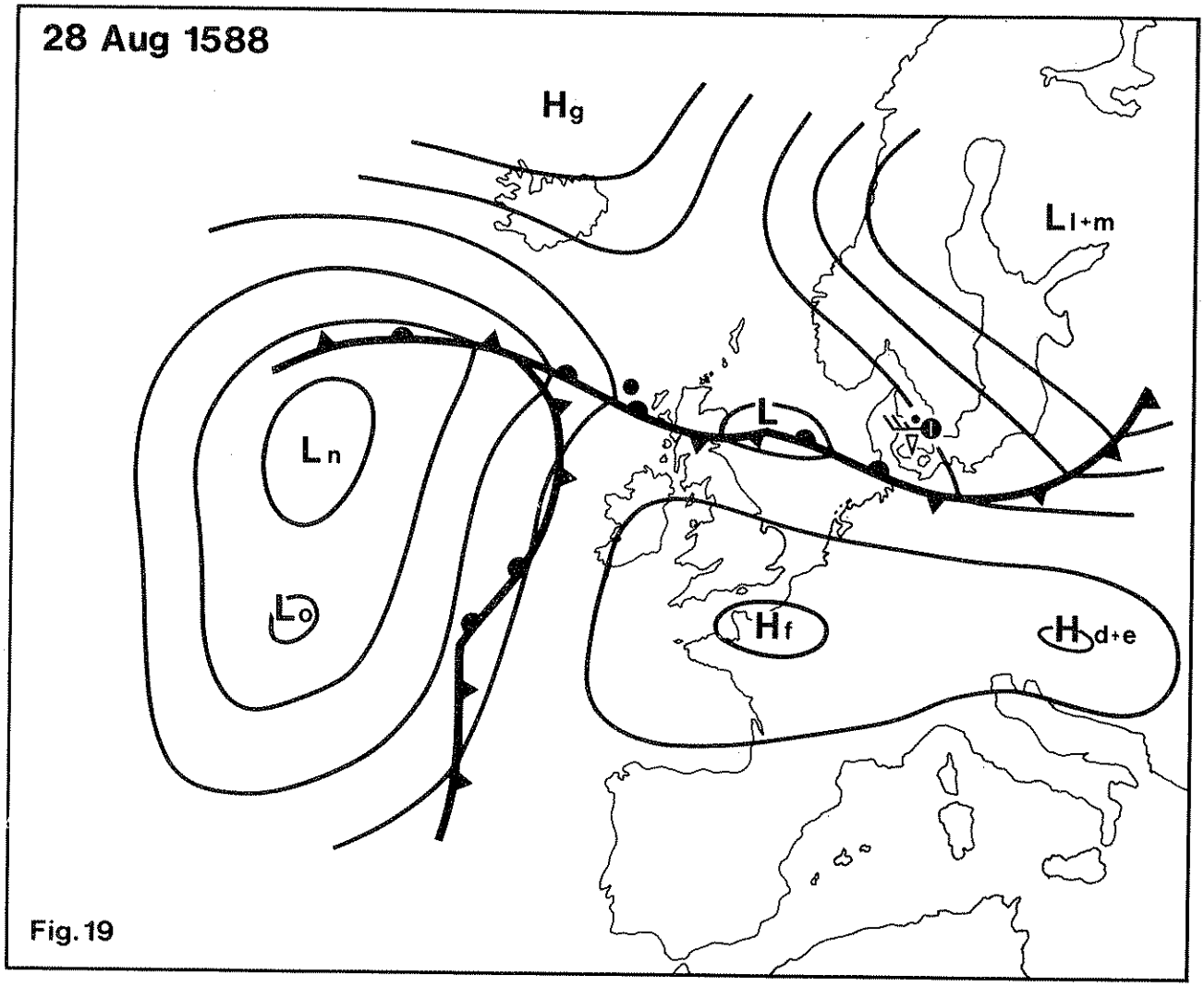
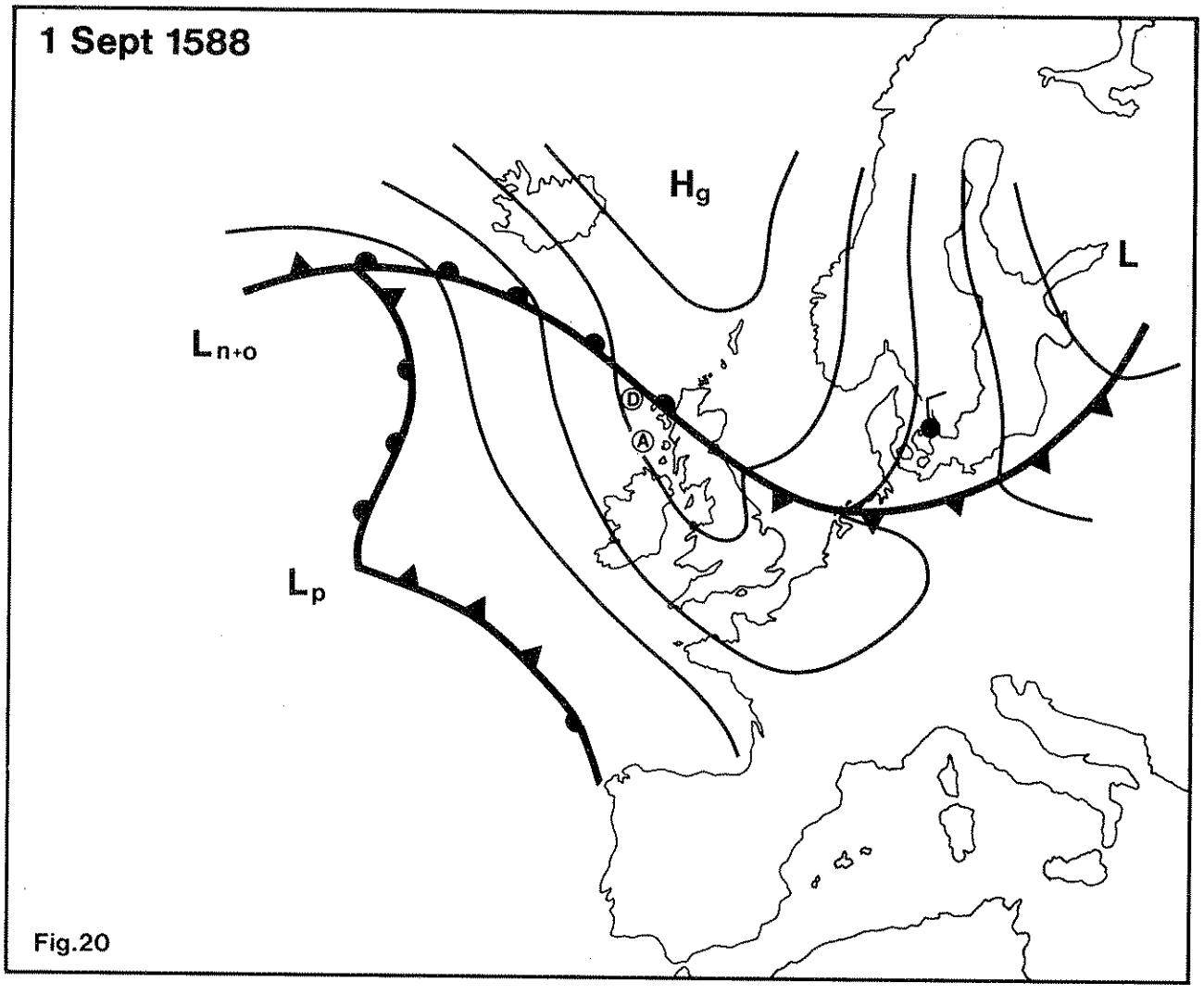


Fig. 19



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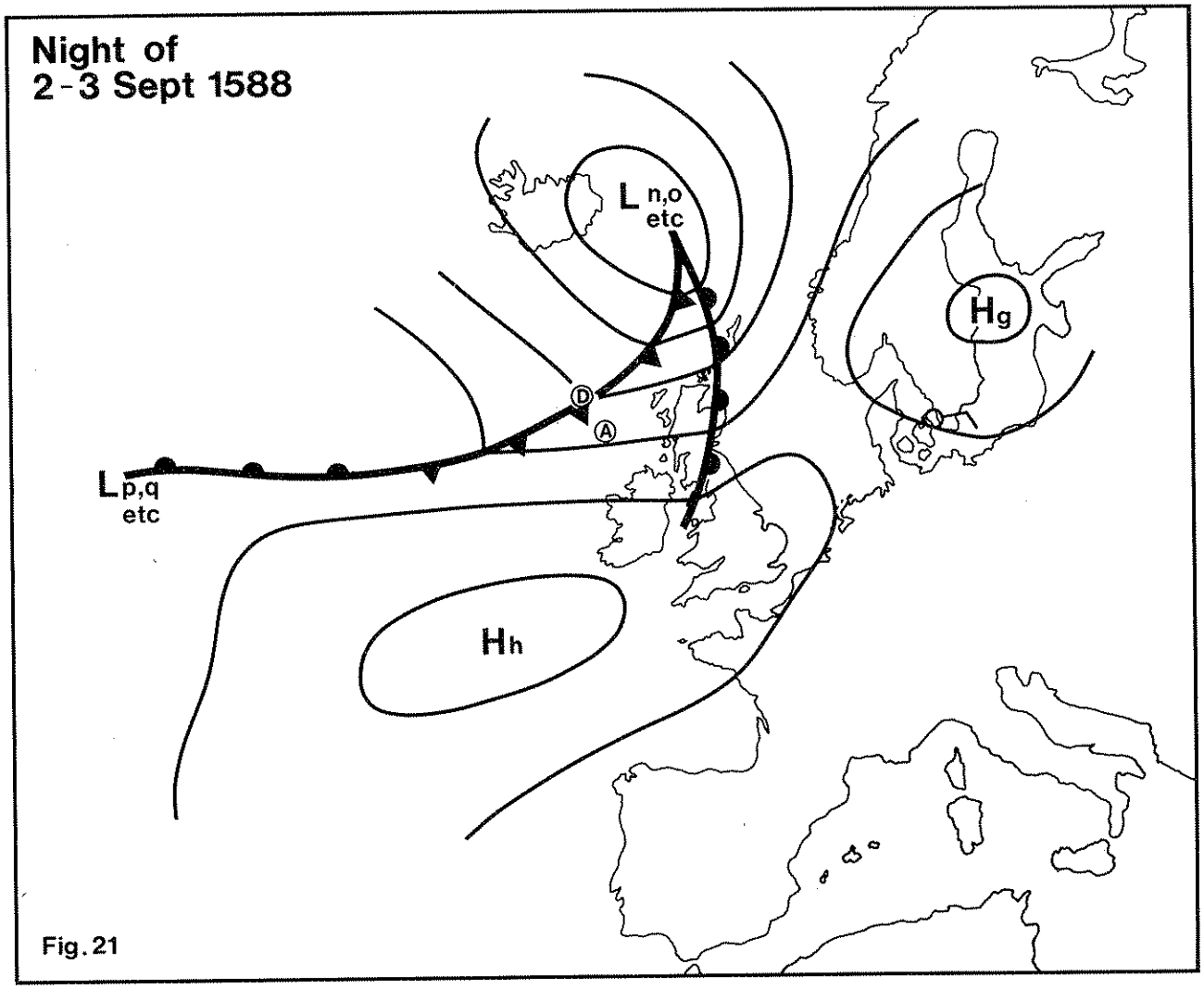
Night of
2-3 Sept 1588
L n,o
etc
Hg
D
A
Lp,q
etc
Hh

Fig. 21

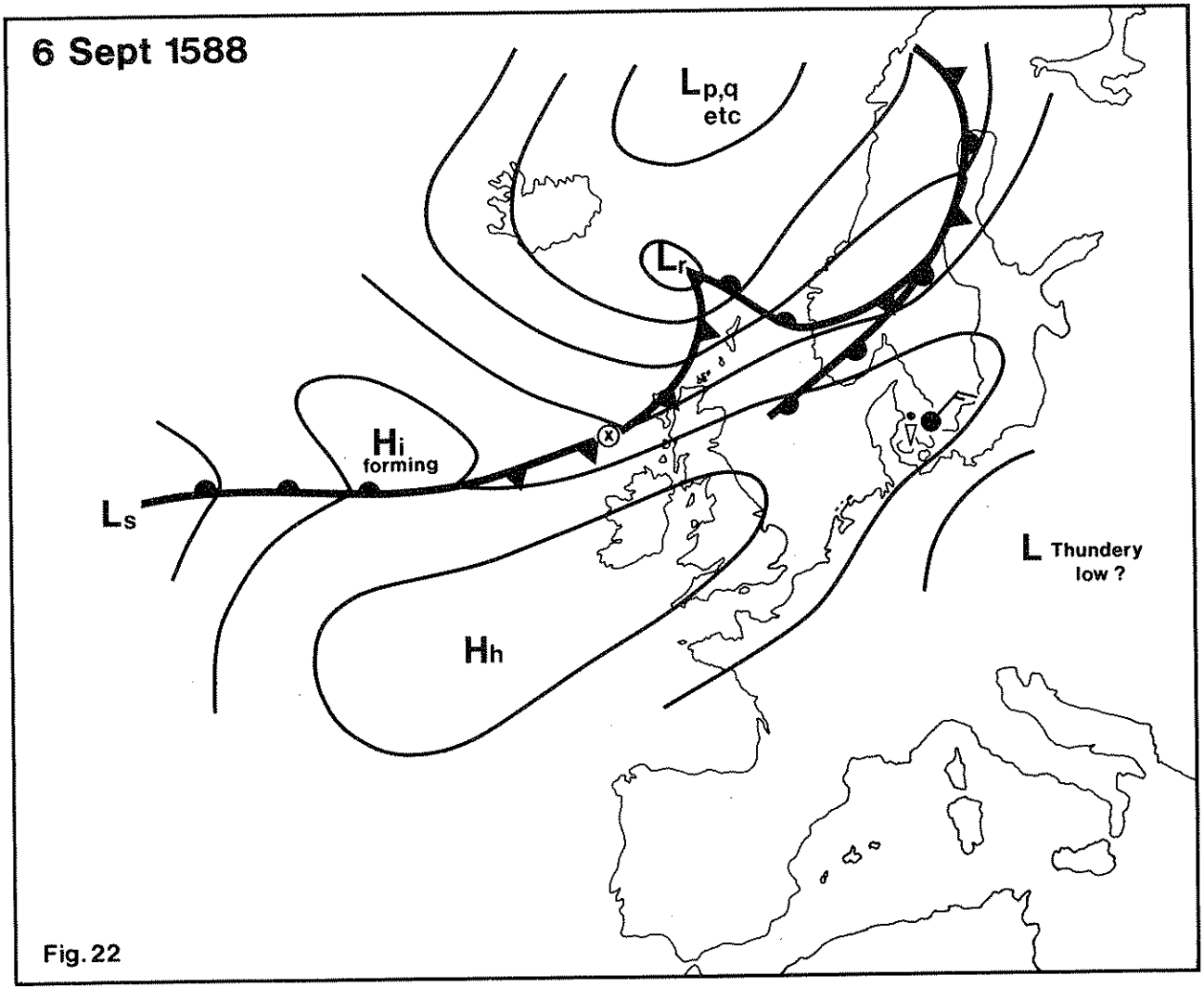
6 Sept 1588
Lp,q
etc
Lr
Hi
forming
X
Ls
L Thundery
low ?
Hh

Fig. 22

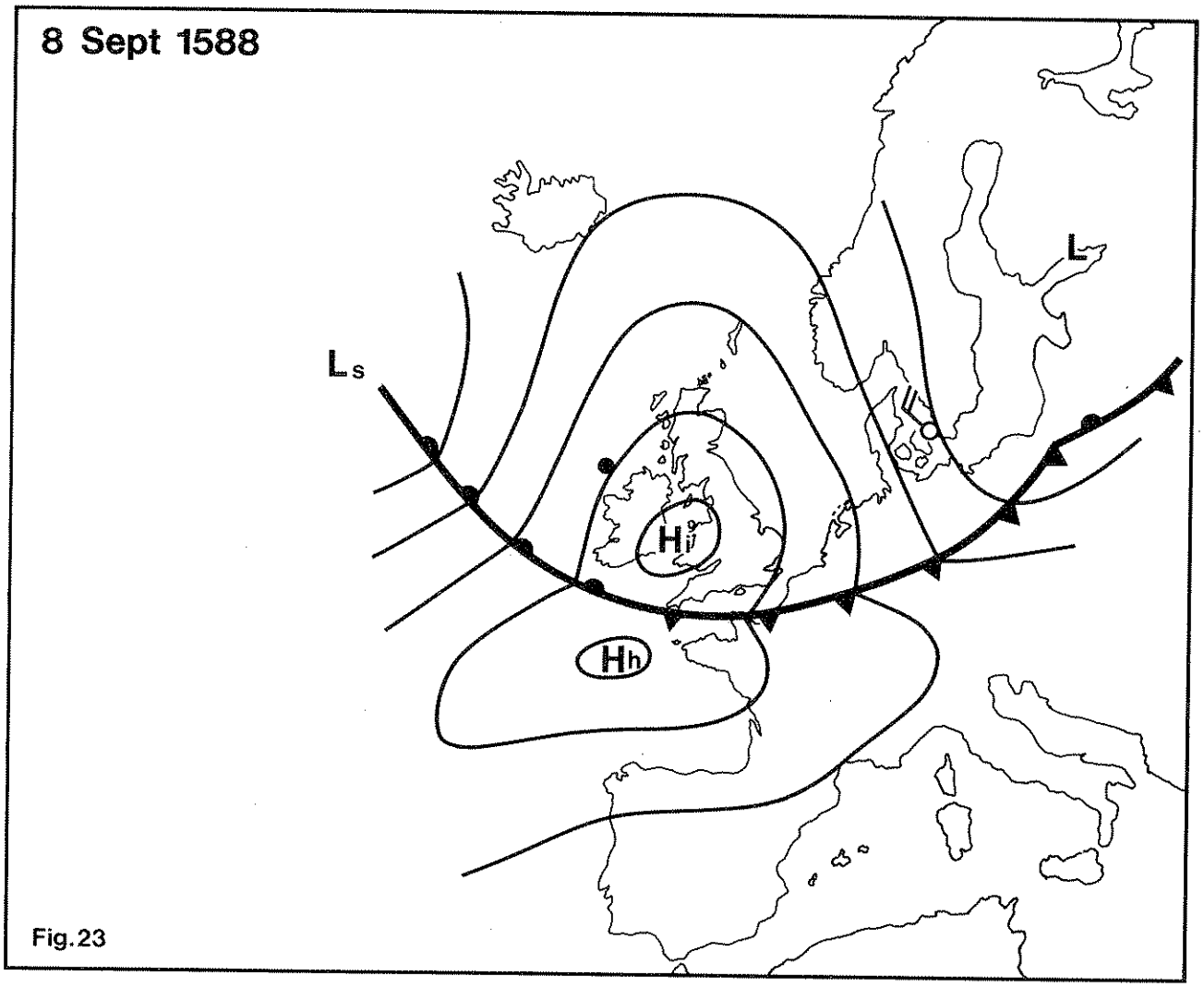

Fig.23

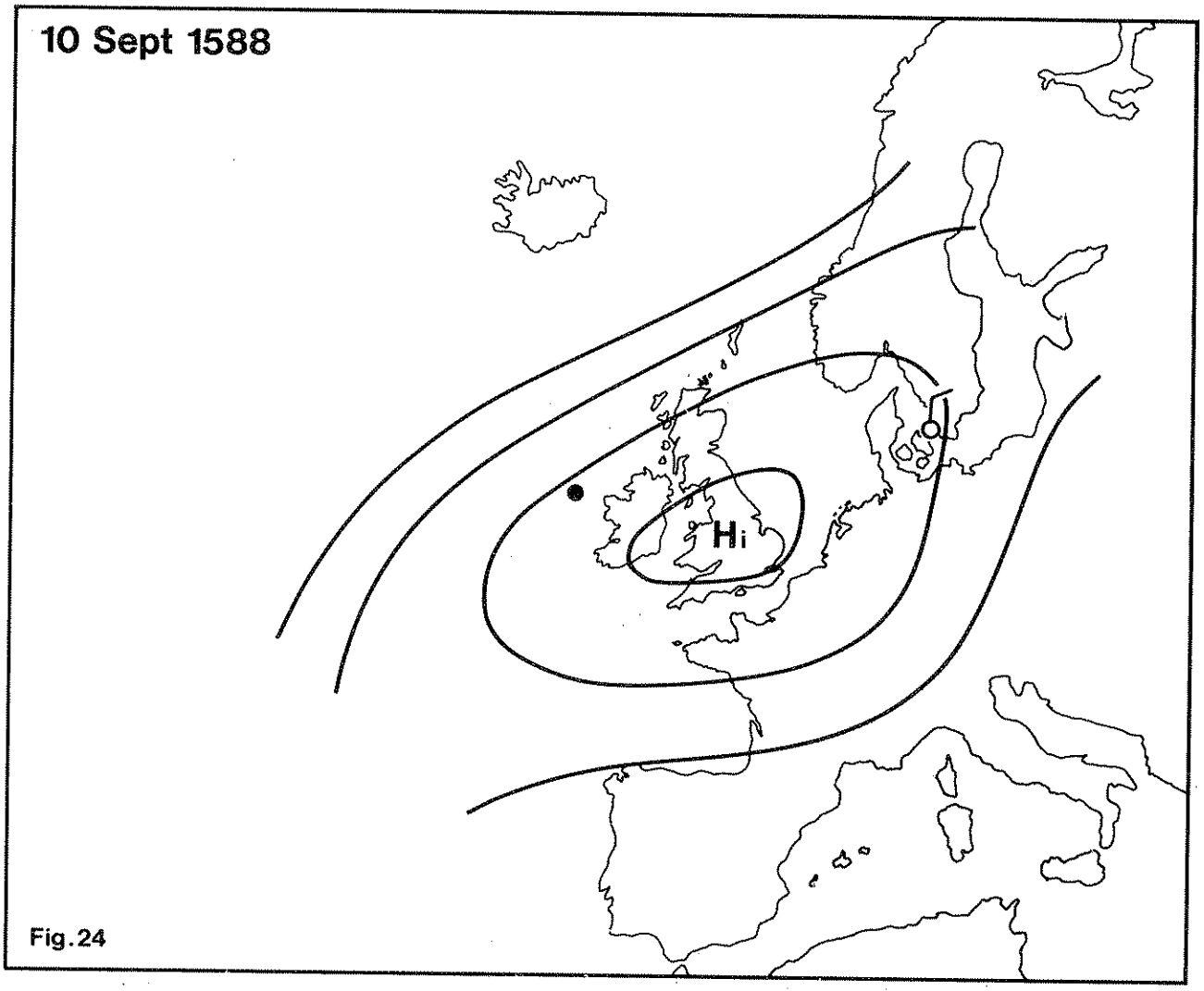

Fig.24

13 Sept 1588

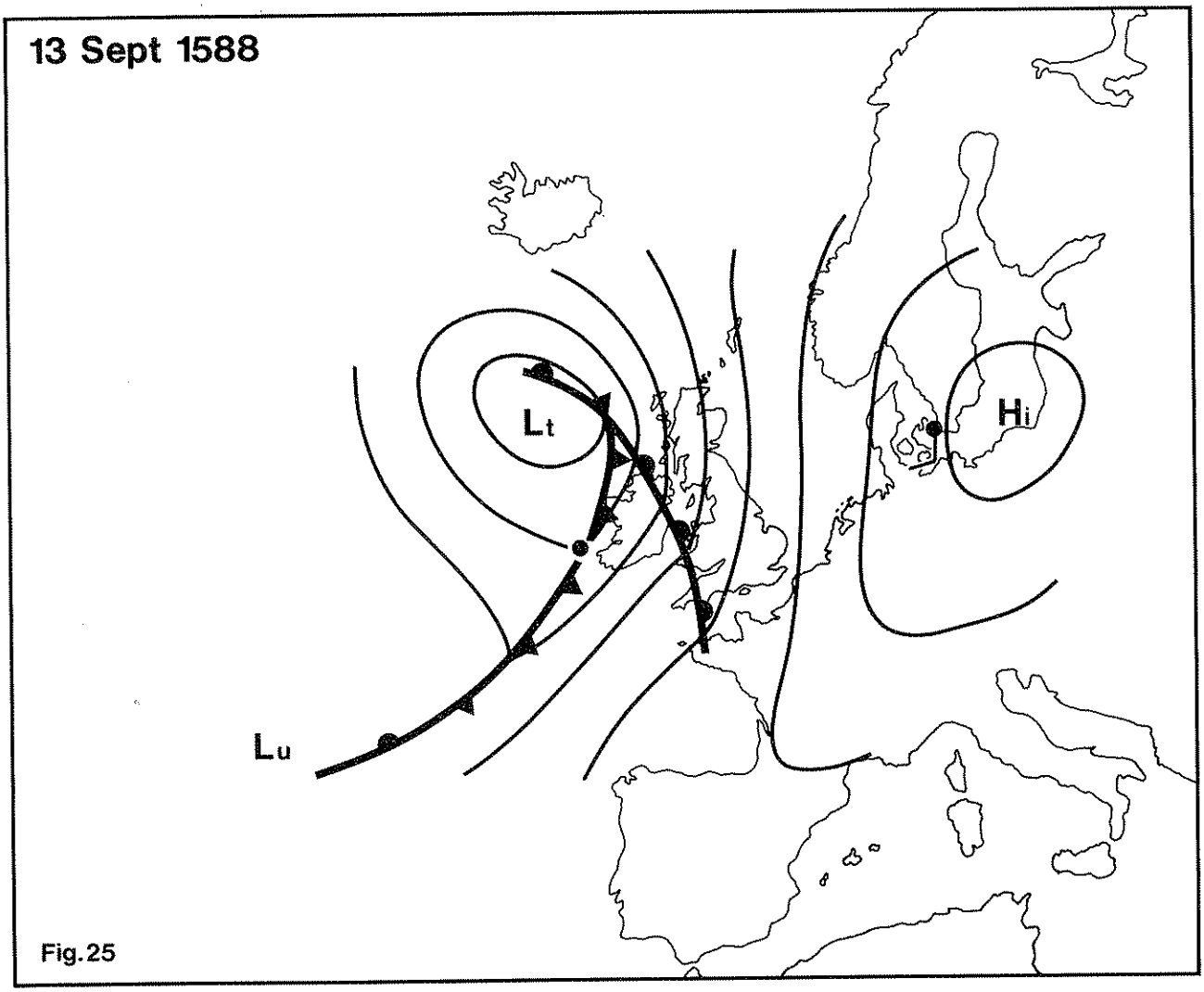

Fig. 25

16 Sept 1588

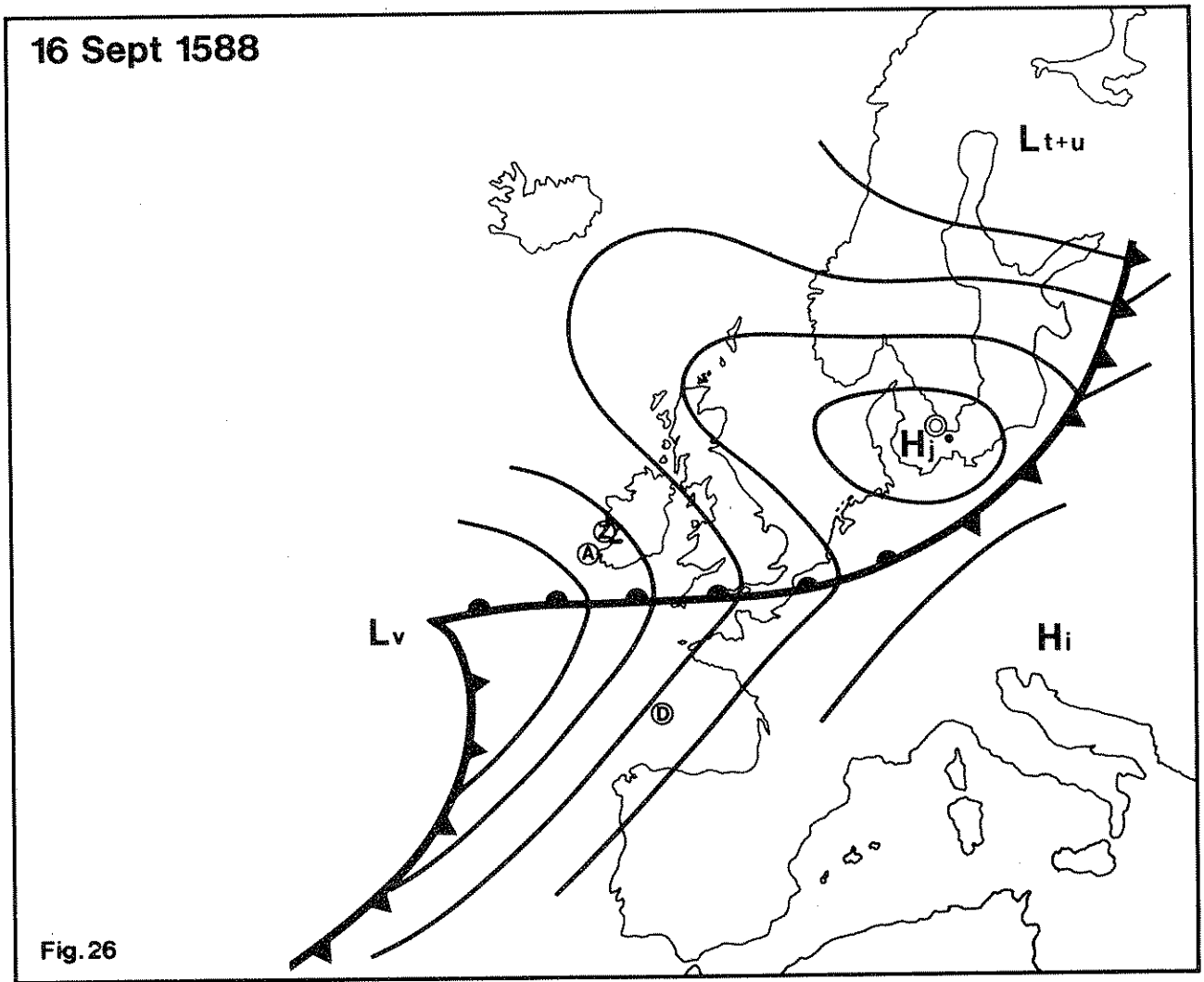

Fig. 26

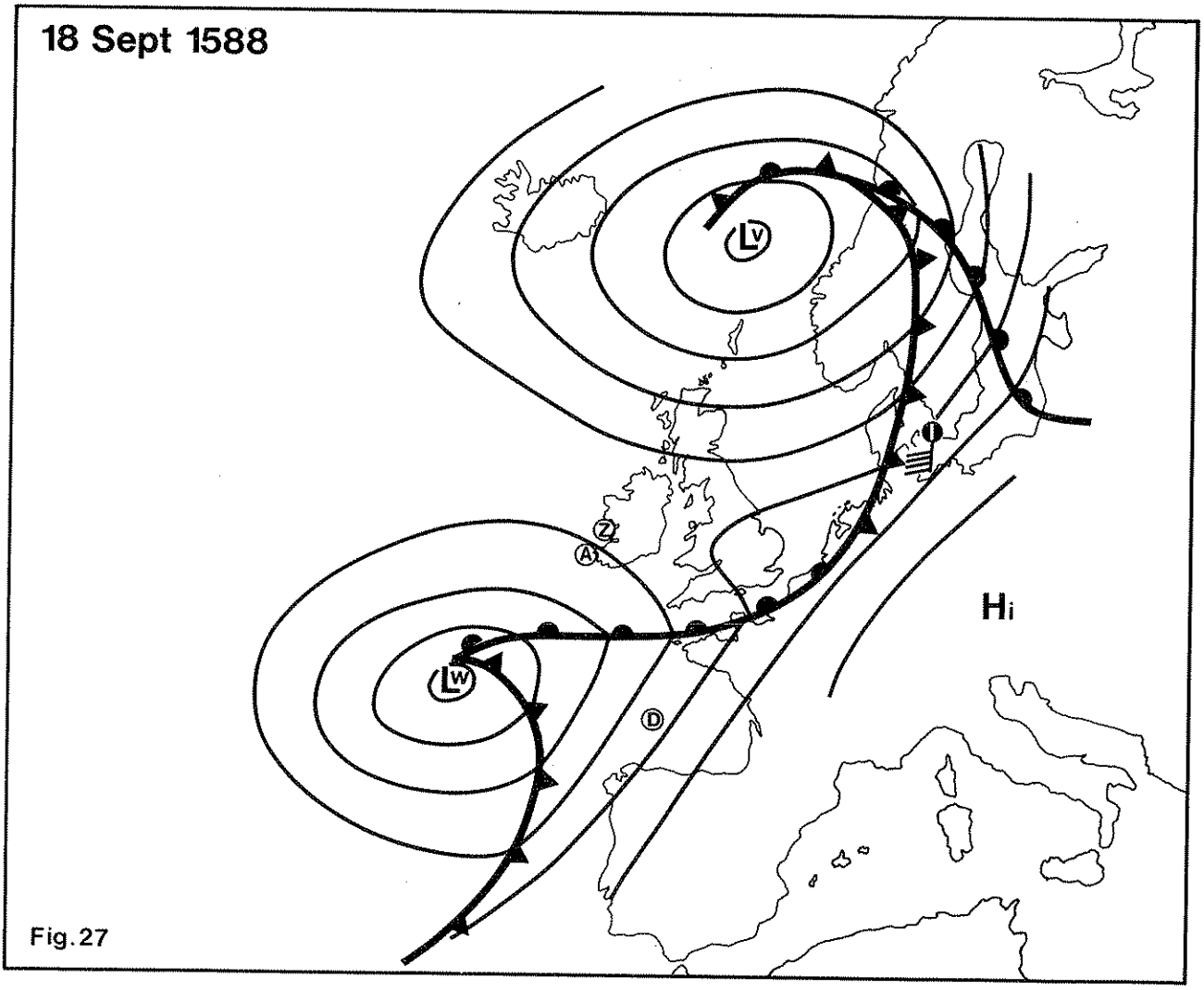

Fig. 27

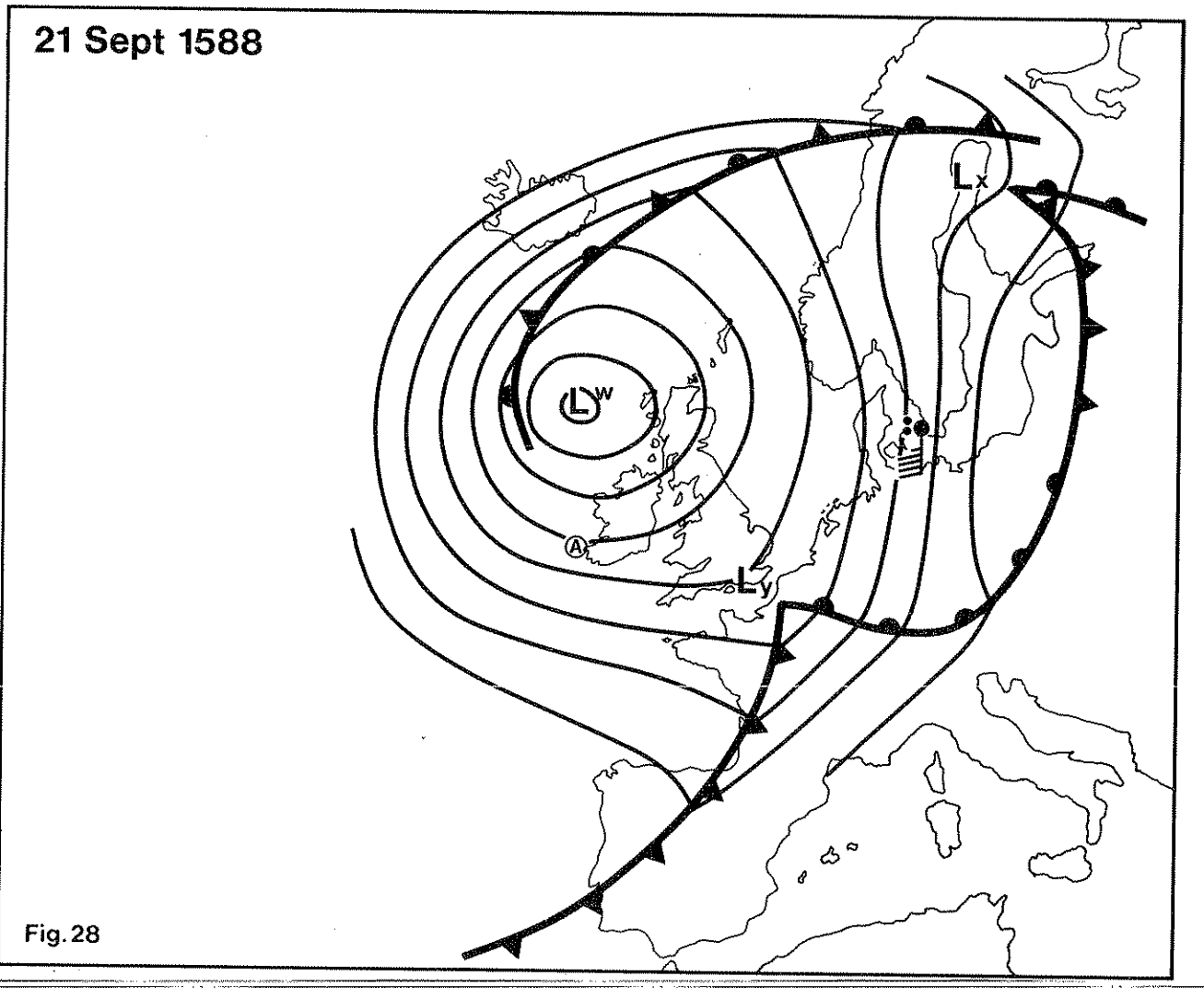

Fig. 28

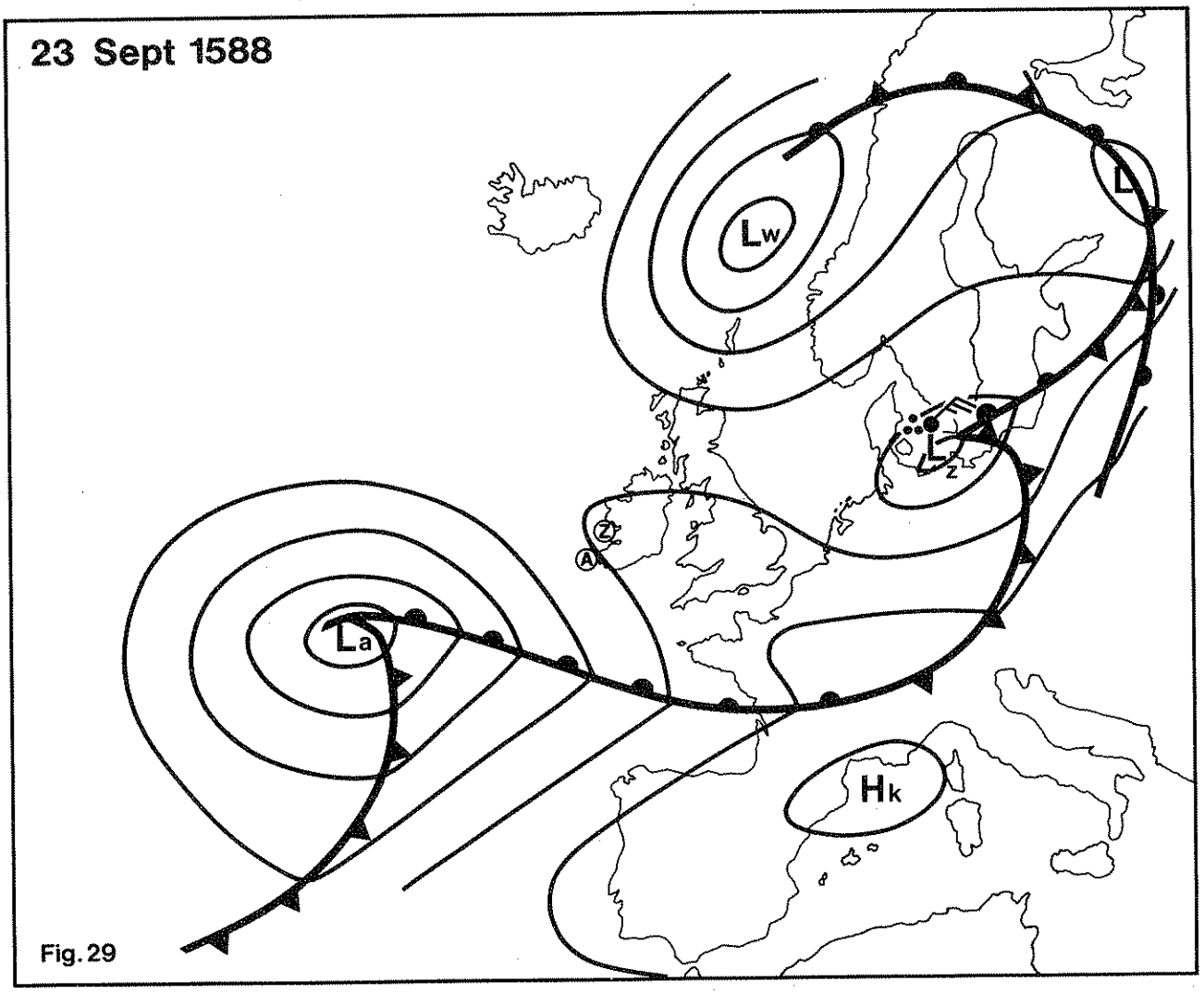

Fig. 29

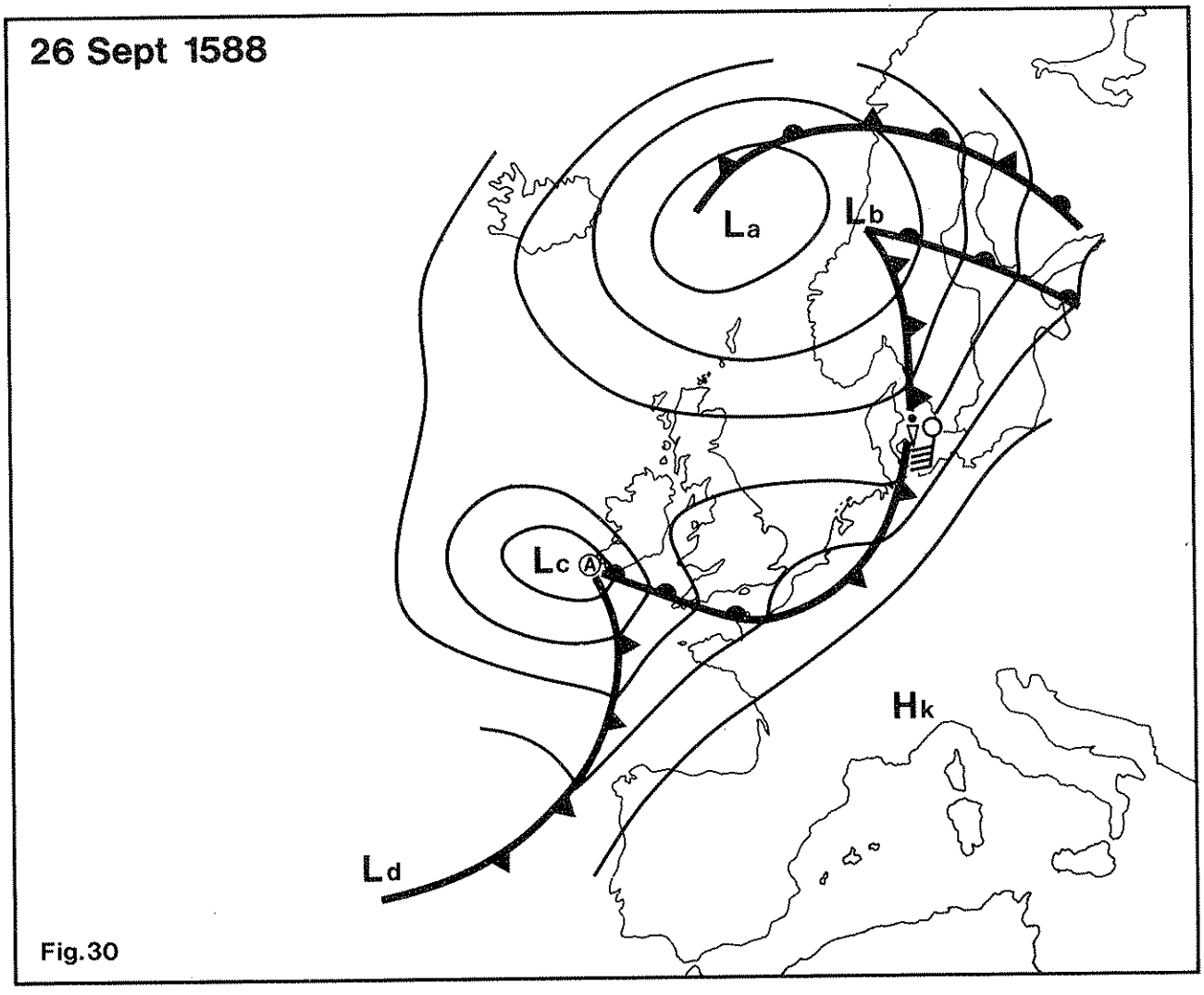

Fig. 30

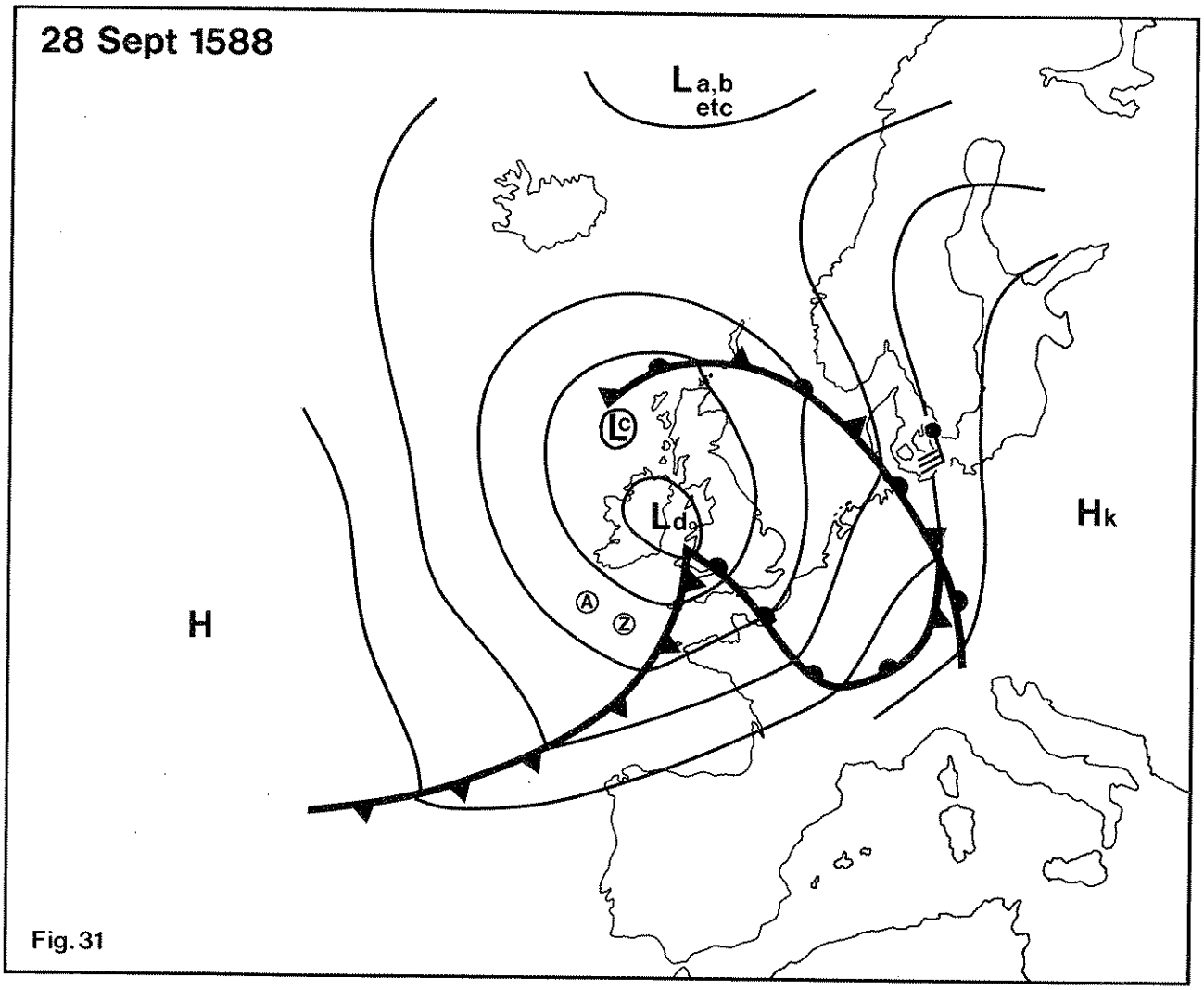

Fig. 31

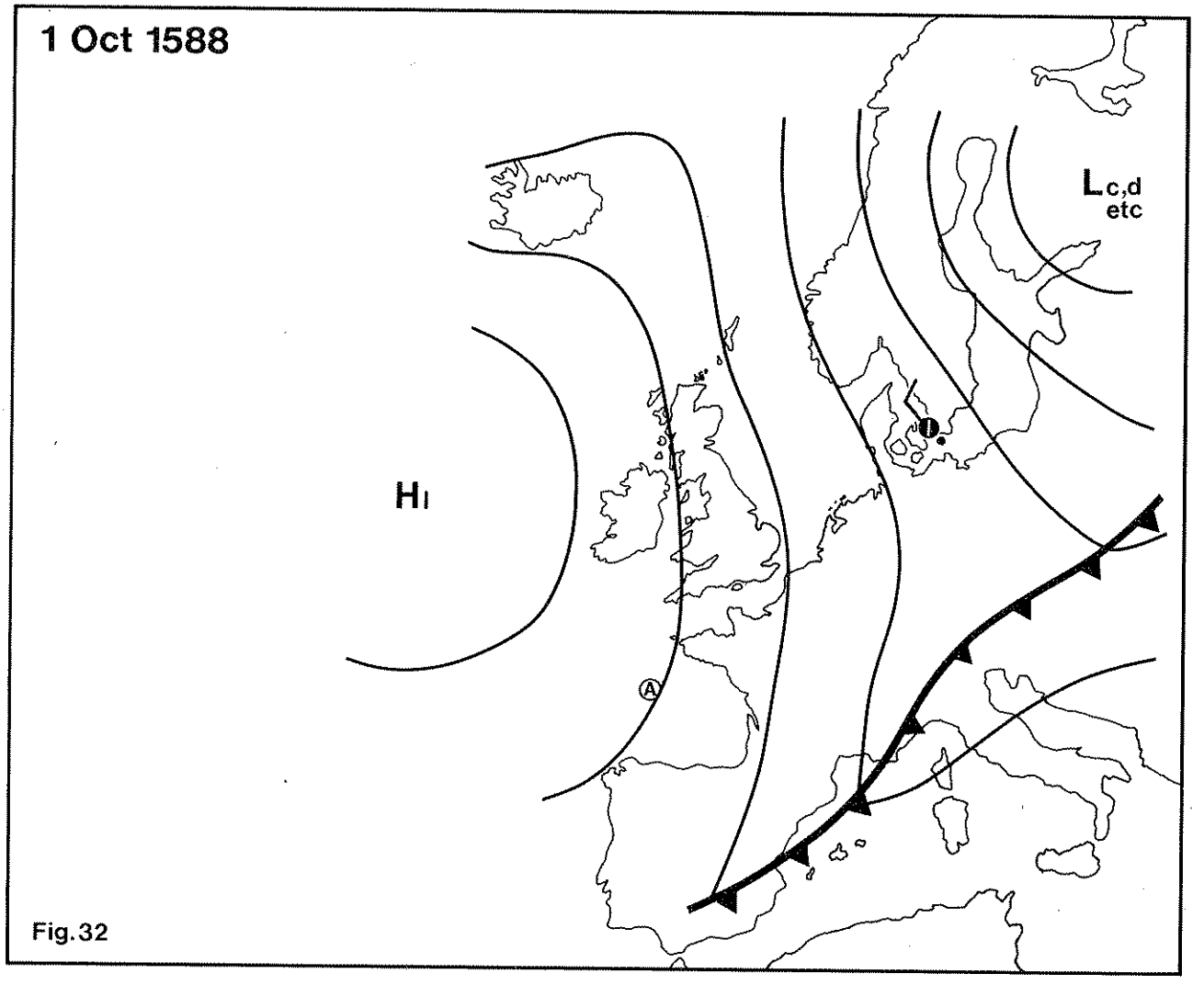

Fig. 32

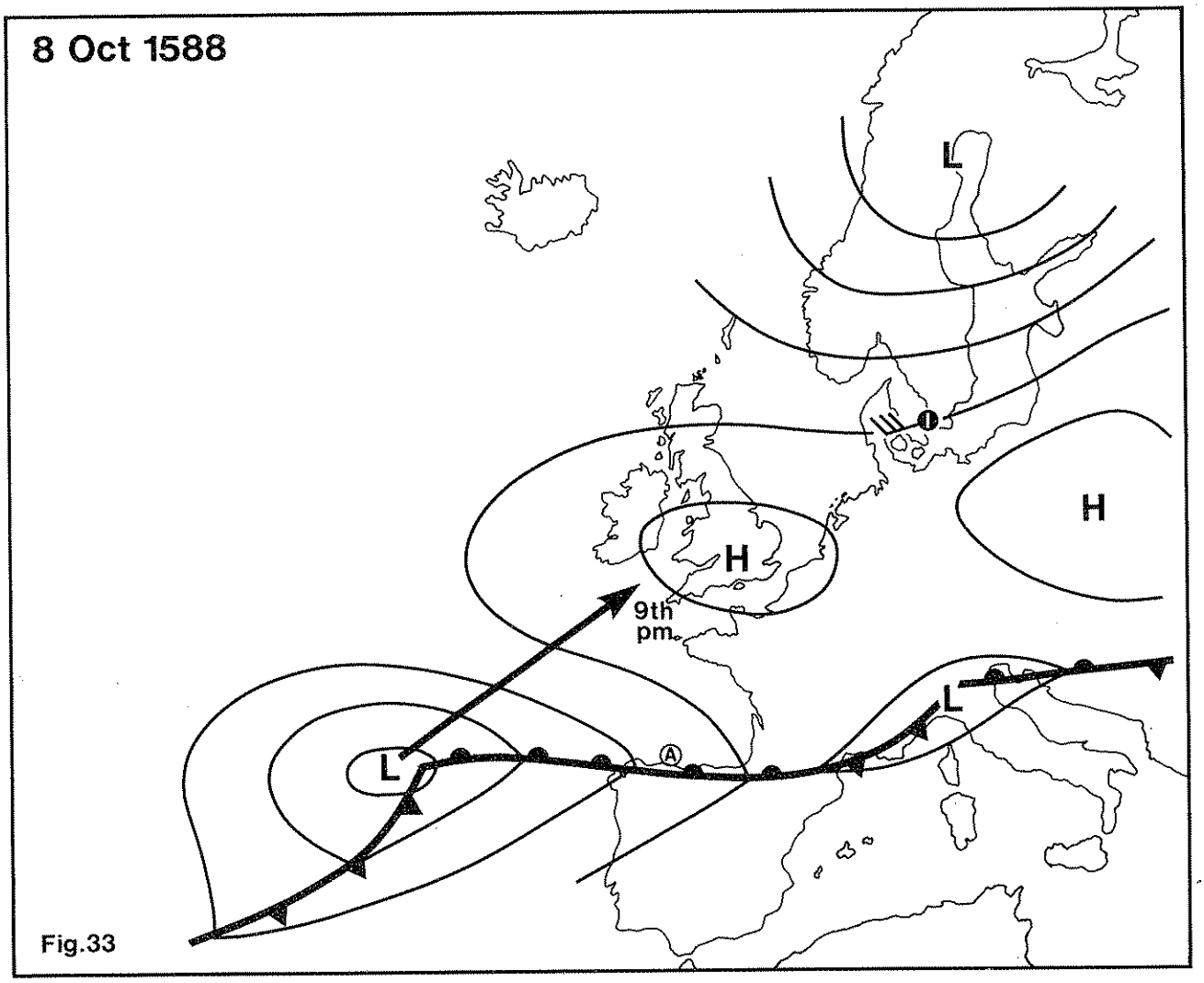

Fig.33

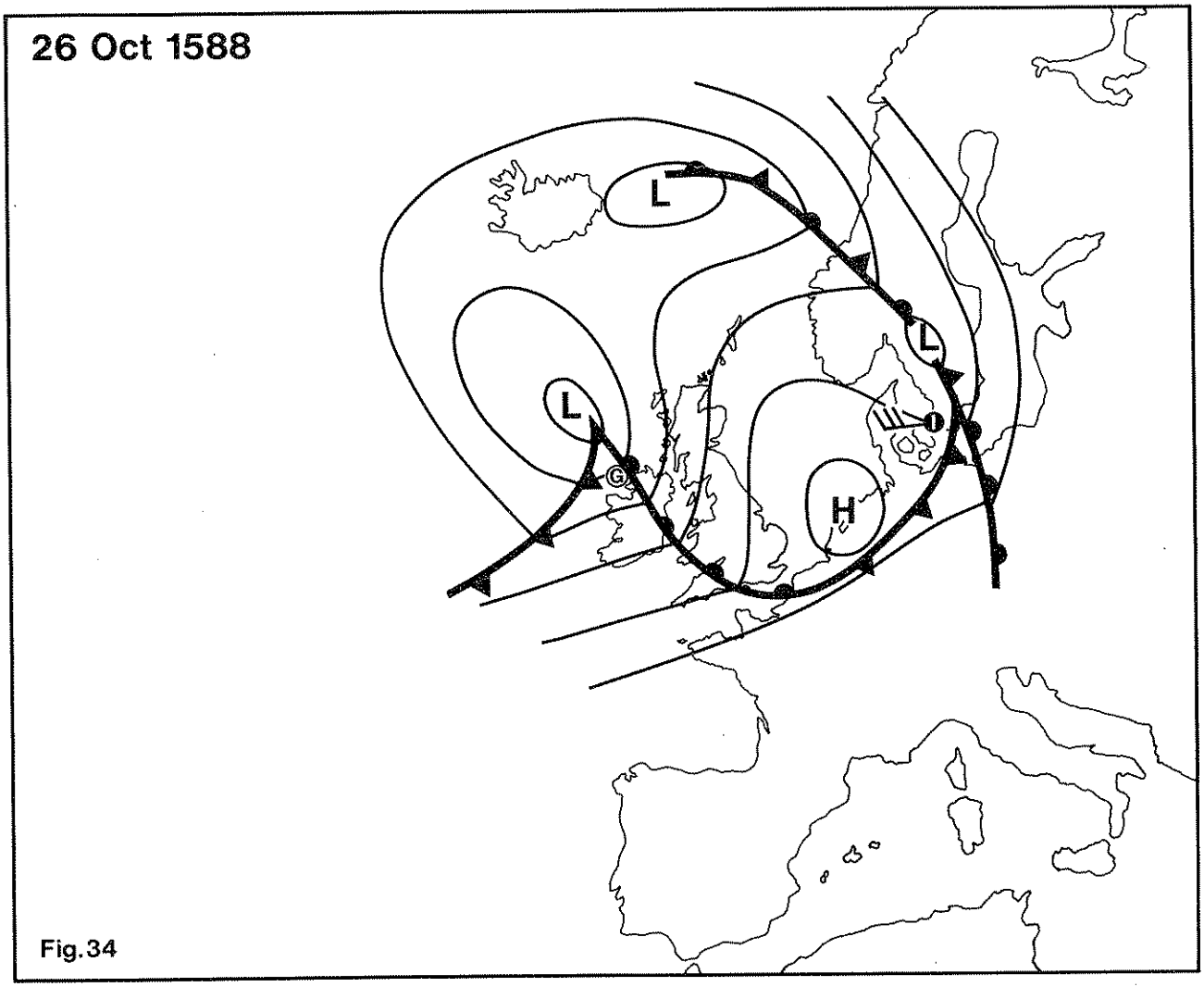

Fig.34

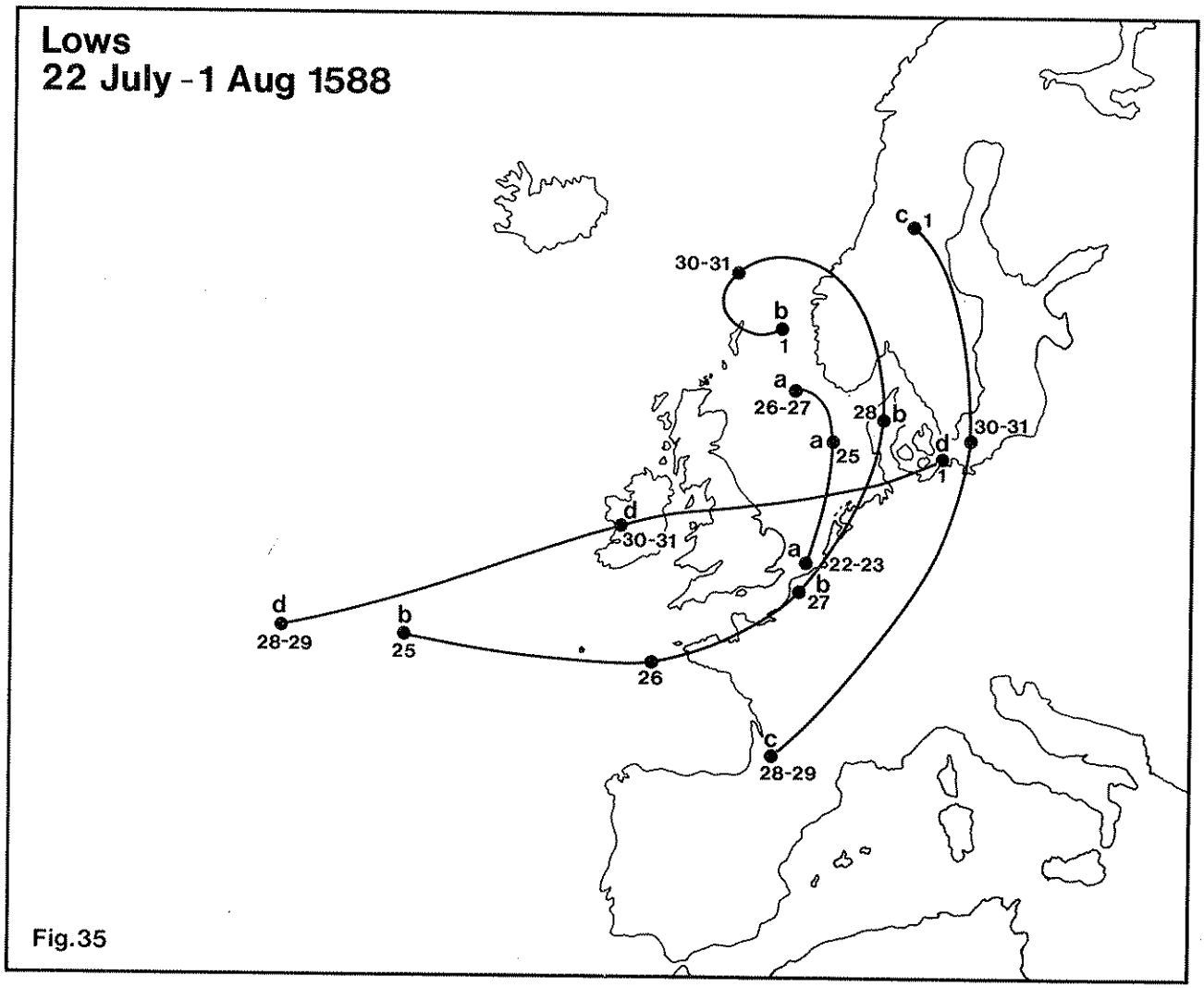
Lows
22 July - 1 Aug 1588
c 1
30-31
b 1
a 26-27
28 b
a 25
d 1
30-31
d 30-31
a 22-23
b 27
d 28-29
b 25
26
c 28-29

Fig.35

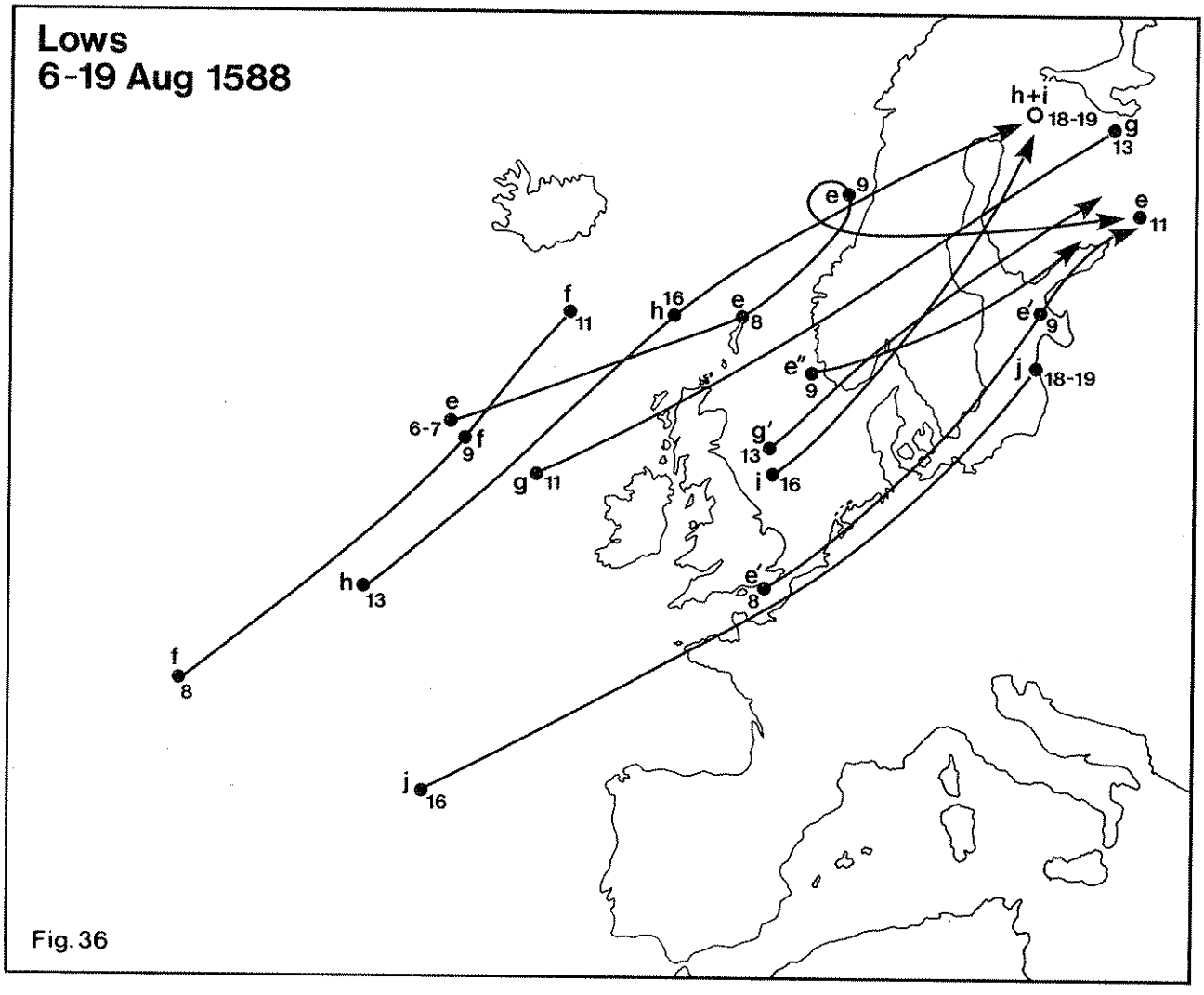
Lows
6-19 Aug 1588
h+i 18-19
g 13
e 9
e 11
f 11
h 16
e 8
e' 9
e" 9
j 18-19
e 6-7
f 9
g 11
g' 13
i 16
h 13
e' 8
f 8
j 16

Fig.36

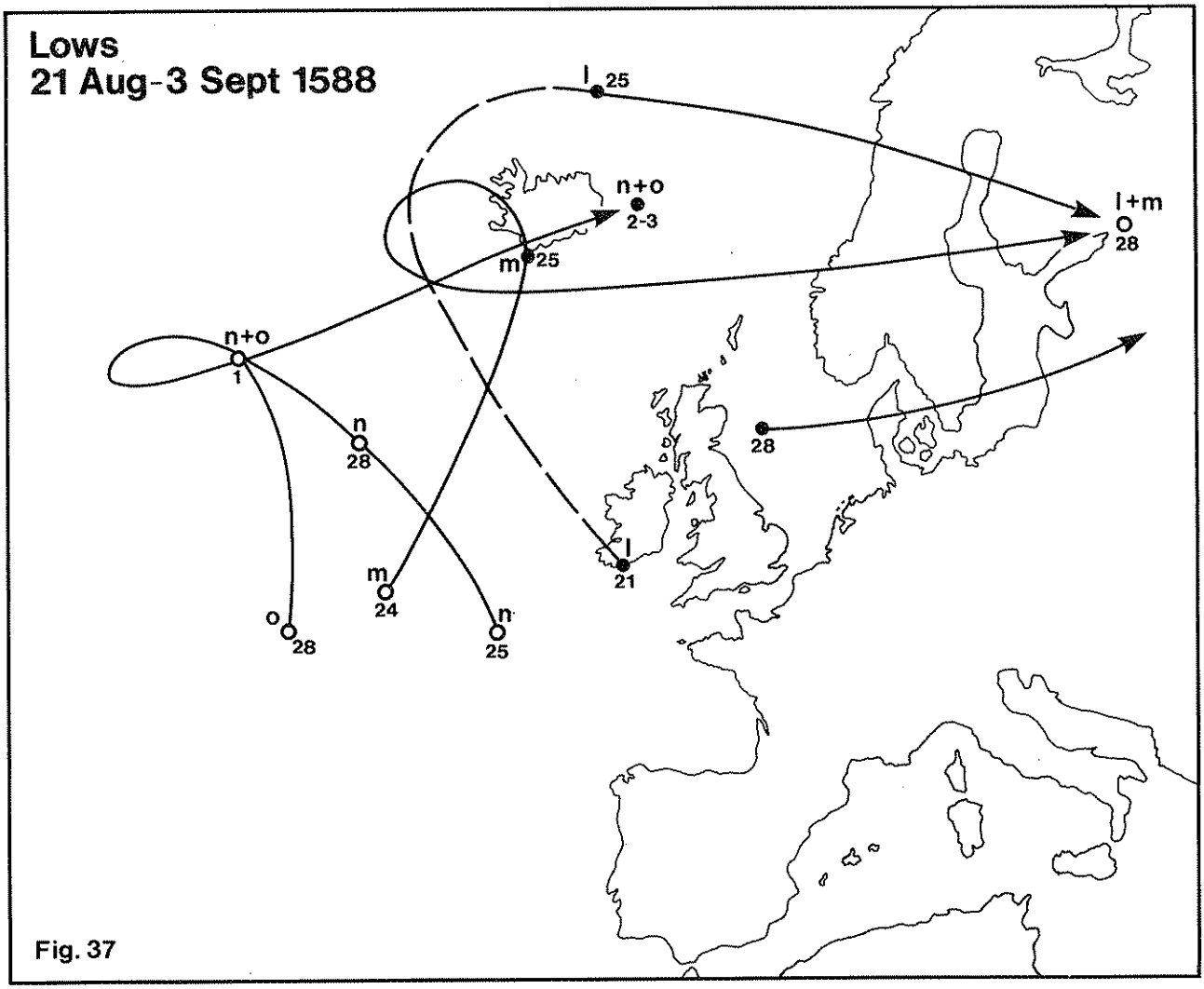
Lows
21 Aug-3 Sept 1588
l 25
n+o
2-3
m 25
l+m
28
n+o
1
n
28
28
l
21
m
24
n
25
o
28

Fig. 37

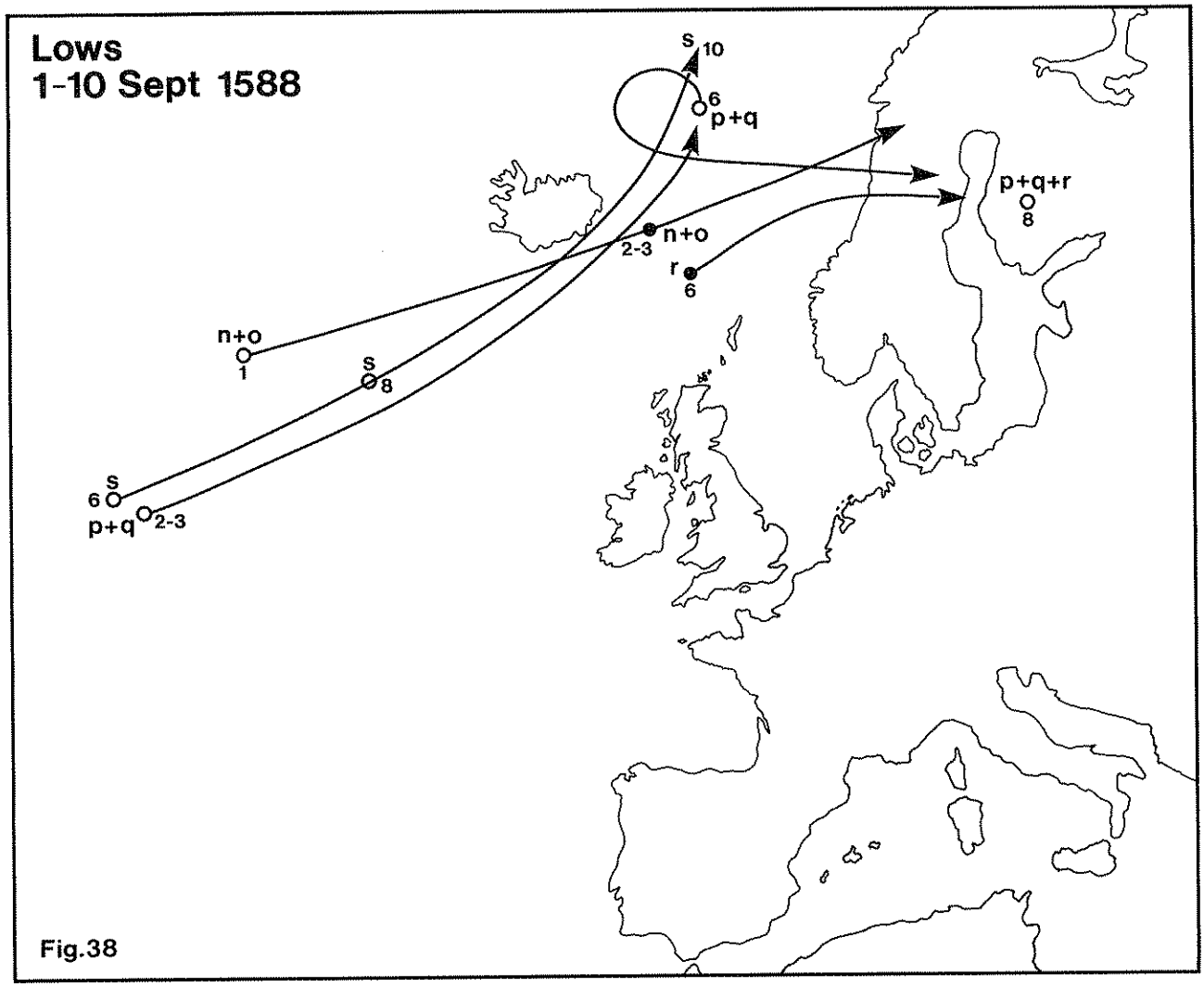
Lows
1-10 Sept 1588
s 10
6
p+q
p+q+r
8
n+o
2-3
r
6
n+o
1
s
8
s
6
p+q
2-3

Fig.38

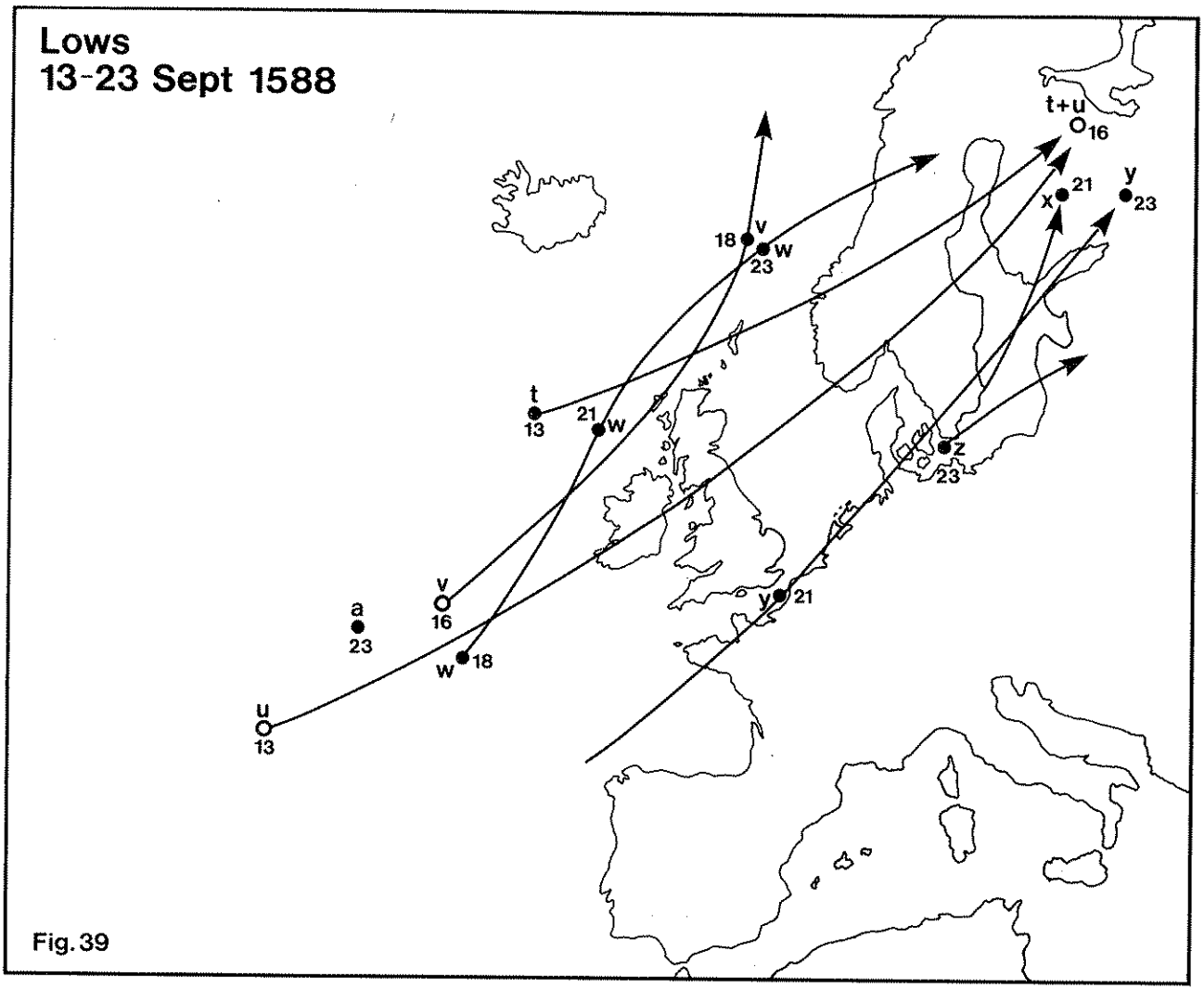
Lows
13-23 Sept 1588
t+u
16
y
23
x
21
v
18
w
23
t
13
21
w
z
23
v
16
a
23
w
18
y
21
u
13

Fig. 39

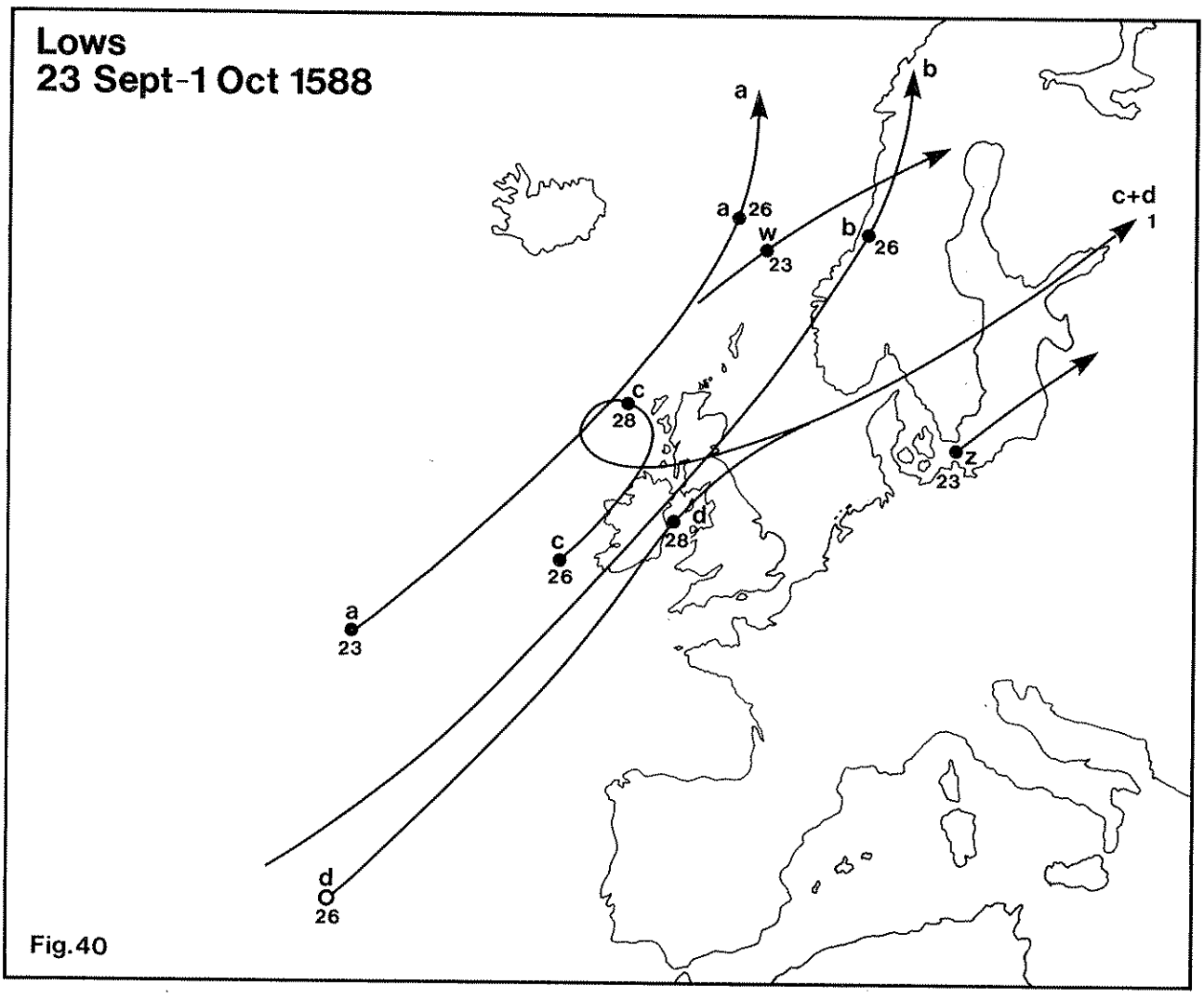
Lows
23 Sept-1 Oct 1588
a
b
a
26
w
23
b
26
c+d
1
c
28
z
23
d
28
c
26
a
23
d
26

Fig. 40

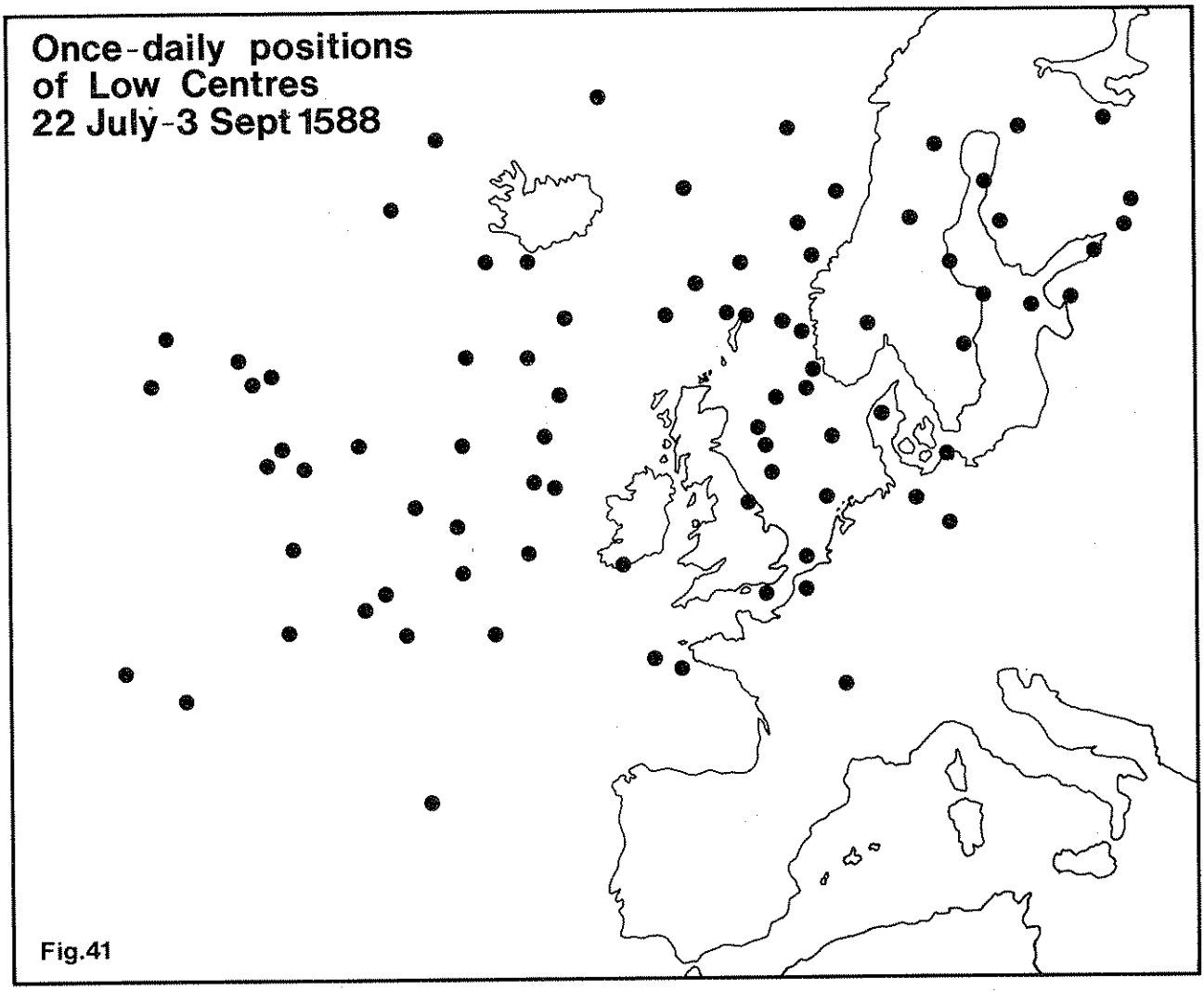
Once-daily positions
of Low Centres
22 July-3 Sept 1588

Fig.41

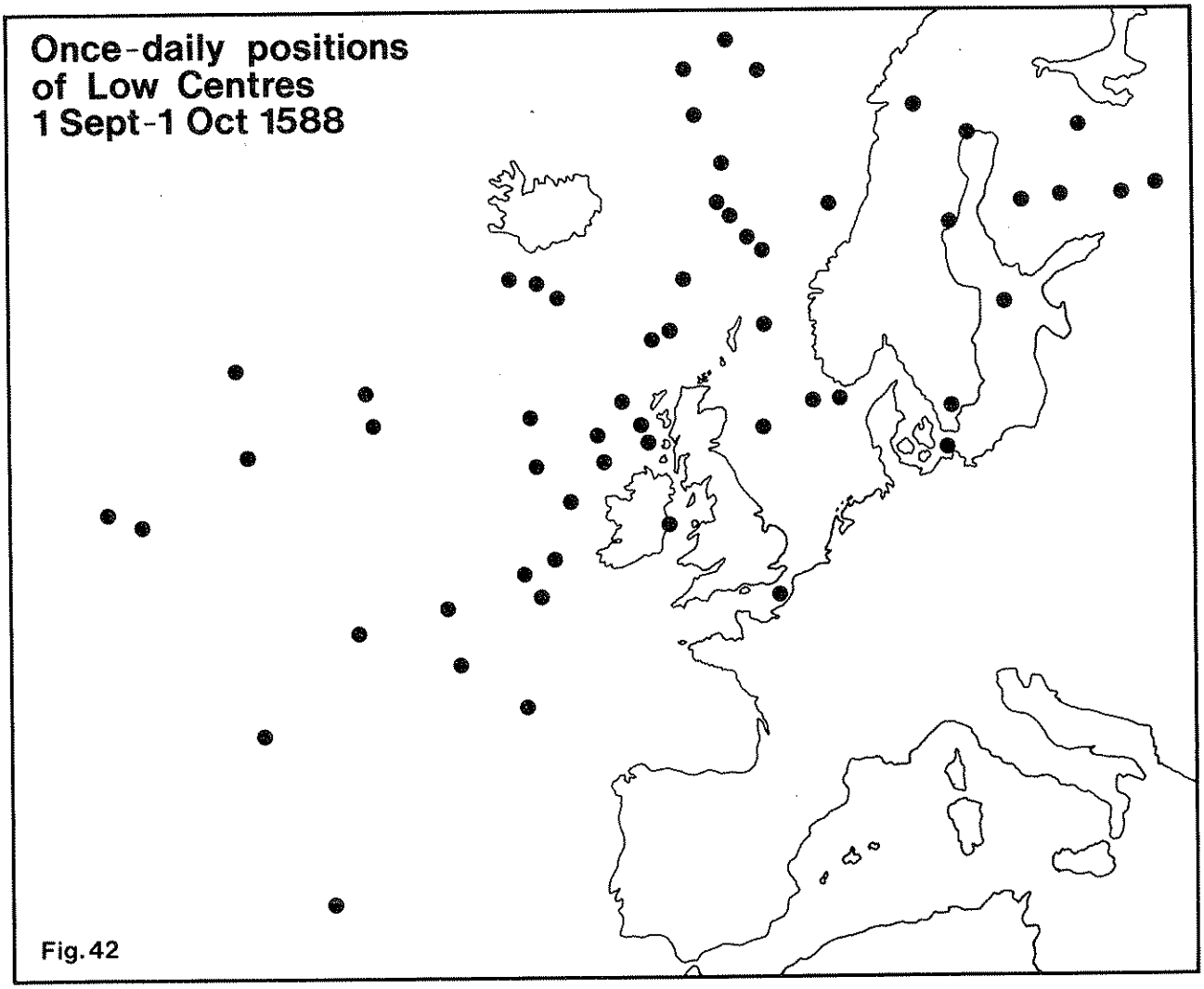
Once-daily positions
of Low Centres
1 Sept-1 Oct 1588

Fig. 42

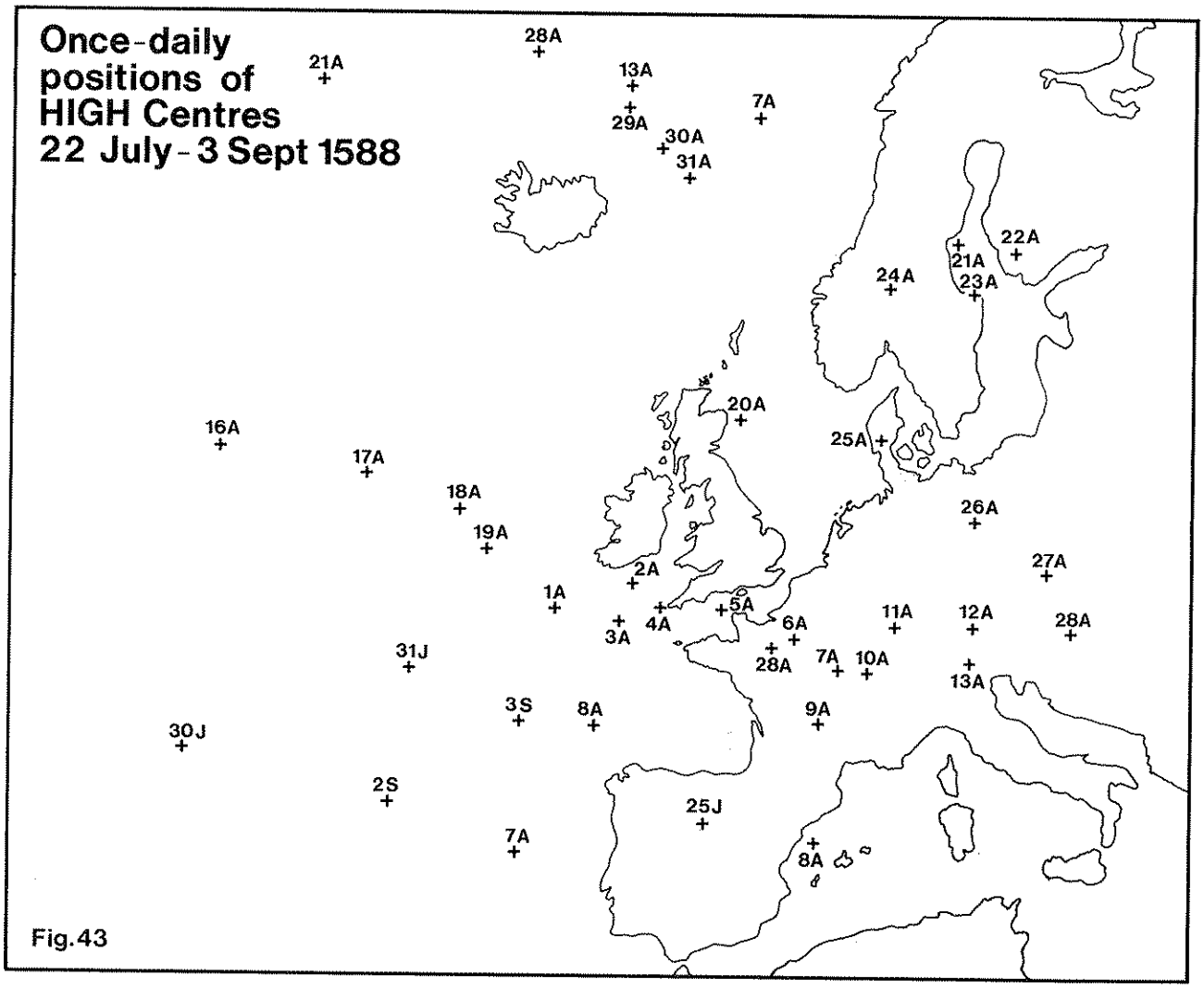
Once-daily positions of HIGH Centres 22 July-3 Sept 1588
28A
21A
13A
29A
7A
30A
31A
22A
21A
23A
24A
20A
16A
25A
17A
18A
26A
19A
27A
2A
1A
5A
4A
3A
6A
11A
12A
28A
31J
28A
7A
10A
13A
3S
8A
9A
30J
2S
25J
7A
8A

Fig.43

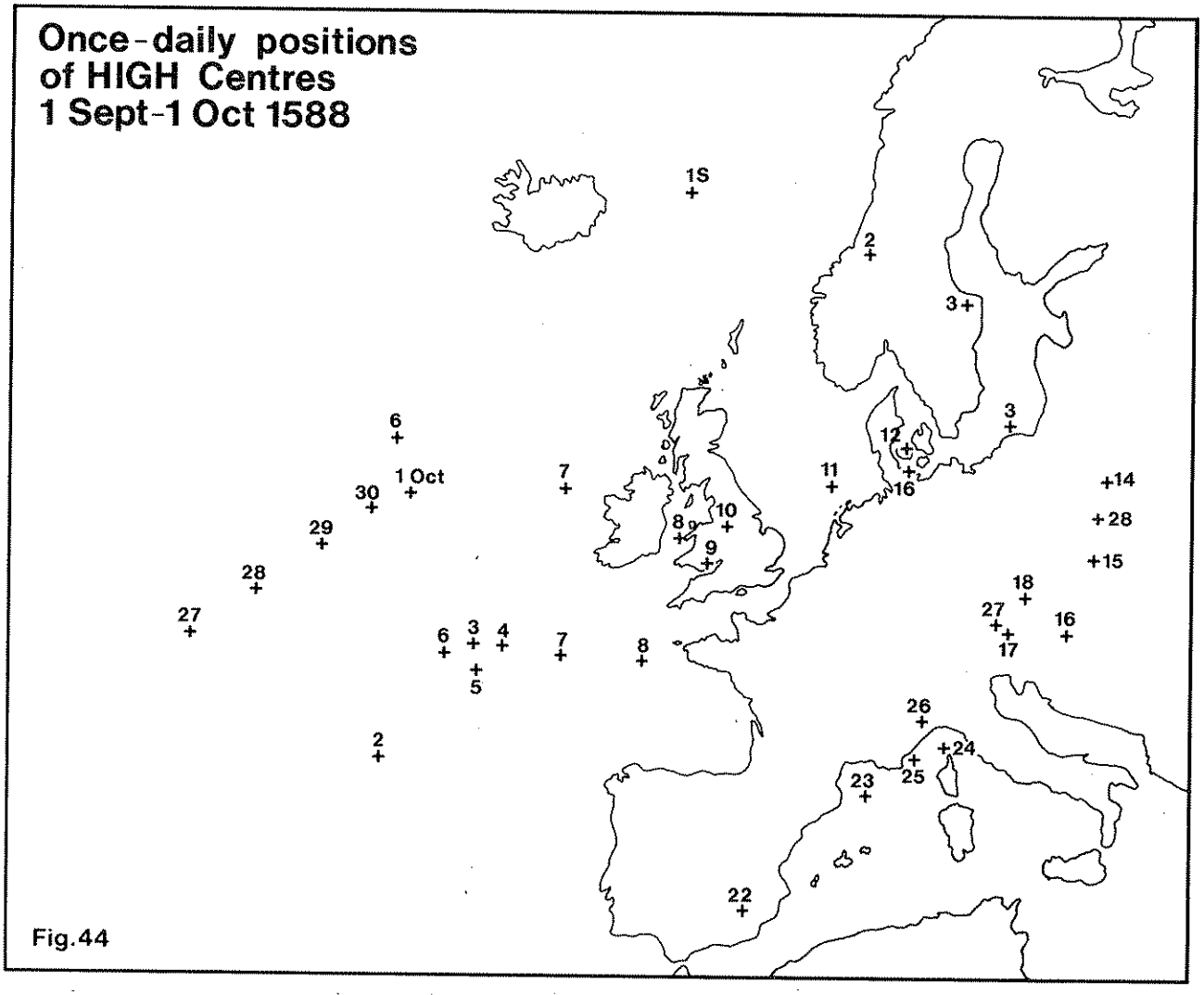
Once-daily positions of HIGH Centres 1 Sept-1 Oct 1588
1S
2
3
3
6
12
1 Oct
7
11
16
14
30
10
28
29
8
9
15
28
18
27
27
16
6
3
4
7
8
17
5
26
2
24
25
23
22

Fig.44

Authors

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C. Loader



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