

AIR MINISTRY.

METEOROLOGICAL OFFICE, LONDON.

PROFESSIONAL NOTES NO. 17.

REPORT

ON THE

THUNDERSTORM WHICH CAUSED
DISASTROUS FLOODS AT LOUTH

ON 29th May, 1920.

BY

E. V. NEWNHAM, B.Sc.

Published by the Authority of the Meteorological Committee.



LONDON:

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REPORT ON THE THUNDERSTORM WHICH CAUSED DISASTROUS FLOODS AT LOUTH ON MAY 29TH, 1920.

BY E. V. NEWNHAM, B.Sc.,

Assistant Superintendent in the Forecast Service of the Meteorological Office.

Part I.—The effects of the Storm.

It is unnecessary to repeat at length the details of this disaster. Full accounts were published in most London and provincial newspapers during the first week in June; the Louth and North Lincolnshire Advertiser of June 5th in particular contained a detailed description.

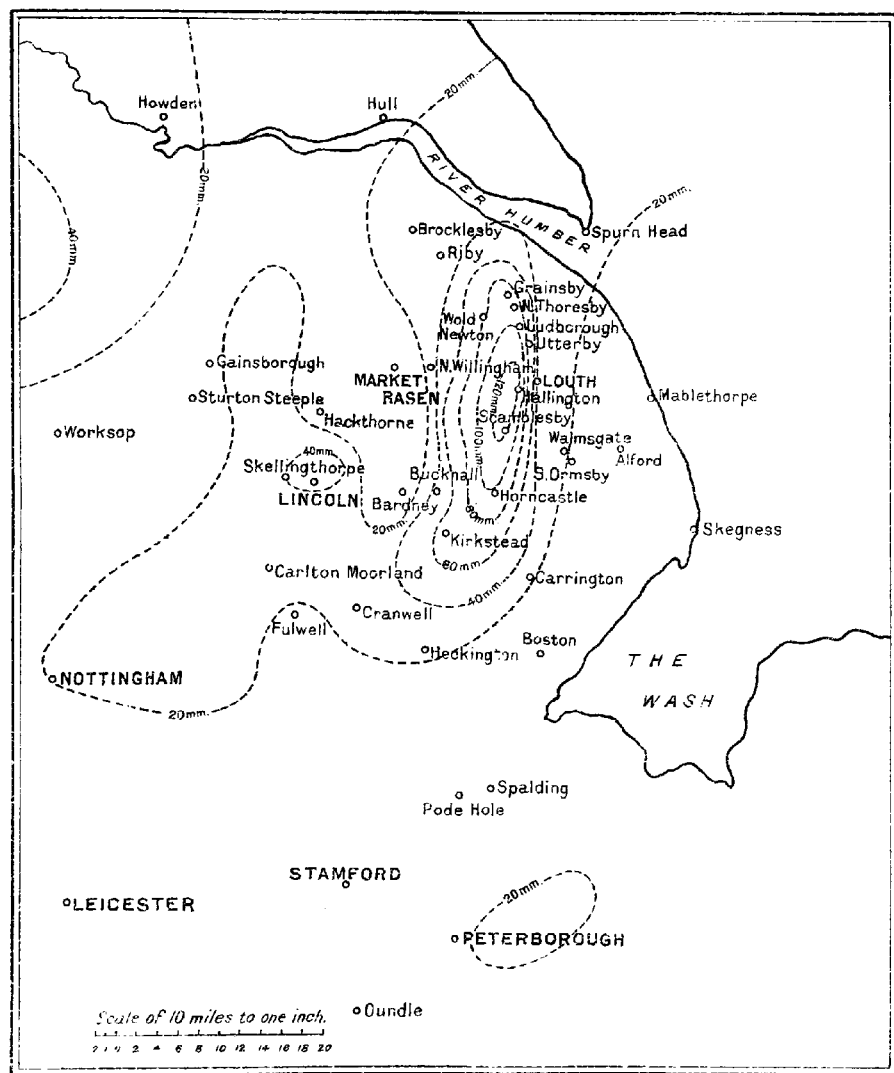
It will suffice to say that at the time of the inquest the bodies of 22 persons drowned in the flood had been recovered, and the damage done in Louth itself amounted to over £100,000. The bulk of this was due to the destruction of houses. Much loss was also suffered in the surrounding country, where a number of small bridges were swept away, and many sheep and pigs were drowned.

Briefly, a thunderstorm of unusual severity had gathered over Lincolnshire during the morning of the 29th, and broke in the afternoon. It was the cause of exceptionally heavy rain over the Wold country to the West of Louth, as is shown in fig. 1.

In Louth the storm began soon after 13h. G.M.T., and it became so dark that lamps had to be lit in the houses between 14h. and 15h.30m. There was little or no wind near the ground, but black clouds were seen to be hurrying in from several directions, with very turbulent motion. To most of the inhabitants, who were sheltering indoors, the flooding of the town came as a complete surprise. The water is reported to have risen 6 feet in 10 minutes, and soon after 16h. G.M.T. a deep torrent 200 yards wide was sweeping through the town. The Lud, normally a small stream, rose 15 feet above its normal level in some places. The waters did not subside before a number of houses had been destroyed and many inhabitants had lost their lives.

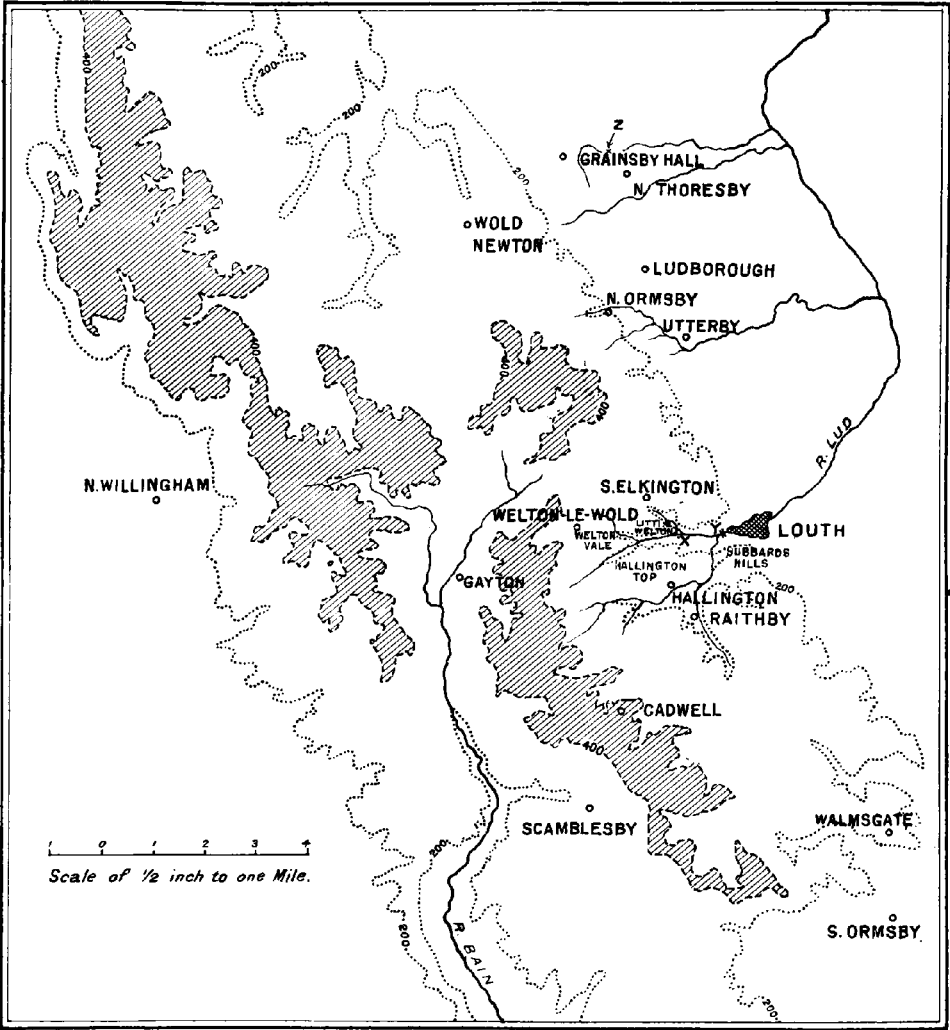
When visiting the surrounding country, ten days later, it was noticed that throughout the region where the rainfall had exceeded 100 mm. (*see* fig. 1) there were traces left by the water, even in fields situated on the tops of the hills. Generally a slightly sloping field showed characteristic mud deposits in one corner or along one side. These were especially noticeable in the neighbourhood of South Elkington (*see* map in fig. 2) Hallington, Welton-le-Wold, Gayton, and Southward to Scamblesby. In many instances the volume of water that

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Map showing rainfall for the 24 hours ending at 9h. G.M.T., May 30th. Nearly the whole amount shown fell between 13h. and 17h. on May 29th. The dotted lines are iso-hyets for intervals of 20 mm. and show that there was a region slightly west of Louth where the fall exceeded 120 mm.

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Contour Map of the Wolds —Note how rain falling on the high ground to the west of Louth partly drains into the Lud and partly into the Bain.

gathered on a few hundred yards of sloping ground was sufficient to cause deep furrows, and this was very well shown on the ground which slopes down from Hallington Top to the lower end of Welton Vale. The damage done in the valleys, on the other hand, varied considerably, but obviously could not be taken as a guide to the intensity of the rain at any one place. My impression, after a careful inspection of those regions not receiving the drainage from elsewhere, was that the 121 mm. recorded at Elkington Hall,* was not greatly exceeded at any other place, and also that it is quite safe to take the 100 mm. line in fig. 2 down to Horncastle, and northward to about Wold Newton. Mention should be made of the considerable flooding that took place $8\frac{1}{2}$ miles north of Louth on the Grimsby road, just past North Thoresby at the point marked Z in fig. 2, which must be regarded as quite independent of the main flood (although caused by the same storm), the drainage being from hilly country well north of the Louth watershed. A brook here passes underneath the road after flowing through Grainsby Park. At the time of my visit, the level of the water was about 12 feet lower than that of the road above; and from marks left on the walls of a farmyard at this point, it was evident that it had risen fully 15 feet during the storm. This was confirmed by a man working in the yard, who said that the animals were all afloat and had to be rescued from drowning, while the water covered the road to a depth of several feet. Near Utterby, which is 4 miles north of Louth, serious flooding also took place where another brook crosses the same road, bringing with it water from the high ground near North Ormsby. The flood reached the ground floor windows of a cottage near by and the hedges were submerged. Streams also overflowed and did great damage at Hallington, Gayton, Raithby and in the valleys leading down from South Elkington and the neighbourhood of Welton-le-Wold to Little Welton. These streams all unite before entering Louth. Those from Hallington and Raithby combine to form a single stream which passes through a wooded valley adjoining Hubbards Hills, and meets the other streams, which have already united, on the western outskirts of the town. It was the body of water formed in this manner that devastated so large a part of the town before spreading out into the flat country further East. The theory that a sudden deluge of water different in character from heavy rain was the cause of the rapidity with which the water rose is not borne out by accounts from the neighbouring hills. Mr. J. Larder, a resident of Louth, advances a simpler and more likely theory, according to which a dam of some kind formed at Little Welton (at the point marked X in fig. 2), which held up a great volume of water between 15h. and 16h. G.M.T. The bridge by the mill (Y in fig. 2) had become blocked by débris, and there was also a considerable head of water at this point, most of which had come down the valley adjoining Hubbards

* The gauge was tested and found to be in every way satisfactory.

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Hills. At about 16h. the dam at X gave way (this supposition is confirmed by the fact that trees and bushes came drifting down at this time) and the flood joined the accumulation at the bridge (at Y) which was then swept away. Something resembling a tidal wave immediately swept into the town. My own enquiries support this theory, for near Little Welton the water had evidently at one time entirely filled a valley 30 feet deep which runs parallel with the road. A little higher up Mrs. Appleby, of Welton Vale Cottage, informed me that the floods went down very suddenly, whereas in Louth they subsided slowly. This is strong confirmation of Mr. Larder's theory, which, if correct, implies that another similar storm, should it ever occur, might not be nearly so disastrous. The flooding of the River Bain, which occurred as a result of this same storm, caused much damage at Horncastle, which town would doubtless have suffered as badly as Louth had the escape of the water been checked for an hour at some point higher up the stream.

Attention may now be directed to the conditions preceding the storm and to the storm itself, the exceptional nature of which has already been proved by the map for rainfall.

Part II.—Conditions over Europe between May 28th and May 30th.

At 7h. G.M.T. on May 28th, the day preceding the storm, there were well developed anticyclones over Scandinavia and the Azores, but from Iceland down to the Southern shores of the Mediterranean, and from Ireland to Russia, pressure was remarkably uniform. Within this area light breezes prevailed. A number of very shallow depressions could be detected; the most definite were those over the Bay of Biscay and near the Farøe. Rain was falling at several British and Continental stations.

During the day the highest temperatures occurred in France: 94°F. at Clermont-Ferrand, and 86°F. at Lyons, while in Southern England a few stations reported maximum readings slightly above 70°F. In Scotland on the other hand the day was very cool, the maximum at Wick being only 51°F. Although there was not at this time the great contrast of temperature between the coastal and inland districts of Lincolnshire which developed later, yet there was evidence of atmospheric instability in these regions. During the middle of the day the sky was nearly covered with Cumulo-Nimbus clouds at Cranwell and a waterspout was seen on the coast a few miles away from Louth.

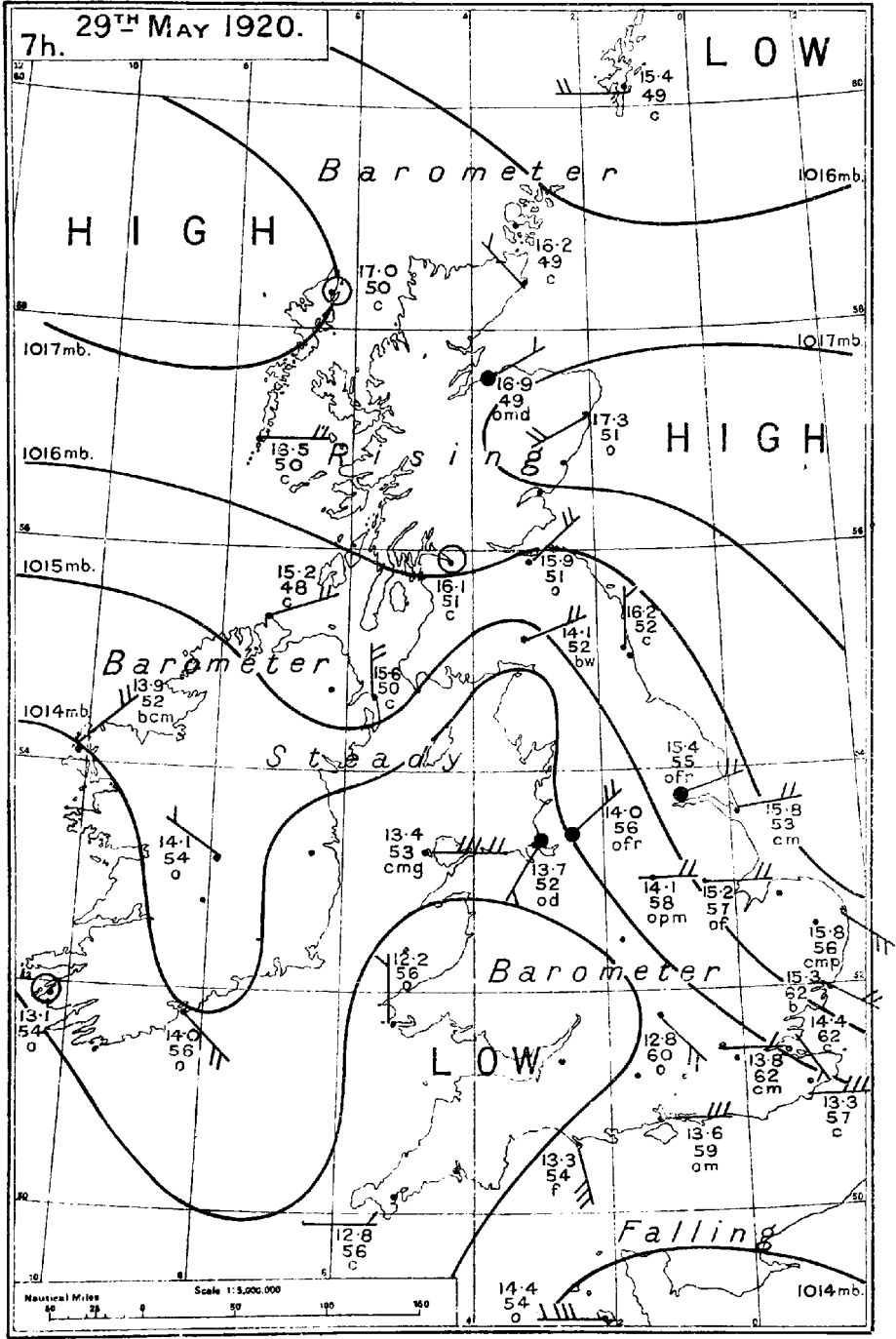
By 18h. on the 28th the depression that had been over the Bay of Biscay in the morning was approaching the English Channel. Next morning it was over the South-West of England and was becoming somewhat deeper (*see* fig. 3), while at 13h. (fig. 4) the centre was over Wales. It was at this time that the violent thunderstorm burst over the wolds of Lincolnshire.

At 18h. (fig. 5) the depression appears to have been centred over Shropshire, and light Easterly breezes prevailed at the sur-

Figure 3.

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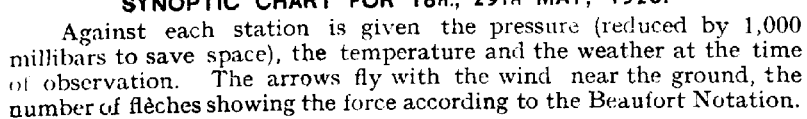


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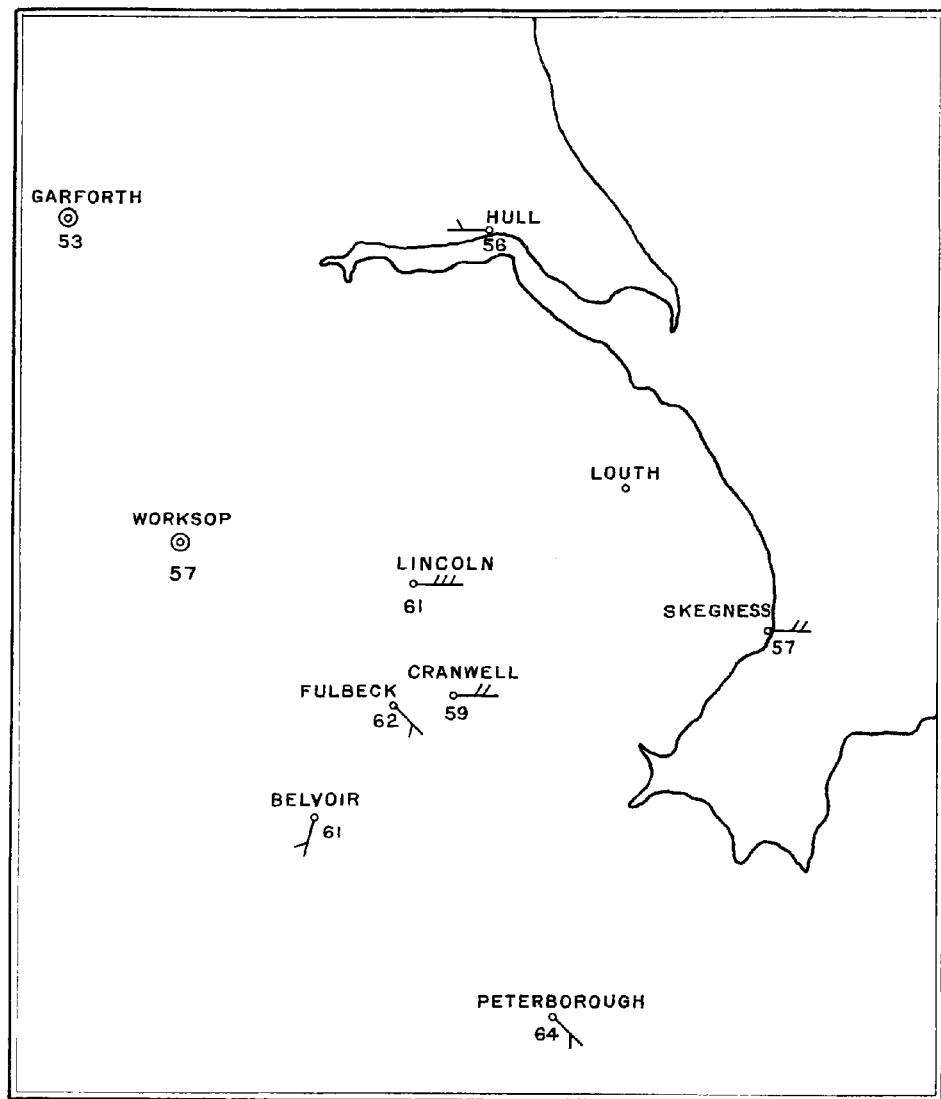


Against each station is given the pressure (reduced by 1,000 millibars to save space), the temperature and the weather at the time of observation. The arrows fly with the wind near the ground, the number of flèches showing the force according to the Beaufort Notation.

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WIND AND TEMPERATURE AT 9h, G.M.T. OVER EASTERN ENGLAND.

face from Lincolnshire across to Liverpool. The storm had by that time entirely died out, and therefore must have occurred in the NE. quadrant of the depression, where the most prolonged and heavy falls of rain are generally found to occur.

During the night and ensuing morning a Westerly current of wind spread across England from the South as the depression passed away towards Scandinavia.

Part III.—The Details of the Storm.

For details of the storm itself there are reports from the observatory at Cranwell, from rainfall observers and climatological stations, and lastly from places visited by myself. My own enquiries extended from Horncastle in the South up to within six miles of Grimsby in the North, and Westward to Market Rasen; they did not include the strip of flat country between Louth and the sea, which lay outside the main area of the storm. More than 50 observations from different parts of Lincolnshire were collected.

During the morning of the 28th calms or light Easterly breezes prevailed over Lincoln, Nottingham and Rutland (*see* fig. 6). A considerable contrast of temperature already existed from South to North over this area, 64°F. at Peterborough, 59°F. at Cranwell, and 53°F. at Garforth. The air was both warm and moist over the inland part of South-East England at this time, and it appears probable that it had drifted across from Northern France during the night from regions which had experienced high temperatures on the preceding day. The minimum during the night at Kew was 59°F., which is 13°F. above the normal, and is equal to the highest minimum recorded there in May for 30 years (1871-1900). Moreover the pressure of aqueous vapour 5 feet above the ground at 7h. amounted to 16 millibars, *i.e.*, 50 per cent. above the normal for the time of year. This same pressure occurred at the same time at South Farnborough, Benson (Oxon), Shoeburyness and Felixstowe, while at Cranwell there was only half a millibar less. The sky was at the same time heavily clouded. Over the Thames Estuary, where it was not entirely overcast, there were both strato-cumulus and alto-cumulus clouds, which suggests that there was much moisture up to a considerable height.

At 9h. a pilot balloon ascent at Lympne (Kent) gave the following winds in the free atmosphere :—

TABLE I.—WINDS IN THE FREE ATMOSPHERE AT 9h.

Height.	Surface.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.	5,000 ft.
Wind from* ...	95°	140°	155°	170°	190°	195°
Velocity ... (m.p.h.)	10	24	27	23	24	18

* Directions are given in degrees measured from true North, so that East = 90°, South = 180°, and West = 270°

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Over Croydon at 7h. the wind at 1,000 and 2,000 feet had the same directions as at Lympne, but the velocities were somewhat less, viz., 14 and 23 m.p.h. respectively. The wind current between 2,000 and 4,000 feet had a velocity and direction which, if continued, would have brought it over the Wolds of Lincolnshire at about the time of the commencement of the storm (13h.). An ascent made further North at Cranwell at 12h.30m. shows again a Southerly current proceeding towards Lincolnshire, and at Felixstowe a stronger current with an East to West component is indicated converging upon the same region. These converging winds are most significant.

TABLE II.—WIND DIRECTION AND VELOCITY (M.P.H.) JUST BEFORE THE COMMENCEMENT OF THE STORM.

Height.		Surface.	1,000 ft.	2,000 ft.	3,000 ft.	4,000 ft.
Cranwell— 12h.30m.	...	135°/3	190°/13	177°/17	178°/24	180°/23
Felixstowe— 13h.	...	120°/10	140°/28	160°/32	175°/30	165°/28

During the morning the sky partly cleared at times in the region immediately South of the storm. At Skegness the sun shone brightly from 11h.10m. to 12h.20m. and at Fulbeck (8½ miles NW. of Sleaford) from 12h.10m. to 13h., while at Belvoir there were gleams of sunshine from 9h.20m. to 12h.30m. The temperature rose to 70°F. or 71°F. in these regions, but further North, where there was practically no sunshine, the air remained relatively cold. Rain had fallen generally during the night and there was more during the forenoon, consequently the rise of temperature was accompanied by a marked increase of moisture in the air near the surface, the vapour pressure increasing by nearly a millibar to rather more than 16 millibars at Cranwell and to 18 millibars at Kew. Thunderstorms had already occurred locally in the South of England.

At 13h. the general situation was as follows:—Two distinct currents of air extending at least up to 4,000 feet were converging upon Lincolnshire from the South, of which the more westerly one was very warm and damp, while the other, although also coming from a heated continental area, may have been somewhat cooler, but which, judging from the dampness of the air near the ground at Shoeburyness, was also very moist. In the region North of the Wolds a cold Easterly current was blowing in from the North Sea, which has here a temperature of about 50°F. at this time of the year. At Spurn Head the temperature was only 55°F. Conditions were, therefore, very favourable for the ascent of great quantities of warm moist air, which appears to be the only possible way of explaining such heavy and widespread precipitation as occurred.

The first mutterings of the great storm were heard shortly before 13h. At Horncastle dark clouds were seen in the South-West towards Kirkstead, and there were occasional peals of thunder. By 13h.15m. rain was falling with tremendous force, and streams of water were soon flowing down the streets. At Kirkstead itself rain began shortly after 13h. At Louth (over 16 miles to the North-East) and for eight or nine miles Westwards of Louth the storm was reported to have broken at just 13h, after some preliminary thunder, while at North Thoresby, seven miles North of Louth it was only a quarter of an hour later. Many observers spoke of the storm appearing to come from the South-West, but this must be taken to mean simply that the clouds on the whole moved from this direction, as the foregoing remarks show that there is no evidence that the storm itself drifted towards the North. The heaviest rain seems everywhere to have been over by 16h., but it did not leave off altogether until 17h. at North Thoresby and Ludborough in the North, and in the extreme South, at Kirkstead, it began again at 16h.15m., continuing for a short time. In an East to West direction there is also no evidence of a general drift of the storm, although there are indications that it expanded during the afternoon. In the West there was bright sunshine still at Market Rasen at 13h.45m., from which direction black clouds were seen hanging over the Wolds, and at North Willingham the heaviest rain did not fall until about 15h. Eastwards, at South Ormsby and Walmsgate, the afternoon was very dark, but there was not much thunder or lightning, and rain did not begin until between 15h. and 16h. and was not very heavy.

Proceeding somewhat further afield, in the neighbourhood of Grimsby and at Brocklesby, that is to say about 15 miles North of Louth, a wet day was experienced. Distant thunder was heard towards the South. On the opposite side of the storm, South of Kirkstead, thunderstorms occurred in the afternoon, but they were of short duration. At Cranwell thunder was heard during the forenoon and a violent storm occurred from 14h.20m. to 15h., at about the time when the storm was reaching its climax at Louth. At Lincoln also there was a storm at this time, and at Peterborough and Stamford. The evidence shows that there was one continuous storm area between 14h. and 15h., extending for over 60 miles in a SSW. to NNE. direction.

The bulk of the precipitation was in the form of rain, but there was some hail in the Central and Southern parts of the Wolds, notably at Little Welton, on Hallington Top, at Cadwell, and down as far as Scamblesby and Horncastle. Most of this fell late in the storm, not until after 15h. at Horncastle.

Squall Phenomena.—Within the area having a rainfall greater than 100mm, the wind appears to have been everywhere light at the surface, although the clouds showed much irregular movement. There must have been considerable instability in the lower layers of the atmosphere for a long distance Southwards, even beyond the storm area. Mr. A. Everett, M.A., of 32, Grove

Road, Surbiton, Surrey, saw clouds on the horizon North of Teddington at about 12h. G.M.T. which reminded him of a tornado cloud that he had seen in Colorado. These were heavy Cumulo-Nimbus clouds from which depended two trunk-like projections, which however did not reach down to the horizon. Mr. H. Harries has kindly furnished me with a copy of a letter he has received from Rear-Admiral Sir Francis Harrison-Smith, of Easton Hall, Stamford, which includes the following passage :—

“ Living on the top of a hill 300 odd feet above sea level, which commands a good view of the weather approaching from all directions, I was waiting to begin cricket from about 13h. until 15h. G.M.T. on May 29th, but the rain left me to pursue a favourite hobby of watching the weather. There was a good deal of thunder about; the wind was fitful and uncertain in its direction, but the upper clouds were travelling slowly from SE. At 14h.45m. a very heavy warm squall struck us from SW., driving great masses of dense low cloud before it. In England I have never seen the cloud so extraordinary, rolling and tumbling over and over exactly as I have seen it do in cyclones, hurricanes, and the like abroad, and reminding me of the clouds from which I have seen waterspouts descend at sea or down the valley of the Yangtse. This warm disturbance travelled right over Easton and Stamford in a direct line for Louth, and I have very little doubt that as it approached the coast it met a colder current from the North Sea, which caused the sudden precipitation of the masses of obviously dense vapour which the shift of wind was collecting in its course.”

Here there is confirmation of the existence of two different currents, one from SE. and the other from SW. What was happening at their boundary at this instant is not quite clear. Had the wind become SW. generally in the course of the storm one would have supposed that the SW. current was replacing the other, and for the moment actually passing underneath it. It seems more likely, however, that both left the surface before reaching the Wolds, there to take part in a general upward convectional movement.

At Cranwell the self-recording anemometer, 13 metres above the ground, showed that something similar took place there at 14h.35m., *i.e.*, ten minutes earlier if the times stated are correct. A light SE. breeze, blowing at about 2 metres per second, was suddenly replaced by a SW. wind blowing 12 metres per second. This strong breeze lasted about four minutes. Ten minutes later it had backed to S. and fallen to 4 metres per second, and the wind was light and very variable in direction until 16h., when it became Easterly or North-Easterly. It was not until 19h.30m. that a permanent change to S. and SW. winds took place. The appearance of the sky was as remarkable as at Stamford. Mr. W. H. Pick, the Meteorologist-in-Charge, describes it in these words :—“ The clouds in the afternoon from 13h. to 15h. were Cumulo-Nimbus in type, the sky being entirely overcast with

them at 14h. and 15h. G.M.T. They gave signs of being in a condition of peculiar turbulence, seeming to be shaped like short stout funnels, these funnels being in a state of rotation about a central axis. The effect was sufficiently rare to impress even experienced observers : the rotation of each hanging cloud being quite distinct."

The squall may have been a warm one, but one cannot be sure. The temperature had been 71°F. at 13h. and fell to 58°F. at about 14h.25m., no doubt as a result of the cooling caused by the heavy thunderstorm at this time. There was a sharp recovery of 1°F. only, at about 14h.40m., which corresponds roughly with the time of arrival of the squall. It is probable that both here and at Stamford, the air near the ground had become temporarily cooler as a result of the rain, and became warmer again during the squall simply because of the churning up of the surface layers.

One more incident of this kind deserves mention. At Boston, according to Mr. J. Shaw, of 2, Sleaford Road, the thunderstorm was at its height from 15h.15m. to 15h.30m., during which time 13mm. of rain fell. For about ten minutes there was a high wind from SE., which overturned stalls and made a roaring noise like the escape of steam at high pressure. At Heckington, however, 13 miles to the West, there was no wind worth mentioning, but the rain was heavier and flooded part of the village to a depth of one foot.
