The relations of pain to weather : being a study of the natural history of a case of traumatic neuralgia / by S. Weir Mitchell.

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S. WEIR MITCHELL, M.D., OF PHILADELPHIA,

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I HAVE not troubled myself to learn how ancient is the popular idea that cases of old wounds, of injuries and diseases of the bones and of chronic rheumatisms suffer renewed pain on the approach of a storm.[1]

But although this is a common belief, I am aware of no essay on the subject, and save an able paper by Dr. Hewson, of none on kindred topics, nor to my knowledge has it ever been submitted to the exact test of a scientific study. In the year 1872, while writing my book on Injuries of Nerves, and their Consequences, I had occasion to study the many curious symptoms belonging to the stumps of amputated limbs, and was struck with the number of persons who stated that their comfort depended largely on the state of the weather. On summing up their accounts of these facts I found, that of fifty cases of amputation, less than half felt unusual sensations upon the coming of an east wind, or during it; of the rest two-thirds insisted on their power to predict such a change in weather, and stated that they were unaffected by a thunderstorm, or a rain coming from the south. The remainder thought any great change in the weather was apt to cause them pain.

A few of these were intelligent persons, but most of them were unfit to serve as witnesses in regard to their own ailments. The subject, however, continued to attract my attention, and I became at length satisfied that it was worthy of a more full and accurate study.

[1] Many authors allude to this belief, and in the great Jenner's lively lines, "Forty reasons for not accepting a friend's invitation, or signs of rain," he says,

"Hark how the chairs and tables crack,
Old Betty's bones are on the rack."

I found that rheumatic people were unsuited to this purpose because of the fact that the sensitive cases were too constant sufferers, and what I wanted were persons who were liable to occasional onsets of pain, and who in the intervals were altogether free of it. I needed also to find these requisites in persons possessed of such freedom from constitutional disease as would liberate my already difficult problem from needless complications. Some of these conditions are to be met with in certain neuralgias, especially such as are of traumatic parentage. They are also present, although in less satisfactory form, in the early stages of some cases of sclerosis of the posterior columns of the spinal cord, with sclerosis of the posterior nerve roots. Such cases are I find exceptionally prone to feel atmospheric conditions—are as it were *sensitized*, to use the photographer's phrase; many of them are in fact *too* delicate tests for the conditions which evolve pain, so that the least exposure is felt; others are less sensitive, and are often in the possession for a time of singular vigour and freedom from other functional disturbances.

It was, of course, requisite that the persons to be used for this novel study should be unusually intelligent, and if possible, accustomed to the accurate examination of facts. Nor was it less needful to have proper instruments, and that large daily knowledge of the movements of storms, which now-a-days the signal office has rendered available; but the absence of which would a few years ago have made utterly futile any attempt to solve the interesting questions involved in this study of the natural history of pain.

I have been fortunate enough to find all of the needed conditions in certain cases of traumatic and ataxic neuralgia, but in the present paper I shall limit myself to the results obtained in a single case of neuralgia of a leg stump, because in it were combined in a high degree all the conditions which seem to me essential. These studies have in this case extended over three years, and after much annoying failure have led to some satisfactory results. Although guided and encouraged by me, they could never have proved successful had it not been for the unusual ability, interest in the task, and perseverance of the accomplished gentleman who has obliged me by making his own torments useful in the solution of the question of how far weather affects the production of certain forms of pain.

Before giving his results, as to which I shall quote largely his own admirable statements, I shall relate his case in full.

Captain Catlin, U. S. A., æt. 35, was in perfect health, when in August, 1864, at the Weldon Railroad, his foot was crushed by a twelve pound round shot. He felt as if the whole leg had been torn off, but had at the moment no pain, and only a sense of mechanical disturbance, neither was there any decided constitutional impression, none of what we call shock. Within three hours the leg was cut off below the knee; and the wound healing readily, he was up in thirty days. There was some pain during

this time, but it did not become important until from six to nine months had gone by. When seen by me in December, 1874, the pain was said to be in the metacarpo-phalangeal articulation of the great toe, and sometimes through all the toes, with more or less sense of twitching. Still more rarely, the attacks are in the heel, but are then unusually severe.

The neuralgic attacks are preceded by a tendency to sleep. They begin with a steady burning pain in the great toe and the inside of the foot, with a sense of twitching in these parts and a visible twitching in the muscles of the stump. The pain, which begins quite abruptly, increases in severity and lasts from twelve to thirty-six and rarely to forty-eight hours, and is intensified by eating a meal. In the intervals it does not exist at all, and sometimes it is replaced by a mere diffuse sense of burning, more or less intense in the small toes. No precaution averts these attacks, and however perfect the general health, the neuralgia continues. The stump itself is liable to be thrown into a state of convulsion on being much handled. These spasms consist in alternate contractions and relaxations of the various muscles, and endure for half a minute or more, a not uncommon phenomenon in stumps, and which I have elsewhere fully described. These curious local convulsions are not, I think, to be distinguished from Brown-Séquard's spinal epilepsies, and as they come on only at long periods after amputations, are possibly due to changes propagated along the diseased nerves to the cord itself, or to an irritative disturbance of the spinal or cerebral centres.

In the spring of 1875, Dr. John H. Brinton, at my request, exsected one and a half inches of the peroneal nerves, but without material influence on the pains.

Captain C., after reading the remarks on weather in my book, began to pay attention to its influence on his own pain. During the progress of this research he has been stationed at West Point, N. Y., which is indicated on the maps by an asterisk.

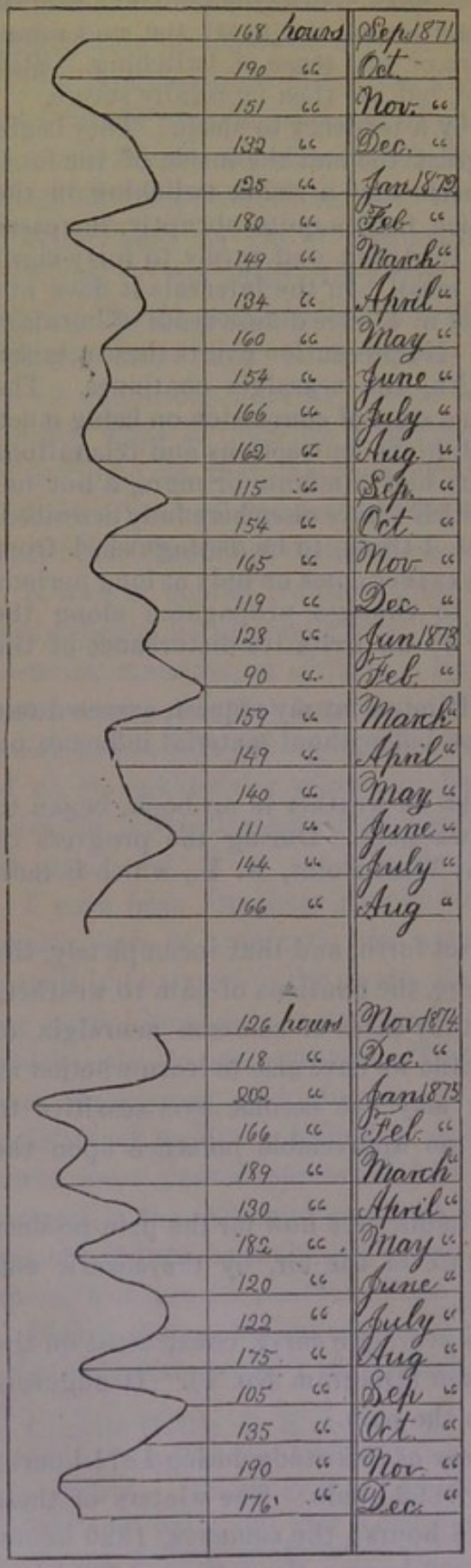
As yet, we are only in condition to set forth, and that incompletely, the laws which govern, in this particular case, the relations of pain to weather; and there will still remain for like study cases of common neuralgia, of ataxic neuralgia, of rheumatic pain; while we have also to learn whether or not, in some acute diseases, the body may not become over-sensitive to atmospheric impressions, which have no appreciable influence upon the man in health.

In the present case we have sought to discover how far the pain-product is influenced by the weight and moisture of the air, by the electric and ozone states, and by the temperature.

We shall begin by giving an annual neuralgic curve, constructed on the monthly ordinates of neuralgic duration (Diagram No. 1). It suggests a comparatively uniform continuity in the pain.

The neuralgia existed for the first year of this study during 1871 hours; second year, 1640 hours; third year, 1892 hours. The winters of these three years gave, added together, 1318 hours; the summers, 1320 hours, nearly the same; the autumns gave 1373 hours; the springs, 1392 hours each, exceeding the seasons of extremes in temperature. The amount for spring, which is our season of greatest depression of health tone, when

Diagram No. 1.



choreas return and epilepsies are difficult of control, but little exceeds the autumn pain crop.

Adding winters and summers, we have 2638 hours of pain; and for the autumns and springs, 2765, an excess of 127 hours.

As regards the relation of Capt. C.'s pain to the seasons, we shall be able to show a much more exact and frequent coincidence between it and certain states of atmosphere in winter than in summer. The factors of summer storms are more numerous than those of the winter, and less easy to study. Owing, says my patient, to the greater effect of locality, on the progress of storms, we shall, I think, find those of the warm months hardest to interpret; because, at that season, radiation, evaporation, watercourses, active vegetation, and forests, all exercise then an influence, which in winter is unfelt. While, then, in summer, we find great trouble in relating the pain attacks to weather changes, in winter the problem is easier, and the relation between the two most manifest. But the amount of pain varies little at the two seasons, whence we have reason to conclude that there still exist, in hot as in cold weather, causal or producing relations between weather and pain.

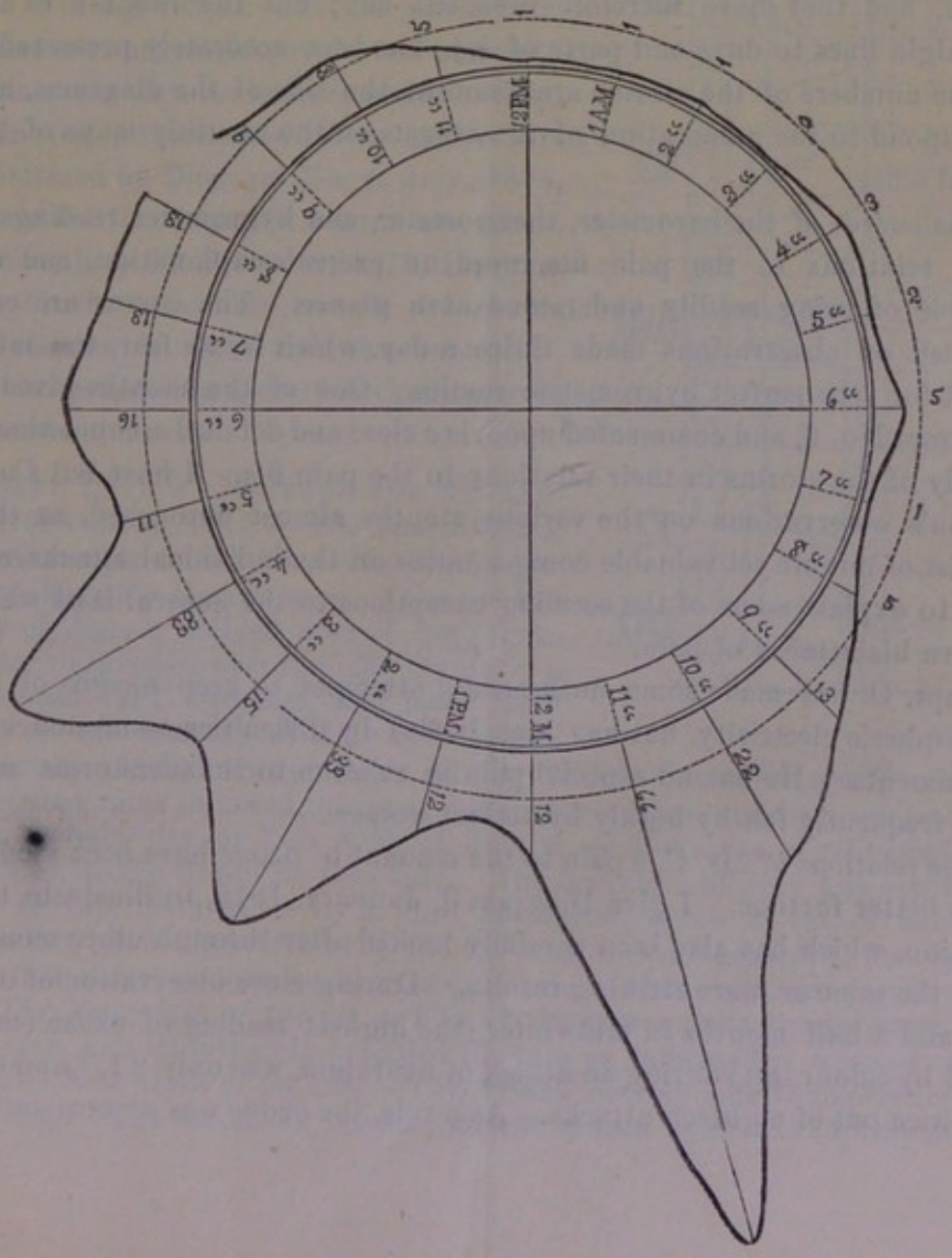
During the existence of attacks of neuralgia, lasting a day or more, there are variations which may be due to some of those curious chronal relations of the human frame which are often so well brought out by disease; or else may be under the influence of the diurnal changes in the ozone, electric or magnetic conditions, as to the two latter of which, as yet, no exact investigations have been made.

The time of day at which the neuralgic disturbance is apt to occur, is another point of interest, as to which we have a good deal of exact knowledge in a number of the neuralgias. Of eleven cases of sciatica, subject to distinct remissions, the onset of acute pain was in nine at night, and in four of the nine between 12 P. M. and 4 A. M., a marked contrast to Capt. C.'s attacks.

The neuralgias of the fifth nerve are so prone to recur at the same hour daily (usually between 10 and 12 A. M.), that many physicians are apt to regard them all as of malarial birth. But even in such as are not due to ague poison, the same tendency has been perceived; and, as I have elsewhere stated, even in pure traumatic neuralgias of the fifth nerve a like peculiarity is often distinctly shown.

The chronal relations of the present case are beautifully exhibited on Diagram No. 2, which seems to show that from 12 P. M. to 3 A. M. the tendency to attacks is least, and that from 7 A. M. to 11 P. M. the tendency is greater, while it is greatest at 11 A. M., and next most common

Diagram No. 2.



at 2 and 4 P. M.; the pain being also, when present, most severe at the hours of greatest frequency of attack.

While, however, it is clear that as night comes on, and in early morning also, the attacks are relatively infrequent, we cannot be absolutely sure as to the zero of immunity being reached as it seems to be at night, because he is not always awakened by the onset, and may feel the continuing attack only in the morning. But, as I have said, the early morning and later evening hours being but little subject to attacks, we may feel certain, at least, that they are rare at night. Sleep is, indeed, a state which indisposes to pain; and a man who goes to sleep with pain of permanent cause, will awaken free of it, and so remain for a limited period.

The diagrams which follow at intervals need some explanatory words. The months are divided into days; and these, in the original diagrams, were again divided into fifths; so that the black lines, which denote the existence of neuralgia, showed at a glance the duration of pain by the number of these space intervals, which they covered. In reducing the diagrams it was found that the division of days in fifths became too close to be useful, and they have therefore been left out; but the relation of the neuralgia lines to days and parts of days has been accurately preserved.

The numbers of the storms are found at the side of the diagrams, and correspond to the numeration of the storms on the monthly maps of the signal office.

The curves of the barometer, thermometer, and hygrometer readings in their relations to the pain fits, need no present explanation, and are capable of being readily understood at a glance. The curves are constructed on observations made thrice a day, which is, we fear, too infrequent for very perfect hygrometric results. One of the months given in Diagram No. 6, and commented upon, is a close and detailed account almost hourly of the storms in their relations to the pain fits. I have left Capt. Catlin's observations on the various months almost untouched, as they consist of minute yet valuable commentaries on the individual attacks, and help to explain some of the seeming exceptions to the general laws which govern his attacks of pain.

Capt. C. has made some unsuccessful attempts to keep records of the atmospheric electricity, but has been baffled by difficulties connected with instruments. He has no especial pain in relation to thunderstorms such as is frequently felt by highly hysterical women.

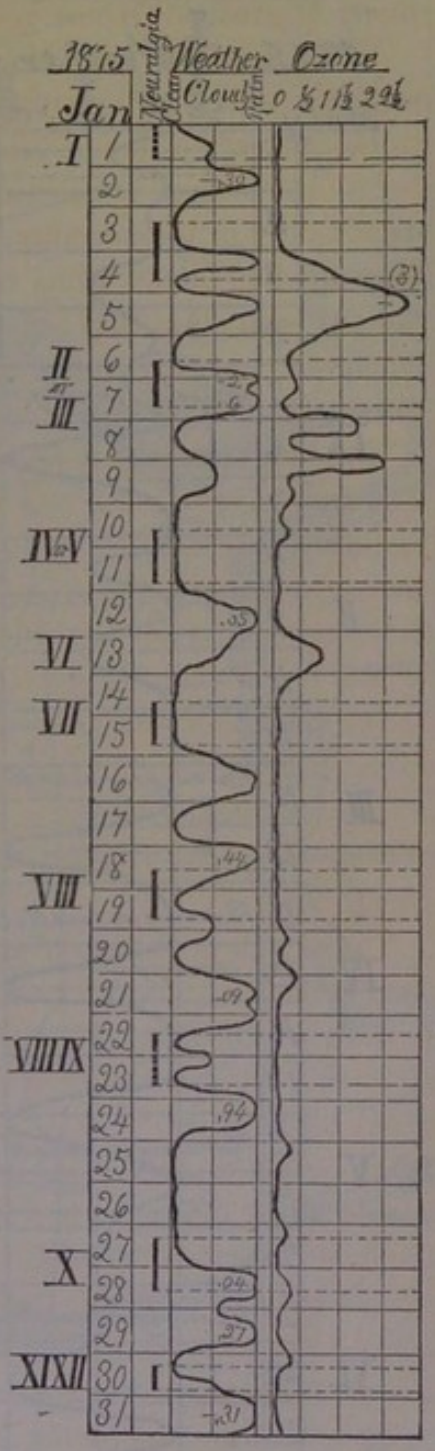
The relations of Mr. C.'s pain to the amount of ozone have been studied with better fortune. I give Diagram 3, January, 1875, to illustrate this relation, which has also been carefully looked after through other months with the same or more striking results. During close observation of over two and a half months in midwinter, the highest reading of ozone (measured by colour test) during an attack of neuralgia, was only "1," and this but twice out of eighteen attacks. As a rule, the ozone was at zero during

the neuralgias, or there was at the utmost but a trace of colour, "$\frac{1}{4}$" at most. The months observed were the latter half of December, January, and February.

Temperature.—The question of temperature in its relations to pain can hardly be considered aside from the barometric status of the atmosphere, and, as part of the perturbations which coincide with storms, and are the principal meteorological parents of pain. A falling temperature alone does not seem to be a competent pain cause, and a rise of the thermometer commonly occurs with a falling barometer. The rare occasions of extreme rise in temperature without much fall in the barometer, do not seem to give rise to pain, and this is in agreement with the general experience of neuralgic people, and also with their experience as regards artificial heat.

In the present case these points are illustrated by Diagram No. 4, July, 1875, where the thermometric curves are given, and in those for December, 1875, Diagram No. 6, where the like records are shown in relation to pain and the barometer, and where the temperature changes were extreme.

Diagram No. 3.

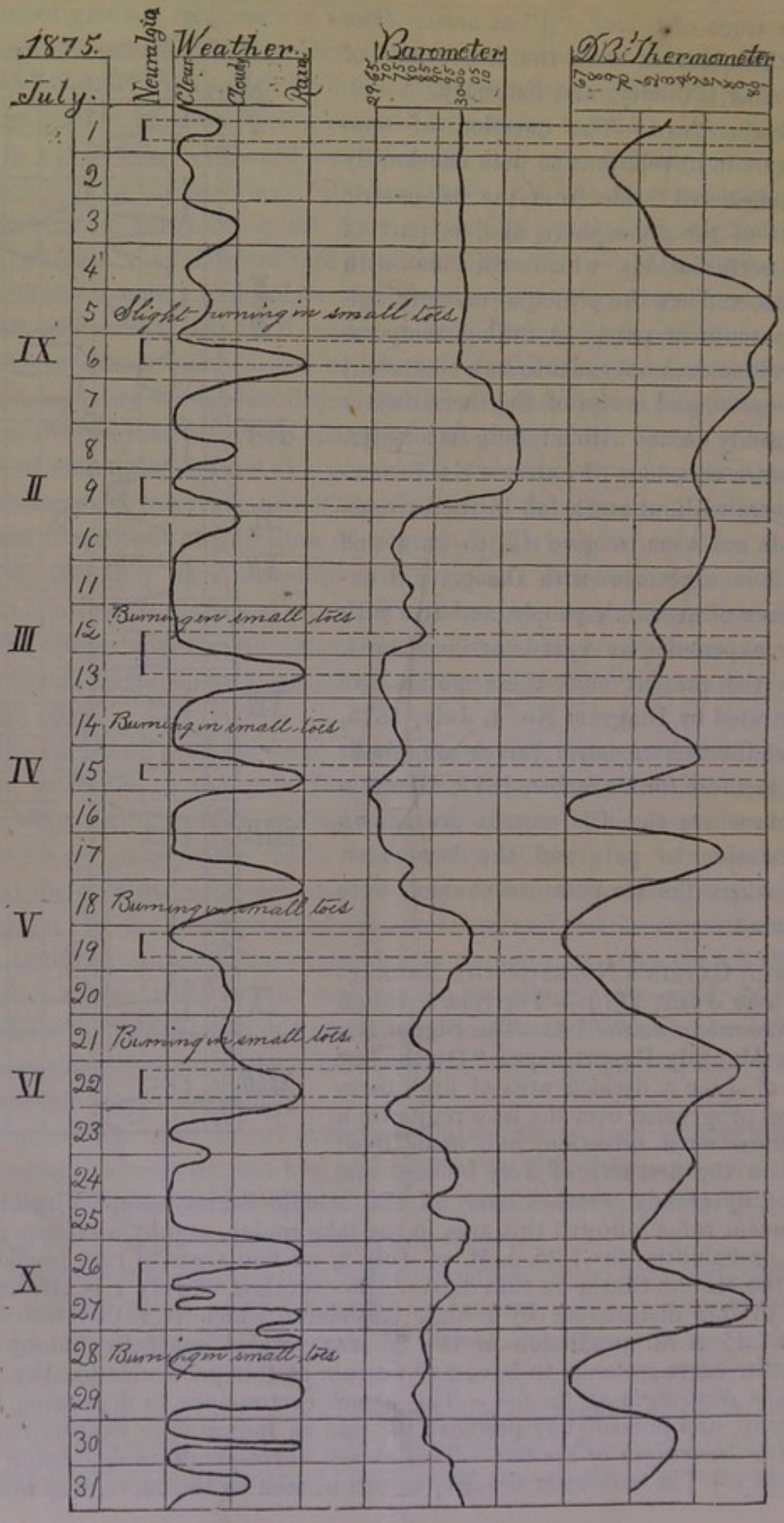


Capt. Catlin's Notes on the Neuralgia for July, 1875.—*The Short Attack of Neuralgia on the 1st.*—The Signal Bureau Monthly Report says: "On the last day of June a decided area of high barometer progressed over the lake region in a southeastward direction, and made itself felt on the first day of July by cool and generally cloudy weather over all the Middle States except Virginia." Frequent rains followed this area in the lake region, and by a reference to the probabilities for 7.35 A.M. of July 2, we find areas of rain predicted for the Middle States on that date. The neuralgia of July 1 is attributable to this disturbance by a high barometer, which is rather unusual. The 7.35 A.M. prediction of the 2d was verified generally, but by the weather curve we seem to have had no rain at this particular locality.

The Neuralgia of the 6th.—This attack corresponds to depression IX. on map, and immediately preceded the rain as indicated in weather curve.

The Neuralgia of the 9th.—This attack corresponds to depression II. on map. The barometer became, as will be seen by the curve, very notice-

Diagram No. 4.


1875.
July.
Neuralgia
Weather.
Clear
Cloudy
Rain
Barometer
29.65
70
75
80
85
90
95
30.00
05
10
15
D.B. Thermometer
67
70
75
80
85
90
95
Slight burning in small toes
Burning in small toes
Burning in small toes
Burning in small toes
Burning in small toes
IX
II
III
IV
V
VI
X

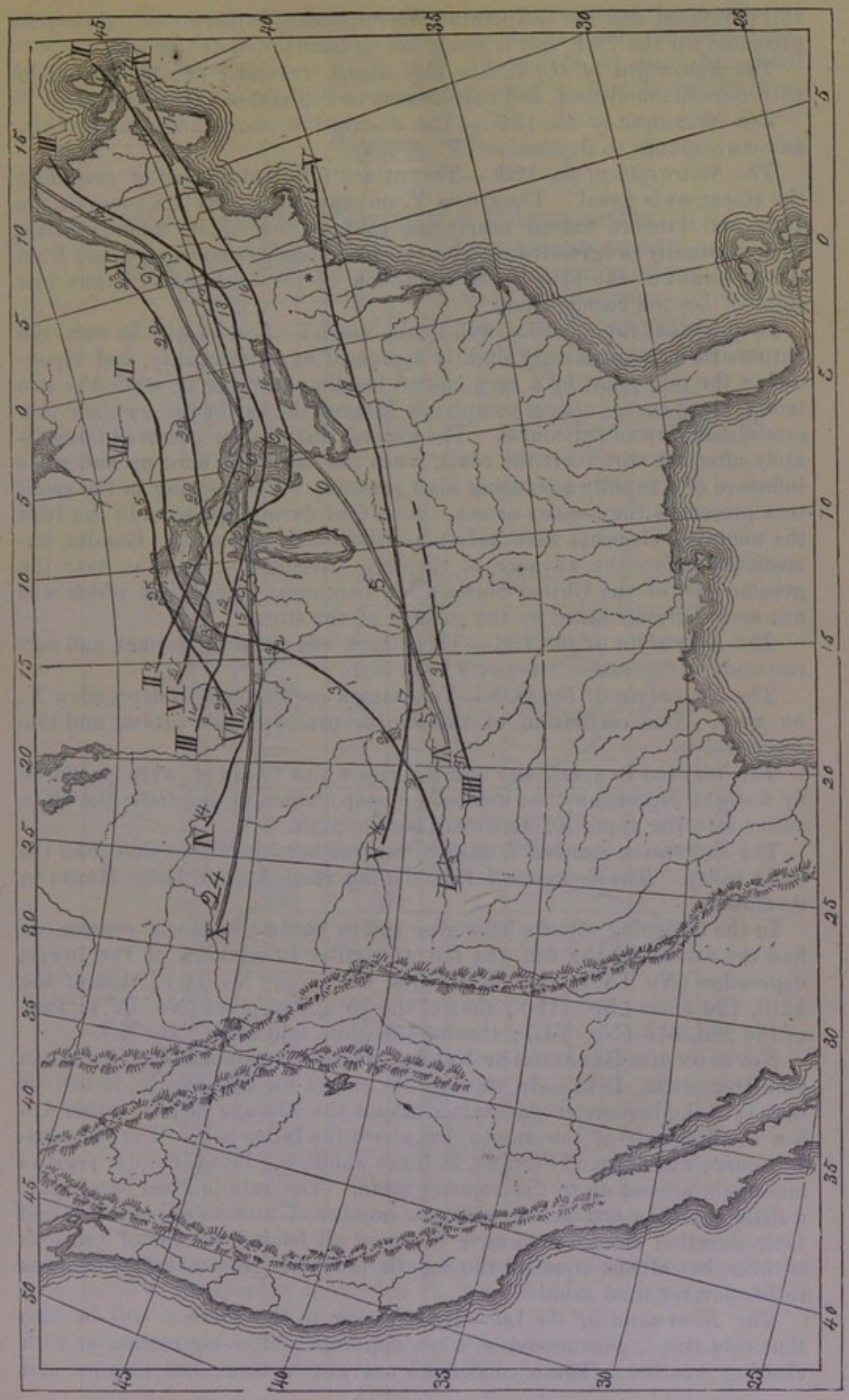


Diagram No. 5.—Storm Map for July, 1875.

ably depressed, and the temperature correspondingly increased. Rain was predicted for the 10th, but it seems not to have fallen at this place.

The Neuralgia of the 12*th.*—This attack regularly preceded the rain with normal conditions, and corresponds to depression III. on map.

The Neuralgia of the 15*th.*—The description above answers for this, and corresponds to depression IV. on map.

The Neuralgia of the 19*th.*—This attack followed instead of preceding the storm, as is usual. The storm V. on map originated in Kansas on the 16th, and "thence moved nearly due east to the middle Atlantic coast with unusually progressive velocity (highest speed 30 miles an hour) from the midnight of the 17th to the afternoon of the 18th, when it was lost sight of beyond Sandy Hook."

Its principal rain-area lay well to the north: And as will be seen, the barometric curve was very slightly depressed at this locality, just recognizing the rain point by a *very* modest bending towards it, while the two temperature curves almost completely ignored the barometer on their pre-established downward course. The greater disturbance occurred immediately after the storm left the coast, when the barometer shot up under the influence of a rapidly advancing high pressure. The burning in the small toes preceding the regular attack, shows that during the storm of the 18th the neuralgic elements were only mustering their strength. Besides, immediately before the advance of the high barometer, there was over the greater part of the United States a low barometer equilibrium which was not materially disturbed by the passage of the storm.

The Neuralgia of the 22*d.*—This attack was perfectly normal, and corresponds to depression marked VI. on map.

The Neuralgia of the 26*th.*—This attack corresponds to depression X. on map. One oscillation of this storm preceded this attack, and two succeeded it.

The burning in small toes and the rain which followed, were produced by a slight depression (not marked on map) which moved from the Ohio valley into the upper St. Lawrence on the 29th.

The *depression marked I.* on the map was not felt further east than the Ohio valley. The *depression VII.* did not reach beyond Lake Huron in its effects.

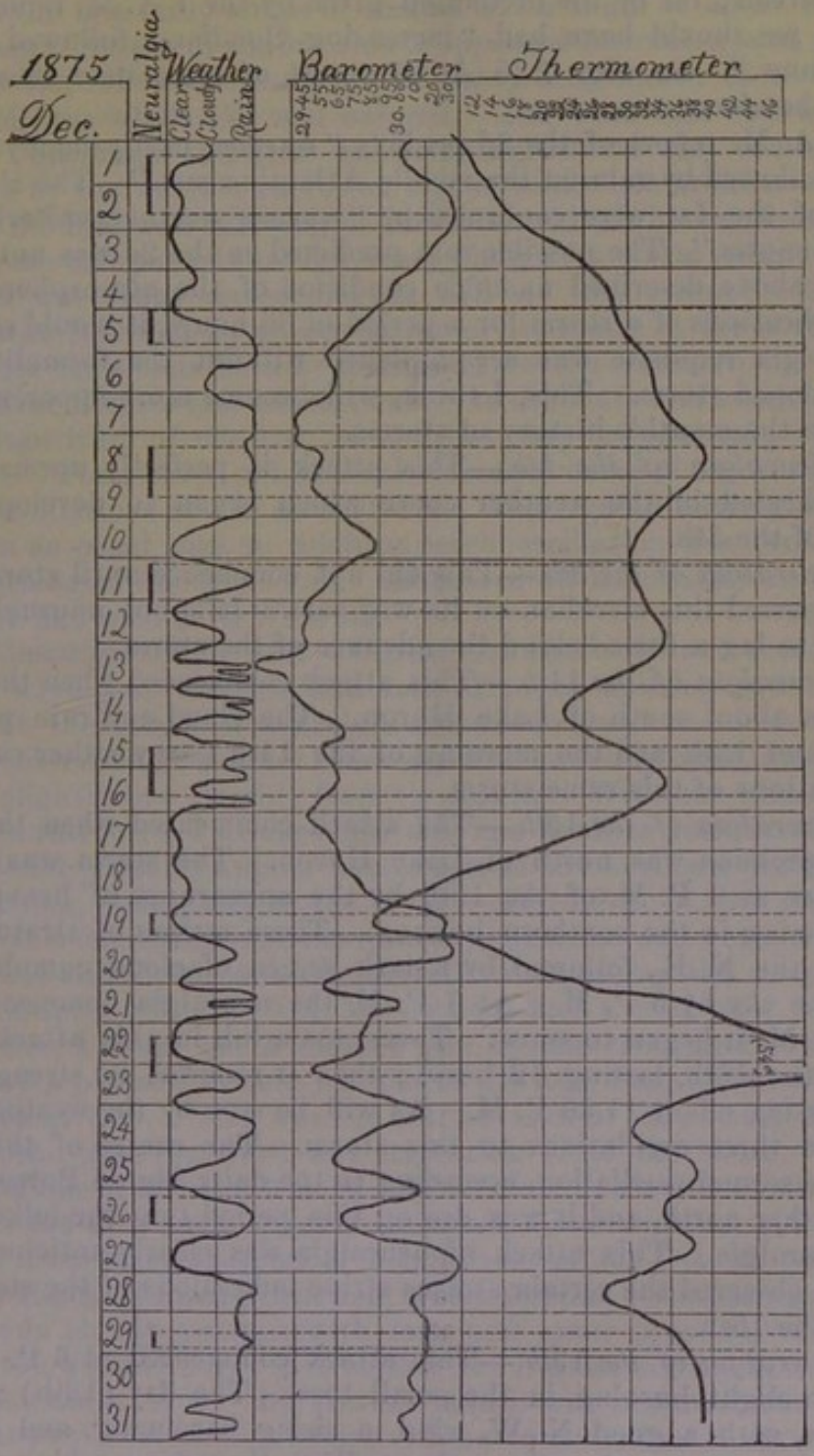
In the foregoing attacks belonging to low barometer storm centres, we find the attack of the 6th was felt 460 miles in advance of the lowest depression (No. IX.); that of the 9th, 900 miles (No. II.); that of the 12th, 720 miles (No. III.); that of the 15th, 640 miles (No. IV.); that of the 22d, 675 (No. VI.); that of the 26th, 360 miles (No. X.).

Notes on the Relation of Neuralgia to Meteorological Changes for December, 1875.—In viewing the curves for this month, it will be seen that the barometer maintained about the average height, rather below the first half of the month, but above the latter half. The temperature curve was unusually erratic, at times wandering into the polar regions and again almost up to the summer mean. The rain-fall has been light, a little less than *two* inches, while the number of attacks of neuralgia and their duration seem not to have fallen at all behind records of previous months, but almost equalled the month previous (November), which was rather severer than usual.

The Neuralgia of the 1*st.*—By referring to the curve, it will be seen that this attack commenced on a medium high and rising barometer with clearing weather. These conditions are not unusual, but they are not

frequent.[1] Before constructing the curve readings (except the weather) I observed during the day (the 1st) clouds moving in nearly opposite directions at the same time, from S. E. to N. W. and N. W. to S. E., which of itself was a good storm sign. At night the stars twinkled with an

Diagram No. 6.



unusual brilliancy even down close to the horizon, which fact most of us know to be a treacherous indication of fair weather, to say the least, as

[1] I have an attack to-day, January 11, 1876, which is exactly parallel to this case, high barometer and N. W. winds, cloudy and blustering.

the very brilliancy of twinkle is due to an increasing moisture in the atmosphere.

On these casual observations, and at the same time noticing an unusually brilliant halo about the street lights, I confidently predicted for the 2d, or by furthest for the 3d, a storm, particularly as my neuralgia continued firm. These anticipations seem to have been confirmed by the Signal Bureau; for by the prediction given by the 1 A. M. report of the 1st inst., we should have had "increasing cloudiness followed by light rain or snow." So also 7.35 A. M. report of same date substantially confirms the above.

The 1 A. M. report of the 2d predicts "warmer, partly cloudy weather, possibly followed by rain on the middle Atlantic coast." The above predictions of the 1st were confirmed by "warmer weather, easterly winds, and light snows." The possible rain predicted on the 2d was not verified.

In the above described unstable condition of the atmosphere, giving strong indications of a storm for a period of 36 hours, it would seem that the neuralgia requisite was accomplished without the formalities of a fully developed storm. This, I think, will become more apparent as we advance in the month's history of storms.

The Neuralgia of the 5th.—This attack is perfectly normal to the storm indicated in the weather curve which began to develop on the morning of the 5th.

The Neuralgia of the 8th.—This did not commence until storm centre had just passed this meridian on its way east. It is not unusual for the neuralgia to lag a little behind the advance of the storm.

The Neuralgia of the 11th.—This attack commenced when the storm-centre was about south of Lake Huron. The cloud and rain points of the 12th and 13th and the morning of the 14th (see weather curve) are but oscillations of this same storm.

The Neuralgia of the 15th.—The attack commenced when the centre of low depression was north of Lake Huron. The storm was first observed here at 1 P. M. of the 15th by the appearance of heavy stratus clouds forming in the southern horizon. These stripes of stratus clouds passed to the N. E., followed by a dark screen of cloud completely obscuring the sky by 5 P. M. At 7 P. M. the neuralgia commenced, and at 7.30 P. M. it began to snow. There was a lull in this attack from 2 A. M. of the 16th, lasting 12 hours; then it renewed its strength at 2 P. M., passing off at 11.30 P. M. As will be seen by the weather curve, there were three oscillations to this storm. The centre of this storm during the second oscillation, according to the daily Signal Bureau maps, moved further north, and it was during this period that the lull occurred in the neuralgia. This attack of neuralgia was clearly anticipated the moment I observed the certain stratus stripe indications of the storm at 1 P. M. of the 15th.

The Neuralgia of the 19th.—This attack commenced at 6 P. M., preceded by a slight burning in the small toes. The day (19th) was perfectly clear, with a good N. W. wind, a rising barometer, and a heavy cold polar current hugging the surface. With these favourable conditions for fair weather I was a little surprised at the attack, and was led to a cautious observance of the sky and wind. At 10.30 P. M. (on the 19th) the wind became less strong from the north, and I thought the temperature was falling less rapidly. At 12 P. M. I again observed and found the wind blowing in spurts, and from every point of the compass. From

this I suspected the general direction of the wind was shifting, and most probably southerly, and that on the morrow the temperature would rise, with a probable fall of the barometer; that the tropical current would attempt to replace the polar with its zero temperature, and that we must look out for the first clouds of the coming storm in the *northern* horizon. After rising on the morning of the 20th, I at once observed in the N. E. quadrant the thin hazy stripe of stratus at an angle of about 25° above the horizon. Stripes of similar clouds appeared succeeding, and all moved to the S. W., followed closely by the heavy hazy screen of cloud, when, by 5 P. M., the whole sky was covered. The wind was now fixed from the S. W. quadrant, and there was every appearance of a coming storm. As shown by the weather curve the clouds somewhat broke away on the night of the 20th and morning of the 21st, without having brought rain, although we had passed through every phase of a storm except precipitation. It was what meteorologists call a "dry storm." This "dry storm" was followed by an oscillation of its centre to the north, but at no time did the clouds entirely descend below the northern horizon until two more oscillations (see weather curve) to the south had taken place, each being a repetition of the first, except that they brought rain—the latter the more. These three points on the weather curve of the 20th and 21st are but oscillations of the same storm. The regular neuralgia preceded the storm as usual, and, in addition, each oscillation was preceded by a slight burning in the small toes. It cleared off beautifully on the morning of the 22d with a N. W. wind.

The Neuralgia of the 22d.—During the afternoon and evening of the 22d the wind was variable, and seemed to be shifting southerly. At 5.30 P. M. the attack of neuralgia commenced, and at 11 o'clock P. M. I again observed the weather; the sky was perfectly clear, and the wind moving slightly but steadily from the south. With the neuralgia continuing in full force, I at once felt that the familiar introductory storm-clouds would probably appear somewhere in the northern horizon on the next morning, most likely in the N. E. At 7.30 A. M. (on the 23d) on rising, I at once peered into the northern horizon, and not a cloud could be seen, but still I did not despair, notwithstanding the neuralgia had already disappeared. At 9 A. M., an hour and a half later, on my way to the office, I could get a distant view up the river, and low down on the northern horizon I could just detect the long hazy stripe of stratus I looked for at 7.30. This was the first advance of the coming storm, and in the mean time the wind was increasing from the south. By 11.30 A. M. the line of cloud of 9 A. M. had advanced as a cumulo-stratus with a light cirrus at a much greater elevation, to an angle of 45° above the horizon, with every prospect of a fulfilment of the 1 A. M. (morning of the 23d) Signal Bureau prediction, which forecast "increasing south and west winds, cloudy weather, with rain and lower pressure." It will be seen by the weather curve that neither the Bureau nor my neuralgia were rewarded, except by a "dry storm," and it was not until the next day (the 24th) by a return oscillation of the same storm that we received our just remuneration, *a rain*. The oscillation, as before, was attended by a burning in the small toes. On the night of the 24th the wind shifted northerly, with clearing weather and rising barometer on the 25th.

The Neuralgia of the 25th.—The wind during the night of the 25th and morning of the 26th shifted southerly. The morning of the 26th

brought the strongly marked bands of stratus clouds well defined in the N. E. At 10.30 A. M. the neuralgia attacked some five or six hours after the storm had begun to form. The storm continued forming in the N. E. toward the S. W., against an increasing southerly wind, and by 6 P. M. the rain began to fall. The neuralgia continued until 5 A. M. of the 27th, and in a few hours afterwards the whole body of cloud lifted in the northern horizon, and breaking into cumulus clouds, moved off in majestic order to the south, under the influence of a northerly wind.

A storm formed early in the morning of the 28th in the N. E., and went through the usual phases up to precipitation. There was no regular neuralgic warning of this storm. It was only heralded by an unusually strong burning in the small toes, which commenced about seven hours before the rain. It will be seen by the weather curve that the rain was exceedingly light, with not a strong depression in the barometer.

The 1 A. M. report (of the 28th) of the Signal Bureau forecast "clear, cooler, followed by warmer weather;" but before they published the 10.30 A. M. report, a "slight depression on the Atlantic coast" had been discovered, and in consequence "rain or snow" was predicted. We ascribe the above "burning in toes" to the disturbance caused by the "slight depression on the coast," which was not sufficiently great to produce stronger and regular neuralgia.

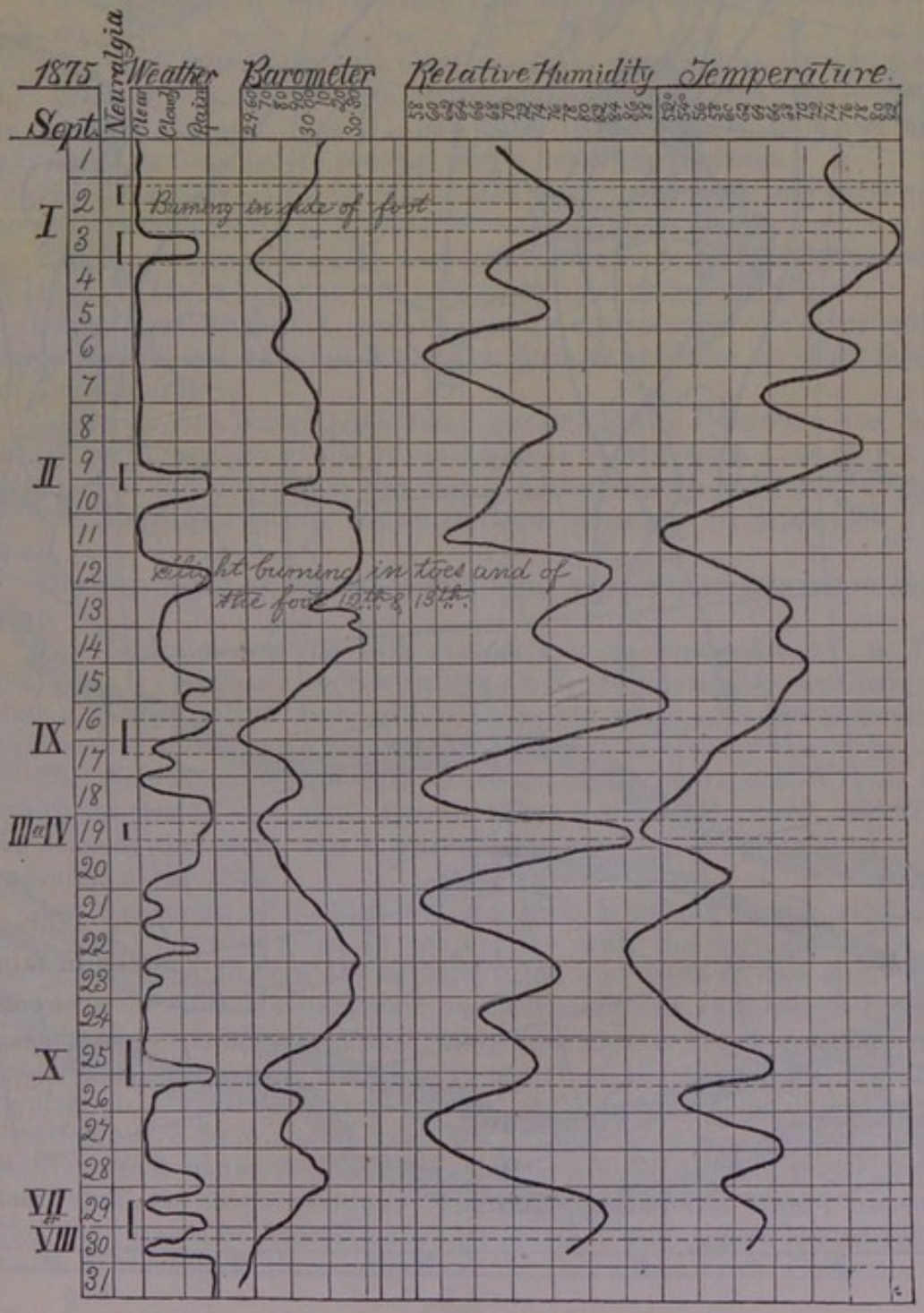
The Neuralgia of the 29th.—The atmosphere continues, as yesterday, in a state of almost stable equilibrium, with hardly a perceptible movement of the atmosphere. Fog and clouds completely obscure the sky. The atmosphere, so to speak, is water-logged, with a comparatively uniform high barometer all over the United States east of the 95th meridian of longitude. There seems to be no low barometer in this whole area to answer the purposes of an atmospheric chimney by establishing the upward and consequently horizontal centripetal currents, and therefore there can be but little disturbance. This condition of the atmosphere which continued till the morning of the 31st with little change in barometer or temperature, affords an opportunity for expressing our belief that it is not the actual moist condition of the atmosphere that causes neuralgia (mine) but it is *atmospheric change*—a want of equilibrium in it. But of course this will bring moisture or rain, which therefore would be an effect of a common cause.

The relations of pain to the states of atmospheric pressure are in this case apparently definite and nearly constant.

Thus we find that when, the atmospheric pressure lessening, the mercury falls, there is apt to occur during the fall, and before it is complete, an attack of neuralgic pain or of burning in the lost foot, and that this is most likely to take place when the lessening pressure culminates in rain. In some months, as in September and October, 1875, this is most constant, indeed almost invariable, so that, at all events in the present case, a falling barometer followed by rain as a rule insures an onset of pain. To this law there are exceptions, readily seen on the diagrams, and some of which are admirably and clearly commented on and explained in Capt. C.'s comments upon the records of the various months, and which I think best to print unaltered.

NOTES ON NEURALGIA FOR SEPTEMBER, 1876, Diagrams 7 and 8.—*Neuralgia of the 2d and 3d* corresponds to disturbance caused by barometric depression marked I. on the map (Diagram No. 8). "This storm," says the *Weather Review* for this month, "was three days in reaching the coast. The rain-belt attending this depression extended from the Missouri Valley eastward over the northern portion of New England and the Middle States during the 2d, 3d, 4th, and 5th. As the storm approached the Atlantic the gradients (of the barometer) increased." It is due to this last fact, I think, that the attack of the 2d was renewed on the 3d. A burning on the outside of the foot filled up the gap between the attacks of the regular neuralgia in the ball of the foot.

Diagram No. 7.



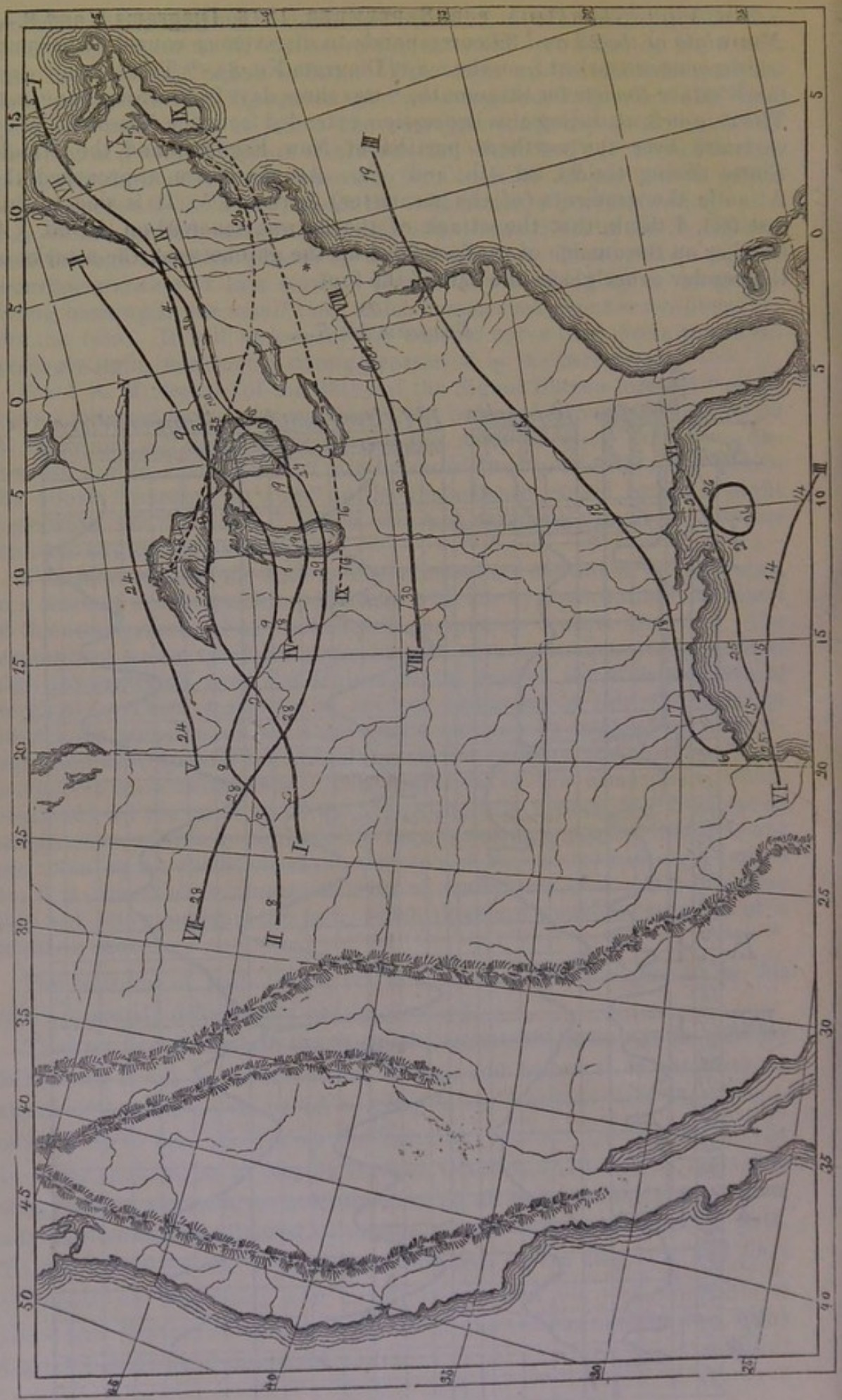


Diagram No. 8—Storm Map for September, 1875.

It will be observed by the weather course that there was actually no rain at this locality. We may here remark that neuralgia is not directly proportioned to the *quantity* of rainfall, but simply seems to be an index of certain conditions, such as low barometer, etc., which generally precede rain, snow, or increase of moisture.

The Neuralgia of the 9*th and* 10*th* corresponds regularly to depression marked II. on the map.

The slight burning Neuralgia in the small toes of the 12*th and* 13*th* does not correspond to any well-defined centre of depression, but as shown by the curves there was a rapid fall and rise of the barometer accompanied by rain. This was quite local in all probability, as no such depression is indicated in the tri-daily reports of Signal Service for these dates, and no rain was predicted.

The Neuralgia of the 16*th and* 17*th* corresponds to depression marked IX. on map.

The Neuralgia of the 19*th* corresponds to depressions marked III. or IV. on map. It will be seen that they passed near the same dates. It is probable, however, that III. had little to do with it, as it had nearly expended its force before coming within neuralgic distance.

The Neuralgia of the 25*th and* 26*th* perfectly normal, and corresponds to depression marked X. on map.

The Neuralgia of the 29*th and* 30*th* corresponds to depressions marked VII. or VIII. or both, as will be seen by their dates on map.

Depressions marked V. and VI. on the map were entirely beyond neuralgic range, and were not felt. The former produced no effect this side of Lake Huron.

Notes on the Neuralgia for October, 1875, Diagrams Nos. 9 and 10.—*The Neuralgia of the* 3*d* corresponds to depression I. on map. The rain-belt of this depression was almost entirely north of its centre.

The Neuralgia of the 6*th* corresponds normally to depression II. on map.

The Neuralgia of the 9*th* corresponds regularly to depression III. on map.

The Neuralgia of the 14*th* corresponds to depression IV. or V. on map, but it is difficult upon which to fix the responsibility, as their dates and centres brought each within neuralgic range. It was probably V. that caused the extreme barometric depression as seen by the curve.

The Neuralgia of the 17*th* corresponds to depression VI. on map, which depression very much diminished as it neared the coast, and as will be seen by the curve, was slight at this locality, being greatest on the morning of the 18th.

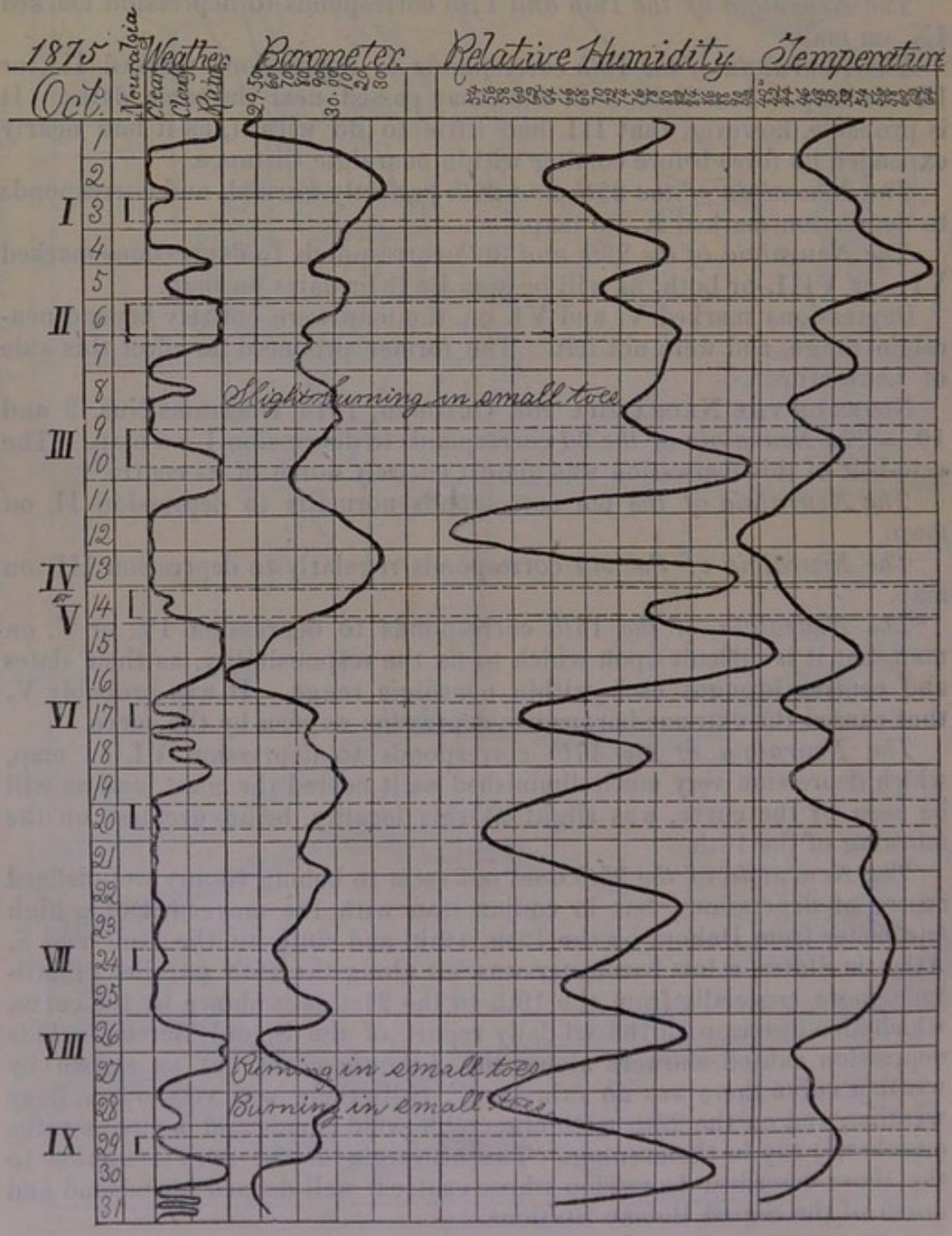
The Neuralgia of the 20*th* does not seem to belong to any well-defined centre of depression; but in conjunction with the movement of a high barometer from Dakota on the 18th, 19th, and 20th to the Gulf and S. Atlantic States, a low barometer was felt along the 45th parallel of latitude, more especially from the 19th to the 21st as is shown by the curve, which also agrees with the tri-daily report of the Signal Bureau. This depression caused showers along the Atlantic coast, but as shown by weather curve there was no rain here. Still there was very warm, hazy weather, and on the 20th were observable wind-clouds and a cirro-stratus (mackerel) sky in the evening. The neuralgia of the 20th I ascribe to the above-described depression whose centre if well defined lay beyond and north of the Signal Bureau Stations.

The Neuralgia of the 24*th* corresponds to depression VII. on map.

The burning Neuralgia of the 27*th in small toes* corresponds to depression marked VIII. on map. It is difficult to explain why this storm did not announce its presence by the usual neuralgia. It may be well, however, to observe that the first half of the course of this depression lay in a direction nearly perpendicular to the usual course of storm axes and its distance was rather remote, particularly as we were kept on the prolongation of the shorter axis.

The Neuralgia of the 29*th* corresponds to the depression IX. on map. Depression X. "is an offshoot" of IX., and they may, neuralgically speaking, be regarded as one.

Diagram No. 9.



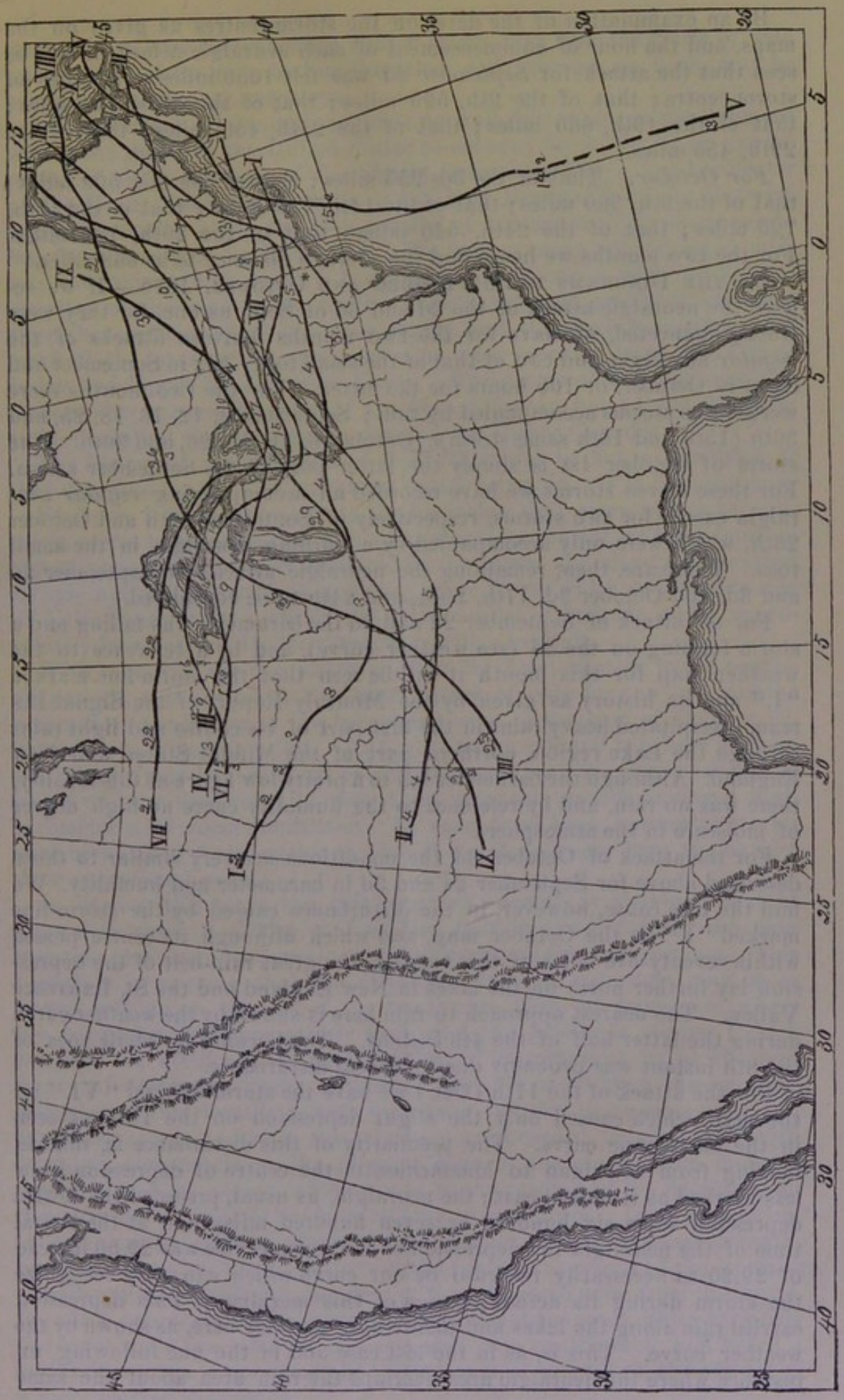


Diagram No. 10.—Storm Map for October, 1875.

By an examination of the dates on the storm-centres as given on the maps, and the hour of commencement of each neuralgic attack, it will be seen that the attack for *September* 2d was felt 1050 miles in advance of storm-centre; that of the 9th, 500 miles; that of the 16th, 440 miles; that of the 19th, 630 miles; that of the 25th, 450 miles; that of the 29th, 450 miles.

For October. That of the 3d, 950 miles; that of the 6th, 500 miles; that of the 9th, 960 miles; that of the 14th, 780 miles; that of the 17th, 720 miles; that of the 24th, 540 miles; that of the 29th, 720 miles. For the two months we hence find the average distance to be 668 miles.

On the Diagrams for September and October, 1875.—If we regard the neuralgic attack of the 2d and 3d of Sept. as one, for they were closely connected, we have for the two months fourteen attacks of the *regular* neuralgia, and two of that of the small toes. Six in September and eight in October, or 105 hours for the latter. For the two months there were eleven storms accompanied by rain; September 9, 12, 16, 18, 25, and 30th (15th and 16th same storm); October 6, 10, 15, 26, and 30th. The storm of October 1st is simply the latter part of the September storm. For these eleven storms we have recorded an accompanying *regular* neuralgia except for two storms, respectively of September 12th and October 26th, which were only accompanied by a burning neuralgia in the small toes. There are, then, remaining the neuralgic attacks of September 2d and 3d, and October 3d, 17th, 20th, and 24th to be considered.

For the attack of September 2d and 3d the barometer was falling and a storm forming on the 3d (see weather curve), and by a reference to the weather map for this month it will be seen that the storm-line marked "I." and its history as given by the Monthly Report of the Signal Bureau, precipitated heavy rains in the first part of its course and light rains through the Lake region, northern part of the Middle States, and New England. Although the barometer fell to a pretty low figure at this locality, there was no rain, and by reference to the humidity curve no high degree of moisture in the atmosphere.

For the attack of October 3d the conditions are very similar to those described above for September 2d and 3d in barometer and humidity. We find the true cause, however, in the disturbance caused by the storm-line marked "I." on the October map, and which although its centre passed within seventy-five miles of this locality, the great rain-belt of the depression lay further north on the lakes in New England and the St. Lawrence Valley. The nearest approach to rain here is shown by the weather-curve during the latter half of the 4th instant. The burning in small toes of the 8th instant was probably due to a local disturbance.

For the attack of the 17th (Oct.) we have the storm marked "VI." on the map, which caused only the slight depression on the 18th as seen in the barometric curve. The peculiarity of this disturbance is, that in moving from Michigan to Massachusetts the centre of depression grew less marked as it moved east; the neuralgia, as usual, preceded the lowest depression some six hundred or seven hundred miles, and at the actual time of the neuralgia the depression of the storm-centre was 29.50 instead of 29.90 as necessarily recorded by our curve which can only recognize the storm during its actual passage of this meridian. This depression carried rain along the lakes and threatening weather here, as shown by the weather curve. This is, as in the last case and in the one following, an instance where the neuralgic area overlaps the rain area about the same

storm centre, and demonstrates that a storm may bear the fruits of rain on one side of its path, and on the other, and perhaps on both, may be capable of producing neuralgia.

For the attack of the 20th we have no well-defined storm development within the limits of the United States to account for it, but by an examination of the daily maps of the Signal Bureau we find a low barometer on the Upper Lakes on the 20th, and in New Brunswick on the 21st with a high barometer along the 35th parallel of latitude with its centre reaching from Memphis to Richmond. We were consequently situated midway between the high and low barometer, and of course with the general direction of the wind to the north. The barometric gradients were not steep, but sufficiently so to cause cloudy and threatening weather over much of the intermediate area, and rains were reported from the Lower Lakes and Upper St. Lawrence Valley. The centre of this storm or disturbance lay beyond the reach of the Signal Bureau, but I think there can be no doubt but that one passed through the Upper Canadas.

The history of the neuralgia of the 24th would be but a repetition of that described for the 17th, its storm centre being No. "VII." on the map.

We have, I think, shown from the foregoing that *every* attack of neuralgia seems to be connected with some storm movement, or some unusual atmospheric disturbance as exhibited by the curves and maps, or described as only apparent exceptions, and that *every* storm which passed this side of Lake Superior, or north of the 35th parallel of latitude, could appropriately be arraigned for its connection with neuralgia.

With regard to the barometric curve in its direct relation to the neuralgic periods, it is noticeable that every attack of pain for the two months occurred on the falling or low barometer, or as in the case of October 29, immediately preceding a fall. And what we have found true here in these two months may be laid down as generally true with the single exception, where we have discovered in rare cases, neuralgia accompanying a high barometer *with storm conditions*. By some these high barometer storms have been called "anti-cyclones," but it is not necessary here to consider these exceptional cases.

In viewing this curve too, this apparent anomaly is striking: that at times with marked, sudden, and decided falls in the barometer the pain seems no greater nor endures longer than in the slighter depressions. This I explain by arguing that the disturbing cause of neuralgia may be as potent well up on the side of the barometric basin of depression, where the barometer is comparatively high, and the gradients steeper (which steepness is, after all, the best measure of disturbance), as at the very centre of depression itself. Indeed, I have on more than one occasion observed at this locality a high barometer invaded by an advancing low barometer storm, and after the reports were recorded found myself with neuralgia very nearly on the superior edge of the storm basin under a pressure of thirty inches, which would be the reading of the depression in the curve corresponding to the attacking of neuralgia. In these particular cases noted, however, the neuralgia was not quite of its usual strength. So, whether we are at the bottom of the basin—the centre of the storm—or half-way up the side, two hundred or three hundred miles from the centre, the effect, neuralgically speaking, would be about the same, while obviously the curve could not serve to measure each case equally well, and hence a minor depression in curve *may* be the measure of as great a disturbance as a more marked depression.

*

With the above considerations it would seem that there may be a much clearer connection between pressure, or something of which it is the measure, and neuralgia than at first we would be led to suspect.

As to the *humidity* curve there seems to be a general parallelism between it and the temperature curve, but I do not perceive that it has any *direct* bearing on the neuralgia. And as for the *temperature* curve itself all we can say is, that it rises as the barometer falls, and falls as the barometer rises.

I add here, as their fitting place, certain *conclusions* in regard to his case in its relations to storm states with which Captain Catlin has favoured me. He says:—

Neuralgic intensity does not seem to be proportional to the *amount* of rain-fall.

At the exterior of a storm disturbance the pain is usually less severe, and indeed at times I have been so far from the disturbed centre as to just perceptibly feel it.

A storm reinforced by another at an angle of say 90°, producing greater eccentricities in the curves, does not seem to produce a corresponding intensity or duration of the neuralgia. He adds: I am unable to state at what point within the disturbed area the pain would be strongest.

The abruptness of the barometric fall does not seem to have much to do with the causing of pain, nor is the length of attack dependent as it seems on the length of the storm.

I have stated on the last page that the pain in this case seems to bear a certain relation to lessened pressure. In those who come suddenly out of the increased air-pressure of diving bells or sub-aqueous chambers, there is said to be a liability to pains in the limbs, and Dr. B. W. Richardson seems to think the experiment thus made valuable as illustrating the influence of lessened pressure accompanying weather changes. The greater abruptness and the excess of difference in the former case seems to me, however, to be something very different from the gradual alteration of pressure in the latter case. In fact, translation of neuralgic cases to high altitudes does not seem to give rise to pain, nor is neuralgia in upper regions so very prevalent as it is apt to be on lower levels.

Increased humidity is a condition which nearly always comes with storm states, and accompanies them whether the barometer be falling, as is then usual, or low, or whether the barometer, as in some rare storms, be steady or high and steady. I think then that an atmosphere surcharged with moisture may be looked upon as the next most favourable single condition for the product of neuralgia.

Apart from these outside conditions of weather which we may conceive of as influencing us by checking or increasing perspiration, and lessening surface pressure, or altering the amount of oxygen inspired and carbonic acid thrown out, there are no doubt personal elements in the equation which are more or less mysterious, and which must be taken to account for

a certain number of the neuralgic fits which do not seem to have perfect relations to causal weather states. Moreover it is conceivable that as *we* are changeful instruments, the body may be sometimes more liable to respond by pain to conditions of weather favourable to its production.

The human economy is arranged by nature to have, as it were, a climate of its own, with very permanent states as to temperature, humidity, electric conditions, and the like; but all of these are subject to variations, some of them natural, and, so to speak, rhythmic and chronal; others more or less irregular. As they are part of the functional activities of the body, so do they, of necessity, enter into every consideration of the causation of pain.

While, however, we may feel sure that they are thus active, their precise relations to the existence or to the favouring of the birth of pain are too uncertain for us to do more than surmise that they sometimes obscure or interfere with or prevent the positive effects of external climatic states in this direction.

Any lowering cause, such as dyspepsia, overwork, and anæmia, however brought about, is apt to increase this sensitiveness to barometric changes; and so every enfeebling agency, as it were, tunes a man's nerves up to the capacity of producing pain, when once there exists a permanent cause in the way of neural disease.

As an illustration, I know of an army officer who is the subject of stump-neuralgia which is very prone to show when a storm is imminent, but his liability is at the maximum in the spring and fall, when he is prone to feel the depressing influence of an old ague-poisoning, and when this is mastered the weather loses its influence.

A large number of neuralgic attacks seem to be definitely related to those perturbations of atmosphere which we know as storms.

The separate factors of storms, such as lessened pressure, rising temperature, greater humidity, winds, appear, as a rule, to be incompetent when acting singly to give rise to attacks of pain.

Either, then, it is the combination which works the mischief, or else there is, in times of storms, some as yet unknown agency productive of evil.

Such an agent may be either electricity or magnetism.

As concerns the former, we have failed to study its relations to pain, because of difficulties as to instruments and methods of research, difficulties which may, I trust, be overcome.

Neither, as I said, have any observations been made as yet as to the influence of magnetism for want of proper instruments, and this is the more to be regretted because of the following facts. In 1867 and 1868 the aurora borealis was frequent and remarkably brilliant, and Captain Catlin then had it most forcibly called to his attention that the neuralgia was apt to prevail when the northern lights were intense. This may be due

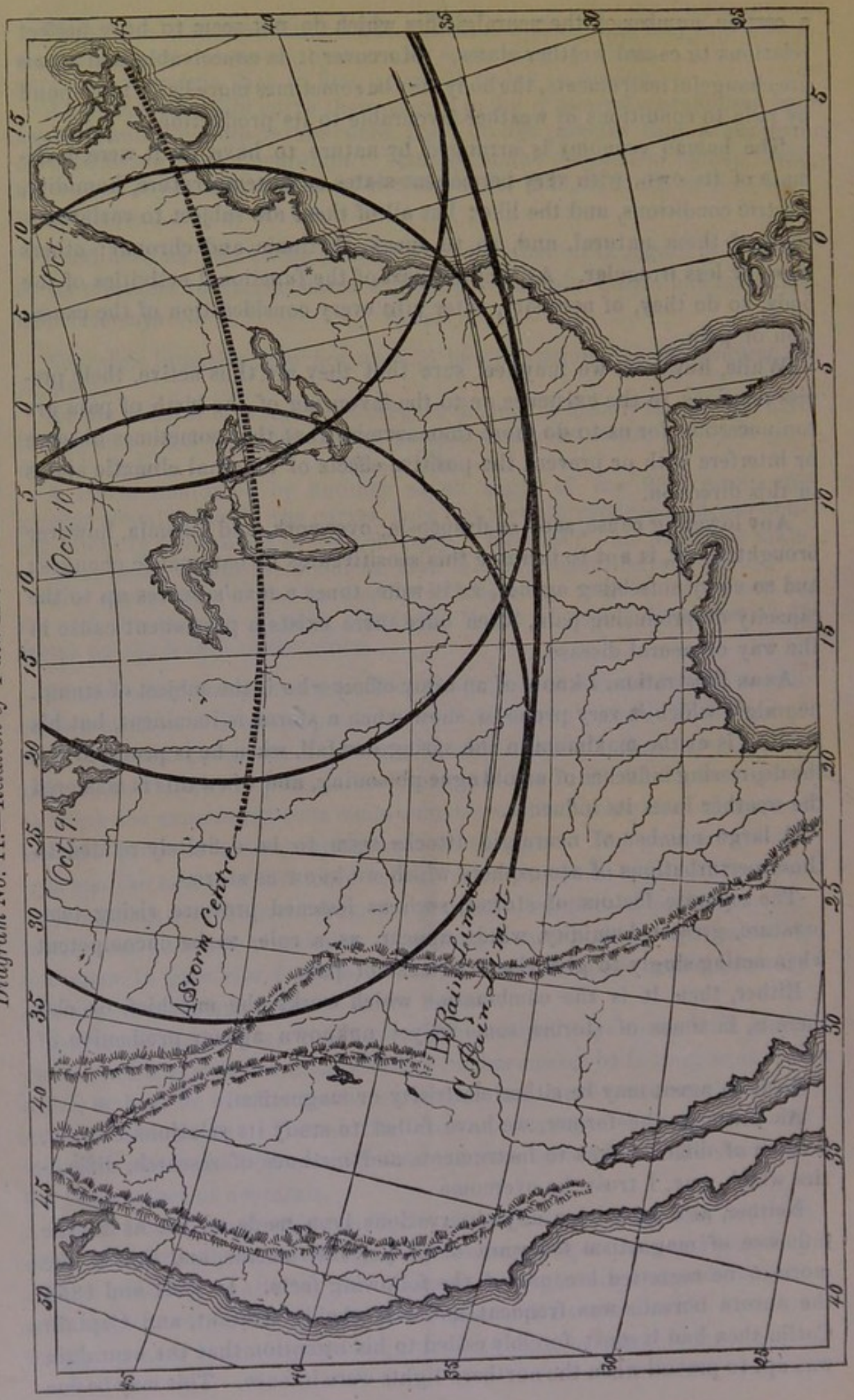


Diagram No. 11.—Relation of Pain Area to Rain Area.

to magnetic or electric disturbance, but also it may be owing to the fact that an intense aurora is apt to be followed by a storm, indeed is almost sure to be, if we may trust the recent observations of Lieut. Weyprecht of the Austrian Polar Expedition; also it is a common belief among our northern Indian tribes. The pain, then, which followed the northern light may be merely an ordinary storm-pain; but the question deserves a more exact answer.

There seems, then, to be every reason to believe that the popular view which relates some pain fits to storms has a distinct foundation, and, as we have seen, it has stood the test in this single case of a long and patient scientific study. At the same time we have failed to detect the single element of mischief, and are thus far driven to believe that it is the combination of atmospheric conditions which starts the pain into being.

A still more valuable and novel conclusion has arisen out of our study. Every storm, as it sweeps across the continent, consists of a vast rain area, at the centre of which is a moving space of greatest barometric depression, known as the storm-centre, along which the storm moves like a bead on a thread. The rain usually precedes this by 550 to 600 miles, but before and around the rain lies a belt, which may be called the neuralgic margin of the storm, and which precedes the rain about 150 miles. This fact is very deceptive, because the sufferer may be on the far edge of the storm-basin of barometric depression, and seeing nothing of the rain, yet have pain due to the storm. (Diagram No. 11.)

It is somewhat interesting to figure to one's self thus—a moving area of rain girdled by a neuralgic belt 150 miles wide, within which, as it sweeps along in advance of the storm, prevail in the hurt and maimed limbs of men, and in tender nerves and rheumatic joints, renewed torments called into existence by the stir and perturbation of the elements.

I give (Fig. 11) a diagram of one storm with the theoretical rain area as founded on Prof. Loomis's observations, and its neuralgic belt as founded on our own observations.