TABLE 8.—*Extract from observations on the north coast of Russia (L. L. Breitfuss)*—Continued

Stations	Month	Temperature			Wind										Days with—					Cloudiness	Precipitation (in mm.)
						Frequency (in per cent)															
		Mean	Max.	Min.	Velocity	N.	NE.	E.	SE.	S.	SW.	W.	NW.	Calm	Storms	Fog	Precipitation	Clear weather	Cloudy weather		
Steamship Eclipse, 1915 (Taimyr Coast near Cape Wild, 75° 40′ N., 91° 25′ E.).	March	−29.7	−4.8	−45.1	2.4	1	9	6	9	5	23	6	1	40	------	3	------	11	3	3.7	------
	April	−13.3	+1.8	−35.4	5.6	4	13	7	2	16	41	9	2	6	------	4	------	4	18	7.3	------
	May	−7.0	+4.7	−15.0	5.5	9	7	12	7	10	21	10	12	12	------	3	------	0	21	8.9	------
	June	+1.4	+10.2	−3.9	2.7	10	19	15	4	4	6	6	4	32	------	14	------	3	16	7.3	------
	July	+2.8	+15.1	−3.0	2.8	15	29	2	2	4	8	13	8	19	------	19	------	6	14	6.4	------
Steamship Sarja. 1901 (Taimyr coast, 76° 8′ N., 95° 8′ E.).	March	−22.8	−10.4	−40.9	4.8	2	3	16	13	9	26	7	1	23	------	------	------	------	------	6.6	------
	April	−23.1	−7.2	−39.1	5.2	3	5	9	3	2	13	18	17	30	------	------	------	------	------	4.4	------
	May	−8.8	+2.4	−29.6	7.0	1	6	16	10	17	17	16	3	14	------	------	------	------	------	7.6	------
	June	+0.4	+10.4	−8.2	7.1	7	10	7	10	20	18	22	4	2	------	------	------	------	------	7.9	------
	July	+2.8	+12.8	−1.7	6.4	5	4	13	11	7	19	27	9	5	------	------	------	------	------	8.4	------
Sagastyr, 1882–1884	March	−34.3	−18.6	−47.5	4.7	1	5	22	25	14	7	12	3	11	0	1	1	------	------	3.2	0.2
	April	−21.6	−4.3	−37.4	5.2	2	7	23	14	7	11	21	10	5	1	3	2	------	------	5.3	0.6
	May	−9.6	+3.3	−27.3	6.2	5	9	23	16	9	9	15	11	3	2	7	10	------	------	7.7	5.0
	June	+0.0	+12.5	−12.6	6.8	4	11	27	19	7	6	15	10	1	4	12	8	------	------	8.0	11.9
	July	+4.9	+12.1	−0.2	8.9	16	21	37	18	0	0	0	8	0	8	18	5	------	------	7.6	6.9
Bulun, 1914	March	−30.1	−12.4	−42.6	6.1	35	3	0	1	10	14	5	1	31	5	0	4	8	10	5.8	2.9
	April	−17.9	+3.0	−41.4	3.6	17	6	1	0	9	18	6	6	37	1	0	8	3	14	6.8	14.1
	May	−4.6	+7.5	−23.3	5.3	40	25	4	1	1	1	3	5	20	0	0	1	2	13	6.8	0.1
	June	+10.0	+26.4	−4.6	5.7	13	27	7	2	14	17	8	3	9	2	0	7	1	13	7.5	11.4
	July	+15.6	+26.9	+2.9	5.4	22	33	10	2	8	7	4	4	10	2	0	7	3	15	7.2	23.8
Kazatchie, 1901–1905	March	−26.5	−6.0	−46.8	2.7	1	0	8	21	13	12	15	6	24	0	0	8	13	3	3.7	3.1
	April	−17.9	−1.1	−39.2	3.5	7	11	14	5	5	8	17	14	19	1	2	8	7	9	5.0	4.2
	May	−5.0	+8.9	−28.5	3.9	9	9	20	15	6	4	13	15	9	0	4	8	5	12	6.3	8.3
	June	+7.1	+27.6	−6.8	4.8	9	7	25	11	4	3	10	18	3	2	6	12	4	14	6.9	26.8
	July	+10.4	+26.5	−0.8	5.2	13	12	18	9	5	5	11	23	4	3	4	15	3	15	7.4	29.0
Steamship Sarja, 1902 (Nerpalach Harbor, Siberia Island, 75° 22′ N., 137° 10′ E.).	March	−32.7	−24.6	−40.1	5.4	2	0	18	55	16	1	1	0	7	------	------	------	------	------	3.4	------
	April	−21.9	−11.8	−36.2	6.8	11	16	40	16	3	2	1	3	8	------	------	------	------	------	5.9	------
	May	−11.0	−0.9	−22.0	4.3	14	14	20	8	11	3	4	12	14	------	------	------	------	------	6.7	------
	June	+0.7	+4.4	−9.8	6.8	8	20	28	8	5	2	1	21	7	------	------	------	------	------	8.4	------
	July	+2.1	+7.8	−1.7	5.8	12	5	11	16	11	5	10	23	7	------	------	------	------	------	8.6	------
Rousskoe Oustie, 1895–1903.	March	−31.0	−14.1	−48.6	3.8	4	8	18	6	2	26	12	4	20	2	0	6	14	4	3.4	7.8
	April	−21.9	−3.0	−44.8	3.9	4	11	25	10	3	17	12	6	12	1	0	3	13	4	3.4	3.3
	May	−6.4	+6.2	−29.9	4.1	6	8	31	17	3	6	8	7	14	1	3	10	5	15	6.7	9.2
	June	+4.8	+29.6	−11.7	5.2	11	10	27	14	5	5	11	10	7	2	2	14	2	17	7.7	27.0
	July	+10.8	+28.5	−1.2	5.2	10	8	23	12	9	5	12	12	9	2	0	12	3	15	7.0	29.7
Nizhne Kolymsk, 1901–1905.	March	−27.1	−0.8	−48.6	2.4	6	6	12	29	6	11	7	5	18	1	0	8	10	4	4.0	4.7
	April	−15.4	+2.2	−38.0	3.2	9	9	12	27	6	6	8	8	15	1	0	8	10	7	4.6	6.1
	May	−2.0	+15.4	−31.3	3.2	16	9	10	21	7	9	8	8	12	1	1	6	6	7	5.4	6.3
	June	+10.1	+25.0	−0.8	3.4	15	9	10	25	9	7	8	12	5	1	1	6	5	6	5.3	17.5
	July	+12.1	+26.7	+0.4	3.1	20	8	10	19	7	9	9	12	6	0	1	12	4	10	6.1	34.3
Pitlekai, 1879	March	−21.6	−4.2	−39.8	------	29	6	2	6	13	8	7	24	5	------	------	------	------	------	5.1	------
	April	−18.9	−4.6	−38.0	------	37	6	2	2	5	8	6	28	6	------	------	------	------	------	6.4	------
	May	−6.8	+1.8	−26.8	------	24	19	13	3	8	5	8	19	1	------	------	------	------	------	8.5	------
	June	−0.6	+6.8	−14.3	------	29	7	2	2	14	20	3	16	7	------	------	------	------	------	7.0	------
	July	+2.7	+11.5	−1.0	------	10	16	16	7	15	18	7	8	3	------	------	------	------	------	7.5	------

THE EFFECTS OF A LIGHTNING STROKE

N. ERNEST DORSEY

[National Research Council]

On the night of Sunday, September 13, a tulip tree (*Liriodendron tulipifera*) in the yard of All Saint's Chapel, Annapolis Junction, Md., was struck by lightning. It was examined the next morning. On the following day it was inspected very carefully and photographs were taken. Other photographs were taken and inspections were made from time to time, for the purpose of confirming or of extending the memoranda previously made. The case is of considerable interest, as the effects produced give quite clear evidence of the direction of the stroke, and show that it was delivered to very restricted areas at points not over about 8 feet from the ground.

Some rain had fallen earlier in the evening; it is not known positively whether it rained much after the stroke, but the appearance, the next morning, of the ground in the corner by the steps (G, fig. 1), and the fact that leaves and dirt were still adhering to the wall of the tower (fig. 6) indicate that it probably rained but little after the stroke.

The prominent objects in the neighborhood of the tree are shown in Figures 1 and 2. Excepting a one-story concrete building about 60 feet to the east, there is no other tree or other prominent object to the west, north, or east within 200 yards of those shown in Figure 1. On the south there are trees, but the nearest is 75 feet distant. The group shown in Figure 1 is essentially isolated. The ground is nearly level to the south, west, and north, and slopes gradually downward toward the east.

The tree which was struck is A; it was 47 feet high, and 6 inches from the ground it had a girth of 49 inches. It stands between a 56-foot tower (wood, stone foundation, no lightning rod) and three other trees of approximately its own height; of these, two are of the same kind as itself. The highest and most exposed tree in the yard is B; it was not damaged in the least. The stroke ignored both B and the tower, passed in a vertical plane between C and D, each about 47 feet tall, and finally struck A about 8 feet from the ground. The most distant splinters were found at K and L; they were small. Small splinters were on the roof of the chapel, one was sticking in the frame of the door. The only large section torn from the tree lay at E; it was 14 feet long, and was bent about as indicated (see also fig. 7). At F, was a splinter 11 feet long, and 0.5 by 1.5 inches in section. With the exception of a 4-foot splinter which was caught in the branches, and which will be mentioned again, the other splinters thrown off were small. Circles indicate the overhang of the branches of C and D.

Figure 3 is a view looking up and slightly to the east of southeast. At 5 feet from the ground, the splintered portion of the trunk lay in the angle HAI (fig. 1), its vertex was 4 inches from the northwest surface of the tree. Notice that the blazed portion did not extend to the top of the trunk. It had a very definite upper limit, 27 feet from the ground. The entire appearance of the damage suggests that the center of violence lay somewhere between the upper and the lower arrow—that is, between 12 feet and 8 feet from the ground. The standing splinter to the left (upper arrow) was 12 feet long, and 6 feet from the ground it had an arc of 4 inches;

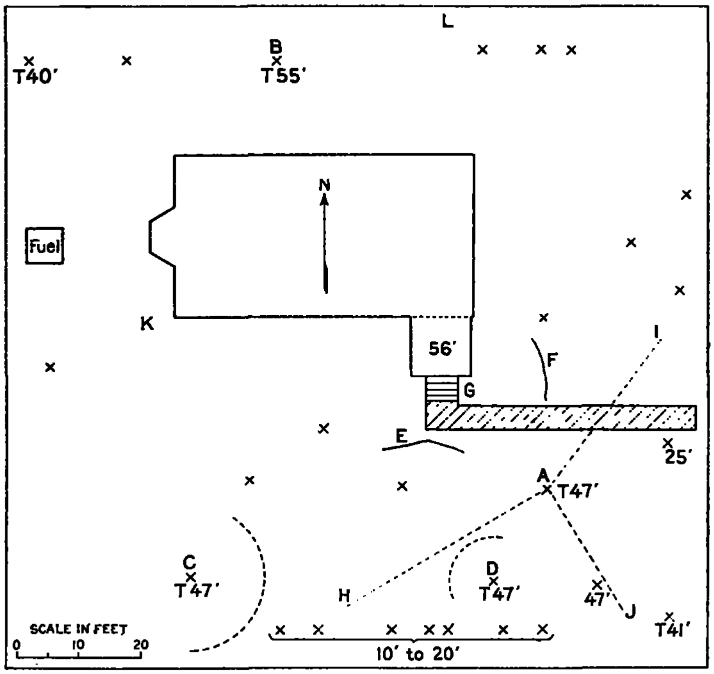

FIG. 1.—Plan of surroundings of tree A which was struck by lightning on September 13, 1925. Trees are denoted by crosses; tulip trees are marked with a T; numbers indicate height. Fuel shed is 6 feet high. Hatched area is a brick walk. Splintered segment lay in angle HAI, near ground the vertex was 4 inches below surface

sides of wedge [1] were 3.5 inches; some grass and dirt were on its upper end on Tuesday morning. At the level of the central arrow is a knot hole in the trunk, where a branch has been broken off and pulled out. On the upper side of the hole, a sliver from the branch still projected from the trunk; it can not be distinguished in the figure. At the lower arrow, notice a splinter which has been split and bent into the form of a T. This is a valuable reference object which will appear in other figures, and to which we shall have occasion to refer. We shall call it the " T splinter." The black, weathered ends of several stubs of branches, which had become inclosed by the trunk, may be seen.

Figure 4 is a view looking upwards and to the northwest; it shows the split in the unsplintered portion of the trunk. The split lay in the vertical plane through AJ (fig. 1). The extreme top of the split was near the top of the blaze, about on the level of the boy's head; he is 4 feet 8 inches tall. The lower 30 inches of the trunk was unsplit. The two sides had merely been bowed apart beyond the elastic limit of the wood. The blunt end of the cross of the T splinter is seen projecting across the top of the frame of the door; just below its end is seen the end of a small splinter which was caught in the frame of the door.

[1] The cross-sections of all splinters have roughly the shape of truncated wedges, the bounding lines approximately coinciding with growth rings and radial lines. The dimensions are given in terms of the length of the outer arc and the average thickness along the two bounding radial lines.

Figure 5 is a view looking slightly north of east. The rod leaning against the tree is 4 feet long. Note the large standing splinters; also the small ones which have been driven out from the interior and broken down, and which are now firmly clamped between two of the standing splinters. At the upper arrow is the top of the T splinter. At the lower arrow and in the interior, may be seen the upward pointing end of a reflexed sliver which is attached to the farther of the two upstanding splinters. This sliver was one inch wide, 0.5 inch thick, and 28 inches long, and was attached to the standing splinter at a point 54 inches from the ground.

At 5 feet from the ground, the standing splinter had an arc of 3 inches, sides of wedge were 3 inches. In order for the sliver to be able to fly clear of the standing trunk so as to be caught and bent into an angle of 30°, as shown, this splinter must have been blown out to a considerable distance from the vertical. If its deflection was such that it was bent into an arc of a circle tangent to the vertical at the ground, then the radius of that circle could not have been greater than 4 feet, and the chord joining the base of the splinter to the point of attachment of the sliver must have made with the vertical an angle of over 30°.

Along the edge of the unsplintered portion of the trunk, extending from the central arrow to the ground, there was a strip of bark 0.75 inch wide which had been frayed out as if whipped by the wind. It lay along a crack. From its lower end, and in the plane of the crack, there was a shallow furrow in the ground. The furrow was an inch in diameter and about 11 inches long. With the exception of two insolated frayed areas and four small punctures, this frayed strip was the only portion of the bark which was damaged except by a purely mechanical tearing. The four punctures will be described in a later paragraph.

One of the isolated areas of frayed bark was on the southwest side of the tree, not far from the frayed strip; it was 1 inch broad and 5 inches high; its lower end was 29 inches from the ground. The other was on the unsplintered segment of the trunk, in the plane of the split (AJ, fig. 1); it was 2 inches broad and 6 inches high; its lower edge was 3 inches from the ground. The trunk was not split under either of these areas, but the sapwood was discolored, and there was a central area which presented a porous appearance, but in which no hole nor crack was found, though a sharp probe was used.

In the plane of the split (AJ, fig. 1) and beginning 11 inches from the unsplintered side of the tree, there is a superficial hole in the ground; its opening was 1.5 inches in diameter; it was traced for a distance of 18 inches, and was nowhere more than 2.5 inches below the surface. Just beyond the brick walk, in the corner by the steps, about 15 feet from the tree, there was another hole about the same size and lying nearly in the same plane; it was even more superficial than the one on the other side of the tree; its opening was directed towards the tree. A little to the northeast of the hole first mentioned, and 6 inches from the trunk, there was a vertical hole 1 inch in diameter and 2 inches deep. It is believed that all three are burrows made by animals or insects; it may be the loose material initially hiding their entrances was sucked out by the electrostatic field attendant upon the dis-

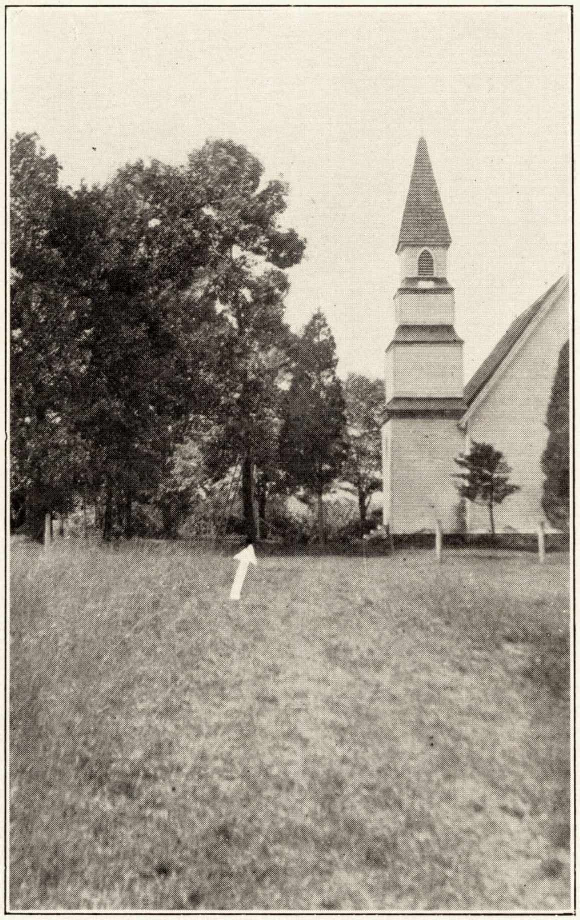

Fig. 2.—The arrow indicates the tree which was struck

Fig. 3

Fig. 4

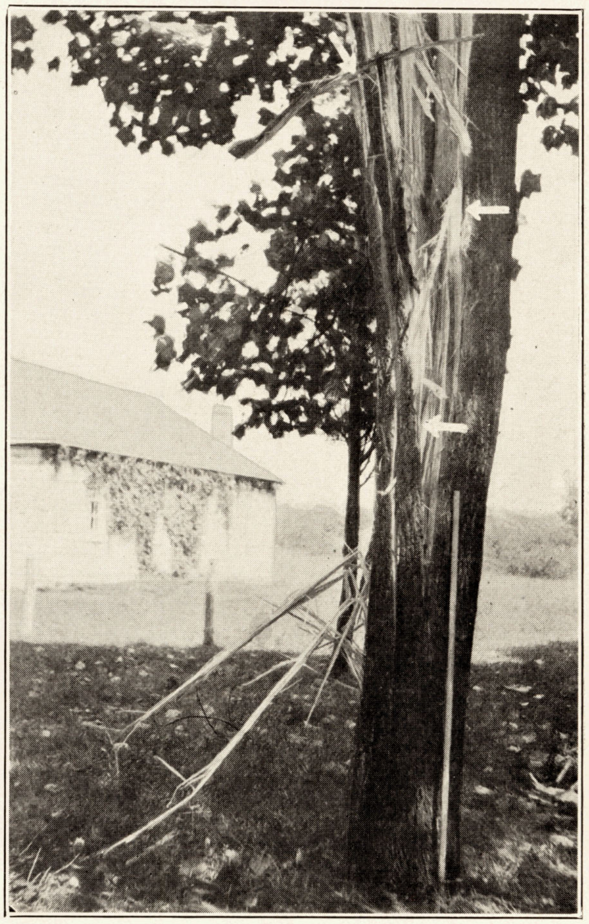

Fig. 5

Fig. 6

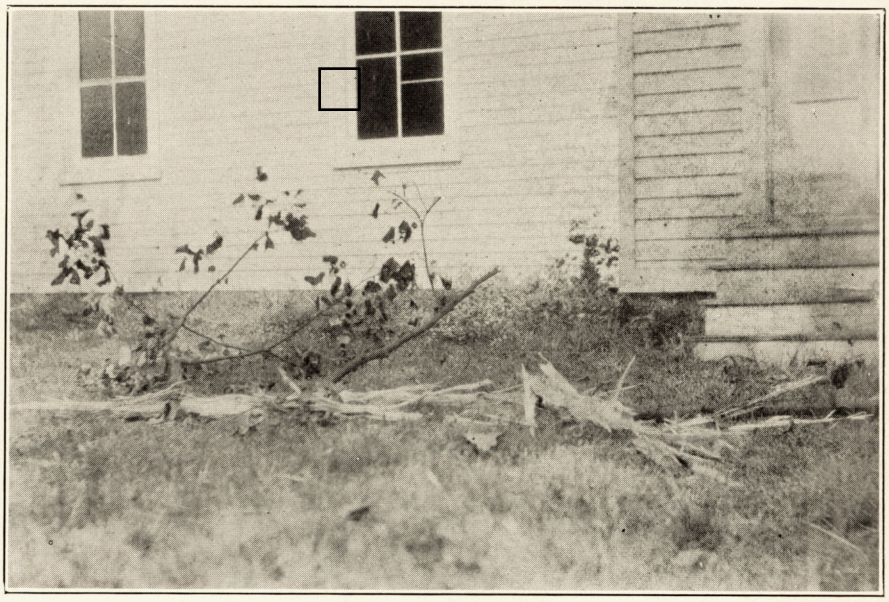

Fig. 7

Fig. 8

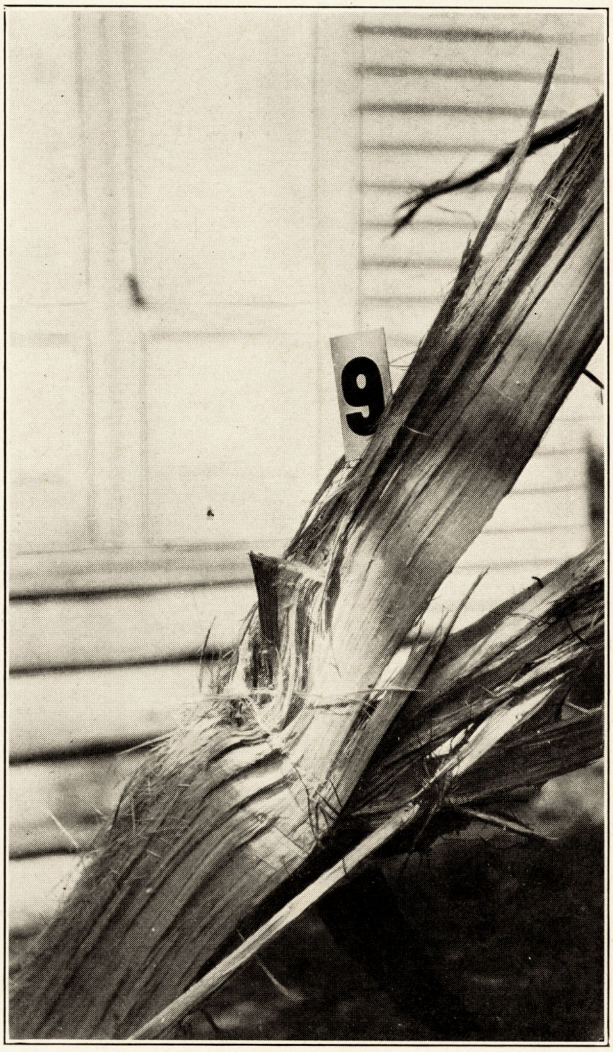

Fig 9

charge, but it seems improbable that they are otherwise related to the stroke.

Figure 6 is interesting in showing how small leaves and dirt were spattered over the south side of the tower, to a height of 9 or 10 feet; none was on the east side. The ground in this corner, between the steps and the wall, gave no evidence of more than very superficial disturbance, but that disturbance was pronounced; the grass and débris had the appearance of having been combed upwards. The disturbed area was entirely within the rectangle (28 by 48 inches) between the steps and the wall (G, fig. 1). Only a few small splinters were found in this corner.

Figure 7 shows the only large section which was torn from the tree. It was bent approximately as shown at E (fig. 1), convex toward the bark; the lower end was to the east; the bend lay 20 feet from the tree. From the bend to the lower end was about 6 feet. This portion points about 30° to the right of the camera; the branch projecting from it and seen lying in front of the steps is the one which came from the knot hole at the central arrow of Figure 3; its junction with the section was about 3 feet from the bend. Neither end of this section dug into the ground; the condition of the ground and the appearance of the dirt adhering to the bend clearly indicated that the section struck upon the bend. The section must have been so bent before it left the tree.

Figure 8 shows the bend of the large section shown in Figure 7; the section has been readjusted so as to obtain a more suitable view; the upper end extends to the left. Notice how the fibers have been crumpled. An examination of the bend showed that the two portions of the section had been driven together, crumpling and crushing the fibers. As the section struck upon the bend, this damage must have occurred before the section left the tree.

Figure 9 shows the broken butt of the limb projecting from the lower portion of the section shown in Figure 7; here it is upside down. The limb itself may be seen below the section. Notice how squarely the butt has been broken; the fibers were not twisted nor split apart in the least. Where the break occurs, the fibers of the limb have become nearly parallel to those of the main trunk. This broken butt fitted into the knot hole at the central arrow of Figure 3. That hole was 10 feet 3 inches from the ground, and was nearly 1.5 inches deep. Furthermore, the sliver which still projected from the trunk fitted into the cavity at the left of the butt; this cavity was about 2 inches deep. The branch has been broken off squarely across the grain, and has been pulled out of the trunk as a tenon might be pulled from a mortise; in doing this, the sliver attached to the trunk has, reciprocally, been pulled from this section without damage to itself, although it was only 1 inch wide and near its tip was only 0.25 inch thick. Such a breaking and pulling apart could have resulted only from a tension which was quite closely along the direction of the fibers lying in the plane between the sliver and the butt; these made an angle of 33° with the vertical. What seems to have occurred is this: A force directed about 30° from the vertical was exerted upon the lower portion of the section (fig. 7) containing the limb; when the limb tore apart, this portion of the section drove into the upper portion, crumpling and crushing the fibers at the bend (fig. 8), prying off the upper 8-foot portion and driving the entire section upward and outward. This tore loose from the outer portion of the trunk a bark-covered splinter, 4 feet long, arc 5 inches, sides of wedge 3 inches, and threw it up into the branches, where it was still hanging on Monday morning, some 3 feet higher than the top of the blaze. This splinter carried the bark which was torn from just below the branch seen in Figure 3 at the left and near the extreme top of the blaze.

The top of the vertical portion of the T splinter (figs. 3 and 5) was 8 feet 3 inches from the ground. Through this splinter, just where it joined the top of the T, was a small hole, scarcely larger than a lead pencil, around which the wood was charred. Markings from a smaller hole were found 13 inches lower, where the right end of the cross of the T would meet the vertical portion, if the splinter were straightened out into its original position. At two other spots, 12 inches and 15 inches, respectively, below the latter, the bark was similarly charred. All four spots lay approximately in the same vertical line. These are the four punctures which were mentioned in the discussion of Figure 5. A careful search failed to disclose any other charred spots; special attention was given to the bend (fig. 8) and to neighboring portions of the trunk. At the lowest spot, merely the surface of the bark was charred; at the next, the bark seemed to have been penetrated, but there was no evidence that the wood under it was damaged. The hole appeared to make with the vertical an angle of about 28°. Marks matching the other two holes were found on the large, torn-out section and on two other (interior) standing splinters. It was thus possible to reconstruct, in part, this portion of the tree. From the region of the highest hole, too much material was missing, and what was available was too damaged by the bending and swaying of the splinter to permit one to draw any very definite conclusion regarding the initial nature of the hole, but it seemed to enter the tree almost horizontally. A large part of the material from around the second hole was available, and had been damaged but little. In particular, a fair length of the hole, including its very end, was found in a single large splinter. In sections normal to the length of the hole, the wood was discolored (grayish) over an elliptical area; 1 inch beyond the bark the vertical axis was 4 inches, the horizontal was 0.75 inch. The hole entered the wood at an angle of about 50° with the vertical. Its entrance was approximately three-eighths inch in diameter, and a very short distance after entering the trunk it was but little larger than the lead of an ordinary drawing pencil. It extended into the wood about 2 inches beyond the bark, and the vertical plane including it deviated but little from that marking the westernmost face (AH, fig. 1) of the unsplintered portion of the trunk; the deviation, if any, was probably to the north. The hole went straight through the sapwood without damaging it except by perforation. The same seemed to have been true of the upper hole, but there a strip of the trunk lying quite near the surface was shredded. Beyond this narrow strip, the wood appeared to have merely been slit apart, until the apex of the splintered portion was reached.

Along the apex, extending the entire length of the blaze and split, there was a column of fibers which had been quite completely shredded. Some idea of the nature of the shredding may be obtained from Figures 8 and 9. At a height of 10 feet, the shredded column was 0.75 inch in diameter. It lay quite closely along the grain of the tree. It was split, probably by a small knot (fig. 9), just below the square break; one segment was much larger than the other. The smaller segment passed to the west, and the larger to the east, of the squarely broken limb; both followed the grain of the trunk, and thus united above the limb. It will be noticed that in passing around the limb to unite above it, the direction of the fibers has a very pronounced horizontal component, and where they reunite, they are nearly perpendicular to the direction of those composing the plane of slipping of the butt of the limb. (To see this more clearly, turn Figure 9 nearly upside down, so that the trunk is in its natural position.) The inner fibers actually formed a kind of inverted cup.

As the shredded strip extended to the top of the split, and possibly beyond it, it is natural to conclude that the tree was struck at a point still higher. But such was not the case. On the Tuesday after the tree was struck, the bark was examined very carefully, from the top of the split to the very highest crotch. It was entirely undamaged, except at one point. The point was 15 inches above the top of the split (hence about 18 feet below the top of the tree), on the unsplintered side of the tree, and on the upper side of a minor branch, close to where it joined the trunk. There, a piece of bark 0.25 inch wide and 1 inch long had been blown off, and at the trunk end of the stripped portion there was a hole about one-sixteenth inch in diameter, from which projected a small tuft of shredded fibers. Not only the presence of the fibers, but the appearance of the edges of the hole and the manner in which the bark was torn showed quite plainly that the damage was caused by a mechanical force acting from within outwards. After cutting off the branch, the hole was probed into the trunk to a distance of 3.5 inches, the probe being a No. 26 copper wire. Obviously the hole was almost completely clear for this depth, or it would have been impossible to have probed it with such a wire. Whatever produced it, blew it almost completely clear of woody material for a distance of about 4 inches.

After the tree had been thrown, it was sectioned. At the section 3 inches below the branch with the hole, the shredded column was evident as a spongy area; a part of it entered the knot corresponding to the branch. At the section 6 inches higher, the spongy area was much smaller; and at the top of the next 6-inch section, there was none to be seen. From that section there was but one branch, and neither it nor the bark of the section was damaged in any way. The top of the shredded column did not reach the surface, but ended in the interior of the trunk.

At the section made a few inches above the original ground level, the diameter of the shredded column was much less than it was at the level of the top of the T splinter.

There were five large, spreading roots (the tulip tree has no taproot). Of these, only one was damaged; of the five, there was but one which was smaller than this. The damaged root was 5.5 inches in diameter, and left the trunk in a nearly northwest direction. The apex of the damage was 0.75 inch from the south face of the root. The entire damage consisted in a rather minor splitting of this side. A small root (1 inch in diameter) from the same portion of the trunk was split on its lower side; the split was nearly radial, and not over one-fourth inch deep. This root lay entirely below the large ones. Here again the source of damage seemed to have been quite narrowly restricted to a small column of fibers; the split seemed to be merely a vent where the root gave way. There were incipient splits nearly coinciding with the growth ring passing through the column.

From these observations, it seems probable that, until it reaches the heart of the tree, the shredded column, marking the apex of the damage, is bounded throughout its length by the same sets of growth rings and radial planes, or by their counterparts in the roots and where knots disturb the regular arrangement. It seems that whatever produced the shredding had its origin near the level of the top of the T splinter, passed both upwards and downwards, with ever decreasing intensity, along a slender column of fibers, and experienced great difficulty in passing in a direction transverse to the fibers. Indeed, there was no clear evidence of any passage transverse to the fibers; in this direction, the trunk was merely splintered or split apart, or, as in the case of the hole in the small branch 15 inches above the split, the fibers are torn and punched out, but are not shredded.

Herein seems to lie the explanation of the square break. In its rush up the fibers, the shredding agent encountered the overhanging and somewhat cupped fibers above the branch, and was unable to penetrate them transversely with sufficient freedom to prevent the stresses from becoming greater than the tree could stand, even though most of the agent continued along the fibers, around the bend, and upwards.

What was the agent which produced this shredding? The orthodox answer seems to be: Steam, or other gases, liberated by the passage of an electric current through the tree. But to me this is not satisfactory; it seems to me improbable that steam or other gas could primarily have been responsible for all of the effects observed. I am of the opinion [2] that in this case the lightning stroke consisted of something analogous to an intense, high-speed beam of cathode rays, which planted in the trunk, at the depth of the shredded column, a large number of electrons. Their mutual repulsion, when their onward velocity was arrested, urged them in all directions; but having become attached to the molecules forming the contents and walls of the cells, they were unable to penetrate the fibers in a lateral direction, although they could travel with moderate freedom along the fibers, in the direction of the flow of the sap. Hence they traveled along the fibers, shredding them as they went; being unable to penetrate the fibers transversely, the tree was split, and the branch was broken squarely and pulled from the trunk.

Although many accounts of the effects produced by lightning have been written, their correlation is exceedingly difficult, owing to the omission of many important details. It is very desirable that there shall be placed on record in appropriate institutions a large number of detailed descriptions of such effects. In this country, the Weather Bureau seems to be the logical place for the assembling of such data. In the study of a tree which has been struck, the following details and types of observations seem desirable; others dictated by the particular case under study will occur to the observer.

1. A plan of the surroundings, drawn to scale, showing all prominent objects and the heights of those which are as tall or taller than the one struck, should be made. The kinds of trees and the types of buildings (whether frame, brick, with lightning rod, etc.) should be stated.

2. Both general and detailed photographs of everything that appears of probable significance or interest as affording information regarding the nature, extent, and location of the damage should be taken.

3. The ground, for a considerable distance in all directions from the tree, should be carefully examined, and notes should be made of all holes, furrows, and other disturbances which may have resulted from the stroke.

[2] For an elaboration of this opinion, see Journ. Washington Acad. Sciences, January, 1926.

Their sizes, locations, and directions are of importance. They should be entered upon the plan.

4. If the tree is splintered, notes should be made of the positions of the most distant splinters, as well as of all the large ones. The positions of the latter should be carefully determined; the distance, position with refererence to the tree, and the position of the bark are of importance. Do they appear to have hit violently upon an end; if so, upon which; if not, is there any evidence of which part bore the brunt of the blow? (The main evidence is to be sought in the ground and in the soiling of the splinter.) All significant features, such as those which relate to the nature of the breaks, should be noted and photographed.

5. The nature of the splintering should be noted. Are all portions of the splintered material damaged in the same way, or is there indication of a path, or of paths, of peculiar damage? In the latter case, how do these paths differ from the rest, how are they situated, do they reach the surface at any point; if so, where, and how is the bark affected at that point? What are the sectional dimensions of the paths, and how do they vary from point to point? Trace the paths as far as possible; do they encounter any knots and; if so, how do they pass around them?

6. Search for punctures of the bark; remember that they may be very small. Are their borders scorched? Do they appear to have been made by a mechanical force acting from within outward, or the reverse, or is there no evidence bearing upon this point? The position of each puncture should be carefully noted, so so that it can be correlated with the other observations. If only a segment of the tree is splintered, an especially careful search for small punctures should be made in the neighborhood of each boundary of the splintered segment. In so far as possible, reconstruct the tree in the region of each puncture so as to determine the size of the hole, depth of penetration, the angle it makes with the vertical, and the plane in which it lies; the latter should be entered on the plan.

7. Note carefully the nature and the location of the damage to the bark and to the sapwood. Distinguish between a mere mechanical tearing of the bark as a result of the splintering of the tree and damages of other kinds.

8. If practical, throw the tree and note the location, extent, and nature of the damage to the roots, photographing everything of interest. Note carefully how the roots lie with reference to the ground plan. Section the tree at such points as seem desirable.

9. Nothing should be moved until everything of interest regarding its original position has been recorded. But after such records have been made, exhibits should be collected, carefully labeled, and preserved, at least until after a detailed report has been written.

10. Above all things, trust nothing to your memory; upon the spot, make written notes of all observations and of the impressions which they produce upon you. If practical to do so, move nothing until after you have written up and studied all the notes which you can otherwise obtain; you will frequently find that additional observations are desirable.

OCEAN TEMPERATURES AND SEASONAL RAINFALL IN SOUTHERN CALIFORNIA

A REVIEW OF THEIR RELATION BASED UPON RECORDS OF THE PAST NINE YEARS

By GEORGE F. MCEWEN, Physical Oceanographer

[The Scripps Institution of Oceanography, La Jolla, Calif., December 28, 1925]

The continuous record of seasonal rainfall at San Diego began in 1850, and may be regarded as typical of southern California in the variation from year to year. What is the likelihood of being able to predict the rainfall for a given year solely from a rainfall record? On examining the record for San Diego, which is the longest available in this region, there appears to be no definite relation of the rainfall during any season either to the rainfall of one year [1] or to that of any sequence of years preceeding it. For example, a rainfall above the average is just as likely to follow a dry year as a wet year. The distribution in time, of seasonal rainfall, appears to be as fortuitous as the result of coin tossing or drawing odd and even numbers from a pack of numbered cards.

Although it is impossible to predict what the next season's rainfall will be solely from the record of rainfall, it is possible to state the probability that it will be between any assigned limits. A suitable frequency curve, fitted to the 75 values of the seasonal rainfall at San Diego, yielded the results entered in Table 1.

TABLE 1.—*Frequency, in number of times per hundred that the rainfall at San Diego may be expected to have a value between the given limits*

Frequency	0.8	9.2	20.7	21.8	16.7	12.3	7.6
Limits	0-3.3	3.3-5.3	5.3-7.3	7.3-9.3	9.3-11.3	11.3-13.3	13.3-15.3
Frequency	4.1	3.0	1.5	1.0	0.5	0.3	0.2
Limits	15.3-17.3	17.3-19.3	19.3-21.3	23.3-25.3	25.3-27.3	27.3-29.3	29.3

[1] In the paper by L. E. Blochman, following, the reader will find a discussion, based on the San Diego rainfall record, which indicates a relation between San Diego summer rains and the rainfall of the ensuing season in southern California.—Ed.

From the frequency distribution of the rainfall, estimates can be made of the chances of having a drouth of given intensity (number of successive years when the rainfall is below a given amount) within any period, 50 or 100 years. For example, in an 11-year interval we may expect 8 or more years to have a rainfall less than 9.2 inches about once in a century.

About once in 50 years an 11-year period will contain 5 or more years during which the seasonal rainfall is less than 7.3 inches. The 11-year period from 1893 to 1904 corresponds to both of these cases. It contained 8 years during which the rainfall was less than 9.2 inches, and 5 years during which it was less than 7.3 inches. Computing the chances of a flood or drouth of given intensity is one kind of prediction, although no information regarding any particular year is thus obtained. Such predictions are of value to engineers in the economic design of storage systems for conserving the maximum amount of water.

Considerable work has been done in attempting to discover cycles or periodicities in various natural phenomena. The possibility of cycles in sun spots, temperature extremes, drouths, etc., and attempts to find correlations based upon such phenomena has aroused the interest of able investigators, as well as those less qualified to deal with such problems. In many cases the advocates of certain cycles have not been able to establish their claims. The problem of determining cycles empirically from observational data is in general elusive and difficult. Many people believe that the seasonal rainfall at San Diego is cyclical, and that the period is about 20 years. While periods of light and heavy rainfall do alternate in