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University of Texas Bulletin

No. 1772: December 25, 1917

The Texas Meteor of October 1, 1917

By

J. A. UDDEN



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The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston

Cultivated mind is the guardian genius of democracy. . . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar

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THE TEXAS METEOR OF OCTOBER 1, 1917.

BY J. A. UDDEN

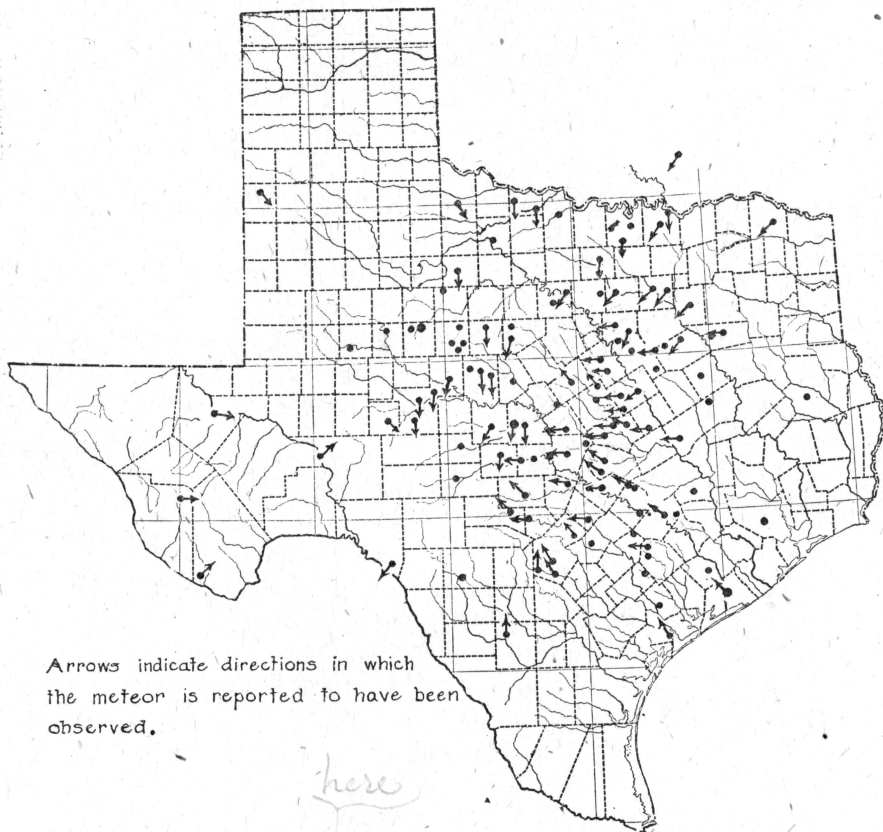
INTRODUCTION

About 10:30 p. m. on the night of the first of October, 1917, there appeared a large meteor in the sky over central Texas. It was seen by many hundreds, if not thousands, of people over the whole state, and was immediately recognized as a meteor by most of those who saw it. To all it appeared to be of unusual size and brilliance. Short notices appeared the next day in a few daily papers. Some made no mention of it. Evidently, and in at least one case, certainly, some doubt was entertained of the truth of the reports that had come. Falls of large meteors are infrequent, and the phenomenon seen was of a very unusual kind.

Data relating to the appearance of meteors have been secured mostly during the last hundred years. They are not as full as might be desired. On the night when this meteor fell, the atmosphere appears to have been clear over the entire region where it was seen. It seemed to the writer that circumstances were exceptionally favorable for securing information from which a fairly full and complete record could be made of the appearance and flight of this meteor. I therefore hastily prepared a set of questions to be submitted to those who had personally seen the bright body in the sky and an advertisement was inserted in several dailies, asking for names and addresses of such persons. A generous response by these newspapers and by the public secured for me descriptions from nearly a hundred observers, mostly from individual correspondents, and also various information supplied by the press. The reports evidenced a general and intelligent interest in the subject. They have supplied sufficient information from all over the state for making out the most important facts relating to the duration, the direction of flight, and the appearance of the meteor.

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Incidentally, the reports furnish a number of details which appear of sufficient interest to be worth recording. (Fig. 1.)



Arrows indicate directions in which the meteor is reported to have been observed.

Fig. 1. Map showing localities from which observations on the meteor of October 1 have been furnished for this paper.

The writer ~~unfortunately~~ did not himself see the meteor. The view of it that is presented in the following pages must be regarded in the light of a composite picture reflected from an intelligent and interested part of the public more fortunate than the writer in seeing the fall. It has been the writer's aim in no way to modify the impressions ~~transmitted from the~~ *received and described by* several correspondents. He has merely tried to bring their salient points into a focus where they may be seen in their true proportions.

It must be remembered that in making observations of any natural phenomenon it is impossible for an observer to take in at a glance all the features of an object. Attention is always more or less concentrated on partial features. Especially is this the case when observations are made in a short limit of time, where there is no opportunity for analysis of details. In the present case, some observers took special note of the explosion of the meteor; others of the direction of its course in the sky. Still others noted with greatest particularity the nature of the color display, and some took special notice of its size or of the speed with which it traveled. In reading some of the statements made by different observers, no one should be surprised at disagreements. In many respects, correct observation requires such disagreements, for the meteor did not look the same from the hundred different points of view from which it was seen. Another circumstance resulting in variations is to be found in the extreme difference of human temperament, nervous resistance, and psychologic sensitiveness. Nor do human eyes and ears transmit sensations with the same promptness or with the same detail in different individuals. Our minds are not equally responsive to the influences brought to bear. Training and bias affect our judgment, which is the final censor of what we communicate to others.

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IMPRESSIVENESS OF THE FALL

The general impression which the appearance of the meteor left on its observers must have been decidedly strong, even in places where it was not seen in its greatest brilliancy. A lady in San Antonio says, "It was a most beautiful sight." A gentleman in McGregor and several observers in Corsicana refer to it as being "awe-inspiring." In Austin, it was spoken of as a "tremendous light." A weekly paper far up in north Texas says: "A huge meteor blazed across the sky with a dazzling glare, leaving a pathway of blue light." An editor in Hillsboro says significantly that "not since the first days of the European war has that subject given way so completely to another as it did today to conversation about the great meteor." I should perhaps state that interest in the phenomenon prompted several persons in that city, the day after the meteor fell, to make excursions with a view to finding it. A serious interest and a sincere appreciation of the unusual in nature is in evidence everywhere. Only in one or two cases does it appear that newspapers made any facetious remarks about it, and in some cases one may almost read between the lines that this attitude is assumed in a spirit of local pride or as a public policy. The various notes speak best for themselves.

Temple: The scene is described as one of the greatest brilliancy, not unmingled with awe-inspiring features.

San Antonio: I have never seen a meteor approaching the brightness and apparent size of this one. (Statement by J. H. Mathey, an amateur astronomer of many years experience.)

Corsicana: It was the most wonderful thing of its kind that I have ever witnessed.

Waco: It gave a very penetrating light. I shall never forget it. It was awe-inspiring.

San Antonio: Marvelous sight, in comparison with which I imagine the explosion of a powder factory would be tame and uninteresting.

Mineral Wells: This mysterious visitor from infinity of space was huge in proportions, brilliant in hue, and awe-inspiring in aspect.

Clifton: It was a most wonderful sight, and one I shall not soon forget.

Llano: It reached the earth with a terrific blast, that exceeded by far any explosion that ever resulted from human agency.

Kerrville: It was the grandest sight ever witnessed.

New Braunfels: No like phenomenon of such intensity has ever been seen before.

The impressiveness of the phenomenon is also apparent from other circumstances. After the severe detonations, which were heard in Llano, Mason, and adjoining counties, several people had long-distance conversation with persons in Waco and in San Antonio, in their eagerness to learn what had happened. A Burnet paper states that "people were unable to determine the cause of the light and explosions until the daily papers were received," the next day. Still more suggestive of intense but subdued eagerness to learn the cause of what was seen, is the frank statement from one place, saying, "We wondered if we really saw it, and looked eagerly for mention in the daily press"; and another statement from an elderly gentleman who had seen a friend passing on the street after the meteor fell. He relates that he did not speak to this friend that night, but went to his office the next morning, when they "discussed the singular phenomenon."

GENERAL APPEARANCE OF THE METEOR

The meteor appeared with a head, surrounded by a fiery envelope, and followed by a fiery trail. The general appearance of its figure no doubt varied at the different points from which it was seen. While a number of notes have reference to the general form of the meteor and its trail, both of these features are mentioned only in a few descriptions.

The Meteor Body.—From several descriptions, it would appear that the luminous body itself was oblong. This is, in fact, indicated also by some comparisons by correspondents made with familiar objects, such as a cigar, a barrel, and an automobile. In a statement made by a correspondent from Brady, apparently referring to the luminous body alone, this same general form is indicated when it is said that "the flash itself seemed about six feet long and one foot wide, tapering posteriorly." The same outline of the meteoric body appears in several sketches as I shall show directly.

Body and Trail.—There are several descriptions which refer to the meteor itself as well as to its trail.

Austin: I saw the huge globular thing with its trail of sparks.

San Antonio: A blue luminous head, apparently round in shape, was followed by a bright tail, seeming a yard wide and terminating in a series of brilliant, detached sparks.

Gainesville: It was a wonderfully large reddish body that threw off streams of flame.

Brenham: It appeared as a ball of fire, and was followed by a train of flames, resembling a great comet.

Wichita Falls: Looked like a ball or stream of fire.

Waco: There was a long and narrow fire trail shot from the sky. It seemed solid red, and its dimensions seemed to me as having the ratio 1:75.

San Antonio: It seemed to be a solid column of red hue.

Kaufman: Tail and head together reached the length of an arc of ten degrees.

The Trail.—From most points where the meteor was seen, the trail following it was a conspicuous feature. It was evidently wider than the light coming from the meteoric body itself, and decidedly wider than the trail after a shooting star, and entirely unlike this. It is compared with flames, and likened to the trail of a skyrocket.

Camp Travis (San Antonio): The light of the trail lasted about one-half of the visible trajectory of the meteorite.

Belton: In the immediate path of the meteor appeared a flame of fire, which lasted for a few moments after the meteor disappeared.

Buffalo Gap: I should judge that the tail of the meteor was about twenty feet long and three feet wide.

San Antonio: It left a trail of sparks, as does a skyrocket.

Austwell: It left a streak similar to the tail of a comet, but much larger and brighter.

Atascosa: A great trail of light extended miles behind in the sky.

Austin: The immediate tail was at least six times as long as the ball.

San Antonio: I saw a streak of purplish red, about the size of an electric wire, extending away up in the sky. It gradually went out, the part nearest to the earth burning longest.

Annona: The meteor seemed to throw off a great volume of flames.

Even with these several descriptions before me, I find it difficult to construct anything like a whole picture of the meteor. To aid those who did not see the meteor in visualizing its image and in order to record some visualizations made by persons who saw it, I have asked a few observers to furnish rough sketches representing its apparent form. Fifteen such sketches have been received, and these are reproduced in figures 2 and 3, on pages 12 and 14, and are numbered from 1 to 15. They are necessarily crude representations, but not quite as crude as earlier representations published to illustrate similar phenomena. Evidently these sketches represent the meteor in different stages of its flight. Number 10, as explained by the contributor, is intended to show rather the path of the meteor than the meteor itself, in order to make clear its sudden increase in size, when it was at a certain elevation in the sky. Number 11 shows only a part of the path. It illustrates the divergent course of the flying fragments from the meteor. Numbers 3, 4 and 5 show only the form of the falling body itself, without showing the trail it left behind. Numbers 2, 6, 9, 12, 13, 14 and probably 15, show the meteor as it appeared at the time of its explosion; while numbers 1, 7, and 8 evidently represent the meteor and its trail shortly before the explosion. Numbers 8 and 14 are to some extent diagrammatic.

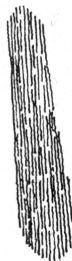
From these sketches, it can be inferred that different observers had their attention for the moment directed to different features of the rapidly moving image they observed. In numbers 2, 7, and 8, it is clearly shown that the sparks making the trail formed a streamer on either side behind the meteor; and these numbers also clearly indicate that these streams of detached material diverged from each other backward. From numbers 8, 11, and 12 we learn that the sparks which left the meteor were retarded in their motion, and therefore moved outward and downward from the main trail, as would naturally be the case. From numbers 1, 7, and 8, we can infer that the trail the meteor left was much wider than the meteor itself, and numbers 2, 6, 9, 13, 14, and 15 indicate that the sphere of illumination resulting from the final explosion had a diameter considerably exceeding the width of the trail. In numbers 3, 4, and 5, we have



1.



2.



3.



4.



5.



6.



7.



8.



9.



10.

Fig. 2. Sketches indicating the general form and appearance of the meteor as recalled by various observers three months after it fell, as seen at—

1. McGregor.
2. Austin. Observer's note: Very bright light in front, white and violet. Red and blue light, not so bright, behind near the junction of the tail with the head.
3. Wichita Falls. Observer's note: Looked like a streak of fire, apparently about 3 by 10 feet in size.
4. Kaufman.
5. Turnersville. Observer's note: There was a carmine band across (indicated by two parallel dashed lines) above the notch or dent, which remained on the lower right side after a piece was blown away. On the upper end there was a soft or yellow glow shaded with metallic color. Farther down (on the upper half) was a brilliant fire red. On the lower half appeared all of the above mentioned colors, blended, with no special outlines.
6. Brady. Last view of meteor and trail.
7. Temple.
8. Haskell.
9. Locality unknown.
10. LaGrange. Observer's note: From a to b it appeared like an ordinary meteor. At b it became bright and burst into a large ball of brilliant light, which gradually grew brighter until it reached c, where it burst into one great flash and disappeared.



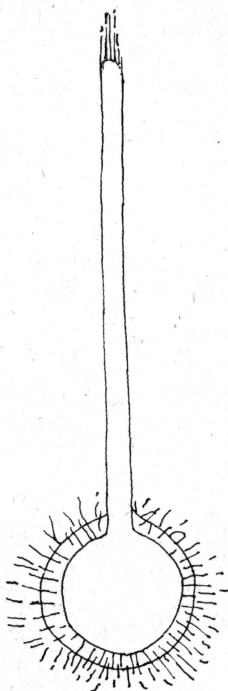
11.



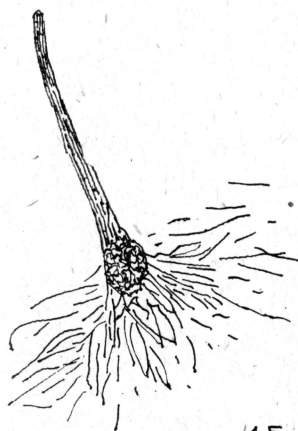
12.



13.



14.



15.

Fig. 3. Sketches indicating the general form and appearance of the meteor, as recalled by various observers three months after it fell, as seen at—

11. San Antonio. Note: Representation of a part of the meteor's trail.
12. Austwell. Observer's note: The streak in the middle looked like a comet and lasted for some seconds. It threw off sparks, as indicated, but not so many in its upper path as appears from the sketch.
13. Terlingua.
14. Locality unknown.
15. Crowell.

verification, of the observations made by several persons that the body of the meteor itself was oblong.

It should be remembered, however, that not only the elongated form of the moving body, but to a great extent also the length of the trail itself, is to be regarded as a physiological phenomenon. Luminous sensations last longer than the stimuli which produce them. This duration of sensation is without a doubt of different time-length in different individuals, and this fact almost certainly explains the divergences noted in the reports of the given ratios of length to width, both of the luminous body and of the width and length of the trail.

POINT OF FIRST APPEARANCE

The material at hand for determining the geographic point above which the meteor first appeared is somewhat confusing. Twelve persons, some of whom were 200 miles apart, report that the meteor first appeared "in zenith," "directly above" them, or "almost right above" them. Reports to this effect came from San Angelo, Buffalo Gap, Brady, Mason, Castell, San Saba, Burnet, San Marcos, Georgetown, Moody, Rosebud, and Cleburne. The geographic center of these places lies about three miles northeast from the southwest corner of Lampasas County. (Fig. 4.)

As our judgment of angular distance in the region of the zenith is extremely defective, more evidence on the location of this point was evidently desirable. I have, therefore, tried to locate it also by selecting a few of the best observations secured on the direction in the sky where the meteor was first seen from various points. With one exception, no observations giving merely one of the four points of the compass or the directions northwest, northeast, southwest, or southeast, were used for this purpose. These involve generalizations. In each case which has been used, the observers report a direction that appears to have been deliberately determined. These observations are as below.

Annona, Red River County.....	S 40 W
Austwell, Refugio County.....	N 35 W
Belton, Bell County.....	W 11 S

Brady, McCulloch County.....	N 45 E
Grandview, Johnson County.....	S 9 ½ W
Turnersville, Coryell County.....	S 10 W
Sherman, Grayson County.....	S 24 W

By drawing lines extending from these points in the directions indicated, a system of triangulations is obtained. Any inter-

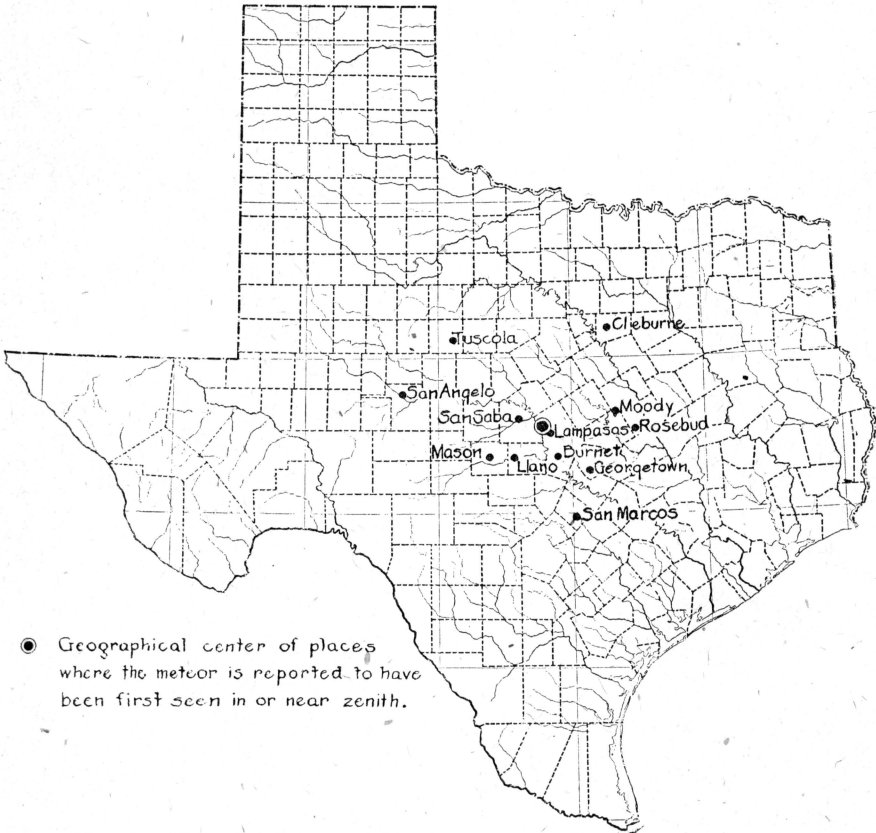


Fig. 4. Map showing points from whence the meteor is reported as first appearing in or near zenith.

section of two of these lines marks a place above which, according to two observers, the meteor was first seen. There result in all nine intersections. Two of these are 280 miles apart. These observations are hence evidently defective. The geographic center of these locations falls within about 12 miles

southwest from the middle point of the boundary between Burnet and Bell counties. (Fig. 5.) From the geographical center found by the zenith observations, this point is located a distance

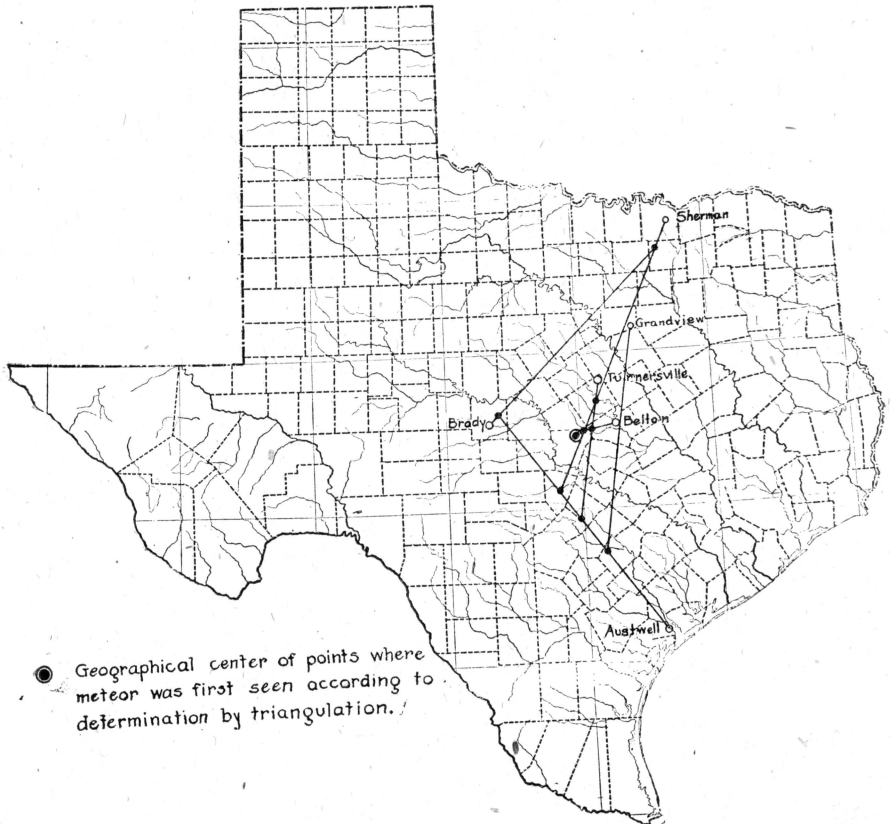


Fig. 5. Map showing points of observations on the direction in which meteor first appeared. Directions observed are shown by straight lines and their intersections by points, or small circles.

of about 23 miles to the east southeast. The two determinations have probably equal value, and, combining the observations of all the nineteen persons who made them, it would appear that when the meteor first began to glow it was somewhere above the station of Tumlinson on the Gulf, Colorado and Santa Fe Railroad, in the north part of Burnet County.

HEIGHT OF POINT OF FIRST APPEARANCE

The height above the earth's surface at which the meteor first began to be luminous cannot be determined within very accurate limits. It probably exceeded 100 miles. It is natural that only a few of the observers should have seen the meteor when it was first visible. Among those who indicated its position when it was first seen was Mr. Stanley A. Williams, of Camp Travis, near San Antonio, and he evidently was one of those who saw nearly all of the meteor's flight. He gives its greatest angular height in the northern sky as 60 degrees. His point of observation was about 110 miles away from Tumlinson, and this would locate the coming meteor for the moment when it was first observed by him, at 186 miles above the earth. This is an unusually high altitude for a meteor to become visible. Both the factors used in arriving at the result may have combined to make the figure too high. But it is not at all likely that the height was less than 100 miles. Observations at three other places indicate heights greater than this latter figure. It is almost certain that many observers failed to see the meteor when it first became luminous, and therefore many observations on its angular height at its first appearance must be discarded. Only eight have been selected for obtaining an average estimate of the height where the meteor first began to glow. These are as in the following table:

OBSERVATIONS ON THE HEIGHT AT WHICH THE METEOR WAS FIRST SEEN IN THE REGION ABOVE TUMLINSON.

Observations made at	Miles distant from Tumlinson.	Angle above horizon.	Height in miles.
San Antonio	107	60°	186
Cypress Mills	40	75°	146
Austin	53	66°	118
Sherman	204	33°	133
Romney	98	45°	98
Santa Anna	85	45°	85
Electra	218	25°	84
Frost	125	32°	68
Average.....			115

INCREASE IN APPARENT SIZE WITH APPROACH.

A score of observers noted the fact that at its first appearance the meteor seemed to be quite small, of the size of an ordinary shooting star, and that as it neared the earth it increased in apparent size and brilliancy. It is evident that most observers did not see it at its initial appearance, but became aware of it only after its emitted light attracted their attention. Most of the descriptions convey the impression that the increase in light and size was gradual and continuous throughout the flight, thus:

San Antonio: A bluish white ball, growing larger every moment.

Austin: It gradually broadened as it approached the earth.

Rosebud: The nearer the earth it came the brighter it got.

Austwell: It increased in size and brightness as it neared the horizon.

LaGrange: At first, it looked like a common shooting star, but it kept growing larger and larger.

San Antonio: The meteor shot down, increasing in brightness and apparent size. When last seen it appeared as large as a house door.

Grandview: It came into my view as a small shooting star, and gradually got bright, and then very bright.

Electra: It began as a falling star, continued with a light streak of fire, and increased until it assumed very large proportions.

Brady: Some boys say that at first the meteor looked like an electric light, but that, as it came closer, the glare blinded them, so they could not tell what became of it.

Decatur: When we first saw it, it looked about the size of an electric globe. As it neared the earth, it spread out to about the width of two yards and looked at least ten or twelve feet long.

Several others, who apparently paid close attention to the phenomenon of the flight, state expressly or leave us to infer that the increase in brightness was more rapid at certain stages in the flight than elsewhere. Whatever may have been the cause of such apparently step-like increases in the light, the observations seem likely to be correct and deserve recording. One observer notes two distinct increments in the light, while five others seem to have noted only one.

Camp Travis: The meteor first appeared as a small moving light. During the first ten degrees of its visible path, it did not increase in

size, but through the next twenty it grew very rapidly, and at the end of this period of its flight it increased to many times its original size almost instantaneously. During the next fifteen degrees of flight, it increased to a size equal to that of the moon.

McGregor: When gone about half its path, then there was a great flare of light.

LaGrange: At first, it was like an ordinary shooting star. Then all at once it burst into a round ball of white light.

Burnet: It appeared first as a small shooting star, and almost instantly flashed into a large brilliant ball.

Castell: It was first a little speck of light. This burst immediately into a dense and glaring streak of fire, brighter than the noonday sun.

Atascosa: When first seen, it appeared to be small, not much larger than an ordinary star, with but a small trail. It increased in size as it came nearer the earth. At one time the light diminished, as if the meteor were passing through a hazy atmosphere.

As this increase in brightness was observed in the central as well as in the peripheral regions where the meteor appeared, and almost with equal distinctness from all directions, it may be regarded as confirming the belief that its angle of incidence to the earth's surface was quite high. The step-like increases in its radiance, which under all circumstances must have taken place at considerable altitudes, suggest the existence of some stratification in the components of the earth's gaseous envelop, but the meagre observations secured would hardly warrant any further deductions bearing on their cause.

CURVATURE OF THE METEOR'S PATH

Fifty-six observers made note as to whether the apparent path of the meteor was straight or curved. One newspaper report quotes a man saying the meteor traveled a zigzag course. This must be regarded as an embellishment in the telling of the tale. Nineteen observers say that the path was "curved" or "slightly curved." The remaining twenty-six reporters describe it as straight. In a few cases, reports from one and the same point are contradictory. As the vertical plane traversed by the meteor extended from east to west, and as gravity tended to deflect the meteor's course downward, we naturally expect that observers farthest out north and south should have noted

the curvature most frequently. That the curvature was small in amount is evident from the fact that several persons who saw the flight of the meteor from near the course of its path speak of it as being straight. It is also natural that from points lying close to this plane the curve should not have been seen by all. At points under the meteor's path, its projection on the sky would appear straight. So we find that in a zone running parallel with this vertical plane of the path, and extending fifty miles away from it, the meteor appeared, to thirteen observers, to follow a straight course. But at Brady and Burnet, on opposite sides and a small distance away from the vertical plane mentioned, a curving course is reported. As the path would appear much shortened from these two points, the curvature of its projection would be more apparent. At San Saba, almost immediately under the meteor's course, it was called straight. In the regions outside the hundred-mile belt just defined, no less than nine persons speak of the meteor's path as being curved, while eleven noticed no curvature. The suddenness of the appearance of the meteor and its unusual size no doubt account for the failure of these observers to recognize the slight curve of the path. The distribution of the persons detecting this feature goes far to corroborate the correctness of the determination of the direction in which the meteor moved. At Austwell, far out from the plane in which the meteor moved, it is said to have distinctly "swerved to the right."

PROJECTED DIRECTION OF THE METEOR'S PATH

Statements describing the direction in which the meteor was judged to travel are contradictory to a surprising degree. Less than forty observers make statements, descriptive of this direction, or make other statements from which it can be inferred. Perhaps most of these are incorrect. In the region nearest the fall, most of the observers describe the course of the meteor as vertical or nearly vertical. Farther away, the course should have had a slant, when projected on the sky, except where seen from the direction from which it came and toward which it passed. It is reported as vertical from San Marcos, LaGrange,

Moody, Sansom, and San Angelo. Moody and Sansom alone of these places, lie close to the plane of the meteor's path. On the south side of this path, its projection in front of an observer would be from right to left, downward; and, on the north side, the slant should be from left to right. Barring some observations made in San Antonio and one doubtful case at Elgin, all observers, both north and south of the meteor's known path, report that it apparently fell at a slant from left to right, which evidently is impossible. The circumstance is mentioned as illustrative of the extreme unreliability of quick determinations of direction in the region of the higher part of the sky. If these observations have any value in the present case, perhaps their effect would be to start the visible path of the meteor some distance farther south in the sky than the other observations indicate. The fact that so many observers disagree also strongly suggests that the path of the meteor was at a high angle with the earth's surface.

THE EXPLOSION

There is no doubt that this meteor was disrupted before reaching the earth. At points farthest out in the area where the meteor could be seen, none of the observers, however, report seeing it explode or break into separate pieces. The meteor evidently went below the visible horizon of these places, and the view did not permit its lowest course to be seen, on account of the curvature of the earth. Among the observers who were within the circle where the last light of the meteor was visible, only two state that there was no explosion, and one of these says that his vision may have been obscured by the haziness of the atmosphere. Sixteen other observers in this area state that they saw the meteor explode.

The accounts given of the appearance of the explosion vary considerably as to details. To some persons, there appeared only a few fragments, while others saw "thousands." When we consider that the fragments must have varied greatly in size and that different observers saw the disruption from different directions and at greatly varying distances, these differences in the reports become perfectly intelligible. Here follow the re-

ports on this feature of the meteor's behavior, as given in the original communications.

Austin: There was a rocket-like shower at end, showing four or five fragments.

Ballinger: The scattering of the parts of the big stone scared us all.

Comfort: As it neared the horizon, it appeared to be torn by an explosion, as a rocket.

Corsicana: Great sparks of fire spread in all directions, just as though a monster skyrocket had exploded.

Cotulla: It burst like a rocket.

Waco: It threw off sparks when it exploded.

Baird: It burst into many fragments.

Llano: The ball of fire seemed to burst into many pieces, like the explosion of a skyrocket.

Brownwood: It exploded into many pieces.

Burnet: It exploded into a number of pieces.

Fort Worth: It gave off many sparks when it exploded.

Moody: It burst into many pieces.

Crowell: It burst in all directions.

Abilene and Rosebud: It burst into a thousand pieces.

HEIGHT OF POINT OF EXPLOSION

This meteor could not have been extinguished lower down than 5 miles above the surface of the earth, and not higher up than 7 miles. The greatest distance between any two points located in opposite directions from where the fall occurred and where the meteor was seen to explode before reaching the ground, is about 350 miles. But there are many points 50 miles nearer the fall where observers saw the light of the meteor reach the horizon without exploding. These disagreements in the reports are evidently due to differences in the topography surrounding the observers. There is thus a zone in the periphery of the area of observations where the reports decidedly disagree as to whether the meteor did or did not reach the plane of the visible horizon in its incandescent condition. (Fig. 6.) At Electra, the last light was a bright and widely dispersed "red glow," evidently rendered such by coming through the lowermost visible strata of the air, possibly even from below the true Electra horizon. An observer at Grandview describes the last light seen as a "sunset glow."

If we take the outer rim of the zone of conflicting reports for the periphery of a circular area beyond which the meteor appeared to reach the horizon of the observers, we are likely to assume true conditions. The curvature of the earth for the

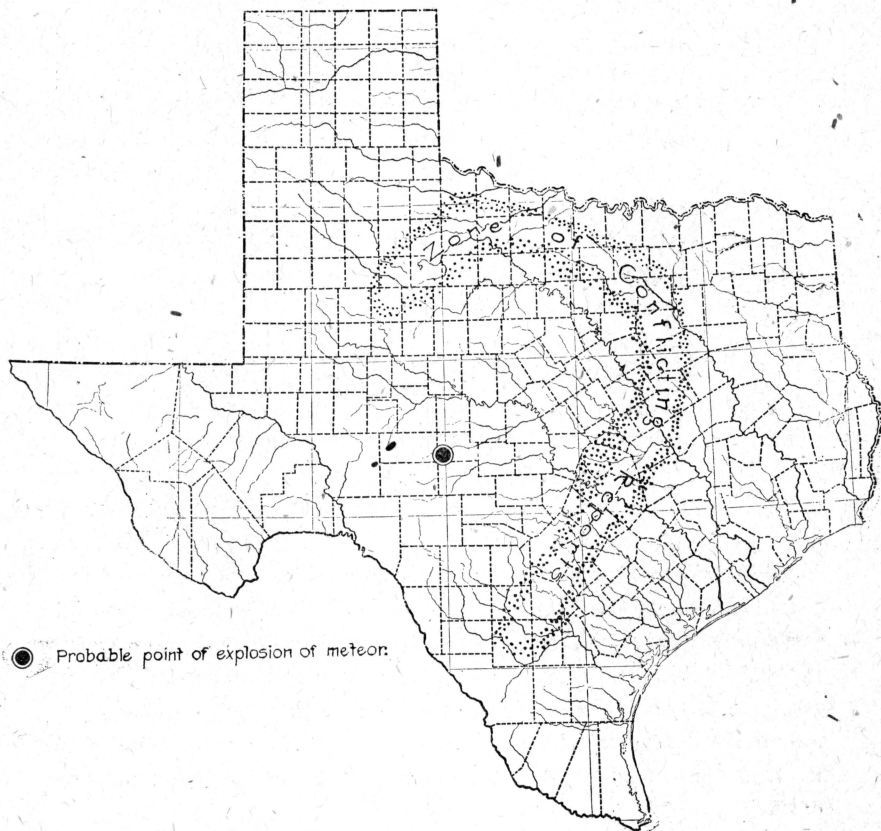


Fig. 6. Map showing the location of a zone separating the region where the explosion of the meteor was visible from the region where it was invisible on account of the curvature of the earth.

radius of this circle approximates 5.8 miles. This, therefore, appears to have been the height above the ground at which the meteor ceased to be luminous. A striking feature of this peripheral zone is that the center of the circle it limits is to the north of the indicated area of the fall. This is without doubt to some extent due to the general topography of this region. The

south extension of the zone of conflicting reports follows the west edge of the coastal plains, where the Balcones Escarpment perceptibly raises the western part of the visible horizon, and limits the view in that direction. In the northwest extension of the zone, the general slope of the ground to the southeast might enable an observer to see a falling light some distance below the true horizon, and would thus throw this part of the zone farther to the northwest.

That the meteor ceased to be luminous somewhere near the height of 6 miles is corroborated by three individual observers who evidently carefully noted the elevation it had at the time it disappeared. Miss Elisa Y. Stiebel, in Brady, noted that the explosion occurred when the meteor was at the height of about one-eighth of the distance from zenith to the horizon. If the extinction occurred at the point to be indicated later, this gives an elevation of a little more than 5.5 miles. Mr. J. H. Mathey, at Losoya, a gentleman accustomed to making accurate astronomical measurements, noted that the meteor at its disappearance was in line with the top of some mesquite trees 15 to 20 feet high, at a distance of about 375 feet. Allowing for the earth's curvature, this gives an elevation of 9 miles. Again, Mr. P. M. Ellis, at San Saba, reports that the meteor disappeared at the height of two and a half hours' time as the sun travels. Estimating this to be nine degrees above the horizon, and allowing for curvature, the disappearance should have taken place at a height of 7 miles. The general agreement of all evidence on this point seems quite conclusive that the meteor ceased to be luminous when within a distance of 6 or 7 miles from the earth.

DURATION OF THE FLIGHT

Estimates on the duration of the flight from the time the meteor first appeared to the time it disappeared vary within very wide limits; from less than 1 second to 300 seconds. This is not surprising. Few people have any practical knowledge of the length of a minute's time, and most people think of a second as only an instant, whereas it equals the time of a step in a lazy walk. Here we have an instance of the superior value of special

training, as in the case of musicians and physicians, and of native deliberate discernment in making observations. It is well known that in matters of this kind the observations of a few capable persons come much closer to facts than the average of a large number of observers, selected indiscriminately. The average of all thirty-five observations in this case is 20 seconds. At this rate, the meteor should have swung around the sky more than once. We must eliminate, in the first place, all estimates exceeding 20 seconds. We must also disregard estimates giving figures that represent generalizations, and that do not necessitate any really careful consideration of the measurements of time, such as the figures 5, 10, or 15. What remains in the present case are estimates varying from less than 1, to 4 seconds. The shortest of these estimates must also be discarded, for they, without a doubt, represent only a part of the time the meteor was visible.

A better approximation, I believe, can be made on the basis of some circumstantial evidence furnished. This evidence involves happenings that either actually occurred or that might have occurred while the meteor was visible. Some of these data are given in general descriptive terms. I have attempted to rate all these estimates, and an average of these ratings makes the time involved slightly in excess of 3.5 seconds. The data on which this estimate is based are given below, in the language of the observers themselves, as follows:

Rated at 3 seconds of time:

1. One man "saw the light, turned around, and saw the bright flash of the meteor."
2. "This meteor lasted as long as you casually would look across the sky."
3. One party "noted growing light, turned face to car window, and saw meteor."

Rated at 4 seconds of time:

4. A man, seeing the meteor, said to others, "See that meteor!" The others turned and saw it.
5. On noting light, one party "had time to turn in bed and see last appearance of meteor."

6. A man "saw the meteor, caught two men by their arms"; these "turned and saw it."

7. "Walking north, on noting light, I turned to south and saw meteor."

8. A woman woke up, raised herself, and saw light bright as day.

The duration of the flight was, of course, the same wherever seen. In a few cases the above observations clearly relate to only the last part of the meteor's flight, when it was brightest. In the average, the short estimates are presumably offset by some ratings that may be too high. Everything considered, 3 or 4 seconds seems as fair an estimate of the time involved in the visible flight of the meteor as it is possible to make from the evidence at hand. My belief is that the time did not much exceed 3 seconds. If this be true, and if its visible path was 120 miles in length the initial velocity of this meteor was relatively high, perhaps 40 miles per second, considering the earth as stationary.

WHERE THE METEOR DISAPPEARED

With the data at hand, the geographic point above which the meteor disappeared can be determined within considerably closer limits than it is possible to locate the point where it first appeared. Out of half a hundred observations, I first selected sixteen which seemed to have been taken with the greatest care. The geographic center of the points of intersection of the lines of directions given by these observers was found to be located practically at the junction of Menard, Mason, and Kimble counties. (Fig. 7.) Among these observers, there were three who had made instrumental or other fairly accurate determinations of the direction in which they had seen the meteor disappear—Mr. W. D. Quinn, of Grandview; Mr. J. H. Mathey, of Losoya; and Dr. S. L. Brown, of Austin. The observations of these gentlemen agree very closely. The directions they determined all three intersect in the southwest corner of Menard county. As the explosion occurred some six miles above the ground, and as the meteor evidently traveled southwest, the fragments into which it divided probably fell in or near the northwest corner

of Kimble county. This region is a more or less wooded upland used as pastures. It is sparsely inhabited, and is owned and frequented mostly only by ranchmen interested in stockraising.

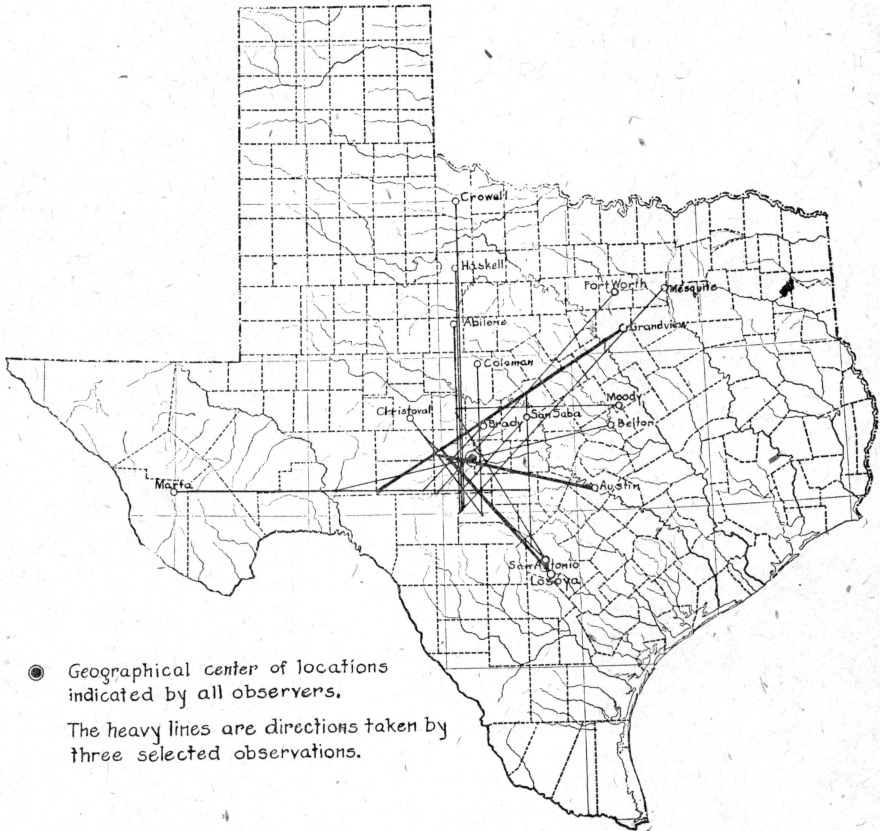


Fig. 7. Map showing places where observations were made on the direction to the point where the meteor disappeared. Directions are indicated by straight lines.

THE LIGHT FROM THE METEOR

Data on the strength of the light emitted by the meteor are quite ample. Statements on this subject are made in nearly all the reports. There is conclusive evidence that over a considerable area near the end of the meteor's path its diffused light was equal to that of the sun, and that the light it shed over the

entire state did not anywhere fall much below the strength of the light of the full moon. In the central part of the state, it was much stronger than the moonlight.

My correspondents were asked to make comparisons between the light of the meteor and other lights they had seen. This gave each observer opportunity to choose the kind of light with which he was most familiar.

Descriptive Estimates

Ten statements, five of which have been gathered from the press, describe the intensity of the light in general terms, involving no comparison with other lights. Excepting the case of one observer at Fredericksburg, none of these refer to places where the light was relatively very strong. They are of little value in estimating the meteor's light, except for one observation at Marfa and one at Wichita Falls, both of which unquestionably indicate that even at these distant places the light of the meteor was comparable with the light of the moon. These general statements are as below.

Marfa: Whole heavens illuminated.

Mineral Wells: The whole heavens were lighted.

Wichita Falls: The heavens were brightly lighted.

Dallas: It lighted up my room.

Jewett: Brilliant flash of light.

San Antonio: The light was strong, brilliant, and beautiful.

San Antonio: Very bright. It lighted up the whole city.

Abilene: The meteor was of unusual brilliance.

Brenham: The meteor was of unusual brilliance. The earth was brilliantly lighted.

Fredericksburg: The streets were brilliantly illuminated.

General Comparisons

Twelve correspondents made general comparisons with all other lights they recollect having seen. They had or had not seen brighter lights. It is probable that at least some of these statements were made with an unconscious elimination of sunlight as an object of comparison. It is quite uncertain what relative light value can be assigned to different ones of these

statements. Evidently these observations vary greatly. Below is an attempt to arrange these observations in order from the weakest to the strongest. The statements are given in the words of the correspondents as nearly as space permits. The phrasing of the writers is often itself significant.

Atoka: Brightest light I ever saw in the sky.

Dallas: Illuminated everything plainly. But I have seen stronger lights.

Dallas: The light was stronger than anything I have seen.

San Angelo: The most brilliant meteor ever seen in this section.

Abilene: As vivid a flash of light as I ever saw.

Rosebud: The brightest light I ever saw.

Austin: Very much greater than other lights I have seen.

Cotulla: The light was much stronger than anything I ever saw.

Athens: I have never seen a light so brilliant.

San Saba: I have never seen a light nearly as strong.

Brady: The light was stronger than any I have ever seen.

Llano: The most brilliant light human eye has ever seen.

The last statement is the only one which certainly indicates a brightness comparable with sunlight. It is evident that some of these observations do not refer to the diffused light dispersed by the meteor, but to the light coming direct from its luminous body. These cannot very well be used in the estimate it is desirable to make on the quantity of the light emitted. This is true also of other observations to follow. All are, nevertheless, placed on record.

Estimates Made on Physiological Effects

In twenty-four instances, attempts were made to convey an idea of measure of the light by its physiological effects on those who saw it. Thus, it is mentioned that the light blinded, dazzled, and startled people, or woke them from their sleep. The human nervous system is a most unreliable standard of measurement, and it would be futile to attempt even to arrange these in any graduated sequence. Perhaps the guess can be made that the light seen in most of these cases was not strong enough to justify a comparison with daylight, while it appears also to have been

too strong to permit a comparison with the light of the moon.
(Fig. 8.)

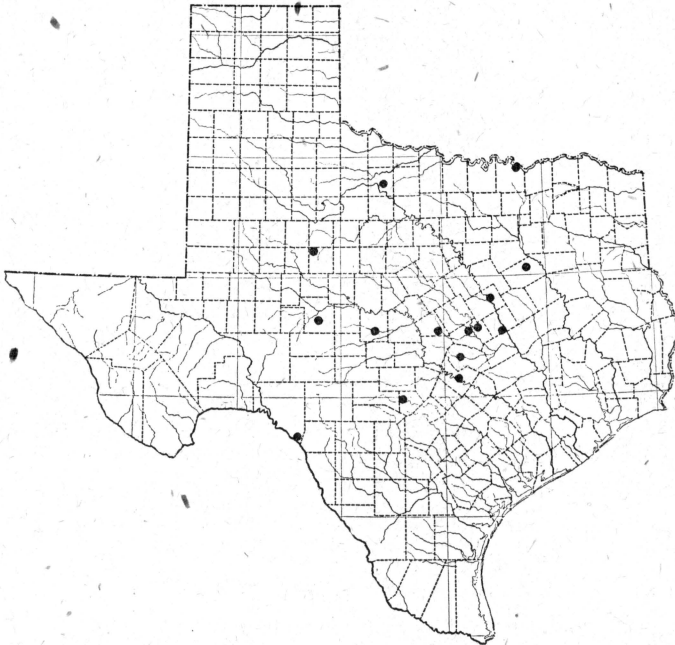


Fig. 8. Map showing places where the light of the meteor is reported to have blinded or dazzled the observers.

Georgetown: Like a blinding flash of lightning.

Waco: It filled my room with a light that was nearly blinding.

Denison: The whole firmament was instantly brilliant. The light temporarily blinded those who looked upon it.

Austin: The full moon was totally eclipsed. No other light I have witnessed can be compared with it. It was unearthly, and blinding.

Roscoe: It produced a blinding light that illuminated the entire heavens.

Christoval: The light was so vivid that it almost blinded those who saw it.

Del Rio: The effulgence almost blinded those who saw the phenomenon.

Lampasas: It made a blinding light.

Austin: So brilliant that it was nearly blinding.

Belton: I could plainly see Temple, eight miles away. The light was blinding.

Brady: People were blinded by the dazzling light.

Corsicana: Blinding white light.

Rosebud: The light almost blinded one to look at it.

Seymour: It had a dazzling glare.

Comfort: Illuminated the heavens with a dazzling brilliance that flooded rooms in houses.

Temple: Dazzling light.

Austin: The light was intense and dazzling.

San Antonio: Very bright, violet light, not glaring or uncomfortably bright.

Cotulla: The light was so brilliant that people at night session in a lighted room in the county courthouse were startled and made a rush to the windows to ascertain the cause.

Gatesville: Some people were awakened by the light while asleep in their rooms.

Frost: Awfully strong. Two persons with eyes closed from sleepiness, while riding in a car, woke up from its flash.

Big Springs: People were startled by the unusual glare.

Junction: The brilliant light . . . brought forth various speculations as to what was happening.

Llano: Lighted up the town with startling brilliancy.

Comparisons with Other Lights

Direct comparisons with other lights are reported in forty-two instances. From Turnersville, it is reported that the meteor was "intensely brilliant, like an iron in welding heat." Evidently this applies to the meteoric body itself. At Georgetown, one reporter says the light was stronger than any lightning he had ever seen; and, at Abilene, a newspaper report says that some people attributed the light to lightning. Three comparisons are made with the light of fire. It is thus stated that, at Electra, it lit up the whole landscape like a rocket. From Fort Worth comes the statement, "No firelight as bright"; and, at Cleburne, the light given out by the meteor is said to have been as strong as the light from a building on fire, four or five blocks away. In Austin, one correspondent notes that the light was like the illumination made by a mercury light on a motion picture screen.

Comparisons with flash lights were made at four points, as below:

Waco: It resembled a flash light used in photography.

San Antonio: It reminded me of a photographer's flash light, only much stronger.

Gainesville: It shed throughout the city the most brilliant flash-light illumination.

Austin: A tremendous flash of light illuminated the entire sky.

The preceding comparisons come from points where the meteor's light was of intermediate brightness, neither as intense as in localities near where the meteor fell, nor as weak as it evidently was far out from that place. The same may be said about ten comparisons with electric lights as given below. It should be stated that nearly all of these descriptions evidently are to be understood as referring to the more or less diffused and reflected light to be noted within the range of practical usefulness of the artificial lights with which the light from the meteor is compared, at a distance of, say, from ten to several hundred feet from the lights themselves, as the case may be.

Clifton: It lit up my room with an intensity equal to the light of an electric light.

San Antonio: Less dazzlingly brilliant than the light of a strong electric light.

Mineral Wells: It lit my room like a light globe.

LaGrange: Comparable with a 100-watt globe.

Coleman: Strong as a locomotive headlight, or stronger.

Kaufman: Comparable with an electric light of immense candle-power.

Round Rock: Like a very intense automobile light.

Austin: More brilliant in my room than the light of an automobile.

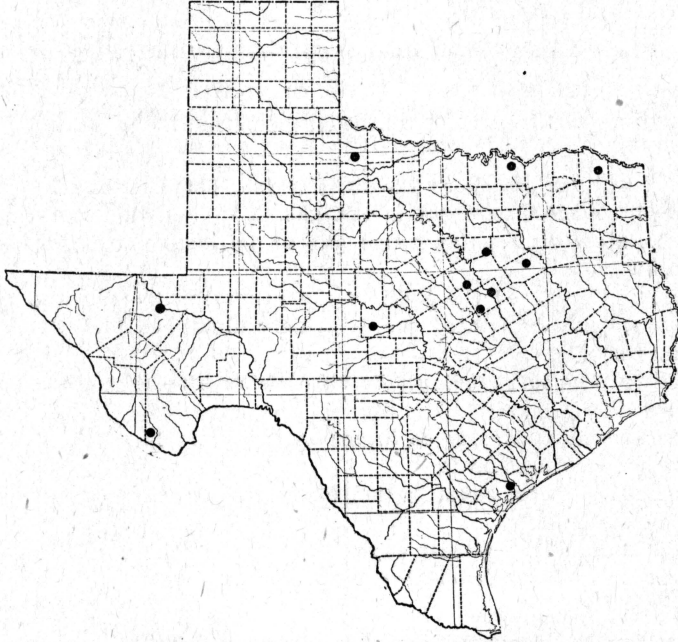
Calvert: Put the moon and the electric lights out of commission.

Temple: It was so bright that it made a locomotive headlight look like a lightning bug.

Comparisons with Moonlight

Comparisons with moonlight have been made either directly or by inference in eleven instances. All of these comparisons come from either farthest out in the peripheral area covered by the meteor's light or from the zone between this peripheral region and the more strongly lighted area nearest to the region

where the meteor's light was most intense. (Fig. 9.) These observations are as below:



ported to have been stronger than the light of the full moon. Fig. 9. Map showing places where the meteor's light is reported to have been stronger than the light of the full moon.

Annona: The light overpowered that of the moon.

Austwell: Stronger than either the moonlight or the light of a car.

Clifton: More brilliant than a full moon.

Pecos: It was so bright as to produce its own shadows in the moonlight.

Sherman: The light was a great deal stronger than moonlight.

Grandview: Brighter than bright moonlight. As bright as day.

Moody: The moonlight, which was bright, was not to be compared with it.

Brady: The light was much brighter than that of the moon.

Corsicana: It was dazzling. Many times lighter than the full moon.

Waco: Bright moonlight was intensified beyond estimation.

Terlingua: Brighter than the moon.

Comparisons with the Sun's Light

In twenty-two instances, comparisons have been made with the light coming from the sun.

In nine reports of this kind, the meteor's light is expressly judged as being less in strength than daylight. Only two of these nine come from the central region, thus:

McDade: As strong as the light is just before sunrise.

Baird: Almost as bright as daylight.

San Antonio: The landscape was lit up nearly as bright as by daylight.

Elgin: It caused the light of the full moon to pale into insignificance, and illuminated the firmament almost as brightly as the noonday sun.

Baird: The surrounding hills were visible almost as plainly as in the day.

San Antonio: Nearly as bright as the sun. It was difficult for me to keep my eyes on it.

Burnet: Almost equal to that of the sun. It far surpassed that of the full moon.

New Braunfels: Almost daylight.

Brady: It lit up the earth almost as bright as day.

In thirteen reports, the light of the meteor is said to have been either as strong as the daylight or else stronger. Seven of these observations come from the region where the strongest light of the meteor developed nearest the earth, and the other six were made near the outer border of this area. (Fig. 10.)

Abilene: The meteor lighted up this entire section as though it were midday.

Abilene: Rooms in houses became as light as day.

San Antonio: Very brilliant. Night turned to day.

Miles: Just like daylight.

Brownwood: Like daylight, it flooded the rooms with light.

Moody: Just like daylight. Could be compared to looking at the noonday sun.

Hamilton: As bright as day.

Mason: Diffused light as bright as day. The meteor itself was as bright or brighter than the sun.

Llano: In brilliancy, it seemed to rival the sun.

Brady: The light seemed stronger than daylight.

San Saba: Stronger than looking directly at the sun.

Castell: A glaring streak of fire brighter than the noonday sun.

Haskell: Lighter than day.

THE COLOR DISPLAY

The light shed by the meteor was in the main pure white, mingled especially in the outer part of the illuminated head and trail with several other colors. During the passage of the me-

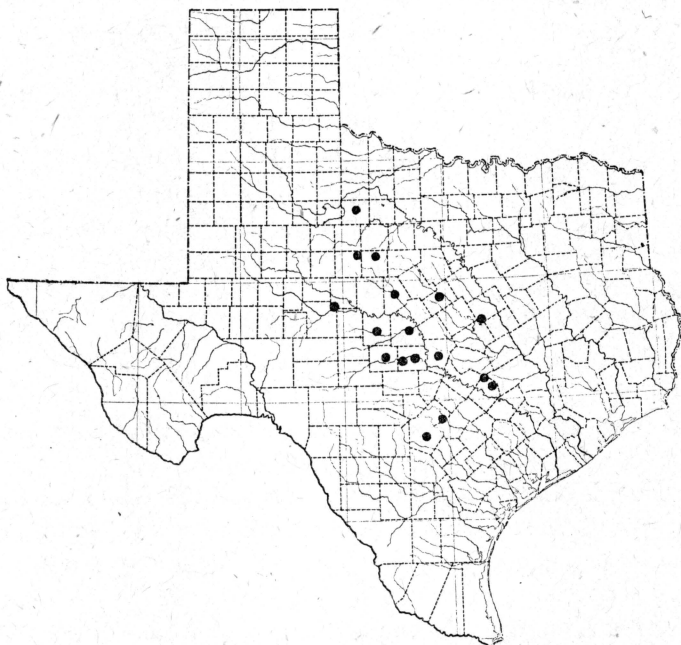


Fig. 10. Map showing places where the meteor's light is reported to have been equal to daylight, or even stronger than this.

eteor, these flashes also seemed to change from one color to another. The colors noted by different observers are not many in number, but they present quite a variety of combinations. The following kinds of light are mentioned as many times as indicated in each case: white, 33; blue, 16; red, 14; firelight, 12; purple, 6; yellow, 5; green, 4; bluish white, 3; orange, 2; rose, 1; silvery white, 1; violet, 1; strontium red, 1; sunset glow, 1.

Two reports state that white was the only kind of light seen, and seven others make no mention of any other light. The nine localities in which these observations were made are neither far out nor close to the central region of the area where the meteor was visible. Twelve reporters speak of the meteor merely as a ball of fire, leaving the inference that it may have shown any of the colors of a flame. Similar inferences are to be made from two reports speaking of the colors of the rainbow and from one stating that the light had "all colors." Four observers mention no other color than red. These reports all come from far out in the lighted circle, where the meteor appeared low down on the horizon. One speaks of it as causing a "sunset glow," and another says it caused a "tremendous red glow." Evidently the red color of the light was caused by the light passing through the lower part of the atmosphere, like the light of the setting sun. The mention of red with other colors, in reports from such places as Cleburne, Gainesville, Big Spring, and Waco, should perhaps be accounted for in the same way, as should also the fact that the last light seen from Coleman was red, and that the meteor was like a red ball of fire when low down on the horizon at Losoya, in Bexar County. But there can be little doubt that some of the other color displays are to be regarded as a result of the burning of some of the elements present in the meteor itself, as in a blowpipe flame. The appearance of green may very well have been due to the presence of nickel or of copper, which is believed to be always present in the nickel-iron alloys of meteors. The yellow noted may have been due to the presence of sodium, and the blue and purple may have been caused by the presence of potassium, or of sulphur in combination with iron or nickel. Very likely, also, some red noted in the outer part of the meteor's trail and in the sparks thrown off, may have been due to the red glow of cooling particles separated from the main body of the incandescent meteor. An observation made at Brady that the diffused "light was lurid white, but the meteor itself was red," may indicate that in its last visible stage its fused exterior rapidly lost its greatest brilliancy through reduction of its temperature. Not all of the reported color display can be explained, however, and it must suffice to only

record the descriptions furnished for future reference. From the last three observations in the following list, it appears that the principal color display was to be seen in the meteor's periphery and trail.

Austin: White, yellow behind.

Austin: White, red, and blue.

Georgetown: White, purple, and yellow.

Frost: White, red, and a deep purple.

Burnet: White, reddish, and blue.

San Antonio: Red, white, and blue.

San Antonio: I saw white, red, blue, and purple.

San Antonio: It did not appear white to me, but was a fiery red hue, with a pink border.

San Antonio: It showed no white light whatever. The light was at all times a violet color. The landscape was lit up with a bright purple glare, like that which is found in the night photograph studios.

Moody: White, red, or yellow; it seemed like many colors.

Austin: White and strontium red, slightly bluish near the border.

McDade: Center red, bordered with blue, and silvery edges to the blue.

Elgin: A bright blue luminous ball of fire was followed by a varicolored tail.

Camp Travis, near San Antonio: The meteor itself was brilliantly white, as was also the fluorescence close to the head; but tail was of different, flashing colors, the predominating ones being purple and red. It was white at the head, violet in the first part of the tail, with a touch of red at the end.

Austin: The meteor itself was white. The sparks radiating from the ball were both orange and red.

Color and Light Changes

As stated above, the influence of the atmosphere probably explains some changes in color that were noted by several observers, as in the case of Mr. J. H. Mathey, at Losoya, who says: "To me, the meteor and tail appeared bluish white nearly half its course, then red, and at last, when low down, a red ball of fire." At Dallas, one report says: "The light was first blue, changing to white with a slight orange tinge." At Grandview, the light first appeared white, and last, at the horizon, it was a "sunset glow." At Turnersville, it is said: "When the explosion occurred, the fragments thrown off became bright yel-

low." The cause of some other color changes seems less evident. A report from Miles states that the light of the meteor was "first white, then blue and other colors"; while another report from the same place describes it as "first red like common fire," and later "it became more bluish the closer it came to the earth." This change to blue is reported also from LaGrange, where it is said to have been "white, with blue for a short time before it disappeared." At San Antonio, it is by one observer said to have turned from white to purple.

From three different directions, the light appears to have changed in color or brightness not only once but twice, and at least one of these changes would appear to have been due to some other cause than the selective influence of different parts of the atmosphere. Thus, at Corsicana, it is said that the light was "first white, then fire-colored, then blinding white." At Coleman, the observation is made that the light "must have been blue at first, because everything looked blue in front of me. When I looked at the meteor, it turned white; and, when it was going out, it turned red." From Atascosa comes another statement to the effect that the intensity of the light was diminished in the middle part of the meteor's course and then again greatly increased. Of course, such changes might be due to the presence of some hazy stratum in the atmosphere, intervening between the meteor and the observers; but, if we reflect that the first change must have taken place at an altitude much higher than the highest zone of clouds, such an hypothesis loses much of its credibility, and the suggestion comes that the change noted may have been caused by a rotation of the meteor, exposing new surfaces to atmospheric friction. This seems all the more probable when we consider the enormous resistance of the atmosphere, which is known greatly to reduce the speed of meteors at the altitudes where the observed changes apparently occurred. The full notes on these changes, observed at Atascosa by Mr. M. Foslin, appear so circumstantial that they deserve to be placed on record. "In its descent, the meteor gave a double flash of light. . . . The first two or three seconds of its visible descent, it passed through a clear atmosphere, and it gave off clear bright light. Then it seems to have struck a more dense or

heavier atmosphere, which seemed to retard its speed. It looked as if it would disappear from view at this time. This period lasted perhaps for a second. During this period, its trail almost faded from view, and it grew dark again. Then it rapidly increased in brilliancy and size until it exploded."

MATERIAL THROWN OFF

One of the questions asked my correspondents was whether the meteor appeared to throw off any sparks or fragments. Fifty-four replies are given to this question. Of these, twenty say that no sparks were seen. It is interesting to note that most of these negative replies come from persons in the periphery of the region of the meteor's appearance. Of the thirty-four observers who note sparks, it is evident that in a number of cases they have reference to the luminous material thrown off to form the trail. Thus, it is said that "there were sparks from the first to the last of the meteor's flight." I interpret in this way, also, the following expressions: "Sparks and bars of light were seen after the meteor"; "it appeared like a fuse on a railroad"; "in the last half of the course, the meteor became red and threw off a wide train of sparks"; "it appeared like a skyrocket"; "a great many fragments and sparks seemed to be left behind." Farthest away, these sparks evidently appeared like a diffused light in the path of the meteor. That some of the material thrown off along the meteor's course consisted of bodies that were large enough to appear separate is indicated by some statements, such as "a few sparks were seen near the end of its tail"; "a blue luminous round head was followed by a bright tail, and this followed by a series of brilliant detached sparks." Nineteen of the reporters state that the course of the meteor terminated with an explosion, from which fragments were seen to fly in all directions. In several of these reports, the meteor is described as resembling a rocket or a bomb. A report from Ballinger says, "The scattering of big stones scared us all." At Corsicana, the meteor appeared as a long blaze of fire, and later there was "an explosion, and great sparks of fire spread in all directions, just as though a monstrous skyrocket had exploded." At Abilene, "it appeared to burst into a thousand pieces." At

Brownwood, an observer says it "exploded into many pieces." At Comfort, "it appeared to be torn by an explosion as a rocket, as it neared the horizon."

There were also connected with the meteor's flight phenomena which resembled flames, evidently extending laterally out, widening the meteor's trail. This is indicated by such statements as that the meteor "for half its distance threw out a great flame of light"; that "a ball of fire was followed by a train of flame"; that it "left an immense trail of light," which one observer describes as having been only "about seven times as long as wide"; that "the large reddish body threw off streams of flame," and that it threw off "a great volume of flames" that "seemed to go straight backward."

THE LUMINOUS CLOUD

The luminous cloud or train which is usually left in the atmosphere by a falling meteor, was noted by several persons. A correspondent in Mason says, "I saw a bright place in the sky where the meteor had come from." From Christobal, it is reported that "the meteor left a cloud of smoke in its path that was visible for several minutes." From San Saba, it is reported that "the meteor left a cloud of smoke behind it," and from the same place comes also the statement that "where the meteor disappeared a large circle formed, and remained at least an hour, as did its path also." This circle probably represented a spherical cloud resulting from the explosion. Still another report from the same place states that the meteor left a bright path, which stayed for about an hour, but changed color. The long duration of the luminous cloud was noted also at Santa Anna, where a report states that "the illumination in the wake of the meteor remained an unusual length of time and assumed a fantastic shape, forming the letter *L* in the sky." The peculiar change in the form of the cloud noted in this case can readily be accounted for as the result of the meteor's path passing through two divergent currents in the atmosphere. From the direction of Mason, this change in the form of the white cloud was evidently less apparent, as we may infer from a note saying: "People saw a great cloud of smoke clear across the

heavens in the path over which the meteor had just passed. This cloud remained about three-quarters of an hour before clearing up." Another note on the same phenomenon by a party at Brady is to the effect that "after the explosion there remained a vapory cloud for fully five minutes where the explosion occurred, and the spot from where it seemed to have started appeared as a misty ball about the size of the moon. . . ." Another reporter from Brady says that the meteor "left a trail of bluish-like smoke in its wake, which remained in the elements some 30 or 40 minutes after its passage." The cloud was even visible as far away as San Antonio, from where a lady writes: "Immediately after the flash, I noted what appeared to be smoke, and for five minutes could distinctly see it take the path as indicated (a figure like the letter L turned over), then seemingly disappeared."

DETONATIONS

The detonations which usually accompany falling meteors were quite pronounced in this case, and were a subject of general observation and comment among people in the central region. Such thunder-like sounds have been described in the case of many earlier falls. The observations made at this time contain nothing new, but corroborate the general facts already known. The reports received will, I think, give a fair idea of the sounds heard.

Calvert: "I heard an explosion in the northwest like that of a big cannon."

Buffalo Gap: "The explosion was not very loud."

Junction City: "An unearthly rumbling noise accompanied the meteor."

Lampasas: Light noise, similar to thunder, was heard a few minutes after the light, and windows in all parts of the city rattled as though there was an earthquake.

Temple: The meteor "exploded and made a roaring noise."

Brady: The dull roar or rumbling noise that followed the meteor rattled windows and dishes.

Cypress Mills: There were two roars like a heavy thunder ten miles away. Each lasted about three seconds, separated by an interval of three seconds. The first sound was heard some time after the light disappeared.

Burnet: "Persons who heard the four or five explosions state that the rumbling was at least five minutes after the light disappeared." "The light was followed a few minutes later by several deep explosions resembling rumbling thunder, which caused some of the houses to shake and tremble."

Belton: Sound "like an airship roaring."

Cypress: Two reports like a cannon and roaring like thunder, or like a heavy railroad train.

Kerrville: "There was a noise as of thunder." "The great detonations following were from three to five minutes in reaching here. The earth apparently trembled and the window panes rattled, so terrific was the sound."

Comfort: "Many still studying the appearance of the heavens about eight or ten minutes after the fall were startled by a loud reverberation as of thunder in the mountains, which caused the houses to tremble and windows to rattle."

Fredericksburg: "A loud concussion followed, then a rumbling noise like distant thunder. The tremor from the concussion could be plainly felt, and was noticeable also by the rattling of windows."

San Saba: "From where it disappeared, a loud thundering noise commenced, lasting several seconds, rolling directly back on its course. Most everyone that did not see the meteor was awakened by the noise. The earth seemed to shake. Some neighbors report the windows shook in houses."

Castell (Llano County): In about three minutes, a terrific report was heard, the roaring and resounding of which lasted for a minute more.

Brady: "Rumbling noise, like thunder, began three minutes after the light, and continued for several minutes. It gradually died out." "Five minutes after the light, most terrific rumblings and explosions were heard, awakening the entire town, shaking windows and dishes, and even houses, with earthquake-like tremor." "One minute after the fall, explosive sounds were heard, first at intervals like cannon, then very rapid with less volume." "The noise was very distinct some minutes after the disappearance, like low distant thunder, with very distinct trembling of the air and shaking of the windows, just as would occur after a heavy rolling thunder." "About two minutes after the flight, we heard a roaring noise in the southwest, which must have lasted two whole minutes."

Llano: "Fearful noise" and "terrific blast" are descriptive terms used in the local papers. "The houses in Llano were badly shaken up." (Telegraphic news item from Llano.)

Mason: "Many heard the roaring noise and ran out of houses. Many say houses were shaken from the jar, and that considerable excitement among dogs, chickens, and stock was caused by the effect

of the meteor and the fuss(!) made by it." "Three or four minutes after, he heard the loudest rumbling and roaring noise he had ever heard, and it appeared to come from the sky where the meteor came." "Immediately following the meteor was the loudest roaring noise that has ever been heard in this place by anyone."

Point of Explosion Indicated by the Sound.

Data on the time-interval between the extinction of the meteor and the first thunder-like sound heard in the central region are very meagre and too uncertain for throwing much light on the location of the explosion. A judicious selection from a dozen estimates at hand would seem to indicate that the first violent sounds were heard at Mason and Castell, about three minutes after the explosion occurred. The sound should then have traveled from a point some thirty miles away from, say, the center of the east half of Mason County—on arriving there. At Brady, the interval appears to have been about five minutes; at Lampasas and Burnet, six. At Comfort, it is reported as nine minutes; and, at Kerrville, only some fifteen miles away to the west from Comfort, it is reported as occurring four minutes after the explosion of the meteor. Averaging these two estimates, we may conclude that the time consumed by the sound waves in traveling from the point of explosion to the east end of Kerr County was about six minutes. A point twelve miles north of Brady, the towns Lampasas, Burnet, Comfort, and Kerrville define, roughly, the east half of a circle whose center should be somewhere in the southwest part of Mason County. (Fig. 11.) The arrival of the sound waves from the explosion appears to have been more or less synchronous at these points. This circumstance confirms my belief that the meteor probably fell not far from Kimble County.

NOTES ON A WHIZZING SOUND

Several persons relate that they heard a whizzing sound, and that this was simultaneous with the appearance of the meteor itself. It is reported by four persons in San Antonio, from where one communication says that it resembled the sound from "escaping steam." At Santa Anna, it is described as "a spew-

ing noise, like that of a small amount of powder." One person in San Antonio says this sound was like the swish of a whip in the air, and it is also stated that it appeared to come from



Fig. 11. Map showing places where sounds are reported to have been heard.

some bushes or from the grass on the ground. Other descriptive phrases used are: "A hissing, whizzing sound"; "a whirring sound"; "a faint buzzing sound."

The first suggestion is that these sounds were merely subjective associations, brought by the rapid motion of the meteor. They could not have been produced as real sound waves in the air by the meteor directly, arriving, at it appears, simultaneously

with its light. But the reports are couched in such reasonable language and come from so many entirely creditable sources that I am inclined to believe the phenomenon is worth future attention and consideration. In furtherance of such an attitude, I have called attention to this reported sound in *Science* for December 21, 1918 (pp. 616, 617). Dr. F. M. Pottenger, of Monrovia, in California, has later informed me that some thirty-seven years ago he saw, in company with his brother one evening, a great meteor in Indiana. He says that their attention was called to something unusual, first by a hissing sound, such as was noted in association with this fall, and then by a bright light, which cast shadows on the ground. Upon looking to the northeast, they then saw a large ball of fire passing across the heavens.

If these observations are not subjective, the cause of the sound may perhaps be sought in ether waves that, on meeting the earth or objects attached to the earth, such as plants or artificial structures, are in part dissipated by being transformed into waves of sound in the air. Whether such a transformation of energy is possible, it is not my purpose here to discuss. The suggestion is merely made for what it is worth.

OBSERVATIONS OF UNCERTAIN SIGNIFICANCE

It is difficult to pass judgment on the real significance of some reported observations. It is well known that certain individuals are sensitive to various stimuli that do not affect the nervous mechanism of most people. Some are gifted with almost abnormally developed acuteness in the most highly specialized sense organs, such as those of vision, hearing, taste, or smell. Some people are also sensitive to barometric changes. It does not at all seem unlikely that the light which the meteor developed should have been accompanied with sufficient heat to have been felt, even by a normally developed capacity for discriminating temperature. It is, therefore, not surprising that one observer at Grandview should relate that he "felt a warm air," and that another at Cleburne reports he "saw the light and felt the heat" of the meteor. These reports are possibly quite correct. Whether the same can be said of a report from San Antonio, to the effect, "We thought we smelled a faint odor, as of sulphur

or chemicals," is questioned by the observer himself, as it appears. Another observer, at La Grange, who says, "I smelt a faint odor as of burning powder," is less uncertain. In the case of faint odors, mental associations are known to be likely to interfere with correct judgment. The significance of two other statements is problematic, as when one report from Cleburne says: "I seemed to feel it rather than hear it. It created a peculiar sensation, which was like a slight electric shock"; and as when another person writes from Brady: "My first consciousness was an oppression of the air, as when a car passes swiftly by us." Both of these sensations may very well have been subjective. But we cannot be absolutely certain that such was the case.

PSYCHOLOGIC REFLEXES

The psychologic effects of the meteor's appearance are to some extent indicative of the unusual phenomena with which it was accompanied, and may be useful to record for future comparison with other falls.

People Were Awakened

Many people had retired at the time the meteor fell, and were already asleep, in the light slumber of their first hour of rest. Reports from Hillsboro, Meridian, Elgin, San Antonio, Lampasas, and from Era relate that people were awakened from their sleep by the sudden light. At Elgin, many rushed from their beds to windows in rooms where they were sleeping, to learn from where the light came. Some had time to see the meteor, as was the case with an observer at Era, who writes, "Sleeping, I woke up and opened my eyes just in time to see the great light." A young lady, riding comfortably in a car near the same place, had gone to sleep, woke suddenly up, and thought she saw the light right in front of the car. At Lampasas, many people were awakened by the detonations which followed the meteor, and in San Saba the noises were so powerful that "almost everyone was awakened."

The Light Was Blinding

That the light emitted by the meteor was quite intense is evident from a number of reports which state that people were blinded. It appears that some persons who were thus blinded happened to look right at the luminous head itself, but evidently others also were momentarily thus affected. Lightning frequently has the same effect, when occurring in the darkness of a cloudy night. The pupil of the eye is then widely relaxed, and the excitation by a bright light of the nerve center controlling the sphincter closing the opening through which the light enters the eye, results in a prompt and violent contraction which may be painful, and which even may produce such a result as is reported from Temple by a person writing, "The light blinded us, and it gave some of the crew (of a freight train) a bad headache." Sensibility to stimuli of this kind no doubt varies greatly in different people, and, for one, I am not inclined very seriously to doubt the correctness of another report from the same place. This is to the effect that a workman who was throwing a switch after an outgoing train, was constrained to have the train back up, so that he might more easily find his way to mount it. Another person farther north reports that he stopped the car he was driving while his blinded eyes returned to their normal condition. The blinding effect of light is partly due to the suddenness of its coming, and it is greatest at night, when there is no previous exhaustion of the nervous center which brings it about. It informs us in this case that the light came suddenly rather than that it was unusually strong.

People Were Startled and Excited

Many people who were awake were startled by the sudden appearance of the light. At Cotulla, "a night session of the district court was being held, and the illumination of the sky was so brilliant that people inside the building were startled, and there was a rush to the windows to observe the cause of the light." Two men sitting in a poorly lighted room in Henrietta stepped out to investigate what made the light. From Comfort, it is reported that "a number of people rushed out

of doors to ascertain the source of the sudden illumination which flooded their rooms, and many remained outdoors for quite a while to watch the sky after the light disappeared." A report from Elgin says that "many people in their homes were startled and puzzled by the extremely brilliant light."

A news item in a paper from Gainesville says that "people were startled," and that "expressions of wonder and amazement were heard from people who witnessed the illumination." Reports from San Antonio, Llano, Mineral Wells, Abilene, and Big Spring mention that people were startled. "It excited me," is the frank admission of a man in Mount Pleasant; and, at Hillsboro, a news item in a local journal says "there was much excitement." A report from San Antonio intimates that the excitement over the meteor was general only among the superstitious negroes and Mexicans. In Waco, we are informed "telephone messages announced the meteor's fall to the newspapers," and from New Braunfels it is reported that "people excitedly rushed out of their homes to ascertain the nature of the event." The significant remark is added that "no explanation has yet been given." At Junction City, "the falling meteor excited many." A San Angelo report says that "it caused intense excitement" there, and a Kerrville paper reports that "great excitement was caused by the meteor."

People Were Frightened

A sense of fear is explicitly indicated as having been experienced by many people living in the region within a hundred miles of where the meteor must have fallen. That such was the case is entirely natural. The intense light alone was so unusual that by itself it would suggest danger to any thoughtful mind. Where this in a few minutes was followed by violent sounds, as was the case in several places, a sense of fear would have been experienced by any normal individual. In the case of a few reports, as in one of the newspapers from Mason, there is a suggestion of a desire not to disclose the true psychological effect, or to speak, as we say, in a tone of bravado, calling the light and noise a "fuss" made by the meteor. In other cases, there is evidence of a desire to ascribe the sense of fear es-

pecially to negroes and Mexicans. But the general language in these reports is such as to leave no doubt that individuals of the Caucasian race as well actually experienced the sense of fear for the moment. No better evidence of this can be given than the words of the reporters themselves, which are here reproduced as nearly as necessary for brief statement in the form they have been made:

Abilene: Residents were badly frightened.

Brady: Several persons were frightened.

Meridian: People were frightened and amazed.

Baird: Two of my family were badly frightened.

Hillsboro: Two boys out hunting were scared and went home.

Santa Anna: A man was scared worse than he had ever been before.

San Angelo: Some people first feared a German Zeppelin was approaching.

Abilene: I am frank to say it frightened me for a moment.

San Saba: It scared me so that I did not note the duration of the flight.

Frost: We stopped the car we were driving, and started to throw it in reverse.

Del Rio: Many of our good people believed the world had caught fire, and the end had come.

Lufkin: Many people in this vicinity were greatly excited, and negroes and Mexicans thought the end of time had come.

Brady: Consternation reigned supreme among the negroes, and it was the universal opinion among them that the end of the world had come.

Fort McKavett and Eldorado: People were thrown into a frenzy, fearing the blazing aerolite might strike their towns.

Buffalo Gap: We were all pretty badly frightened. My wife screamed when the meteor burst into a thousand pieces, apparently only about twenty feet from the ground.

Grandview: A man was scared so that he went home, not knowing how to account for the light. Later he decided to go back and look for what he had seen falling.

Elgin: At least one mammy at a colored gathering called for prayer, as she was sure that the immediate destruction of the world by fire was imminent.

Llano: Some trembled, some wept, some laughed. Some thought the day of reckoning had come. Many woke up and crawled out of bed to see where the fearful noise was coming from. No one was hurt and no buildings were damaged(!).

Fort McKavett and Eldorado: While there was intense excitement in many places in San Angelo when the big blazer went sailing through the sky, it is not to be compared with the excitement that prevailed at Fort McKavett and Eldorado. Reports from these places say people were thrown into a frenzy, and many of them thought the burning matter would strike their towns.

Immediate Suggestions

It is evident that almost all observers soon recognized the true nature of the phenomenon. But that the light and the sound which the meteor produced were unusual is evident from the associations suggested to many of those who saw it descend. On the moment of its first appearance, especially to those who did not see it at its first visible start, it was natural that suggestions should come, depending in their nature on the general trend of thought of each individual. The extraordinary nature of the fall is probably in no case more impressively suggested than by the philosophical statement made in a weekly published in New Braunfels, that "some imaginative observers thought it might mark some great world event." To a young lady in Brady the momentary suggestion came that "something disastrous had happened to the moon," and to some one else in that place the earth-shaking rumbling of the detonations suggested an earthquake shock. At Junction City, in the central area, where both the light and the sound were severe, people naturally were reminded of the familiar account of the end of time. The same suggestion is said to have firmly impressed itself on the mind of an aged and pious woman of the African race, even as far away from the central area as at Elgin. An observer at Mount Pleasant says, "Knowing that the great world war was going on, I thought that the Germans were invading our country with aeroplanes." Like suggestions occurred to several parties. A man in San Antonio, where large military camps are now located, naturally for a moment thought of a magazine explosion. In San Angelo, people thought of German Zeppelins approaching. Bombs, searchlights, liquid fire, and other modern war devices were thought of by some people in Elgin. Speculations involving aeroplanes and rockets were

heard in Seymour, and in San Antonio it occurred to some that a house might be on fire, and to still another that there had been lightning in the sky.

Apparent Distance

To judge correctly the distance to a moving light of unknown size and unfamiliar intensity, when such a light suddenly appears on the starlit sky, is evidently impossible. Nevertheless, there is always left with us some impression of distance to the objects we see. This is based on our experiences and on our more or less correct appreciation of the phenomena that present themselves. From the communications received relative to this meteor, it is evident that many who saw it understood to what class of objects it belonged, and such estimates as were made on its apparent distance are really more or less related to the attendant circumstances. One man judged it to be at least fifty and another possibly two hundred miles away. These observers saw the meteor from the periphery of the area, far out from the central region, and where its resemblance to a shooting star was still within the range of instant comprehension. Even from more centrally located points, a realization of the meteor's true nature was quite general, and many people who saw it fully understood that it must have been far distant from their immediate surroundings. But its unusual size and the intensity of its light prompted in many cases an immediate judgment of distance, quite out of proportion with any judgment formed after subsequent reflection. We may call this the apparent distance of the meteor. No less than twenty-seven such estimates have been submitted. These were made at points from 60 to 250 miles away from where the meteor disappeared. They range from ten feet to two miles. The average of the apparent distances given was 5,151 feet, or about one mile. The ratio between this apparent distance and the true distance is, when both are averaged, as 1:140. The average actual distance was 134 miles. It is to be noted that this ratio itself varies with the actual distance of the points of observation from the meteor. For the zone extending from 60 to 110 miles and having an average distance of 95 miles from the point of disappearance

of the meteor, the ratio is 1:118, and for a zone extending from 110 to 250 miles from the same center, or for an average distance of 180 miles, it is 1:159. These two ratios are not far apart. Evidently there are some general experiences at the basis of these estimates, and these must have been more or less common to all the observers. It is natural to infer that these common experiences are the knowledge generally acquired of distances to artificial lights of like intensity seen near the earth's surface at night. These are apt to fall within the limits of distances given in this case, from ten feet to a few miles away, as already indicated.

Apparent Size

In a similar way, non-reflective and immediate judgments were made by many as to the size of the meteor. There are in all nineteen such estimates. An average of all the estimates, which were made at an average distance of 126 miles from the point of disappearance, is that the object had a diameter of 5.6 feet. These estimates also clearly have a common basis in the experiences of the observers. An average of nine estimates made at points from 15 to 120 miles distant and averaging 73 miles from the point of disappearance, make the diametric dimension of the meteor 1.9 feet, while ten observations taken at points from 130 to 220 miles away and averaging 172 miles distant, make the diameter equal to 9 feet. We have seen that the apparent estimated distance bears a fairly constant ratio to the actual distance at which the meteor was seen, being as 1:140, and varying from 1:118 for localities from 60 to 110 miles distant, to 1:159 for points from 110 to 250 miles distant. From the estimates given as to size by persons at points averaging 73 miles and 172 miles distant, it is evident that the factor of apparent distance, which has been shown to vary with actual distance, influenced the judgments made as to size as well. People who judged the distance short made their estimates of size larger than people who judged the distance greater and *vice versa*. The ratios between apparent and actual distance and apparent and actual size have probably a related if not identical psychological basis, being founded, as already stated, on the

general experience of people, in this case, in observing strong artificial lights near the earth's surface. Our experience in making such observations is at the best very limited, and varies greatly with different individuals. In this case, the observations on distance were mostly made by other persons than those noting size or intensity. The number of observers of distance was twenty-seven. Those reporting size are nineteen. With all these inadvertences, there is no harm in making these observations a basis for speculation as to the size of the meteor, or rather of the incandescent body of air and glowing sparks of meteoric material surrounding the solid mass within.

The equation is of the simplest kind. If the light which appeared on an average to be 5,151 feet away really was 126 miles distant, its actual size should by the same ratio be not 5.6 feet in diameter, but 126 times this measure, which is 706 feet. It is evident that this figure cannot represent the diameter of the meteor itself. In the first place, there is no doubt that all the highest estimates represent exaggerations. Discarding these, the average of other estimates will reduce the apparent size observed to about one-fifth of 5.6 feet, making the calculated size having a diameter of about 100 feet. But even this would not represent the size of the meteor. It appears that most of the observations refer to the size of the light produced at the time of the explosion. How far out from the exploding meteor would the energy released cause the surrounding air and the flying fragments to become incandescent? We can to some extent judge of this by taking a look at some of the figures furnished by several observers. In figures 10, 11, 12, and 14, which bear the stamp of natural representations of phenomena of this kind, it appears that the incandescent envelop of the solid body interiorly located occupies only about one-fifth of the entire flaming head of the meteor. Figures 2 and 13 suggest decidedly that the final explosion resulted in a lighted sphere of much greater diameter than the width of the trail, which we perceive from such figures as 1, 6, and 7, was itself at least five times wider than the solid missile, by which it was produced. The solid meteor, by itself, should then not have been more than five feet in diameter. In view of the observed size (apparent), it would

perhaps be a safe guess that this meteor could not have been one of the smallest nor could it have been an exceptionally large meteor, as meteors go.

CONCLUSION

The event which has been recorded in the preceding pages began and ended within the limit of three or four seconds. It can be told in very short space also. The meteor was first seen some 110 or 120 miles above Burnet or some adjoining county. It traveled about 130 miles, with an initial velocity of some 35 or 40 miles a second, slantingly through the atmosphere toward Kimble or adjoining counties, and exploded when about six miles above the ground. In its general behaviour as to light, sounds, and explosion, it resembled the stony meteorites. It is my belief that the sequence to this tale will be a description of some of the fragments into which the meteor broke, when they shall have been found in or near Menard, Mason, or Kimble counties.