Norton, KA.

THE ACHONDRITIC SHOWER OF FEBRUARY 18, 1948

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At about 4:56 P.M., CST, on February 18, 1948, the appearance of a very large and brilliant detonating fireball startled the inhabitants of Kansas, Nebraska, and several adjoining states. Two hours later, shortly before 6:00 P.M., MST, an account of the extraordinary pheonomena of light and sound accompanying the fall of this bolide reached the Institute of Meteoritics through the alertness of Lieutenant R. E. Young of the New Mexico Wing of the Civil Air Patrol. Although the initial reports described the incident as an airplane falling in flames southeast of the air base at McCook, Nebraska, Lieutenant Young (who had earlier received precisely the same sort of descriptions of the great meteorite fall of October 30, 1947, in the Four Corners region of New Mexico, Arizona, Utah, and Colorado) sensed that the reports from Nebraska and Kansas might also relate to a meteorite fall and promptly relayed them to the Institute as they were received at Kirtland Field in Albuquerque over the CAP communications network.

In the next few hours much additional information was secured through CAP channels and by long-distance telephone calls to personnel at the McCook air base and to others in the area from which the fireball was reported. Through the courtesy of Major Charles L. Phillips, then AF-CAP liaison officer at Kirtland Field, not only Lieutenant Young, but also Captain John Featherstone and Lieutenant Allan Bolles, CAP communications officers, were enabled to co-operate fully with the Institute. The importance to meteoritics of such co-operation can hardly be overestimated. On the other side of the ledger, it seems clear that benefits accrue to the Civil Air Patrol and to other military personnel by co-operating in meteorite hunts, because the circumstances attending the infall of, and the search for, meteorites are in many respects analogous to those encountered in search and rescue work, and resemble even more

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closely those that may arise, if our nation has occasion to defend itself against attack by rockets and other guided missiles.

Because of the notorious inability of the untrained observer to accurately estimate the elevation and bearing of a position, *P,* in the sky—for example, the point of appearance of a meteor—it is axiomatic that wherever possible, transit observations should be made by a trained operator on the basis of directions pointed out by the actual observer at the exact spot from whence his observation was made. It may be impractical, however, to take a transit to all locations where good observations are believed to have been made, and in the preliminary phase of the investigation of a meteorite fall, one has a greater desire to obtain fairly dependable values speedily than to procure highly accurate measures at the cost of much time and labor, which may eventually turn out to have been expended on a "barren" fall.

The considerations just set forth have prompted meteoriticists to devise many schemes whereby even the untrained observer may be expected (by the sanguine) to obtain fairly accurate bearings and elevations. Experience with the sort of data usually secured from even the best-intentioned layman provided with the elementary devices for securing azimuth and altitude readings forced the author to conclude that the instrument best handled by the untrained meteor observer is his timepiece. A method for the determination of azimuth has therefore been derived which requires only that an observer, at a known location, align a pair of pins, driven vertically into a horizontal table top with the point, *P*, in the sky, the azimuth of which he wishes to find, and then record the exact time when the shadow of the sunward pin falls centrally on the other pin. Since the shadow is cast by the true sun, it becomes an easy problem for the armchair meteoriticist to calculate from data tabulated in the *Nautical Almanac* the azimuth of the point *P*.[1] This method was used on the February 18 fall.

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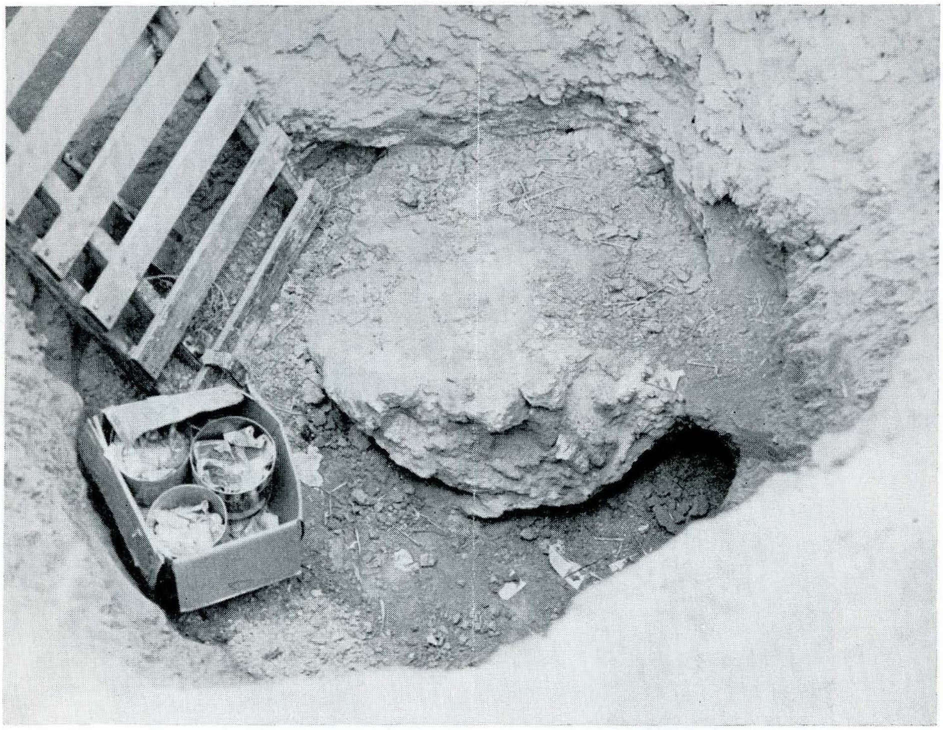
[1] Details concerning this method of azimuth determination were given by the writer in a paper presented at the Eleventh Annual Meeting of the Meteoritical Society in September 1948. This paper will soon appear in the *Contributions of the Meteoritical Society*.

PLATE IV



EXCAVATING THE METEORITE

The partially excavated Furnas County achondrite at the bottom of its impact funnel.

PLATE V

EXCAVATING THE METEORITE

The preliminary phase of encasing the Furnas County stone in a protective sheath of plaster of Paris.

The best observations on this fall, particularly those coming from numerous men with aviation training, were so concordant that by March 3, calculations at the Institute had led to the determination of a provisional "strewn-field" location. This field was elliptical in shape, with major and minor axes of eight and four miles, respectively. The major axis, the direction of which was about 25° east of true north, extended from a point about four miles south of the Kansas-Nebraska line and almost exactly on the 100° meridian, to a point about four miles north of the state line (Figure 1).

With the opening of the Easter vacation at the University of New Mexico on March 24, a field survey party was sent out from the Institute under the leadership of Douglas M. Gragg. From March 25 until the end of the Easter vacation the members of this party attempted to search the calculated strewn-field. Because of blizzards and roads blocked with snow, however, they succeeded only in circling the northeast boundary of the strewn-field in Nebraska and, on March 26, in penetrating a short distance inside its southwest boundary. Although the snow-covered terrain made effective field search out of the question, the Institute party on March 26 interrogated Orville Brown who lived not far south and west of George W. Tansill who was to be the first inhabitant of the region to recover specimens of the fallen meteorite. Later, Brown interested all of his neighbors in the search for the meteorite and was instrumental in bringing to our attention the initial discovery made by Tansill.

Mr. Gragg's party not only obtained much valuable testimony from eyewitnesses, but also made many accurate transit measures of the positions of various points on the apparent path of the fireball. These measures fully confirmed the provisional determinations made earlier at the Institute. Consequently, as soon as weather and ground conditions permitted, a second field survey party, led by the author, returned to search the designated elliptical area. Because there was every indication that the main mass of the fall had come to earth in the northern end of this area, namely, in Furnas County, Nebraska, the second Institute party took quarters at the Commercial Inn in Beaver City, Nebraska, on April 27, and from this base carefully investigated the portion of the ellipse situated in Nebraska. Although the concordant testimony obtained in this area from numerous persons, who still had the keenest recollections of the startling phenomena observed on February 18, completely sub-

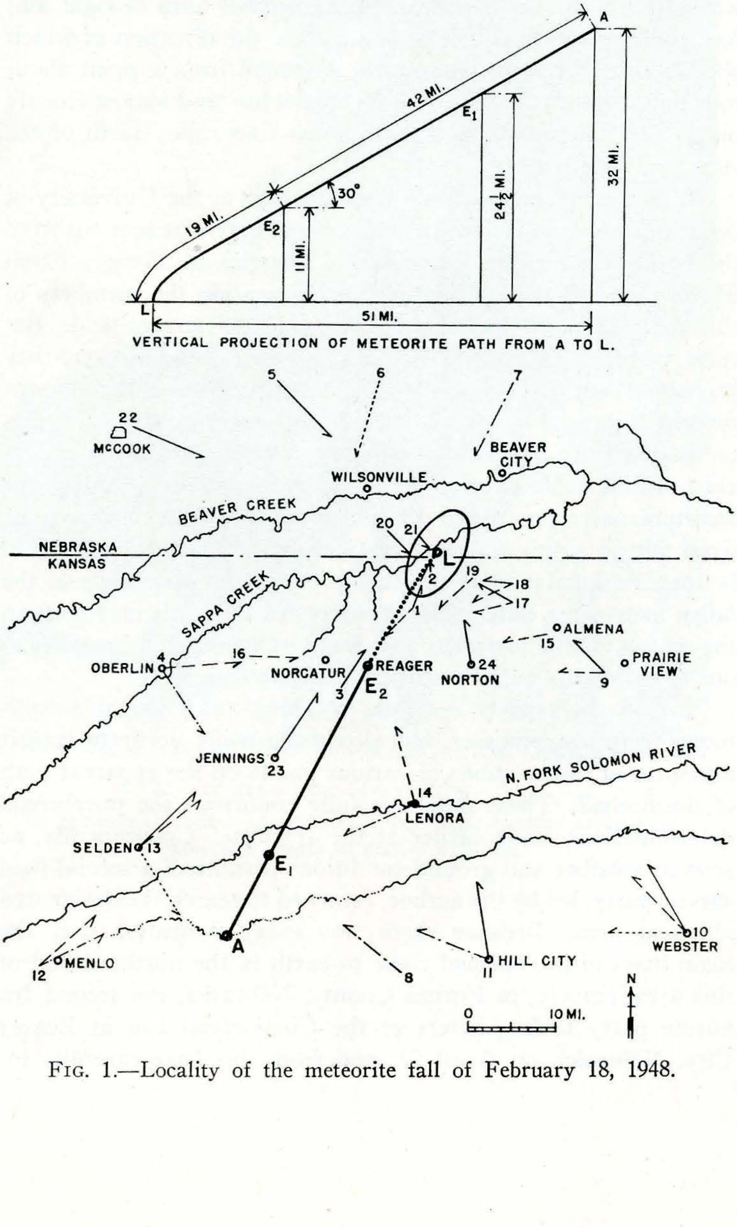


FIG. 1.—Locality of the meteorite fall of February 18, 1948.

stantiated the conclusion that the main mass had indeed fallen in Furnas County, we were, nevertheless, unable to find any trace of its point of impact.[2] Our failure to do so was later attributed to the facts that at the time of the fall the only dwelling close to the point of impact (Collins' house No. 2, Figure 2) was unoccupied and that the impact occurred in a field so overgrown with weeds and stubble that even the large crater made by the record-breaking main mass of the fall was finally located only when by chance a caterpillar tractor started to fall into it.

Because of our continued failure to locate the main mass in Furnas County, we decided to shift operations to the south end of the strewn-field in the hope that this area would prove to have been sprinkled with smaller, unburied fragments disengaged by the violent "explosions" which were universally commented on by the Nebraska observers. Calling again on Orville Brown, we received the welcome information that his neighbor, Bill Tansill, had found a strange stone on April 6, quite unlike any of the country rocks, which he had been waiting anxiously for someone to identify. Inquiries speedily made at Tansill's farm resulted in identifying his strange stone, which "smelled of sulfur and had metallic specks in it," as an achondrite, a rare type of stony meteorite. All-out search of the entire south half of the strewn-field in Kansas was now carried out by the Institute party, aided by Tansill and his neighbors, Harrison, Kenneth, and Stanley Davis. Recoveries of additional achondritic masses were made by all members of the search group, Tansill and the Davises very

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[2] Legend for Figure 1: *A–L* is the horizontal projection of the path of the meteorite. The insert above is the vertical projection of the path from *A* to *L*. The arrows indicate observed directions of first appearance, *A*, dotted; of first explosion, E_1, dash-dot; of second explosion, E_2, dashed; and impact, *L*, solid. The elliptical area surrounding *L* is the provisional search area determined on March 3 by the Institute of Meteoritics. Numbers on the arrows correspond to observers listed below:

1. Orville Brown	9. Kenneth Hays	17. Hugh McGinnis
2. Mrs. Orville Manning	10. Rev. J. G. Shaw	18. C. M. McClellan
3. L. J. Collins	11. Harold Thompson	19. Ray Sheley
4. Howard Saum	12. John Steiger	20. Frank Applegate
5. Mary Lou Conroy	13. Kelley Fowler	21. Hugh Donnelly
6. R. P. Brigham	14. John Niehaus	22. McCook Air Base
7. Mrs. Velma Schnacker	15. Earl Rhoades	23. Creta Carter
8. R. W. Osburn	16. Mrs. W. J. Yoho	24. David Doney

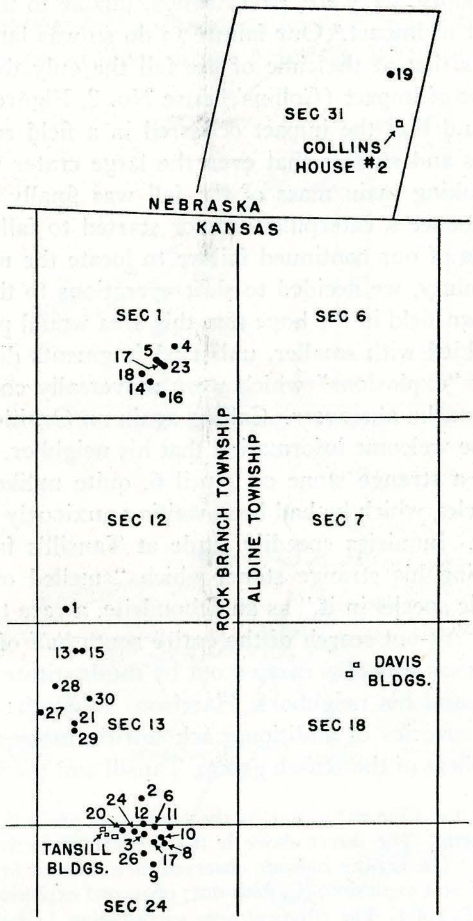


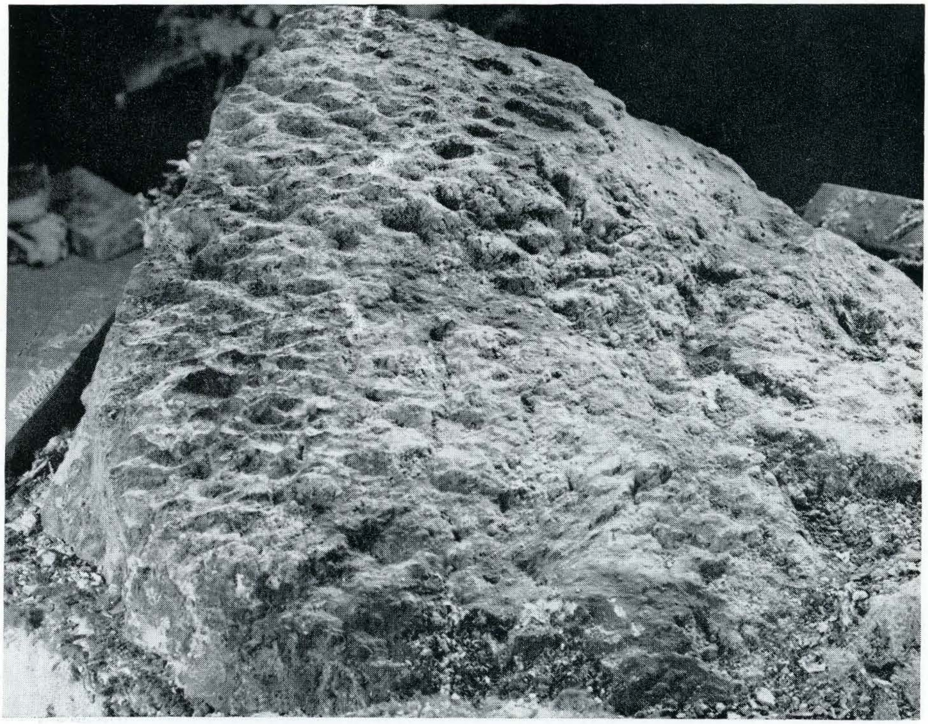
FIG. 2.—Distribution of recovered fragments of the Norton County, Kansas–Furnas County, Nebraska, meteorite fall of February 18, 1948. No. 18, the 130-pound meteorite. No. 19, the 2000-pound meteorite. The entire area shown here is in the lower left quadrant of the elliptical search area shown in Figure 1.

PLATE VI

LOADING THE METEORITE

The final stage of the delicate task of loading the one-ton meteorite. From left to right, Morris Mendenhall, Creighton Davis, and L. E. Dixon guide the ponderous but fragile mass into the truck.

PLATE VII



SURFACE OF THE METEORITE

A portion of the partially exposed surface showing pressure markings (piezoglyphs).

generously donating all of their finds to the Institute of Meteoritics. These new discoveries raised interest in the achondrites to a white heat in that area and soon it was possible to look in almost any direction and see a farmer plodding slowly across his fields scrutinizing the earth at his feet.

On May 1, a deeply buried achondrite weighing over 130 pounds was discovered by fourteen-year-old Ralph DeWester on the T. R. McKinley ranch in the very center of a region already carefully searched by many adult meteorite hunters.[3] The discovery of the McKinley meteorite, then justly regarded as a giant among achondrites, was the crowning achievement of systematic visual search in the area. Although many additional fragments were found during the remainder of 1948, all such recoveries, and indeed the McKinley meteorite itself, were overshadowed by the chance discovery of the world record-breaking Furnas County achondrite weighing more than a ton, in an area which had been searched as early as April 27–28 by the second Institute field party.[4] The six-foot crater marking its resting place was found on July 3 by O. E. Gill (a member of a family personally alerted by the writer prior to April 29), and his companion, Arthur E. Hahn. Excavation of this crater (Plate IV) revealed that the one-ton meteorite had penetrated more than ten feet into the earth. The excavation was conducted by the Institute of Meteoritics and the University of Nebraska, which had jointly acquired possession of the stone from Miss Helen Whitney of Cambridge, Nebraska, owner of the land on which the meteorite fell. Under the expert direction of Dr. C. B. Schultz and Professor E. F. Schramm of the University of Nebraska, this largest of all recovered aerolites was carefully encased in a thick sheathing of plaster of Paris, burlap, and boards in order that the ponderous but fragile mass might safely be hoisted out of its deep impact hole.

In connection with this sheathing process an amusing situation developed. The tissue used as a foundation layer for the plaster coating (see Plate V)—a "name-brand" purchased in carload lots by the University of Nebraska in prewar days—

[3] L. LaPaz, *Science,* **107**, 543, 1948; *Science Illustrated,* **3**, 22, 1948.

[4] Frederick C. Leonard, *Contr. Meteor. Soc.*; *Pop. Astr.,* **56**, 434, 1948.

proved almost as much of a temptation to "collectors" as the achondrite itself and members of the scientific staffs had to be constantly on the alert to prevent its loss.

On August 25 the achondrite, completely encased in its protective plaster-of-Paris armor, was lifted out of the ground and placed on a truck (Plate VI) for transportation to Albuquerque, where it was planned to section the meteorite for division between the two universities. Arrival of the meteorite at the Institute of Meteoritics was a gala occasion and the giant achondrite (Plate VII) was the center of attention at the Eleventh Annual Meeting of the Meteoritical Society of the University of New Mexico in September 1948.

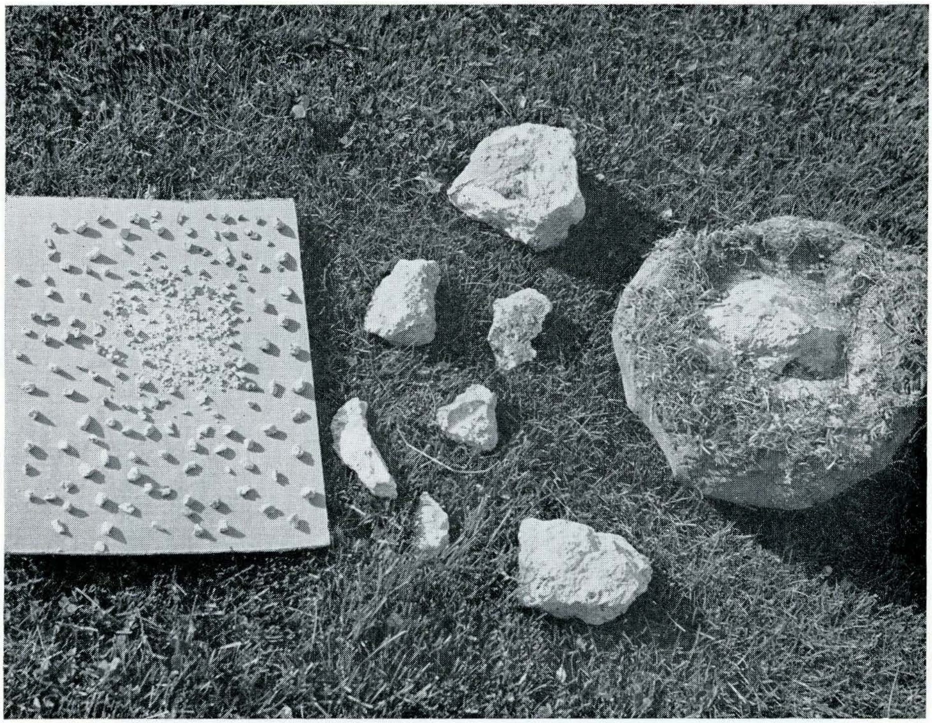
During the five surveys made in connection with the location and recovery of meteorites from the shower of February 18, members of the Institute of Meteoritics drove over ten thousand miles and interviewed several hundred eyewitnesses of the fall. On the basis of the data from such interviews and from letters and sketches submitted in answer to questions, it is possible to determine the apparent radiant point of the fireball and its real path through the atmosphere. The radiant point, R, as determined from the best observations of the apparent path plotted on a central zenith-projection of the celestial sphere, is shown in Figure 3. The point, R, had an altitude of 30° and an azimuth, measured from the south point, of 27°; the corresponding values of the right ascension and declination being 17° 45′ and —15° 36′, respectively. The fireball therefore entered the earth's atmosphere along a path inclined 30° to the plane of the horizon (see insert above Figure 1). The highest point of the visible path seen by any of the observers interrogated by the Institute had a linear altitude of about thirty-two miles. At an altitude of approximately twenty-four and a half miles a widely observed "explosion" of the fireball occurred; and at an altitude of about eleven miles a second, and almost simultaneously, a third "explosion" took place. These explosions produced beautiful mushrooming meteoric clouds (Plate VIII) which remained visible for upwards of two hours, during which time very pronounced changes in the form and position of the clouds were produced by high-altitude atmospheric currents.

PLATE VIII

METEORIC CLOUD

Changes in the form and position of meteoric clouds like this one, at altitudes between eleven and twenty-five miles, showed the effects of high-altitude winds. Photograph by Edna Aller, Clayton, Kansas.

PLATE IX



SPECIMENS OF THE ACHONDRITE SHOWER

Individual specimens from the shower of February 18, 1948, ranged in size from dust-like particles to the huge one-ton Furnas County stone. The largest stone shown here, imbedded in the buffalo sod which it penetrated at the time of the fall, was about the size of a coconut.

Beyond the explosion center, E_2 (Figure 1), the real path of the fireball, as revealed not only by visual observation but also by actual meteorite recoveries, veered slightly out of the vertical plane of the fireball trajectory toward the east. A similar, but

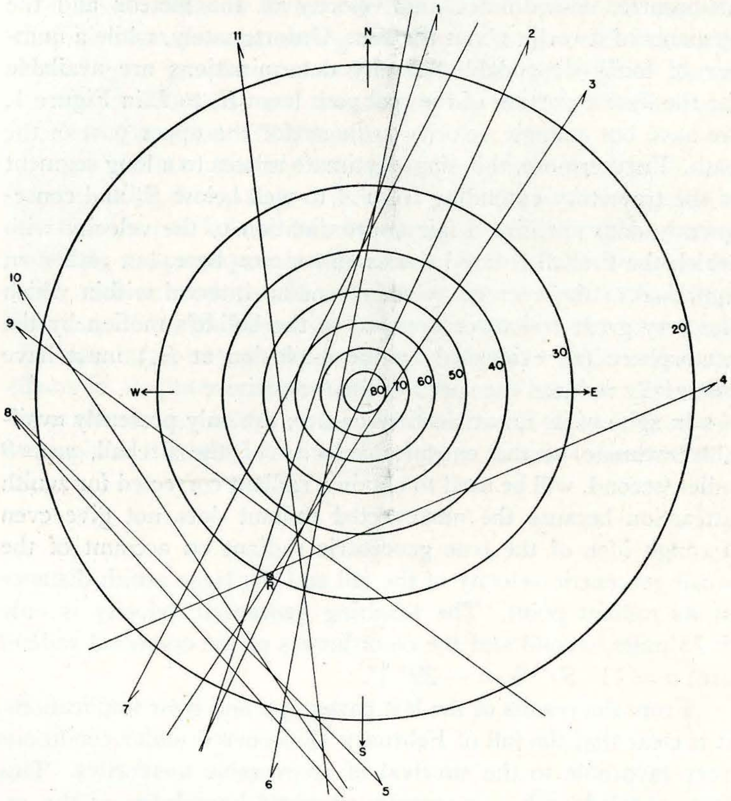


FIG. 3.—Graphical derivation of the apparent radiant, *R*, of the fireball of February 18, 1948, from a zenith-projection of the celestial sphere. The radiant, *R*, had an altitude of 30° and an azimuth, measured from the south, of 27°.

much more pronounced, turning of the lower portion of real paths toward the east has been noted for other well-observed falls.

Were an accurate determination of the apparent velocity of the fireball available, it would be possible to obtain from the co-ordinates of the apparent radiant, corrected for diurnal aberration and zenith attraction, those of the geocentric radiant and to deduce the geocentric velocity; and, thence, to determine the heliocentric co-ordinates and velocity of the meteor and the elements of its orbit about the sun. Unfortunately, while a number of fairly dependable velocity determinations are available for the lowest portion of the real path from E_2 to L in Figure 1, we have but a single velocity *estimate* for the upper part of the path. Furthermore, this single estimate relates to a long segment of the trajectory extending from A to well below E_1 and consequently does not give a fair approximation to the velocity with which the fireball entered the earth's atmosphere, but rather an appraisal of the average velocity over an interval within which the very great resistance opposed to the bolide's motion by the atmosphere (as evidenced by the explosion at E_1) must have materially reduced the speed of the meteorite.

In spite of its unsatisfactory nature, the only presently available estimate of the entrance velocity of the fireball, $w = 9$ miles/second, will be used to obtain a radiant corrected for zenith attraction because the uncorrected radiant does not give even a rough idea of the true geocentric radiant on account of the small geocentric velocity of the fall and the large zenith distance of its radiant point. The resulting geocentric velocity is only 5.75 miles/second and the co-ordinates of the corrected radiant are: $\alpha = 11° 50'$; $\delta = -29° 1'$.

From the results of the last paragraph and their implications, it is clear that the fall of February 18 occurred under conditions very favorable to the survival of recoverable meteorites. This fact, coupled with our recently acquired knowledge of the remarkably friable nature of the Norton-Furnas achondrites and its probable extra-atmospheric size, suggests a possible explanation of one of the puzzles of meteoritics. For many years the latter part of the month of February has been notable for *meteoric* phenomena of unusual intensity. In 1921 W. F. Denning[5] listed nearly a score of outstandingly spectacular fireballs

[5] W. F. Denning, *Mon. Not.*, **82**, 307, 1921–22.

seen in the interval February 7–22 during the years 1871–1921. In spite of the remarkable nature of the bolides occurring in this interval, the month of February has long been noted for the small number of *meteorites* seen to fall within it. The deficiency of meteorite falls in February has been a persistent one, the absolute minimum occurring in the latter part of February, according to graphs prepared as long ago as 1845 by Arago (based on 206 falls) and as recently as 1941 by Frederick C. Leonard (based on 581 falls).

This curious anomaly between the number of exceptionally bright, often detonating, February fireballs and the rarity of actual *meteorite* falls in this month may find its explanation in relatively frequent encounters during this month between the earth and achondrites like those recovered from the fall of February 18, 1948. Meteorites of such composition and structure, although large enough to produce spectacular light and sound effects in the intermediate layers of the atmosphere, might disintegrate so completely during transit through the denser lower atmosphere that only dust would survive to reach the earth.