

U. S. Eclipse Observatory, With Four Inch Telescope Set up at Des Moines, Iowa, for Observation of the Total Eclipse of August 7, 1869.

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ON THE TRAIL OF THE CORONA

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The pages of the book of nature are well thumbed at the chapter on searching the corona of the sun for solution of the riddle of the universe.

The study groups of ancient times camped in the deserts; this year, 1947, men intrigued by the same phenomena climbed high mountains and winged their way into the upper air. On one occasion, in our time, the regiment of scientists took over the green fields of Iowa for their point of observation. Here it was that the curtain of the ages was lifted and new wonders were revealed for the chapter by results greater than ever before obtained. There is such close relation between what happened in Des Moines, Burlington, and elsewhere in Iowa, and the work planned more recently for the wilds of central Brazil that it seem worth while to set down a rank outsiders' remembrance of the Iowa part in the trail of the corona while yet the trail is being followed round the world.

First, as to the 1947 show. World scientists pre-empted best seats in the mountains and highlands 400 miles Rio Janiero and other good observation places in Africa and Arabia. They took with them all the most modern instruments for measuring, photographing and analyzing. At Des Moines they first tried out making photographs of the eclipse of the sun and the corona with wet glass plates; at Bocayuva the research squad had marvellous instruments for making records and pictures in colors. In Iowa there was dependence upon the naked eye for

much; in Brazil it was all to be with the greater precision of electrically operated instruments. The elevation of the observation point far above sea level necessitated taking the equipment there by airplane. Then it was provided that men with proper instruments would go far above the possible clouds with other cameras and measuring things. Special equipment was made. New instruments had been thought up and adopted. In fact there never before had been such extensive and careful preparation for seeing an eclipse of the sun. Much was expected from all this. Astronomers from many countries joined in following the trail of the corona. The time of totality of the eclipse was computed to be as one of the longest ever known. The date of the eclipse was May 20, 1947. The one for which Iowa was the favored place was August 7, 1869.

What are these followers of the trail seeking? An answer to the old question about man and his universe—how, whence, whither? They want to know if the rays of light from a star are bent as they pass close to the sun. They are asking about the passing of sunlight through the earth's atmosphere. They are inquisitive about the moon and the little stars. But above all else they want to know more about that mystery of mysteries, the corona of the sun. In these days nearly all of the records will be made with automatic instruments and it will be after months of study that results are announced. Now let us turn back three-quarters of a century and get another approach to the story.

I

WARNINGS OF THE ECLIPSE

Eclipses are best recorded of all historic events. Babylon was the great capital of an empire more than thirty centuries ago, when its cultured people were shocked by dim-out of the orb which they regarded as the seat of the divinity from which proceeds all earthly life. The terror was but little softened by the fact that their wise

men had long been keeping record of these mysterious disturbances and knew in advance of their coming. The people of Iowa were not less shocked by their first watching of a total eclipse of the sun. There was ample notice and warning, as of old; but no one will ever witness such an eclipse without feeling a deep sense of the immensity and unity of the universe.

In the capital city of Iowa there is a public park in which Drake university has set up a small telescope, near what the surveyors call a "correction line" running straight across Iowa. If you should follow this line westward some eighteen miles you would come to a farm that on the date of the celebrated Iowa eclipse was at the edge of a prairie just being taken over. It was to be a Dallas county farm, the sod freshly turned for a skimpy corn crop, a small farm house not yet finished, improvised sheds for livestock thatched with rough slough grass, rail fences that wound in and out for the garden and orchard, a rivulet of cool water flowing from the muskrat ponds, the bluebirds catching butterflies in the shady woodyard. The prairies were not yet fully conquered, the rosin weeds grew rank and the prairie chickens served as alarm clocks in the spring time. Iowa was young and happy.

The eight youngsters in the family of Ephraim and Elizabeth were alert to the goings on in the world. They had, every one of them, sat on the hard seats in the McGuffey one-room school two miles away. Once a week someone traversed the orchard path to the nearby county seat town of Adel and swapped butter and eggs for coffee and sugar. At the postoffice was picked up copies of the *American Agriculturist*, the *Hearth and Home*, the *New York Sun* and the *Dallas Weekly Gazette*. More than that, by what strange change not now recalled, at one time or another on the black walnut table in the meager farm home there rested copies of *Harper's Monthly*, the *Living Age*, the *Scientific American*, *Godey's Lady Book*, and even the *Edinburgh Review* and other foreign publica-

tions. Being youngest of the family, the writer had the advantage of picking up automatically all the bits of knowledge that had been gleaned by the rest of the family.

There were good fish to be caught in the near-by river, and in the stillness of the night we counted the stars in the Pleiades as the cork bobbed up and down in the fishing pool. Best of all, a school teacher sister had given the writer an *Atlas of Astronomy* in which was charted the heavens with all the bears and dragons nicely located. Also there was a full-page picture of that celebrated shower of meteors in 1833, about which Mother Elizabeth had told of seeing in her Ohio home. I spread the atlas out on the floor of the best room and scanned its pages in wonderment at the immensity of the universe. Iowa people were kept advised of the coming of the eclipse show by S. V. White, who was something of an amateur astronomer, and later became the "Deacon" White of the Beecher tabernacle in Brooklyn. Unlike the Barnum and Van Amburgh show that came to our town by wagon, the celestial circus far surpassed the claims of the advertisements.

It fell to my lot, of course, to carry the water from a wooden pump to fill a washtub stationed at a strategic spot so that if deemed best we could watch the sun by reflection rather than risk our eyes by direct observation. But we provided the auxiliary instruments of pieces of glass smoke-covered from tallow candles. We were overjoyed because the sky was clear when we were all set for the big event. It was middle afternoon. The shadow of the moon hit right where it was promised. The approach to fullness was gradual. The shadows of the trees grew fainter. There was a perceptible chill in the midsummer air. We made comparison of what we saw with what we had been told to expect. We looked for the stars but they were slowly revealed. We saw what appeared to be a large black disk creeping across the face of the glorious sun. Then there was just a rim partly around this disk, showing very bright and irregular.

There were what appeared to be great mountains of light seeming to be reaching out into the vast regions of space. They might have been volcanoes erupting or the explosions of atomic accumulations. The sky changed its hues. Just at the moment when totality was to become a fact the spectacle was vast and gorgeous beyond the power of description. We and our neighbors stood almost breathless and silent. There was nothing we could say that would fit the occasion.

THE MOMENT BROUGHT TERROR

Totality came as a sharp turn in the orderly procession of events. Regardless of all forewarning, the actual event alone gave us a comprehension of the immensity of the show. We found ourselves set adrift, as it were, without compass or anchorage, away from the world we had known. We were cut off and stood waiting for the next turn in the grand drama. The little group huddled near the garden gate could almost hear the heartbeats of the other. "Ah!" gasped someone, and an expressive "Oh!" came from one of the children. Then came cries of surprise and anguish from the feed lots. A frightened cow called loudly to her young, the pigs squealed in resentment over being sent to bed hungry, the dominique rooster screamed to his flock as he sought the limb of a cottonwood tree, and the white geese hustled out of the pond and waddled to a favorite corner of the yards. The birds with their nests in the box on a high staff circled the orchard and called defiantly to the darkness. It was a moment of inexpressible terror for all.

There was little to say. Few words were spoken. The kindly father uttered a few sentences to inspire confidence. Brothers and sisters spoke almost in whispers. There was a blank spot in the western sky. Eyes with vision blurred by the strain of the time could not be readily adjusted to the change. The last high peaks of the sun's atmosphere, rising like a giant volcano or an atomic outburst, had been swallowed up. But lo, there was a faint light as if a halo hovered over the crest of

the divinity of the day. The corona could be seen. What was it? A minute passed as an hour. Another minute, and then a third. Quite as suddenly as before, the great signals of light were thrown out at the under side of the black disk. In five minutes the sun was on the way back. The end of the world had not come.

The king of his flock jumped down from his roost and the bluebirds circled the chimney, the cow with the bell walked back to the feedlot with a sheepish air, and the pigs grunted for their evening meal. We were all back on earth again. The show was over.

I may be wholly wrong, as often I have been, but I have thought a thousand times about that celestial spectacle, and am profoundly convinced that the solar eclipse of Aug. 7, 1869, widened and colored the thinking of my brief lifetime.

CENTER OF TOTALITY IN IOWA

Not before, in recent centuries, had there been any total eclipse visible in the very heart of a great civilized continent. The eclipse of the year before and the one in the following year were seen only in distant lands. The one of 1869 created a broad band of totality sweeping from Alaska to the Antilles. The precise center of totality, where the sun would be hid for longest time, had been computed to be near Mitchellville, Iowa. Several million Americans were able to see the eclipse.

For a hundred and more centuries men had been watching these celestial shows with the naked eye. Only a few years before, men had set up cameras and made daguerreotype pictures of what they saw. Then came the era of photography, and for the first time, on any extensive scale, the scientists were able to make hundreds of photographs of the sun in the various phases of eclipse. The spectrum, also, had been greatly improved, and it was used. The science of astronomy was making strides.

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INTEREST CENTERED AT DES MOINES

Des Moines was the place on which science converged for the eclipse of 1869. Hoyt Sherman told the writer about it, as he sat in his home that is now the property of the Des Moines Women's club. The barefoot country boy had become city editor of the old *Iowa State Register*, and under the direction of the famous "Ret" Clarkson was on the trail of good stories. Major Sherman opened a copy of the Report on Astronomical and Meteorological Observations of the U. S. Naval Observatory, dated 1867, and displayed the official but preliminary report on eclipse observations in Iowa. The eclipse matter was so significant that these pages were slipped into a report dated ahead of the time of the eclipse. From this report, and from personal interviews, and newspaper clippings, came forth a narrative of the Iowa stepping-stone in the long pathway of searching the corona for its secrets. Des Moines was a growing little city only twenty years old when the men with telescopes came out of the east. It was a big event in which the pioneers joined with zest.

The mathematicians had figured it out that the path of the totality would sweep diagonally across the North American continent in a band fifty miles or more wide. The precise center of totality would be near the town of Mitchellville, only a short distance from the captial city of Iowa. Therefore Des Moines was selected for setting up the official United States observatory.

Commodore B. F. Sands was at that time in charge of the Naval observatory at Washington. He directed that Simon Newcomb, William Harkness and J. R. Eastman should come to Des Moines and set up a temporary observatory. They brought with them a number of astronomical instruments. A substitute for a telescope was made of wood and the lenses were placed therein. Spectroscopes and cameras and chronometers were with the equipment. Surgeon General J. K. Barnes also sent

with the party Major Edward Curtis, an army officer skilled in photography. There also was sent to Des Moines a group from the United States Coast Survey headed by J. E. Hilgard for the purpose of ascertaining locations. The work of the Washington observers was to be supplemented in Des Moines by a group from the Litchfield observatory who set up an independent station.

The citizens of Des Moines, then a city of 16,000 inhabitants, cooperated with the officials and gave them great assistance. An informal committee consisting of Major Hoyt Sherman, Mayor J. H. Hatch and District Judge J. B. Miller welcomed the visitors. In fact, according to newspaper reports, some of the work on building temporary observation rooms was done by volunteers. The railroad officials joined in the work and the telegraph company gave free service for checking up as to time. Some members of the official party were in Des Moines for several weeks prior to the date of the eclipse. The courthouse and courtyard were offered for the use of the observers and a tract of land about a mile and a half north was given freely by the owner and became the site of the chief observatory.

At that time, much more than now, the Washington observatory led in all study of the stars; but there were fine telescopes at various universities and many in the hands of amateurs. The latter were not overlooked. A circular of advice and instruction was sent out and as a result reports were received from a number of volunteer observers. Near Sioux City W. S. Gilman, of New York, headed a party of observers and made a fine report. Others came from Marion, Mechanicsville and Red Oak.

Iowa was recognized as the center of totality for the eclipse and everywhere there was interest. Independent observatories were set up at many places, including Burlington, Mt. Pleasant, Cedar Falls, Ottumwa, Cherokee and Oskaloosa. One of the most valuable of these stations was at Burlington, where the Franklin institute located a large telescope and C. A. Young of Princeton

made a report of great value. The Washington observatory also sent to Alaska a party to watch the early phases of the eclipse and others went into the mountains of Tennessee and Kentucky, and a small party to St. Louis. In fact the trail of the corona was covered quite completely at almost every point.

Des Moines and Iowa were still pretty much out on the wild prairies even after the boys in blue came marching home from their adventure in nation saving, and so it was necessary to find out just where Des Moines was located on the globe. This job fell to the Coast Survey party. They had the city of Washington located by minutes and seconds and degrees. There was a big clock somewhere that kept the time of the world. But where was Des Moines? Remember, at that time there was no direct telegraph wire from Washington to Des Moines, or even to Chicago, for that matter. On account of the great distance it was impossible to transmit telegraphic signals directly, therefore the line was broken into a number of circuits with relays. These were given as:

Washington to Philadelphia, 138 miles,
Philadelphia to Pittsburgh, 355 miles,
Pittsburgh to Crestline, 189 miles,
Crestline to Chicago, 279 miles,
Chicago to Des Moines, 361 miles.

It was necessary to have the signals repeated at each end of the lines. Getting at the precise time was thus seen to be subject to errors. But it was finally determined that the difference in time between Washington and Des Moines was 1 hour, 6 minutes, 16.05 seconds.

OFFICIAL LOCATION OF DES MOINES

A stone was set in the courtyard in Des Moines indicating location as follows:

Longitude $16^{\circ} 43^m 52^s$ West
Latitude $41^{\circ} 35^m 45^s$ North

The longitude was west from Washington not Greenwich. The stone remained undisturbed until a new court

house was built in 1905. At the same time there was marked on the cornerstone of the United States postoffice just across the street a statement that the elevation of the spot above sea level was 849 feet. This has been replaced by a brass plate showing that the Geological survey has more recently computed the elevation to be 807 feet.

The triangulation and observations from three points was possible by the location of the three stations in Des Moines. The Coast Survey had squatted on the northeast corner of the courthouse square with J. Homer Lane in charge. Professor Newcomb had taken over the north part of the courthouse grounds with the north gable of the building. Professor Harkness had located the main laboratory and observatory at the corner of Second and Short streets, a mile north and slightly east of the courthouse, which was then quite out in the woods. Professor Peters for the Litchfield observatory had set up on the hill east of the Des Moines river a short distance south of the University avenue bridge. By an exchange of information between the three and observations of the sun the location of Des Moines was obtained.

The erection of a temporary observatory on the north hill, at Second and Short streets, had been done before the main body of scientists arrived. A barn-like structure was built, with open roof at the west, covered with canvas that could easily be rolled up. As this was to be the place for the big work of making photographs, a dark room was provided. Here it was that they placed the large equatorial telescope of the United States Naval academy at Annapolis loaned for the purpose by Admiral D. D. Porter, then in charge of the academy. It had an object glass of 7.75 inches clear aperture and 9 feet 6 inches focal length. This telescope was to be used for photography alone. A camera box was made and vats for the plates, for the old glass plate method was the only one then known. When the eclipse was actually on, there was quick work by all concerned, in the handling

of the camera plates and timing from a chronometer. Professor Harkness reported the whole program well carried out, and of course, the photographic plates were sent immediately to Washington for study.

COURTHOUSE CROWD ENTERTAINED

At the courthouse where Professor Newcomb held forth, there was perhaps the more spectacular phase of the event. A temporary shack had been built and large screens to keep out unwanted light. Telescope observation was used as well as the naked eye. The telescope glasses had been brought along and placed in an improvised wooded device, which seems to have worked well.

The professor in charge got a big scare from the crowd of Des Moines sightseers. The people crowded around on the streets and in the yard and all who could do so got front seats on the roof-top of the courthouse. As the moment the totality commenced and the darkness at once seemed so incredible, the crowd set up a shout that drowned out the calling of the seconds from a chronometer by an assistant to the professor. For a moment he feared the noise of the crowd would interfere with the work in hand. Everything was to be carefully timed. No allowance was made for any demonstration. But when darkness became complete, the watchers on the roof-top became silent and remained so.

Weather conditions were good. There had been delay in building the temporary observatory in the woods on the hill because of rain. On the morning of the eclipse day there were clouds and a changeable wind. The early cloudiness partly disappeared in the forenoon, but at noon fresh clouds appeared, and by one o'clock the sky again became clear. At the time of the eclipse there was only a light haze. It was a hot afternoon, but when the disk of the sun disappeared, there was a sudden drop in temperature and as one stated it "the sudden chill was appalling." There were no electric lights and lanterns were used in the building. All business was suspended for a

time and everyone turned out to watch the extraordinary exhibition.

Some things might well be made of record as to the Iowa eclipse of 1869. It was the first eclipse of the sun with the belt of totality extending directly across the North American continent, of which there had been any record. It was, therefore, the first time the American astronomers had a good chance at the trail of the corona. Dates of eclipses of the sun are known as far back as the year 1096 B. C. This was described in the annals of Babylon. On May 28, 584 B. C. occurred what was called the celebrated eclipse of Thales, concerning which that reporter gave a fine account. The people of Rome became greatly excited over an eclipse in 399 B. C. In the Anglo-Saxon Chronicles a number of dates of eclipses are given. By the year 1715 A. D. there were telescopes in use and a notable eclipse was scanned in England by Prof. Halley who contributed much to the science of the heavens. In the year 1806 the New England people were favored by a brief show of a total eclipse.

It will be noted that the telescope brought from Washington to Des Moines was a miniature affair as compared with some of the instruments of today. The first effort to make pictures of the sun and its corona was in 1851, in Scandinavian countries, when daguerreotype plates were used. Not much was accomplished. By 1868 the use of the spectroscope had been devised and used in India. Good photographs were taken in France in 1860. But not until the Iowa vent did science get full benefit of the spectroscope and the camera in recording the solar show.

It is also worthy of note that in Iowa there was for the first time a considerable group of observatories set up by competent scientists engaged in collaborating as to results. Nothing like that had ever happened before. Of course the tempo of the pursuit for basis facts about the structure of the universe has been much accelerated since, but certainly one of the most important of the steps was taken in Iowa 78 years ago.

I I I

THE CORONA IDENTIFIED AND DESCRIBED

The reality of the corona was established in Iowa.

That had been a debatable matter ever since the wise old men took note of what was seen from the banks of the Tigris river. Men with keen eyes, and later assisted by good lenses, had discovered that there appeared to be something surrounding the sun that could be seen only at times of eclipse. Some said it was a gas that emanated from the sun. Others declared it was something in the upper atmosphere of the earth. Many felt that it was a mere optical illusion. They called it the corona—but what was it?

Prof. William Harkness, in his report to his superior on the results at Des Moines, summed up as to two things, namely:

The corona is a highly rarefied self-luminous atmosphere surrounding the sun, and, perhaps, principally composed of the incandescent vapor of iron.

The study of the corona was the one big thing he had been detailed to do. This study was by the use of the spectrum and photography. His pictures of the corona showed great streams of light radiating from the sun out into space many thousands of miles, in a more or less irregular shape. The form of the corona has been described as a trapezoid. It did not appear to all observers the same. One of the puzzling things seen by the astronomers was a very bright line crossing the spectrum of the corona. This was the famous bright line in the green part of the spectrum. Of this the *Encyclopdia Britannica*, 11th edition, said:

At the total eclipse of August 7, 1869, it was independently found by Professors C. A. Young of Princeton and W. Harkness of Washington that the continuous spectrum of the corona was crossed by a bright line in the green, which was long supposed to be coincident with 1474 of Kirchoff's scale. This coincidence is, however, now found not to be real, and the line cannot be iden-

tified with any terrestrial substance. The name "Coronium" has therefore been given the supposed gas which forms it. It is now (1910) known that 1474 is a double line, one component of which is produced by iron, while the other is of unknown origin.

As to that mysterious bright line in the green, it should be said that Professor Harkness came at least near to discovering its true character. He reported that "owing to the very moderate dispersive power of my spectro-scope" the iron lines would certainly coalesce and "appear as a single rather thick line, which was what I actually saw." Then he appended a footnote as follows:

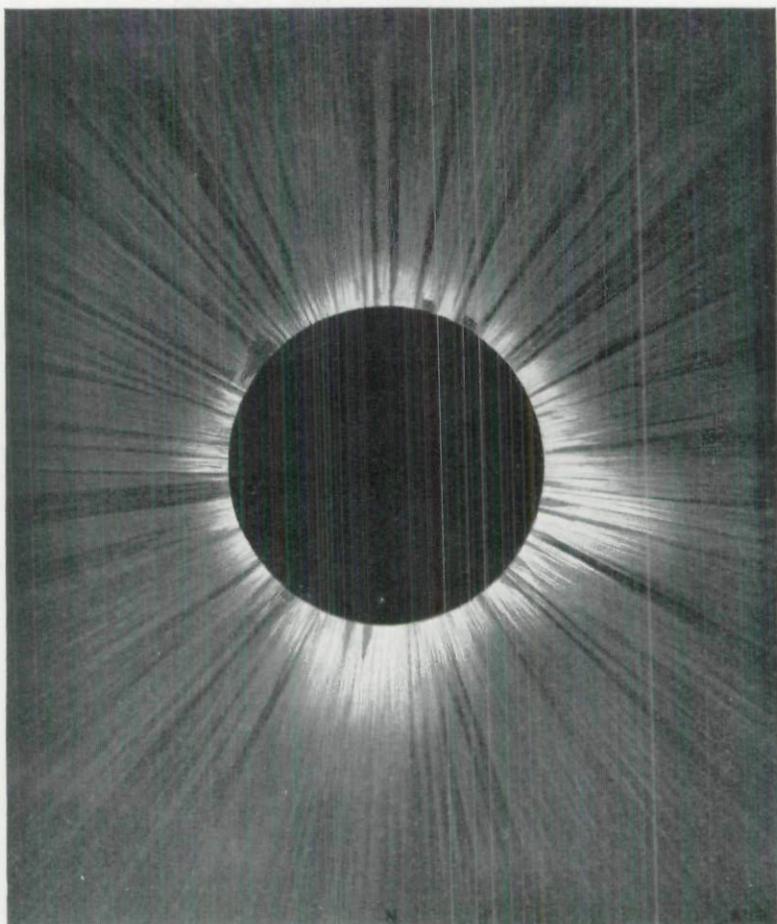
I do not wish to be understood as stating that the bright line in the corona is either double or triple. I only assert that so far as my observations are concerned, such may be the case; and that, at all events, I think it will be found to coincide with one or more of the three iron lines in question.

All of this suggests that at the time of the Iowa eclipse the stargazers were getting somewhere, but by no means had they reached any definite goal. The corona was a real thing, and that old dispute was laid on the shelf for all time. But that one bright line was a puzzler. It had compelled making of a new name, that of coronium for an unknown basic element.

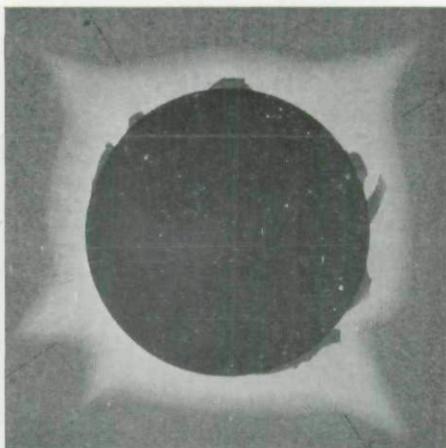
It is the business of the astronomers who went to Brazil and to Arabia to do a little more studying of the broad problem of the corona. The trail is far from at an end.

Before leaving the subject of the corona, some other quotations are necessary. Professor Eastman, of the U. S. Navy, who was with the party in the north woods, recorded:

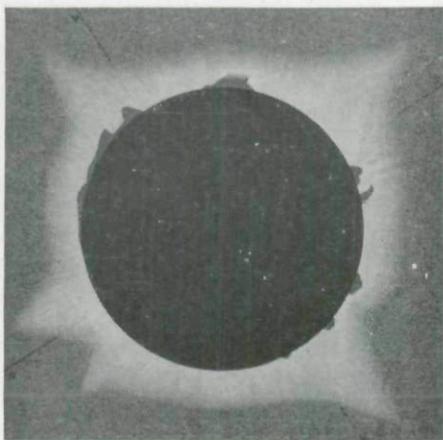
The total obscuration was coincident with the appearance of the corona and protuberances and with the rush of a peculiar, almost tangible, darkness. The corona appeared as if a screen had been suddenly withdrawn to present it as a background for the better exhibition of the black body of the moon and the colored prominences. I was considerably disappointed with the appearance of the color and brilliancy as well as with the extreme contour of the corona. Most observers have described the color as "pure" or "clear" white and the light as very brilliant, while nearly all



The Corona of the Total Eclipse of August 7, 1869, at Des Moines.
As Seen by the Aid of a Four Inch Telescope.



Appearance of Corona and Protuberances
Immediately After the Beginning
of Totality.



Appearance of Corona and Protuberances
Just Before the End of Totality.

the published sketches represent the contour as nearly circular and regular and the coronal rays as radial and equally distributed about the body of the sun. The color of the corona, as I observed it both with the telescope and without, was a silvery white, slightly modified in the outer portions by an extremely faint tinge of greenish-violet, and I could not detect the least change in the color or in the position of the rays during totality. The light of the corona was not brilliant—perhaps from the effect of the haze—but appeared more like the pale light from the train of a meteor than like anything else I could recall at the time.

The corona seemed to be composed of two portions, both visible to the naked eye, in which, with the small instrument which I used, I was unable to trace any similarity of structure.

The portion nearest the sun was about 1' high, forming nearly a continuous band about the sun, and appeared to be a mass of nebulous light, resembling in structure the most brilliant irresolvable portions of the milky way. Its color was silvery white, and like its density, appeared the same throughout its whole extent. The outer portion consisted of rays of light arranged in two different ways. In five places they were arranged into groups resembling star points composed of slightly convergent and radial rays, but elsewhere were disposed as radial lines. The color of the bases of the star points and of the radial lines was the same as that of the inner portion, while the outer portion of the points had a very faint greenish-violet tint. The radial lines were the most prominent.

Four of the star points project farther from the sun than the ordinary radial lines, and give the contour of the corona the form of a trapezoid. Between two of the protuberances scarcely any corona was observed.

OBSERVATIONS OF DOCTOR CURTIS

It should be remembered that all of the observers were directed to see everything and report on all that was seen, and that they noted things seen in connection with the body of the sun and the sunspots which were not numerous at the time, also as to the chromosphere and the spectacular protuberances that represent the eruption of fire thousands of miles high. Doctor Curtis was quite free in telling of what he saw while engaged in making pictures. Not many were taken since by the wet-plate process only one a minute could be turned out.

But the doctor summed up as to his own independent observations as follows:

Having thus reviewed the photographs both of the total and partial phases, we may sum up their teachings in solar and lunar physics as follows:

First. They prove that the corona cannot belong to the moon, by showing that it was progressively eclipsed by the latter body in its transit over the solar disk.

Second. They render it almost equally certain that the corona does belong to the sun, by exhibiting a marked relationship between corona and proturbances, and showing what would a priori be expected in an extensive solar atmosphere, that the corona, at the time of the eclipse at least was comparatively deficient in the neighborhood of the solar poles.

Third. Considering the corona as necessarily a gaseous atmosphere, they tend to confirm the deductions from theory that the gas of its composition must be of exceedingly low specific gravity, and in a state of extraordinary rarefaction, by showing that the underlying red prominences on the occasion of the eclipse exhibited traces of being acted upon by atmospheric currents only at one spot, where, from the character of the supposed currents, the interpretation that this was a local eddy originating in the chromospheric matter itself is as probable as the assumption that it was a whirlwind of the corona.

Fourth. They show that the protuberances are, certainly in the great majority of instances, if not invariably, produced by an upheaving or ejecting force operating from within or beneath the envelope of the chromosphere.

Fifth. They exhibit phenomena of which one interpretation may be that the down rush of cooled gas following an unusually tumultuous and extensive upheaving of the matter of the chromosphere, may take the form of an eddy or cyclone of unprecedentedly vast dimensions.

Sixth. They fail to show any marked connection between sun-spots and proturbances; one sun-spot only of those visible on days preceding and following the eclipse being even in proximity to any of the prominences seen during the total obscuration.

Seventh. Their evidence on the question of whether there was any appreciable motion to the protuberances during the duration of totality at Des Moines is, so far as it goes, opposed to the assumption of any such actual motion.

Eighth. The evidence they afford that the corona cannot belong to the moon, taken in conjunction with the experimental proof adduced that the glow of light bordering the moon's limb as projected upon the sun during the partial phase is purely an effect of diffraction, and that the encroachment of the protuberances upon the lunar disk in the photographs of totality is a phenomenon of the dark room alone, shows that none of the varied phenomena of the solar eclipse can be assumed to afford the least evidence of the existence of an appreciable atmosphere to the moon.

At Des Moines for the first time in history the sun's corona had been tied up with the sun for certainty. On this basis the astronomers were able to give definite form to the sun itself. It is in fact a gaseous body. It is several layers of gas. The photosphere, or inner body of the sun, is a gas much compressed and therefore intensely hot. Some of the observers compute the temperature up to 6000 degrees, which would vaporize all known elements. It is the surface of this photosphere that is seen as sun-spots when openings are made in the chromosphere that is seen as sun-spots when openings are made in the chromosphere. The latter is the bright red and highly luminous envelope many thousands of miles deep surrounding the sun's body. Then there is the corona which is lighter gas extending many hundreds of thousands of miles out into space. Outside of this, perhaps only lightly attached to the sun, is an envelope of highly tenuous matter which appears as the zodiacal light.

Within the comparatively few years since the observations in Iowa of the greatest of modern eclipses, the astronomers have made tremendous progress, and out of the studies made in the year 1947, in Brazil, in Africa, in Arabia, there should come much additional information.

IV

RECORDED GENERAL OBSERVATIONS

The eminent men of science who came to Iowa in 1869 did not confine themselves entirely to the study of the corona, though that was at the time the liveliest topic for

consideration. Professor Eastman turned aside for a moment to see how things looked on the earth at the time the light of day was diminishing.

The landscape on the eastern bank of the Des Moines river, he said, had a greenish-yellow hue, as if seen through a tinted glass, and the shadows of the trees had almost disappeared. The countenances of the observers had a sickly, ghastly appearance, and the peculiar chilliness had increased until it was very uncomfortable.

Mrs. Eastman had a part in the work of the observatory on the north hill, and she operated a device for measuring heat and general light. She observed a star that was quite dim and sought to locate it near the sun's rim at the beginning of the eclipse, and then:

On the reappearance of the limb of the sun the "star" could at first be seen only as a faint, blurred image, but gradually the points of the "star", then the ring, and finally the dot, appeared by the light from the full aperture.

Professor Newcomb was in charge in the improvised observatory in the Polk county courtyard. As to his job he stated:

Coming now to the preparations for total phase, I remark that the main object I kept in view was to determine whether there was anything at all visible outside the usually assigned limits of the corona, and yet so near the sun as to be invisible at other times. More especially was it determined to search in the neighborhood of the sun for an immense group of very small mercurial planets, the existence of which had been rendered so probable by the researches of the LeVerrier on the motion of Mercury.

He did not find anything, but reported that "though I knew theoretically that the sky in the direction of the moon ought to seem darker than that outside of the corona, I was wholly unprepared for so strong an illusion of a black globe hanging in mid air." He looked at the corona with naked eye and said that it had a jagged outline extending out into four sharp points. He found that the outline of the moon was quite smooth and regular near the point of last contact. Professor Newcomb, as responsible head of the entire expedition, in submitting

all the various reports remarked that "both their number and apparent precision exceed what we had reason to expect."

As this was the first time in history that the camera men got a good chance at an eclipse, it is well to record some of the picture-maker trouble of Dr. Edward Curtis and his assistants. First, he had trouble with the water used, and finally at the last moment resorted to cistern water, but at the right time all was set for handling the plates, with each assistant assigned to a specific task. Doctor Curtis continued:

At 9^h 59^m 57^s by my chronometer I made the first exposure, and passed seven plates through the camera in rapid succession, as had been arranged. An interval of about four minutes then elapsed while Mr. Ward refilled the baths, after which we settled down to our steady work of one plate a minute. At the thirty-ninth plate, Mr. LeMerle calling for more exposure, I removed the diaphragm cap from the object-glass, and from that time on worked with the full aperture of the lens. As the eclipse advanced and the sun's disk narrowed to a crescent the light became very gloomy, and the air growing suddenly damp and chilly, I was glad to don a coat to prevent shivering. At the same time the image from the finder on the ground-glass became so faint that I was obliged to slip up the white card-board screen that had been prepared for use during totality. At exactly two minutes before the calculated time for the commencement of that phase I gave the prearranged signal to the operators in the dark-room. The four plate-holders were then quickly filled, and Brennan came out to assist me. A holder was placed in the camera and the telescope was adjusted as well as possible by the fine crescent image of the sun. With my back to the heavens and my eye riveted upon this little image on the white cardboard, I watched it shrink to a mere line and then suddenly melt away in all directions like an icicle thrown into boiling water. With its fading came a solid, rushing darkness, that seemed to grow in the very air and close upon me from all sides, producing a strange sensation as of positive engulfment by something black and material, whose embrace was all the more thrilling from being swift, noiseless, and impalpable. Out went the last twinkle of sunlight, and out flashed the light in the lantern swinging by my chronometer, as suddenly as the blaze from a match struck in the dark. The totality had come, and the "Oh! Oh! Oh!" of the distant crowd which had followed the rapid fading of the sunlight changed to one shout of admiration, and was then suddenly hushed.

But to me the moment was one of dismay, for, with the vanishing of the sun's image from the cardboard screen, a most unexpected difficulty presented itself, that threatened to destroy all chance of making but one exposure during the totality. This was that the image of the corona thrown by the finder was so excessively faint that at first I could see absolutely nothing upon the screen when the sun disappeared. But, as previously mentioned, the telescope required readjusting after each change of plate-holders in the camera, no matter how carefully that operation was performed, and it instantly flashed through my mind, how will it be possible to effect this readjustment after the present plate is removed, if the image from the finder is too faint to be seen? Fearing, then, that everything would have to be staked upon the single plate already in the instrument, I shrank from making the exposure until I could be absolutely sure that in this case, at least, the rather uncertain preliminary adjustment by the fast dwindling crescent of sunlight was correct. I therefore strained my eyes to the utmost, and at last, by putting my face close to the screen, was able to make out a faint halo of light, defining the disk of the dark moon. Seeing, then, that the centering of the image was very nearly exact as the telescope stood, I wasted no time attempting to better it, but at once threw open the shield to make the exposure. This difficulty of the faintness of the image of the corona was totally unexpected, and the more provoking because, to make sure, as I thought, that I was secure against just this mishap, and that the plan of receiving the image from the finder upon white cardboard was safe for use during totality, I had previously carefully tested the arrangement upon the moon, whose light that of the corona was universally held to equal, and had found that I could see the image of that luminary upon the screen with perfect distinctness when standing so as to command the adjusting-screws of the telescope. Whether it was that the real amount of light of the corona has been overestimated, or whether its feebleness on this occasion was entirely due to the prevailing haze, I cannot, of course, positively say, but am inclined to think that most of the trouble was from the latter cause.

DOCTOR CURTIS' REACTIONS EXCITING

Doctor Curtis was quite free in his comments on what he saw and as to his conclusions. After all he was there just as an amateur photographer using plates and getting only one negative a minute. He turned from his instruments to take an eye view of the big show in the western heavens. His first feeling was of disappointment

at the appearance of the corona, which did not look as bright or extensive as he had been led to expect. He thought it did not extend to a distance more than one-fifth or one-quarter of the moon's diameter. He was not entirely disappointed at the show:

But the magnificence of the red prominences, and the distinctness with which they could be seen by the naked eye, filled me with astonishment, for I had supposed they would scarcely be visible without a glass, especially to slightly near-sighted eyes like mine. They were, however, readily to be seen, and, instead of being pink or rose color, they looked to me of a pure, rich carmine tint, and seemed to glow and sparkle as if the moon were a disk of jet studded on its eastern side with rubies or garnets flashing in the sun.

Never before had these fantastic limbs of the sun been so well observed and so well described. From the pencil sketches made and the photographs produced, lithographed pictures were made in colors and officially published that have ever since been accepted as standard. The doctor looked around and saw two stars which he supposed to be Venus and Mercury but was not interested in them at the time. He was disappointed at the general appearance of the sky. He said "the color was rather leaden bluish-gray than the deep indigo generally observed where the atmosphere has been clear." The darkness outside was not so dark as he thought it would be. He was pleased with results of his photography. On this subject he made of record:

It is a matter of very great satisfaction that, despite all the difficulties experienced on account of the hazy weather, two such exquisite negatives of the total phase of the eclipse were secured, negatives that are of value not only as affording pictures perfect in every detail of some unusually remarkable groups of solar protuberances, but also, it is believed as marking an era in eclipse photography, proving as they do, that by a proper selection of chemicals and with a sufficiently short exposure to the plates, the photographic art is capable of yielding pictures of the red prominences of a beauty and delicacy of detail never approached before.

He was evidently a man of imagination and vision; but he could not have stretched his dreams into any near-

ness to the magnificent accomplishments of the present day art of the camera. The one-a-minute speed in picture making was forgotten in Brazil. The snapshots and film rolls will have much to tell, but will not astonish the world more than the glass plate productions in Iowa.

J. Homer Lane, who was with Professor Hilgard of the party from the United States Coast Survey, did some hard gazing at the whole show. He seems to have been assigned the task of studying the immediate rim of the sun to find out the connection between the chromosphere and the corona. He reported specifically on seeing certain clouds at the inner edge of the corona and he compared them to telescopic comets without tails.

The independent reports from volunteer observers added little to the sum total of information either as to the corona or other phenomena.

V

THE PRESS REPORTS INFORMATIVE

The Iowa eclipse of 1869 ought not to be forgotten. It was a historic event. No attempt is here given to present it from a laboratory viewpoint, but rather from that of an everyday newspaper reporter. It is therefore deemed appropriate to add a reporter's account of what happened in Iowa as made at the time. The *Iowa State Register* had a fine editorial the day after the eclipse, which closed with the following account of the end of the phenomenon:

The humiliation and the awe of the appalling presence was not more majestic in its terror than the restoration of the sun was in its glory. The first burst of the returning light was of a splendor beyond all words. Quicker than a heart throb a mist of golden glory shot from out the mass of blackness, a tinsel of gold flashed along the edge of the great hanging shadow, the stars retired before the flood of spreading light, and the earth was once more sunny with the smiles of Heaven. Every heart thrilled with a joy unspeakable, and a prolonged cheer went up from the happy thousands. The blessed sunlight had returned, pouring through the darkness, illuminating the land with its glory, and baptizing men with its genial glow back into the mercy and protection of

God. The brilliant crescent was as another bow set in promise, and as its rays fell upon the earth they fell in a sweetness and power that made man better and God nearer.

The news columns of the same daily paper, contained an extended account of the entire event, as follows:

THE TOTAL ECLIPSE!

HOW IT APPEARED IN DES MOINES!

Its Effect on the Atmosphere and the Animal Creation

THE CORONA AND STARS

A BRIGHT DAY AND GOOD OBSERVATIONS

IMPORTANT DISCOVERY

The eclipse has come and has passed away, leaving us all in wonder and astonishment at this grand and sublime celestial phenomena. The bad weather that been making its stay in this region on Friday and Friday night took the wings of the morning, and left for other parts, giving us a clear, cool and bright day. There was a slight haze in the atmosphere, but of not sufficient strength to obstruct the view of the heavens while the eclipse was passing.

With other members of the press, we stationed ourselves near the Naval Observatory at the head of Third Street, and from which we had a perfect view of the western heavens and of the country north of that locality.

APPROACH OF THE SHADOW

The approach of the shadow was perceptible, and came on very like twilight, and nothing of that "awful dark cloud" was visible in its coming. At 3^h 43^m 14^s, the moon made its first contact with the sun, in the northwest quadrant, nineteen and a half degrees from the west. Preceding the time of contact, the atmosphere became feelingly cooler, with a fresh breeze blowing from the east. The time first computed for the first contact was 3^h 42^m 26^s, which was found to be in error just 22 seconds. At 4:04 the shadow over the surrounding country became more distinct, the disc of the sun being about one-fifth obscured. A large spot was observed on the south-western limb of the sun, and as the moon progressed over its disc, it elongated and spread out to at least one-third more in size than it first appeared. At 4:08.50 it was totally obscured.

The atmosphere became perceptibly more damp with the shadow growing deeper, giving the foliage of the trees a deep green appearance, while the prairies north of the observatory appeared as if bathed in a flood of dim twilight. The birds in considerable numbers flocked to the trees, and chirped and piped away as if greatly frightened. At 4:37 the chickens started for their roosts, but for some cause or another backed out and continued their scratching. A flock of geese near by started and commenced the usual clatter they make when a rain is threatening. Jaybirds became very boisterous, either from fear, or singing a royal welcome to the celestial show. At 4:38 the sun was fully three-fourths obscured, and the darkness increased in ratio. Away to the northward the groves and farm houses were standing out in bold relief, just as if a heavy thunder-storm was passing, and seemingly the darkness was much greater than at the observatory. The birds became much more animated, and fluttered from bush to tree, chirping as if in great dread. At this time not a cloud was to be discerned in the heavens, while in the south-eastern horizon the heavens took on a faint coloring of muddy yellow. This time the chickens made another start for the roost, and remained until after totality. Young chickens dropped down in the weeds and laid there chirping as long as the totality lasted.

TIME OF TOTALITY

At 4^h 45^m 30^s two-tenths of the sun was completely obscured, and the darkness became very dark indeed, for an eclipse. The country northward became an indistinct mass, while at the station it was very difficult to read the scale on the instruments. A very cool wind commenced blowing strongly at this time, from the east, and the air became suddenly cooler, almost uncomfortably so, for a few minutes. Just before the obscuration, an irregularity appeared ten degrees south of east, in the northwest, which defined to be a large protuberance. Now we come to the most beautiful and grand sight that this generation has ever witnessed, and that is

THE CORONA

As soon as the obscuration was total, a gloriously bright ring or nimbus formed around the sun, and sent its rays far out into space in all directions. The light at this time was about equal to that of the light of a new moon. In the south part of the sun a large protuberance was visible to the natural eye. It was estimated to be one-fourth part of the diameter of the sun, and to compare this with the large protuberance discovered at the April eclipse, it must be at least fifty thousand miles high. On the eastern limb of the sun two other protuberances, about fifteen degrees apart, were also visible. The rays on the southern edge

of the nimbus extended as far as one-third the diameter of the sun. On the northern edge they were more spread, and in the east were more diffused. The corona was flame-shaped, and very brilliant, but not so bright nor prominent as was expected.

The moon hanging out boldly in the sky, surrounded by this magnificent corona, was one of the grandest sights that man ever beheld. With totality there burst into sight, Mercury, a little north of the sun lower down, and Venus, about five degrees to the east, who shone with great brilliancy. Mercury disappeared with the time of total obscuration, while Venus continued in the show 3:45 after the sun had again partially appeared. No other stars were visible. The time of total obscuration was 2:52½, ending at 4^h 48^m 22^s, being six and two-tenths seconds later than the computed time. It was also late in the first appearance of totality twelve and three-sixteenths seconds, the entire eclipse ending at 5^h 45^m 25½^s. The difference in the duration of totality here makes Des Moines to have been about nineteen miles south of the central line. The computations were made by Prof. Safford, from the *Washington Nautical Almanac*, and by Mr. Elias Colbert, of the *Chicago Tribune*, from the English *Ephemeris*, Professor Safford being in error just 12 seconds, and the last named gentleman only four.

During the last half of the total obscuration the horizon on the north and southeast were beautifully lighted up with an orange-colored hue, which changed to dark blue in the south as the shadow passed on in its course. The phenomena of the orange-colored horizon was the effect of the light of the sun reflecting on the clouds behind that portion of the heavens then under eclipse. The shadow did not seem to move away, but rolled or lifted itself away, like the rolling of heavy ground swell waves of the ocean. The effect on the cattle and horses in sight of the observatory was not so strange as accounts had almost made us believe it would be. There was no terror shown by them, save that they quit grazing and took the homeward way.

THE OBSERVATIONS

taken by Prof. Harkness and his party were as good as any that have yet been taken of a total obscuration. Several perfect and distinct spectrums were taken by Professor Harkness and Safford with the spectroscope, which will be analyzed, and in that way the component parts of the sun discovered and fixed. This is the most important observation, for the scientific world, that could be taken. Professor Eastman, assisted by Mrs. Eastman, conducted the meteorological observations. A copy of the results obtained is found below, showing the various changes in the at-

mosphere, as denoted by the dry bulb and solar thermometers, and the barometer. (Here were given some tables of temperature and barometer.)

FAST PHOTOGRAPHY

Dr. Curtis had charge of the photography department, assisted by Hospital Steward LeMerle, and Messrs. Brennan and Ward. During the time of the eclipse, less than two hours one hundred and twenty-three perfect negatives of the sun, in its various stages of total and partial obscuration, were taken, and will be a valuable addition to the knowledge of the astronomical world.

POLARIZATION OF THE LIGHT

All of Professor Safford's party were engaged at the Naval Observatory, and made some important discoveries. Mr. Stone used the Polariscopes and discovered strong polarization of the light around the sun.

ALLEN'S OBSERVATORY

From observations made by S. V. White, Esq., on the lawn in front of B. F. Allen's residence, with a five inch glass of the manufacture of Alvin Clark & Son's of Cambridgeport, Mass., the time of first contact was noted as two seconds later than that of Professor Newcomb at the observatory on courthouse square, but within a half second of the meantime as seen by the different observers. All other observations correspond substantially with the observations herein noted. Mr. White speaks particularly of the phenomena resulting from the inequalities on the moon's surface. When the sun's disc was about five-sixths obscured, the crescent formed by the portion of the sun not obscured, was cut in two by an elevation on the moon's surface, and a light spot, from seven to ten degrees in length, appeared at the lower end of the crescent, wholly separate from the rest of the sun, and continued visible some ten seconds, before the moon's body entirely darkened it.

AT THE LITCHFIELD OBSERVATORY

Doctor Peters and party were eminently successful in their observations. Doctor Peters used the spectroscope, and confirmed the theory that the protuberances on the sun were in great part composed of hydrogen. The great horn was measured by Professor Rogers, and its height figured out to be eighty thousand miles. The protuberances were visible from this observatory while more than twenty degrees of the sun were yet unobscured, and they were also seen by Professor Hall one minute and seventeen seconds after totality. Doctor Peters some months ago published it to the scientific world that the protuberances that appeared yesterday

would be seen in the same locality that they were seen. Best of all, and what will gratify the scientific world at large, Professor Rogers has made an important discovery among the planets, the nature of which has not yet been made public, but will be as soon as the proper papers on the matter have been prepared. We have the word of one of the gentlemen composing the party that the Home Observatory will be richly repaid by this expedition in the discoveries made and theories confirmed.

NO INTER-MERCURIAL PLANETS

Professor Newcomb, whose observatory was situated in the courthouse square, and whose observations were solely for the discovery of inter-mercurial planets, or planets between Mercury and the sun, searched that region thoroughly, and found nothing that would indicate the existence of planets of that class. The question of their existence has been a mooted one among astronomers, and as Mercury is very seldom visible, even with the aid of powerful telescopes, research has been very limited, and as this total obscuration of the sun opened the whole field for observation, Professor Newcomb, assisted by Professor Armstrong, availed himself of the opportunity.

THE GOLDFINCH*

Exultant is their motion and their song;
 They rise on wing and with a wavy flight
 Again float down into their paradise
 On thistle blooms or mullein stalks to light;
 There, clinging to the swaying, slender stems
 And swinging airily among the weeds,
 They peck upon the stately mullein stalks
 And lunch upon the thistle's fluffy seeds.

As bright and yellow, as they soar aloft,
 As glint of sunshine or of golden rod,
 The echoes of the mingled rhapsody
 Come floating downward from the realms of God;
 Wild, sweet and incoherent melody—
 Of brown and gold—a perfect harmony.

—Inez Sheldon Tyler
 Editor of BLUE MOON
 3945 Connecticut Avenue, N. W.
 Washington 8, D. C.

*The Eastern Goldfinch, *Spinus tristis tristis* (Linnaeus), often referred to as a wild canary, was made the official State bird of Iowa by the General Assembly, March 22, 1933.

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