Kodaikanal Observatory.

BULLETIN No. LV.

# THE SOLAR PROMINENCE OF 1916, MAY 26.

BY J. EVERSHED, F.R.S.

A good series of photographs of this remarkable eruptive prominence was secured by Dr. Royds at Kodaikanal with the Cambridge spectroheliograph, and at Srinagar Kashmir another series was obtained by the author, using the new spectroheliograph installed there in the autumn of 1915. The definition at Kodaikanal was very good at the time of the display, but there were some interruptions from cloud. At Srinagar the conditions were practically perfect throughout the day which was cloudless.

The two series of plates supplement one another, and the development of the prominence can be studied with the quite exceptional advantage of an uninterrupted series of well defined images obtained at short intervals of time. In plate IV, I give a selection of photographs from both observatories illustrating the different stages in the development of the prominence.

In studying spectroheliograph images of a rapidly changing prominence it is necessary to consider the time taken in building up the image by the successive slit sections. Owing to the comparative faintness of the light the slits of the spectroheliograph are made to move slowly across the image (or the image across the slits) and the time when the base of a large prominence is impressed on the plate may differ by a minute or more from the time when the highest parts are photographed. Thus the complete image does not represent the prominence at any one moment of time. In plate IV the times given under each image are the times when the slits reached the base of the prominence.

In estimating movements the exact time the slit reached any particular point of reference in the prominence has to be carefully computed, the speed of the slits, or of the image, being ascertained by noting the time taken in traversing the solar diameter. In the Kodaikanal spectroheliograph this speed was about 6′ per minute, and the Kashmir spectroheliograph it was 9′ per minute; but the two instruments are of different design and the movement is in opposite directions: thus at Kodaikanal the prominence was photographed successively from base to summit, and at Srinagar from summit to base.

In table I, page 215, I give a list of all the photographs taken, with the approximate times the centre of the image was photographed. Of the seventeen exposures only Nos. 3 and 4 were made practically simultaneously at Kodaikanal and at Srinagar; these images are apparently identical in all details, but comparisons with a "Blink" apparatus would probably reveal slight differences in the higher and also the lower parts of the prominence where the exposure times would differ slightly.

The exposure times of the Srinagar series were determined by a mean time chronometer by Frodsham the error and rate of which was periodically ascertained by solar altitude observations with a sextant. These times are probably correct within one second. The Kodaikanal times are determined from the standard clock of the Observatory the error of which is daily observed by time signal from the Madras Observatory.

*General description of the photographs.*—Photograph No. 1 of the combined series is a large scale image of the disc obtained with the 40-foot focus objective at Srinagar. This was accidentally over-exposed for the flocculi but shows the prominences rather well. A prominence the denser part of which is 90″ in height is shown at latitude + 48° on the east limb and there are also shown bright detached streaks issuing from the chromosphere at + 63° which extend to over 4′ above the limb, they probably extend much further than this but the plate is under-exposed for the prominences.

In the second photograph exposed at $8^{h}\ 6^{m}$ (see plate IV) the denser part of the prominence at + 48° is found to be 136″ in height, and at + 63° there is seen a complicated system of bright streaks connected with the prominence at + 48° and extending over it to a vast height, the highest filaments being over 12′ above the limb.

In Nos. 3 and 4 exposed after an interval of 16 minutes, faint streaks and patches are still found at a height of 12′ above the limb over latitude + 33° but the lower part of this prominence has contracted and brightened (plate IV at $8^{h}\ 21^{m}\ 47^{s}$). The prominence at + 48° now shows signs of rapid development and from this time on the rate of ascent of the upper limit of the prominence increases as is shown in table II.

At $8^{h}\ 36^{m}$ the prominence has reached a stage of great brilliance and complexity of structure and would doubtless have presented a magnificent spectacle viewed in the spectroscope in H$\alpha$ light. Faint whisps can still be traced up to a height of 11′ over the top of the ascending mass.

In the photographs taken at $8^{h}\ 50^{m}$, $8^{h}\ 55^{m}$, and $8^{h}\ 57^{m}$ the main stem of the great eruption turns over at the highest point towards the north, bending round as if to fall back on the sun. There are also three or four branching steamers from the upper part of the column also turning over like the streams of a fountain. Hanging suspended over the more northern prominence, now moved to + 68°, there is a very bright elongated condensation resembling a falling rocket, and there are other bright condensations higher up in the prominence.

At $9^{h}\ 3^{m}$ a rapid dissolution of the entire prominence had set in, the main column is shown by the photographs to be breaking up and the " falling rocket " appears very much fainter and has *risen* slightly.

At $9^{h}\ 9^{m}$ the main column consists of separate filaments elongated in the direction of the column in the lower part but condensed into roundish spots in the higher region. The larger of these points of light although very small in relation to the prominence as a whole would be roughly 10″ or 7,000 km in diameter. In this plate (one of the Kodaikanal series) the field of view is limited by a circle 15′ above the sun's limb and the top of the prominence is cut off at this height. (The white streaks shown in the photograph are due to a passing cloud diffusing sunlight on to the slit.)

At $9^{h}\ 19^{m}$ the entire column has vanished. The spectroheliograph records blank space where ten minutes earlier brightly glowing masses of gas were photographed. There is however a little group of bright points at a height extending from 13′ to 17′ above the limb and these are probably the same as the group photographed in the last plate. In photograph No. 13 exposed at nearly the same time at Kodaikanal the bright points are not seen, being outside the field of the photograph, but a faint remnant can be traced of the " rocket." The ow bright prominence extending from latitude 35° to 48° and the small prominences to the south of it, are just as clearly shown in this photograph as in all the others, proving that no change of adjustment of the K line on the camera slit had occurred.

At $9^{h}\ 22^{m}$ photograph No. 14 still shows the group of bright points, but they are much fainter, and have ascended to the enormous height of 16′ to 18·5′ above the limb. This highest point in the group is equal to half a million of miles above the sun, a height which greatly exceeds all our previous records.

In the Kodaikanal photograph No. 15 exposed at $9^{h}\ 27^{m}$ very faint remnants of the rocket are still visible although I cannot trace these on the Srinagar plates taken earlier.

In the last two photographs Nos. 16 and 17 obtained at Srinagar it is no longer possible to distinguish faint remnants of the prominence from slight defects in the film. The photographic field extends in the last plate to a distance of over 30′ or about solar diameter from the limb, and at the position which the bright ascending masses might be expected to occupy there are very faint markings on the film, but I hesitate to regard these as parts of the prominence. This last plate shows the low bright prominence extending from latitude +35° to latitude +48° practically unaltered, the immense eruption taking place immediately over its northern end has apparently had no effect whatever on it. This prominence was of a long enduring type and had been visible for several days on the limb, attaining its greatest apparent development on May 24 and 25 when it was 120″ in height. Its last appearence was on May 27.

It is very remarkable that the whole of the eruptive prominence faded away practically simultaneously, not only the main column at latitude +48° but also the prominence about 20° to the north. This had steadily moved northward along the sun's limb between $8^{h}\ 6^{m}$ and $8^{h}\ 57^{m}$ changing its position by 6° from + 63° to +69°.

The eruption occurred outside the sunspot zones, and in the disc photographs no trace can be seen of any bright flocculus in the region. There is however a dark flocculus unusually well shown on the calcium plates and clearly shown on the $H\alpha$ plate, which probably was connected with the eruption. On May 25 the flocculus extends from latitude $+34^\circ$ and longitude $19^\circ$ east of the central meridian in an irregular line meeting the limb at latitude $+58^\circ$. On the 26th the western end had advanced towards the central meridian and at $8^h\ 9^m$ and $8^h\ 12^m$ the eastern end, in the form of a narrow line, meets the limb almost at the base of the big eruption at about latitude $50^\circ$. Twenty minutes later the $H\alpha$ photograph was obtained and on this the portion of the flocculus near the limb has entirely vanished.

*Movements in the prominence and velocity of ascent.*—A general ascending movement from a height of $130''$ at $8^h\ 6^m$ to over $15'$ at $9^h\ 9^m$ is obvious (see plate IV). Measures of the upper limits of the ascending mass on the successive plates reveal what is not so obvious that the ascending motion accelerates, the velocity increasing from 79 km/sec to 292 km/sec, as is seen in table II. These measures were made in a direction radial to the sun.

Measures of definite points in the prominence which can be identified on two or more plates have also been made, and in nearly all cases where more than one determination was possible an acceleration is shown. Table III gives the results of these measures. An acceleration of velocity of ascent has been measured in several eruptions previously recorded, notably in the very large prominence of 1907, February 18.[1]

The straightness of the main column seems to imply rapid motion in the direction of the column and this is confirmed by measures of points in and near the column. It was therefore thought best to measure the positions of points at a distance from the column in two co-ordinates, one in the direction of the column and the other at right angles to this. A considerable number of separate determinations of apparent velocity have thus been obtained. The resultant directions of movement and velocities are the projections of the real directions and velocities in a plane normal to the line of vision. There may be and probably are components in the line of sight, but these will be comparatively small, not exceeding about 30 km/sec as will be explained later. These measures are of course only possible in the case of definitely marked spots, not in the case of long drawn out filaments. The results are very interesting; contrary to what might have been anticipated from the close resemblance to a fountain, it appears that all points which can be identified on successive plates are moving radially outward from a point in the chromosphere at the base of the main column.

Taking the mean velocities or those which would result from the first and the last observations of a marking, omitting the intermediate positions, I have represented the movements in the diagram following plate IV. The arrows here show the direction of movement and the relative velocity indicated by the length of the shaft, the actual mean velocities in km/sec are given in figures at the points of the arrows. The general form and details of the prominence are carefully drawn from the photograph exposed at $8^h\ 57^m$, a print of the prominence being laid on the drawing paper and the salient points pricked through with a fine pin. The detached fragments above the top of the "fountain" were photographed at $9^h\ 22^m$ after the dissolution of the main stem had taken place, and the movement of the lower limit of these fragments was measured in a direction radial to the sun only, the motion at right angles being indeterminate owing to the indefinite boundaries in that direction; the arrow here, therefore, does not truly represent the direction of movement. It is probable that the movement of these fragments was also directed from the same point in the chromosphere as in the other cases. It was the upper faint extensions of these flying fragments that attained the unprecedented height of over $18'$ above the limb.

The highest velocity recorded is not in the highest part of the prominence, but about halfway up the main column where a little bright projecting point could be recognized on photographs Nos. 8 and 9. From the movement in the direction of the column the velocity was found to be 457 km/sec. In the measures a high degree of accuracy is not possible owing to the constant change of form in the details measured, moreover the kaleidoscopic nature of these changes render the identification doubtful in some cases. Possibly they may be relied on to give the order of velocity within 10 or 15 per cent. The true velocities may be slightly greater than the observed since the components in the line of sight are neglected. That these will be relatively small results

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[1] Astrophysical Journal, XXVIII, 79.

from the peculiar limitations of the spectroheliograph image which only represents that part of the prominence which has a small or zero motion in the line of sight. With slits of insensible width and perfect adjustment of the spectrum line on the camera slit the image would represent zero motion only, since any increase or decrease of wave-length due to motion would throw the spectrum line off the slit, and the light would not reach the plate at all. But in practice slits of quite considerable width are used in prominence work, and an appreciable range of wave-lengths will therefore reach the plate. In the Kashmir spectroheliograph the camera slit was 0·10 mm in width and the dispersion between H and K being 5 angstroms per millimetre the possible range of wave-length admitted to the plate with a narrow collimator slit will be 0·5A. But the collimator slit was even wider than the camera slit, a width of 0·15 mm being found by experience to give the best results, with this width a displacement of 0·6 angstrom to red or violet will not throw the light entirely off the camera slit although the intensity will be greatly reduced. With the intensity reduced four times only a very feeble impression would be made on the plate, and this would result from a displacement of 0·5A each way or 33 km/sec approach or recession. It is very improbable therefore that any parts of the prominence as photographed had velocities in the line of sight exceeding about one-tenth the velocities found across the line of sight.

In visual observations of a prominence in the spectroscope the parts which have large motions in the line of sight are clearly seen, often projected on the bright continuous spectrum adjacent to the H$\alpha$ line. At Kodaikanal the prominence of May 26 was observed in the grating spectroscope attached to the 6-inch equatorial by First Assistant S. Sitarama Ayyar, and he noted a displacement of 3A to the red at $8^h\ 50^m$ over the lower half of the prominence, and a slight displacement to violet in the upper part. The largest displacement he observed would imply a velocity of recession of 137 km/sec in the lower part of the main column, and here a drawing would probably have differed somewhat from the photograph.

The "spectro-enregistreur des vitesse" designed by Deslandes would be an invaluable adjunct to the spectroheliograph for the complete determination of velocities in eruptive prominences, but it would need to be worked as an entirely independent installation with a separate heliostat, on account of the very limited time available during the progress of a great eruption.

In the prominence of May 26 the components of motion across the line of sight appear to have been much larger than those in the line of sight, which are relatively of small importance. The striking feature resulting from the measurements is the unexpectedly consistent nature of the motion, all the parts of the prominence being found to be moving radially from the central point situated in the chromosphere at the base of the main stem. The bright rocket-like condensation which gives the impression of falling back towards the sun is in reality moving upward and outward from the main column but with a lesser speed than the higher parts of the prominence, and the prominence 20° to the north of the column is moving horizontally along the sun's surface with the smallest speed of all. The greatest velocity is found in the main column and the movement is here all in the direction of the column. The straightness of this column is remarkable especially in view of the fact that it is inclined 27° to the direction of the solar radius. It bends over at the top but not in the direction one would expect from the action of gravity. The column inclines towards the equator, yet the branching streamers bend back towards the pole : these streamers however possibly represent the projections of more or less spherical shells of luminosity expanding outward from the central point of radiation in the chromosphere.

*Discussion of results.*—The physical interpretation of the phenomena observed in an eruptive prominence such as that of May 26, 1916, is not easy. The total quantity of matter concerned is probably small and the density almost inconceivably low, as will appear from the following considerations. Prominences in general and the chromosphere from which they arise are certainly cooler than the photosphere, their emissive power being less. This is shown by the strong absorption lines of hydrogen $\alpha$, $\beta$, $\gamma$, and the calcium lines H and K in the solar spectrum ; the hydrogen line $\delta$ is however comparatively weak, $\epsilon$ is almost absent as a dark line, and the rest of the Balmer series in the ultra-violet are entirely missing as dark lines although they are conspicuous emission lines in eclipse spectra. But at the centre of the sun's disc the depth of hydrogen through which the photospheric light has to pass is about 6,000 km and it increases to 90,000 km at the limb, yet no trace of absorption due to these ultra-violet lines occurs in any part of the disc. This behaviour of the hydrogen lines might be due to molecular scattering in the photospheric region reducing the intensity of the continuous spectrum background, as has been suggested by Schuster.[1] But if this were so, the lines of other elements besides hydrogen might be expected to show a similar tendency to become less dark, or to disappear altogether in the ultra-violet region, which is certainly not the case.

It appears to me more probable that the disappearance of the less absorptive radiations of hydrogen is simply due to insufficiency of material. As in the case of helium, the total quantity of gas in the chromosphere is not sufficient to produce appreciable absorption. The emissive (and absorptive) power of hydrogen increases with the wave-length for the Balmer series of lines, and it may be that the total quantity of gas in the chromosphere is only sufficient to give an intensity of emission and absorption comparable with that of a black body at the same temperature for the three less refrangible lines.

Now it is only by extrapolation that an estimate can be made of the actual emissive power of a black body, or of a gas of sufficient thickness, at solar temperatures, but it is probably greater than that produced in the laboratory by the electrical stimulation of gases. It will perhaps be safe to assume that the emissive power will be at least equal to that of hydrogen in a partially exhausted tube in which an electrical discharge is passing But with a tube reduced to 1 mm pressure the thickness of gas necessary to give the maximum emission, or absorption, will perhaps be only of the order of a few cm for the less refrangible lines and possibly as much as a metre for the ultra-violet lines of the Balmer series. If this is so, in order to produce the partial absorption ending at H$\epsilon$ observed in the chromosphere, the total depth of gas lying above the photosphere must be the equivalent of something less than a meter at 1 mm pressure ; but as it is spread over a depth of $6 \times 10^6$ meters the density will be reduced six million times.

The assumption as to the total thickness of gas necessary to give maximum emission and absorption in the laboratory may be varied within very wide limits without altering the conclusion that the partial nature of the hydrogen absorption in the sun indicates an excessively low density. If the hydrogen in the chromosphere had a density approaching that in the vacuum tube at 1 mm pressure it is probable that in a depth of about 180,000 km at the limb the accumulation of feeble radiations between the Balmer lines would produce a continuous emission spectrum instead of the narrow bright lines with clear spaces seen at eclipses.

The same arguments apply with still greater force to the prominences, if we may assume that the radiation is due to heat alone and that Kirchoff's law applies, for only a small proportion are dense enough to produce absorption in the H$\alpha$ line even when the line of sight passes through a thickness of some 50,000 to 100,000 kilometers. These denser absorbing prominences are also brighter than the average, not because of a higher temperature, but because they approximate to black body radiation which the majority of prominences never attain, notwithstanding the vast depth of space occupied.

We may form a rough estimate of the total mass and of the density of the hydrogen constituent of a prominence assuming that the amount of hydrogen is equivalent to that in a layer one centimeter thick at a pressure of 1 mm of mercury at normal temperature. The equivalent volume of a prominence of say one square minute of arc apparent area, or actually at the sun's distance $18{\cdot}9 \times 10^{18}$ square centimeters, will be $18{\cdot}9 \times 10^{18}$ cubic centimeters, and the mass $2{\cdot}21 \times 10^{9}$ kilograms.

If the prominence has a thickness which is the equivalent of 1 minute of arc or 43,480 kilometers, the density will be less than that of the gas at 1 mm pressure in the ratio of 1 centimeter to 43,480 kilometers or 4,348 million times. This excessively low density will not affect the emissive power of the prominence since the angular size is the same whatever thickness be assumed. Notwithstanding this extremely low density the number of hydrogen molecules will still be of the order of $8{\cdot}2 \times 10^{6}$ in a cubic centimeter.

If as is possible the emission under solar conditions is greater than that in the hydrogen tube, the amount of matter present in the prominence and its density must be correspondingly diminished.

Under this condition of excessively low density the prominence matter will of course not conduct electricity as in the discharge tube, that is, we cannot expect to observe electric discharges on a big scale in the prominences. The atoms may indeed carry charges and be impelled by electric forces, although the apparent absence of any Stark effect tells against such a hypothesis. The calcium lines H and K in the prominences are usually very sharply defined narrow lines about 0·10A in width, but they are frequently bent and

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[1] A Schuster, "Radiation through a Foggy Atmosphere," Astrophysical Journal, XXI, 21, 1905.

distorted or bodily displaced by motion, and there is often a tendency to a diffused widening in the higher parts of a prominence. The Hα line is similar but wider, it measures 0·9A in the chromosphere and about 0·4A in the prominences. In neither H and K nor Hα have I met with anything suggesting a separation of the lines into two or more components, but possibly the conditions would not be favourable for the production of a Stark effect even if strong electric fields are actually present in the region immediately above the chromosphere.

There is some evidence that eruptive prominences consist in their earlier stages of unusually dense low-lying gas giving strong absorption in Hα and the calcium lines $H_3$ $K_3$. The mass of gas may persist for several days apparently unchanged and then suddenly become unstable, coming under the influence of a force which apparently tears it to shreds and sends the fragments flying into space with accelerating speed. Considering the comparative rarity of these outbursts it is remarkable that another eruption having much the same character as that of May 26 was observed by Buss two days later.[1] This also developed from a dark hydrogen flocculus and is stated to have resembled "a stupendous luminous fountain," it appeared in the same solar quadrant but in a lower latitude, the end of the dark absorption marking as photographed at Kodaikanal in K light being at latitude 26° on the eastern limb. In this case the entire length of the dark flocculus appears to have been dissipated by the eruption, whereas in the prominence of May 26 only the eastern end of a long and straggling flocculus disappeared. The sudden disappearance of Hα absorption markings photographed on the disc of the sun has been noticed on several occasions at Kodaikanal but in positions too far removed from the limb to observe any accompanying eruptive prominence.

The relation between unstable prominences and absorption phenomena has also been observed by A. M. Newbegin especially with regard to absorbing hydrogen when seen in projection on bright prominences.[2]

It would seem from these observations and others I might mention that prominences dense enough to give strong absorption in Hα and the calcium lines $H_3$ and $K_3$ are for some reason unstable and liable to sudden explosive dissolution. That the dissipating force lies at the surface of the sun and may be localized in a very limited region appears to be indicated by the radiating movements measured in the photographs of May 26.

The rapidity with which apparently large masses of gas fade away to invisibility may probably be explained by the extremely low density, for each atom of gas occupies so large a volume of space that it is independent of all the others, its mean free path being practically infinite; the gas can thus have no temperature in the ordinary sense, and its emissive power is not dependent on mutual collisions but only on absorption of photospheric radiation, which is apparently insufficient to maintain luminosity at great heights above the sun's surface. The prominence as a whole may continue luminous if a constant supply of gaseous atoms endowed with great internal energy is emitted from the chromosphere, but the moment this supply ceases the prominence would fade. This is suggested by the behaviour of the main stem of the big prominence; this evidently consisted of a stream of rapidly moving gas which maintained a brilliant luminosity during the period when it formed a continuous column, but as soon as the supply of gas from the chromosphere ceased and breaks in the continuity occurred, the separate detached masses faded very rapidly. However an examination of the photographs reveals another feature not readily explained in this way. If the photograph at $8^h$ $50^m$ is compared with that taken six minutes later it will be found that some of the detached masses high above the chromosphere such as the "rocket" formation and other bright condensations have increased in luminosity although no connection with the chromosphere is apparent; this almost suggests collision of the moving gases with denser matter already existing in this region.

Another remarkable and at present mysterious feature is the almost simultaneous fading of the entire prominence, already alluded to. When the main column disappeared the subsidiary column 260,000 km to the north of it succumbed also as well as the rocket formation and all its appurtenances, distant some 300,000 km from the main column and an equal distance above the chromosphere.

THE OBSERVATORY, KODAIKANAL,
*25th January 1917.*

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*Director, Kodaikanal and Madras Observatories.*

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[1] The Observatory, XXXIX, 352.

[2] Journal of the British Astronomical Association, XXVI, 307.

TABLE I.

| Photograph number | Centre of Prominence exposed at | Photographed at |
|---|---|---|
| | H. M S | |
| 1 | 7 47 07 | Srinagar. |
| 2 | 8 05 34 | Do. |
| 3 | 8 21 31 | Kodaikanal. |
| 4 | 8 21 33 | Srinagar. |
| 5 | 8 36 06 | Do |
| 6 | 8 47 15 | Kodaikanal. |
| 7 | 8 49 50 | Srinagar |
| 8 | 8 55 18 | Do |
| 9 | 8 57 32 | Kodaikanal. |
| 10 | 9 04 06 | Do. |
| 11 | 9 10 45 | Do. |
| 12 | 9 18 40 | Srinagar |
| 13 | 9 20 16 | Kodaikanal |
| 14 | 9 22 37 | Srinagar. |
| 15 | 9 27 31 | Kodaikanal. |
| 16 | 9 42 12 | Srinagar. |
| 17 | 9 47 52 | Do. |

The times are 5½ hours fast on Greenwich civil time.

TABLE II.—GENERAL MOVEMENT OF ASCENT OF THE PROMINENCE

| Photograph number | Time | Interval | Motion radial to sun | |
|---|---|---|---|---|
| | H. M. S. | M. S. | ″ | KM/SEC |
| 2 | 8 05 34 | | | |
| | | 15 46 | 100 | 79 |
| 4 | 8 21 20 | | | |
| | | 14 24 | 184 | 157 |
| 5 | 8 35 44 | | | |
| | | 13 10 | 219 | 203 |
| 7 | 8 48 54 | | | |
| | | 5 10 | 123 | 292 |
| 8 | 8 54 04 | | | |

The velocities in direction of column are about 5 per cent greater.

## Table III.—Movements of parts of the prominence

### *A.—Movements measured parallel to column*

| Photograph number | Time | Interval | Motion parallel to column | |
|---|---|---|---|---|
| | **Spot near base of column** | | | |
| | H. M S. | S. | ″ | KM/SEC |
| 6 | 8 46 30 | 244 | 63 | 189 |
| 7 | 8 50 34 | | | |
| | **Projecting point on column** | | | |
| 8 | 8 55 20 | 122 | 76 | 457 |
| 9 | 8 57 22 | | | |
| | **Arrow like marking near column** | | | |
| 6 | 8 46 45 | 215 | 64 | 218 |
| 7 | 8 50 20 | 300 | 101 | 247 |
| 8 | 8 55 20 | 125 | 72 | 423 |
| 9 | 8 57 25 | | | |
| | Whole interval ... | 640 | 237 | 272 |
| | **Streamer near top of column** | | | |
| 7 | 8 49 42 | 296 | 133 | 329 |
| 8 | 8 54 38 | 212 | 85 | 296 |
| 9 | 8 58 10 | | | |
| | Whole interval .. | 508 | 218 | 316 |

### *B.—Motion measured radial to sun*

| Photograph number | Time | Interval | Motion radial to sun | |
|---|---|---|---|---|
| | **Detached remnants of prominence** | | | |
| | H M. S. | S. | ″ | KM/SEC |
| 13 | 9 18 45 | 232 | 100 | 319 |
| 15 | 9 22 37 | | | |

*C.—Movements measured in two co-ordinates*

| Photograph number | Time | | | Interval | Motion parallel to column | | Motion at right angles to column | |
|---|---|---|---|---|---|---|---|---|
| | | | | BRIGHT POINT UNDER THE ARCH. | | | | |
| | H | M | S | S | " | KM/SEC | " | KM/SEC |
| 7 | 8 | 50 | 14 | | | | | |
| | | | | 303 | 118 | 285 | 47 | 115 |
| 8 | 8 | 55 | 17 | | | | | |
| | | | | 137 | 63 | 335 | 28 | 152 |
| 9 | 8 | 57 | 34 | | | | | |
| | Whole interval .. | | | 440 | 181 | 302 | 75 | 127 |
| | | | | | | Resultant mean velocity | | 328 km/sec |
| | | | | BRIGHT CONDENSATION ABOVE THE ROCKET-LIKE MARKING | | | | |
| 6 | 8 | 47 | 05 | | | | | |
| | | | | 187 | 23 | 89 | 19 | 75 |
| 7 | 8 | 50 | 12 | | | | | |
| | | | | 308 | 57 | 136 | 48 | 113 |
| 8 | 8 | 55 | 20 | | | | | |
| | | | | 125 | 32 | 190 | 23 | 134 |
| 9 | 8 | 57 | 25 | | | | | |
| | | | | 403 | 81 | 148 | 97 | 176 |
| | 9 | 04 | 08 | | | | | |
| | Whole interval .. | | | 1023 | 193 | 139 | 187 | 133 |
| | | | | | | Resultant mean velocity | | 192 km/sec |
| | | | | ROCKET-LIKE MARKING | | | | |
| 7 | 8 | 50 | 34 | | | | | |
| | | | | 317 | 6 | 13 | 36 | 84 |
| 8 | 8 | 55 | 51 | | | | | |
| | | | | 71 | 8 | 78 | 19 | 197 |
| 9 | 8 | 57 | 02 | | | | | |
| | | | | 404 | 34 | 62 | 80 | 145 |
| 10 | 9 | 03 | 46 | | | | | |
| | Whole interval ... | | | 792 | 48 | 44 | 135 | 125 |
| | | | | | | Resultant mean velocity | | 132 km/sec |

*D.—Motion of prominence at latitude* 65° — 69°

| Photograph number | Time | | | Latitude of base |
|---|---|---|---|---|
| | H. | M. | S. | ° |
| 2 | 8 | 06 | 32 | 63 |
| 3 | 8 | 20 | 55 | 65½ |
| 5 | 8 | 36 | 47 | 66 |
| 6 | 8 | 45 | 55 | 67½ |
| 7 | 8 | 51 | 23 | 68 |
| 8 | 8 | 56 | 51 | 69 |
| 10 | 9 | 02 | 43 | 69 |
| 11 | 9 | 09 | 06 | 68 |

Motion between 8h 21m and 8h 57m = 3½ degrees of latitude in 36 minutes, equivalent to 20 km/sec tangent to sun.

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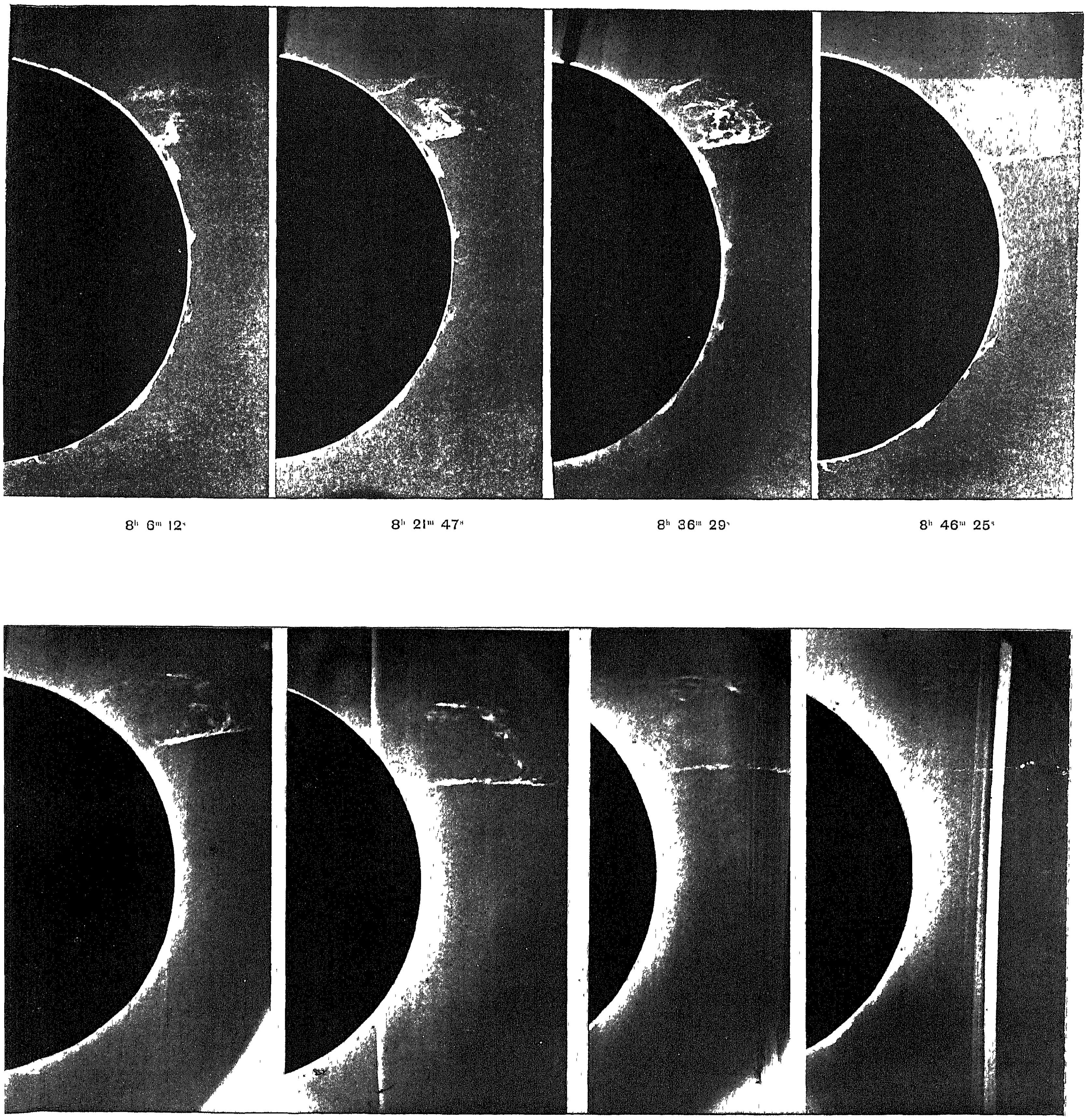

$8^h\ 6^m\ 12^s$ $8^h\ 21^m\ 47^s$ $8^h\ 36^m\ 29^s$ $8^h\ 46^m\ 25^s$

$8^h\ 50^m\ 40^s$ $8^h\ 56^m\ 40^s$ $9^h\ 3^m\ 19^s$ $9^h\ 9^m\ 34^s$

ERUPTIVE PROMINENCE
1916 May 26.

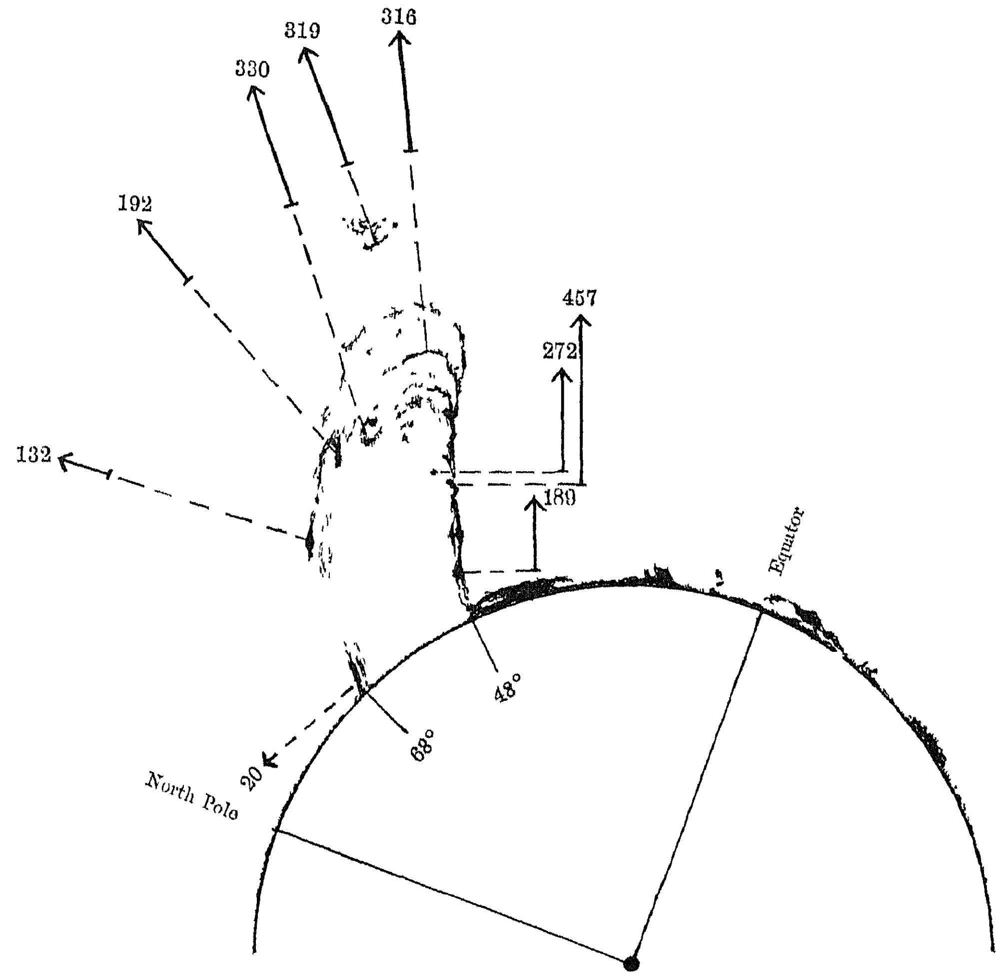

DIAGRAM SHOWING DIRECTIONS OF MOVEMENT AND VELOCITIES OF PARTS OF THE PROMINENCE IN KILOMETERS PER SECOND. THE DRAWING REPRESENTS THE PROMINENCE AT $8^h\ 57^m$ I. S. T., EXCEPTING THE HIGHEST DETACHED PORTION WHICH WAS ALL THAT REMAINED AT $9^h\ 22^m$.