THE FLARE-SURGE EVENT

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Summary

Studies of flare-surges recorded on low magnification Hα flare patrol films show that dark surges on the disk come directly from flares, the initial direction of motion being almost invariably away from the nearest large sunspot.

The basic feature of the event is the emission of a substantially continuous particle stream having different appearances at different stages. The first trace is usually the ejection from the flare of diffuse matter, brighter than the chromosphere, which fades and disappears by becoming transparent, though it can be detected if the stream crosses the limb. The dark surge subsequently appears at the base of the stream, close to the flare.

Dark surges, bright streamers on the disk, and ejected flares seem to be closely related phenomena. It is shown that dark surges can develop only if the temperature is decreasing, while in ejected flares whose brightness increases during flight the temperature must be increasing.

I. Introduction

The term " surge " is usually applied to ejections of matter from the solar chromospheric regions, observable on the disk or at the limb because of significant absorption or emission in Hα and certain other spectral lines ; the term does not include ejections arising from pre-existing filaments.

The occurrence of surges at times of flares has often been noted, but one vital aspect of the association has remained obscure, namely, the location of the surge with respect to the flare. The main papers on surges agree that, when first observed, the surge appears near but not usually in contact with the flare. The question arises whether the surge comes from the flare or whether it is an allied event occurring simultaneously in another part of the active region and having a cause in common with the flare. We propose to describe observations which settle this matter and enable a clearer description of the flare-surge event to be given.

The surges which accompany some flares, appearing dark against the chromospheric background when viewed with a suitable Hα monochromatic telescope, had been studied first by Giovanelli (1940), Ellison (1942), Newton (1942), and Bruzek (1951). From visual observations they had found that surges were associated with about one-third of the flares of class 1 or greater, being ejected with velocities of 100 km/sec or more ; and that when first observed these surges were usually displaced from the flare by a gap of some 10^4–10^5 km.

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It is well known that flares themselves do not generally show velocities of such magnitudes, though Giovanelli (loc. cit.) had already observed in 1939 a limb flare rising at 78 km/sec. Severny and Shaposhnikova (1954) have pointed out, however, that in some flares there are motions of matter in the shape of streaks and ejections. Earlier, Dodson and Hedeman (1949) had recorded the ejection from several flares of long streamers, initially brighter than the undisturbed chromosphere, but subsequently becoming dark; they suggested that some flares are the root points or bases of surges, and in particular that the bright streamer on the disk is the counterpart of the rarer limb surges which are more brilliant than usual. Dodson and McMath (1952) drew attention to some exceptionally bright surge-type prominences which, they said, might or might not be the limb aspects of features that would appear as small flares or flare-like brightenings if seen on the disk. Also they reported a very small number of major prominence phenomena believed to be the limb aspects of important flares; in one case, portion of a very brilliant formation rose with a velocity of 700 km/sec to a height of 50,000 km. Dodson and Hedeman (1952) described the presence of a short-lived prominence, bright in projection against the disk, after a flare. More recently, Bray *et al.* (1957) noted the ejection of a bright flare on the disk, at a velocity of 300 km/sec. This severed contact with a stationary base flare and reached maximum brightness at a height of 25,000 km above the chromosphere. This ejection later crossed the limb, where its appearance resembled an ordinary surge.

The observations described below reveal no new phenomena, but enable us to obtain a coherent picture of the flare-surge event. In particular, it appears that dark surges observed on the disk come directly from the flares; but almost invariably, at least when the resolution permits it, the first trace of the surge is the ejection of diffuse matter, brighter than the chromosphere. The stream of ejected matter generally fades and disappears by becoming transparent, though the ejection of invisible material continues. Subsequently, absorbing matter appears in the stream, either superimposed on or close to the flare, and travels outwards to appear as the normal dark surge. The ejection of high speed flares of the type observed by Bray *et al.* is interpreted as an extreme case of the flare-surge event.

II. Observations

The Sydney Lyot-monochromator, with a bandwidth of 0·7 Å centred on Hα, is used in conjunction with a 5 in. telescope to obtain, for "flare patrol" purposes, 16 mm diameter photographs of the solar chromosphere on 35 mm Eastman Kodak IV E film at 0·5 min intervals. While these records lack much of the resolution obtainable with higher initial magnification, they have enabled us to observe a great number of flares over the past 2 years. We believe that most flares occurring during the time of observation have been recorded if their areas exceeded about 2×10^{-5} of the Sun's hemisphere. Surges are also observable, though not necessarily with maximum contrast, since line-of-sight velocities shift the centre of the absorption line away from the wavelength of maximum transmission.

The present discussion is based on observations from November 9, 1955 to July 4, 1957. The numerical analyses are based on observations from November 9, 1955 to August 16, 1956, and November 5, 1956 to December 12, 1956, though not all flares observed during these intervals have been included. For convenience, before July 23, 1956 our study has been confined to periods when simultaneous radio-frequency spectrum observations were being made at Dapto, N.S.W. For the subsequent period flares have been included only if they occurred within about 45° of the central meridian. These two sets cover 482 flares, the majority being very small, of class 1−. The distribution of apparent flare areas is given in the histogram of Figure 1; the drop for areas

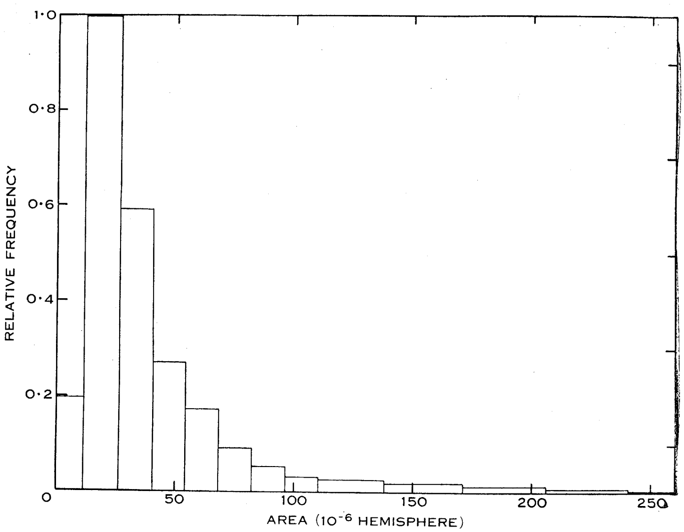

Fig. 1.—Distribution of apparent areas of 482 flares (millionths of the Sun's hemisphere) observed in Sydney during the period described in Section II.

below $1 \cdot 4 \times 10^{-5}$ of the Sun's hemisphere is probably due to the limits of resolution. Of the above flares, 78 were accompanied by dark surges on the disk, some large, some very small. In 46 other cases, the observations were inadequate to decide; deducting these from the total, we find that 18 per cent. of the flares were associated with surges. There was no statistically significant variation with flare size.

During this whole period we have discovered no dark surges which were not associated with flares. We conclude that all dark surges are associated with flares, most of which are of class 1−.

Plates 1–4 and Plate 5, Figure 1, show a number of flares and associated surges which are typical of the general range of surge appearance. Descriptions of interesting features are given below; times are U.T.

January 24, 1957

This flare developed in a region with only a very small sunspot group. The flare expanded rapidly northwards until $00^{\mathrm{h}}\ 53^{\mathrm{m}}\ 15^{\mathrm{s}}$. A minute later, traces of a dark surge appeared superimposed on the flare ; as the flare faded, the surge gradually extended outwards in the same direction as the bright expansion.

July 4, 1957

A bigger flare, this time near a larger sunspot, showing a similar sequence of events. An initial diffuse bright expansion of the flare occurred away from the sunspot, with maximum development at $00^h\,33^m\,0^s$. The diffuse part faded rapidly. A dark surge appeared in the same region at $00^h\,37^m\,0^s$, and expanded radially away from the sunspot.

November 26, 1956

One of a number of fine flare-surges associated with this sunspot. The flare, expanding away from the sunspot, had a very diffuse outer edge. The major dark surge can be traced back to the appearance of absorbing matter superimposed on the flare at $01^h\,08^m\,30^s$; this gradually expanded outwards until about $01^h\,50^m$. In its earlier stages the dark surge appeared fairly transparent—it is possible to detect underlying structure through it—though it would seem to have been fairly opaque over most of its length at $01^h\,29^m\,30^s$. Faint bright extensions of the flare were present on either side of the dark surge, e.g. at $01^h\,22^m$, but these gave place to the much wider dark surge later.

The stream of ejected matter seemed to have been in existence during most of the event. It was never of very high opacity ; the substantial changes in appearance during the event (e.g. from $01^h\,25^m\,30^s$) seem to have been due more to changes in excitation and opacity than to major changes in overall dimensions.

May 18, 1956

The flare, beginning at $01^h\,23^m\,52^s$, showed a rapid bright expansion away from its neighbouring sunspot, starting at $01^h\,29^m\,22^s$ and with maximum extent at $01^h\,30^m\,52^s$. It then faded back from the tip of the flare until the appearance at $01^h\,36^m\,52^s$ (not shown) resembled that shortly after commencement. At $01^h\,37^m\,52^s$ (not shown), however, a small spike appeared on enhanced exposures made at the limb. A dark surge also made its first appearance at this time in the position formerly occupied by the bright flare expansion. This dark surge moved out, joining the limb spike at about $01^h\,47^m\,52^s$; the continuous outward development of this spike demonstrated the continuity of the stream of ejected matter throughout the event.

The time between the initial flare expansion at $01^h\,29^m\,22^s$ and the first appearance of the limb spike at $01^h\,37^m\,52^s$ was about the same as that taken by the dark surge to reach the limb, so that the average velocity of the stream was approximately constant over this period, while a time plot of the position of the tip of the dark surge shows that the transverse velocity was effectively constant along the stream. Now, except perhaps just after its first appearance, the dark surge was separated from the flare, with the chromosphere apparently visible between ; certainly the chromosphere was plainly visible in the later stages. The continuous increase in length of the dark surge therefore seems to have been due to the continual formation of new absorbing material at the rear of the dark surge; in other words, an invisible stream of matter ejected from the flare became opaque.

The resolution was not sufficient to establish whether the same material forming the base of the diffuse bright stream at $01^h\ 34^m\ 52^s$ formed the tip of the dark surge further out at $01^h\ 38^m\ 52^s$.

August 24, 1956

This was rather similar to the event of May 18, 1956. A flare expanded away from a neighbouring sunspot, having maximum extension at about $04^h\ 09^m\ 35^s$. A minute later, an enhanced exposure revealed a small projection beyond the limb, though the high transparency of the stream was indicated by its non-appearance immediately within the limb. The bright stream faded, particularly near the flare, leaving a distant brightish part near the limb at $04^h\ 13^m\ 35^s$. In the meantime a dark surge developed on the upper side of the stream. At about $04^h\ 12^m\ 35^s$ it extended out to the limb. Even allowing for the movement along the stream, it seems very likely that some of the originally bright matter at the base of the stream at $04^h\ 10^m\ 35^s$ had moved out and become dark by $04^h\ 12^m\ 35^s$. The enhanced limb photograph at $04^h\ 23^m\ 35^s$ showed that the particle stream was much more extensive than indicated by its appearance on the disk, providing clear evidence for the high transparency of most of the stream.

January 18, 1957

Immediately after its outbreak this flare showed a bright diffuse expansion away from the small neighbouring sunspot, reaching maximum extent at $04^h\ 03^m\ 12^s$. A dark surge appeared first at $04^h\ 06^m\ 12^s$, in contact with the flare. From $04^h\ 07^m\ 12^s$ the rate of expansion of the surge was approximately constant, much less than the apparent rate between $04^h\ 06^m\ 12^s$ and $04^h\ 07^m\ 12^s$; furthermore, backward extrapolation of the rate of growth indicates that the material was ejected initially at the time of bright expansion. This is a clear case where the dark surge was formed by a pre-existing invisible particle stream becoming opaque. It is uncertain whether any of the material participating in the bright diffuse expansion of the flare at $04^h\ 03^m\ 12^s$ was identical with that forming the top of the dark surge, but it seems very likely.

May 30, 1956

In this event a bright streamer was ejected from a tiny flare near the limb. The bright streamer crossed the limb, beyond which its faintness showed that it was fairly transparent. An enhanced limb exposure at $00^h\ 51^m\ 35^s$ showed a surge, providing evidence of the diffuseness of the edges of the ejected stream.

May 7, 1957

This is a rare type of ejection, similar to that described by Bray *et al.* (1957), in which part of the flare was itself ejected. By $02^h\ 38^m\ 37^s$ no trace of the ejection could be seen on the disk; it had become quite transparent. However, an enhanced exposure half a minute later revealed a surge beyond the limb, from whose size it is clear that the stream was more extensive than appeared on the disk. At 02^h 39^m 07^s first traces of a dark surge were seen in contact with the stationary flare. This travelled out along the same path, disappearing, however, before reaching the limb.

August 23, 1956

This event consisted of a flare in contact with a sunspot. At 03^h 32^m 15^s the flare expanded away from the sunspot and began to fade a few minutes later. About 03^h 36^m 15^s a dark marking could be seen adjacent to the western edge of the now fading flare and extending radially away from the sunspot. The subsequent frames show the development of the dark marking into a fine dark surge. Simultaneously the bright matter ejected by the flare moved further outwards, apparently in contact with but below the dark surge, and appeared, particularly at 03^h 39^m 15^s, as a bright marking separate from the remnants of the flare.

III. Relative Positions of Flare and Surge

As illustrated by Plates 1–4 and Plate 5, Figure 1, most surges have been found to overlap or to start almost in contact with their associated flares. In cases where the surge has not originated in contact with the flare, almost invariably the direction of motion has been such that, if projected backwards, it would have crossed or touched the flare. However, as seen clearly in the events of July 4, 1957 and August 23, 1956, the surge has not always come from the centre of the flare.

In 2 cases out of 78 the surge appeared to originate near the flare but not in the flare itself.

IV. Direction of Surge

Since our observations do not yield line of sight velocities, we are able to deal only with the projected paths of the dark surges on the Sun's disk.

In the examples already given the initial paths of surges lie generally radially away from the nearest sunspot. To see whether this is a general conclusion we have carried out two sets of analyses:

(*a*) November 9, 1955–June 21, 1956. Sketches have been made of the positions of 29 surges in spot groups well away from the limb, without any attempt to correct for foreshortening.

(*b*) June 19, 1956–December 14, 1956. The solar image has been projected onto a hemispherical screen, sketches of the positions of surges in spot groups thus being approximately corrected for foreshortening. The 48 surges involved all occurred within about 45° from the centre of the disk.

For each set the sketches have been superimposed, with the nearest large sunspot at a fixed position (Figs. 2 (*a*), 2 (*b*)). With only one or two exceptions, the initial paths of these surges are more or less radially away from the sunspot.

V. Diffuse Bright Expansion preceding Surges

We have noted an interesting feature which is almost always followed by a dark surge. This is a diffuse, usually asymmetric, expansion of the flare. As the diffuse bright material fades, it gives place to the dark surge which then moves outwards. Plates 1–4 and Plate 5, Figure 1, all show this effect, though it is much more evident when the films are examined in cinematographic projection.

Of 78 flare-surge events studied on the disk, this feature could be identified in 39, with 16 doubtful cases. Discarding the latter, it appears that at least 60 per cent. of our events are of this type. Further, they include 82 per cent.

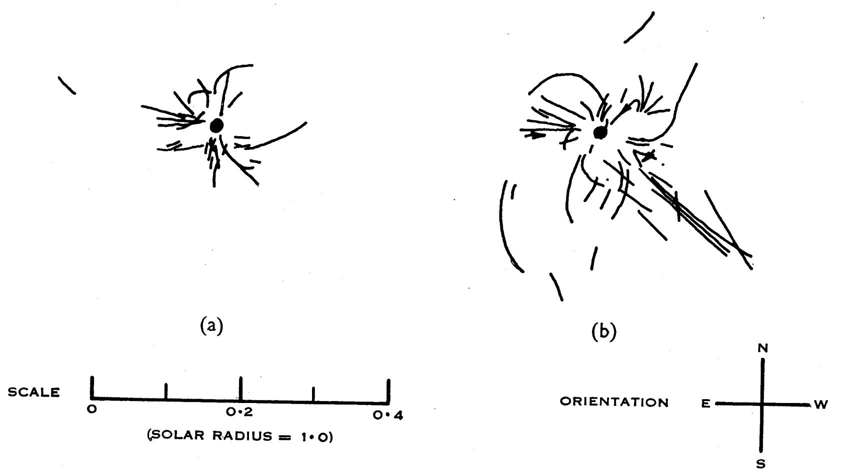

Fig. 2 (*a*).—Positions of 29 surges superimposed with respect to the nearest sunspot. Surges occurred between November 9, 1955 and June 21, 1956. All regions are well away from the Sun's limb, and the surges have been drawn without correction for foreshortening. Directions of surges are substantially away from the sunspot.

Fig. 2 (*b*).—Positions of 48 surges superimposed with respect to the nearest sunspot. Surges occurred between June 19, 1956 and December 14, 1956. The solar image has been first projected onto a hemispherical screen, sketches then being made of the positions of surge and sunspot. All surges occur within about 45° from the centre of the disk. Directions of surges are substantially away from the sunspot except where indicated by arrows.

of events involving flares of apparent area exceeding $2 \cdot 8 \times 10^{-5}$ of the Sun's hemisphere, as against 30 per cent. of events involving smaller flares. We believe that the difference is due solely to our inability to resolve the smaller flares adequately.

This is the type of event described first by Dodson and her collaborators. We can now state, however, that it is probably the normal mode of development of all flare-surge events.

VI. Limb Appearances of Surges

It is of interest now to consider the appearance of similar flare surges at the limb.

The best example we have observed occurred on the west limb on November 30, 1956, when the large spot group at 25 °S. was just disappearing. This group had been remarkable in surge productivity, some of our finest examples being observed in its neighbourhood on November 26, 1956 (see Plate 2, Fig. 1). Flare surges were noted on succeeding days. On November 30, a similar type of event occurred on the limb (Plate 5, Fig. 2), where a flare broke out at $05^h\ 05^m\ 50^s$, rising slowly to a height of 7000 km by $05^h\ 09^m\ 50^s$. The edges of the flare were very diffuse, and the brightness exceeded that of the chromosphere out to a height of 28,000 km at this time. Photographs of longer exposure showed the feature to be much wider and higher. The flare faded soon after $05^h\ 09^m\ 50^s$, but a fine surge had developed to a height of 130,000 km by $05^h\ 19^m\ 50^s$.

Many spikes or surges seen at the limb would be invisible if on the disk. Not only are they of low brightness, requiring longer exposures for registration, but they are highly transparent. This is illustrated by limb surges associated with the spot group at 20 °S., 70 °W. on May 30, 1956. On this day 17 distinct small flares were observed at a mean longitude 75 °W. from the central meridian. Enhanced limb exposures showed that 10 of these flares emitted small surges, following the emission of faint bright matter which in most cases did not appear to extend to the limb. Only in one case did the bright matter turn dark on the disk; in all other cases the ejected surge was of very low optical thickness.

VII. The Transition from Flare to Dark Surge

In the transition from flare to dark surge the question arises whether the ejected material passes through a completely transparent stage or through an opaque stage in which it is of the same brightness as the background. One of our difficulties in studying this point has been the small scale of the photographs, because of which there are very few events suitable for examination.

The flares of Plate 1, Figure 2; Plate 2, Figure 2; and Plates 3 and 4 show quite conclusively that the bright expansion which occurs at the beginning of the flare disappears by becoming transparent. The clearest example is that of May 18, 1956, in which enhanced limb exposures showed the ejected matter passing beyond the limb while previously invisible on the disk. This conclusion is reinforced by numerous other such examples.

The flares of November 26, 1956 and January 18, 1957 provide clear examples in which the dark surge forms as the result of an invisible cloud of ejected particles becoming opaque. In many other events, such as those of November 26, 1956 and July 4, 1957, the appearance strongly suggested the same mode of development. There are no incontrovertible examples of material, initially bright, becoming dark, though we suspect that this was so in a number of events, including those of August 24, 1956 and January 18, 1957.

All the evidence is in favour of the initial bright expansion disappearing by becoming transparent, and the dark surge appearing by a transparent stream becoming opaque. We consider this to be the normal behaviour.

Our observations have been made with a $0 \cdot 7$ Å filter centred on the normal Hα line. The surge Hα line in general suffers Doppler displacements, so that the observed changes in transparency refer to wavelengths displaced by unknown amounts from the surge line centre. There is little doubt, however, that similar changes occur at the centre of the surge Hα line.

VIII. Ejected Flares

These events, comprising the ejection of November 12, 1956 described by Bray *et al.* (1957) and that of May 7, 1957, are very rare. So far we have not observed such flares on the limb, though Dodson and McMath's observation mentioned in Section I may have related to one of this type.

Both events showed the ejection of part of a flare, the main bulk of the flare remaining stationary. In each case the ejection faded, eventually crossing the limb to appear as a surge. The brightness of the November 12, 1956 ejection passed through a maximum in flight; it did not disappear against the disk, though its much greater extent on the limb, revealed by enhanced exposures, showed much of the material to be highly transparent; it is interesting to note that on falling back towards the Sun's surface some of the matter appeared dark, some slightly bright, against the disk. The ejection of May 7, 1957 became transparent and disappeared before crossing the limb where it, too, was revealed on longer exposures. In each case the bright ejection was followed, some time later, by a small dark surge on the disk.

The events of August 23 and 24, 1956 provided intermediate cases in which bright matter was ejected from and eventually separated from the flare. While brighter than the normal chromosphere, neither ejection was bright enough to be classed as an ejected flare.

IX. Discussion

We have shown that the flare-surge is a common event and that probably all dark surges originate in flares. Matter is expelled from the flare itself or from its immediate neighbourhood, and in most cases the surge appears in contact with the flare. Initially the surge moves in a direction generally radially away from the nearest large sunspot. However, we have been unable to find any preferred location for this type of flare within the spot group, or any spot group characteristic favourable to surge production, though some are obviously far more prolific than others. We have not found any substantial difference in surge productivity between large flares and small.

The essential feature of all these events is the ejection of a stream of particles soon after the beginning of the flare. The first indication is an expansion of the flare, usually asymmetric and diffuse though at times in the form of a streamer, which soon fades and becomes transparent. The particle stream continues on its path, outward though invisible. Usually, though not always, part of the stream becomes opaque above or near the flare and extends outwards as the dark surge.

The varying appearances of the stream depend on changes in the physical conditions. Jefferies (1955, 1956, 1957) has recently shown that both in bright flares and in stable prominences the temperature is of the order of $10\text{–}15\times10^3$ °K, but that the electron concentration is somewhat higher in flares ($5\times10^{11}-10^{13}\,\mathrm{cm}^{-3}$)

than in prominences (10^{10}–5×10^{10} cm^{-3}). That flares are about as bright in Hα as a 6000 °K black body, despite their much higher temperature, but prominences are much fainter is due to their large departures from thermodynamic equilibrium. It follows also that relative temperatures in various parts of a flare-surge cannot be deduced solely from brightness observations.

In this regard it is important to note that in the outward particle stream there is an expansion, demonstrated by the initial bright phase of the flare and by the shape of the dark surges which expand with height. This is also to be expected as the material rises into the low pressure corona. But, at temperatures of the order of 10^4 °K, if the expansion were to occur isothermally or with increasing temperature, the recombination rate would drop rapidly and so would the optical thickness. The increase in opacity during the development of a dark surge therefore indicates that the temperature is decreasing. On the other hand, in the ejected flare described by Bray *et al.* (1957) the brightness increased during flight; according to Jefferies' (1957) analysis, this can happen during expansion only if the temperature increases suitably.

In our view, dark surges, bright surges on the disk which fade without turning dark, and ejected flares are basically similar phenomena, in which a particle stream is expelled from the flare. They differ in rate of heating, density, thickness, and rate of expansion; the one stream can exhibit a wide variety of appearances at various stages of its life.

X. References

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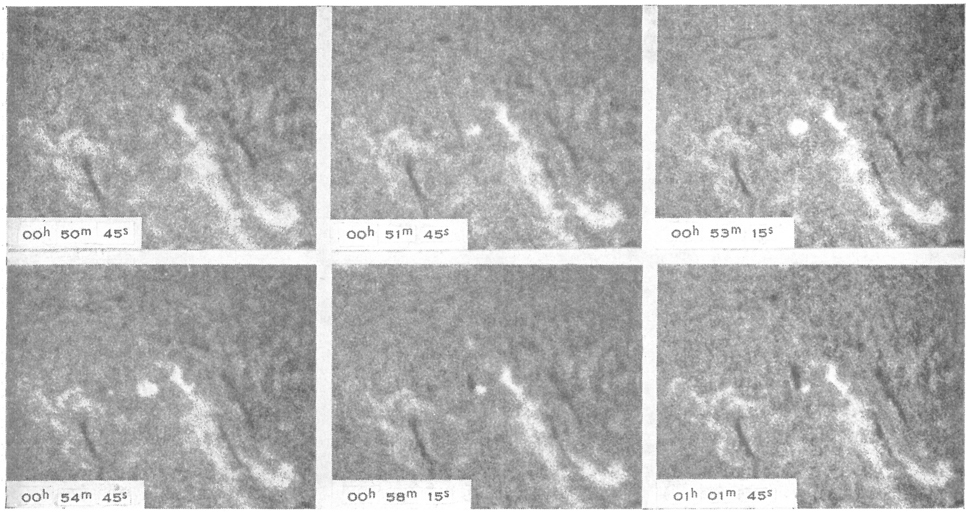
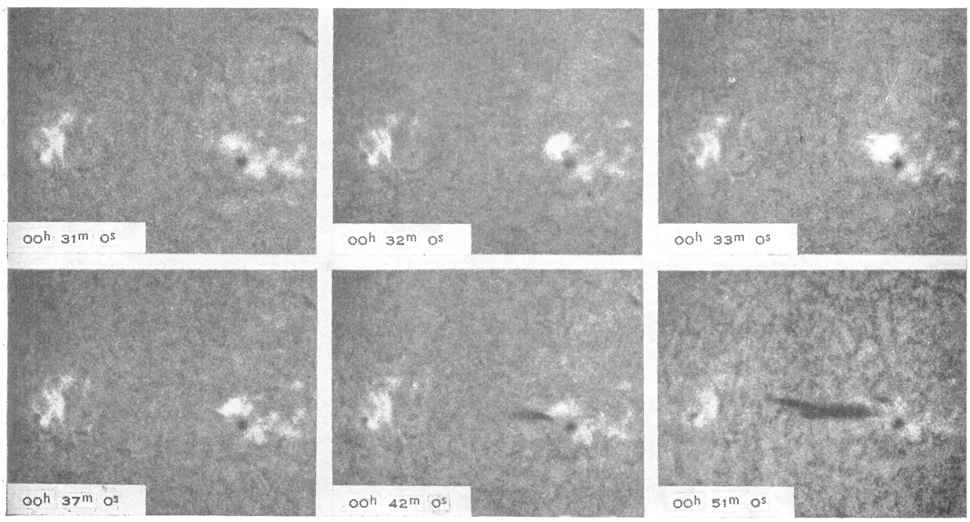
THE FLARE-SURGE EVENT



1 JANUARY 24. 1957



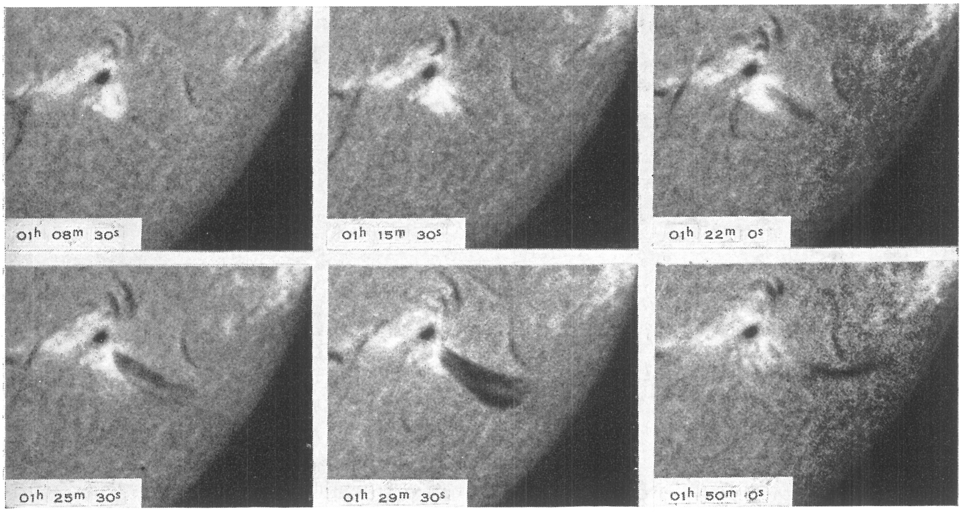
2 JULY 4. 1957

Fig. 1.—Flare-surge on January 24, 1957 (26 °N., 0 °W.). No sunspots are visible in these prints, but a very small group was indicated near this position on the Fraunhofer Institut chart for this day.

In this and all subsequent plates the Sun's polar axis runs from top (N.) to bottom (S.), with the east and west limbs respectively on the left and right-hand sides.

Fig. 2.—Flare-surge on July 4, 1957 (13 °N., 23 °E.). Note the initial diffuse bright expansion of the flare and the subsequent development of the dark surge almost radially away from the sunspot, rather than from the flare.

THE FLARE-SURGE EVENT



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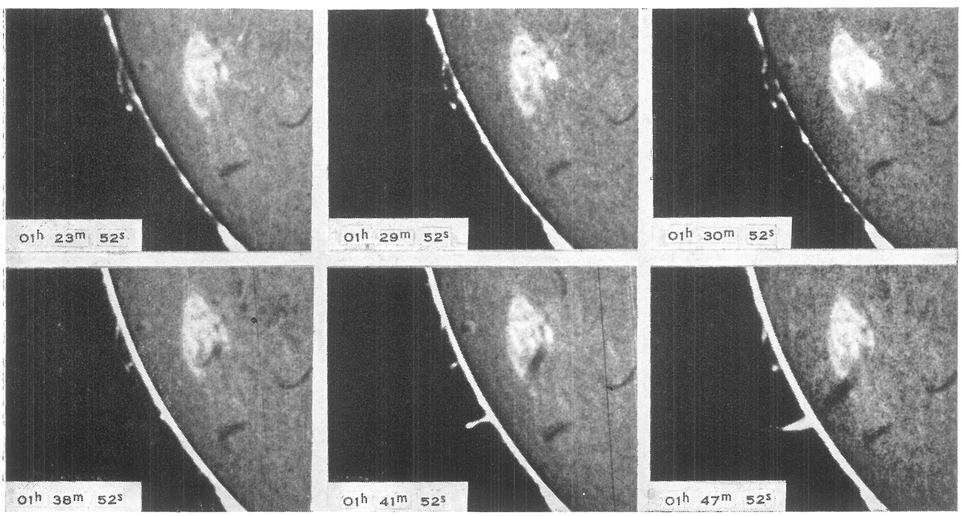


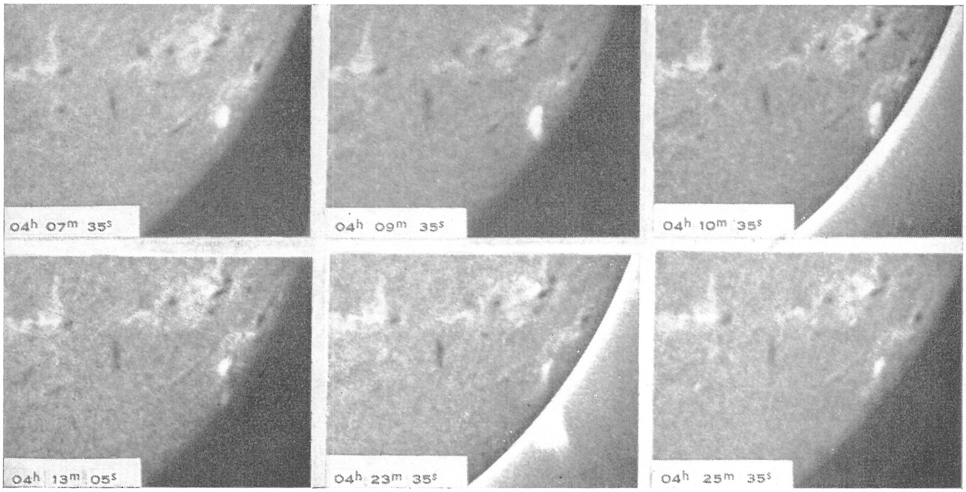
2 MAY 18, 1956

Fig. 1.—Flare-surge on November 26, 1956 (24 °S., 38 °W.). This is one of many such events observed near this spot group. The limb appearance of a flare-surge from the same group is shown in Plate 5, Figure 2.

Fig. 2.—Flare-surge on May 18, 1956 (26 °S., 52 °E.). Enhanced exposures have been given to the limb by covering the image of the Sun's disk after a suitable exposure ; faint prominences, otherwise invisible, are then recorded on the same frame as the disk.

The present sequence demonstrates the continuity of emission of the surge particle stream, initially in the form of a bright expansion of the flare, then becoming faint and transparent while moving outwards to be visible beyond the limb on enhanced exposures. The dark opaque surge forms a lower part of the emitted particle stream.

THE FLARE-SURGE EVENT



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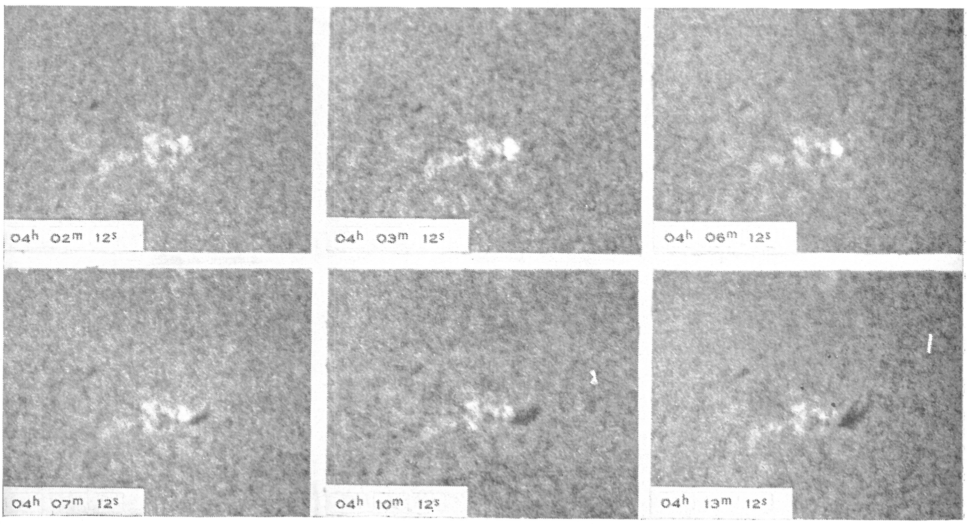
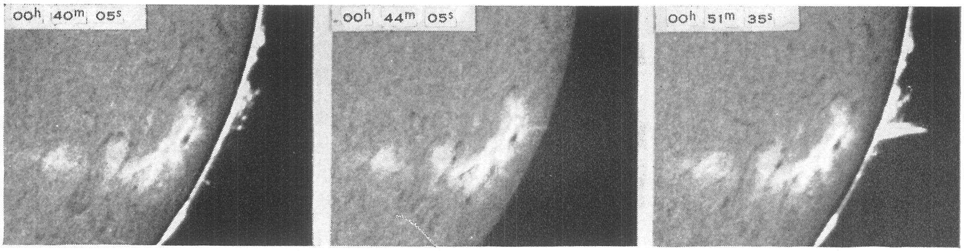


2 JANUARY 18, 1957

Fig. 1.—Flare-surge on August 24, 1956 (25 °S., 63 °W.). Note the diffuse bright expansion of the flare. Enhanced limb photographs at $04^{h}\ 10^{m}\ 35^{s}$ and $04^{h}\ 23^{m}\ 35^{s}$ show the development of a faint transparent surge prominence during this period.

Fig. 2.—Flare-surge on January 18, 1957 (7 °S., 18 °W.). Note the rapid development of the dark surge between $04^{h}\ 06^{m}\ 12^{s}$ and $04^{h}\ 07^{m}\ 12^{s}$, after which the dark surge has an approximately uniform outward velocity.

THE FLARE-SURGE EVENT



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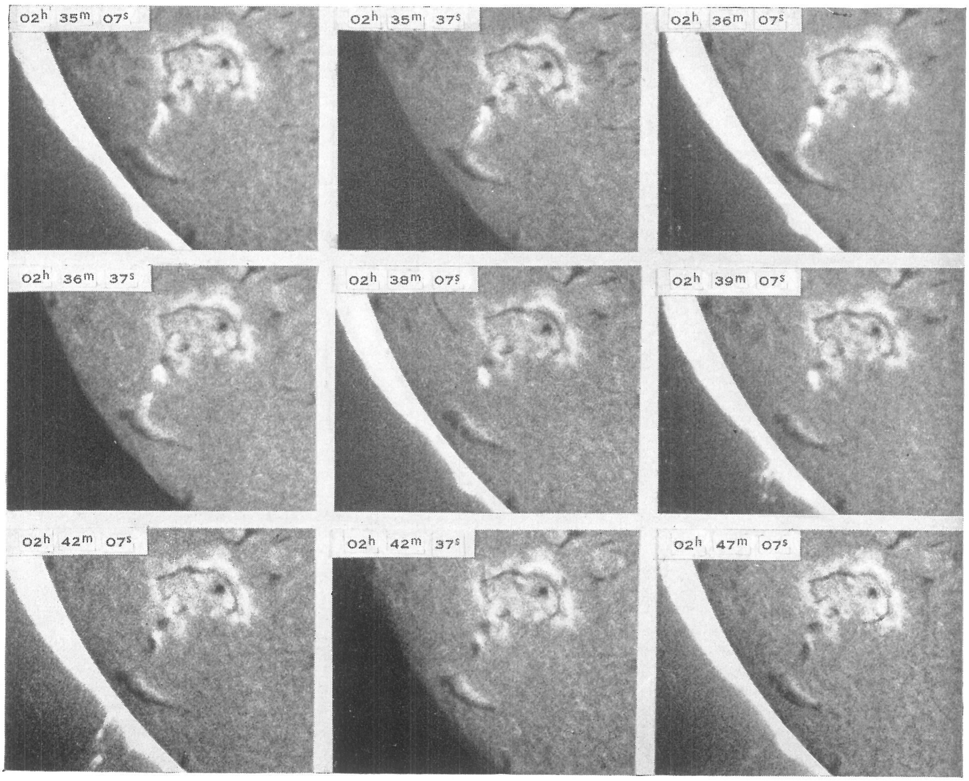
MAY 30, 1956



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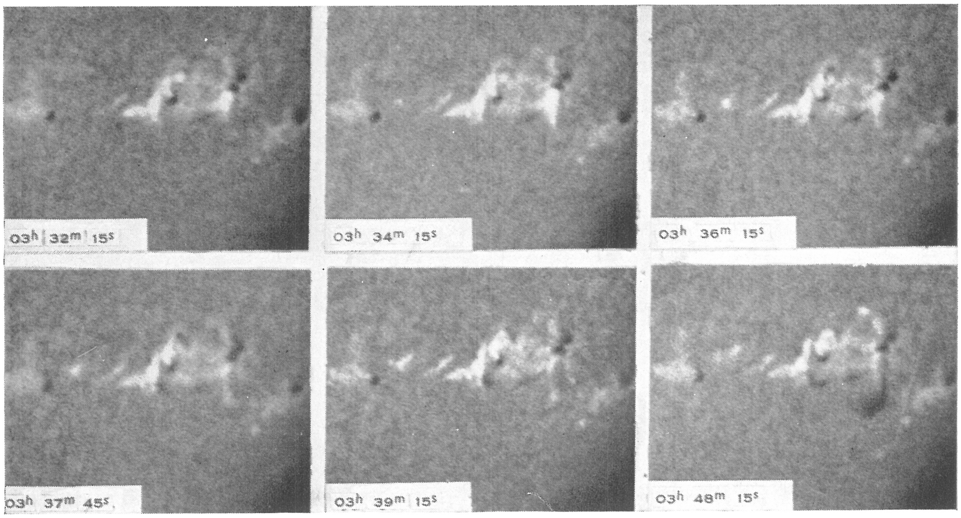
MAY 7. 1957

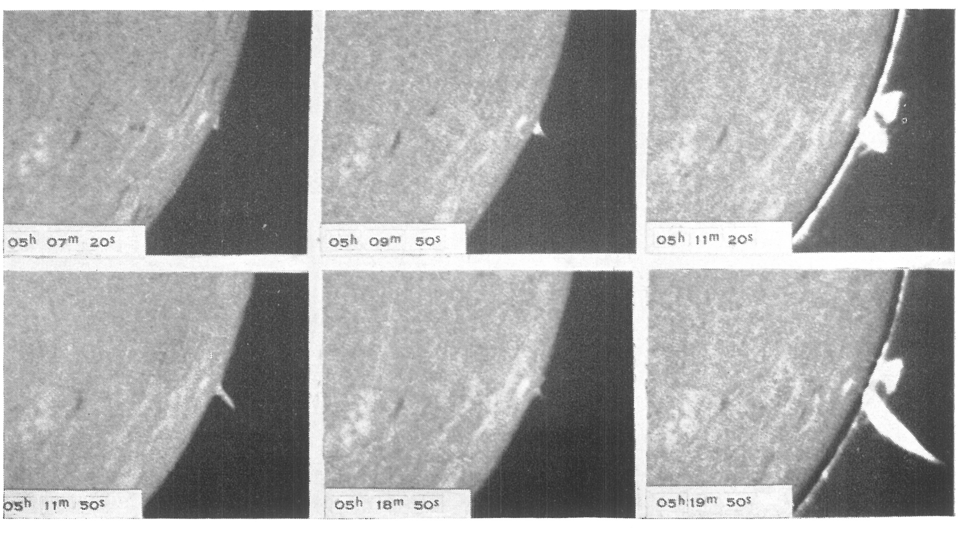
Fig. 1.—Bright streamer on May 30, 1956 (20 °S., 70 °W.). An enhanced limb exposure shows the development of the streamer into a faint transparent surge. The tiny flare at the base of the bright streamer lasted from $00^{\mathrm{h}}\,36^{\mathrm{m}}$ to $00^{\mathrm{h}}\,43^{\mathrm{m}}$, and can be seen best by studying the film in cinematographic projection ; it is difficult to detect on these prints.

Fig. 2.—Ejected flare on May 7, 1957 (30 °S., 55 °E.). Enhanced limb exposures show the ejection, now faint and transparent, crossing the limb at $02^{\mathrm{h}}\,39^{\mathrm{m}}\,07^{\mathrm{s}}$; simultaneously a dark surge starts moving outwards along the same path.

THE FLARE-SURGE EVENT



1 AUGUST 23, 1956



2 NOVEMBER 30, 1956

Fig. 1.—Flare-surge on August 23, 1956 (19 °S., 41 °W.).

Fig. 2.—Flare-surge at the limb on November 30, 1956 (25 °S., 90 °W.). This occurred in the same spot group as the event of Plate 2, Figure 1. Enhanced limb exposures demonstrate the extent of diffuse faint matter surrounding the brighter regions. Maximum flare brightness occurred early in the event.