THE SOLAR FILIGREE

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Abstract. As a birefringent filter is tuned from the center of Hα to the continuum the Hα bright mottles appear to break up into a network of grains. The name 'filigree' is suggested for this bright network. Its size, shape, contrast and time evolution is described as well as its relation to the 'abnormal' granulation, magnetic field and spicules.

1. Introduction

The coarse network coincident with the pattern of solar supergranulation cells has been studied extensively in recent years. The early work of Simon and Leighton (1964), which showed that photospheric magnetic fields are enhanced in the network, has been extended and refined by Sheeley (1967), Chapman and Sheeley (1968), Vrabec (1971), Livingston (1968), and others. Sheeley's work has shown that the photospheric field exists in tiny clumps (magnetic knots, $\sim 1''$ in diameter), arranged in a long-lived, large-scale 'photospheric network' that is bright in the cores of weak Fraunhofer lines. The brightness elements of the network tend to coarsen with increasing height, e.g. the network elements seen in the core of the calcium K line are apparently several arc-seconds in diameter, (Livingston, 1968) compared with $1''$ at the photosphere. Noyes and Simon (1971) have shown that this tendency persists into the inner corona, where the network elements seen in Mg x have mean diameters of ~ 15000 km. It seems plausible, therefore, that the magnetic field, which is tightly confined to small patches at the photospheric level, diverges rapidly with height.

The coarse network is visible in any strong Fraunhofer line, including Balmer lines. In Hα, of course, the network away from active regions resolves into rosettes of spicules at the network vertices. Beckers (1968a) has described this fine structure and its time-changes. At the center of the Hα line the rosette has a bright core, with bright and dark elongated mottles radiating outwards. Beckers identifies the latter with the spicules that appear in emission at the limb. Photospheric granulation is invisible at the line center, but becomes easier to see as we tune into the line wings. At $\frac{1}{2}$ to $\frac{7}{8}$ Å off center, the dark spicules are very obvious and the bright rosette center dissolves into a few fine bright mottles (~ 1–$2''$). This relationship shows nicely in photographs taken near

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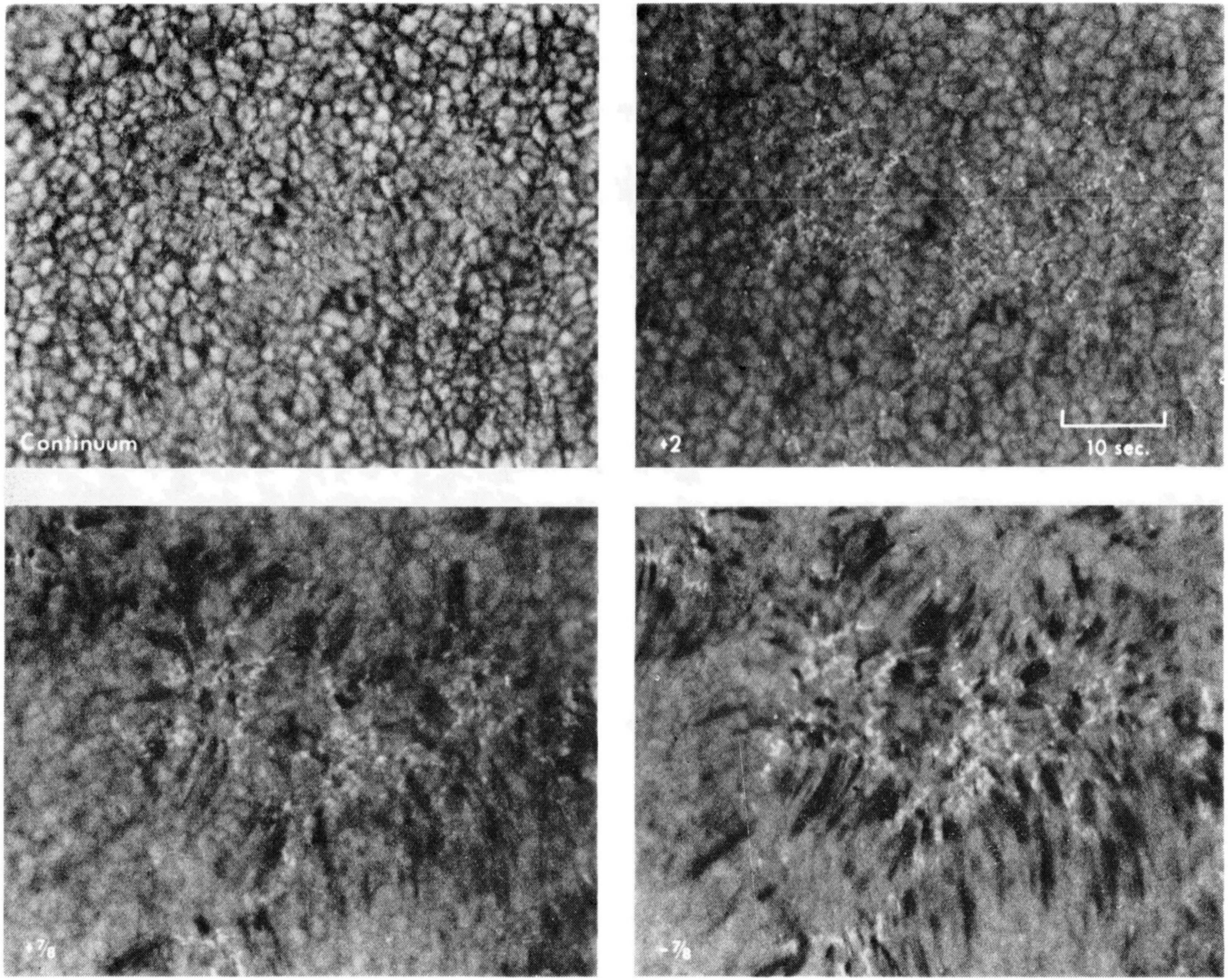

Fig. 1. Comparison between the granulation (continuum), filigree (+2) and spicules (±7/8). The times are relative to Figure 6 and are as follows: Continuum, 0926; +2Å, 0836; +7/8Å, 0813; and −7/8Å, 0848.

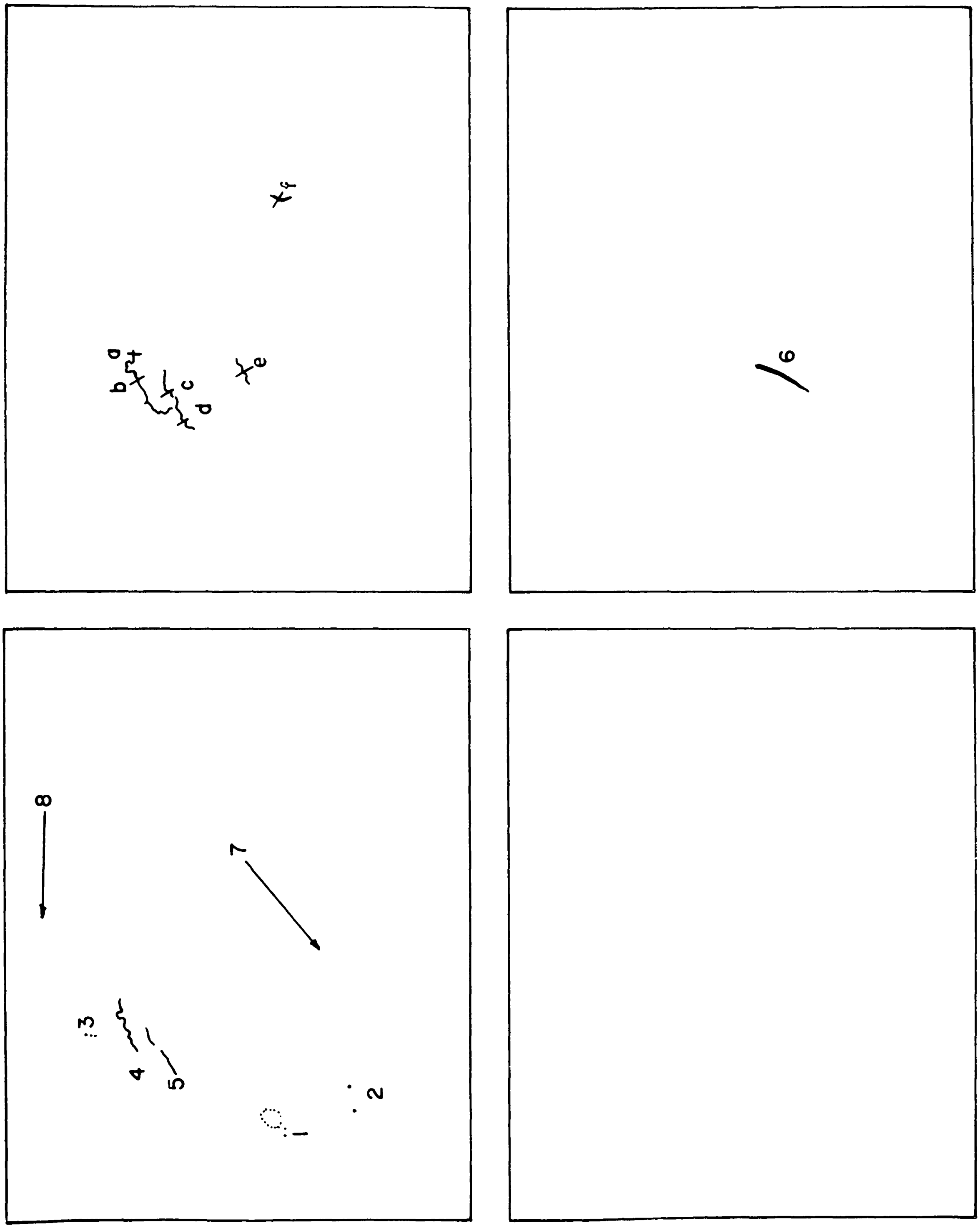

Fig. 1 (overlay). Features referred to in text are marked and are in registration with Figure 1.

the limb (Dunn, 1972). At 2 Å from the line center the granulation shows dimly, as do the last vestiges of the fine bright mottles. These photospheric remnants of the bright mottles form a network and they appear to break up into strings of grains that lie at the limit of our telescopic resolution ($\sim 0.25''$). We suggest the name 'filigree' for this bright photospheric network, and the name 'crinkle' for the individual elements because they seem to be zigzagged or crinkled in shape and not just a string of bright dots. This structure may be a deeper extension of Sheeley's tiny clumps and therefore may represent the footpoints of the magnetic field in the granulation.

We think there is a smooth transition in the appearance of chromospheric structures from *quiet network*, with its bright and dark mottles, to *enhanced network*, in which the bright mottles are closely packed to form 'plagettes' (Zirin, 1972), to active region *plages*, with extensive bright areas and dark fibrils. Figure 1 shows a plagette, far from an active region but near the center of the solar disk. Because the filigree is more obvious in plagettes than in quiet network, we have concentrated our observations on them. We do not know yet whether the properties of the filigree differ in quieter or more active regions.

If the filigree is cospatial with the photospheric magnetic field, as we suggest, then it appears possible to photograph the interaction of the field and granulation and to investigate whether this interaction produces spicules, as Beckers (1964a) has suggested.

In this paper we present some preliminary measurements of the properties of the filigree and describe our attempts to follow the birth of spicules.

2. Observational Technique

All the photographs are made with the $\frac{1}{4}$ Å Zeiss filter on the Solar Vacuum Telescope at Sacramento Peak. Because of some residual spherical aberration in the vacuum window due to imperfect compensation of solar heating, the system was diaphragmed down to approximately 60 cm. The image diameter is 38 cm. The filter is tuned automatically to study the relationship between the features. Table I shows the sequence taken every 30 s.

The bandwith is changed by manually flipping a lever on the end of the Zeiss filter and the prefilter is manually interchanged between the Hα line at λ6563 and the calcium line at λ6439 at the appropriate time in the sequence. The latter line was suggested to us by J. M. Beckers.

The wavelength of $+0.32$ Å with the prefilter set for λ6439 selects the red wing of the Ca 6439 line which shows down-going granulation with increased contrast similar to that found by Beckers for the Fe line at λ6569.2 (Beckers, 1968b). By tuning to $+2$ Å we sample the red continuum about 1.7 Å to the red of the Ca line, where there are no lines exceeding a few percent of the continuum. The λ6439 prefilter transmits less than 0.25% of the Hα light.

Repeatability of the wavelength scan system is better than 1/32 Å. Differences in the contrast between $\pm\frac{7}{8}$ Å frames suggested that the zero-point of the scale might

TABLE I

Photo sequence every 30 s

	$\Delta\lambda$	Bandwidth	Frames in sequence
(1)	+2.00	1/2	13
(2)	+0.80	1/4	1
(3)	+0.62	1/4	1
(4)	+0.00	1/4	1
(5)	−0.62	1/4	1
(6)	−0.80	1/4	1
(7)	+0.32[a]	1/4	1
(8)	+2.00[b]	1/2	6

[a] Red wing of calcium line at λ6439.
[b] 1.7 Å to red of calcium line at λ6439.
Kodalith Pan Film, developed D19 − 8 min, gamma = 5.0.

be offset, but our measurements of the position of the filter passband confirmed that the contrast differences are real.

3. Properties of the Filigree

The observations we describe here refer not to a single rosette but to an aggregate of rosettes forming a plagette far from an active region but very near the center of the solar disk.

3.1. Location with respect to the granulation

As we indicated in the introduction, the filigree is the photospheric remnant of the bright fine mottles within the rosettes and plages. Figure 1 shows the spatial relation of the granulation, filigree, bright mottles, and spicules. These frames are taken within about a minute.

The filigree shows best by itself at $\Delta\lambda = +2$ Å but traces of the filigree remain even in the continuum picture (Figure 1) taken at λ6439. Indeed we have blinked the contiuum and +2 Å pictures on Figure 1 and found that virtually all the detail visible at +2 Å also appears in the continuum picture but with lower contrast and different intensity. For instance, the two bright points at position 1 at the tip of a rhomboid-shaped granule show in both scenes as do the two at position 2. The three vertically placed dots at position 3 also show on both frames. The filigree can be seen as two tiny trails at positions 4 and 5.

Comparison of the continuum and +2 Å scenes on Figure 1 also shows that the granulation in the vicinity of the filigree is decidedly peculiar. It has a fine structure intermixed with or overlying the granules. At first we attributed this effect to patches of poor seeing over portions of the frame, but then concluded that it is real because the abnormal granulation only appears where the filigree occurs and persists throughout the time series. Figure 2 shows the changes in the patches of abnormal granulation over 67 min (zero time in Figure 2 is the same as that in Figure 6). We identify four patches of abnormal granulation on the 0926 scene in Figure 2, which is the same scene as the continuum in Figure 1 and can be compared with the +2 Å scene to

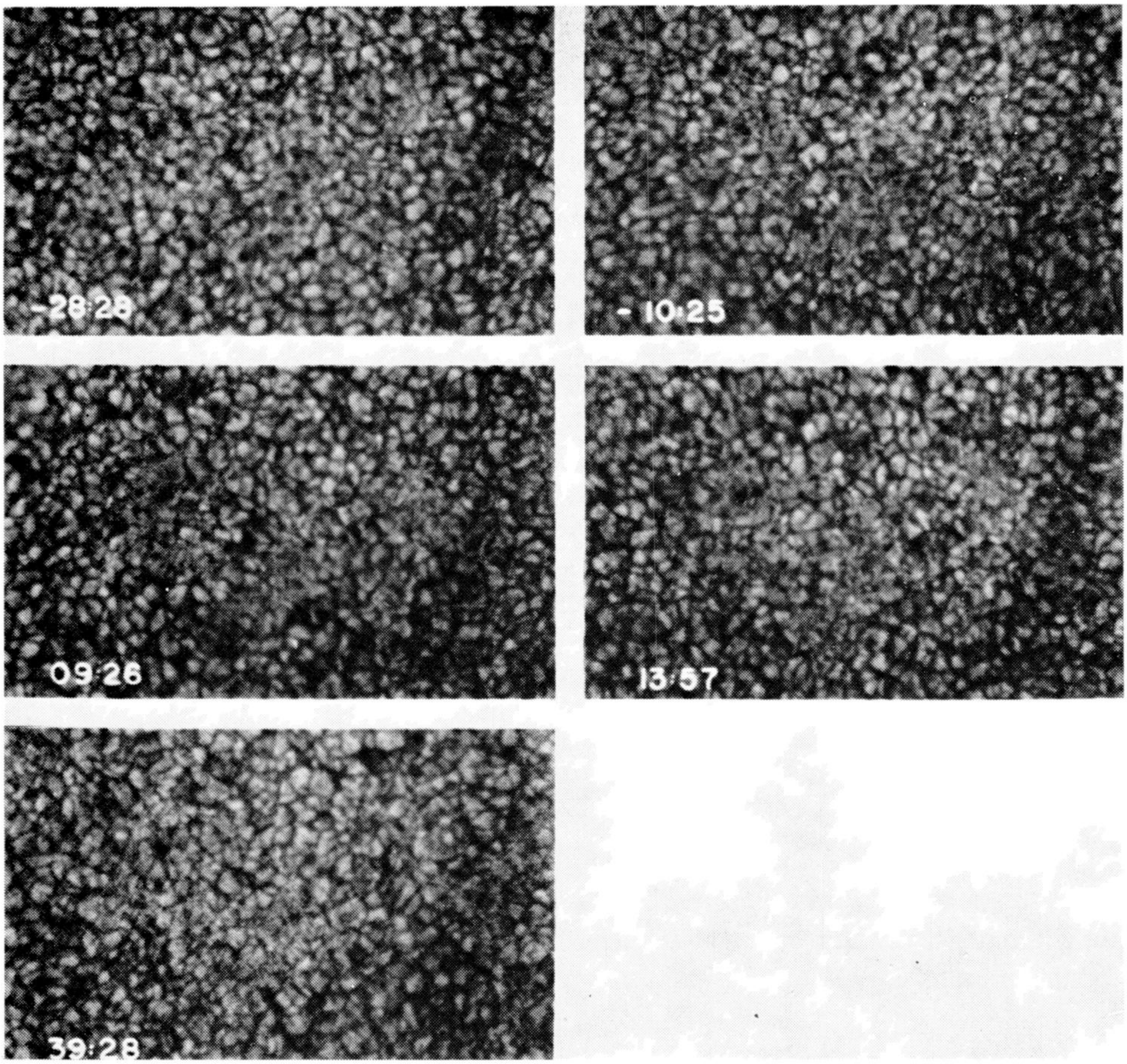

Fig. 2. Time series showing the changes in the abnormal granulation. Times are relative to Figure 6 and are in minutes and seconds. The long dimension of one of the scenes is 60″.

see the association with the filigree. For convenience we have superimposed our drawing on the other scenes.

None of the patches are particularly prominent at −2828, but if one blinks the pictures parts of 2, 3 and 4 are visible. Patches 1 and 4 are gone by 3928 but patch 3 and part of 2 are still visible. The abnormal granulation is best seen at 0926. There is a suggestion in the time series to be discussed later that the number of crinkle structures may have also reached a maximum at 0926, but this may be due to poorer seeing in the other frames.

We conclude then that the abnormal granulation is real and not caused by seeing and that it comes and goes on the order of 30 min.

The microphotometer tracings on Figure 3, whose positions are marked on Figure 1, are of regions of abnormal (7) and normal (8) granulation. The tracings have the same

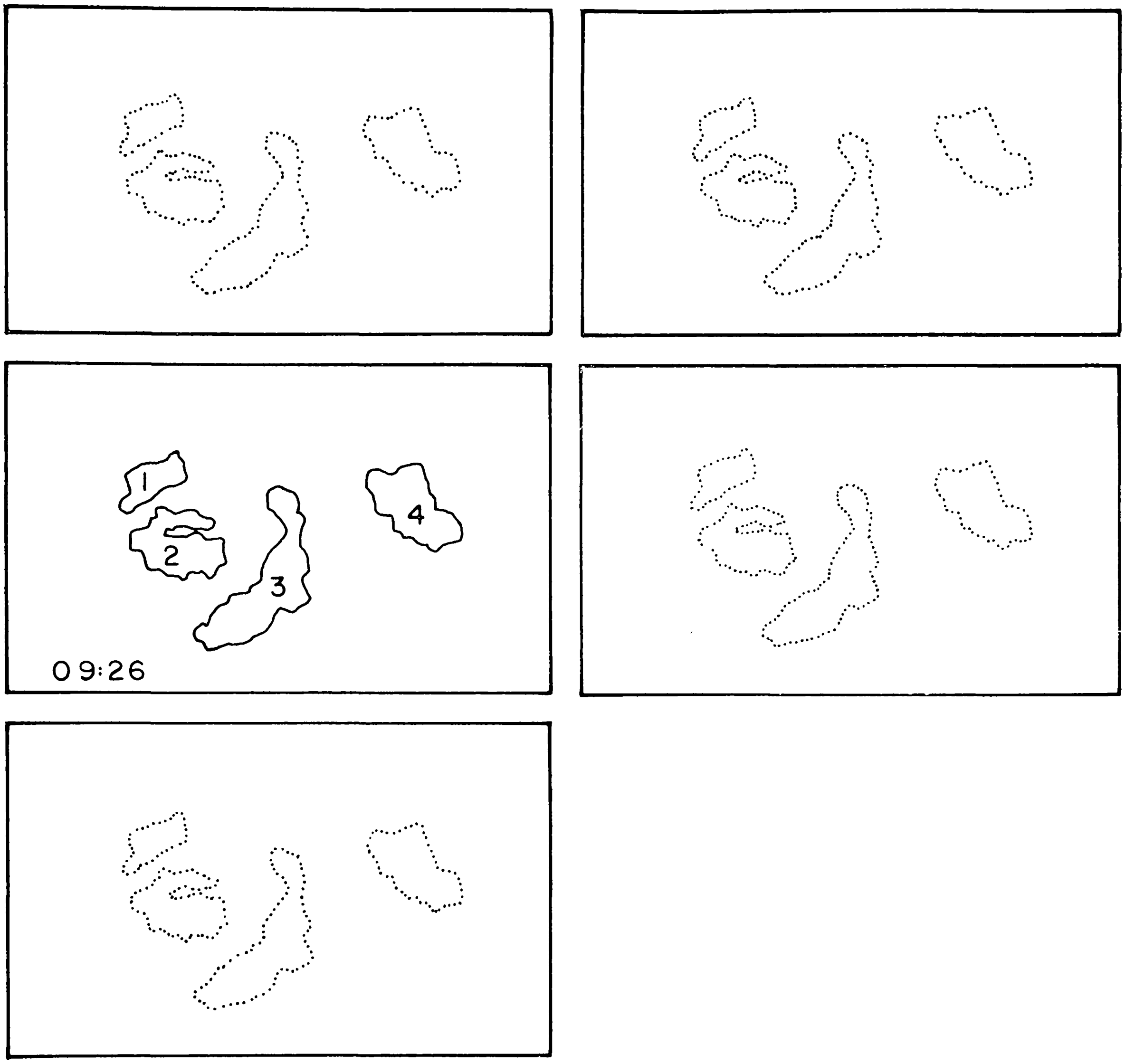

Fig. 2 (overlay). Patches of abnormal granulation are marked in the 0926 scene. This same pattern is dotted on the other scenes and is in registration with Figure 2.

brightness but, in the case of the abnormal granulation, the larger peaks and valleys (noise) of the tracings are smoothed out. Indeed at first glance there is a strong suggestion that the filigree lies within the intergranular lanes, thus contributing to the lower contrast between lanes and the granules. This is not true everywhere; for instance at 9 or 10 in Figure 1 one cannot tell where the granule boundaries lie and, as we shall discuss later, there is some evidence that the crinkle becomes washed out during part of its life.

Only a very good movie will decide whether granulation near the filigree is normal

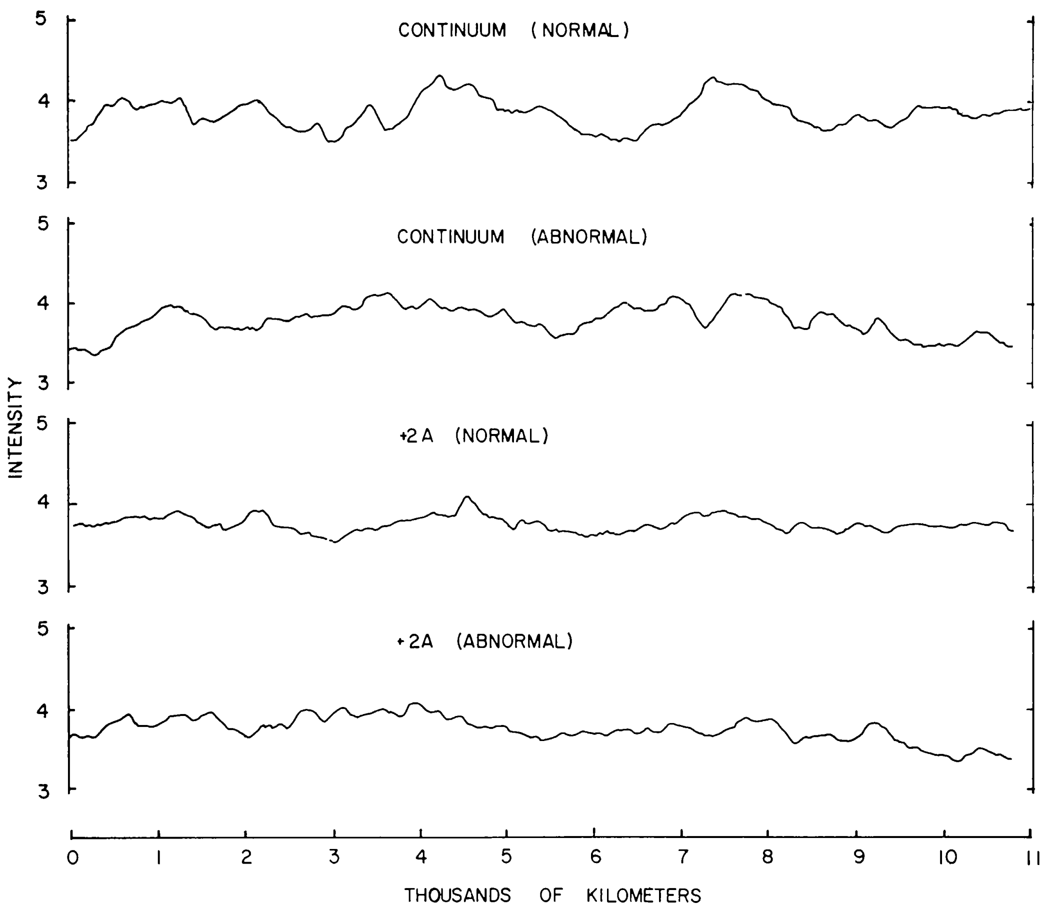

Fig. 3. Microphotometer tracings of the abnormal granulation. The tracing of the abnormal granulation region is marked as 7; that of the normal region is identified as 8 on Figure 1.

in size, lifetime and contrast, and appears 'abnormal' only because of the presence of intergranular crinkles.

We believe the abnormal granulation shows on the granulation pictures taken by a balloon telescope discussed by Andreiko *et al.* (1972). In their photographic reproduction we believe some abnormal granulation shows in the upper left of their scene. It would be more convincing if we had the corresponding off-band Hα picture to accompany the continuum picture so that we could see if there were a corresponding patch of filigree.

We do not believe the abnormal granulation is the 'reseau photospherique' referred to by Janssen (1903). We think the telescope was too small (13.5 cm aperture) to resolve it and we are satisfied with Bray and Loughhead's (1967) discussion that suggests this phenomena was due to seeing.

3.2. Size and Shape

We have traced with a microphotometer the crinkles marked as a through *f* on Figure 1 and also the bright points at 1 and 2. In the latter case a small raster was made to be sure we observed the central maximum. We did this at all the wavelengths near Hα and also in the continuum. We used a microphotometer slit of $0.065'' \times 0.26''$.

Table II shows that the halfwidths at +2 Å are ~0.25″ and increase monotonically as we approach line center. Since the Modulation Transfer Function (MTF) of a perfect 60-cm telescope vanishes at 0.22″ (Goodman, 1968), it is clear that the intrinsic crinkle width must be very narrow compared with 0.22″ and because of film-noise correction of the observed widths for the telescope MTF will be difficult and uncertain.

TABLE II

Filigree halfwidths (seconds of arc)

	Wavelength ($\Delta\lambda$ in Å)					
Location	+2	+7/8	+5/8	−5/8	−7/8	Continuum
(a)	0.27	0.29	–	0.68	0.66	0.27
	(0.16)	(0.22)	–	–	–	(0.25)
(b)	0.27	0.41	0.49	0.58	0.48	0.30
	(0.16)	(0.36)	–	–	–	(0.28)
(c)	0.39	0.43	0.74	0.57	0.47	0.35
	(0.32)	(0.39)	–	–	–	(0.33)
(d)	0.28	0.46	0.61	0.57	0.63	–
	(0.17)	(0.42)	–	–	–	–
(e)	0.26	0.46	–	–	0.38	0.28
	(0.14)	(0.42)	–	–	–	(0.26)
(f)	0.32	0.36	0.48	0.60	0.56	0.33
	(0.23)	(0.31)	–	–	–	(0.31)
Average	0.30	0.40	0.58	0.60	0.53	0.31
	(0.20)	(0.35)				(0.29)

The locations are marked on Figure 1. The halfwidths are the full width at 50% intensity. The halfwidths in parentheses are corrected for the average halfwidths of the dots at locations 1 and 2 measured at the respective wavelengths.

Our attempts to derive corrected widths by two-dimensional Fourier deconvolution of a digitized filtergram confirmed this pessimistic forecast. Although we believe that the size increase towards the center of the line is real, there is still the possibility that the scenes have different seeing. To suppress seeing effects we would photograph the granulation simultaneously with each Hα wavelength or, better still, use a balloon or space telescope.

As the reader can see on Figure 1, crinkles vary in shape from points to folded segments up to ~2.5″ in length. The uncorrected amplitude and wavelength of the folds are ~0.3″ and ~1″, respectively. Circles of crinkles appear over the region and may be a fundamental pattern, but additional observations are needed to confirm this. Figure 4 shows typical dimensions of these structures.

3.3. Contrast

Figure 5 summarizes our microphotometer measurements of the brightness of 6 crinkles as a function of wavelength in the Hα line. The filigree shows more contrast in the blue wing of the line and is significantly brighter at all wavelengths.

Any correction for the telescope instrumental profile or for scattered light would

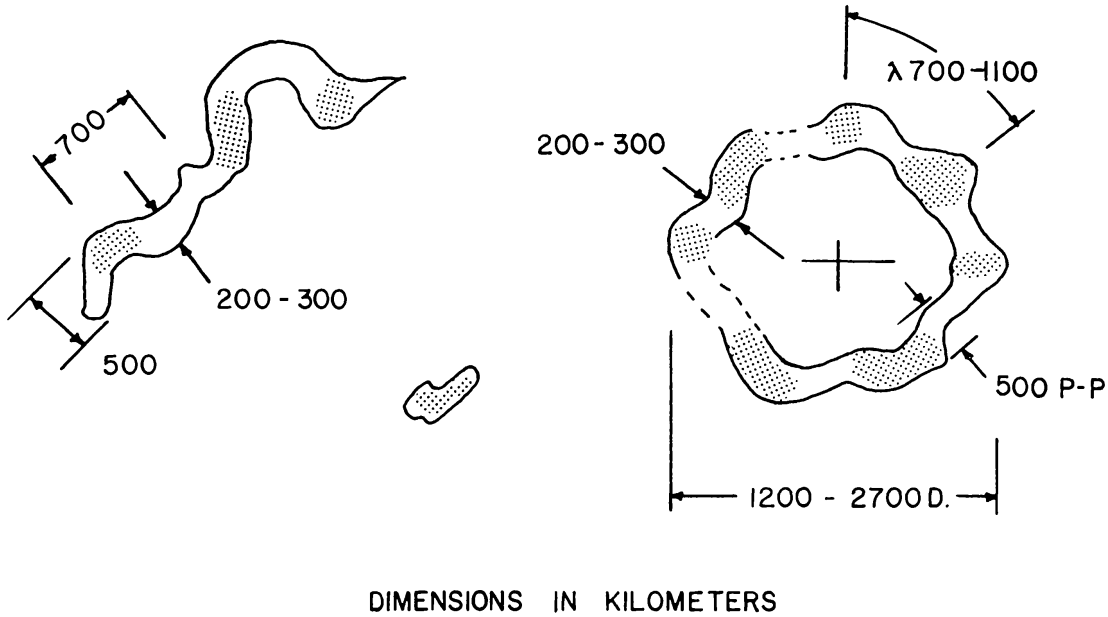

Fig. 4. Crinkle dimensions.

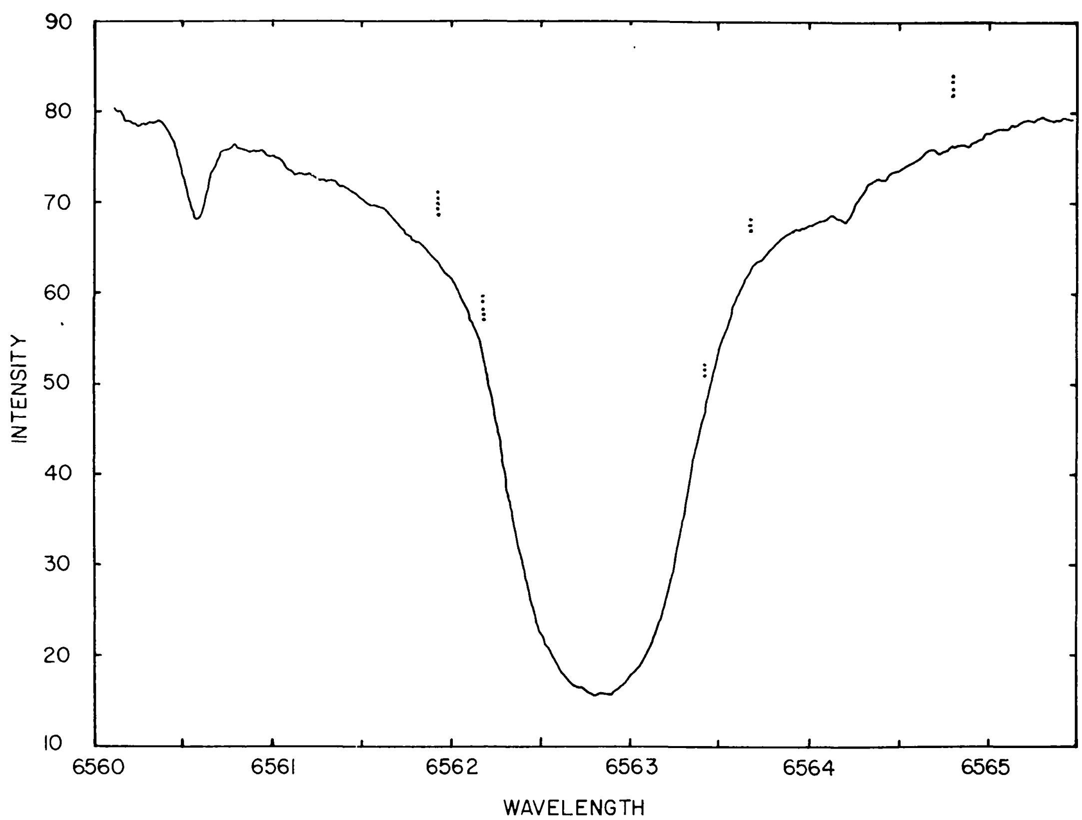

Fig. 5. Increase in brightness of the filigree relative to the Hα line at different $\Delta\lambda$. The dots mark the measurements of filigree marked as *a* through *f* on the overlay for Figure 1. The measurements were not plotted if the region was obscured by spicules.

greatly enhance the observed contrasts. Any light-leak in the continuum would cause the granulation to be more apparent. As one can see in Figure 1 the granulation in the $+\frac{7}{8}$ Å scene shows more contrast than in the $-\frac{7}{8}$ Å. This appears to be real.

3.4. Evolution

Figure 6 shows almost all of the acceptable frames of a sequence that extended over 39 min. The pictures are in reasonable good registration and one can compare the details by measuring from the borders.

We assembled the scenes in Figure 6 as a movie of 12 frames to try to see changes. The time interval between the acceptable frames is too long, however, and many features are difficult to follow. We tried unsuccessfully to overlay the granulation scene with high contrast copies that showed just the filigree and also low contrast copies of the spicules in order to see their relationship. After studying Figure 6, our conclusions are as follows:

(1) The general location of the filigree is stable. It persisted through the entire movie. This is not surprising since it is an element of the plagette which is itself associated with the long-lived magnetic field. Sheeley (1966) and others have found similar results for elements of the photospheric network.

(2) The individual crinkles are jostled a distance on the order of a granule diameter during 39 min. This motion, plus the observation that some crinkles clearly lie in the intergranular lanes, suggests that the granules have enough energy to move or collect parts of a crinkle and hence perhaps the local magnetic field. According to Beckers and Parnell (1969) the RMS vertical velocity of a granule is only 0.45 km s^{-1}. The jostling of the filigree implies velocities on the order of 1.5 km s^{-1}, suggesting that granules may spread faster than they rise and fall.

(3) There is some evidence that the crinkles are spread or washed out until a granule evolves near by to push them all back together into a circle or line that lies in the intergranular lane. Portions of the crinkle seem to fade in place, perhaps spreading out again at a low contrast level that is difficult to follow until the process starts over again. This evolution is shown schematically in Figure 7. The dissolution of a circle can be seen at position 5. An earlier picture not shown suggested that three granules caused the circle to form. It is a complete circle at 01 01 and parts of it fade by 05 40. By 15 35 very little is left. Did it form less perfectly again around 28 30? The variation in seeing makes one wonder. The circle at position 3 is completely formed by 08 36. The lower left part is gone by 11 34 and the parts fade until 28 30 when there is nothing left but some bright broader areas. The crinkle at 6 is already formed by 05 40. Is seeing spoiling the image earlier at 01 01 or was it actually washed out? A hook develops by 08 36. The hook is clearly gone at 11 34, only to partially reappear oriented at 90° by 15 35. It washes out and disappears altogether by 32 42 except for a few diffuse patches. What happened to the excellent crinkle at 7?

The washed out phase may be illustrated by the diffuse filigree near position 8. Compare the filigree in the upper structure to the continuum picture. It appears that the filigree is lying on top of the split granule, perhaps outlining it.

Fig. 6 (overlay). Features referred to in the text are marked and are in registration with Figure 6.

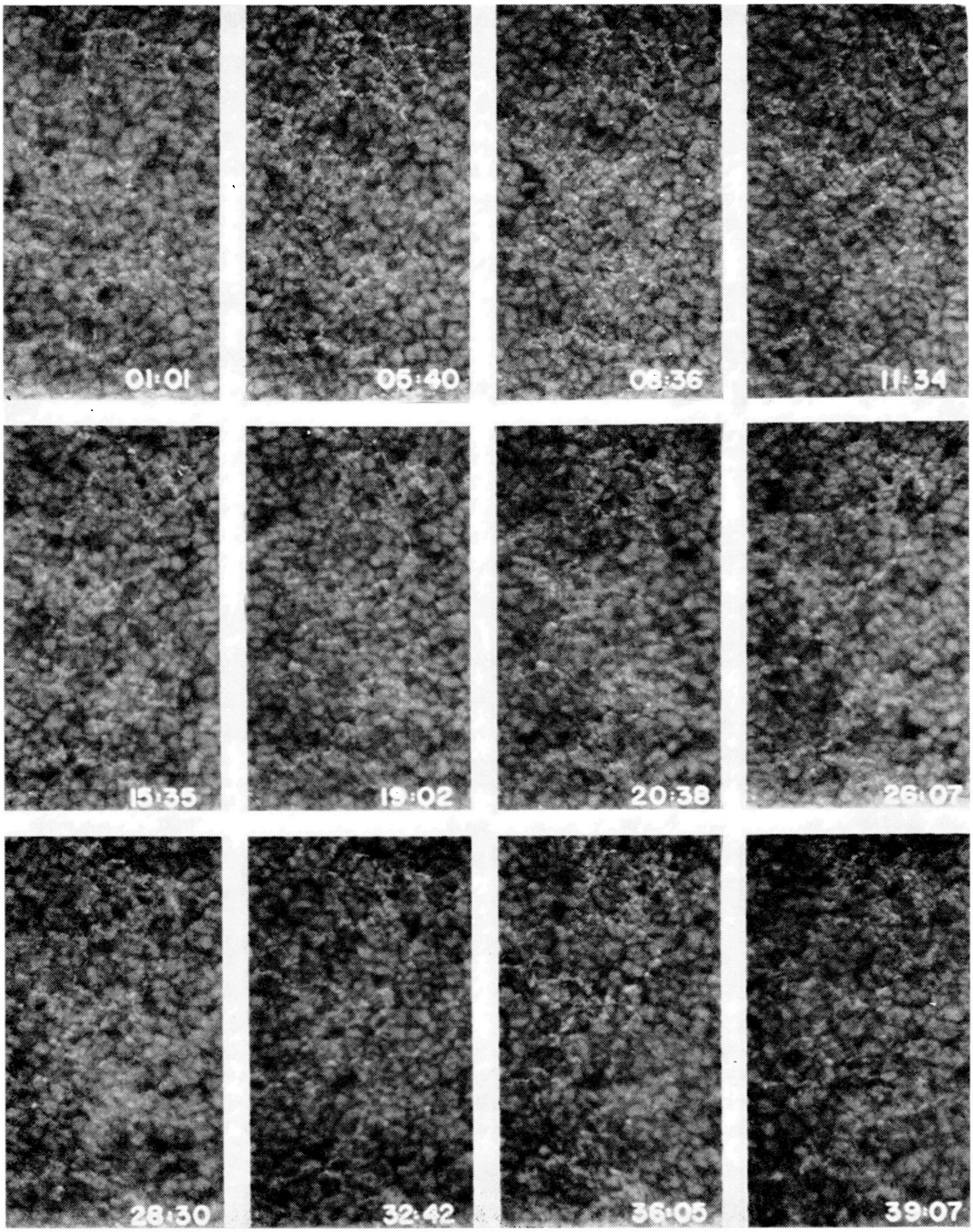

Fig. 6a. +2 Å.

Fig. 6a–g. Time series showing the relationship between the scenes at the various wavelengths. The scenes are in registration. The times are in minutes and seconds. The long dimension of one of the scenes is 49″.

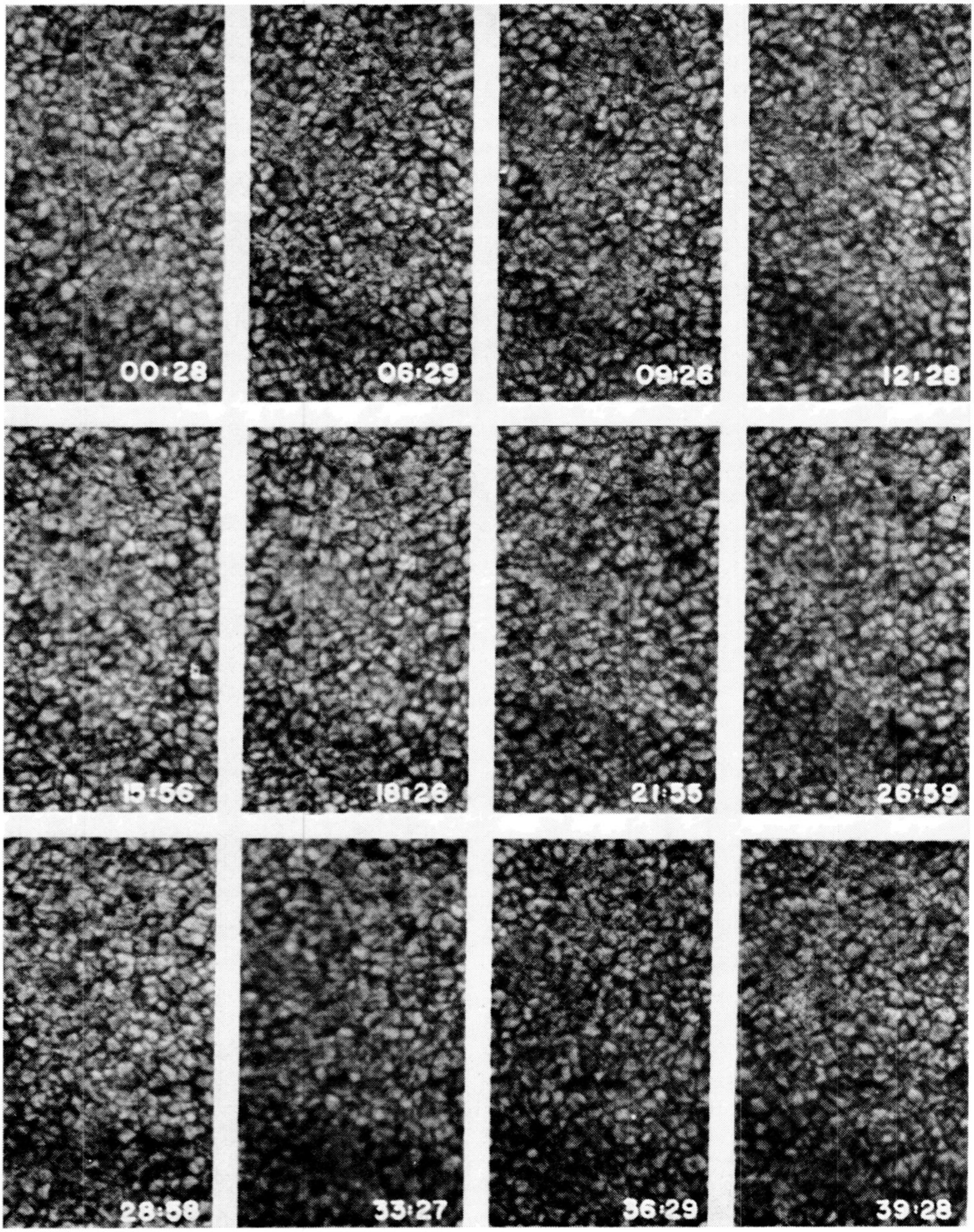

Fig. 6b. Continuum.

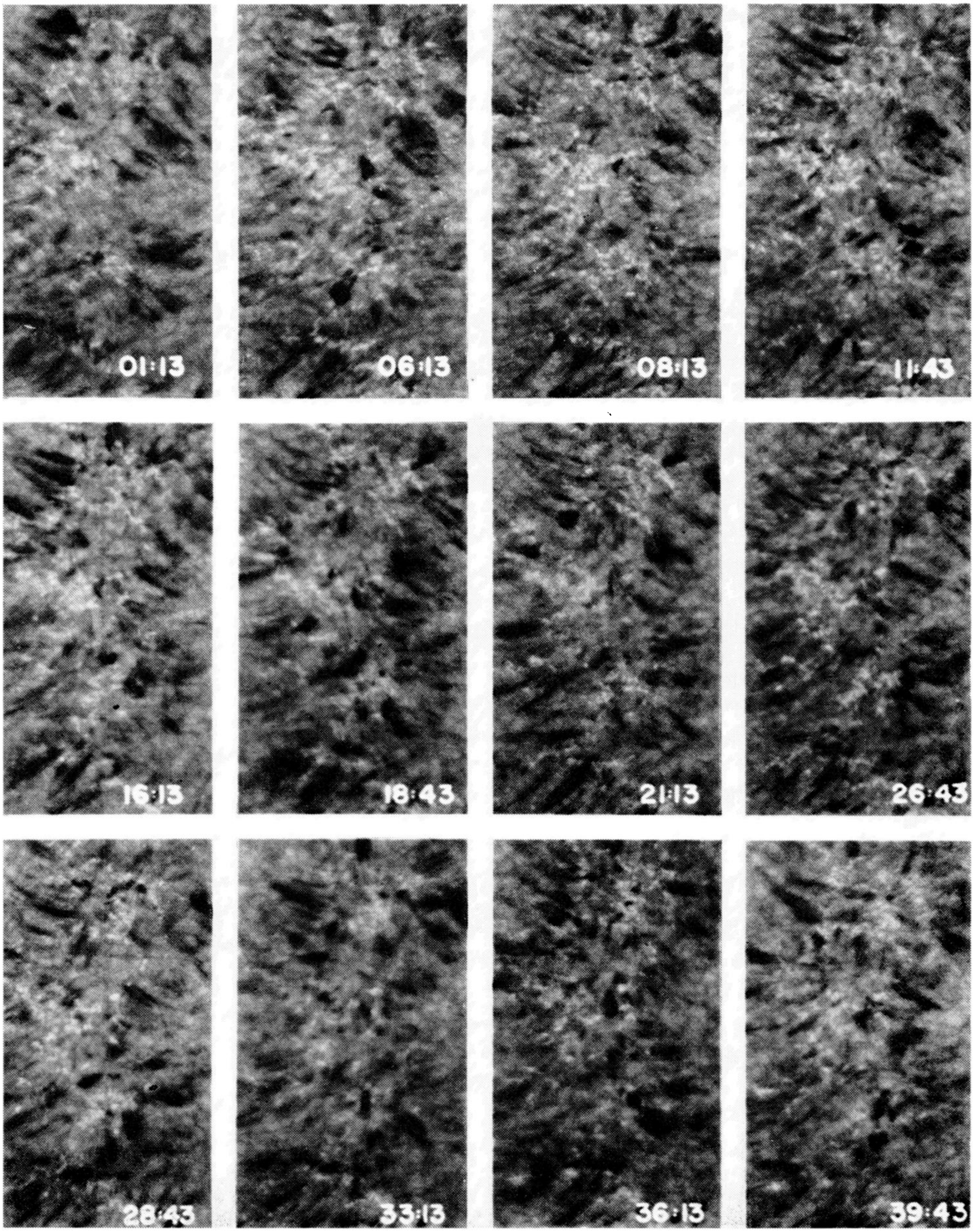

Fig. 6c. $+\frac{7}{8}$ Å.

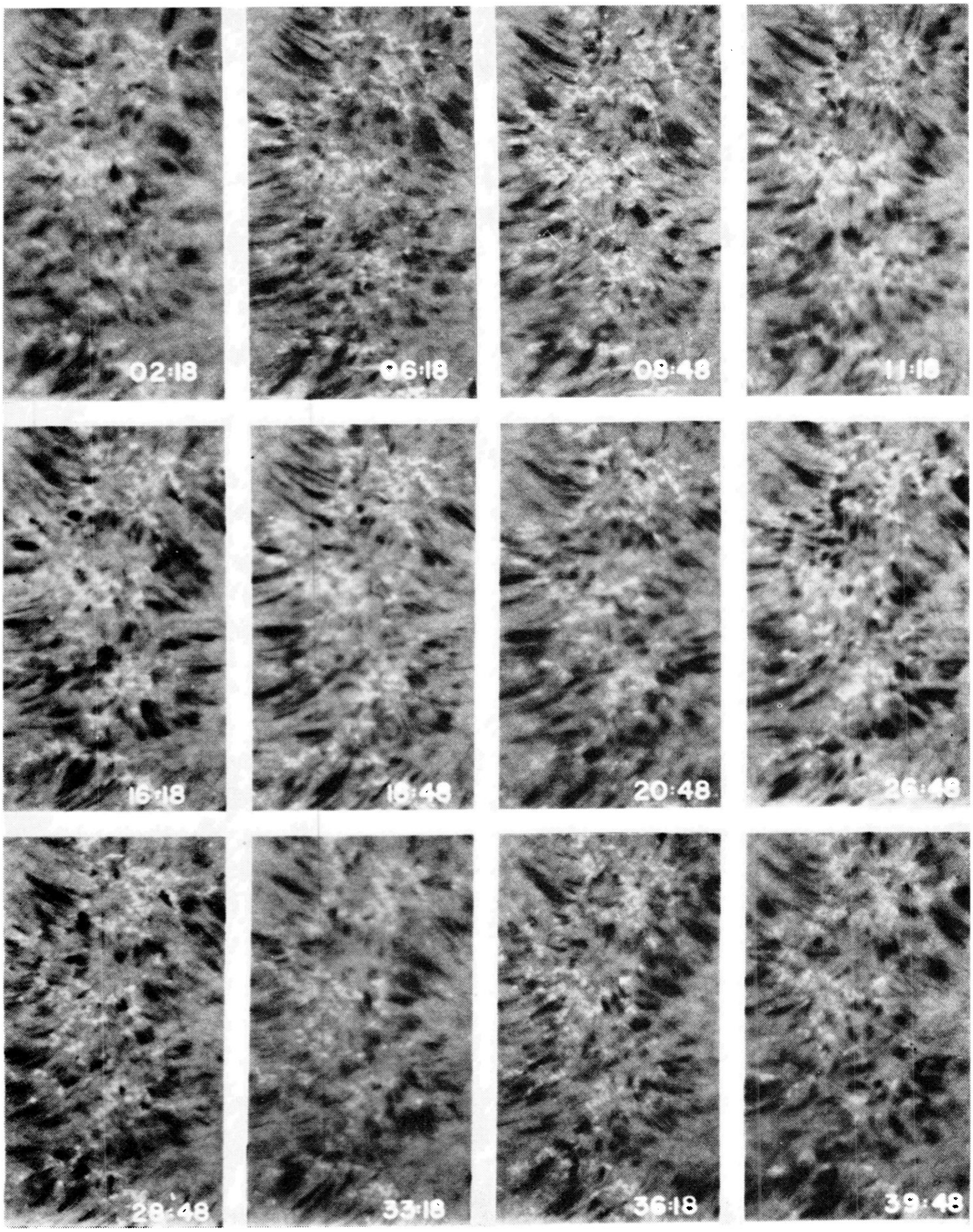

Fig. 6d. $-\frac{7}{8}$ Å.

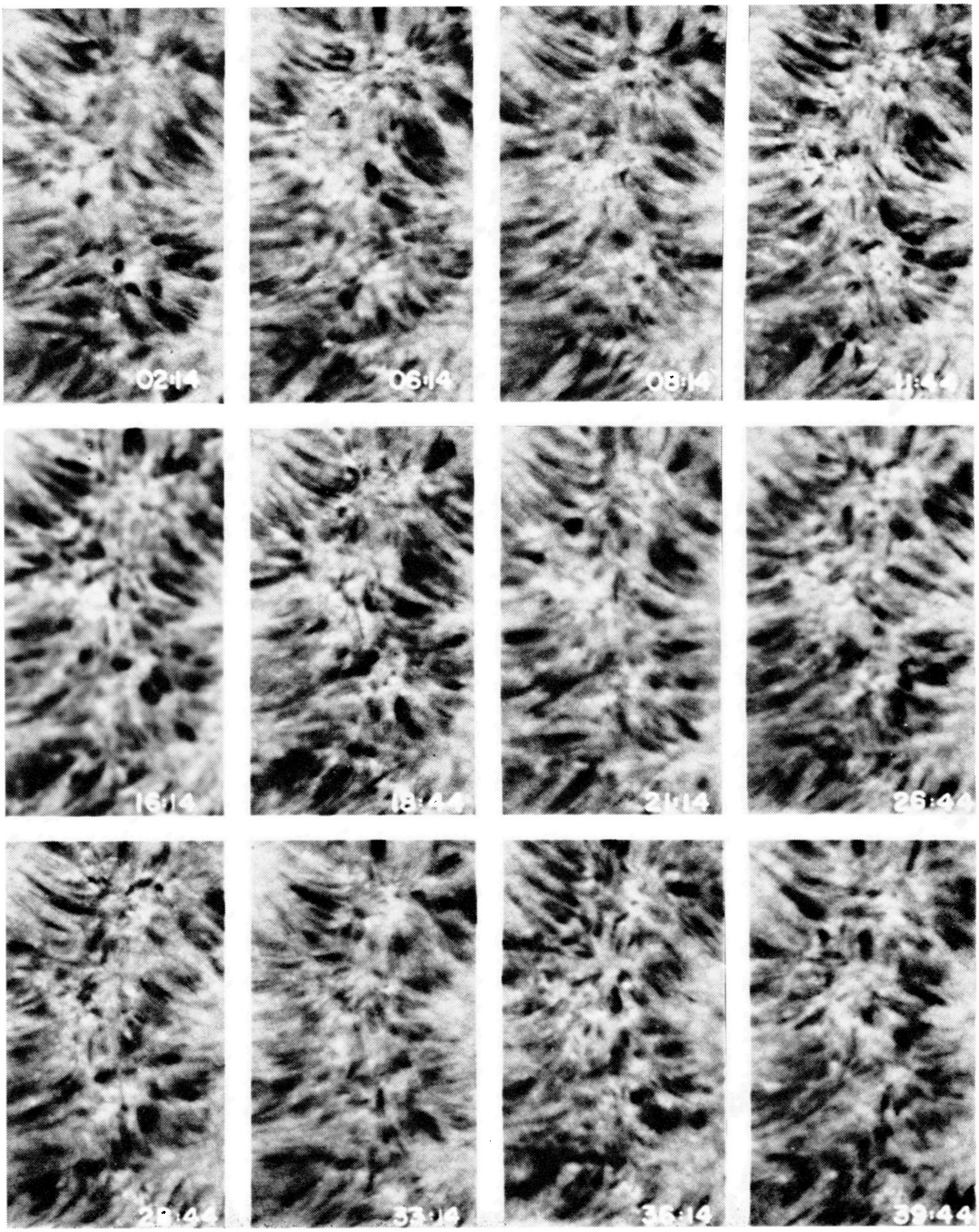

Fig. 6e. $+\frac{5}{8}$ Å.

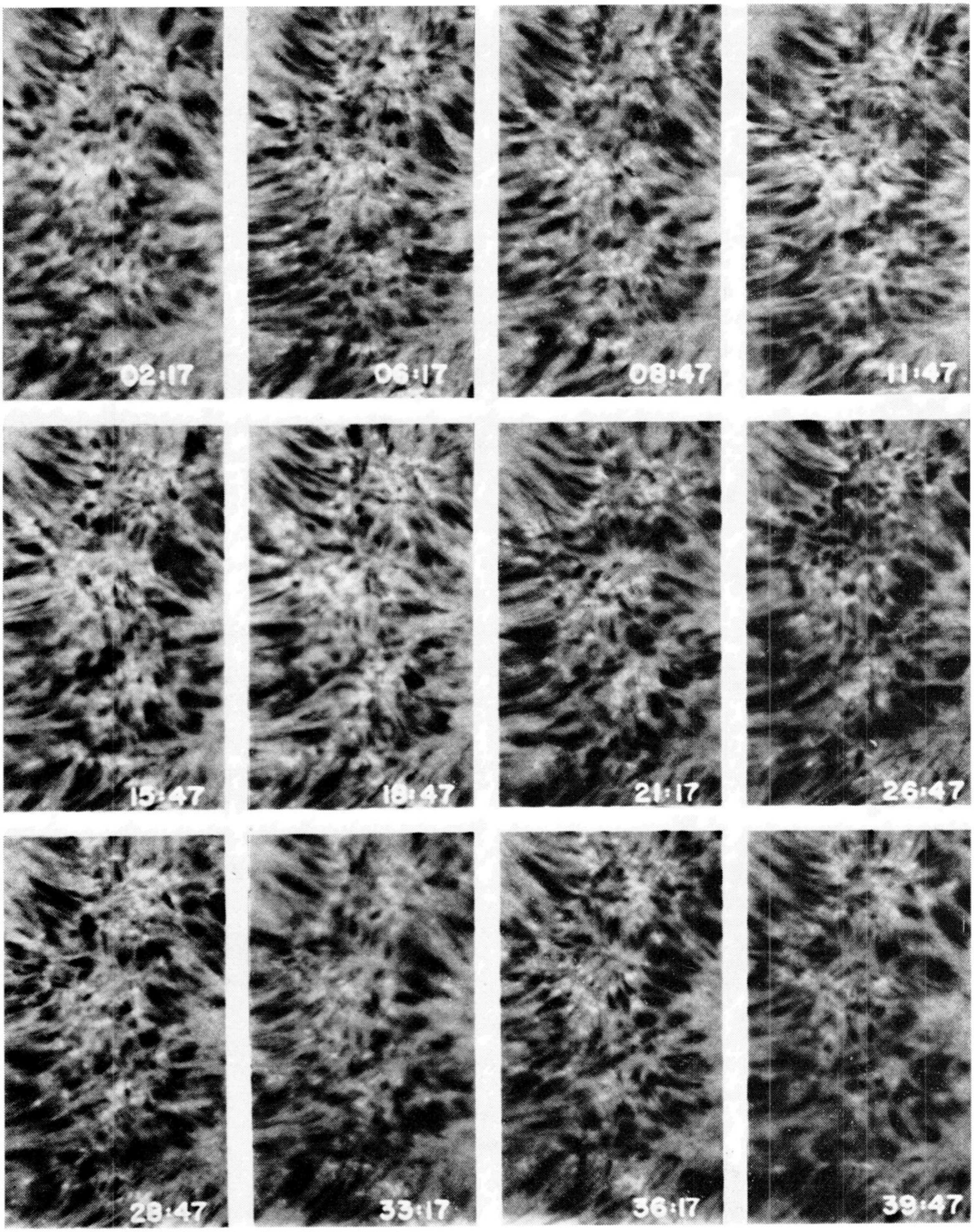

Fig. 6f. $-\frac{5}{8}$ Å.

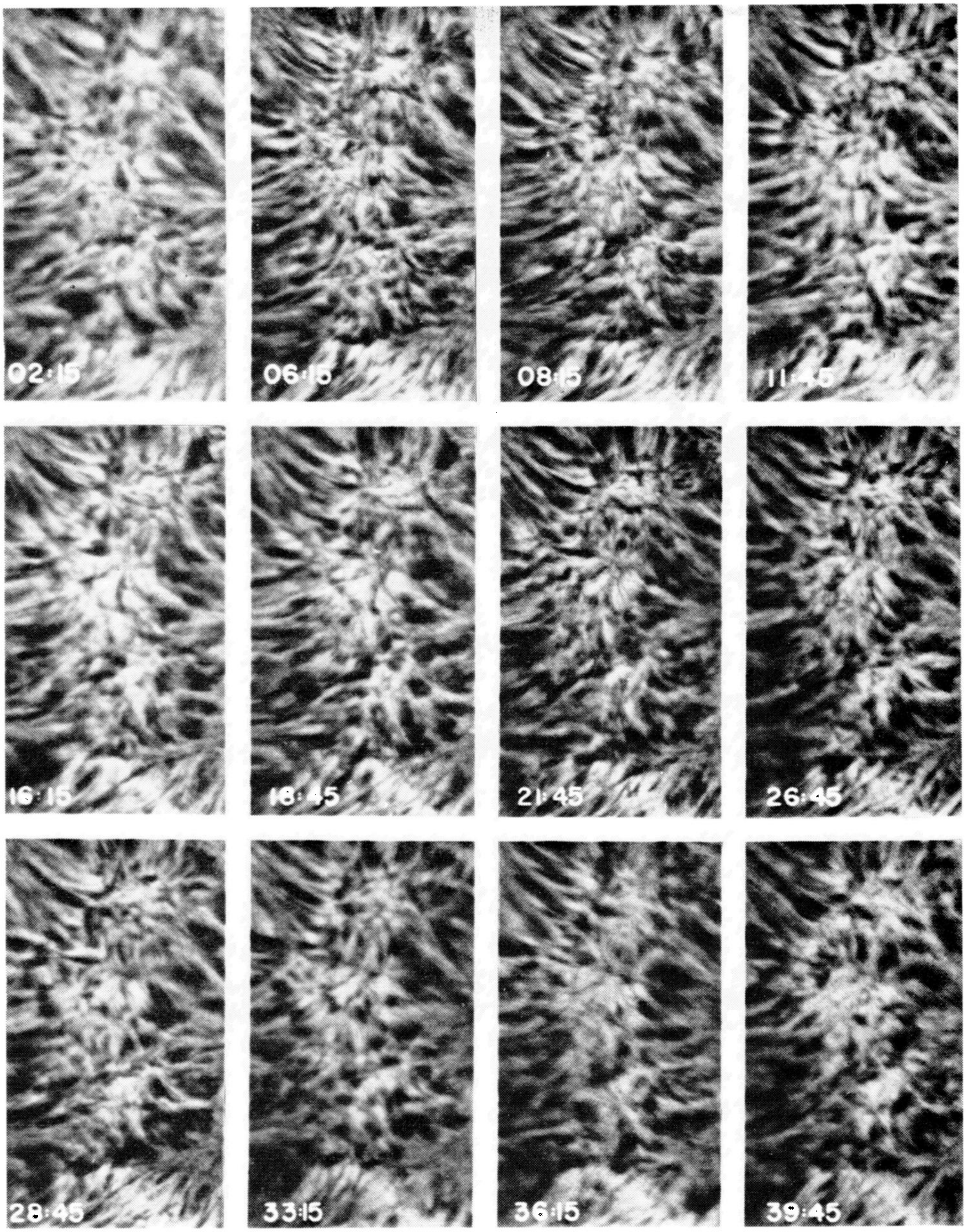

Fig. 6g. 0 Å (line center).

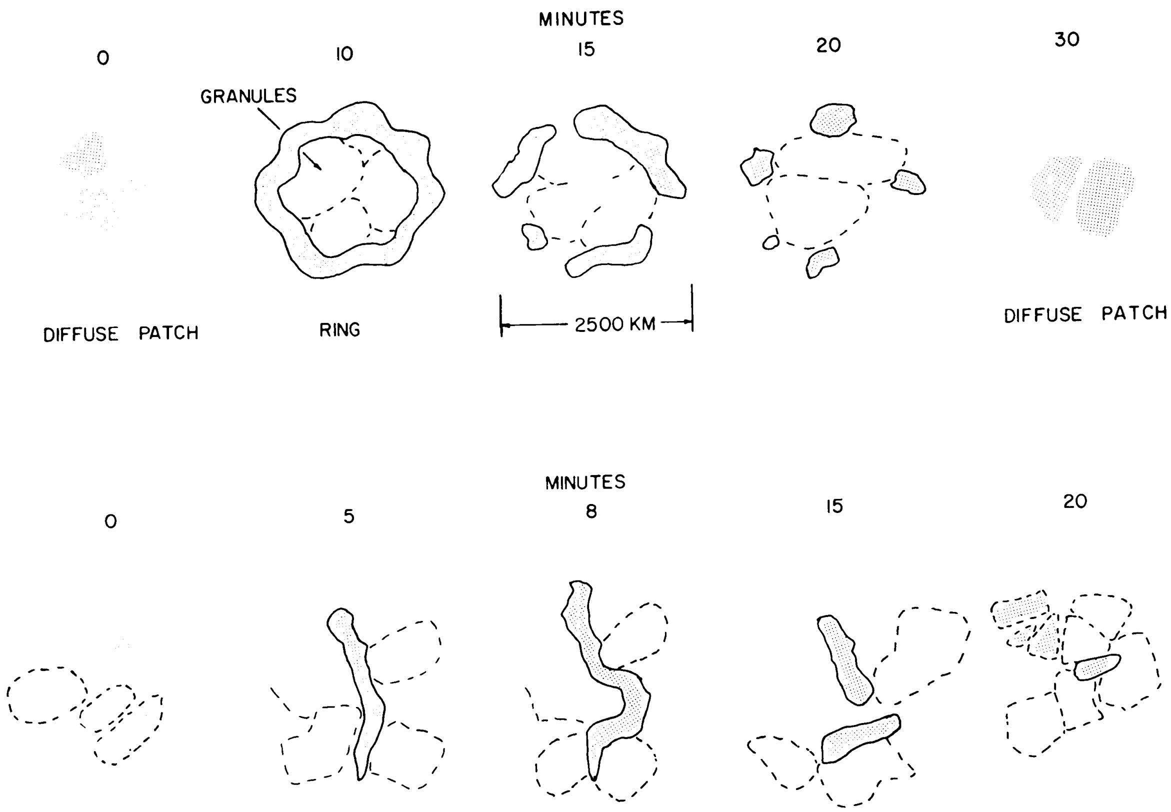

Fig. 7. Schematic showing the time evolution of a circle and line of crinkles. The schematic represents position 5 and 6 on the overlay for Figure 6.

One can only hope that a better time series with higher resolution will become available to make the changes more apparent.

3.5. Magnetic field

Simon and Zirker (1973) have measured the longitudinal magnetic field near crinkles, using the sensitive line Fe I λ6302.5. They found fields of 100–1000 G in patches 2–3″ in diameter centered on the mottle. They present evidence against the idea that the photospheric magnetic flux is confined within the area of the crinkles. Instead, they suggest the field emerges over a much larger area, has sufficient strength to inhibit convection and thus produces the abnormal granulation.

Pores appeared in the region (Figure 6, positions 9 and 10) during the movie. At maximum development these are ringed with filigree. Even smaller pores, also ringed by filigree, appear at position 11 and perhaps at 7. The area near position 11 is enlarged on Figure 8. Some of these pores can be identified on the corresponding continuum and sometimes even on the $\pm\frac{7}{8}$ Å pictures. This suggests to us that the filigree occurs at field strengths intermediate between pores (1500 G) and the background field ($\ll 10^2$ G) and may be closely associated with the footpoints of the magnetic field. The larger pores are relatively stationary in the granulation and are probably footpoints as suggested by Sheeley (1967). Our time series suggests, however, that the filigree *is*

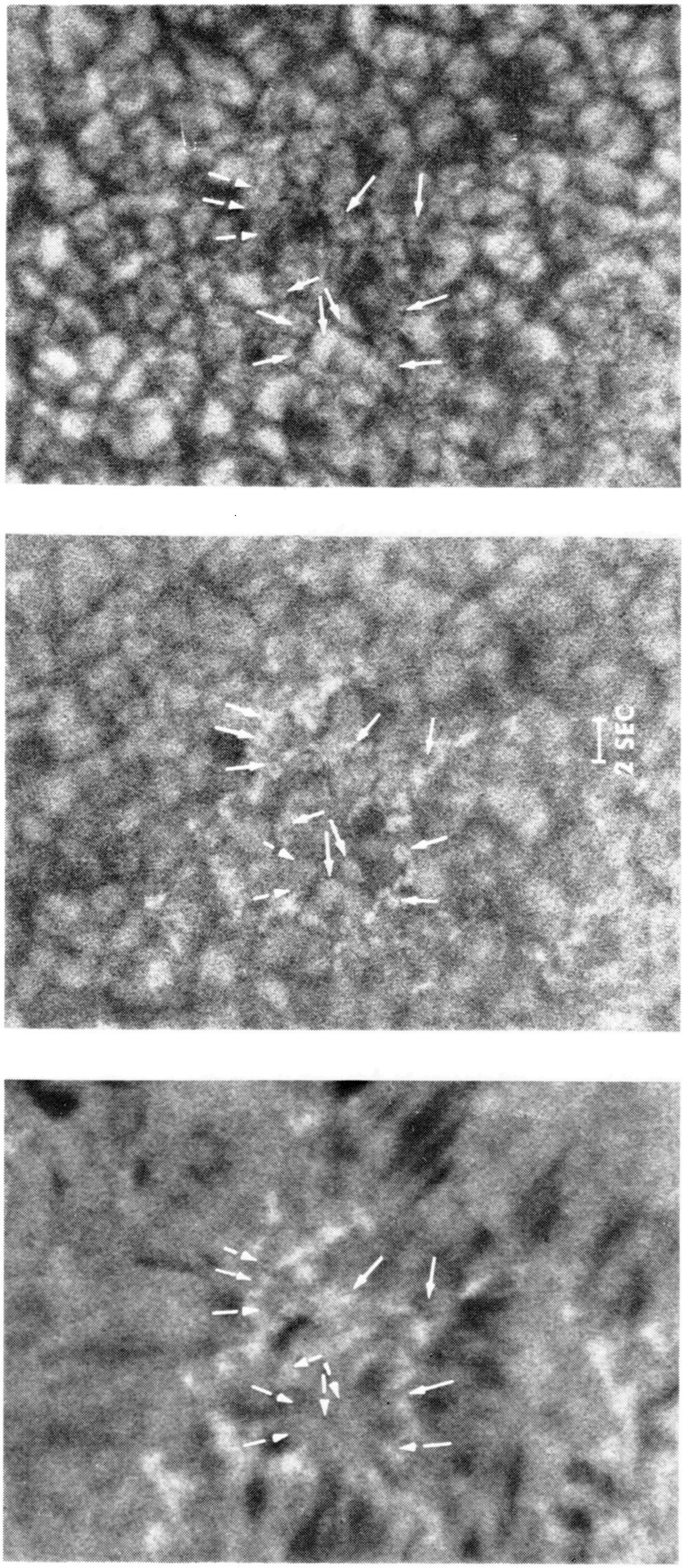

Fig. 8. An enlargement of position 11 in Figure 6. Solid arrows point to very small pores embedded in filigree. Interrupted arrows point to corresponding locations but the pores are not visible. The left picture is − 7/8 Å (2048), the center + 2 Å (2038) and the right the continuum (21 55).

moved around by the granulation, again suggesting intermediate field strengths.

The wavelength variation of crinkle widths demonstrated in Table II strongly suggests that a diverging field is rooted in crinkles. CN photographs of the same region as the filigree (Sheeley and Dunn, 1972) show a close positional correlation between the filigree and the CN structures. However, the size of the detail in the CN appears to be larger, but this could easily be attributed to seeing. Using the Solar Vacuum Telescope, Beckers (1973) and also Mehltretter (1973) are observing the filigree in other lines with great success and we are awaiting their conclusions.

4. Comments on the Birth of Spicules

Beckers (1964a) pointed out that the spicules and granules within a 5″ radius of the center of a rosette have statistically the same birth rate (defined as the ratio of the average number to the average lifetime). He suggested that new granules produce new spicules by interaction with an enhanced magnetic field at the rosette center.

We have tried to observe this process, using the additional working hypothesis that the crinkles outline the relevant flux tubes, either in a rosette or in a plagette. For this purpose, we identify the long dark mottles in Figures 1 and 6 ($\pm\frac{7}{8}$ Å) as spicules seen on the disk. This identification has much supporting evidence, although it is still open to some question (Beckers, 1964b, 1968a).

The gross spatial relation between spicules and the filigree pattern can be seen in Figures 1 and 6 ($\pm\frac{5}{8}$ Å and $\pm\frac{7}{8}$ Å). There, the spicules do not cross over the filigree pattern but fan outward from its borders. The time series in Figure 6 shows, in addition, that spicules are born at the edges of the filigree, possibly with some preference for specific sectors and with some tendency to recur.

We have had limited success in photographing the interaction of granules, crinkles and spicules, however, or in establishing whether spicules arise near crinkles. In Figure 1, only a few spicules terminate near a crinkle. The one at position 6 appears to come from between two crinkles. Our best examples of the birth of spicules are at position 1 on the $-\frac{5}{8}$ Å and $-\frac{7}{8}$ Å scenes of Figure 6. The lower spicule appears to come from a gap or dark area between the crinkles, while the upper one comes from a dark area that may be a pore. These dark areas also appear on the continuum scene.

We followed one spectacular granulation event that did *not* result in the birth of spicule (see Figure 6, position 4). Three granules almost explode into existence and then shatter. The chromosphere shows some spicules in the location but they do not seem to be associated with the event. The granules are far from any filigree, which might account for the absence of any corresponding feature in the chromosphere. From this one event one might conclude that the granulation in the absence of magnetic field has no influence on the chromospheric structure.

As we pointed out above, spicules originate only at the borders of the filigree pattern. We think the magnetic field strength there may fall to an intermediate value ($\sim 10^2$ G) that is critical for the production of spicules. We suggest that *within* the filigree pattern either (a) the field strength is too high to produce spicules or (b) the granulation is somehow inhibited from producing spicules and thus appears 'abnormal'.

Our best spicule-granule association was pointed out earlier and is hardly very convincing. Clearly there are granules near the base of the spicule and the crinkles and pores are in fact changing. Presumably the magnetic line of force or magnetic sheet is jostled by a granule and this could cause the spicule. However, one cannot be at all sure of the details, and certainly the source of all the other spicules in the scene seems even more uncertain.

5. Concluding Remarks

Our observations suggest a number of hypotheses:

(1) The crinkles occur where the magnetic field is strong ($<10^2$ G) but not as strong as in pores (~ 1500 G).

(2) The magnetic field in enhanced network elements (rosettes, plagettes) is generally more diffuse than the crinkles and is associated with the abnormal granulation.

(3) The crinkle occurs, possibly as an instability, at the interface between the granule and the field as the granule jostles and concentrates the field. At this stage in its development the crinkle does represent a field concentration. Any residual field between the crinkles might more closely resemble a sheet than isolated lines of force.

(4) A critical field strength, which occurs mainly at the borders of the filigree pattern, is necessary for the production of spicules by granules.

A better time series, with a shorter interval between acceptable frames, might test these hypotheses. We are preparing a new time series taken on a different region with the hope it will show the details of the interaction of granules, crinkles and spicules.

Acknowledgements

We wish to acknowledge the excellent microphotometer work and the reduction of halfwidths done by Ms. Joyce Wu of the University of Washington during her stay at Sac Peak in the summer of 1972 and Douglas Wilson of the University of Colorado for his attempt to correct for instrumental profiles by Fourier techniques after digitizing the entire filigree frame. Finally, all the photographs were pieced together very carefully by Richard Faller at Sac Peak.

References

Andreiko, A. V., Karpinsky, V. N., and Kotljar, L. M.: 1972, *Solar Data* No. 10, 98.
Beckers, J. M.: 1964a, *Astrophys. J.* **140**, 1339.
Beckers, J. M.: 1964b, Thesis Utrecht, AFCRL Env. Res. Papers No. 49.
Beckers, J. M.: 1968a, *Solar Phys.* **3**, 367.
Beckers, J. M.: 1968b, *Solar Phys.* **3**, 258.
Beckers, J. M.: 1973, private communication.
Beckers, J. M. and Parnell, R. L.: 1969, *Solar Phys.* **9**, 39.
Bhatnagar, A. and Tanaka, K.: 1972, *Solar Phys.* **24**, 87.
Bray, R. J. and Loughhead, R. E.: 1967, *The Solar Granulation*, Chapman and Hall Ltd., London, p. 3.

Chapman, G. A. and Sheeley, N.: 1968, *Solar Phys.* **5**, 442.
Dunn, R. B.: 1972, *Solar Phys.* **22**, No. 2, Frontispiece.
Goodman, J. W.: 1968, *Introduction to Fourier Optics*, McGraw Hill Book Co., New York, p. 113.
Janssen, M. J.: 1903, *Atlas de Photographies Solaire* **1**, Obs. d'Ast. Phys. de Paris, Gauthier-Villars, Paris, p. 2.
Livingston, W. C.: 1968, *Astrophys. J.* **153**, 929.
Mehltretter, P.: 1973, private communication.
Noyes, R. and Simon, G. W.: 1971, in R. Howard (ed.), 'Solar Magnetic Fields', *IAU Symp.* **43**, 663.
Sheeley, N. R.: 1966, *Astrophys. J.* **144**, 723.
Sheeley, N. R.: 1967, *Solar Phys.* **1**, 171.
Sheeley, N. R. and Dunn, R. B.: 1972, unpublished.
Simon, G. W. and Leighton, R. B.: 1964, *Astrophys. J.* **140**, 1120.
Simon, G. W. and Zirker, J.: 1973, submitted for publication.
Vrabec, D.: 1971, in R. Howard (ed.), 'Solar Magnetic Fields', *IAU Symp.* **43**, 329.
Zirin, H.: 1972, *Solar Phys.* **22**, 43.