CHAPTER 5

The Dark Fine Mottles at the Centre of H_α - disk Chromosphere

5 - 1 **Introduction** The identification of spicules as the bright features on the disk is in general agreement at present. (Bhavilai 1965, Beckers 1966). The problem then arises as to the interpretation of the dark mottles on the H_α - filtergrams. Beckers (1964) studied the general characteristics of the dark mottles and identified them with the spicules. Bhavilai 1965) gave a three dimensional model of the solar chromospheric structures, from which the dark mottles were identified as motions of matter in a loop, inwards to the central parts of clusters of mottles. Becker (1966), however, later agreed to the identification of spicules with bright features on the disk and suggested that the dark fine mottles might be identified with the post mortem phase of a spicule when it is falling back to the photosphere. De Jager (1966) suggested that the dark mottles are inward streaming material or stream lines of the supergranules.

In this report, the dark fine mottles in both wings of the H_α - line are studied by the method of superimposing to verify the hypothesis that dark mottles arise from the flow of matter in loops.

5 - 2 **Data** Seven sets of filtergrams of the centre of the solar disk were taken on 15.8.67 by R. Bhavilai through the 12 - in. Domeless Coude' Refractor (1966) at Capri. A solar image of 150 mm. in diameter is produced at the final image plane of the telescope. This gives the scale of 0.1 mm. on the film to 1.26 sec. of arc on the sun. Each set contains 9 filtergrams in the light from 9 positions in the H_α - line profile. Two good quality sets were selected for reduction.

5 - 3 Reduction The two sets of filtergrams were enlarged 7 times on high contrast papers and also on transparent films. For convenience in superimposing, the dark mottles on each print were sketched on a transparent paper with cross-marks representing the positions of the bright features. As found by the author, in same case the same bright features are visible in the line centre and both the red wing and the blue wing of the H_{α} line without variations of position. They can be used as the reference positions in superimposing. By this method, different pairs of the sketches, either from the same wing or opposite wings of H_{α} line were superimposed on each other. In some cases the sketch from the line centre was used to identify the pair of dark mottles, formed by comparison of two sketches of opposite wings.

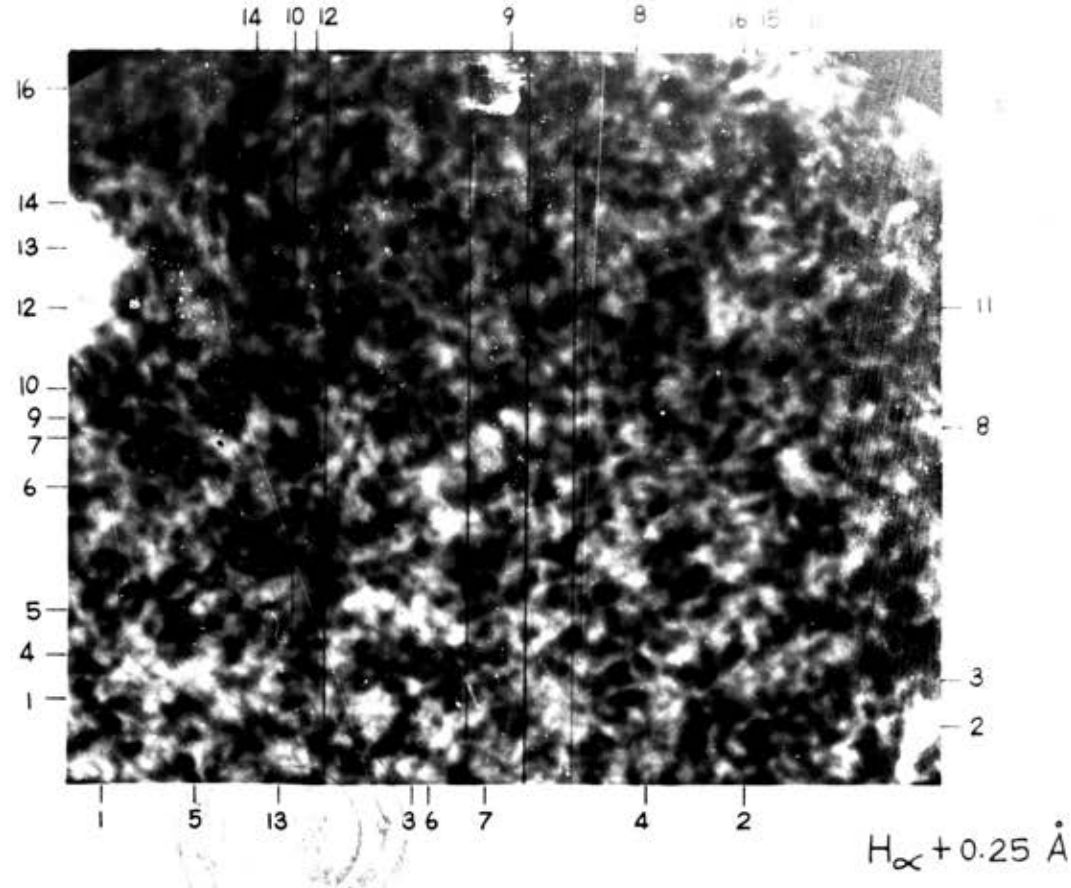
Prints with 7.0 times enlargement were also made from one of the two sets of filtergrams used in the study of bright features.

5 - 4 Results In general, the bright features in the filtergram at the line centre coincide with those in all filtergrams in both red and blue wings as shown in Plates 5 - 1 and 5 - 2. However, there are a few features which are invisible in the blue wing and appear as regions which are darker than average (Plate 5 - 3). It is more convenient to use transparent prints in this identification because bright features are still visible in the H_{α} + 0.75 Å prints. From twenty bright features studied in the transparent prints, three are found to lose visibility in the blue wing.

The cross-marks, representing the bright features in the filtergram are now used as reference positions in the superimposings. The first pair of sketches from H_{α} + 0.5 Å and H_{α} + 0.75 Å (Plate 5 - 4 a) is

PLATES5-I, 5-2, 5-3

Comparisons of the H + 0.25 A, H - 0.25 A; H 3 0.50 A, H - 0.50 A; H + 0.0 A, H 6 0.50 A are shown in the plates 5-I, 5-2, 5-3 respectively. Some bright features (8,9,I3) which appear clearly in the H + 0.0A filtergram are invisible in H - 0.50 A. This suggests the upward motion of the spicules.


14 10 12 9 8
16 15
16
14
13
12
10
9
7
6
5
4
1
11
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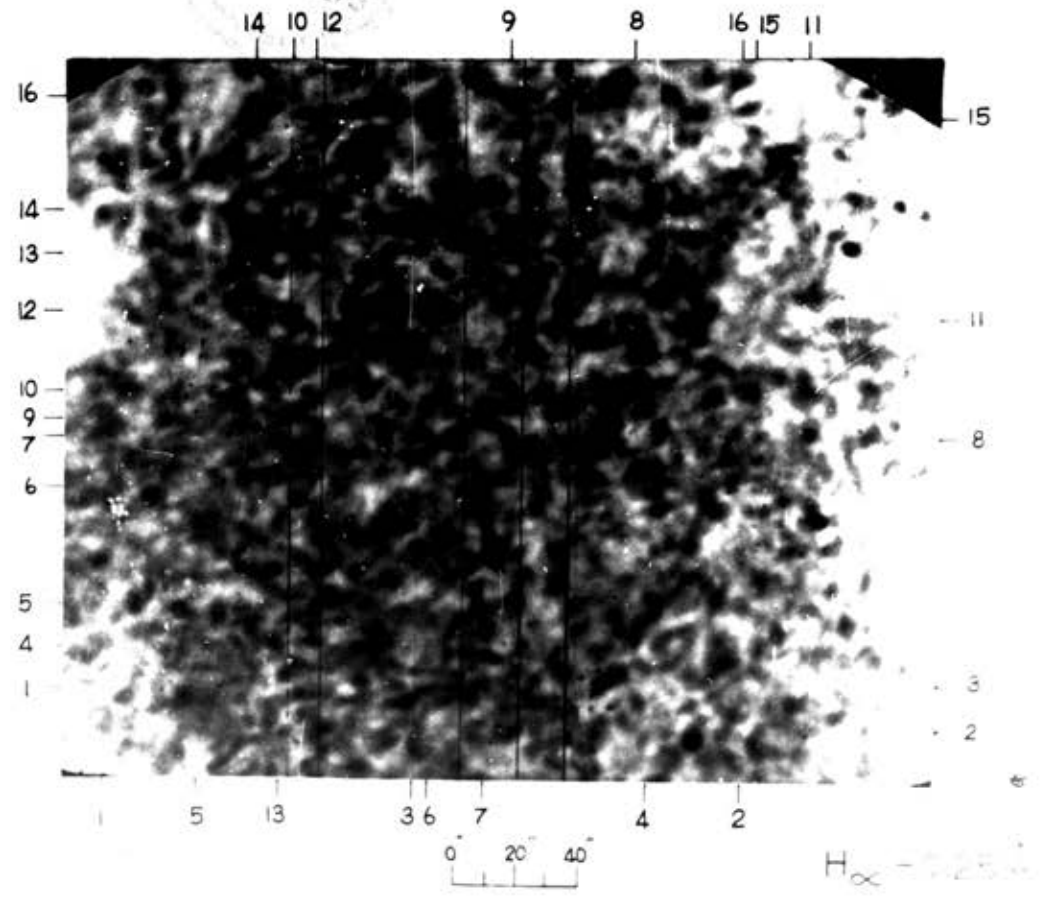
3
2
1 5 13 3 6 7 4 2
H_α + 0.25 Å


14 10 12 9 8 16 15 11
16
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13
12
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9
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3
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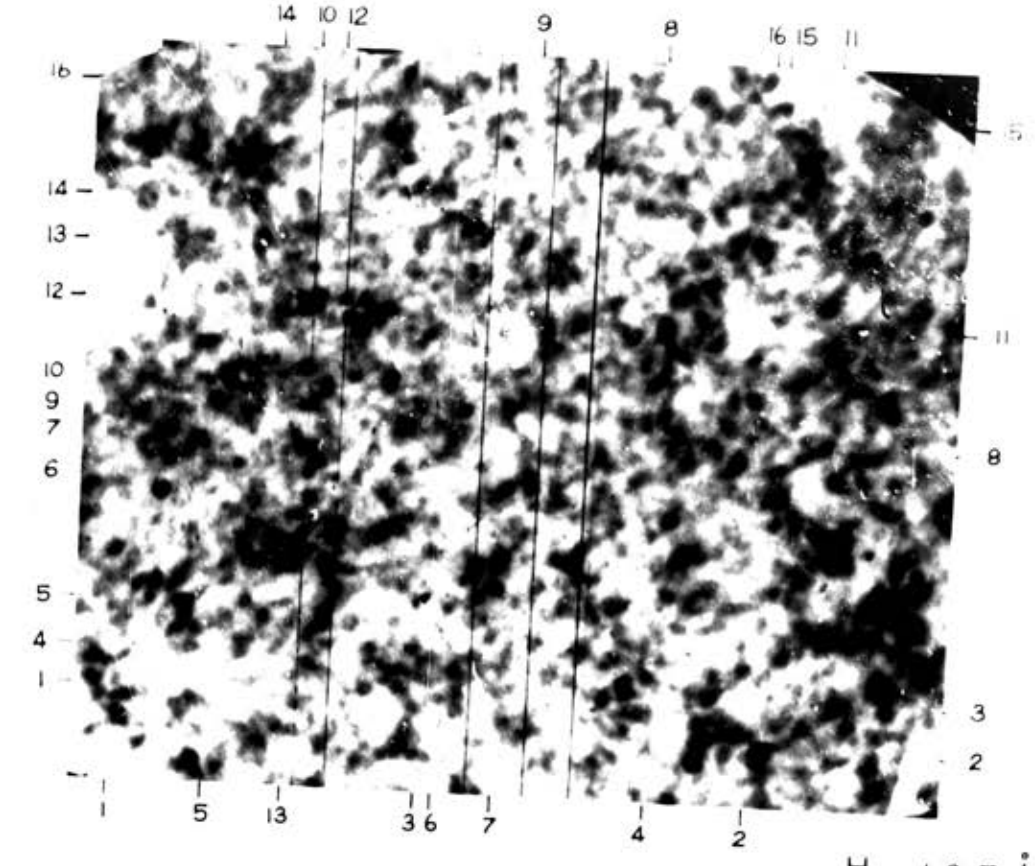
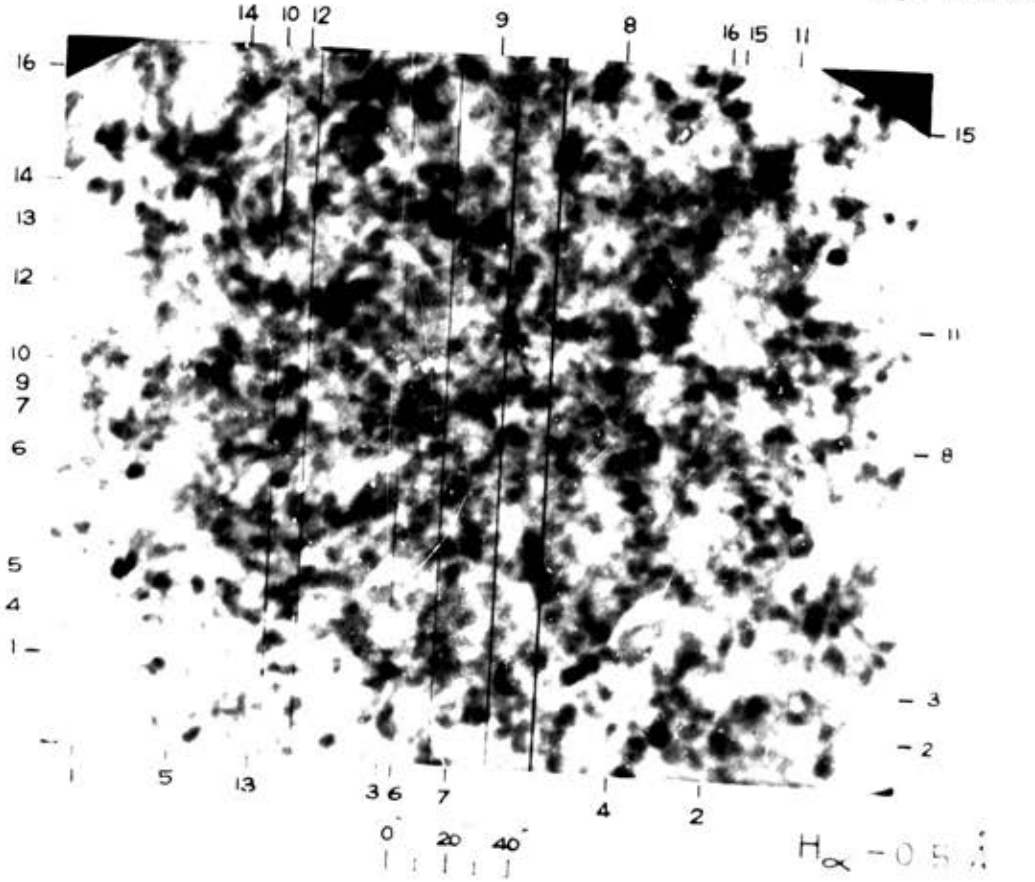
1 5 13 3 6 7 4 2
0 20 40
H_α

PLATE 5-1



H_α +0.5 Å



H_α −0.5 Å

PLATE 5-2

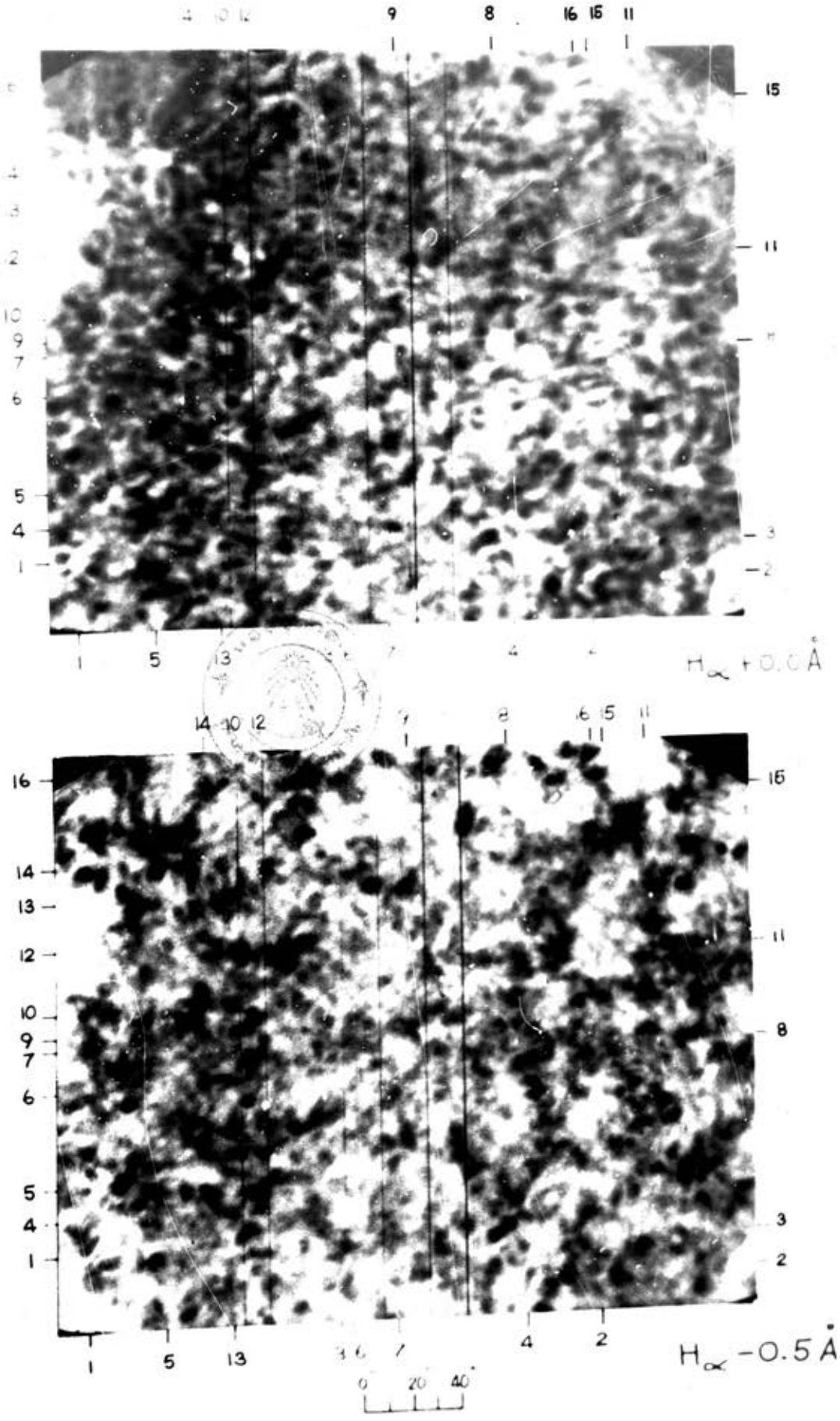


PLATE 5-3

examined giving result that although the dark mottles in both sketches do not coincide completely, each pair of dark mottles has its components aligned in the same direction (their lengthes are almost parallel to each other). The same results is obtained from pairs of dark mottles at H_{α} - 0.5 Å and at H_{α} - 0.75 Å.

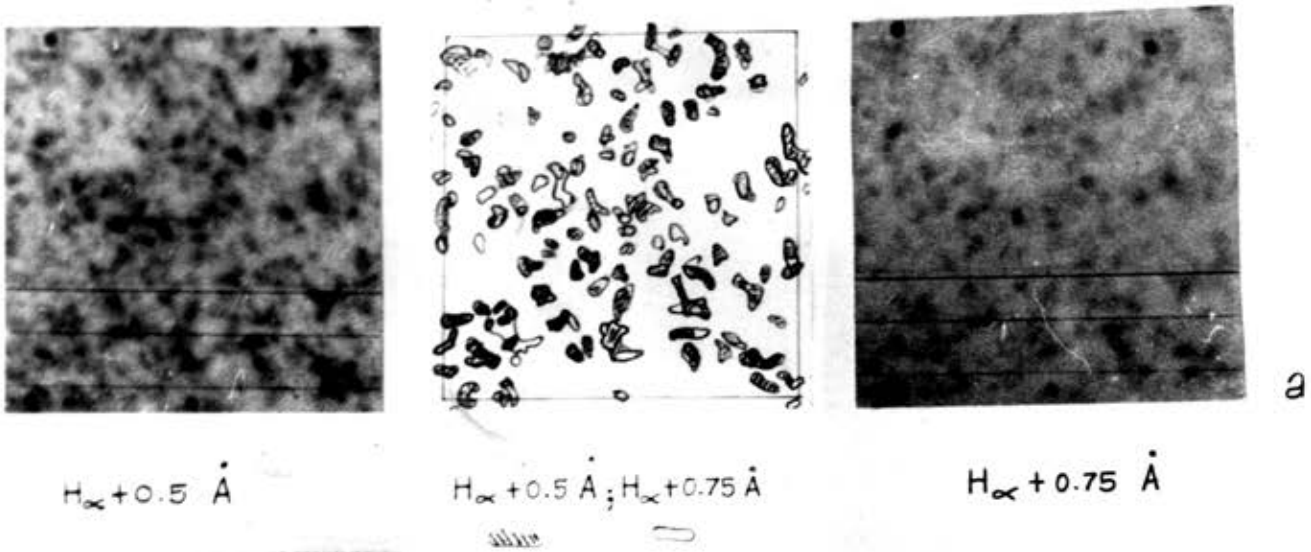
The two sketches of the same wing at H_{α} + 0.25 Å and at H_{α} + 0.5 Å (Plate 5 - 4 b) are further compared and the same parallel orientation of pairs of mottles is found. It is noted that the dark mottle at H_{α} + 0.25 Å which have an average length of 8".4 of arc are generally longer than those of H_{α} + 0.5 Å, which have an average length of about 7".2 of arc. Their average widths, however, are just the same, i.e. about 2".9 of arc for those in H_{α} + 0.25 Å and 3".0 of arc for those in H_{α} + 0. 5 Å.

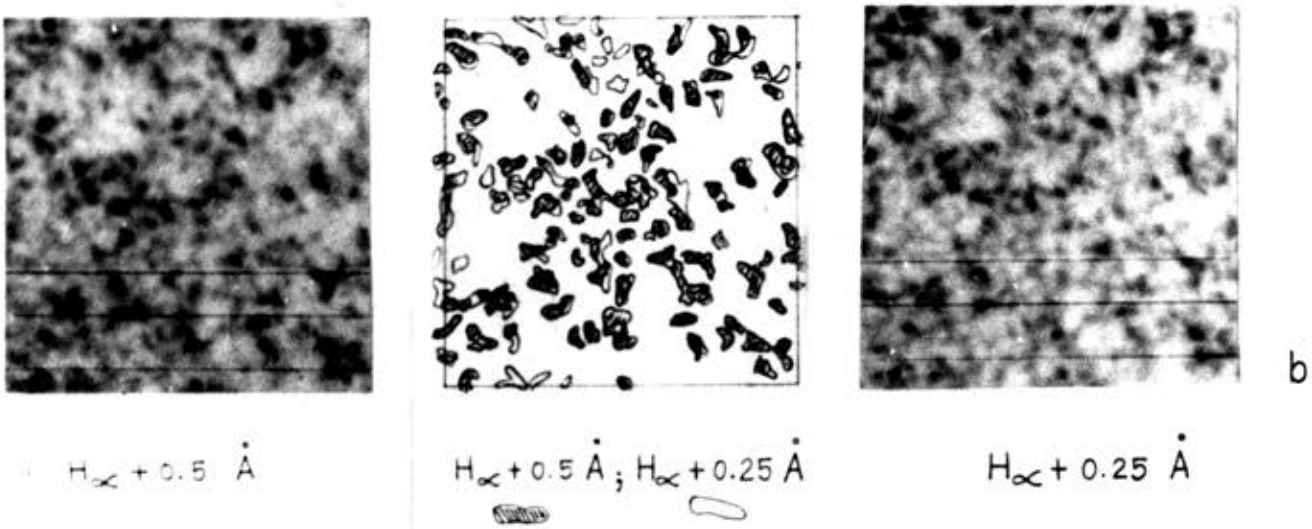
Next, a comparison of mottles at H_{α} + 0.5 Å and H_{α} + 0.0 Å (Plate 5 - 4 c) is made. Some pairs of mottles are found to be aligned in the same direction with greater variations in positions along their long axes. In general, a short dark mottle of H_{α} + 0.5 Å always lies at one end of a long dark fibril of H_{α} + 0.0 Å. The average length of the dark mottles in H_{α} + 0.0 Å increases to about 9".0 of arc while the average width is about 3".1 of arc.

Two sketches at H_{α} + 0.25 Å and (Plate 5 - 5 a) from opposite wings are now considered. The elongated dark mottles of averate length about 8".4 of arc in the red and about 8".1 of arc in the blue wings are arranged in pairs such that for each pair, a portion of each mottle coincides with the other. The long axes of some mottles in the pair, however, do not lie parallel to each other, but lie at an angle while others are parallel. The average total length of the pairs of mottles

PLATES 5 - 4, 5 - 5

Superimposing of different pairs of sketches of filtergrams taken in wavelength scan along H - line profileoon I5.8.67 are shown. All filtergrams show the same quiet region near the centre of the chromospheric disk.


a
H_α + 0.5 Å
H_α + 0.5 Å ; H_α + 0.75 Å
H_α + 0.75 Å


b
H_α + 0.5 Å
H_α + 0.5 Å ; H_α + 0.25 Å
H_α + 0.25 Å

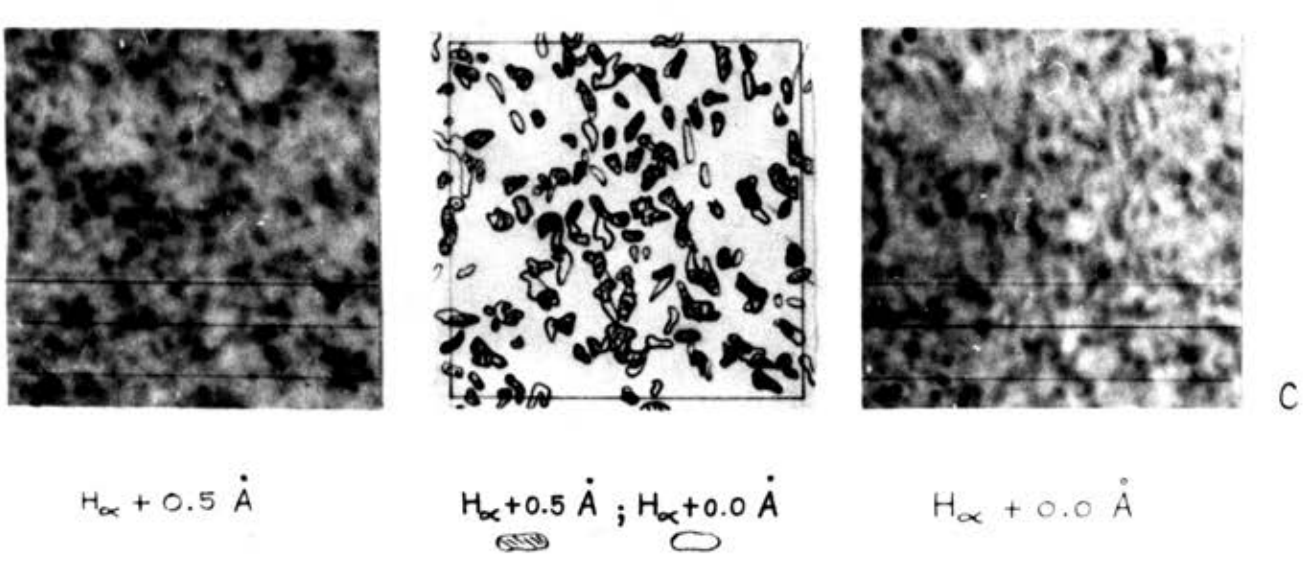
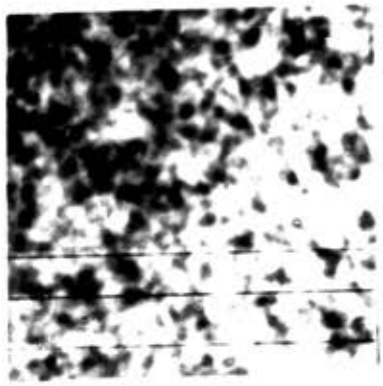
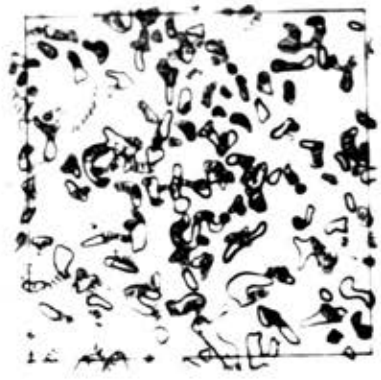

C
H_α + 0.5 Å
H_α + 0.5 Å ; H_α + 0.0 Å
H_α + 0.0 Å
0" 20" 40"

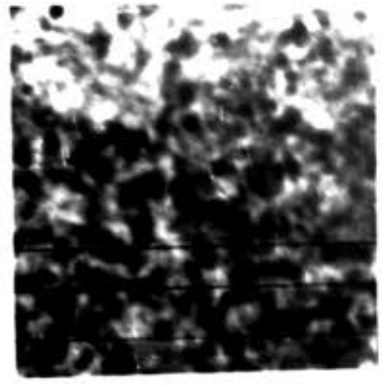
PLATE 5-4



H_{α} + 0.25 Å

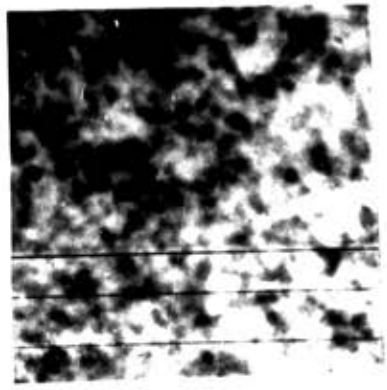


H_{α} +0.25 Å ; H_{α} -0.25 Å

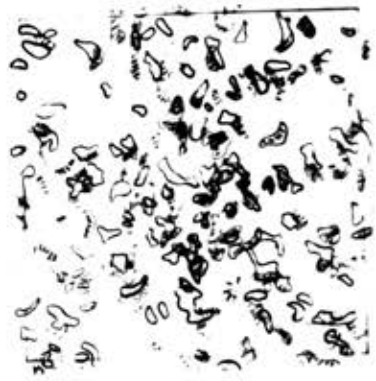


H_{α} - 0.25 Å

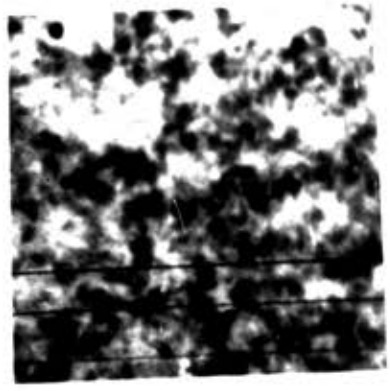
a



H_{α} + 0.5 Å

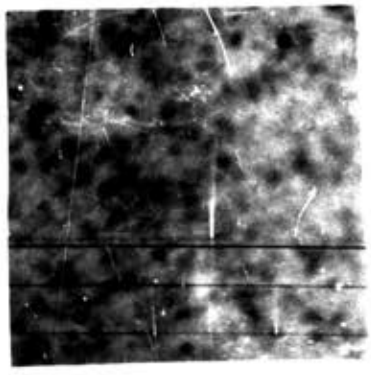


H_{α} +0.5 Å ; H_{α} -0.5 Å

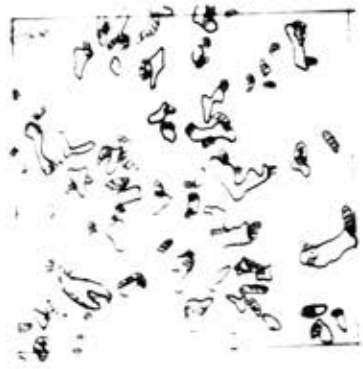


H_{α} - 0.5 Å

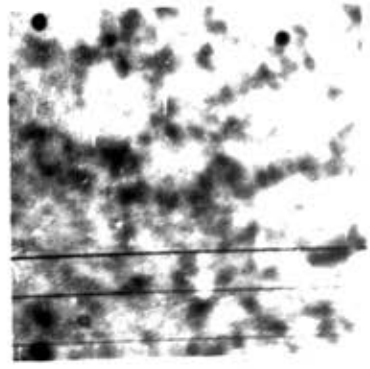
b



H_{α} + 0.75 Å



H_{α} -0.75 Å ; H_{α} -0.75 Å



H_{α} - 0.75 Å

c

PLATE E-5

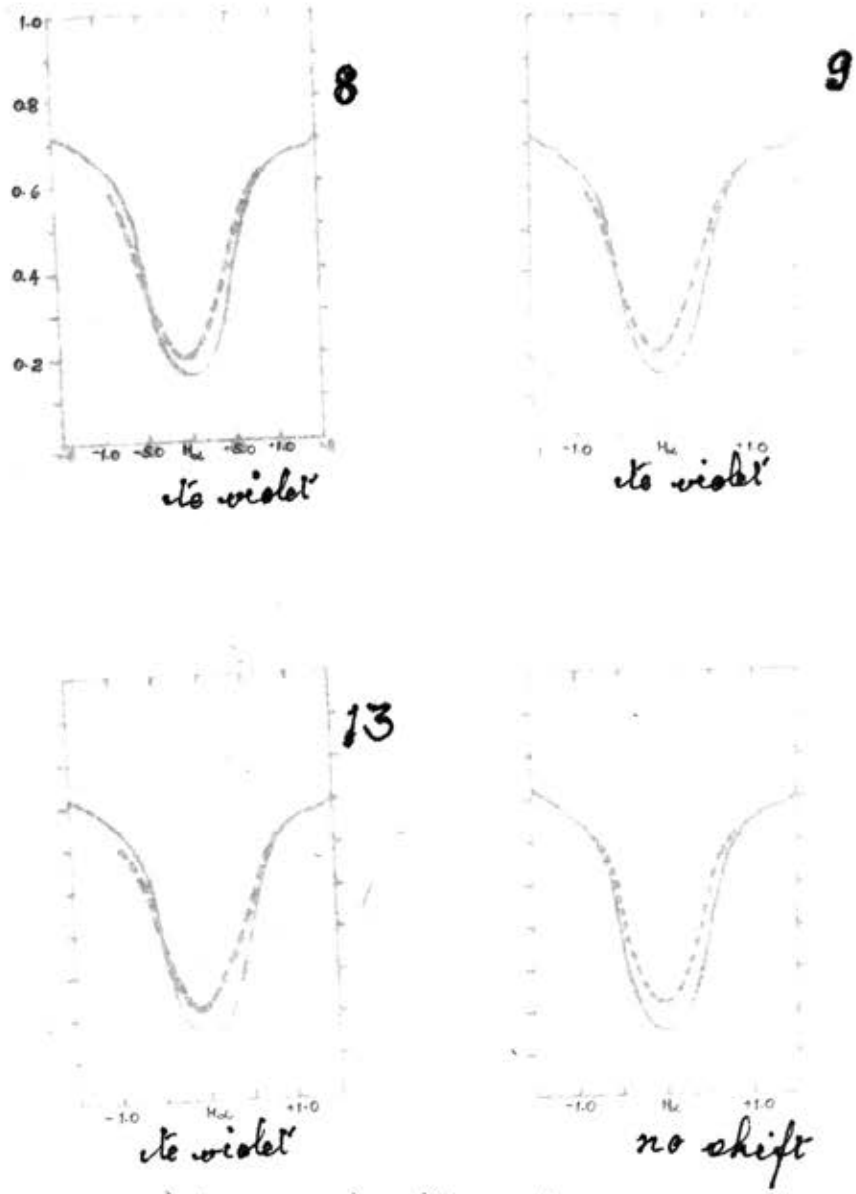
is about 12.4 sec. of arc. Note that the average widths of dark mottles in H_α + 0.25 Å and H_α - 0.25 Å are the same.

In the comparison of filtergrams at H_α + 0.5 Å and at H_α - 0.5 Å, (Plate 5 - 5 b), the variations in positions along the direction of dark mottle lengths increase in each pair to the average total length of about 14".6 of arc, compared with the average length of about 7".6 of arc for those in H_α - 0.5 Å. When the sketch for H_α + 0.0 Å is placed over those for H_α + 0.5 Å and H_α - 0.5 Å at the same time, most of the dark mottles in the sketch for H_α + 0.0 Å bridge the underlying pairs in the sketches for H_α + 0.5 Å and H_α - 0.5 Å.

The average length of the pairs of dark mottles in H_α + 0.75 Å combined (Plate 5 - 5 c) seems to decrease to about 12"7 of arc. The unresolved dark mottles in the H_α - 0.25 Å make a detailed study of the pairs imposible.

Ten pairs of dark mottles are also followed as shown in the Table 5 - 1 . The profiles of each dark mottle in the pairs numbered 2, 5,9 are drawn with respect to the average profile of the surroundings (1964) Plate 5 - 6 b. The two dark mottles in each pair show different directions of Doppler shift, one to the red and the other to the violet. These results confirm the idea that there exists matter moving up and down in the same neighbourhood.

5 - 5 Discussion The visibility of the same bright features in both the red and blue wings of line profile can be interpreted by comparing the average profiles of the bright features and the average profile of the surroundings (White 1964) as shown in Plate 5 - 6 a. Since the differences in contrast (bright features to background) cannot be estimated by the eye,



Doppler shift to violet of 3 bright features are drawn. Solid lines represent the average profiles of the surrounding (White 1964)

PLATE 5-6 a.

PLATE 5 - 6 (b)

The profiles of each dark fine mottles in the pairs numbered 2,5,9 (Table 5-I) are drawn with respect to the average profile of the surrounding (White 1964). The two dark mottles in each pair show different direction of Doppler shift, one to the red and the other to the violet.

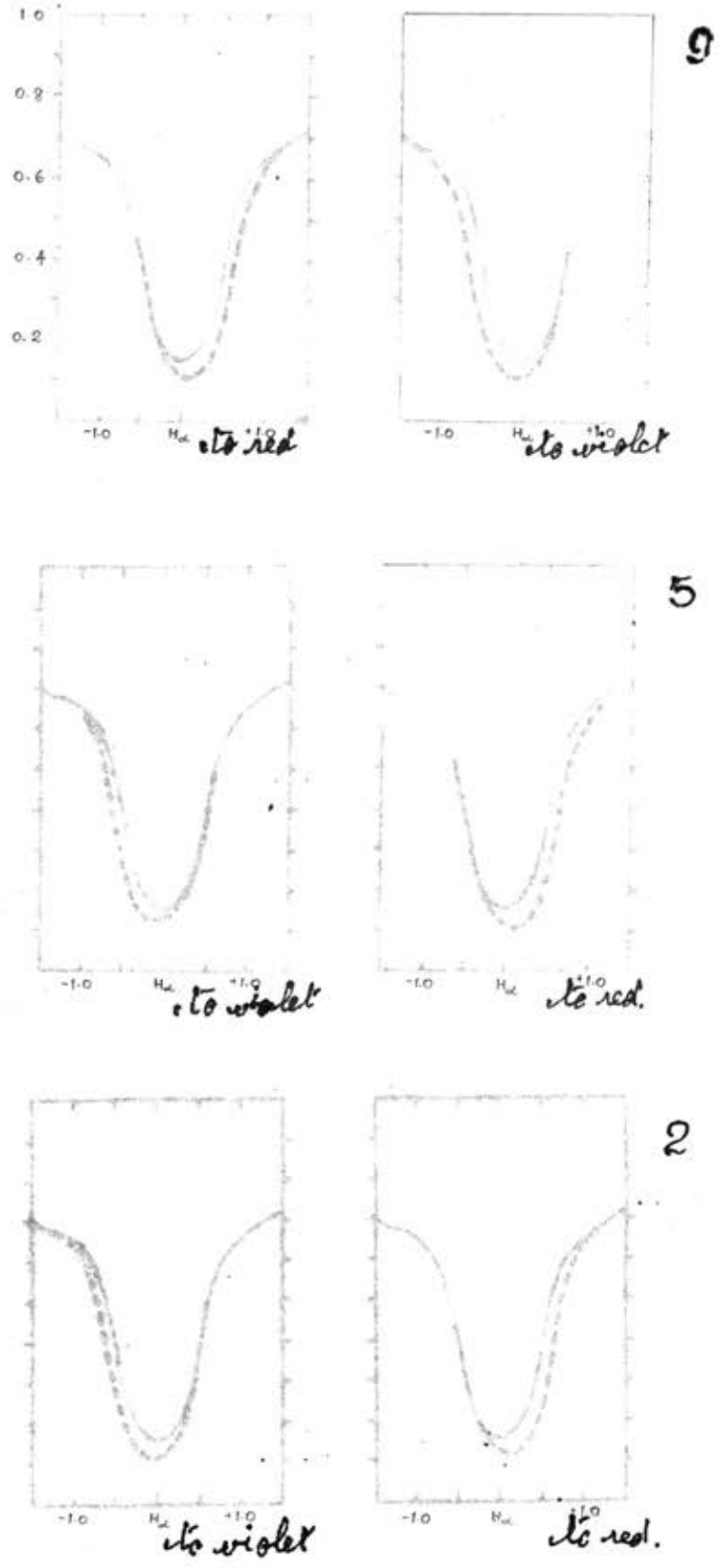

1.0
0.8
0.6
0.4
0.2
-1.0
+1.0
9
to red
to violet
5
to violet
to red.
2
to violet
to red.

PLATE 5-6 b.

the direction of Doppler shift of this type of bright features cannot be determined. For the bright features which disappear in the blue wing, interpretation in terms of Doppler shift to violet can be applied, giving the result that spicules seem to move up (outwards). In the Plate 5 - 6 a, violet Doppler shift of the three bright features are shown.

Now, consider the alignment of the dark mottles in pairs in the six comparisons. In the pairs at H_α + 0.75 Å and at H_α + 0. 5 Å, the sketch indicates portions of matter with downward motion and diameter about 3".0 of arc seen in the low level with the former under the latter as shown in the fig. 5 - 1 a. The sketch for the H_α + 0.25 Å and H_α + 0.5 Å comparison shows the portions moving up at two levels with the level s visible in H_α + 0.25 Å overlying that visible in H_α + 0.5 Å (fig. 5 - 1 b). These levels are between 3500 km. and 5000 km. above the photosphere.

In the H_α + 0.5 Å and H_α + 0.0 Å pairs, the highest portions of matter at the level of about 5000 km. are seen superimposed on the moving down matter. In some cases, there exist some long dark fibrils in H_α + 0.0 Å superimposed on two or three short dark mottles at H_α + 0.5 Å. This suggests two or three columns of matter moving down from a higher level thus raising the question as to their sources. The answer is obtained by examining the H_α + 0.5 Å and H_α - 0.5 Å pair which shows the darks mottles with upward motions near the mottles with downward motions. An examination of filtergrams at H_α + 0.25 Å and at H_α - 0. 25 Å confirms this result by showing that the dark mottles are arranged in pairs (fig. 5 - 1 c, d). These pairs can be traced to the lower level at H_α + 0.75 Å and H_α - 0.75 Å.

If a certain pair is examined beginning from the first to the last columns respectively in the Table 5 - 1, the loop model of dark mottles can be conceived and constructed. Note that the average width of about 3".0 of arc of dark mottles, i.e. the loop, is constant throughout all the levels. This value is also in agreement to the width of about 2".5 of arc of fine dark mottles at the extreme limb, taken in H_{α} + 0.75 Å (CHAPTER 3).

TABLE 5-1

	H_2 +0.75 H_2 +0.5	H_2 +0.25 H_2 +0.5	H_2 +0.0 H_2 +0.5	H_2 +0.25 H_2 −0.25	L_1 in sec of arc	H_2 +0.5 H_2 −0.5	L_2 in sec of arc	H_2 +0.75 H_2 −0.75	L_3 in sec of arc.
1					9".0		14.4		12.6
2					16.2		16.2		14.4
3					14.4		14.4	—	—
4					11.7		15.3	—	—
5					11.7		15.3		9.0
6					11.7		12.6		10.8
7					9.0		12.6		13.5
8					16.2		21.6		11.7
9					14.4		18.0		16.2
10					9.9		12.6		12.6

L_1, L_2, L_3 are total length in sec of arc.

Short horizontal lines show the positions of H_2 +0.5 in.

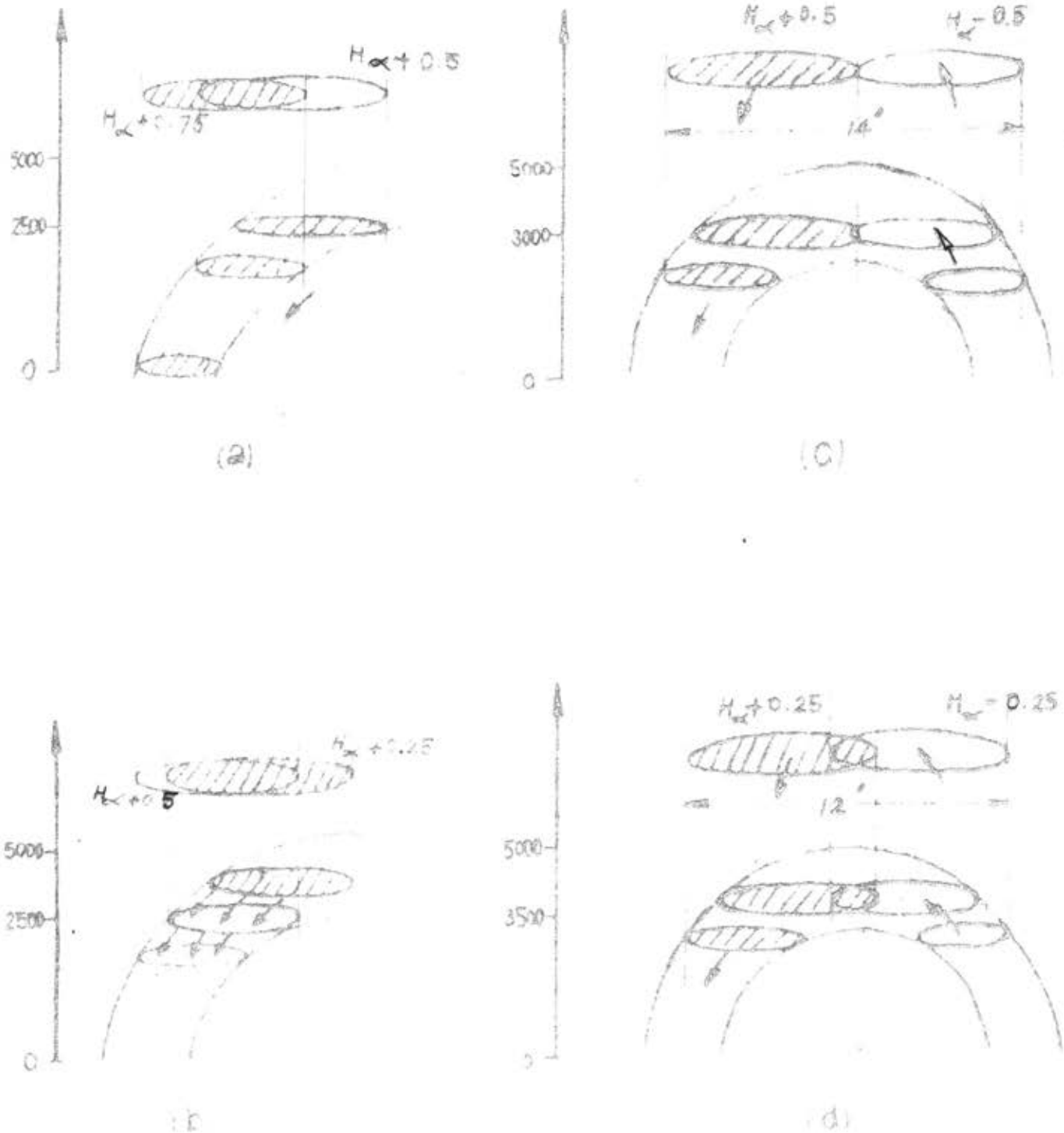


Figure 5-1 Representation of a loop model of dark fine mottles.