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A Database of Sunspot Observation I. Sketch Images

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Abstract Hisako Koyama, an ex-researcher of National Science Museum, observed sunspots for more than fifty years. The sketches are valuable for solar research and are also useful for astronomy education. The authors scanned the images and processed them to make three types of digital images in order to keep the information and to be used with a database of sunspot observation, which will be made public through the Internet.

Key words: Sunspots, Solar activity, Database

1. Introduction

The Sun is the only burning star that we can observe the photosphere in detail, and the sunspots on the surface are the most conspicuous phenomenon in visible light. The number of sunspots is a significant indicator of solar activity, and the observation of individual sunspot groups brings important clues for understanding behavior of solar plasma.

In the observation of sunspots, drawing is a basic method, and there have been left many sketches since the historical age. As each sketch is a unique valuable record of solar activity at that time, archives of sketches are maintained at many astronomical observatories. The archives of Mt. Wilson Observatory, which began daily drawings in 1917, is one of the greatest.

At National Science Museum, the regular observation was begun by Hisako Koyama in 1947. She published a part of results such as daily sunspot numbers in tabular form (Koyama 1985), but the excellent sketches were wrapped with care and have never been exposed to others. It is certain that causes of stains must be avoided, but it is a thousand pities that such valuable sketches have no sunshine.

For this reason, we decided to scan the sketches of more than ten thousands and to make a database of the sunspot observation. Converting sketch images to digital images is beneficial not only to preservation but also to opening images to the public through the Internet. These data are useful for study of the global Sun, such as active longitudes, as well as of the local activity, such as the structure and the development of sunspots. We believe that the database is also useful for education of astronomy. In this paper, we present processing procedures of the images that are the most important components of the database.

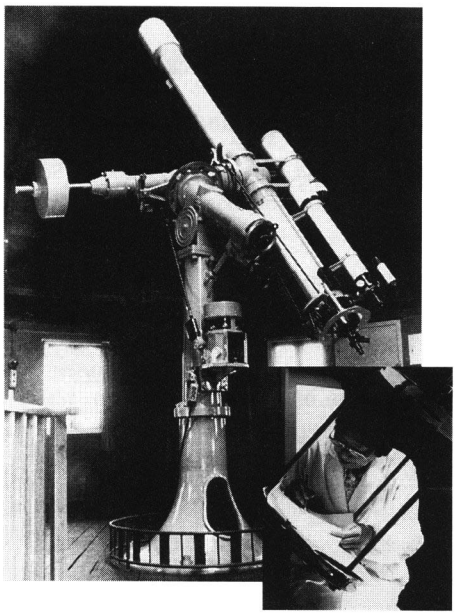

Fig. 1. 20-cm refractor of National Science Museum and Koyama.

2. Observation

Hisako Koyama, who was a staff of National Science Museum, is one of the most famous sunspot observers in the world. She continued observation for more than half a century as her lifework until she expired in 1997. She started her observation in 1944 and drew sketches by attenuated direct viewing in 1945. She got a position in National Science Museum in 1946 and began observation by eyepiece projection with 20-cm refractor of the museum (Figure 1). The diameter of projection was 10 cm in the first year, but was changed and fixed to 30 cm from the next year to the last. Figure 2 is a sample of her sketch drawn on 1957 December 25.

Her observation is very unique and valuable because it was done

(1) for a long period (1947–1997),
(2) by the same observer (Hisako Koyama),
(3) with the same instrument (20-cm refractor, except for the last 6 years by a private 15-cm refractor),
(4) by the same observing method (eyepiece projection)
(5) with a large diameter (30 cm).

The sketches of more than ten thousands are incomparable records of homogeneous observation.

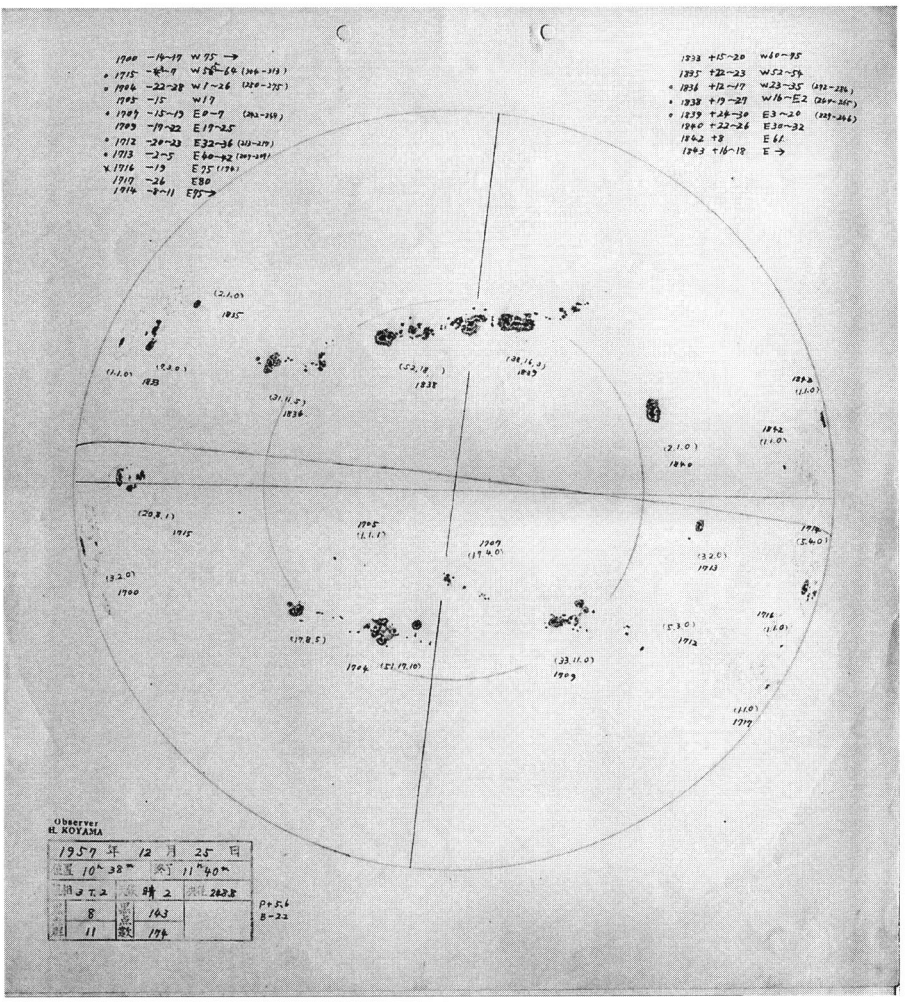

Fig. 2. A sketch on 1957 December 25.

3. Image Processing

In order to keep details of sketches as fine as possible and to make the file size reasonable for storage and for processing, we adopt 150 dpi as scanning resolution. Scanning has been done twice for each sketch, northern half and southern half (Figures 3, 4), since the paper size of a sketch is 35 cm $\times$ 38 cm, which exceeds the maximum paper size available to an ordinary image scanner. The scanning depth is monochromatic 8-bit and the typical pixel size of an image is 2100 $\times$ 1300. Finally, each image is compressed to a JPEG file whose size is about 500 kB.

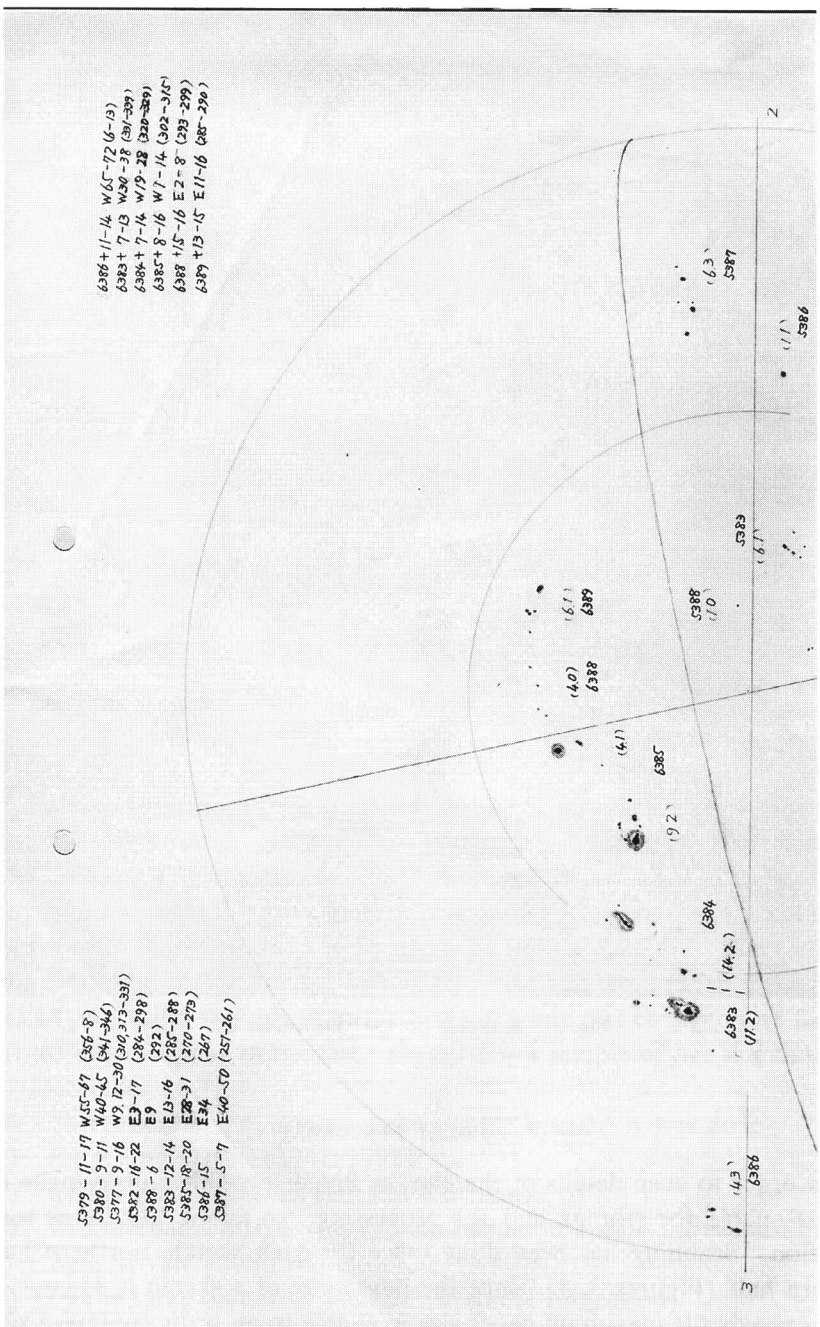

Fig. 3. A scanned image of the northern part of a sketch on 1982 February 3.

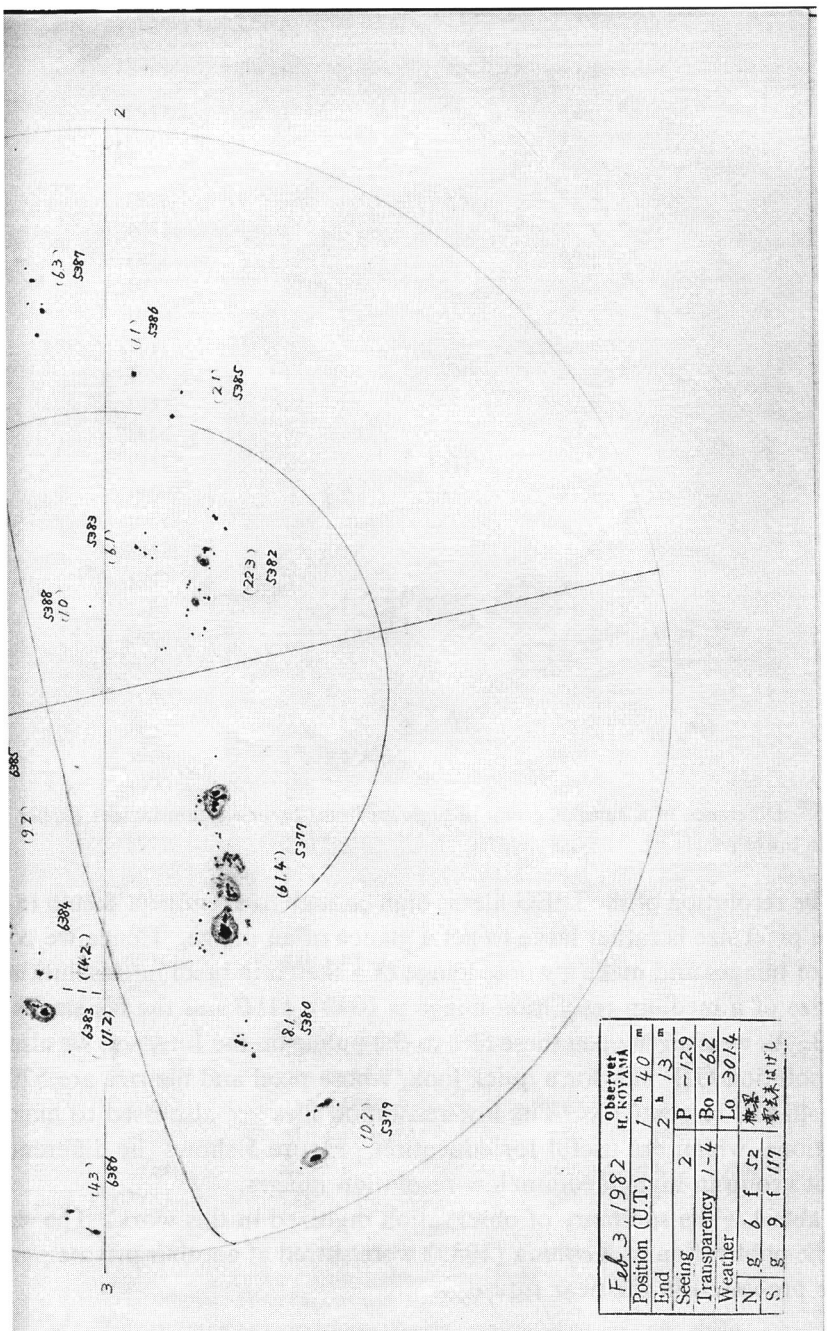

Fig. 4. A scanned image of the southern part of a sketch on 1982 February 3.

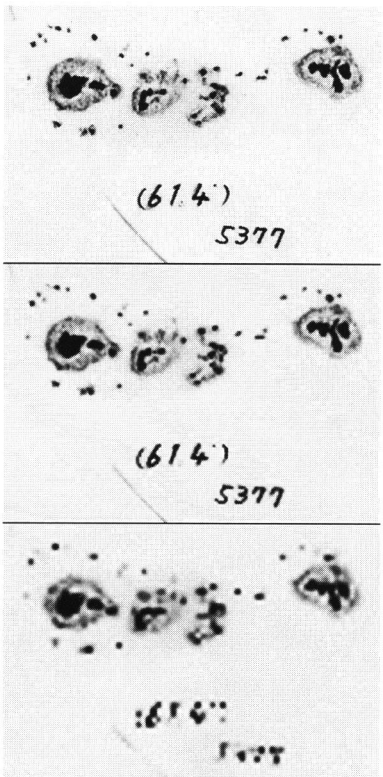

Fig. 5. Difference of a sunspot group in high/medium/low-resolution images (upper panel to lower panel).

The resolution of the JPEG files is high enough to examine a sketch in detail, but the pixel size is rather large to get a glance of an image. Hence we combine a pair of images and make a whole image of a sketch in medium resolution. The pixel size of a medium-resolution image is 1040×1150 and the file size is about 150 kB. As we plan to open these files to the public on the Internet, we also make low-resolution GIF files for a quick look, whose pixel and file size are 520×575 and $\sim$40 kB, respectively. The low-resolution files are also used to make GIF animations, which are useful for education. Figure 5 shows the difference of a sunspot group in high/medium/low-resolution images.

Table 1 is the summary of observation digitized in this work. The sketches after the publication of Koyama (1985) were stored at another private place and will be processed in the near future.

4. Summary and Future Works

Hisako Koyama, an ex-researcher of National Science Museum, observed sunspots for more than fifty years, and left ten thousands of sketches of the whole

Table 1. The number of processed sunspot observations.

Year	Days	Sketches
1947	147+2*	147+3*
1948	172+1*	172+2*
1949	177	177
1950	154	154
1951	179	181+2*
1952	190	190+2*
1953	184	184+1*
1954	151+1*+35**	151+3*+35**
1955	198	198+3*
1956	166+1*	166+6*
1957	171+1*	171+3*
1958	157	157
1959	157	157
1960	161	161+2*
1961	184	184
1962	196	196+5*
1963	211	211+7*
1964	218+1*	218+7*
1965	199+1*+27**	199+1*+27**
1966	155+3*+52**	155+5*+52**
1967	228+1*	228+2*
1968	222+2*	222+5*
1969	160+1*	160+1*
1970	188	188
1971	227+1*	227+1*
1972	220	220+1*
1973	244	244
1974	218	218+1*
1975	256	256+2*
1976	236+1*	236+4*
1977	250	250
1978	240	240+1*
1979	188+38**	188+38**
1980	223+1*	223+3*
1981	217+3**	217+3**
1982	210+1*+1**	210+2*+1**
1983	223+1**	224+5*+1**
1984	246	246+1*
Total	7523+19*+157**	7526+81*+157**

* incomplete observations due to clouds, etc.

** substitutive observations during maintenance of the main telescope, etc.

disk of the Sun. Most of the sketches were obtained with the same telescope, 20 cm refractor of National Science Museum, and by the same observing method, 30 cm eyepiece projection. The homogeneity and the long continuity of her observation is unrivaled, and we have scanned the sketches held in National Science Museum in order to preserve the images permanently and to open them to the public.

Koyama noted daily relative numbers and the development of each sunspot group with Zürich classification. We are going to put the data into database tables and to link them to the sketch images. We also plan to construct WWW pages for the sunspot observation and to make public through the Internet. The data and images of excellent quality will certainly bring many fruits not only in the field of research but also of education.

Reference

Koyama, H., 1985. Observation of Sunspots 1947–1984. 354 pp. Kawadeshoboshinsha, Tokyo.

Appendix. A Flare Event on 1960 November 15

During the observation of fifty years, there were many particular events that were just witnessed and recorded. We introduce here one of such observations, a great white-light flare on 1960 November 15. Figure A1 is the primary sketch, and Figures A2 and A3 are the supplemental sketch and the part of sunspots at which the white-light flare occurs, respectively. The comments on the supplemental sketch written in Japanese are as follows:

"At 11 h 21 m (within 0.2 m error), when Koyama sketched the large sunspot group, the region "1" started brightening. The white light became very bright and gradually extended to the region "2". At about 21 m 30 s, Koyama confirmed the time by telephone service and contacted Murayama. When Murayama came into the dome (a little after 22 m), the brightness had weakened. We observed carefully for a while, and then the two ribbon-like regions, "2" and "3", began brightening again.

The light was very dazzling and the color was like pearl. It was so obvious that several pupils who happened to look the flare were surprised.

The brightening regions changed the shape violently and looked like winding ribbons. There may exist small bright points other than the ribbons, and the structure of nearby sunspots seemed to vary rapidly. The most obvious feature was an L-shaped bridge on the largest umbra "D", which disappeared with the end of the flare. The second brightening was at about 11 h 23 m 30 s (by telephone service), and the duration was less than 1 m.

After a few minutes, the flare finished. The structure of sunspots after the flare seemed almost unchanged compared with the (unfinished) sketch before the flare. Hence the bright regions were supposed to hang over a part of umbrae and penumbrae of the sunspots. (In intensity, the initial brightening was the strongest.)"

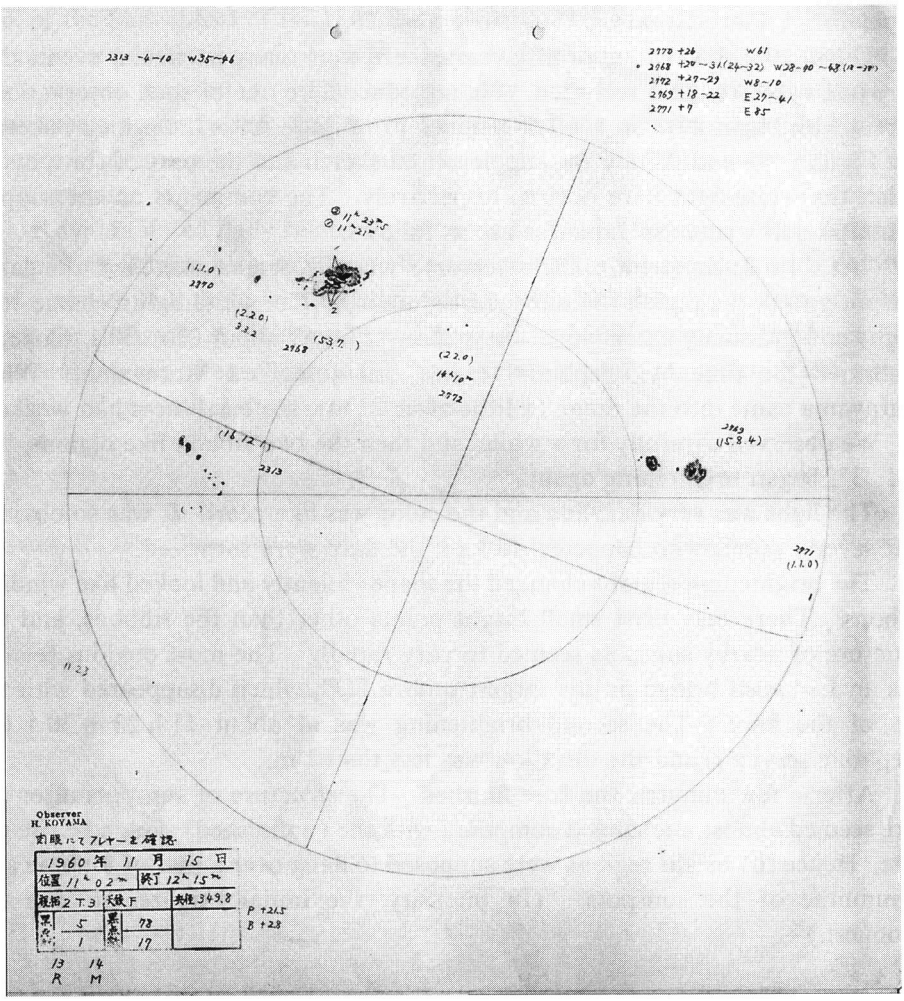

Fig. A1. The primary sketch on 1960 November 15.

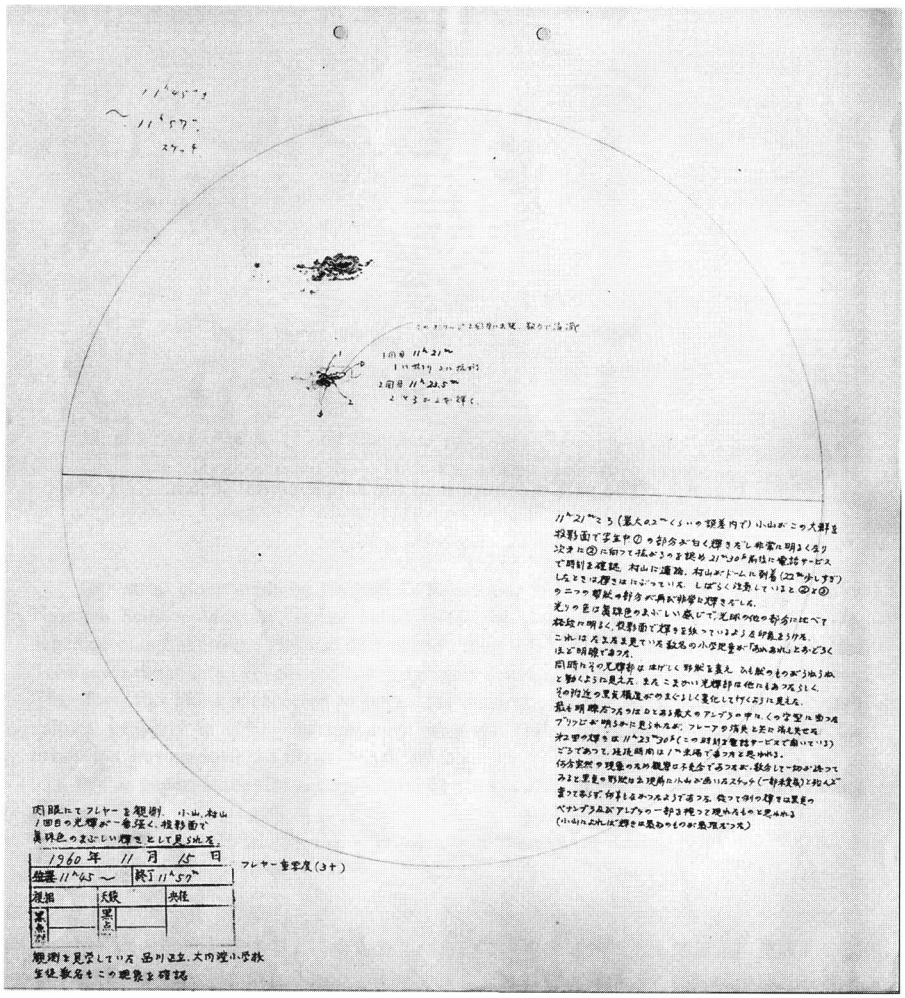

Fig. A2. The supplemental sketch on 1960 November 15.

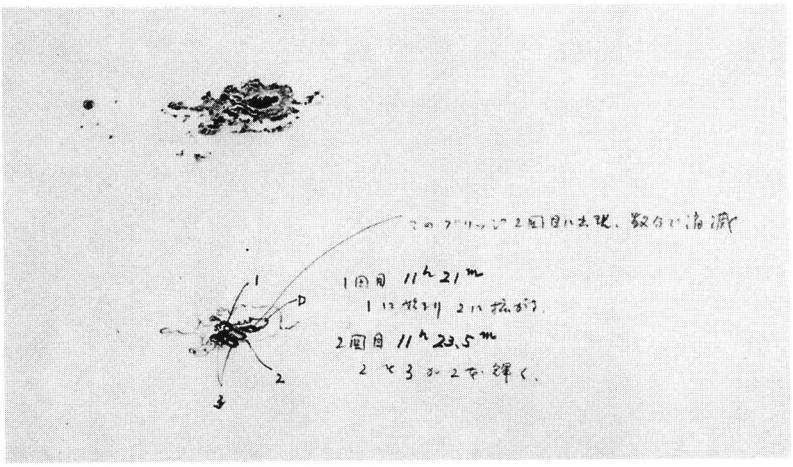

Fig. A3. The part of sunspots of the supplemental sketch.