Morphological Study on Sudden Commencements of Magnetic Storms and Sudden Impulses (IV)

by

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Abstract

In this paper are presented the results of the morphological study on sudden impulses, si's, concerning a few charateristics of the horizontal disturbance vector changes in high latitudes, and their individual equivalent current systems at several successive stages. These results are compared with the morphology of sudden commencements of magnetic storms, ssc's, which is obtained in the previous papers. It is found that si's differ slightly from ssc's in a character concerning the occurrence distribution of the polarity of the vector change, but are quite similar in the other characters. Various kinds of equivalent current systems of si's which show some great different features from each other are found. Of course, the ones which show a pronounced similarity to those of ssc's are also found.

§ 1. Introduction

It has been pointed out by many research workers that sudden commencements of magnetic storms, ssc's, and sudden impulses, si's, are morphologically quite similar (Matsushita, 1960 ; Sano, 1961, 1962, 1963 ; Nishida and Jacobs, 1962). It is considered that the mechanisms of si's (including positive si's, +si's and negative si's, −si's) are quite identical to that of ssc's except a reversed process for −si's. Namely, +si's are caused by a sudden compression of the geomagnetic field due to an enhancement in the pressure of the solar corpuscular stream. Analogusly, −si's are caussed by a sudden expansion of the geomagnetic field due to a sudden diminution in the pressure of the solar stream (Nishida and Cahill, 1963 ; Sano, 1963). In this paper, for the purpose of justifying the conception said above the additional study on the morphology of −si's is mainly carried out.

The distribution of the polarization sense of horizontal disturbance vectors of si's has not yet been examined so in detail as that of ssc's (Wilson and Sugiura, 1961 ; Sano, 1961). Only a few examples have been analysed so far in this concern(Sano, 1962). More numerous cases of −si's are analysed in the present study, and it is found that the polarization of −si's shows similar distribution as that of ssc's except the next difference. In the case of −si's the boundary between two predominant occurrence regions of the clockwise and counterclockwise polarizations seems to be shifted easterly by $30° \sim 45°$ from the 10h and 22h local time meridians in the case of ssc's (Wilson and Sugiura, 1961 ; Sano 1961), This difference has been suggested preliminarily in the previous paper.

The directions of the main axes of elliptically polarized horizontal disturbance vectors during the ssc and si change are studied on their local time dependency for the several stations in high latitudes. This matter has little been examined hitherto.

The many averaged and individual equivalent current systems of ssc's have been reported (Oguti, 1956 ; Abe and Nagata, 1955 ; Jacobs and Obayashi, 1956, Sano 1961; Sato, 1961; etc), However, individual current systems of si's at their successive stages of change have been little studied hitherto. Then, in this paper, equivalent current systems of si's for several individual cases are discussed comparing with those for ssc's. The main purposes are as follows;

(1) To find how the current systems of si's change from the initial stage to the main stage.

(2) To confirm whether or not the essential feature in current systems is quite similar between +si's or ssc's and −si's.

(3) To find what differences are there in the feature of current systems in case by case.

A comparison of the current systems of +si's and −si's in the averaged feature for several cases is carried out by Nishida and Jacobs. They concluded that the current systems of +si's and −si's are quite similar except, of course, the opposite direction of current flow (Nishida and Jacobs, 1963).

From the present study for several individual cases, the current systems which are quite similar in essential feature to those of the ssc's are just found for some si's. On the other hand, it is also found that there are various kinds of current systems even for typical −si's in low latitudes. Of course, these current systems differ greatly in form from the current systems of ssc's obtained by Oguti, Obayashi and Jacobs, etc.

§ 2. Used Data and Stations

In this study are used rapid-run magnetograms during the IGY, mainly in 1958. The stations from which the data are used are listed in Table 1 and their locations are shown in Fig. 1. The stations shown by open circles give no rapid-run magnetograms but only normal-run magnetograms. The data of si's are collected at the author's option from these magnetograms. Selected si's include, therefore, those which are not listed in the formal report of each station.

The variations of si's are scaled at the interval of one or half minutes during the period of ten or more minutes from the beginning time of each event. From these data are obtained the horizontal disturbance vector diagrams as shown in Fig.2.

For the study of equivalent current systems of si's, two +si's and four −si's of which data are available at almost all the stations are selected suitably. These si's are shown in Fig. 3 by arrows on the normal-run magnetograms of Kakioka. As

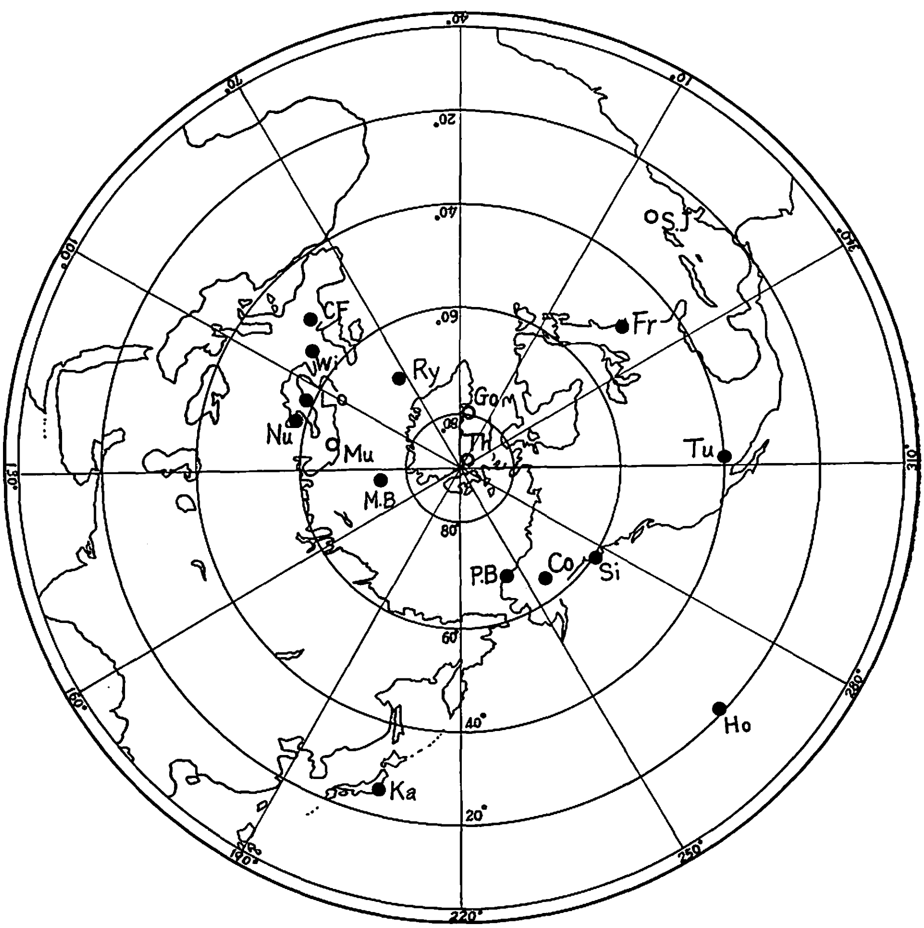


Fig. 1. Distribution of magnetic observatories whose data are used in this study.

shown in the figure, all the −si's are typical in low latitudes but the +si's are not. These si's all occurred in the relatively calm periods.

Table 1. List of stations used in this study.

	Abbr.	Geographic		Geomagnetic		Declination
		Lat.	Long.	Lat.	Long.	
Thule	Th	N77°29′	W69°10′	N 88.9°	357.8°	W79°32.7′
Godhavn	Go	N69°14′	W53°31′	N 79.9°	32.5°	W52°13′
Point Barrow	P. B	N71°18′	W156°45′	N 68.6°	241.2°	E26°09′
Murmansk	Mu	N68°57′	E33°03′	N 64.1°	162.5°	E11°19′
College	Co	N64°52′	W147°50′	N 64.6°	256.5°	E28°52.3′
Reykjavik	Ry	N64°11′	W21°41′	N 70.2°	71.0°	W23°44.5′
Nurmijarve	Nu	N60°30′	E24°39′	N 57.8°	112.5°	E03°41.9′
Sitka	Si	N57°04′	W135°20′	N 60.0°	275.4°	E28°51.7′
Lovö	Lo	N59°21′	E17°50′	N 58.1°	105.8°	E03°18′
Witteveen	Wi	N52°49′	E06°40′	N 54.2°	91.0°	W04°52.2′
Chambon la F.	C. F	N48°01′	E02°16′	N 50.4°	83.9°	W06°32.8′
Fredericksburg	Fr	N38°12′	W77°22′	N 49.6°	349.8°	W06°35.7′
Kakioka	Ka	N36°14′	E140°11′	N 26.0°	206.1°	W06°26′
Tucson	Tu	N32°15′	W110°50′	N 40.4°	312.2°	E13°15.0′
Honolulu	Ho	N21°18′	W158°06′	N 21.1°	266.5°	E11°37.5′
San Juan	S. J.	N18°23′	W66°07′	N 29.9°	03.2°	W07°17.6′

§ 3. Occurrence Feature of Polarization of −si's

In the previous paper, the occurrence distributions of rotational sense of horizontal disturbance vectors for ssc's and si's (both +si's and −si's) have been shown. Such occurrence distributions for si's, however, are not so precise as for ssc's because of a few numbers of examples. In Fig. 4 are shown the occurrence distributions of the clockwise polarization of horizontal disturbance vectors and the counterclockwise ones for −si's in high latitudes, including the previous results.

As can be seen in the figure, the clockwise polarization distributes almost in the afternoon hemisphere except in higher latitudes (about 70°), and the counterclockwise polarization mainly distributes in the forenoon hemisphere. Generally speaking, these occurrence distributions are similar to those for ssc's. However, two predominant occurrence regions of the clockwise and counterclockwise polarization for ssc's are divided nearly by the 10h and 22h local time meridians, while such two regions

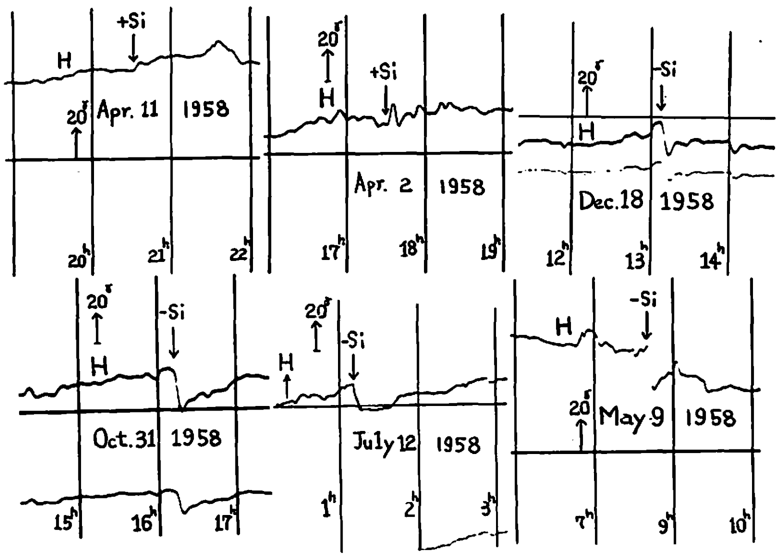


Fig. 2. Reproductions of normal-run magnetograms of Kakioka recording si's whose equivalent current system are obtained.

Table II. List of si's used in the study of equivalent current systems.

Type	Date	Occurrence Time (U. T.)
+Si	Apr. 11, 1958	20h 30m
−Si	Dec. 18, 1958	13h 07m
+Si	Apr. 2, 1958	17h 32m
−Si	Oct. 31, 1958	16h 12m
−Si	July 12, 1958	01h 11m
−Si	May 9, 1958	07h 38m

for −si's seem to be divided by the 12h and 24h meridians. This difference is much notable, although it is still distinctly unknown whether or not this is an essential character of the phenomena. This may be possibly due to a certain difference of the solar corpuscular streams responsible for these phenomena.

§ 4. Direction of Main Axis of the Horizontal Disturbance Vector Changes.

In general, hcrizcntal disturbance vectors of ssc's and si's in high latitudes are

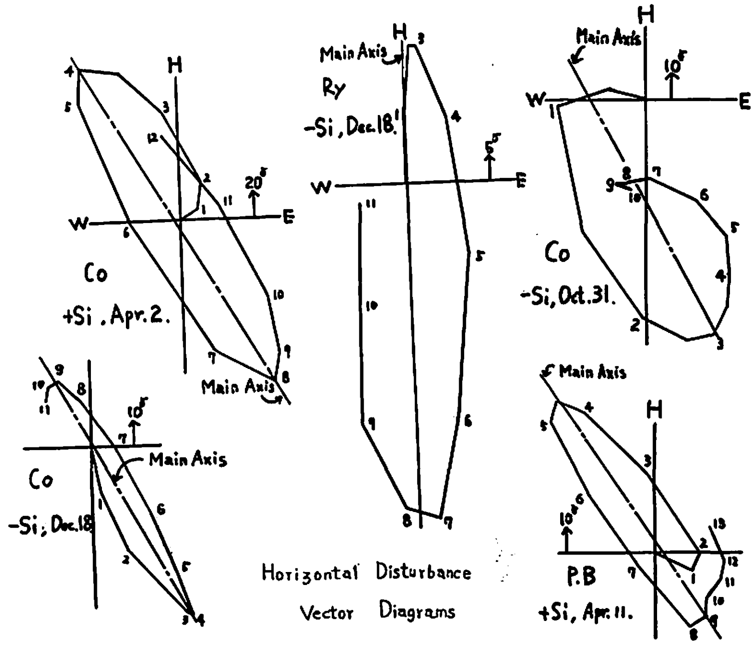


Fig. 3. Several examples of horizontal disturbance vector diagrams of si's in high latitudes.

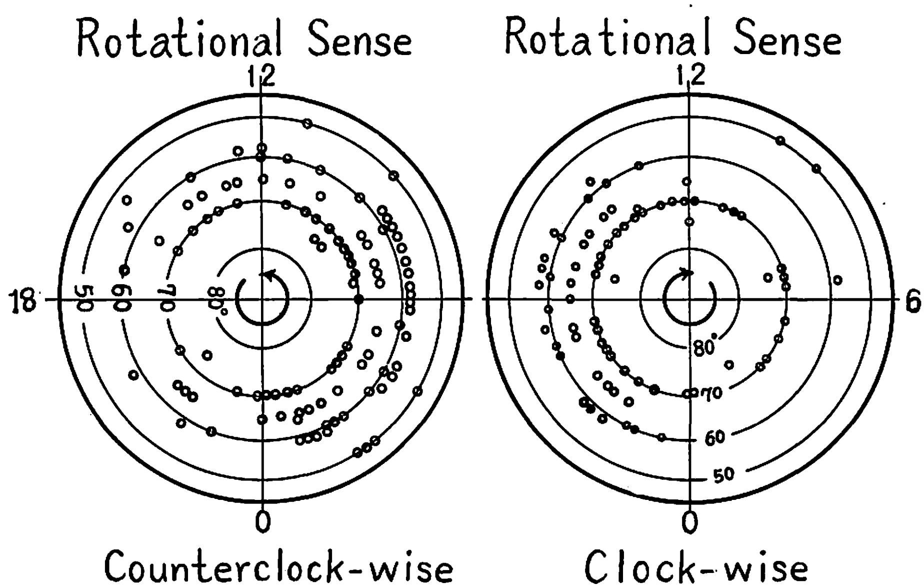


Fig. 4. Distributions of the clockwise and counterclockwise polarizations of horizontal disturbance vectors for -si's.

polarized elliptically as shown in Fig. 2. Then, the main axis of such polarizations is defined as shown by the broken line. In this section the direction of the main axis is examined in association with the declination of the geomagnetic field at each station. The direction is expressed by the angle between the main axis and the declination.

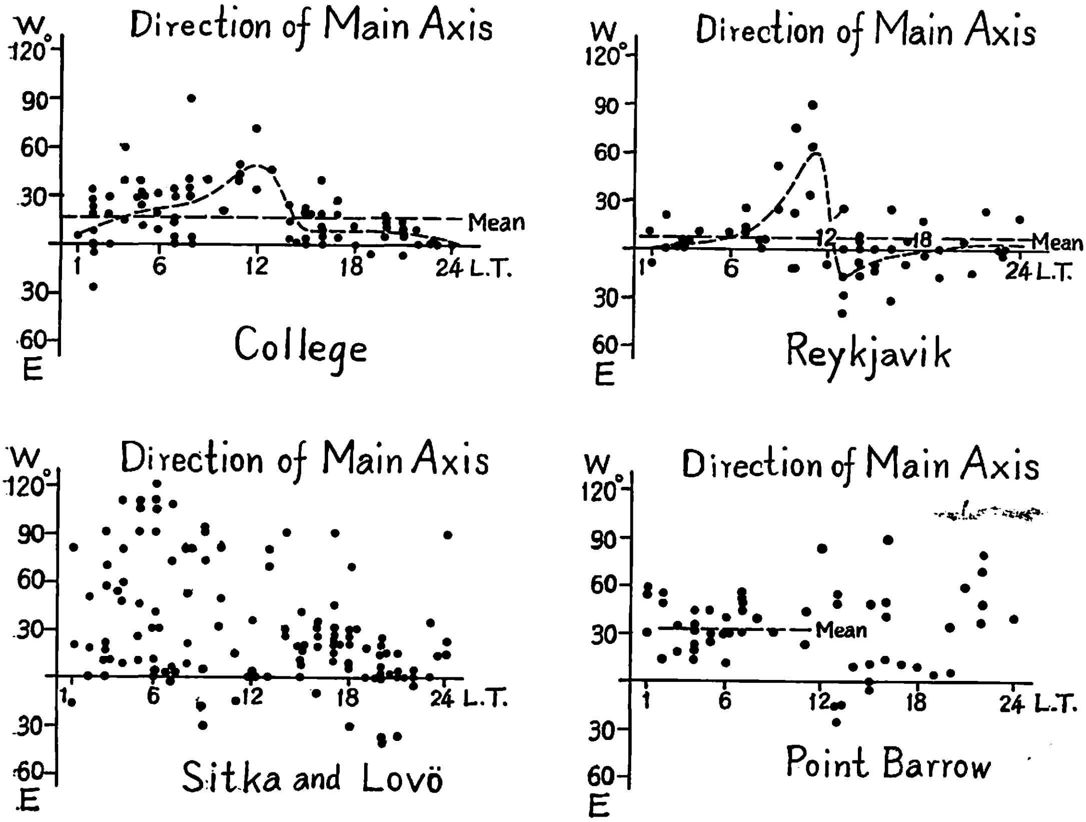


Fig. 5. Direction of the main axis of horizontal disturbance vector diagrams at the high latitude stations.

Fig. 5 shows the local time dependency of such directions for five stations ; Point Barrow, Reykjavik, College, Sitka and Lovö. From the figure it can be found that the directions of the main axes for Reykjavik and College demonstrate a similar local time dependency as shown by a broken line. This local time dependency is mainly characterized by a predominant maximum of the westerly direction around the noon. On the other hand, the changes of directions at the other stations behave rather irregularly and randomly. However, the directions at Sitka and Lovö indicate a relatively constant value (about $0°\sim30°W$) in the "afternoon". The direction for Point Barrow indicates a relatively constant value shown by a straight broken line (about 30°W) in the "forenoon". These features mean possibly that the direction of the main axis strongly depends upon not only the local time but also the latitudinal location of the stations.

At any rate, the directions of the main axes for all the stations are extremely westerly at any time. No detailed interpretation of the features mentioned above is done yet.

§ 5. Equivalent Current Systems for Several Individual Si's.

Six si's (two +si's and four −si's) are selected from the si's used for the study in the preceding sections in order to examine their individual current systems at various stages. These si's are summarized in Table 2 and each variation on the normal-run magnetograms of Kakioka is reproduced in Fig. 2. The equivalent current systems at four stages are illustrated for each event in Figs. 6–11. These four stages are named (a), (b), (c) and (d), in each figure and defined roughly as follows;

(**a**) : The stage when a preliminary impulse is maximum at suitable one of the key stations such as Point Barrow, College, Reykjavik.

(**d**) : The stage when a main impulse is maximum at suitable one of the key stations.

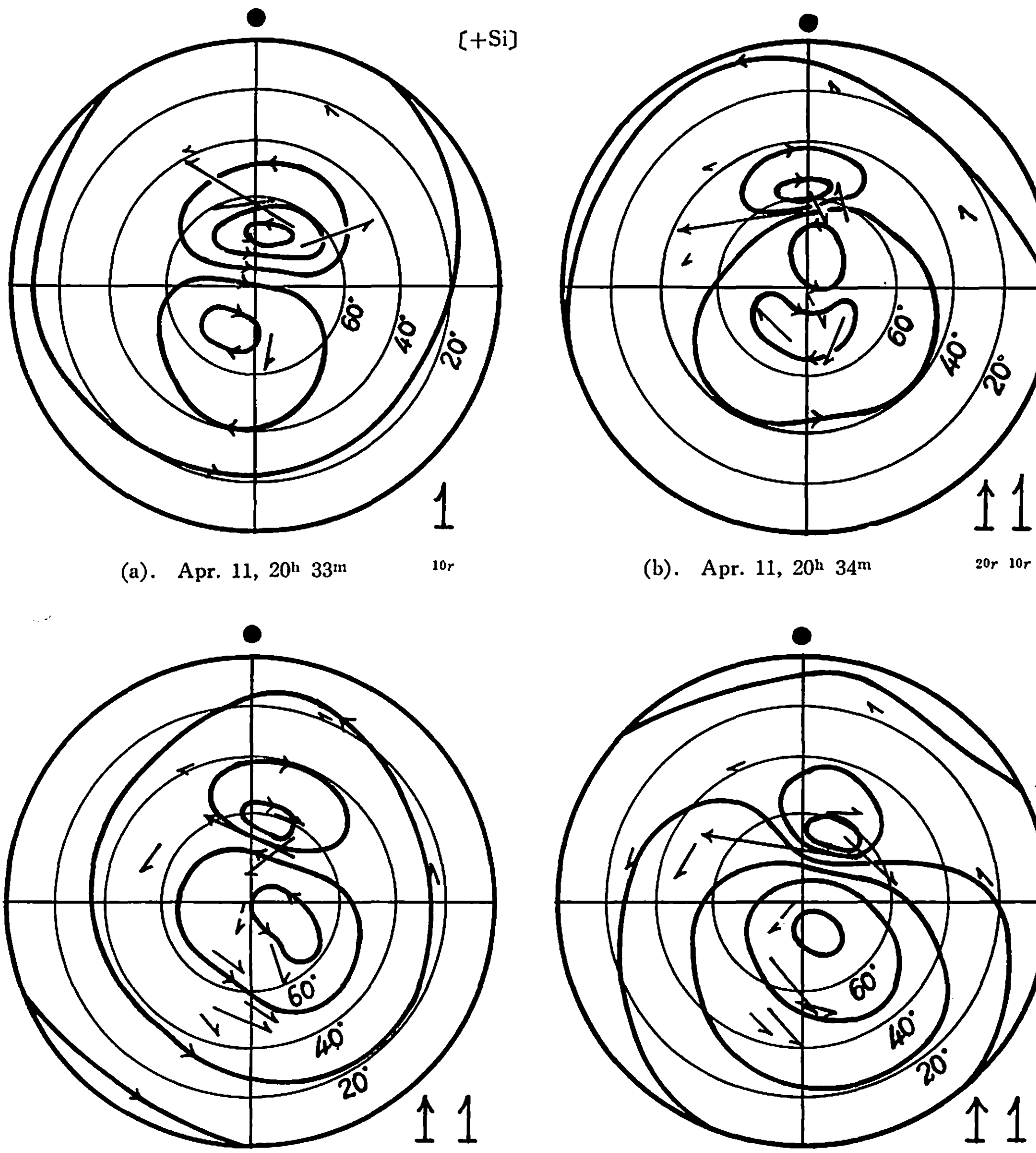
(**b**) and (**c**) : The stages which are taken suitably between the above two stages, (**a**) and (**d**).

Accordingly, the stages (a) and (d) are corresponding to the initial and main stages, respectively, and the stages (b) and (c) are generally corresponding to the transient stage. Characteristic behaviors of the current systems are discussed in the following.

It is considered generally that ssc and si variations are composed of two parts ; the Dst represented by a zonal current system and the Ds represesnted by a dipole-like current system. Since these two parts can not be separated reasonably from the actual variation for individual cases, the current systems obtained here are combinations of Dst and Ds parts.

(1) *Current system of +si on Apr. 11, 1958*

Fig. 6 shows the equivalent current arrows and the corresponding equivalent current systems at four stages of the +si. This +si occurred at about 20h 30m on Apr. 11, 1958 (U.T.) and is of relatively small magnitude. (The amplitude of H component at Honolulu is about 10γ). The current system (a) at the initial stage is clearly characterized by the very typical dipole-like current system. The (d) (including (c)) at the main stage is characterized by the rather typical dipole-like current



(a). Apr. 11, 20^h 33^m

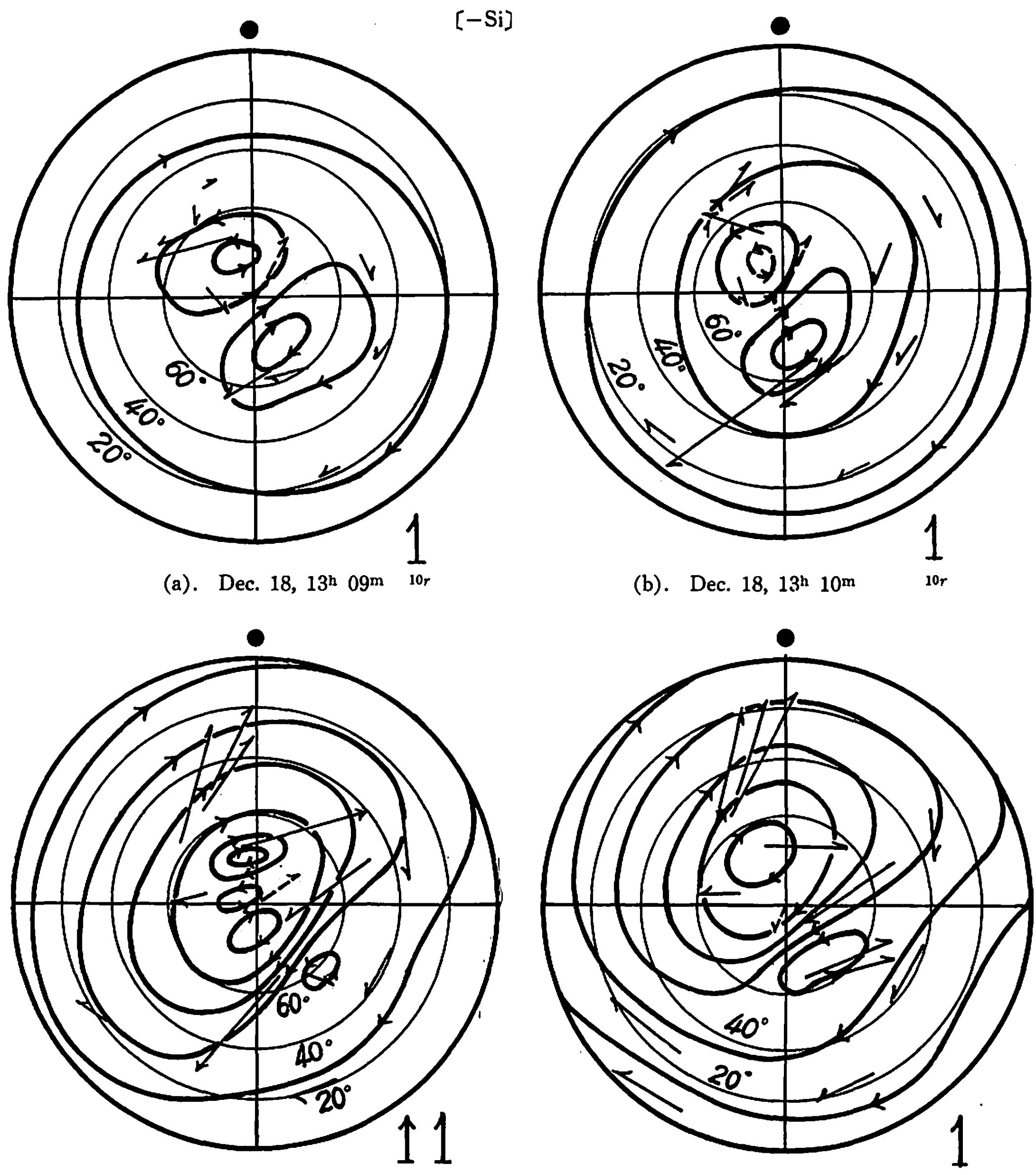
(b). Apr. 11, 20^h 34^m

(c). Apr. 11, 20^h 35^m

(b). Apr. 11, 20^h 36^m

Fig. 6. Current systems at four stages of +Si at 20h 30m on Apr. 11, 1958 (U.T.)

[−Si]

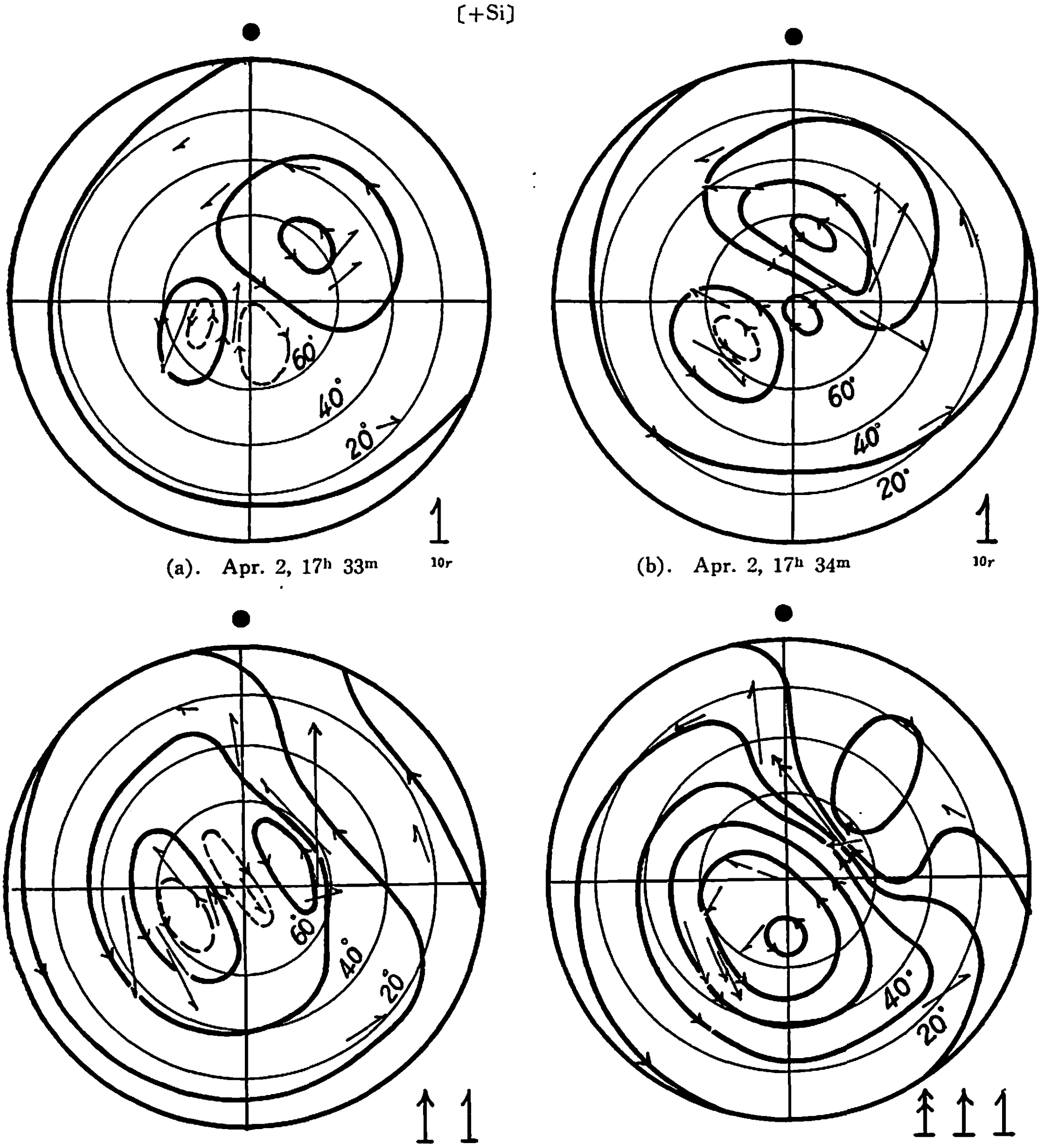


(a). Dec. 18, 13h 09m (b). Dec. 18, 13h 10m (c). Dec. 18, 13h 13m (d). Dec. 18, 13h 16m

Fig. 7. Current systems at four stages of -Si at 13h 07m on Dec. 18, 1958 (U. T.)

system with the opposite direction of current flow. The vortices of this current system are asymmetrical in form.This is quite similar to the idealized current system of the main stage of ssc's shown by Oguti (Oguti, 1956). Of course, this extremely asymmetrical form of the current system is due to an effect of the Dst part, being not an essential matter. The essential matter is that the current systems at the initial and main stages show the proper dipole-like form. At any rate, the current systems shown above are quite similar to the respective ones of the ssc's obtained by Jacobs and Obayashi, Abe and Nagata or Sano except a great difference in the direction of the dipole-like current system as will be discussed latter. (This direction is meant by

[+Si]



(a). Apr. 2, 17^h 33^m

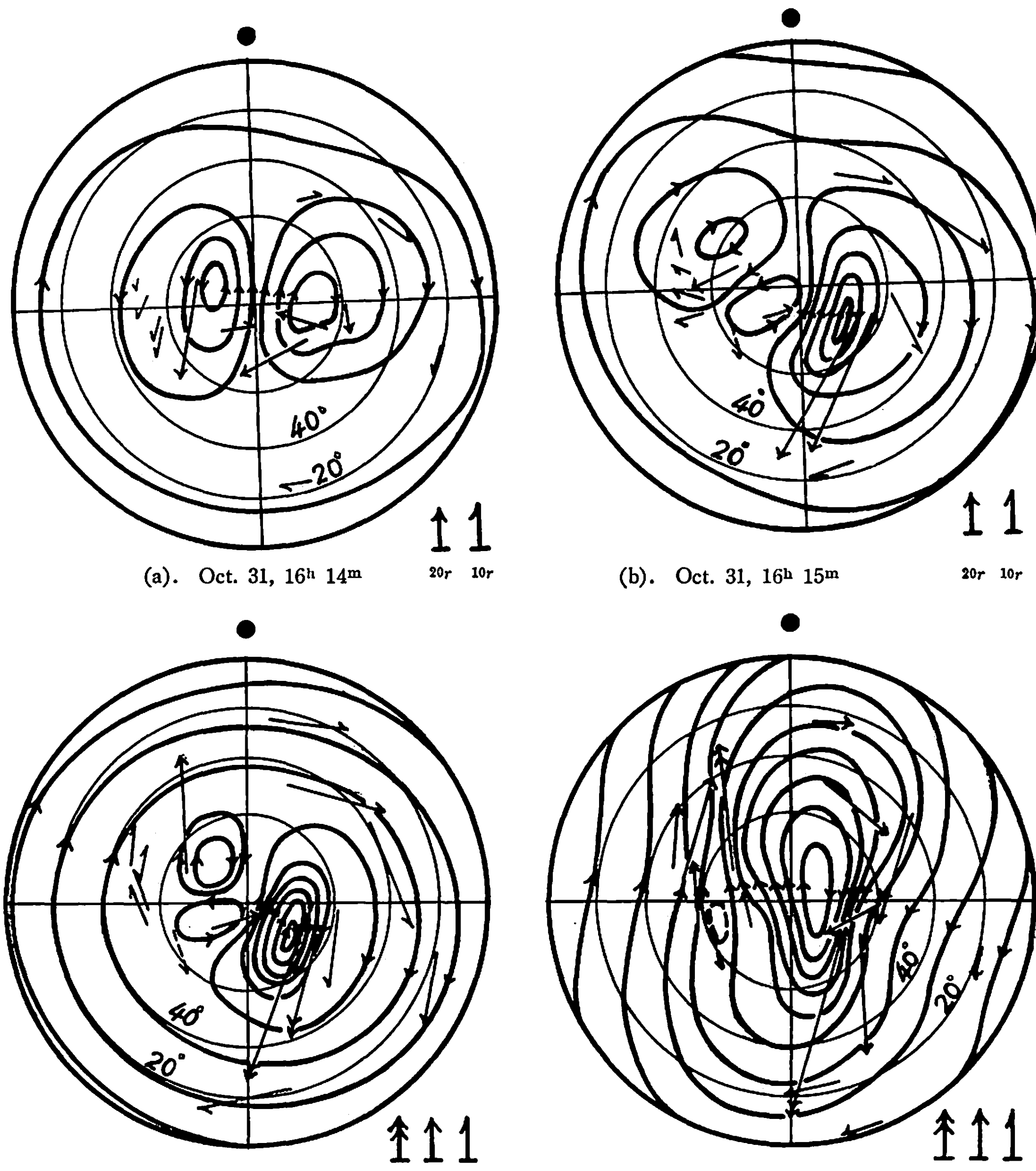
(b). Apr. 2, 17^h 34^m

(c). Apr. 2, 17^h 35^m

(d). Apr. 2, 17^h 36^m

Fig. 8. Current systems at four stages of +Si at 17h 32m on Apr. 2, 1958 (U. T.)

[−Si]



(a). Oct. 31, 16h 14m

(b). Oct. 31, 16h 15m

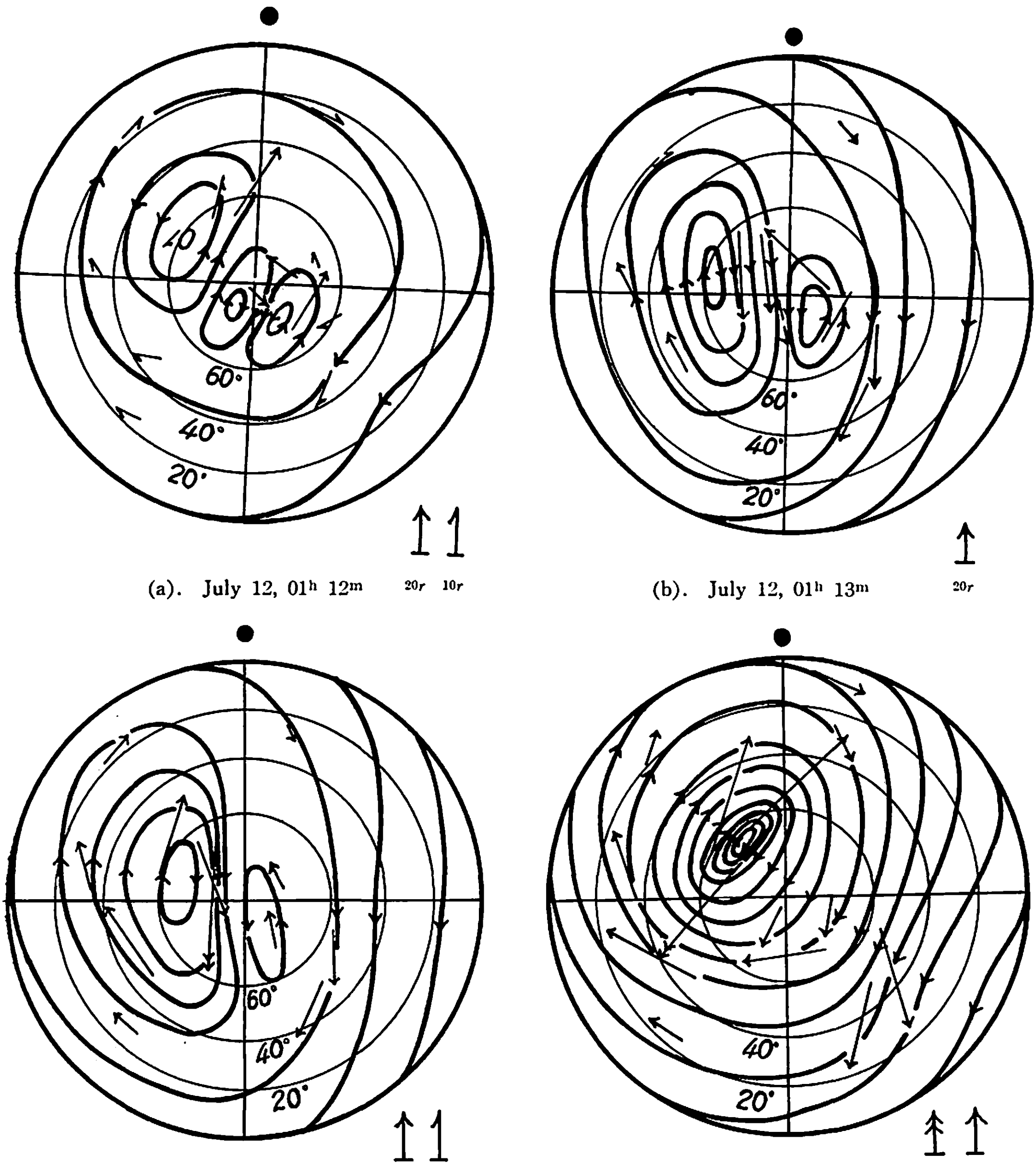
(c). Oct. 31, 16h 16m

(d). Oct. 31, 16h 18m

Fig. 9. Current systems at four stages of -Si at 16h 12m on Oct. 31, 1958 (U. T.)

the direction of a parallel current-sheet flowing between two vortices of the dipole-like current system.) After examining the current systems for several stages, it is found that the mode of transient changes from the initial stage to the main stage is

[-Si]



(a). July 12, 01h 12m 20r 10r

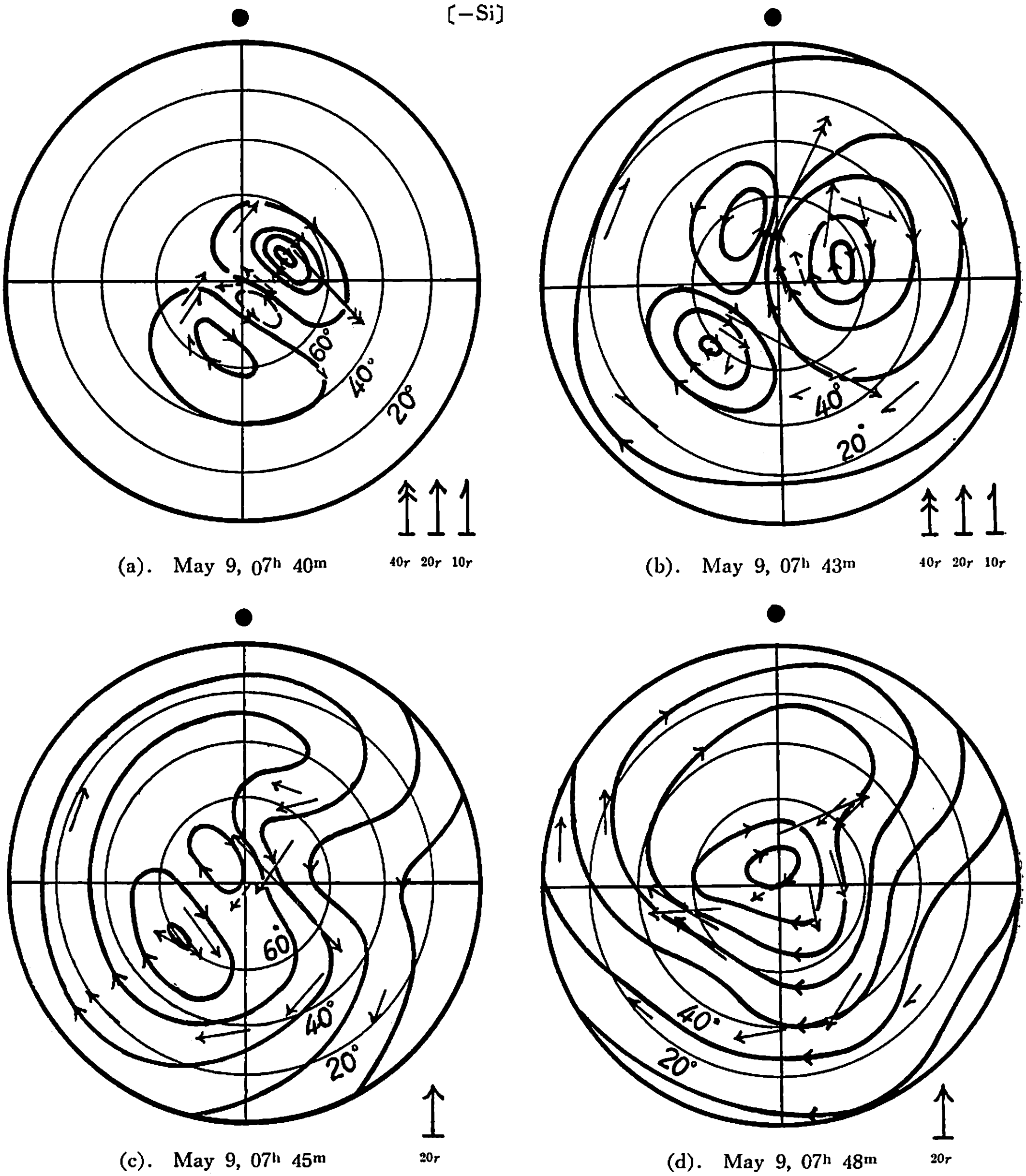
(b). July 12, 01h 13m 20r

(c). July 12, 01h 14m 20r 10r

(d). July 12, 01h 16m 40r 20r

Fig. 10. Current systems at four stages of -Si at 01h 11m on July 12, 1958 (U. T.)

also identical to the one for ssc's which has been shown in the previous paper. The transient mode revealed in the present case is typically represented by the current system (b). The current systems are independent each other and take place in the



(a). May 9, 07h 40m (b). May 9, 07h 43m (c). May 9, 07h 45m (d). May 9, 07h 48m

Fig. 11. Current systems at four stages of -Si at 07h 38m on May 9, 1958 (U. T.)

following mode.

At the initial or main stages an only specified dipole-like current system exists respectively and at the intermediate stage these two current systems coexist with some amplitude ratio in such a manner as shown by the current system (b) in Fig.

6. Furthermore, each current system seems to show a mode of latitudinal moving mainly towards the pole, at least apparently, similarly to the case of the ssc's. There can not be seen the mode like that the dipole-like current system at the initial stage is rotated westerly by about 180° and becomes the current system at the main stage as pointed out by Oguti (Oguti, 1956), these two current systems being the identical one. Consequently, the direction of the dipole-like current systems for all the stages seems to change little. It is nearly parallel to the 18h local time meridian. This direction is greatly different from the 10h local time meridian of usual ssc's although usual ssc's themselves show an appreciable inequality of the direction from a case to another. This matter will discussed again in the following section.

In these ways, the current systems of the present +si are quite similar to those of the usual ssc's except the above difference in the direction of the current systems. This difference may be minor as will be shown latter. Therefore, it can be considered that the current systems. for the present case represent an essential or the general feature of the morphology of +si's.

(2) *Current system of −si on Dec. 18, 1958*

The current systems of −si commenced at about 13h 07m on Dec. 18, 1958 are illustrated in Fig. 7. This -si is one of very typical exsmples of −si's during 1958 as shown in Fig. 2, its range of H-component at Honolulu being about 25γ. This example shows typical current systems of −si's.

The current systems (a) and (b) are corresponding to the initial stage. And those (c) and (d) are corresponding to the transient stage and the main stage, respectively. It is found easily from the figure that these current systems are quite identical to those of the ssc's in almost all features, if the direction of current flow is reversed. Namely, the current systems at both the initial and main stages are represented by the respective typical dipole-like forms and the one at the transient stage is shown as the combined current systems of these two typical current systems. Of course, it can be recognized that the mode of transient changes in current system is quite the same as for the ssc's.

The extremely asymmetrical form of the current systems (c) and (d) is due to the effect of Dst part as stated in the preceding case (1). This effect, however, seems to be stronger than that not only for the preceding example of +si, but also for the usual ssc's.

The direction of the current systems changes little during the whole stages, too, and coincides with that of the usual ssc's. It is parallel to the about 10h local time meridian.

At any rate, the degree of similarity to the ssc's in the present $-$si is closer than the preceding $+$si. From the same point of view as for the preceding $+$si, it can be considered that these current systems represent an essential or the general feature of $-$si's.

From the study of these examples of si's it can be satisfied strongly that si's are the equivalent phenomenon to ssc's morphologically as introduced in the first part of the paper. The morphology of the above mentioned examples is what can be expected to some extent from the similarity of the statistical features between ssc's and si's as shown in the previous papers and in the sections 3 and 4 of the present paper. Then, it can be said again that the above-shown current systems are general in the morphology of si's. The following four examples, however, are much or slightly different in form of current system from the above-shown current systems. Such differnce may not be essential but caused by a mere deformation of the general feature due to some unknown reason or an irregularity of the phenomena themselves in case by case. Because the essential feature is not lost even for these examples. At any rate, the current systems for those examples are illustrated in the articles following.

(3) *Current system of +si of Apr. 2, 1958.*

The first example is the $+$si commenced at about 17h 32m on Apr. 2, 1958. This $+$si is also small and unique as shown in Fig. 2. (The magnitude of H-component at Honolulu is about 10γ.) The current systems at four stages, being shown in Fig. 8, ((a)$-$(b)), demonstrate rather complicated forms, especially at the initial stage.

The current systems (a) and (b) at the initial stage are not so typical as the dipole-like current systems of the previous examples. Each of them consists of a large vortex of the counterclockwise current flow in the day-side and a small dipole-like current system in the night-side. The large vortex in the day-side is regarded as the half of the dipole-like current system at the initial stage. The other half in the night-side does not appear so clearly, but the half part of the current systems of the main stage appears so early even at this stage around the evening meridian. In other words, these stages begin to show already a feature of the transient stage in the night-side in spite of generally showing the initial stage in the day-side. This feature is different from the general cases.

The current systems (c) and (d) are infallibly of the transient and main stages, respectively. They are quite similar to those of the former examples (Figs. 6 and 7). There is no essential difference concerning the transient changes in current system.

Accordingly, the direction of current systems also changes little through the whole stages, although the direction itself is greatly different from that of the usual ssc's. It is nearly parallel to the 16h local time meridian.

After all, this example is equivalent to the general case, except the rather complicated feature at the initial stage. It is not any essential matter that the present current systems show the above-stated differences.

(4) *Current system of −Si of Oct. 31, 1958*

The second example is the −si occurred at about 16h 12m on Oct. 31, 1958. This −si is relatively great as shown in Fig. 2 and is typical in low latitudes. Its current systems at four stages are shown in Fig. 9.

The current system (a) at the initial stage is quite similar to the general cases such as the +si of Apr. 11 and the −si of Dec. 18 (Fig. 6 and Fig 7). The current systems (b) and (c) at the transient stage indicate rather complicated features, especially in the afternoon-side, like those at the initial stage of the example (1). The current system (d), however, at the main stage is quite different from the cases shown in Figs. 6, 7 and 8. Namely, the dipole-like current system of the main impulse is hardly found in this case. This means that the main impulse is not intensified so strongly as to increase its magnitude farther than that of the preliminary impulse or the Dst part even in high latitudes or the polar region. (It is certain from the horizontal disturbance vector diagrams at the key stations that the main impulse exists in this case.) Consequently, the vortex in the forenoon-side out of the dipole-like current system of the preliminary impulse continues to exist through the whole stages. In the afternoon-side the vortical current system almost disappears.

In these ways, the present current systems are strongly deformed from the essential or general feature shown in Figs. 5 and 6. However, the essentially different features such as the rotation of the current system are hardly found also from this example.

The direction of the current systems points nearly parallel to the noon meridian, although it can not be decided except for the current system (a).

(5) *Current system of −Si on July 12, 1958*

The third example is the -si which shows a very opposite manner in variation to the former −si discussed in the part (4). This −si occurred at about 01h 11m on July 12, 1958, being also relatively great and typical in low latitudes as shown in Fig. 2. Its current systems at four stages are shown in Fig. 10. The current systems both

(b) and (c) show the general feature of that of the main impulse shown in Fig. 8 (d). While, the current systems (a) and (d), belong to a quite irregular case. The first one (a) at the initial stage shows such a different feature from the general one that the current system of the preliminary impulse appears only in the forenoon-side, but in the afterncon-side appears the current system of the main impulse in spite of the just very early stage. This becomes already a current system like that at the transient stage, similarly in the previous case. The current system (d) also shows a quite different feature like that it is extremely condensed around some narrow auroral zone with the clockwise current flow and in the other region it is characterized by the relative uniform zonal current system. At this stage it can be considered that the dipole-like current system of the main impulse is extremely intensified in the forenoon -side, but in the afternoon-side it is nearly disappeared due to the effect of Dst part.

Furthermore, from these current systems the following transient feature can be found clearly. The dipole-like current system of the main impulse which appear in the forenoon-side from the very initial stage is rapidly developed extending its region towards the afternoon-side. From the next stage the vortex in the forenoon-side begins also rapidly to be weakened, finally disappear due to the effect of relatively great Dst part. On the other hand, the other vortex in the afternoon-side continues to exist changing a little its form and intensity. The above transient mode is essentially consistent with the general one.

The outstanding feature in the present case is quite opposite to the former case (Fig. 9) : in the former case the vortex in the "forenoon-side" of the current system of the "preliminary impulse" continues to exist extremely intensified through the whole stages, on the contrary, in the present case the vortex in the "afternoon-side" of the "main impulse" does so. Concerning the direction of the current system, it seems to vary slightly from stage to stage comparing with for the other cases. However, it is nearly parallel to the meridians between 9h and 12h in local time. These directions are similar to that of the usual ssc's.

(6) *Current system of $-si$ on May 9, 1958*

The current systems at four stages of the last example of $-si$ which occurred at about 7h 38m on May 9, 1958 (U.T.) are shown in Fig. 11. As can be seen in the figure this example shows a very complex and different feature comparing not only the usual ssc's and si's but also the above stated unique $-si$'s. The outstanding differences are as follows;

(1) This $-si$ has a mode of transient changes ((a) to (b) and (b) to (c)) like that the dipole-like current system in the day-side is "rotated" westerly

while the vortex in the night-side does not move as much.

(2) The current system (b) (or including (c)) at the main stage is strongly characterized by the zonal current flow even in higher latitudes, although it is rather irregular especially in the day-side.

The first point is more important, but it is unknown whether or not this is an essential difference from the other cases. In order to answer to the question it needs to analyse much more events.

On the other hand, the current system (a) at the initial stage is rather similar to the one at the transient stage shown in Fig. 8 (b). In these cases the preliminary impulses in the night-side or in the afternoon-side are much weaker than those in the opposite sides, respectively.

Since the −si indicates these complex features, the direction of the current systems can not be decided exactly except for the current system (a). The direction of the latter is parallel to the 16h local time meridian, being rather similar to the cases of the +si's.

In these ways, two +si's and four −si's are examined individually on their equivalent current systems and transient changes from the initial stage to the main stage. After these morphological studies of si's, it can be said safely that there are so many varities of si's that almost nothing of their individual characteristics can be clarified by any process of simply averaging these several event, maybe even if much more events were used.

§ 6. Comparison between the directions of current systems of ssc's and si's

The direction of the dipole-like current systems of the si's is again discussed comparing with that for ssc's which has been obtained for several individual ssc's by Jacobs and Obayashi (Jacobs and Obayashi, 1956). Fig. 12 shows a longitudinal inequality of the direction for the ssc's and si's after Jacobs and Obayashi. The ordinate in the figure is the direction of dipole-like current systems expressed in terms of the angle θ between the direction and the noon meridian, or the meridian expressed by local time, and the abscissa is the geographic longitude of the subsolar point at the time of the ssc. The black and white circles represent the directions at the main and initial stages of the ssc's, respectively. Similarly, the black and white triangles represent the directions at the main and initial stages of the si's discussed in the preceding section.

As can be seen in the figure, there is an appreciable longitudinal inequality of the direction even in the case of the ssc's. However, it can be said generally that for

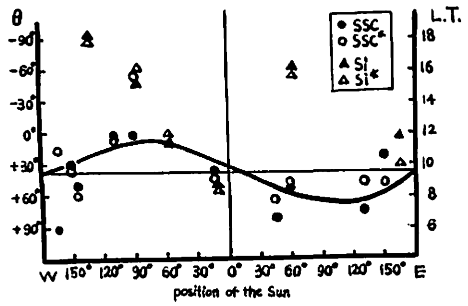


Fig. 12. The longitudinal inequality of the direction of polar-cap current of ssc's.
ordinate : the angle between the direction of polar-cap currents and noon meridian.
abscissa : geographic longitude of sub-solar point at the time of ssc (After Jacobs and Obayashi)

an ssc which occurs when the sun is in the western hemisphere (U. T. 12h—24 h), the angle θ is about 0° ~45° W, i,e. the direction is towards the 9h—12h local time meridian, while in the case when the sun is in the eastern hemisphere (U.T. 0h—12h), the angle is about 45°~90°W. The mean angle for the ssc's is nearly 30° W (the 10h local time meridian). On the other hand, there are shown three si's (which are two +si and the —si(May 9)) of which directions are very much different from the general feature shown above for the ssc's. The angle θ is about 60°~90°E, being different by about 100° from that for the ssc's. The directions of the rest of the —si's are closely consistent with the general one for the ssc's.

The reason for the great difference in the direction of the current systems in the above-mentioned cases is uncertain. Even the reason for the appreciable longitudinal inequality for the ssc's themselves is now uncertain. It is suggested, however, by Jacobs and Obayashi that this inequality may possibly be due to the obliquity of the geomagnetic axis with the geographic one causing an asymmetry in the local distribution of impinging charged corpuscles. But the differences in the above-mentioned cases are so great that it can not be explained by the above reason. This may be due to an irregularity of the solar corpuscular wind which is responsible for these phenomena.

§ 7. Conclusion

After examining a number of horizontal disturbance vector changes of —si's from the several high latitude stations, it is known that the occurrence distribution of their clockwise and counterclockwise polarizations differs a little bit from that for ssc's shown in the previous paper : the boundary between the dominant occurrence regions of the clockwise and counterclockwise polarizations seems to be the 00h and 12h local time meridians in the case of —si's instead of the 10h and 22h local time meridian in the case of ssc's.

Almost all of —si's, +si's and ssc's in high latitudes show the westerly direction of main axes of elliptically polarized horizontal disturbance vector changes. The local time dependency of degree of changes of the direction is much different from station to station and case by case. There seems to be a considerable latitudinal dependency.

From the study on the equivalent current systems of several individual si's the various types of current systems are illustrated in detail. And these current systems are compared with each other and with those of the ssc's reported higherto in order to find the similarity and difference between them. The main results are as following.

(1) The si's which show the quite similar current systems to those of the usual ssc's are found in their individual cases as expected from the other statistical results. On the other hand, the si's which show the quite different current systems are found also.

(2) The direction of the dipole-like current system for the si's which is defined by the direction of the parallel current flow near the pole takes the great (longitudinal) inequality of 100° or more.

(3) However, the direction of the current systems at various stages for one si itself changes little.

(4) The transient changes in the current systems between the initial stage and the main stage are rather complicated in some si's. But the most cases show the essentially similar transient changes chracterized by the superposition and latitudinal motion of two dipole-like current systems with the opposite directions as well as in the case of the ssc's.

In conclusion it is still strongly desired to study these matters for much more events in order to lead to much definite conclusions.

Acknowledgements

The author wishes to express his sincere thanks to Dr. T. Yoshimatsu, the director of the Kakioka Magnetic Observatory and Dr. K. Yanagihara, the chief of the observational section of the Observatory for their encouragements and valuable advices.The author also wishes to express his same thanks to Prof. T. Obayashi of the Kyoto University for his interest in this study and valuable advices.

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概　　要

高緯度地方における −Si の水平変化ベクトルの極性の出現様相を調べ，前回までに報告したSSCに対するそれと比較して見た結果を報告する。これら両者の特性は全くといって良いほど類似している。しかし次の様な相違点も見い出された。すなわち，反時計および時計廻りの極性分布領域の境界が −Si と SSC の間では地磁気経度にして 30°～45° ずれているらしいということである。この相違は本質的なことか断言はできないが，興味あることである。

さらに今回は2つの +Si と4つの −Si の個々の等価電流系を求め，これらも種々報告されている SSC の等価電流系と比較して見た。 +Si あるいは −Si の等価電流系の形態も本質的にはSSCの双極子状のそれと同じであることが知れた（−Siの場合は電流の向きは反対であることはいうまでもない）。 しかしながら各個々の場合に予想以上に大きな相違点，たとえば変化強度分布の不規則性，あるいは双極子状電流系の向きの不規則性などのあることも見い出され，等価電流系の形状は見かけ上場合々々において大きな相違を示している。