Investigation on the Magnetic Disturbance by the Induction Magnetograph,Part ???. On the Damped Type Rapid Pulsation Accompanying ssc

著者	Kato Yoshio, Saito Takao
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Investigation on the Magnetic Disturbance by the Induction Magnetograph, Part VII On the Damped Type Rapid Pulsation Accompanying ssc.†

By YOSHIO KATO and TAKAO SAITO

Geophysical Institute, Faculty of Science, Tôhoku University.

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Abstract

As already reported (Y. KATO), there are interesting relationships between the geomagnetic pulsation and the storm. The main results are as follows.

1) The pulsational feature is very different in the initial and main phases. The activity of pc type geomagnetic pulsation is very quiet during the initial phase, while it grows remarkably during the main phase, particularly on the day side of the earth.

2) As above stated, it is seldom that continued wave train "pc" pulsation developes remarkably during the initial phase.

3) But single train of pt type pulsation sometimes appears on the sudden commencement in the daytime; on the other hand it is very much weakened or unnoticeable in practice during the night-time.

In this paper we investigated on the pure single train of pt type pulsation which appeared on the sudden commencement (Fig. 1 for example), and we found these pure single train of pt type pulsations appear not only with ssc, but also with some magnetic disturbance, in which the intensity of horizontal component is increased without exception.

We discussed the nature of these damped type pulsations, according to the idea of hydromagnetic oscillation of the outer atmosphere proposed by KATO and WATANABE, or DUNGEY and AKASOFU.

1 Introduction

It is very interesting that a single train of pt type pulsation sometimes appears on the sudden commencement in the daytime; on the other hand it is very much weakened or unnoticeable in practice during the night-time. Actually these characters are observed clearly on the records of the induction magnetometer obtained at the Onagawa Magnetic Observatory ($\varphi=38°26'3$ N, $\lambda=141°27'5$ E; geomagnetic $\varphi=28°.9$ N, geomagnetic $\lambda=206°.8$). Particularly the fine damped pt type pulsation was observed on the sudden commencement of the magnetic storm of June 25, 1957 as shown in Fig. 1. As this pt type pulsation shows fine damped and characteristic features, it can be found clearly in the records of the induction magnetometer.

† The work has been carried out as a part of research programme of geomagnetic pulsation in the Geophysical Institute, Faculty of Science, Tôhoku University. Contribution No. 44.

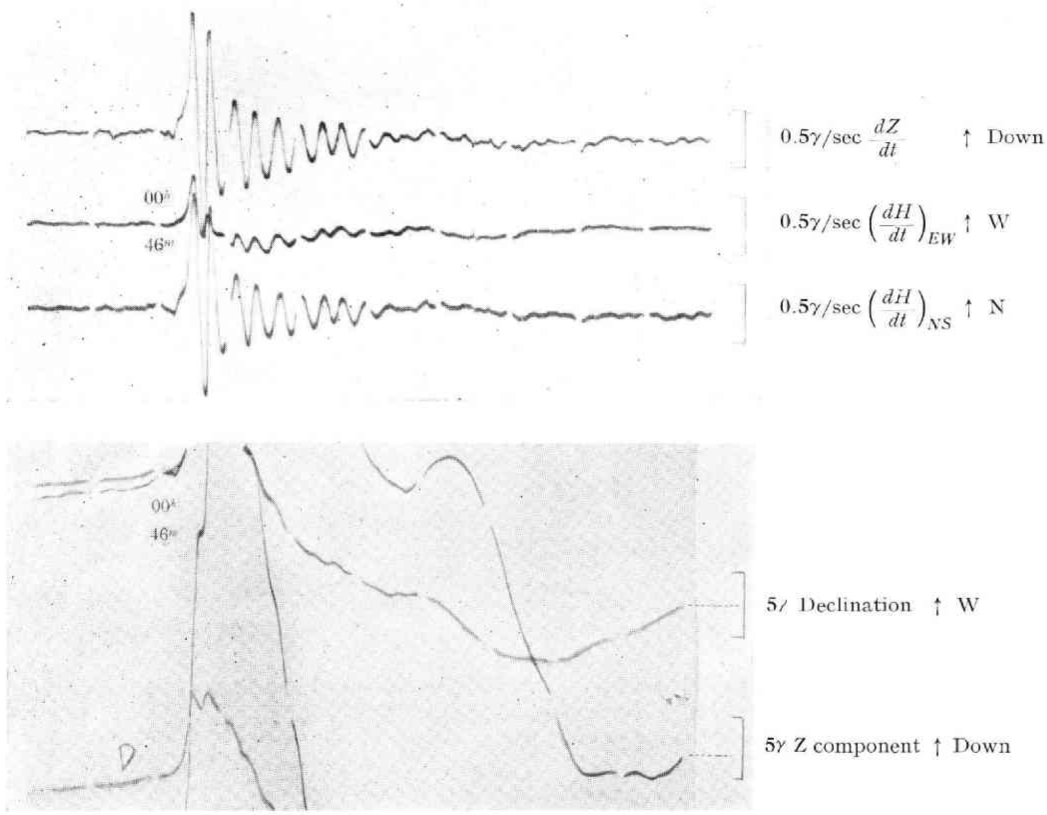

Fig. 1. An example of the fine damped pt type pulsation accompanying the ssc of the magnetic storm observed by (a) the induction magnetometer and (b) the high sensitive rapid-run magnetometer. (Jun. 25, 1957, 00h46m)

Moreover, thirty-three fine damped pulsations were indicated, too, on the records of the induction magnetometer during the period from January 1956 to December 1957. Among these examples, five cases appeared on the sudden commencement of magnetic storm, one on si phenomenon and the remainning occured on the small sudden increasing magnetic disturbances as shown in the figures at the end of this paper.

As all these pulsations have simple and fine damped type oscillation, we consider their cause to be the same, therefore discussions will be given on this cause.

2 Morphorogical Similarity

During the period from January 1956 to December 1957, the thirty-three examples as shown in the following table were observed.

At first we measured the period and damping ratio of each individual oscillation of these pt type pulsations and found the following facts.

(1) The period of each individual oscillation is almost the same, being about 20 sec. as shown in Fig. 2.

(2) Damping ratio of each individual oscillation is also almost the same and its value is 0.85 or the damping time is from about 100 sec. to 120 sec. (Fig. 3.)

1956				1957			
No.	Date	Time (G.M.T.)	Remarks	No.	Date	Time (G.M.T.)	Remarks
1	Apr. 29	$03^h 20^m$		1	Mar. 28	$04^h 08^m$	
2	May 1	02 23		2	Apr. 4	18 39	
3	5	00 56		3	29	06 49	
4	7	00 44		4	May 19	22 57	
5	13	22 21		5	Jun. 4	01 21	
6	24	05 48	si	6	24	03 40	ssc
7	28	02 52		7	25	00 46	ssc
8	Jun. 1	02 14		8	26	01 54	
9	Aug. 12	08 39		9	26	23 22	
10	13	05 31		10	27	00 28	
11	Dec. 29	00 53	ssc	11	29	23 45	
				12	Jul. 16	07 13	ssc
				13	Aug. 6	05 08	ssc
				14	12	23 45	
				15	Sep. 3	21 54	
				16	3	21 57	
				17	4	00 39	
				18	4	06 40	
				19	6	01 17	
				20	29	00 51	
				21	Oct. 15	00 35	
				22	Dec. 12	01 44	

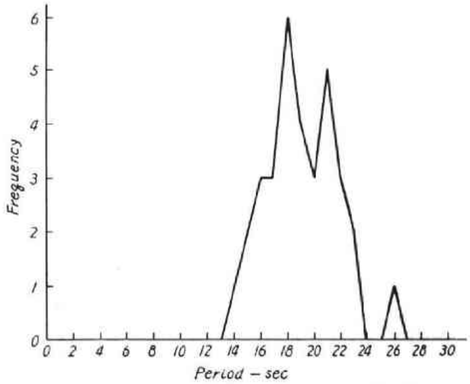

Fig. 2. Periodic distribution of individual oscillation of the fine damped pt type pulsation.

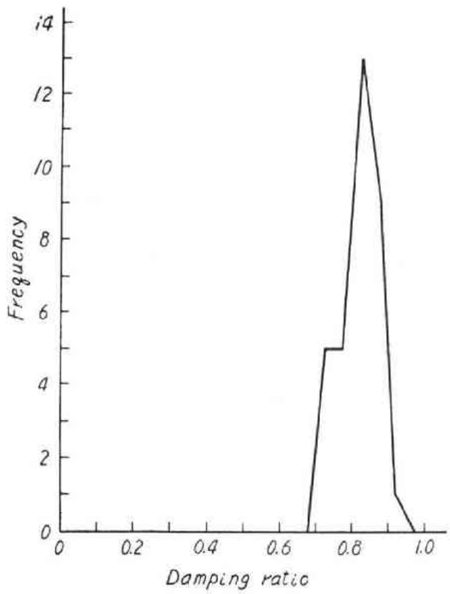

Fig. 3. Distribution of damping ratio of the fine damped pt type pulsation.

(3) These fine damped pt type pulsations occured in the daytime and were most frequently observed at about 9h local time. (Fig. 4.)

(4) It seems that these pulsations are less frequent in winter than the other seasons. (Fig. 5.)

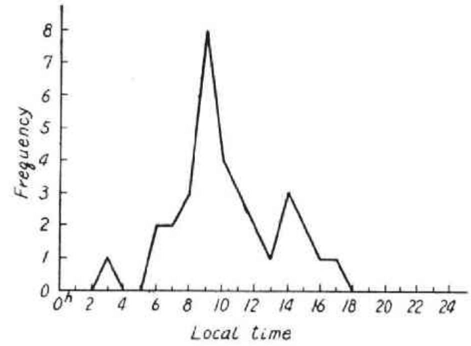

Fig. 4. Daily distribution of the fine damped pt type pulsation.

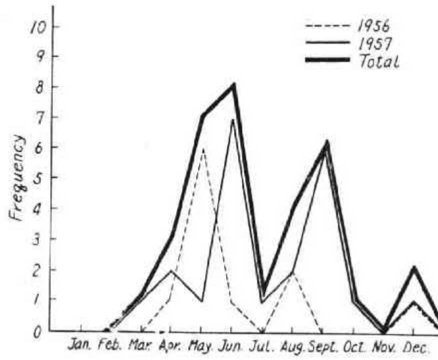

Fig. 5. Annual distribution of the fine damped pt type pulsation.

3 Features Common to ssc

As already stated, among these thirty-three cases, six occured on ssc or si, and it is very interesting that the remainning cases occured on such small sudden increasing magnetic disturbances as ssc which are recognized by high sensitive and rapid-run magnetogram as shown in the appended figures.

The remarkable characters are as follows.

(1) When these fine damped pt pulsations appear the intensity of the horizontal component increases simultaneously without exception.

(2) The local time dependency of rotational sense in the vector diagram of mean development* of this pulsation is almost the asme as that of ssc. (Figs. 6(a) and (b).)

*Actually we first draw the envelope of these pulsational oscillations then the mean curve

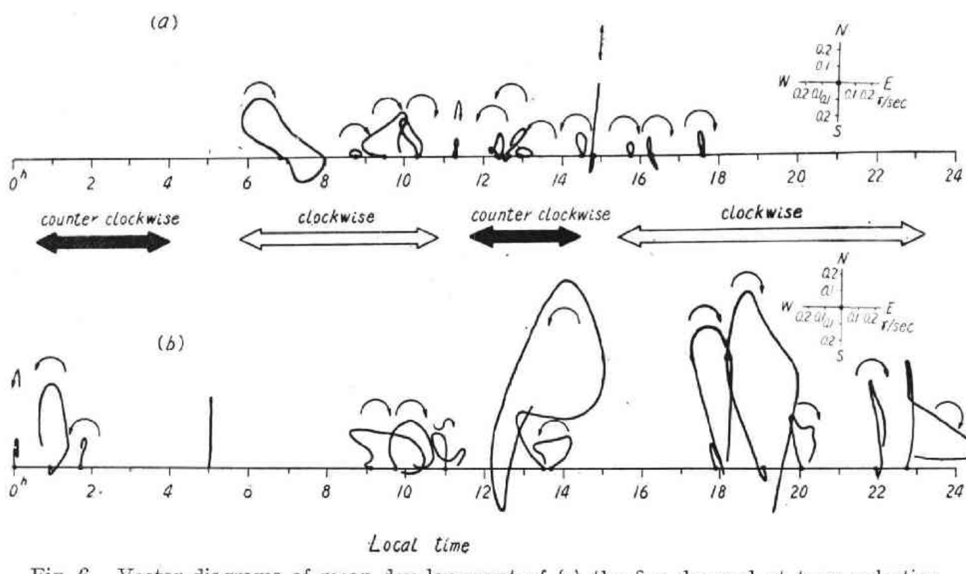

Fig. 6. Vector diagrams of mean developement of (a) the fine damped pt type pulsation and (b) the storm sudden commencement.

of the upper and lower envelopes, therefore, this mean curve shows the general developement of the pulsation.

(3) The vector diagram of individual oscillation of this pulsation shows that the principal axis of this diagram coincides with the meridian of north-north-west and south-south-east.

4 Comparison with pt Accompanied with Bay

It is well known that the damped type pulsation is observed frequently at the beginning time of bay disturbance, but as above stated the fine damped pulsation may be distinguished clearly from this pulsation. (Fig. 7.) The comparison of the characteristics of these two pulsations is as follows.

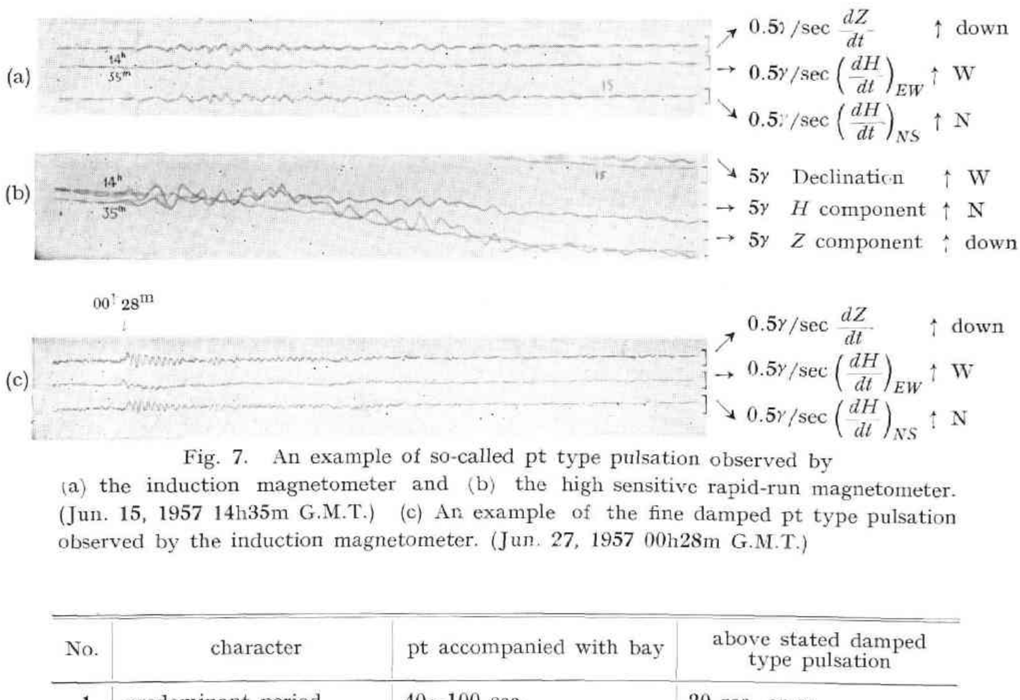

Fig. 7. An example of so-called pt type pulsation observed by (a) the induction magnetometer and (b) the high sensitive rapid-run magnetometer. (Jun. 15, 1957 14h35m G.M.T.) (c) An example of the fine damped pt type pulsation observed by the induction magnetometer. (Jun. 27, 1957 00h28m G.M.T.)

No.	character	pt accompanied with bay	above stated damped type pulsation
1	predominant period	40∼100 sec.	20 sec. or so
2	oscillation	two or three pulsations are superposed	very simple pulsation
3	wave form	asymmetry	symmetry
4	occurence time	night hemisphere (Fig. 8.)	sunlit hemisphere
5	magnetic field	not always increased	always increased
6	accompanied phenomena	bay	ssc or si

5 Discussion on the Mechanism of this pt Type Pulsation

As stated already we consider that these fine damped pulsations have the same characteristics and the same mechanism as ssc, that is, five cases among the 33 form the magnetic storm with the main phase, but the remainning ones do not follow the main phase, and are accompanied only with an abrupt increase of the magnetic force though it is not so remarkable as ssc. In other words, the ssc phenomenon happens more

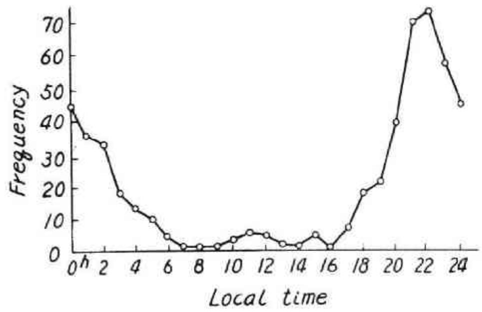

Fig. 8, Local time dependency of frequency distribution of pt type pulsation. (After Y. Kato, et al.)

frequently than generally considered.

One of the authors (Y. KATO) and T. WATANABE proposed a new idea on the mechanism of the magnetic storm, and described the mechanism of ssc in their new theory on the magnetic storm. To explain the steep front of the corpuscular stream, they proposed the formation of the shock front in the interplanetary matter as stated by Gold, Singer and Akasofu. Such a shock front may reach the earth several hours before the main solar corpuscular stream.

Immediately following the shock front, the interplanetary matter, the density of which may be in the order of 600 protons/cm^3 near the earth, is sweeped forwards. The interplanetary matter flow with the steep frontal surface approaches the outer atmosphere of the earth where the kinetic pressure of corpuscular stream is balanced to the magnetic pressure of the earth's magnetic field because the latter surpasses the static pressure of the outer atmoshpere. *Then this motion of the frontal surface of corpuscular flow force to oscillate this boundary of the outer atmosphere. The hydromagnetic poloydal type oscillation thus set up is the origin of the above stated pt type pulsation.*

When the medium has a finite conductivity and viscosity, it gives rise to the energy dissipation. KATO and AKASOFU calculated this damping effect and estimated the damping time under the condition that no other mechanical effects are operative except that by viscosity. The observed value of damping time of this pt type pulsation, 100 sec. ~120 sec. for the period of 20 sec, is reasonable.

Next, because of the extremely good conductivity of the corpuscular stream, the earth's magnetic field cannot diffuse into it. Thus, the lines of force will be compressed into the side of the earth and the compression of the magnetic lines of force will necessarily accompany the compression of the outer atmospheric matter, because the magnetic lines of force will be frozen into the outer atmospheric matter due to its extremely good conductivity. The outer atmosphere will be contracted more severely in the sunlit side than in the night. Consequently, the magnetic field intensity is more increased in the daytime. This is the origin of ssc and also of the small abrupt increase of the magnetic field which accompanies the pt type damped oscillation of the outer atmosphere, but in the latter case the width of frontal surface of this corpuscular flow may be more narrow and it may attack on the more limited boundary of the outer atmosphere than in ssc and the following main solar corpuscular stream may be only more feeble in this case than in ssc.

6 Conclusion

We found that very fine damped pt type pulsation appear not only on ssc, but also with some small abrupt increase of the magnetic field and we considered that this is caused by the hydromagnetic oscillation of the outer atmosphere excited by the steep frontal corpuscular flow.

In conclusion the authors thank the Ministry of Education for financial support.

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2. KATO, Y. and T. WATANABE: Further Study on the Cause of Giant Pulsations. *Sci. Rep. Tôhoku Univ.*, Ser. 5, **8**, 1-10, 1956.
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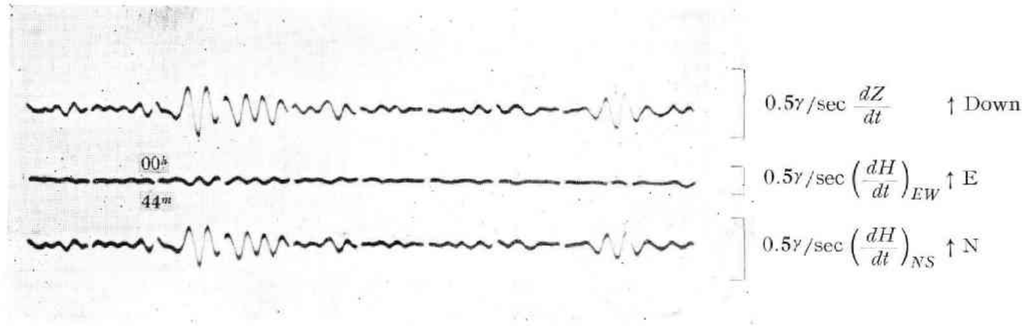
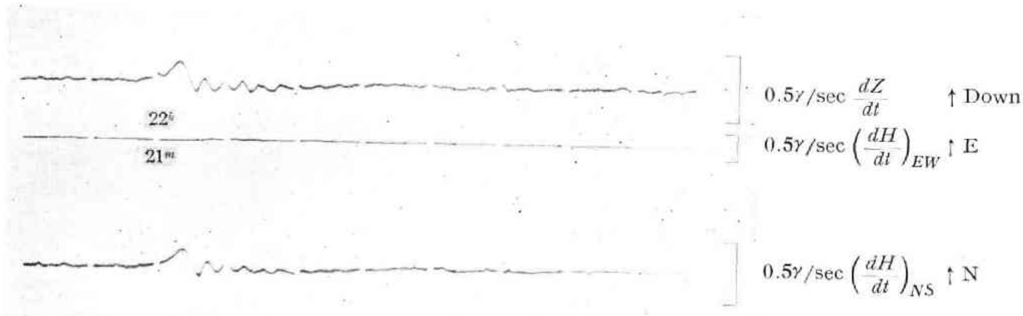
4. KATO, Y. and T. WATANABE: Studies on Geomagnetic and Cosmic Ray Storms in Relation to Geomagnetic Pulsation. Read at the General Meeting of I.U.G.G. which held at Tronto in Sept. 1957.

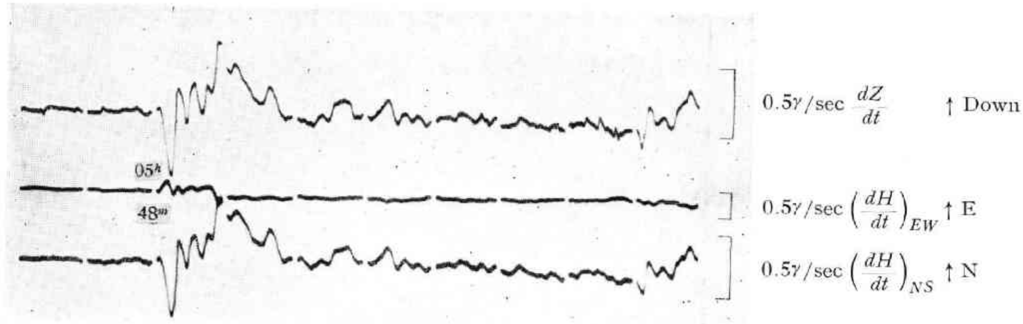
(I) The examples of the fine damped pt type pulsation



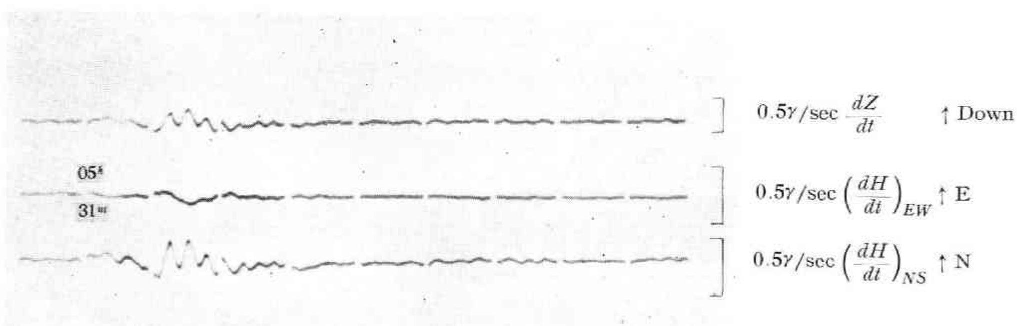
May 7, 1956 00h 44m G.M.T.



May 13, 1956 22h 21m G.M.T.

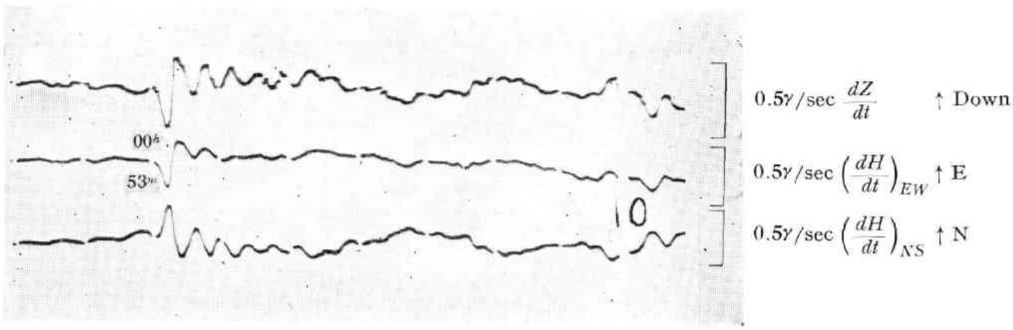


Ma/ 24, 1956 05h 48m G.M.T. (si)

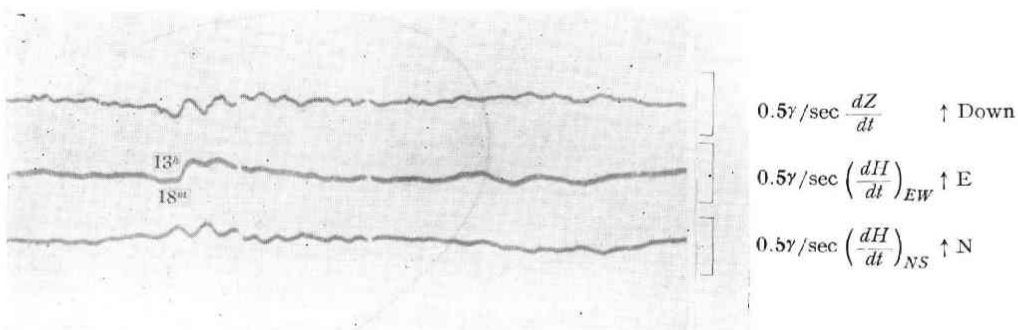


Aug. 13, 1956 05h 31m G.M.T.

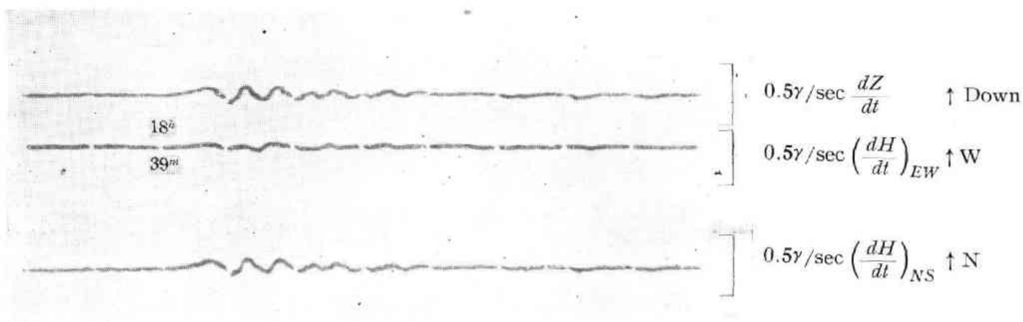
observed by the induction magnetometer.



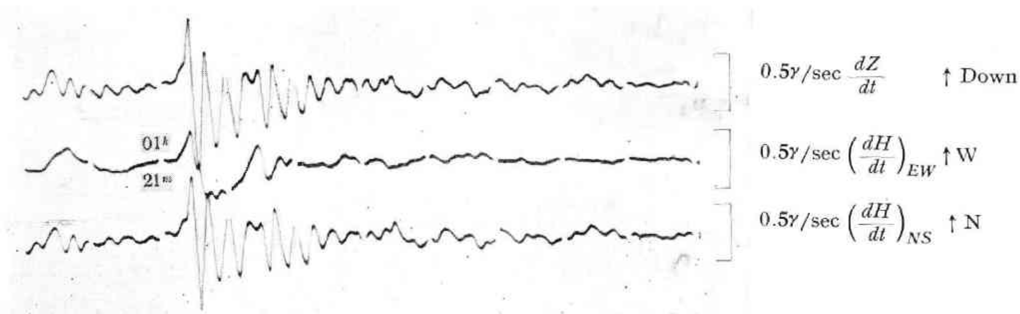
Dec. 29, 1956 00h 53m G·M.T. (ssc)



Mar. 28, 1957 13h 18m G.M.T.

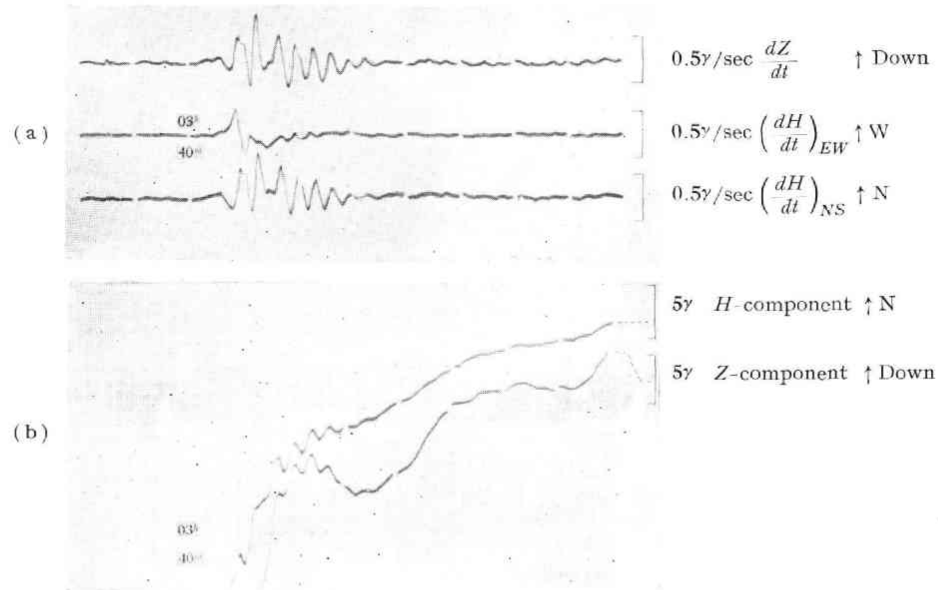


Apr. 4, 1957 18h 39m G.M.T.

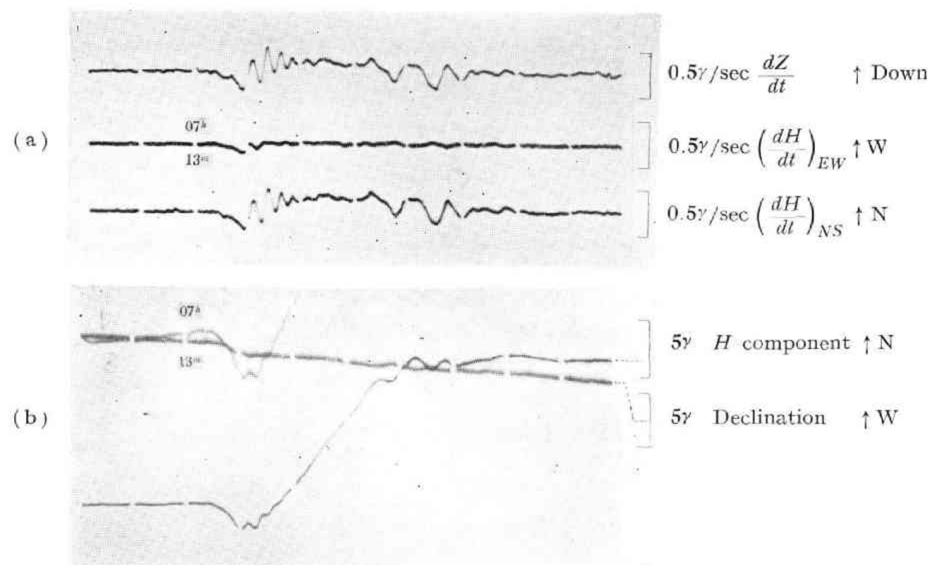


Jun 4, 1957 01h 21m G.M.T.

(2) The examples of the fine damped pt type pulsation observed by (a) the
(The latter have been recording since

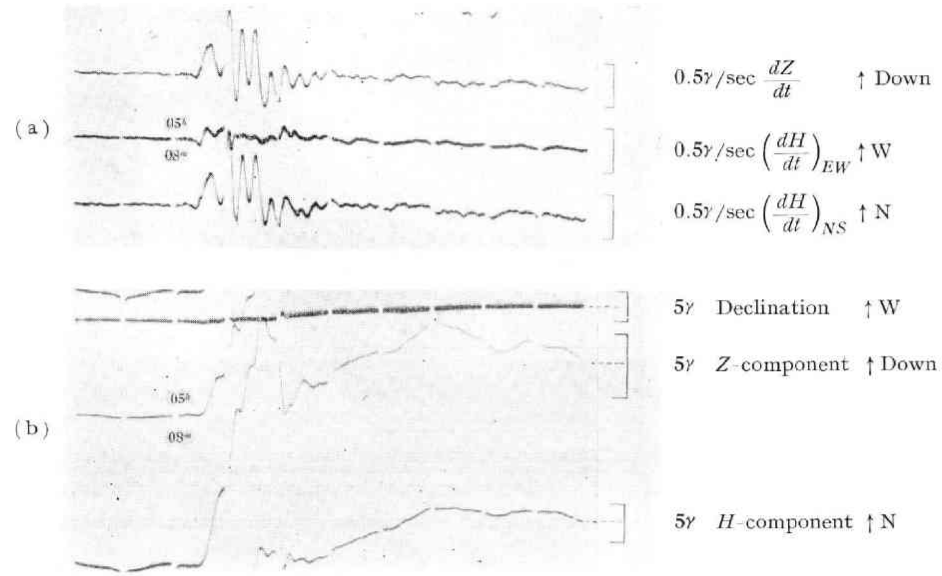


Jun. 24, 1957 03h 40m G.M.T. (ssc)

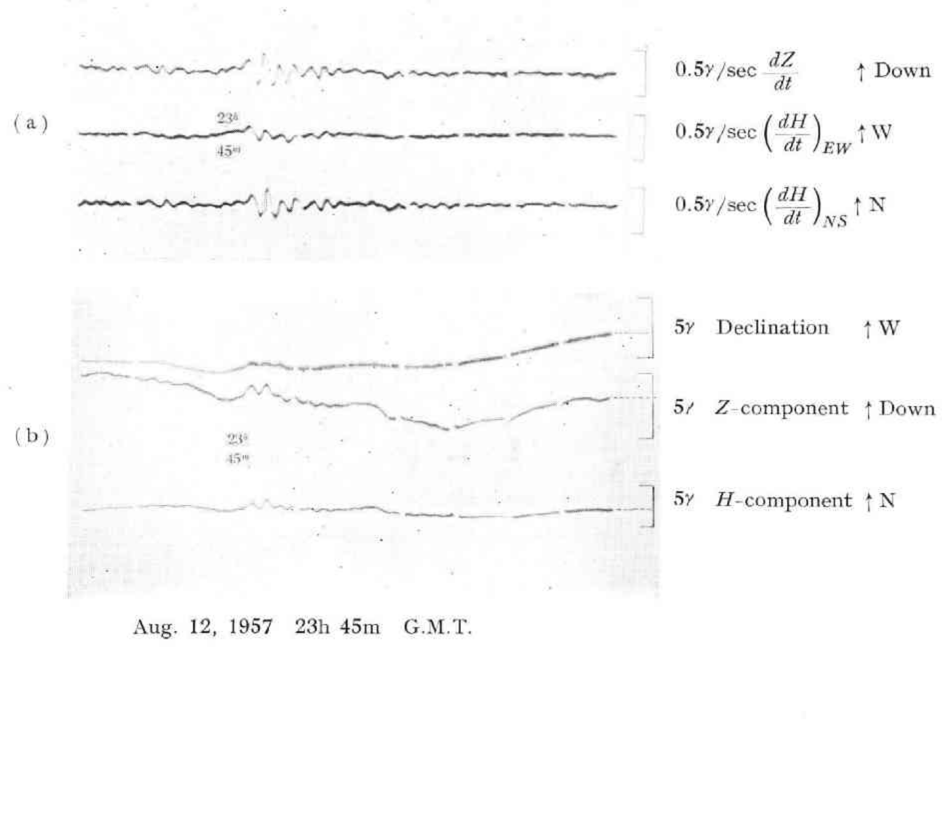


Jul. 16, 1957 07h 13m G.M.T. (ssc)

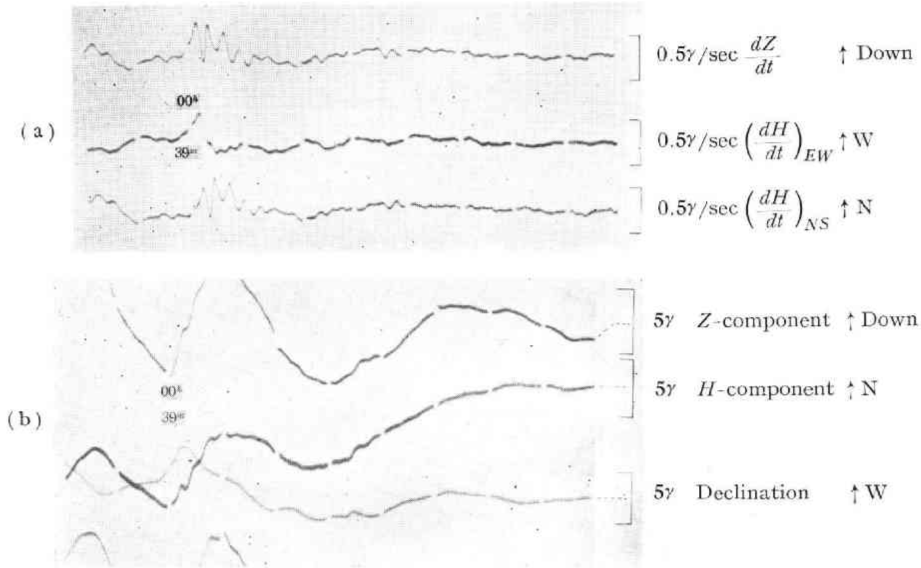
induction magnetometer and (b) the high sensitive rapid-run magnetometer.
the middle of June 1957.)



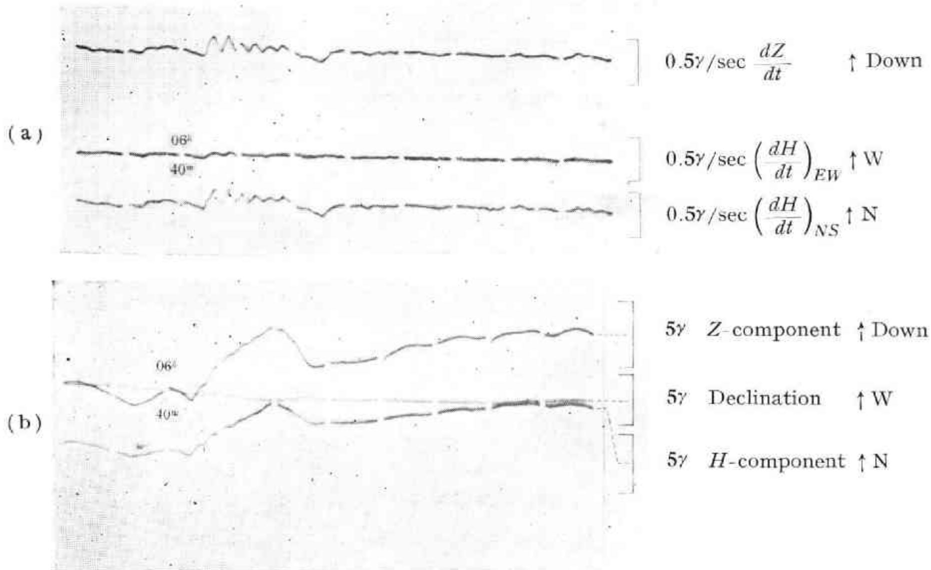
Aug. 6, 1957 05h 08m G.M.T. (ssc)



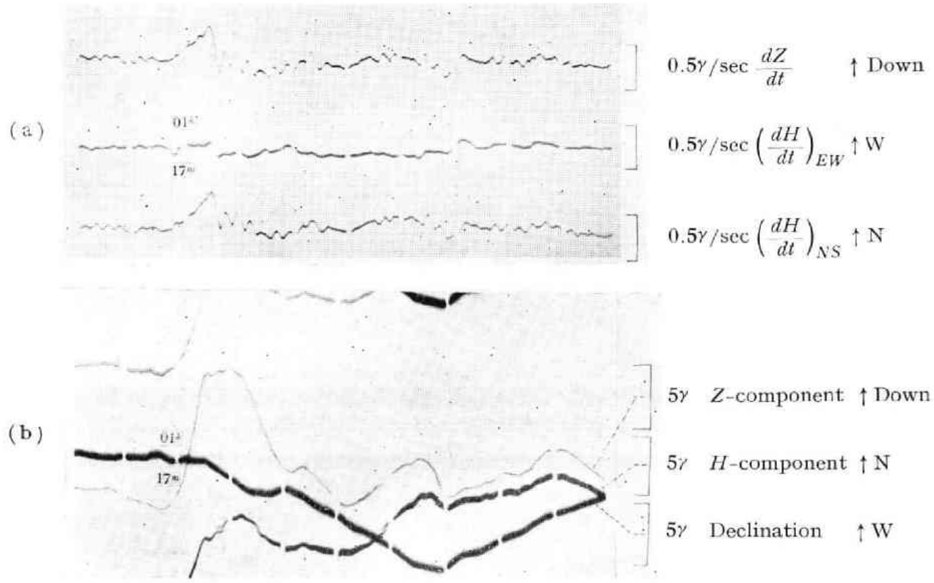
Aug. 12, 1957 23h 45m G.M.T.



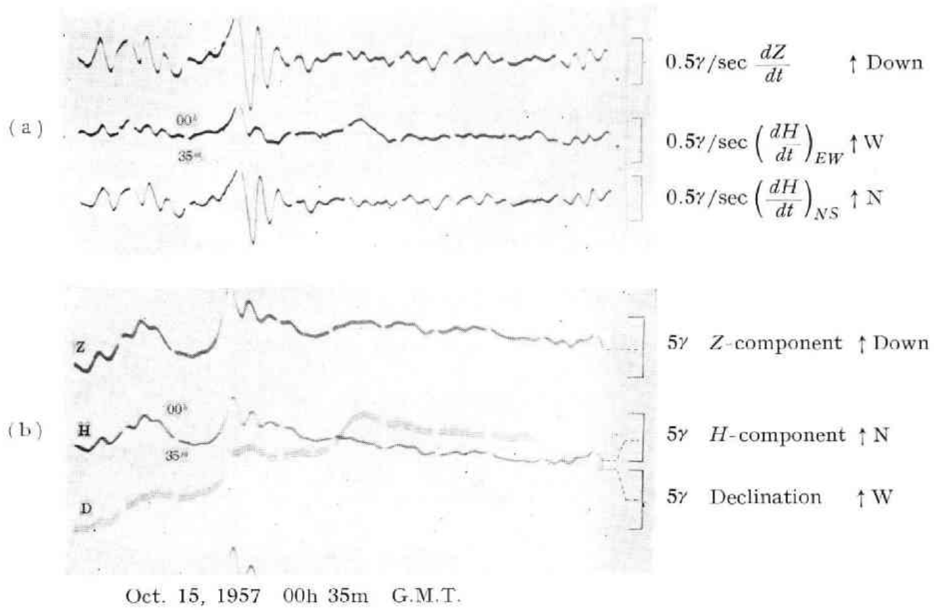
Sept. 4, 1957 00h 39m G.M.T.



Sept. 4, 1957 06h 40m G.M.T.

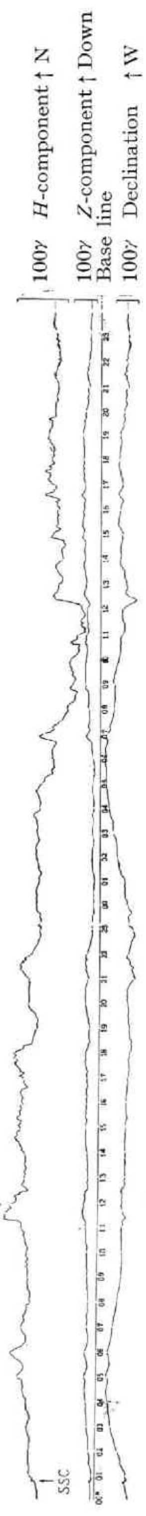


Sept. 6, 1957 01h 77m G.M.T.

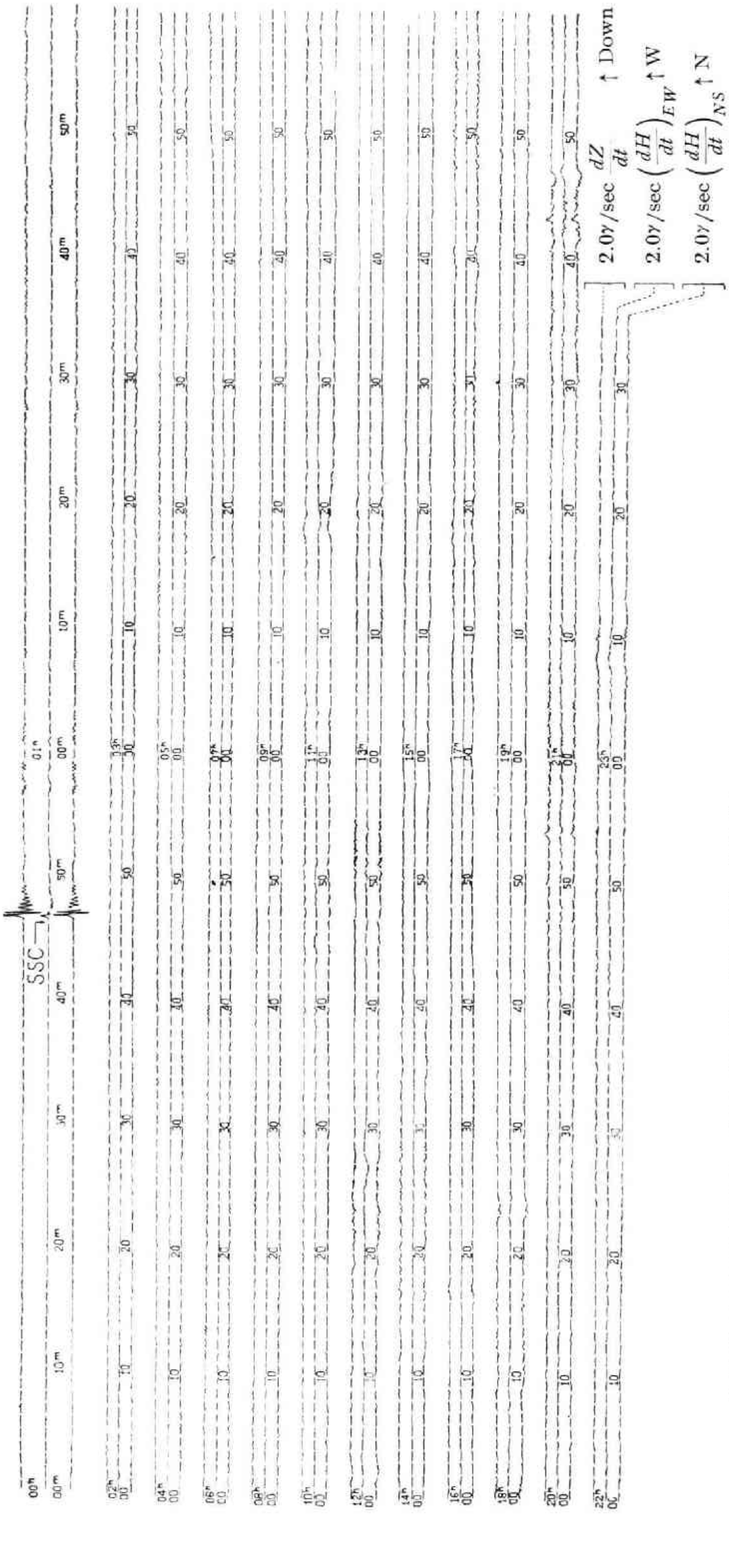


Oct. 15, 1957 00h 35m G.M.T.

(3) Records of the magnetic storm accompanying the fine damped pt type pulsation on ssc.



Ordinary magnetogram. (Jun. 25, 00h~Jun. 26, 24h, 1957, G.M.T.)



Induction magnetogram. (Jun. 25, 00h~24h, 1957, G.M.T.)