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Pulsations in Terrestrial Magnetic Field at the Time of Bay Disturbance

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Abstract

The rapid pulsations in terrestrial magnetic field are observed constantly at Tamanrasset magnetic observatory of Alger University (Director G. GRENET) and Onagawa magnetic observatory of Tôhoku University, Sendai, Japan (Director Y. KATO) by induction magnetographs. We found very interesting facts after comparing the data of dH/dt at the time of magnetic disturbances, obtained at these two observatories which are situated at nearly opposite sides of the globe. In this paper, we investigated the rapid pulsations which are observed at the time of bay disturbance, using the data of dH/dt, obtained at these two observatories. The results obtained from this investigation are as follows:

The rapid pulsation of dH/dt at the time of bay disturbance is observed only at the initial part of disturbance and reduced to calm at the time when the amplitude of horizontal component reaches to its maximum. The oscillation of dH/dt which is experienced at the time of bay disturbance begins always with positive sign ($dH/dt>0$) everywhere in the world. The time of occurrence of the oscillation is same at both stations within the error of 0.1 minute and the mode or the phase of oscillation is also similar, though these stations are situated at nearly opposite sides of the globe. G. GRNET and Y. KATO discussed the mechanism of these rapid pulsations and concluded that these pulsations are caused directly by the corpuscular beam approaching to the earth.

1. Introduction

The rapid pulsations in terrestrial magnetic field are observed constantly by induction magnetograph at Tamanrasset magnetic observatory of Alger University, Algerie and Onagawa magnetic observatory of Tôhoku University, Sendai, Japan. The positions of these two observatories are shown in Fig. 1 and their situations are as follows:

Tamanrasset Magnetic Observatory		
Geographic	latitude	22°.8 N
	longitude	5°.5 E
Geomagnetic	latitude	25°.4 N
	longitude	80°.6 E
Onagawa Magnetic Observatory		
Geographic	latitude	38°26′ N
	longitude	141°27′ E
Geomagnetic	latitude	28°.3 N
	longitude	153°.2 E

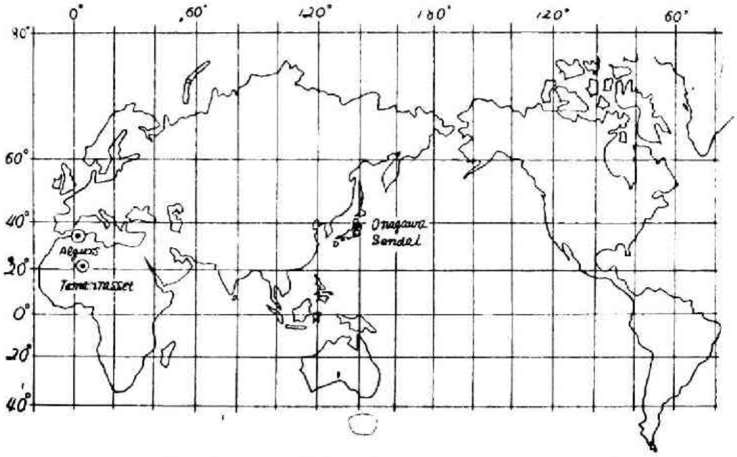
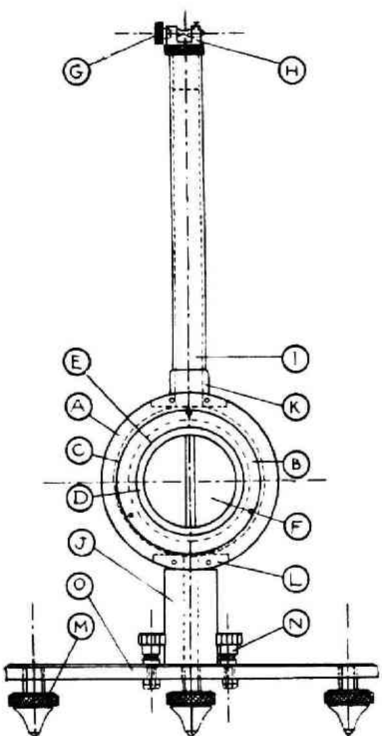


Fig. 1. Localities of two observatories.



Rep.	Désignation	Matiéer
A	Flasques maintenant le bobinage	Ebonite
B	Flasques maintenant les verres	Ebonite
C	Flasque central séparant les bobines	Ebonite
D	Verre de 2 m/m transparent	Verre
E	Cylindre de Fibre de 1/2 m/m enroulée	Fibre
F	Aimant suspendu par un fil d'acier	Alnico
G	Vis de reglage de suspension de l'aimant	Dural
H	Support de la vis de suspension	Dural
I	Tube encastré dans K	Dural
J	Cylindre percé d'un trou de 8 m/m	Dural
K	Entretoise et support de I	Dural
L	Entretoise	Dural
M	Vis calantes	Dural
N	Bornes	
O	Chassis de 195×195×7. J. étant au centre	Dural
P	Bobinage : Un seul enroulement comportant 1100 spires de fil de 18/1100 de chaque cote du flasque C.	

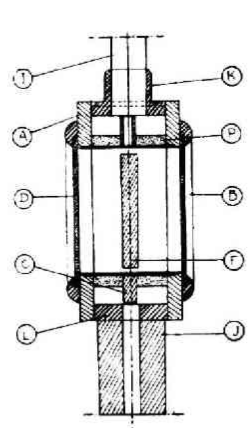
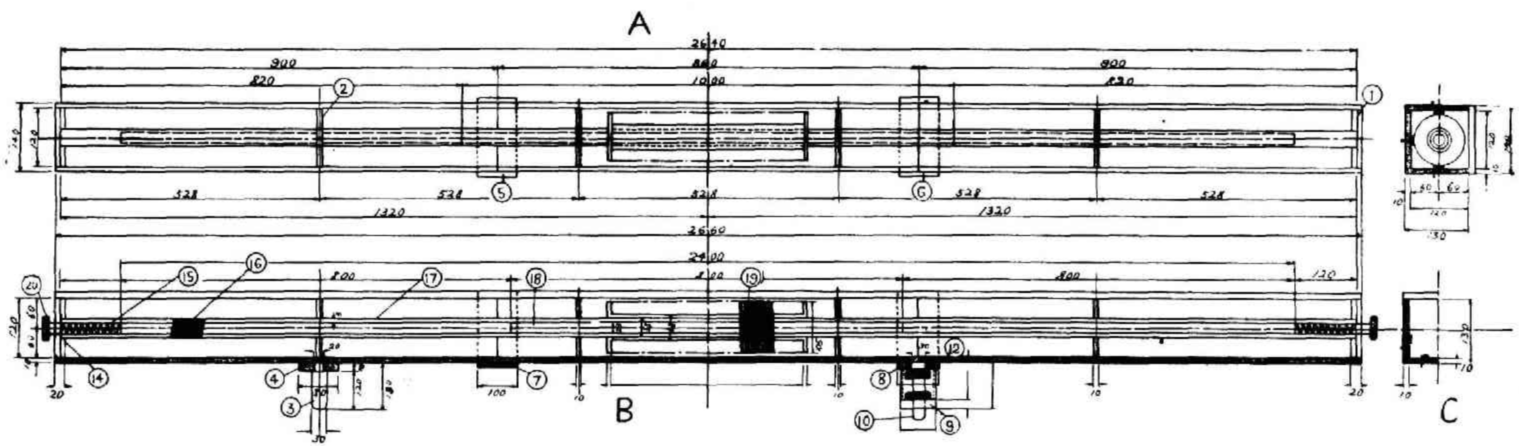


Fig. 2. Induction Magnetometer used at the Tamanrasset Observatory. (after G. GRENET and J. L. BUREAU)



A. Section (plan) B. Section (Elevation) C. Section (Side view)

No.	Article	Material	No.	Article	Material
1	Shaft Supporter	Al	11	Shifter	Bs
2	〃	Al	12	Plate	Bs
3	Leg	Bs	13	Plate	Bs
4	Leg Supporter	Bs	14	Packing	Bakelite
5	Joint Plate	Al	15	Shifter	Sup
6	〃	Al	16	Enamel Wire	Cu
7	〃	Al	17	Bakelite Cloth	
8	Leg Supporter	Bs	18	Core	Sendust
9	Supporter	Bs	19	Enamel Wire	Cu
10	Leg	Bs			

Fig. 3 Induction Magnetometer used at the Onagawa Observatory

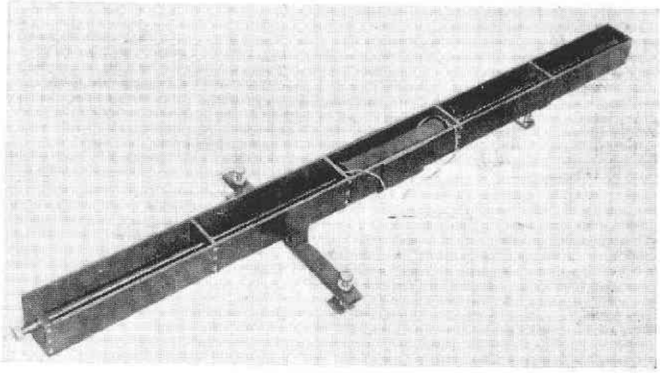
The constructions of the induction magnetographs which are used at these two observatories are not the same each other. Induction magnetograph which is used at the Tamanrasset observatory is constructed by a coil and a magnetic needle which is suspended in the center of the coil. The induction current induced in the coil by the rapid oscillation of magnetic needle at the time of magnetic disturbance is recorded by the galvanometer. Fig. 2 shows the induction magnetometer, constructed by G. GRENET and J. L. BUREAU [1]. By the induction magnetograph of this type, records of dH/dt and dD/dt are obtained. On the other hand, the induction magnetograph which is used at Onagawa magnetic observatory is constructed by the induction coil which is wound around the high permeable alloy and galvanometer [2]. For the high permeable metal we used the Sendust bar, the alloy of Fe, Al and Si. We constructed newly this type of induction magnetograph as shown in Fig. 3 and 4. The length of sendust bar is 240 cm and its diameter is 2.3 cm and its apparent permeability is ca. 1000 e.m.u., Number of turns of the coil is 7200 and its resistance is 33 ohm and the inductance is ca. 30 henry. The error of amplitude and phase lag caused by the inductance of the coil is not larger than 10% for the former and 20° for the latter for the period of the oscillation above 8 sec. The time variations of three components, dH/dt, dD/dt and dZ/dt ore recorded by the galvanometer, with its natural period 4 sec, on the same photographical paper, keeping its speed 5 mm/min. Fig. 5 is one of the example of the records of the rapid pulsation of earth's magnetic field at the time of bay disturbances obtained at Onagawa magnetic observatory.

2. Rapid pulsation of dH/dt observed at Tamanrasset and Onagawa Magnetic Observatories

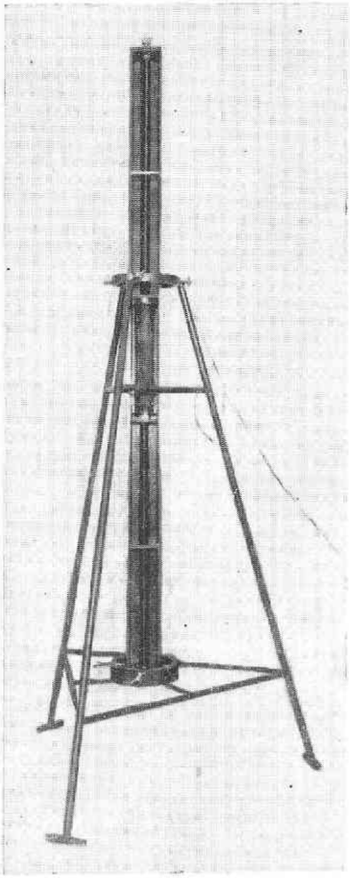
Now, Fig. 6 to 9 show some examples of records of dH/dt at the time of magnetic bay disturbance obtained at both magnetic observatories. These are picked out from twenty two cases of bay disturbance which occured simultaneously at both observatories in 1950. As the figures show, the rapid pulsations accompanying the bay disturbance, cleared by the record of induction magnetograph, are observed only at the initial part of bay disturbance and reduced to calm at the time when the amplitude of horizontal component reaches to its maximum. This characteristic is common at both observatories. O. MEYER also found this characteristic using the data obtained at Wingst Observatory, Hamburg, Germany. [3] It is remarkable fact that the time of occurrence of these rapid pulsations is the same at both observatories and the mode and the phase of oscillation are perfectly similar at both observatories, though these two stations are situated nearly opposite sides of the globe. Moreover the oscillation of the pulsation begins always and world-widely with positive sign ($dH/dt>0$).

3. Discussions

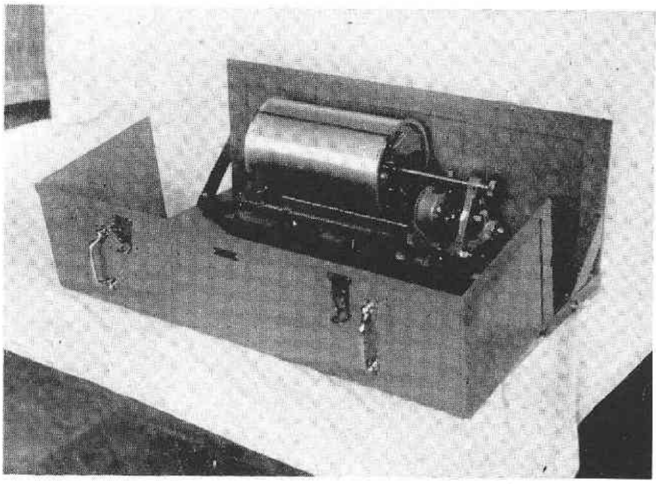
Fig. 10 shows the equivalent current system at the time of bay disturbance obtained by E. H. VESTINE. As the figure shows the type of bay disturbance will be so-called negative bay at Tamanrasset when it is positive bay at Onagawa and vice versa, while the rapid oscillations of dH/dt have the same sign and similar mode and begins always with postitve sign at both observatories. This suggests the oscillation of dH/dt is not caused by the



(a)



(b)



(c)

Fig. 4.

(a) Induction Magnetometer (Horizontal Component)
(b) Induction Magnetometer (Vertical Component)
(c) Recorder.

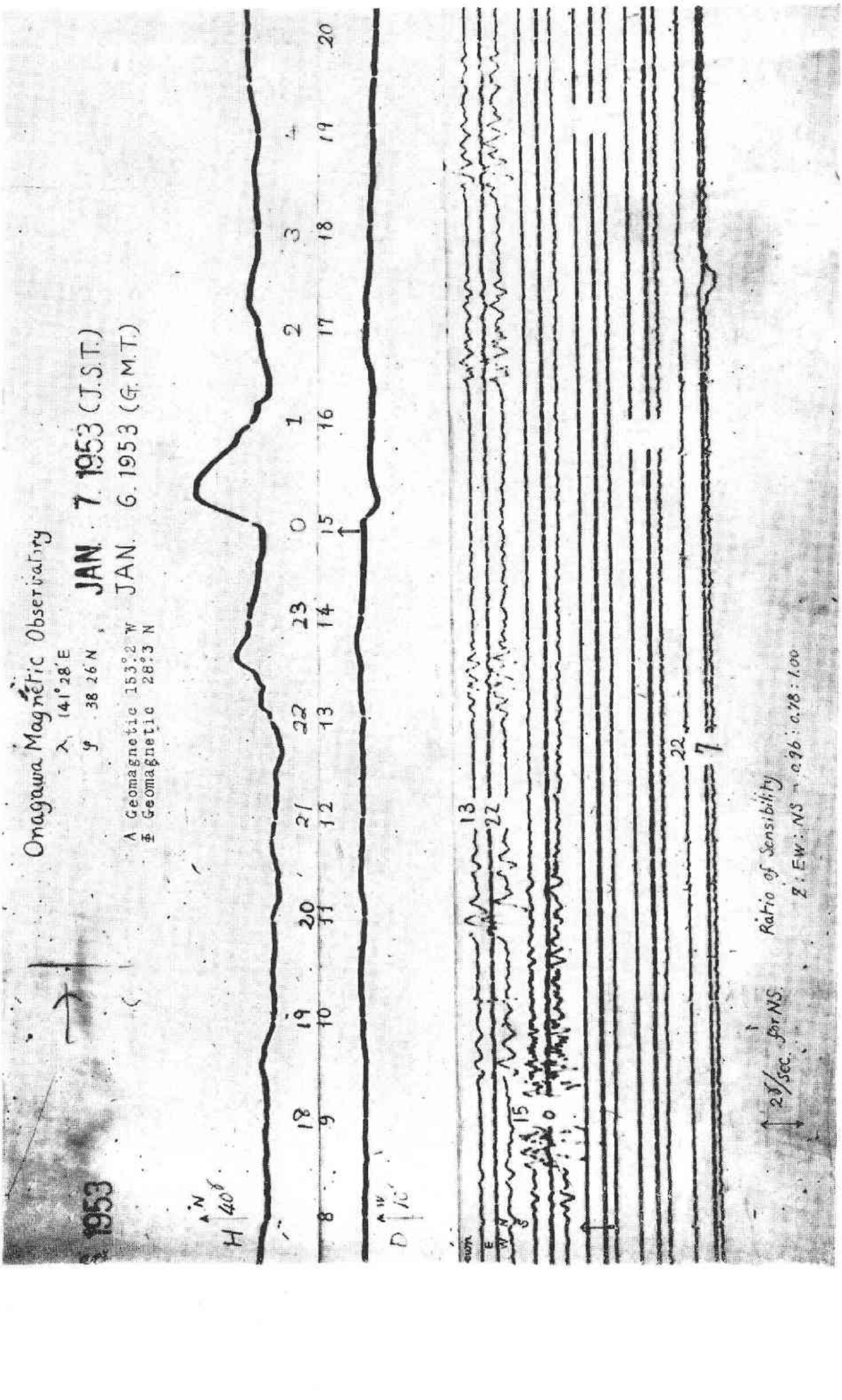


Fig. 5. Record of rapid pulsation at the time of bay disturbance obtained at Onagawa magnetic observatory for example.

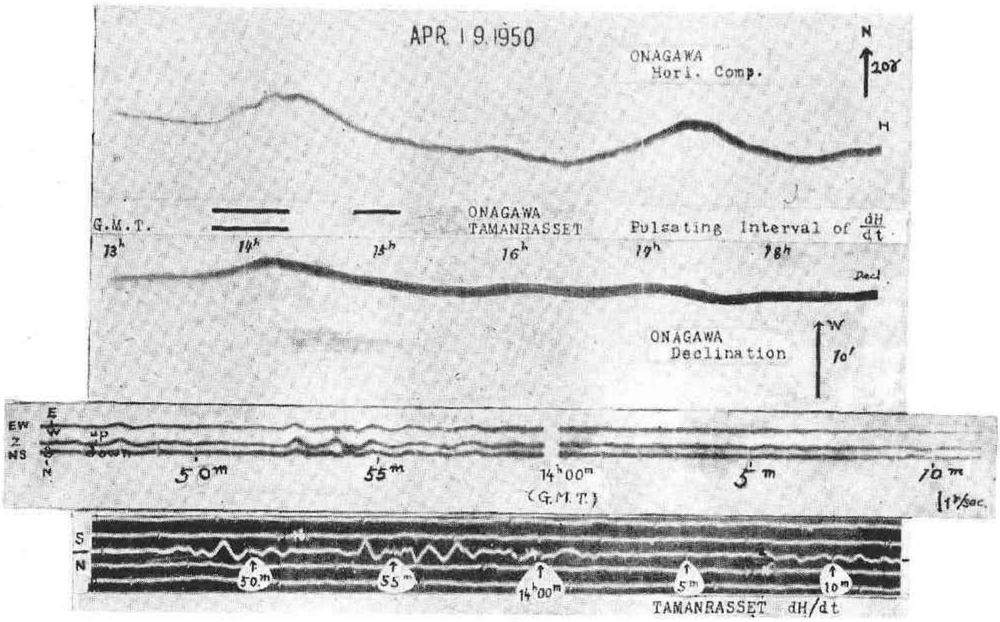

APR. 19. 1950
ONAGAWA
Hori. Comp.
N
20γ
H
G.M.T.
ONAGAWA
TAMANRASSET
Pulsating Interval of dH/dt.
13h
14h
15h
16h
17h
18h
Decl.
ONAGAWA
Declination
W
10′
EW
Z
NS
E
W
up
down
S
N
50m
55m
14h00m
(G.M.T.)
5m
10m
1γ/sec.
50m
55m
14h00m
5m
10m
TAMANRASSET dH/dt

Fig. 6.

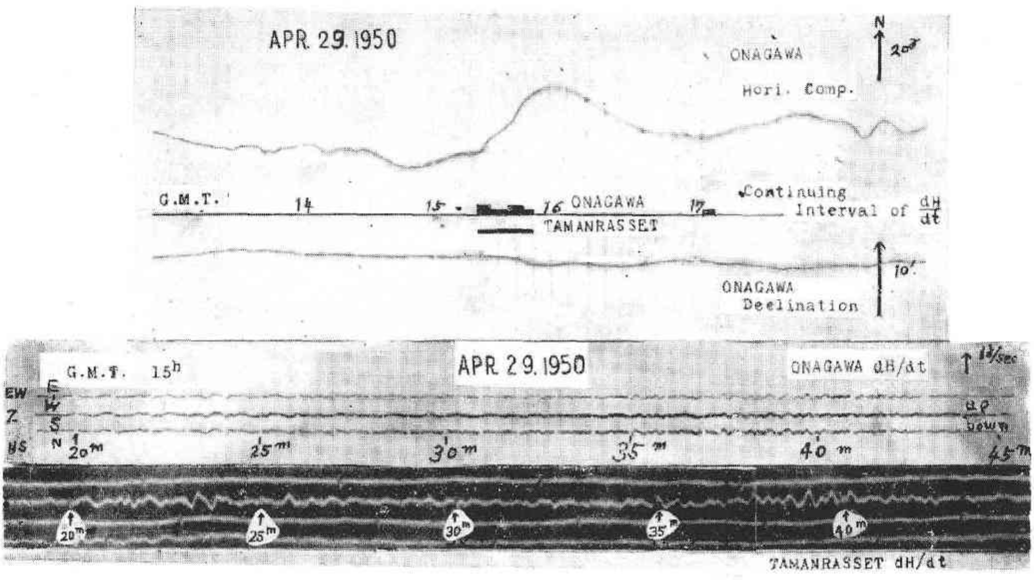

APR. 29. 1950
ONAGAWA
Hori. Comp.
N
20γ
G.M.T.
14
15
16
17
ONAGAWA
TAMANRASSET
Continuing Interval of dH/dt
10′
ONAGAWA
Declination
G.M.T. 15h
APR. 29. 1950
ONAGAWA dH/dt
1γ/sec
EW
Z
NS
E
W
S
N
up
down
20m
25m
30m
35m
40m
45m
TAMANRASSET dH/dt

Fig. 7.

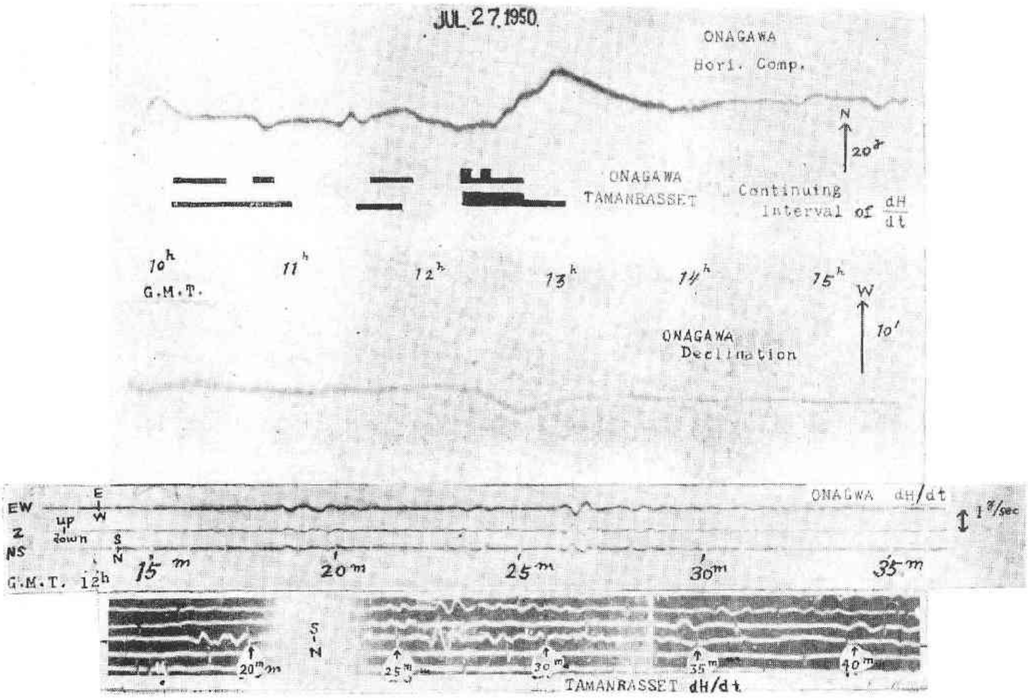

JUL. 27. 1950.
ONAGAWA
Hori. Comp.
N
20γ
ONAGAWA
TAMANRASSET
Continuing Interval of dH/dt
10h
G.M.T.
11h
12h
13h
14h
15h
W
10'
ONAGAWA
Declination
EW
Z
NS
E
W
up
down
S
N
ONAGWA dH/dt
1γ/sec
G.M.T. 12h
15m
20m
25m
30m
35m
S
N
20m
25m
30m
35m
40m
TAMANRASSET dH/dt

Fig. 8.

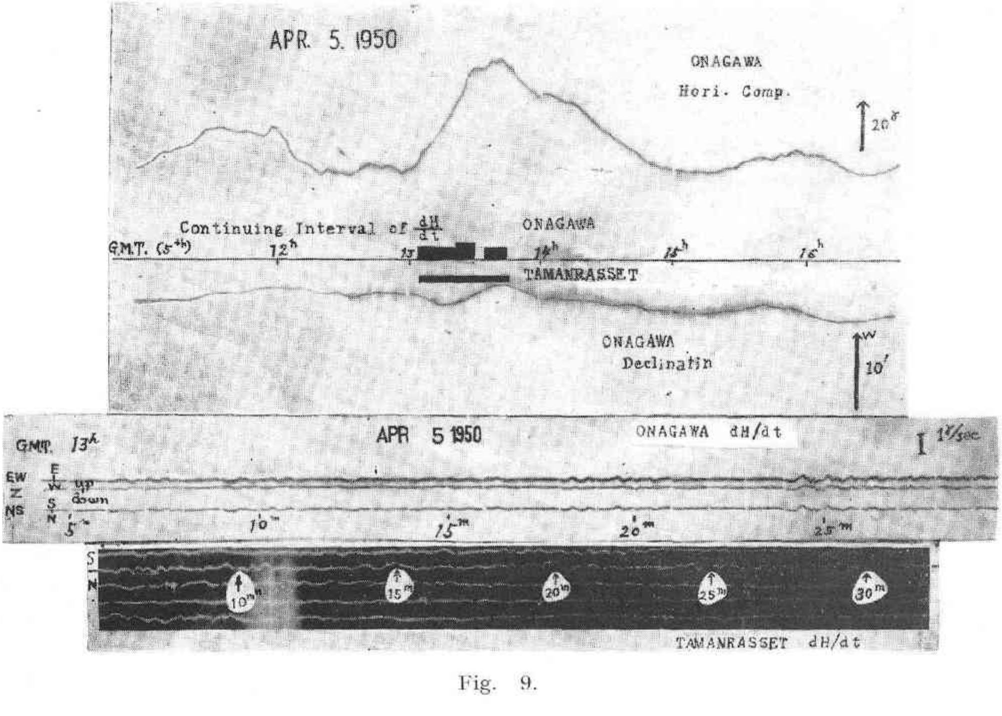

APR. 5. 1950
ONAGAWA
Hori. Comp.
20γ
Continuing Interval of dH/dt
ONAGAWA
G.M.T. (5th)
12h
13
14h
15h
16h
TAMANRASSET
ONAGAWA
Declinatin
W
10'
GMT. 13h
APR 5 1950
ONAGAWA dH/dt
1γ/sec
EW
Z
NS
E
W
up
down
S
N
5m
10m
15m
20m
25m
S
N
10m
15m
20m
25m
30m
TAMANRASSET dH/dt

Fig. 9.

fluctuation of this equivalent current system. One of the authers (G. GRENET) concluded that the rapid pulsation (p. s. c.) is caused by the electric current system induced on the advancing plane of neutral ionized stream. According to the corpuscular theory of magnetic disturbance (as stated by CHAPMAN and FERRARO, and others) the neutral corpuscular beam approaching near the terrestrial magnetic field is retarded by the action of the terrestrial magnetic field and so the magnetic field is set up due to the electric current system induced on the advancing plane conducting surface of neutral ionized stream. This rapid change of the magnetic field may be observed on the record of dH/dt. So the rapid change of dH/dt is always positive ($dH/dt>0$) and its mode and phase are simillar everywhere in the world.

(Un des auteurs (G. GREKET) considére qu'une conséquence de toute théorie faisant intervenir des particules chargées (comme la théorie de CHAPMAN et FERRARO) est un commencement trés progressif des perturbations avec $dH/dt>0$. Précisément les enregistrements de dH/dt montrent qu'un tel début est une caractéristique de beaucoup de p. s. c.

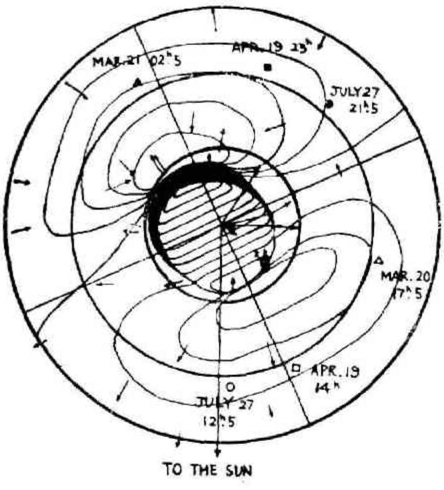


Fig. 10.

Ceci est donc un argument en faveur d'une origine corpusculaire des débuts brusques pulsatoires.)

While one of the authors (Y. KATO) concluded that the rapid pulsation of dH/dt observed at the initial part of bay disturbance is the rapid change of the magnetic field caused directly by the incoming corpuscular beam at the time when it approaches around the auroral zone of the earth, that is the fluctuation of velocity and density of the corpuscular beam is considered as the cause of the oscillation of dH/dt.

His opinion is as follows. The corpuscles emitted from the sun will form the neutral corpuscular beam consisting of charged corpuscles of positive and negative signs in equal numbers of which density will be 0.1 per cc and velocity be the order of 10^9 cm/sec. But when the beam approaches the terrestrial magnetic field, the positives and negatives become differentiated by the terrestrial magnetic field. As the electron cannot approach so near the earth, the particles which approach near the earth are almost proton. This proton beam in the allowed zone approaches near the earth surrounding the auroral zone eastward (as calculated by C. STÖRMER). The density of this proton beam may be fluctuated and it will form the patched beam.

The time variation of dH/dt may be caused directly by the magnetic field which is set up by this approaching proton beam. So the oscillation begins always in positive sign ($dH/dt>0$). If the denstity of beam is 0.1 particles per cc and the velocity is 3×10^9 cm/sec and the height of beam spreads from 500 km to 1000 km, then we can expect the oberved value of the amplitude of dH/dt after correcting the shielding effect of the ionosphere.

In either case, the cause of the time variation of dH/dt observed at the bay disturbance is not due to any agency in the ionosphere but due to the corpuscular beam outside of the ionosphere of the earth.

4. Conclusion

The rapid pulsation at the time of bay disturbance is observed only at the initial part of disturbance and reduced to calm when the amplitude of horizontal component reaches to its maximum. The oscillation of dH/dt begins always and everywhere with positive sign and simultaneously all over the world. The mode and phase of the oscillation are perfectly simillar at both stations which are situated at nearly opposite sides of the globe. The cause of the rapid pulsation of dH/dt is not due to the fluctuation of the current system of bay disturbance in the ionosphere but due to the rapid change of magnetic field caused by the corpuscular beam approaching near the earth.

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