Result of Rocket Experiment at Syowa Station (Magnetic Field)

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昭和基地におけるロケット観測結果（磁場）

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要旨：電離層内における electrojet や birkeland 電流による磁場を測定する目的のために，成分測定用の磁力計をS-210型ロケットにとう載して南極昭和基地において，1972年12月14日00時23分（地方時）実験が行われた．

この実験で得られた最初の結果では，ロケットの上昇時，及び下降時における profile が著しく異なっている．下降時のデータからは，西向きの電流によるものと考えられる磁場変化が測定されるが，上昇時においては複雑である．これらの結果から予想される事は，電流の分布がかなり局所的なものである．本論は現在まで得られているこの解析結果と，使用した磁力計についてもふれてある．

1. Instrumentation

Included on the payload were three components hybrid-digital fluxgate magnetometers and a solar aspect sensor for determining vehicle attitude. Figure 1 shows one of the magnetometer systems which can measure magnetic field with a wide dynamic range and a high sensitivity. The main loop consists in digital system. The output is supplied to the comparator which a quantified level is from −300 to +300 gammas and the comparator output controls gates. The clock pulse at the frequency of 1 kHz is counted with a reversible counter under the gate control. Simultaneously, the digital signal is converted into analog current and is applied to the sensor coil for cancelling the field within one quantified level. Therefore, the field in the sensor is always kept within ±300 gammas, even if any field change occurred. Digital information of this reversible counter is transferred to telemetry synchronized with the reading operation. On the other hand, the input of the comparator is measured by analog form. The value obtained by subtracting the digital value from the observed one, that is within 600 gammas, is detected by analog form. Therefore, field change can be distinctly observed so far as the counter is in the normal state. Digital counter output is 8

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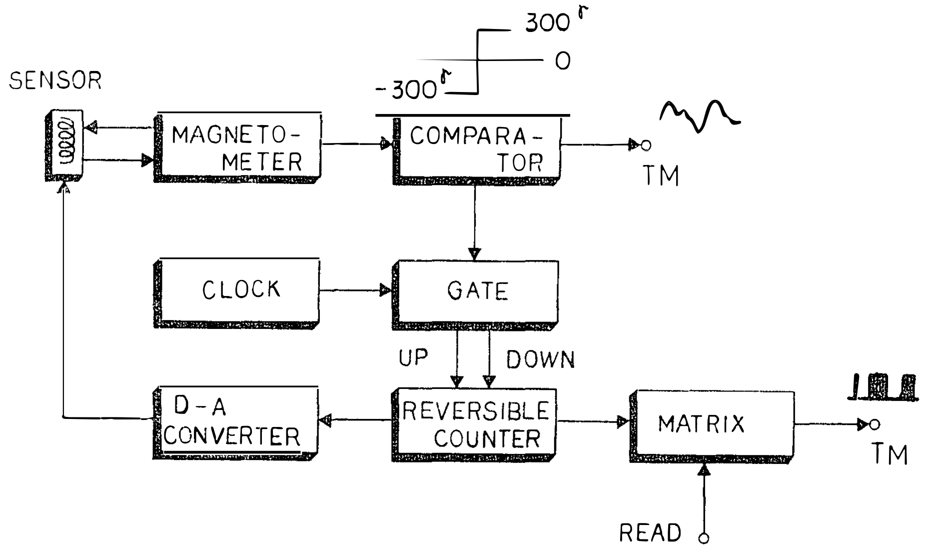

Fig. 1. Block diagram of hybrid-digital fluxgate magnetometer.

binary bits and the analog voltage of 0 and 5 volts is −300 and +300 gammas respectively.

Figure 2 shows geometry of the sensor system, direction of the magnetic field and rocket axis. The magnetometer used has three sensors, one of which is mounted so as to comply with the rocket axis (Z sensor) and the other two are perpendicular to the rocket axis (H sensor and C sensor). H sensor rotates on the plane that is perpendicular to the rocket axis corresponding to the rocket's rotation. Therefore, this sensor produces a signal that is proportional to the projected magnitude in the direction of H sensor on this plane and consequently, the magnitude of H sensor corresponds to the rocket's rotation. C sensor is mounted on the same rotated plane as H sensor but separate from the H sensor by 85

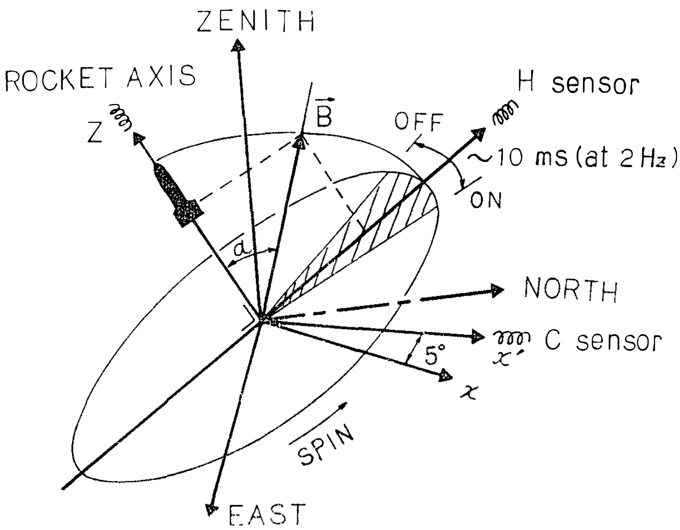

Fig. 2 Schematic diagram showing vehicle co-ordinates and sensor systems.

degrees. When C sensor crosses zero field intensity on the rotated plane, H sensor reaches near the direction of the maximum field intensity. At this time, C sensor makes a gate open and the reversible counter starts to count. And after about 10 ms, the gate is closed automatically. The digital information is held until the next gate openning, so that a constant cancel field is applied to the sensor coil. Consequently, the measurement is made on the shaded region in the figure, and the residual field is detected by analog technique. The field azimuth can be determined by comparing the time of the maximum intensity with the position of the independent reference object like as the sun or the moon.

Table 1 shows the characteristics of the magnetometer. The signals for telemetry are 8 serial binary bits which correspond to 0 to 76,000 gammas and 600 gammas full scale in analog form.

Table 1. The characteristics of the magnetometer.

1 Sensors: Three axis vector measurements with fluxgate magnetometer

2 Sensitivility: $\sim\pm 5\gamma$

3 Output form: Digital data (8-bit) + Analog data ($\pm 300\gamma$)

4 Power and weight: $\sim$1.5 W; 2.5 kg

2. Data Analysis

S-210 JA7 sounding rocket was launched from Syowa Station (geomagnetic latitude: 66.7°S, geomagnetic longitude: 72.5°E). Antarctica at 0023 local time on December 14, 1972 by the wintering party of the 13th Japanese Antarctic Research Expedition. Rocket performance was normal with apogee of 126 km at 171 seconds after launch, and all the instruments functioned well during the flight The trajectory of the rocket was obtained by radar tracking. The orientation of the rocket axis was measured by a solar aspect sensor and the magnetometer which gave the attitude for the geomagnetic line of force.

Figure 3 shows the orientation of the rocket axis described on the stereographic net for the period between 90 and 260 seconds after the launching. The origin corresponds to the west at the launching point, and "M" and "Sun" correspond to the direction of geomagnetic field and of the sun at the time of the firing, respectively. The half corning angle was 21 degrees until 190 s and 19 degrees until 260 s.

Magnetograms of Syowa Station at the time of launching are shown in Fig. 4. They are, from the top, horizontal component, declination and vertical component. The dotted line represents the quiet level of each component. The rocket was launched during the bay disturbance which showed a decrease of about 200

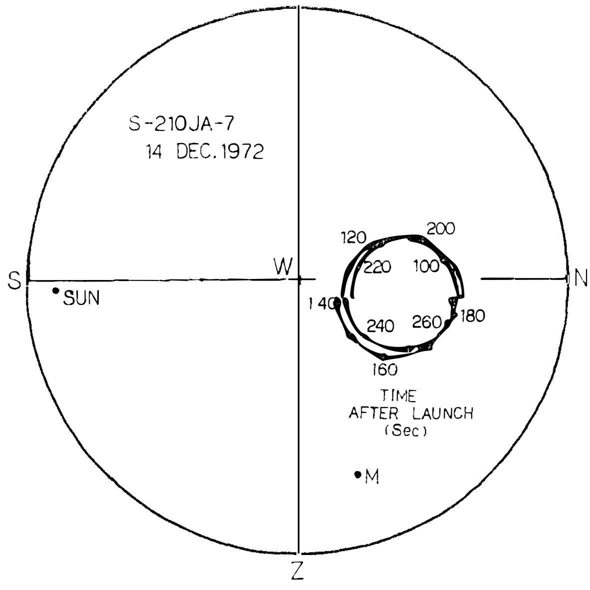

Fig. 3. Rocket axis direction on the Wuff net.

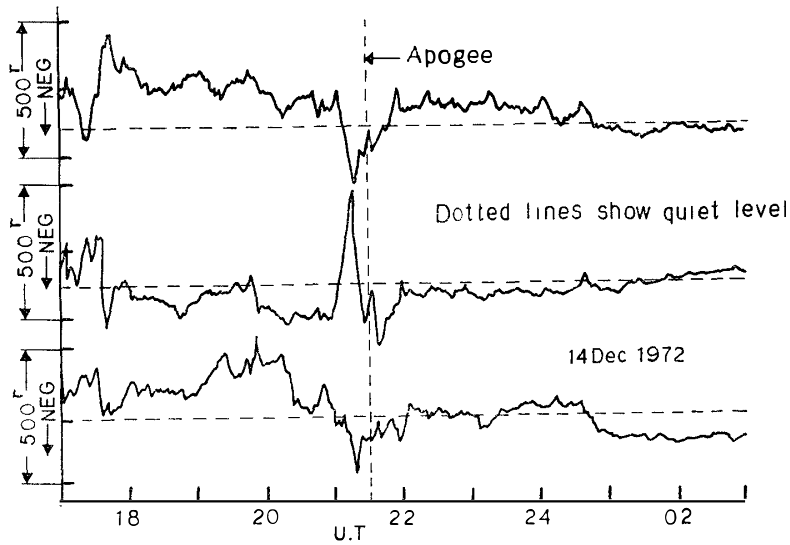

Fig. 4. Magnetogram from Syowa Station, Antarctica.

gammas in the horizontal component, suggesting the existence of a westward electrojet.

The magnitude of the main geomagnetic field along the rocket trajectory was calculated from the coefficient of spherical harmonic expansion and was substracted from that of the measured magnetic field. The difference fields on the upward leg and downward leg of flight are shown in Fig. 5. In the figure, the difference field of the upward leg gradually decreases till about 100 km and increases till 112 km and then it decreases again. On the other hand, the profile on the downward leg shows an increase of 600 gammas near 100 km. After that difference

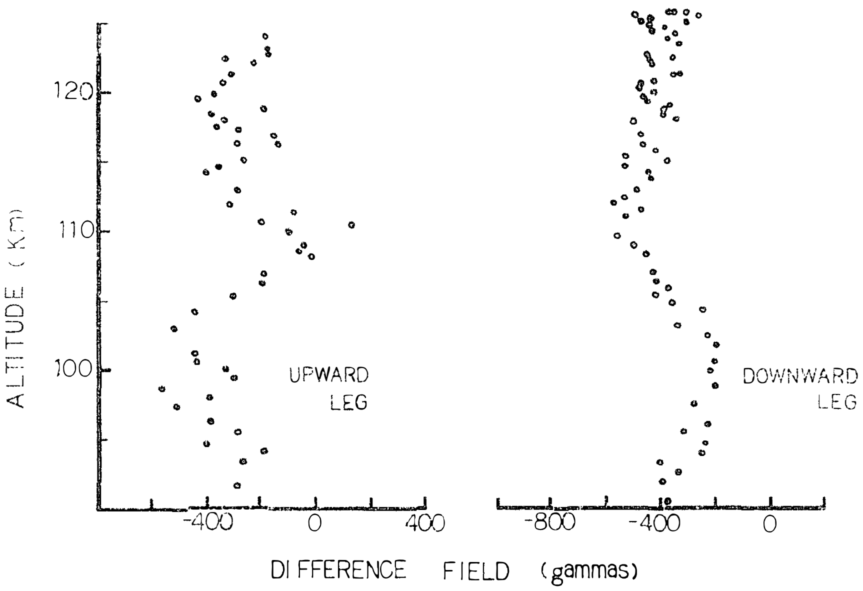

Fig. 5. The difference field between the measured and the calculated by S-210 JA7 as a function of the altitude in kilometers

field gradually decreases and becomes flat. These two field profiles are different from each other.

3. Preliminary Results

The difference field on the downward leg of flight, which is obtained after subtracting the calculated main magnetic field from the observed magnetic field along the trajectory of the rocket, shows the existence of the magnetic field due to the westward flowing electrojet at the altitude of 100 km. However, the upward profile of the difference field does not show the field at the same altitude, and the electrojet seems to exist at 112 km. These profiles indicate that the current system of the electrojet is quite narrow and localized. It is suggested that the vehicle may have passed near the edge of an electrojet on the upward leg of flight and entered into a current system on the downward leg. At the altitude of 100 km, the rocket position of the upward leg was about 55 km away from that of the downward leg. According to the preliminary interpretation, the intensity of the westward flowing current is calculated to be about 4.5×10^5 amperes and it may have produced negative bay disturbance.

More detail analysis of the data and vector field profiles associated with Birkeland currents is under way.

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