

Study of the Attitudes of Rockets Launched at Syowa Station

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S-210JA 型ロケットの姿勢について

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要旨: 南極ロケット S-210JA 5機の飛しょう中の姿勢について報告し、その飛しょう性能に関して検討する。

Abstract: The purpose of this report is to present a study of the attitudes of the rockets which were launched from Syowa Station, Antarctica by the wintering party of the 13th Japanese Antarctic Research Expedition.

Geomagnetic attitude sensors consisting of biaxial fluxgate magnetometers were used and successfully measured the attitudes during five separate rocket flights.

1. Introduction

In order to determine the attitude of a rocket with reference to the geomagnetic field line, fluxgate magnetometers were used. We have succeeded in making five experiments.

In addition, a sun sensor was used in the S-210JA-7 rocket and in this case we were able to determine the absolute attitude of the rockets with reference to geocentric co-ordinates. The results will be described in this report.

There are several different types of sensors which are used to determine the attitude of a rocket. These are the sun, geomagnetic, star and horizon sensors. The geomagnetic sensor is used most frequently. The geomagnetic attitude sensor (GA) is a biaxial fluxgate type magnetometer which we have designed specifically for use in rocket attitude measurement systems.

2. Instrumentation

The geomagnetic attitude sensor type GA is a two component magnetometer having a sensitivity of 5 volts per oersted and a range of ± 0.5 oersteds.

An alternating current of approximately 20 kHz (typical) is passed through one of the windings (drive coil). The signal output of the phase-sensitive rectifier is biased within the electronic unit at 2.5 volts. Owing to this 2.5 volts bias, the signal output will remain within the normal 0 to 5 volts input range of the tele-

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metry systems for magnetic fields ranging from -0.5 to $+0.5$ oersteds.

The specifications of the GA are as follows:

Range of field: 0 to 0.5 Oe.

Sensitivity: 5 volts DC per oersted.

Stability of sensitivity: 1% (0 to 40°C).

DC output for zero field: 2.5 volts DC.

Frequency response: 10 Hz (-3 db).

Weight: 0.9 kg.

Input current: $+50$ mA ($+20$ V), -20 mA (-20 V).

3. Results Obtained

Measurements of the attitudes of rockets using the geomagnetic sensors were made at Syowa Station, Antarctica. The rockets for which the attitudes referred to the geomagnetic field line were determined were S-210 type vehicles. Results obtained from these measurements are summarized in Table 1.

Table 1. Attitude parameters for the S-210 type.

	Rocket Type: S-210				
	JA-7	JA-8	JA-9	JA-10	JA-11
Date of firing	Dec. 14	Aug. 11	May 14	May 17	Aug. 7
Launching time (LT)	0023	0401	0213	0202	0445
Max. altitude (km)	125.8	126.6	129.3	115.4	125.8
Spin frequency (Hz)	1.1	1.2	1.1	1.1	1.2
Half conical angle (degrees)	21	52	38	14	50
Coning period (s)	90	60	120	20	55

The attitude of each rocket which is referred to the direction between the geomagnetic field line and the rocket axis are shown in Fig. 1 and Fig. 2. The conical (precessional) angle and its period can be determined from these data.

From these figures, it appears that the attitude of the S-210JA-10 rocket was different from the other rockets. However, the measurements were carried out with reference only to the geomagnetic field line. For this reason another explanation for this data is possible. We believe it likely that the actual value of the conical angle and period are double those shown in Table 1.

Figure 3 shows the spin frequency of the rocket during the flight. The mean magnitude of the spin frequency is about 1 Hz as was anticipated.

Figure 4 shows the orientation of the S-210JA-7 rocket axis described on a stereographic net for the period between 90 and 260 seconds after launching. The

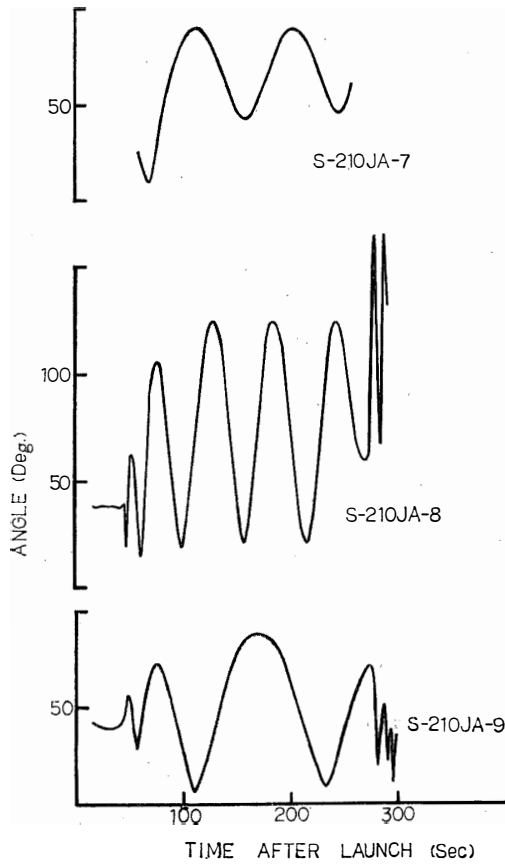


Fig. 1. Attitude of the rocket referred to the geomagnetic field line.

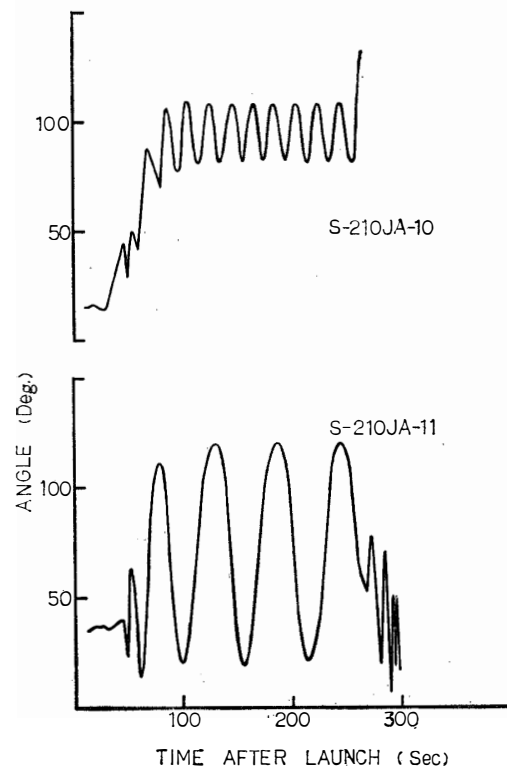


Fig. 2. Attitude of the rocket referred to the geomagnetic field line.

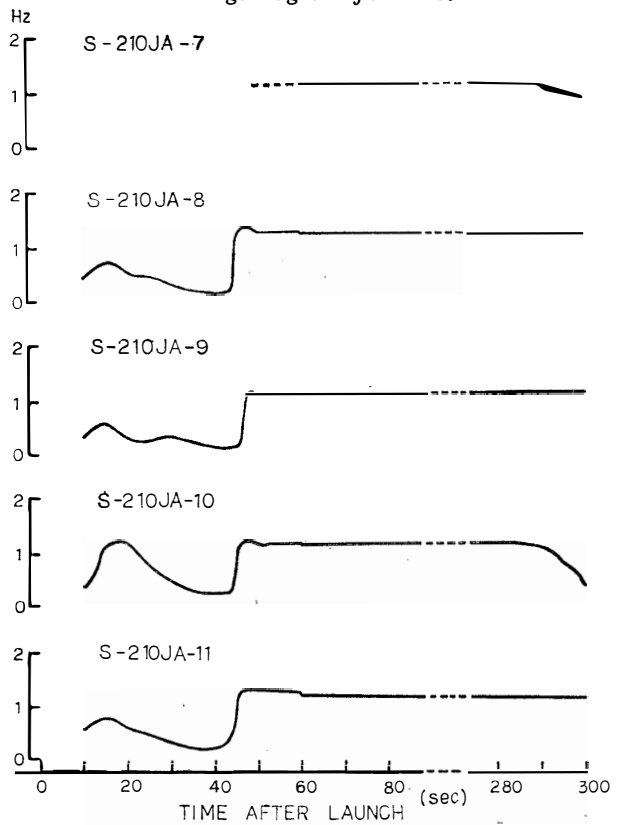


Fig. 3. Change of the rocket spin frequency.

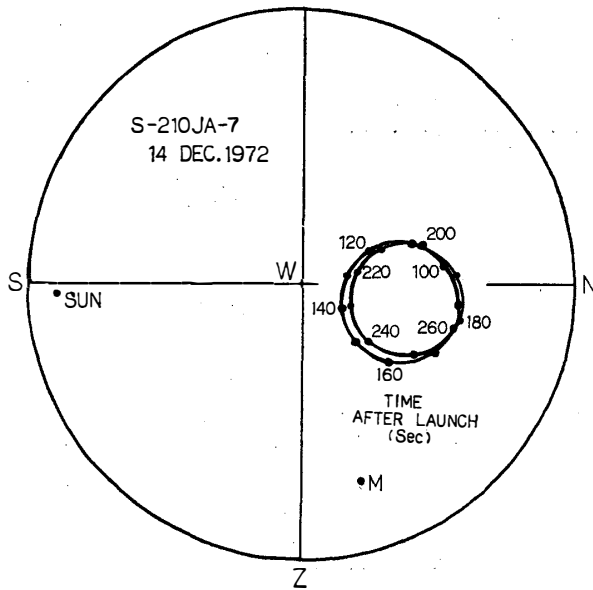


Fig. 4. Absolute attitude referred to the geocentric co-ordinates.

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.

Acknowledgments

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