THE SATELLITE TELEMETRY RECEIVING STATION OF TERRE ADELIE: THREE YEARS OF OPERATION

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Abstract: Since January 1972, satellite telemetry reception has been carried out on the routine basis at French Antarctic station Terre Adelie, in connection with the ISIS programs. Up to date, 2245 ISIS-II passes and 524 ISIS-I passes with an average length of 20 minutes have been recorded, giving a rather good seasonal and temporal coverage for statistical purposes.

Although, systematic analysis has been limited as yet to summer days with low magnetic activity ($Kp \leq 2_t$), two types of regularly appearing ionospheric disturbances have been found. The first type occurs between 06 and 18 MLT, at invariant latitudes from 76° to 82°, consisting in an increase of the electron density at all altitudes, and an increase of the plasma scale height particularly at high altitudes. The second type occurs between 17 and 22 LMT at invariant latitudes from 67° to 75°, consisting in an increase of the electron density at the satellite height, concomitant with a decrease at $H_{max}F2$.

1. Introduction

Despite important efforts during the last decade, the behavior of high latitude ionosphere is not yet well understood.

I see two main causes to this situation:

1) Physics of the ionosphere at these latitudes is closely connected to magnetospheric phenomena, hence more complicated than at lower latitudes.

Such processes as energetic particles precipitations, field aligned electric fields and currents, convection electric fields are of crucial importance in these regions.

2) Due to access difficulties and to the severity of local conditions, the network of geophysical stations in these regions is rather scarce, particularly in the southern hemisphere.

The acquisition of data from artificial satellites or automatic ground stations is therefore of special importance.

During the last five years, results of satellites experiments have brought a major progress by giving us the morphology of particles precipitations and the topology of the convection electric field.

But again, there is a relative lack of data due to the scarceness of receiving stations and the unreliability of on board tape recorders. In the case of Antarctica,

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since Byrd Station (where Alouette-ISIS data were received up to 1971) was closed, Terre Adelie Station, opened in 1972, is the only satellite receiving station in operation.

2. Description of the Station

Terre Adelie Station (Dumont d'Urville Base) is located on a small island, about one mile from the Antarctic Continent. Its geographic coordinates are 66.7° south and 140.6° east; Dip angle is 89.5° and invariant latitude 81°.

The station, which is near the polar border of the cleft region during low or moderate magnetic conditions, and well inside the polar cap during strong magnetic activity, has then a particularly suitable position for studies of phenomena typical of the cleft and polar cap regions.

Terre Adelie geophysical station began operating in 1956, on the occasion of the IGY. Since then, it has been working continuously with a progressively im-

Table 1. Equipments of Terre Adelie geophysical station.

Experiment	Characteristics	Comments
Ionospheric sounder (LGE)	Frequency range: 0.25–20 MHz	Installed in 1956 (Sp 3516)
1005 Magnetic AB (J5)	Peak power: 20 kW	Improved in 1966
	Impulsion length: 70 μs	One ionogram each
	Sweep-frequency legnth: 30 s	15 minutes on 35 mm film
	Antenna: Δ type	and each 5 minutes on 16 mm film
Riometers (LGE)	Four operating frequencies at 13.7, 20.5, 30.1 and 75 MHz.	
	Yagi type antenna with a bandwidth of 30 kHz.	
Magnetometers (IPG)	Three Lacour magnetometers recording slow variations of the magnetic field.	
	Recording of rapid variations (Pi1 and Pi2; Pc1 to Pc5)	
Optical experiments (I.A.P.)	All sky camera	
	All sky photometer type PH 7C with 8 filters (7250, 6300 broad and narrow, 4861, 5577, 5200 broad and narrow, 4278)	
	Zenithal photometer at λ 5577 Å with 6° field.	
	Photometer for the study of auroral pulsations with λ=5200 and 6500 Å (broad and narrow).	

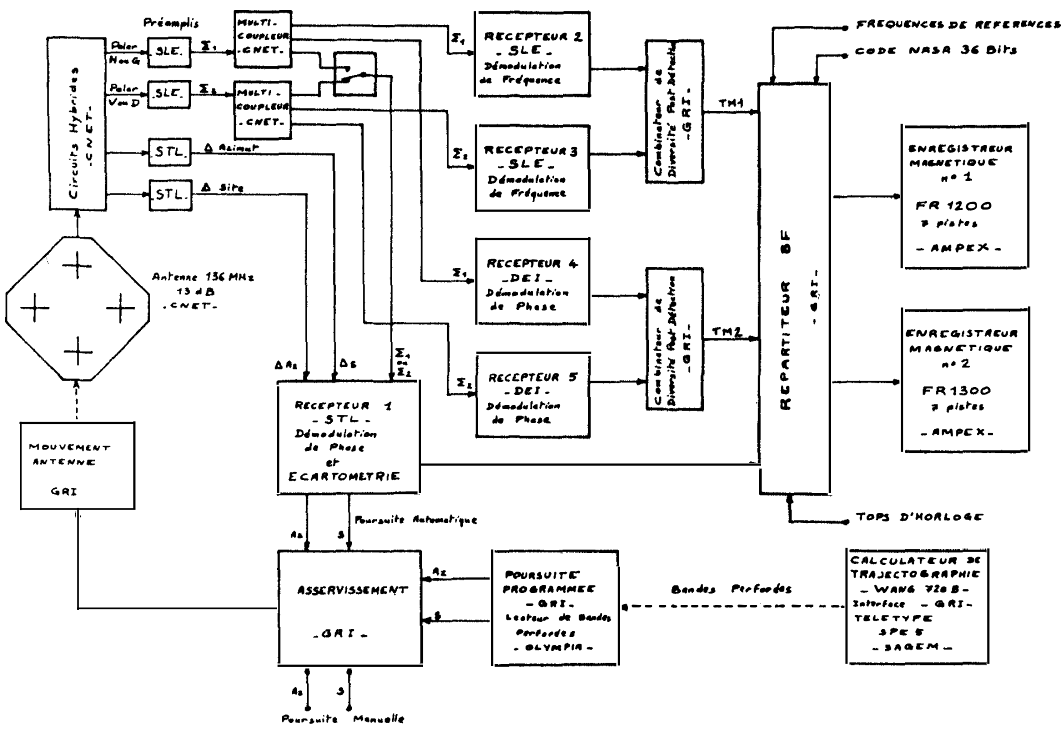

Fig. 1. Block diagram of the Terre Adelie satellite acquisition station.

proved scientific equipment.

The experiments presently in operation are given in Table 1.

A satellite telemetry receiving equipment operating in the 136–138 MHz frequency range began to work in January 1972. The possibilities of the station have thus been greatly increased.

The station is operated by the LGE (formerly GRI*) on behalf of the TAAF administration (Terres Australes et Antarctiques Françaises).

The block diagram of the Terre Adelie receiving station is shown in Fig. 1.

The reception antenna, mounted under a protective radome, consists in an array of four crossed dipoles elements and hybrid mixing circuits. The gain of this antenna (including losses in hybrid circuits) is 13 dB and its half-power beamwidth is 30°.

The antenna is mounted on a CGE platform (modified by the GRI) which allows a rotation of ±350° in azimuth and from 0° to 90° in elevation.

A choice of polarizations is possible: vertical and horizontal or left and right circular.

The two outputs from the receiving antenna are fed to SLE preamplifiers with a gain of 30 dB and a noise figure less than 3.5 dB.

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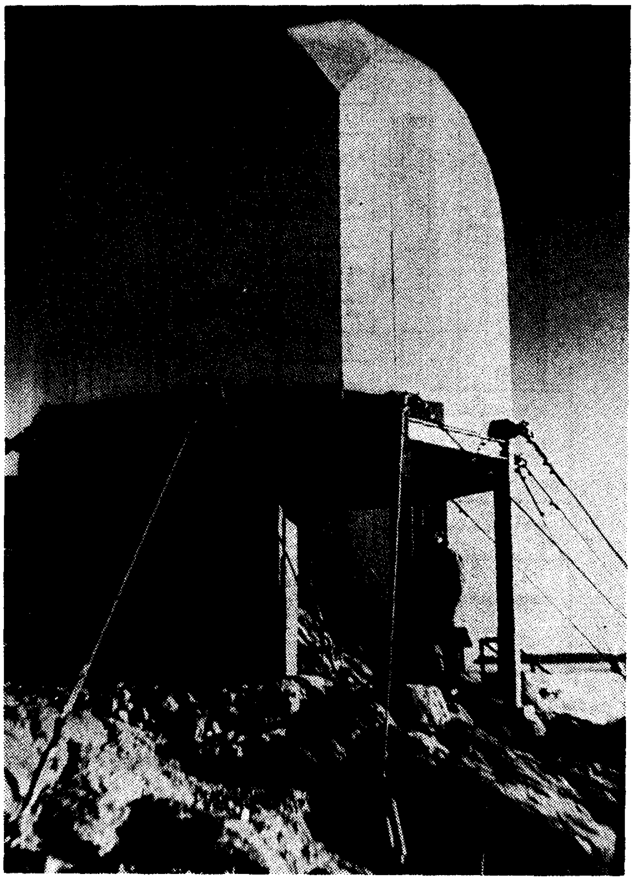

Fig. 2. View of the radome (Photograph taken by G. PENAZZI).

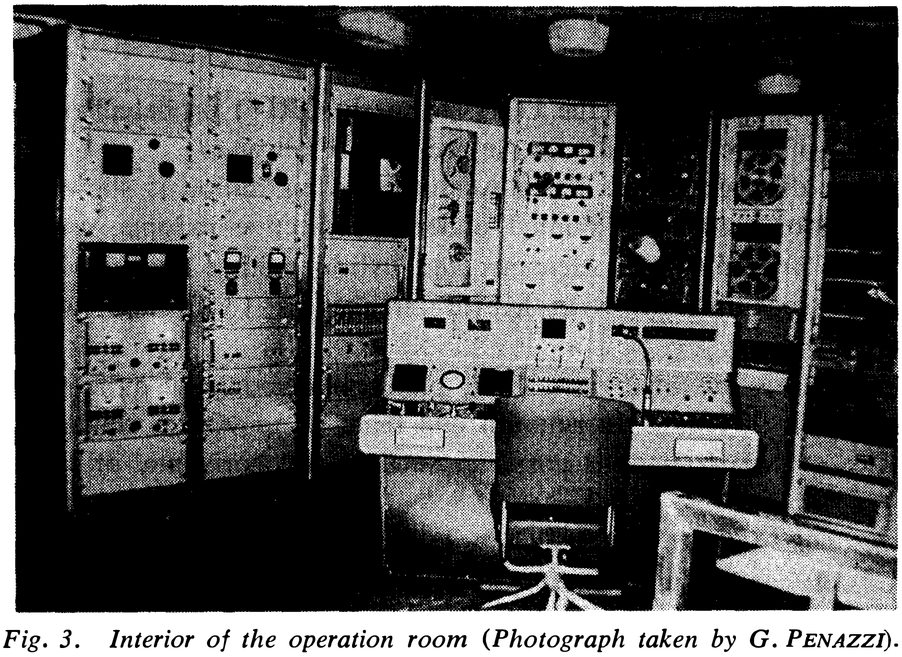

Fig. 3. Interior of the operation room (Photograph taken by G. PENAZZI).

There are two receiving systems. An FM system with two SLE receivers and a PM system with DEI receivers.

All receivers have an IF bandwidth of 100 kHz and a LF bandwidth of 50 kHz, and can be controlled by two synthesizers.

Two post-detection diversity combiners (built by the GRI) allow to combine signals from the PM and FM receiving systems. They are controlled by the AGC outputs of the receivers and select the signal with the best signal to noise ratio, or add them up if these ratios are similar.

An LF repartitor chooses output signals from the receivers and servitude signals to be recorded.

There are two Ampex magnetic tape recorders, an FR 1200 and an FR 1300.

They use 7-track tapes with a half inch width and a maximum wheel diameter of 10-1/2 inches.

The speed of recording goes from 1-7/8 to 60 ips.

Direct and FM recording modes are possible.

The bandwidth is 5 kHz at 15 ips for FM mode and 75 kHz at 15 ips for direct mode.

Most servitude signals are derived from the Rohde and Schwarz clock, a quartz clock with a time precision better than 5 ms.

This clock gives all the reference frequencies (10 kHz, IRIG standard frequencies of 100 kHz, 50 kHz, 25 kHz, 12.5 kHz and 6.25 kHz, and 60 Hz used by the speed-lock of the FR 1300 recorder) and monitors the NASA time coder built by the GRI.

All controls are performed on the control desk.

Following three types of control are available:

1) Manual tracking in which the error signals in azimuth and elevation are fed by the operator to a speed-lock which commands rotation of the antenna.

2) Manual positionning of the antenna at a fixed position, by a remote position control system. This mode of control is to be used before the satellite pass.

3) Digital process control of tracking, which is the most used mode of operation. Successive positions to be given to the antenna are pre-computed from orbit elements and stocked on a paper tape.

An automatic tracking mode had been designed and is shown in Fig. 1 but had never been used.

Fig. 2 shows the radome of the antenna and Fig. 3 a view of the control equipment.

It is expected to complete the receiving station during the next local summer by installing a command equipment working in the 140 MHz frequency range. This would help particularly in relation with the ISIS program, limited since

December 1974, due to command restrictions following a failure in the ISIS-II on board main clock. But such an equipment might be used also in other satellites programs.

3. Report of Operation

Telemetry reception began, in relation with the ISIS program, on January 19th 1972.

An advantage of such high latitude station in the case of polar-orbitting satellites is the possibility to receive them at each revolution. It has been done with ISIS-II on June 10th 1972, thus allowing a precise experimental determination of the coverage of the station, and to compare it with computations (Fig. 4). It appears that the station allows a good coverage of the polar cap, cleft region and auroral zone.

From the first day up to August 1st 1975, 2245 ISIS-II passes, and 524 ISIS-I passes with an average length of 20 minutes have been recorded, giving a rather good seasonal and temporal coverage for statistical purposes.

If the station was primarily intended to work on ISIS program, it was soon operated for other ones.

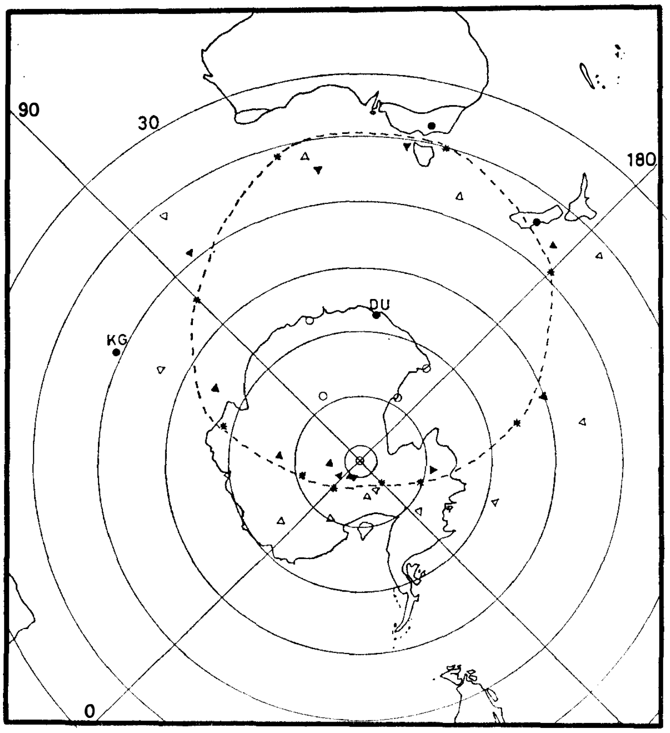

Fig. 4. Map showing computed coverage zone (dashed lines and stars) and experimental coverage determined in June 10th 1972 (open and full triangles).

Following failures of their on board tape-recorders, passes from the ESRO satellite TDIA (2668 passes from July 1972 to December 1973) and from the German satellite AEROS B (about 700 at the end of July 1975) have been recorded.

More recently, and for a one-year period ending in April 1976, has been engaged a program of reception of the US satellite Hawkeye 1, with presently one pass recorded each two days with an acquisition length of about 50 minutes.

The Satellite Control Centre of the CNES (Centre National d'Etudes Spatiales) is responsible for the coordination of satellites reception above Terre Adelie. It sends each week to the station the list of passes to be acquired. A report on recorded passes is sent daily by the station.

4. Scientific Results

Concerning the scientific results obtained from satellite data acquired in Terre Adelie, I shall limit myself to ISIS data.

A general remark I would like to make concerns the complementarity of satellite and ground-based measurements. Ground-based data, due to temporal continuity, allow precise statistical analysis; but they are of an integrated nature which makes it difficult to identify the physical processes involved. On the other hand, satellites give simultaneous *in situ* measurements more easily related to physical processes but are discontinuous in time and space. Last, only use of simultaneous satellite and ground-based data makes possible (in some conditions) to separate temporal and spatial variations.

As data from Terre Adelie are carried back to Europe only once a year, their processing is very slow and at the present time, results are limited to the topside sounder.

Topside ionograms from polar stations often exhibit a great variety of secondary traces which sometimes make an interpretation difficult.

Most common is the presence of spread-F which can appear at all levels from the satellite height down to the F2 layer top density level, attesting the presence of small scale irregularities.

There are also present large-scale electron density irregularities, causing multiple echoes, sometimes with interchange of the main trace along the satellite path. An indirect evidence of the existence of such large scale structures is also given by electron true height analysis: in many cases, the computed level of the maximum of density is too low, indicating that traces on the ionograms are due to obliquely propagating waves.

Fig. 5 shows an example of high latitude topside ionogram.

We have begun a systematic study of observed large scale irregularities. As

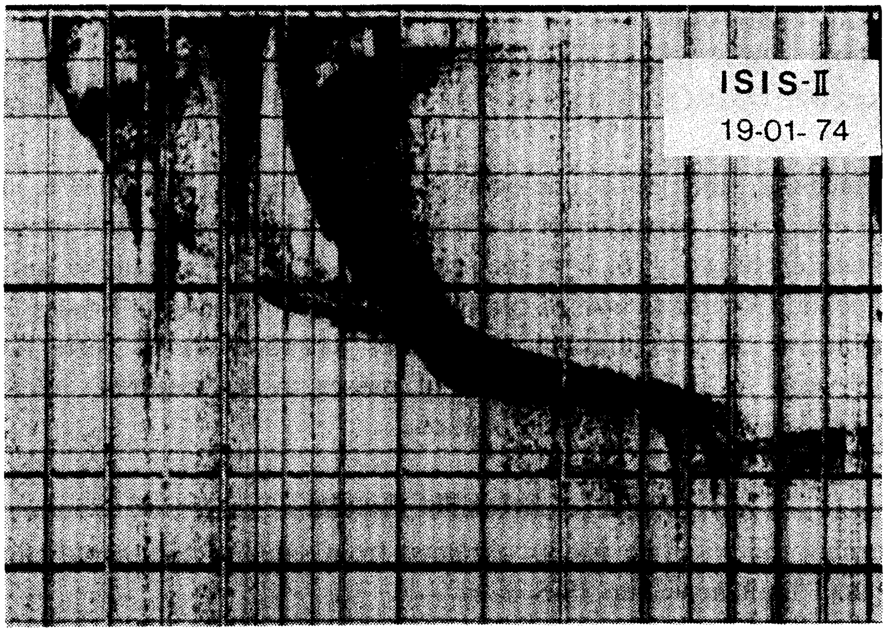

Fig. 5. Example of high latitude topside ionogram.

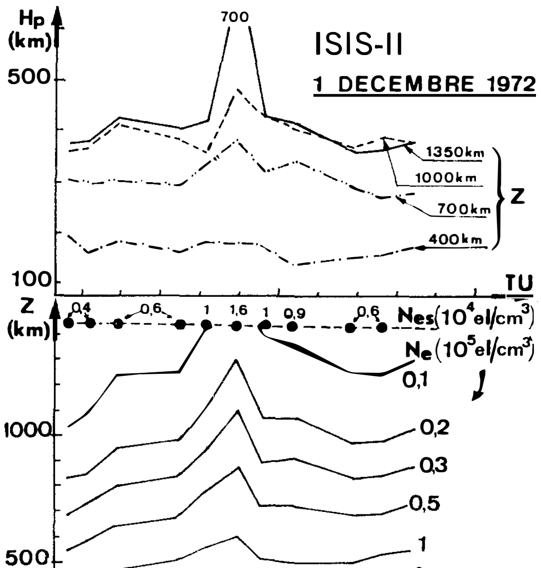

Fig. 6. Typical pass exhibiting the first type of high latitude ionosphere disturbance.

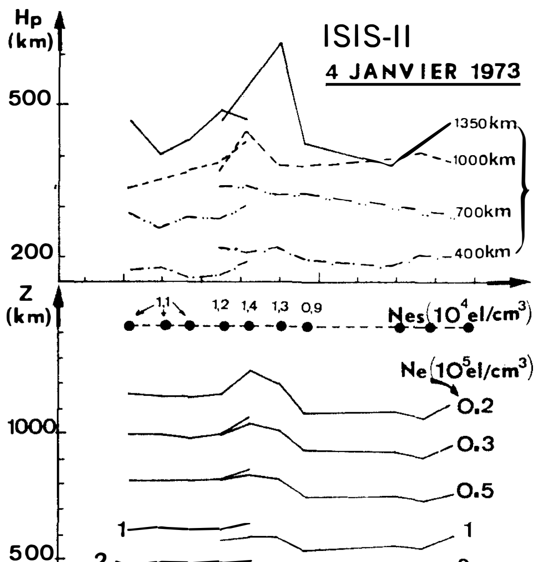

Fig. 7. Typical pass exhibiting second type of high latitude ionosphere disturbance.

yet, analysis has been limited to summer days with low magnetic activity ($Kp \leq 2+$).

Two types of regularly appearing disturbances have been observed.

The first type occurs between 06 and 18 MLT, at invariant latitudes from 76 to 82°. It consists in an increase of the electron density at all altitudes, and an increase of the plasma scale height (computer as $Hp = -Ne\ dZ/dNe$) particularly at high altitudes (Fig. 6).

The second type occurs between 17 and 22 MLT at invariant latitudes from 67 to 75°. It consists, for a poleward pass, in an increase of the electron density at the satellite height, concomitant with a decrease at $h_{max}F2$ (Fig. 7).

Both types of disturbances have a latitudinal extension of around 3°.

Fig. 8 shows all the cases of occurrence observed.

More detailed results of this study are to be found in ROUX (1975).

It is sometimes possible to go further than a simple statistical analysis. The most interesting case we have found as yet is a pass on January 23rd 1973, for which we had simultaneously ground-based data, ISIS topside ionograms, balloon-borne electric field measurements and data concerning the IMF.

It was then possible to build up a complete model of the isodensities and to

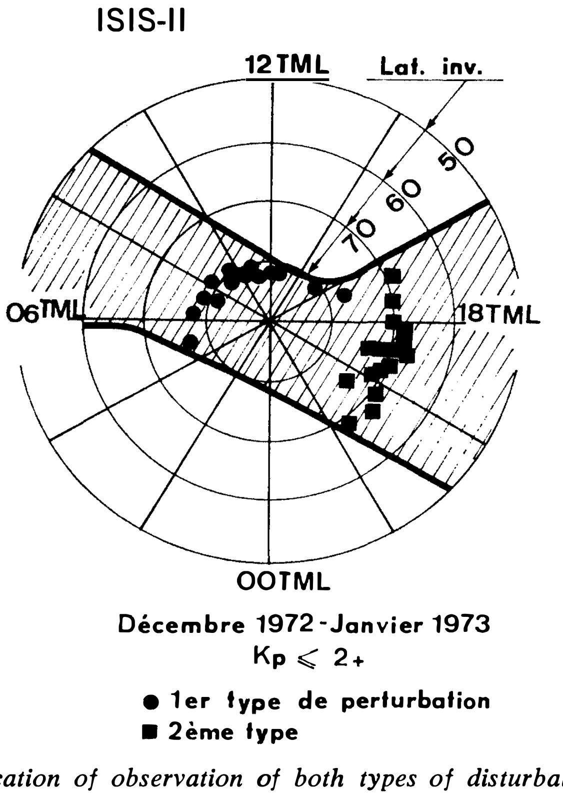

Fig. 8. Location of observation of both types of disturbance in a MLT, INLAT diagram.

interpret observations as large scale electron irregularities drifting towards the inside of the polar cap (SYLVAIN *et al.*, 1975).

An interpretation of the generation of irregularities by changes in the convection pattern induced by variations of the interplanetary magnetic field polarity is given in BERTHELIER *et al.* (1975).

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