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30 MM, XM552, SPIN RATE MEASUREMENT UTILIZING SPINSONDE.(U)

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30 MM, XM552 SPIN RATE MEASUREMENT UTILIZING SPINSONDE

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by

Peter B. Ayyoub

September 1976

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(cont fr p. 2)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A simple system was used to determine the spin rate history for the 30 mm, XM553 HEDP projectile. The system, developed by Harry Diamond Laboratory, called Spinsonde, consists of an oscillator and a power supply which is installed in the nose of the projectile. The telemetry package transmits a signal in free flight which is received on a station downrange.

(cont on p 1473 B)

Spin rate is a critical parameter in designing shaped charges and self-destruct fuzes. Therefore, an accurate determination of spin rate history

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#20. ABSTRACT (Cont)

over the entire projectile trajectory in free flight is necessary. This report describes the method used to measure the spin rate and presents a comparison between the theoretical and experimental results.

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INTRODUCTION

Spin rate is a critical parameter in designing shape charges and self destruct fuzes. Therefore, an accurate determination of spin rate history over the entire free flight trajectory of the projectile is important.

Consequently, Harry Diamond Laboratory developed an instrument, called spinsonde for the determination of spin rate of automatic cannon caliber projectiles. The 30-mm XM552 cartridge, with the 30 mm XM553 high explosive dual purpose (HEDP) projectile, was the test vehicle for this investigation. The Spinsonde system (cont. on p 1473A)

This report will present the results utilizing Spinsonde for free flight testing of the 30 mm HEDP XM553 projectile as compared to theoretical predictions of the spin rate obtained from the U.S. Army Spinner Computer Program.

EXPERIMENTATION

The Spinsonde technique is a simplified on-board system of a modified proximity fuze oscillator with a configured antenna pattern to give the maximum amount of amplitude modulation on the received signals when the projectile is spun.

The system consists of a standard 30 mm fuze RF oscillator, a loop antenna, and a battery. The oscillator and the antenna were mounted and secured in the nose of the projectile under a foam plastic windshield. The plastic windshield was used in order to simulate the weight of the 30 mm XM553 projectile. The frontal nose contour was kept the same as that of the 30 mm XM553 projectile shown in Figure 1.

The oscillator as seen in Figure 2 consists of a transistor that can deliver up to 50 milliwatts at 600 MHZ. The oscillator and the antenna were mounted on a steel ground plane in the projectile nose. A liquid reserve battery was installed on the rear side of the steel plane, and a setback force of 40,000 g was needed to initiate the battery which is capable of delivering power for a period of 60 seconds.

The loop antenna was positioned in a plane parallel to the axis of the projectile. Since a signal was transmitted from both the projectile's body and the loop antenna, the receiving antenna was oriented orthogonal to the projectile's axis in order to cross polarize the projectile's radiation and to pick up the loop radiation.

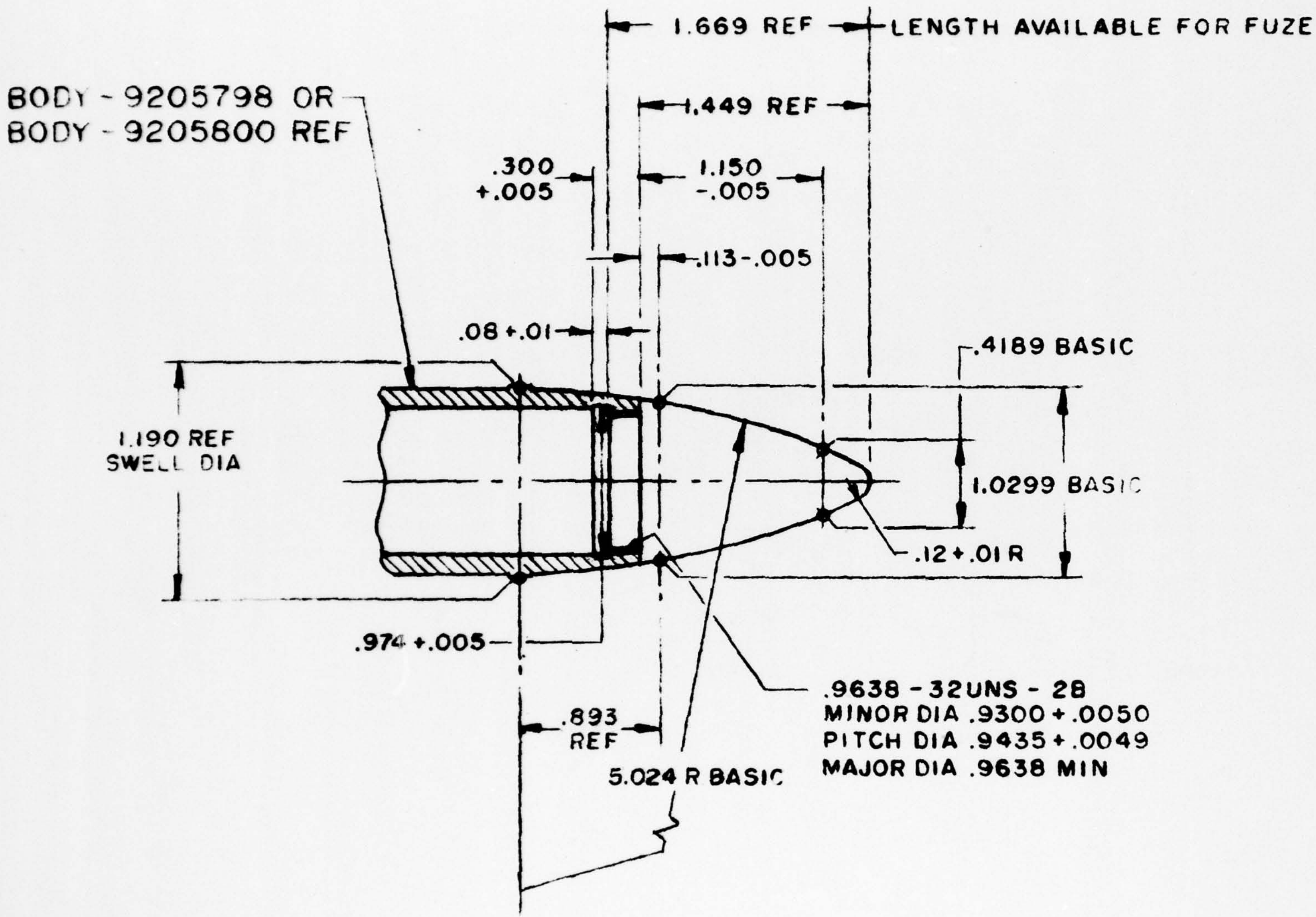

Figure 1. Diagram of the Nose of the 30 mm XM553 Projectile

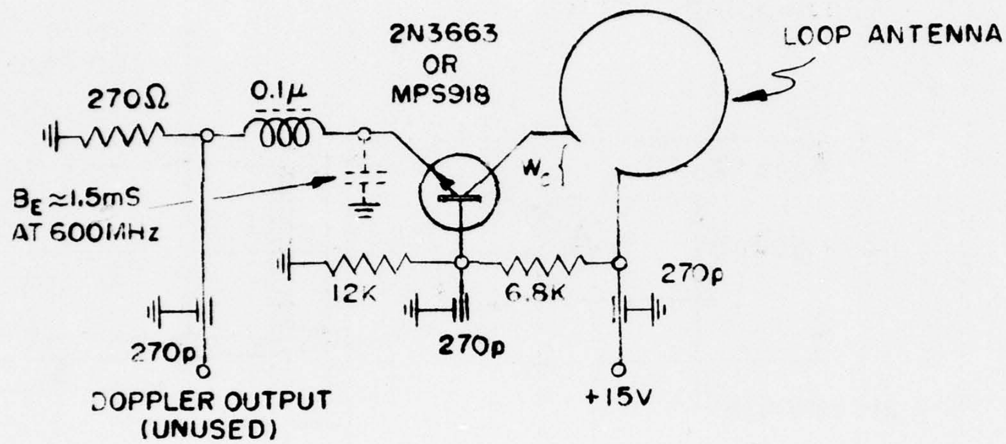

Figure 2. Schematic of the Oscillator Circuit

The transmission radio frequency of the Spinsonde was designed to be 470 MHZ to 600 MHZ in range to facilitate tracking by the two ground stations. Table 1 is a list of rounds fired in the approximate design frequency of each.

Table 1. 30 mm XM552 Firing Summary

ROUND NO.	APPROXIMATE DESIGN FREQUENCY (MHZ)	REMARKS
1	600	Good Signal
2	560	No Signal Pick Up
3	560	No Signal Pick Up
4	550	Good Signal
5	550	Good Signal
6	540	Good Signal
7	540	Good Signal
8	540	Good Signal
9	540	Good Signal
10	540	No Signal
11	540	No Signal
12	520	No Signal
13	520	No Signal
14	520	Good Signal
15	500	Good Signal
16	500	Good Signal
17	490	No Signal
18	490	No Signal
19	480	Good Signal
20	475	Good Signal
21	470	No Signal
22	475	No Signal

A receiving and recording station was set up close to the gun mount (main site) and another station consisting of the telemetry (Tm) wagon was located 4000 feet away from the first station. The main site included all the standard Tm receivers as well as equipment for demodulating and recording the signal. The signals were recorded on magnetic tape and then played back in disc recorder graphic print.

Twenty-two rounds of the modified 30 mm XM553 projectiles were fired at the U.S. Army Testing Facility, Hurrican Mesa, Utah. The rounds were fired from a quadrant elevation of 121 mils for an average flight time of 17 seconds. A standard 30 mm gun barrel with an exit angle of 4.73^{o} was employed for this testing. All of the rounds used the same charge weight and were of the same propellant lot. The test projectile's nose weight and load distribution as well as the overall projectile weight were kept the same as that of the 30 mm XM552 cartridge.

The information recorded during the firing were the following:

(a) Amplitude modulation of the received signal

(b) Time signal

(c) Receiver voltage

As expected, an initial signal delay of less than 50 milliseconds was experienced on all the rounds. The delay was required to initiate the reaction in the battery that supplied the power for the system.

DISCUSSION

Twenty-two rounds were fired, twelve of which produced good telemetry records. Recorded spin modulation was of a good quality and without any outside interference (i.e. noise) so that data reductions in .1 second increments were adequate for good spin rate readings.

Typical recorded data are shown in Table 2; here, Spinsonde measured data of the time in seconds and cyclic frequency in revolutions per second is presented.

Table 2. Typical Spinrate History for 30 mm XM553 Projectile

Round 1

Time (Sec)	Range (meters)	Measured Spin-Rate (Rev/sec)
0.000	0	581
0.0034	0	580
1.75	700	496
3.01	1110	460
4.01	1400	435
5.01	1620	407
6.01	1900	387
7.01	2100	370
8.01	2300	355
9.01	2500	334
10.01	2650	320
11.01	2800	308
12.01	2950	295
13.01	3150	285
14.01	3280	274
15.01	3420	265
16.01	3600	263

Table 2. Typical Spinrate History for 30 mm XM553 Projectile (Cont)

Round 6

Time (Sec)	Range (meters)	Measured Spin Rate (Rev/sec)
.000	0	581
.146	150	570
.446	292	570
1.146	522	535
2.146	873	506
3.146	1165	472
4.146	1432	440
5.146	1678	422
6.146	1908	403
7.046	2122	390
8.146	2322	373
9.146	2514	356
10.146	2693	340
11.146	2863	327
12.146	3000	313
13.146	3180	310
14.146	3350	292
15.146	3500	234
16.146	3650	276

Using the measured frequency for each round at t = 0, the muzzle velocity was determined. The following equations facilitated this calculation:

$$f = \frac{\omega}{2\pi}$$

$$\omega = \frac{2 V_i \tan \theta}{d}$$

where f = frequency, Rev./sec.
ω = angular velocity, Radians/sec
Vi = muzzle velocity, ft./sec.
θ = projectile exit angle, Radians
d = bore diameter, ft.

Results of this calculation for the individual rounds are summarized in Table 3. It is noted that the average calculated muzzle velocity for the test projectiles is 2179 ft./sec. while that for the standard 30 mm XM552 round is approximately 2200 ft./sec. at an average peak chamber pressure of 28,000 psi.

Figures 3 and 4 present the experimental, Spinsonde measured, data as compared to the theoretical predictions obtained utilizing the U.S. Army Spinner Computer Model. Spin rate in rev./sec. as a function of range in meters is shown in Figure 3. Here it is seen that the difference between the experimental and theoretical spin rates increases with range - for example, approximately 7, 13 and 22 percent differences exist at 1000, 2000 and 3000 meter, respectively. Figure 4 depicts spin rate in rev./sec. as a function of time in seconds. Once again the difference between the experimental and the theoretical results increases; spin rate varies by approximately 8, 14 and 22 percent at 4,8 and 12 seconds, respectively. Since considerable differences exist between the measured and the predicted results, the U.S. Army Spinner Computer Model does not represent an adequate method of determining the spin rates for automatic cannon caliber projectiles.

Table 3. Data Tabulations

Round No.	Frequency (rev/sec)	Angular Velocity (rad/sec)	Exit Angle (deg.)	Muzzle Velocity (ft/sec)
1	581	3650	4.73	2170
4	544	3419	4.73	2032
5	592	3720	4.73	2211
6	581	3650	4.73	2170
7	593	3726	4.73	2215
8	580	3644	4.73	2166
9	593	3726	4.73	2215
14	588	3694	4.73	2196
15	588	3694	4.73	2196
16	587	3688	4.73	2192
19	585	3676	4.73	2185
20	590	3707	4.73	2204

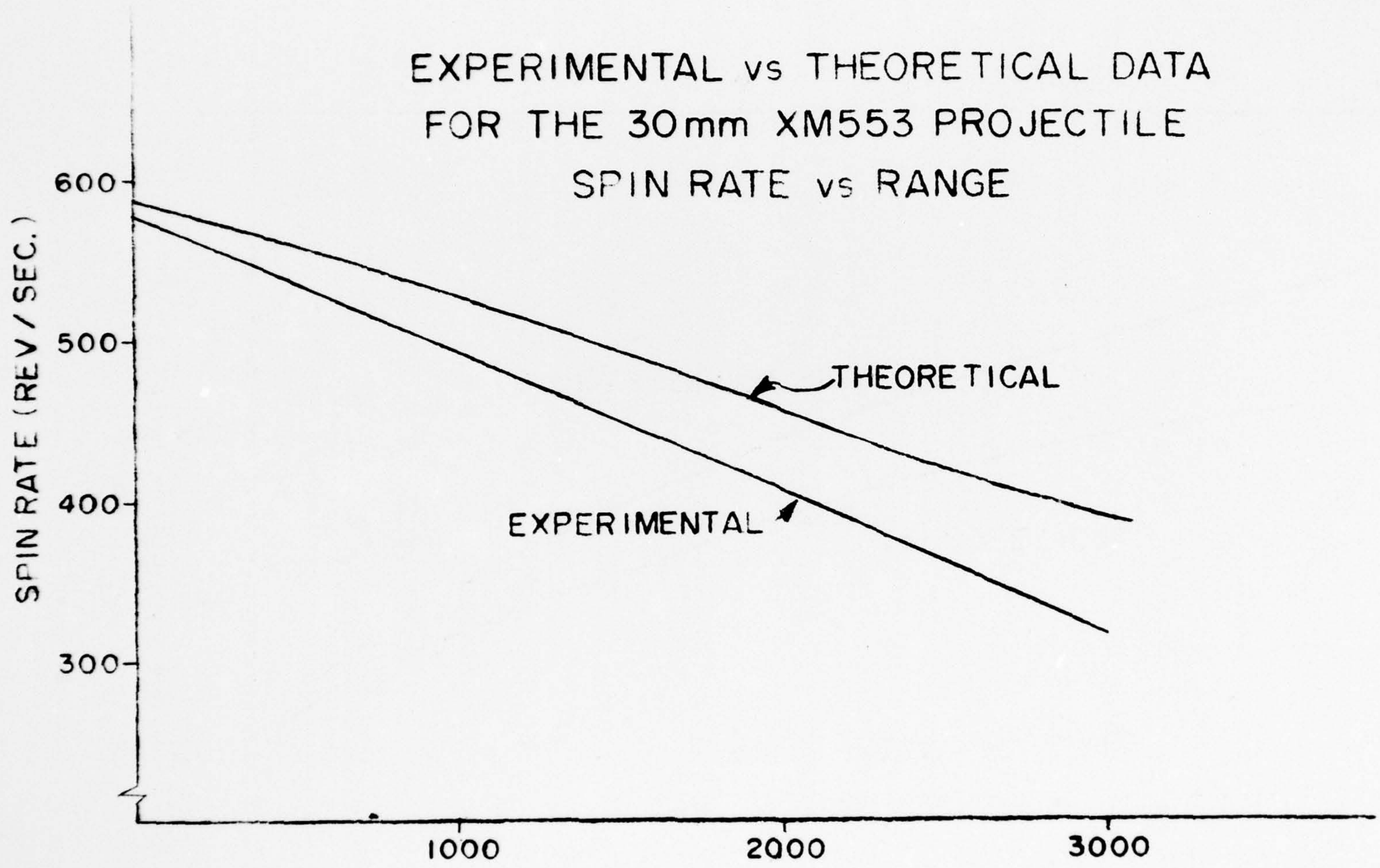

Figure 3. Range (Meters)

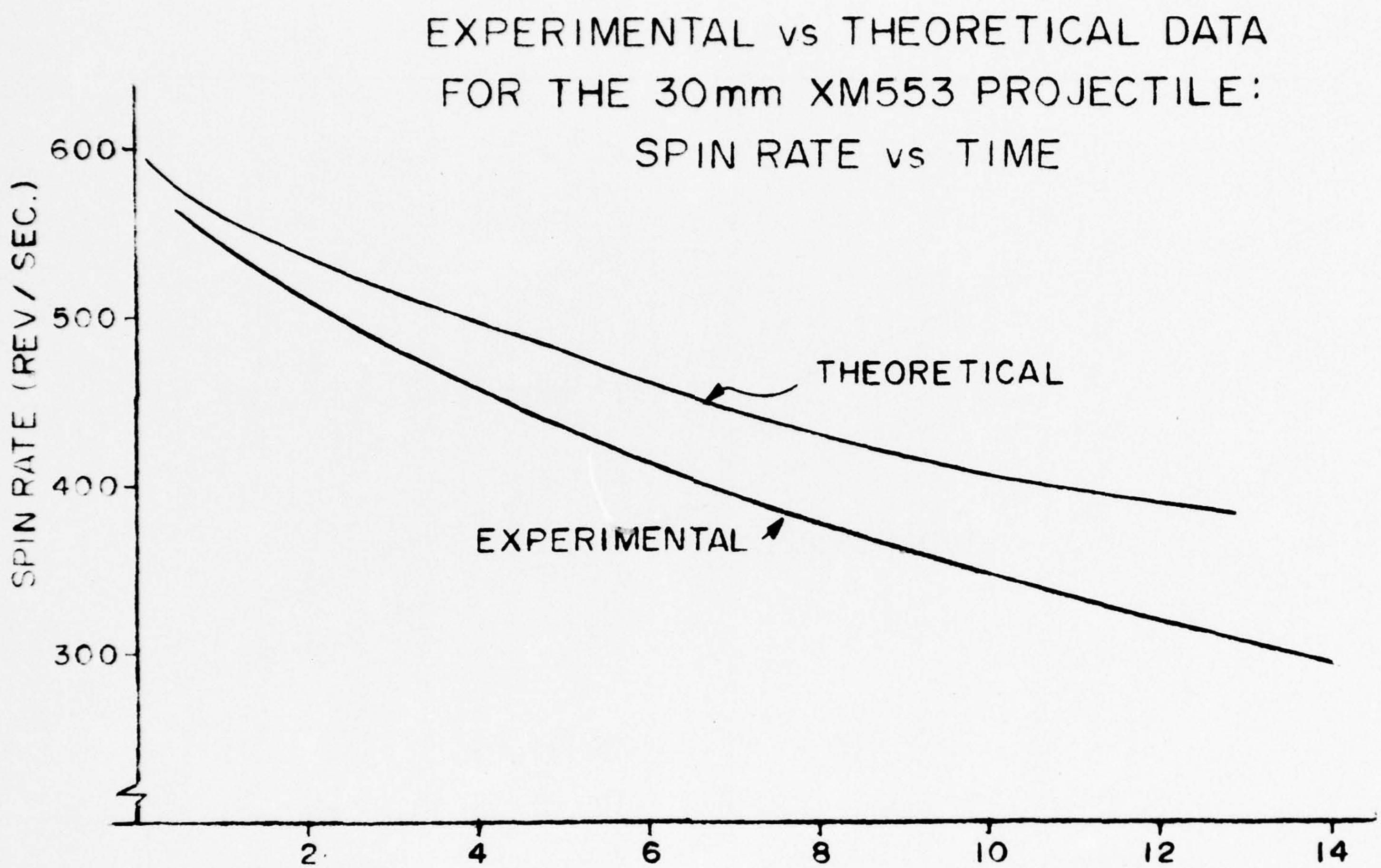

Figure 4. Time (Sec.)

CONCLUSIONS AND RECOMMENDATIONS

As a result of the tests, it is concluded that:

(a) Spin decay was successfully recorded and measured for the 30 mm HEDP XM552 round.

(b) A discrepancy of up to 22 percent at 3000 meters exists between experimental test firings using Spinsonde and theoretical prediction utilizing the U.S. Army Spinner Computer Model.

It is recommended that further investigation be conducted to develop a method or computer model to predict spin rates for the medium caliber range (20-40 mm).

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