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Blast Pressures Recorded During Launching of 5-inch High-Velocity Aircraft Rockets from A Type PV-2 Naval Patrol Bomber
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Measurements were made, in flight, of the blast pressures imposed on aircraft by the launching of 5-inch high-velocity aircraft rockets. The rockets were fired from a zero-length launcher under the wing of a PV-2 Naval patrol bomber, and pressure-time records were obtained with a capacity-type gage and an electronic recording system. Similarities and differences between flight-launching, ground-launching, and static firing records are discussed. The flight-launching data are analyzed. Additional flight tests are required in order to establish whether it will be possible to obtain the required pressure and frequency data for flight launching by suitable adjustment of data obtained during ground launchings.

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Ordnance and Armament (22)
Rockets and Launchers (10)

Rockets - Launching from aircraft (82705)

C-22-10

NAVY DEPARTMENT
DAVID TAYLOR MODEL BASIN
WASHINGTON, D.C.

BLAST PRESSURES RECORDED DURING LAUNCHING OF 5-INCH HIGH-VELOCITY AIRCRAFT ROCKETS FROM A TYPE PV-2 NAVAL PATROL BOMBER

by

Thomas A. Perls, Ph.D.

17

May 1948

Report C-93

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ABSTRACT

In this report are presented the data from what are believed to be the first records ever obtained of the pressures behind 5-inch high-velocity aircraft rockets launched from an aircraft in flight. Similarities and differences are brought out between flight-launching, ground-launching, and static-firing records. Additional flight tests are required in order to establish whether it will be possible to obtain the required pressure and frequency data for flight launchings by suitable adjustment of data obtained during ground launchings.

INTRODUCTION

The David Taylor Model Basin is engaged in the concluding stages of developing instrumentation for the measurement, in flight, of blast pressures imposed on aircraft by the firing of aircraft rockets. This work is being done at the request of the Bureau of Aeronautics (1)* under BuAer Project TED-TMB-2406, BuShips Symbol E-241.

This instrumentation has been tested during static firing of 5-inch high-velocity aircraft rockets, HVAR's, at the Naval Powder Factory, Indian Head, Maryland, and during flight launching at the Naval Ordnance Test Station, Inyokern, California. Blast pressures recorded during firing of 5-inch HVAR's from a Type PV-2 aircraft in flight are discussed in this report and are compared with similar data obtained in static-firing and ground-launching tests (2).

TEST APPARATUS

In the flight tests conducted at the Naval Ordnance Test Station, Inyokern, California, 5-inch HVAR's were fired from a "zero length" launcher under the wing of a Type PV-2 naval patrol bomber.

Pressure-time records were obtained with a capacity-type gage (3) and an electronic recording system (4) operating on the same principle as the equipment used for similar measurements during ground launching of 5-inch HVAR's (2). The instrumentation had been modified to make it airborne and to extend its uniformity of response to cover the range from zero to approximately 20,000 CPS while maintaining negligible sensitivity to heat and acceleration as well as negligible microphonics and cable signal.

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* Numbers in parentheses indicate references on page 4.

The gage was mounted in a panel under the wing of the aircraft as shown in Figure 1. The sensitive face of the gage was flush with the outside face of the panel and was protected against excessive heat from the rocket flame by an 80-mesh cooper screen.* Figure 2 shows the position of the gage with respect to the rocket nozzles.

The two main electronic units were mounted on standard ARC-1 racks in the cabin of the plane as shown in Figure 3, together with the remote-control unit which makes it possible to operate this equipment at distances up to 50 feet from the two main units. Remote operation might be necessary, for instance, if the instrumentation were used in a fighter plane and had to be operated by the pilot.

TEST RESULTS

Six records were obtained at the gage location shown in Figure 2. The significant portion of one, Record C, is shown in Figure 4, which includes the entire time history of the blast pressure up to the point where the rocket has left the launcher and has gone a sufficient distance to make the blast pressures at the gage very small. The pertinent data from these six records are assembled in Table 1 which also includes, for comparison, the averages and ranges of similar data for both ground launching (2) and static firing of 5-inch HVAR's.

ANALYSIS OF DATA

The data shown in Table 1 and Figure 4 will be analyzed according to the five time phases established in Reference (2).

1. The initial short positive pulse has a pressure amplitude which is, in general, at least 1/3 smaller in flight launching than in ground launching or static firing. Its duration and general shape are subject to considerable variations and the duration differences apparent in Table 1 cannot be taken as significant without additional data.

2. The next phase, previously designated as the negative pulse, has not been entered in Table 1 because it does not consistently occur immediately after the positive pulse, as in Figure 4. In several of the recent records, in both static firing and flight launching, a pronounced negative pulse has been observed the duration of which is comparable to the initial positive pulse. This negative pulse occurs between 10 and 30 milliseconds after the start of the record.

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* Static-firing tests conducted at the Naval Powder Factory, Indian Head, Maryland, had shown that any effect of this screen on the recorded pressures was negligible in comparison with the random variations from one rocket to another.

3. The phase of high-frequency, low-amplitude oscillations is shortest for static firing, somewhat longer for ground launching, and longest for flight launching (in Figure 2 it occurs in the time interval from 2 to 95 milliseconds after the start of the record.)

4. The phase of low-frequency, large-amplitude fluctuations is definite in only about 75 per cent of the records. Its frequency has very little spread for each of the three types of records. Its amplitude is approximately the same for static firing and ground launching but is over 30 per cent lower for flight firing.

5. The tapering off of the pressure variations takes place in a similar manner in all records. The total duration of the record, however, equals the entire burning time (about 1.1 second) of the rocket for static firing but is less than 0.2 second when the rocket is launched; it was consistently about 15 per cent smaller on the ground than it was in flight.

DISCUSSION OF RESULTS

A comparison of the data in Table 1 from static firing, ground launching, and flight launching of 5-inch HVAR's shows that the following features appear consistently:

1. The pressures recorded for flight launching are considerably lower than those recorded for the other two types of firing. However, the individual effects of altitude, temperature, and air speed cannot be separated on the basis of the records obtained to date.

2. The frequency recorded in the low-frequency, large-amplitude pressure fluctuations does not seem to be sensitive to altitude, since very nearly the same values were obtained at ground level at Indian Head, Maryland, and Inyokern, California, in spite of the difference in altitude of more than 2000 feet. It is reasonable to assume that the cause of the large difference in frequency observed in flight firing will be found by a systematic investigation of the effects of temperature and air speed.

3. The duration of the records obtained in flight launching was greater than for ground launching, and the low-frequency fluctuations appeared at a somewhat later time on the flight record. This indicates that the rocket is slower in leaving the plane than in leaving a ground launching stand, presumably because of increased velocity-dependent resistance to its motion when launched from a plane.

CONCLUSIONS AND RECOMMENDATIONS

Certain similarities and differences have been brought out between ground- and flight-launching records of 5-inch HVAR's. It is apparent that a considerable number of additional flight launchings should be made under controlled conditions of temperature, altitude, and air speed. It should then be possible to determine the effects of these parameters on the observed pressures and frequencies. When this is done for several types of aircraft rockets, it may be possible to realize the hope expressed in the authorizing letter (1) for this project to deduce from blast records of rockets launched on the ground the pressures and frequencies that would be present had the rocket been fired in flight, at a given temperature, altitude, and air speed.

The significance of the reported data in terms of the effect of rocket blast on airplane structures can best be decided by designers of planes. The scantiness of the data has already been emphasized. It should be noted, however, that the data indicate a possible decrease with increasing air speed of the frequency associated with the phase of large-amplitude pressure fluctuations. If this trend is confirmed in tests at higher air speeds, it is possible that the frequency of these fluctuations might fall in the range of frequencies associated with airplane structures, and a critical condition might then result.

REFERENCES

(1) BuAer CONFIDENTIAL letter Aer-E-2411-RAC of 2 December 1944 to BuShips.

(2) "Blast Pressures Recorded during Ground Launching of 5-Inch High-Velocity Aircraft Rockets" by Thomas A. Perls, Ph.D., TMB CONFIDENTIAL Report C-54, January 1948.

(3) The TMB Condenser-Type Pressure Gage, by Thomas A. Perls, Ph.D., TMB Report 625, in preparation.

(4) "A Resonant-Bridge Carrier System for the Measurement of Minute Changes in Capacitance," by George W. Cook, TMB Report 626, in preparation.

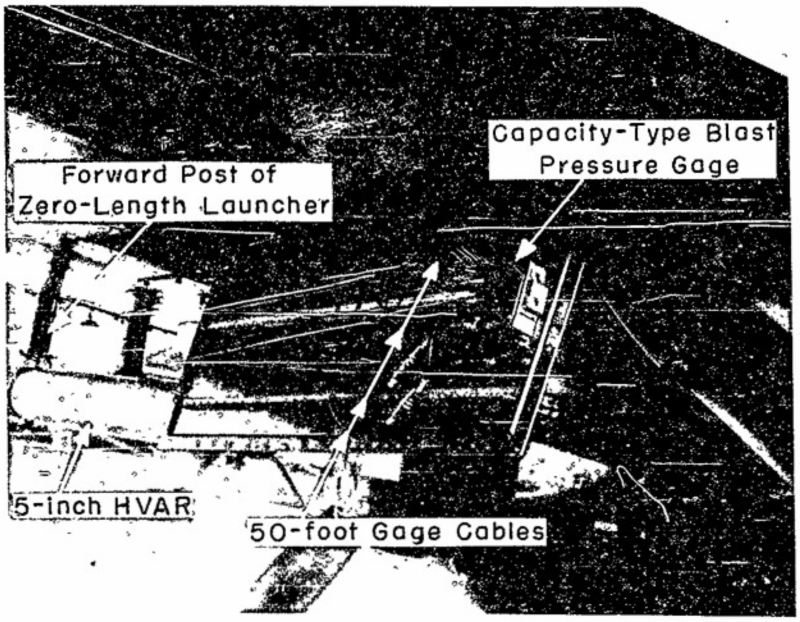

Figure 1 - Capacity-Type Blast Pressure Gage Mounted in a Panel under the Wing of a Type PV-2 Aircraft

The panel in which the gage was mounted is open to show the body of the gage and the cables leading to the associated electronic equipment.

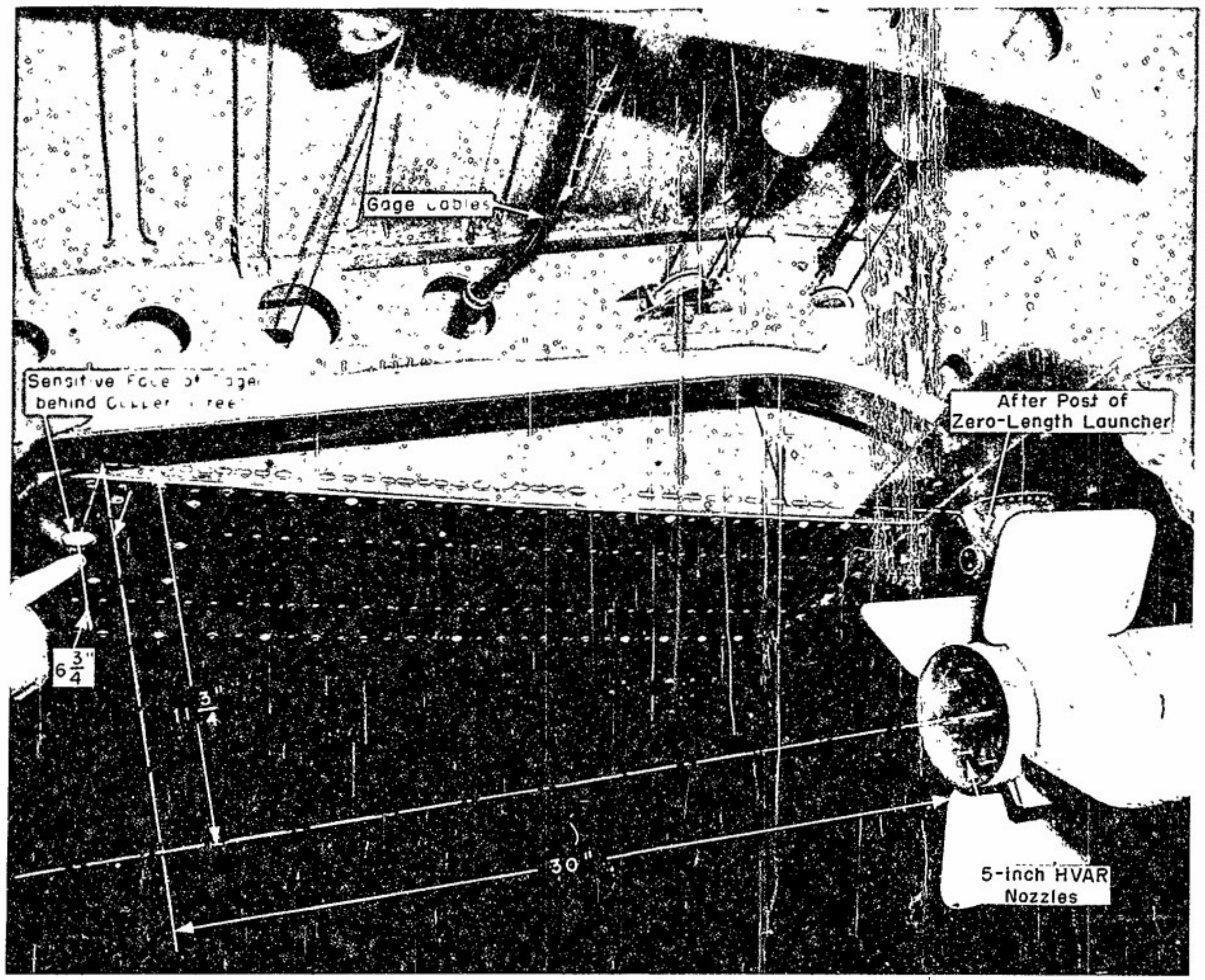

Figure 2 - Capacity Type Blast Pressure Gage in Test Position

View taken under the wing looking toward wing tip.

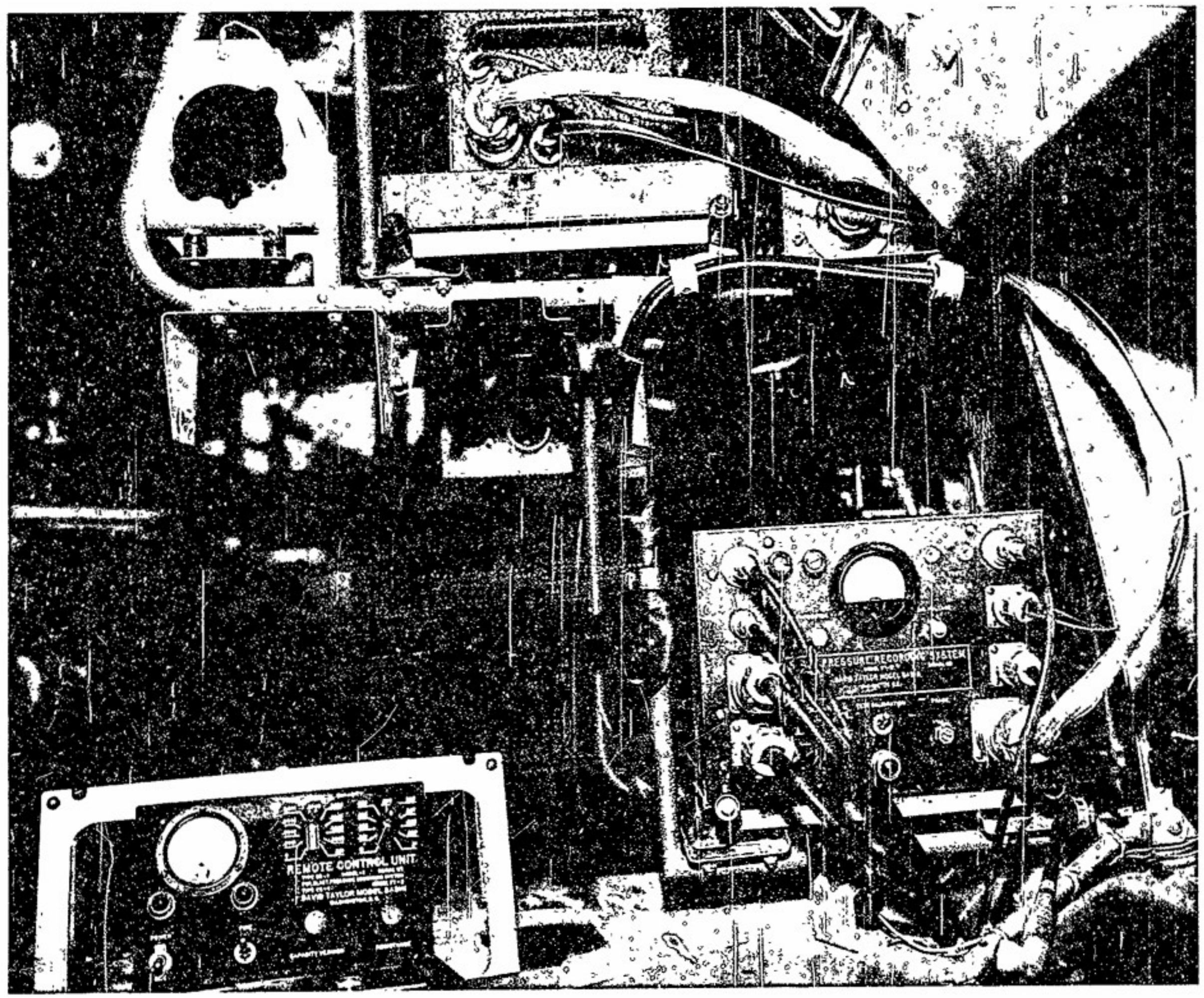

Figure 3 - Blast Pressure Recording System with Camera Unit and Remote-Control Unit Mounted in the Cabin of a Type PV-2 Aircraft

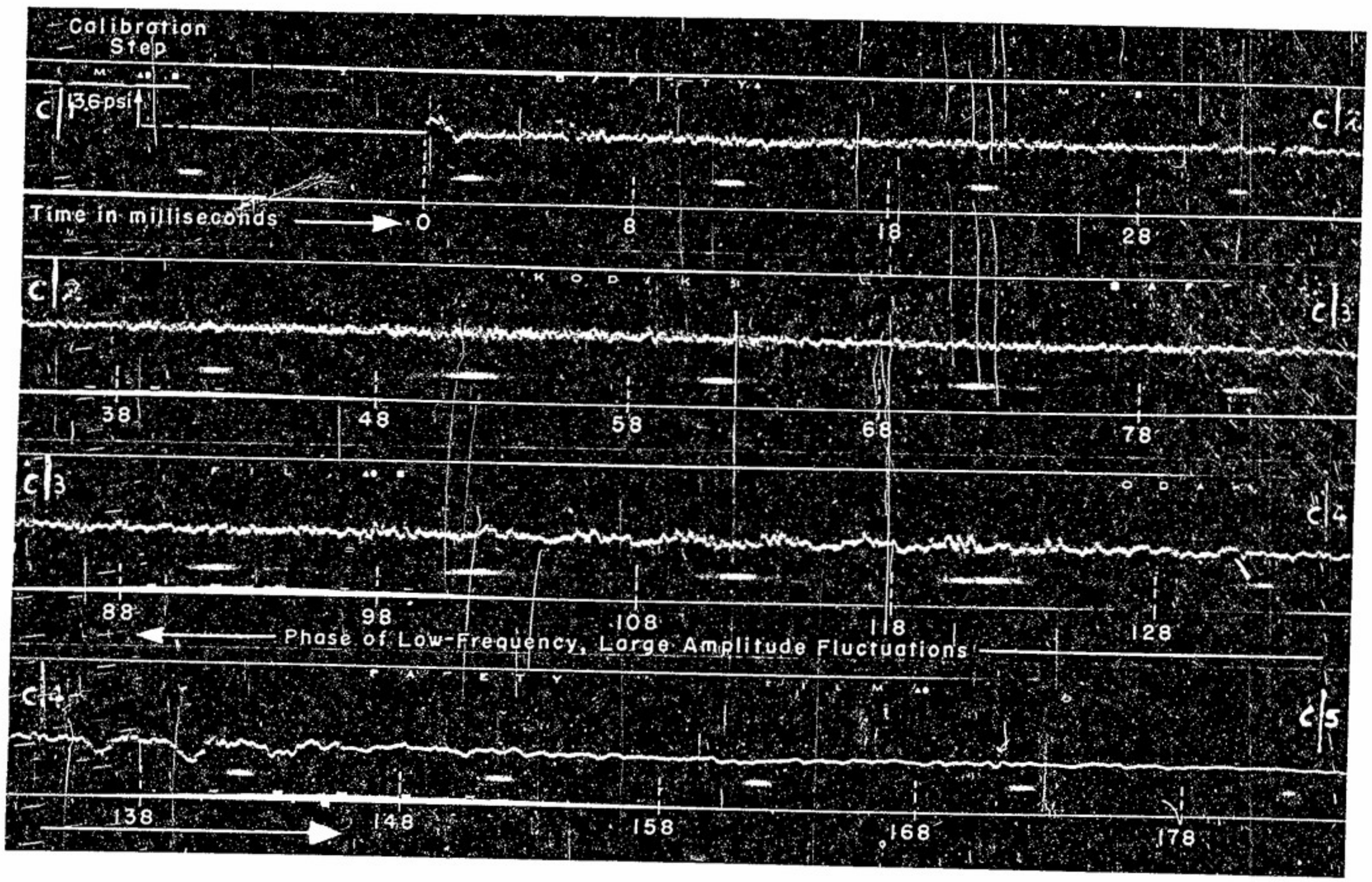

Figure 4 - Typical Pressure-Time Record Taken, in Flight, of the Blast behind a 5-Inch HVAR

Table 1 - Pressure Data from Firing of Five Inch HVAR's

Record	Gage Distances inches	Altitude above Sea Level feet	Temperature degrees Centigrade	Indicated Air Speed knots	Peak Pressure in Initial Positive Phase lb/in²	Duration of Initial Positive Phase ms	Phase of Periodic Pressure Fluctuations: Time Interval* ms	Phase of Periodic Pressure Fluctuations: Frequency CPS	Phase of Periodic Pressure Fluctuations: Maximum Peak-to-Peak Value** lb/in²	Total Duration of significant Record seconds
A	See Fig.2	10,000	0	170	10.1	0.61	100-125	282	8.2	0.18
B	See Fig.2	10,000	0	175	6.4	0.79	95-120	274	7.5	0.19
C	See Fig.2	10,000	0	165	5.6	0.94	95-145	278	11.8	0.19
D	See Fig.2	10,000	0	175	5.1	1.22	Not Definite		5.9	0.20
E	See Fig.2	9,000	0	170	7.5	0.92	Not Definite		7.0	0.20
F	See Fig.2	8,000	0	165	9.4	0.90	100-150	287	12.5	0.20
Average of A,B,C,D, E,F.	See Fig.2	9,500	0	170	7.3	0.90	95-135	280	8.8	0.19
Range of Values from Ref.(2)	†				9.0 to 15.1	0.48 to 0.80	65-95 to 75-105	410 to 445	11.4 to 15.3	0.15 to 0.17
Average of 2,3,4,5, Table 1, Ref.(2) (Ground Launching)	See Ref. (2)	2,200 (Ground Level)			11.0	0.69	70-95	423	13.1	0.16
Range of Values from Static Firing	All records taken at same position				8.8 to 16.1	1.08 to 2.25	Starts between 39 and 72	399 to 431	8.5 to 13.0	
Average of Static Firing ††	30 in. aft 9 1/2 in. off axis	30	21		12.1	1.54	Starts at 52+	410	9.8	++

*All times were measured from the start of the record.

**The peak-to-peak value of the low-frequency component of these fluctuations is on the average 50 per cent of the values given.

†The gage was located 12 to 30 inches aft of the rocket nozzles and 9.5 to 14 inches off the axis.

††These are the averages of seven records obtained at the Naval Powder Factory, Indian Head, Maryland.

+The low-frequency fluctuations fade out several times over small time intervals but occur up to the end of the record.

++The time was not measured but was approximately 1.1 second.

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