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Report 4337

LANDING CRAFT SHOCK ABSORBER MEASUREMENTS

18

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Bethesda, Md. 20084

12

LANDING CRAFT SHOCK

ABSORBER MEASUREMENTS

by

K. G. Morris

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STRUCTURES DEPARTMENT
UNDERWATER EXPLOSIONS RESEARCH DIVISION
PORTSMOUTH, VIRGINIA
RESEARCH AND DEVELOPMENT REPORT

December 1974

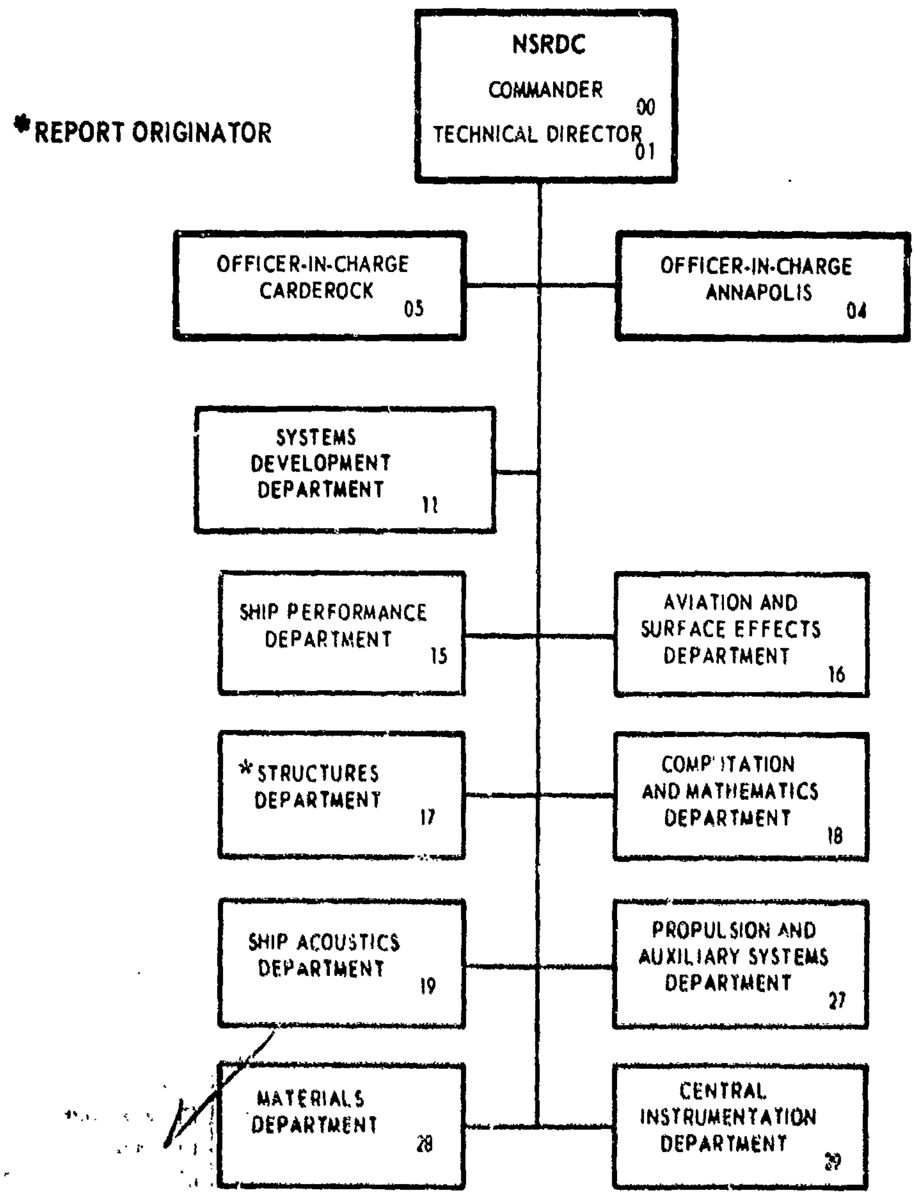
Report 4337

The Naval Ship Research and Development Center is a U. S. Navy center for laboratory effort directed at achieving improved sea and air vehicles. It was formed in March 1967 by merging the David Taylor Model Basin at Carderock, Maryland with the Marine Engineering Laboratory at Annapolis, Maryland.

Naval Ship Research and Development Center

Bethesda, Md. 20084

MAJOR NSRDC ORGANIZATIONAL COMPONENTS



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Trials were conducted in July and August 1974 to study the response of an aircraft nose-wheel assembly when mounted as a protective fender on a landing craft. Under the sponsorship of the Office of Naval Research, the Underwater Explosions Research Division of the Naval Ship Research and Development Center provided instrumentation and data processing services required to measure forces and motions produced during operations of a landing craft alongside a larger vessel. This report provides the experimental data obtained during the trials.

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ABSTRACT

Trials were conducted in July and August 1974 to study the response of an aircraft nose-wheel assembly when mounted as a protective fender on a landing craft. Under the sponsorship of the Office of Naval Research, the Underwater Explosions Research Division of the Naval Ship Research and Development Center provided instrumentation and data processing services required to measure forces and motions produced during operations of a landing craft alongside a larger vessel. This report provides the experimental data obtained during the trials.

ADMINISTRATIVE INFORMATION

The work described in this report was authorized and funded during Fiscal Year 1975 by the Office of Naval Research under Project Order 4-0287, Work Unit 1 1773-480.

INTRODUCTION

The Amphibious Force, Atlantic Fleet, and the Office of Naval Research (ONR) conducted a series of trials in 1974 to study the feasibility of using shock absorbing devices as protective fenders on landing craft. The operational success of such devices could extend the capability of these craft to operate alongside or within larger vessels in higher states of sea.

Initial trials were directed toward preliminary evaluation, on several types of landing craft, of various aircraft nose-wheel assemblies as the shock-absorbing devices. The effectiveness during these trials of the nose-wheel assembly indicated the need for further evaluation to determine the shock loading and response of the aircraft landing gear.

The Center proposed to ONR that dynamic measurements of the axial forces encountered by a shock absorber and of the motions with which it responds would help determine the adequacy the installation and would provide, if necessary, a basis for extrapolating this principle to other designs.

As a result of the proposal, instrumentation was included in the trials conducted in July and August of this year. For these trials, Dr. Allyn Vine of Woods Hole Oceanographic Institute supervised the selection and installation of two Bendix aircraft nose-wheel assemblies (Model M-763) on an LCM-6 (mechanized landing craft). One of the assemblies was installed forward and one aft so as to extend horizontally from the portside of the craft. The Center provided the instrumentation and data-processing services required to measure the forces and motions encountered by the forward assembly during impact with the side of a larger vessel. The installed forward assembly can be seen in Figure 1. The assembly during impact is shown in Figure 2.

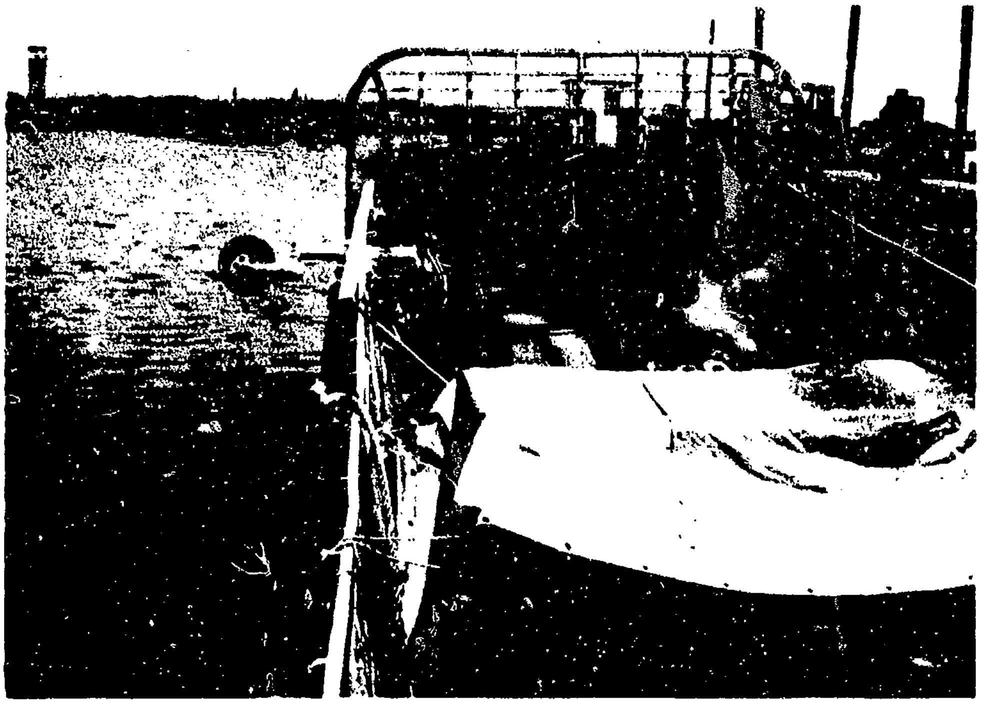

Figure 1 - Nose-Wheel Assembly Installation

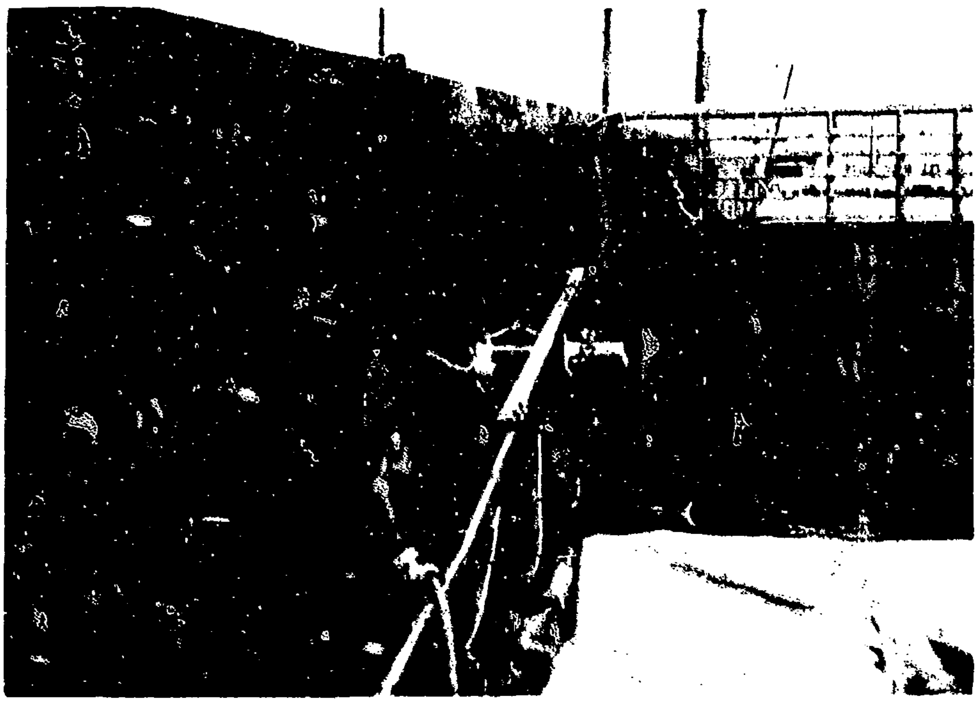

Figure 2 - Impact of Nose-Wheel Assembly With Dock Landing Ship

Operations were conducted alongside a moored dock landing ship (LSD) in the Little Creek Amphibious Base, Norfolk, and alongside an LSD anchored in the Chesapeake Bay off Cape Henry.

The purpose of this report is to describe the force and motion measurement system and to present the data histories obtained.

MEASUREMENT SYSTEM

The instrumentation measurement requirements for each test comprised three channels of loading and response data dynamically recorded on an oscillograph, located in the landing craft. Parameters recorded during impact of the strut (nose-wheel assembly) were axial strut force, horizontal acceleration of the foundation, and displacement of the hydraulic ram.

Axial force measurements were obtained by incorporating a force gage consisting of two strain-gaged, 3/4-inch-diameter steel studs into the attachment of the strut to the landing craft. The instrumented strut was installed on the craft so that the studs were subjected to negligible lateral and vertical forces. Axial forces, however, would be transmitted and therefore sensed by the force gage. The force gage installation is shown in Figure 3.

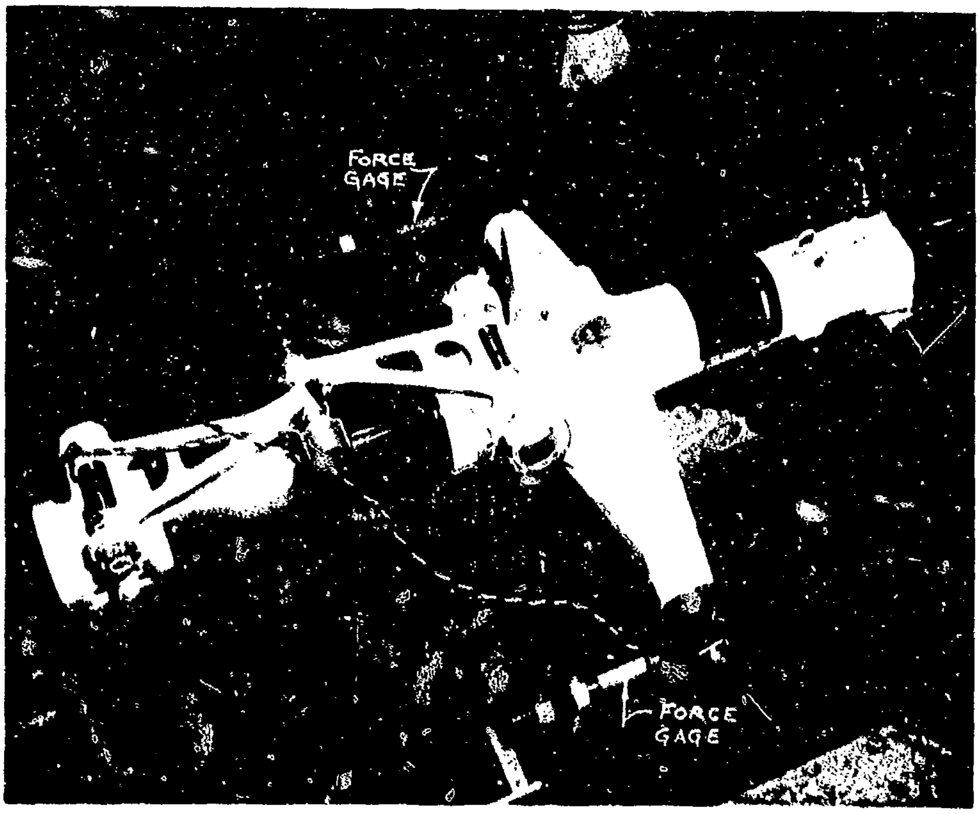

Figure 3 - Force Gage Installation

Each of the two studs in the force gage had two axial strain gages connected as a series pair, to compensate for bending, and two circumferential strain gages connected as a series pair, to provide temperature compensation as well as a slight increase in sensitivity. The instrumented studs are shown in Figure 4. The two pairs of gages on each stud were connected to form a half-bridge network and, in turn, the two half-bridge networks were connected as a full bridge. The two-stud, full-bridge force measurement system was calibrated with a hydraulic jack and an accurate pressure gage.

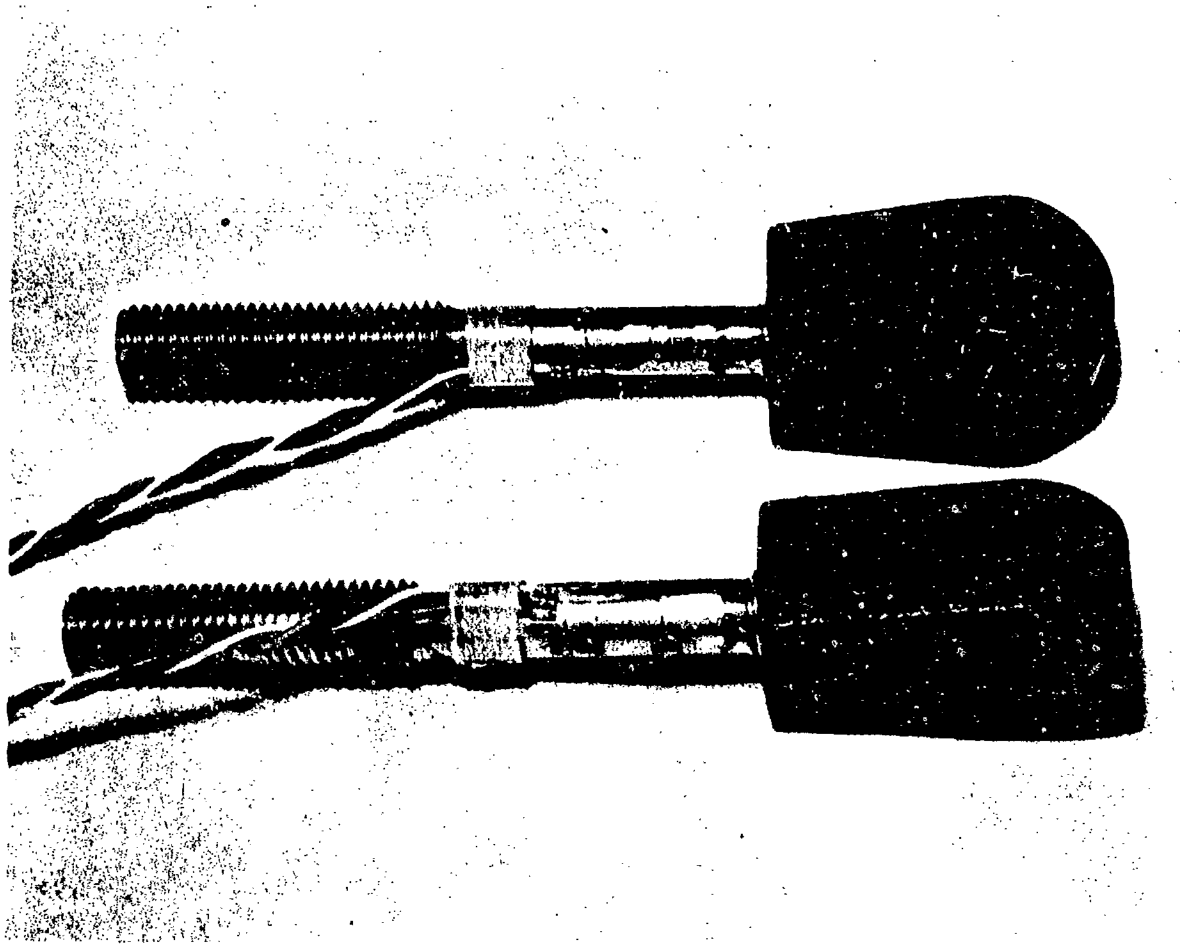

Figure 4 - Force Gage Studs

An angular displacement transducer was installed at the pivot point on the strut torque arms as shown in Figure 5. This transducer was a potentiometer calibrated in volts per degree of rotation so that the output voltage represented the change in angle between torque arms.

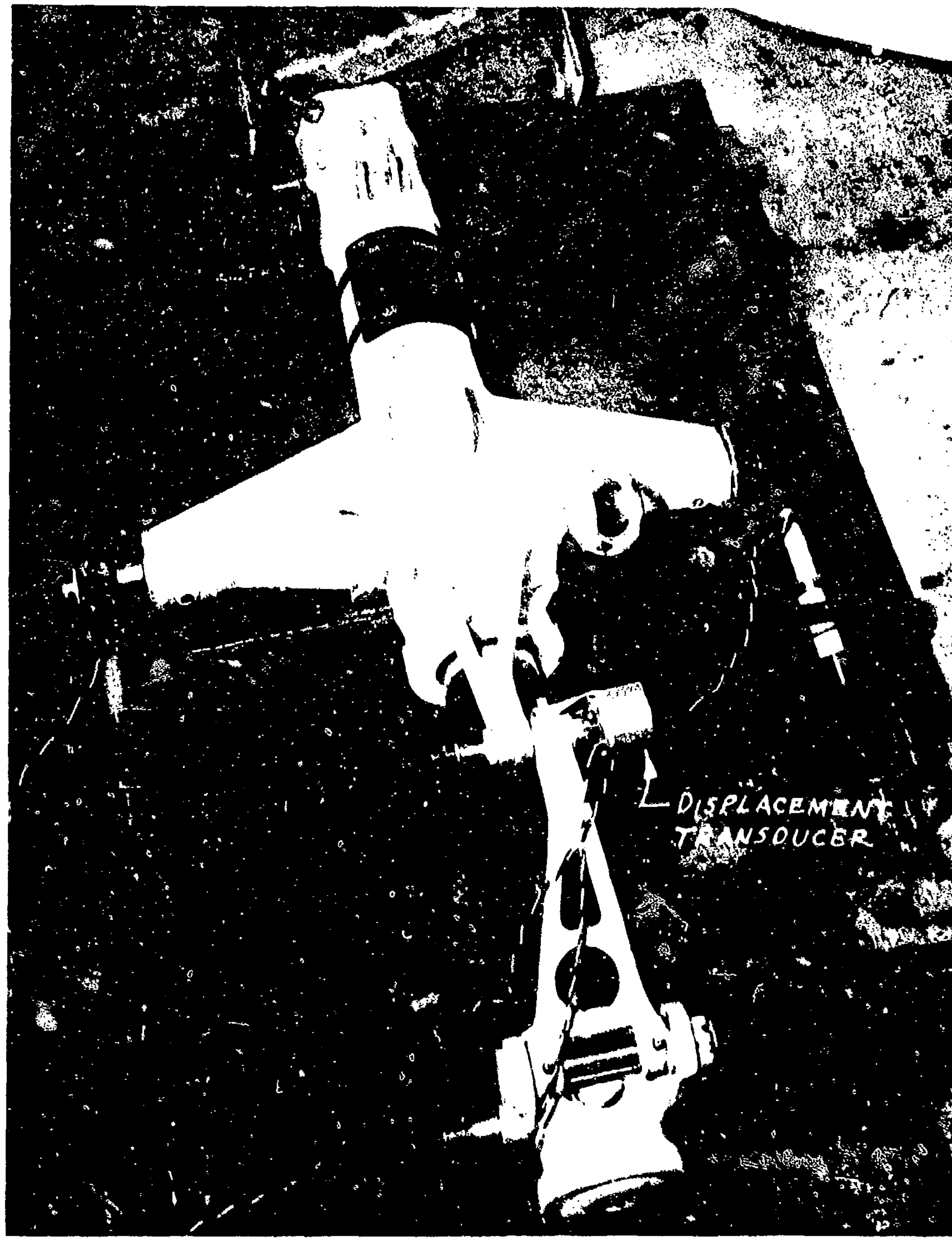

Figure 5 - Displacement Transducer Installation

The horizontal acceleration of the landing craft at the point of strut attachment was measured, using a Kistler Instrument Corporation Model 303B accelerometer. One volt of output represented 5 g's of horizontal acceleration. Figure 6 shows the accelerometer foundation.

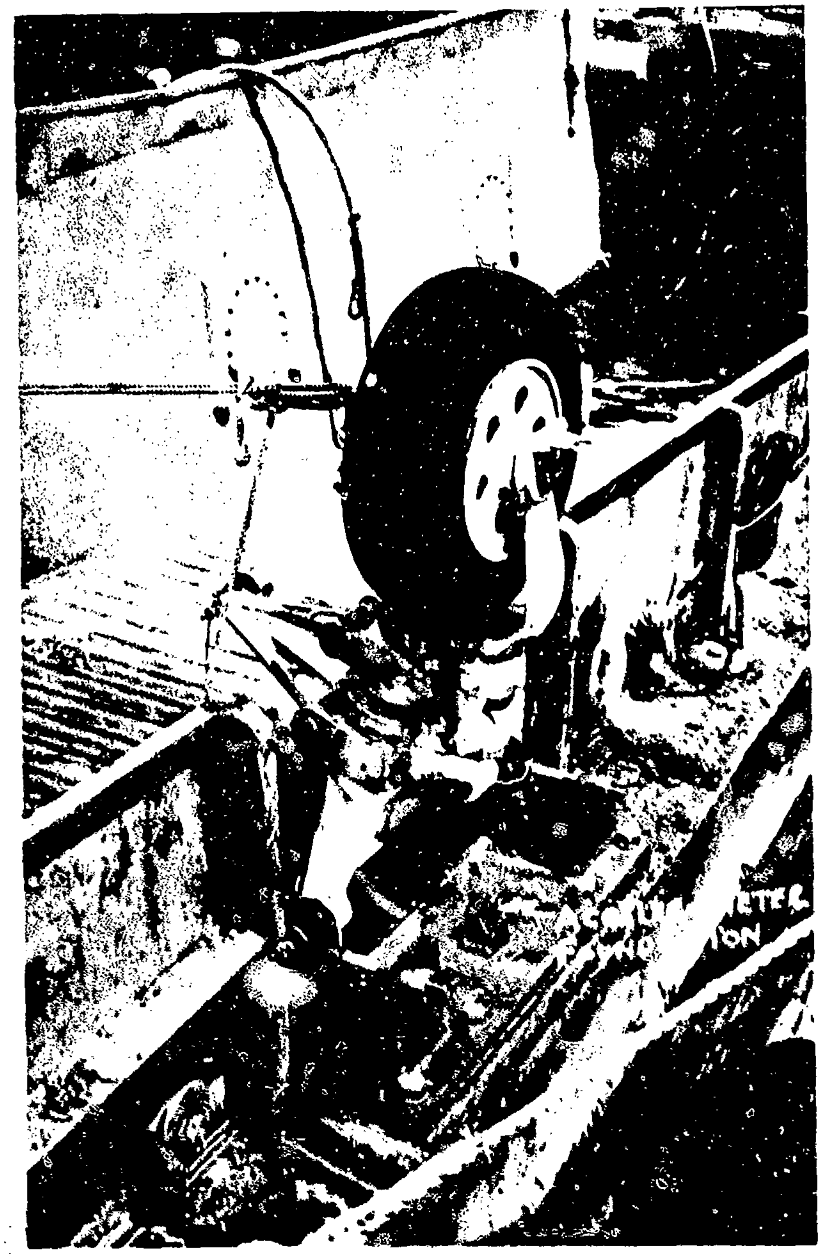

Figure 6 - Nose-Wheel Assembly in Stowed Position

All transducers were connected via shielded cable to signal conditioning and recording equipment, located in the well of the craft. The signal conditioning and recording equipment was assembled into two portable units that received operating power from a portable gasoline generator.

All recordings were produced on a Minneapolis Honeywell Model 906 visicorder oscillograph, using a paper speed of 5 inches per second. Heiland Type V-1000D fluid damped galvanometers which have a nominal undamped natural frequency of 1000 Hz were used.

Signal conditioning and channel calibration were provided by a Center Type 585 bridge amplifier. The force transducer channel was calibrated with precision resistors shunted across one leg of the full bridge so as to provide a change in output voltage calculated to be equivalent to the voltage produced by a known force applied to the transducer. The displacement and acceleration transducers were calibrated, using a voltage substitution method. In each case the calibration was applied to the signal-conditioning equipment so that the channel, with the exception of the transducer, was calibrated before recording.

All oscillograph recordings had a 60-Hz timing signal which was derived from the a-c power generator and was displayed as one channel of the data.

DATA PROCESSING

Twenty-one runs were made during the trials. A run is defined as an approach of the landing craft to impact the side of the large vessel. The runs have been numbered in the order in which they were made. The first 15 runs were recorded while operating in the Chesapeake Bay area, and the remaining runs were made in Little Creek Harbor. During some runs, the strut impacted more than once. Letter suffixes have been added to these run numbers to indicate additional impacts.

All transducers and recording equipment functioned properly during the trials, and data were successfully recorded for each measurement attempt. Recordings were made on light-sensitive oscillograph paper so that the measured parameters were traced with respect to time. Data recorded during the trials were later plotted to convenient scales at the Center. A pantograph and x-y recorder were used to transform the original oscillograph tracings into graphical form. All plotted data have been presented in the appendix. Data presented in the appendix do not include measurements made during several very mild impacts which did not produce enough force to compress the strut.

There are two pages of plotted data for each impact. Force and torque arm displacement are both plotted on the same sheet to facilitate comparison. Acceleration is plotted separately. All data for a particular impact are time correlated. The acceleration history, therefore, may be compared with the force and displacement plots having the same run number.

All data were recorded and reproduced so as to maintain consistent polarity. A positive displacement was defined as a contraction of the ram. The fully extended ram had a 150-degree angle between its torque arms; when contracted, it had a 36-degree angle between arms. These 114 degrees of angular change represent a ram displacement of 11.2 inches. An equivalent displacement plot is provided in Figure 7 to facilitate conversion of the angular degrees between torque arms to equivalent ram displacement in inches.

DISCUSSION

The high-frequency oscillations apparent on accelerometer tracings are the result of local vibrations that produced accelerations much higher than the response data of interest. The force gage, however, provides an indication of the impact accelerations.

Force and displacement plots show a variation in the force required to initiate movement of the ram for different impacts. This variation in initiating force seems to be related to the preload condition of the strut. The fluid-filled cylinder was pressurized with 100 psi of nitrogen for the first three runs and was increased to 200 psi for runs 4 through 16. Runs 17 through 21 had 180 psi of nitrogen in the cylinder. The average force required to initiate movement of the ram for the three different cylinder pressures was 1350, 1850 and 1700 pounds, respectively.

The state of sea during the trial was practically zero in both the Chesapeake Bay and Little Creek areas. The results, therefore, do not reflect the more severe conditions under which landing craft may have to operate. However, several relatively hard impacts were recorded, providing data that may be useful in estimating the forces and motion expected under more severe sea conditions.

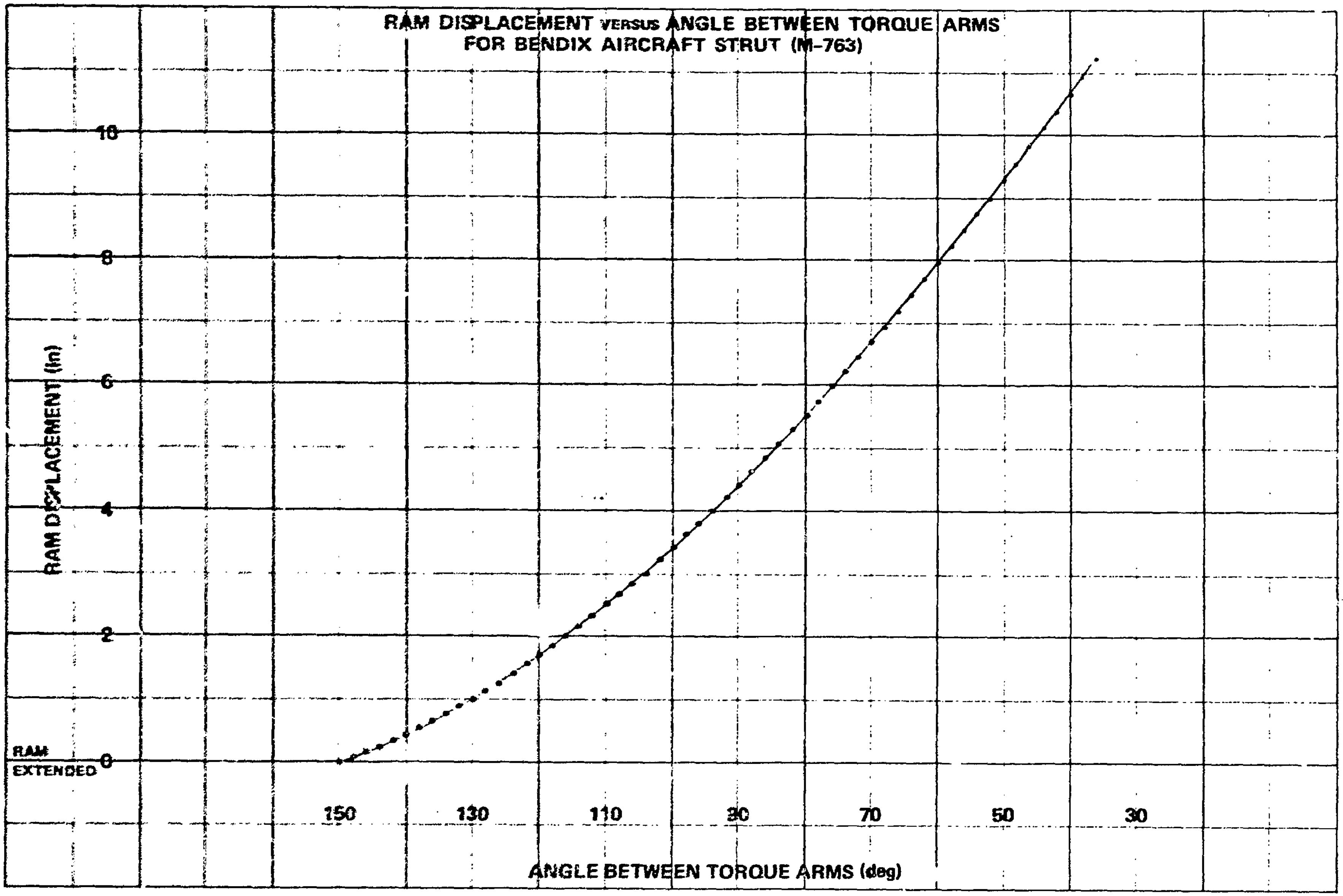

Figure 7 - Equivalent Angular and Linear Displacements

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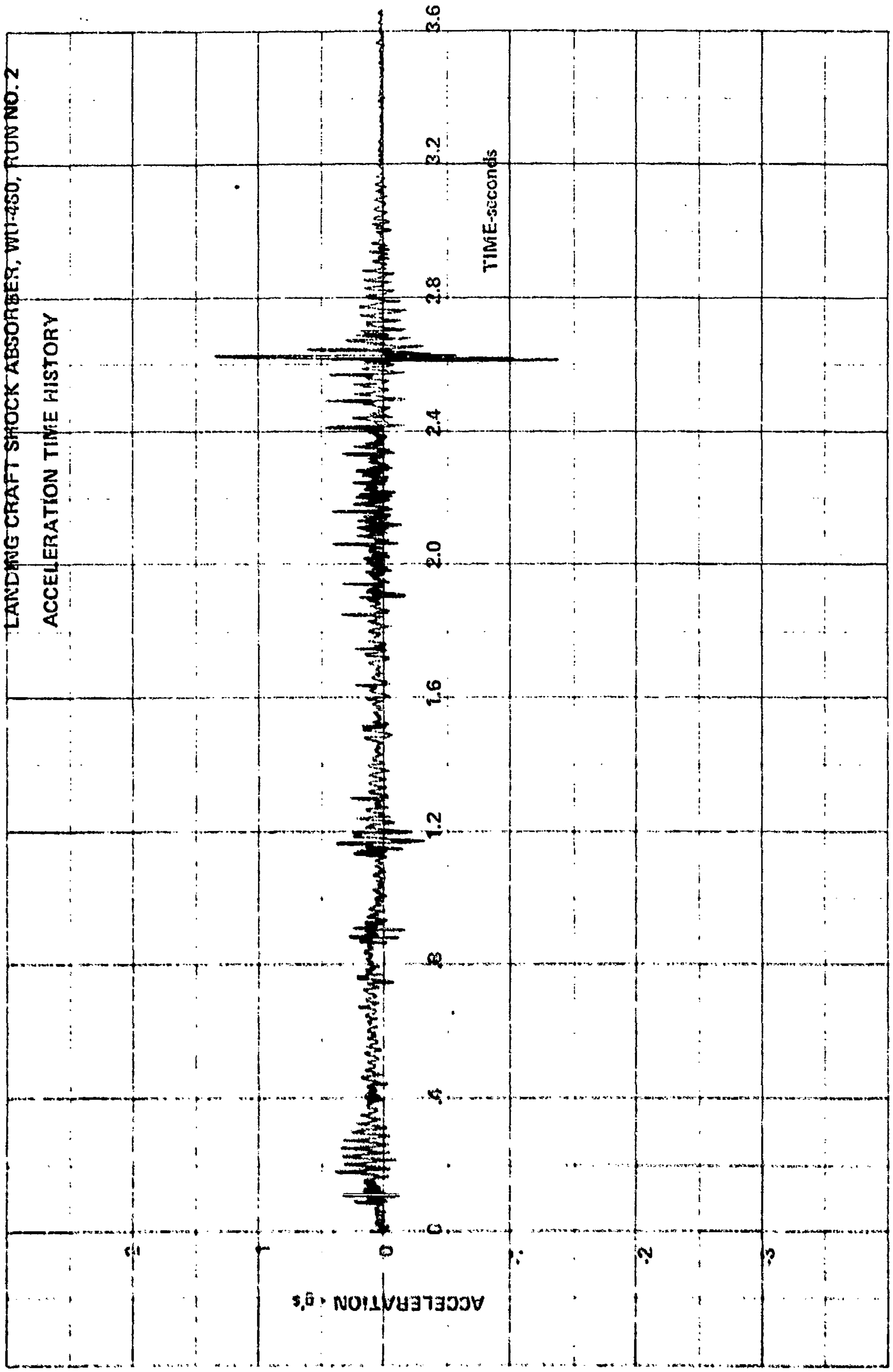
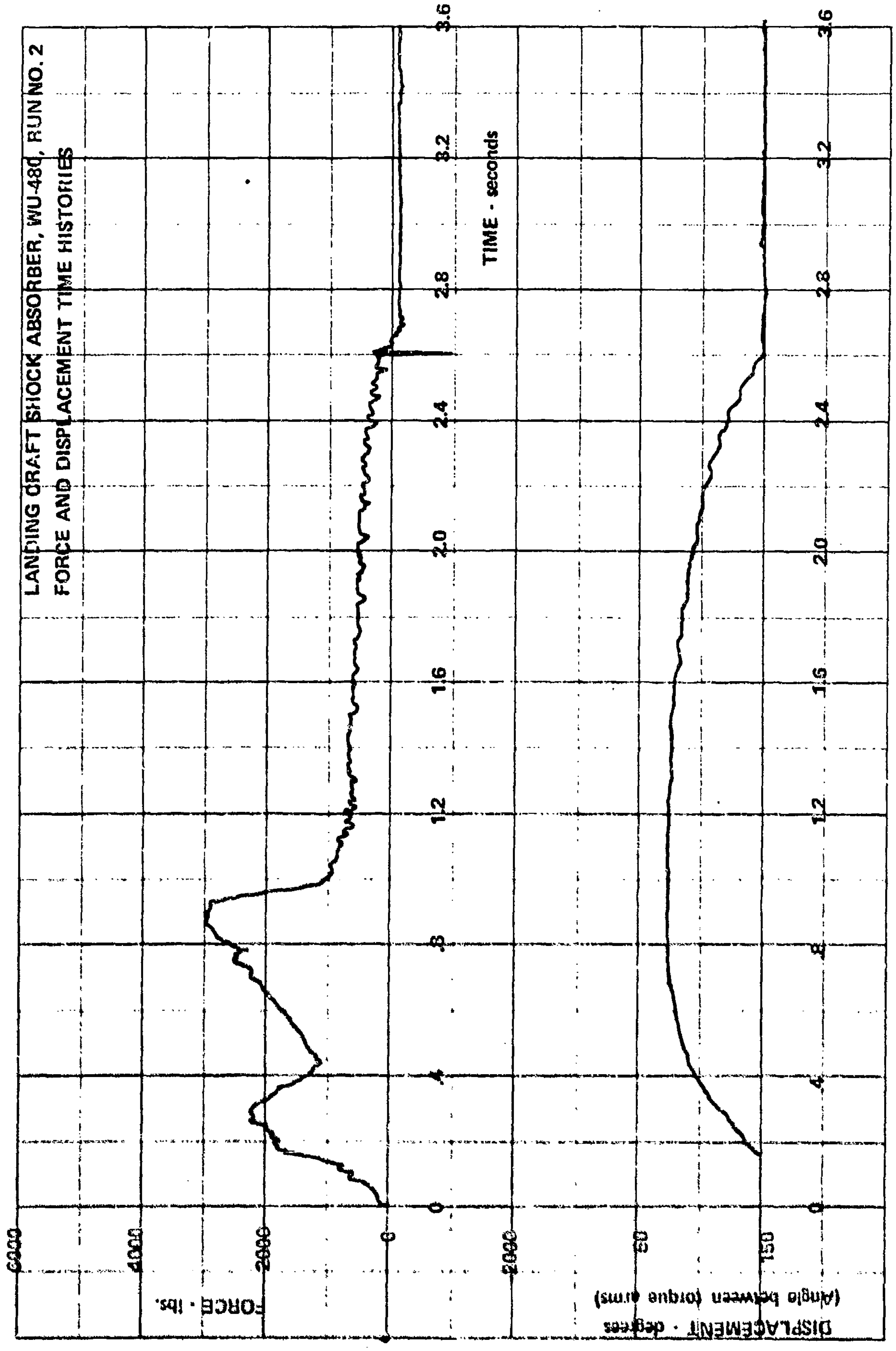
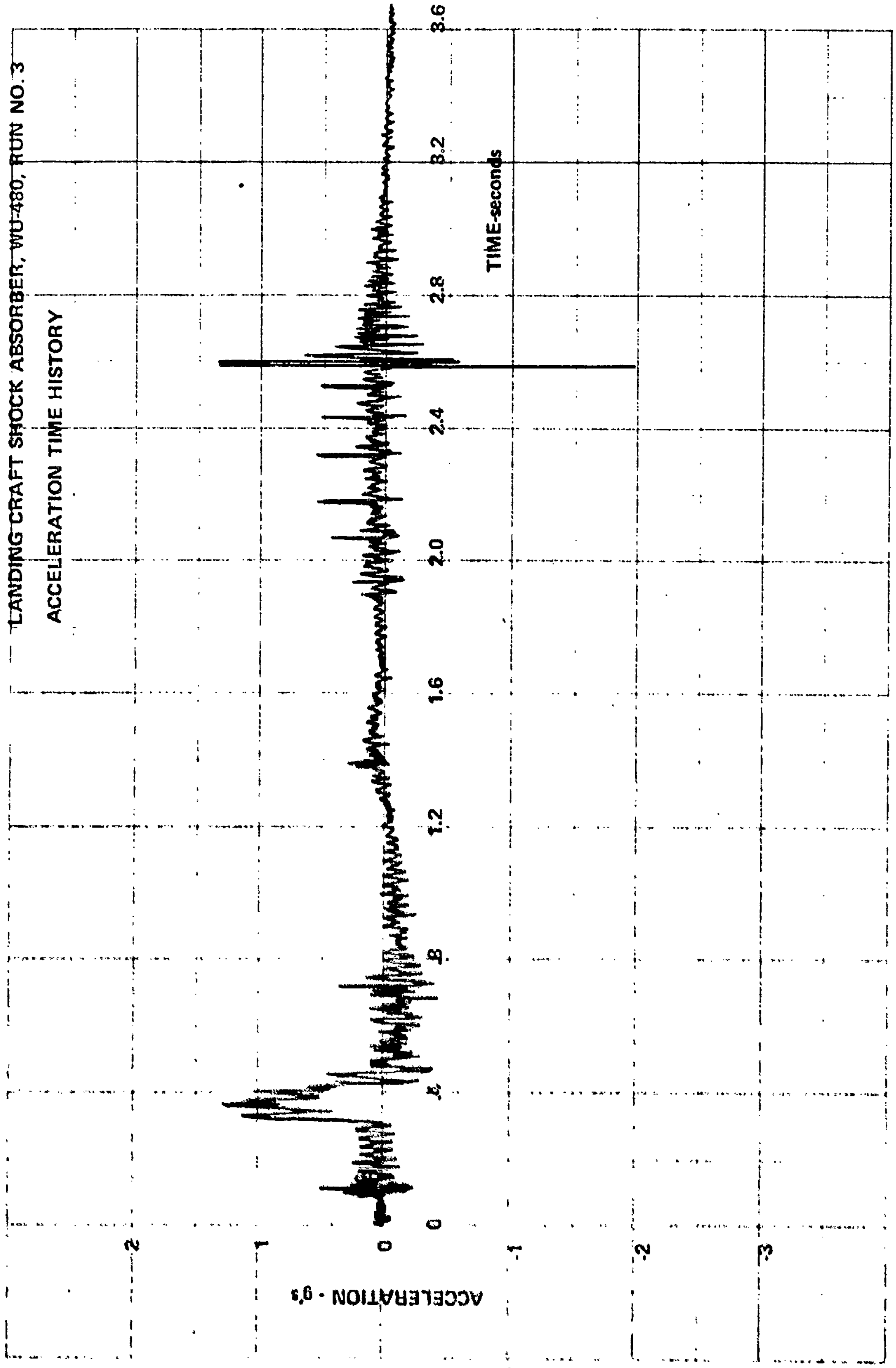
APPENDIX

ACCELERATION, FORCE, AND DISPLACEMENT TIME HISTORIES


LANDING CRAFT SHOCK ABSORBER, WD-450, RUN NO. 2
ACCELERATION TIME HISTORY
TIME-seconds
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
ACCELERATION - g's
2
1
0
1
2
3

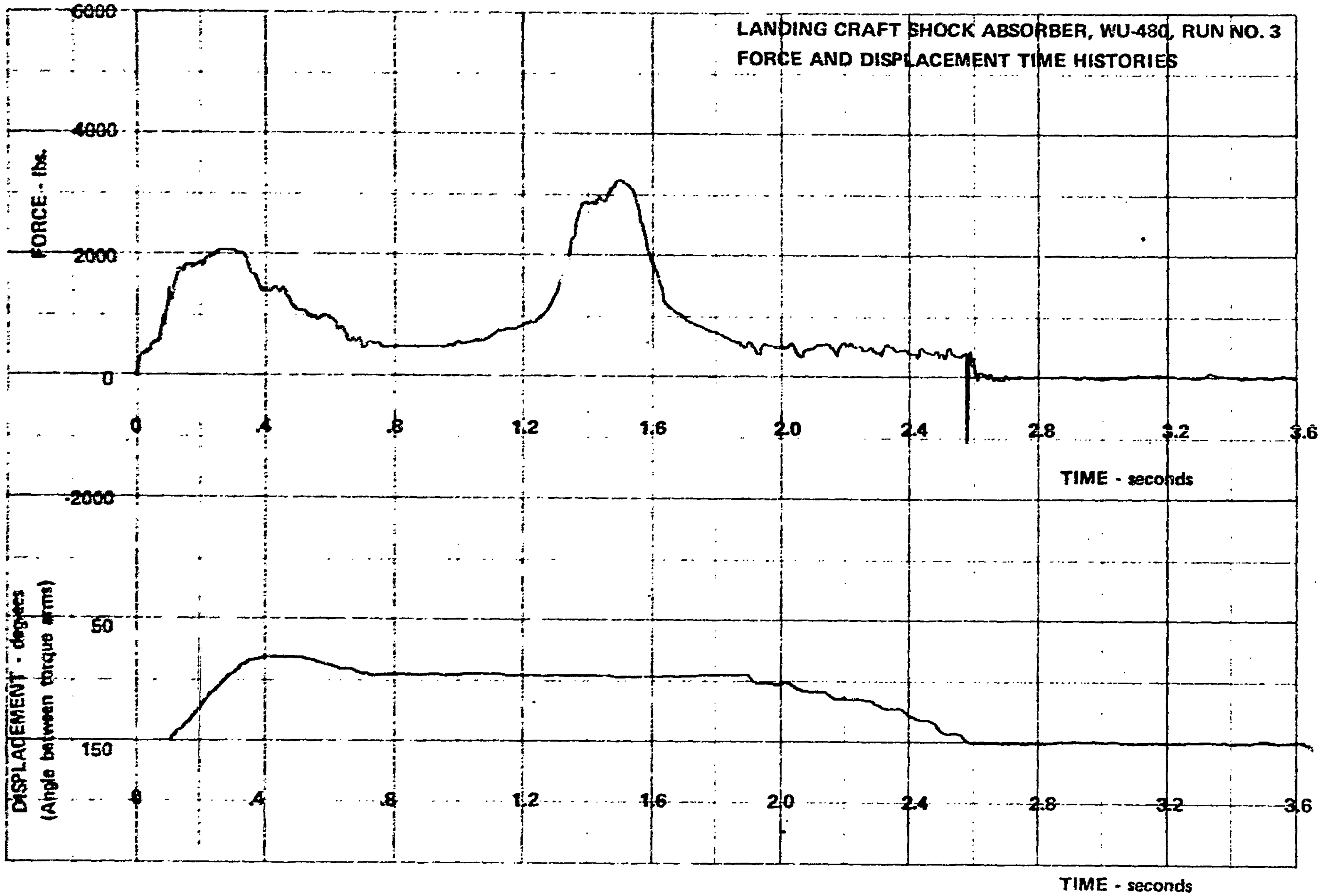


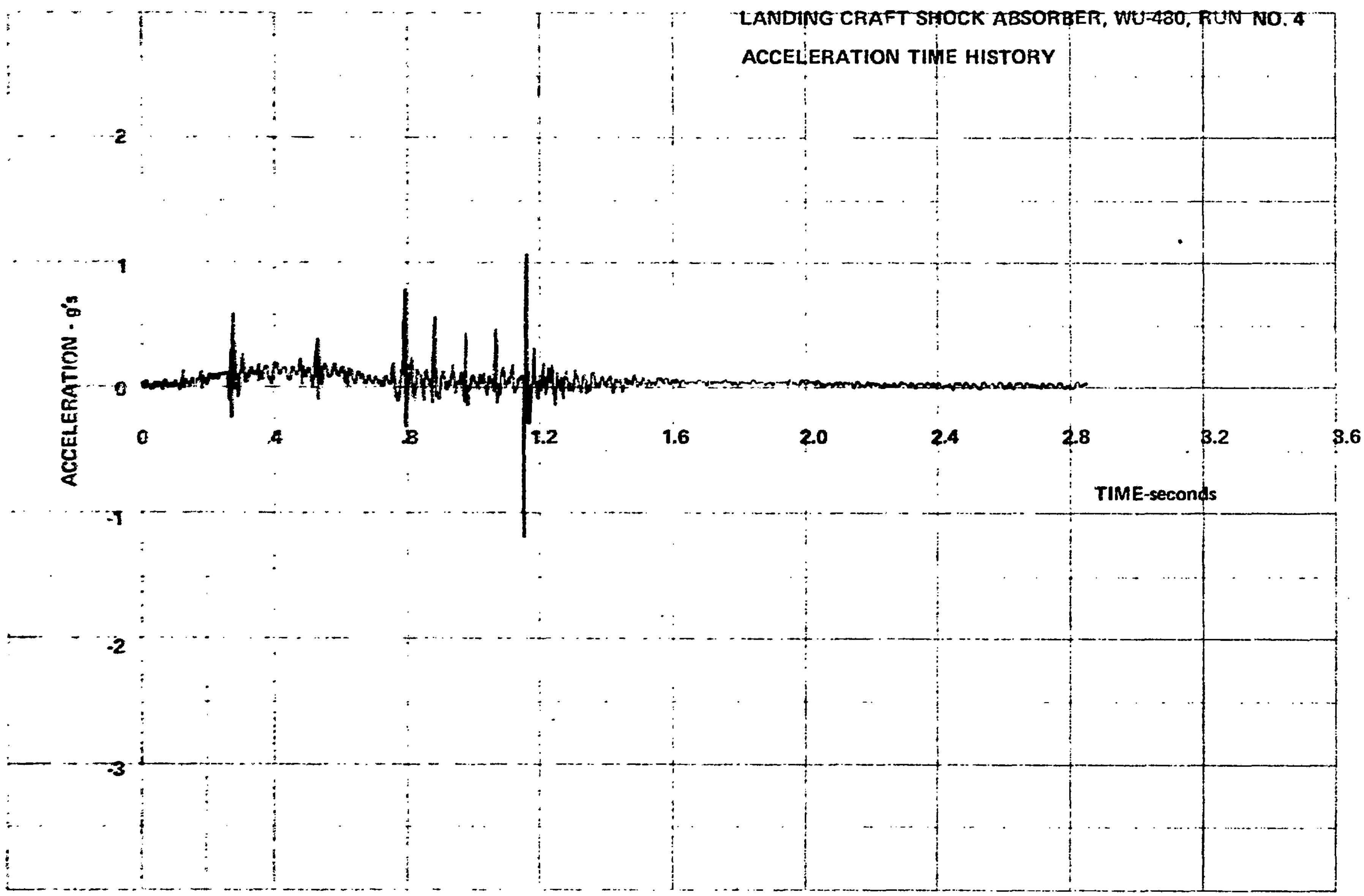
LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 2
FORCE AND DISPLACEMENT TIME HISTORIES

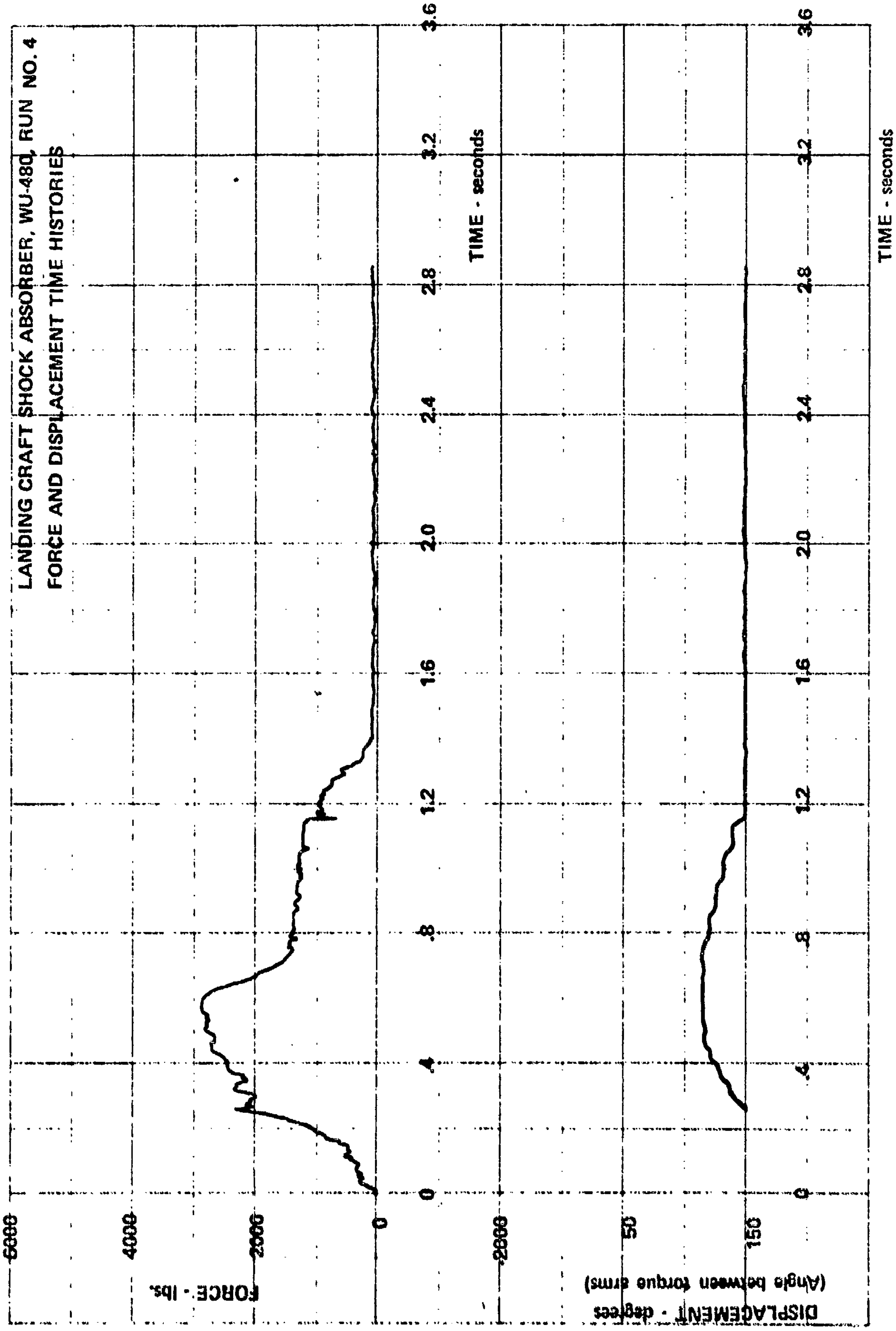


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 3

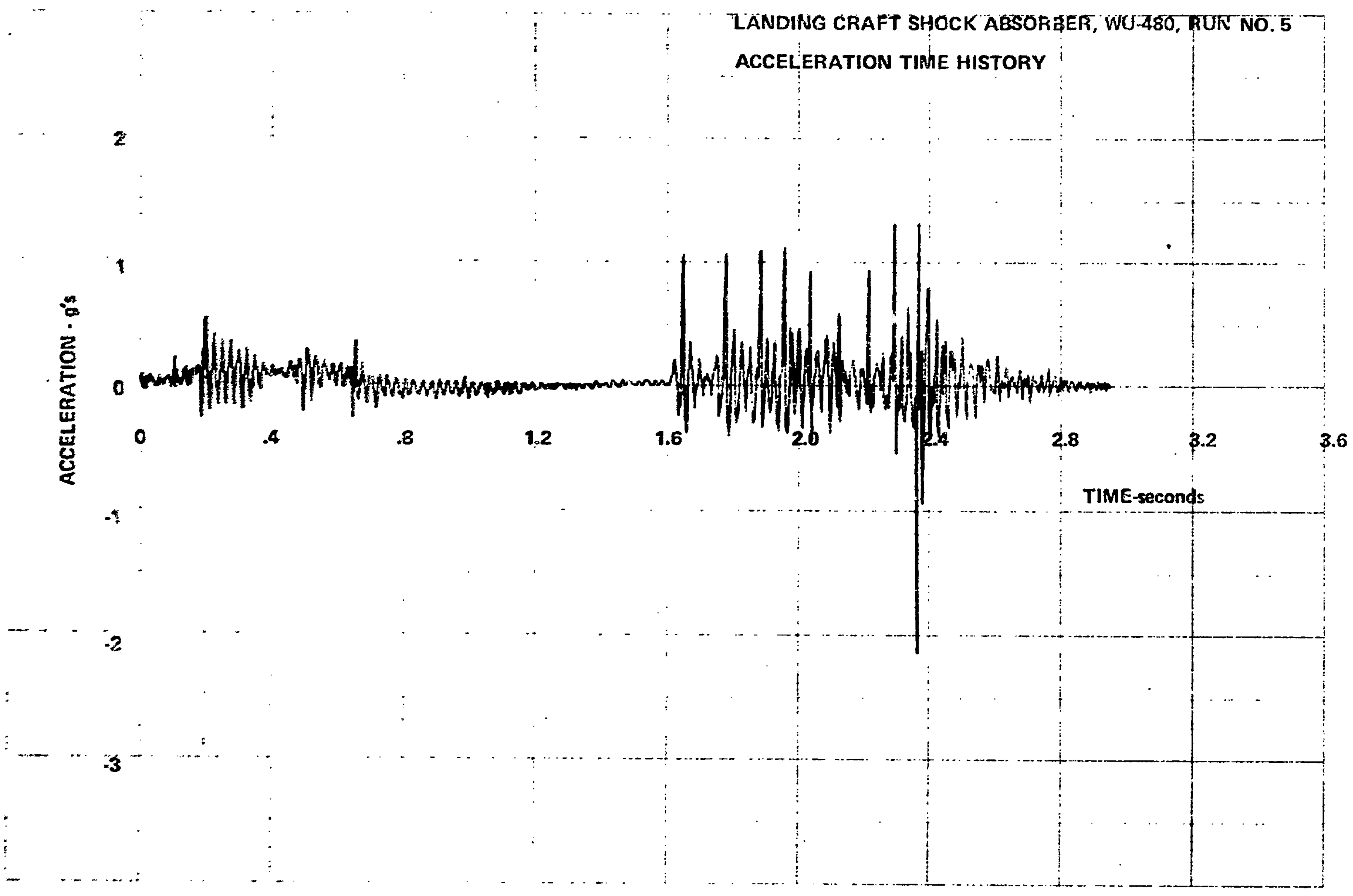
ACCELERATION TIME HISTORY

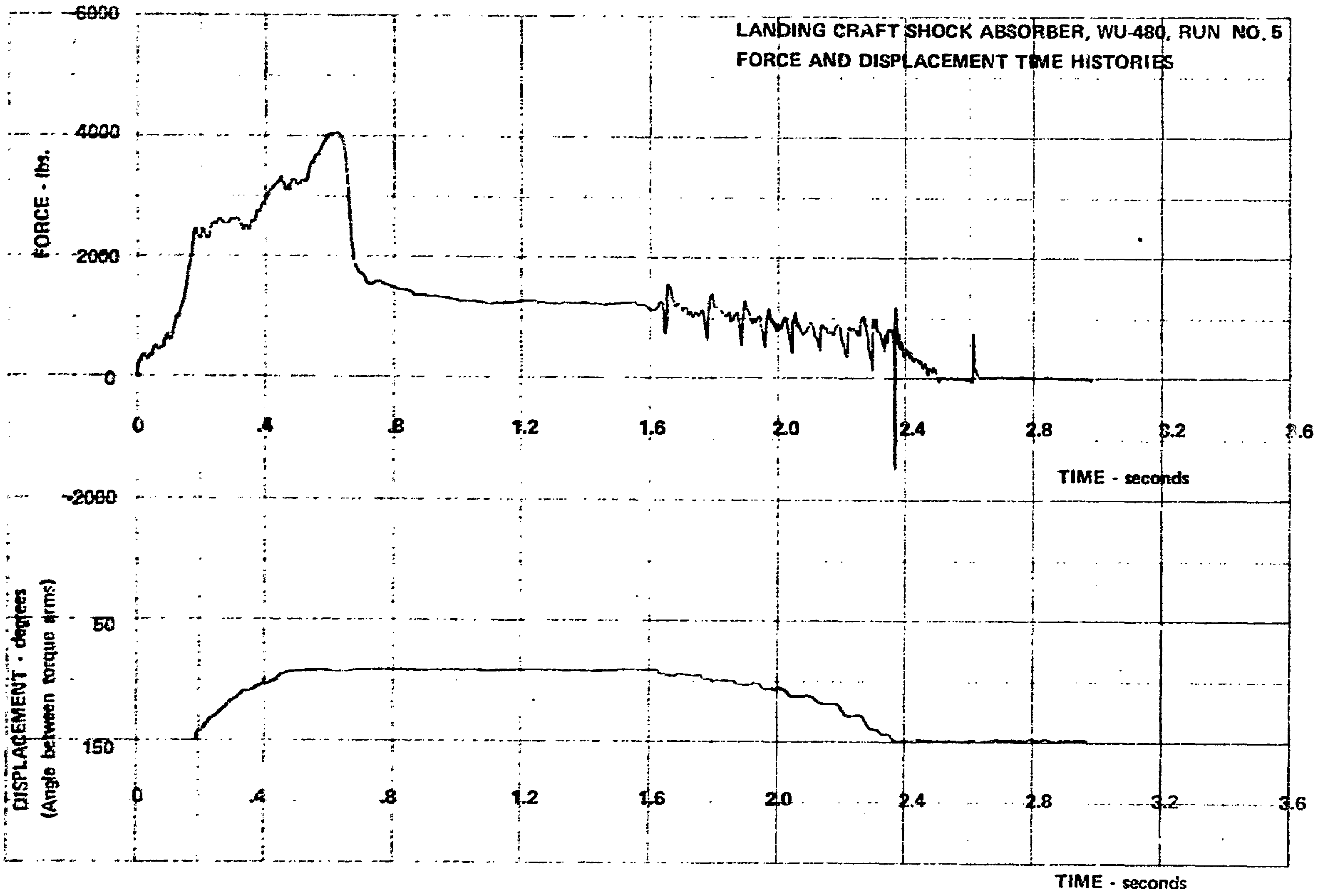

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 3
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 4
ACCELERATION TIME HISTORY
ACCELERATION - g's
2
1
0
-1
-2
-3
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME-seconds



LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 4
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
TIME - seconds
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 5
ACCELERATION TIME HISTORY
ACCELERATION - g's
2
1
0
-1
-2
-3
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME-seconds



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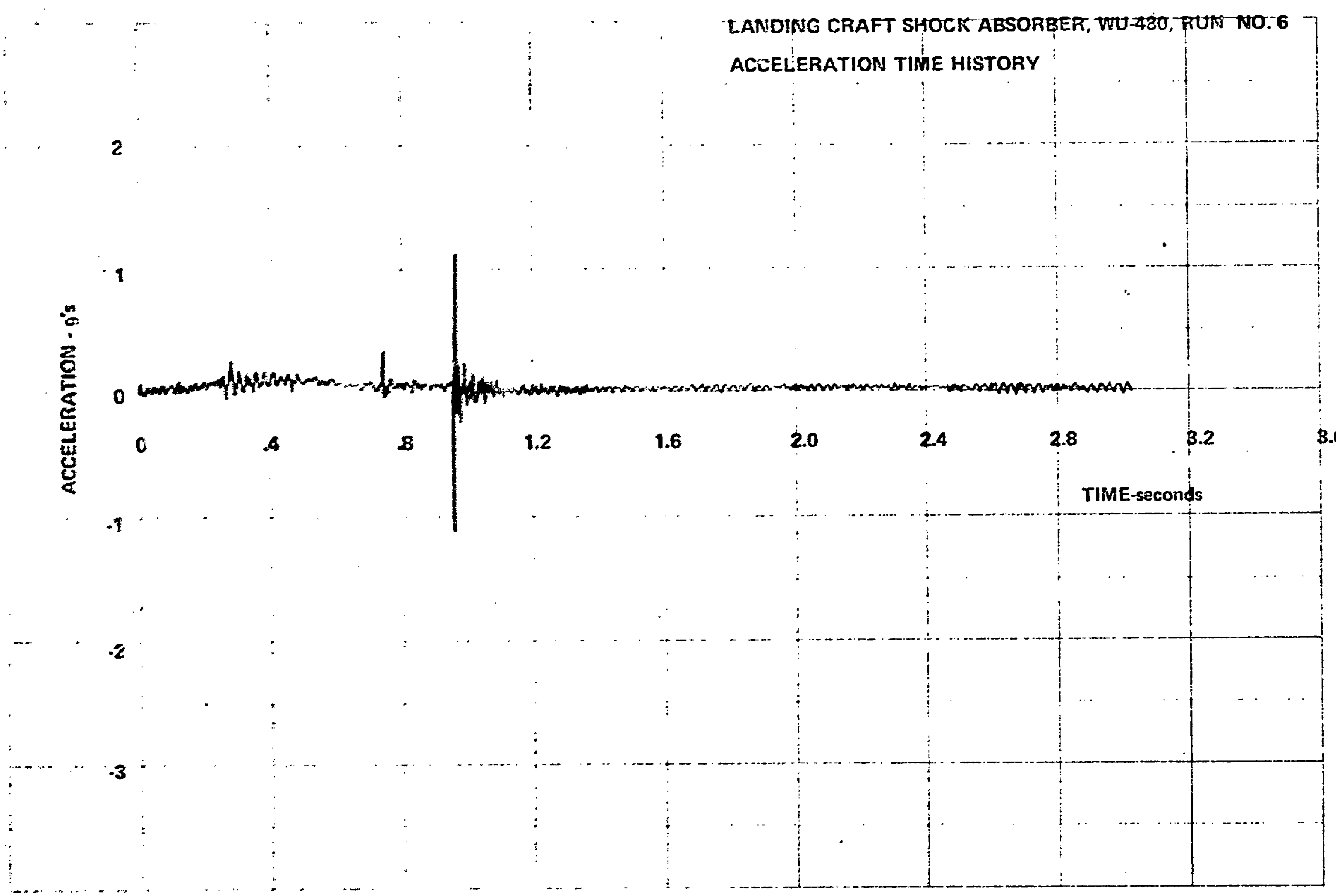
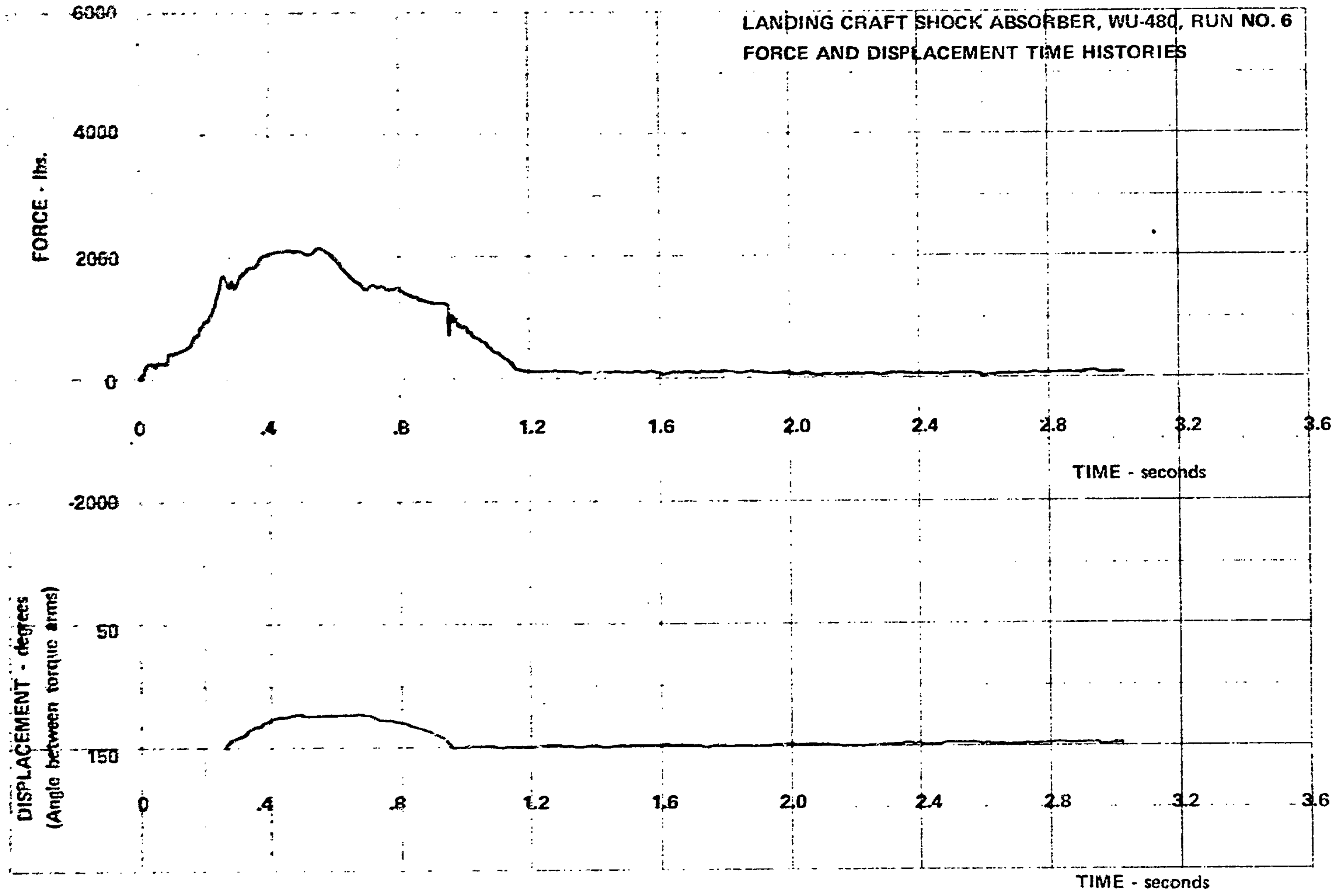
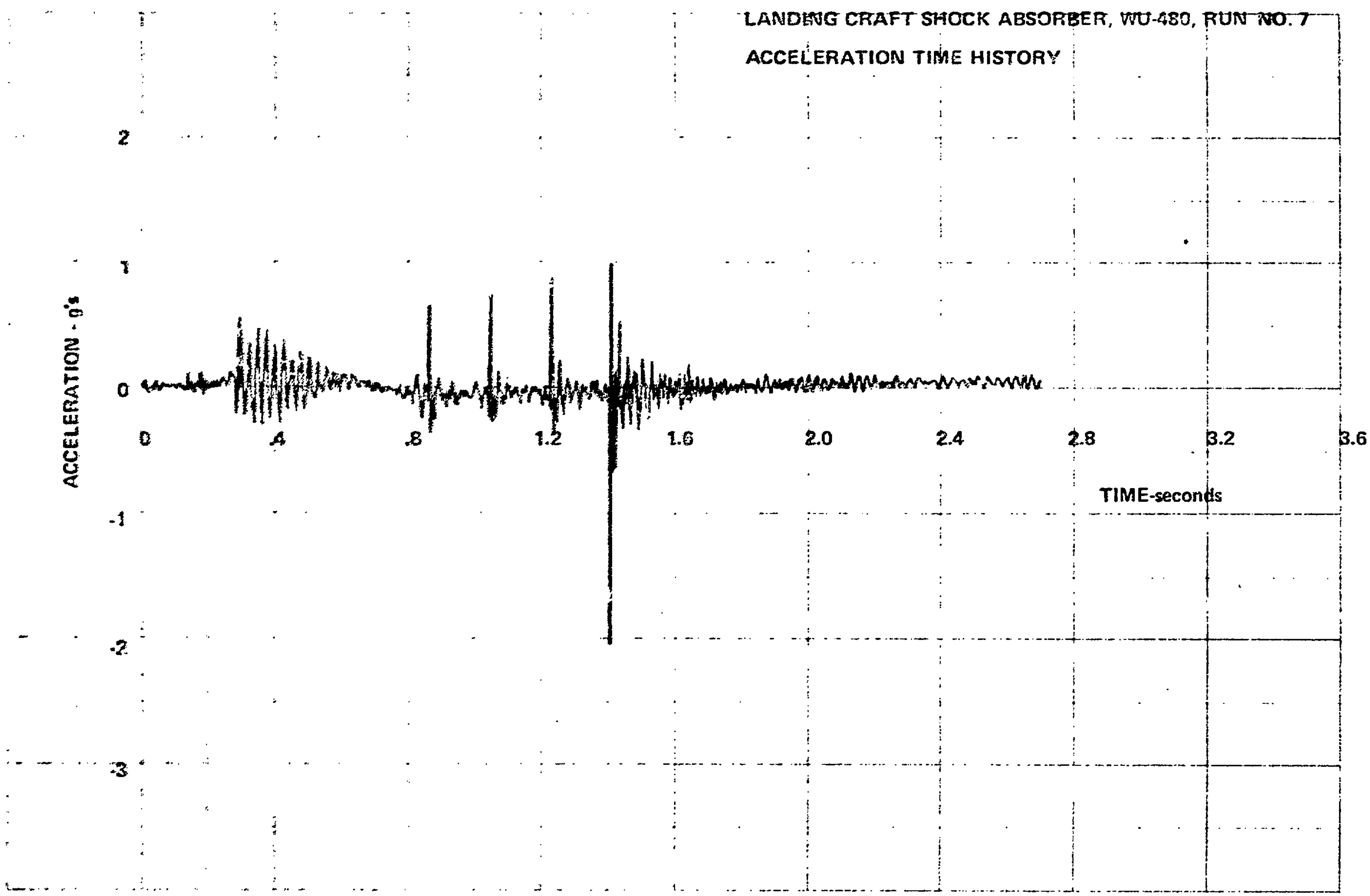
FORCE AND DISPLACEMENT TIME HISTORIES



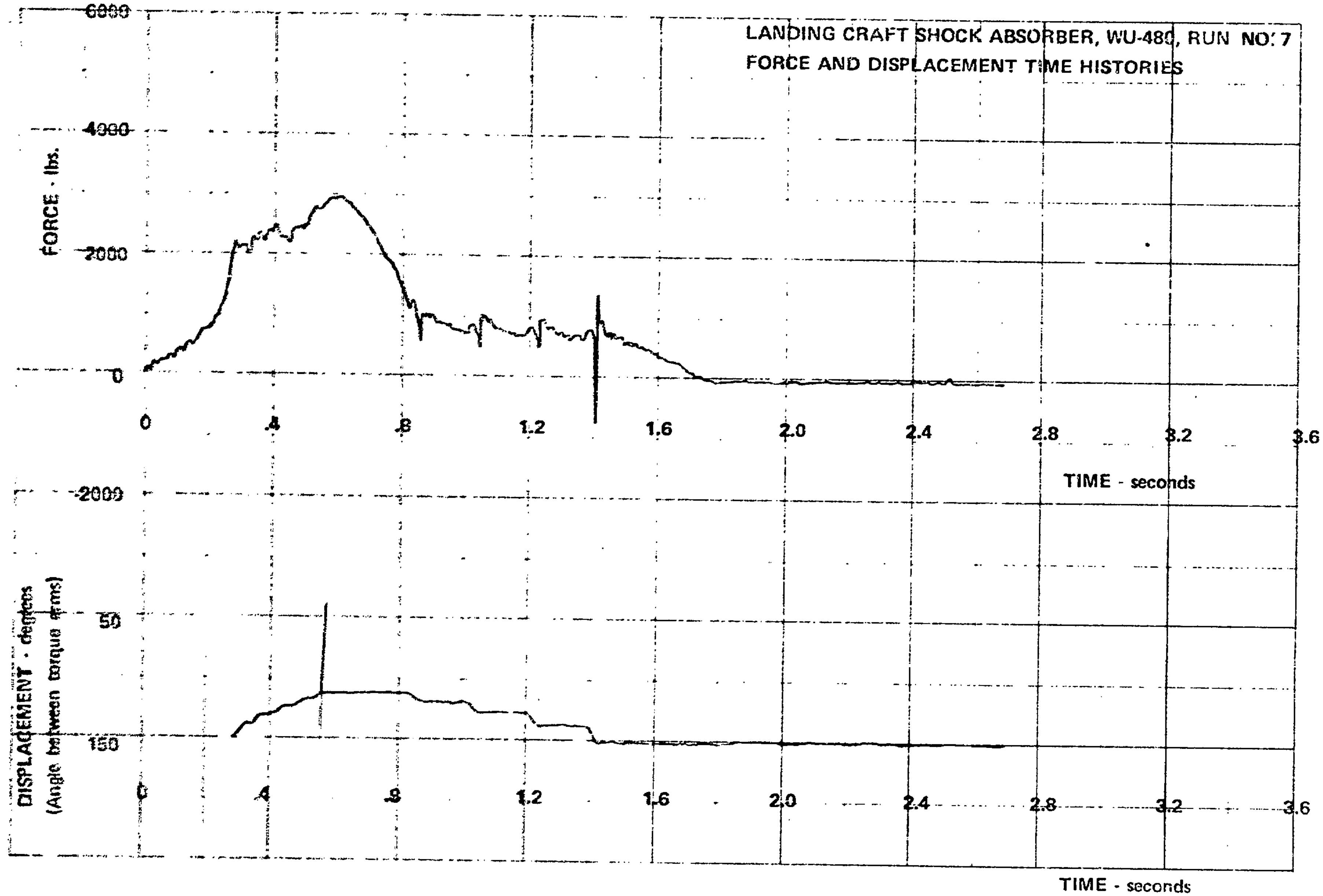
LANDING CRAFT SHOCK ABSORBER, WU-430, RUN NO. 6
ACCELERATION TIME HISTORY

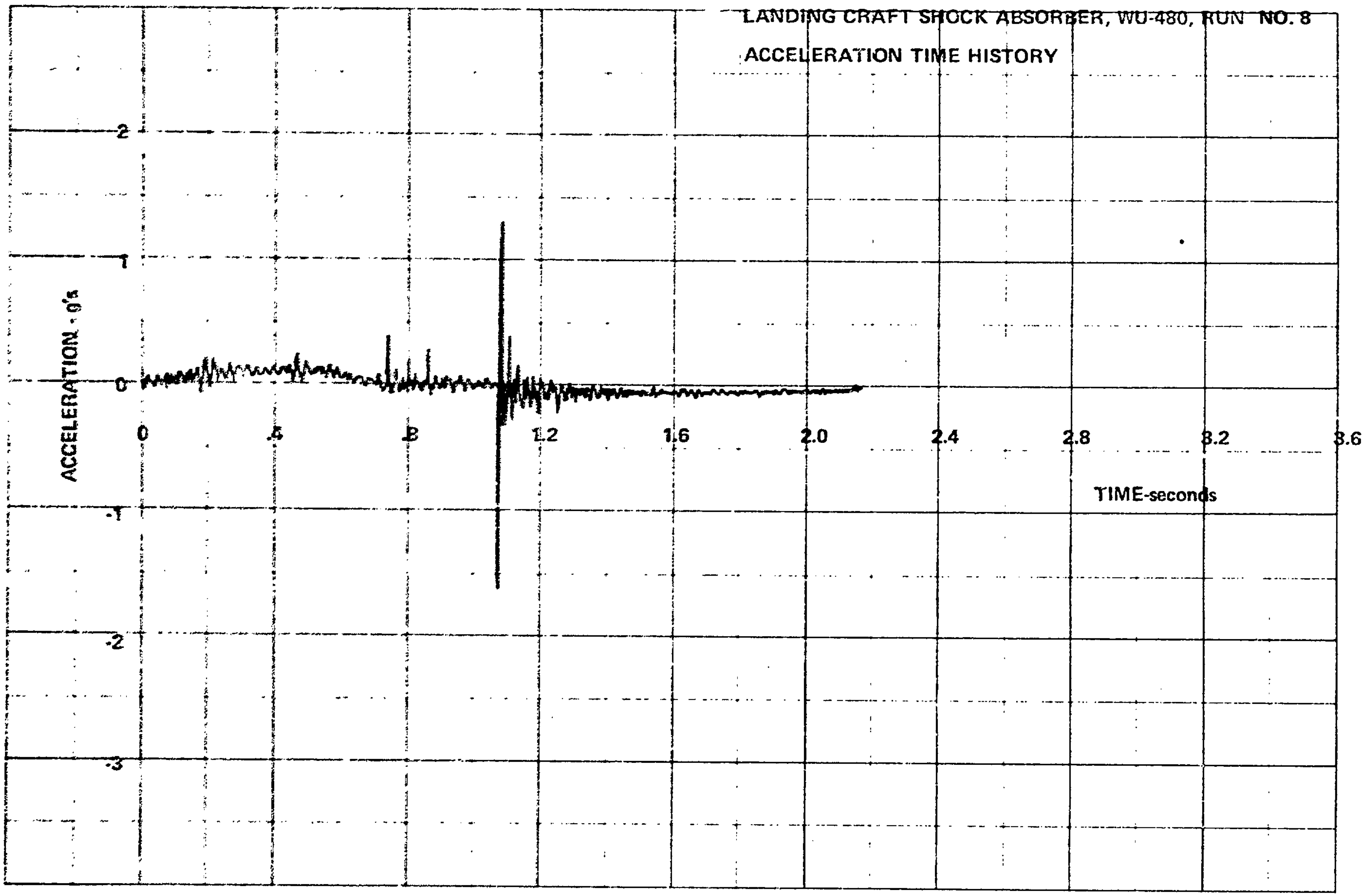


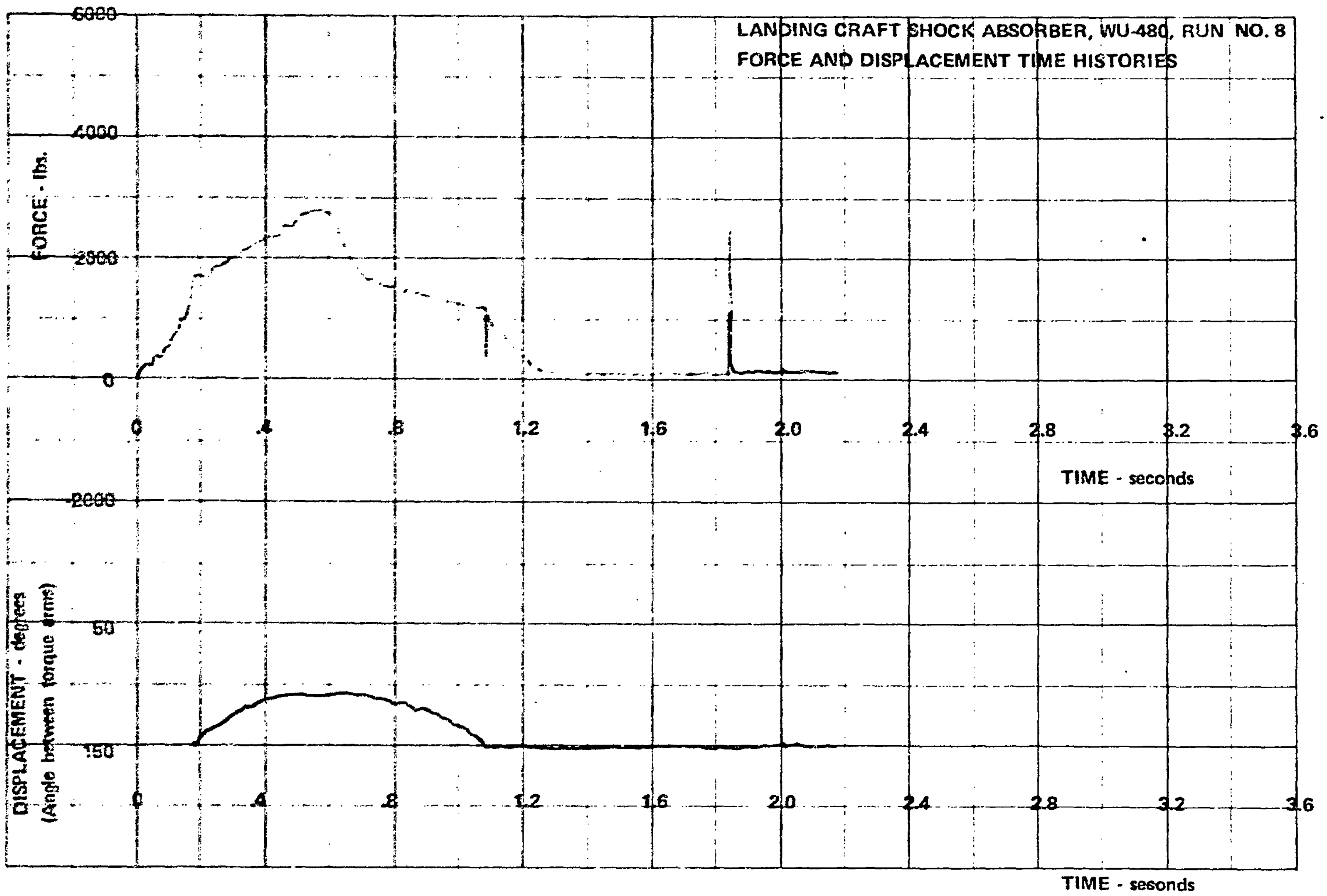
LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 6
FORCE AND DISPLACEMENT TIME HISTORIES


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 7
ACCELERATION TIME HISTORY
ACCELERATION - g's
2
1
0
-1
-2
-3
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME-seconds

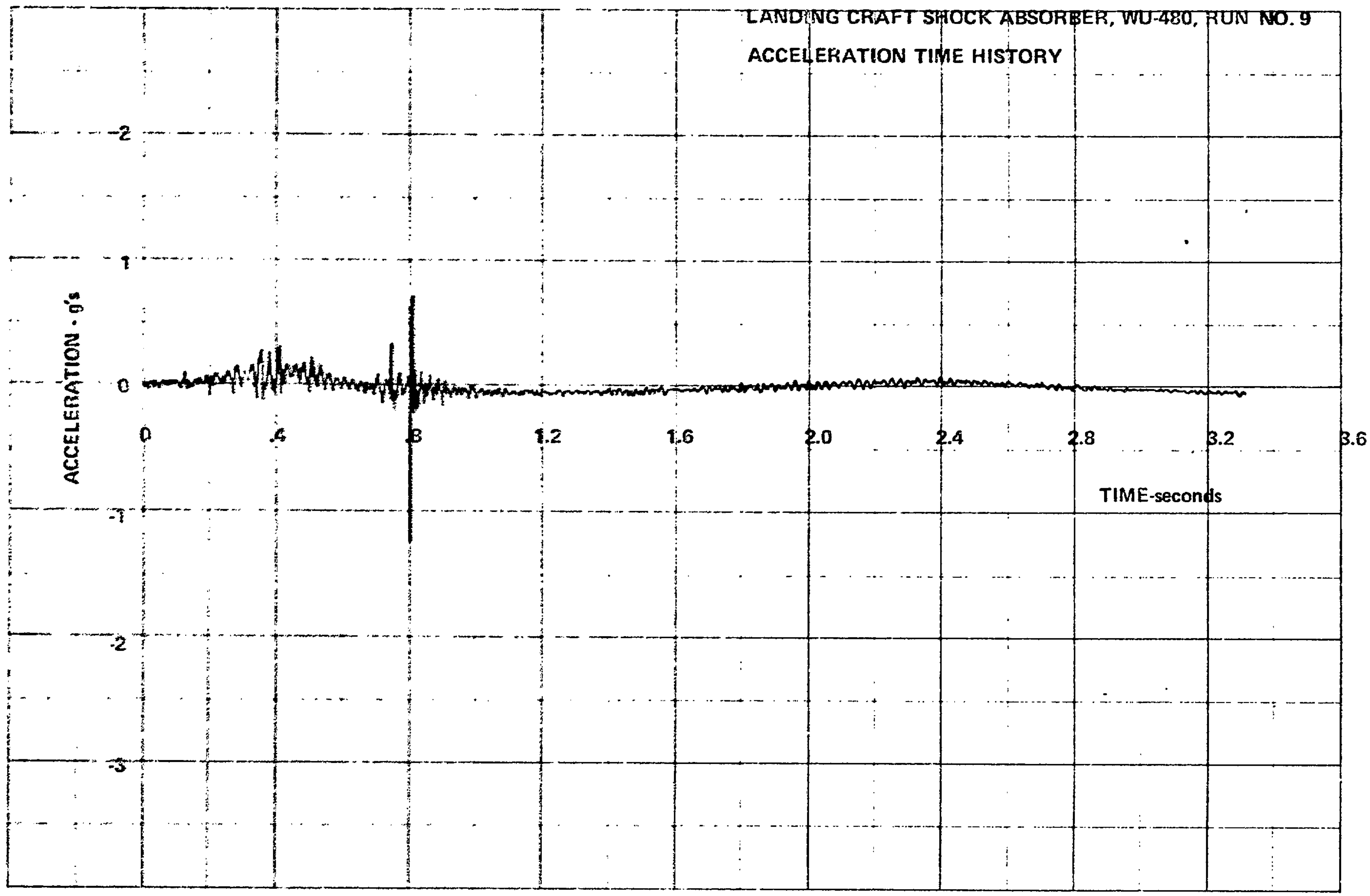
LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO: 7
FORCE AND DISPLACEMENT TIME HISTORIES

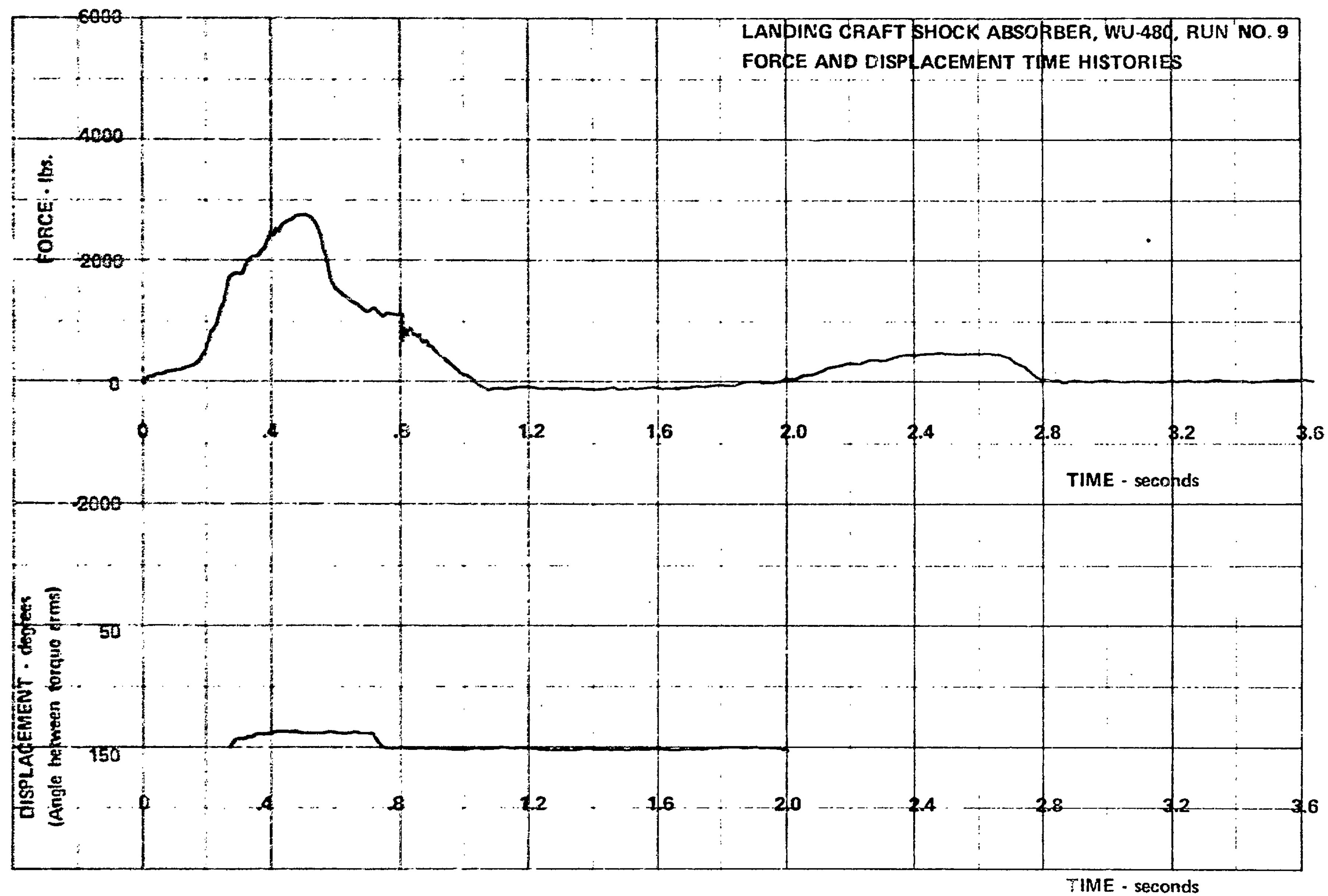


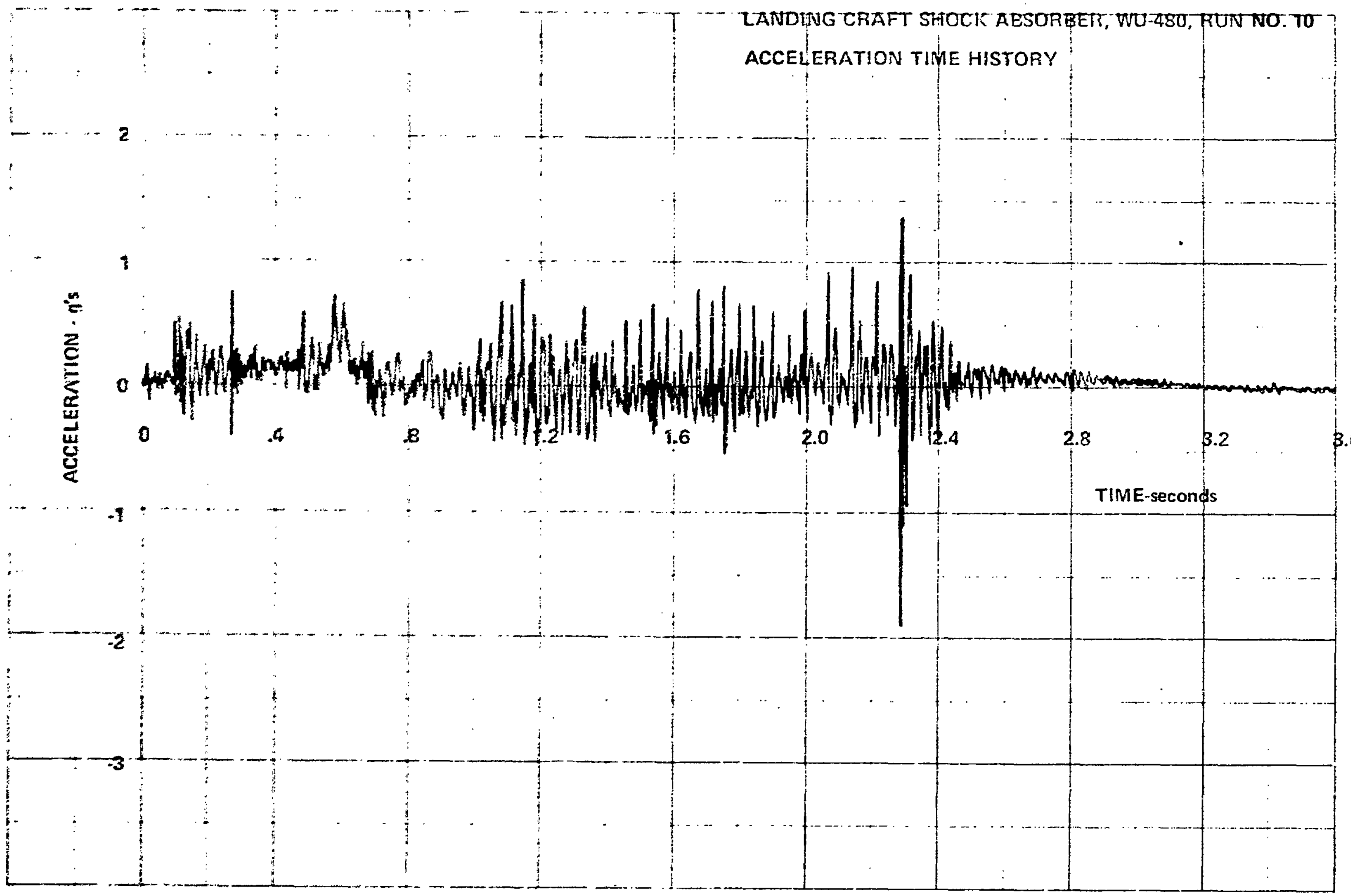

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 8
ACCELERATION TIME HISTORY
ACCELERATION - g's
TIME-seconds
2
1
0
-1
-2
-3
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6

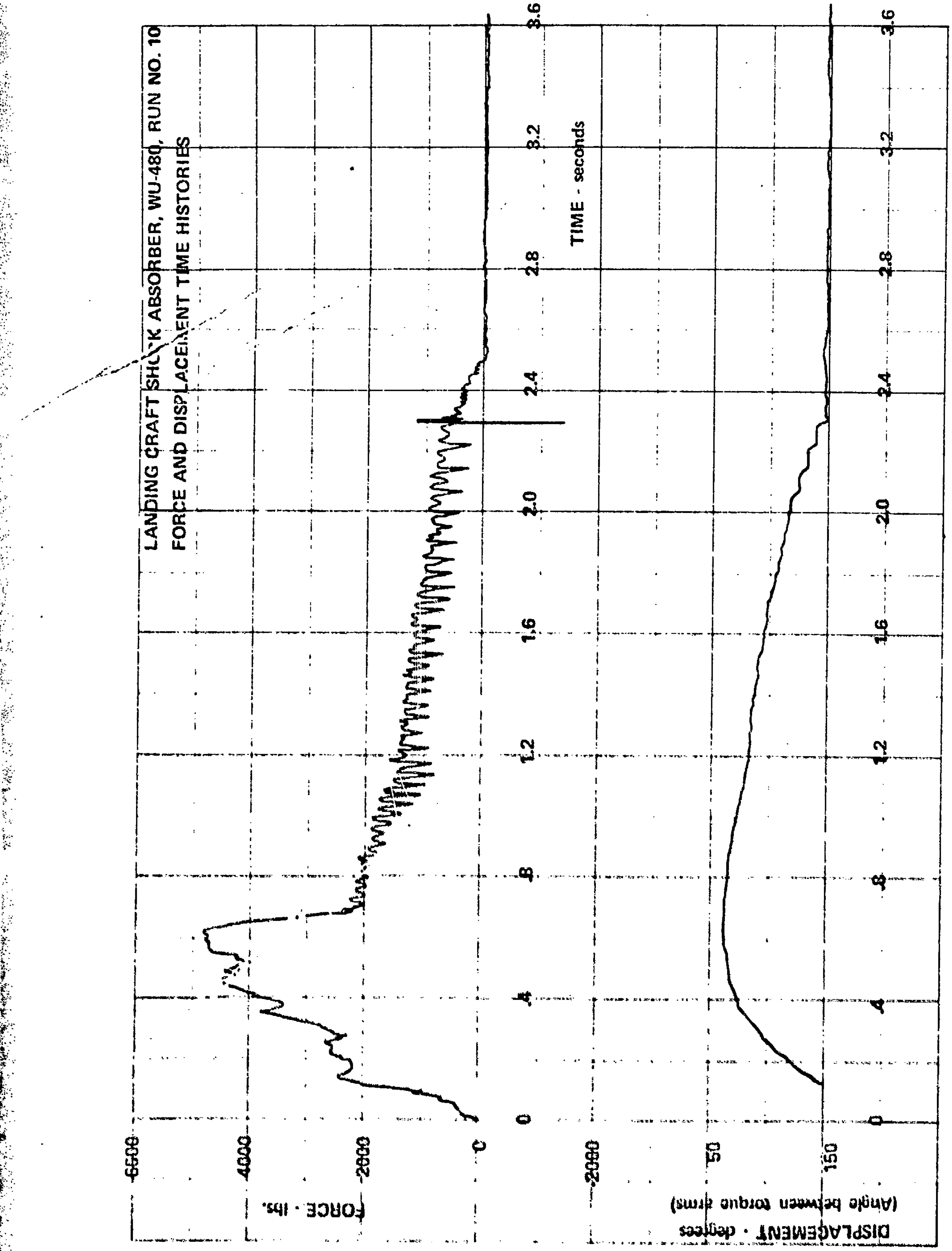


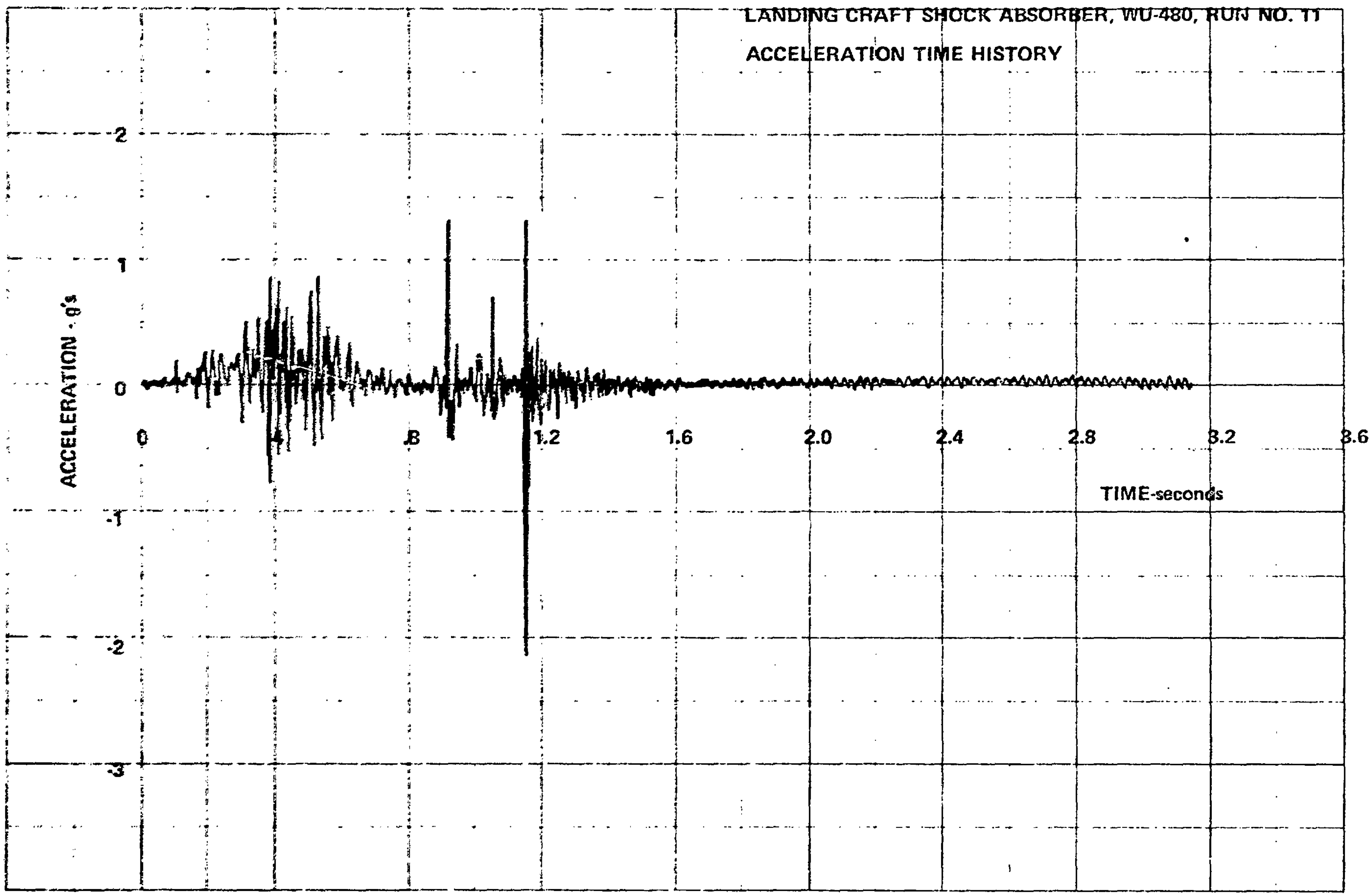
LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 8
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - sesonds


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 9
ACCELERATION TIME HISTORY
ACCELERATION - g's
2
1
0
-1
-2
-3
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME-seconds

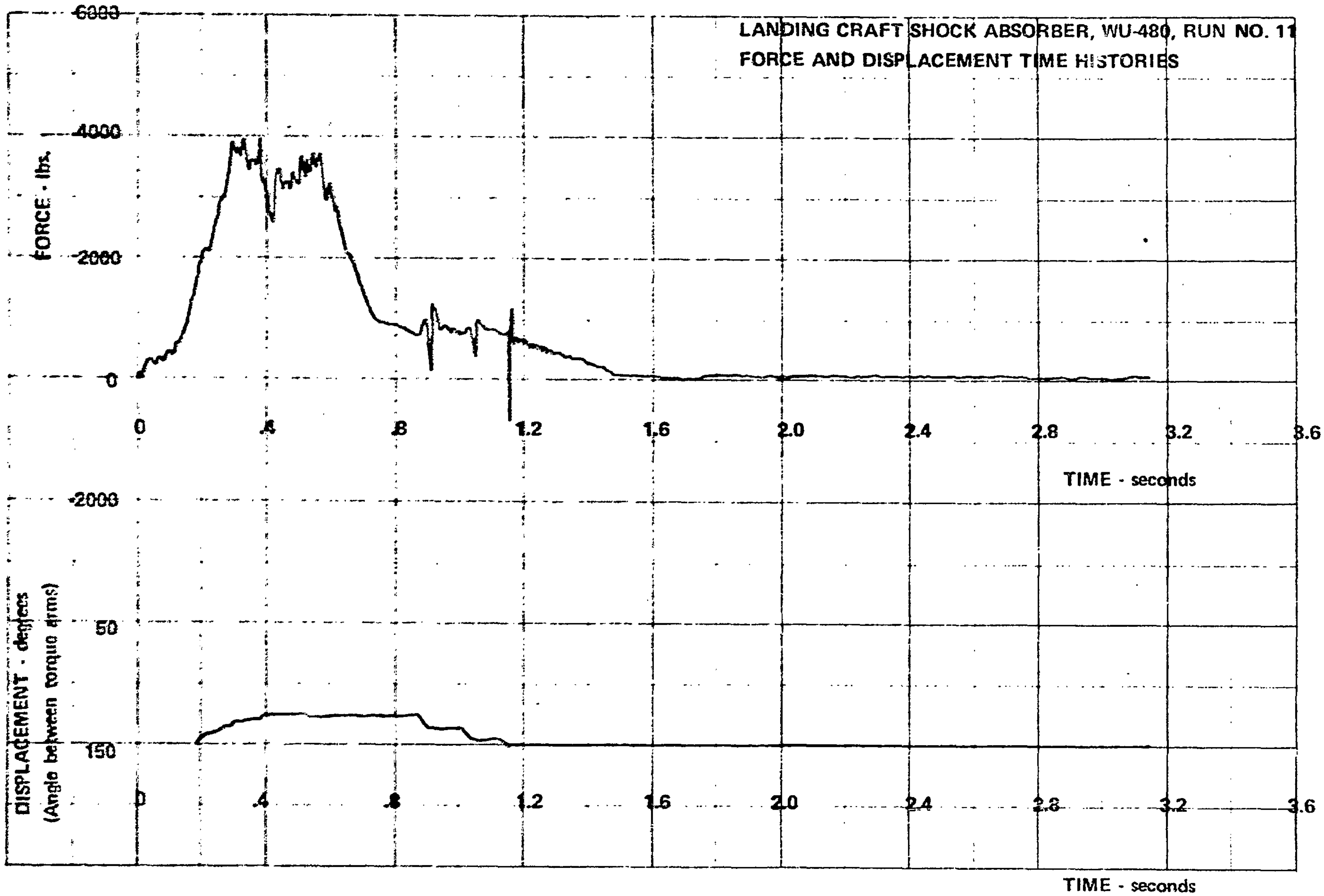

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 9
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 10
ACCELERATION TIME HISTORY
ACCELERATION - g's
TIME-seconds
2
1
0
-1
-2
-3
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 10
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
TIME - seconds



LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 11
ACCELERATION TIME HISTORY
ACCELERATION - g's
2
1
0
-1
-2
-3
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME-seconds


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 11
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
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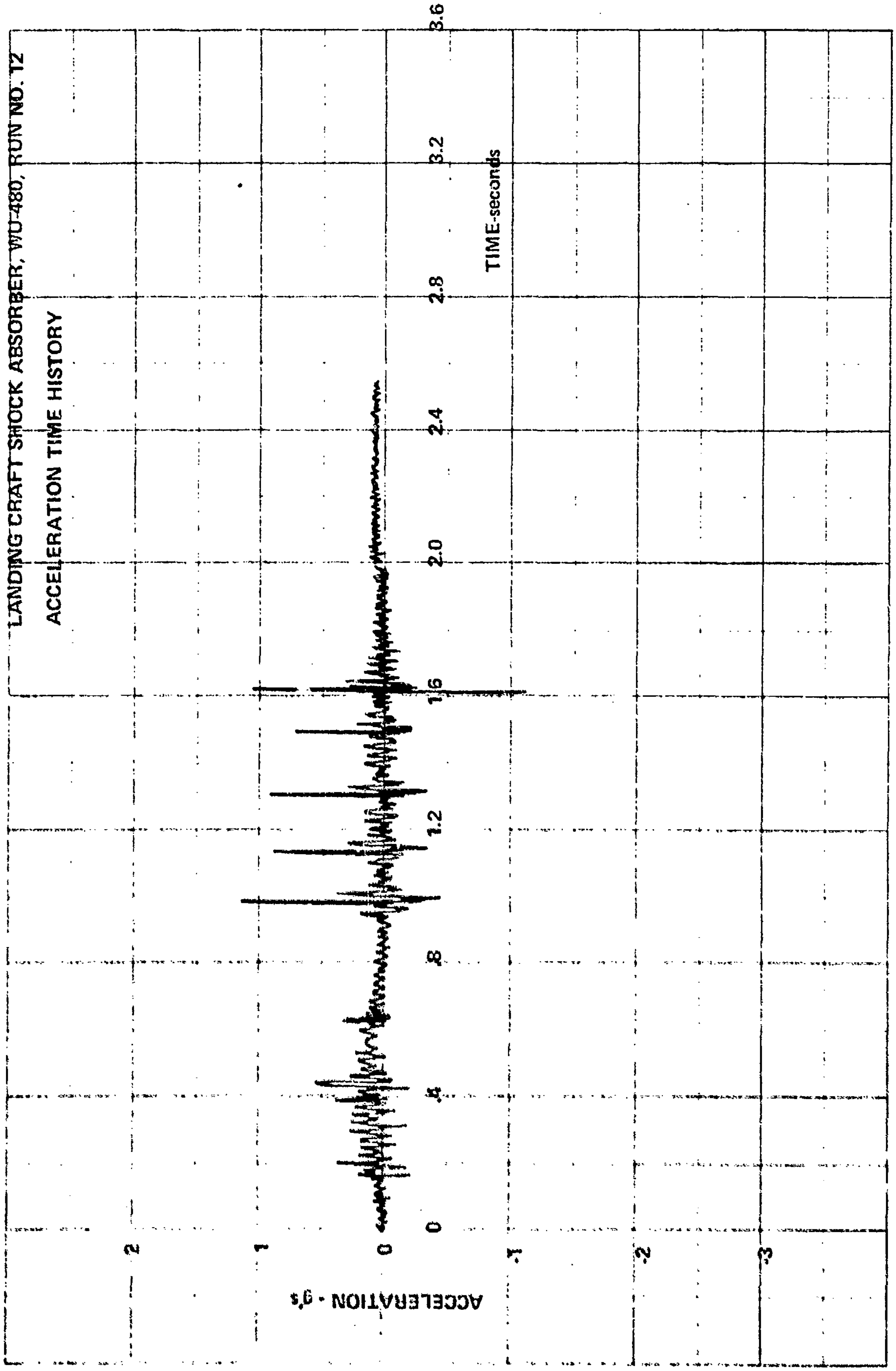
3.2
3.6
TIME - seconds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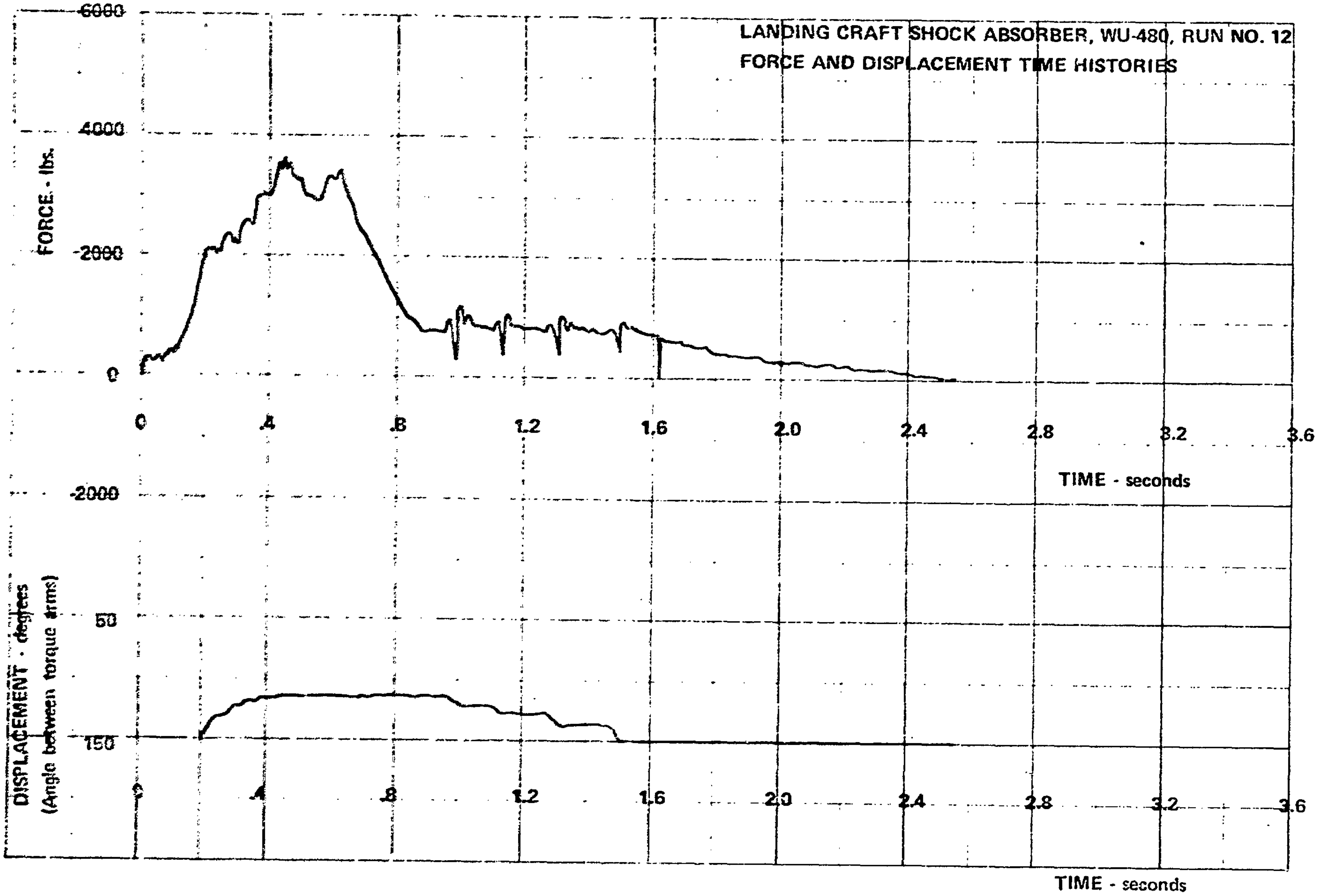
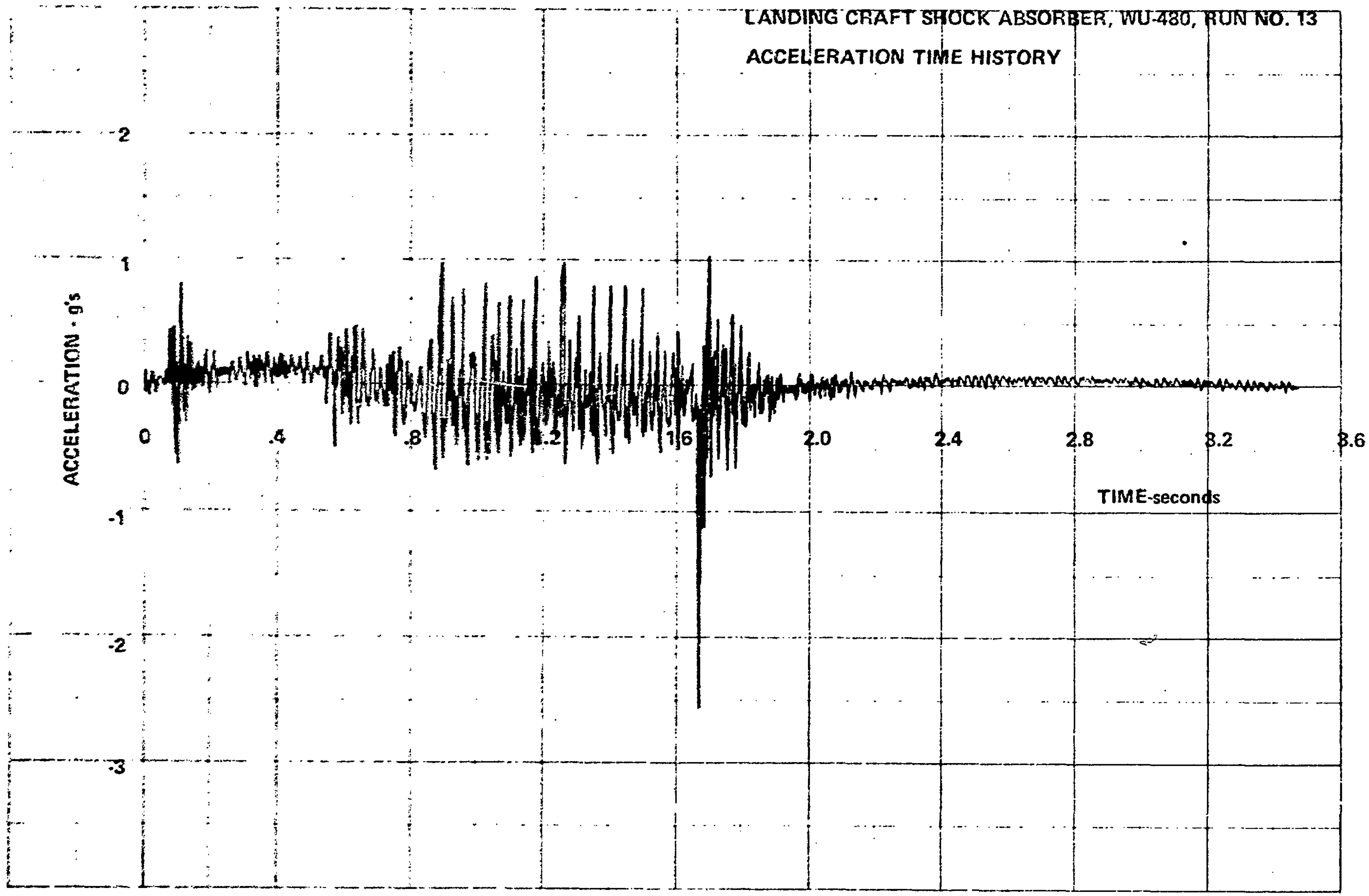
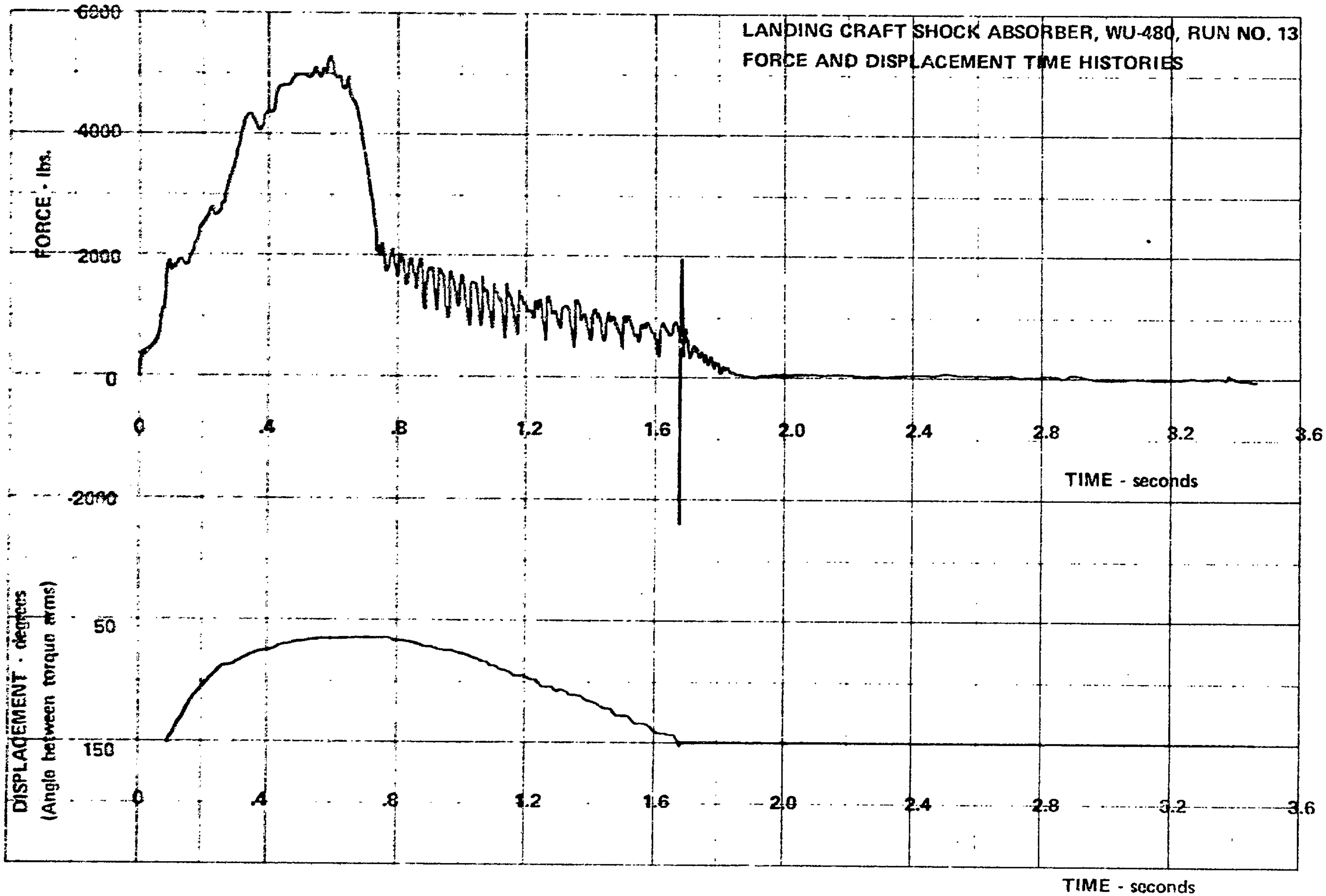
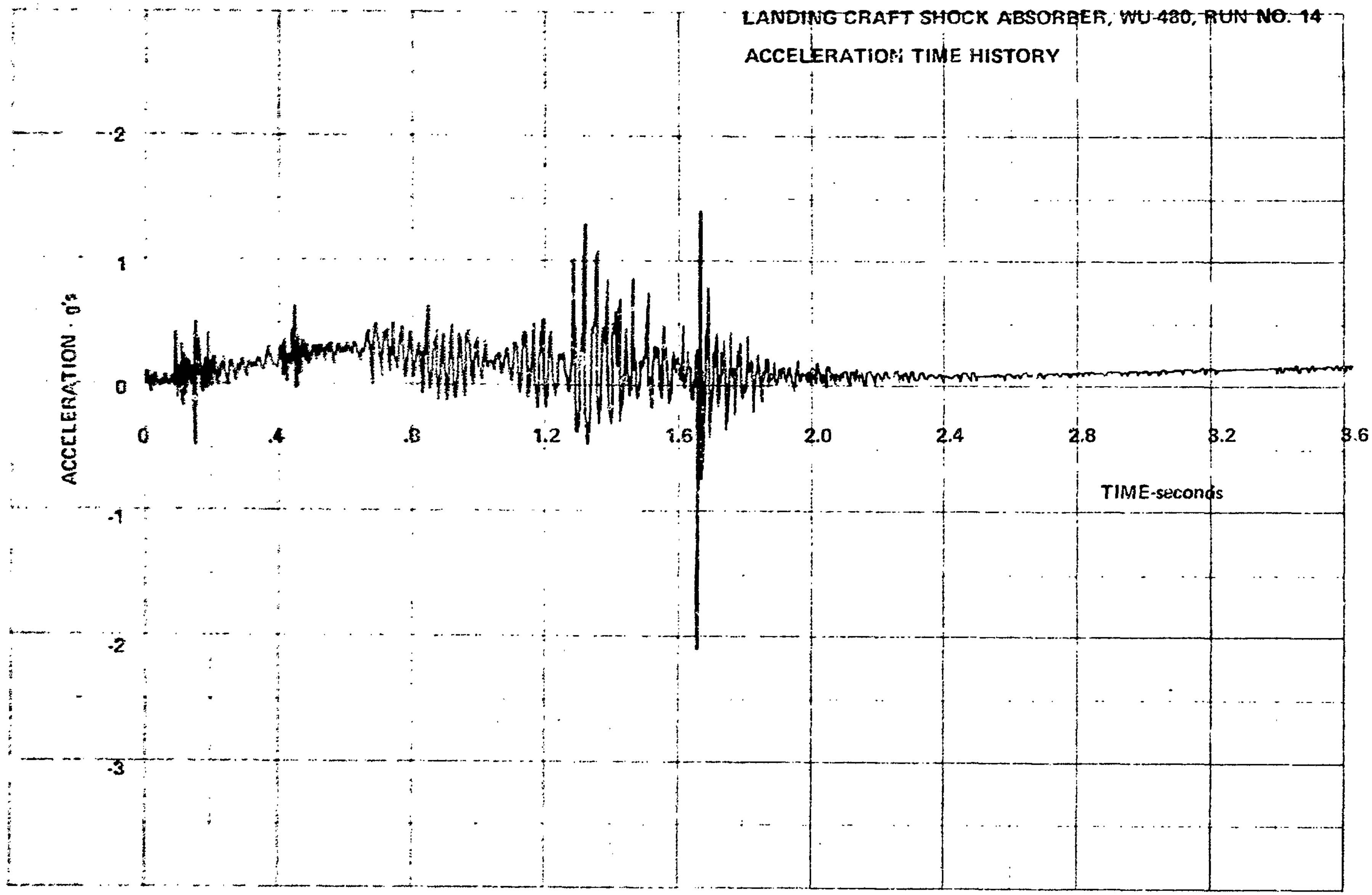
ACCELERATION TIME HISTORY
ACCELERATION - g's
TIME-seconds
2
1
0
-1
-2
-3
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6

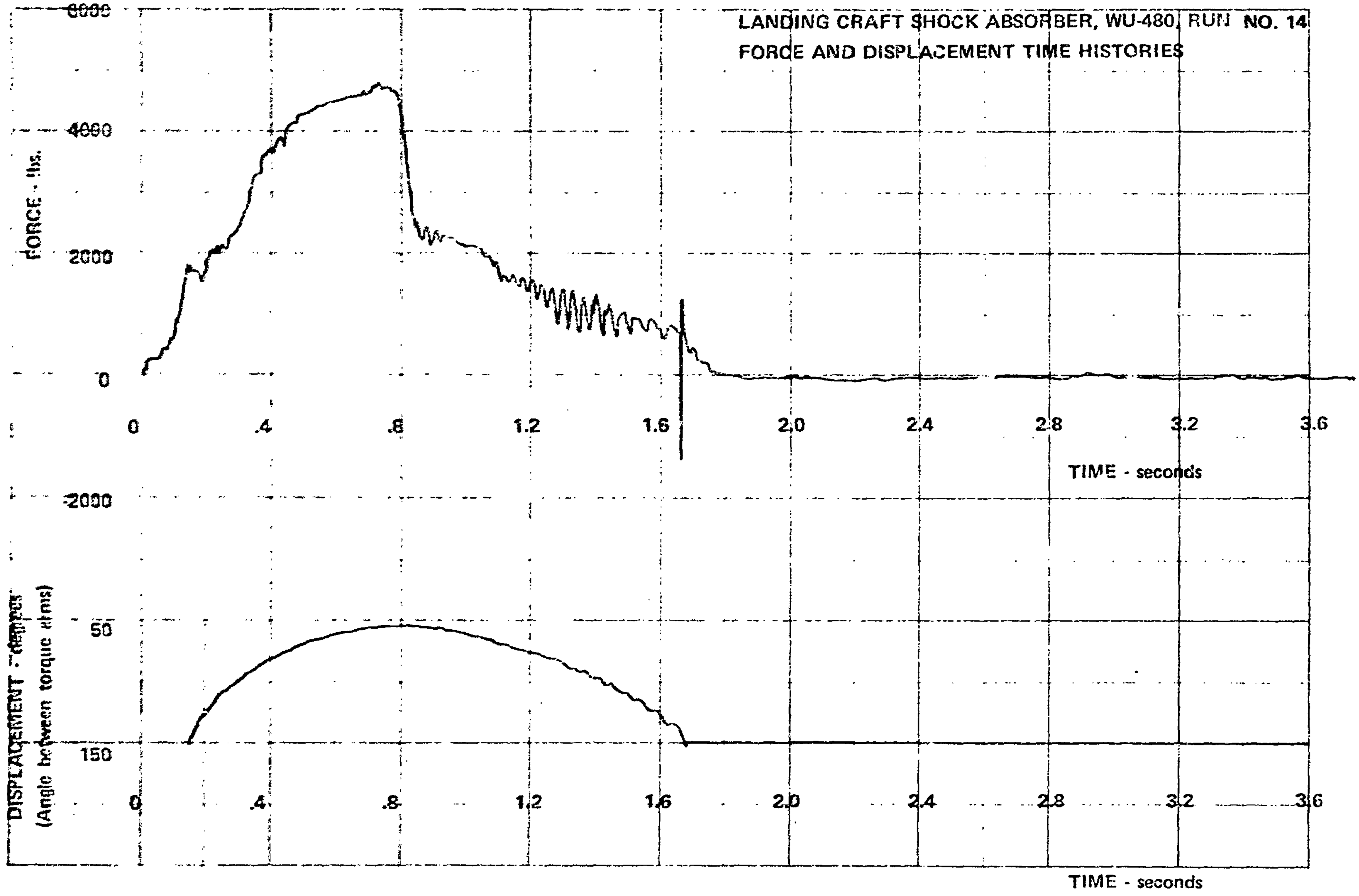

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 12
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds

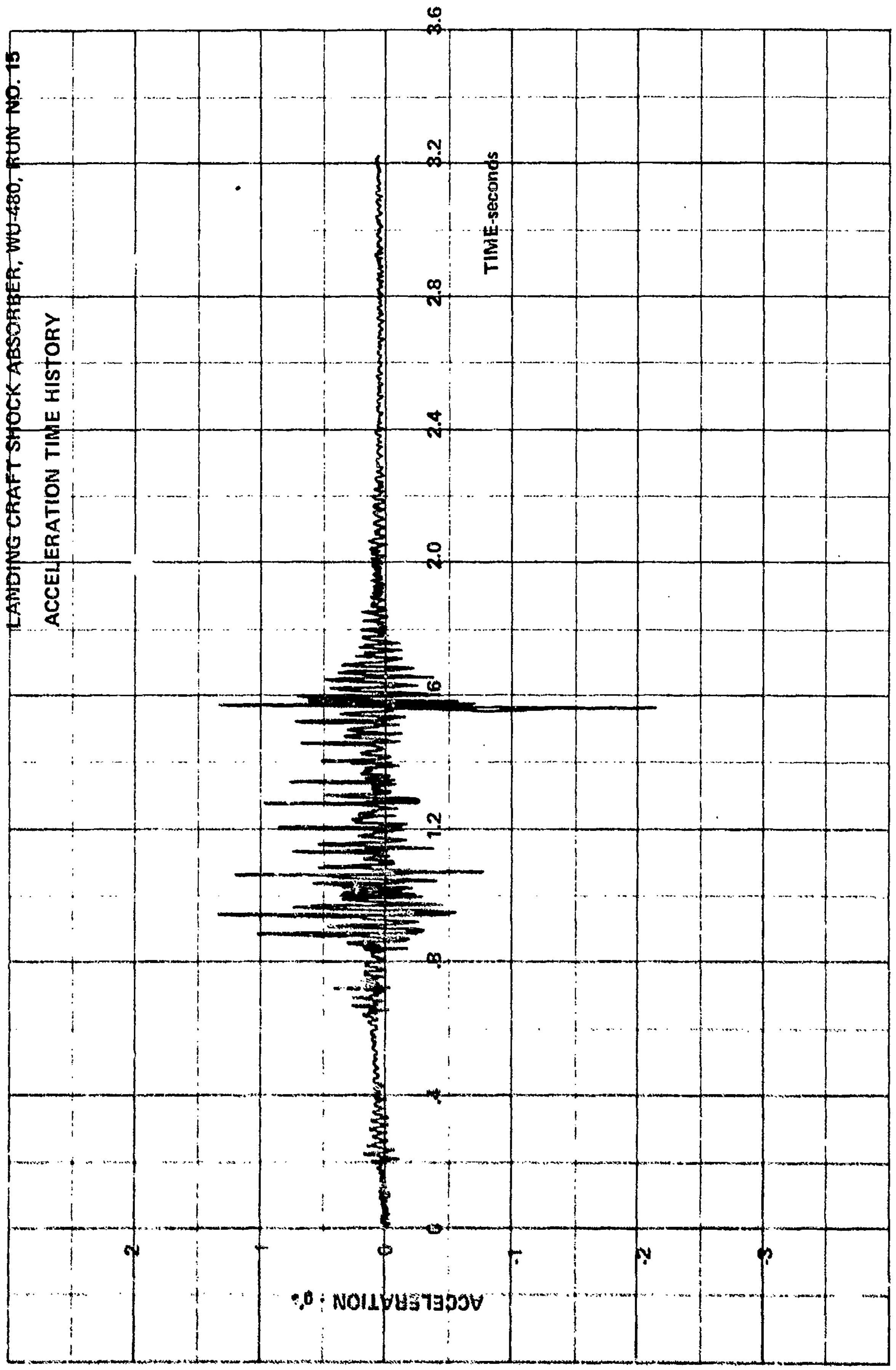

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 13
ACCELERATION TIME HISTORY
ACCELERATION - g's
2
1
0
-1
-2
-3
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME-seconds

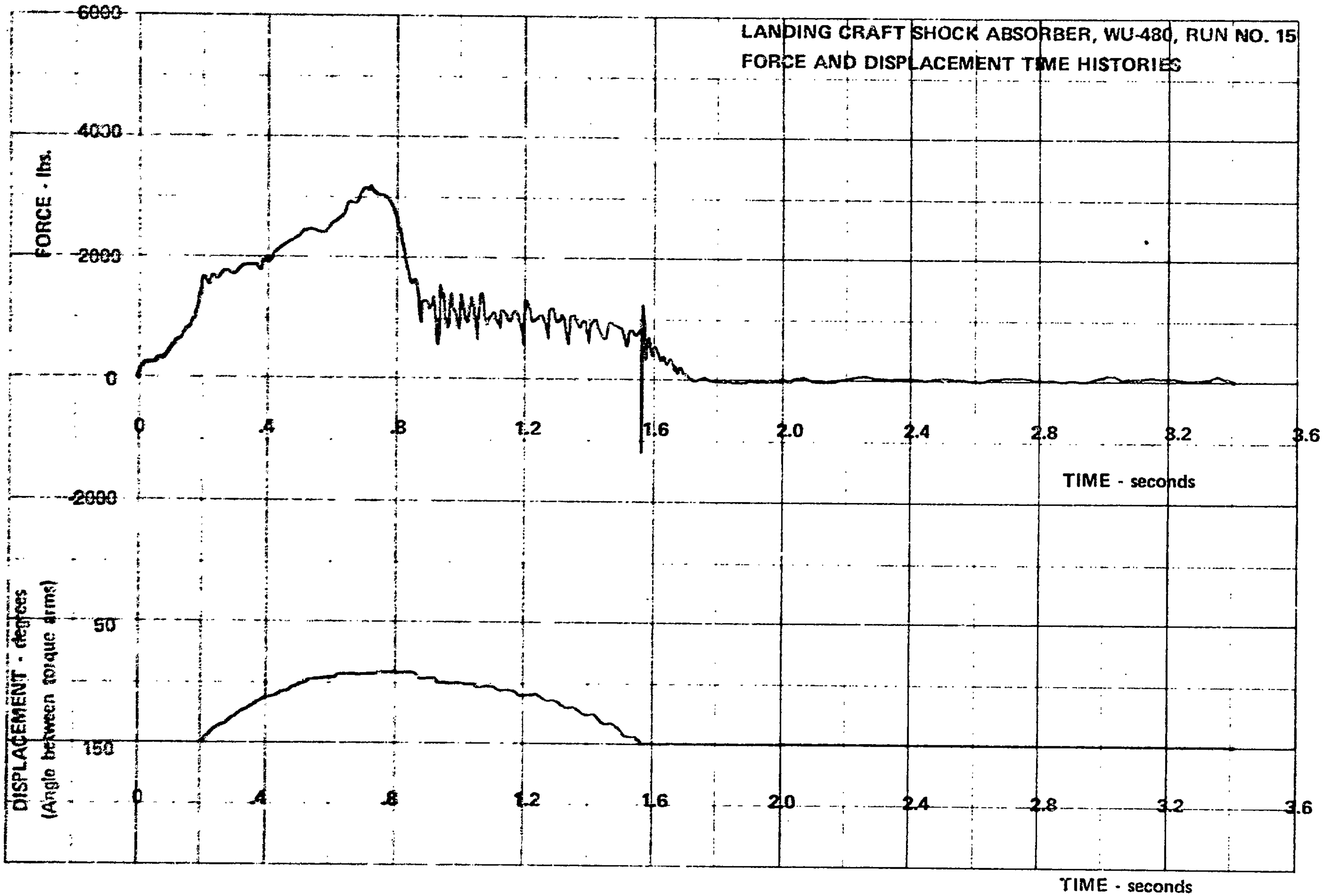

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 13
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds

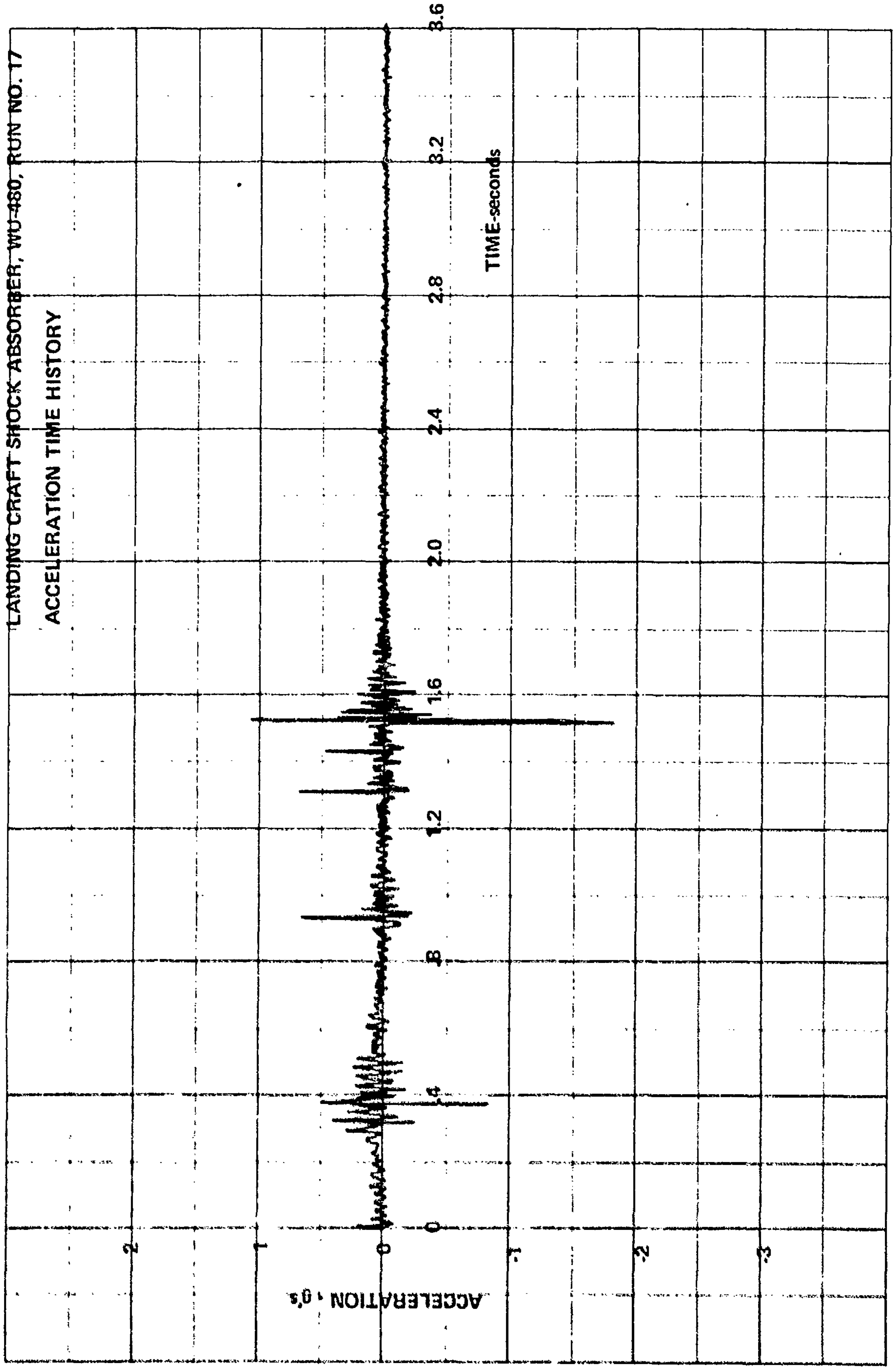


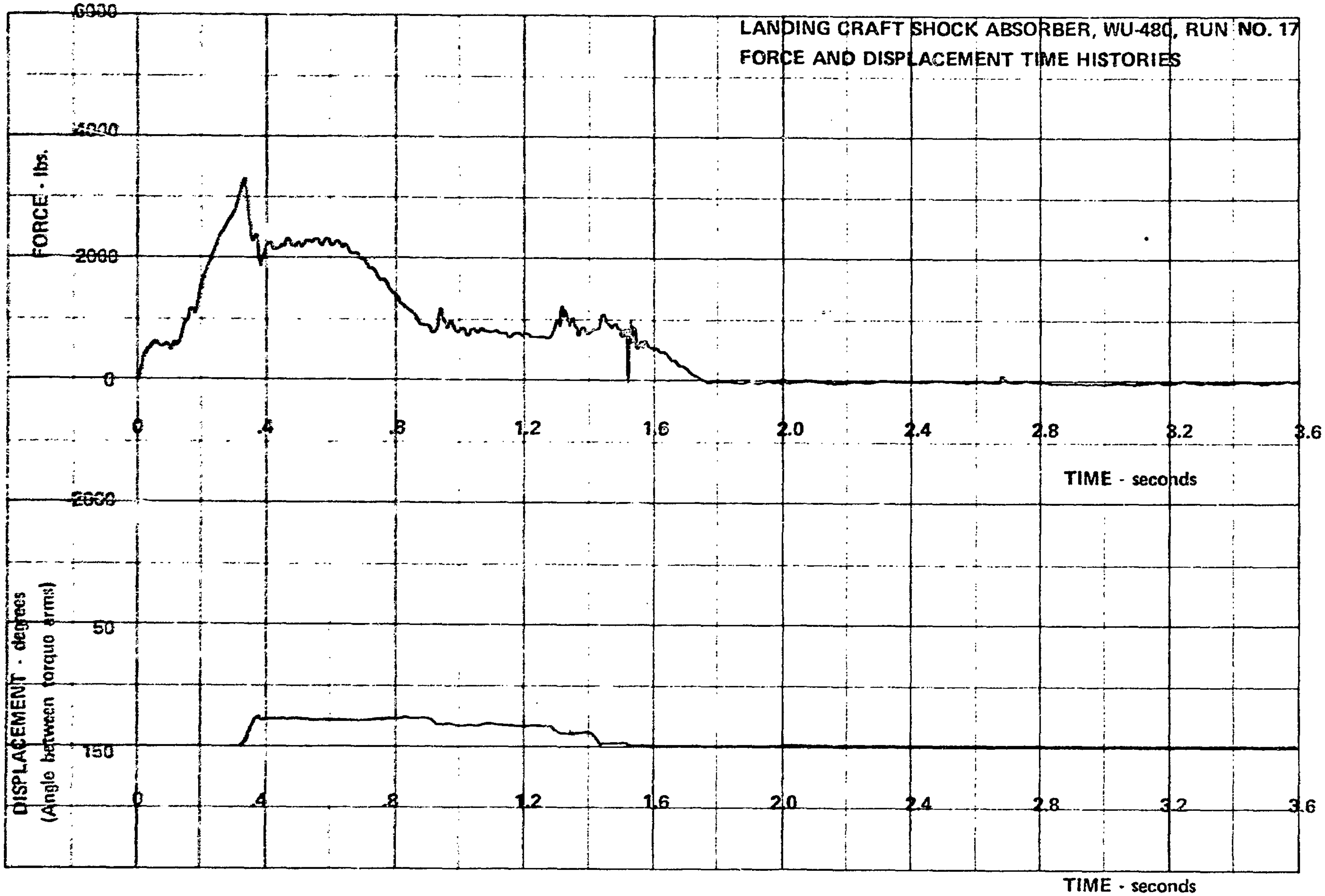
LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 14
ACCELERATION TIME HISTORY
ACCELERATION - g's
2
1
0
-1
-2
-3
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME-seconds


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 14
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
TIME - seconds

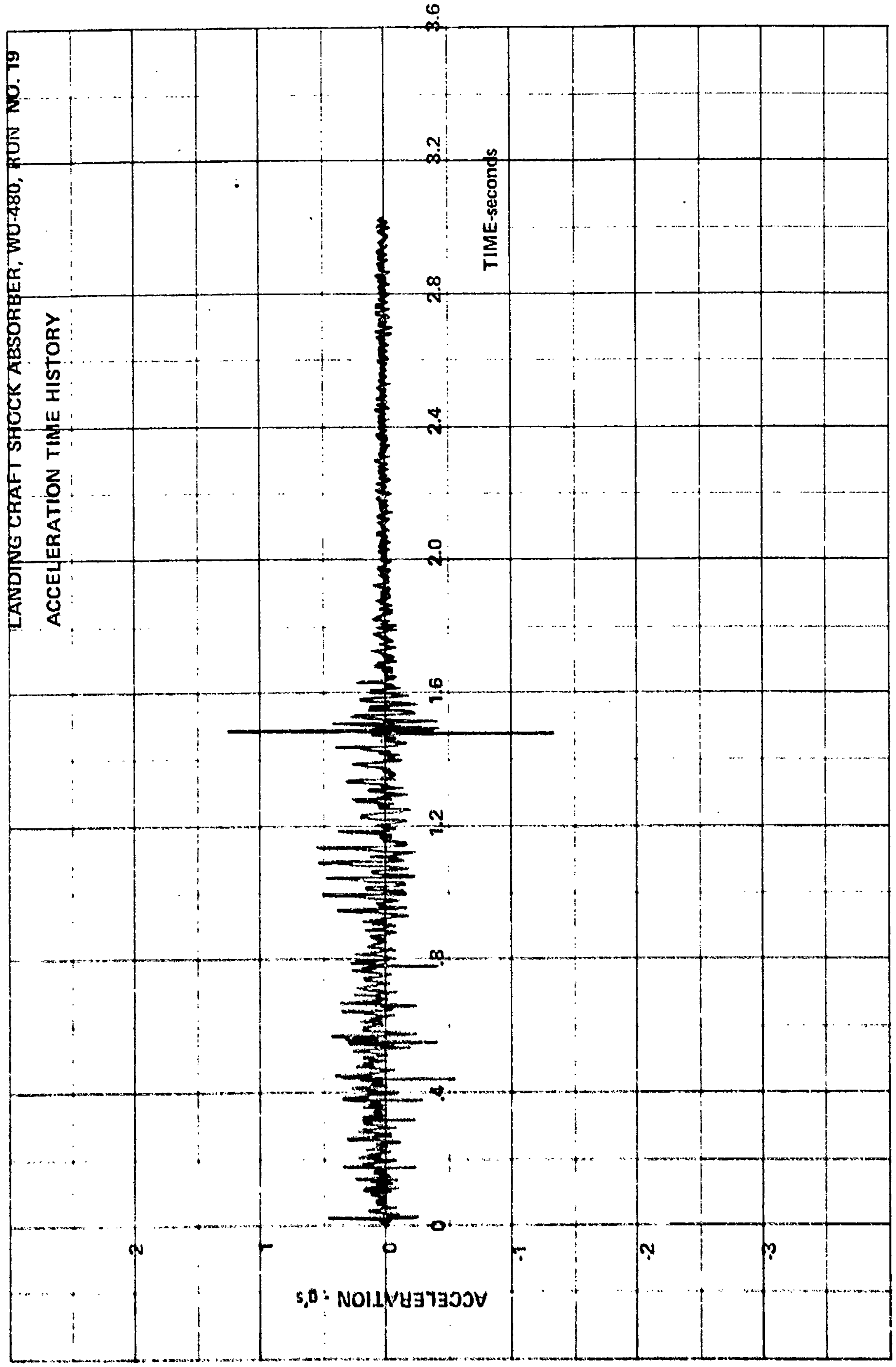

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 15
ACCELERATION TIME HISTORY
TIME-seconds
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
ACCELERATION - g's
2
1
0
-1
-2
-3

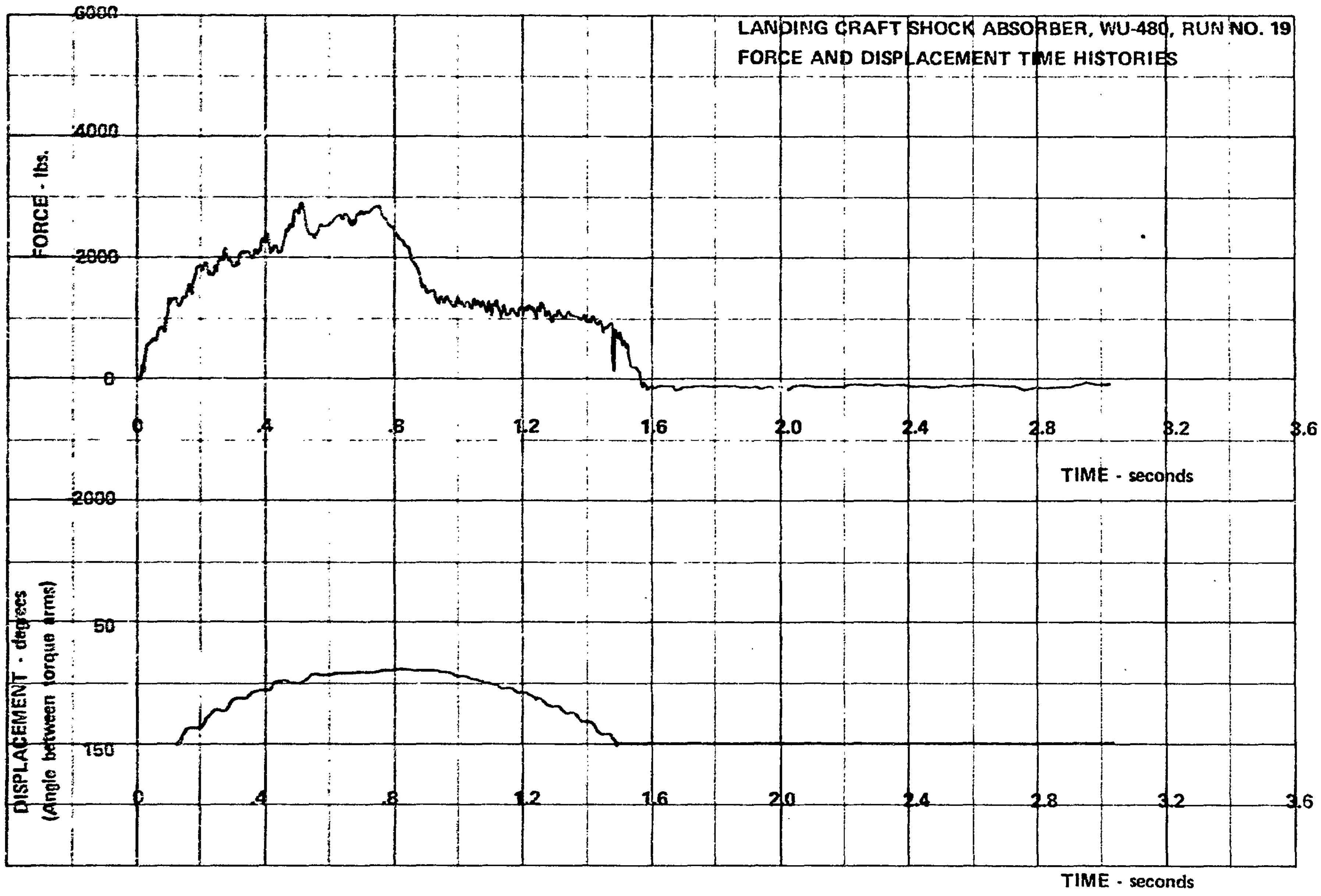

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 15
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
TIME - seconds

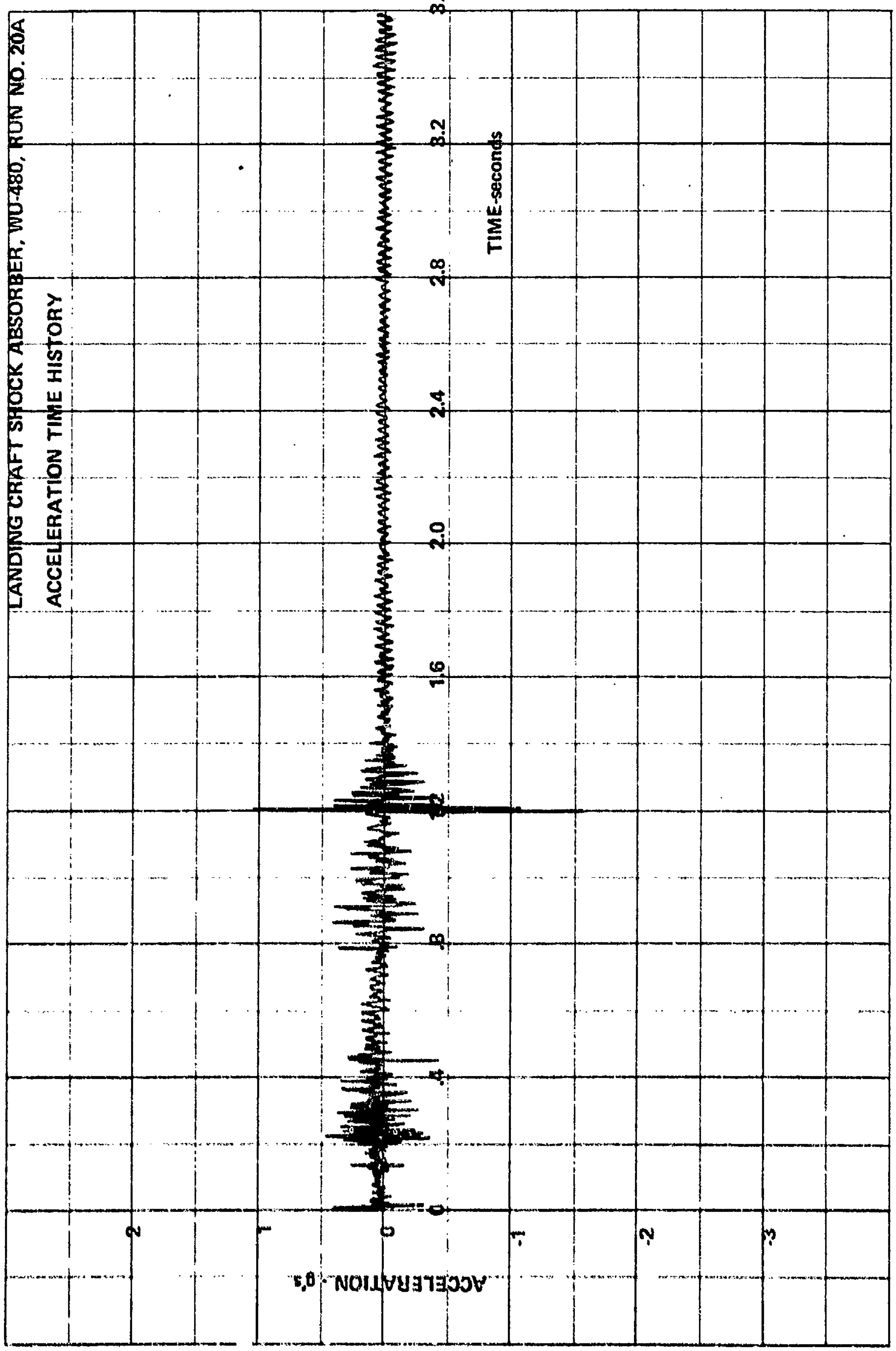

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 17
ACCELERATION TIME HISTORY
TIME-seconds
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
ACCELERATION , G's
2
1
0
-1
-2
-3

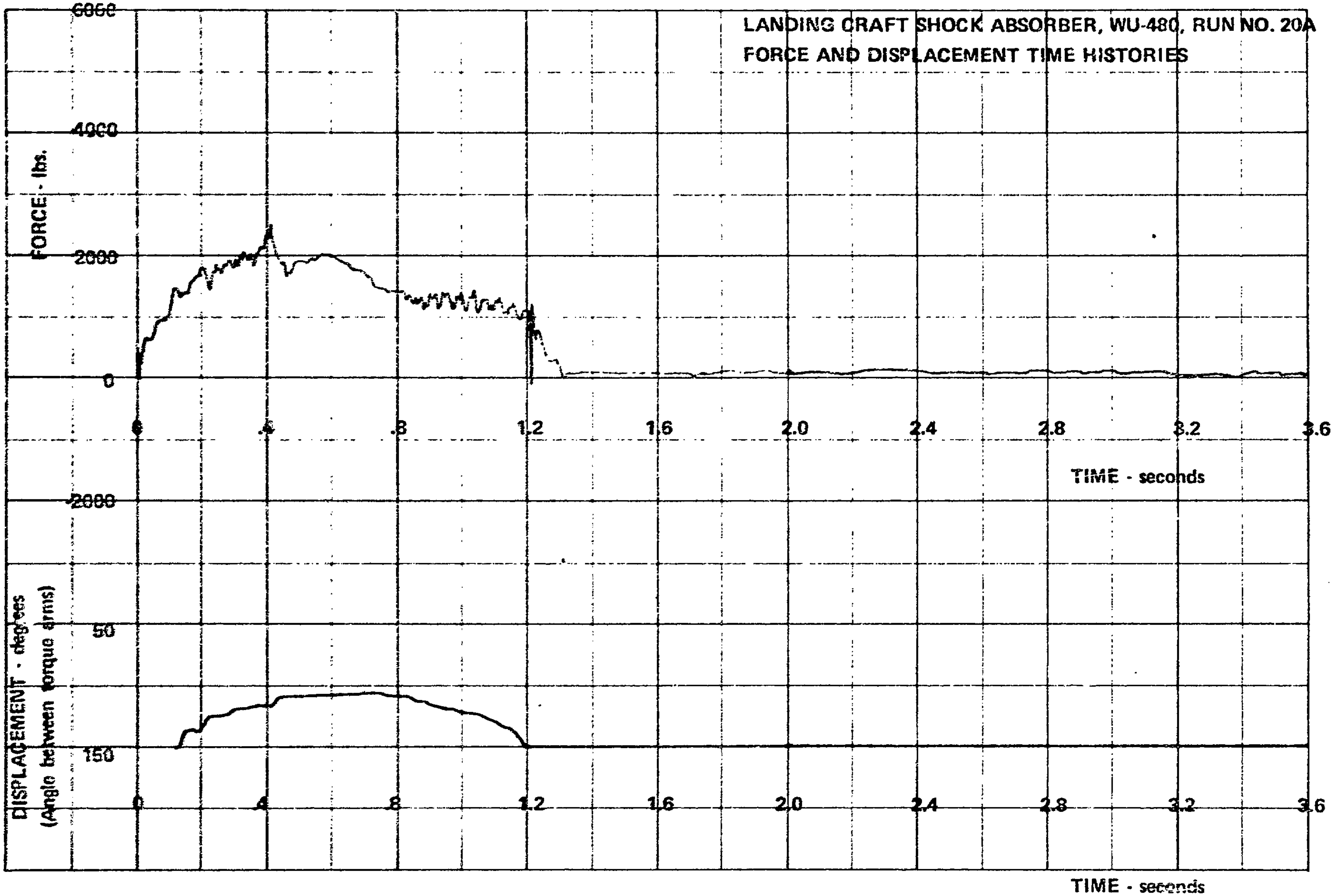


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 17
FORCE AND DISPLACEMENT TIME HISTORIES

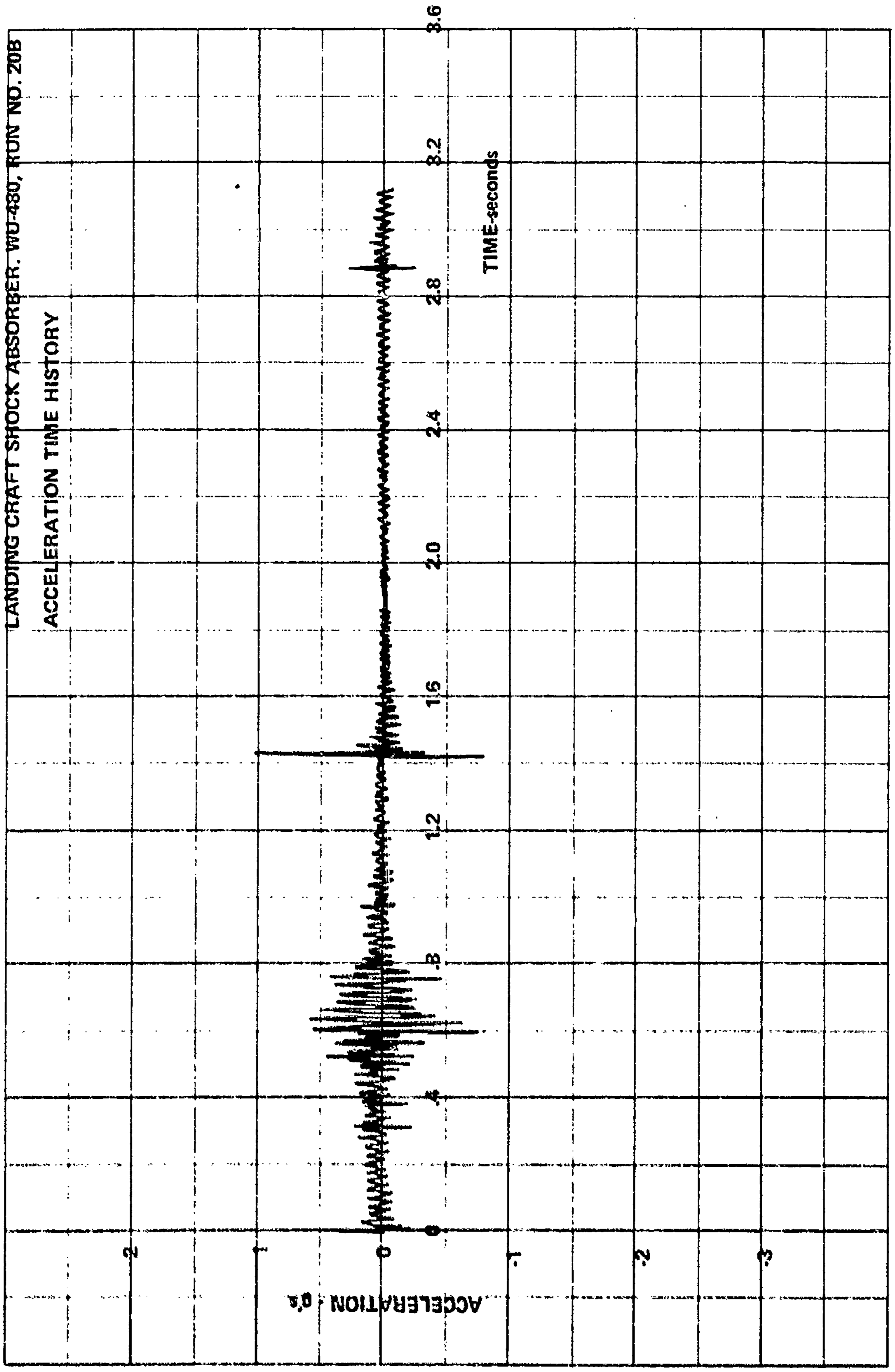

LANDING CRAFT SHOCK ABSORBER, WD-480, RUN NO. 19
ACCELERATION TIME HISTORY
TIME-seconds
ACCELERATION - g's
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
2
1
0
-1
-2
-3

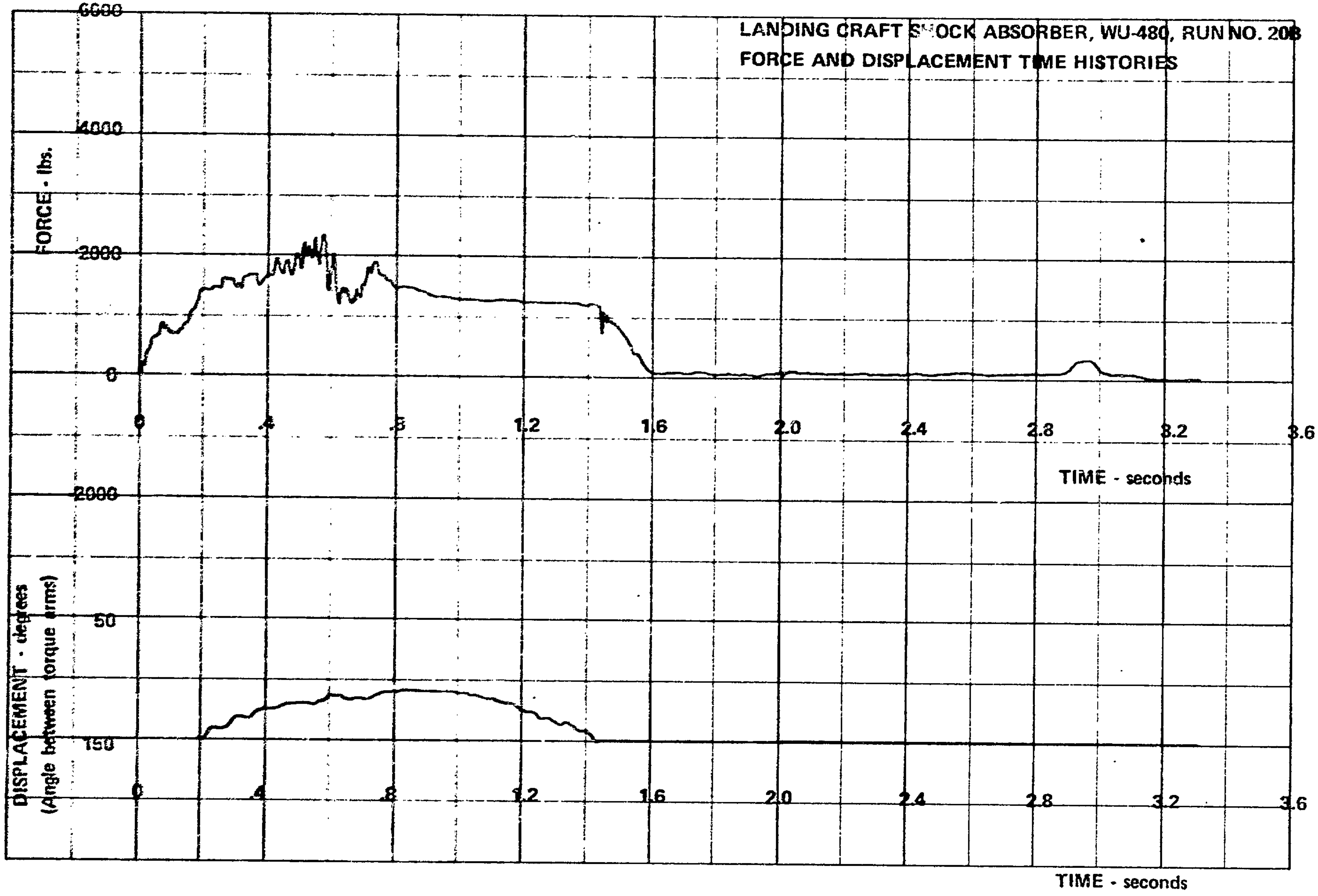

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 19
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
2000
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds

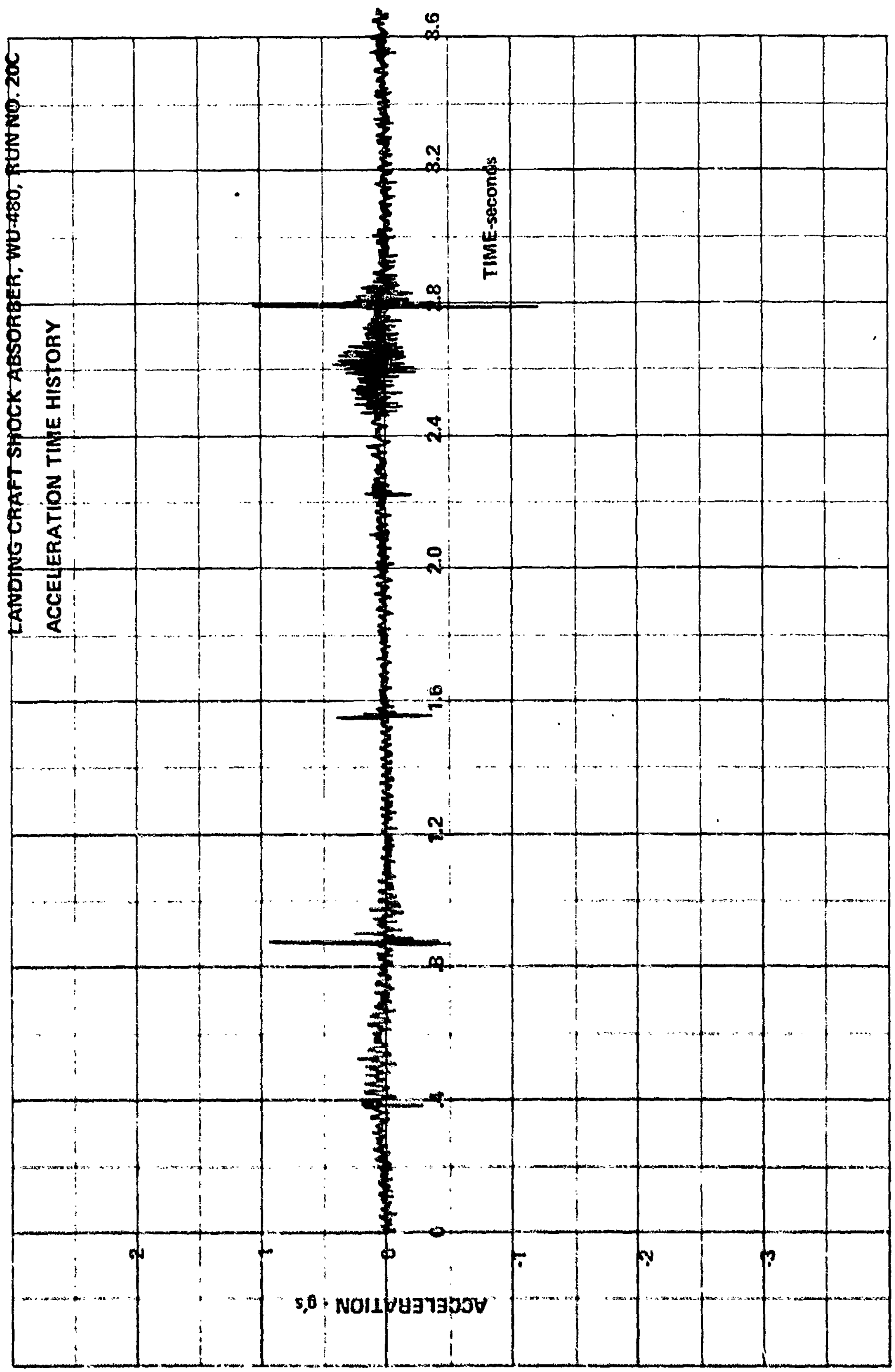

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 20A
ACCELERATION TIME HISTORY
TIME-seconds
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
ACCELERATION - g's
2
1
0
-1
-2
-3

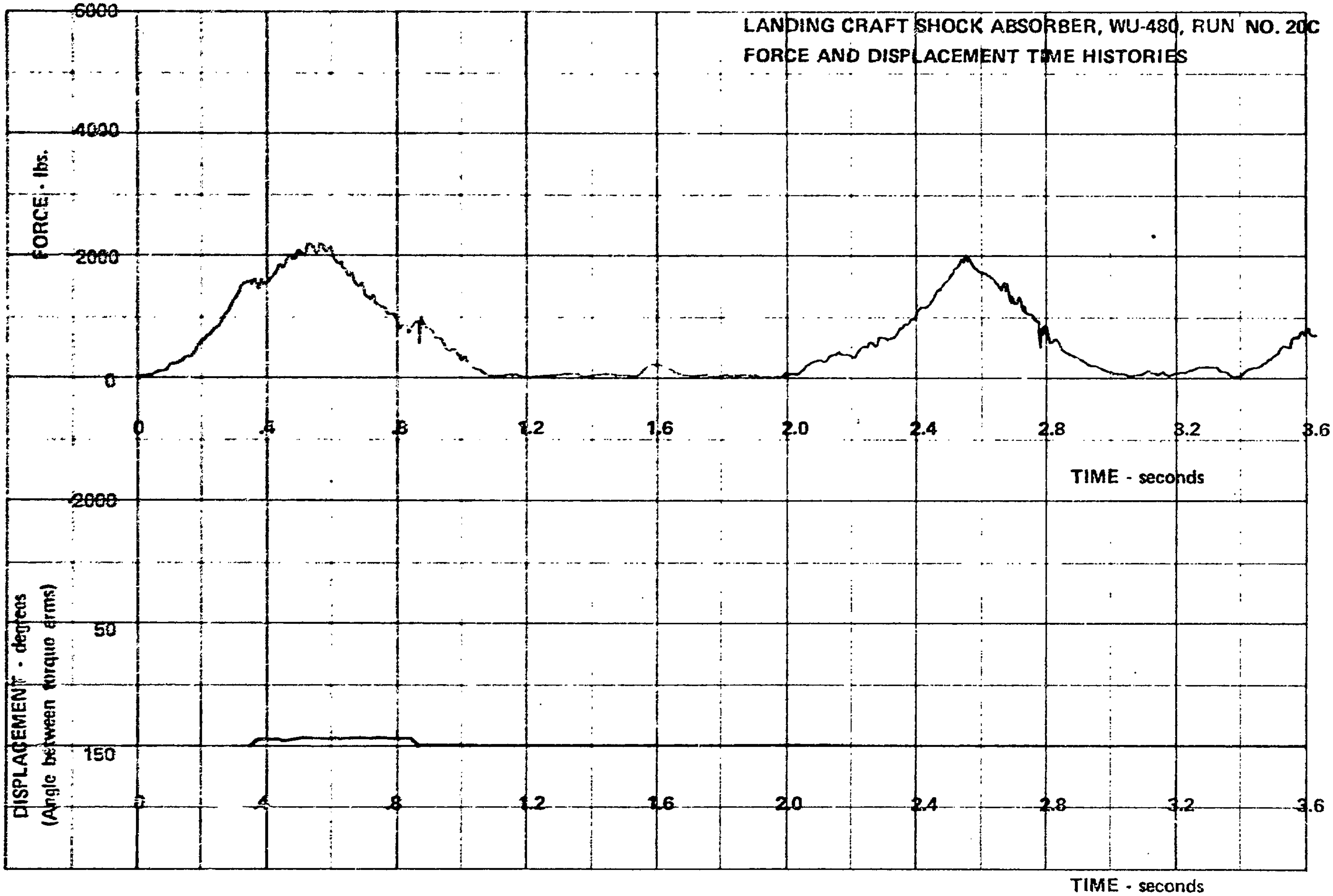


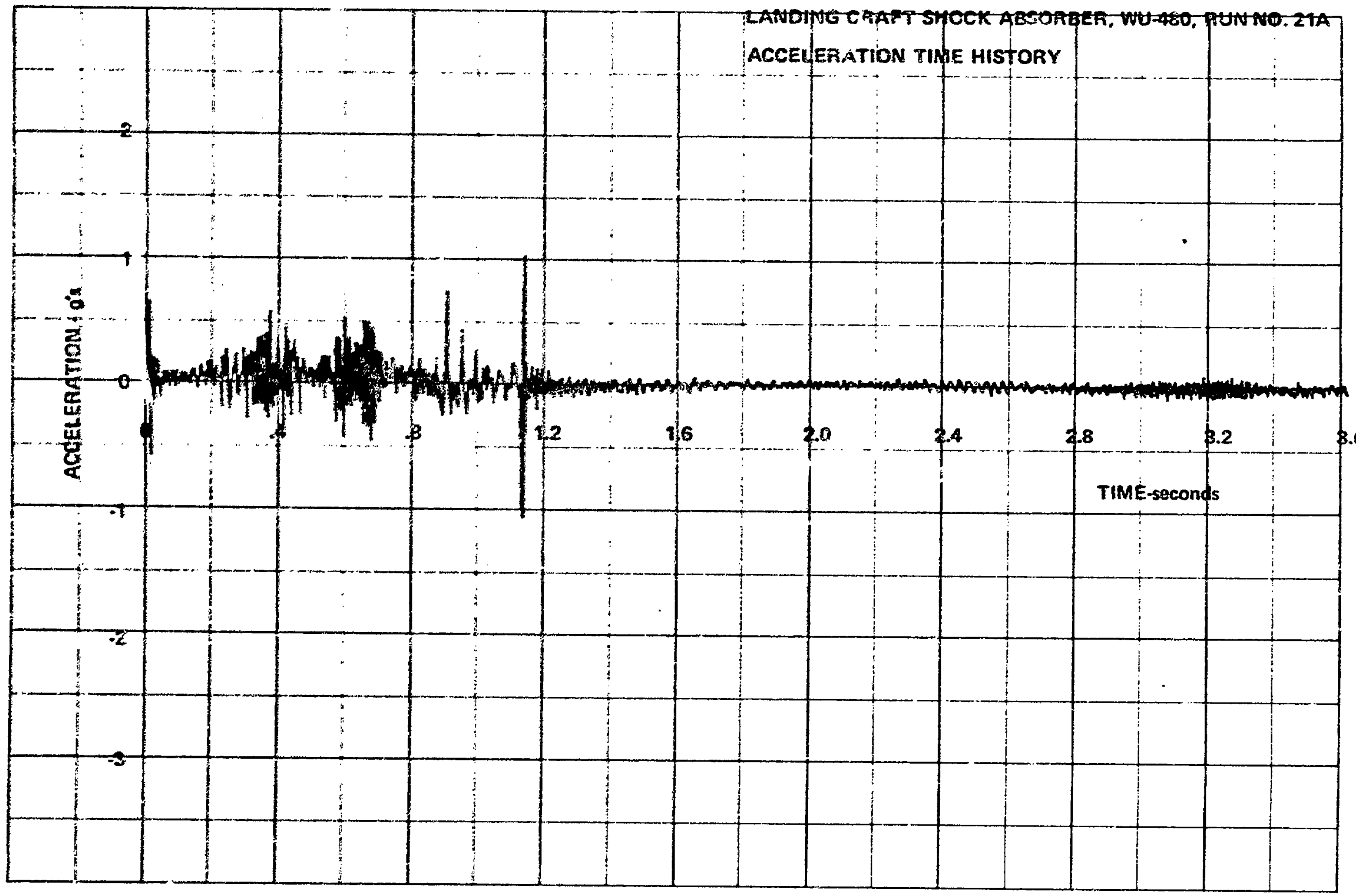
LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 20A
FORCE AND DISPLACEMENT TIME HISTORIES


LANDING CRAFT SHOCK ABSORBER, WD-480, RUN NO. 20B
ACCELERATION TIME HISTORY
TIME-seconds
ACCELERATION - g's

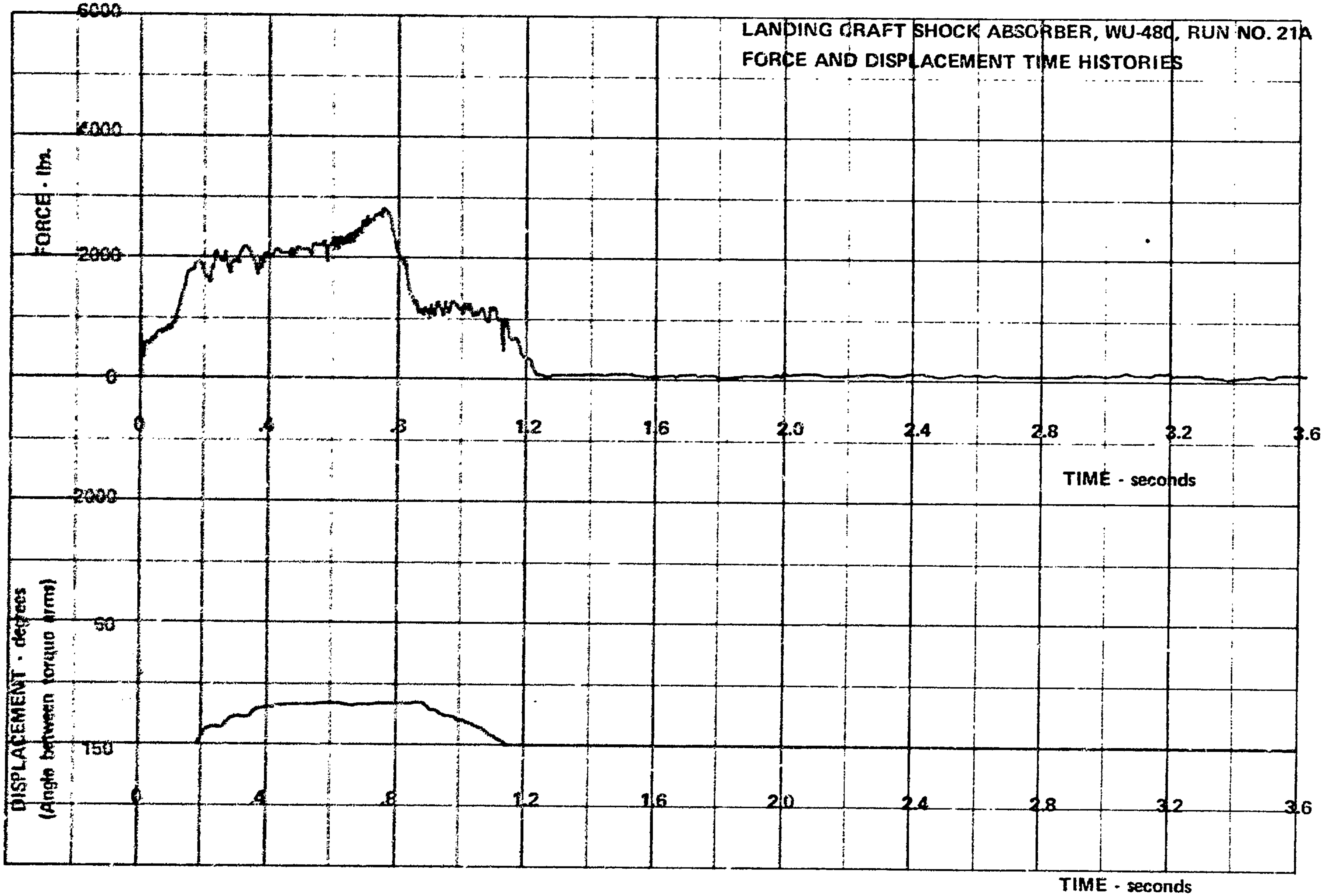

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 208
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
2000
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
TIME - seconds

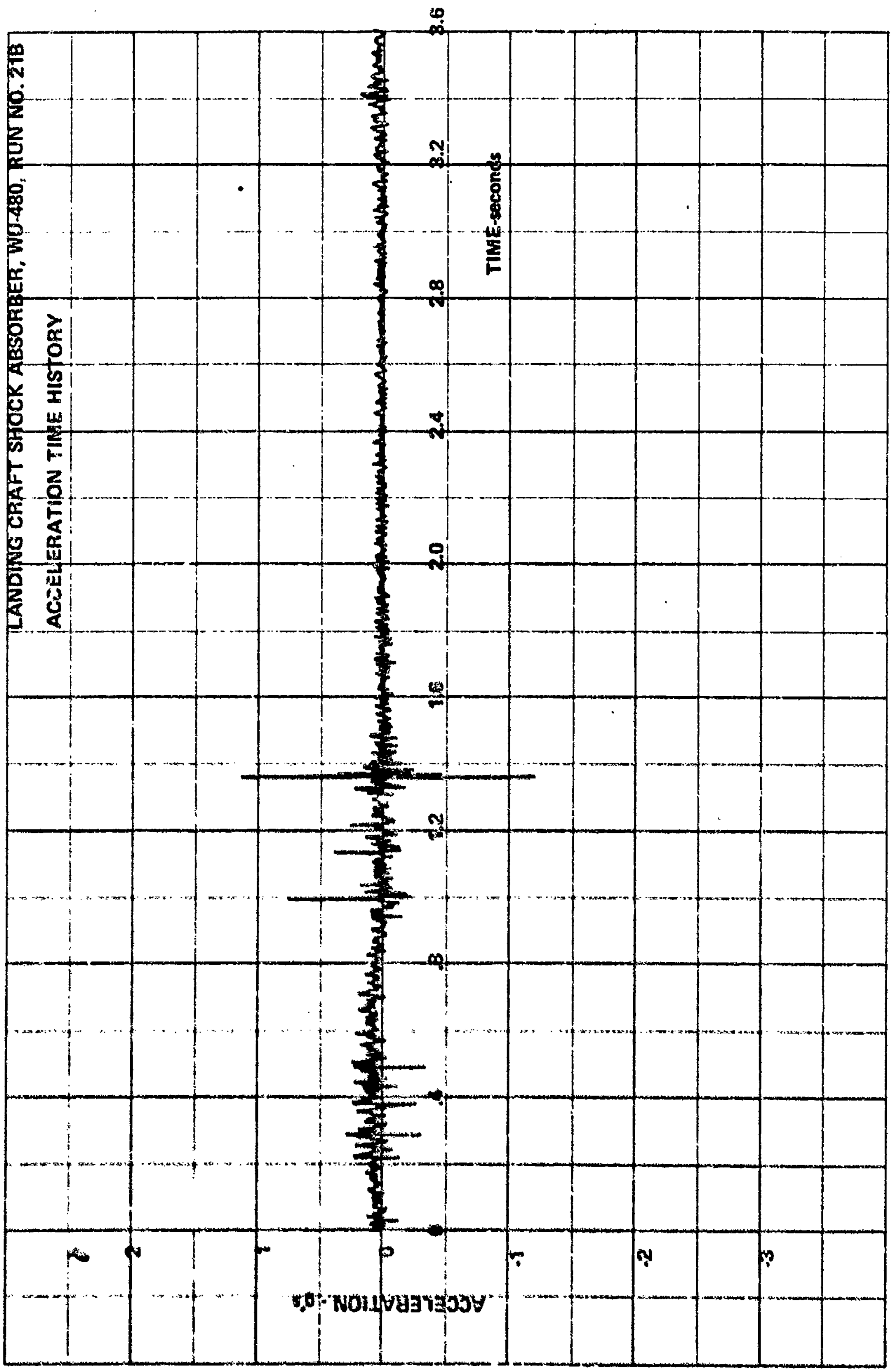

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 20C
ACCELERATION TIME HISTORY
TIME-seconds
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
ACCELERATION - g's
.2
.1
0
-.1
-.2
-.3

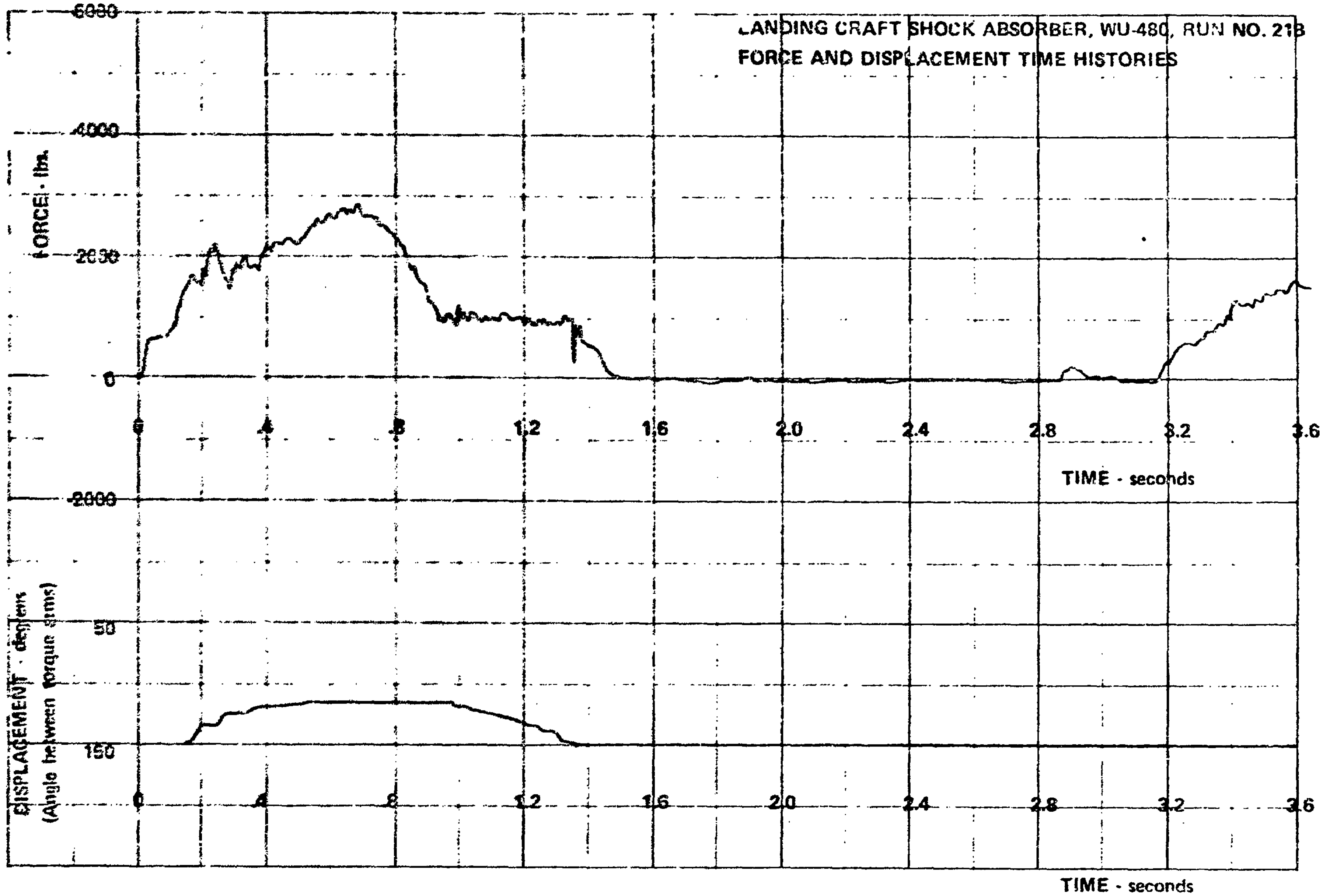

LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 20C
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds



LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 21A
ACCELERATION TIME HISTORY
ACCELERATION, g's
2
1
0
-1
-2
-3
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME-seconds


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 21A
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
2000
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds
TIME - seconds


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 21B
ACCELERATION TIME HISTORY
TIME-seconds
ACCELERATION - g's
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
2
1
0
-1
-2
-3


LANDING CRAFT SHOCK ABSORBER, WU-480, RUN NO. 21B
FORCE AND DISPLACEMENT TIME HISTORIES
FORCE - lbs.
6000
4000
2000
0
-2000
DISPLACEMENT - degrees
(Angle between torque arms)
50
150
0
.4
.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
TIME - seconds

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