AD-A191 349 ELECTRICAL IGNITION OF HAN-BASED LIQUID PROPELLANTS(U) 1/1
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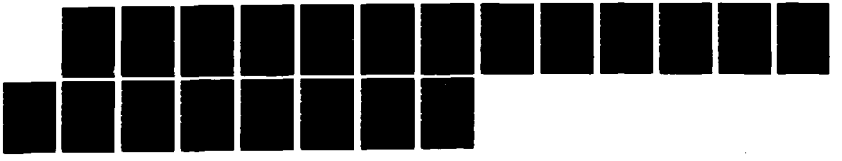
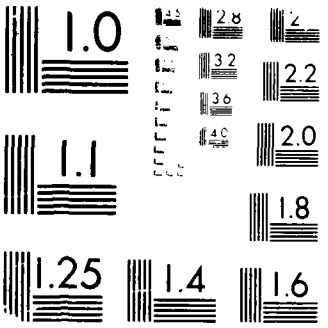




MICROCOPY RESOLUTION TEST CHART

Fraunhofer-Institut für Kurzzeitdynamik
Ernst-Mach-Institut
Abteilung für Ballistik

ELECTRICAL IGNITION OF HAN-BASED LIQUID PROPELLANTS

G. Klingenberg
(Principal Investigator)

CONTRACTOR:

FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG e.V.,
ATTN: CONTRACTS DEPARTMENT, LEONRODSTRASSE 54,
D-8000 MÜNCHEN 19, FEDERAL REPUBLIC OF GERMANY

CONTRACT No. DAJA 45-86-C-0029

First Interim Report

1 October 1986 - 1 December 1986

SECOND INTERIM 1 OCT 86 - 1 APR 87
THIRD INTERIM 1 APR 87 - 1 OCT 87

The research reported in this document has been made possible through the support and sponsorship of the U. S. Government through its European Research Office of the U. S. Army. ~~This report is intended only for the internal management use of the Contractor and the U. S. Government.~~

A. Objectives

The present First Interim Report informs on the current status of the Contract No. DAJA 45-86-C-0029 entitled: "Electrical Ignition of HAN-Based Liquid Propellants". This contract is supported and sponsored by the U. S. Government through its U.S. Army Research, Development and Standardization Group in the United Kingdom (U.S.A.R.D.S.G. - UK).

The scope of this study is to investigate and optimize the electrical ignition of hydroxyl-ammonium nitrate (HAN)-based liquid monopropellants (LP) in conjunction with its use as a propellant charge in the regenerative liquid propellant gun (RLPG). In this research, the fundamentals of LP ignition will be investigated which will contribute to the design at electrical igniter devices suitable for large caliber RLPG systems. Specific goals are:

- to investigate various means of electrical ignition of LP,
- to develop quantitative ignition criteria,
- to achieve reproducible igniter output energies,
- to obtain igniter energy effluxes that are capable of starting the regenerative process and producing sustained ignition in the gun chamber
- to scale the ignition requirements to large volumes

B. Research Efforts Proposed for 1986

In the first months of the first year program, i.e., during the period October 1 to December 1, 1986, it was proposed to build suitable test fixtures for achieving controlled eletrical ignition of HAN-based LPs.

C. Work Done During the Reporting Period

The work done during the reporting period included the design and production of a suitable test fixture. An igniter was designed which, according to the wishes of the contract monitor at the Ballistic Research Laboratory, Aberdeen Proving Ground, MD, adopted the setup tested by BRL in the 30-mm Regenerative Liquid Propellant Gun. The propellant cavity of the igniter has a nominal volume of about 2 milliliters. The igniter was designed so that the cavity geometry can be varied and the effect on the ignition of the liquid propellant studied. Positive and negative polarities can be applied to the electrodes with a suitable power supply.

The present design is being tested while the polarity of the electrodes are interchanged. A specially derived computer code will be used to predict the electrical field configurations in order to guide the igniter design. Results for the first igniter configuration are expected during December 1986.

D. Brief Statement of Research Plans 1987

Research plans for the next six months are to

(1) achieve controlled ignition,

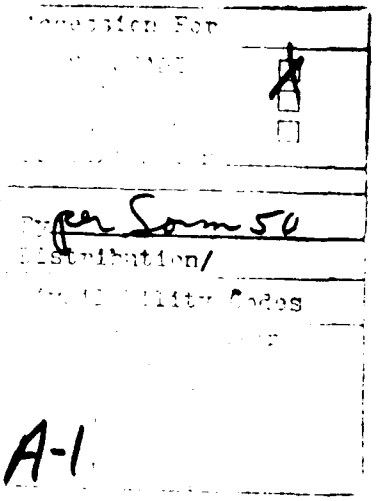
(2) test diagnostic capabilities to measure the

- ignition, decomposition and combustion in the igniter case,
- igniter output,
- conditions in a suitable test chamber.

(3) develop further igniter cases.

E. Visits, List of Papers etc.

Due to the relatively short reporting period no visits have been undertaken and no papers were published under this contract. Also, no property was acquired with contract funds during this period.



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CONTRACT No. DAJA 45-86-C-0029

Second Interim Report

1 October 1986 - 1 April 1987

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A. Objectives

The present Second Interim Report informs on the current status of the Contract No. DAJA 45-86-C-0029, entitled: "Electrical Ignition of HAN-Based Liquid Propellants". This contract is supported and sponsored by the U. S. Government through its U. S. Army Research, Development and Standardization Group in the United Kingdom (U.S.A.R.D.S.G. - UK).

The scope of this study is to investigate and optimize the electrical ignition of hydroxylammonium nitrate (HAN)-based liquid monopropellants (LP) in conjunction with its use as a propellant charge in the regenerative liquid propellant gun (RLPG). In this research, the fundamentals of LP ignition will be investigated which will contribute to the design of electrical igniter devices suitable for large caliber RLPG systems. Specific goals are:

- to investigate various means of electrical ignition of LP;
- to develop quantitative ignition criteria;
- to achieve reproducible igniter output energies;
- to obtain igniter energy effluxes that are capable of starting the regenerative process and producing sustained ignition in the gun chamber;
- to scale the ignition requirements to large volumes.

B. Research Efforts Proposed for the First Six Months

In the first six months of the 1986 to 1987 years program, i.e., during the period October 1, 1986, to April 1, 1987, it was proposed to

- build suitable test fixtures,
- achieve controlled electrical ignition of HAN-based LPs,
- test diagnostics capabilities to measure the ignition and combustion of LPs.

C. Work Done During the Reporting Period

The work done during the reporting period included the design and production of a suitable test fixture. An igniter was designed which, according to the wishes of the contract monitor at the Ballistic Research Laboratory, Aberdeen Proving Ground, MD, adopted the setup tested by BRL in the 30-mm Regenerative Liquid Propellant Gun. The propellant cavity of the igniter has a nominal volume of about 2 milliliters. The igniter was designed so that the cavity geometry can be varied and the effect on the ignition of the liquid propellant studied. Positive and negative polarities can be applied to the electrodes with a suitable power supply.

This design has been tested while the polarity of the electrodes was interchanged. The diagnostics applied included pressure and temperature measurements as well as photography. A specially derived computer code is used to predict the electrical field configurations in order to guide the igniter design. Results for the first igniter configuration indicate that the controlled ignition of the HAN-based LPs is difficult to obtain at high energy levels. In two firings we had fast combustion so that the test setup was destroyed. These parts were taken to the shop and were newly manufactured. Then we reduced the rise time and the amplitude of the ignition pulse to achieve controlled ignition. The altered electrical pulse resulted in controlled ignition reactions.

D. Brief Statement of Research Plans 1987

Research plans for the next six months are to

(1) achieve controlled ignition by varying the electrical pulse of the igniter,

(2) measure the

- ignition, decomposition, and combustion in the igniter case,
- igniter output,
- conditions in a suitable test chamber.

(3) develop further igniter cases.

E./F. Visits, List of Papers, etc.

Due to the relatively short reporting period no visits have been undertaken and no papers were published under this contract.

G. Significant Administrative Actions

(1) A full-time technician has been employed by the Fraunhofer Society supported by this contract.

(2) An increase of funding of U.S. $ 5,000.-- per year has been requested on February 9, 1987 by an Adjunct to the Contract. The increase was accepted by the U.S. Army Ballistic Research Laboratory and forwarded to USARDSG-UK, London. The additional funding will be requested at the end of the first year, i.e., October 1, 1987 pending the approval of USARDSG-UK.

H. Amounts of Funds and Property Acquired

Since only the first partial payment of 6,600.-- US $ for 1986 was made, no unused funds remain on the contract. Also, no property was acquired with contract funds during the reporting period.

Fraunhofer-Institut für Kurzzeitdynamik

Ernst-Mach-Institut

Abteilung für Ballistik

ELECTRICAL IGNITION OF HAN-BASED LIQUID PROPELLANTS

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CONTRACT No. DAJA 45-86-C-0029

Third Interim Report

1 April 1987 - 1 October 1987

The research reported in this document has been made possible through the support and sponsorship of the U. S. Government through its European Research Office of the U. S. Army. ~~This report is intended only for the internal management use of the Contractor and~~ the U. S. Government.

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Fraunhofer-Gesellschaft zur Förderung der angewandten
Vorstand: Prof. Dr. rer. nat. Max Syrbe, Dr. jur. Eberhard Schlephorst

A. Objectives

The present Third Interim Report informs on the current status of the Contract No. DAJA 45-86-C-0029, entitled: "Electrical Ignition of HAN-Based Liquid Propellants". This contract is supported and sponsored by the U. S. Government through its U. S. Army Research, Development and Standardization Group in the United Kingdom (U.S.A.R.D.S.G. - UK).

The scope of this study is to investigate and optimize the electrical ignition of hydroxylammonium nitrate (HAN)-based liquid monopropellants (LP) in conjunction with its use as a propellant charge in the regenerative liquid propellant gun (RLPG). In this research, the fundamentals of LP ignition will be investigated which will contribute to the design of electrical igniter devices suitable for large caliber RLPG systems. Specific goals are:

- to investigate various means of electrical ignition of LP;
- to develop quantitative ignition criteria;
- to achieve reproducible igniter output energies;
- to obtain igniter energy effluxes that are capable of starting the regenerative process and producing sustained ignition in the gun chamber;
- to scale the ignition requirements to large volumes.

B. Research Efforts Proposed for the Research Period April to October 1987

In the Third Interim Research Program, i.e., during the period April 1, 1987, to October 1, 1987 it was proposed to

- achieve controlled ignition in the igniter cavity filled with about 2 cm^3 HAN-based liquid monopropellant LPG 1846,

- measure during the decomposition and combustion of the LGP 1846 the igniter output in terms of gas pressure inside a special, newly designed test chamber,

- develop further igniter cases.

C. Work Done During the Reporting Period

The work done during the reporting period was, at first, severely impeded by the difficulties encountered in the ignition within the igniter cavity. In most of the tests, the 2 cm^3 LP charge was rapidly ignited releasing so much energy that the cavity was destroyed and had to be replaced by a new test fixture. In some cases, the igniter charge was not ignited, but the liquid was sprayed into the surroundings. This behavior did not change as the electrical pulse width and the pulse rise was altered.

To overcome these difficulties, discussions were held with the Scientific Liaison and other scientists during a visit to BRL in July 1987 with the conclusion that the power supply should be replaced by a device which permits the generation of currents with rise times of about 0.25 to 0.3 ms or longer and larger pulse widths. Therefore, a new power supply has been made which yields pulse rise times variable from 0.1 ms to about 1 ms and pulse widths variable from 1 ms to 1 sec depending upon the condensator battery used and the ignition behavior of the propellant. Figure 1 in Appendix 1 shows schematically the circuit.

Also, the two igniter cavity configurations shown in Fig. 2 of Appendix 1 have been designed and made to study the ignition behavior of the LGP 1846. The first design corresponds to one of the BRL configurations. This igniter cavity was made according to the wishes of the Scientific Liaison. In addition, the second design was developed using predicting schemes of a model, in order to obtain a more symmetrical electric field distribution.

In addition, a further new test fixture was made, to be able to measure the energy output of the igniter cavity used in the test chamber. The volume of this test chamber can be varied from about 41.5 cm^3 to 101 cm^3, see Figure 3 of Appendix 1. With these altered devices, controlled ignition was achieved. For example, with a fill of 1.9 cm^3 LGP 1846 and a voltage of 1600 volts (maximum) and a rise time of 0.25 ms (10 % to 90 %), a maximum current of 120 ampères (190 Watts or 116 Joules), the LGP 1846 was properly ignited, and after venting the igniter output into the test chamber a maximum pressure of about 6 atmospheres or 0.6 MPa has been measured. An example of such a pressure record is shown in Figure 4 of Appendix 1.

Thus we could overcome the difficulties and so controlled ignition can be studied in further tests.

D. Brief Statement of Research Plans 1988

Research plans for the next six months are to

(1) study under controlled ignition the energy output of various igniter configurations,

(2) measure the igniter output in terms of pressure and temperature in the test chamber.

E./F. Visits, List of Papers, etc.

The principal investigator attended meetings at several institutes.

- 24.6. - 26.6. Visit to BICT, Bonn, together with the Scientific Liaison, Mr. J. D. Knapton, BRL

- 29.5. - 5.6. Visit of various UK installations to get information on LP research.

- 7.7. - 22.7. Visit to BRL and other US installations with BRL scientists.

G. Significant Administrative Actions

A full-time technician has been employed by the Fraunhofer Society supported by this contract.

H. Amounts of Funds and Property Acquired

Since only the first and second partial payment was made, no unused funds remain on the contract. Also, no property was acquired with contract funds during the reporting period.

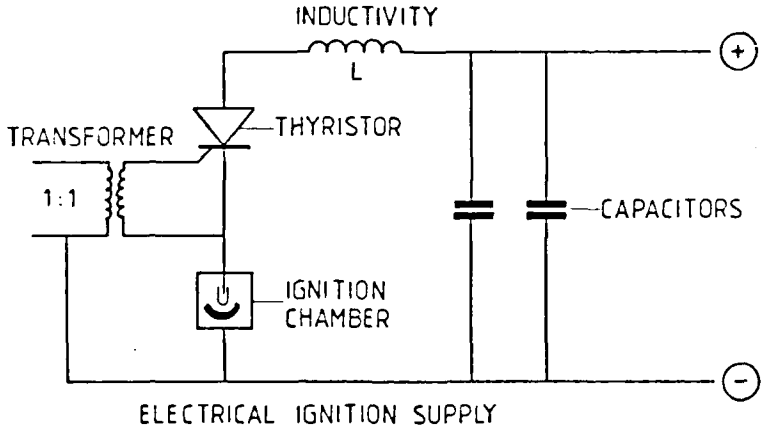
APPENDIX 1

Power Supply

Igniter Cavity

Test Fixture

Pressure History


INDUCTIVITY
L
TRANSFORMER
THYRISTOR
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CAPACITORS
IGNITION
CHAMBER
ELECTRICAL IGNITION SUPPLY

Figure 1

IGNITER CAVITY CONFIGURATION

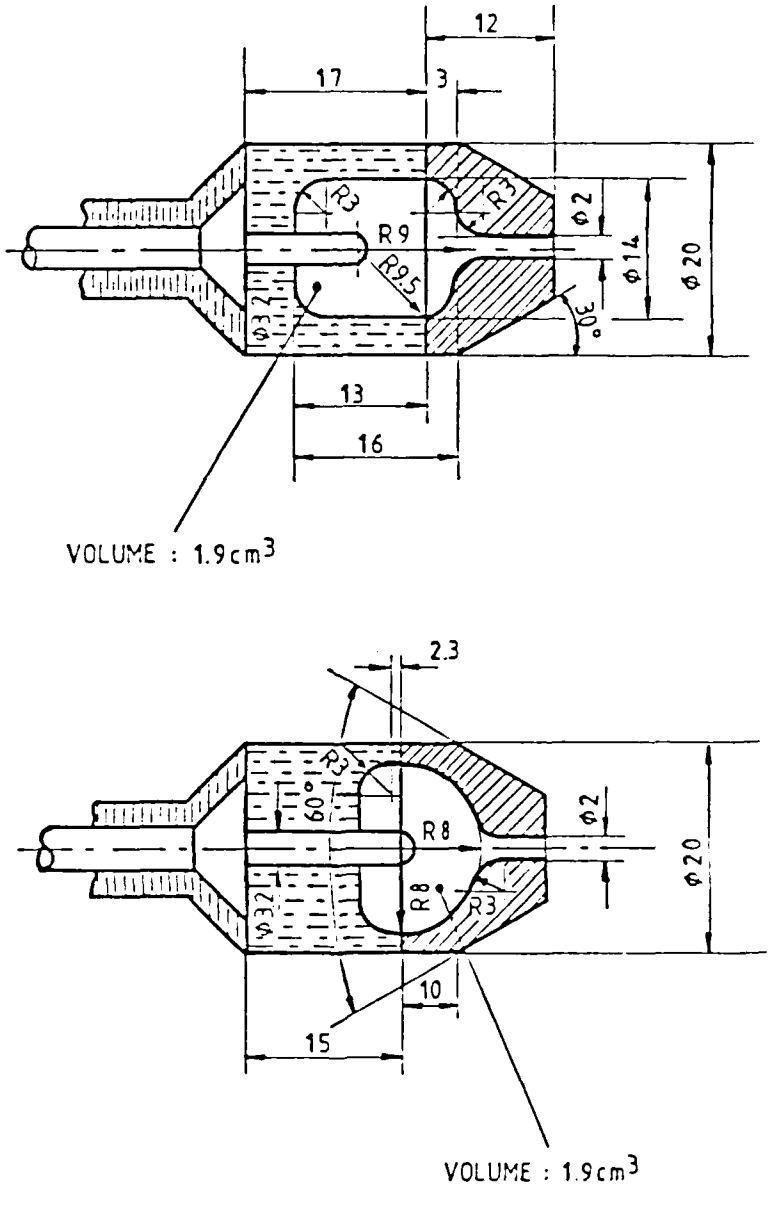

Figure 2

EMI-AFB 1987

TEST FIXTURE
ELECTRICAL IGNITION OF HAN-BASED LP

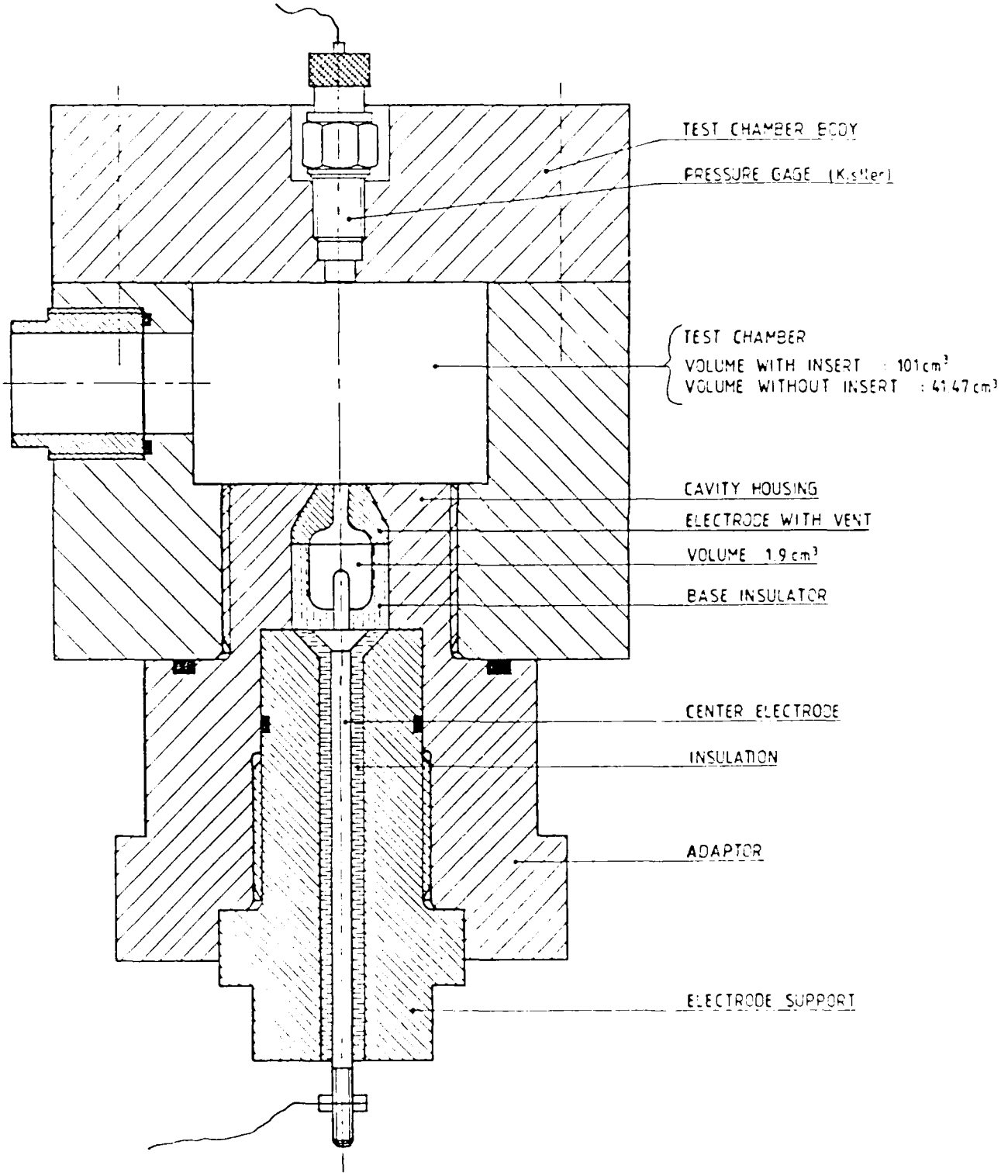

Figure 3

EMI - AFB 1987

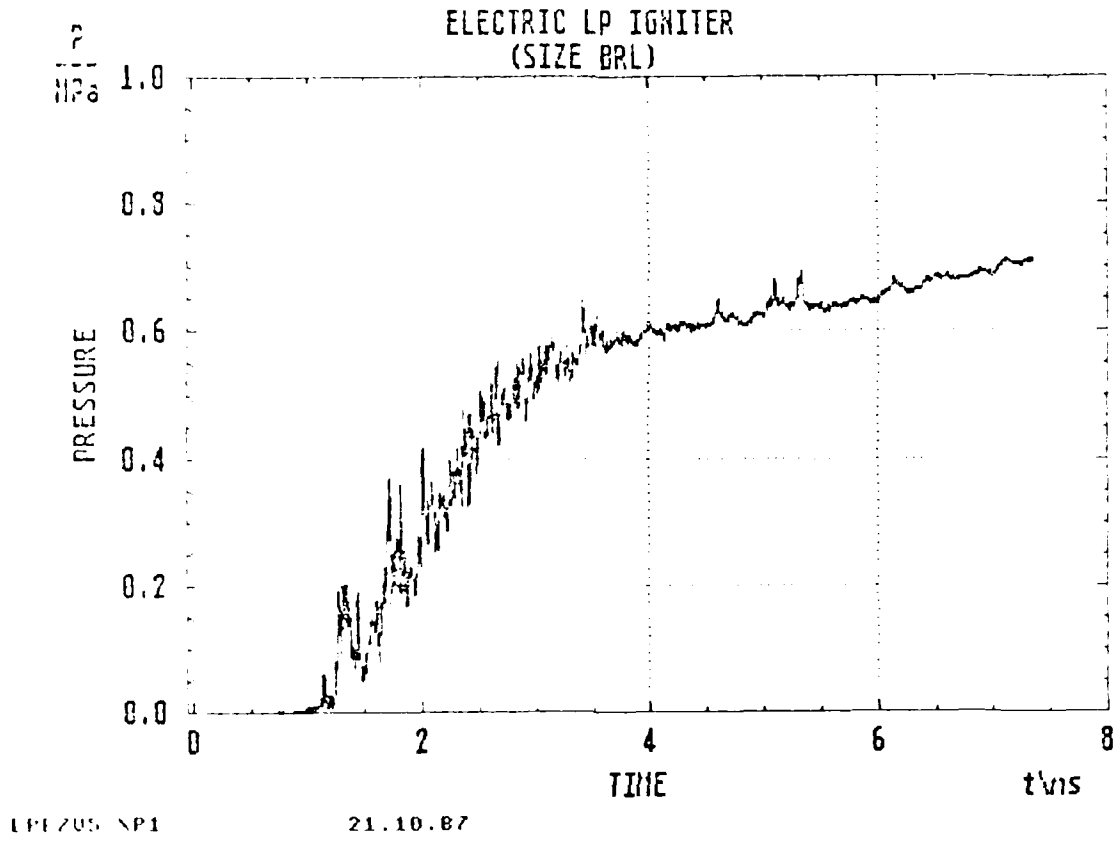

Figure 4. Pressure history of first igniter configuration shown in Fig. 2

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