ENCLOSURE (B) 10

STUDIES ON THE COMBUSTION OF HYDROGEN PEROXIDE AND HYDRAZINE HYDRATE

by

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LIST OF TABLES AND ILLUSTRATIONS

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SUMMARY

The thrust and internal pressure in a specially designed rocket type combustion chamber decreases in accordance with lowering of the concentration of hydrogen peroxide, although 60% hydrogen peroxide is still combustible.

The combustion does not greatly depend upon the amount of potassium-cuprocyanide added.

The combustion pulsates when the type of injection nozzle is inadequate.

I. INTRODUCTION

A. History of Project

These studies on a fuel which was to be used for SHUSUI, a jet airplane, were started in December 1944. An apparatus was designed in January 1945 to test ignition and combustion quality of the fuel. The apparatus was constructed during February and March; experiments were begun in April.

B. Key Research Personnel Working on Project

Chem. Eng. Lieut. M. SHIMO

II. DETAILED DESCRIPTION

A. Description of Test Apparatus

1. Two types of injection nozzles are shown in Figure 1(B)10.

2. Flow sheet of the test apparatus is shown in Figure 2(B)10.

B. Test Procedure

1. The quantity of injection liquid is controlled by putting an orifice in the pipe of each liquid.

The following compositions were used for the injection liquids:

Solution A.....80 wt.% H_2O_2

Solution B.....30 wt.% $NH_2.NH_2.H_2O$
57 wt.% CH_3OH
13 wt.% H_2O
2.7 gm/lit $K_3\left[Cu(CN)_4\right]$

A : B = 10 : 3 (by weight)

Six liters of solution A and three liters of solution B were used in experiments. The rates of injection for both solutions were selected as follows:

Solution A 600 gm/sec; i.e., 4350cc/sec. (d=1.38 gm/cc at room Temp.)
Solution B 180 gm/sec; i.e., 2000cc/sec. (d=0.91 gm/cc at room Temp.)

2. After filling up tank A (See Figure 2(B)10) with solution A and tank B with solution B(C is a spare tank) and opening valve C, valve D is opened slowly.

In starting, after the internal pressures of both tanks A and B reach 3 kg/cm^2, valves E & F are opened to let both solutions flow into the combustion chamber. After starting, valve D is opened so that the internal pressure of both tanks reach 25 kg/cm^2 for a running condition of continuous combustion.

The internal pressures of both tanks are always adjusted by controlling valve D to maintain the above pressure of 25 kg/cm^2. If the internal pressures of both tanks are 25 kg/cm^2, instead of 3 kg/cm^2, from the beginning of the test, excess solution accumulates in the combustion chamber during the latent period, and a sharp explosion occurs which usually damages the thrust unit, gas analyzer connection, and internal pressure indicator.

3. Measurement. During combustion the following data are measured.

a. Internal pressures of combustion chamber with a pressure gauge and a piston and spring type indicator. (Maihak type)

b. Thrust with a thrustmeter of the magnetic striction type. (See Figure 3(B)10.)

c. Gas analysis by Orsat method (See Figure 4(B)10.) Gas analysis was planned, but not actually performed.

4. After the experiment is over, valve G is shut. Valves H and I are opened to send wash-water from tanks J and K to the combustion chamber through tanks A and B and the connecting pipe lines.

C. Summary of Data

1. Results of experiments on the combustion of hydrogen peroxide of different concentration using Nozzle No. 2 are shown in Table I(B)10. The results are plotted in Figure 5(B)10.

These experiments were made in summer, and therefore, the temperatures of the solutions were comparatively high. Experiments in colder weather are necessary.

2. Results of experiments on the influence of the amount of added catalyst (Potassium-cuprocyanide) using nozzle No. 2 are shown in Table II(B)10.

3. Experiments on pulsating combustion due to different types of injection nozzles.

No pulsating combustion occurred when injection nozzle No. 2 (in Figure 1(B)10)was used, but pulsating combustion occurred with nozzle No. 1. The indicator curves (Figure 6(B)10)show distinct differences between the two types of combustion.

III. CONCLUSIONS

The testing procedure seemed to be satisfactory.

The small amount of test data available, as shown in the summary, is due to the short period of time that this research work was in progress.

ENCLOSURE (B)10

Table I(B)10
COMBUSTION OF VARYING CONCENTRATIONS OF H_2O_2*

Conc. of H_2O_2	Internal Pressure of Combustion Chamber	Thrust	Note
80 wt.%	10 kg/cm^2	80 kg	Standard
75 wt.%	9 kg/cm^2	75 kg	Nearly same as that of 80% conc. of H_2O_2.
70 wt.%	8 kg/cm^2	73 kg	Somewhat reduced combustion.
60 wt.%	6 kg/cm^2	40 kg	Can be ignited but combustion is very mild.

*Nozzle No. 2.

Table II(B)10
EFFECT OF CATALYST CONCENTRATION ON COMBUSTION OF H_2O_2*

Catalyst added (gram/liter)	Internal Pressure of Combustion Chamber (kg/cm^2)	Thrust (kg)	Note
0	9.5	78	Sound of combustion is low but inter. press. and thrust are normal.
1	10.0	78	
2	9.5	80	
3**	10.0	80	Results about equal
6	10.0	78	
9	9.5	80	

*Nozzle No. 2.
**Standard amount of catalyst.

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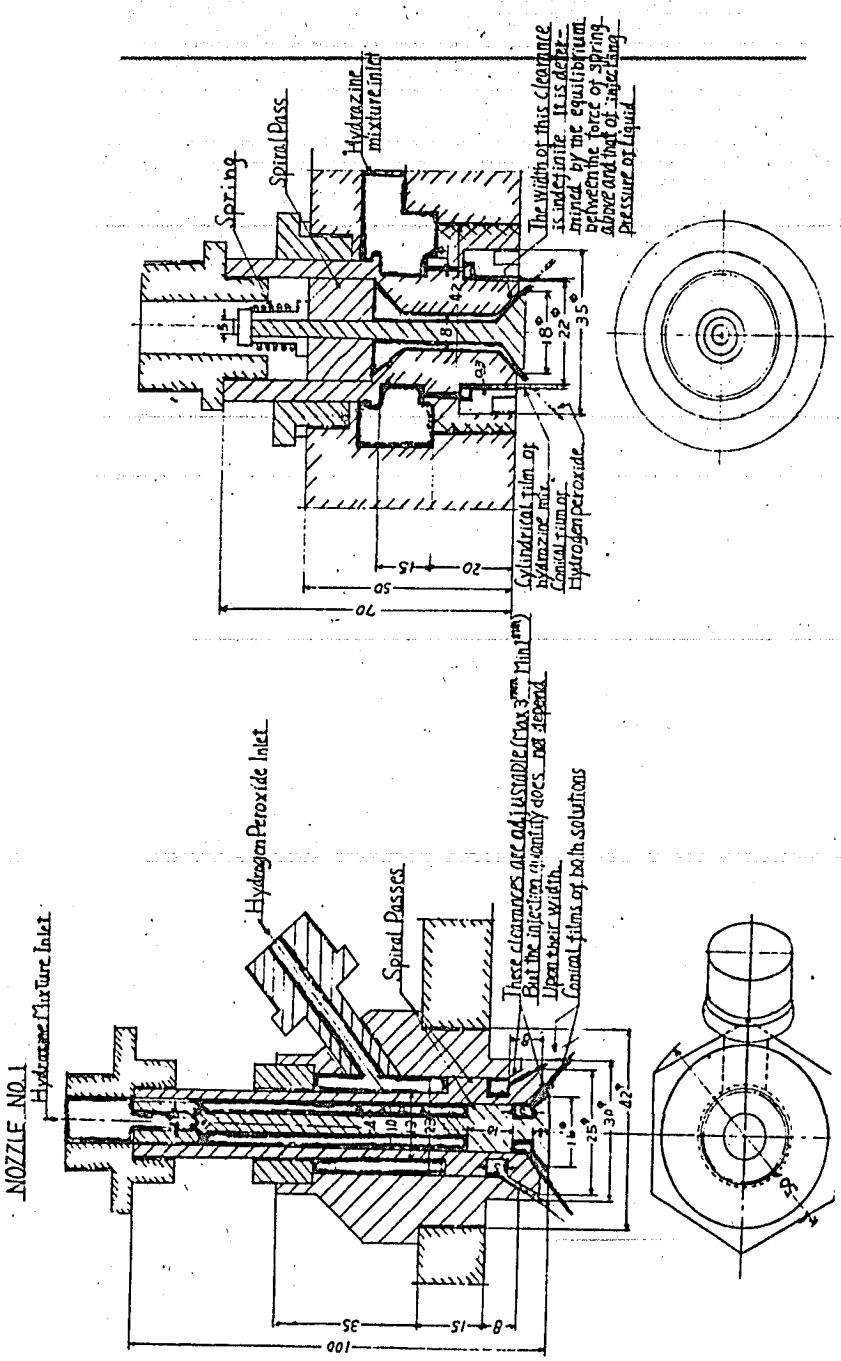


Figure 1 (B)10
SKETCH OF INJECTION NOZZLE

ENCLOSURE (B)10

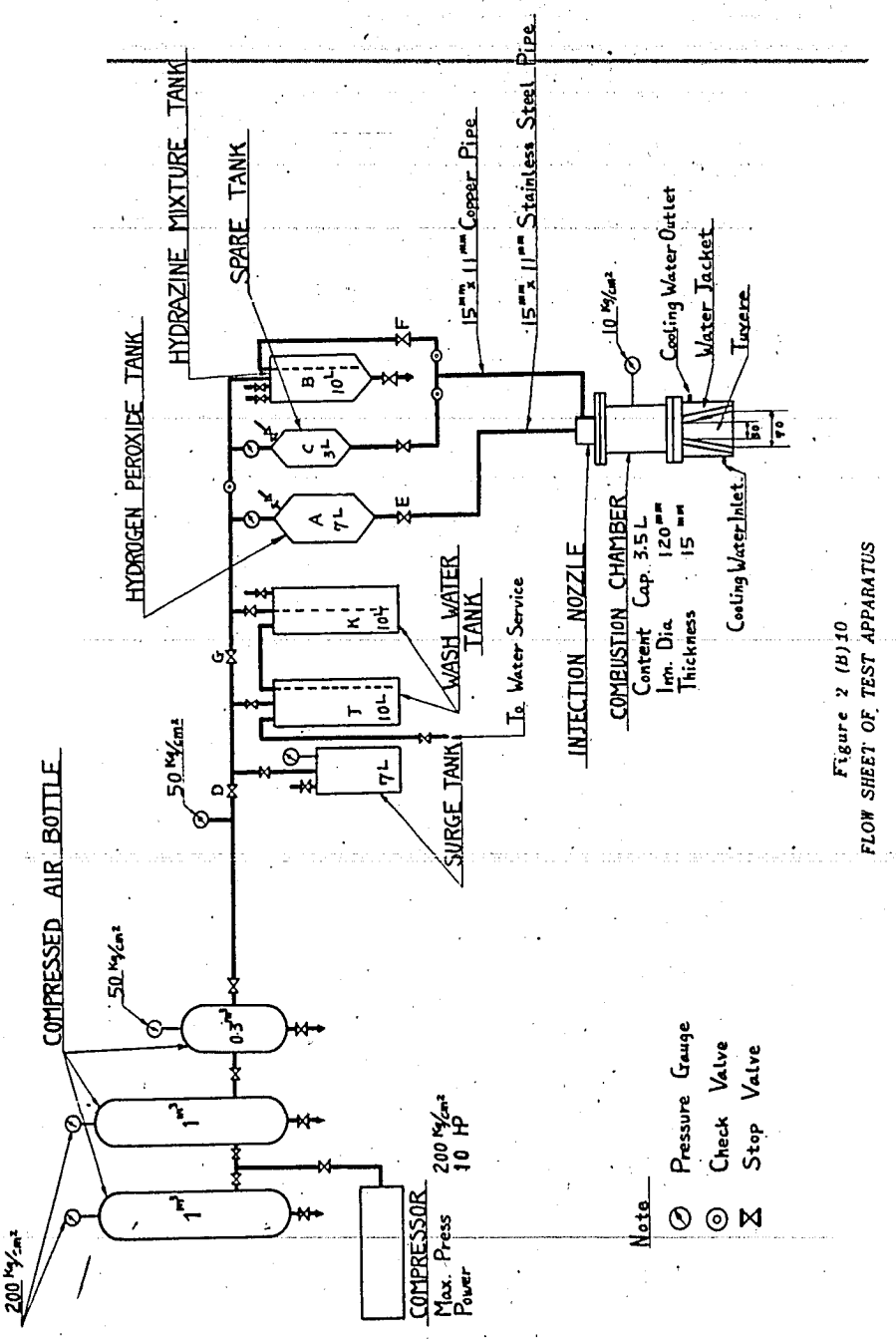


Figure 2 (B)10
FLOW SHEET OF TEST APPARATUS

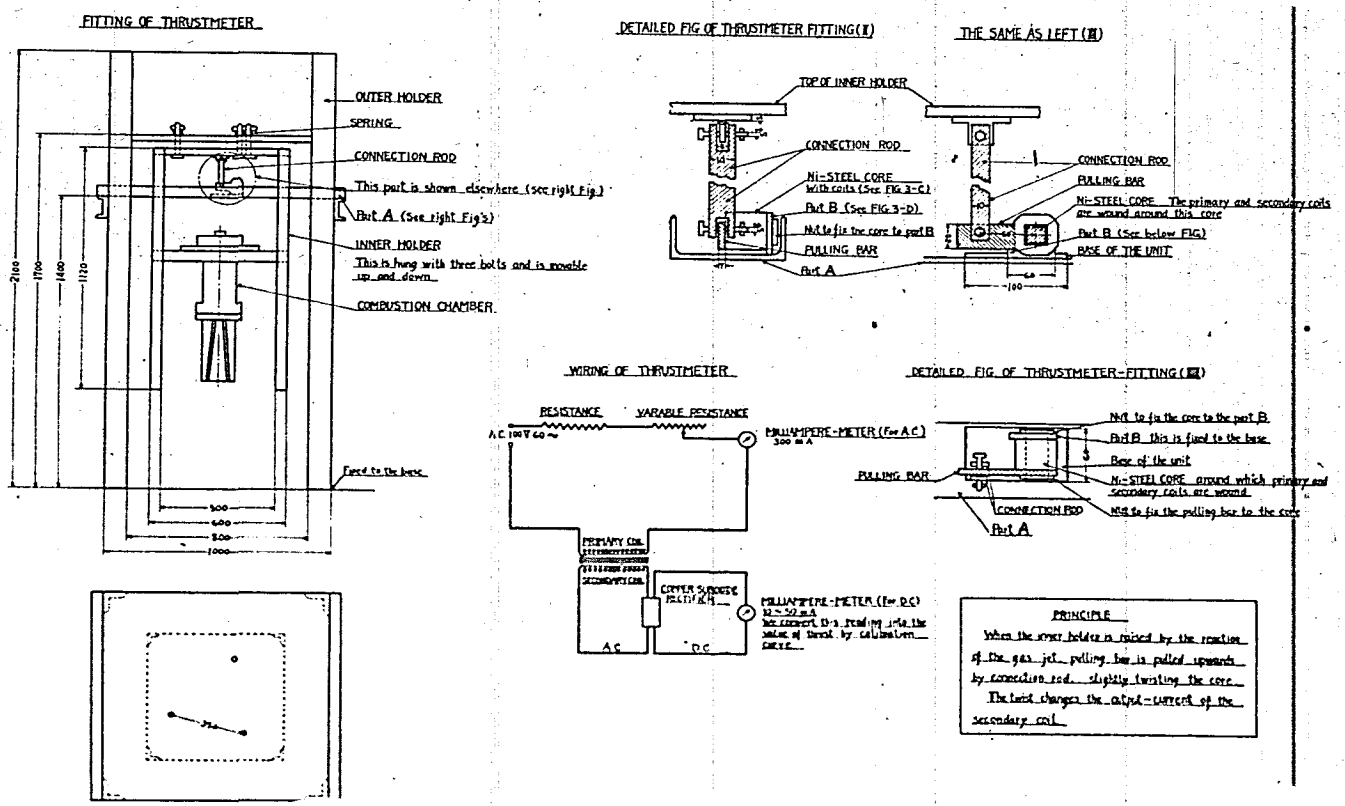
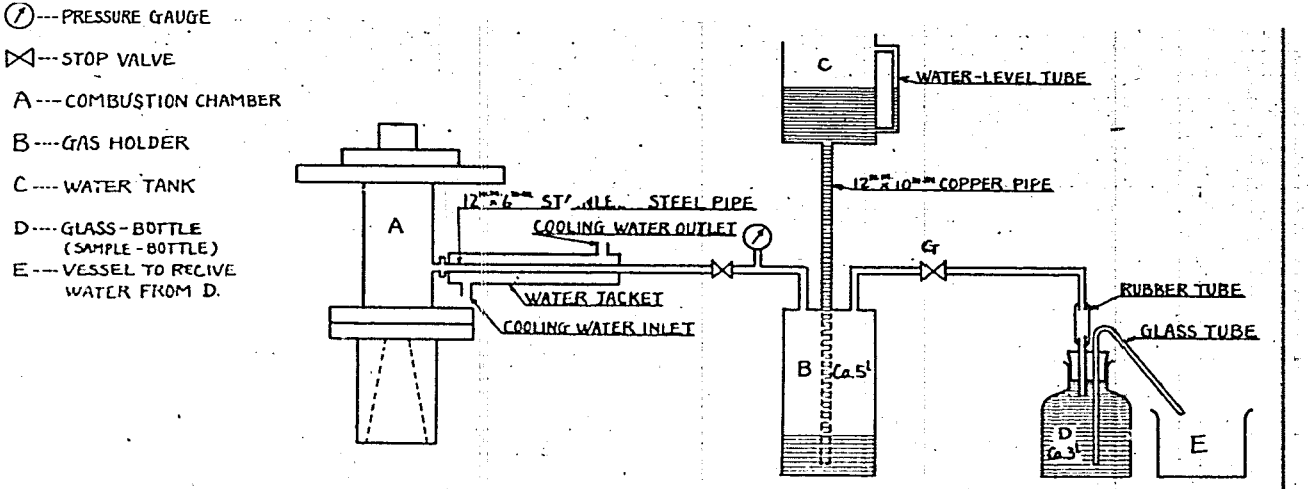


Figure 3 (B)10
FITTING OF THRUSTMETER



Gas-sampling is made as follows:

B and D are filled with water before-hand, and valves F and G are shut.

Soon after the combustion begins, the valve F is opened and combustion gas is pressed into B on account of high pressure of A.

After the combustion is over the valve F is shut and G is opened, the gas is transferred to D by means of water head.

Disconnecting the rubber tube from copper pipe and closing it by pinch-cock, the bottle D is taken off.

Figure 4 (B)10
FLOW SHEET OF GAS-SAMPLING

(Thus sampled combustion gas is analyzed with gas analyzer of the Orsat type.)

ENCLOSURE (B)10

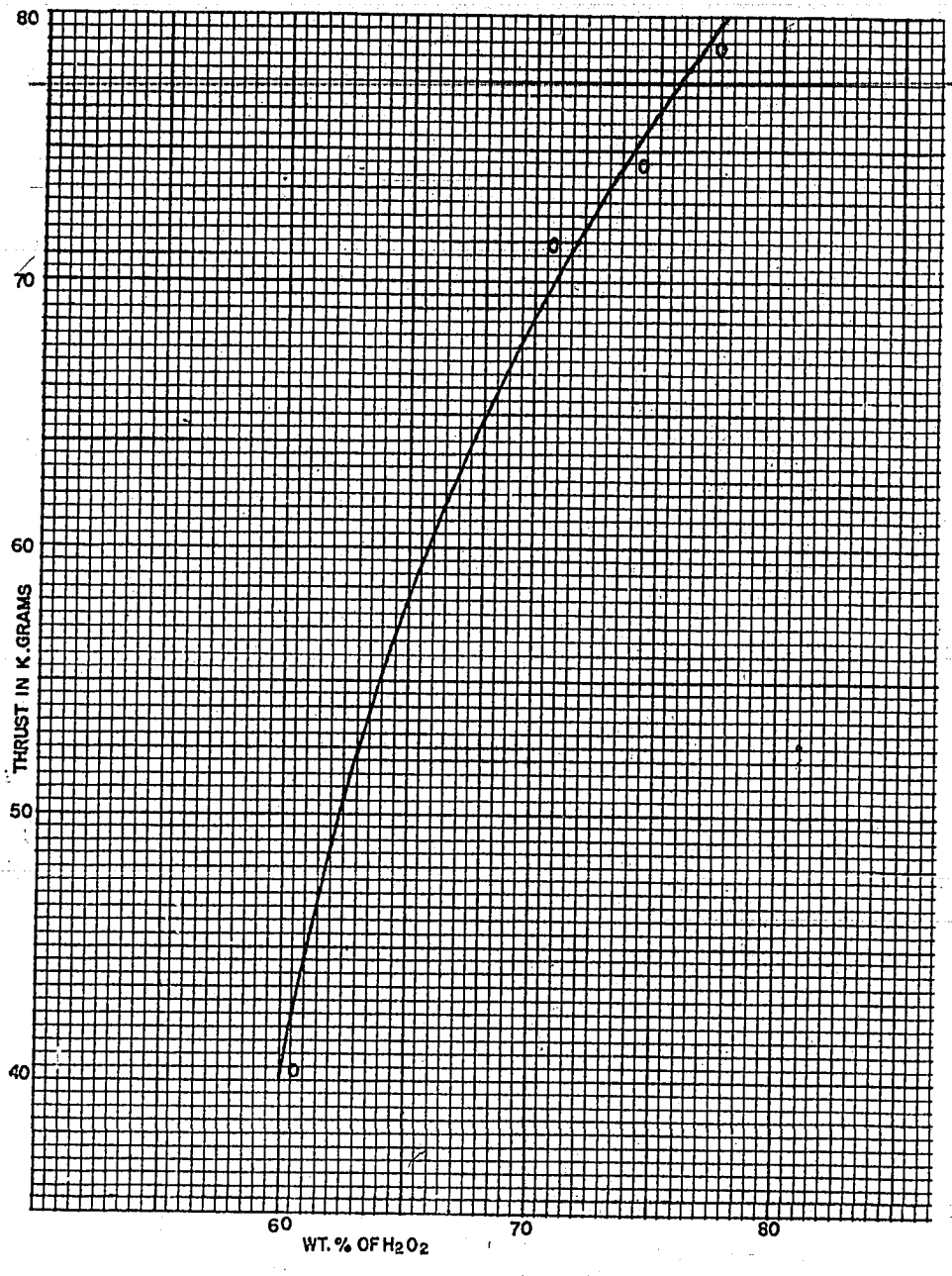


Figure 5 (B)10

THRUSTS AND CONCENTRATIONS OF H_2O_2

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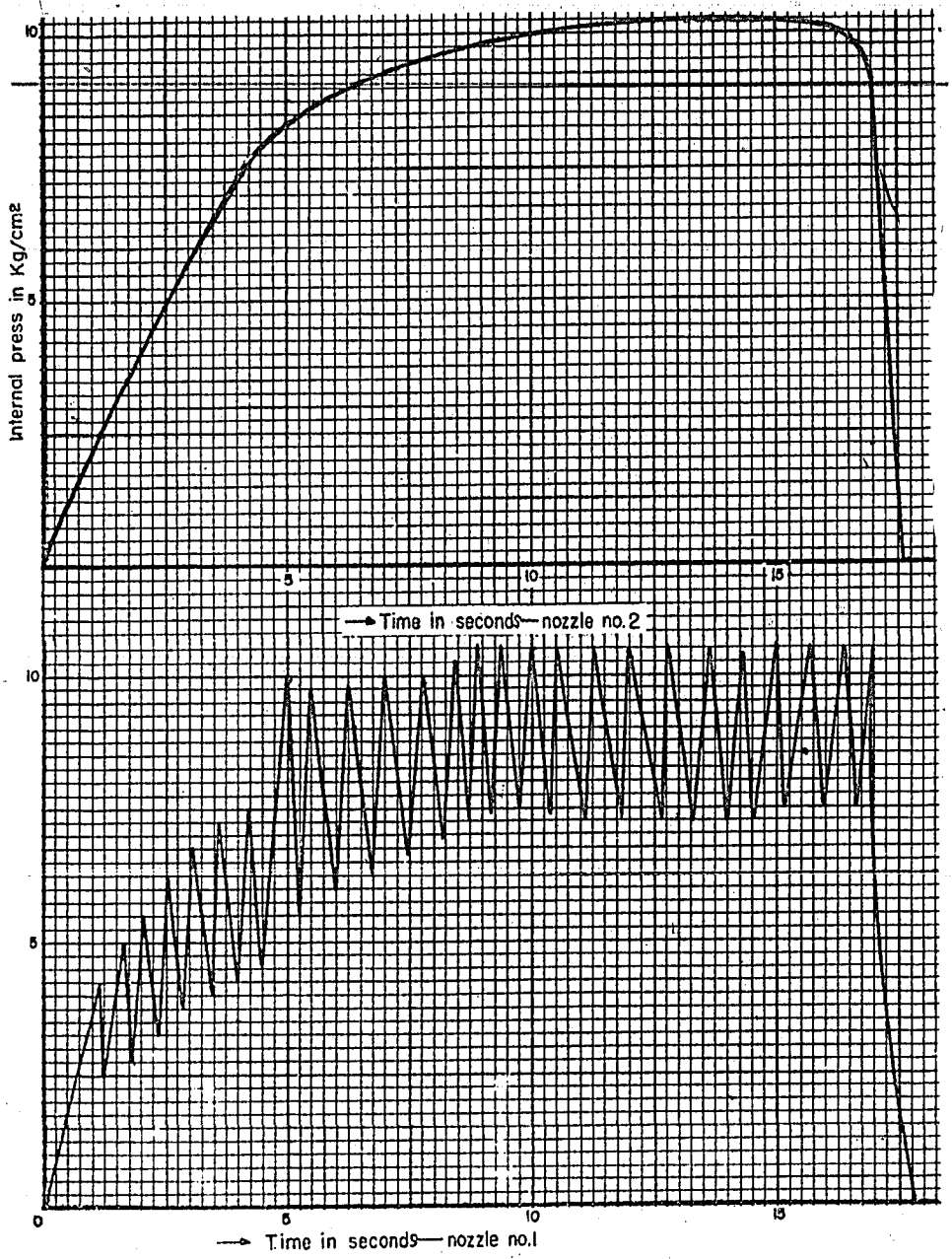

Figure 6 (B)10
INDICATOR CURVES

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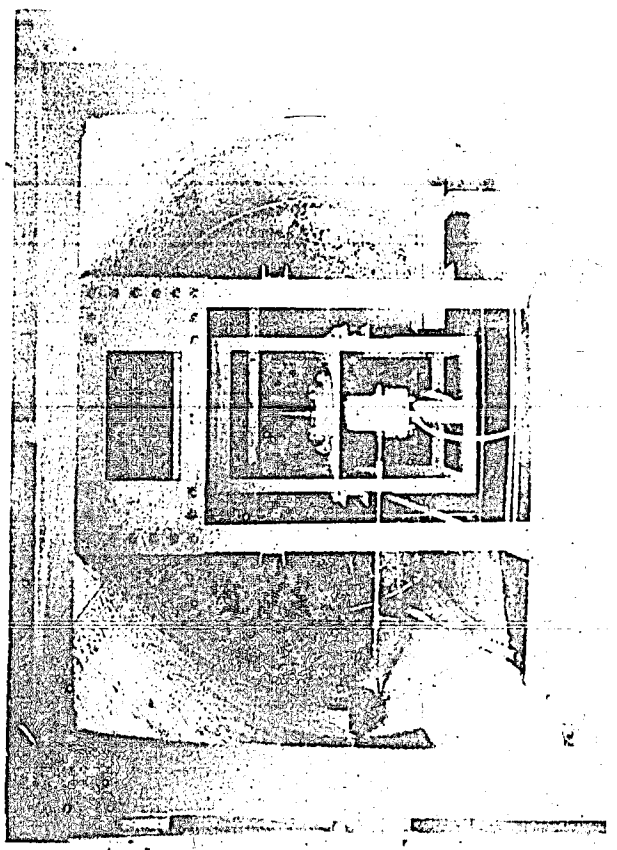

Figure 7 (B)10
TEST APPARATUS FOR ROCKET