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onr ltr 28 jul 1977

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SCHOOL OF ENGINEERING [redacted] and Applied Science.

JET PROPULSION RESEARCH PROGRAM
DEPARTMENT OF AERONAUTICAL ENGINEERING
THE JAMES FORRESTAL RESEARCH CENTER

(11) 17 Jan[redacted]61

Director
Advanced Research Projects Agency
Room 3E-183
The Pentagon
Washington 25, D. C.

(9) [redacted] Quarterly Letter Report, no. 3, 1 Jul - 30 Sep 60,
(10) by Martin Summerfield.

(16) Order No.: 23-59; 23-60 Amend. 5 Term: Date: 31 December 1961
Proj. [redacted] 610; ARPA Order 23[illegible]59 Proj. Scientist: Dr. Summerfield
Contractor: Princeton University NA-1-8000
Cont. Date: January 1959
Amount: $234,712

(6) Solid Propellant Burning. (Upper Case)

Gentlemen:

This report summarizes the status of our work on six technical research topics (TABLE I), plus the status of construction of a specialized Solid Propellant Processing Building for use in conjunction with this and other solid propellant researches. The period covered is from 1 July through 30 September 1960.

TECHNICAL STATUS

The status of research on the six topics of TABLE I follows:

Topics 1 and 2 - No new results to report.

Topic 3 - Measurement of the total emissive power of the flame zone of two propellants during actual motor firings in the pressure range 100 to 300 psi yielded values whose magnitudes suggest that the flame zone (in this pressure region) is indeed a diffusion flame, and in accordance with diffusion flame theory burns at approximately the stoichiometric ratio regardless of the final, overall stoichiometry. In other words, there appear to be certain localized regions of the flame in which the temperature exceeds the theoretical overall flame temperature of the propellant. (The propellant used contained no metal additive.)

A discrepancy between the values of radiative emissive power measured with burning strands and values of the same quantity measured in the firing rocket motor was resolved by a critical experiment which demonstrated the presence of smoke attenuation in the strand experiments. These radiation experiments are more fully reported in the Project SQUID Semi-Annual Report covering the period

1 April 1959 to 30 September 1960.

Topics 4 and 5 - Further study of the burning rate "plateau" which was encountered with polysulfide propellants containing 65% of fine unimodal ammonium perchlorate revealed that the plateau is dependent on oxidizer loading, and is no longer present at 70% loading. It also appears to be related to the flame extinguishment phenomenon of Topic 5, since lowering the oxidizer level to 60% produces a propellant in which the beginning of plateau burning is observed as the test pressure is increased to about 300 psi, but which undergoes extinguishment above 400 psi. Apparently plateau burning and extinguishment are related to one another. The implications of such a relationship relative to the burning mechanism in the plateau region are not immediately apparent; but deserve and are receiving careful thought.

Topic 6 - Still inactive.

The Solid Propellant Processing Building is now complete and being placed in service. Photographs of the building are appended.

MAJOR ACCOMPLISHMENTS

During the past quarter these have included:

1. Completion of the new Solid Propellant Processing Building.

2. Discovery from radiation measurements performed on certain propellant compositions that, for the pressure range of 100 to 300 psi, localized portions of the gaseous flame seem to exhibit temperatures greater than the theoretical flame temperature. Such a situation is typical of a diffusion flame.

3. Discovery that "flame extingulshment" and "plateau burning" seem to be related phenomena for the types of propellants we are studying.

PROBLEMS

No major ones at present.

FUTURE PLANS

With the close of the quarter covered by this report our contract with Project SQUID on the topic "Radiation from Solid Propellant Flames" has expired. We do not plan any further work on radiation measurement at the present time.

The work on particle size will continue, with emphasis on (1) the plateau region, (2) a complete survey at a higher oxidizer level than 65%, and (3) if possible an examination of the parameter--ease of pyrolysis of the binder--and its influence on the effect of particle size.

ACTION REQUIRED BY ARPA

None.

Very truly yours,

Martin Summerfield

Martin Summerfield
Professor of Jet Propulsion

KPH:hh

Encl: Photographs of Solid Propellant Building

TABLE I
TECHNICAL TOPICS INCLUDED IN CONTRACT

1. A more detailed experimental evaluation of Professor Summerfield's recently developed "granular diffusion flame" theory for the burning rate of ammonium perchlorate propellants.

2. An attempt to verify experimentally the theoretically predicted effects of oxidizer particle size on the burning rates of such propellants, using the widest obtainable range of sizes.

3. Refinement of the granular diffusion flame theory to include the effects of radiation as a mechanism of energy feed-back, and to include also the effect of changes in the propellant surface temperature due to catalysis, or to changes in fuel binder decomposition properties.

4. Experimental studies of the flame zone of unusual propellants, such as those containing metal additives, and/or those exhibiting marked discontinuities in the pressure-burning rate curve (e.g. "plateau" propellants).

5. A more detailed study of the phenomenon of flame extinguishment in thin propellant strands, both for its fundamental connection with steady state burning and for the possibility of its practical utilization.

6. Examination of other oxidizers, such as ammonium nitrate, or possibly lithium perchlorate.

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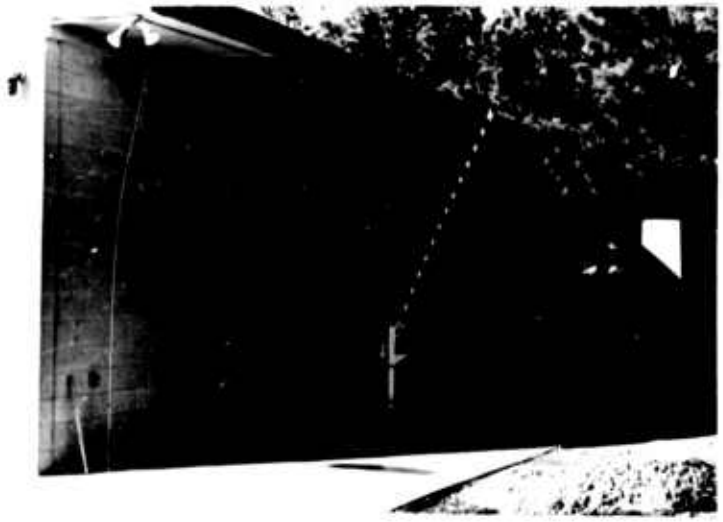
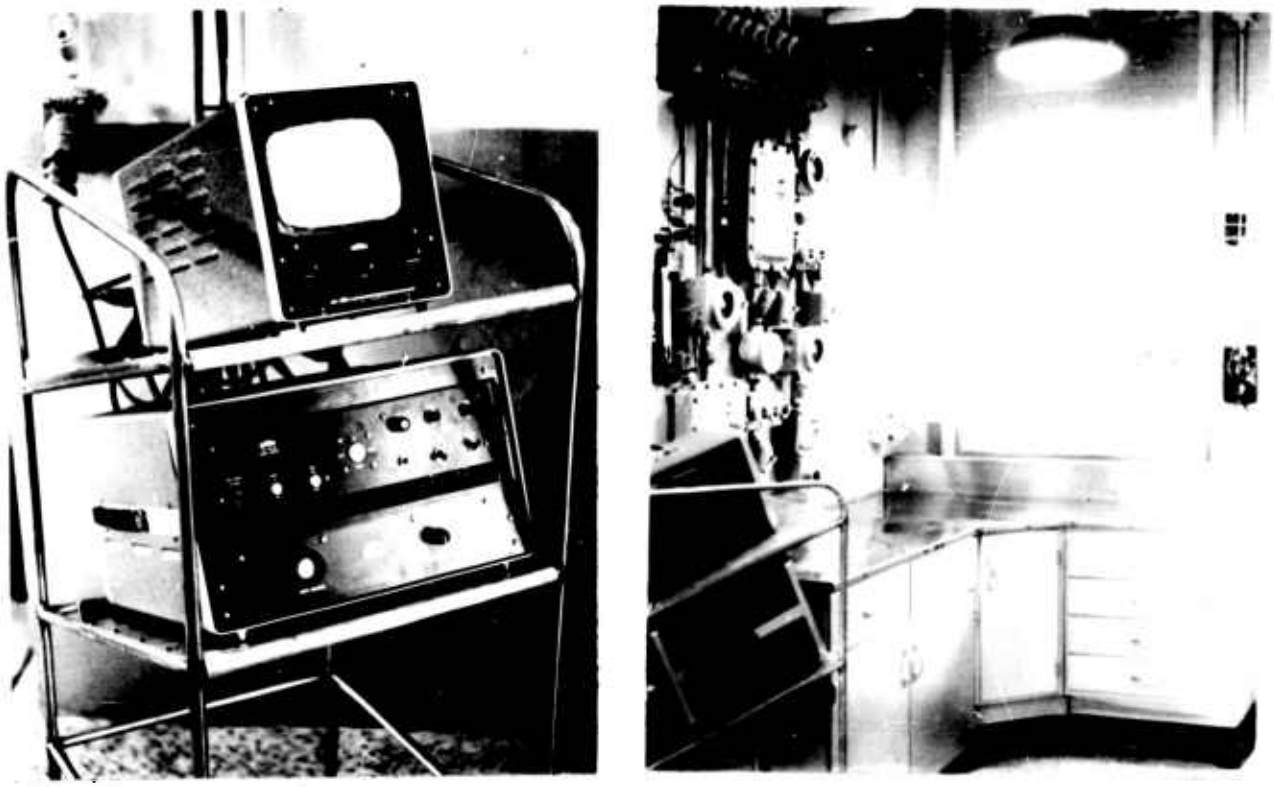
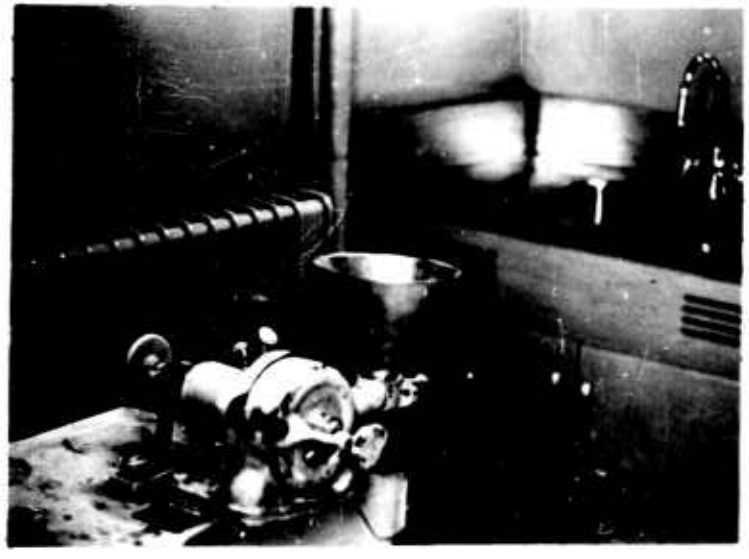


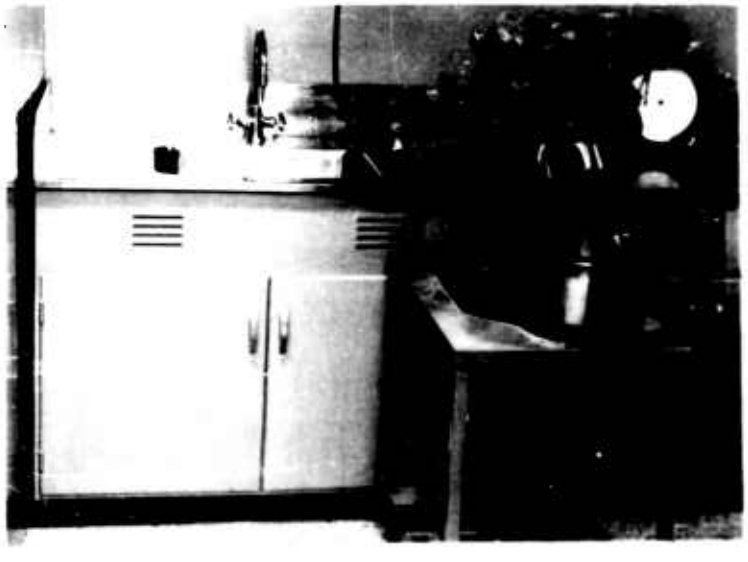
EXTERIOR VIEWS OF NEW SOLID PROPELLANT BUILDING



THREE VIEWS OF THE COMBINATION
LABORATORY AND CONTROL ROOM



OXIDIZER GRINDING ROOM



PROPELLANT MIXING ROOM

PROPELLANT CURING ROOM

UNCLASSIFIED