The Use of Hydrogen Peroxide for Propulsion and Power

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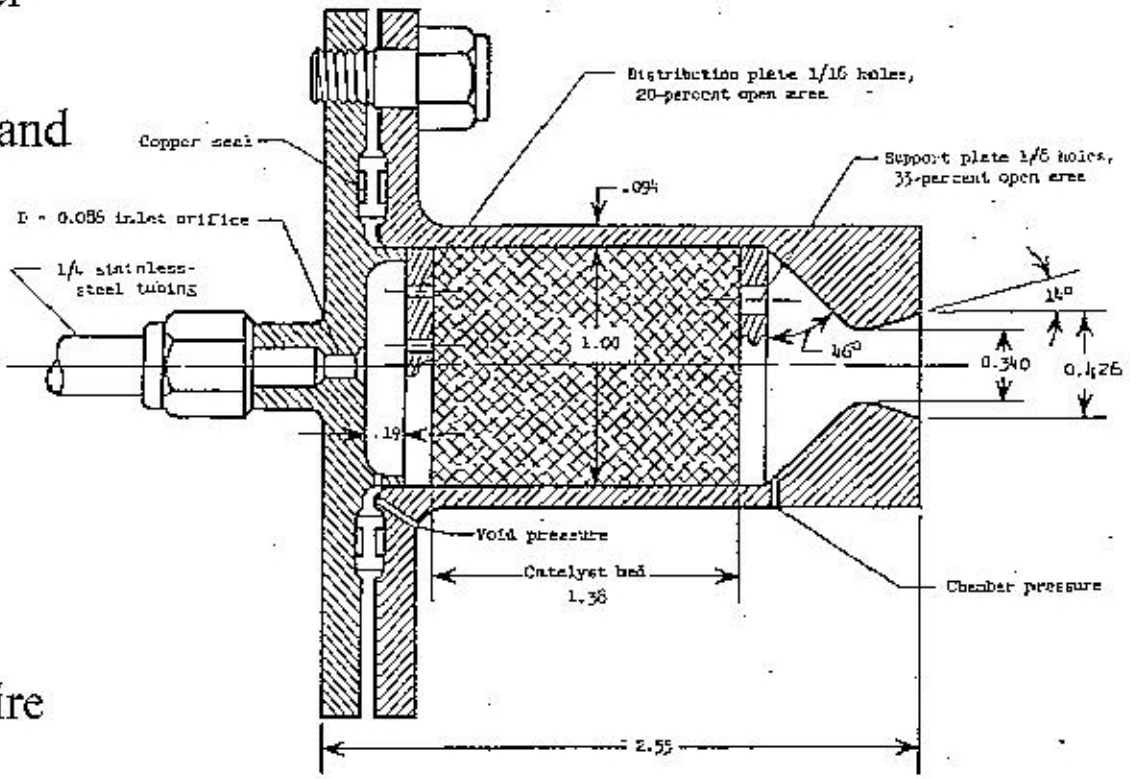
Overview

- General Description
- Uses of Hydrogen Peroxide
- Important Features for Applications
- Submarine Propulsion
- Torpedo Propulsion
- Rocket Assist Take-Off
- Reaction Control Systems
- Turbo-Pump Gas Generators
- Bi-Propellant Rocket Engines
- Vacuum Aspirators
- Other - Rocket on Rotor, Flying Belts, etc…
- Conclusions

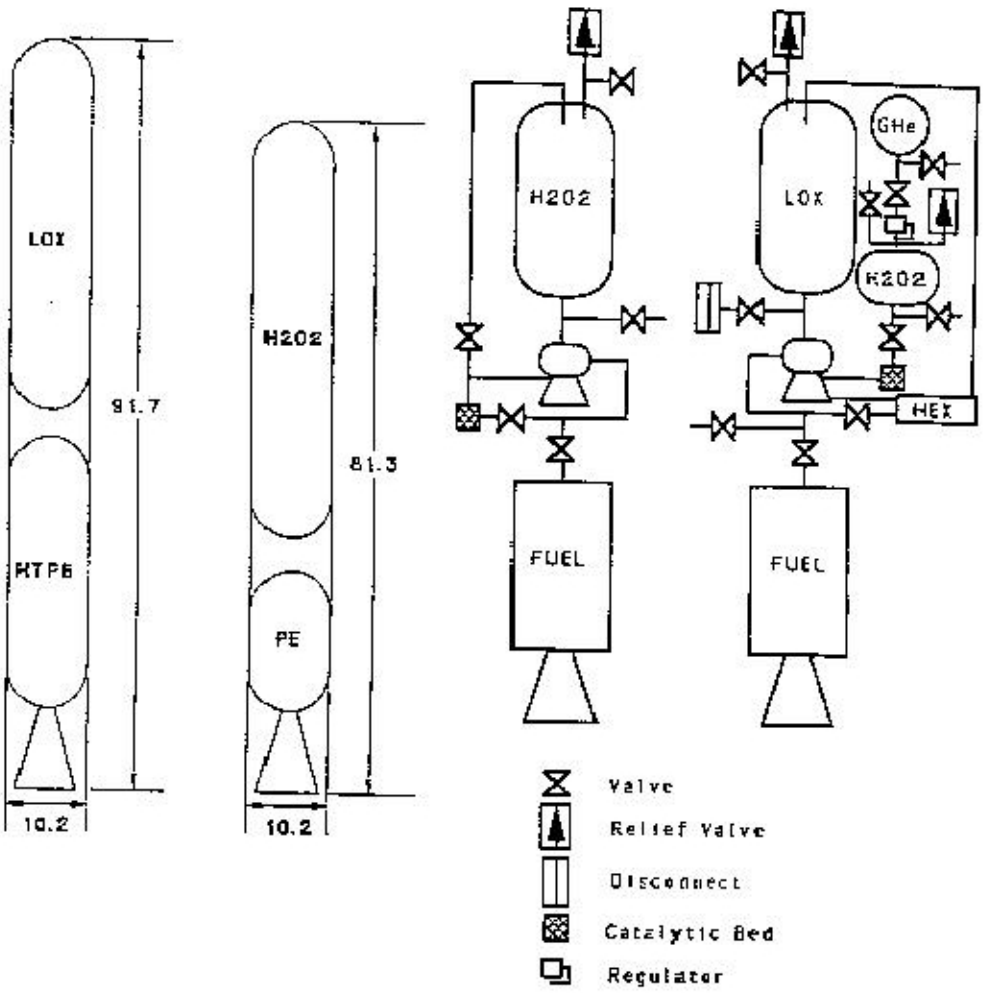
General Description

- Used in numerous applications as propellant and for power over last 60 years
- Review of prior capabilities and uses helps define current applicability
- High density liquid oxidizer
- "Non-toxic"
- Mono-propellant
- Large commercial usage, propellant usage is small
- Typically used with silver wire cloth catalyst



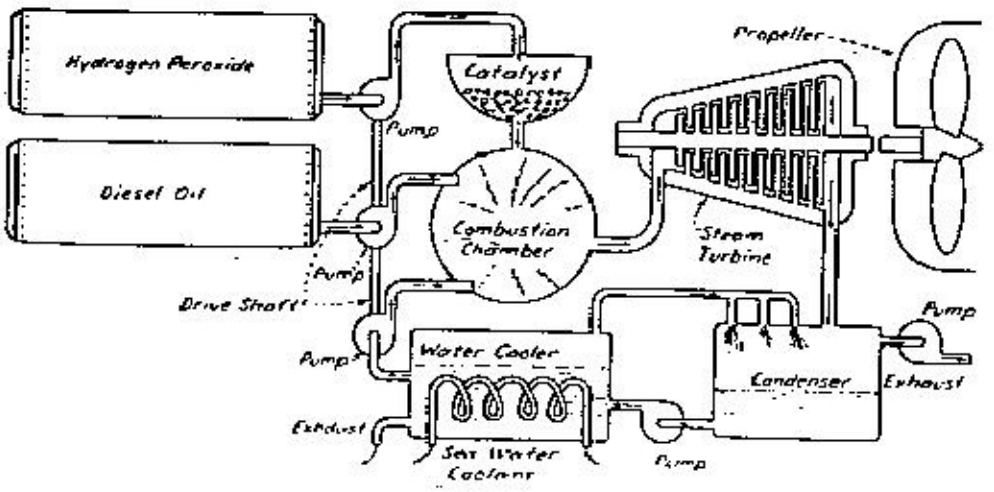
Important Features for Use

- Performance as monopropellant
- Performance as liquid oxidizer
- High density
- Storable propellant
- Non-toxic
- Non-reactive with atmosphere
- High oxidizer to fuel ratio
- Low vapor pressure
- High specific heat
- Water referee fluid
- Integrated propulsion and power
- Compatible with various pressurants



Submarine & Torpedo Propulsion

- First identified by Germany as a submarine propellant
- Very quickly successfully built and operated a 400 hp turbine with liquid injection of catalyst
- Germany build torpedoes in parallel, UK and US follow after WWII
- Remarkable success considering the adverse environment, and very new technology of both submarines and H2O2

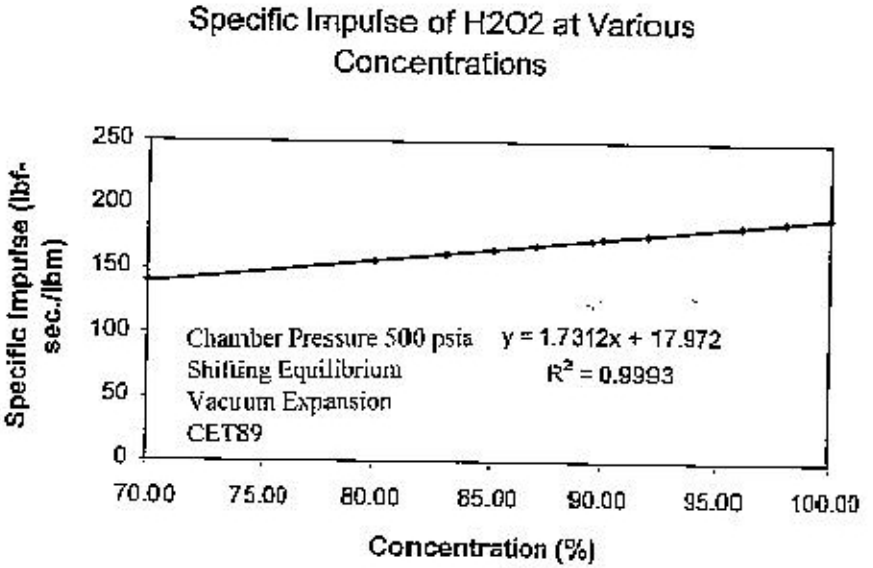


Rocket Assist Devices

- Walter develops "cold" and "hot" ATO
  - "Cold" units use liquid injection of permanganate salts
  - "Hot" units burn fuel with oxygen
- UK improves Walter ATO
- UK evolves technology into rocket engines

Reaction Control Systems

- H2O2 is the first viable monopropellant
- Dominates early RCS systems
  - X-1, X-15, Centaur, Mercury, Little Joe
- Most systems use 90%
- Displaced in the 1960's with higher performance of N2H4
- New systems using it in applications where N2H4 is undesirable
  - LLNL micro-sats
  - Future-X

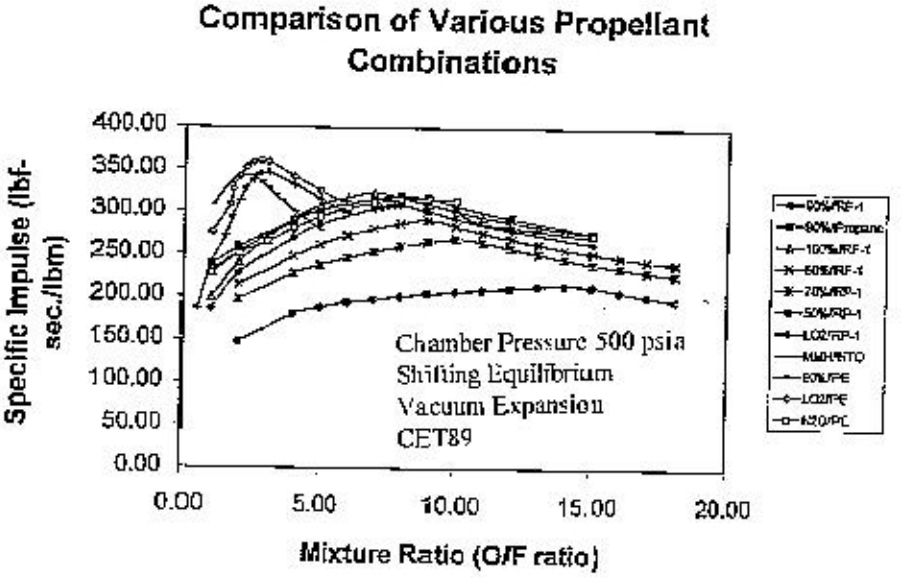


Turbo-Pump Gas Generators

- Most influential use to US was V-2 GG
- Von Braun preferred H2O2 for TP GG's
- Many applications: X-1, X-15, submarines, Jupiter, Redstone, Viking, Centaur boost pumps
- Gas temperature matches well for turbines
- Early systems used liquid injection, later US systems used pellet catalyst

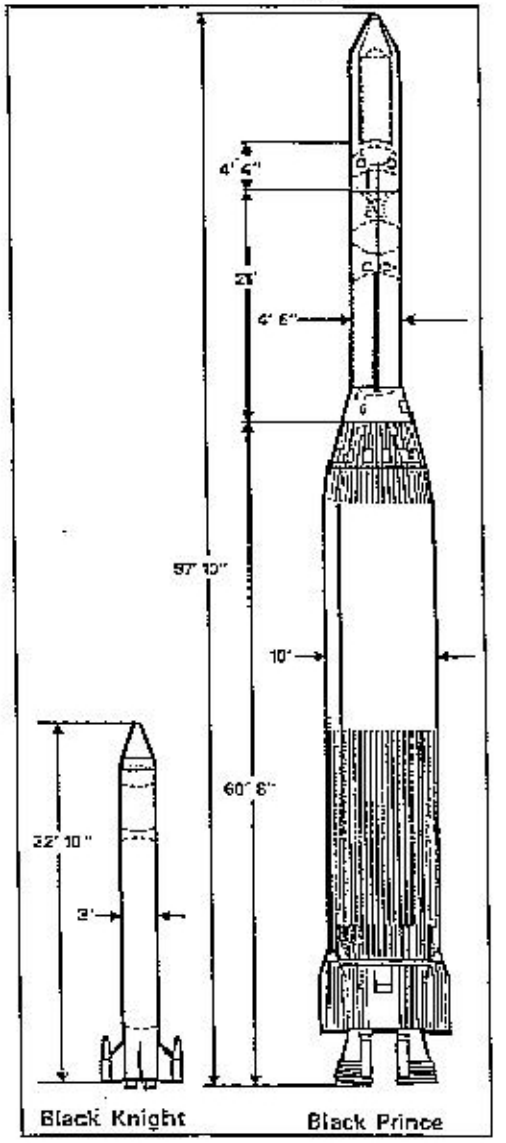
Oxidizer for Bi-Propellant Rockets

- Three major rocket engines used H2O2
  - UK Gamma 201/301 - Black Knight & Prince
  - US Rocketdyne AR family
  - US Reaction Motors LR-40
- Engines never developed past 1960's
- UK reaches highest level of development
- Potential shown by AR2 and LR-40 for impressive applications



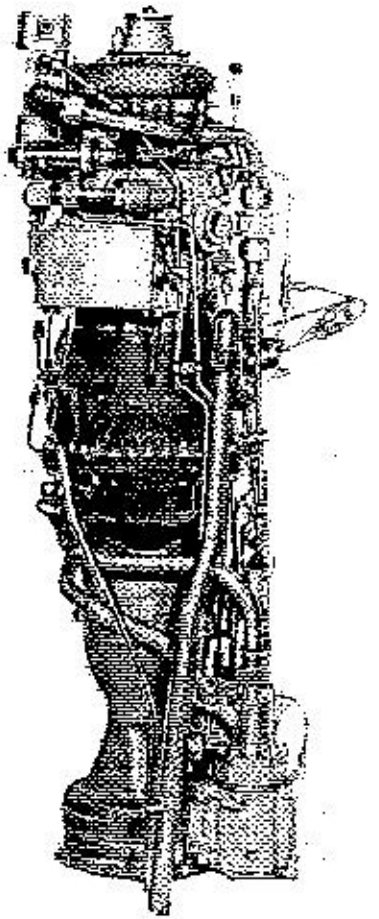
Black Knight - Gamma Engines

- Gamma 201 and 301 pump fed regenerative robust rocket engine
- Black Knight well developed
- Black Prince was Thor-like vehicle, not developed
- Black Arrow built as compromise
- Black Arrow deploys payload to space



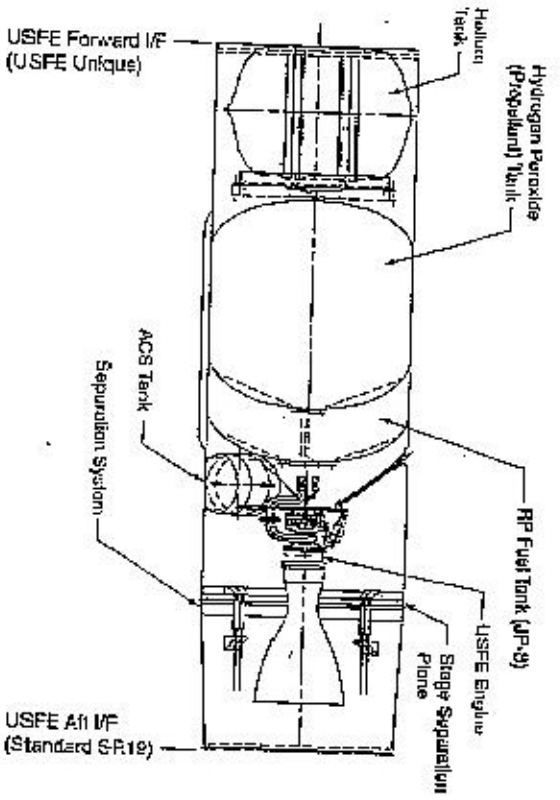
US Superperformance Engine

- Two engines competed for aircraft assist mission
- AF supports RD with AR
- Navy support RMI with LR-40
- LR-40 does not reach production
- AR2-3 used for flight tests
- Engine requirement ends, neither engine is used again, until present



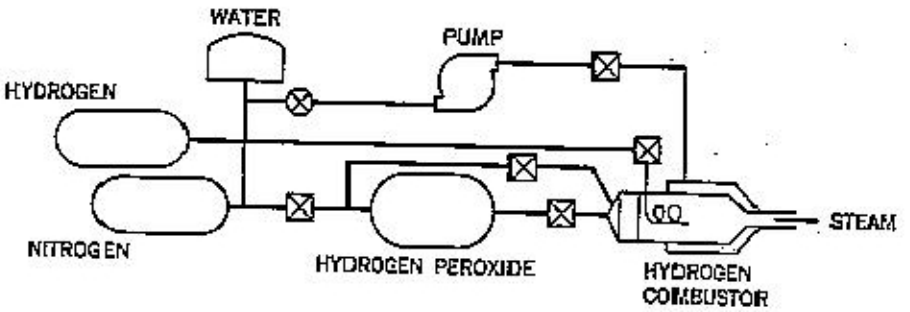
Current Bi-Propellant Usage

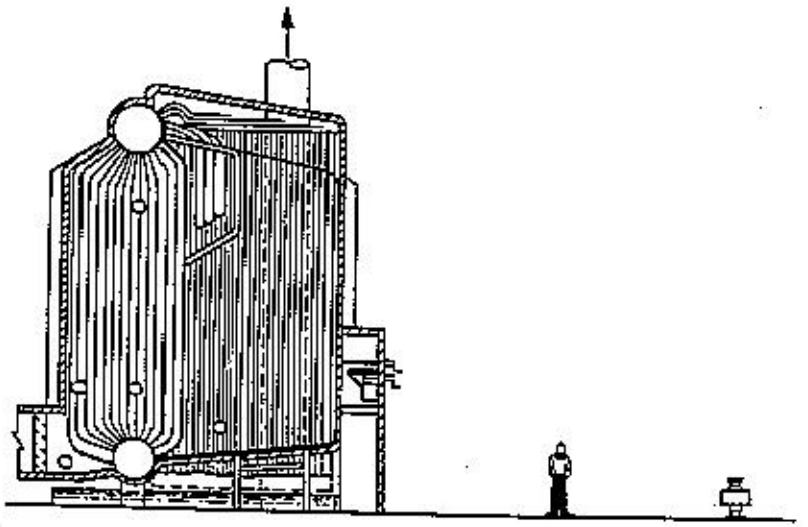
- OSC USFE
  - Pressure fed, 10,000 lbf, H2O2-kerosene
  - Development engine in test
- Future-X
  - Main engine to be RD AR2-3
  - Engine available and to be in test soon
- Beal Aerospace
  - Three stage platform, all pressure fed ablative
  - Very large, Atlas like vehicle
  - Anticipated near term deployment (~ 2001)
- NAWC
  - Research with hypergolic fuel formulations
  - Some testing in work



Vacuum Aspiration

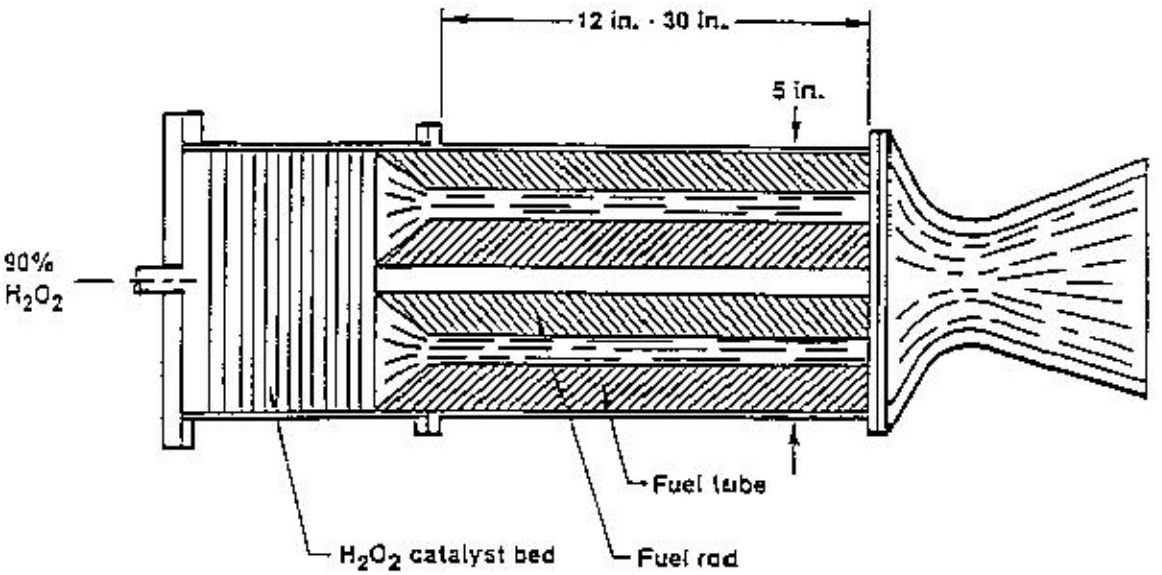
- Used significantly in past
  - Thiokol Hyprox systems
- Current usage is most mature application of H2O2
  - THEL and ABL
  - Systems well into development
  - Most likely will be "first" new H2O2 propulsion/power system on-line
  - Used for vacuum aspiration of laser





Other Applications

- Rocket on Rotor
- Rocket belts
- Man-Heater
- Decontamination of N2H4 spills
- Mine sweeping by detonation with N2H4
- Oil well pressurization
- Black Horse
- Hybrids



Lessons Learned

- In highly performance constrained applications it has been displaced by N2H4, LO2, and NTO
- Used most often as monopropellant for RCS or TP GG
- Used many times in close proximity to humans
- Selected in past for same characteristics that are desirable today
- Used in integrated fluid systems applications

Conclusions

- Potentially good future for alternate to NTO and N2H4
- Better suited for systems with human interaction
- Better suited for systems that do not want cryogenic complexities
- Changes in the way "performance" is evaluated (non-cold war environment) may alter prior trade decisions