BC73-60

the lance rocket engine

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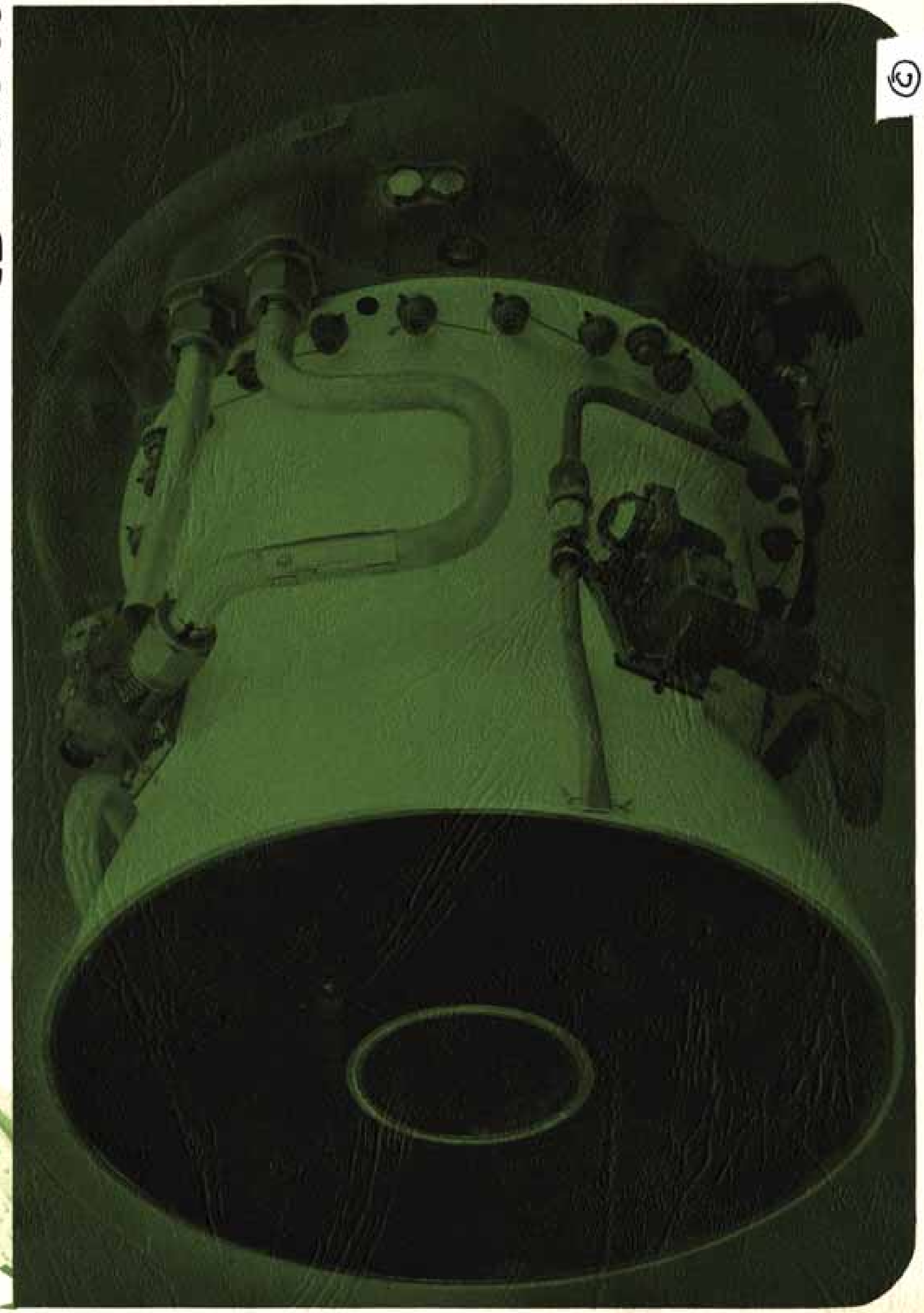


Rocketdyne Division
Rockwell International

BC73-60

the lance rocket engine

the lance rocket engine

The LANCE rocket engine was developed by Rocketdyne for the LANCE Missile. The development was conducted under the joint direction of the U.S. Army Missile Command and LTV Aerospace System Division.

The LANCE engine operates on storable, bipropellants. The design utilizes dual, concentric thrust chambers with propellants pressure-fed from the propellant tanks.

The LANCE engine is an integral-unit, fixed-mounted to the missile. The engine, and propellant tankage and feed system, are capable of being stored, fully loaded with propellants — in a ready-for-flight condition — for a period of 5 years.

The performance and reliability of the LANCE engine has been demonstrated in extensive engine and flight tests.

The LANCE engine has received Final Technical Approval from the U.S. Army Missile Command. The engine is in rate production.

240-551AT

the lance rocket engine

High-Performance, Dual-Thrust-Mode Bi-Propellant Rocket Engine.

Engine Configuration

- Annular Bell-Nozzle Booster
- Center Bell-Nozzle Sustainer (Throttleable)

Storable Propellants

- IRFNA
  (Inhibited Red Fuming Nitric Acid)
- UDMH
  (Unsymmetrical Di Methyl Hydrazine)

Thrust Class

- Boost Phase: 50,000-Pound Class
- Sustainer Phase: 5,000-Pound Class

Zero Field Maintenance Design

Versatility with Simplicity

- Squib activated boost termination control
- Fuel Injection pulse thrust vector control
- Fully throttleable sustainer

Rugged Low-Cost Construction

- Cast aluminum injector
- Forged steel thrust chamber body
- Ablative liner

240-551A

application and flight operational modes

The LANCE Missile System provides the U.S. Army with a highly mobile surface-to-surface missile capable of supplying accurate long range artillery support at the division level with nuclear or conventional warheads. The range of the LANCE is greater than that of HONEST JOHN.

A key element in achieving the high accuracy which the LANCE missile provides is the propulsion system's ability to provide an accurate sustainer-phase thrust level equal to the missile's aerodynamic drag. This allows the missile to follow a predictable ballistic trajectory (after the boost-phase cut-off) using only a pre-launch target guidance system setting.

Firing of the 20.5 foot long LANCE missile is accomplished from either a light-weight trailerable launcher or a self-propelled tracked vehicle.

During the boost-phase of the LANCE trajectory both the sustainer and booster thrust chambers operate. The boost-phase thrust level is fixed with the boost-phase cutoff occurring upon electrical signal from the missile guidance.

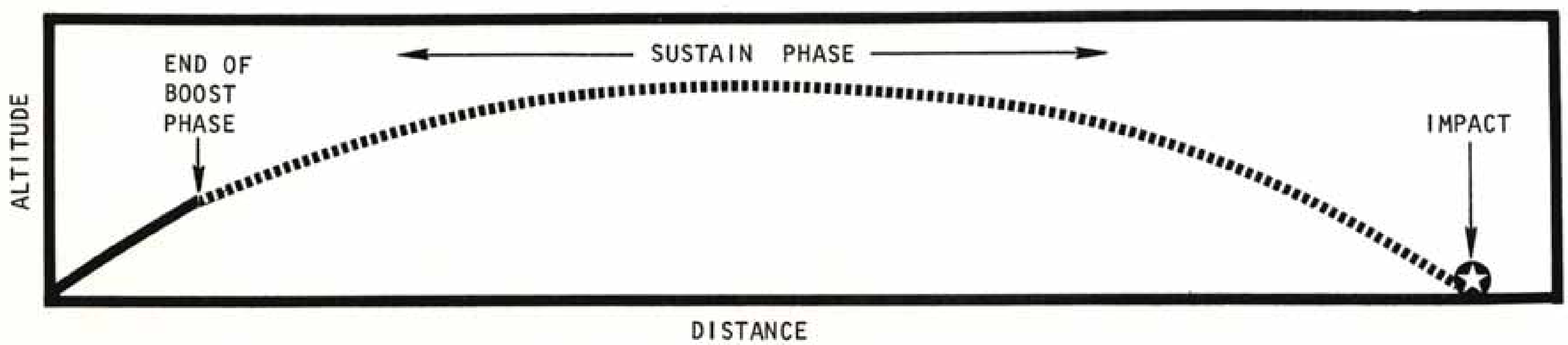
Thrust vector control for missile pitch and yaw control is provided by pulsed fuel injection into the boost nozzle.

The sustainer thrust chamber continues to operate after booster cutoff. The sustainer thrust level is continuously variable upon demand to meet the needs of the flight trajectory. The sustainer engine is capable of complete shutdown and subsequent restart during flight.

240-552AT

flight operation

BOOST-PHASE SEQUENCE ▲



240-552

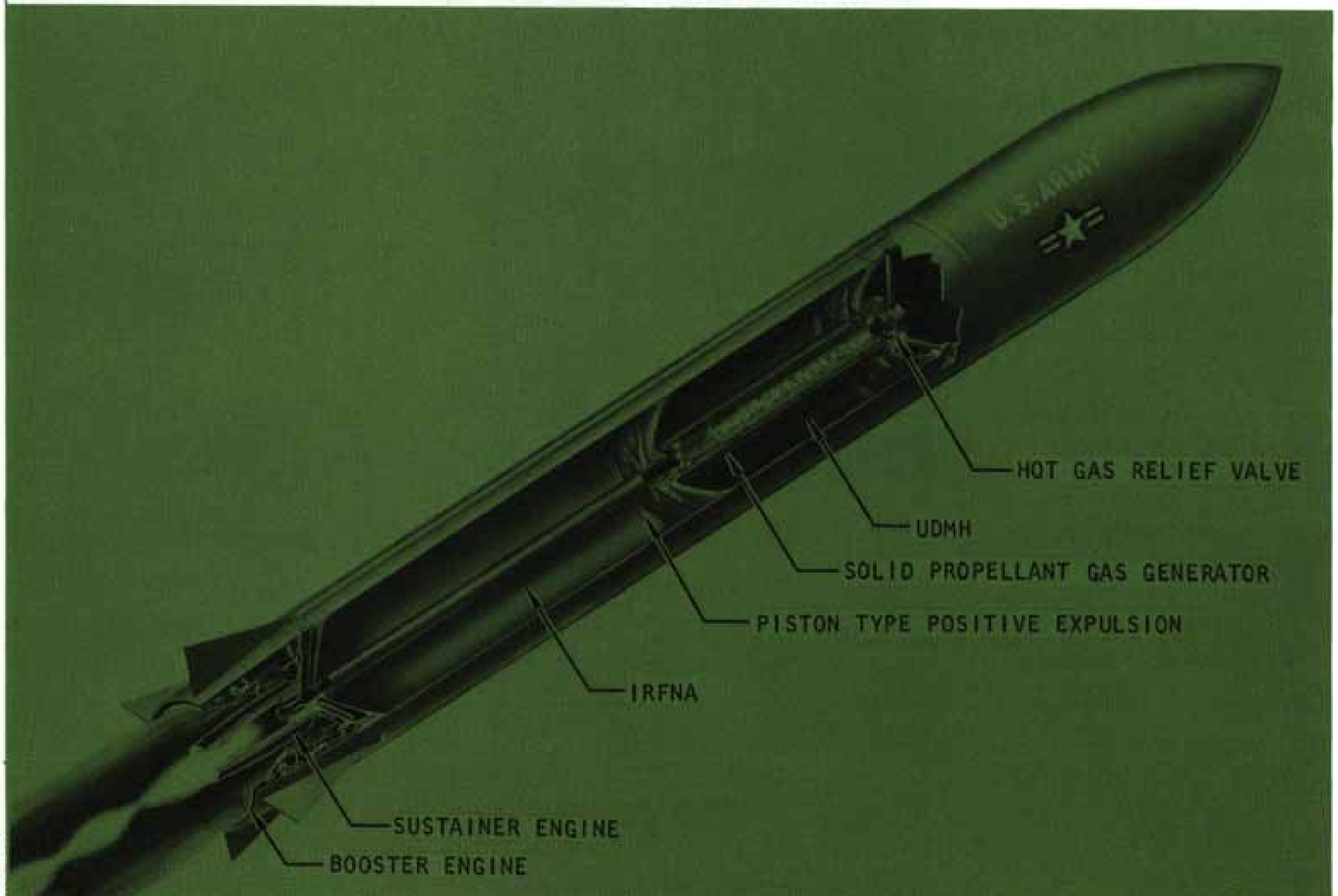
lance propulsion system

The LANCE engine is provided propellants by a piston-type, positive expulsion tankage system. The system is loaded with propellant and sealed.

Start of the system is initiated by ignition of the solid propellant gas generator which pressurizes the propellant tanks, provides engine start, and provides a gas flow through side-mounted spin nozzles for missile rotation.

240-564AT

lance propulsion system



240-564A

basic features

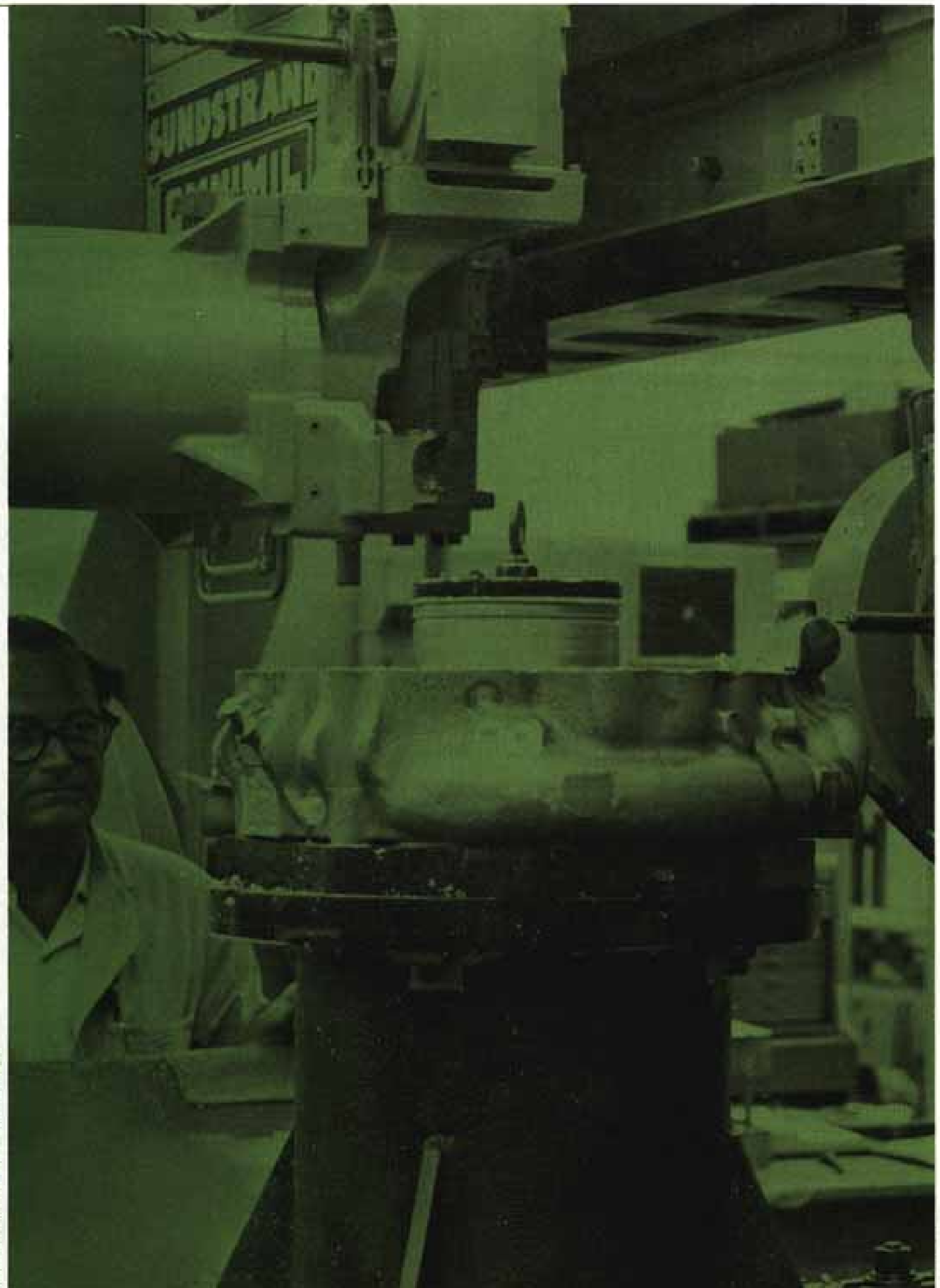
The LANCE engine is cold calibrated and preset to provide boost thrust and mixture ratio within tight limits. There is no requirement for hot firing test calibration or performance adjustment.

The sustainer thrust chamber operates with a controlled thrust; the thrust control command is provided by the missile guidance system. Boost phase shutdown and the sustain phase mission are controlled through electrical signals to the engine system by the missile guidance system.

Stability of the LANCE engine has been demonstrated over wide ranges of operation during the development test program. Attainment of high stability over a wide frequency spectrum in this high performance engine has been attained with injector baffles and the innovative use of acoustic cavities and feed system isolation.

THROUGHOUT THIS TECHNICAL BROCHURE A SERIES OF PHOTOGRAPHS OF THE LANCE PRODUCTION OPERATIONS ARE PROVIDED TO COMPLIMENT THE TECHNICAL INFORMATION CONTAINED IN THE CHARTS. THE PHOTOGRAPHS ILLUSTRATE THE PRODUCTION OPERATIONS AND ENGINE DESIGN DETAILS.

INJECTOR MACHINING



240-565AT

basic features

DESCRIPTION

- Liquid-Propellant Rocket Engine: Pressure-Fed; Dual Thrust Mode.
- Propellants: IRFNA and UDMH.
- Concentric Booster and Sustainer Engines:
  - Booster Engine (Outer);
  - Sustainer Engine (Inner).
- Nozzle Area Ratio:
  - Booster: 5.7:1
  - Sustainer: 4.0:1
- Thrust Chambers: Ablative Lined.
- Thrust Vector Control Provided by Radial Injection of UDMH in the Nozzle.
- Thrust Control:
  - Boost Phase: Calibrated, Fixed Thrust.
  - Sustainer Engine: Throttleable

PERFORMANCE AND WEIGHT

	BOOST PHASE	SUSTAIN PHASE
• Thrust Class, Lb.	50,000	5,000 to 0
• Chamber Pressure, (P_c) PSIA	950	966 to 0
• Engine Mixture Ratio	3.4:1	3.19:1
• Length, In.	19.4	
• Diameter, In.	21.2	
• Operating Duration, Sec.	6.1	114.0
• Weight (Dry) Lb.	173	

240-565A

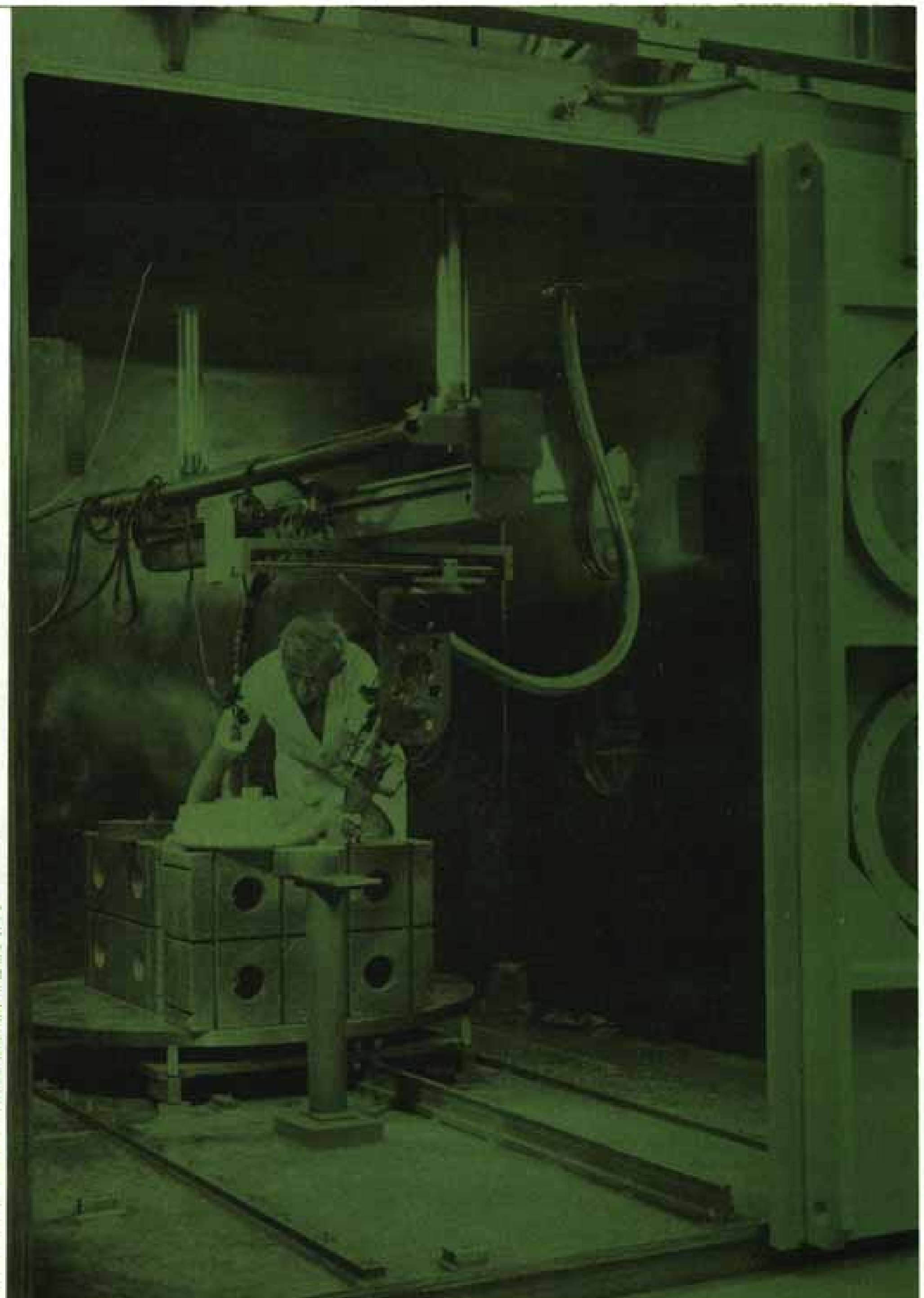
engine configuration

The overall simplicity of the LANCE engine is shown in the engine isometric cutaway drawing. The booster engine is an annular bell nozzle configuration; the inner sustainer engine is a conventional bell nozzle design.

Significant aspects of the design include a cast aluminum injector, ablative lined concentric chambers and simple, squib-released, propellant-actuated boost-termination valves. With maximum use of castings and relatively few total parts, the engine achieves the basic design objective of low cost.

The sustainer thrust chamber injector provides full-range throttleability by use of a movable pintle which seals off tapered slots cut into the inner fuel core and outer oxidizer ring. Positioning of the pintle is controlled by fuel pressure through the servo valve.

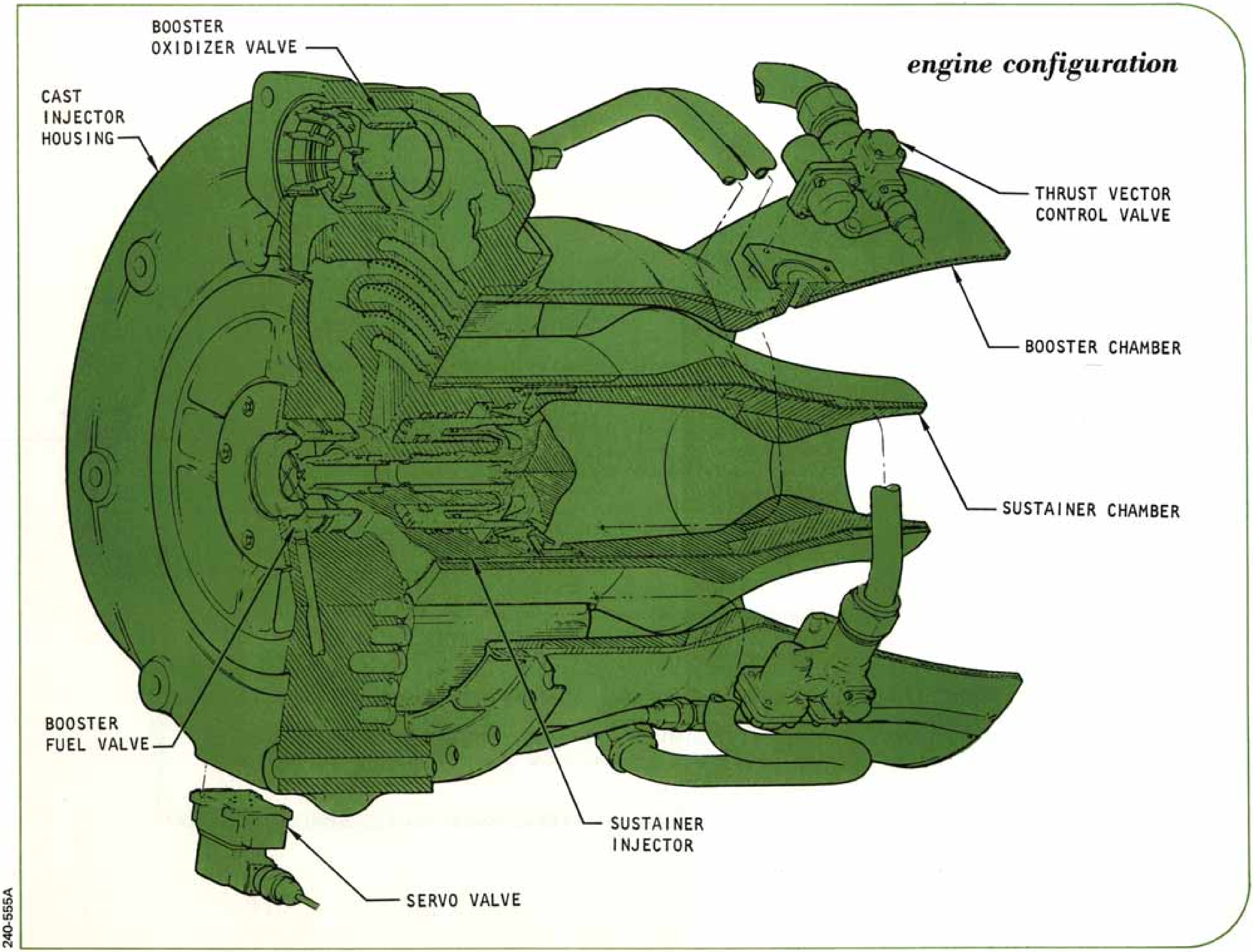
The side-fluid-injection, thrust vector control valves are shown. This system provides the forces necessary for missile pitch and yaw control during the boost-phase.



INJECTOR ELECTRON BEAM WELDING

240-555AT

engine configuration

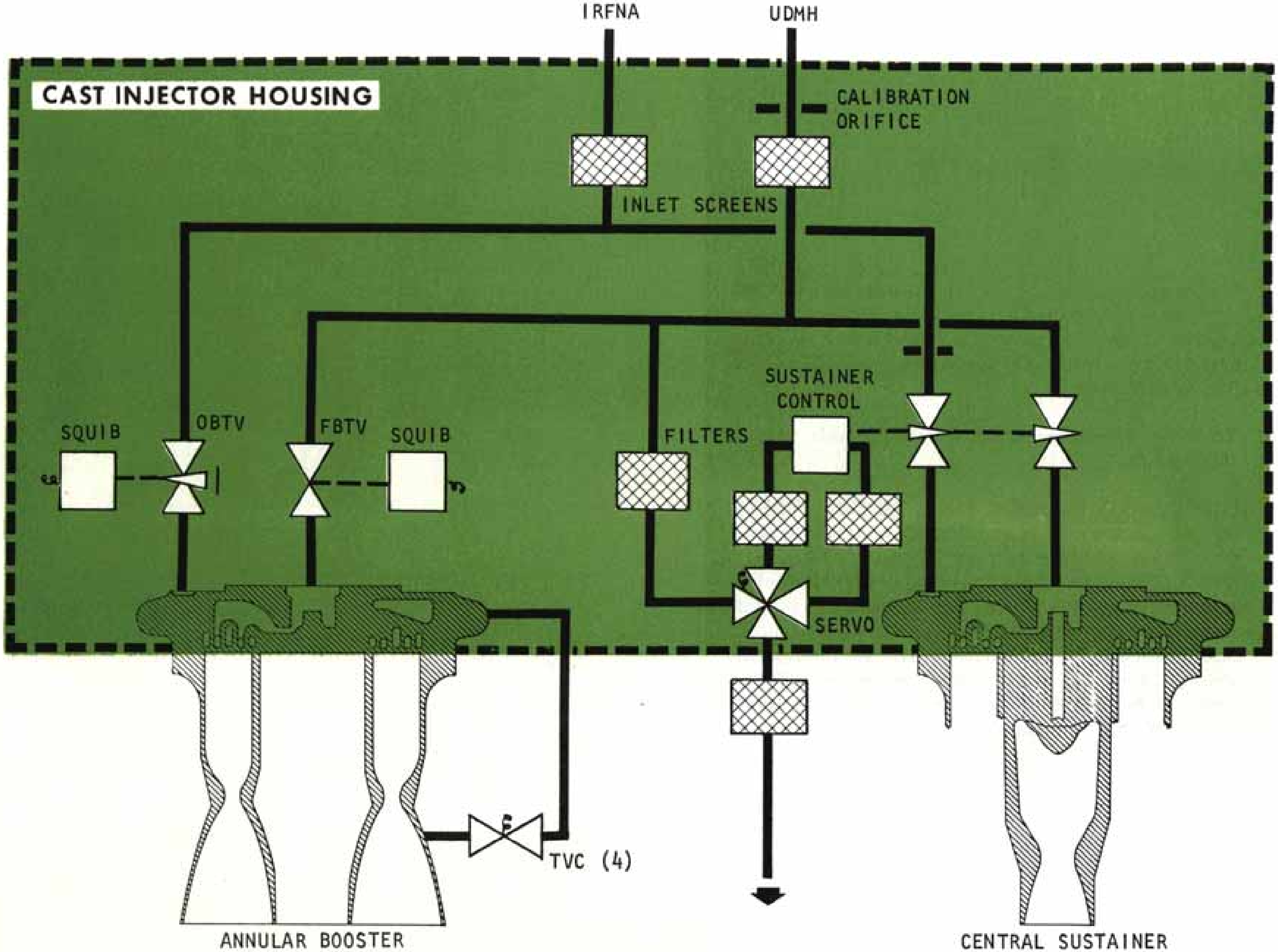


system operational description

START	The flow of propellant at start is achieved by rupturing of burst discs in the feed system, above the engine valves. The OBTV and the FBTV are normally open. The priming pressures developed by the tank pressurization system open the sustainer propellant flow control (throttling).
BOOST	Boost thrust is developed by the booster and sustainer thrust chambers for a 6.1 second (nominal) boost duration.
TVC.	With application of the electrical command signal the valves respond open within 4 ms. A thrust vector control (TVC) side force of 400 lbs results at any single TVC valve (of 4) with a fuel flow of 5.5 lbs/sec at 950 psig inlet pressure.
BECO	The booster cutoff (BECO) is accomplished by squib activated valves. These valves fully close in about 25 ms after the electrical command signal.
SUSTAIN.	Sustainer thrust is varied by the servo-valve control. The thrust range is essentially 0.3 to 100%; the corresponding chamber pressure range is 3 to 966 psia.
RESPONSE	Sustainer phase thrust rate-of-change is greater than 50,000 lb/sec.
SECO	At sustainer cutoff (SECO) the sustainer thrust chamber injector is closed against inlet pressures limiting the chamber pressure to less than 3 psig.

240-556T

system schematic



240-556A

nominal performance characteristics

Engine system thrust during the boost-phase (6.1 seconds maximum mission) is in the 50,000-pound class utilizing both the booster and sustainer. Chamber pressure for both is 950 psia, and overall system mixture ratio is 3.4:1.

Maximum thrust vector control (TVC) side force is 400 pounds.

During sustainer operation, maximum thrust (rated at sea level conditions) is in the 5000-pound class, operating at a chamber pressure of 966 psia and a mixture ratio of 3.19:1. The sustainer can be throttled to approximately zero thrust. The chamber can provide a sustainer operating duration of approximately 15 seconds for continuous full power (for the boost phase and following the boost phase), as well as approximately 105 seconds of throttled operating duration for the normal flight-profile.

240-567AT

nominal performance characteristics

BOOST-PHASE

System Thrust Class, Lb.	50,000
System Specific Impulse, Sec.	* * *
Booster Oxidizer Flowrate, Lb./Sec.	* * *
Booster Fuel Flowrate, Lb. Sec.	* * *
Sustainer Oxidizer Flowrate, Lb./Sec.	* * *
Sustainer Fuel Flowrate, Lb./Sec.	* * *
Oxidizer Inlet Pressure, PSI	1190
Fuel Inlet Pressure, PSI	1160
Chamber Pressure, PSIA	950
System Mixture Ratio	3.4 :1
Boost Phase Duration, Sec.	6.1*
TVC Side Force, Lb.	400.0
TVC Fuel Flow, Lb./Sec.	5.5**
Thrust Decay Time, MS	8.1
Boost Cutoff Impulse, Lb.-Sec.	445

SUSTAIN-PHASE

Sustainer Thrust Class, Lb.	5,000
Sustainer Specific Impulse, Sec.	* * *
Chamber Pressure, PSIA	966
Mixture Ratio	3.19:1
Full Power Duration, Sec.	15*
Throttle Phase Inlet Pressure, PSI	1200 TO 500
Required Injector ΔP, PSI	150
Sustainer Throttle Rate, Lb./Sec.	50,000
Sustainer Minimum Thrust, Lb.	14
Sustainer Minimum Chamber Pressure, PSI	3
Total Mission Duration, Sec.	120*

*Maximum Mission Requirement

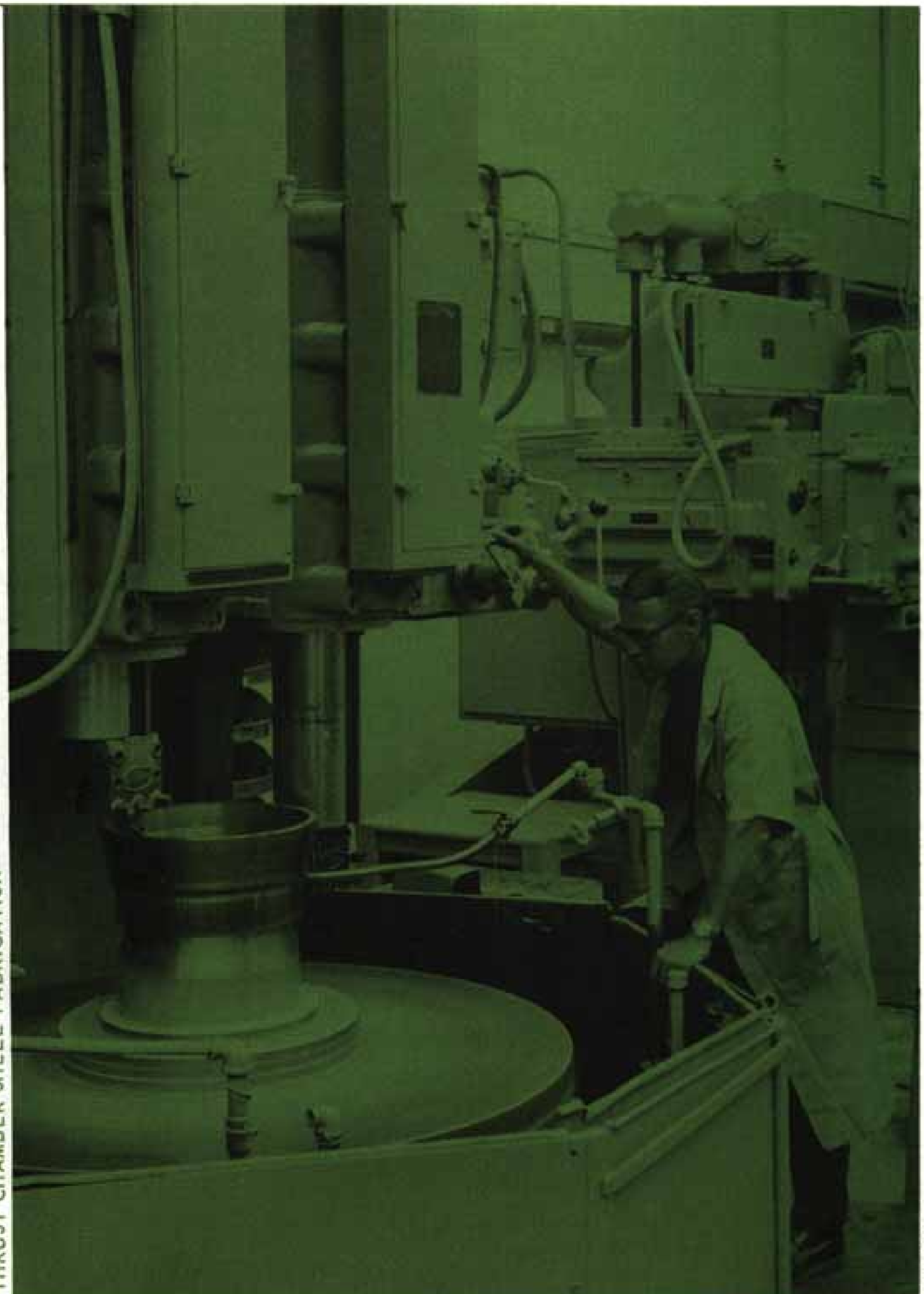
**Per Injection Port

NOTE: All thrust and specific impulse values quoted at sea level conditions.

240-567A

inlet and control requirements

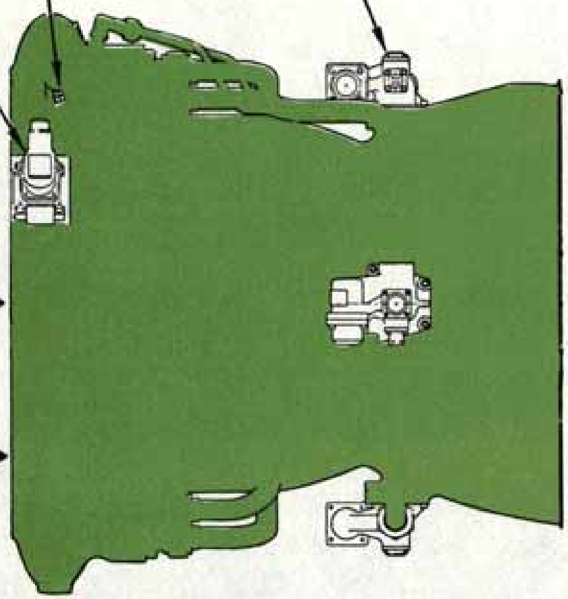
The oxidizer inlet is located on a radius 8.5 inches from the engine axis. The fuel inlet is located at the engine axis. Four thrust vector control valves are located 13.5 inches aft of the engine interface mounted at 90° intervals around the booster thrust chamber. The Boost Termination Valve (BTV) squibs and the servo-valve are mounted on the outer periphery of the injector housing. Fuel for the servo system is provided from within the housing and is filtered at each of the servo-valve supply, control and vent ports. Fuel is provided by four external lines from the injector housing to the thrust vector control (TVC) valves.



THRUST CHAMBER SHELL FABRICATION

240-559AT

inlet and control requirements



BOOST PHASE

Oxidizer Inlet Pressure	1190 PSI
Fuel Inlet Pressure	1160 PSI

SUSTAIN PHASE

Oxidizer Inlet Pressure	1200 TO 500 PSI
Fuel Inlet Pressure	1200 TO 500 PSI

Thrust Vector Control Valves	25.0 – 33.0 Volts DC 0.551-1.27 AMPS
Electrically Fired Squibs Control Boost Termination Valve Closure	Missile Contractor Furnished
Sustainer Servo Current for Throttling and Cutoff	±10 Milliamperes at 100 Milliwatts Power Dissipation

240-559

engine design and installation

The compact LANCE engine assembly is attached to the feed system interface with bolts passing through the injector casting. Geometric thrust alignment is controlled by appropriate dimensional tolerances of detail parts.

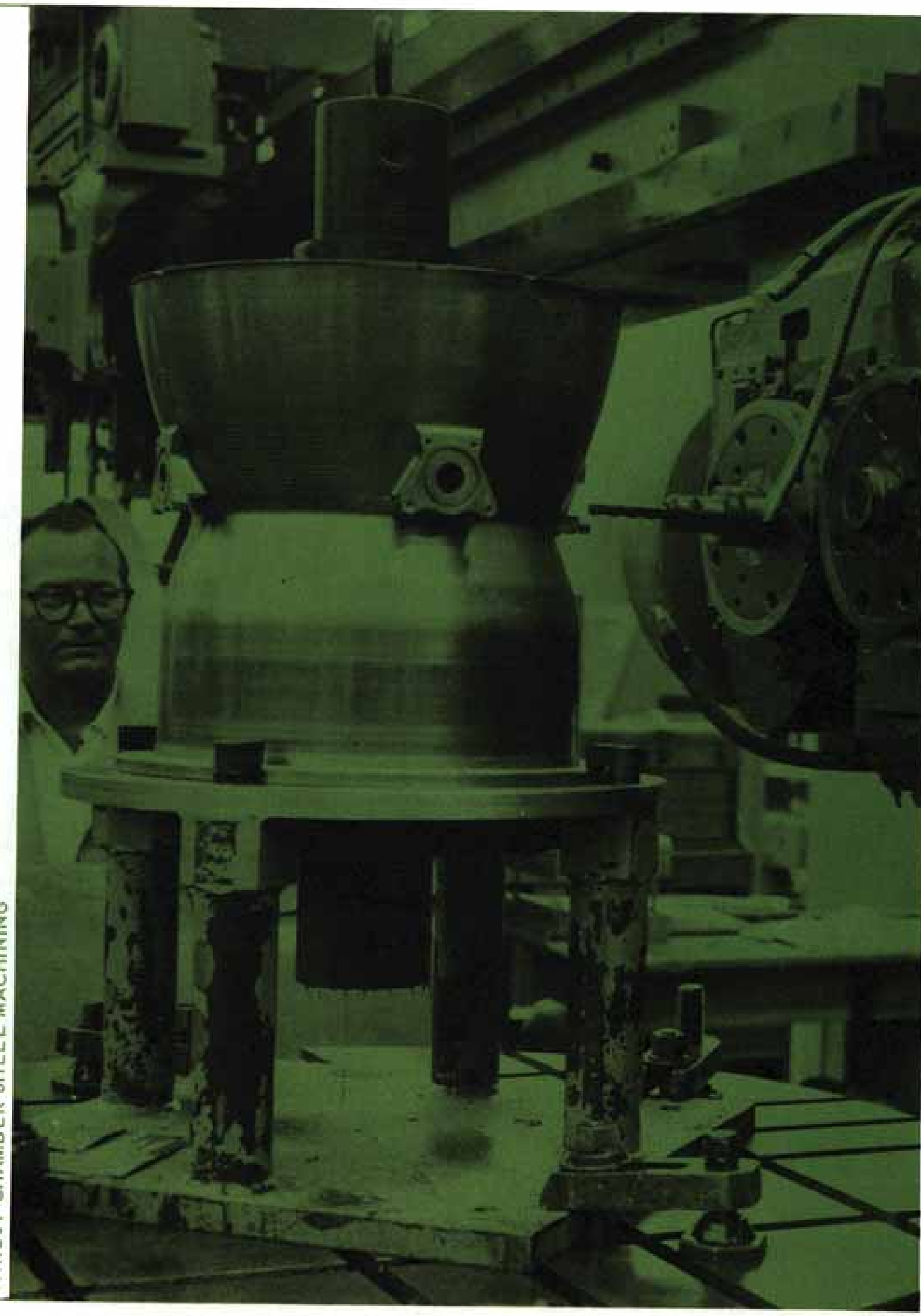
Engine System Thrust Vector:

- within 1.5 milliradians of the engine centerline
- within 0.055 in. of the interface centerline

Sustainer Thrust Vector:

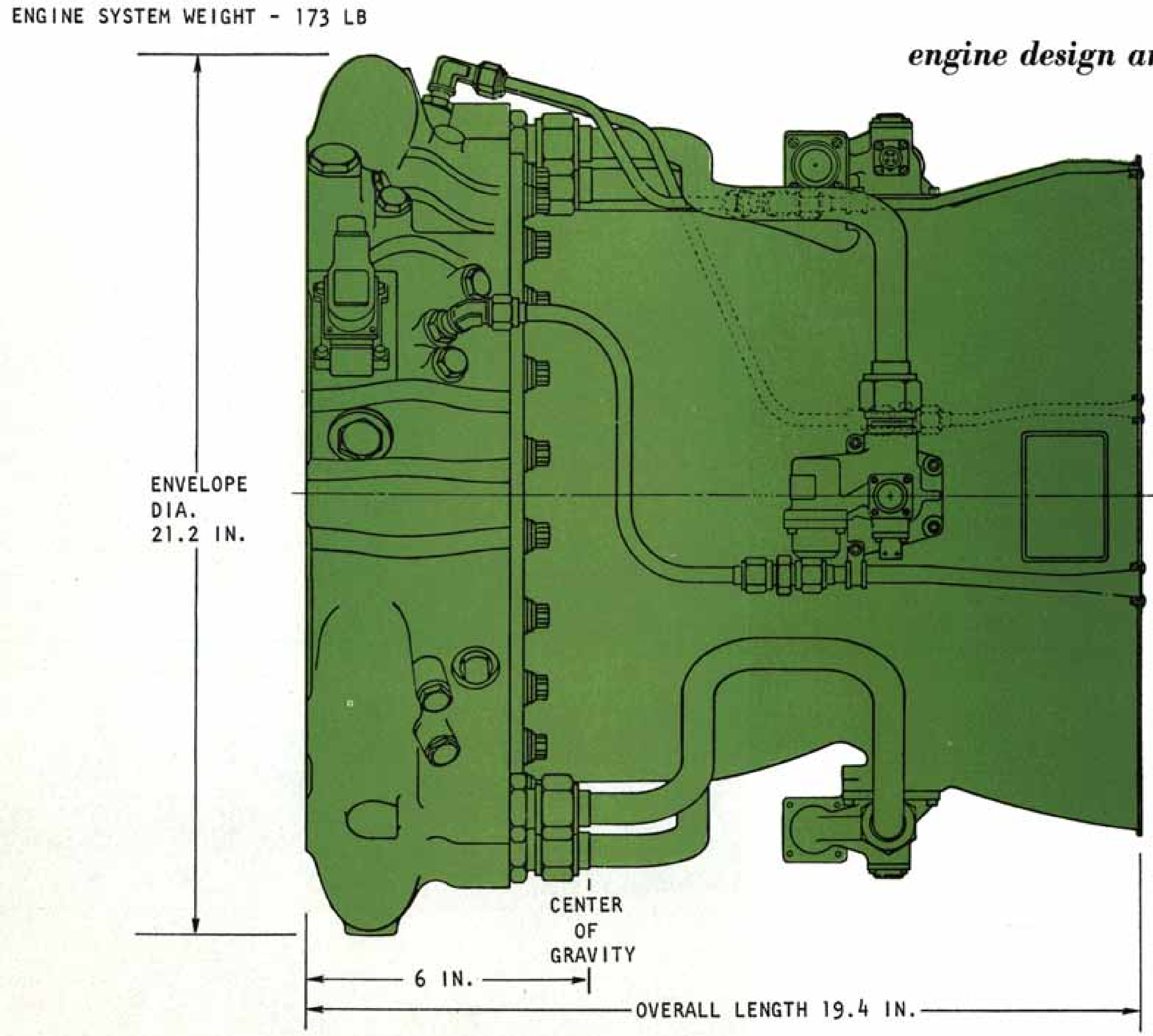
- within 2.8 milliradians of the engine centerline
- within 0.027 in. of the interface centerline

The engine is enclosed in a sealed missile boattail providing a relative humidity level not exceeding 30% at 70°F.



THRUST CHAMBER SHELL MACHINING

240-568AT

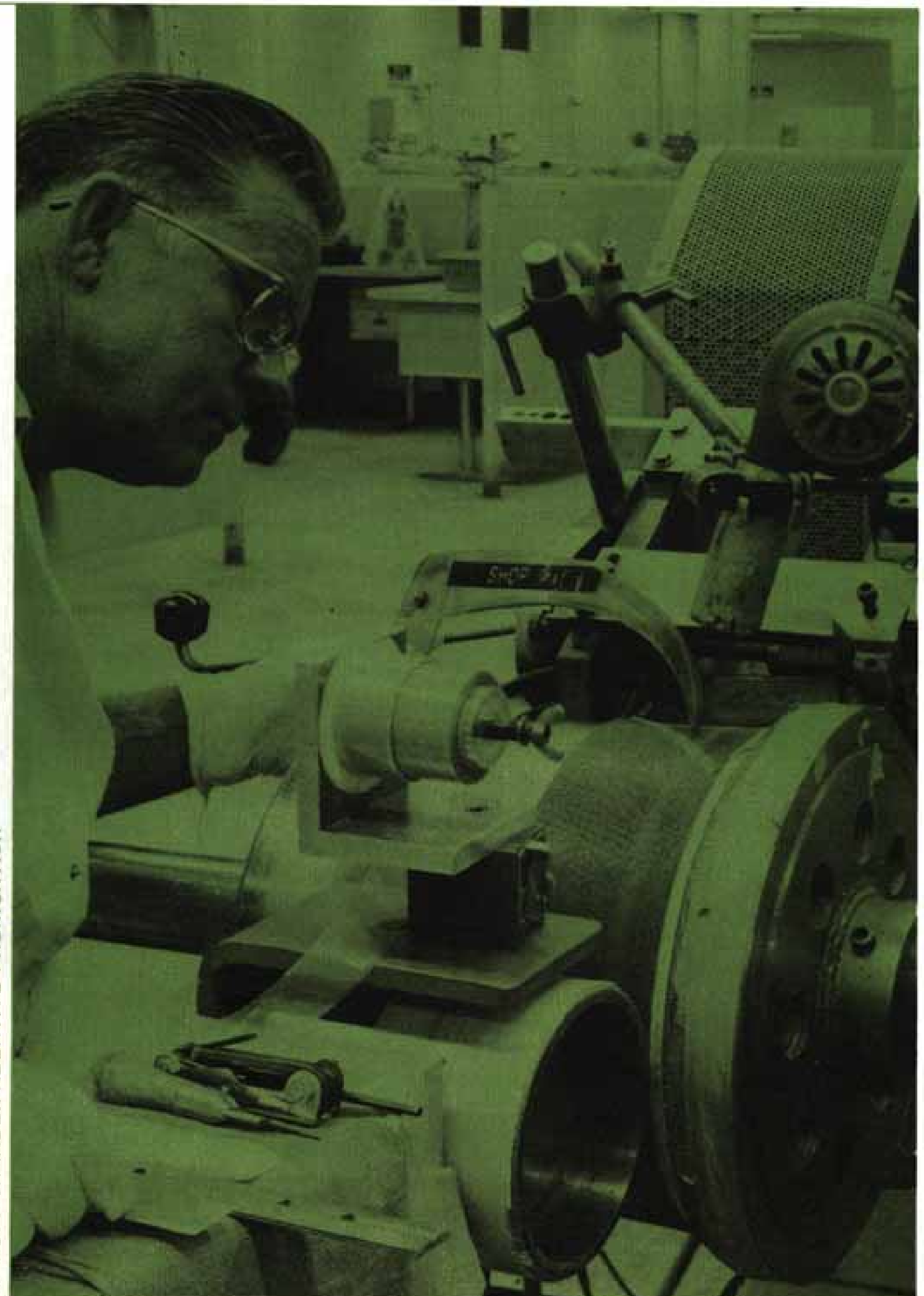

ENGINE SYSTEM WEIGHT - 173 LB
ENVELOPE
DIA.
21.2 IN.
CENTER
OF
GRAVITY
6 IN.
OVERALL LENGTH 19.4 IN.

240-568

engine ruggedness

Operational suitability of the LANCE engine has been verified during engine testing, propulsion system testing and field missile flights over a wide range of thermal and weather environments. In addition, transportation conditions and shock conditions have been tested and engine compatibility verified.

The operational margin of the ablative chambers has been demonstrated by hot firing tests which are well in excess of the 6.1-second and 120.0-second duration requirements of the LANCE booster and sustainer respectively.



THRUST CHAMBER ABLATIVE FABRICATION

240-561AT

LANCE ENGINE FIRING

240-561A

engine ruggedness

Engine test experience has verified operation over a wide range of environmental extremes without functional problems:

TEMPERATURE LIMITS

- Operation

  +140°F to
  -40°F.

- Static Exposure

  +155°F to
  -65°F.

TRANSPORTATION VIBRATION

- 12.8 Hours at 5 g's: 20-500 Hz,
- 6.4 Hours at 1/4 in. Oscillation at 5-20 Hz.

SHOCK

- 24 shocks at levels to 70 g's.

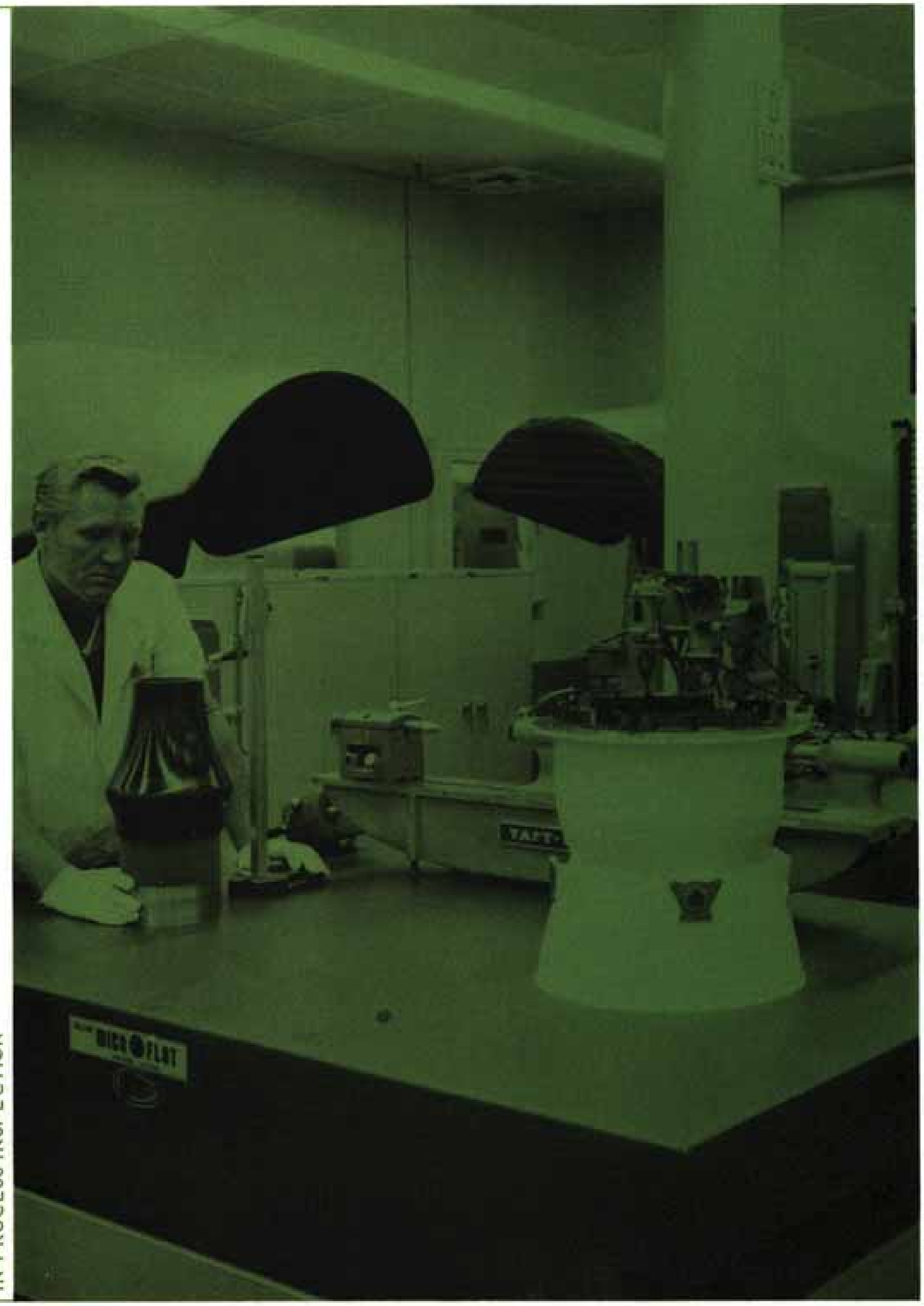
EXTENDED DURATIONS (DEMONSTRATED)

- Booster:7.5 seconds
- Sustainer:175 seconds.

engine maturity

Operational experience with the LANCE engine design has progressed from the component development and engine test phases, through propulsion system ground tests, and into full missile flight conditions.

Overall LANCE engine maturity and capability have been demonstrated.



IN-PROCESS INSPECTION

240-562AT


ENGINE ASSEMBLY
240-562A

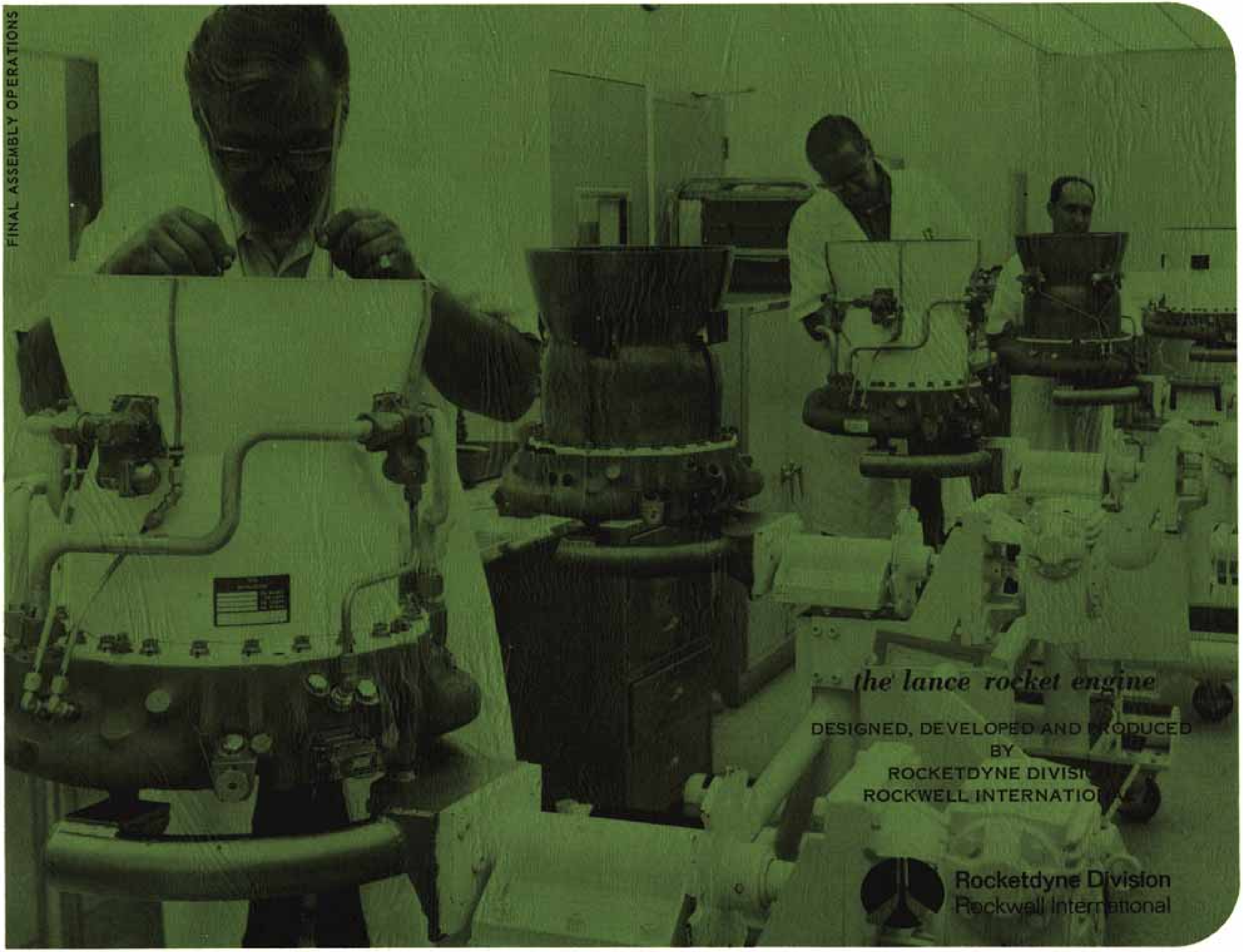
summary

The LANCE engine is in rate production for the U.S. Army LANCE missile. Design simplicity and streamlined production operations provide a low cost, extremely reliable engine.

The full range throttle capability offers maximum thrust flexibility to accommodate a vast array of LANCE missile flight profiles.

All durability, performance, and reliability requirements for the LANCE engine have been achieved and demonstrated.

240-563AT


FINAL ASSEMBLY OPERATIONS
the lance rocket engine
DESIGNED, DEVELOPED AND
BY
ROCKETDYNE DIVISI
ROCKWELL INTERNATIO
Rocketdyne Division
Rockwell International

240-563A

John Robins

Rocketdyne Division
Rockwell International