V.6

1967

LIST OF EQUIPMENT, COMPONENTS,

MATERIAL AND/OR SERVICES

NOW BEING DEVELOPED, FABRICATED, OR PERFORMED

* * * * *

LIQUID PROPELLANT ROCKET ENGINES

Rocket engines with the following characteristics have been developed and tested under contracts, unless otherwise indicated.

Thrust Range	- 15 lbs. to 1.5 million lbs.
Propellants	- All known useful liquid propellants including liquid oxygen, liquid hydrogen, liquid fluorine, oxygen difluoride, RP-1, hydrazine, UDMH, IRFNA, Monomethyl hydrazine, hydrogen peroxide, ammonia, and chlorine trifluoride.
Feed Systems	- Pump and pressure fed. Hydrogen pumps for rocket engines up to 200K have been extensively tested in hot firings in engine systems.
Thrust Chamber Cooling Systems	- Regenerative, ablative, radiation, transpiration, dump and film.
Throttling Capabilities	- Several methods have been successfully demonstrated.
Thrust Vector Control	- Hinged and gimbaled chambers in wide service use. Other methods under test.
Applications	- Ballistic Missiles Redstone, Thor, Jupiter, Atlas, Lance (Missile B) - Target drone - KD2B-1 - Aircraft, Super performance F86, F104, FJ-4R - Space Vehicle Boosters Saturn S-I Stage (Used as 1st stage of Saturn I and IB vehicles) (8 H-1 Engines) Saturn S-IC Stage (Used as 1st stage of Saturn V vehicle) (5 F-1 Engines) - Space Vehicle Upper Stages Saturn S-IVB (Used as 2nd stage of Saturn IB vehicle) (1 J-2 Engine) Saturn S-II (Used as 2nd stage of Saturn V vehicle) (5 J-2 Engines)

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- Space Vehicles
  - Gemini Vehicle
    - (1) Attitude Controls
      Re-entry and Orbiting Module
    - (2) Orbiting and Maneuvering Controls
    - (3) Retro-rockets for re-entry vehicles.
  - Apollo Vehicle
    - (1) Reaction Control System, Command Module
    - (2) Lunar Excursion Module Descent Engine
  - **Titan III**
    - Trans Stage Attitude Controls

SOLID PROPELLANT ROCKET MOTORS

Rocket engines with the following characteristics have been developed and tested under contracts.

Thrust Range	- 45 lbs. to 244,000 lbs.
Propellants	- Ammonium nitrate extruded
	- Ammonium perchlorate high energy castable.
Throttling Capabilities	- Limited range throttling successfully demonstrated.
Thrust Vector Control	- Hinged chamber demonstrated
Nozzle Cooling Methods	- Ablative with refractory throats
	- Destructive distillation
	- Lithium cooling
	- Heat sinks
Applications	- JATO Boosters MK25 JATO for A4D Aircraft (5-NS-4500) M15AI JATO for B47 Aircraft (16-NS-1000)
	- Supersonic Sled Boosters Producer (4-NS-250,000) Megaboom (10-NS-100,000) Segmented case booster has been proposed to Holloman AFB

- Zero Length Launching Boosters (ZELS)
  - Redhead target drone
  - Roadrunner target drone
  - ZEL for F-100 Aircraft (M34) (4-NS-130,000)
  - ZEL for F104 Aircraft (7.9-NS-65,000)
  - ZEL for KD2U-1 Aircraft (4-NS-130,000)

- Ullage Motor
  - S-II Stage, Saturn V

- Air Launched Missile Motors
  - Sparrow III - AAM

SOLID PROPELLANT GAS GENERATORS

Tartar and Terrier Surface to Air Missiles
Gas generators to power auxiliary power system (APS)

Saturn I, Atlas Booster, and Atlas Sustainer
Gas generators to impart initial spin to the turbopump.

A3J Stores Ejector

Turbojet Engine Starting

Lance (Missile B) Auxiliary Power

Rocketdyne's products and technical capabilities in the fields of Nuclear Rocket Engine Systems (less reactor), Power Conversion, and Research are contained in Enclosure (2).

ROCKETDYNE'S PRODUCT DIVISION

CAPABILITIES

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LIQUID ROCKET DIVISION

Research, development, and production of liquid rocket engines for over sixteen years has established Rocketdyne as a leader in the rocket propulsion industry.

With few exceptions, the nation's space probes have been launched by Rocketdyne engines. Rocketdyne's experience dates back to the Navaho boosters and the Redstone ballistic missile. Engines have been developed and produced for the Thor, Jupiter, and Atlas missile programs. These missiles have been adapted to serve as the launch vehicles for the great majority of national space and satellite flights.

Programs for advancement of the state-of-the-art have led to the pressure-fed Aspen, storable propellant vehicle, and the Nomad, a complete upper stage which features the use of liquid fluorine as an oxidizer.

Current projects are the development and production of H-1 engines for the Saturn I first stage; F-1 engines for the Saturn 5 first stage; and J-2 liquid hydrogen engine for Saturn upper stages. These programs require extensive development testing both of components and the engine systems. Rocketdyne's Propulsion Field Laboratory (PFL), located near the main plant, is the site of engine component and H-1 engine testing. The J-2 area has an altitude simulation capability as part of the PFL testing facility. The F-1 is undergoing development testing at the NASA High Thrust Test Area of Edwards, California.

Research for higher energy propellants, stronger heat resistant metals, and more efficient combustion processes is actively pursued in the Research Laboratories of the main plant and at the Propulsion Field Laboratory.

SPACE ENGINE DIVISION

The capabilities and experience of Rocketdyne's Space Engines organization in the design, development, and production of liquid rocket systems for application in space missions and tactical weapons are described below. Rocketdyne possesses the required technology, personnel, test facilities, and reliability techniques necessary to fulfill the propulsion requirements for space programs and tactical weapons.

Current development programs include systems with thrust ranges at various levels. The space engine organization is staffed and equipped to develop systems for any thrust level between .01 to 50,000 pounds. Space systems may be required for maneuvering, reaction controls, upper stage, docking, attitude, orbit changes, or combinations of these requirements. Packaged, storable propellant, rocket propulsion systems for various vehicles and tactical missiles (up to about 50,000 lb. thrust) are also under the cognizance of the Space Engine Division.

The facility at our Propulsion Field Laboratory includes six test cells tied into a central control and recording center. One module of two test cells is equipped for environmental work. The rocket nozzle test facility (wind tunnel) may simulate altitudes up to 100,000 feet. An altitude simulation chamber for testing space engine systems in a space-simulated environment is a part of this facility. A portion of the research areas of the Propulsion Field Laboratory are assigned to space engine development.

The Space Engine Division is currently engaged in the following storable pre-packaged systems, thrust chamber and component development programs:

Ablative Thrust Chambers

Experience includes: Long duration runs of low-thrust, thrust chambers and successful firings of semi-flight weight chambers w/throttling injectors.

Radiation Cooled Thrust Chambers

Experience includes: Chamber w/oxidation resistant coatings fired successfully with no configuration change.

Advanced Transpiration Cooled Thrust Chambers

Matrix w/resin to provide cooling, with inner liners of refractory metal to maintain close control of inner contour to minimize shift in thrust magnitude and vector orientation.

Fast Acting Valves

Includes: Repeatable start transients, short impulse bits with response of approx. 3 milliseconds.

Pressure Regulators

All metal construction, single-stage design for maximum reliability including internal relief.

Positive Propellant Expulsion

Provides: Positive supply of propellants at zero gravity, multiple expulsion cycle capability, long time propellant storage, and inherent rigidity to reduce sloshing and minimize propellant c.g. shift.

Storable Prepackaged Systems

Complete propulsion systems including such features as co-axial thrust chambers, throttling, positive expulsion tankage, and prepackaging of storable propellants for long term storage.

Experience

Development Programs

Includes: Flight weight completely integrated attitude control system capable of high rate on/off cycling.

Nominal thrust range, retro and orbit change system with wide range throttling range capabilities.

Other systems include: Low thrust pitch and yaw and roll control, and upper stage engines for controlled space maneuvering; Prepackaged storable propulsion system for tactical missiles.

Current programs are listed in Enclosure (1).

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SOLID ROCKET DIVISION

Research, development, and manufacture of solid rocket components is assigned to this division. The Waco (McGregor, Texas) facility (18 miles SW of Waco) extends over 12,000 acres, with a propellant processing capacity for nitrates (20 million lb/year) and perchlorates (18 million lb/year). Enclosure (4) contains a complete list of facilities and equipment for research, development, and production of solid propellant rockets and gas generators.

Flexadyne is a Rocketdyne solid propellant research achievement. Control of the chemistry and polymerization process has resulted in outstanding physical properties for Flexadyne fuel-binder. These excellent physical properties extend over a temperature range of -70 to 170°F with a high resistance to tear. A Flexadyne propellant is currently being used in the Sparrow III-6b, air-to-air missile which is subjected to very severe environmental conditions.

Quickmix is Rocketdyne's continuous process for producing solid propellants. By this method, the fuel and the oxidizer are suspended in separate streams of inert carrier and are brought together in a simple jet mixer. Only a few ounces of propellant are in process at any one time for a 500-pound-per-hour production rate, which lends a high degree of safety to the production method. A higher degree of propellant uniformity can be achieved by Quickmix than by other processes. Negotiations for design and fabrication of a composite, modified double base propellant quick mix facility are underway with the Navy.

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NUCLIONICS DIVISION

Nuclear Rocket Engines

Capabilities include design and development of components and engine systems (less reactors). Experience is being accumulated in design, development, and production of liquid hydrogen pumps, nozzles and complete feed systems for KIWI and ROVER programs. Preliminary designs and program requirements have been generated for a family of nuclear rocket engines based on the Phoebus-type fuel element of the Los Alamos Scientific Laboratory.

Power Conversion

Power Conversion capabilities include a new, well equipped laboratory occupying an area of 3,500 sq. ft. The laboratory is fully equipped to perform basic and applied research as well as component testing for space and terrestrial power conversion systems. Rocketdyne has completed studies to definitize the potential of an advanced nuclear thermomechanical system for space power. This study considered such unique components as the Belt radiator and Naydyne generator. The system is of the double loop type with the primary reactor loop using lithium as the working fluid. Other projects are: Development of IBM code for system optimization, 2-5 MWE advanced Rankin cycle APU study, low power APU studies; operation of boiling convective FC-75 loop, analysis and design of 2-MWE regenerative steam PCS.

Rocketdyne has been conducting alkali metal lubricated journal bearing research for almost two years. Experiments have been conducted using a molybdenum shaft, both uncoated and spray coated with tungsten carbide. Bearings have been fabricated from molybdenum and tungsten carbide. This facility contains three separate bearing test systems and a closed cycle argon supply system.

Water Lubricated Bearing Equipment - Analytical and experimental research program to investigate journal bearings that derive their support from liquid film formed by the condensation of vapor has been conducted. As a result, an expanded research program covering the study of vapor-lubricated bearings is currently being sponsored by the Office of Naval Research. Bearings capable of operating in a hard vacuum are being tested in equipment developed by Rocketdyne under contract with the Air Force.

RESEARCH DEPARTMENT

The Canoga Park Research Laboratories are fully equipped and staffed to conduct all types of chemical research, chemical synthesis, chemical analysis, materials research and instrument development. Supporting shops and data processing equipment are located in the same facility. There are 42 fume hoods, 22 of which are large, full enclosed, individually facilitized, double walk-in types. These laboratories occupy 10,000 sq. ft. of floor space in the Canoga Plant. Rocketdyne's Research facility has a total of 153 scientists involved in basic research and applied sciences.

The Research Department's facilities at the Propulsion Field Laboratory include laboratories and test cells for conducting testing and development programs on numerous phases of high energy liquid and solid propellants. 4000 sq. ft. of space is currently assigned to the Research Department at PFL.

Methods of handling and mixing both high energy liquid and solid propellants are being investigated and Rocketdyne's "Quick-Mix" method of solid propellant formulation is being developed on a small scale pilot plant operation. Remote handling devices developed for some high energy propellants have been installed so that exotic fuels and oxidizers may be mixed and handled with the greatest efficiency and safety.

Included in this Research area are several test cells fully instrumented and staffed to accomplish any research program requiring investigation into heat flux studies, high pressure studies, small solid propellant grain mixing, fabrication and firing and handling, mixing and firing of high energy storable liquid propellants.

Typical highly specialized equipment available for analytical chemistry is listed below. This is by no means a complete list of scientific apparatus available in the Research Department, but is included here to indicate the quality of equipment available at Rocketdyne.

Differential Thermal Analyzer	- Deltatherm
2 Mass Spectrometers	- (1) Bendix Time of Flight (2) CEC Type 21-103C
4 Infrared Spectrometers	- (1) Beckman IR-7 (2) Perkin-Elmer Mod. 112 (3) Two (2) P&E Infracords
5 Gas Chromatographs	- (1) Consolidated Electrodynamics Corp. (2) P&E 154D (3) Beckman Megachron (4) Ortho-Pashydrogen Analyzer (5) Reactive Chemical Analyzer (Custom made)
Optical Emission Spectrograph	- 1.5m film read out
X-Ray Diffraction & Fluorescence	- General Electric XRD5
Ultraviolet & Flame Photometer	- Beckman DK-2
2 Polarographs	- (1) Sargent Mod. XV (2) Sargent Mod. XXI
Micromerograph	- (Sharples (for particle sizing)
3 Dry Boxes	- (1) Two (2) D. L. Herring (2) Kewanee
Chemical Shock Tube	- (Custom made)
Nuclear Magnetic Resonance Spectrometer	- Varian Associates DP-60
Induction Furnace	- Leco, Mod. 537
2 Cryogenic Samplers	- Cosmodyne Corp. Mod. 054.4
Liquid-Alkali-Metal Analyzer	- Custom made

Current Research Programs include:

Development and Evaluation of Storable, Bipropellant Systems.

Research on Hybrid Combustion.

Liquid Propellant Combustion Instability.

Research in Synthesis of High-Energy Storable Oxidizers.

Studies and Tests of High Energy Storable Propellant Rocket Engines.

Development of Systems to Identify Rocket Exhaust Products.

Studies of Cesium Corrosion.

Cooling Problems at High Chamber Pressure.

Research in Fluorine Chemistry.

Ceramic Studies.

Refractory Metallurgy.

Fuel Cell Studies.

Polymers.

STRUCTURAL PLASTICS DEPARTMENT

Glass Filament Winding

Since 1954, Rocketdyne has been engaged in a concentrated effort to advance the art of producing high-strength, lightweight, filament-wound reinforced structures. An extensive program has evolved for evaluating processing techniques, basic materials, and the many variables which affect the final product.

The originally developed winding machines of a purely mechanical nature have been supplemented by new, tape-controlled machinery.

Experience, personnel, and advanced facilities enable Rocketdyne to conduct any filament winding program, whether it is one of fabrication of an article according to the customer's specifications, or one including design and development with fabrication.

Savings of 25 percent in weight and costs have been realized in filament-wound thrust chambers. Pressure vessels 18 inches in diameter and 24 inches long have exhibited wall stresses as high as 170,000 psi at burst.

Ablative Projects

Rocketdyne is actively engaged in the development of ablative thrust chambers for both liquid and solid propellant rocket engines. Sizes range from 3 inch dia x 8 inch long, space vehicle altitude control chambers, to 12 ft dia x 6 ft long, nozzle extensions for the F-1 chamber.

Ablative thrust chamber projects currently under development include Gemini and Apollo propulsion systems. A large range of propellant combinations including both cryogenic and storables have been fired in ablative chambers.

A group of well qualified engineers within the Structural Plastics Department is specifically assigned to ablative projects.

A completely integrated shop (at the Van Nuys facility) has been established which is fully equipped for development, fabrication and test of ablative thrust chambers and related items. The more important items of equipment used for these projects are given below.

FILAMENT WINDING EQUIPMENT

Type Machine	Diameter (Swing)	Length (Capability)
1 Tape Controlled Helical Winding	12 feet	40 feet
1 Tape Controlled Helical Winding	36 inches	120 inches
1 Circular Winding	4 feet	11 feet
1 Polar Winding	48 inches	84 inches
1 Ablative Filament Winding	30 inches	55 inches
1 Tape Wrapping	14 inches	40 inches
1 Helical Winding	10 inches	65 inches
3 Smaller Circular Winding Machines		
* Ablative Tape Edge Winding (Vertical)	58 inches	72 inches
** Ablative Edge Winding Machine (Horizontal)	20 inches	48 inches
*** Reinforced Grain & Filament Winding, Tape Controlled (Dual Purpose)	72 inches	27 feet

* Estimated Completion Date - February 1963
** Estimated Completion Date - Indefinite
*** Estimated Completion Date - July 1963 (This machine will be installed at McGregor Facility.)

SUPPORTING EQUIPMENT FOR FILAMENT WINDING
AND ABLATIVE CHAMBER FABRICATION

Item		
Electric Oven	38" x 20" x 25"	Max. 650° - Recorder & Programer
Electric Oven	25" x 20" x 25"	Max. 650° - Recorder & Programer
Autoclave	24" Dia. x 8' Long	Max. 350°, 250 psig, Vacuum Optional
Muffle Furnace	11-1/4" x 8-1/4" x 14"	1850°F Max.
Dispatch Ovens (2)	54" x 68" x 66"	Thermostatic Control 24 hr. recorder - 100°F to 650°F
Hydrostatic Test Cell	10' x 12' x 14'	Withstand 2000 psig
Hydrostatic Test Console	(used with test cell)	15000 psig (for small test items)
Hydrostatic Test Console	(used with test cell)	3000 psig (for high volume pressure vessels)
Walk-in Deep Freeze	10' x 20' x 8'6"	Temp. 0 ± 5°F (used for storage of filament material)
Pressure Impregnating Vessel	36" dia. x 36" deep	100 psig to 29" vacuum. Heating Blanket for 250°F, Thermo Controlled
Melting Pot	20 gal capacity	For Melting Molding Materials.

NOTE: This list includes only the larger, more important specialized equipment in Structural Plastics Shop. The shop is also equipped with standard machine tools, handling equipment, power supplies, etc. required for a completely integrated shop.

SPECIAL CAPABILITIES

* * *

COMPUTER SYSTEM CAPABILITIES

Rocketdyne has made extensive use of analog and digital computers since its inception. Company effort in these fields was accelerated by the ability to draw upon the computing experience gained by other divisions of NAA.

There are over 190 pieces of equipment in use in the Data Processing area, completing an average of 390 computing problems daily. This equipment includes:

2 - IBM 7090 computer systems

2 - 1401 computer systems (with 600-line-per-minute printed three-tape drive and read-punch units)

2 - High-speed, 500-line-per-minute printers

1 - RAMAC, two-disc, computer system

Electronic Digital Computer Facilities

Electronic digital computing facilities are available at the Rocketdyne Canoga Park plant. The two IBM 7090 electronic digital computers can be employed for engineering problems on a three-shift basis, five (5) days per week. In addition, four additional 7090 systems at other NAA divisions are immediately available through micro-wave hookup. This combination of six computers makes Rocketdyne a part of the largest inter-locking data processing system in the business world.

Analog Computer Facilities

Rocketdyne Analog Computer Facilities are composed of five (5) general-purpose analog computers and the necessary peripheral equipment. Each of these computers may be operated independently or in conjunction with any of the others. Two of these analog computers are:

Berkman/Berkley Model 1032 containing 0.1 per cent accuracy computing components.

The three remaining computers are:

Two (2) Berkman/Berkley Model 1132 and one (1) Electronic Associates Model 16-131-R. All of these units contain 0.1 per cent accuracy computing components.

ROCKETDYNE'S FURNACE BRAZING

The technique of furnace brazing large thrust chambers has been developed at Rocketdyne's Canoga Park facility. This furnace, the largest of its kind, uses natural gas for fuel while the part being brazed is kept in an inert gas atmosphere. This method of brazing has two major benefits: First, a uniform flow of the brazing alloy assures a high quality and highly reliable thrust chamber, and secondly, it reduces cost by eliminating man hours consumed by the slow, hand-brazing method.

Fit-up, brazing alloys, alloy placement, furnace cycle and tooling are the five deciding criteria which determine the quality of the end product.

NUMERICALLY CONTROLLED MACHINES

At the present time, there are 15 numerically controlled machines located at Rocketdyne's Canoga Park and Van Nuys plants, and 10 at the Neosho facility. These machines are programmed on punch cards and tape, and are capable of performing intricate and multiple machining operations in a fraction of the time required by manual methods. This type of equipment, programmed and operated by Rocketdyne's trained personnel, reduces costs in tooling and material, has highly accurate repeatability, and assures quality parts.

ROCKETDYNE FACILITIES

* * *

Description of Buildings (Type of Construction and Use)

Canoga (USAF Plant No. 56) - Concrete tilt-up construction.

Neosho (USAF Plant No. 65) - Concrete tilt-up construction.

McGregor (USAF Plant No. 66) - Explosive areas:
Structural steel frame with cemesto blow-out walls and 12" reinforced concrete blast walls.
Inert areas: Wooden frame construction with cement asbestos siding and roll roofing.

Reno - Headquarters building - 15,000 sq. ft., concrete tilt-up construction.
Out buildings - Sheet metal construction

Rocketdyne Covered Areas

Canoga Complex

Canoga Avenue Complex		Square Feet
Main Building		526,701
Office Annex	*	50,312
Van Owen (Research & Space Engines)	*	152,207
Cafeteria	*	15,350
Manufacturing Building #1	*	163,378
Material Building	L	93,490
Eton Warehouse	L	48,320
Other (Warehouse, etc.)		56,731
Manufacturing Building #2	L	168,000
Manufacturing Building #3	L	105,600
Headquarters Building (Four Floors)	*	60,900
Propulsion Field Lab.		
Research	*	51,434
Engineering		177,416
Warehousing	*	13,777
Other		92,315
Rocket Test Site - EAFB		
Shop and Office Areas		77,250

Other		Square Feet
Nordhoff Facility	L	24,000
Van Nuys Facility	L	140,864
Area Offices (Less Huntsville, Ala. & Washington, D.C.)	L	8,651
Corporate Warehouse	*	54,515
Mira Loma (Gov't. Admin.)	L	44,510
TOTAL		2,125,730

Neosho Complex

Main Building Complex		228,503
Barracks Building		14,400
Storage Building		1,250
Test Area Complex		59,004
Harmony Facility	L	16,000
TOTAL		319,157

McGregor Complex

Area		
A & B - Administration		68,945
A - Staff Housing		34,742
C - Industrial Security		9,454
D - Shops		91,854
E - Warehousing		68,545
F - R & D Propellant Processing		87,509
G - Storage		48,529
H - Magazines		125,367
L - Test Facility #2		102,637
M - Manufacturing		288,162
R - Test Facility #1		22,175
T - Crating & Shipping		5,620
Q & Z - Utility		6,976
TOTAL	**	925,773

Reno Test Site

Operations Support Building (Rocketdyne Occupied)	*	14,000
Solid Propellant Facility	*	3,911
North Hangar	*	4,760
Advanced Liquid Facility	*	8,916
Space Engine Facility	*	7,920
TOTAL		39,507

L Contractor Leased
* Contractor Owned
** Includes 128,686 Stand-By-In-Place
NOTE: All covered areas are Air Force Property except as indicated.

Rocketdyne Areas

	ACRES		
	Leased	Owned	Government
Canoga Ave. Complex (Incl. Van Nuys and Nordhoff)	40	41	36
Propulsion Field Laboratory	77	785	409
Rocket Test Site - EAFB	-	-	187
Neosho, Missouri	2	-	266
McGregor, Texas	-	-	3,107
Reno (Rocketdyne Used)	-	1,460#	-
TOTAL	119	2,286	4,005

#Advanced liquid research - 640 acres, Solid Research - 160 acres, Space Engines Research - 640 acres, operations support area - 20 acres.

Description of Manufacturing, Test and Research Facilities

Manufacturing of Liquid Rocket Engines is conducted at Canoga Park, California and at Neosho, Missouri. The main plant of Canoga Park assembles the Atlas Sustainer engine and is engaged in the development of the 1,500,000 pound thrust F-1 Engine and the 200,000 pound thrust J-2 Liquid Hydrogen Engine. Development activities for small liquid storable propellant space engines and ordnance propulsion systems are performed at the Canoga Park and Van Nuys Plants.

The Neosho Plant assembles and tests Atlas and Thor booster and vernier engines, H-1 Engines and P-4 Target Drone Engines. The Neosho Test Facilities include two all-weather test stands and eight component test positions.

Manufacturing of Space Engines and tactical hardware is conducted at the Canoga Park and the Van Nuys facilities. The Canoga facility assembles and functionally tests hardware systems in the development of space engines for the Gemini capsule control systems, attitude control systems on a classified program, attitude control systems for the Titan III Transtage, and rocket engine assemblies for the Apollo. The Van Nuys facility assembles and functionally tests propellant valves and regulators, performs final assembly and functional testing of rocket engines, and machines, bonds, installs injectors, and final filament winds thrust chambers for the same programs. Shortly, the Van Nuys facility will be engaged in the machining, final assembly, and functional testing of the tankage for the Lance missile, as well as machining injector heads and assembly of thrust chambers.

Manufacturing Capabilities of the Canoga Park and Van Nuys Plants include 100,080 sq. ft. of air-conditioned and dust-controlled shop areas which are used for the assembly of precision rocket engine components. Fabrication of rocket engine hardware is accomplished on over 350 general purpose machine tools, 15 numerically controlled machine tools and measuring equipment, metal forming equipment, extensive metal joining and processing facilities, production development laboratories, and modern quality control facilities. Two large brazing furnaces, one of which can accommodate F-1 (1.5 million pound thrust, 8' dia. x 13-14/' long) thrust chambers, are also installed in the Canoga Plant.

Special facilities used exclusively for the manufacture of Space Engines include an environmentally controlled white room at Canoga of 4800 sq. ft. Micron particle count in this area is no more than 5 per cu ft of class 25-50 and no more than 10 per cu ft of class 10-15. Adjacent to this area is a walk-in type furnace (temperature 125° - 150°) dust controlled for assembly of expulsion devices and a particle counting laboratory for evaluation of samplings for contamination within assembled hardware. The Van Nuys facility has an environmentally controlled white room of 650 sq ft and filament winding equipment. In addition, both Canoga and Van Nuys Space Engines facilities are supported with additional space for general purpose machine and welding tools, special functional testing equipment, and quality control facilities.

Manufacturing Capabilities of the Neosho Plant include 12,420 sq. ft. of air conditioned and dust controlled shop areas. Over 150 general purpose and 10 numerically tape and card controlled machine tools are installed.

The Propulsion Field Laboratory for the Canoga Plant consists of 1,271 acres of rugged, isolated land in the Santa Susana Mountains, located about 10 miles northwest of the plant. This testing facility houses numerous research laboratories, large engine test stands, offices, shops and components test laboratories. The main function of the Propulsion Field Laboratory is the performance of research and the development and acceptance testing of large and small liquid propulsion systems.

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Liquid Rocket Test Facilities - Propulsion Field Laboratory:

Nineteen large engine or thrust chamber stands (status 3-1-63):

Canyon Area:	1	-	Inactive
	2	-	H-1 Engine R&D
	3A	-	Inactive
	3B	-	H-1 Engine R&D
Bowl Area:	VTS 1	-	J-2 Thrust Chamber
	2	-	J-2 Engine R&D
	3A	-	J-2 Engine altitude chamber
	3B	-	J-2 Engine R&D
	HTS	-	J-2 thrust chamber
Alfa Area:	1	-	Atlas MA-3 Engine R&D
	2A	-	Atlas sustainer engine-acceptance
	2B	-	Atlas sustainer engine-acceptance
	3	-	Atlas MA-2 or 5 booster engine or sustainer acceptance
Bravo Area:	1A	-	Misc. Thrust Chamber
	1B	-	Misc. Thrust Chamber
	2A	-	F-1 pump
	2B	-	F-1 pump
	2C	-	F-1 pump
	3	-	Inactive
Coca Area:	1	-	S-II Battleship test stand (in construction)
	2	-	Abandoned
	3	-	Inactive
	4	-	S-II Flightweight test stand (in construction)
Delta Area:	1A	-	Thor/Jupiter overhaul engines
	1B	-	Thor/Jupiter overhaul engines
	2A	-	J-2 engine acceptance *(in construction) *(Altitude)
	2B	-	J-2 engine acceptance *(in construction) *(Ambient)
	3	-	Lance R&D (in construction)

Sixty-two Component test laboratory (CTL) test positions

CTL I (9 positions)	J-2 LOX pump, MK-4 turbopump, misc. regulators, turbines, seals and bearings. R&D hot firing pits and flow benches.
CTL II (8 positions)	H-1, Thor, Jupiter gas generator and turbopump testing. AR Engine (overhaul acceptance).
CTL III (19 positions)	F-1 and J-2 gas generator R&D testing. Gemini and X-8 engines, J-2 LOX turbopump, X-8 turbopump, J-2 hydrogen turbopump.

Repro

CTL IV (19 positions)	Space Engines testing (includes altitude chambers).
CTL V (8 positions)	J-2 Hydrogen turbopumps, nuclear turbopumps, F-1 and J-2 LOX and LH_2 electric drive.

Liquid Rocket Test Facilities - Edwards Air Force Base, Calif.

Test Stand 1A	F-1 Engine R&D
Test Stand 1B	F-1 Engine R&D (2 position test stand)
Test Stand 1C	F-1 Engine production acceptance (environmental test stand - under construction)
Test Stand 1D	F-1 Engine production acceptance (under construction)
Test Stand 1E	F-1 Engine production acceptance (under construction)
Test Stand 2A	F-1 thrust chamber R&D (3 position stand)

Test and Research Facilities - Reno, Nevada

Space Engines Test Facility

This test complex includes two small engine test positions. One altitude test position which is used for the Gemini Thrust Chamber Production Acceptance testing and an ambient position which is scheduled for the SE-5 Space Engine reliability program. A combination instrumentation control center-shop building provides support services to this test complex.

Research Solids Processing and Test Facility

Processing, storage and testing facilities used for Research and Development activities in connection with advanced upper stage solid propellants.

Advanced Liquids Test Facility

This facility includes one 2-position test stand and control center which is used for Research and Development testing activities in conjunction with high energy liquid propellants.

Liquid Rocket Test Facilities - Neosho, Missouri

Two - 2-position large engine test stands (status as of 2/22/63)

Test Stand No. 1	MA-5 Booster and H-1 Engine acceptance testing.
Test Stand No. 2	MA-3 Booster and Thor Engine acceptance testing.

Liquid Rocket Test Facilities - Neosho, Missouri (Cont'd.)

Four 2-position rocket engine component test cells

Components Cells No. 1 & No. 2 Atlas and Thor vernier engines

Components Cells No. 3 and No. 4 Atlas, Thor and H-1 gas generators.

Testing of the P-4 Drone engine and all turbopumps is accomplished adjacent to Cell No. 4

Test and Research Facilities - Solid Rocket Division, McGregor, Texas

Mixing
- 1 - 300 gallon vertical mixer
- 3 - 200 gallon vertical mixers
- 12 - 100 gallon horizontal mixers
- 1 - Banbury copolymer mixer

Casting
- 1 Pit - 65 inches dia. x 13 feet deep
- 2 Pits - 20 feet x 35 feet deep

Extruders
- 5 - 2140 ton
- 2 - 1070 ton

Curing
- 4 ovens - 11 feet high x 8 feet wide x 25 feet long
- 2 ovens - 11 feet high x 12.5 feet wide x 132 feet long
- 2 bays - 18 feet high x 15 feet wide x 20 feet long

One automated case preparation line (JATO)

Four propellant grain trimmers

Firing
- 6 bays - Motors with thrust up to 1,000,000 lbs. may be test fired
- 1 bay - Motors with thrust up to 1,500,000 lbs. may be test fired

Quality Control
- 1 - 13 MEV linear accelerator

Driers
- 2 - 8000 lb/hour oxidizer driers

Grinders
- 3 - Grinders (1750 lb/hour each)

R & D Propellant Processing - Area F

Capable of all phases of processing from small batches to 1200 lb. batches. The oxidizer preparation building contains:

1 - Rotary drier
1 - Twin shell blender
1 - 1500 lbs. per hour Sweco separator
1 - Anikro atomizer
1 - Baker-Perkins mixer (adapted for vacuum)
small mixers and instrumentation

Casting facilities for vacuum casting up to 65 inch motors and up to 15,000 lbs. of propellant.

Air conditioning system control within $\pm$ 1°F. 300 KVP and 400 KVP X-ray units. Reinforced grain fabrication facilities. Complete propellant processing equipment. Nine laboratories. Five Research Cells.

Static Test Areas - R & D

4 - Small firing cells
Test bays for vibration humidity, salt spray, rainfall, shock, etc. Instrumentation Laboratory
1 - Large firing pad
1 - Drop test pad
1 - Long-term storage - accelerated aging
8 - Storage facilities (-75°F to 200°F)
1 - Three cell, large storage building:
Cell #1 - ambient to +200°F
Cell #2 - +30°F to +100°F
Cell #3 - ambient to -100°F