Pinellas Plant

U.S. Department of Energy
Pinellas Area Office

General Electric Company
Neutron Devices Department

September 1986

DISCLAIMER

Pinellas Plant

PRO-GEND

GEPP-CB--986

DE87 013100

FACTS

U. S. Department of Energy
Pinellas Area Office

General Electric Company
Neutron Devices Department

MASTER

GEPP-CB-986 September 1986

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THE
PINELLAS PLANT

AN INTRODUCTION

BACKGROUND AND HISTORY

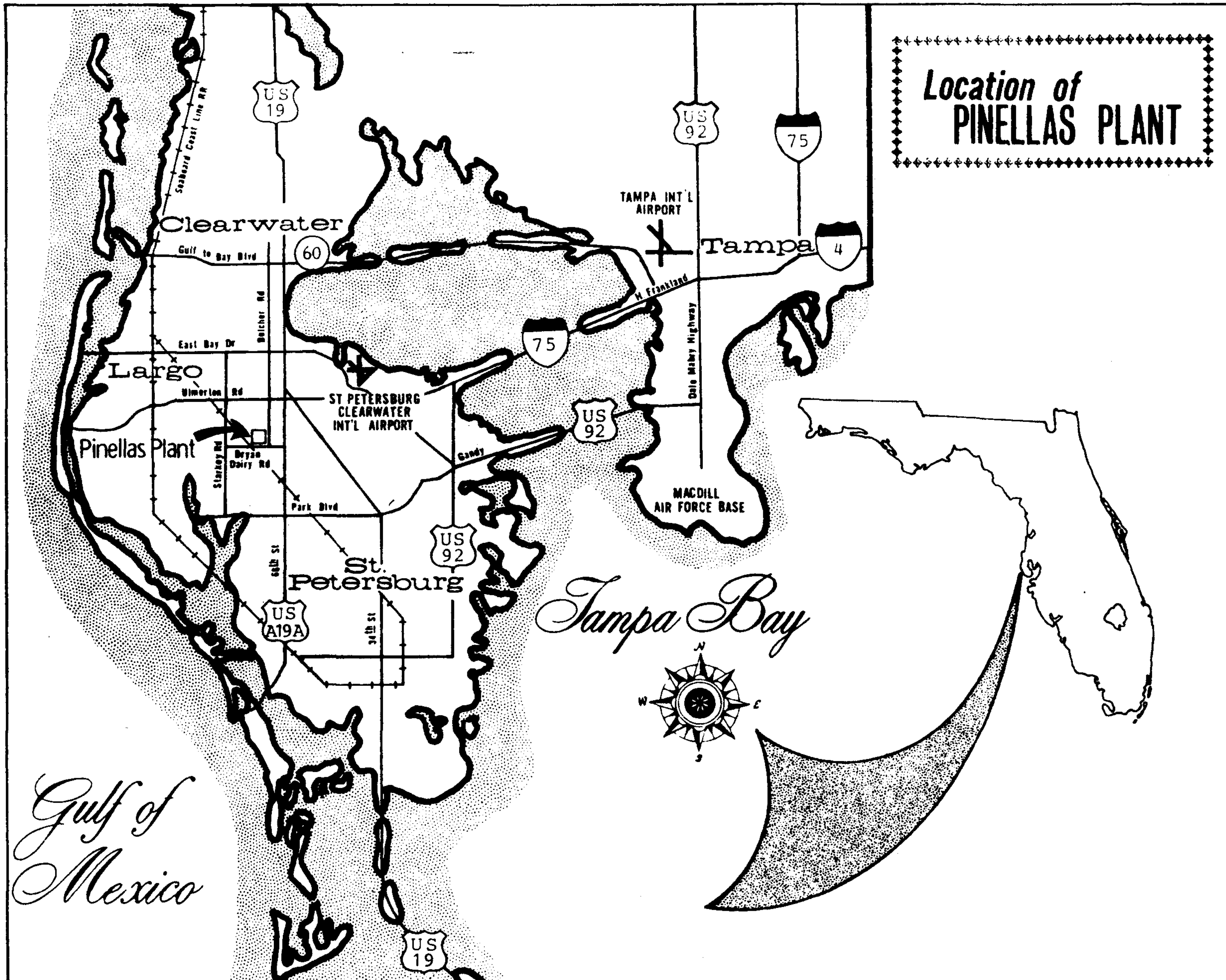
The Pinellas Plant, near St Petersburg, Florida, is wholly owned by the United States Government It is operated for the Department of Energy (DOE) by the General Electric Company s Neutron Devices Department (GEND)

This plant was built in 1956 in response to a need for the manufacture of neutron generators, a principal component in nuclear weapons The neutron generators built at the Pinellas Plant consist of a miniaturized linear ion accelerator assembled with the pulsed electrical power supplies required for its operation Production of these devices has necessitated the development of several specialized areas of competence and supporting facility The ion accelerator, or neutron tube, requires ultra clean, high vacuum technology hermetic seals between glass, ceramic, glass-ceramic, and metal materials plus high voltage generation and measurement technology The existence of these capabilities at the Pinellas Plant has led directly to the assignment of the lightning arrester connector, specialty capacitor, vacuum switch, and crystal resonator Active and reserve batteries and the radioisotopically-powered thermoelectric generator draw on the materials measurement and controls technologies which are required to ensure neutron generator life

Almost all Pinellas Plant products use ceramic materials in some form A product development and production capability in alumina ceramics, cermet (electrical) feedthroughs, and glass ceramics has become a specialty of the plant the laboratories monitor the materials and processes used by the plant s commercial suppliers of ferroelectric ceramics

In addition to the manufacturing facility, a production development capability is maintained at the Pinellas Plant During the history of this plant, GEND has worked closely with the Department of Energy's laboratories in converting their designs into production units The Pinellas Plant s product development laboratories are staffed with production experienced engineers and technicians capable of providing fast response to product change and evolution

The Pinellas Plant employs approximately 1900 people In addition, DOE's Pinellas Plant Area Office is located on the same site with a staff of about 25 people The plant, which is approximately 670,000 square feet in size, is located on 100 acres in central Pinellas County with easy access to highway and air transportation Further information concerning the Pinellas Plant s capabilities and expertise is given on the following pages

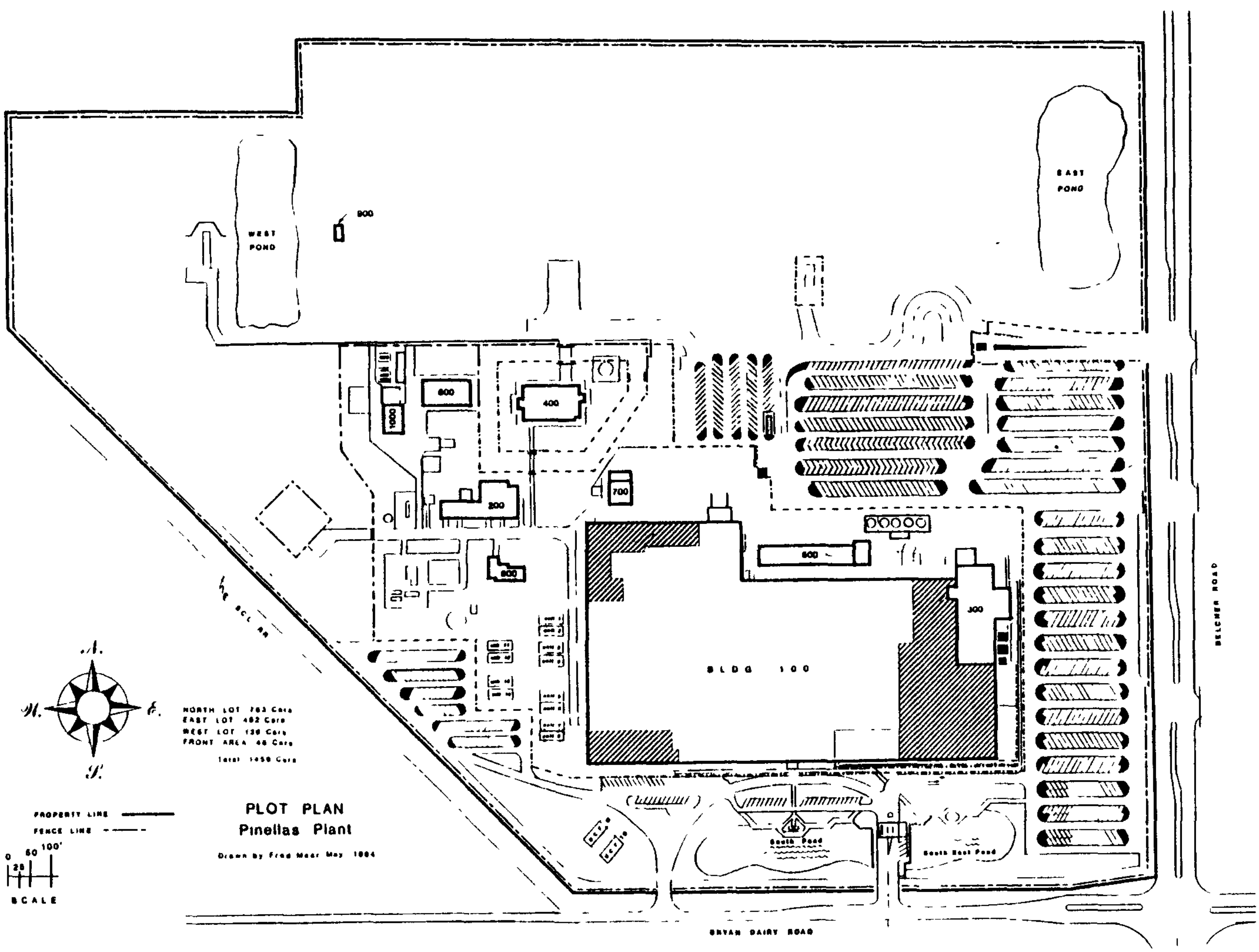

Location of
PINELLAS PLANT
Clearwater
Largo
Pinellas Plant
St. Petersburg
Tampa
Tampa Bay
Gulf of Mexico
TAMPA INT'L AIRPORT
ST PETERSBURG CLEARWATER INT'L AIRPORT
MACDILL AIR FORCE BASE
Gulf to Bay Blvd
East Bay Dr
Ulmerton Rd
Belcher Rd
Bryan Dairy Rd
Starkey Rd
Park Blvd
66th St
34th St
Gandy
Dale Mabry Highway
Seaboard Coast Line RR
US 19
US 92
US A19A
75
60
4
N
W
E
S

SITE DESCRIPTION

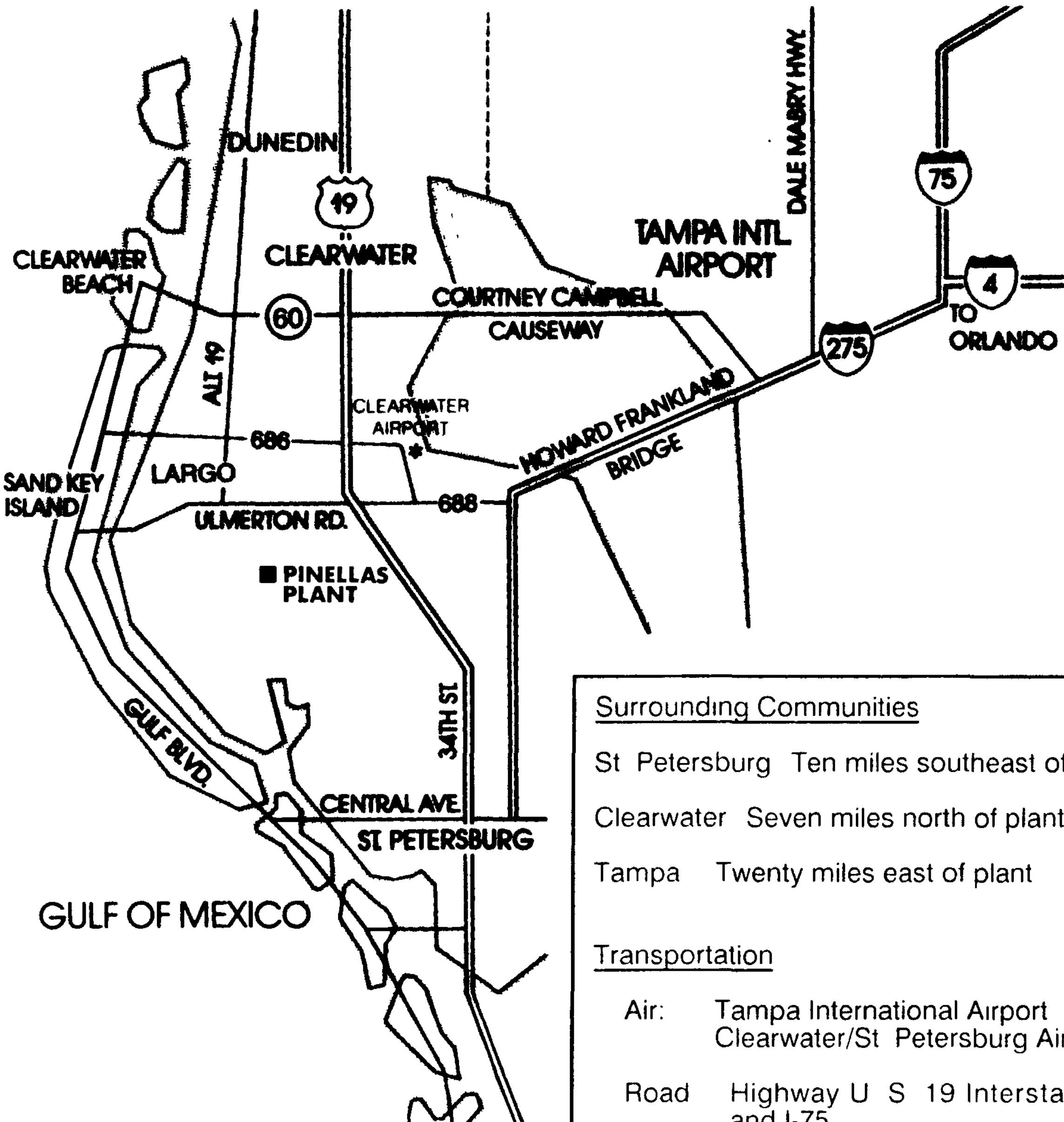
Pinellas Plant is located near the center of Pinellas County, Florida The county itself is a peninsula bordered on the west by the Gulf of Mexico and on the east and south by Tampa Bay Pinellas County has for a number of years been experiencing a rapid population growth and is currently the most densely populated county in the state The April 1986 population estimate was 816,015 Latest population estimates for the major cities are Clearwater, 97,882; Largo, 62,624; Pinellas Park, 40,720 and St Petersburg, 243,090

Some light industry and warehousing operations are conducted in the area immediately surrounding the site. The closest residential areas are approximately 0 4 kilometers (1/4 mile) from the plant

The plant is bordered on the east by Belcher Road (County Road 27), on the south by Bryan Diary Road (County Road 135), on the west by the Seaboard Coastline Railroad tracks, and on the north by light industry The size of the site is approximately 100 acres



Current Site Layout



Surrounding Communities

St Petersburg Ten miles southeast of plant

Clearwater Seven miles north of plant

Tampa Twenty miles east of plant

Transportation

Air: Tampa International Airport
Clearwater/St Petersburg Airport

Road Highway U S 19 Interstates I-4 and I-75

PINELLAS AREA OFFICE

The Pinellas Area Office was established in Florida in February 1958, following the Atomic Energy Commission s purchase of the Pinellas Plant from the General Electric Company at a cost of more than $4 million

With a staff of 25, the Area Manager (1) administers a contract with General Electric, (2) provides direction to the contractor, (3) inspects and accepts the products for the DOE, and (4) represents the Pinellas Plant in dealings with local, state, and federal agencies This requires a staff with knowledge of, or familiarity with, all products, processes, and assigned functions All staff members are involved in the review of contractor activities to assure compliance with governmental policy and DOE operational and contractual requirements Staff members also provide direction and assistance to the operating contractor in all functional areas

UNITED STATES DEPARTMENT OF ENERGY
PINELLAS AREA OFFICE

September 1986

OFFICE OF THE MANAGER

Area Manager	E. E. Patenaude
Secretary	E. G. Webb

ADMINISTRATIVE BRANCH

CHIEF	W. C. SHERARD
SECRETARY	VACANT
CONTRACT SPECIALIST	J. CAPONITI, JR
BUDGET ANALYST	J. S. O'KEEFE
CONTRACTOR INDUSTRIAL RELATIONS SPECIALIST	G. L. DIXON
PROCUREMENT ASSISTANT	F. M. HITE
MAIL & FILE CLERK	S. N. PAYNE
CO-OP TRAINEE	R. B. TENNANT
STAY-IN-SCHOOL	VACANT

OPERATIONS BRANCH

CHIEF	J. R. KIRBY
SECRETARY	M. A. CARNES
GENERAL ENGINEER	F. E. DAVIS
GENERAL ENGINEER	A. R. MULLICAN
CIVIL ENGINEER	K. P. BROOKS
ENGINEERING TECHNICIAN	T. P. LEARY
GENERAL ENGINEER (INTERN)	VACANT
GENERAL ENGINEER (INTERN)	C. A. WELCH

QUALITY & MANAGEMENT SUPPORT BRANCH*

CHIEF	H. O. WILLIS
SECRETARY	VACANT
QA ENGINEER	P. A. MULLICAN
QA ENGINEER	C. A. BROUSSARD
QA ENGINEER	T. D. COUNTS
QA SPECIALIST	T. J. DOWELL
QA SPECIALIST	F. J. MCNEELY
QA SPECIALIST	D. B. RYAN
OCCUPATIONAL HEALTH & SAFETY MANAGER	D. G. INGLE
SECURITY OFFICER	A. J. HEYSEL
SECURITY ASSISTANT	M. H. HALLISKY

*Reorganization approval pending

NEUTRON DEVICES DEPARTMENT

The Neutron Devices Department was formed within the General Electric Company in 1966 for the purpose of operating the Pinellas Plant under contract to the DOE This department was created to succeed the 908 section of the company s X-Ray Department which had participated with the Sandia National Laboratories (SNLA) and the GE Corporate Research Center in the original development of the neutron generator Originally under contract to Sandia National Laboratories (later under contract to the Atomic Energy Commission), GE built the Pinellas Plant and with 285 employees began the operation of the 160,000 ft^2 facility in January 1957

For about the first ten years of its operation, the plant produced only neutron generators to be used as external initiators for nuclear weapons In the succeeding years the plant has grown to a total size of 670,000 ft^2, employing approximately 1,900 people in the production of the products listed in this booklet

Functional
Organization Chart
September 1986

S. N. SUCIU
General Manager

General Electric Company
Neutron Devices Department
Largo, Florida

W. C. PIJAWKA — Manager-Engineering

- Product Engineering
- Neutron Generator Development
- Energy Devices Development
- Advanced Development
- Laboratory Operations
- Engineering Support & Development

D. L. PILINI — Manager-Finance

- Auditing & Contract Analysis
- Financial Planning
- Cost Accounting

S. L. MATHER — Manager-Manufacturing

- Manufacturing Planning & Control Operation
- Procurement & Distribution Operation
- Equipment Engineering Operation
- Quality Control Operation
- Shop Operation

S. L. MATHER (acting) — Manager-Programs

- Weapons Programs
- Electromagnetic Devices & Ceramics
- Frequency Components
- Power Sources
- Neutron Generation

D. W. SUPINA — Manager-Employee & Community Relations

- Organization & Staffing
- Communciations
- Hourly & Nonexempt Relations
- Professional Relations
- Medical Director
- Relations Programs

T. E. HILDICK — Manager-Computer Services

- Systems Planning & Development
- Data Processing Support
- Communications & Integration
- Computer Systems Support
- Advanced Computer Technology & CIM

J. S. CAVEN — Manager-Plant Services

- Plant Facilities
- Construction Projects
- Plant Security
- Environmental Health & Safety Programs
- Resources Planning

HEALTH AND SAFETY

Overall Safety Record

There have been no major accidental releases into the environment of radioactive substances which significantly exceeded radiation standards

The National Safety Council (NSC) publication, Work Injury and Illness Rates, includes a listing of the Best Records Known in Industry It shows the number of continuous hours worked without an occupational injury or illness involving days away from work or death in accordance with the Occupational Safety and Health Administration (OSHA) record keeping requirements The 1985 edition shows that for the Electronic Components Industry (Standard Industrial Classification, 3679) the record is held by the Pinellas Plant with 9,665,511 hours The Plant received the NSC Award of Honor for this record and has received numerous other awards from the National Safety Council and the Department of Energy for outstanding safety performance

Emergency Medical - On-Site

There is a two-bed dispensary with three nurses and a doctor on first shift, and one nurse on second shift Equipment includes x ray, defibrillators, and electrocardiogram (EKG) reading service Complete physicals can be given except for lab work, which is sent out

Fire Protection Systems

Approximately 99 5 percent of the Plant is protected by automatic wet-pipe sprinkler systems The systems are fed from the Plant s fire protection water system, which consists of two 1,500-gal/min diesel-driven pumps taking suction from a 400,000 gallon water tank, and a 1,000-gal/min electrically driven pump taking suction from a 150,000-gal tank Both tanks are reserved for fire protection use and have no connections to the domestic water system, except for fill lines If all pumps should fail, a connection between the fire protection water system and the county system would automatically open

The few unsprinklered areas have ionization type products of combustion detectors on National Fire Protection Association (NFPA) standard spacing or better Both the sprinkler systems and the smoke detection systems are connected to the continuously manned Security Patrol Office

Several Halon extinguishing systems protect high value and/or critical operation areas and equipment

Adequate extinguishers of the proper type are provided plant-wide In addition, hose reels with 150 ft of 1-1/2 in fire hose are located throughout the Plant

A trained fire brigade is also maintained on the Plant site

A written contract is provided for back-up firefighting assistance from the Seminole Fire Department

PRODUCTS

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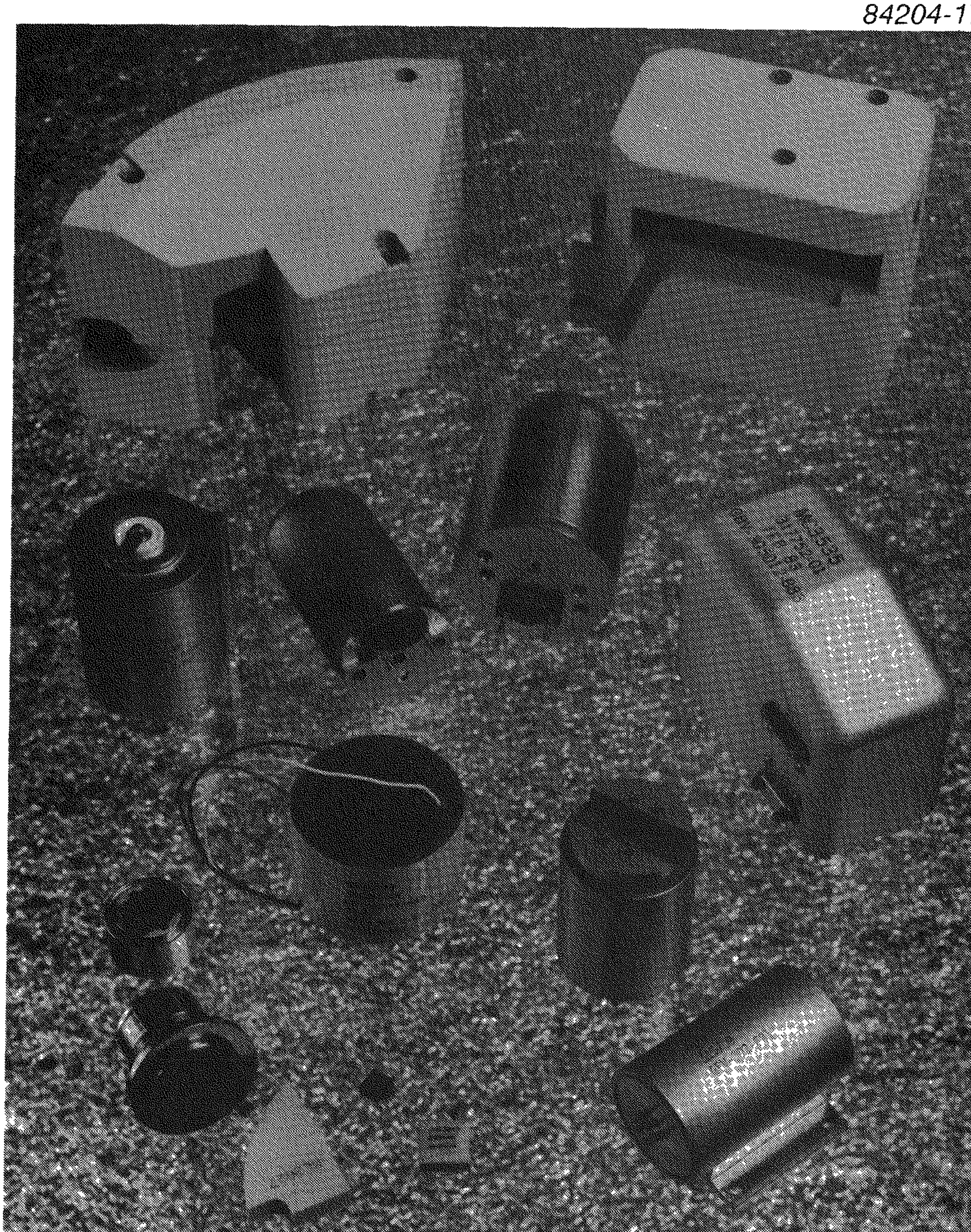

PRODUCT OVERVIEW

The products of the Pinellas Plant are:

Neutron Generators

A controlled source of neutrons used in the initiation of nuclear weapons and underground nuclear tests

Neutron Detectors

Miniaturized electronic detectors capable of recognizing preset levels of neutron flux

Vacuum Switch Tubes

Low energy electric arc activated, high vacuum switch designed to withstand high thermal and mechanical shock

Speciality Capacitors

Aluminum foil capacitors using Mylar* film and liquid dielectrics capable of high volumetric efficiency in energy storage In some designs the dielectric is modified to provide greater radiation resistance and connections specifically designed for minimum inductance

Thermal Batteries

A long inactive shelf life fused salt battery capable of being activated thermally to supply power in a time range of a few milliseconds to an hour

Electromagnetic Devices

A wide variety of components are used to perform functions such as pulse shaping, filtering, voltage and current conversion, current monitoring, and activation of mechanical devices

LAMB Batteries

LAMB is an acronym for "lithium ambient and refers to the lithium anode commercial cells purchased and acceptance tested by Pinellas for the DOE weapons complex

Radioisotopically-Powered Thermoelectric Generator

Long life producer of direct current power from a thermopile and radioisotopic heat source

*Trademark, E I du Pont de Nemours and Co , Inc

Frequency Control Devices

A quartz crystal in an ultraclean, high vacuum sealed ceramic package tuned to precise frequencies and capable of long time stable operation used in the production of clocks and oscillators

Resonant Accelerometers

The tension on a miniature crystal quartz tuning fork is varied in proportion to acceleration The resultant change in frequency is a measure of acceleration

Lightning Arrester Connectors

Electrical connector for weapons cables designed to short circuit lightning strike pulses to ground

Foam Support Pads

Components molded from syntactic foam materials having controllable mechanical crush characteristics used to support sensitive parts within the weapon

Product Testers

Electronic test assemblies designed and built at GEND, which are used by DOE for the acceptance of their products

Alumina Ceramics

These materials are formulated in house from the basic materials and fabricated into numerous shapes in both developmental and production quantities

Ferroelectric Ceramics

Used in explosively activated neutron generators, the production needs are purchased from commercial sources however, Pinellas maintains a development level capability in support of these suppliers

Cermet Feedthroughs

Alumina ceramic electrical feedthrough in which the electrical conductor is an integral part of the ceramic insulator

Glass Ceramics

A family of vitreous materials which can be cast into complex shapes and formulated so that they will seal to a wide variety of metals A subsequent heat treatment converts this material to a polycrystalline form, producing the strength and gas permeation characteristics of a ceramic

NEUTRON GENERATORS

The Pinellas Plant was constructed in 1956 for the sole purpose of producing neutron generators to be used as atomic weapon initiators. These components are designed by SNLA who have over the years both reduced their size and weight, and increased the useful life of this limited life component.

The main subassembly of the neutron generator is the neutron tube, which requires expertise in glass-to-metal and ceramic-to-metal seals, physical vapor deposition of metals, controlled metal hydriding, and advanced vacuum technology. Also, incorporated in the neutron generators are two styles of power supplies. They are composed either of discrete electronic components or ferroelectric ceramics which in operation will be depolarized by an explosively generated shock wave.

Electronic power supplies require high voltage and high current pulse-forming circuitry. They also require production proficiency in techniques and equipment for circuit board assembly and specialty coil winding. Electronic timers, pulse-forming networks and direct current-to-direct current transverters are typical of the circuits assembled in production. Ferroelectric ceramics are procured from commercial suppliers and assembled into generators using high voltage insulating resins.

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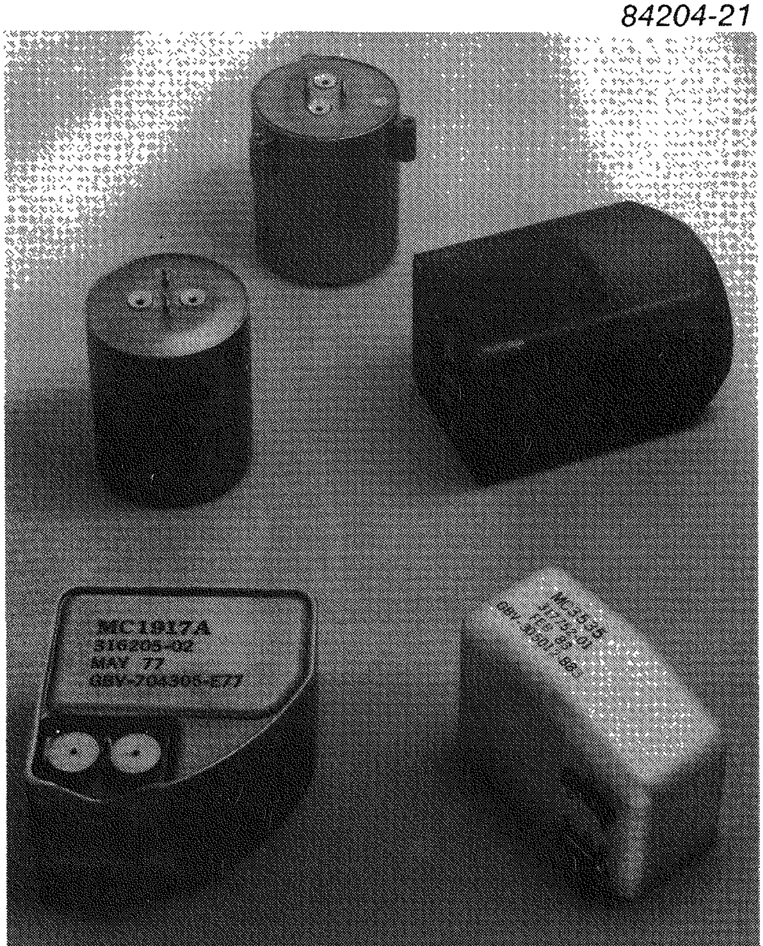
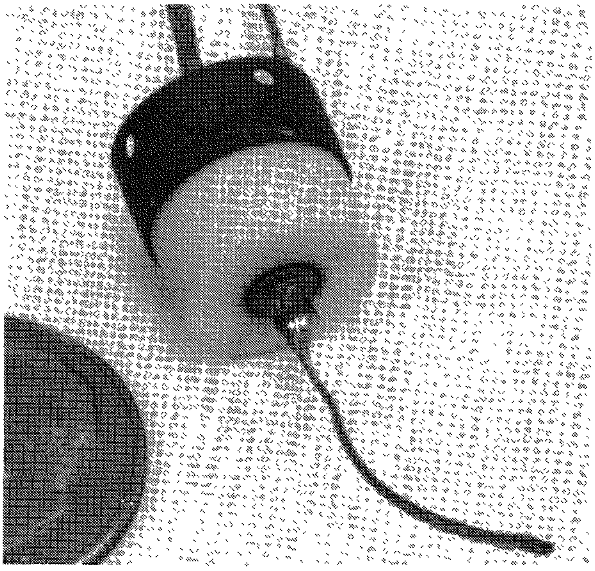


Typical Ferroelectric and Electronic Neutron Generator

VACUUM SWITCH TUBE

8364-4



The Pinellas Plant-produced switch tubes are high vacuum gaps capable of holding off 10,000 volts. This gap can be placed in a conducting condition by a small amount of energy into the trigger electrode. In a typical application, the tube conducts 200 amperes for about ten microseconds. Under these conditions, several thousand operations can be expected during product lifetime.

High Vacuum Switch Tube

NEUTRON DETECTORS

Neutron detectors are small electronic assemblies used in joint test assemblies to vertify the output of a neutron generator during an actual flight test.

In a joint test assembly, all fissile and explosive materials are removed from the weapon. A number of sensing and measuring devices (including the neutron detector) are installed in place of the assemblies removed. Later, the weapon is launched or dropped. During flight, all instrumented events are measured, recorded and transmitted via radio to a receiving site where the data are analyzed. Based on the information received, operation of the weapon can be verified without initiating a nuclear explosion

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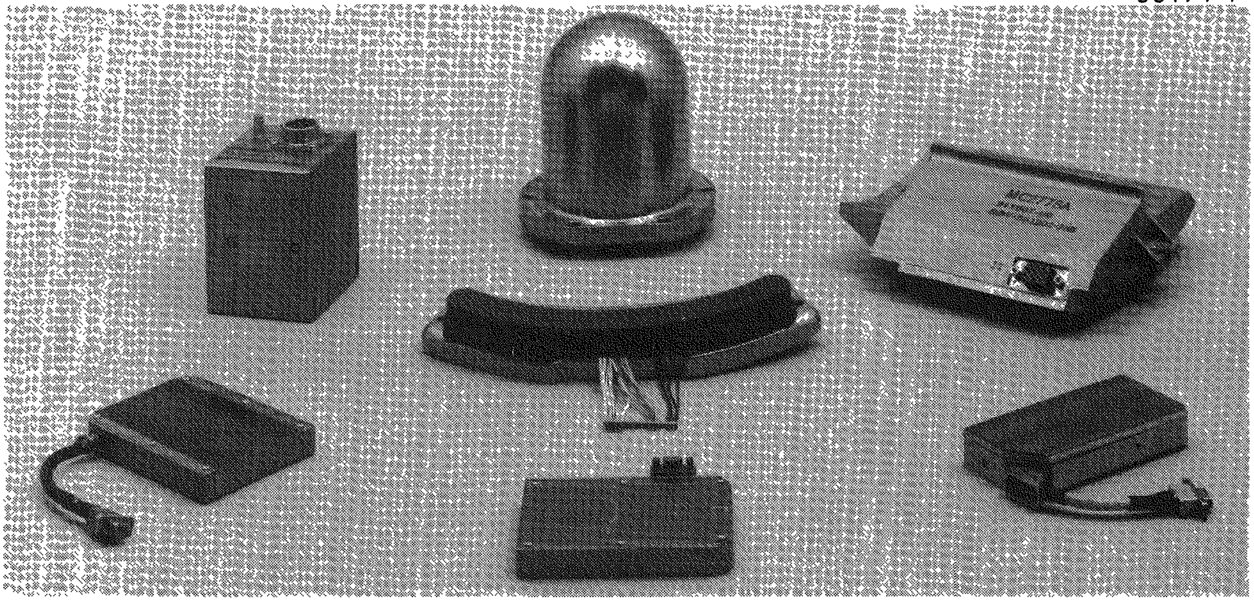

Typical Examples of Neutron Detectors

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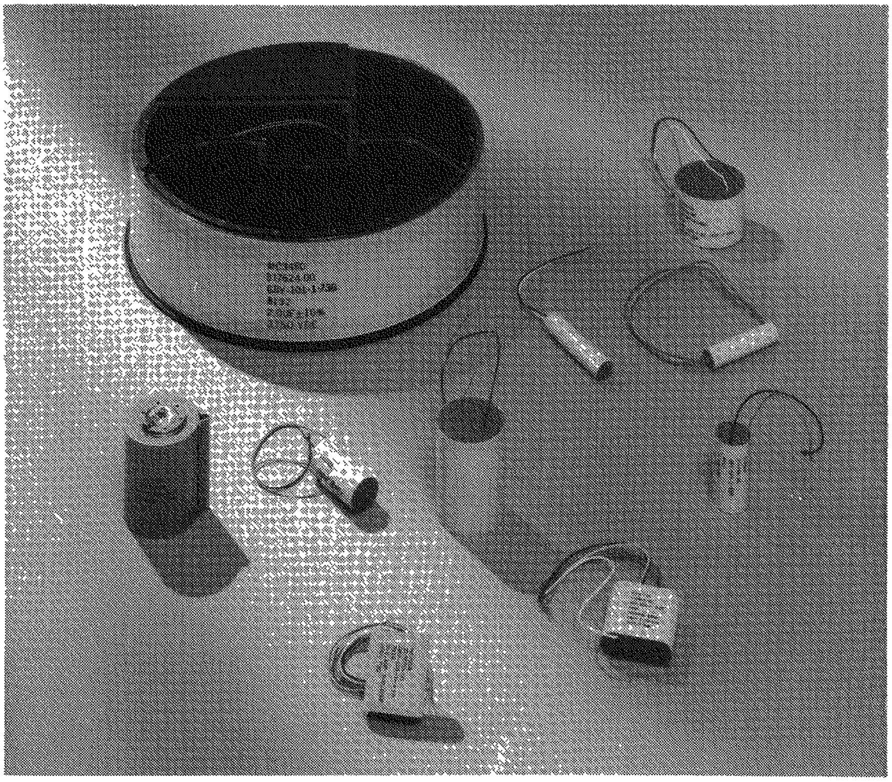

Typical Capacitor Designs

SPECIALITY CAPACITORS

Capacitors are used for the storage of electrical energy. More than a dozen designs are in production at the Pinellas Plant to serve the needs of the electronic neutron generator and weapons firing sets.

All designs can be placed in one of two general design categories called either "wrap and fill" or "liquid filled" capacitors. In both cases the basic capacitor element is produced by winding a roll of interleaved aluminum foils and Mylar films. The elimination of particulate contanimate through clean room technology increases product reliability.

In the "wrap and fill" design the aluminum-Mylar roll is sealed with a polymer resin and used in both neutron generator and firing set applications

For some firing set applications, the capacitor roll is hermetically sealed within a stainless steel enclosure, evacuated and dried, and then filled with Fluorinert* dielectric liquid This combination provides an energy storage density of more than four times that available with the conventional dry enclosure.

Treated Mylar films are available for use in designs which must resist the discharging effects of radiation.

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*Trademark, 3M Company

ELECTROMAGNETIC DEVICES

Electromagnetic devices are used to perform functions such as pulse shaping, filtering, voltage and current conversion, current monitoring, and activation of mechanical devices.

GEND has many years of experience in the design and production of high voltage pulse transformers and inductors for application in neutron generators, and in 1985 received the mission assignment for development and production of electromagnetic devices for other applications within the DOE Weapons Complex. By the end of 1987, GEND will be in full production on more than 100 different devices.

The list of products covers a wide range of operational parameters and construction methods. Operating voltages range from a few volts to hundreds of kilovolts. The physical configurations vary from the single layer solenoids of a few turns to very complex winding geometries on toroidal cores, ferrite pot cores, and laminated "C" cores of magnetic material. Programmable microprocessor controlled linear and torodial winding machines are used in the construction of the windings.

Most electromagnetic devices are encapsulated to provide mechanical stability in the use environment. A number of resin systems, both filled and unfilled are used to satisfy specific electrical, mechanical, and environmental requirements of the application. The encapsulation process is usually performed at low pressure to minimize voids.

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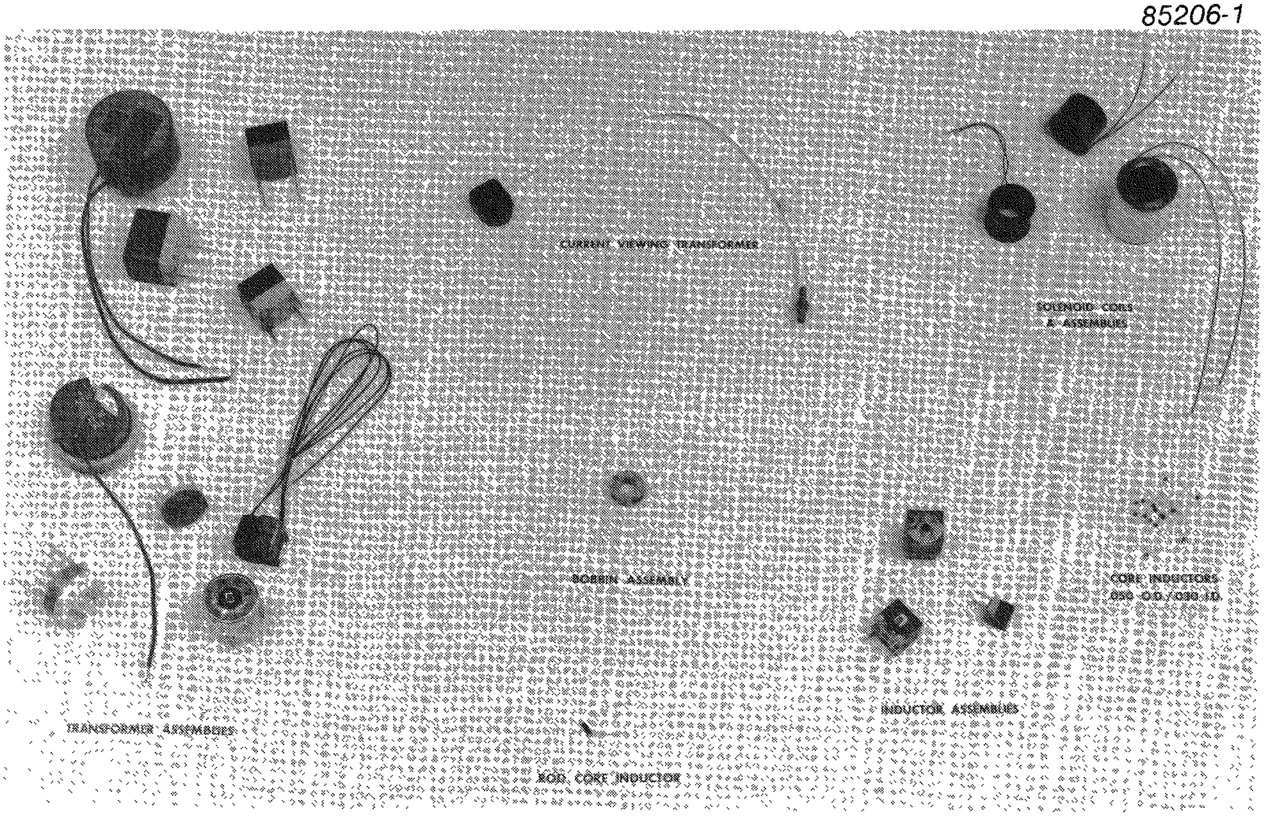

Typical Electromagnetic Components

THERMAL BATTERIES

A thermal battery is a group of primary electrical cells in which the electrolyte is solid (frozen) at room temperature. In this state the battery is inactive, it produces no power; however, in this condition it has a very long nondeteriorating shelf life. This characteristic makes the thermal battery ideally suited to maintenance-free weapons application.

The battery is activated, whether electrically or mechanically, by the ignition of an exothermic reaction between iron powder and potassium perchlorate. These materials are pressed together to provide heat sources in wafer form which are then used as integral parts of the cell construction.

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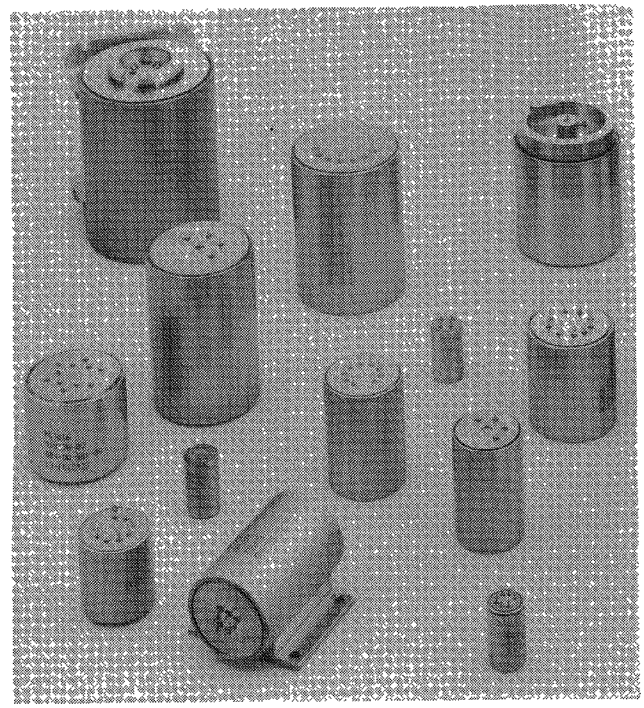
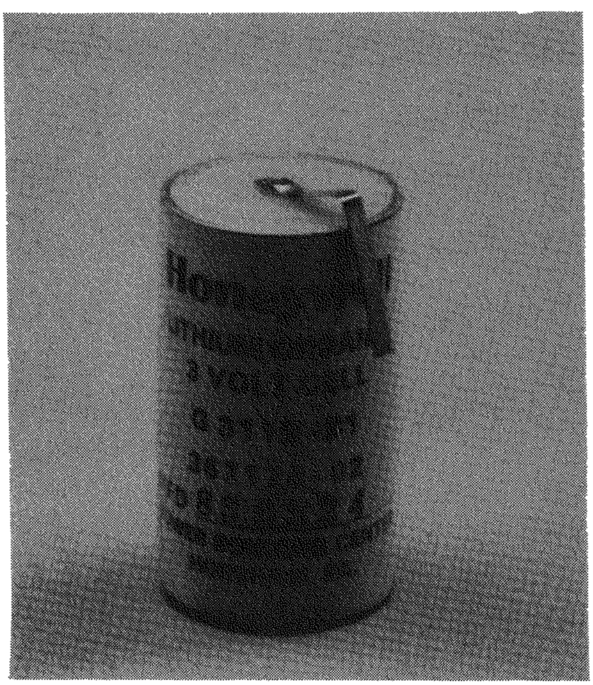


Thermal Batteries

LAMB BATTERIES

In addition to thermally activated batteries, Pinellas supports SNLA in their work on long life ambient cells. Since the bulk of this present effort uses lithium in an ambient temperature operation, the acronym LAMB has been coined. At this time, LAMB cells are procured from two commercial sources, acceptance tested and built into battery assemblies by Pinellas. A long term goal is the development of a cell with sufficiently long life to perform in place of the RTG.



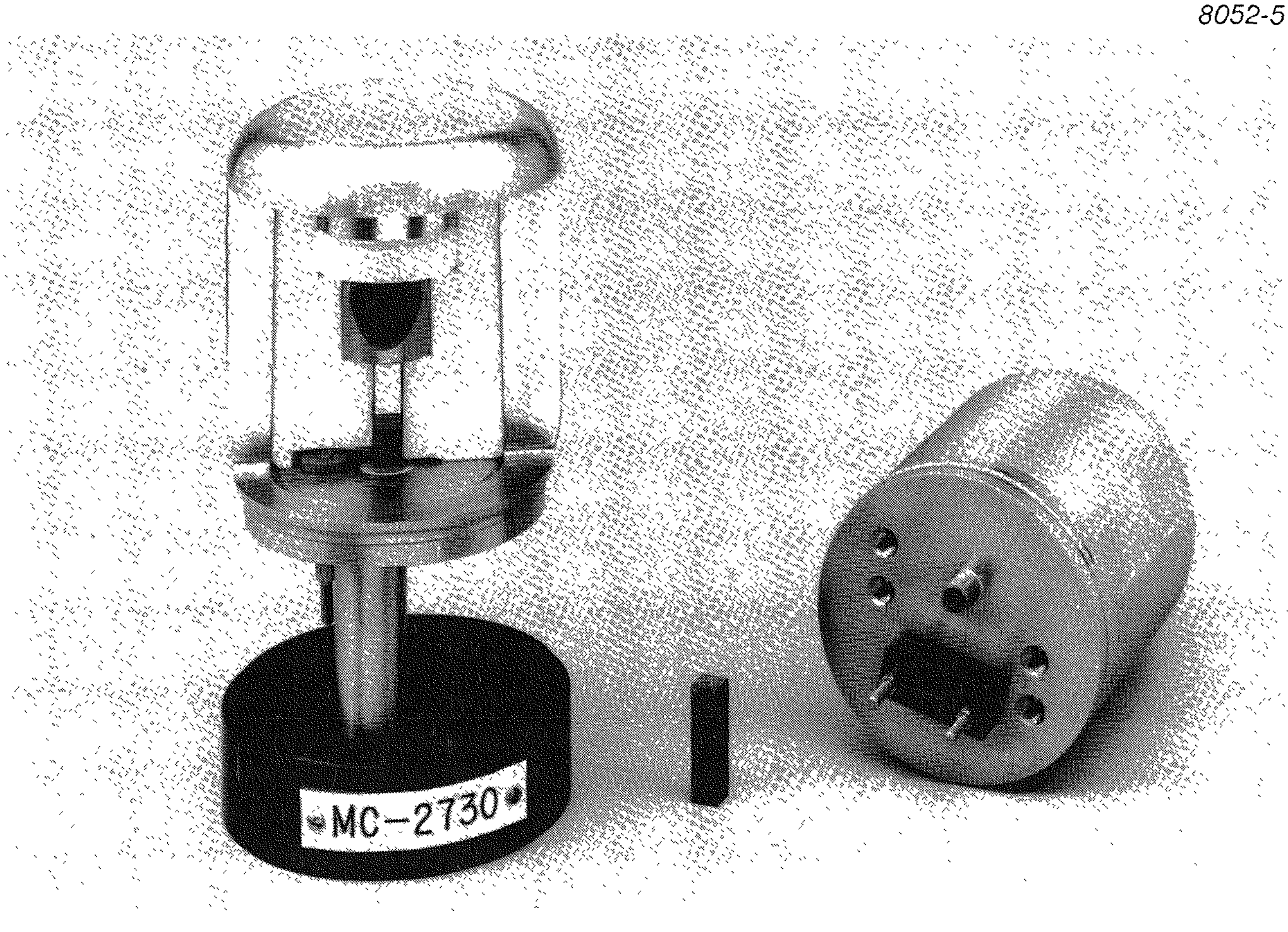
Lithium Anode Cell

RADIOISOTOPICALLY-POWERED THERMOELECTRIC GENERATOR

The need for a long-term source of electrical energy led SNLA to the development of the radioisotopically-powered thermoelectric generator (RTG). The device consists of a plutonium-238 oxide heat source (about five watts thermal) which is converted by thermoelectric effect to electrical energy. The present design produces 25 milliwatts of electrical power at two volts for longer than 25 years.

The radioactive heat source is produced by Los Alamos National Scientific Laboratories (LANL) while the thermal-to-electric energy converter is produced entirely within the Pinellas Plant. Elemental silicon and germanium are combined to form semiconductor materials These semiconductors are prepared in two forms having either predominantly electron or hole charge carriers. Using fused glass, wafers of these two materials are assembled into a thermopile; a group of thermocouples, electrically in series and thermally in parallel. This product requires vacuum metal casting, powdering and sintering technologies. Tungsten sputtering and photolithography techniques are used for the configuration of electrical connections.

8052-5



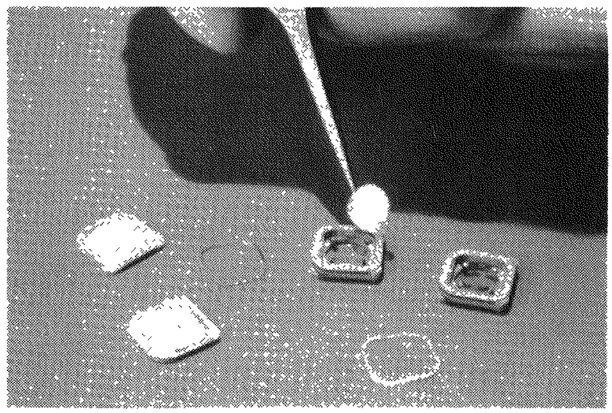
Left to Right: Cutaway RTG Assembly, Thermopile, Bottom View of RTG Assembly

FREQUENCY CONTROL DEVICES

For more than 50 years, quartz crystal resonators have been used for frequency control purposes. Within the weapons production complex, there is a growing need for precision tuned frequency and time standards that have long-term stability and resistance to the negative effects of mechanical shock. These requirements have produced a new emphasis on crystal cleanliness and gas impermeable envelopes to enclose them.

The U. S. Army Electronic Research and Development Command (ERADCOM), sponsored at SNLA the development of a ceramic crystal enclosure which maintains the crystal in the required clean environment. Because of the existence of high vacuum, cleanliness control, and ceramic production equipment, the Pinellas Plant was assigned the responsibility of developing a quartz crystal fabrication facility to manufacture these devices.

The crystal resonator consists of a quartz wafer that has been cut, ground, etched, and gold plate electroded to a specified frequency. This crystal is mounted in an alumina ceramic enclosure which is sealed by a gold diffusion bonding process. The final stages of processing, which include cleaning by ultraviolet radiation, gold plating to frequency (in two steps), and the sealing of the enclosure, are accomplished in an unbroken vacuum atmosphere. These processes occur in an all metal vacuum system maintained in pressure no greater than 1×10^{-8} Torr.



Components of the Crystal Resonator

Two models are offered. A 5- to 10-MHz unit for use as an ultrastable reference enclosed in a ceramic package 20 mm^2 by 4 mm thick, and a high shock resistant model 10 mm^2 by 3 mm thick in a 15- to 25-MHz range of frequencies. High frequencies are obtained by operating the crystal in an overtone mode.

Crystal resonators and clock oscillators are now being produced at the Pinellas Plant for various weapon applications.

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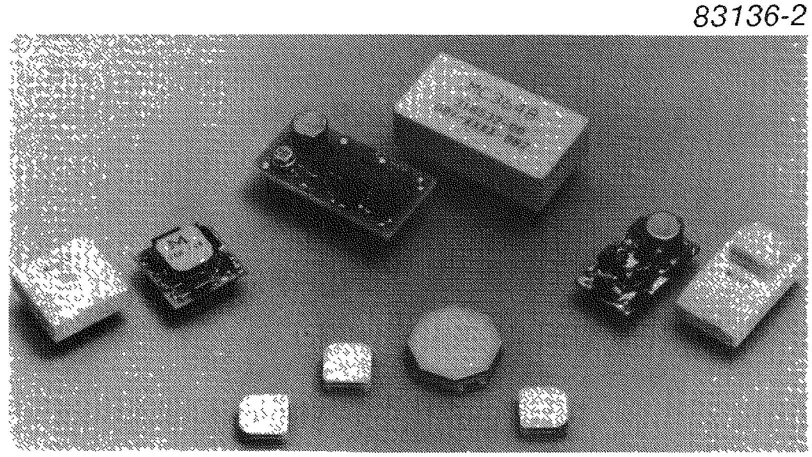

Typical Crystal Resonators and Oscillator/Clock Assemblies

RESONANT ACCELEROMETER

Mechanical stresses produced by acceleration can cause a change in the frequency at which a quartz crystal resonates. Since the measurement of acceleration is extremely important to guidance and control of a weapon or any moving device, Sandia engineers have designed a small resonant quartz device in which acceleration forces will produce a change in output frequency proportional to acceleration.

The resonant accelerometer is a cantilevered beam, rigidly mounted at one end and supporting a small mass on its other. Acceleration produces a corresponding force on the mass, bending the beam. The elements of the beam are composed of two double tuning forks etched from quartz. Proper electroding provides a means for exciting the forks to resonance through the piezoelectric effect.

The beam is positioned so that when it is bent, one set of tuning forks is in tension and the other is in compression. This effect, which is a direct function of acceleration, produces a reduction in the frequency of the forks in compression and an increase in the frequency of the set in tension. The difference in these frequencies is a sensitive measure of acceleration.

The forks resonate at about 70 kHz, and in the present designs one G acceleration produces a frequency difference of about one Hertz. During a change of temperature, both forks are similarly affected and no frequency difference results.

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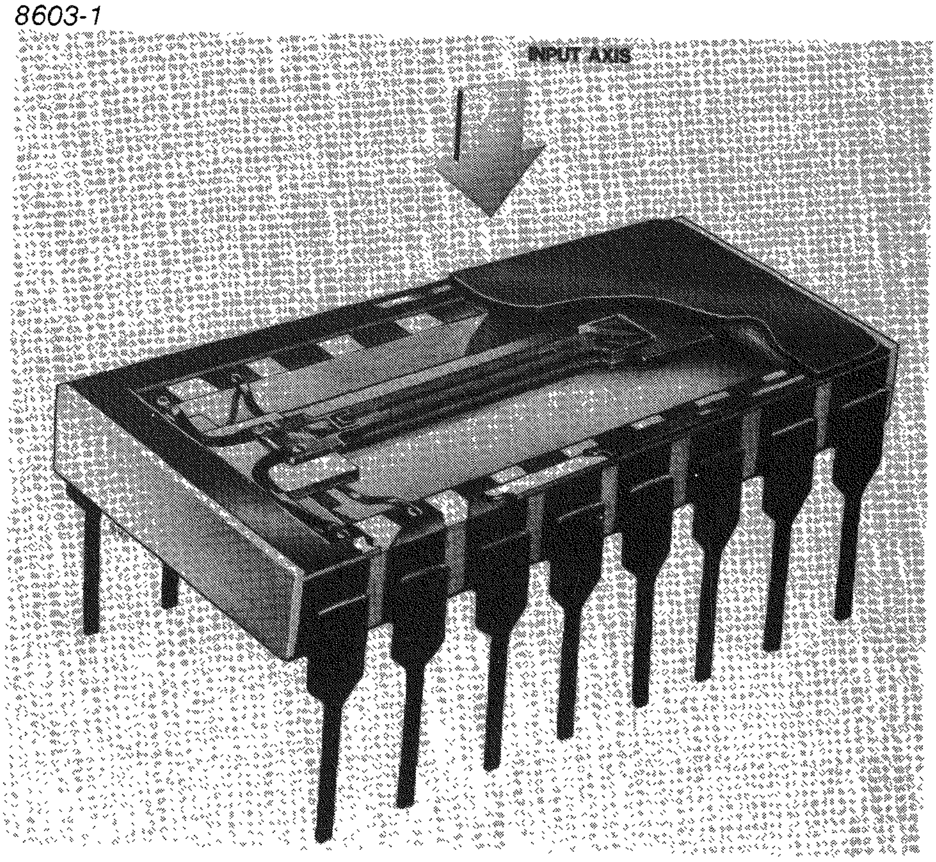

Crystal Resonator Accelerometer

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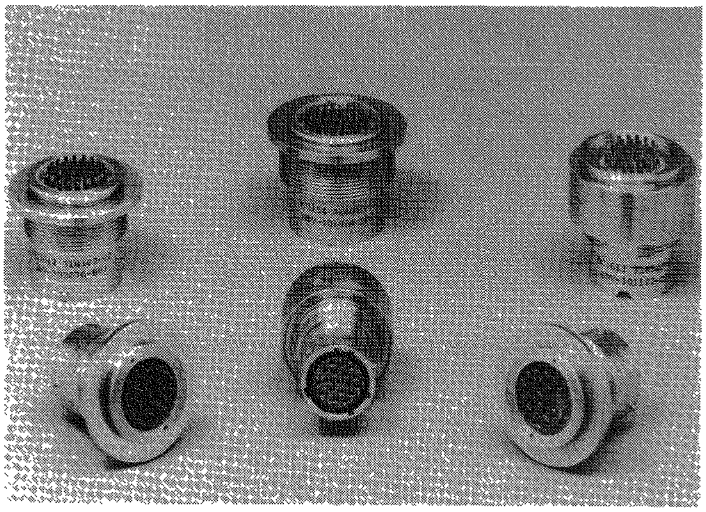
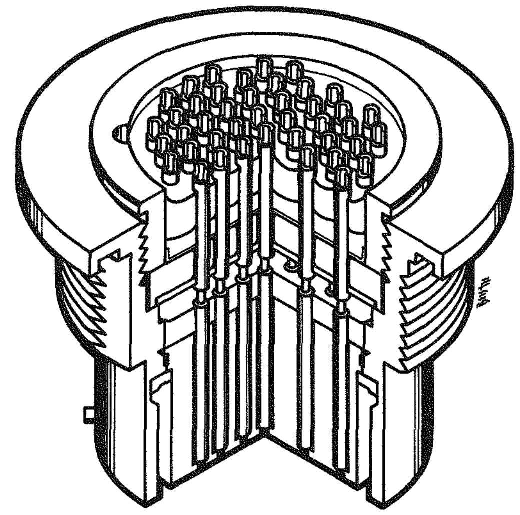


Typical Lightning Arrester Connectors



Cutaway Drawing of Typical LAC

LIGHTNING ARRESTER CONNECTOR

Cables between the various electrical components of a nuclear weapon are terminated in a variety of connectors. One such termination is called the lightning arrester connector. It is the purpose of the LAC to protect the weapon against accidental detonation in the event of a lightning strike.

Each conductor in the LAC is provided with protection against voltage surge by passing it through a hole in a heavy metal plate within the connector. The plate is held at ground potential and the conductors are separated from that plate by well packed granules of rutile (titanium oxide) or varistor material.

This construction allows a selection of surge control voltages ranging between 900 and 1500 volts.

There are more than 15 models of LAC in production. Primary differences between designs concern the number of conductors in each; however, there are also differences in maximum surge voltages and in operating characteristics. Rutile granule LACs are used in applications where highest resistance to ground is needed during normal operation. When varistor granules are used in place of the rutile, there is minor current leakage at all voltages but lower surge voltage limits can be enforced.

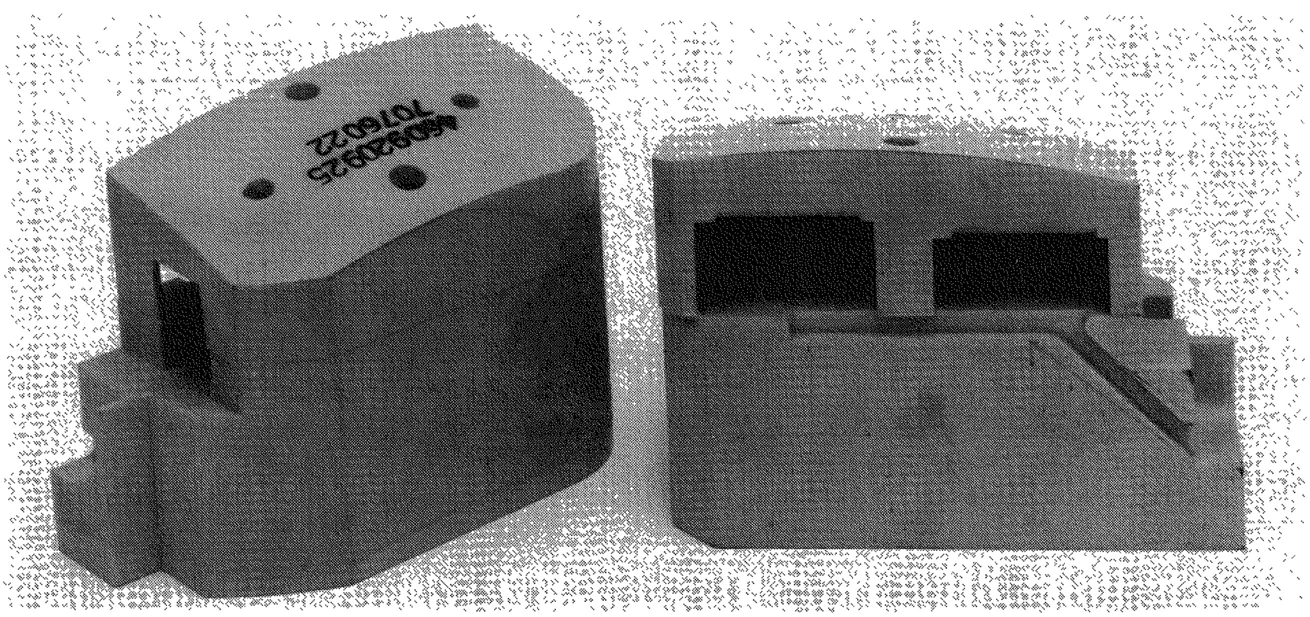
MECHANICAL CERAMICS

A formulation and machining facility is dedicated to the fabrication and inspection of 94 percent alumina ceramics, cermet feedthroughs, and glass ceramic parts and materials. Parts are produced in both developmental and production lot sizes. Generally, Pinellas parts are small, from several to many pieces in a handfull. The capability exists for parts of these sizes to be molded, machined, metallized and inspected.

FERROELECTRIC CERAMICS

primarily composed of the oxides of lead, zirconium and titanium, ferroelectric ceramics are used at Pinellas to power neutron generators. Production quantities of these materials are purchased to SNLA specifications from commercial sources. Pinellas Plant maintains the laboratory capability to characterize materials at all stages of production. This is done for the two-fold purpose of assisting the suppliers in solving problems and for product acceptance in plant.

8364-3

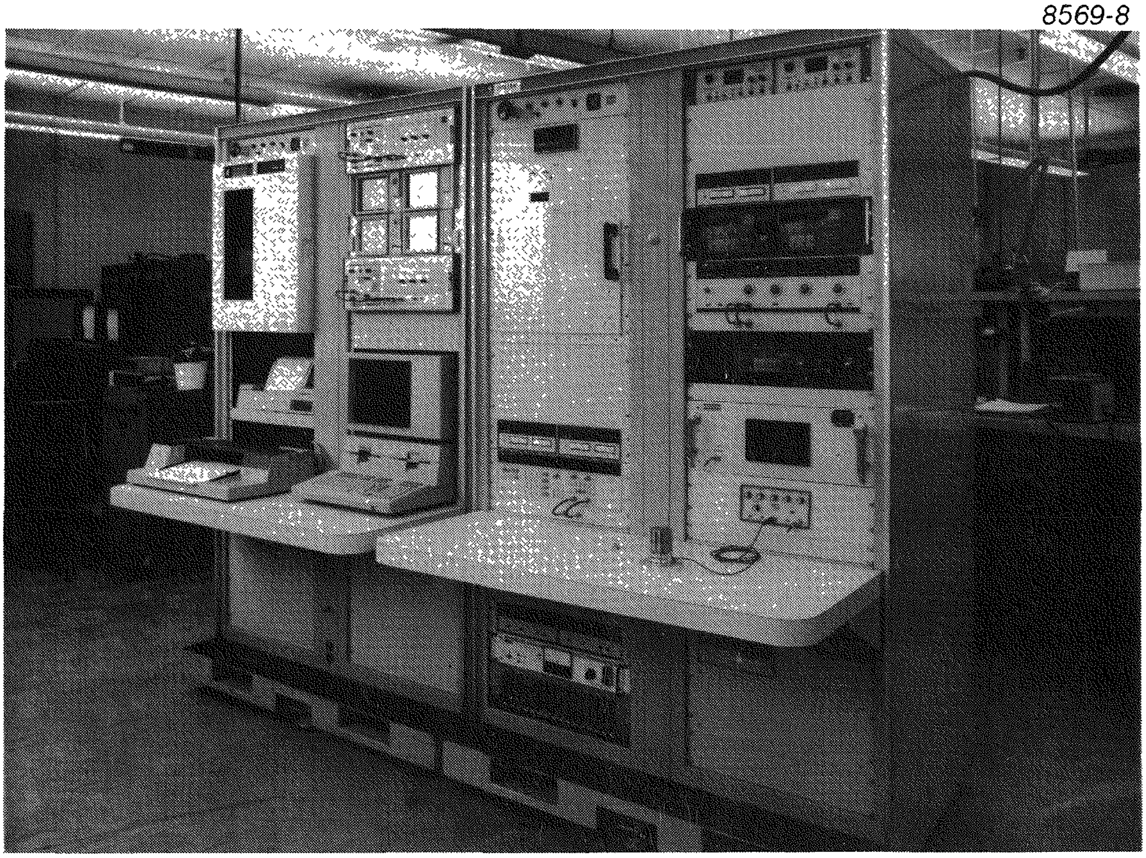


Foam Support Pads

FOAM SUPPORT PADS

Foam support pads are used to protect weapon components within the weapon assembly. Support pads are made from syntactic foam utilizing a urethane elastomer and in present designs are molded into the two separate sections that surround the component. The pads are designed by LANL, and are produced in the Pinellas Plant's resin casting-encapsulation area.

8569-8



Specialized Test Equipment Designed and Built in Pinellas Plant

TEST EQUIPMENT

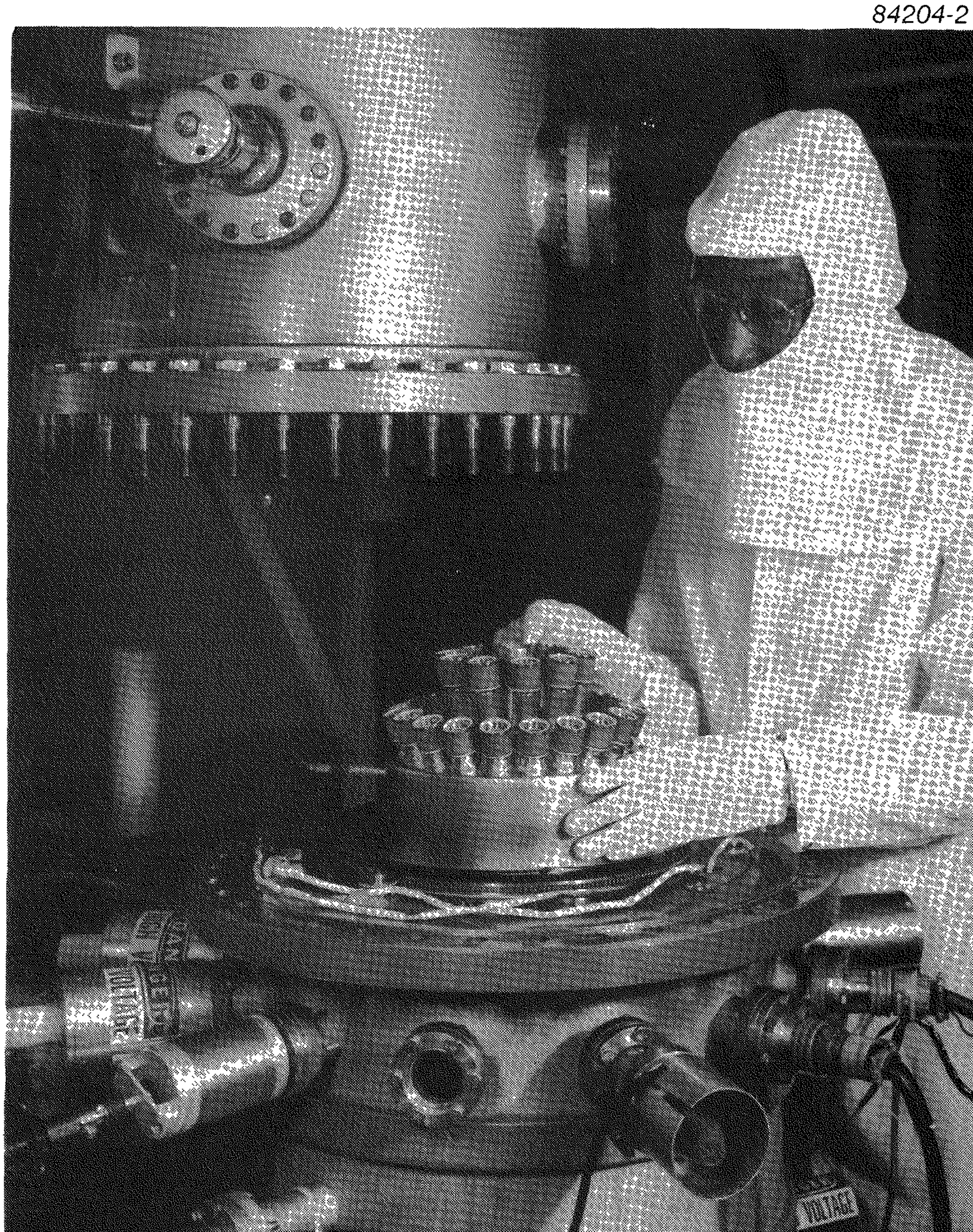
Pinellas Plant maintains an internal Equipment Engineering Organization under Manufacturing. This organization is responsible for the development, design, documentation, and fabrication/purchase of equipment required for product manufacturing processes as well as quality assurance testing. A high level of technical expertise is maintained within the organization to meet equipment provision need. These areas cover: instrumentation control computer interfacing technology. Computers involved are the Hewlett Packard Series 200 and 80 DEC's PDP-11, Perkin-Elmer Interdata.

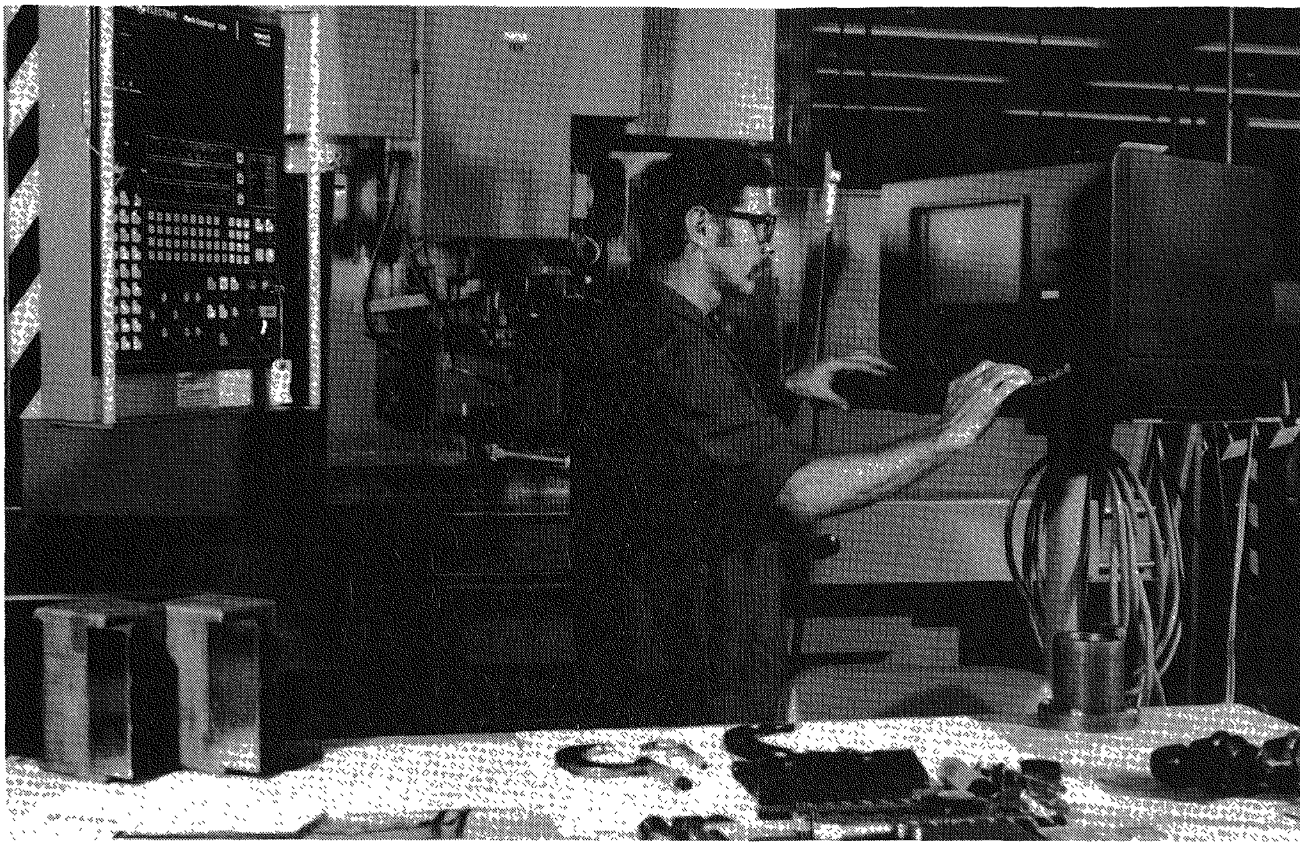
The Equipment Calibration and Maintenance group has the trained staff, equipment, facilities and reference Standards Laboratory necessary to provide calibration and repair support for the most demanding quality assurance program. Routine service is provided on many systems including: high vacuum (10^{-10} Torr) pumps, control measurement and data systems; laser systems from low to medium power; computer and data equipment from micro to large scale; numerical control and distributive numerical control systems, robotics from small to medium size; environmental tests (electrical and physical); precision neutron test and measurement.

The Standards Laboratory (electrical, physical and dimensional) provides standards and measurement control fully traceable to the National Bureau of Standards.

PROCESSES

84204-2





A Machining Facility on the Distributed Numerical Control System

COMPUTER INTEGRATED MANUFACTURING

A Hewlett-Packard HP3000-64 computer is the heart of a Material Requirements Planning System which plans and coordinates the total manufacturing process from the initial ordering of raw materials, through the production phase, to the finished product ready for shipment.

Two Calma Engineering Support interactive graphics systems (IGS) with Data General S-140 Eclipse CPUs are used to support the design/drafting of product, tooling, and test equipment. A similar system is used by Plant Facilities for space planning. Paper and magnetic tape systems, formerly used to control numerical control (NC) machine centers, have been replaced by a Distributed Numerical Control System which utilizes a Digital Equipment Corporation (DEC) Vax 11/750 computer to download data to intelligent factory terminals.

The Shop Floor Control System uses an HP3000-64 computer to plan, monitor, and control the production of specific products on the shop floor.

A DEC Vax 11/780 supports the Quality Control data system by maintaining six months of product test data on-line for IGS access by design engineers at a remote location via leased 56-Kbps lines.

MACHINE SHOP CAPABILITIES

The Parts Manufacturing Unit has the capability of producing a wide variety of metal and ceramic piece parts from a large range of materials This capability includes the blanking of flat parts of various configurations, forming of these sheet metal blanks into cups, tubes or other configurations, and a machining capability which ranges from pins and value stems, to larger machined devices This capability includes small lot sizes produced on manual equipment by skilled machinists to large quantity runs produced on semiautomatic, or NC machine tools Standard machining standards are ± 0 002, however, with the use of NC machines, grinding, and reaming, tolerance control within ± 0 0005 may be achieved

MACHINE SHIP EQUIPMENT CAPABILITY

	Maximum Size Capability	Tolerance Control Capability
Metal Working		
Blanking	22-in diam (200 ton)	± 0 002
Forming	up to 22-in. blank	± 0 005
Hydroforming	2-in diam by 3-3/4-in length	± 0 001 i d
NC Lathes	12-in diam chucked 4-1/2-in bar	
	22-in diam adapter	± 0 001
NC Mills/Drills	20-in by 40-in	± 0.0005 position
Screw Machines	7/8 diam bar	± 0 001
Manual Lathes	1-in diam bar	
	4-in chucked	± 0 002
Centerless Grinding	1-in diam bar	± 0 0005
Manual Milling	12- by 30-in table	± 0 002
Ceramics		
Isostatic Pressing	6-in diam by 12-in length	--(logs)
Dry Pressing	1-1/4-in by 1/2-in length	1 of diam
Manual Machining	within press capability	± 0 002
Grinding	within press capability	± 0 0005

ROBOTICS AUTOMATION

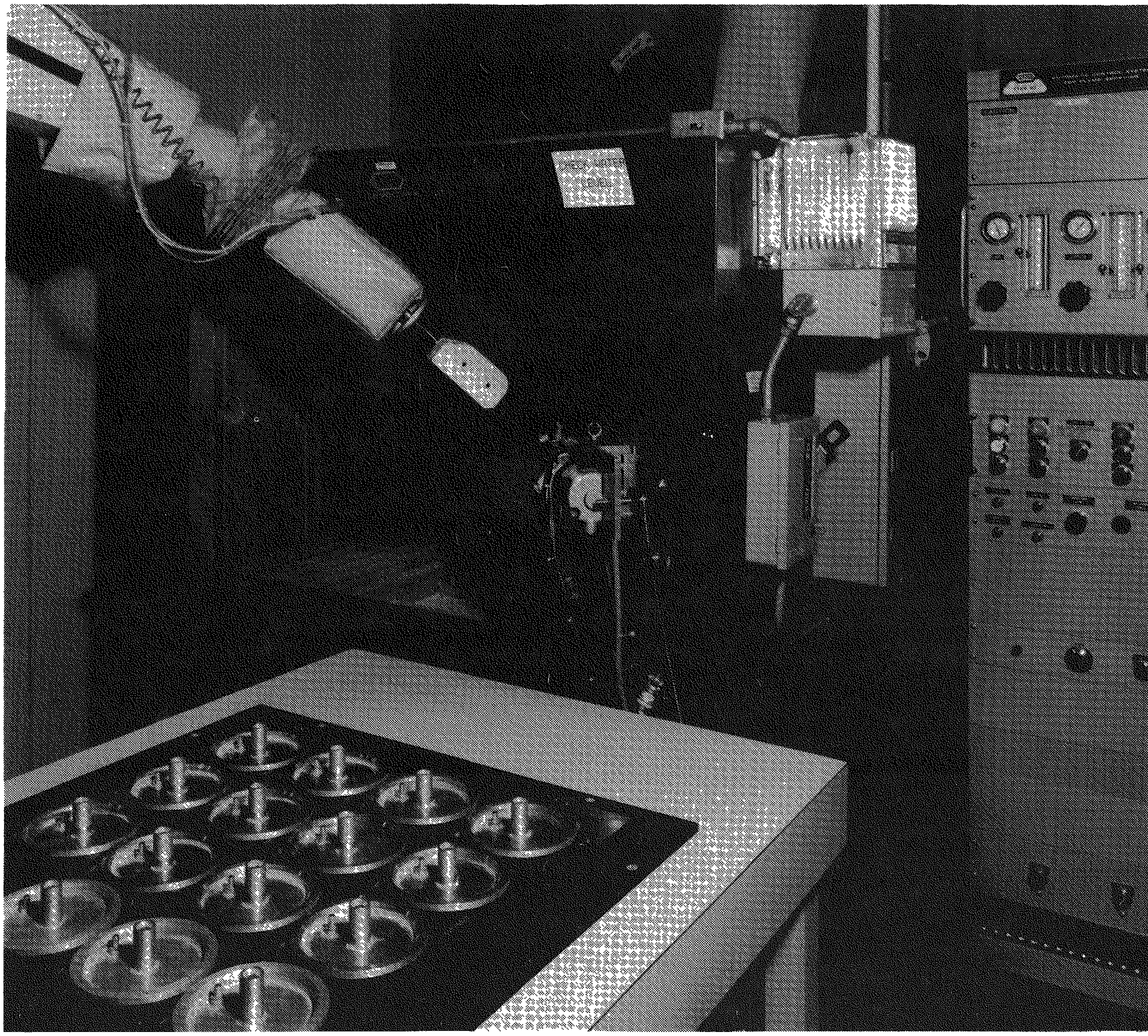
Robot technology is a key computer integrated manufacturing (CIM) element, encompassing both information flow and product flow implementations, for automation of the manufacturing operations at GEND Robots are an example of flexible, reprogrammable automation which is more cost effective than hard automation for small batch size manufacturing

GEND s first robot was purchased in 1981, installed in the Purezone Clean Room in December 1981 and released to production for routine daily use in February 1982 A Robot Development Laboratory was established in October 1981 to stage robot implementations during application development activities and to house experimental robots which are used for demonstrations, training, gripper and sensor development, programming, and to assist in determining the feasibility of proposed robot applications Robotics activity is integrated with the CIM program The Factory Automation effort has expanded the planned use of this technology

Examples of robots in daily production include

- Two Puma 250 series robots perform particle removal cleaning of neutron generator tube parts in a Class 100 clean room,
- A Puma 560 series robot mechanizes an industrial X-ray facility for safety, improved consistency of measurement and increased production,
- A Puma 560 inspects printed circuit boards,
- A Cincinnati Milacron T3-726 robot mechanizes vapor honing processes resulting in greatly increased consistency of product,
- A Puma 700 series robot performs vapor spray metallize coating of product assemblies,
- Microbot Alpha robots produce powdered metallurgy pellets needed in relatively high volume quantities for thermal battery production,
- General Electric P50 process robot with alpha-numeric recognition ability labels, counts and acceptance tests purchased components

84204-10



A Puma 700 Series robot vapor spray metallizes a foam support pad.

MATERIALS JOINING - WELDING, BRAZING AND SOLDERING

The Pinellas Plant has materials joining capabilities ranging from cold welding (welding with pressure only, no heat) to laser welding (welding with energy beams of 10^6-W/cm^2 power densities) Within this wide heat range are materials joining processes used in the fabrication of the various products manufactured at the Pinellas Plant

Solid state welding processes such as cold welding and ultrasonic welding are used in applications where little or no heat can be used on the part or when dissimilar metals must be joined Cold welding is used in sealing electronic tubes while ultrasonic welding is used in sealing capacitors

Thermocompression bonding of gold surfaced parts is used to seal the covers on the ceramic flat packs which contain precision quartz resonators As many as twenty five sets of flatpacks are sealed in one operation Each set of parts includes a frame and two covers (94 percent alumina ceramic), making a package approximately 0 4-in^2 by 0 1-in thick A similar package, approximately 0 75-in^2 by 0 1-in thick is sealed using the same basic process

The covers and flatpacks are prepared by gold plating (0 999 pure) the contact area After firing and ultraviolet cleaning, a gold gasket is used to bond the two plating surfaces

The sealing is accomplished in a chamber having a vacuum of 5×10^{-7} Torr or less and at a temperature of 300 ± 20°C A hydraulic ram applies 350 to 360 lb/in^2 (a higher pressure is used for the larger assembly) to the stack of parts resulting in final seal

The resonators are 100 percent leak checked by Radiflo* against a specification of leak rate not to exceed 1×10^{-9} std cm^3/s

Resistance welding, using either direct or alternating current, is the most common welding process in production It is used in all product lines as a tacking operation prior to permanently brazing or welding parts together, or as a final joint between components

The most common resistance equipment used at the Pinellas Plant is the direct current capacitive discharge type It is capable of welding almost all our products except for very thick or very thin parts Large components up to 1/4 in thick are ac resistance welded The thin parts, which may be only a few thousandths of an inch thick, are parallel gap direct current welded In addition, parallel gap welding is used in reflow soldering as well as brazing of thin gold plated parts

Arc welding plays an important part in most fabrication sequences, as gas tungsten arc welding and plasma arc welding are key contributors to successful materials joining Gas tungsten arc welding with steady level alternating and direct current has been used with excellent results for many years

Today s designs trend to components either with critical heat resistance tolerances, or with precision joints that require an overall low heat input

*Trademark, Iso Vac Engineering

To solve these problems, several pulsed gas tungsten arc welding and microplasma arc welding units that are capable of producing extremely fine welds are in use. In addition, these welders are computer controlled and coupled with the movable part holding fixtures to provide precise coordination between welding current and travel speed These pulsed gas tungsten arc welding and microplasma welding machines represent the latest in state of the art technology in arc welding.

The Pinellas Plant has acquired state of the art technology in high energy welding processes. Electron beam (EB) welding has been in use for many years, but is still a very advanced welding tool. A further refinement is electron beam welding stations that are kept busy producing a variety of critical welds in many components. Also the plant has five laser welding stations with others planned in the near future. These welders are capable of producing small, precise welds in devices where these welds are near heat sensitive components. As these laser welding stations have computer control of the workpiece movement and the laser energy, they have high production rates without required skilled operators.

8364-7

Laser welder operator loads a component into the fixture in preparation for welding.

CERAMIC PARTS AND MATERIALS PRODUCTION

Pinellas purchases most ceramic parts for war reserve (WR) production from commercial sources. For development or classified parts the plant has complete ceramic manufacturing processes that include the production of powders from ball milling and spray drying to the production of cermet powder through blending of molybdenum and aluminum oxide. Ceramic pressing can be accomplished either through the use of Stokes presses (dry pressing) or isostatic (wet pressing). We have full capability for machining highly precision ceramic parts which range in size and complexity from simple rings to highly intricate shapes. Capability includes grinding and lapping hardened ceramics to tolerances of ± 0.0005 using diamond wheels and slurry.

PROCESS CAPABILITIES OF CERAMIC MACHINE SHOP

Process 94 Percent Alumina Powder (94ND2): Ball milling then spray drying.

Process Cermet Powder (CND50): Blending 94ND2 and molybdenum then slurry loading

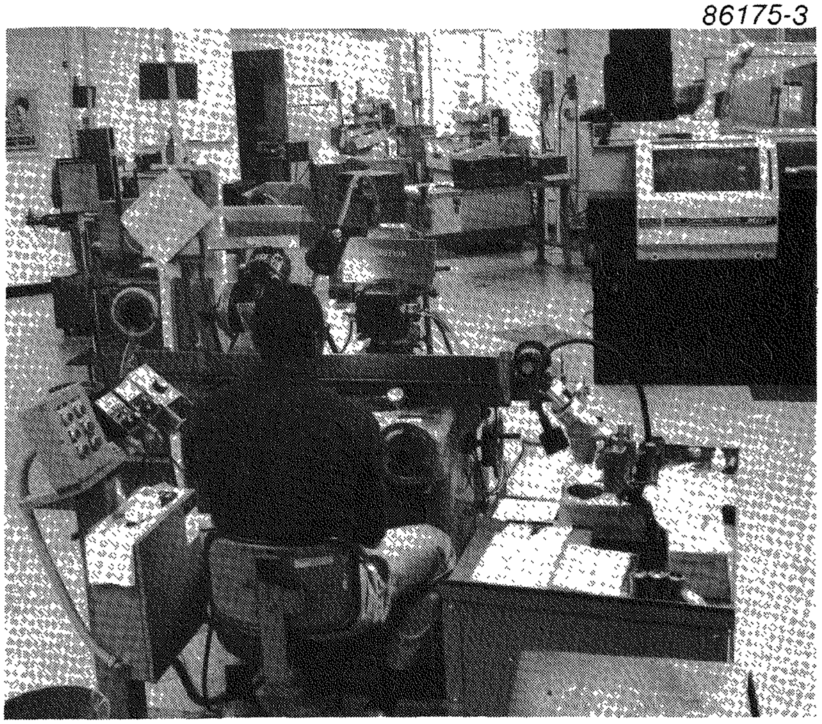
Fire Ceramic Powder: Prefire, airfire, or hydrogen fire.

Press Dry Powder Blanks: Stokes dry press or isostatic press to 30,000 lb/in^2.

Maching Green Ceramic: Drilling, turning, or milling.

Machine Fired Ceramic: Cut off, grind surface, grind i.d. and o.d., lap, and vibratory mill.

86175-3



Ceramics Machine Shop

CERAMIC METALLIZATION

Metallization of alumina ceramic is a process used at Pinellas Plant in the preparation of brazed assemblies or to produce electrically conductive circuits This metallization is a surface layer of powdered metal and fused glass that will allow the ceramic to be joined to another metallic surface The metal is in a continuous phase in the glassy matrix so it can also function as a conductive path for electric currents

7138-2

Hand Painted Metallizing

The metallize is applied to the ceramic as a slurry, formulated in the plant from basic materials These slurries consist of molybdenum, manganese, and titanium hydride powders, in an organic binder They can be applied by hand painting, screen printing, air brushing, or vacuum drawing Hand painting is usually done on irregular (nonflat) surfaces Air brushing is replacing hand painting in many applications, particularly now that it is being robotized for greater productivity and consistency

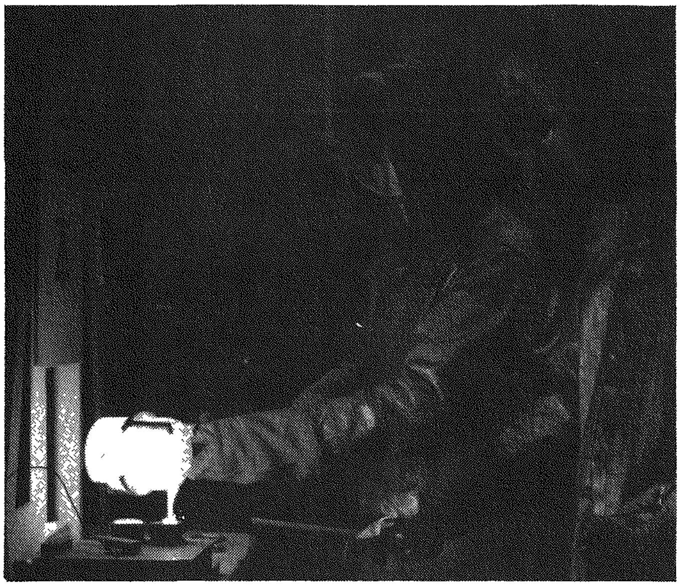
Screen printing is used on flat surfaces to speed coating and improve uniformity The screens are manufactured in-house, photographically, to produce metallized patterns with tolerances on the order of a few thousandths of an inch on the finished part

These metallize coatings are dried following their application and then sintered in controlled atmosphere furnaces for maximum strength and density Quality controls are in place throughout the processing to ensure precise pattern application, thickness of material, and bond strength

7138-3

Screen Print Metallizing

Specialty glasses are formulated to Sandia National Laboratories specifications.



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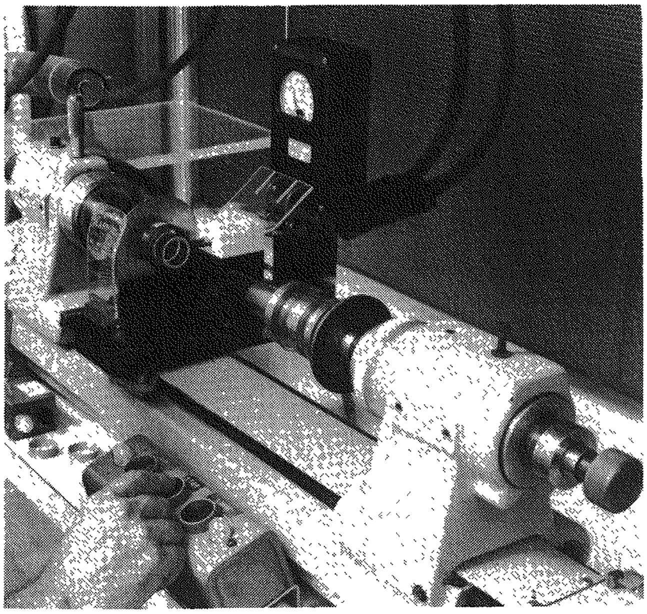
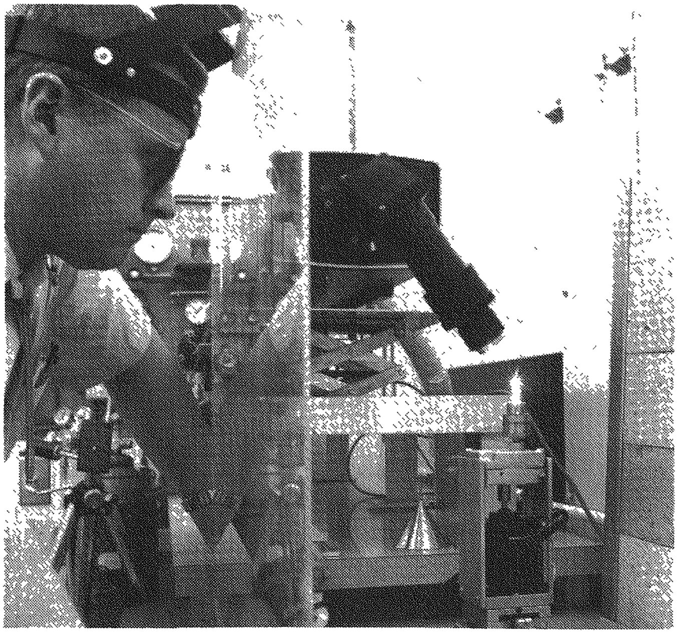


Glass-to-metal seals are produced semiautomatically using radio frequency heating.

Precision glass-to-glass seals utilize the control available in laser energy.

7138-10



GLASS FORMULATION AND PROCESSING

Glass in many forms has been used in the Pinellas Plant since its beginning, originally as the envelope of the neutron tube.

The equipment used in one process is a standard glass lathe coupled with a water-cooled copper coil and a radio frequency (rf) generator that supplies heat for the glass sealing process. Control of metal penetration into the glass is by spring tension with a hard stop. Position of the coil for proper heat distribution around the required seal area is controlled by micrometer settings. The heat distribution is also controlled by continuous rotation of the piece parts. Time at temperature is controlled by electronic timers that remove the heat from the seal but do not interrupt the part rotation. The lathe will accommodate a 6-in. diameter piece part and an assembly 12-in. long.

The current assemblies require a glass to metal seal fabricated from three piece parts. The specification requirements are a center line requirement concentricity of 0.010 in. and a seal width of 0.120 ± 0.030 in. with a metal penetration of 0.080 ± 0.010 in. into the glass.

Glasses having specifically controlled thermal expansion characteristics are formulated in the plant using formulae generated by SNLA. A particular glass has been used in production that matches 21-6-9 alloy steel.

Sealing of this material is done in either of two vacuum chambers equipped with Honeywell DCP-7700 microprocessor controllers. The chamber size is 30-in. diam by 24-in.high.

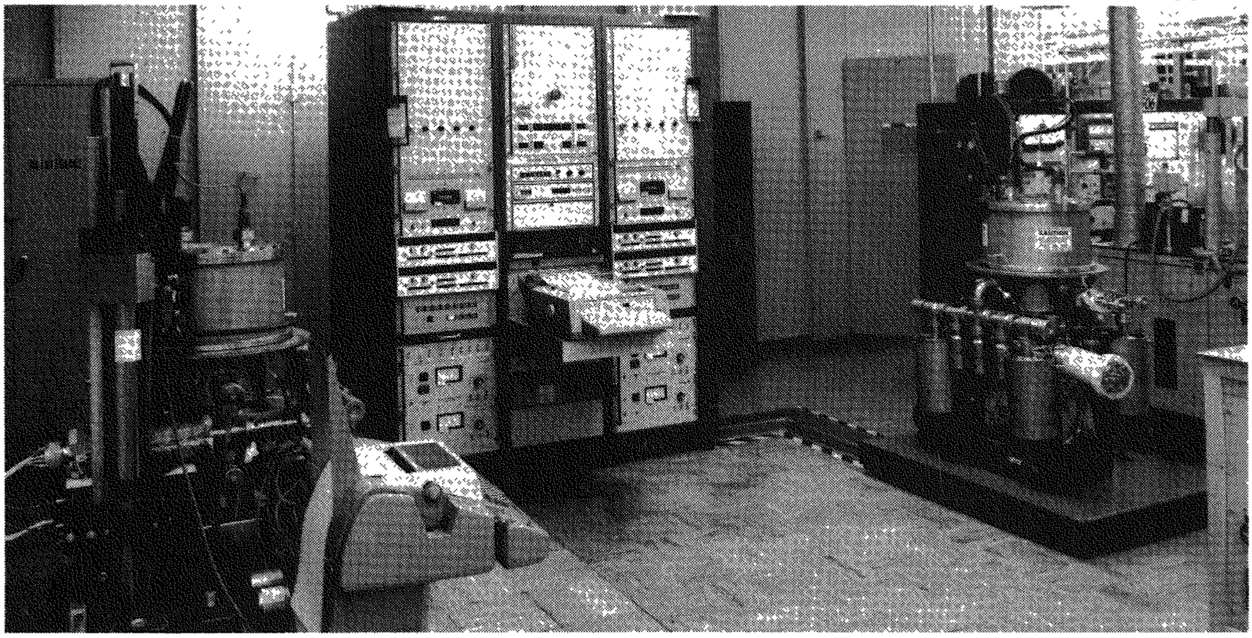
The vacuum capability of these chambers is approximately 1×10^{-7} Torr with most processing done in the 5×10^{6} Torr range. These furnaces have argon purge capability in order to bleed from vacuum up to atmosphere.

Temperature capability is room temperature to about 1100°C, after which point deterioration of Type R PT-Pt-Rh thermocouples takes place.

The Honeywell microprocessor controllers can be scheduled to accept 9 different programs of up to 200 functions total (i.e. ramps, soaks or event switches).

Glass seals are made to many other materials also. This would include seals to ceramics, stainless steel headers and quartz. Seals are produced to withstand high gas pressures and can be tested to 50,000 $lb/in.^2$. Carbon dioxide lasers are used extensively where needed to produce precision seals and in cases in which the seal cannot be exposed to the potential contamination of heating gas flames.

7755-1



All metal exhaust and bake-out systems are used in neutron tube production.

HIGH VACUUM

The neutron generator produced at the Pinellas Plant employs a high vacuum tube which is similar in operation to a miniature linear ion accelerator. High vacuums are obtained in production using all-metal "dry" systems consisting of sorption pumps for "roughing" and ion pumps for further exhaust. In systems such as these, no diffusion pumps or mechanical fore pumps, with their attendant vapor back-streaming problems, are used.

As subsequent part of this process, hydrogen isotopes may be admitted to the evacuated tubes. Ultraclean metal films, which are deposited on internal tube electrodes, are hydrided to controlled ratios of gas-to-metal atoms.

The Pinellas Plant excels in its ability to measure high vacuums and minute leaks, to produce thin metallic films, and to hydride the films produced.

Leak detection is used throughout the plant for qualifying the integrity of weld and braze joints in a variety of products. Most parts are leak checked on standard commercial helium leak detectors to a specification of 1×10^{-9} std. cm^3/s, and a system which uses Freon* to leak check to a specification of 5×10^{-12} cm^3/s.

The vacuum integrity of a completely sealed unit may be measured using a commercially available system, Radiflo. This device operates by immersing the sealed unit to be checked in a radioactive gas atmosphere at elevated pressure for a specified time period. The leakup rate of the volume is correlated to a radioactive decay level. The technique has a supplier rated leaked detection sensitivity to 1×10^{-11} atm cm^3/s. Volume down to 0.03 cm^3 and leak rate to 1×10^{-11} are regularly being evaluated with the system.

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*Trademark, E. I. du Pont de Nemours and Co., Inc.

74106-17

Sputtered tungsten provides long life electrical connection for the RTG thermopile.

METAL FILM DEPOSITION BY SPUTTERING

Metal films may be deposited on properly prepared surfaces by the process of sputtering. An example of this is the application of tungsten electrical connections to the thermopile produced for an RTG.

There are five sputtering systems in the Plant. Two dc diode sputter systems capable of sputtering approximately 30,000 A of tungsten simultaneously onto both sides of an RTG thermopile and a single target dc diode system which can sputter tungsten onto only one side of a thermopile. Power level for the dc diode sputter system is 6 kV and 107 mA.

The vertical sputter system contains rotating fixtures permitting multiple sputtering onto both sides of a substrate without air exposure. Magnetron sputter targets (one dc and one dc/rf) are available for sputtering various material. To date, aluminum, molybdenum, boron nitride, gold, platinum and rhenium have been deposited onto substrates. The magnetron sputter system is used to sputter only nonmagnetic sputter materials. A vertical dc/rf Magnetron Sputter System which is capable of housing three 5- by 12-in. sputter targets is also used.

METAL FILM DEPOSITION BY PHYSICAL VAPOR DEPOSITION (EVAPORATION)

There are 14 metal vacuum systems equipped with either single or double crucible electron beam guns for heating materials to the evaporation point These systems are capable of maintaining pressures in the 10^{-6} to 10^{-8} Torr range while depositing films with substrates at elevated temperatures Film thicknesses range from 1000 to 75,000 A. Materials being deposited today include titanium, erbium, vanadium, gold, molybdenum and aluminum Materials are either deposited as pure films, pure films with underlays or as mixtures

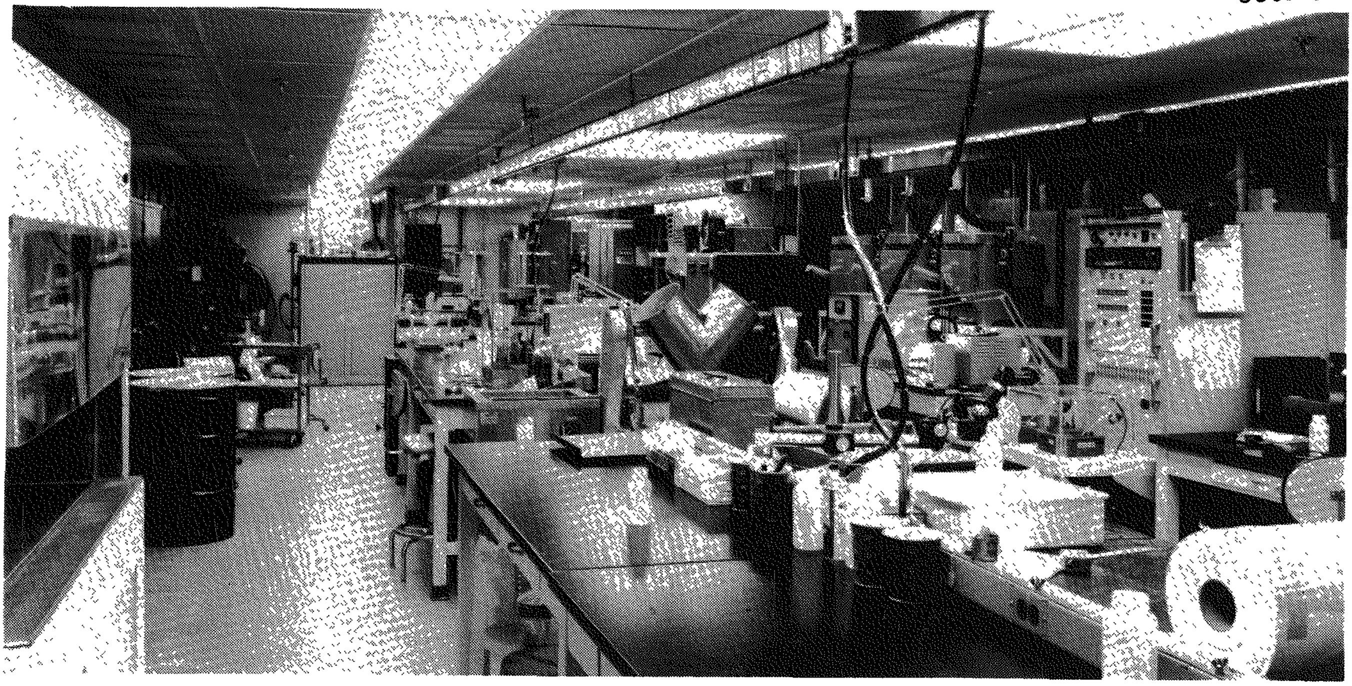
71101-2

Metallic Film Evaporation, Deposition, and Hydriding

HYDRIDING OF METAL FILMS

Pure and reactive metal films produced as described above are hydrided in the Plant to controlled gas to metal atom ratios In general, all systems used for hydriding are all metal capable of processing at pressures in the 10^{-6} to 10^{-9} Torr range The gas-to-metal ratio attained approached theorectical limits which imply that films are very pure All systems are computer or automatically controlled

8052-9



Dry rooms are used for handling hygroscopic materials such as those used in thermal batteries.

DRY ROOM CAPABILITIES

The fabrication of thermally activated batteries requires the use of materials which must be protected from moisture. For this reason, development and production dry rooms are available

The Production Dryroom consists of 2700 ft^2 of space maintained at a relative humidity of less than 3 percent (frost point of -23°C; equivalent to 750 ppm by volume: water vapor/air).

These manufacturing processes can be performed in a dry atmosphere:

- Powder Processing: Grind, mill, blend, size, fuse to 650°C, vacuum dry, dry storage, and pellet pressing 20 to 250 tons.
- Metal-Working: 10 ton OBI punch presses with CAM feed, Diacro* punch and shear with a large selection of round punch and dies and many special steel rule dies.
- Welding: 75-ampere pulsed tungsten inert gas (TIG), 100 W-s spot welders
- Electronic and General Assembly: Including handling of highly flammable and explosive components

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*Trademark, Div. of Houdaille Industries, Inc.

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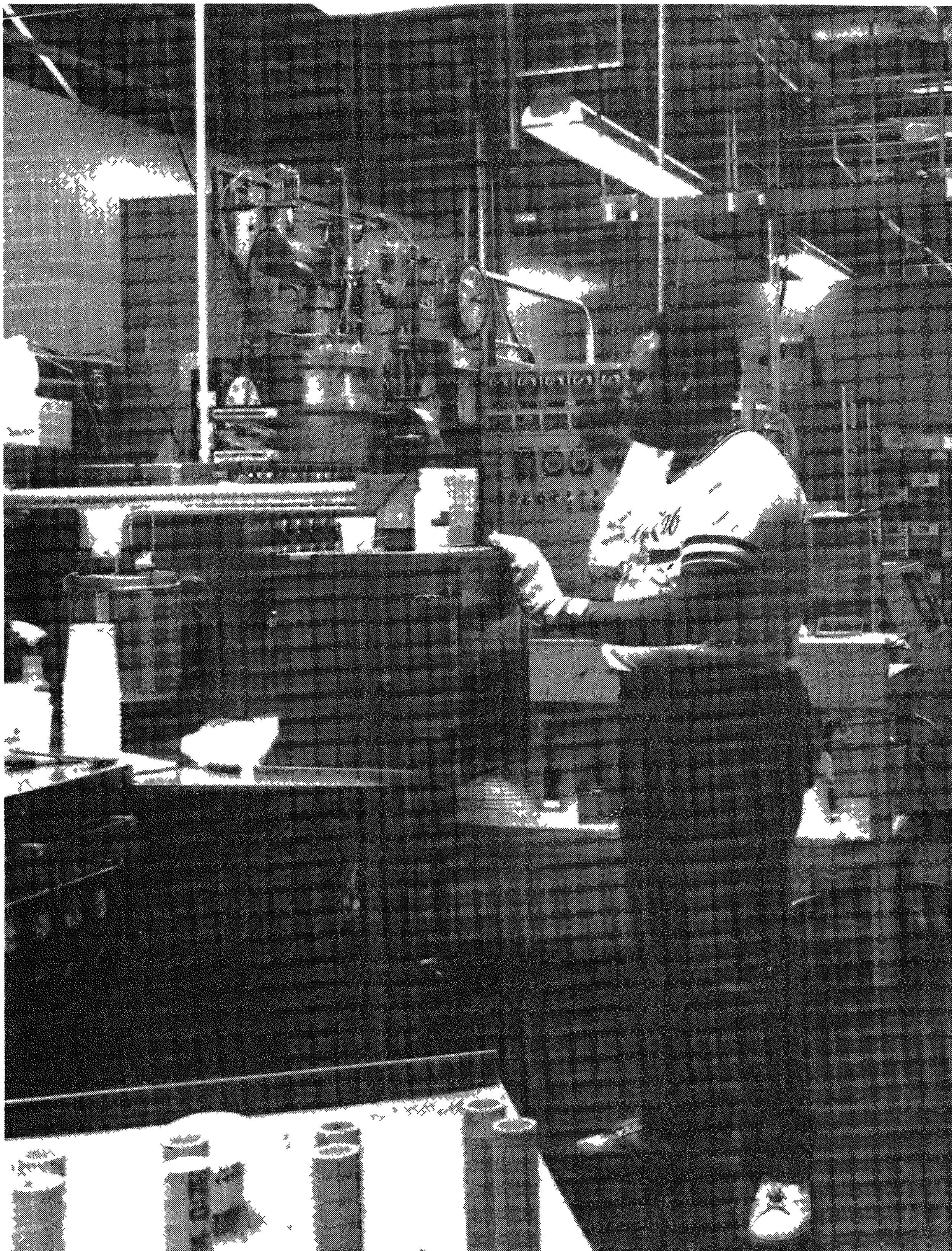

ENCAPSULATION CAPABILITIES

Many Pinellas products are encapsulated in multicomponent resin mixtures for physical or high voltage breakdown protection. The materials used and machine capabilities are listed below:

Rigid Urethane Foam

Automatic machines meter, mix and dispense rigid urethane foam, maintaining ratio accuracy in the mixture of the various components of ± 1 percent. Machine capability is 20-g minimum shot size, 85-g maximum, at a rate of 80 shots an hour maximum.

Filled Epoxy Resins

Automatic machine meter, mix, and dispense resin systems filled with $A1_2O_3$ at pressures to 0 8 Torr maintaining a ratio accuracy of ± 1 percent and a shot size of 75 to 150 grams (30 to 60 cm^3) The shot size can be maintained ± 1 percent at 150 g, and 60 shots per hour.

Automatic metering, mixing, and dispensing of glass microballoon filled resin systems maintaining a ratio accuracy of ± 1 percent at pressures to 1 Torr and a rate of 2 3 grams (2.5 cm^3)/s

Unfilled Epoxy Resins

Two machines automatically meter, mix, and dispense unfilled resin systems, at pressure to 0.1 torr, maintaining ratio accuracy of ± 1 percent, and a shot size of 20 to 40 grams (18 to 36 cm^3) with a rate of 60 shots an hour maximum.

Other Resins

Filled and unfilled urethane elastomer systems can be processed by hand, same capability as unfilled epoxy resin systems.

Support Equipment

Plasma cleaner, argon plasma at 0.5 torr and up to 500 W

CAM or microprocessor controlled ovens for cure schedules to 250°C and 40 h.

ENVIRONMENTAL TESTS

A comprehensive test facility has been established to ensure the adherence of our products to environmental requirements To verify that the products are capable of meeting the shocks and vibrations expected in use, many mechanical tests are available at the Pinellas Plant A typical capability is a high acceleration sled, shown at right A high pressure gas-driven ram accelerates the sled carrying a part to be tested along the track shown This sled is stopped by materials of various mechanical constants providing deceleration forces as high as 9,000 Gs

As another example of environmental testing, automatic temperature cycling chambers are used to evaluate thermal effects on products and subassemblies These chambers can be controlled through both heat and refrigeration cycles by a preprogrammed cam or microprocessors

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ENVIRONMENTAL TESTING CAPABILITY

Shock Test

12-in ^{3} maximum size
30-lb maximum weight
5000 Gs peak, haversine
1 0-ms duration at 10 percent amplitude

4-3/4-in cylinder, 12 in long
5-lb maximum weight
20,000 Gs peak, haversine
1 5-ms duration at 10 percent amplitude

Accuracy ± 15 percent, amplitude and duration
Test Record Strip chart or photo of shock signature

Temperature

Range -70°C through +150°C
Accuracy ± 2°C
Records Strip chart or circular chart
Size 18- by 18-in maximum volume

Vibration

Frequency Range 10 through 3,000 Hz
Displacement Max 0 5-in pk/pk
Velocity Max 35-in /s
Acceleration Max 100 Gs with 20-lb

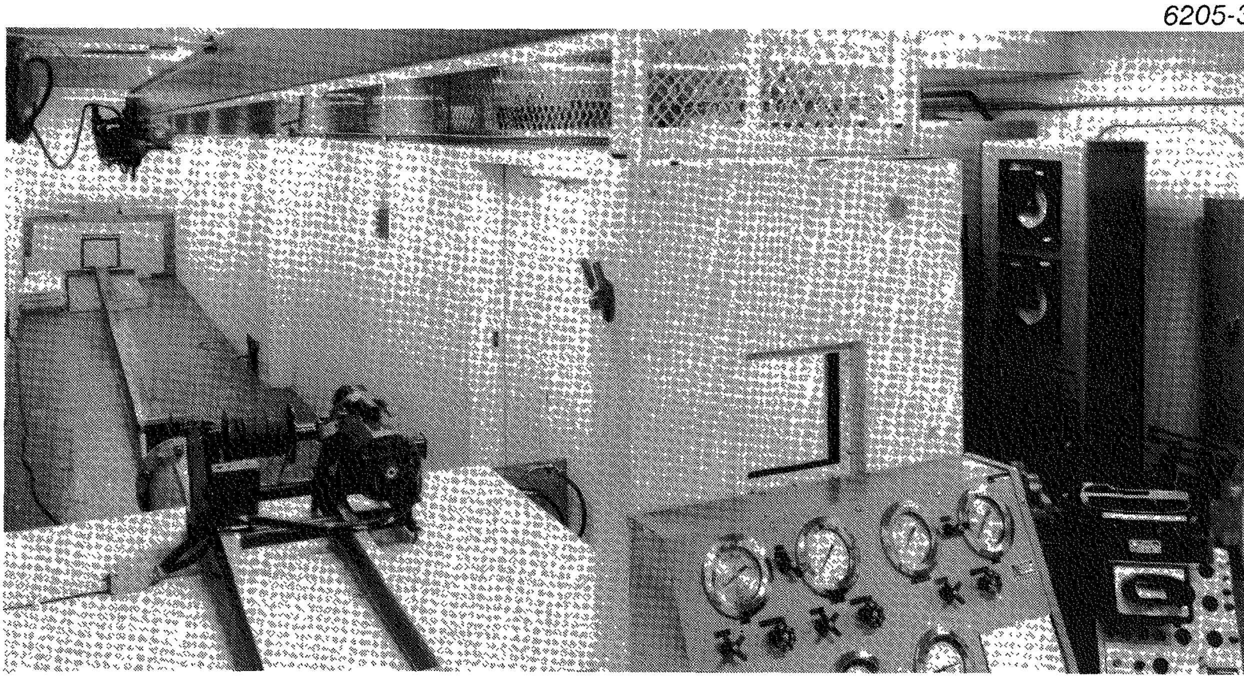
Control Digital Computer with sine, random, and transient
Records Copy of test spectrum and actual test condition, with two accelerometers maximum
Temperature Combined vibration and temperature within -70 to 150°C ± 5°C

Linear Acceleration

190 Gs maximum
12- by 12- by 12-in maximum
50-lb maximum

Accuracy ± 10 percent

6205-3



Hyge Sled

FURTHER TEST CAPABILITY

Ultrasonic

An onboard capability is available to interrogate macro and miniaturized products for fabrication integrity via ultrasonic techiques. Ultrasonic nondestructive material evaluation techniques are sensitive to material discontinuity. GEND's on-site capabilities include four water immersion, flat or cylindrical component scanning systems with a maximum volume capability of 216-in^3. Frequency ranges employed are 5, 10, 20, and 25 MHz. The minimum flaw size detection presently required by product specification is the equivalent of a 10-mil diam flat discontinuity at a depth which is material dependent. Equipment development facilities include a transducer sonic beam profiling system and a Schilieren optical system for the optical viewing of the sonic energy path and dispersion profile.

Thermography

Temperature problems are one of the major causes and indicators of component failures. The Pinellas Plant has acquired a thermal imaging system for the nondestructive, nonintrusive evaluation of products and components. The technique uses infrared scanning to measure the variations in heat emitted by an object. It converts the scanned object's surface thermal pattern into a visible image which can be compared to standard/expected image patterns and profiles.

X-Ray

Six X-ray facilities are maintained for the radiographic analysis of the integrity of manufactured components and products. These are 0.5- and 3-kVA systems with maximum voltage rating of 130 and 320 kV respectively. The productivity of one of the systems has been enhanced by the application of robotics for film and component manipulation.

CLEANLINESS AND CONTAMINATION CONTROL

The Pinellas Plant contains 20 downflow clean rooms to support critical assembly, welding and cleaning operations. Many of these rooms are Class 100, meaning they maintain a level of particulate airborne contaminants less than 100 particles (0.5 μ or larger) per ft^3 of air.

Two new clean rooms were added in 1982 to provide the ultimate in cleanliness conditions needed to develop and assemble high voltage vacuum tubes used in neutron generators. A thorough investigation was conducted to determine the best clean room design and construction contractor capabilities. The result has been two world class, state of the art rooms which operate reliably, can be efficiently monitored and maintained, and have met or exceeded all specifications.

The development room is 515 ft^2 while the production room is 2470 ft^2. Both were specified as Class 100 or less and both rooms are operating at a Class 10 level.

The plant has used laminar downflow tents to house individual pieces of equipment, or groups of equipment, in clean conditions when modular flexible work areas are desired. This has been very successful in providing a Class 100 level of cleanliness at lower cost.

Typical operations are high vacuum processing stations, assembly, and inspection equipment.

Pinellas also provides up to date cleaning capabilities including acid, UV, plasma, ultrasonic, high pressure spray and programmable degreasing processes. A deionized water system provides the cleaning operation with 120 gal/hr of high purity water having a bacteria level less than 1 colony per 1000 cm^3.

The Plant supports the contamination control and cleaning facilities with a contamination control laboratory that performs microscopic analysis, product contamination studies and clean room monitoring capabilities.

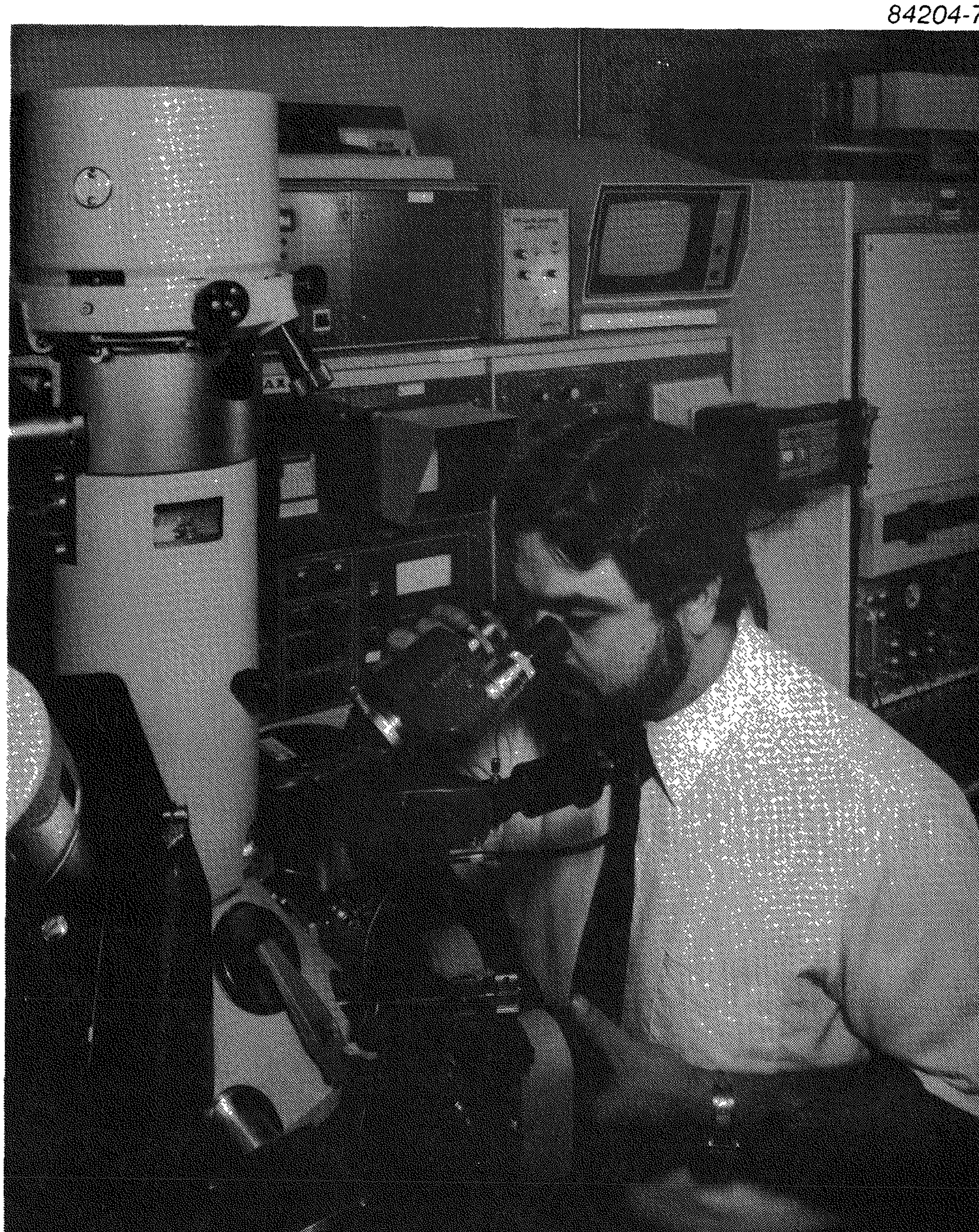
Consultation and training courses in contamination control and cleaning have been provided within the complex as requested and to National Technical Conferences.

84204-4

Centralized parts cleaning facility services the entire plant.

LABORATORY FACILITIES

84204-7



LABORATORY OPERATION

The Pinellas Plant Laboratory Operation provides the capability to support the production and development of our products. This capability goes beyond that which might be expected in a production facility, and is required to ensure the quality of the weapons components produced. Research and development activity for production process development is also carried on here.

Several speciality equipments are shown and briefly discussed on the following pages, and highlights of major laboratory capabilities are given in tabular form in the final section of this booklet.

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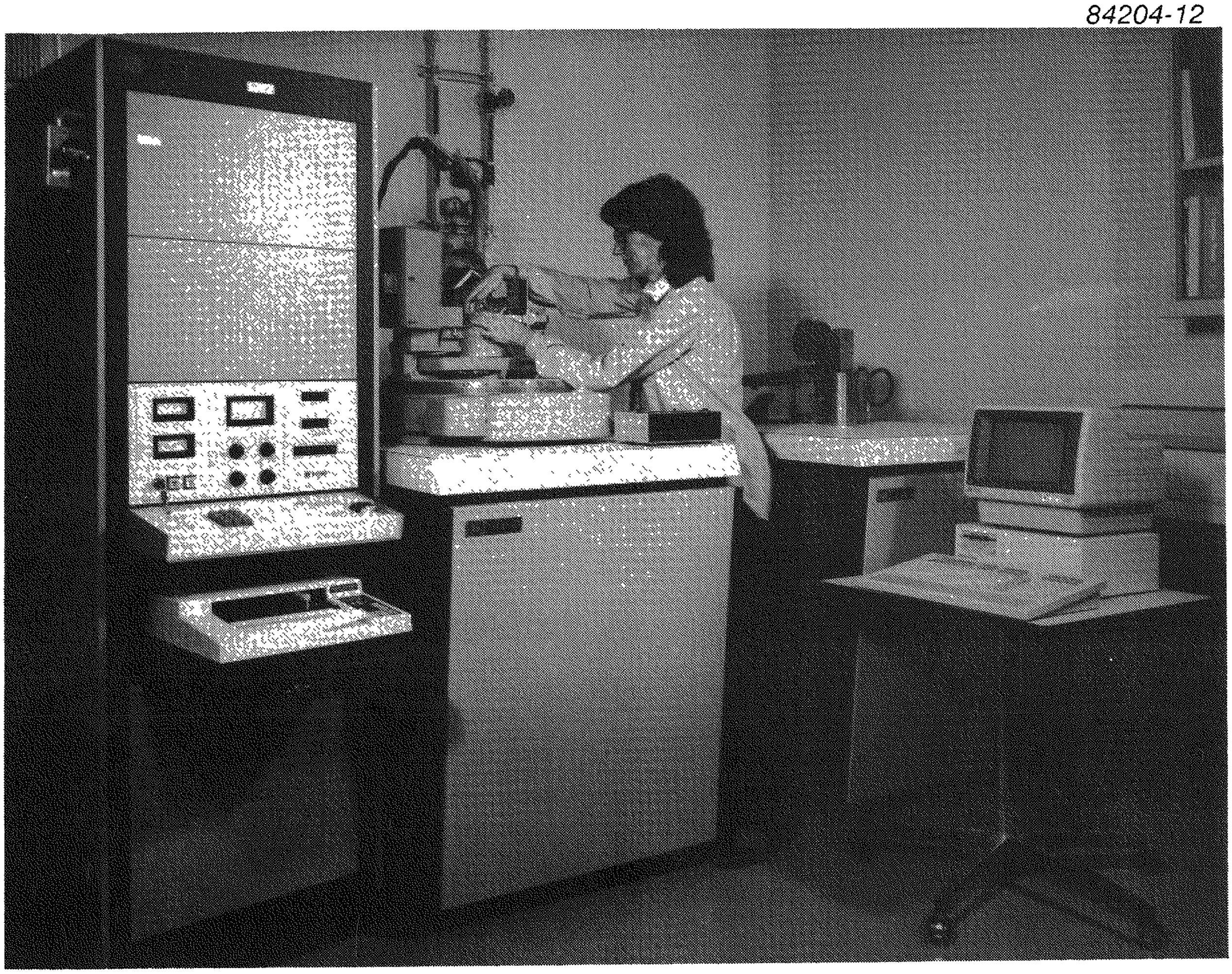

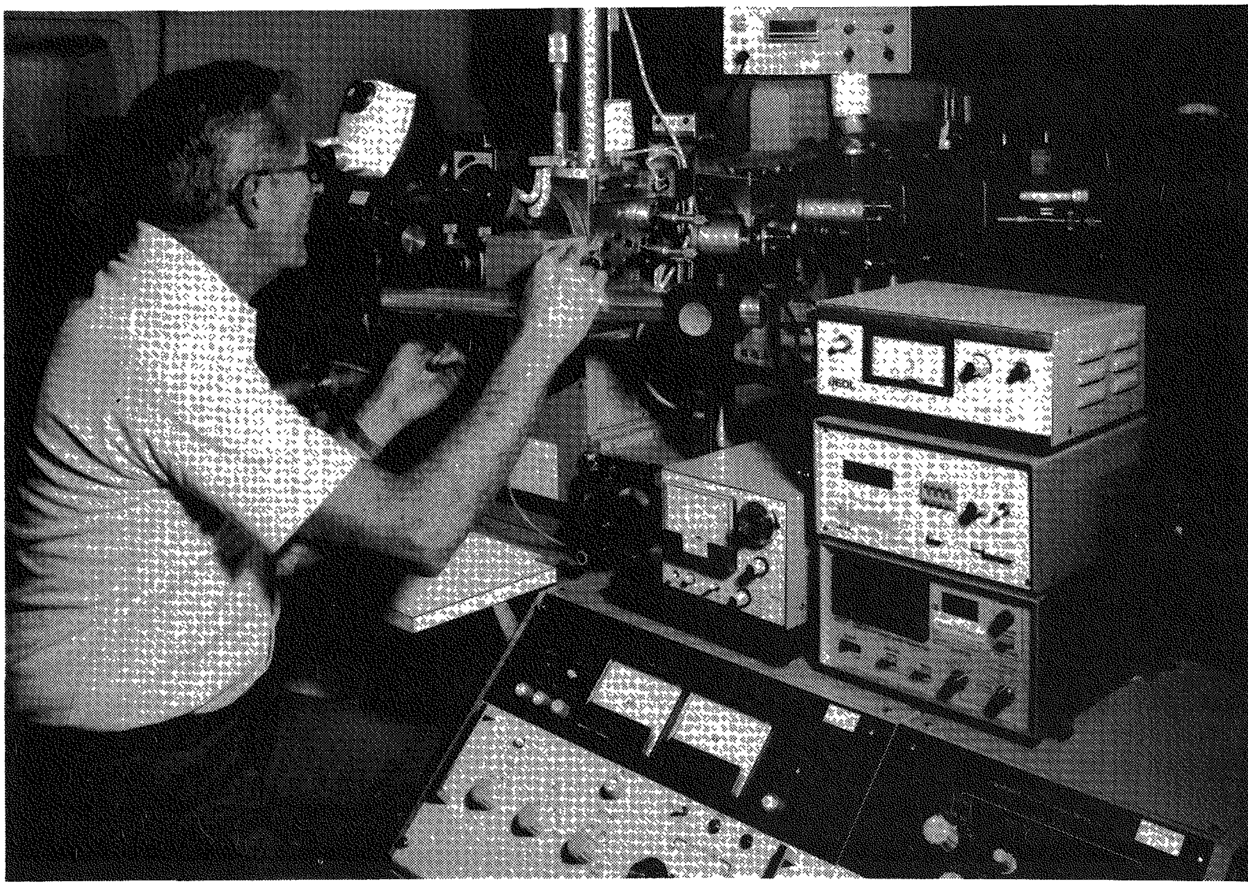

Spark Source Mass Spectrometer

SPARK SOURCE SOLIDS MASS SPECTROMETER

The JEOL spark source mass spectrometer Model 01BM-3, provides the ability to analyze electrically conductive solids for all elements from lithium through uranium. The sensitivity of the instrument is 10 ppb.

In use, two small slices of the material to be analyzed are sparked together in the instrument with a 300-Hz, 60-kV source. The resultant ions are accelerated through electrostatic and magnetic analyzers where they are separated by mass and detected on a photographic plate. The position of the lines formed identifies the element and the line darkness is a measure of quantity.

Typically this instrument is used to analyze the impurities in such high purity materials as silicon (99.999 percent), germanium (99.999 percent), gold (99.99 percent), copper (99 9 percent), and molybdenum (99 99 percent).

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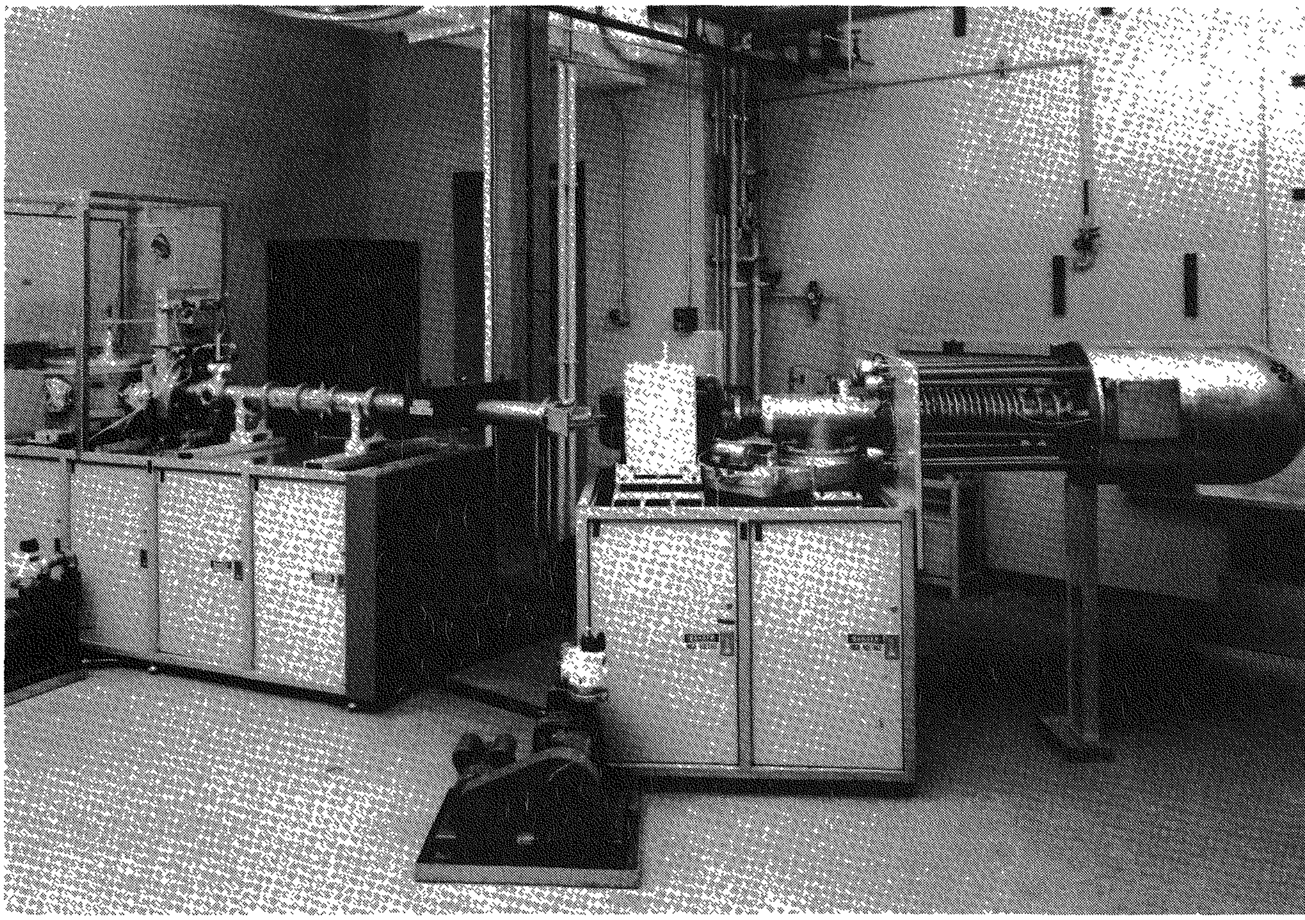


Ion Accelerator Facility

ION ACCELERATOR FACILITY

The Pinellas Plant s target assessment facility was originally established to evaluate the performance of neutron generator targets It consists of a 200-keV ion accelerator and two experimental sample chambers equipped with various detectors, target manipulators and surface analysis instruments It is contained within a monolithic concrete building which provides adequate radiation shielding

The facility is presently equipped to make the following kinds of measurements, each of which can be obtained from an area as small as 0 065 mm^2 at any point on the target

Deuterium and Tritium Distribution

The technique of low energy nuclear reaction spectroscopy is utilized to profile the distribution of both deuterium and tritium in metal hydrides The profile can be determined to a maximum depth of 1 μ with a depth resolution of 0 1 μ

Neutron Output

The neutron output of both DT and DD reactions are measured using the associated particle technique This method results in an accuracy of ± 5 percent for the DT reaction and ± 10 percent for the DD reaction

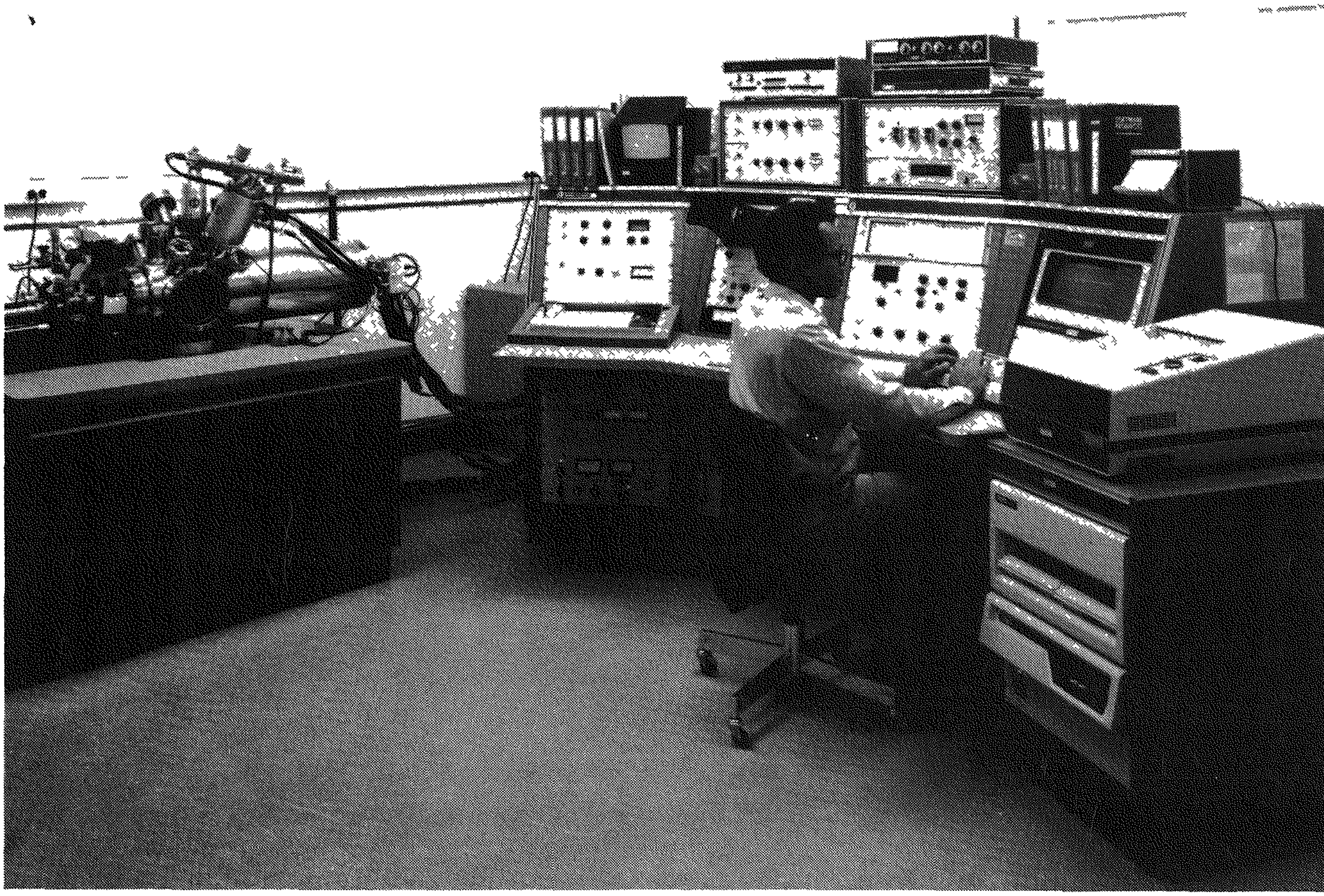
Secondary Electron Emission

The coefficients of ion induced secondary electron emission target surfaces are measured with an accuracy of ± 5 percent using a constant fraction beam monitor This information is used to investigate the relationship between target conditions and high voltage breakdown

Rutherford Backscatting

Doubly ionized He-3 is used to make 400-keV backscattering measurements The low energy limits this technique to the analysis of surface contamination and the study of interfaces between various thin targets and their substrates

In addition to making the kinds of measurements described, the target assessment facility can serve other useful functions The accelerator can provide an accurately known source of 17-MeV neutrons (pulsed or continuous) with a maximum output of 1 25 x 10^{11} n/s The accelerator can also be used to implant any of a wide variety of ion species over a 6- by 6-cm area The facility is being upgraded continuously and many new capabilities are being developed to ensure state of the art performance



Auger ESCA System

AUGER/ESCA/SIMS SYSTEMS

The Electron Spectroscopy Chemical Analysis system consisting of a scanning Auger microprobe (SAM), X-ray photoelectron spectrometer (XPS or ESCA), and a secondary ion mass spectrometer (SIMS) is used to determine the elemental and chemical composition of solid inorganic surfaces and thin films The SAM is capable of fast elemental mapping and point analysis while the ESCA provides detailed elemental and chemical bonding information Both techniques can detect less than a tenth atomic layer of all elements except hydrogen and helium

The system has ion sputtering capability to obtain elemental depth distribution profiles The SIMS is sensitive to all elements and their isotopes to 1 ppm or better, and provides complimentary data to the other techniques The system is equipped with a rapid sample introduction chamber and a specimen transfer system that permits reactive or sensitive samples to be mounted in a controlled environment, transported, and installed in the analysis system without exposure to atmosphere

LABORATORY TECHNOLOGY OVERVIEW

On the following pages the technologies available in the Laboratory Operation are listed, with a description of the equipment, the equipment's capability, and the most common applications of this capability.

8683-5

POLYMER

TECHNOLOGY	CAPABILITY	APPLICATIONS
Automatic Resin System Processing		
Decker urethane foam dispenser	Dispense various density urethane foams through a wide ratio at a rate of up to 10 lbs/min	Encapsulation of electronic assemblies for shock protection, and fabrication of handling cryogenic tooling
Foam Machine (CHEM-MIXX)	1 to 350 cm^3 shot size	Dispense urethane foam
Transfer Molder (GLUCO)	10 ton clamp, 93 to 200°C	Molding thermosets, Thermoplastics
Manual Resin Processing		
Vacuum encapsulator, designed and developed by GEND	Process various resin systems under vacuum using manual encapsulation techniques and to degas all types of resin systems	Encapsulation of electrical assemblies and high voltage or shock applications
Pilot plant	2 gallons, RT to 120°C, stirring action	Blending and reacting metallize binder solution
Organic Coating		
Fluidized bed coating manufactured by Polymer Corp	Apply pinhole free coatings on various substrates using polymeric powders such as polyurethane epoxy polypropylene	Coating of parts and equipment for acid or corrosion protection or for electrical insulation purposes
Resin System Curing		
Approximately 9 microprocessor-controlled programmable circulating air ovens 10 CAM controlled pressure tanks, and 2 microwave ovens	Perform preheat and curing operations within a temperature range of 30 to 600°C Ovens operate independently through any time-temperature profile	Preheat and cure of various resin systems
Ultraviolet source (fusion)	200 to 400 nm range, elliptical focus 2 1 inch 10 inch long bulb	Ultraviolet curing of resin
Thermoforming		
Thermoform equipment manufactured by Kostur Industries for processing thermoplastic sheet materials	Perform thermoform (vacuum form) types of operation on various thermo plastic sheet materials	Material handling fixtures, tooling masks, etc

TECHNOLOGY	CAPABILITY	APPLICATIONS
Stress Analysis		
Photoelastic stress using polariscope manufactured by Photoelastic, Inc.	Perform various types of photoelastic stress analyses on materials such as epoxies, glass, etc.	Perform stress analysis on many encapsulated electrical assemblies to show high stress concentration areas and to provide assistance in the elimination of same.
Rheometrics dynamic spectrometer	Angular vel to 100 radians/s, torque 2 to 2000 g-cm, temperature to 350°C	Solid and liquid Tg, shear modulus, viscosity, strain rate, creep rate
Computer strain system for monitoring strain gages and stress analysis	Stress analyses.	Perform stress analyses on vacuum tubes, various ceramic configurations, etc.
Adhesives	Process various types of adhesive including silicones, urethanes and rubbers.	Develop adhesive for product application.
Surface Preparation		
Fluoroptic Thermometer (Luxtron 1000 A)	20 to 240°C; nonconductive fiber optic probe; low thermal conductivity	Measure temperature in RF field of plasma generator
Wet honing by Vapro Blast, Inc.	Preparation of surface using aluminum oxide suspended in water.	Surface preparation.
Pencil blast by S.S. White Airbrasive	Preparation of surface using aluminum oxide in air blast media.	Surface preparation.
Plasma Cleaner manufactured by Bronson Corp.	Plasma cleaning with argon, oxygen, or hydrogen plasmas at 0.5- to 1.5-Torr pressure at 50- to 600-W RF energy at 13.56 mHz.	Removal of surface contaminants, especially organic films.
Plastic Tooling	Preparation of various types of plastic tooling for use in many areas of the plant. Materials include silicone urethane elastomers and tooling epoxies.	Preparation of plastic tooling.
Resin batch mixer Baker Perkins, Inc.	60-lb batch mixer, 2 blade, hydraulic dump	Resin mixing

TECHNOLOGY	CAPABILITY	APPLICATIONS
Metallizing	Provide metallizing slurries for screen print and hand paint metallizing vehicles for slurries.	Metallizing of ceramic parts for ceramic metal seals and electrical feedthroughs.
Environmental Conditioning		
Controlled relative humidity chamber by Thermotron Co.	Temperature conditioning from 21 to 93°C with relative humidities to 95 percent.	Humidity-temperature conditioning.
Temperature cycle chamber (Thermotron)	-73 to 177°C; 4 ft^3; programmable	Thermal conditioning of units, resin curing
Shear Modulus Testing		
Torsion pendulum designed and fabricated at GEND	Shear modulus daming decrement measurements at temperatures from -60 to 150°C.	Measurement of dynamic modulus characteristics or elastomeric materials.
Tensile Testing		
Tensile tester by Instron Corp.	Tensile strengths, compressive strengths, and flexural strength measurements and modulus up to 10,000-lb loads.	Tensile, compression and flexural characteristics of materials.
Test chamber-temperature range	Temperature chamber allows physical testing from -65 to 200°C.	
Die shear tester	Measurement of shear strength of adhesives.	Incoming material test. Evaluation of selected adhesives in specific applications.
Micro-pull tester (Dage)	0 to 10 KG; programmable	Wire bond testing
Impact tester (IZOD)	o to 5 ft-lb	Fracture testing of plastic
Viscosity Measurements		
Cone and plate viscometer manufactured by Brookfield Engineering Laboratories	Measures viscosities from 261 to 191,608 centipoise.	Viscosity measurements on metallize slurries, especially formulations with volatile solvents.
	Requires only from 0.5 to 2 cm^3 of sample.	
	Provides constant temperature control of sample from 0 to 100°C, but normally runs at 25 to 56°C.	
Viscometer (HAKKE)	Cone and plate; 50-10X10 E6 cps; -20 to 150°C	Rheological, viscosity measurements of resins and metal slurries

TECHNOLOGY	CAPABILITY	APPLICATIONS
Surface Analysis		
Nikon stereo/photo microscope	Magnification 6.6 to 40X, 4 by 5 polaroid film format, electronic exposure.	Visual surface analysis and photographic record keeping.
Microtone slicer, Sorvall MT5000 ultra microtome	Microprocessor controlled diamond knife to secion polymers; depth of cut from 995 to 5 nm, repeatable within 5 Å per cutting cycle.	Microstructural analysis of crystalline plastics for failure analysis, part design, and processing optimization.
Meseran surface analyzer	Radioactive evaporative method	Surface cleanliness
Color video camera/recorder	Microscope mounting 19-inch color monitor, 3/4-inch tape recorder	Monitor reaction, procedures, education, stop action of events
Dielectric Measurement		
Audrey 380 dielectric spectrometer	Wizard microprocessor temperature controller, X-Y plotter, minipress PP-45.	Measure dielectric constant, capacitance, and loss factor of polymers during and after cure.
Computers		
HP87 and HP150 computers manufactured by Hewlett-Packard Corp.	Cathode ray tube (crt) display, dual disk drive, printer, multiprogrammer.	General pupose computing capability to interface with physical transducers.
Sample Cutting		
Pistorius cutoff wheel	Cut hard materials such as ceramic, alumina-filled resin, thin wall tubing, and glass.	Preparation of samples for physical testing.
JDC precision sample cutter	Accurate cutting of thin film material to be used in physical testing.	Preparation of tensile strength and modulus sample.
Sample Cleaning		
Vapor degreaser	Able to solvent clean parts without actual physical contact with the solvent.	Used to remove oil imbedded in ceramic or other porous material.
Ultrasonic cleaner (3)	Clean parts by immersion in fluid subjected to ultrasonic vibration.	General parts cleaning.
Press		
Carver laboratory press	Hydraulic press 0 to 11 ton, 18-in. platen separation, platen heated 150 to 500°F.	General pressing operations, sample curing under pressure/heat conditions.

CERAMICS

TECHNOLOGY	CAPABILITY	APPLICATIONS
Powder Characterization		
Microtrac	Patricle diameter determination by means of light scattering (Rayleigh) analysis Relatively fast, particle diameter range ~0 2 to 150 micron, Cumulative volume distribution	PZT varistor powders, tape casting slips, metallized, RTG, MCP thermal battery powders
Sedigraph	Particle diameter determination by means of X-ray sedimentation measurements Relatively slow, particle size range ~0 2 to 100 microns Cumulative mass distribution Assumes spherical particles can only be used on pure materials Limited to elements with atomic numbers > 13	
Horiba	Particle diameter determination by means of centrifugally induced sedimentation Faster than the Sedigraph Time varies from a fraction to 20 min Same limitation as above except for atomic number	
Zetasizer	Automatic zeta potential deter mination Particle diameter determination by means of diffraction of light	
Zeta Meter	Zeta potential determination in suspensions or slurries	
Leitz-Orthlux Optical Microscope	Particle shape and size analysis Mineral identification Material morphological properties particle shape absolute size and cleavage of single particles Identification of phases and mineral content of a sample Homogeneity of sample	
Chemical Preparation of Ceramic Powders	Preparation of ceramic powders from aqueous solutions Affords ease of preparation of nearly any composition ease of dispersing trace additives control of composition homogeneity and purity	PZT, varistor powders, tape casting slips Compositions requiring a high degree of control

TECHNOLOGY	CAPABILITY	APPLICATIONS
	Variety of equipment for the preparation of large batches of solutions, mixing, precipitation and filtering. Precise control Tempress furnace, control atmosphere and vacuum furnace.	
Ceramic Fabrication	Prepare body powder - ball mill raw material, spray dry. Press powder - isostatic (50,000 lb/in^2), automechanical die. Sinter (up to 1750°C) - air, hydrogen, argon or nitrogen atmosphere. Machine and finish grind - tracer and turret lathes, vertical mill, centerless grinder, rotary surface grinder, LNC Lathe, CNC Mill. Ultrasonic impact machine, vibratory finisher. Cleaning and inspection - dye penetrant testing, specific gravity, inspection microscope.	Electrical insulators (94 percent alumina ceramic; special compositions - doped alumina, pure alumina, rutile, varistor, ferroelectric), cermet feedthroughs, prototype components, braze fixtures, gages, rework of purchased parts, vendor support and problem solving.
Tape Casting	Able to produce layers of thin ceramics (down to 0.001 inch) of various compositions for use as single layers or pressed together into laminates.	Production of multilayer ceramic capacitors (barium titanate), current stacks (PZT), thin substrates (alumina).
Material Forming	Injection molding of ceramics (low pressure air injection). This machine is still new to NDD but we have been able to mold a 94% alumina body with an 82% solids content. We anticipate molding other ceramic compositions such as PZT. Dual objectives are near net shape forming to save machining time and/or produce higher quality ceramic structures	
Glass Melting	Weigh and blend raw materials - precision balances, twin shell blenders. Melt and fine glass - electric furnaces (bottom loading with platinum crucibles and stirrers).	Glass-ceramic insulators, preforms for glass-to-metal seals.

TECHNOLOGY	CAPABILITY	APPLICATIONS
	Glass casting - molds with preheat furnace, vacuum assisted molding, transfer molding with arbor press.	
	Annealing - belt annealing furnace, box annealing furnaces.	
	Finishing - slice and grind, chemical etch and polish.	
Glazing and Enameling	Slurry preparation and application equipment.	Glazing of ceramics and enameling of metals.
<u>Glass to Metal Sealing</u>		
Firing Capability	Nine zone belt furnace using hydrogen. forming gas, argon, and nitrogen for glass-to-metal sealing The furnace length provides excellent annealing capability for a belt furnace	
	Vacuum and inert gas retort furnace for glass-ceramic sealing and active metal brazing. Control system allows excellent control of part temperature over complex profiles making it very suitable for controlling the devitrification of glass-ceramic compositions.	
Material Joining	Active metal bonding/brazing performed in vacuum using nonsilver braze material as well as conventional silver bearing alloys.	
Sealing	Capable of sealing a wide variety of materials to various glasses producing high quality seals. Appropriate sealing furnaces are available.	
Measurement and Test	Microscope/photographs documentation toolmakers microscope IR and DC breakdown equipment; leak detector Helium	
<u>Physical Testing</u>		
Tinius Olsen universal tester	Computer controlled units capable of testing to 30,000 lb in compression or tension, with data acquisition, analysis, display and recording.	Testing of ceramic, metal adhesive bonding for incoming inspection, research and development, and product certification requirements.

TECHNOLOGY	CAPABILITY	APPLICATIONS
Olsen cup tester	Measurement of relative ductility (formability) of sheet metal.	To determine if material will perform well during forming operations.
Dilatometer	Measurement of linear coefficient of expansion to within 0.01×10^{-7} in./°C, from -70 to 700°C.	Measurements of metals, glasses and plastics for incoming test and research and development.
Active Ceramics (ferroelectric, piezolectric, etc.)		
PT3138 Hysteresis looper	Provides applied potential hysteresis looping for ferroelectric materials	Ferroelectrics
Fractometer	Measures fracture toughness of short bar notched samples	Ferroelectrics and other ceramics
PT3387 hydrostatic depoler	Depolarizes ferroelectric materials with pressure to 100 ksi	Ferroelectrics
Hot poler	Polarizes ferroelectric at elevated temperatures	Ferroelectrics

METALLURGY

TECHNOLOGY	CAPABILITY	APPLICATIONS
Hardness Testing		
Rockwell hardness, superficial Rockwell hardness and macrohardness measurements	Measure macrohardness of sample, surface hardness, hardness of an individual grain of material. Both metals and polymers (plastics and rubber) can be tested.	Measure hardness of material to determine if it meets material specifications.
Shore hardness tester	Shore A and D.	Measure hardness of elastomers and rubbers
Metallography		
Sample preparation equipment	Cut, mount, grind, and polish metallurgical or ceramic samples.	All metallographic or ceramographic samples.
Dexton vacuum evaporator	Vacuum deposit metal and carbon.	Preparation of nonconductive materials for electron microprobe examination. Preparation of replicas.
Technics sputtering system	Sputter deposition of metallic and nonmetallic films.	Preparation of nonconductive materials for electron microprobe examination. Preparation of replicas.
Optical microscopy - Zeiss Axiomat, Reichert MeF2X metallograph, Bausch and Lomb Balphot I metallograph, Zeiss upright microscope, Wild dual observation microscope.	Light optic observation and photography from 40 to 400X in relected light with normal, dark field, polarized and Normarski differential interferences contrast capabilities.	All specimens prepared for metallographic or ceramographic observations. Usage ranges from routine sampling to research applications.
AMR 1000A scanning electon microscope with Tracor Northern EDA	Electron optic observations and photography of materials from 5 to 300,000X, with 70 Å resolution, excellent depth of field. EDA for elemental analysis.	Any solid material 6-in. diameter by 10-in. height or less. No special sample preparation required.
Jeolco CX-100 transmission electron microscope (TEM)	Microscopic examination of replicas or specially prepared thin samples from 3,000 to 200,000X.	Prepared and replicated metallographic or ceramographic samples.
Gaton dual ion mill	Thinning of metallic and nonmetallic specimens by sputtering.	Preparation of thin specimens for examination in the TEM.
Quantimet 900 with Stereoscan 100 scanning electron microscope (SEM)	Evaluates surface features on metallographic samples and photographs.	Measurement, evaluation, and counting of selected features of sectioned welds, brazes, alloys, powders, and ceramics.

TECHNOLOGY	CAPABILITY	APPLICATIONS
Radiography		
Picker X-ray system	Locates and measures flaws inclusions, and piece parts within opaque assemblies Range 1 5-in. steel thickness or equivalent 250 kV max , 5 mA max	Nondestructive evaluation of parts and assemblies
Ultrasonics		
Tek Tran Immerscope II	Detects flaws and measures thickness of solid materials in the range 0 15 to 2 00 in Flaw size minimum diameter - approximately 0 010 in	Nondestructive evaluation of welds, braze joints, raw stock, machined parts
Nortec NDT 125 thickness gage	Measures thickness of solid materials in the range of 0 010 to 0 5 in , with digital display	Measurement of thickness of tube frame walls or sheet stock.
Scanning ultrasonic microscope Panametrics Model 5601 pulser receiver (2) Tektronix 7912 transient digitizer (2) DEK MicroVax II Computer Automation Industries 510 Tank and Midus Controller with contour following capability AeroTech 3-Axis Scanner	100 MHZ maximum operating frequency permits resolution of defects as small as one-half mil Depth profiling and real-time image enhancement with preprogrammed scanning allows semi-automatic inspection	Detects cracks, and porosity in all types of welds, voids and unbonded areas in brazes, voids and delaminations in potted assemblies and pores and interfacial defects in ceramic-to-metal seals
Eddy Currents		
NDT Instruments Vector 131	Measures thickness of metallic or nonmetallic coatings in the range of 0 to 10 mils with digital readout	Inspection of metal coatings, nondestructive evaluation of vendor-supplied platings.
Ancillary NDE Facilities		
Spatial data image enhancer	Enhances edges and discontinuities of radiographic images, magnifies radiographic images and records	Quantitative measurement of feature size and location on product radiographs Detection of previously unknown flaws

TECHNOLOGY	CAPABILITY	APPLICATIONS
Laser holometry system, 50 nW	Measures deformation of surfaces in response to various stimuli. Can detect and record displacements as small as 10 μin., approximately.	Determine location of weak spot in walls of pressure vessels.
Schlieren system	Produces visual analogs of ultrasonic beams in water.	Quantitative evaluation of ultrasonic transducers. Assistance in design of ultrasonic inspection schemes.
Radiographic darkroom	For developing radiographic films, as well as photographic plates used in X-ray diffraction, spectrographic, and TEM studies.	Development of all Engineering X-ray films and photographic plates. Backup for Manufacturing automatic film processor.
<u>Infrared</u>		
Inframetrics infrared system	Thermal radiation sensing for gross defects in materials and assemblies.	Portable system. Coating, pipes, ducts, electronic components.

COMPONENT AND PRODUCT EVALUATION

TECHNOLOGY	CAPABILITY	APPLICATIONS
Anode Voltage Critical Rate of Rise (dv/dt) Testing	Three bench setups utilizing digital oscilloscopes, pulse generators, and dv/dt testing.	Acceptance testing of silicon controlled rectifiers (SCRs)
Integrated Circuit Testing	Electrical parameters tested in various environments utilizing bench setup.	Acceptance testing of monolithic and hybrid integrated circuit.
Discrete Semiconductor Testing	Electrical parameters tested in various environments utilizing curve tracer or bench setup.	Acceptance testing of transistors, silicon controlled rectifiers (SCRs), and diodes.
Discrete Passive Component Testing	Inductance and capacitance at frequencies from 100 Hz to 10 MHz. Resistance from 1 kilohm to 100 teraohm, direct current. NOTE: Full scale ranges.	Acceptance testing of inductors, transformers, capacitors, resistors, wire, metal oxide varistors.
Dielectric Analysis	Two separate systems to measure permitivity and loss tangent for thin sheets ($<254\ \mu$) and flat plates (<8 mm) at five frequencies between 120 Hz and 1 MHz in various environments.	Acceptance testing of capacitor dielectric and ceramic insulator samples. Development of Dielectric Materials technology.
AC Hi-Pot	Detection of electrical breakdowns up to 60 kV at room temperature.	Acceptance testing of insulating materials.
Reverse Recovery Time (Trr) Testing	Bench setup utilizing a digital oscilloscope, pulse generator, power supplies and Trr fixture	Acceptance testing of diodes.
PC Board Testing	Point-to-point continuity and insulation resistance testing utilizing bench setup.	Acceptance testing of printed printed circuit boards.
Chip Capacitor Testing	Capacitance, dissipation factor and DC leakage from 100 Hz to 1 MHz at temperatures up to 150°C (except for 1 MHz), utilizing bench setup and probing station.	Acceptance testing of chip capacitors.
Oscillator Test and Analysis	Waveform parameter measurement with one part in 1025 V and time resolution repetitive. Three percent resolution on single shot waveforms from dc to 225 MHz. Frequency measurement to 8 digit resolution.	Performance verification of production assemblies.
<u>Environmental Capabilities</u>		
Vibration - both sinusoidal and random vibration	Either sinusoidal or random vibration in a temperature range from -75 to 125°C and at a force pound rating of 7000 sine, 5500 random.	Analysis of all final units, components and subassemblies.

TECHNOLOGY	CAPABILITY	APPLICATIONS
Shock - mechanical impact shock	Haversine shock pulses up to 20,000G's (0.2 ms 5 lb package), lower G levels up to 50 lb. mix.	Analysis of units, components and subassemblies.
High altitude simulation	Simulation of altitudes to 125,000 ft over a temperature range of -75 to 100°C.	Analysis of final units, components and subassemblies.
Humidity	Steady state controlled humidity or programmable temperature and and humidity conditions simulated as required via microcomputer.	Component and subassembly evaluation plus material analysis.
Temperature	Microcomputer controlled four and eight cu. ft. chambers capable of automated ramping and profiles from -75 to +125°C.	Final units, subassemblies, components, and material analysis.
Temperature shock	Mictocomputer controlled 2-zone/ 3-zone carrier transfer and temperature controlled chamber from -75 to +125°C.	Final units, subassemblies, components, and material analysis.
Rate table	Microcomputer controlled precision 22 in. rate table with a max. speed of 8,000°C capable of performing tests from -65 to +125°C and monitoring specimen electrical parameters via 30 slip ring circuits.	Analysis of accelerometers and future development projects.
Energy Storage Capacitor Test Capability	Discharge current life test, capable of 15,000 V and 75,000 A, direct current, and life test to 10,000 V; dielectric strength in a 3-Torr vacuum to 35,000 V, insulation resistance, breakdown tests to 20,000 V, all at room ambient and environmental extremes. Capacitor internal parameter measurements at high voltages.	Development of capacitor technology and analysis.
<u>Quartz Resonator Test and Analyses</u>		
Resonator Characterization	Measures resonant frequency and motional parameters of quartz resonators from 1 to 80 MHz at room ambient temperature.	

TECHNOLOGY	CAPABILITY	APPLICATIONS
Resonator Frequency and Resistance vs. Temperature	Measures the change in resonant frequency and resistance of 1 MHz to 80 MHz quartz resonators over a temperature range of -55 to 125° C with a minimum step size of 0.25° C. The upper turning point, or the temperature of minimum frequency variation, and a third order curve fit are typical outputs.	
Resonator and Clock Aging Determination	Predicts the 20-year frequency drift of a clock or resonator based on 30 days of aging. The frequency of each device operating at its upper turning point is measured with better than one part per billion precision per day. Ovens presently exist for 8 MHz, 16 MHz, 21 MHz, and 96 MHz quartz resonators and for 4 MHz, 16 MHz and 96 MHz clocks. Ovens are commercially available. Frequency measurements is capable from DC to 100 MHz.	
Clock Parameters vs. Temperature	Measures clock frequency stability during startup, clock power supply current draw and output waveform parameters of multiple output clocks from 1 MHz to 100 MHz over a temperature range of -65 to 150° C.	
Clock Burn-In	Monitors clock frequency at a constant temperature from -55 to 150° C with a frequency precision of better than one part per million and reports the date and time of a failure.	
Transistor Scattering Parameters	The S-parameter tester is capable of measuring the scattering parameters of TO-5, TO-12 or stripline transistors over the frequency range of 500 KHz to 1.2 GHz.	
Remote Cesium Beam Frequency Standard	Two long time constant local oscillators in cascade are phase locked to a remote Cesium Beam Frequency Standard accessed through the Loran-C transmission network. The phase error of each phase lock loop is continuously recorded on a strip charge for system verification. The frequency precision and stability of the standard is at least two orders of magnitude better than the most precise measurement data.	

COMPONENT AND PRODUCT EVALUATION (Continued)

TECHNOLOGY	CAPABILITY	APPLICATIONS
Defect Analysis		
Testing, failure verification; disassembly by machining, grinding, and microsectioning; chemical dissolutions; optical microscopy; macro-and micro-photography; instant color photography, including Viewgraphs, up to 8x10; scanning electron microscopy and energy dispersive X-ray analysis with image processing	Perform electrical, mechanical, and temperature tests using test chambers, meters, oscilloscopes, curve tracers, bridges, thermocouples and liquid crystals to verify defects in products, components and hybrid microcircuits. Fabricate fixtures and open specimens using milling machine, lathe, cut-off saw, hand grinders, wafering saw, grinding and lapidary polishing equipment.	Failure verification, postmortem analysis and reporting, including color photographs, on electronic components, semiconductors, hybrids and products including neutron generators, detectors, lightning arrester connectors, radioisotopic thermoelectric generators, internal vacuum switches, crystal resonators, and clocks.
	Use magnifiers, copy cameras, stereo microscopes and differential interference contrast metallurgical microscope to view and photograph, on instant film, subjects from life-size to 1000X or up to 20,000X on the SEM. Elementally identify materials, process SEM images and construct X-ray dot maps in color on the EOA	
Neutron/X-Ray Measurement		
SE-1065 Engineering digitized Data System	Measurement and analysis of transient nuclear and electrical phenomena	Acceptance testing of neutron generators. Neutron generator development.
Biomation 8100 Digitizers	6 digitizers available. Computer controlled. Measurements of 1000 samples at rates up to 10 nS./sample. Automatic calibration.	Tube-transformer assembly development.
1600 BPI tape drive	Storage and retrieval of waveforms/data.	
10 Megabyte disk drive	Storage of test parameters. Logs all activity on system.	

ADVANCED INSTRUMENTAL - DEVELOPMENT CHEMISTRY AND GAS ANALYSIS

TECHNOLOGY	CAPABILITY	APPLICATIONS
Gas Analysis		
Atlas Werke, CHIV mass spectrometer	Analysis of gases and liquids, mass range m/e 1-2400, resolution to mass 1500, detection down to 1 ppm.	Quantitative analysis of mixtures, especially hydrogen isotope analysis; qualitative analysis, identification of unknown components in complex mixtures; micro-analysis and purity test; quantitative and qualitative chromatograph; standardization of standard gas leaks.
Finnigan MAT 251 HDT mass spectrometer	Analysis of gases; ;mass range 1 to 200 resolution 1/1300; detection limit of 0.02 μl.	Quantitative analysis of gas mixtures; analysis of hydrogen isotopes outgassed from metal hydrides.
Finnigan MAT 271 mass spectrometer (magnetic sector, gas inlet system, HP9845 computer and disk drive	Analysis of gases, multiple resolution (200-2500), mass range 1-300, external source slit selection, 3 faraday cups, 1 electron multiplier, detection limit 1 ppm.	Analysis of ppm level impurities in pure gases, 200, 2500 resolution; high precision analysis of hydrogen isotopes (1300 resolution).
DuPont 21-104 mass spectrometer	Quantitative analysis of gaseous samples resolution 2000, mass range 1-1500, detection limit 0.02 μl.	Analysis of hydrogen isotopes, outgassing analysis of metal hydride occluder films.
Consolidated Electrodynamics	Analysis of gases; mass range m/e 1-150; resolution 1/200; detection 50 ppm.	Quantitative analysis of gas mixtures; purity test of bulk gas samples; gases evolved from metals heated to 900°.
200-kV linear accelerator system (Accelerator Inc., Model 200 MP Accelerator, three independent beam lines, HP data system, Ortec multichannel analyzer, particle and gamma ray spectroscopy systems.)	Nuclear reaction analysis, rutherford backscattering analysis and ion implantation with focused ion beams; analyzed beam currents up to 1 mA with singly charged energies between 20 and 200 keV; analysis chamber vacuums down to 1.2×10^{-8} torr; fast neutron production, continuous or pulsed, with fluxes up to 10^{12} per s.	Nondestructive measurements of the neutron ouptut efficiencies, hydrogen isotope content, helium-3 content and surface oxide thickness of hydride films; spatial and depth profile measurements of heavy elements in light element matrices, hydrogen isotopes and helium-3 in hydride films. Trace analysis of oxygen and nitrogen by fast neutron activation analysis in bulk materials; calibrated neutron production for neutron detector calibrations and development.

TECHNOLOGY	CAPABILITY	APPLICATIONS
Laser milliprobe	Qualitative identification and semiquantitative analysis of all trace impurities in solid insulating samples. Mass range is from lithium through uranium. Sensitivity of 10 ppb. Mass resolution 1 part in 10.000. Minimal sample preparation.	Analysis of high purity ceramics, glasses, and quartz as well as the qualitative analysis of small (15 micron diameter or larger) spots or inclusions in both insulators and conductors.
Varian VXR-300 nuclear magnetic resonance spectrometer	Analysis of liquids and solids which contain certain magnetic nuclei possessing a nuclear spin. Limits are both concentration and nucleus dependent. Most common are proton and carbon-13 analyses. Through fourier transform analysis millimolar solutions may be studied	Quantitative analysis of solutions, liquids, and solids, especially organics. Presence or absence of certain magnetic nuclei in different functional groups can be confirmed. Structural and geometric relationships among the magnetic nuclei can be examined. Reaction rates of polymers, resins, and other organic reactions, composition of plating baths and other solutions can be monitored.
Gas chromatograph/mass spectrometer	Separation. qualitative identification and quantitative measurement of the constituents of organic mixtures. Limit of detection is about 100 picogram. Mass range 1 to 15.000 AMU. Mass resolution 1 part in 50.000	Analysis of organic mixtures, gold phosphate complexes, high molecular weight polymers, measurement of solvent purities, analysis of organic pollutants in water. analysis of organic incoming solvents and materials, process solvents. etc.
Analytical quadrupole analysis system (turbomolecular pumped high vacuum system. HP data system. UTI 100C quadrupole mass spectrometer)	Analysis of gases via scanning or peak stepping. scan rate of 2 AMU per s. step settling time AMU2 to AMU300 of 1 s. sample environment of $5x10^{-8}$ torr or better, external manifold for calibration gases, external sample manifold with controlled temperature operation.	Permeation testing of vacuum materials, analysis of trace amounts of residual gases in small components. small sample outgassing studies, gas phase reaction kinetics studies.
Thermal desorption analysis system (UTI 100C quadrupole mass spectrometer, HP data system. Research Inc.	Analysis of gases, scan rate of 1 scan/s with computer data reduction 2M, sample vacuum environment of $1x10^{-7}$ torr or better, detection limit of $1x10^{-8}$ std cm^3, programmed sample temperature ramping capability from ambient to 1000°C.	Measurement of gases evolved from solid materials heated in a vacuum; measurement of tube exhaust gases. measurement of gettering characteristics of solid materials in a high vacuum environment.
JOEL 01B-M spark source mass spectrometer	Analysis of solid material; mass range 36 to 1 (e.g., m/e 7-252 in a single setting); limit of detection 0.01 ppm.	Analysis of high purity metals and thin films, semiconductors, powders. liquids and solids.

ADVANCED INSTRUMENTAL - DEVELOPMENT CHEMISTRY AND GAS ANALYSIS (Continued)

TECHNOLOGY	CAPABILITY	APPLICATIONS
X-ray diffraction/micro-diffraction	Identification of crystalline phases for specimens as small as 30 μ; quantitative determination of phases; surface residual stress measurements.	Metal hydride identification; RTG Si-Ge alloy composition; incoming inspection; shelf life studies.
X-ray emission	Qualitative and quantitative analysis of elements $Z > 14$; film thickness measurements.	Incoming inspection; film areal density measurements; materials identification.
EDA	Rapid, nondestructive identification and analyses $Z > 20$; nondestructive film thickness and gas content measurements in tritided films.	Incoming inspection; film areal density measurements; identification and sorting of materials.
Electron microprobe	Qualitative identification and quantitative analysis of elements $Z > 6$, especially particulates in the range of ~100Å and greater; small area film thickness measurements, X-ray mapping and secondary electron backscatter photographs.	Areal density measurements; Quasi-metallize thickness; particulate contamination identification; diffusion studies.
Auger/ESCA/SIMS	Nondestructive characterization of solid surfaces; detects less than 0.1 monolayer of surface atoms; ESCA/Auger sensitive to all elements atomic number 3 and greater; quantitative indication of elemental spatial distribution; 5-μm point analysis; depth composition using inert gas sputtering; information on surface topography; performs elemental mapping; obtain photographs using secondary electron backscattering and absorbed current. Provides chemical bonding information; SIMS detects all elements and their isotopes; provides ppb elemental sensitivity.	Chemical analysis of surfaces, evaluation of surface conditions after processing, sputtering and depth profiling; evaluation of cleaning and degassing procedures; point analysis of small areas; element maps for detailed comparison of elemental concentration; determine location of impurities on surface; characterize solid-solid-gas interfaces to obtain information about the chemical state and bonding processes; study effects of surface reactions such as solid-gas reactions in the oxidation of metals; determine distribution of hydrogen isotopes in materials.
Airborne particle counter - Royco 220	Quantitative analysis of airborne contamination levels; sizes and counts particles in 0.5, 1.0, 2.0, 5.0, 10.0, and 15.0μ range/ft^3 of air; capable of collecting data in in data processing tape form.	Determine airborne contamination levels in a form comparable to Federal Standard 209B; dynamic collection of particulate contamination information.

ADVANCED INSTRUMENTAL - DEVELOPMENT CHEMISTRY AND GAS ANALYSIS (Continued)

TECHNOLOGY	CAPABILITY	APPLICATIONS
Airborne particle counter - Royco 245	Quantitative analysis of airborne contamination levels; sizes and counts particles in 0.5 to 20.0 μ range/ft^3 of air.	Determine airborne contamination levels in a form comparable to Federal Standard 209B; stationary monitoring of clean rooms.
Airborne particle counter - Royco 245 commuter interface	Same as above plus collected data can be processed and plotted to allow easy interpretation of data.	Determine airborne contamination levels in a form comparable to Federal Standard 209B; stationary monitoring of clean rooms.
EPI fluorescence microscope Olympus Vanox	Microfluorescence observation of opaque and nonopaque materials by illumination with ultraviolet, violet, blue and green light at magnifications of 120 to 1200X; photomicrographic, CCTV and video taping capabilities are provided.	Differentiation of particulate and fibrous materials undistinguishable by more usual microscopic methods; detection and quantification of bacteria, pyrogens and contamination associated with deionized water systems, surfaces and production processes.
Microscope - brightfield/ darkfield/EPI - Normarski interference contrast - Olympus Vanox	Sizing and counting of collected particulate matter, magnification up to 400X (1000X with EPI Normarski); used to study the morphology and characteristics of discrete particulates and surficial contamination; has photographic, CCTV, and video taping capabilities.	First line of identificaton of unknown contaminants; can be used independently or in conjuction with other laboratory instrumentation; also, optical micrometry to approximately 0.5 μ and percentage areal analysis of surfaces.
Polarizing microscope - Olympus Vanox	Qualitative and quantitative determinations of the optical characteristics of nonopaque microspecimens at magnifications up to 1000X; used to observe morphology of internal structures or microstresses within crystalline and noncrystalline transparent materials; has photographic, CCTV, and video taping capability.	Identification of nonopaque particulates and fibrous materials; refractive index determinations of transparent solids; optical micrometry and angular measurement of microscopic features.
Polarizing microscope - Wild M-20	Thermomicroscopic determination a continuous observation of material behavior at controlled temperatures to 360°C and at magnifications up to 400X; optional polarization capability affords greater accuracy and allows for enhanced monitoring of minute changes in internal morphology of nonopaque materials.	Individual and mixed melting point determinations of microgram scale samples; dynamic behaviour studies of materials at elevated temperatures; purification of minute samples by sublimination.

GENERAL CHEMISTRY SERVICES

TECHNOLOGY	CAPABILITY	APPLICATIONS
Total organic carbon analysis	Quantitative analysis of water for organic carbon (50 ppb to 2 ppm)	Determine organic carbon levels in DI process and product water
Liquid scintillation Counters, two Beckman series 5800	Quantitative analysis for alpha, beta, and gamma emitters in liquid samples, measurements of activities due to tritium at pci/ml levels and 10 percent counting error.	Determination of activities due to tritium in environmental, bio-assays and smear samples
Alpha spectrometer	Determination of activities due to alpha emitting isotopes in the 4 0 to 6 0 MeV energy range	Determination of environmental levels of plutonium isotopes in air soil water an bioassays
LASS I alpha scintillation	Measures gross alpha particles	Plutonium contamination monitoring
Beta, gamma counter	Measures low levels of radiation due to Beta or Gamma emissions.	Sealed, radioactive sources, fallout samples, and lead probes
Absorption/Emission Spectrometry		
Atomic absorption/flame emission spectrophotometer, Perkin-Elmer Model 5000 with Zeeman graphite furnace accessory	Quantitative determination of metal concentrations as ppm levels in solution by flame AA or at ppb levels in solution by graphite furnace AA	Chemical analysis of metals glasses, and ceramics, trace impurity analysis in environmental samples and plating baths, precision thin film measurements
Optical emission spectrograph Bausch and Lomb dual grating 1 5-m spectrograph with Zeebac arc source and Apex arc stand	Semiquantitative multielement analysis of chemical constituents and impurities at trace ad ultra-trace levels in solid samples	Quality control of incoming materials and metallize powders, first test performed for identifying unknown inorganic residues
Inductively coupled plasma-atomic emission spectrometer, Instruments SA, Inc Model JY-38VHR sequential spectroanalyzer	Multielement chemical determination of metals and some nonmetals at subpart per million levels in solution, measures five elements per min with a precision of better than 1 percent (R S D)	Measurement of trace metal impurities at ppb levels in solvents and materials, analysis of high purity metals and alloys, thin film analysis at microgram levels.
Atomic fluorescence spectrometer, Baird AFS/ 2000 with automatic sample changer	Quantitative determination of metals and some nonmetals at ppm levels in solution; simultaneous measurement of up to 12 elements	Chemical analysis of metallize powders, glasses, ceramics, and various alloys; analysis of environmental samples for trace impurities, analysis of plating baths for major and minor constituents and trace impurities
Calorimetry and Electrochemistry		
Adiabatic calorimeter, Parr Model 1241 and 1243	Measurement of heat of combustion and heat of reaction of sample sizes in the range of 500 to 5000 calories	Determination of calorific output of thermal battery heat pellets, heat papers, and other heat source materials, characterization of iron powders

GENERAL CHEMISTRY SERVICES (Continued)

TECHNOLOGY	CAPABILITY	APPLICATIONS
Polarographic analyzer EG and G Model 384	Differential pulse polarography and differential pulse stripping analysis, normal pulse polarography, normal pulse stripping, dc polarography and linear sweep voltometry.	Quantitation of electrochemically active ions in solution at trace levels; analysis of soluable incoming materials, sovents, battery materials, plating bath impurities and environmental samples.
Spectrophotometry		
Infrared spectrophotometer/ Perkin-Elmer Model 283B	Provides structural identification information of organic and inorganic solids, liquids, and gases; can detect absorbing species down to microgram levels.	Verification of incoming materials solvents; defect analysis and characterization of resins and polymer systems; analysis of contamination control and environmental health samples.
Fourier transform infrared spectrometers, Nicolet Model 20-SX, and Nicolet Model 5SX-B.	Performs identification of organic and inorganic solids, liquids, and gases at trace levels; spectral substraction, integration, peak picking, baseline correction, and spectral library searching.	Quantitative measurement and molecular structure identification of incoming materials; characterization of polymers, glass-ceramics sol gel glasses, battery materials and ferroelectrics.
Ultraviolet (UV)/visible spectrophotometer, Beckman Acta MVI spectrophotometer	Quantitative determination of metals and nonmetals in solution with high precision and accuracy; sensitive down to ppm levels.	Characterization of metals and alloys; precision thin film measurement and calibration; analysis of pollutants in water and air samples.
Chromatography		
High performance liquid chromatography, Waters Associates Model 224 with refractive index and UV detectors	Provides liquid/solid (absorption), liquid/liquid (partition), ion exchange and gel permeation (size exclusion) modes of separation for complex mixtures of liquids and/or solids.	Qualitative and quantitative characterization of polymer systems, water pollutants and transformer fluids.
Gas chromatography, Perkin-Elmer Model 2000 with flame ionization, thermal conductivity, and electron capture detectors; and Tekman Model LSC-2 liquid sample concentrator	Separation and identification of volatile compounds in complex mixtures, and concentration of ppb components for separation and identification.	Identification and quantitation of volatile organic components and contaminants; measurement of incoming solvent purity; analysis of organic pollutants in water, wastewater, and air samples.
Gas chromatograph, Varian Model 3700 with thermal conductivity and electron capture detectors	Separation and quantitative measurement of volatile halogenated organics down to ppb levels.	Analysis of wastewaters for chlorinated organics and PCBs in in and oil samples.

TECHNOLOGY	CAPABILITY	APPLICATIONS
Gas chromatograph, Perkin-Elmer Model Sigma 2000 with flame ionization thermal conductivity and electron capture detectors	Separation, identification and quantitative measurement of mixtures of gases and volatile compounds, headspace analysis	Quantitative measurement of LAMB cell gages
Ion chromatograph, Dionex Model 16 with conductimetric and electrochemical detectors	Separation and quantitative detection of organic and inorganic anions and cations in aqueous media	Quality control analysis of incoming materials, chemicals and solvents, analysis of ionic pollutants in water and air samples, characterization of battery materials
Thermal Analysis		
DuPont 990 and 1090 thermal analyzers equipped with high pressure differential scanning calorimeter, dual sample differential (-200 to 750° C), scanning calorimeter, intermediate differential thermal analysis (DTA) cell (-200 to 800° C) high temperature DTA cells (0 to 1200° C and 0 to 1600° C) thermomechanical analyzer (TMA) and thermogravimetric analyzer (TGA)	Determination of heat of reaction glass transition temperature specific heat, crystallization temperature, melting and boiling points, degree of cure of polymer, coefficient of thermal expansion, and quantitative weight change as a function of temperature	Characterization of ferroelectrics varistor materials, glass ceramics sol gel glass, thermal battery materials, and polymer systems
DuPont Model 903H moisture evolution analyzers (two)	Determination of moisture in organic and inorganic solid materials as a function of temperature	Quantitative measurement of moisture content of polymers PZT glasses thermal battery materials and polymer systems
Elemental analyzer Perkin-Elmer Model 240B	Quantitative microanalysis of organic and inorganic materials for percent carbon, hydrogen, and nitrogen	Quality control measurement and characterization of resins and polymers, technique for studying polymer mixing and extent of reaction
Thermometric titrator, Sanda Model DVR thermotitration system	Automatic and fast thermometric titrations for measuring acid base, redox and precipitation titrations	Characterizations of incoming materials thermal battery materials and plating baths
Surface Area Analysis		
Monosorb surface area analyzer Quantachrome Corp Quantasorb surface area analyzers Quantachrome Corp (two)	Surface area measurements on powders using both the modified single point and multipoint BET techniques, allows measurements of average pore volume pore size distribution adsorption and desorption isotherms true powder density permeametry and average particle size for nonporous powders	Powder characterization and quality control of powder grinding including ceramics metallize powders, and thermal battery materials

TECHNOLOGY	CAPABILITY	APPLICATIONS
Classical Methods and Instrumentation		
Gravimetric, volumetric, ion exchange	Quantitative elemental analysis of materials for purity, composition, and trace impurities.	Inorganic and organic incoming materials and solvents capable of dissolution.
Automatic titrator, Metrohm Model 636 titroprocessors (two) with autosamplers	Performs automatic pH_2 colorimetric or potentiometric titrations, recording the volume-potential curve or the first derivative.	Application in all precision volumetric analyses for supporting incoming inspection and production.
Kjeldahl nitrogen analyzer, Tecator digestion/distillation apparatus	Quantitative measurement of total nitrogen in organic and inorganic materials.	Measurement of nitrogen content in polymer materials and nitrogenated phosphate glasses.
Digital pH/mV meter with automatic restandardization, Orion Research Model 801A, Corning pH/ion meter	Precision potentiometric and pH measurements and trace ion analyses with specific ion electrodes.	Measurement of pH and inorganic ions in incoming materials and solvents; chemical characterization of battery materials; anion impurity analysis.
pH meter, Sargent-Welch Model LS	pH measurements to 0.01 pH unit.	pH measurement of incoming materials and solvents.
Carbon/sulfur analyzer (LECO)	1 ppm carbon or greater; 10 ppm sulfur or greater.	Carbon and sulfur in metals.
Moisture analyzer, Photovolt	Quantitative measurement of moisture content in the ppm range.	Moisture content on incoming, production, and development liquids and solids.
Carbon dioxide (CO_2) Apparatus	Quantitative analysis for CO_2 from 0.01 to 10 percent.	CO_2 content of inorganic compounds.
Air/Helium Pycnometer	Density determination on particulate materials to 0.1 cm^3, 0.1 g/cm^3.	Density measurement of production and development materials.
Flash point tester, Fisher Scientific Co.	Measurement of flash point of organic solvents.	Incoming solvents and materials, environmental samples, production process solvents.