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LABCOM RESONATOR PHASE III FINAL REPORT

Contract Numbers 79-EDTL-DLM-01, 79-19587, 79-19449

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ABSTRACT

The purpose of this project was to develop quartz crystal resonator designs, production processes, and test capabilities for 5-MHz, 6.2-MHz, and 10-MHz resonators for Tactical Miniature Crystal Oscillator (TMXO) applications. GE Neutron Devices (GEND) established and demonstrated the capability to produce and test quartz crystal resonators for use in the TMXO developed by the U.S. Army ERADCOM (now LABCOM). The goals for this project were based on the ERADCOM statement of work.

The scope of work indicated that the resonator production facilities for this project would not be completely independent, but that they would be supported in part by equipment and processes in place at GEND used in U.S. Department of Energy (DOE) work. In addition, provisions for production test equipment or for eventual technology transfer costs to a commercial supplier were clearly excluded from the scope of work.

The demonstrated technical capability of the deep-etched blank design is feasible and practical. It can be manufactured in quantity with reasonable yield, and its performance is readily predictable. The ceramic flatpack is a very strong package with excellent hermeticity. The four-point mount supports the crystal to reasonable shock levels and does not perturb the resonator's natural frequency-temperature behavior. The package can be sealed with excellent yields. The high-temperature, high-vacuum processing developed for the TMXO resonator, including bonding the piezoid to its mount with conductive polyimide adhesive, is consistent with precision resonator fabrication.

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INTRODUCTION

The purpose of this project was to develop quartz crystal resonator designs, production processes, and test capabilities for 5-MHz, 6.2-MHz, and 10-MHz resonators for Tactical Miniature Crystal Oscillator (TMXO) applications. The resonators are intended to meet the U.S. Army Electronics Technology and Devices Laboratory (ETDL) technical requirement, "Development of a Tactical Miniature Crystal Oscillator" dated March 17, 1978, and the requirements stated in Drawing No. 404B046 from the Bendix Corporation.

Under Contract Nos. 79-EDTL-DLM-01, 79-19587, and 79-19449, GE Neutron Devices (GEND) established and demonstrated the capability to produce and test quartz crystal resonators for use in the TMXO developed by the U.S. Army ERADCOM (now LABCOM). The goals for this project were based on the ERADCOM statement of work, "MM&T for Processing High Stability Quartz Crystal Units," dated August 8, 1979 (see Appendix A). Four areas of work were requested in the statement as follows:

- Expand the capabilities of the ceramic flatpack production facility to accommodate the HC-XM49/U style flatpack. (Figures 1 and 2 show the two types of resonator packages.
- Establish a plan to manufacture a TMXO resonator for $65 (1979 dollars), develop commercial sources for piece parts, and implement cost-effective aspects of the plan.
- Evaluate replacement conductive adhesives and qualify at least one of them.
- Deliver reports and drawings and deliver 400 engineering samples, 80 confirmatory samples, 700 pilot line samples, and equipment and tools.

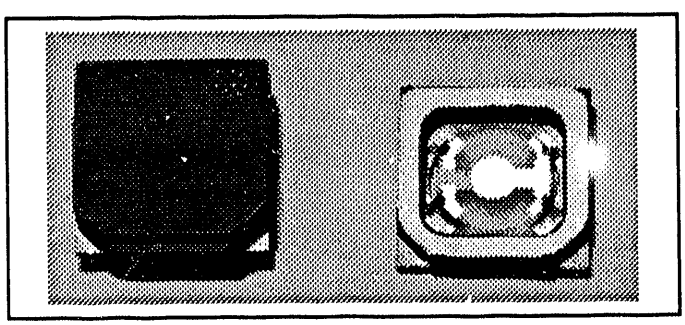


Figure 1. Ceramic Flatpack Crystal Resonator Package of Prior Work

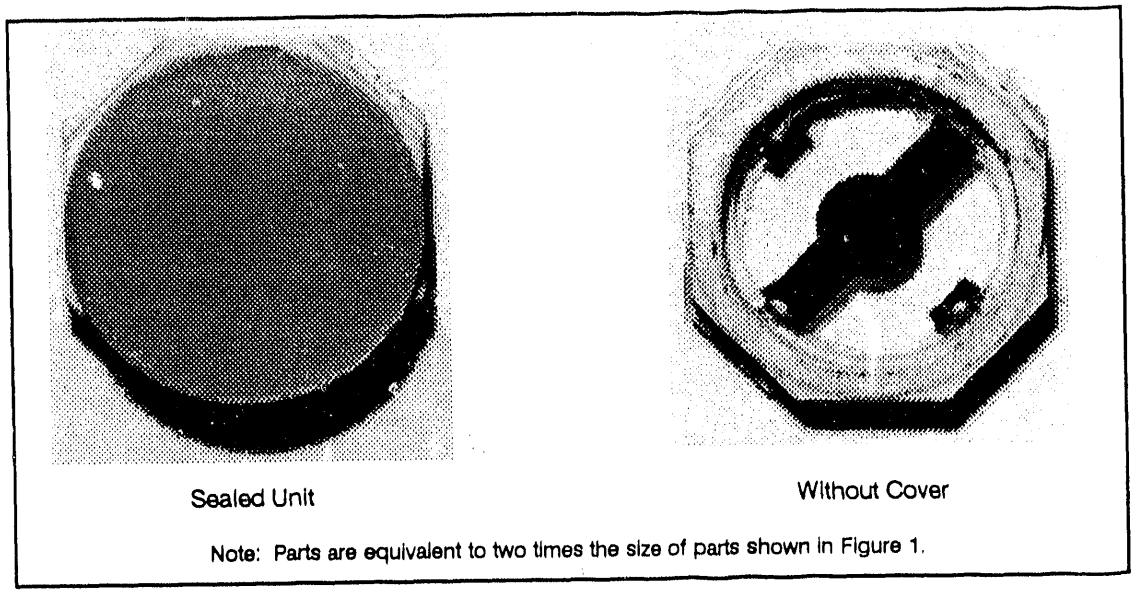


Figure 2. HC-XM49/U Flatpack Crystal Resonator Package Used in Current Work

The military product specification for the TMXO resonator (dated August 1979) is included in Appendix B of this report. The following details selected from the TMXO product specification highlight the technical goals of the work:

- Type designation: CR-(XM-151)/U
- Evacuated package: 1E-6 torr
- Shock induced frequency shifts: less than 1E-9
- Frequency sensitivity to vibration: less than 1E-9 per G
- Package hermeticity: 1E-10 std cc/sec or better
- Short-term frequency stability: 1E-11 from 1 to 1200 s
- Long-term frequency stability: less than 2E-10 per week

In May 1980, GEND responded to ERADCOM with a cost estimate which identified the funds required and defined the scope of work for the Phase III TMXO resonator program. This document, included in Appendix C, was updated on June 24, 1981.

The scope of work indicated that the resonator production facilities for this project would not be completely autonomous, but that they would be supported in part by equipment and processes in place at GEND used in U.S. Department of Energy (DOE) work. In addition, provisions for production test equipment or for eventual technology transfer costs to a commercial supplier were explicitly excluded from the scope of work.

BACKGROUND

ERADCOM set goals for the TMXO crystal in the draft military specification, "Ceramic Flatpack Enclosed Quartz Crystal Resonator for Tactical Miniature Crystal Oscillator Assemblies," dated August 6, 1979 (see Appendix B).

Principal design features included:

- Ceramic flatpack style case
- Precision third and fifth overtone thickness/shear design
- Conductive polyimide cement to ribbon mount.

Principal performance goals were:

- Short-term frequency stability: 1 E-11 from 1 to 1200 s
- Long-term frequency stability: 2 E-10 per week
- Frequency temperature hysteresis: 3 E-9.

Principal processing features were:

- Complete in-vacuum tuning and sealing
- High temperature processing

GEND had previously established a pilot production capability which incorporated the essential features proposed for the TMXO resonator. It had been installed to manufacture and test 20-MHz ceramic flatpack resonators for ERADCOM under Contract No. 79-EDTL-MQ-01. This previous work will be referred to as "Phase II" activity.

The pilot production capability employed a vacuum system called the Quartz Crystal Fabrication Facility (QXFF), which baked-out, tuned, and sealed ceramic flatpack resonators, maintaining them at all times in a high-vacuum, high-temperature environment. A photograph of this system is shown in Figure 3. Descriptive sketches are shown in Figures 4 and 5. Substantial modifications prepared the QXFF to finish the larger format TMXO resonator.

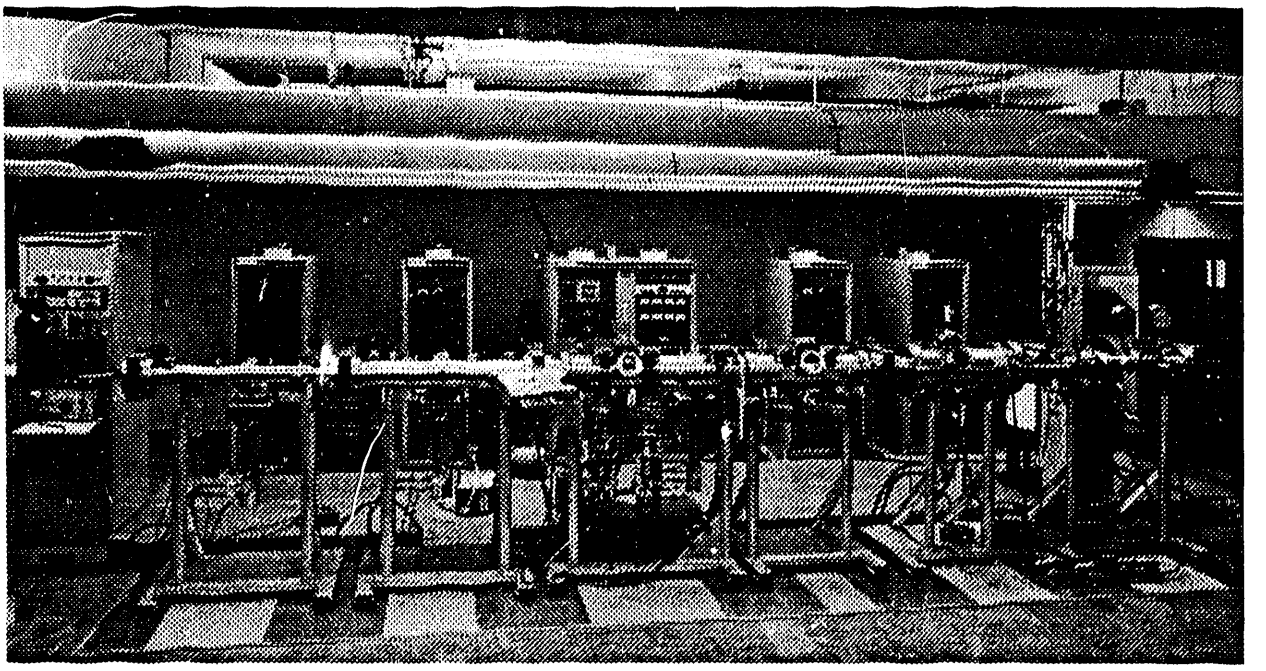


Figure 3. Quartz Crystal Fabrication Facility

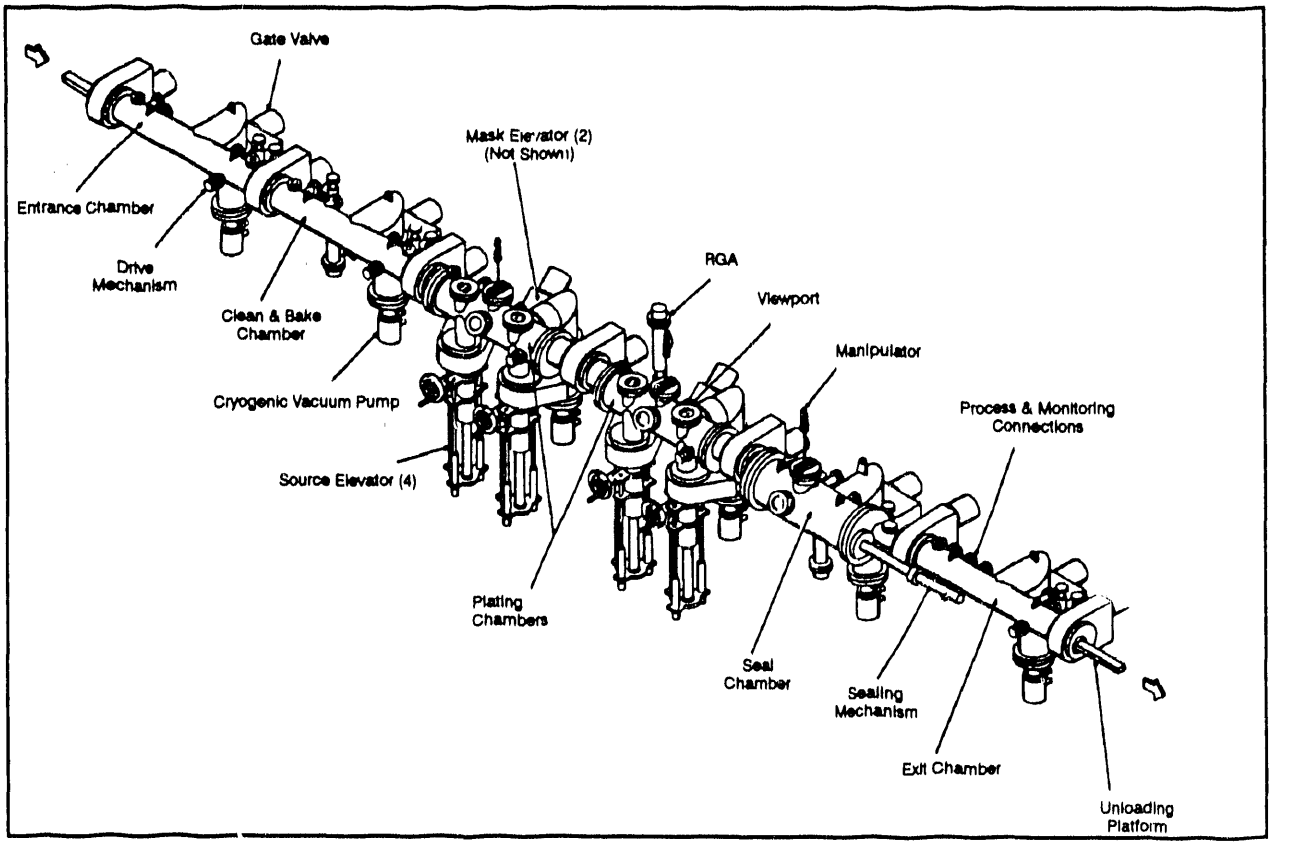


Figure 4. An Isometric Sketch of the (24-foot long) QXFF System, Denoting the Five Chambers

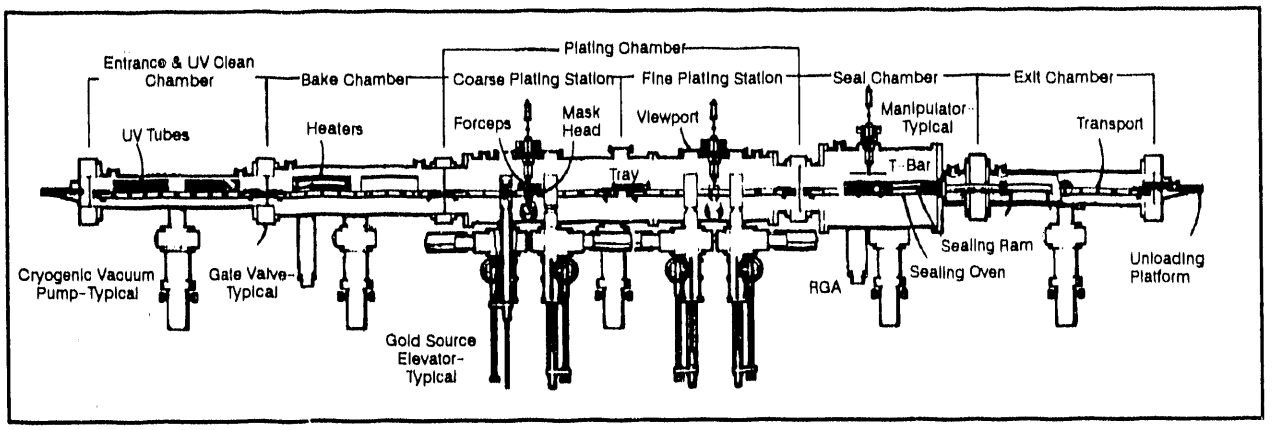


Figure 5. Cross-Section Sketch With Detail to the Inner Workings of the QXFF

DESIGN SIMILARITIES TO PHASE II

In GEPP-FR-677, "ERADCOM Resonator Phase II Final Report," dated July 15, 1984, the ceramic flatpack resonator technology at GEND was presented in substantial detail. In that report, the design philosophy, the realization of the design, the process technology, and the process results were given in the context of the ceramic flatpack enclosed 20-MHz fundamental mode AT (a two letter designation of crystal cut) resonator. The current Phase III TMXO work is based greatly on the experience of Phase II. Issues discussed in this report relate primarily to the 10-MHz, third overtone TMXO flatpack crystal unit. Specifically, the differences between current and prior work will be emphasized.

DESIGN PRINCIPLES

The design of the TMXO resonator, like its predecessor, was primarily the responsibility of ERADCOM. The development of parts, technology, and vendor sources was primarily the responsibility of GEND. Materials were chosen to be compatible with processing temperatures above 350°C and vacuum levels below 1E-7 Torr. The essential principles of strict attention to cleanliness and high-temperature, high-vacuum processing, which were employed in Phase II, were also employed in Phase III.

EQUIPMENT AND PROCESSES

GENERAL PROCESSING EQUIPMENT

Nearly all of the equipment needed to process and assemble the Phase III resonator was in place either from previous or concurrent work. It may be described as either special purpose process equipment, or general purpose equipment.

General purpose equipment is listed below. The general purpose equipment will not be discussed further, unless details of its operation are considered important to the process and were not presented in the Phase II report. This equipment includes:

- Various process ovens
- U/V ozone cleaners
- Wet-cleaning stations
- Clean assembly benches
- Brazing furnaces
- Vacuum-firing furnace
- Electroplating baths
- Screen print, dry and fire equipment
- Inspection microscopes and instruments
- Environmentally-controlled storage .
- E-beam thin-film deposition systems
- Water drop contact-angle goniometer

SPECIAL PURPOSE PROCESSING EQUIPMENT

Some of the processing equipment is special to resonator fabrication and had to be constructed or modified to accommodate the 14-mm diameter blank employed in the Phase III resonator. This equipment is discussed in the following paragraphs.

Braze Fixturing

Molybdenum clips support the quartz wafer in the ceramic flatpack. The clips are formed from ribbons which are brazed to the metallizations. Ceramic braze fixtures establish and maintain precise alignment of the ribbons on the ceramic frame as they are brazed in place. These fixtures are typical and are fabricated at GEND.

Clip Punch and Form Tooling

After the molybdenum ribbons are brazed in place, they are cut to the correct length and bent to form the resonator mounting clips. The punch must be carefully maintained in order to shear the 0.001-in thick molybdenum ribbon without leaving burrs.

Gasket Press

The pneumatic gasket press assembles a gold gasket to the gold plated seal area of the ceramic covers. It simply coldwelds the gasket to the cover slightly, permitting the cover/gasket assembly to be handled as a unit in further processing. The Phase III press is a larger model of the one used in Phase II.

QXFF Carrier and Sealing Boats

The parts carriers used to transport the resonators from station to station through the QXFF were redesigned to fit the larger ceramics. In principle and in practice they are enlargements of Phase II carriers. They were designed to minimize the need for modifications to the QXFF itself.

Contact Fixtures

Before the quartz wafer is cemented into its frame, it must have thin film metallization deposited onto its four mounting areas shown in Figure 6. Like its predecessor, the Phase III resonator uses a molybdenum/gold contact metallization. The masks that hold the quartz wafers in the deposition system and define the deposited film pattern need only to accommodate the 14-mm diagram blank.

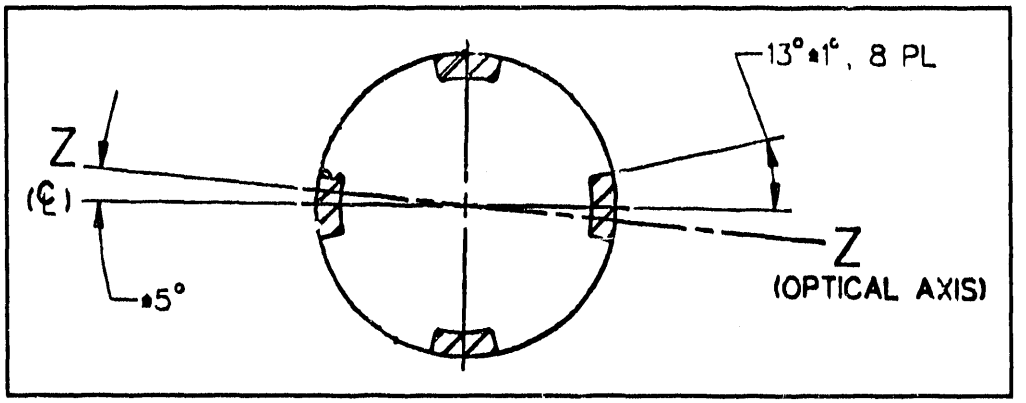


Figure 6. Contacted Blank

QXFF

The quartz crystal fabrication facility required modifications to handle the larger format resonator. Those modifications are exemplified by the manipulator that transfers each resonator from the carrier tray into the course electrode deposition and the fine tuning stations while the QXFF stays at ultrahigh vacuum. The modified manipulator is shown in Figure 7, and the original version is shown in Figure 8 for comparison.

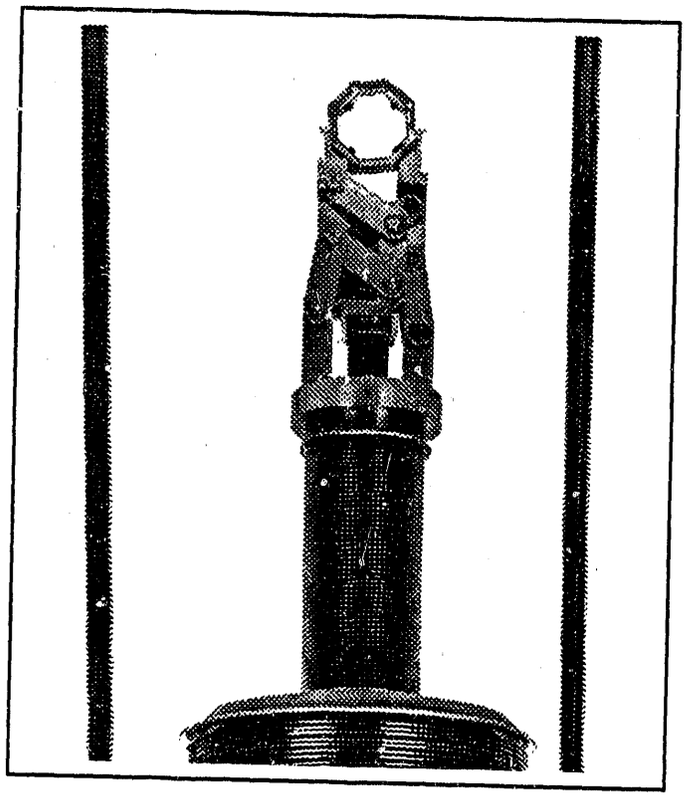


Figure 7. Modified Manipulator

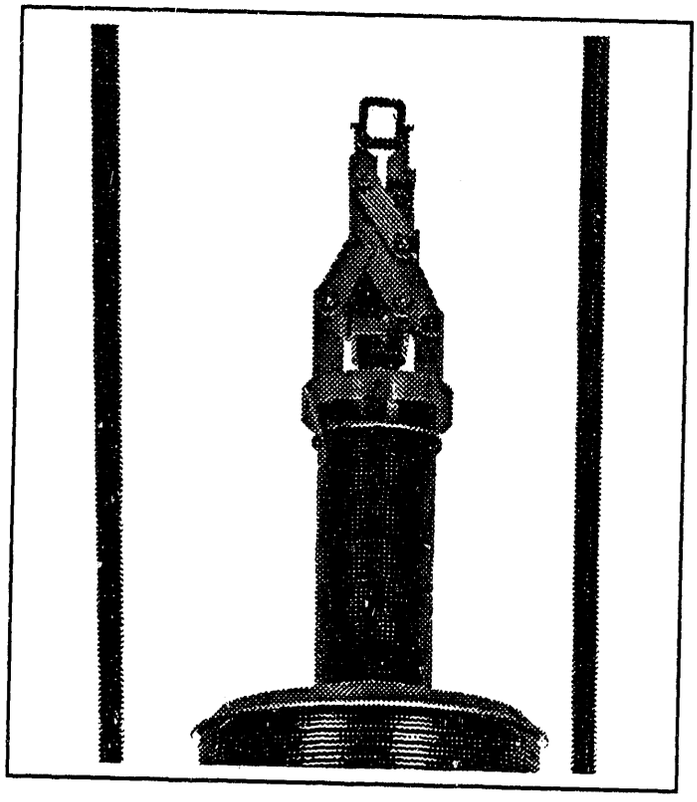


Figure 8. Original Version Manipulator

Etch, Rinse, and Spin Dry Equipment

The crystal carrier used in the wet processing, cleaning, and etching of the wafers is a commercially available carrier used without modification (Fluoroware, Inc., Catalog No. A-16-01). Other process equipment for etching, wet cleaning, and drying the blanks is unchanged from that used in Phase II.

Contact Angle Goniometer

The waterdrop contact-angle goniometer is used to evaluated the effectiveness of quartz blank cleaning process. It is used routinely for all resonator production at GEND and is unchanged from Phase II.

PIECE PARTS AND MATERIALS

As shown on the process flow chart in Appendix D, the resonator comprises seven major piece parts. These parts are discussed in the following paragraphs, and the drawings for these parts are included in Appendix E.

LAMINATED FRAME

The laminated frame is shown in Figure 9 (Drawing No. 46C926307 in Appendix E). Design and fabrication of this ceramic frame employs the same principles and techniques as did its smaller predecessor. It is a three-layer laminate of high alumina ceramic. The tungsten metal feedthroughs are printed onto the bottom layer before the layers are stacked and fired.

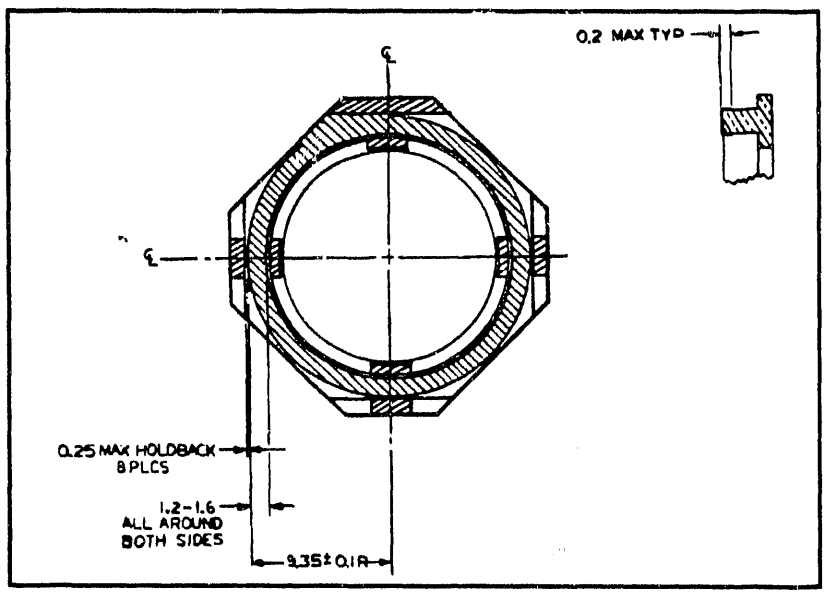


Figure 9. Frame Processed

A critical feature of this package is the flatness of the top and bottom sealing surfaces. Sealing yields are highly dependent on the flatness of these surfaces.

There are two types of metallization used on the package. For metallized areas that must be co-fired with ceramic, tungsten is used. GEND buys frames with the tungsten metallization in place as shown in Figure 10. The frames include the feedthroughs. Those metallizations that are applied after firing the ceramic are performed either by the vendor or by GEND. The surfaces are first screen-printed with a molybdenum/manganese/titanium conductive metallization and then gold electroplated. The surfaces include the sealing surfaces on the top and bottom of the frame. The metallizations done at GEND are detailed in Drawing Nos. SS284790 and SS329971, Appendix E.

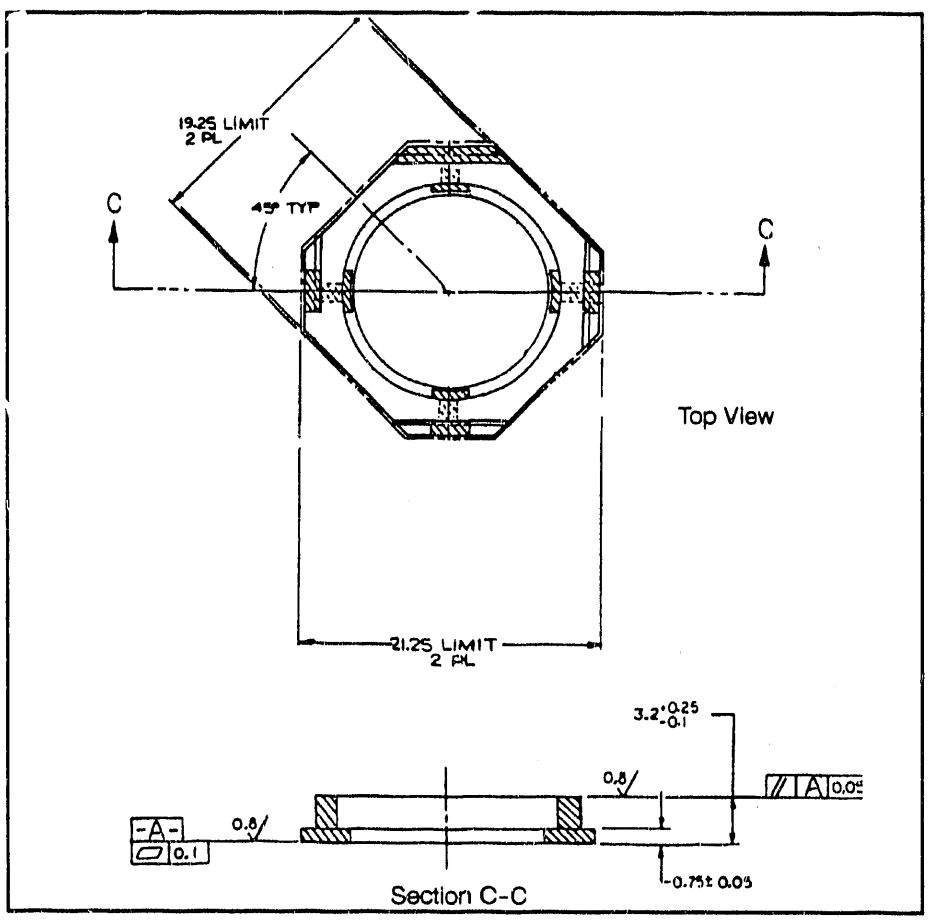


Figure 10. Laminated Frame

CERAMIC COVER

The ceramic cover is shown in Figure 11a and in Appendix E, Drawing No. 46C924946G1. The cover is a single thickness of ceramic, the same type used in the frame. No co-firing of metallization is necessary, as in the case of the frame. The metallization of the sealing surfaces is screen printed with molybdenum/manganese/titanium and then gold electroplated following the same procedures used in metallizing the laminated frame shown in Figure 11b.

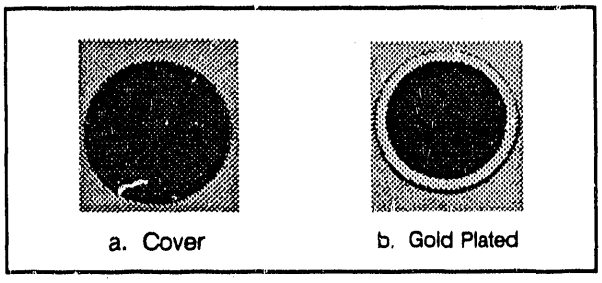


Figure 11. Ceramic Cover

The flatness of the cover is essential to successfully sealing the package. A warped cover will crack when the sealing pressure is applied to it. Grinding or lapping the cover is not necessary if the part flatness meets the drawing requirements as fired. The purity of the electroplated gold and the cleanliness of the gold surfaces are also important for successful sealing.

QUARTZ BLANK

The quartz blanks used in this work are described in Drawing Nos. 46A924940, 46A926845, 46A926846, 46A926922, and 46A927146, in Appendix E. LABCOM explored the advantages of 5-MHz and 10-MHz designs in both AT- and SC-cut resonators. Most of the designs were etched about 15 "f-squared." (For example, the 10-MHz, third overtone units were etched such that their fundamental frequency increased by approximately 155 kHz from its final polish frequency.) All of the blanks were 14 mm in diameter. Blanks were prepared by several vendors and were supplied to GEND by LABCOM. Mounting the blank in the ceramic frame, tuning the resonator to frequency, and sealing the package were done independently of the blank design. Details of these processes are given in Appendix E.

MOLYBDENUM MOUNTING CLIPS

Drawing No. 46A924943 in Appendix E gives details of the mounting clips that support the quartz element. The resonator blank is supported by four clips equally spaced around its periphery. The clips are formed from gold-plated molybdenum ribbons that have been brazed to metallized areas on the ceramic frame (Figure 12a). The ribbon is 0.060-in wide and 0.001-in thick. After forming, the four clips provide four coplanar pads to which the blank is cemented (Figure 12b).

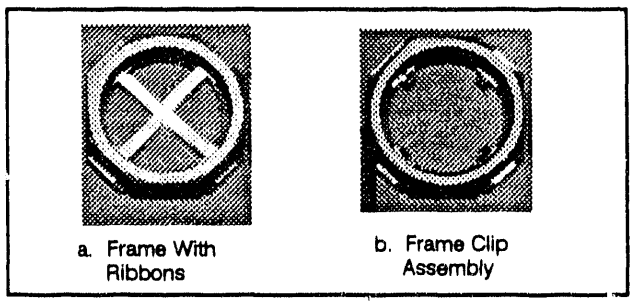


Figure 12. Mounting Clips

POLYIMIDE CEMENT

The polyimide cement is described in Drawing No. 46A923763 in Appendix E. The resonator blank is cemented to the molybdenum clips with silver-filled conductive polyimide. It is the same adhesive used in the fabrication of Phase II resonators and is used for the same reasons, i.e., high-temperature stability and low outgassing.

BRAZE WASHERS

The braze washers are described in Drawing No. SS268140-200 in Appendix E. The molybdenum clips are brazed to the metallization on the ceramic using a conventional braze alloy of nickel, copper, and silver.

SEALING GASKET

The sealing gasket is described in Drawing No. 46A924945P1 in Appendix E. A pure gold sealing gasket forms the seal between the gold metallized frame and each lid. The gasket is a thin loop of rectangular cross-section gold wire. It is punched from sheet material because it must be seamless. The gasket for this work was scaled-up in size from Phase II, but performs exactly the same way.

TESTING

In-process inspection points are shown on the flow chart in Appendix D, and the requirements are given in the associated drawings. In-process tests are for process control only.

Many of the "tests" shown are environmental treatments with the operating characteristics of the crystal units measured before and after the treatments to evaluate their effect.

- Bondability (frames)
- Visual and mechanical inspection
- Seal (Radiflo*)
- Characterization of electrical parameters
- Accelerated aging (120°C, 168 hours)
- Unwanted modes
- Slew (frequency and resistance versus temperature)
- Thermal frequency repeatability
- Thermal time constant
- Thermal shock

*Trademark, Iso Vac Engineering

- Vibration
- Shock
- Aging
- Short-term stability
- Nuclear survivability

PHASE III ACTIVITY

RESONATOR DESIGN

Description

The TMXO resonator package (HC-XM49/U) accommodates a 14-mm diameter crystal blank and, therefore, is roughly equivalent to the HC-6 style crystal holder and is adapted to similar applications. The finished crystal unit enclosure is an octagonal ceramic flatpack about 20-mm across and 6-mm thick. Four edge tabs at 90-degree angles to one another are metallized to provide electrical contacts to hermetic feedthroughs.

Package

The high density alumina ceramic package consists of an octagonal frame and a top and bottom lid. Each ceramic lid is about 1-mm thick, and the frame is about 4 mm. Tungsten feedthroughs are fired into the ceramic frame, and matching annular zones are screened onto both the lids and the frame to provide metal-to-metal seal areas for final package closure.

Resonator Blank

While several successful designs have been tested, most TMXO resonators built have been 10-MHz, third overtone SC designs developed by the ETDL. Precision crystal techniques and processes have been employed universally.

Mount

The final TMXO resonator design employs a four-point, 90-degree ribbon mount. The molybdenum ribbons are brazed to metallized contacts inside the ceramic frame. The 0.001-in thick by 0.060-in wide molybdenum ribbon provides high lateral stiffness along with high radial compliance which makes it a strong, yet low-stress mount.

The quartz blank is cemented to the mount with silver-loaded conductive polyimide. Polyimide was chosen in earlier work for its combination of strength, high-temperature resistance and low outgassing.

RESONATOR PROCESSES

General

Most of the processes described below were developed in Phase II work (reference GEPP-FR-677). The processes are shown in Table 1. This report will focus on the changes that were necessary in order to accommodate the larger package and resonator blank. Current process specifications and drawings are provided in Appendix E. The guiding principles were similar to those developed earlier: continuous high-vacuum processing, extensive use of UV/Ozone cleaning, and clean room handling techniques.

Blank Preparation

In all activity, blanks were prepared and supplied by the U.S. Army ETDL or were purchased in their final surface condition which met ETDL specifications. The blanks had either a standard, or deep etch, chemically polished finish.

Blank preparation at GEND, therefore, was confined to cleaning and to the vacuum deposition of molybdenum/gold mounting pads. A water drop contact-angle test was used to verify cleanliness. No changes were needed in the mounting pad evaporation process.

Table 1. Fabrication Processes

Equipment	Processes
Frame/cover	Degrease, metallize, goldplate
Frame/clip assembly	Braze, punch, form, vacuum fire
Cover gasket assembly	U/V clean, assemble, vacuum fire
Processed crystal blank	Clean and etch, measure frequency and water drop contact angle
Crystal blank contacted	Vacuum deposit Mo/Au contact pads
Frame/blank assembly	Mount/cement
Frame/blank (electroded and sealed)	QXFF processing: entrance, bake, tune to frequency, seal, exit

Package Preparation

Piece parts for the enclosure were purchased as bare ceramics with only the tungsten metallized feedthroughs applied. All subsequent lapping, metallizing, goldplating, brazing, and clip-forming operations were developed and performed at GEND. The technology base was in place as a result of Phase II activity.

Blank Mount and Cement

The procedure for mounting the quartz blank into the prepared package is a manual operation, and was not changed for Phase III. The polyimide cure schedule, however, received substantial attention. (The final schedule is given in the set of process drawings in Appendix E.) Care in the handling, storage, and use of the conductive polyimide is important to the strength of the resulting bonds.

Crystal Unit Finishing

The finishing processes (UV/Ozone cleaning, tuning, and sealing) represent most of the Phase III development effort, since it is these processes which are primarily responsible for the performance of the final unit.

TEST EQUIPMENT

Several tests for the TMXO relate to its application as a precision resonator. Aging and short-term stability tests are two examples where the specification imposes test equipment requirements substantially different from those of Phase II work. Thus, test oscillator ovens are different from earlier ones.

The Bendix Corporation in Baltimore, Maryland, provided the test ovens for Phase III development. Both ETDL and the Component Test Laboratory at GEND provided software for automatic data retrieval and analysis.

TECHNOLOGY TRANSFER

Information to Industry

GEND and DOE have declared their intention to support any effort by industry to establish a facility to produce TMXO resonators. The ETDL has sponsored several tours at GEND to exhibit the equipment and processes that are in place.

Information to Potential TXMO Manufacturers

GEND, in cooperation with the ETDL, has provided process and design details to interested parties. Part and process drawings, vendor lists, and development histories have been provided, and are part of this report.

RESULTS

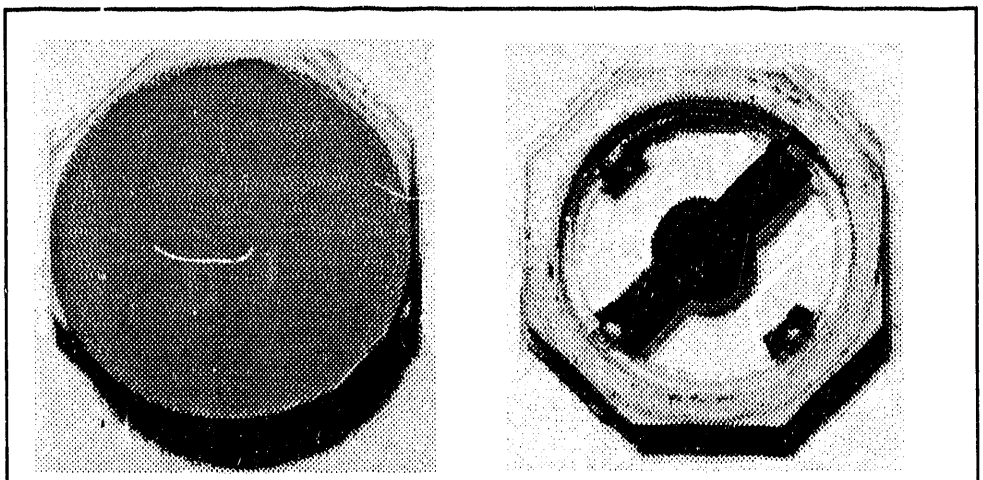
FINAL DESIGN

The TMXO resonator design resulting from this development effort are given by GEND Part Nos. in Table 2. These part differ only in frequency, processing is otherwise identical. The design of the resonator family is detailed in supporting documents included in Appendix E of this report. Figure 13 shows a photograph of the crystal, and Figures 14, 15, and 16 shows photographs of its component parts.

The resonator shown in Figure 13 is a 10-MHz, third overtone SC-cut crystal packaged in an octagonal ceramic flatpack on a four-point mount. Gold is the electrode material, and the package is evacuated for final seal. As much as possible, all crystal finishing work is performed in laminar-flow, HEPA-filtered air or in ultraclean or evacuated equipment.

Table 2. TMXO Resonator Design Results

MHz	Operating Mode	Crystal Cut	Drawing Nos.
5.115	Third overtone	AT	46C927098
5.115	Fundamental	SC	46C924975
10.00	Third Overtone	AT	46C927102
10.00	Third Overtone	SC	46C927106
10.23	Third Overtone	SC	46C927110



Sealed Unit Without Cover

Note: Parts are equivalent to two times the size of parts shown in Figure 1.

Figure 13. Photograph of TXMO Resonator

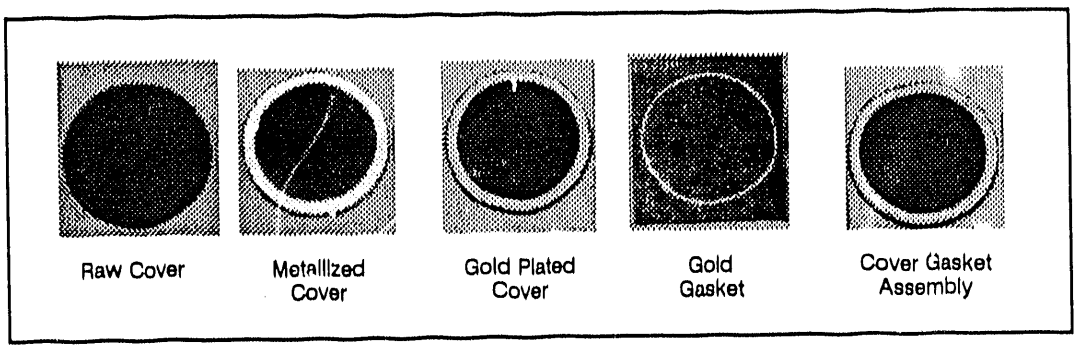


Figure 14. Photograph of TXMO Resonator Component Parts, Step 1

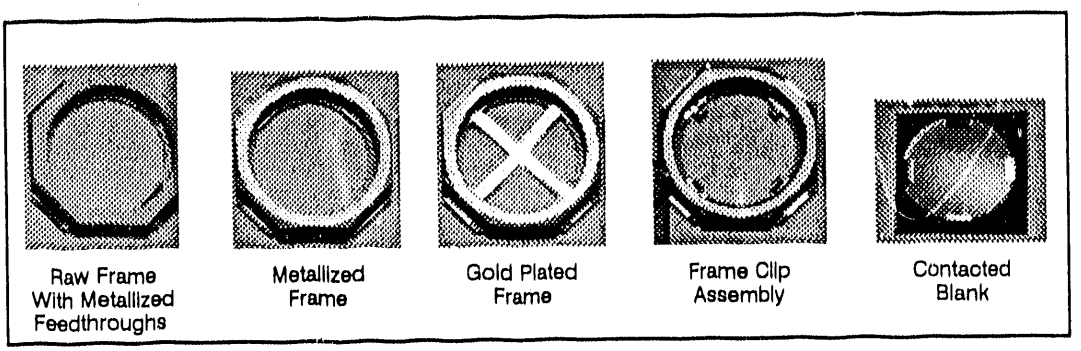


Figure 15. Photograph of TXMO Resonator Component Parts, Step 2

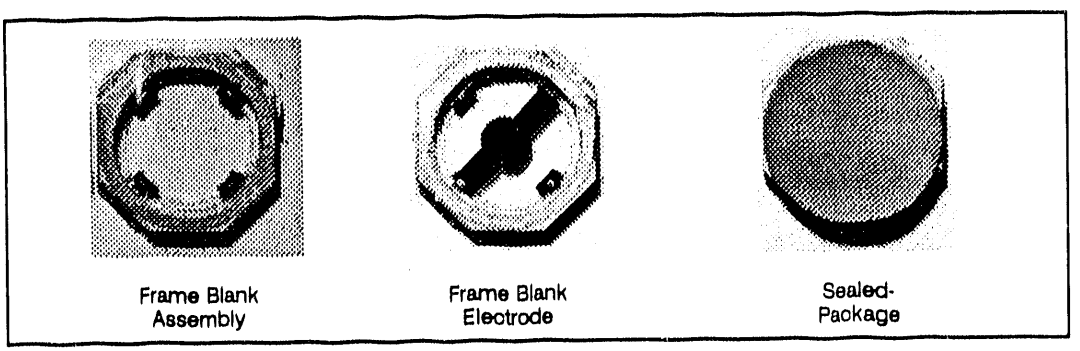


Figure 16. Photograph of TXMO Resonator Component Parts, Step 3

FINAL TEST RESULTS

LABCOM performed most of the resonator testing at Fort Monmouth, New Jersey. Detailed analysis of resonator aging is given in Appendix F which was provided by Dr. R. L. Filler, U. S. Army, LABCOM.

CONCLUSIONS

DEMONSTRATED TECHNICAL CAPABILITY

Blank

The deep-etched blank design is feasible and practical. It can be manufactured in quantity with reasonable yield, and its performance is readily predictable.

Package

The ceramic flatpack is a very strong package with excellent hermeticity. The four-point mount supports the crystal to reasonable shock levels and does not perturb the resonator's natural frequency-temperature behavior. The package can be sealed with excellent yields.

Processing

The high-temperature, high-vacuum processing developed for the TMXO resonator, including bonding the piezoid to its mount with conductive polyimide adhesive, is consistent with precision resonator fabrication.

TECHNICAL PROBLEMS

Mount

Shock survivability of this design is greatly degraded from that of the Phase II design. This is due to the more massive (30 times or more) quartz element. All failures were the result of adhesive failure. Improvement of the polyimide bonding process is needed in order to endorse the current design for use with more massive blanks such as those used in the 5-MHz third overtone flatpack crystal unit. An inorganic bonding agent to secure the piezoid to its mount is desirable.

Testing

Problems in testing TMXO resonators are typical of those in testing precision resonators of any kind. Test oscillators with sufficient flexibility to be applied to a variety of products remain generally unavailable or extremely expensive. Isolation of the unit under test from other sources of noise also remains a problem for short-term stability measurements on multiple

oscillators. There are no testing or measurement problems peculiar to the TMXO resonator, except for the problem of making electrical connection to a non-standard package.

RECOMMENDATIONS

MOUNT

Develop a stronger polyimide bonding process than that tested to date or substitute another bonding method.

PACKAGE

Develop a simpler package design which provides a way to hold the parts during processing (e.g., frame and covers with snap-off tabs for handling and operation-to-operation registration).

RESONATOR BLANK

Include self-locating and self-holding features in the mount for the resonator blank and in the package for the covers.

Develop metal covers to replace the ceramic ones. This could save about 1.5 mm in overall package thickness. It would also eliminate the need to metallize the cover(s) for some applications.

CLEANING

Continue to investigate the dependence of resonator performance on final cleaning methods, all-vacuum processing, nozzle-beam source electroding, polyimide bonding, and high temperature processing.

BONDING

Develop a sealing process that is less sensitive than the gold-to-gold diffusion bond used in the current TMXO resonator design. This would encourage more wide spread adoption of the design.

ACKNOWLEDGMENTS

Acknowledgment is given to LABCOM as the contractor in this project. Also, a special thank you to Dr. R. L. Filler, of the U. S. Army LABCOM, for the test data in Appendix F and elsewhere.

APPENDIX A

ERADCOM STATEMENT

DEPARTMENT OF THE ARMY
US ARMY ELECTRONICS TECHNOLOGY AND DEVICES LABORATORY
FORT MONMOUTH, NEW JERSEY 07703

DELET-MQ

8 August 1979

Mr. D. K. Nowlin, Director
Special Programs Division
Department of Energy
P. O. Box 5400
Albuquerque, NM 87115

Dear Mr. Nowlin:

The U.S. Army Electronics Technology and Devices Laboratory requests Department of Energy assistance, in accordance with the US Army/DOE Memorandum of Understanding No. AT(29-2)-2138, with developing manufacturing methods and technology (MM&T) for Processing High Stability Quartz Crystal Units. The Statement of Work is inclosed.

This program is intended to be a continuation (Phase III) of an ongoing (Phase II) MM&T program at GEND, Project Order No. 78-ETDL-MQ-01. We envision that the bulk of Phase III will be performed subsequent to the completion of Phase II. Completion of Phase III by 30 July 1981 is requested.

The Army intends to continue to seek commercial suppliers for the production of quartz crystals required by future Army systems. A commitment is requested from DOE that, when such a supplier is found, DOE will provide, through GEND, consulting and support services until the transfer of the manufacturing capability and technology is completed.

As we would like to place this order prior to the end of FY-79, would you kindly provide us with your cost estimate and scope of work prior to 12 Sep 79. A copy of this request is being sent to PAO and GEND to help expedite matters. A copy of the preliminary specifications had been provided to GEND several weeks ago.

Sincerely,

V. G. Gelnovatch

V. G. GELNOVATCH, Director
Microwave & Signal Process Devices Division

1 Incl
as

CF:
P. Ramey, DOE/PAO
A. Kuntz, GEND ✓ Rec'd 8/14/79

6 August 1979

Statement of Work

M&T for Processing High Stability Quartz Crystal Units

1. Expand the capabilities of the pilot production line being established under project order No. 78-ETDL-MQ-01 to permit the fabrication and testing of quartz crystal units that meet the specifications entitled "Ceramic Flatpack Enclosed Quartz Crystal Units for Tactical Miniature Crystal Oscillator Assemblies", dated 6 Aug 79. (Incl. 1)

2. Prior to the completion of Phase II, develop a plan aimed at reducing the cost of both the high shock and TMXO crystals to below $65 (in FY-79 dollars) in quantities of 25,000 per year. Establishing commercial sources for chemically polished crystal blanks and metallized ceramic flatpacks (with formed clips), and the automation and simplification of the various processes shall be among the major factors considered in this plan. Implement those aspects of the plan which would be cost effective for a production run of 5,000 units. Revise the plan at least once every three months during Phase III. Include the final plan in the Final Report of Phase III.

3. Evaluate potential substitutes for the Ablebond 71-1 polyimide adhesive with the goal of qualifying at least one bonding process for replacing the 71-1 (which the manufacturer is discontinuing).

4. Deliverables:

A. Software:

1. Monthly cost and performance reports (3 copies)

2. Final report (100 copies)

3. Drawing set, including a description of all processes, materials, parts, fixtures, equipment and facilities required to fabricate and test the crystals. (Quantities, as required).

4. Operator instructions, deliverable if and when pilot line is transferred to a commercial source.

B. Hardware:

1. 400 engineering samples

2. 80 confirmatory samples

3. 700 pilot line samples

4. All hardware developed or purchased with project funds are deliverable if and when the pilot line is transferred to a commercial source.

APPENDIX B

MILITARY SPECIFICATION

"MILITARY SPECIFICATION"
CERAMIC FLATPACK ENCLOSED QUARTZ CRYSTAL RESONATOR
FOR TACTICAL MINIATURE CRYSTAL OSCILLATOR ASSEMBLIES

1. SCOPE

1.1 This specification covers the detailed requirements for ceramic flatpack enclosed precision quartz crystal resonators. These resonators have an AT-cut quartz vibrator mounted in a ceramic flatpack enclosure, and are designed to operate under controlled temperature conditions.

1.2 Type Designation - The type desigation applies only to resonators meeting all requirements of the specification. The type designation shall be CR - (XM - 161)/U - I, and CR-(XM-161)/U - II as detailed in Table VI.

2. APPLICABLE DOCUMENTS

2.1 Issues of Documents - The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein. (Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

SPECIFICATIONS

Military

MIL-C-3098 - Crystal Units, Quartz

STANDARDS

Military

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes

MIL-STD-202 - Test Methods for Electronic & Electrical Component Parts.

MIL-STD-810 - Environmental Test Methods

MIL-STD-883 - Test Methods and Procedures for Microelectronics

2.2 Other Publications: The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated the issue effect on date of invitation for bids or request for proposal shall apply.

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC-302 - Standard Definitions and Methods of Measurement for Piezoelectric Vibrators Operating over the Frequency Range up to 30 MHz.

IEC-121-i - Quartz Crystal Units for Frequency Control and Selection.

(Application for copies should be addressed to American National Standards Institute, 1430 Broadway, New York, NY 10018).

NATIONAL BUREAU OF STANDARDS (NBS)

Monograph l4O - Time and Frequency, Theory and Fundamentals

[Application for copies should be addressed to Superintendent of Documents, US Government Printing Office, Washington, DC 20402. (Order by SD Catalog No. C13.44:140)].

NATIONAL TECHNICAL INFORMATION SERVICE

AD A011113 - Proceedings of the 28th Annual Frequency Control Symposium

(Application for copies should be sent to National Technical Information Service, Sills Building, 5825 Port Royal Road, Springfield, VA 22161).

2.3 Other specifications:

General Electric Company (GEND)
P. 0. Box 11508
St. Petersburg, FL 33733

Drawing GE 46C 924937 and all drawings indicated therein.

The Bendix Corporation
Communications Division
Baltimore, MD 21204

Drawing 4046046 Resonator, Crystal, Quartz

USA Electronic Technology and Devices Laboratory
Microwave and Signal Process Devices Division
ATTN: DELET-MF
Fort Monmouth, NJ O77O3

Technical guidelines for "Development of a Tactical Miniature Crystal Oscillator," date - 17 March 1978.

3. REQUIREMENTS

3.1 Materials - All materials shall conform to the government approved product drawings and materials shall be consistent with operating in, and maintenance of a vacuum of 1 x 10^{-6} torr.

3.2 Design and Construction - All fabrication processes and final configurations shall conform to the applicable drawings detailed on the Flow Chart drawing, GE 46C924937. All process steps from pre-electroding cleaning through seal shall be performed in a closed vacuum system. Details of availability of such a Quartz Crystal Fabrication Facility (QXFF) can be obtained from the contracting officer.

3.3 Marking - Marking is not required, but is preferred. Method used must be consistent with para 3.1. In either case unit serialization, date of manufacture, and manufacturer code shall be provided for each unit.

3.4 Frequency - The frequency of resonance shall be as specified in Table VI, when measured in series with a load capacitor as specified in Table VI at a drive current of 1.4 ma ± 0.1 ma. The temperature of measurement shall be the upper turning point temperature as measured by the method specified in paragraph 3.12.

3.5 Equivalent Series Resistance - The maximum allowable equivalent series resistance shall be as specified in Table VI, at the upper turnover temperature.

3.6 Shunt Capacitance - The total shunt capacitance ($Co = C_{electrode} + C_{holder}$) shall be as specified in Table VI.

3.7 Motional Capacitance - The motional capacitance, C_1, shall be as specified in Table VI.

3.8 Bond Strength - When tested as specified in 4.5.7 there shall be no severing of the ribbon lead, detachment of the bond, or separation of the metallization.

3.9 Shock - The frequency change due to the effects of shocks received as a result of rough handling, transportation, and military operations shall be less than 1 x 10^{-9}. The equivalent series resistance shall not change by more than 10% nor exceed the value specified in para 3.5.

3.10 Vibration - When subjected to the vibration levels specified, the output of the resonator shall not contain modulation sidebands corresponding to frequency deviations exceeding 1 x 10^{-9} times the peak acceleration levels.

3.11 Thermal Time Constant - The thermal time constant of the resonator assemble shall be TBD secs maximum.

3.12 Temperature Run - The upper turnover temperature shall be 90°C ± 5°C. The frequency vs temperature characteristic shall be free of coupled modes.

3.13 Thermal Frequency Repeatability - The frequency of the resonator shall not change by more than 3 x 10^{-9}, after five cycles of warm up from -40°C to the upper turning point temperature (See Figure 1) $Fu_1 - Fu_5 = 3 \times 10^{-9}$.

3.14 Unwanted Modes - Unwanted modes shall have a resistance which exceeds twice the value specified in para 3.5.

3.15 Thermal Shock - When subjected to rapid changes in temperature, no part of the resonator shall crack, chip or break.

3.16 Solderability - The mounting surfaces of each resonator shall be tested as specified in 4.5.15, except Sn62 solder, in accordance with QQ, 5-571, shall be used in lieu of Sn60 and the immersed metallized surface shall be 95 percent covered with a smooth solder coating. The remaining 5 percent of the surface may contain small pinholes or rough spots; however, these shall not be concentrated in one area.

3.17 Resistance to Soldering Heat - When tested as specified in 4.5.16, resonators shall meet the following requirements:

- Visual Examination - There shall be no evidence of mechanical damage or delamination.
- Frequency - The frequency shall not be changed more than TBD nor exceed the limit specified in 3.4.
- Resistance - The equivalent series resistance shall not change by more than 1 ohm nor exceed the value specified in 3.5.
- Shunt Capacitance - The shunt capacitance shall not change by more than 0.1 pF nor exceed the limit specified in 3.6.

3.18 Seal - The leakage rate of the resonator enclosure shall not exceed 10^{-10} atm - cc/sec.

3.19 Salt Spray - When subjected to a salt spray atmosphere, there shall be no evidence of excessive corrosion. Corrosion that causes impairment of the electrical or mechanical performance of the resonator shall be considered excessive.

3.20 Moisture Resistance - After subjection to temperatures of up to 65°C and a relative humidity of up to 100% for 10 days, the frequency of the resonator shall be as specified in 3.4, The insulation resistance, terminal to terminal shall not be less than 500 Meg ohm.

3.21 Accelerated Aging - After being conditioned at 120°C for 168 hours (7 days) and then allowed to stabilize at room temperature, the difference in frequency between the measurement mode immediately prior to and immediately after conditioning shall not exceed 5×10^{-7}. The equivalent series resistance shall not exceed the maximum specified in Table VI.

3.22 Reduced Level of Drive - The difference in the equivalent series resistance when measured at the two specified levels of drive shall be less than 25% and the absolute values of the equivalent series resistances shall not exceed 10 ohms. The measurement must always be made subsequent to the accelerated aging test and only after the resonator has been undriven for 168 hours.

3.23 Short Term Stability - The RMS frequency deviation shall not exceed 1×10^{-11} for averaging times ranging from 1 second to 20 minutes.

3.24 Reliability (Aging) - The aging rate shall be less than 2×10^{-10} per week after 30 days at the upper turnover temperature.

3.25 Resistance to Ionizing Radiation: When subjected to the radiation environment specified, the steady state frequency offset shall be less than 5×10^{-9}. The equivalent series resistance shall not change by more than 10% and shall not exceed the value specified in paragraph 3.5.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection - Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the government. The government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.1.1 Test Equipment and Inspection Facilities - Test and measuring equipment of sufficient accuracy, quality and quantity to permit performance of the required inspection shall be established and maintained by the supplier.

4.2 Classification of Inspections - The inspection requirements specified herein are classified as follows:

1. Confirmatory sample inspection (does not include preparation for delivery) (see 3.4), to be performed only at initial start-up of production.

2. Quality conformance inspection (see 3.5).

4.3 Inspection Conditions - Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in the "General Requirements" of MIL-STD-202.

4.4 Confirmatory Sample - Unless otherwise specified in the contract, the confirmatory sample inspection shall be performed by the contractor.

4.4.1 Confirmatory Samples - The contractor shall furnish the number of crystal resonators as specified in the government approved test plan.

4.4.2 Confirmatory Sample Inspection - The confirmatory sample inspection shall consist of Table I and all other tests included in the government approved test plan (see 4.1.2) to show compliance with Section 3. No failures shall be permitted in Table I. The tests in Table I are to be performed in the order shown.

4.5 Quality Conformance Inspection - Quality conformance inspection shall consist of tests specified in Table II, III, IV, and paragraph 3.23 in the order shown.

4.5.1 Inspection of Product for Delivery - Inspection of product for delivery shall consist of tests specified under 100% inspection and Group A inspection (Table II and Table III).

4.5.1.1 Inspection Lot - An inspection lot shall consists of all crystal resonators of the same type and frequency produced under essentially the same conditions, and offered for inspection at one time.

4.5.1.2 100% Inspection - 100% inspection shall consist of Table II. Rejection is on a unit by unit basis. All delivered items must pass all tests in Table II. All data will be supplied with delivered items.

4.5.1.3 Group A Inspection - Group A inspection shall consist of Table III. The inspection shall be made with the same or separate samples for subgroups 1 and 2.

4.5.1.3.1 Sampling Plan - Statistical sampling and inspection for Group A inspection shall be in accordance with MIL-STD-105 for general inspection level II. The acceptable quality level (AQL) shall be 1.0.

Lot Size:	0 - 150	151 - 500	501 - 1200	1201 - 3200
Sample/Results Allowed:	13/0	50/1	80/2	125/3

4.5.1.3.2 Rejected Lots - If an inspection lot is rejected, the supplier may rework it to correct the defects, or screen out the defective units, and resubmit for reinspection. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lot and shall be clearly identified as reinspected lots.

Table I. Confirmatory Sample Inspection

Inspection	Requirement Paragraph	Test Method Paragraph
Frequency	3.4	4.6.3
Resistance	3.5	4.6.4
Shunt Capacitance	3.6	4.6.5
Motional Capacitance	3.7	4.6.6
Shock	3.9	4.6.8
Vibration	3.10	4.6.9
Thermal Time Constant	3.11	4.6.10
Temperature Run	3.12	4.6.11
Thermal Frequency Repeat	3.13	4.6.12
Unwanted Modes	3.14	4.6.13
Thermal Shock	3.15	4.6.14
Solderability	3.16	4.6.15
Resistance to Soldering Heat	3.17	4.6.16
Seal	3.18	4 6.17
Salt Spray	3.19	4.6.18
Moisture Resistance	3.20	4.6.19
Accelerated Aging	3.21	4.6.20
Reduced Level of Drive	3.22	4.6.21
Short Term Stability	3.23	4.6.22
Aging	3.24	4.6.23
Bond Strength	3.8	4.6.7
Resistance to Ionizing Radiation	3.25	4.6.24

Table II. 100% Inspection

Inspection	Requirements Paragraph	Test Method Paragraph
Frequency	3.4	4.6.3
Resistance	3.5	4.6.4
Shunt Capacitance	3.6	4.6.5
Motional Capacitance	3.7	4.6.6
Temperature Run	3.12	4.6.11
Seal (Leakage)	3.18	4.6.17

4.5.1.3.3 Disposition of Sample Units - Sample units which have passed all Group A inspection may be delivered, if the lot is accepted and the sample units are still within specified tolerances.

4.5.2 Qualification Verification Inspection - Qualification verification inspection shall consist of Group B (Table IV). Except where the results of these inspections show noncompliance with the applicable requirements, delivery of products which have passed Group A shall not be delayed pending the results of these qualification verification inspections.

4.5.2.1 Group B Inspection - Group B inspection shall consist of Table IV. Group B inspection shall be made on sample units which have passed Group A inspection.

4.5.2.1.1 Sampling Plan - Statistical sampling and inspection shall be in accordance with MIL-STD-105 for special inspection level S-4. The lot or batch can consist of several inspection lots for Group A inspection. The acceptable quality level shall be 1.0.

Lot Size:	0 - 1200	1201,150,000
Sample/Resets Allowed:	13/0	80/1

4.5.2.1.2 Disposition of Sample Units - Sample units which have been subjected to Group B inspection shall not be delivered on the contract or purchase order.

4.5.2.1.3 Noncompliance - If a sample lot fails to pass Group B inspection, the supplier shall take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Delivery of the product shall be discontinued until corrective action has been taken, Group B inspection shall be repeated on additional sample units (all inspections or the inspection which the original sample failed, at the option of the government). Group A inspection may be reinstituted; however, final acceptance shall be withheld until the Group B reinspection has shown that the corrective action was successful. All failures of Group B inspection shall be reported immediately to the government.

Table III - Group A Inspection

Inspection	Requirement Paragraph	Test Method Paragraph
Subgroup I		
Thermal Time Constant	3.11	4.6.10
Thermal Frequency Repeat	3.13	4.6.12
Unwanted Modes	3.14	4.6.13
Short Term Stability	3.23	4.6.22
Subgroup II		
Accelerated Aging	3.21	4.6.20
Reduced Level of Drive	3.22	4.6.21

4.5.3 Reliability Inspection - Reliability inspection shall consist of Aging Test (see 3.24).

4.5.3.1 Sampling Plan - All resonators which have successfully completed Groups A and B inspection shall be included in this test. A lot for reliability can include several lots for Group B. When subjected to the reliability test cycle specified, the failure rate shall not exceed 1%/1000 hours at a 60% confidence level (i.e., equivalent to 1 failure for 200 units over a 1000 hour period of testing).

4.6 Methods of Examination and Test

4.6.1 Test Equipment - All tests shall be performed on government approved test equipment using a government approved test plan.

4.6.1.1 Test Plan - The contractor prepared test plan, as cited in the order, shall contain:

a. Time schedule and sequence of examinations and tests.

b. A description of the method of test and procedures.

c. Programs of any automatic tests including flow charts and block diagram.

d. Identification and brief descriptions of each inspection instrument with calibration procedures and intervals.

Table IV - Group B Inspection

Inspection	Requirement Paragraph	Test Method Paragraph
Shock	3.9	4.6.8
Vibration	3.10	4.6.9
Thermal Shock	3.5	4.6.14
Solderability	3.16	4.6.15
Resistance to Soldering Heat	3.17	4.6.16
Bond Strength	3.8	4.6.7
Resistance to Ionizing Radiation	3.25	4.6.24

Table V - Reliability Inspection

Inspection	Requirement Paragraph	Test Method Paragraph
Aging	3.24	4.6.23

4.6.2 Conditions

4.6.2.1 General - Unless otherwise specified herein, all inspections shall he performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of MIL-STD-202.

4.6.2.2 Ground Connection - All measurements of frequency shall be made with the metallized surfaces of the enclosure electrically connected to ground. Non-metallized ceramic enclosures shall have metal plates attached to the major surfaces of the enclosures and electrically grounded.

4.6.2.3 Measurement Before and After a Test - When frequency and equivalent resistance are measured before and after a test to determine change during a test, both measurements shall be be at series resonance with the resonator in thermal equilibrium at the same temperature ± 1°C, at the same drive current ± 0.1 ma, and with the same lead configuration and length ± 2.0 mm.

4.6.2.4 Mounting for Testing - When specified in the test procedure, the resonators shall be mounted on a suitable substrate. The substrate material shall be such that it shall not be the cause of, nor contribute to, the failure of any test for which it may be used. The resonators shall be mounted on the substrate as follows:

a. A substrate shall be either metal or prepared with metallizing of sufficient area to permit mounting of the resonators.

b. Solder paste, type R or RMA in accordance with QQ-S-571 shall be applied to each surface of each resonator.

c. The resonator shall be placed between two substrates so as to make contact with each metallized area, proper fixturing shall be employed to provide the proper pressure.

d. The assembly shall then be placed in or on a suitable heat transfer unit (hot plate, tunnel oven, etc.) so that both substrates are heated uniformly with the temperature maintained at 260° ± 50°C for two minutes or until the solder melts and reflows forming a homogeneous solder bond.

4.6.3 Frequency - The frequency shall be measured with a load capacitance as specified in Table VI at a drive current of 1.4 ma ± 0.1 ma at the upper turnover temperature ± 0.1°C.

4.6.4 Equivalent Series Resistance - The equivalent series resistance shall be measured without a load capacitor at a drive current of 1.4 ma ± 0.1 ma at the upper turnover temperature ± 0.1°C.

4.6.5 Shunt Capacitance - The shunt capacitance shall be measured from contact area to contact area at a frequency which is lower than the fundamental frequency of the resonator and at which the resonator shows no oscillation response. Alternatively the shunt capacitance may be calculated from the equation in paragraph 4.6.6.

4.6.6 Motional Capacitance - The motional capacitance shall be measured by a method specified in the government approved test plan.

C_1 is defined as : $C_1 = \frac{2\Delta F_n}{F_s}(Co + C_{L_n}) = \frac{2\Delta C_L}{F_s}\ \frac{\Delta f_1 \Delta f_2}{\Delta f}$

$\Delta F_n = F_{L_n} - F_s$

F_{L_n} = Frequency with load capacitor, C_{L_n}

F_s = Series resonant frequency

Co = Shunt capacitance

C_{L_n} = Load capacitance n

$\Delta f = f_{L_1} - F_{L_2}$

$\Delta C_L = C_{L_2} - C_{L_1}$

4.6.7 Bond Strength - Bond strength shall be measured by method 2011.2, of MIL-STD-883 using test condition A, Bond-peel. Minimum bond strength is TBD gms.

4.6.8 Shock - The test will be performed in accordance with MIL-STD-202, method 213, condition G. The frequency and equivalent series resistance shall be measured before and after the test at series resonance.

4.6.9 Vibration - The resonator will be vibrated in accordance with MIL-STD-810, method 514.2, condition M. The resonator will be operating during the test. The amplitude of the modulation sideband at the frequency of instantaneous vibration shall be monitored.

$$SSB = \frac{\text{Sideband level}}{\text{Carrier level}} \quad (db) = 20 \log\left(\frac{fs\ K\ g}{2\ Fv}\right)$$

$$K = \text{vib. sensitivity} = \frac{2\ fv}{f_s\ g} \times 10^{\ SSB/20}$$

f_s = resonant frequency = 5.1×10^6 Hz

g = acceleration level in g's

fv = vibration frequency

K = acceleration sensitivity in parts/g.

$$K\ (ppm/g) = \frac{(0.39)\ fv}{g} \quad 10^{\ (SSB/20)}$$

4.6.10 Thermal Time Constant - The resonator, at room ambient temperature (24°C ± 2°C) shall be immersed in a suitable liquid bath, held at 80°C ± 1°C. The frequency shall be recorded every 0.1 sec. The time required for the frequency to change by 65% of its ultimate excursion shall be recorded as the thermal time constant.

4.6.11 Temperature Run - The temperature run shall be performed at a drive current not to exceed 2.0 ma. The resonator shall be run with a load capacitance as specified in Table VI. The temperature of the resonator shall be varied so as to traverse the temperature range of 30°C to 115°C. The rate of change of temperature will not exceed 0.1°C/minute. Measurement of frequency, equivalent resistance, and temperature shall be recorded continuously or at intervals of not over 0.01°C. The upper turnover temperature shall be ascertained to a tolerance of 0.1°C. Freedom from coupled modes shall be defined by the frequency vs. temperature characteristic not having deviations from a cubic equation which are larger than 1 ppm. The resistance vs. temperature characteristic shall not have deviations from a straight line which are larger than 1 ohm. The maximum rate of change of resistance with temperature shall be 1.0 ohm per 10°C.

4.6.12 Thermal-Frequency Repeatability - The crystal resonator shall be subjected to the temperature cycle of Figure 1. Thermal equilibrium shall be achieved at each upper turning point segment of the cycle. The maximum rate of change of temperature shall be 10°C/minute.

4.6.13 Unwanted Modes - Unwanted modes shall be measured on a government approved test circuit of the bridge or Pi type. The test shall be performed at room ambient temperature. A frequency range of 10% of the nominal frequency shall be swept.

4.6.14 Thermal Shock - The crystal resonators shall be tested for resistance to thermal shock by being immersed in boiling water for at least 15 seconds and immediately thereafter being immersed in ice water for at least 15 seconds. The volume of water shall be large enough so that its temperature will not be appreciable affected when the sample resonators are introduced. After completion of the rest the resonators shall be examined for cracks, clips or breaks.

4.6.15 Solderability - Resonators shall be tested in accordance with method 208 of MIL-STD-202. The following details and exceptions shall apply:

a. Each mounting surface shall be immersed to a depth of 0.020 inch + 0.10 inch, - 0.000 inch.

b. Examination of mounting surface shall be in accordance with 3.16. In case of despite, the percent coverage with pinholes or rough spots shall be determined by actual measurements of these areas, as compared to the total area of each surface.

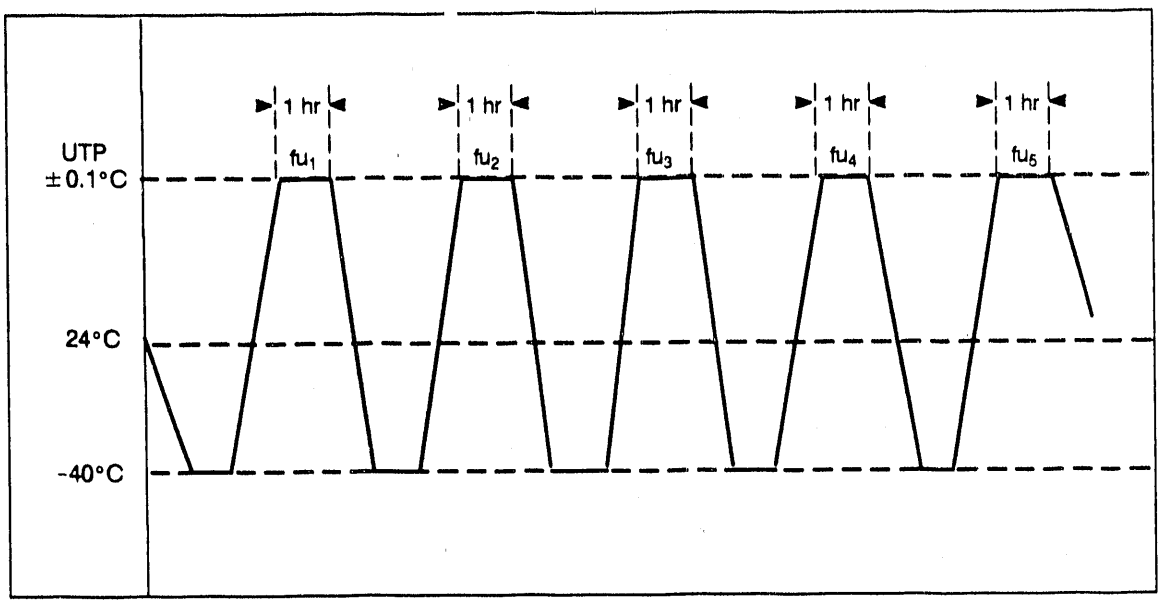


Figure 1.

4.6.16 Resistance to Soldering Heat - Resonators shall be tested in accordance with method 210 of MIL-STD-202. The following details shall apply:

a. Resonators shall be mounted as specified in 4.1.3.

b. Test condition B.

c. Examination and measurement after test - resonators shall meet the requirements of 3.17.

4.6.17 Seal - The sealed resonators shall be tested for hermeticity according to MIL-STD-202, method 112, test condition C, procedure IIIb. Upon completion of this procedure, the specimen shall be checked for gross leaks in the method specified in the government approved test plan.

4.6.18 Salt Spray - MIL-STD-202E, method 101, test condition B.

4.6.19 Moisture Resistance - Crystal resonators shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

a. Mounting - as specified in 4.1.3.

b. Initial measurements - frequency and equivalent series resistance.

c. Subcycle - step 7B, the vibration subcycle, shall be omitted.

d. Polarization and loading voltage - not applicable.

e. Final measurement - After the drying period, frequency, equivalent resistance, and insulation resistance shall be measured. Insulation resistance shall be measured in accordance with method 302 of MIL-STD-202, using a test potential of 50 to 55 volts. This measurement shall be made from terminal pad to terminal pad.

4.6.20 Accelerated Aging - Resonators shall be measured at seres resonance for frequency and equivalent resistance. The resonators shall then be conditioned at 120°C for 168 hours. The resonators shall then be allowed to stabilize at the same temperature as the initial measurement (±1°C). The units shall be measured again for frequency and resistance.

4.6.21 Reduced Level of Drive - The measurement must follow the accelerated aging test and after the resonator has been undriven for 168 hours. The initial measurement following accelerated aging is preferred. The measurement shall be performed by inserting a 10 ohm resistor into the test set and adjusting the dissipated power to 20 microwatts (1.4 ma ± 0.1 ma). The power is then attenuated by 60dB. The resonator is substituted for the 10 ohm resistor and the equivalent series resistance is recorded. The 60dB of attenuation is removed and the equivalent series resistance is recorded again.

4.6.22 Short Term Stability - The short term stability will be the Allen variance as defined in Time and Frequency: Theory and Fundamentals, NSB Monograph 140, page 157, eq 8.13a.

$$(\text{Allen Variance})^2 = \sigma_y^2(\tau) = \frac{1}{2(M-1)} \sum_{k=1}^{M-1} (\bar{y}_{k+1} - \bar{y}_k)^2$$

where τ = average time

$\bar{y}_k$ = Fractional frequency fluctuations

$$\bar{y}_k = \frac{\Phi(t_K + \tau) - \Phi(t_K)}{2\pi f_o \tau}$$

M = Numbers of samples - 256 suggested

$$t_{k+1} = t_k + \tau$$

Suggested methods of measurement: Time and Frequency, NBS Monograph 140, (1974); Proc. 6th Annual PTTI, page 109; 28th Annual Symposium on Frequency Control, page 177 (1974).

4.6.23 Reliability (Aging) - Resonators will be stored in an oven maintained at the upper turnover temperature ±0.1°C stable to at least 0.01°C. The oven shall be constructed with suitable electrical connectors so each resonator can be oscillated and measured to the required accuracy. The oven shall be stabilized for 7 days. The resonators shall be maintained at the upper turnover temperature for an additional 23 days. The frequency of each resonator shall be measured a minimum of twice weekly with two to four days separation between measurements, more frequency measurements are encouraged. The data shall be fit to the equation $\frac{\Delta f}{f} = K_1 + K_2 \ln(T)$ by method of least squares, where T is the number of days the resonator has been continuously on aging. The regression coefficient, r,

$$r = \text{TBD}$$

shall be greater than .8 after correction for temperature fluctuations if necessary. The aging rate per day at day D is K_2/D. Units showing an aging rate of 2×10^{-10}/week or more ($7 * K_2/30$) after 30 days or units with an erratic behavior as evidenced by a regression coefficient greater than .8 shall be classified as failures. Units which showed an equivalent series resistance of greater than the maximum specified in Table VI at the end of the aging cycle shall be classified as failures.

4.6.24 Resistance to Ionizing Radiation - The resonators shall be exposed to the radiation environments specified for Army tactical equipments. (These environments shall be specified later.) The frequency and series resistance shall be measured before and after the test, at series resonance. This test shall always follow aging.

5. PACKAGING

5.1 Preservation-Packaging - Crystal resonators shall be clean, dry and packaged in a manner that will afford adequate protection against corrosion, deterioration and physical damage during shipment and storage.

5.2 Marking - Individual containers shall be marked as specified in contract.

5.3 Data Supplied - Unit serialization, date of manufacturer, manufacturing code and all date from 100% inspection shall be supplied. In addition, any data specified in the contract shall be supplied.

6. NOTES

6.1 Intended Use - Crystal resonators produced under this specification are intended for use in Tactical Miniature Crystal Oscillator Assemblies (TMXO), and are intended to meet the requirements as stated in Bendix drawing 4046046 and ET&DL Technical Requirement "Development of a Tactical Miniature Crystal Oscillator," date - 17 March 1978. Thermal control of the resonator enclosure is obtained through its common surface with the oscillator microcircuit.

6.2 Ordering Information - Procurement documents should specify the following:

a. Title, number and date of this specification.

b. If a procurement contract permits the addition, omission, relaxation, or modification of any requirement(s) of this specification, the type designation (see 1.2) is not to be used to identify the crystal resonator.

c. Any marking required on crystal resonator.

d. Special packaging including package marking required.

6.3 Definitions - Definitions conform to IEC-122-1, IEC-302, and MIL-C-3098, with "Quartz Crystal Resonator" being equivalent to "Crystal Unit".

Table VI.

Requirement	Requirement Paragraph	CR (XM-161)/U	CR--(XM-161)U	Test Method Paragraph
Frequency	3.4	5,115,000 Hz ± 25 Hz with a (100 ± 1) pF load capacitor	10,000,000 Hz ± 150 Hz with a (30 ± 0.5) pF load capacitor	4.6.3
Equivalent Series Resistance	3.5	10 ohms max	20 ohms max	4.6.4
Shunt Capacitance	3.6	(5.0 ± 0.5) pF	(4.5 ± 0.5) pF	4.6.5
Motional Capacitance	3.7	(1200 ± 1.2) fF	(1.10 ± 0.20) ffs	4.6.6
Mode of Operation		Fundamental	Third Overtone	

APPENDIX C

PHASE III COST ESTIMATE

GENERAL ELECTRIC

NEUTRON DEVICES DEPARTMENT

GENERAL ELECTRIC COMPANY, P.O. BOX 11508, ST. PETERSBURG, FLORIDA 33733
Phone (813) 541-9001

June 24, 1981

Mr. J. H. Grayson, Chief
Operations Branch - DOE/PAO

Subject: ERADCOM Phase III Estimate of Cost

On May 23, 1980, a cost estimate for the ERADCOM Phase III Program was submitted to PAO to be forwarded to DOD through ALO. The attached document is an update of that estimate as a result of schedule changes and some scope of work modifications.

A total of $860,875 has been received from ERADCOM to be used for Phase III. To date, $68,442 of these funds have been expended in support of Phase III as a result of prior authorizations.

The cost summary shows additional funds of $464,099 required to complete Phase III. It is ERADCOM's intent to provide an order for $395,000 in the very near future. The balance of the required funding is then expected to be available in early FY 82.

A summary of this cost estimate and schedule were presented to ERADCOM during our visit to Fort Monmouth on June 9 & 10.

The above cost estimate is submitted in accordance with terms and conditions of contract DE-AC04-76DP00656.

R.P. Ouimette, Specialist
Contract Administration

T.E. Wagner
Project Manager

TEW:sre

cc: D.H. Ahmann
B.E. Belnap
E.J. Cronin
R.A. Fleming
A.B. Hammac
A.N. Kenly
L.D. Lawrence
F.J. Leonard
D. Marcum
H.A. Maurer
M.W. Osborn
R.L. Peterson
D.L. Pilini
F.J. Scerbo
T.M. Snowden
W.D. Wannamaker

ESTIMATE OF COST TO PERFORM PHASE III

TACTICAL MINIATURE CRYSTAL OSCILLATOR (TMXO) RESONATOR PROGRAM

INTRODUCTION

This estimate of cost is submitted to identify funds required to complete an MM&T type program for TMXO resonators and define the scope of work.

BACKGROUND

An estimate of cost and scope of work for Phase III was submitted to ERADCOM (DOD) through PAO/ALO (DOE) in May, 1980. This document updates that estimate as a result of schedule changes and some scope of work modifications.

OBJECTIVE

The objective of the Phase III program is to expand the capabilities of the pilot production line being established under Project Order No. 78-ETDL-MQ-01 (Phase II) to fabricate and test 5 and 10 MHz TMXO crystal resonators. When complete, the pilot production facility will provide a product capable of being produced at some on-going rate. This rate will be determined based on the demonstrated capability of the processes during the confirmatory and pilot production builds. The capacity will be determined by taking into account actual processing times and downtime of the equipment involved. The test program will evaluate and define a product as produced from the pilot production facility from which a finalized product specification can be defined.

The currently defined program will not result in a stand-alone ERADCOM production facility. To do this, additional equipment fixturing, tooling, etc., would be required in some areas. A key piece of equipment is the contact evaporator. A DOE contact evaporator will be shared to support the Phase III program. No provisions are being made at GEND to provide production test equipment. Cost of transferring the technology to a commercial supplier is not included in this estimate of cost.

SCOPE OF WORK

Work required to perform Phase III has been broken down into four activities. Three of the activities pertain to readiness efforts required to perform the fabrication and testing of the engineering, confirmatory and pilot run builds. The fourth activity is the actual fabrication and testing of the three builds. The engineering build will start 100 units into the QXFF, the confirmatory build will start 150 units into the QXFF and the pilot run build will start 1100 units into the QXFF. For purposes of this estimate the individual activities have been identified as A through D.

Activity A - Engineering, Confirmatory and Pilot Run Build
B - QXFF Modification
C - Test Equipment Modification
D - Fixturing/Tooling/Gages

A scope of work and cost summary for each of the activities is included.

COSTS

The cost of completing the Phase III order is estimated to be $1,324,974. Funds available to date provided from ERADCOM are $860,875. Therefore, additional funding of $464,099 is required to complete the Phase III effort as defined in this estimate. A cost estimate summary is given in Exhibit 1. Details of the costs are given with each activity summary.

ASSUMPTIONS

The following assumptions and conditions apply to this estimate.

1. A minimum of 25 test oscillator ovens will be available and meet all required specifications.
2. ERADCOM will provide fixtures and software for the 2 "G" tip-over test. No other vibration test will be required.
3. Nuclear survivability test will be performed by ERADCOM.
4. Both the 5 and 10 MHz crystal blanks will be furnished to GEND etched to frequency.
5. The 10 MHz blank specification will be released by mid-July, 1981; to allow procurement of crystals.
6. The estimate assumes no inspection will be required on purchased blanks other than visual. Parameters not inspected by GEND will be accepted by vendor certification with ERADCOM approval.
7. Price escalation factors used are as follows:

FY 82	FY 83	FY 84
11.5%	12%	13%

8. The decision to go ahead with the pilot run will be based on the confirmatory run test data without aging.
9. The six month delay shown on the schedule between the pilot run decision and starting the QXFF may vary depending on what design changes are required.

ACTIVITY A - Engineering, Confirmatory and Pilot Run Build (Fabrication & Test)

Activity A provides for the fabrication and testing of 5 and 10 MHz units required for Phase III.

It is the object of this activity to process into the QXFF a total quantity of 100 engineering run units, 150 confirmatory sample units, and 1200 pilot run units. Each run will contain approximately equal quantities of 5 and 10 MHz units.

Engineering Run units are scheduled to begin into the QXFF in March, 1982. Confirmatory samples will begin in mid-May, 1982, and pilot run units will begin into the QXFF in April, 1983. Testing of the confirmatory samples is scheduled for completion in January, 1983. Testing of the pilot run units is scheduled for completion in March, 1984. Reference the schedule shown in Exhibit 2.

Tests performed will be those called out in the Product Specification, Drawing Number 46A926172. Sequential sampling will not be performed after initial sampling. From the sample tests an estimate will be made to a 90% confidence level as to the percent of remaining units that would be expected to successfully pass lot sample tests. Any additional testing requested will be considered a change in the scope of work.

The test plan estimate is based on the following projected yields into test.

	100% Tests	Lot Samples
Engineering Units	50	25
Confirmatory Units	100	100
Pilot Run Units	752	100

The cost estimate to complete Activity A, fabrication and testing the Phase III units, is $933,268.

Cost Breakdown

Material	$109,476
Overhead	21,896
Direct Labor	63,451
Overhead	77,410
Manufacturing Support Labor	133,202
Overhead	162,506
Engineering Support Labor	45,578
Overhead	53,783
Test Labor	43,012
Overhead	51,537
Product Cost	761,851
G&A/Fee	171,417
Total	$933,268

Activity B - QXFF Modification

Processing of 5 and 10 MHz Phase III units through the QXFF will begin after processing of the 22 MHz units for Phase II have been completed. In order to convert the QXFF to an interchangeable 20 MHz and 5/10 MHz production capability, the following additions or modifications must be made.

1. Fabricate 5/10 MHz lid/frame trays - 6 each
2. Replace existing bellows and manipulators
3. Provide for new masks and mask holder
4. Reposition contacting mechanism
5. Rework two parallel motion forceps

The estimated cost of this conversion is $94,309 and will be completed following Phase II processing. Reference schedule shown in Exhibit 2.

Cost Breakdown

Material	$23,775
Overhead	4,755
Engineering Labor	18,3[illegible]
Overhead	21,[illegible]94
Manufacturing Labor	3,853
Overhead	4,700
Product Cost	76,987
G&A/Fee	17,322
Total	$94,309

Activity C - Test Equipment Modification

Basic equipment is available from Phase II (22 MHz) to support Phase III testing. However, some additional equipment is required for Phase III to perform the required testing.

It is the object of this activity to provide and set up the equipment required to do the necessary testing of Phase III (5 and 10 MHz) product. Additional equipment required is as follows:

Equipment

H.P. Synthesizer for Frequency Repeatability	$10,000
H.P. 9825 for Short Term Stability and Thermal Time Constant	8,000
Misc. Fixtures	6,500
TOTAL	$24,500

The total cost for completing Activity C is $63,993. This activity is scheduled for completion in March, 1982. Reference schedule shown in Exhibit 2.

Cost Breakdown

Material	$24,500
Overhead	4,900
Engineering Labor	8,761
Overhead	10,362
Manufacturing Labor	1,665
Overhead	2,031
Product Cost	52,239
G&A/Fee	11,754
Total	$63,993

Activity D - Fixtures/Tools/Gages

Activity D provides for fabrication of fixtures, tools and gages required to support fabrication and inspection of the Engineering, Confirmatory, and Pilot Run builds.

It is the object of this activity to fabricate and check out fixtures, tools and gages to support the following process and inspection points.

Brazing	Spin Dry
Metallizing	Crystal Cleaning
Gold Plating	Gasket Press
Contact Evaporation	Clip, Cut Off Die
Polyimide Application	Extra Boats for Pilot (3)
Punch and Form	Tooling for Ceramic Vendor
UV/Polyimide Cure	QC Charts
QXFF	QC Gages

Cost Breakdown

Material	$ 49,200
Overhead	9,840
Direct Labor	22,545
Overhead	27,505
Drafting Labor	4,864
Overhead	5,740
Product Cost	119,694
G&A/Fee	26,931
TOTAL	$146,625

This activity is scheduled for completion in December, 1981. Reference schedule of Exhibit 2.

EXHIBIT I

COST ESTIMATE SUMMARY

READINESS		
Activity B -	QXFF Modification	$ 94,309
C -	Test Equipment Modification	63,993
D -	Fixturing/Tooling/Gages	146,625
FABRICATION		
Activity A -	Engineering, Confirmatory and Pilot Run Build	933,268
	Sum of Cost	1,238,195
	Contingency @ 15% on Material & Labor + G&A/Fee	86,779
	Total Program Cost	1,324,974
	Funds Available	860,875
	Additional Funds Required	$ 464,099

NDD DEPARTMENT PLAN

NEUTRON DEVICES DEPARTMENT
St. Petersburg, Florida

PHASE III - 5/10 MHz TMXO RESONATOR

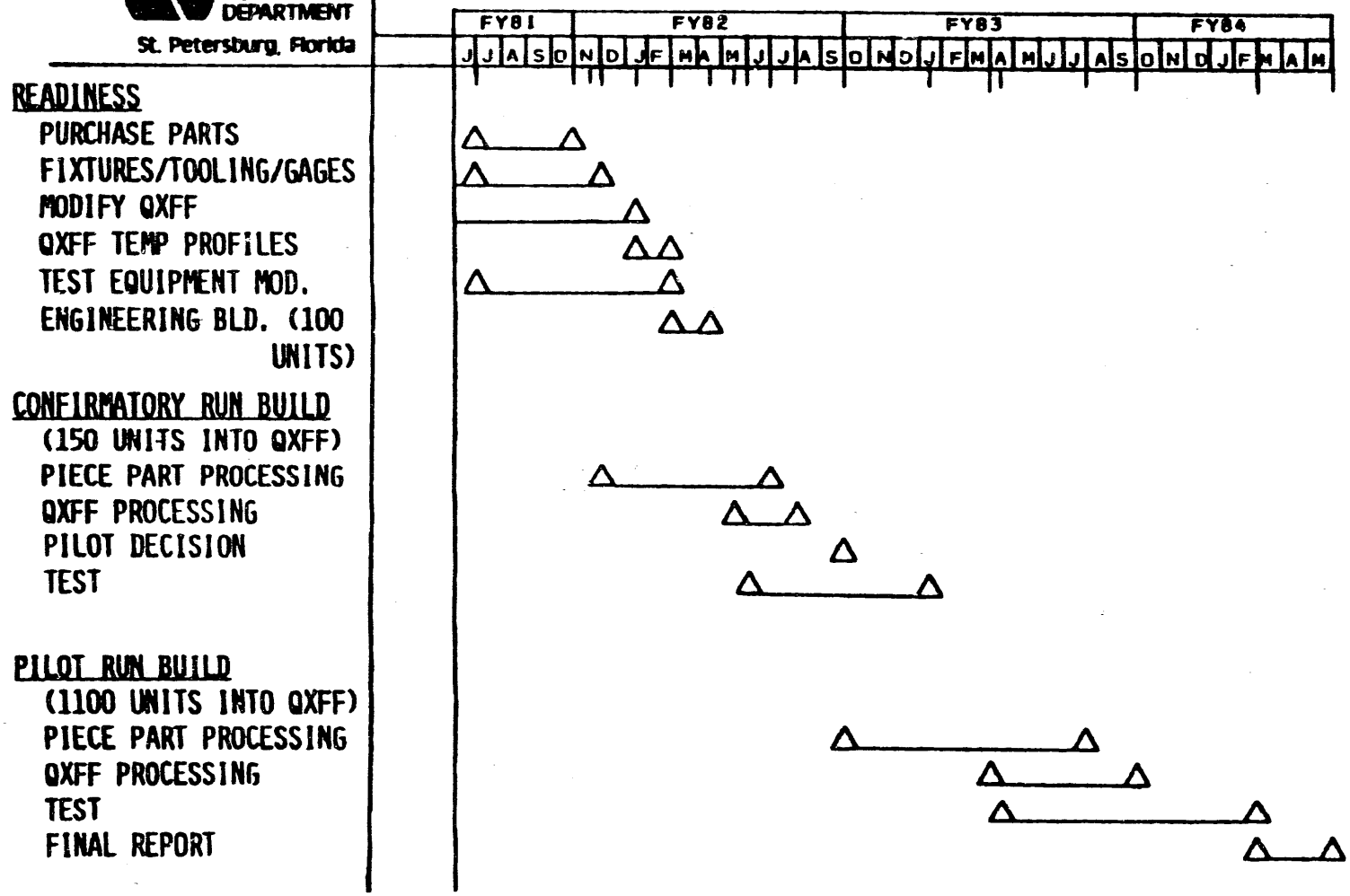
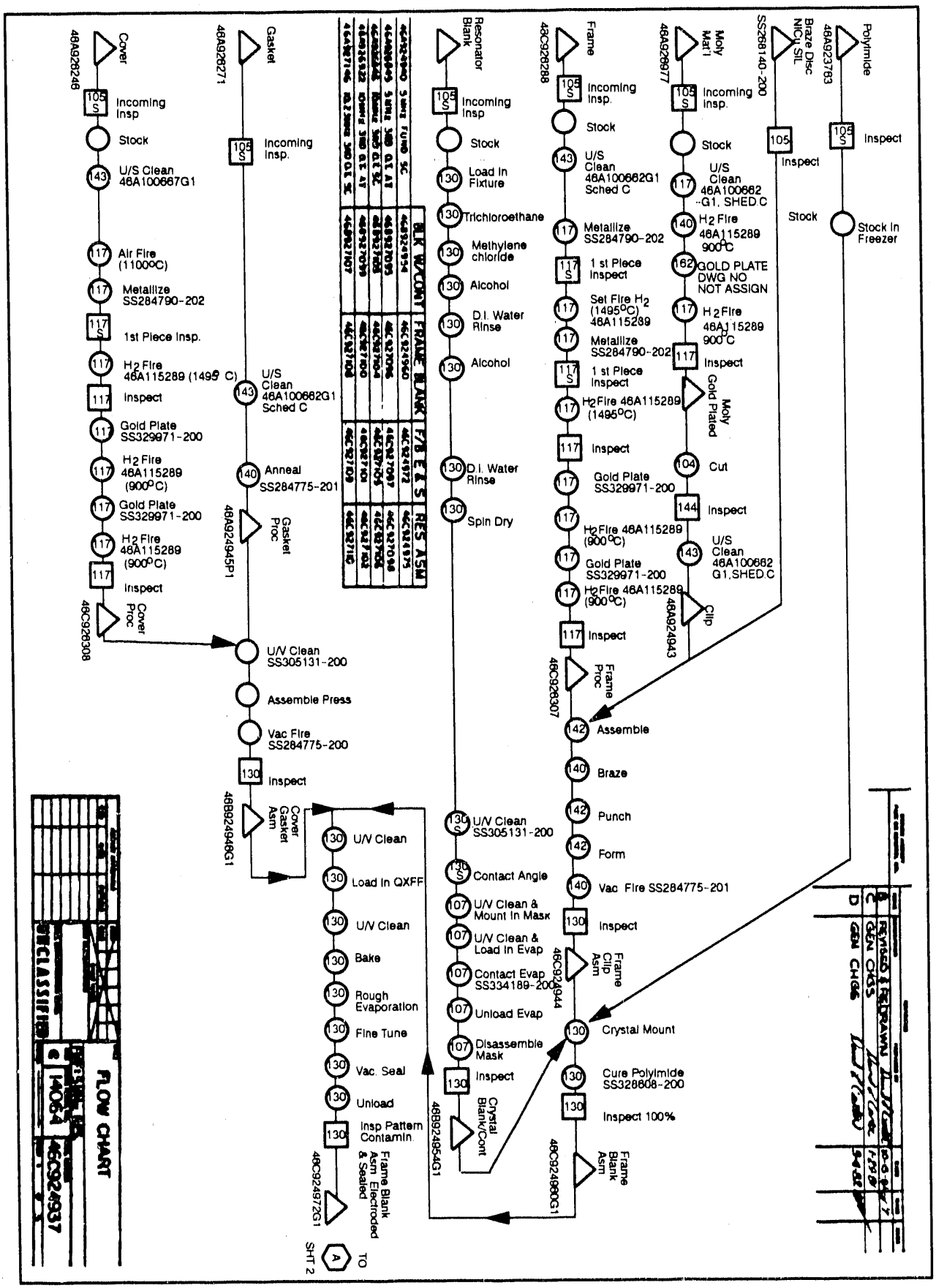
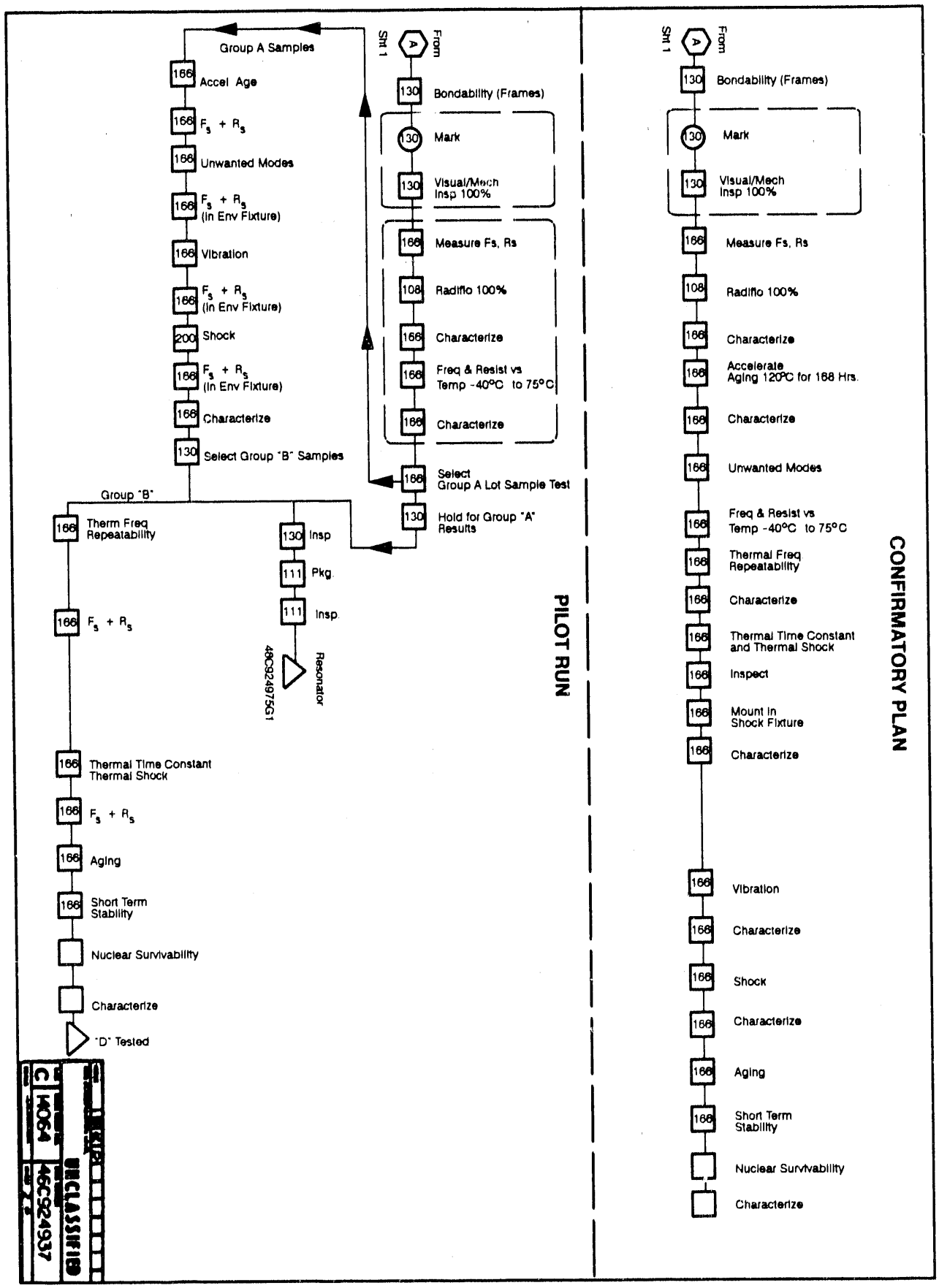


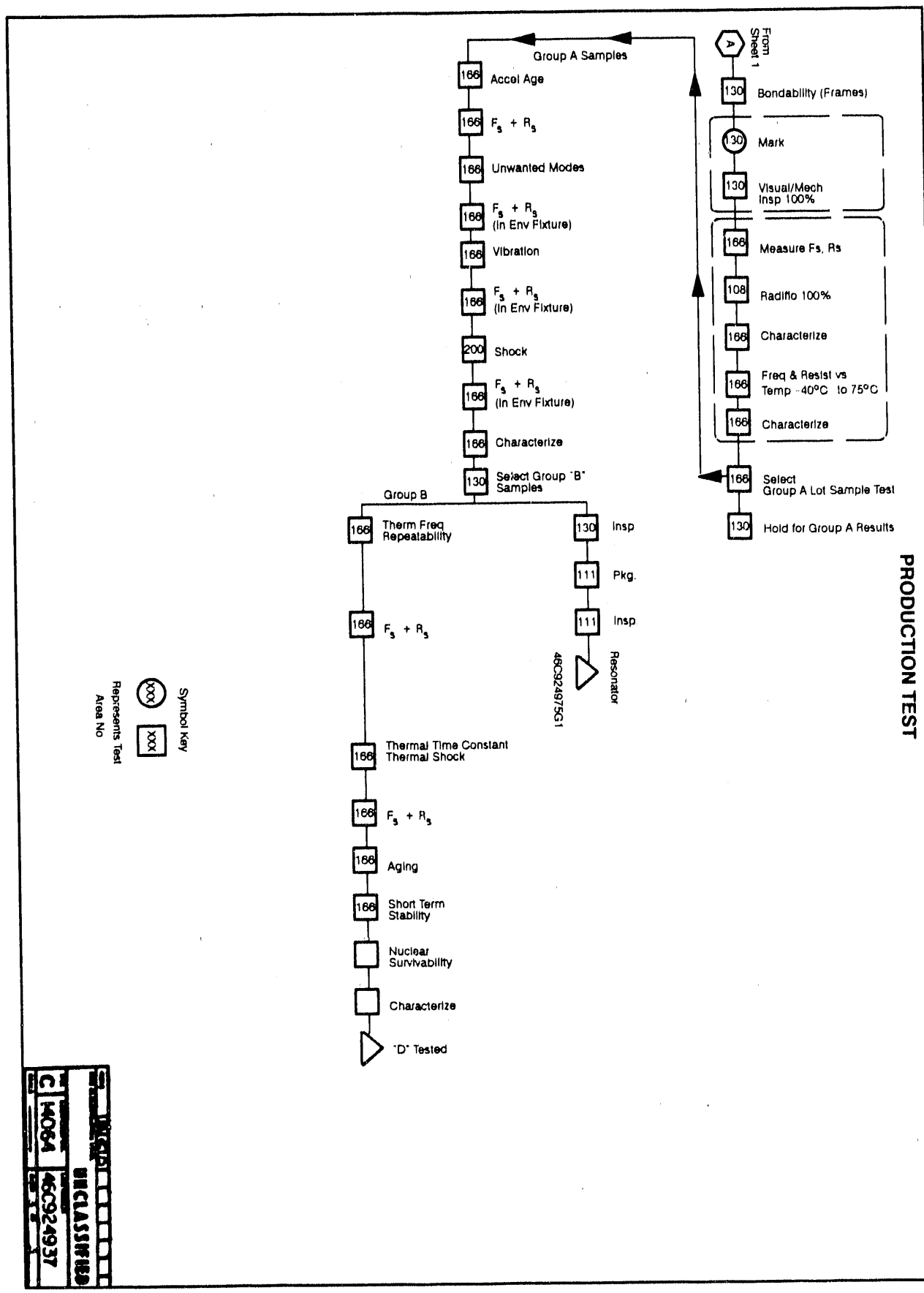
EXHIBIT 2

APPENDIX D

FLOW CHART
(DRAWING NO. 46C924937)


Cover
46A926246
105 S Incoming Insp
Stock
143 U/S Clean 46A100667G1
117 Air Fire (1100°C)
117 Metallize SS284790-202
117 S 1st Piece Insp.
117 H2 Fire 46A115289 (1495 C)
117 Inspect
117 Gold Plate SS329971-200
117 H2 Fire 46A115289 (900°C)
117 Gold Plate SS329971-200
117 H2 Fire 46A115289 (900°C)
117 Inspect
Cover Proc
46C926308
Gasket
46A926271
105 S Incoming Insp.
143 U/S Clean 46A100662G1 Sched C
140 Anneal SS284775-201
Gasket Proc
46A924945P1
U/V Clean SS305131-200
Assemble Press
Vac Fire SS284775-200
130 Inspect
Cover Gasket Asm
46B924948G1
130 U/V Clean
130 Load In QXFF
130 U/V Clean
130 Bake
130 Rough Evaporation
130 Fine Tune
130 Vac. Seal
130 Unload
130 Insp Pattern Contamin.
Frame Blank Asm Electroded & Sealed
46C924972G1
A TO SHT 2
BLK W/CONT FRAME BLANK F/B E & S RES ASM
Resonator Blank
105 S Incoming Insp
Stock
130 Load In Fixture
130 Trichloroethane
130 Methylene chloride
130 Alcohol
130 D.I. Water Rinse
130 Alcohol
130 D.I. Water Rinse
130 Spin Dry
130 S U/V Clean SS305131-200
130 S Contact Angle
107 U/V Clean & Mount In Mask
107 U/V Clean & Load In Evap
107 Contact Evap SS334189-200
107 Unload Evap
107 Disassemble Mask
130 Inspect
Crystal Blank/Cont
46B924954G1
Frame
46C926288
105 S Incoming Insp.
Stock
143 U/S Clean 46A100662G1 Sched C
117 Metallize SS284790-202
117 S 1 st Piece Inspect
117 Set Fire H2 (1495°C) 46A115289
117 Metallize SS284790-202
117 S 1 st Piece Inspect
117 H2Fire 46A115289 (1495°C)
117 Inspect
117 Gold Plate SS329971-200
117 H2Fire 46A115289 (900°C)
117 Gold Plate SS329971-200
117 H2Fire 46A115289 (900°C)
117 Inspect
Frame Proc
46C926307
142 Assemble
140 Braze
142 Punch
142 Form
140 Vac Fire SS284775-201
130 Inspect
Frame Clip Asm
46C924944
130 Crystal Mount
130 Cure Polyimide SS328608-200
130 Inspect 100%
Frame Blank Asm
46C924960G1
Moly Mat'l
46A929977
105 S Incoming Insp.
Stock
117 U/S Clean 46A100662 -G1, SHED.C
140 H2 Fire 46A115289 900°C
162 GOLD PLATE DWG NO NOT ASSIGN
117 H2 Fire 46A115289 900°C
117 Inspect
Gold Plated Moly
104 Cut
144 Inspect
143 U/S Clean 46A100662 G1,SHED.C
Clip
46A924943
SS268140-200
Braze Disc NiCu SIL
105 Inspect
Stock
Polyimide
46A923783
105 S Inspect
Stock In Freezer
FLOW CHART
UNCLASSIFIED
C 14064
46C924937
REVISED REDRAWN
GEN CHGS
GEN CHGS


PILOT RUN
CONFIRMATORY PLAN
From A Sht 1
Bondability (Frames)
Mark
Visual/Mech Insp 100%
Measure Fs, Rs
Radiflo 100%
Characterize
Freq & Resist vs Temp -40°C to 75°C
Characterize
Select Group A Lot Sample Test
Hold for Group "A" Results
Group A Samples
Accel Age
Fs + Rs
Unwanted Modes
Fs + Rs (in Env Fixture)
Vibration
Fs + Rs (in Env Fixture)
Shock
Fs + Rs (in Env Fixture)
Characterize
Select Group "B" Samples
Group "B"
Therm Freq Repeatability
Fs + Rs
Thermal Time Constant Thermal Shock
Fs + Rs
Aging
Short Term Stability
Nuclear Survivability
Characterize
"D" Tested
Insp
Pkg
Insp
Resonator
46C924975G1
Accelerate Aging 120°C for 168 Hrs.
Unwanted Modes
Thermal Freq Repeatability
Thermal Time Constant and Thermal Shock
Inspect
Mount in Shock Fixture
Vibration
Shock
Aging
Short Term Stability
Nuclear Survivability
Characterize


PRODUCTION TEST
From Sheet 1
A
130 Bondability (Frames)
130 Mark
130 Visual/Mech Insp 100%
166 Measure Fs, Rs
108 Radiflo 100%
166 Characterize
166 Freq & Resist vs Temp -40°C to 75°C
166 Characterize
166 Select Group A Lot Sample Test
130 Hold for Group A Results
Group A Samples
166 Accel Age
166 Fs + Rs
166 Unwanted Modes
166 Fs + Rs (In Env Fixture)
166 Vibration
166 Fs + Rs (In Env Fixture)
200 Shock
166 Fs + Rs (In Env Fixture)
166 Characterize
130 Select Group "B" Samples
Group B
166 Therm Freq Repeatability
166 Fs + Rs
166 Thermal Time Constant Thermal Shock
166 Fs + Rs
166 Aging
166 Short Term Stability
Nuclear Survivability
Characterize
"D" Tested
130 Insp
111 Pkg.
111 Insp
Resonator
46C924975G1
Symbol Key
XXX
XXX
Represents Test Area No

APPENDIX E

PROCESS SPECIFICATIONS AND DRAWINGS

DRAWING NUMBERS AND TITLES

46A100661	General Ultrasonic Cleaning Specification
46A100662	Cleaning Process
46A100663	Cleaning Process
46A100667	Cleaning Process
46A100669	Cleaning Process
46A100670	Deionized Water
46A100702	Handling and Storage of Vacuum Tube Parts
46A100853	Dense Alumina Ceramic
46A101546	Ammonium Bifluoride
46A102297	Molybdenum, Unalloyed
46A115289	Hydrogen Firing Spec.
SS268140	Braze Alloy
SS277052	Cleaning Process
SS284775	Vacuum Firing
SS284790	Metallize Specification
SS284790	Metallize Specification
SS302235	Gold, High Purity
SS305131	Ultraviolet Cleaning
SS328609	Adhesive Polyimide
SS329971	Gold Plating Process (Dequest)
SS329986	Handling and Storage
SS332871	Gold Plating Process (Dequest)
SS334182-200	Cleaning and Insp. Procedure
343283-200	Gold Cleaned
344922	Crystal Resonator
46A923742	Cleaning and Insp. Procedure
46A923763	Polyimide Application and Cure
46A923912	Evaporation Process Mo/Au
46C924934	Frame Proc
46B924935	Cover
46C924936	Cover Processed
46A924940	Fundamental Mode 5 MHz SC-Cut Crystal Blanks
46A924943	Clip
46C924944	Frame Clip Assembly
46A924945	Gasket Processed
46B924946	Cover Gasket Asm.
46B924954	Blank Contacted
46C924960	Frame Blank Assembly
46C924972	Frame Blank Electroded and Sealed
46C924975	Resonator
46A925072	Handling and Storage
46A926172	Product Specification, 5 MHz and 10 MHz Quartz Crystal Resonator
46A926246	Cover
46A926271	Gasket
46C926288	Laminated Frame (Reson)
46C926307	Frame Processed
46C926308	Cover Processed
46A926845	Third Overtone 5 MHz AT-Cut Crystal Blanks
46A926846	Third Overtone 10 MHz SC-Cut Crystal Blanks
46A926922	Third Overtone 10 MHz AT-Cut Crystal Blanks
46A926977	Molybdenum Ribbon
46A927146	Crystal Blanks
46A927252	Gold Plating Process for Molybdenum Ribbon
46A927253	Molybdenum Ribbon Plated
46B927564	Cover Gasket Assembly
46A927742	Electroding and Sealing Process

DWG CLASSIFICATION LEVEL	PRODUCTION

DESIGN AGENCY PART OR CONTROL NO.	REVISIONS					
	ISSUE	DESCRIPTION	PREPARED BY	DATE	CHKR	ENGR
	8	790723GE	[illegible]	[illegible]	JB.	

GROUP NO.	Part No.	Name	Description
G1			
X	1	Assembly	
AR	2	Detergent	Bendix Aviation Corp. #251 Compound Pioneer Central Div. Davenport, Iowa

1. GENERAL

Generally it is more desirable, especially in large tanks, to contain the cleaning solution in a separate container, of glass or stainless steel construction, immersed in a driving medium. Glass or stainless steel mesh baskets may be utilized to contain the parts; however, baskets of less than 1/4 inch mesh must have solid bottoms unless they are placed in intimate contact with a solid surface.

The volume of cleaning solutions used should be at least ten times the bulk volume of small parts or must completely cover large pieces. Blind holes and cavities must be filled with the solution to obtain proper cleaning. This may involve rotation of parts during cleaning or even "vacuum filling as is done in vacuum impregnation. It is absolutely necessary that the solution be in contact with the area to be cleaned.

Power must remain on during removal of each piece part or assembly from the liquid in which it has been cleaned to insure that the dirt that has been removed from it has no opportunity to settle back on the clean part

The cleaner must be tuned to maximum efficiency. This tuning must be checked on every run and adjusted if necessary. If a driving medium is needed, it shall be a 0.5 to 1.0 per cent solution of P2 in water in the transducer tank. The water used must be put into the tank and the transducer operated for approx. 15 minutes to degas the water before adding the detergent. If the parts come in contact with the liquid in the transducer tank, this liquid shall be the cleaning material. The cleaning containers are to be suspended so that the bottom of the container is at least 1 1/2 inches above the bottom of the transducer tank.

Inspection of parts after cleaning is usually done visually. The finer dirt or dust, if left from vapor blasting or sand blasting, produces a mottled appearance.

Generally, a completely out gassed part or subassembly does not suffer any ill effect in ultrasonic cleaning and does not require a repeat

AGENCY APPROVALS			PART CLASSIFICATION	TITLE
ORG	DATE	INITIALS		GENERAL ULTRASONIC CLEANING SPECIFICATION
	10-20-59	SG.		
	10-30-59	L.C.W.		
GE	10-29-59	R.K.		
			DWG CLASSIFICATION LEVEL: UNCLASSIFIED	SIZE: A; CODE IDENT NO.: 14064; DWG NUMBER: 46A100661; SCALE: ; SHEET 1 OF 2

1. continued

outgas before use. Vaporblasted ferrous surfaces tend to have adhering microscopic magnetized particles. So to facilitate cleaning, they shall be demagnetized just prior to final ultrasonic cleaning before assembly into a tube.

NOTE: Tolerance on specified times to be +50% -0.

FSCM NO. 14064
FCO:860214GE
JL Burton, GEND
Diskette 6688A-0296A
SC/GE

46A100662
G1
Issue 17

Date: 06/06/86

Title: Cleaning Process

SHEET INDEX

SHEET	1	2	3												
ISSUE	17	17	17												

QTY	DWG/PART	DESCRIPTION	ITEM
AR	124A1105P1	Alcohol	2
AR	46A101581P1	Meth. Chldr.	3
AR	SS302227-200	Trichloroethane, (Alt for Item 8)	4
AR	124A1219P1	Acetone	5
AR	46A101581P2	Alt. Part 3	6
X	46A100661	Cleaning Process	7
AR	46A101584P1	Trichloroethylene	8

Purpose:

To remove spinning lubricant, drawing or machining compounds, or protective coatings from metal piece parts or sub-asms, degreasing parts prior to firing and removing grit, abrasive binder, metal particles and powder from polished parts and sub-asms. Unless otherwise noted on detail drawings schedule A & B shall be considered equivalent.

Schedule "A" - Trichloroethylene

a. Equipment: National Ultrasonic Model D-310 or Equivalent

b. Procedure:

1. Spray parts with nozzle.

2. Immerse parts in vapor over boiling solvent (Item 8) for 2 minutes min.

Schedule "A" continued

3. Immerse parts in liquid (Item 8) over transducer for 4 minutes min.

4. Remove parts slowly from vapor allowing part to dry as removed.

5. Dry preventing oxidation and contamination.

Schedule "B" - Trichloroethylene

a. Equipment: Detrex Model 2DS500S Ultrasonic Vapor Degreaser or equivalent.

b. Procedure:

1. Immerse parts in vapor over boiling solvent (P4) for 2 + 1.0-0 minutes. Drain and transfer to next step.

2. Immerse parts in liquid (Item 8) over transducer for 8 + 1.0-0 minutes.

3. Spray parts with nozzle over boiling solvent.

4. Remove parts slowly from vapor allowing part to dry as removed.

5. Rinse parts in fresh P5.

6. Dry preventing oxidation and contamination.

Schedule "C" - Methylene Chloride:

a. Equipment: Bendix Type UG-1B-2 or Equivalent.

b. Procedure:

1. Ultrasonically clean for five minutes in Part 3 or Part 6.

2. Ultrasonically clean for five minutes in Part 2.

3. Dry, preventing oxidation and contamination.

Schedule "D" - Trichloroethylene

a. Equipment: Detrex Vapor Degreaser or Equivalent.

b. Procedure:

1. Immerse parts in vapor over boiling solvent (Item 8) for 2 +1.0 -0 minutes.

2. Immerse parts in liquid (Item 8).

3. Spray parts with nozzle over boiling solvent.

4. Remove parts slowly from vapor allowing part to dry as removed.

Schedule "E" - Trichloroethylene

a. Equipment: Detrex Vapor Degreaser or Equivalent.

b. Procedure:

1. Immerse parts in vapor over boiling solvent (Item 8) for 2 +1.0 -0 minutes.

2. Immerse parts in liquid (Item 8)

3. Remove parts slowly from vapor allowing part to dry as removed.

GENERAL ELECTRIC

46A100663

CONT ON SHEET 2 SH NO. 1

F Z-7456

46A100663

CONT ON SHEET 2 SH NO. 1

TITLE CLEANING PROCESS

FIRST MADE FOR

			G3	G2	G1	PART NO.	NAME	DRAWING NO., DESCRIPTION, MATERIAL, WEIGHT
			X	X	X	1	ASM.	
			AR	AR	AR	2	DETERGENT	46A102073 P1
			AR	AR	AR	3	ACETONE	124A1219 P1
			AR	AR	AR	4	DEIONIZED WATER	46A100670 P2

A. PURPOSE:

FOR CLEANING CERAMIC-METAL OR GLASS-METAL ASSEMBLIES WHICH HAVE NOT REQUIRED MASKING FOR VAPOR BLAST OR SAND BLAST (SEE NOTE 1, NOTE 2, AND NOTE 3) OR CERAMIC OR METAL PARTS PRIOR TO ASSEMBLY.

B. EQUIPMENT: (FOR G3-OMIT THIS SECTION)

SONAGEN TYPE AP50 OR EQUIVALENT.

C. PROCEDURE:

1. ULTRASONIC CL[illegible]N FOR 4 MINUTES IN 0.5 TO 1.0% P2 IN P4 (15 ML OF P2 IN 2 LITERS OF P4).
2. RINSE IN FRESH P4 UNTIL ALL TRACES OF DETERGENT ARE REMOVED. THIS MAY BE ACCOMPLISHED BY A CASCADE RINSE OR BY USING FRESH QUANTITIES OF P4. ULTRASONIC EXCITATION IS NOT USED DURING THIS STEP.
3. ULTRASONIC RINSE FOR 8 MINUTES IN P4. CASCADE RINSE MAY BE USED.
4. REPEAT (3) IN FRESH P4.
5. GIVE THE PART A DIP RINSE IN FRESH CLEAN P3 TO FACILITATE DRYING.
6. DRY PREVENTING OXIDATION & CONTAMINATION.

NOTE 1: FRAMES FOR TUBES, OR OTHER CUP SHAPED ASSEMBLIES, REQUIRE SPECIAL CARE IN RINSING AT EACH STEP. AS A FRAME IS PUT INTO A BATH, IT IS TO BE RINSED BY FILLING AND THEN EMPTYING BACK INTO THE SOLUTION FOUR TIMES BEFORE IT IS SET IN ON ITS SIDE FOR THE SPECIFIED CLEANING PERIOD. AT THE

UNLESS OTHERWISE SPECIFIED USE	APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS FRACTIONS	DECIMALS	ANGLES
	46A100702 46A100661	✓	±	±	±

DESCRIPTION OF GROUPS

REVISIONS

4	OCT. 1, 1962 [illegible]	1196 P5	1	[illegible]	P[illegible] C	
ADD P1 AFTER P3.			NOTE 2 - P2 WAS P3 ADDED G3			
5	SEPT. 25, 63 [illegible]	8421 P4	2	[illegible] 12-7-60	P6127	
P2 WAS 110A131 5 P3.			GENERAL CHANGE			
6	DEC. 3, 1963 [illegible]	1236 P3	3	[illegible] 2-16-61	P6721 P4	
DWG. NO. FOR P4 WAS 46A100[illegible]			CHANGED WATER			

PRINTS TO: R, Z, X, C

MADE BY [illegible] July 16, 1959 — APPROVALS [illegible] — PINELLAS PENINSULA PLANT

ISSUED EN 240 [illegible] 2-5-60 — [illegible] 2/19/60 — ST. PETERSBURG, FLORIDA

46A100663 CONT ON SHEET 2 SH NO. 1

G3 P4565

REVIEWED FOR C* — [illegible] 8/25/59 [illegible] 4-5-60

PRINTED IN U.S.A.

A

GENERAL ELECTRIC

46A100663
CONT ON SHEET FINAL SH NO. 2

46A100663
CONT ON SHEET FINAL SH NO. 2

TITLE
CLEANING PROCESS

FIRST MADE FOR

PART NO.	NAME	DRAWING NO., DESCRIPTION, MATERIAL, WEIGHT

END OF THE SPECIFIED CLEANING PERIOD, IT IS AGAIN TO BE RINSED 4 TIMES IN THE SAME WAY BEFORE PROCEEDING TO THE NEXT STEP. TO MINIMIZE CARRY-OVER FROM ONE BATH TO THE NEXT, AS MUCH EXCESS FLUID IS TO BE REMOVED AT EACH FINAL RINSE AS FOSSIBLE WITHOUT THE PART. DRYING.

NOTE 2: THE DETERGENT (P2) SOLUTIONS ARE NOT TO BE USED MORE THAN 4 TIMES. FOR ESPECIALLY DIRTY PARTS, IT MAY BE NECESSARY TO CHANGE THEM OFTENER . THE DEIONIZED BATHS (P4) ARE TO BE CHANGED EACH TIME.

NOTE 3: IF AN ASSEMBLY IS NOT CLEAN AFTER A RE-RUN THROUGH THE CLEANING CYCLE, IT IS TO BE RETURNED FOR RESAND BLAST, REVAPOR BLAST, OR REPOLISHING, AS THE CASE MAY BE.

GROUP	A	B
1	8	5
2	12	7.5
3	8	5

NOTE 4. WHEN ARGON OVEN DRYING IS USED, NO ACETONE RINSE IS REQUIRED.

UNLESS OTHERWISE SPECIFIED USE	APPLIED PRACTICES	SURFACES	TOLERANCES ON MACHINED DIMENSIONS: FRACTIONS	DECIMALS	ANGLES
	46A100702 46A100661	✓	±	±	±

DESCRIPTION OF GROUPS	REVISIONS	PRINTS TO

MADE BY Thomas P Enge July 16 1959
ISSUED

APPROVALS
[illegible] 7-24-59
[illegible] 8/11/59

PINELLAS PENINSULA PLANT
ST PETERSBURG, FLORIDA

46A100663
CONT ON SHEET FINAL SH NO. 2

8/25/59
ORM/266 3-2-60

PRINTED IN U.S.A.

MANUFACTURING AGENCY
GENERAL ELECTRIC
NEUTRON DEVICE DEPT.

DWG. CLASSIFICATION LEVEL
UNCLASSIFIED

DWG. STATUS
PRODUCTION

FIRST MADE FOR

REVISIONS

ISSUE	DESCRIPTION	ISSUE	DESCRIPTION	ISSUE	DESCRIPTION
11	7800326G J.H. Baggs 2-28-76				

GROUP NO.

QUANTITY REQ'D G1	DRAWING OR PART NUMBER	DESCRIPTION	ITEM
X		ASM	1
AR	46A102073P1	DETERGENT	2
X	4CA100GG1	GEN. ULTRASONIC CLEANING SPEC.	3
AR	46A101565P1	NITRIC ACID	4
AR	46A100670P2	DEIONIZED WATER	5

DIST CODE

DESIGN AGENCY APPROVAL

ORG.	DATE	INITIALS

MFG AGENCY APPROVAL

DATE	INITIALS

TITLE
CLEANING PROCESS

SIZE A | CODE IDENT. NO. 14064 | SC GE

DWG. NO. 46A100667

SHEET 1 OF 2

MADE BY REDRAWN J.H. Baggs | DATE 2-28-76 | APPROVAL | DATE

ORIGINATED AT GEND

A. PURPOSE:

For cleaning raw unprocessed ceramics to remove loose dust, dirt and ceramic particles and to identify stainless steel fastening hardware.

B. EQUIPMENT:

Sonagen Type AP50 or equivalent.
Polyethylene covered stainless steel baskets or equivalent.

C. PROCEDURE:

1. Ultrasonic clean for 8 minutes in 0.5 to 1.0% P2 in P5 (for example: 15 ml of P2 in 2 liters of P5). The solution is to be maintained at 60°C ± 10°C.

2. Rinse in fresh P5 until all traces of detergent is removed. This may be accomplished by a cascade rinse or by using fresh quantities of P5. Ultrasonic excitation is not used during this step.

3. Ultrasonic clean for 5 minutes in 50% P4. Maximum temperature of acid will be 30°C.

4. Rinse in three separate quantities of P5. Ultrasonic excitation is not used during this step.

5. Ultrasonic rinse for 5 minutes in P5. Cascade rinse may be used.

6. Repeat (5) in fresh P5.

7. Dry to minimize oxidation and contamination.

NOTES:

1. Cup-shaped parts, cylindrical parts or parts with blind holes shall be positioned in such a manner as to assure contact of the fluid with all surface areas of the part.

2. Minimize carry-over from one fluid to the next by removing as much excess fluid as possible at the end of each process step without letting the part dry.

GENERAL ELECTRIC **46A100669**

CONT ON SHEET SH NO.

46A100669

CONT ON SHEET SH NO.

TITLE CLEANING PROCESS

FIRST MADE FOR

01	PART NO.	NAME	DRAWING NO., DESCRIPTION, MATERIAL, WEIGHT
X	1	ASM.	
AR	2	ACETONE	124A1219 P1

A. PURPOSE:
FOR CLEANING PAINTED, UNFIRED, METALLIZED POWDER FROM CERAMICS.

B. EQUIPMENT:
BENDIX TYPE UG-1B-2 OR EQUIVALENT.

C. PROCEDURE:

1. ULTRASONIC CLEAN FOR 3 MINUTES IN P2.
2. REPEAT STEP 1, USING FRESH, CLEAN P2.
3. REPEAT STEP 1, USING FRESH, CLEAN P2.
4. DIP RINSE IN FRESH, CLEAN P2.
5. DRY, PREVENTING OXIDATION & CONTAMINATION.

UNLESS OTHERWISE SPECIFIED USE	APPLICABLE PRACTICES	SURFACES	FRACTIONS	DECIMALS	ANGLES
	46A100661	✓	±	±	±

DESCRIPTION OF GROUPS	REVISIONS	PRINTS TO
	1 ... ADDED PT ... MATL. P2	X C

MADE BY Thomas R. ... July 17 1957

ISSUED END 2A6 ...

APPROVED

[illegible] 46A100669

SH NO.

PF ... PRINTED IN U.S.A.

REVISED NO. 6

R.K. 4/5/2?

FSCM NO. 14064
FCO830394GE
JL Burton, GEND
Diskette 6326A-0293A
FMF: MC1238

46A100670
See Below
Issue 10

Date: 06/22/83
PART CLASS: UNCL

Deionized Water

PART NO.	MATERIAL
P1	1 Megohm-CM Water
P2	5 Megohm-CM Water
P3	12 Megohm-CM Water
P4	16.6 Megohm-CM Water
P5	10.0 Megohm-CM Water

1. GENERAL

1.1 Scope. This specification covers the requirements for high purity deionized water manufactured and used within Plant facilities.

2. DOCUMENTS

2.1 ASTM D1125 -- Electrical conductivity and resistivity of water.

2.2 ASTM D859 -- Silica in water.

2.3 ASTM D1193 -- Reagent water.

2.4 ASTM F60 -- Microbiological contaminants in water used for processing electron and microelectronic devices.

3. REQUIREMENTS

3.1 Manufacturers

3.1.1 General Electric Company

3.2 Material

		P1	P2	P3	P4	P5
3.2.1	Electrical resistivity, min megohm-cm at 25°C.	1	5	12	16.6	10
3.2.2	Silica, max. mg/liter	2.0	1.0	0.5	0.1	0.7
3.2.3	Minimum color retention time of potassium permanganate, minutes.	10	10	60	60	60
3.2.4	Maximum total bacteria count colonies/ml.	1000	1000	100	10	300

4. QUALITY PROVISIONS

4.1 Test Methods (Mandatory only in case of dispute)

4.1.1 Electrical Resistivity ---------- ASTM D1125

4.1.2 Silica (Colorimetric Method)--------ASTM D859

4.1.3 Color Retention Time ----------ASTM D1193
of Potassium permanganate

4.1.4 Total Bacteria Count ---------- ASTM F60

5. PACKAGING AND HANDLING

5.1 The following list is the priority of storage and handling materials in decreasing order of preference.

a. Tin (handling only)

b. Stainless Steel (handling only)

c. Corrugated Teflon tubing

d. Polyvinyl Chloride - Type 1 (free of plasticizers or additives)

e. Polyethylene

f. Glass

6. NOTES

None

FSCM NO. 14064
FCO 850131GE
J. Burton, GEND
Diskette 3858A-0187A

46A100702
Page 1 of 8
Issue 46
Date: 05/17/85

TITLE: Handling and Storage of Vacuum Tube Parts

1. GENERAL:

1.1 Scope. This drawing covers approved practices for handling and storage of vacuum tube parts and assemblies.

1.2 Notes. Referenced notes are listed on last sheet.

2. DOCUMENTS:

2.1 46A102131 - Detergent, non-ionic.

2.2 46A101756 - Detergent, anionic.

2.3 46A102642 - Radioactivity decontaminant.

2.4 46A102143 - Oil, electrical insulating, high purity.

2.5 46A100670P2 - Deionized water.

3. REQUIREMENTS:

3.1 General

3.1.1 Handling. Parts and assemblies shall not be handled unnecessarily even if approved methods are observed; and when they are handled, it shall be in a manner to ensure against contamination and minimal damage such as dents, nicks, scratches, chips, etc.

3.1.2 Furnace Materials. Container materials for high temperature furnace applications are not included in this drawing. Furnace handling materials consisting of molybdenum, stainless steel, ceramic and asbestos shall be used in accordance with furnace conditions required.

3.2 Handling Materials in Decreasing Order of Preference (See Note 6.1)

3.2.1 Containers	Manipulation
Code	Code
1 - Glass	A - Stainless Steel Tools
2 - Stainless Steel	B - Ceramic Tipped Tools
3 - Plastic (See Note 6.2)	C - Plastic Tools (See Note 6.2)
4 - Wood	D - Nylon Gloves plus External Finger Cots
	E - Finger Cots
	F - Nylon Gloves
	G - Cotton, Plastic or Rubber Gloves
	H - Bare Hands

3.2.1.1 All containers shall be adequately covered whenever it is necessary to protect material within from airborne contamination.

3.2.1.2 Patapar paper may be used alone or in conjunction with other materials where cleanness is necessary without regard to scratching or slight paper particle contamination.

3.2.1.3 All blasting and chemical treatment operations and glove boxes require use of rubber gloves.

3.3 Metal Parts and Subassemblies

3.3.1 GEND Fabricated Parts	Code
3.3.1.1 Incoming raw stock thru fabrication and final clean in machine shop	3H
3.3.1.2 After final clean in machine shop thru fabricated parts in stock	3G
3.3.1.3 From fabricated parts in stock to vacuum firing (See Note 6.7)	3E, G
3.3.1.4 After vacuum firing thru tube assembly	2E

Code

3.3.2 Purchased Fabricated Parts

3.3.2.1 Prior to and including parts in stock.----------3G

3.3.2.2 From parts in stock, proceed thru same handling and storage conditions beginning with 3.3.1.3.

3.4 Glass Parts and Subassemblies

3.4.1 Preforms

3.4.1.1 After casting through anneal----------3H

3.4.1.2 After anneal through fabrication and to final clean in machine shop----------3H

3.4.1.3 After clean in machine shop to fabricated parts in stock-----3G

3.4.1.4 After fabricated parts in stock to clean etch----------3G

3.4.1.5 After clean and etch through assembly----------1E

3.4.2 Glass Cylinders and Glass-Metal Assemblies

3.4.2.1 Prior to and including glass - metal assembly.----------4G

3.4.2.1.1 For glass-metal assembly, use tweezers with glass sleeving to remove frames. Use asbestos trays during assembly and anneal. Do not use nylon gloves unless covered with finger cots.

3.4.2.2 After glass-metal assembly thru vapor blast.----------4G

3.4.2.3 After vapor blast to vacuum fire.----------3E

3.4.2.3.1 Stainless steel or plastic inserts may be used in containers for glass-metal assemblies.

3.4.2.4 After vacuum fire thru tube assembly:

3.4.2.4.1 External tube surfaces----------2A or 2D only

3.4.2.4.2 Internal tube surfaces----------2A

Code

3.5 Ceramic Parts and Ceramic-Metal Assemblies

CAUTION: Take necessary precautions to prevent metal marks from occurring on bare ceramic areas. Ceramic tipped tools used on metals shall not be used on ceramics because of possible metal transfer.

3.5.1 GEND Fabricated Ceramics

3.5.1.1 Raw stock thru fabrication and final clean in shop.--------3H

3.5.1.2 After final clean in shop thru stock.----------3E

3.5.2 Purchased Ceramics

3.5.2.1 Prior to and including parts in stock.----------3E

3.5.3 Substrate Ceramics

3.5.3.1 Prior to vacuum nickel sinter----------3E
(see Note 6.3)

3.5.3.2 After vacuum nickel sinter to vacuum fire----------3E

3.5.3.3 After vacuum fire thru tube assembly.----------2A
(see Note 6.8)

3.5.4 Ceramic Processing

3.5.4.1 From stock and including ultrasonic clean.----------3E

3.5.4.2 After ultrasonic clean to vacuum nickel sinter.----------3E
(see Note 6.3)

3.5.4.3 After vacuum nickel sinter to dry hydrogen fire:

3.5.4.3.1 External Tube Surfaces----------3E

3.5.4.3.2 Internal Tube Surfaces----------3E

3.5.4.4 After dry hydrogen fire to vacuum fire:

3.5.4.4.1 External Tube Surfaces----------3E
(see Note 6.8 except 1081 Frame)

3.5.4.4.2 Internal Tube Surfaces----------2B
(see Note 6.8)

Code

3.5.4.5 After vacuum fire thru tube assembly:

3.5.4.5.1 External Tube Surfaces----------2D
(see Note 6.8)

3.5.4.5.2 Internal Tube Surfaces----------2B
(see Note 6.8)

3.6 Processing Materials

3.6.1 Erbium

3.6.1.1 Prior to and including purification----------3D

3.6.1.2 After purification thru material in stock----------1D

3.6.1.3 From material in stock thru processing----------1D
(see note 6.5)

3.6.2 Titanium & Vanadium

3.6.2.1 Prior to and including material in stock----------3D

3.6.2.2 After cleaning thru processing:

3.6.2.2.1 Wire coils or bar----------2D

3.6.2.2.2 Cut pieces----------2D
(see Note 6.5)

3.6.3 Getters and Formed Getters

3.6.3.1 Between operations, getters and formed getters shall be kept in gasket sealed stainless steel or glass containers purged with clean dry inert gas. After vacuum firing, assemble into completed tubes and evacuate within 8 weeks. Storage of assembly during intermediate assembly operations shall be in covered stainless steel or glass containers purged with clean dry inert gas.

3.6.4 Braze Materials — Code

3.6.4.1 Prior to and thru cleaning----------3E

3.6.4.2 After cleaning----------2E
(see Note 6.3)

Code

3.6.5 Chemicals

3.6.5.1 All containers shall be tightly closed except when material is being removed and only glass, stainless steel and Engineering approved plastic materials shall be used for handling.

3.7 Tube Assemblies

3.7.1 MC1081

3.7.1.1 After assembly thru tube exhaust----------2G
(see Notes 6.6 & 6.7)

3.7.1.2 Tube exhaust thru stock----------3G
(see Notes 6.6 & 6.7)

3.7.2 MC2993

3.7.2.1 After assembly thru tube exhaust----------2G
(see Notes 6.6 & 6.7)

3.7.2.2 Tube exhaust thru stock----------4G
(see Note 6.7)

3.7.3 MC1238A, MC1451B, and MC3601

3.7.3.1 After assembly thru tube exhaust----------2G
(see Note 6.7)

3.7.3.2 Tube exhaust thru stock----------4G
(see Note 6.7)

3.7.4 MC3578

3.7.4.1 Deleted

3.7.4.2 Difussion bonding thru dry blast----------4G
(see Note 6.7)

3.7.4.3 Dry blast thru stock----------2E
(see 6.6 and 6.8)

3.7.5 MC3368, MC3140, and MC3386

3.7.5.1 After assembly thru tube exhaust ----------2G
(see Notes 6.6 and 6.7)

3.7.5.2 Tube exhaust thru serialization ----------3G
(see Notes 6.6 and 6.7)

3.7.5.3 Serialization thru stock ----------4G
(see Note 6.7)

3.7.5.4 Stock thru next assembly ----------3D

3.8 Tooling. Unless otherwise authorized by Engineering, all tooling shall be handled and stored under the same conditions as the parts or assemblies with which they are used to prevent damage or contamination.

3.9 Containers. All containers shall be maintained in clean condition at all times using one of the following methods:

3.9.1 Hand Cleaning. Wash with Alconox (46A101756) and warm water followed by deionized water (46A100670P2) rinse and drying.

3.9.2 Machine Cleaning. Wash with Alcojet (46A102131) and warm water followed by deionized water (46A100670P2) rinse and drying.

3.9.3 Radioactive. Machine clean using decontaminant 46A102642 followed by water rinse and drying.

3.10 Storage. Storage is defined as any period of time that a part, subassembly or assembly is not being processed through normal scheduling.

3.10.1 Incoming Materials. All incoming materials after inspection shall be stocked in their shipping container unless repackaging is necessary per material specification.

3.10.2 Machine Shop. Corrosive type metal parts fabricated in the machine shop shall be coated with high purity oil 46A102143 prior to storage or stocking.

3.10.3 General Production Area. Unless otherwise specified, parts and subassemblies shall be stored within materials required per 3.2.1 and further contained in covered plastic or stainless steel containers or maintained at 28° to 60°C in heated storage cabinets.

3.10.4 Special Handling. Parts and subassemblies after cleaning and firing that require high degree of cleanness and dryness shall be stored within materials required per Table 3.2.1 and either maintained at 28° to 60°C in heated storage cabinets or contained within covered stainless steel or glass containers. After completion of vacuum firing or film deposition, assemble into completed tubes and evacuate within 8 weeks. (See Note 6.9).

3.10.5 Glassing Operation. Parts and assemblies oxidized during glassing operation require no special storage conditions.

3.10.6 Chemicals. Unless otherwise specified, all solid or liquid chemicals shall be stored in accordance with provisions of the material specifications.

3.10.7 Molybdenum, Manganese & Titanium Hydride Powders and Dry Mixtures. Store in glass containers.

3.10.8 Tube Assemblies. See 3.7

3.10.9 Getters. See 3.6.3

SECTIONS 4 AND 5 NOT APPLICABLE

6. NOTES:

6.1 Code number or letter without the word "only" means that material and any of the preceding materials in that table under para. 3.2.1 are acceptable for use.

6.2 The choice of plastics for handling of tube parts and assemblies is very important and each application shall be thoroughly studied to ascertain correct usage. Factors to be considered are as follows:

a. Marking. Plastics that will rub off on a part shall not be used if this marking will not be totally removed by cleaning, firing or blasting in accordance with subsequent cleanness requirements.

b. Stability. Thermal and chemical stability are required to the extent that the plastic will not deteriorate or deform nor in any way contaminate the material with which it comes in contact.

6.3 After cleaning, parts may be dried on clean linen or cotton toweling.

6.4 Deleted.

6.5 Closed containers or heated storage cabinets at 28° to 60°C.

6.6 Use plastic inserts to hold parts in containers.

6.7 Do not use cotton gloves.

6.8 Handle by metal part only.

6.9 The 8 week "clock" may be stopped by storing the parts in vacuum (10^{-6} torr or less).

MANUFACTURING AGENCY: GENERAL ELECTRIC, NEUTRON DEVICES DEPT.

DWG. CLASSIFICATION LEVEL: UNCLASSIFIED

DWG. STATUS: PRODUCTION

FIRST MADE FOR	REVISIONS					
	ISSUE	DESCRIPTION	ISSUE	DESCRIPTION	ISSUE	DESCRIPTION
	8	ECN 23223 P4 J.M. 10-2-69	11	720505GE [illegible] 12-8-71		
PART NO. CONTROL NO.	9	ECN 25285 P4 [illegible] 12-2-69	12	750163GE [illegible] 5/8/75		
	10	720542GE [illegible] 8-21-72	13	[illegible] 5-30-74		

1. SCOPE.

1.1 THIS SPECIFICATION COVERS THE GENERAL REQUIREMENTS FOR VACUUM TIGHT, DENSE ALUMINA CERAMIC OF 92% - 95% Al_2O_3 CONTENT FOR USE IN VACUUM TUBE AND ASSOCIATED CONSTRUCTION.

2. DOCUMENTS.

2.1 46A115030 - DY-CHEK PROCEDURE

2.2 ASTM D792 - SPECIFIC GRAVITY AND DENSITY OF PLASTICS BY DISPLACEMENT, TESTS FOR.

2.3 ASTM D116 - VITRIFIED CERAMIC MATERIALS FOR ELECTRICAL APPLICATIONS, TESTING.

2.4 ASTM C773 - COMPRESSIVE (CRUSHING) STRENGTH OF FIRED WHITE WARE MATERIALS, TEST FOR.

2.5 ASTM D257 - D-C RESISTANCE OR CONDUCTANCE OF INSULATING MATERIALS, TESTS FOR.

2.6 ASTM D150 - A-C LOSS CHARACTERISTICS AND DIELECTRIC CONSTANT (PERMITTIVITY) OF SOLID ELECTRICAL INSULATING MATERIALS, TESTS FOR.

3. REQUIREMENTS.

3.1 SUPPLIERS - AS SPECIFIED ON PART DRAWING.

MADE BY	DATE	APPROVAL	DATE
J. PAGE REDRAWN		REH	12/2/59
ORIGINATED AT GEND		LCW	2/13/60

DESIGN AGENCY APPROVAL

ORG.	DATE	INITIALS

MFG. AGENCY APPROVAL

DATE	INITIALS
12/7/59	JK
3/1/60	RK/DO

DWSV. CODE: R IVS C ICO#2

TITLE: DENSE ALUMINA CERAMIC (92%-95% Al_2O_3)

SIZE: A | CODE IDENT NO.: 14934 | SC: GE

DWG. NO.: 46A100853

SHEET 1 OF 6

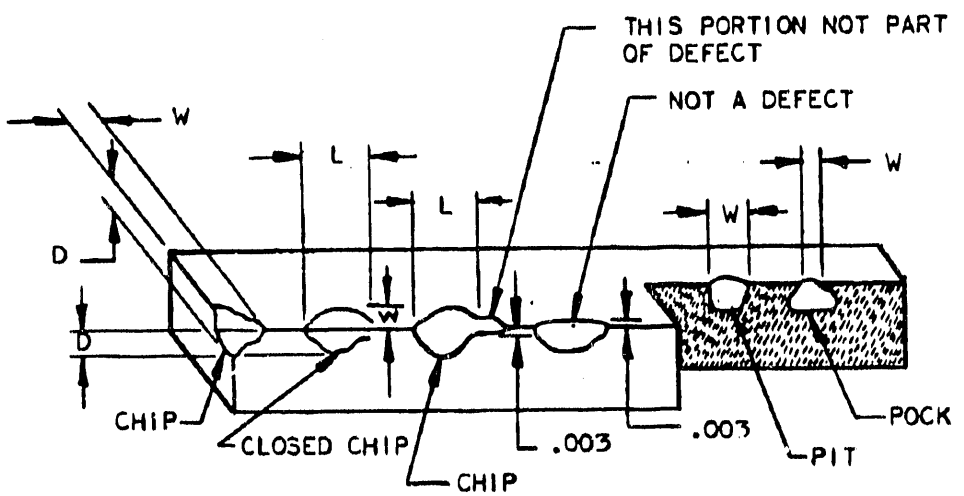
3.2 DEFINITIONS

3.2.1 CHIP- AN AREA ON AN EDGE OR CORNER WHERE MATERIAL HAS BEEN BROKEN OFF AND WHICH IS GREATER THAN .003 IN BOTH WIDTH AND DEPTH AS MEASURED ON THE SURFACE PLANE PERPENDICULAR TO THE EDGE. ANY PORTION OF A CHIP WITH ONE OF THESE DIMENSIONS AT .003 OR LESS SHALL NOT BE PART OF THE DEFECT. LENGTH OF THE CHIP (PARALLEL TO EDGE) IS WITHOUT LIMIT UNLESS SO SPECIFIED ON PART DRAWING.

3.2.2 CLOSED CHIP- A CHIP WITH THE FRACTURED PIECE STILL ATTACHED.

3.2.3 PIT- A SURFACE CAVITY GREATER THAN .003 ACROSS THE WIDEST OPENING.

3.2.4 POCK- A PARTIALLY CLOSED SURFACE CAVITY GREATER THAN .003 ACROSS THE WIDEST OPENING.



D - DEPTH W - WIDTH L - LENGTH

SIZE	DWG. NO.	46A100853
A	SHEET	2 OF 6

3.3 MANUFACTURE

3.3.1 FIRING - MATERIAL SHALL BE SUITABLY FIRED TO COMPLETELY REMOVE ALL TEMPORARY BINDERS, LUBRICANTS AND ORGANIC MATTER.

3.3.2 CONTAMINATION - THE FOLLOWING MATERIALS SHALL NOT BE USED IN PROCESSING THE CERAMIC OR FABRICATION OF PARTS:

A. SULFUR BASED AND HIGHLY CHLORINATED OILS, GREASES AND COMPOUNDS.
B. HIGH VAPOR PRESSURE METALS SUCH AS ZINC, MAGNESIUM, LEAD, CADMIUM, AND ALUMINUM.

3.3.3 DEFECTS - THE MATERIAL SHALL BE FREE OF STRATIFICATION, FOREIGN MATERIAL, CRACKS, METAL MARKS, SCRATCHES, AND LUBRICANTS. THE DEGREE OF DEFECTS SUCH AS CHIPS, PITS, SURFACE FINISH, ETC. WILL BE SPECIFIED ON THE PART DRAWING. IN ADDITION TO THAT SPECIFIED, THE FOLLOWING SHALL APPLY:

A. PITS WHOSE BOTTOMS ARE NOT VISIBLE AT 10X MAGNIFICATION ARE UNACCEPTABLE.

3.3.4 DYE PENETRANT SEPARATION - PRIOR TO SHIPMENT, ALL PARTS SHALL BE INSPECTED USING DYE PENETRANT PER 3.4 AND 4.2.1 AND ONLY NON-DEFECTIVE MATERIAL SHIPPED TO THE BUYER.

3.3.5 PROCESS CHANGES - THE MANUFACTURER SHALL NOTIFY THE BUYER OF ANY CONTEMPLATED PROCESS CHANGES THAT WOULD AFFECT THE PHYSICAL, MECHANICAL OR CHEMICAL PROPERTIES OF THE FINISHED PART AND MUST RECEIVE WRITTEN APPROVAL FROM THE BUYER PRIOR TO INCORPORATION OF THESE CHANGES.

3.3.6 SPRAY DRYING - FOR DRY PRESSING PROCESS, WET-MILLED BODY SHALL BE SIMULTANEOUSLY DRIED AND GRANULATED BY SPRAY DRYING.

3.4 DYE PENETRANT TEST ----- NO DEFECTS ALLOWED AS DEFINED BELOW.

3.4.1 BEFORE USE OF DEVELOPER:

A. PARTS INSPECTED IN GOOD LIGHT WITHOUT MAGNIFICATION SHALL SHOW NO DYE PENETRANT ON ANY SURFACE.

3.4.2 AFTER USE OF DEVELOPER:

A. PARTS SHALL NOT SHOW ANY BLEEDERS (RED PENETRANT ON WHITE DEVELOPER) WHICH HAVE A LENGTH 5 TIMES OR GREATER THAN THE WIDTH (CRACKS).
B. PARTS SHALL NOT SHOW ANY CONTINUOUS OPENING THROUGH A CERAMIC WALL AS INDICATED BY BLEEDERS OF ANY SIZE ON BOTH SIDES OF THE WALL.
C. PARTS SHALL NOT SHOW ANY BLEEDERS OF 1/32" OR MORE WHEN MEASURED ACROSS GREATEST DIMENSION.

3.5 PROPERTIES

3.5.1 SPECIFIC GRAVITY 23/23°C----3.70 MIN. (NO DEFECTS ALLOWED)

3.5.2 FLEXURAL STRENGTH, PSI----------35,000 MIN.

3.5.3 COMPRESSIVE STRENGTH, PSI-------300,000 MIN.

3.5.4 DIELECTRIC STRENGTH VOLTS RMS/MIL------180 MIN.

3.5.5 VOLUME RESISTIVITY, OHM-CM @ 121°C---------1X10 ^{13} MIN.

3.5.6 DELETED

3.5.7 DIELECTRIC CONSTANT--------------------9.0 - 9.6

3.5.8 DISSIPATION FACTOR, TANGENT DELTA------.0005 MAX.

3.6 DIMENSIONS AND TOLERANCES------AS SPECIFIED ON PART DRAWING.

4. QUALITY PROVISIONS.

4.1 CERTIFICATION - AT THE DISCRETION OF THE PURCHASING AGENCY, THE SUPPLIER SHALL SUBMIT WITH EACH SHIPMENT OF MATERIAL: (1) A STATEMENT OF COMPLIANCE TO THIS SPECIFICATION AND ISSUE NUMBER AND/OR (2) VARIABLES TEST DATA AS REQUESTED. THIS CERTIFICATION SHALL INCLUDE THE PURCHASE ORDER NUMBER, QUANTITY SHIPPED, AND ONE OR MORE OF THE FOLLOWING WHERE APPLICABLE: (1) LOT NUMBER, (2) BATCH NUMBER, OR (3) MELT NUMBER.

4.2 TEST METHODS (MANDATORY ONLY IN CASE OF DISPUTE.)

4.2.1 DYE PENETRATION----------GE DRAWING 46A115030.

4.2.2 SPECIFIC GRAVITY----------ASTM D792, METHOD A, KEROSENE

4.2.3 FLEXURAL STRENGTH----------ASTM D116, 3/8"-1/2" DIA. X 6" LONG SPECIMEN

4.2.4 COMPRESSIVE STRENGTH-------ASTM C773, 1/4" DIA. X 1/2" LONG SPECIMEN

4.2.5 DIELECTRIC STRENGTH--------ASTM D116, 1/4" THICK X 2 1/16" SQ. SPECIMEN, 60 CPS & 25°C.

4.2.6 VOLUME RESISTIVITY--------ASTM D257, 1/8" THICK BY 4" SQ. SPECIMEN

4.2.7 DELETED

4.2.8 DIELECTRIC CONSTANT-------ASTM D150, 1/4" THICK X 1 3/4" DIA. DISCS, 10^6 CPS AT 25°C.

4.2.9 DISSIPATION FACTOR----------ASTM D150, 1/4" THICK X 1 3/4" DIA. DISCS, 10^6 CPS AT 25°C.

4.2.10 DIMENSIONS----------MEASURING INSTRUMENT CAPABLE OF BEING READ AT LEAST ONE-TENTH OF THE TOLERANCE.

4.3 LOT DEFINITION.

A LOT SHALL BE AS THOSE PRODUCTS OF A SINGLE TYPE (I.E., PART NUMBER) MANUFACTURED UNDER ESSENTIALLY THE SAME CONDITIONS USING MATERIAL FROM THE SAME BATCH.

4.4 TEST DATA

IN THE EVENT THAT PROCESSING INDICATES CHANGES IN CERAMIC CHARACTERISTICS OR AT THE DISCRETION OF THE BUYER, THE SUPPLIER WILL BE REQUESTED TO FURNISH ACTUAL TEST DATA ON ANY OR ALL OF THE REQUIREMENTS AT ANY TIME DURING THE LIFE OF A PURCHASE ORDER OR CONTRACT. THE TESTING SHALL BE PERFORMED ON SUITABLE TEST SPECIMENS FORMED FROM THE SAME BATCH AND TREATED UNDER EQUIVALENT CONDITIONS AS THE FURNISHED LOT EXCEPT THAT METHOD OF FORMING SHALL BE COMPATIBLE TO SIZE AND SHAPE OF TEST SAMPLES. IF THIS BATCH MATERIAL IS NO LONGER AVAILABLE, THEN TEST SPECIMENS SHALL BE USED THAT ARE AS CLOSE TO THIS MATERIAL AND THE CONDITIONS AS POSSIBLE. THIS TESTING WILL BE MADE AT THE EXPENSE OF THE BUYER.

4.5 TEST SPECIMENS

AT THE DISCRETION AND EXPENSE OF THE BUYER, THE SUPPLIER MAY BE REQUESTED TO FURNISH SUITABLE TEST SPECIMENS SO THAT VERIFICATION TESTS MAY BE PERFORMED BY THE BUYER ON ANY OR ALL REQUIREMENTS.

5. PACKAGING AND HANDLING

5.1 PACKAGING - PARTS SHALL BE PACKAGED IN A MANNER TO ENSURE AGAINST DAMAGE OR CONTAMINATION DURING SHIPMENT AND STORAGE AS APPROVED BY THE BUYER.

5.1.1 APPROVED METHODS OF INTERNAL PACKAGING: (EXTERNAL PACKAGING IS OPTIONAL)

A. INDIVIDUALLY PACKAGED IN HIGH-IMPACT POLYSTYRENE OR POLYETHYLENE CUP TRAYS COVERED BY SAME TYPE OF PLASTIC MATERIAL OR BY NONCONTAMINATING TYPE OF PAPER SUCH AS "PATAPAR" (VEGETABLE PARCHMENT PAPER) MADE BY THE PATERSON PARCHMENT PAPER CO., BRISTOL, PA.

B. INDIVIDUALLY OR BULK PACKAGED IN "PATAPAR" TYPE PAPER, THEN SEALED IN POLYETHYLENE PLASTIC BAGS. PARTS SHOULD NOT BE ALLOWED TO ABRADE OR STRIKE ONE ANOTHER TO THE EXTENT OF BEING CHIPPED OR DAMAGED DURING SHIPMENT.

5.2 MARKING - EACH EXTERNAL PACKAGE SHALL BE LEGIBLY MARKED OR TAGGED WITH BUYER'S PART DRAWING NUMBER AND REVISION NUMBER, SUPPLIER'S NAME, AND BATCH OR LOT NUMBER IF AVAILABLE. ADDITIONAL MARKING IS OPTIONAL.

6. NOTES - NONE

MANUFACTURING AGENCY	DWG CLASSIFICATION LEVEL	
GENERAL ELECTRIC NEUTRON DEVICES DEPT.		**PRODUCTION**

DESIGN AGENCY PART NO.	REVISIONS					
	ISSUE	DESCRIPTION	PREPARED BY	DATE	CHKR	ENGR
P1	5	760295GE	MLC	6-14-76		
	6	790731 GE	Draftsman	11-30-79	DAB	

1. GENERAL:

1.1 Scope - This specification covers ammonium bifluoride in crystal flake form.

2. DOCUMENTS: NONE

3. REQUIREMENTS:

3.1 Manufacturers

Any manufacturer's product conforming to requirements of this specification is acceptable.

3.2 Material

3.2.1 Appearance - white crystal flakes. Any lumps shall be readily crumbled by finger pressure.

3.2.2 Assay (NH_4FHF), Min. by Wt.----------98.0%

3.2.3 Insoluble Matter, Max. by Wt.----------0.02%

AGENCY APPROVALS			TITLE
DATE	INITIALS		AMMONIUM BIFLUORIDE
4-2-81	RTK		First Made For: MC1238
		DWG CLASSIFICATION LEVEL: UNCLASSIFIED	SIZE: A; CODE IDENT NO.: 14064; DWG NUMBER: 46A101546; SHEET 1 OF 2

4. QUALITY PROVISIONS:

4.1 Certification - At the discretion of the Purchasing Agency, the supplier shall submit with each shipment of material: (1) a statement of compliance to this specification and revision number and/or (2) variables test data as requested. This certification shall include the purchase order number, quantity shipped, and one or more of the following where applicable: (1) lot number, (2) batch number, or (3) melt number.

4.2 Test Methods (Mandatory Only in Case of Dispute)

4.2.1 Appearance----------Visual

4.2.2 Assay (NH_4FHF) - Weigh accurately about 2.5 grams, transfer to a large platinum dish and dissolve with 40 ml. of water. Add 10 ml. of saturated potassium nitrate solution, cool to 0°C., add 3 drops of phenolphthalein indicator solution and titrate with 1 N sodium hydroxide solution till the pink color persists for 15 seconds. One ml. of 1 N Sodium hydroxide is equivalent to 0.05705 gram ammonium bifluoride (NH_4FHF).

4.2.3 Insoluble Matter - Dissolve 10 grams with 100 ml. of water in a large platinum dish and allow to stand on the steam bath for 1 hour. Filter through a tared plastic filter crucible, wash thoroughly with hot water, dry at 105°C for 1 hour, cool and weigh.

5. PACKAGING AND HANDLING:

5.1 PACKAGING - The material shall be packaged in noncontaminating containers in a manner to ensure safe delivery and storage and comply with carrier's regulations.

5.2 Marking - Each container shall be legibly marked or tagged with buyer's specification number, revision number, and supplier's name. Additional marking is optional.

5.3 Storage Temperature* - 4° to 38°C

5.4 Shelf Life* - Unlimited

* Buyer's requirement only.

6. NOTES: None

FSCM NO. 14064
FC0840011GE
JL Burton, GEND
Diskette 0275C-0009C
SC/GE

46A102297

Issue 12
Page 1 of 7
Date: 03/23/84
PART CLASS: UNCL

Molybdenum, Unalloyed

PART NO. CONTROL NO.	NAME	MATERIAL	FIRST MADE FOR
P1	Foil	Vacuum Arc Cast Molybdenum	MC1238
P2	Sheet & Strip	Vacuum Arc Cast Molybdenum	
P3	Plate	Vacuum Arc Cast Molybdenum	
P4	Wire	Vacuum Arc Cast Molybdenum	
P5	Rod & Bar	Vacuum Arc Cast Molybdenum	
P6	Tubing, Seamless	Vacuum Arc Cast Molybdenum	
P7	Foil	Powder Metallurgy Molybdenum	
P8	Sheet & Strip	Powder Metallurgy Molybdenum	
P9	Plate	Powder Metallurgy Molybdenum	
P10	Wire	Powder Metallurgy Molybdenum	
P11	Rod & Bar	Powder Metallurgy Molybdenum	
P12	Tubing, Seamless	Powder Metallurgy Molybdenum	

1. SCOPE - This specification covers stress relieved unalloyed molybdenum for use in high temperature vacuum applications.

2. DOCUMENTS

2.1 ASTM E8 - Methods of tension testing of metallic materials.

2.2 ASTM F219 - Methods of testing fine round and flat wire for electron devices and lamps.

2.3 ASTM F205 - Method for measuring diameter of fine wire by weighing.

2.4 ASTM E140 - Standard hardness conversion tables for metals.

3. REQUIREMENTS

3.1 Manufacturers and Product Designation

3.1.1 Amax Specialty Metals Corp.

3.1.2 Wah Chang Corp.

3.1.3 Thermo Electron Corp.

3.1.4 Electro Arc Mfg Co.

3.1.5 Superior Tube Co.

3.1.6 Schwarzkopf Development Corp.

3.2	Chemistry % By Wt.	Arc Cast	Powder Met
3.2.1	Molybdenum	99.90 Min	99.90 Min
3.2.2	Carbon	0.040 Max	0.010 Max
3.2.3	Oxygen*	0.010 Max	0.010 Max
3.2.4	Nitrogen*	0.004 Max	0.004 Max
3.2.5	Hydrogen*	0.002 Max	0.002 Max
3.2.6	Silicon	0.010 Max	0.010 Max
3.2.7	Nickel	0.010 Max	0.010 Max
3.2.8	Iron	0.020 Max	0.020 Max

*Pending approved methods of analysis, deviations from these limits alone shall not be cause for rejection.

3.3 Manufacture

3.3.1 Material shall have a clean smooth surface and be free within basic commercial practice of blisters, laminations, slivers, seams, pits, dents, grooves, inclusions, cracks, oxidation, oil, grease, tool marks, or other defects and contamination which would adversely affect the intended purpose.

3.4 Condition

3.4.1 All material shall be stress relieved unless otherwise specified.

3.5 Mechanical Properties

3.5.1 Sheet, strip and foil (thickness 0.187 max).

3.5.1.1 Tensile strength, PSI - - - - - - - - - -85,000 min.

3.5.1.2 Elongation in 2 inches- - - - - - - - - -3% min.

3.5.2 Plate (thickness over 0.187 inches)

3.5.2.1 Tensile strength, PSI- - - - - - - - - - 85,000 min.

3.5.2.2 Elongation in 2 inches- - - - - - - - - -2% min.

3.5.3 Wire & Rod

3.5.3.1 Tensile Strength and Elongation

Diameter Inches	Tensile Strength PSI Min.	Elongation % Min	Hardness, Max. Vickers - 10KG
.000 - .019	115,000*	6	-
.020 - .125	85,000	15	-
.126 -1.875	75,000	10	280

*Or min. 39.6 g/mg/200mm

3.5.4 Tubing

3.5.4.1 Hardness - Max. 280 vickers or equivalent conversion per ASTM E140.

3.6 Dimensional Tolerances

3.6.1 Foil

3.6.1.1 Thickness, Inches

Specified	Tolerance +/-
.0005	.00005
.001	.0001
.002	.0002
.003	.0003
.004	.0004
.005	.0005

3.6.1.2 Width, Inches

Specified	Tolerance +/-
As Rolled	1/8
All sizes, slit	.015

3.6.2 Sheet, Strip & Plate

3.6.2.1 Thickness, Inches*

Specified	Tolerance +/-
.005 - .010	.001
.011 - .020	.002
Over .020	10%

*For 18 inch width and under. Measurements taken 3/8" from the edge of material 1" and over in width and at any place on material below 1" width.

3.6.2.2 Sheared Dimensions, Inches

	Tolerance +/-
Width	1/16
Length	3/32

3.6.3 Wire & Rod

3.6.3.1 Diameter and out-of-round tolerance, as drawn or swaged, inches unless otherwise specified.

Specified	Diameter Tolerance	Out-of-round Max.
.000 - .020	± 5% by wt/200mm	-
.021 - .062	+.001 - .001	.001
.063 - .281	+.002 - .002	.004
.282 - .406	+.010 - .005	.008
.407 - .625	+.010 - .005	.012
.626 - .875	+.015 - .005	.015
.876 -1.000	+.020 - .005	.015
1.001 -1.375	+.020 - .010	.018
1.376 -1.500	+.020 - .015	.020
1.501 -1.625	+.025 - .015	.020
1.626 -2.000	+.030 - .020	.025
2.001 -2.500	+.032 - .032	.025
2.501 -3.250	+.032 - .032	.027
3.251 -3.500	+.045 - .045	.040

3.6.2.3 Centerless Ground Rods

.062 - .500	+.002 - .002	-
OVER .500	+.003 - .003	-

3.6.4 Tubing, Seamless

3.6.4.1 Outside Diameter, Inches

Specified O.D.	Tolerance +/-
.125 - .250	.003
.251 - .312	.0035
.313 - .375	.004
.376 - .437	.0045
.438 - .500	.005
.501 - .625	.006
.626 - .750	.007
.751 - .875	.008
.876 -1.000	.010
1.001 -1.500	.011

3.6.4.2 Wall Thickness, Inches

Specified Wall Thick.	Tolerance +/-
.016 - .120	10%

5. PACKAGING AND HANDLING:

5.1 Packaging - The material shall be packaged in a manner to ensure safe delivery and storage and comply with carrier's regulations

5.2 Marking - Each container shall be legibly marked or tagged with Buyer's specificaion number, issue number and Supplier's lot number where applicable, additional marking is optional.

6. NOTES:

None

5. PACKAGING AND HANDLING:

5.1 Packaging - The material shall be packaged in a manner to ensure safe delivery and storage and comply with carrier's regulations

5.2 Marking - Each container shall be legibly marked or tagged with Buyer's specificaion number, issue number and Supplier's lot number where applicable, additional marking is optional.

6. NOTES:

None

GENERAL ELECTRIC

46A115289
CONT ON SHEET FINAL SH NO. 1

REV NO. 0123

46A115289
CONT ON SHEET FINAL SH NO. 1

TITLE

HYDROGEN FIRING SPEC.

FIRST MADE FOR 46B100098G1

EQUIPMENT

1. SUITABLE HYDROGEN FURNACE.
2. THERMOCOUPLE AND RECORDING METER OR EQUIVALENT.
3. OPTICAL PYROMETER OR EQUIVALENT
4. SUITABLE FIRING BOATS.
5. RODS TO PUSH BOATS INTO AND OUT OF THE FURNACE.
6. SOURCE OF DRY HYDROGEN DEW POINT -60°F TO -90°F. LINE HYDROGEN MAY BE PURIFIED BY PASSING IT THROUGH A DEOXO PURIFIER OBTAINABLE FROM BAKER CHEMICAL COMPANY, PHILLIPSBURG, NEW JERSEY AND A LECTRODRYER OBTAINABLE FROM THE PITTSBURGH, LECTRODRYER DIVISION OF MCGRAW EDISON COMPANY, PITTSBURGH, PENNSYLVANIA OR EQUIVALENTS.
7. A HUMIDIFIER BOTTLE OBTAINABLE FROM CM MANUFACTURING COMPANY, BLOOMFIELD, NEW JERSEY OR EQUIVALENT.

PROCEDURE

.1. THE FURNACE IS BROUGHT UP TO THE SPECIFIED TEMPERATURE. THE PARTS ARE LOADED IN SUITABLE FIRING BOATS AND PUSHED INTO THE HOT ZONE WHERE THEY ARE FIRED AT THE SPECIFIED TEMPERATURE FOR THE SPECIFIED TIME.

2. UPON COMPLETION OF THE SPECIFIED FIRING SCHEDULE THE PARTS ARE PUSHED INTO THE COOLER AND REMOVED, WHEN COOL.

3. ALL TEMPERATURES ARE MEASURED WITH A OPTICAL PYROMETER OR EQUIVALENT AND ARE PART TEMPERATURES NOT FURNACE TEMPERATURES.

4. DRY HYDROGEN FIRING IS ACCOMPLISHED BY PASSING THE HYDROGEN DIRECTLY FROM THE DRY HYDROGEN SOURCE TO THE FURNACE.

5. WET HYDROGEN FIRING IS ACCOMPLISHED BY PASSING THE HYDROGEN FROM THE DRY HYDROGEN SOURCE THROUGH A HUMIDIFIER BOTTLE FILLED WITH DISTILLED WATER, WITH A PURITY OF 10 PPM OR BETTER DEIONIZED WATER 46A100679P1, BEFORE IT ENTERS THE HYDROGEN FURNACE.

LIMITATIONS

1. THE SPECIFIED TIMES AND TEMPERATURE APPEAR ON THE APPROPRIATE DRAWING AND IN ALL CASES INDICATE THE PERIOD OF TIME FOR WHICH THE PARTS ARE TO BE HELD IN THE HEAT ZONE AFTER THE PARTS HAVE COME UP TO TEMPERATURE. WHEN TEMPERATURE ONLY IS SPECIFIED PARTS ARE TO BE BROUGHT UP TO THAT TEMPERATURE, THEN PUSHED INTO THE COOLER. UNLESS OTHERWISE SPECIFIED A TOLERANCE OF ± 25°C SHALL APPLY TO ALL TEMPERATURES AND A TOLERANCE OF ± 10% SHALL APPLY ON ALL TIMES.
2. ALL FIRING SHALL BE IN DRY HYDROGEN UNLESS OTHERWISE SPECIFIED.

X	
C	
PRINTS TO	

MADE BY J. E. Grady 11/30/60
ISSUED EEN-925 Pat Diechle

APPROVALS

DIV OF PINELLAS PENINSULA PLANT
LOCATION ST. PETERSBURG, FLORIDA

46A115289
CONT ON SHEET FINAL SH NO. 1

JSC 11/30/60
R. K. 2/20/61

MANUFACTURING AGENCY	DWG. CLASSIFICATION LEVEL	DWG. STATUS
GENERAL ELECTRIC NEUTRON DEVICES DEPT.	UNCLASSIFIED	PRODUCTION

REVISIONS

ISSUE	DESCRIPTION	ISSUE	DESCRIPTION	ISSUE	DESCRIPTION	ISSUE	DESCRIPTION
C	ECN 28684 PAL SAM 4-17-70	E	750225GE [illegible] 12/12/75				
D	120812 GE E.J.M. DWG REVIEW 1-21-72	F	7005OOGE [illegible] 9/9/75				

PART NO. CONTROL NO.			MATERIAL	FIRST MADE FOR
-200			WIRE, ANNEALED	MC2041
-201			SHEET, AS COLD ROLLED	

1. GENERAL

1.1 SCOPE

THIS SPECIFICATION COVERS A HIGH PURITY SILVER-COPPER ALLOY WITH A SMALL NICKEL CONTENT FOR BRAZING APPLICATIONS REQUIRING MINIMUM AMOUNT OF HIGH VAPOR PRESSURE IMPURITIES.

2. DOCUMENTS

2.1 ASTM E56 - METHODS FOR CHEMICAL ANALYSIS OF SILVER BRAZING ALLOYS.

2.2 ASTM E54 - METHODS FOR CHEMICAL ANALYSIS OF SPECIAL BRASSES AND BRONZES.

2.3 ASTM F16 - METHODS OF MEASURING DIAMETER OR THICKNESS OF WIRE AND RIBBON FOR ELECTRONIC DEVICES AND LAMPS.

2.4 FED STD 151 - METALS; TEST METHODS

3. REQUIREMENTS

3.1 MANUFACTURERS AND PRODUCT DESIGNATION

3.1.1 WESTERN GOLD AND PLATINUM CO. ----- NICUSIL 3-VPOF (VACUUM PROCESS OXIDE FREE)

3.1.2 THE WILKINSON CO. ---------- WILBRAZ S7115

APPLIED PRACTICES		DIST. CODE	A	KKI								
UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING		DESIGN AGENCY APPROVAL										
SURFACES	TOLERANCES ON DIMENSIONS	CHG.	DATE	INITIALS								
✓	DECIMALS 2 PLC ± / DECIMALS 3 PLC ± / ANGLES ±											
MADE BY J. PAGE	DATE 4/17/70	MFR. AGENCY APPROVAL										
ORIGINATED AT GEND	APPROVED THR	DATE 4/20/67	DATE 11/28/72	INITIALS								

TITLE: BRAZE ALLOY 71 AG - 28 CU - .75 NI

SIZE A | CODE IDENT. 14213 | SC GE

DWG. NO. SS268140

SHEET 1 OF 4

3. REQUIREMENTS (CONT'D)

3.2 CHEMISTRY

3.2.1	SILVER	70.0 - 72.0
3.2.2	COPPER	27.0 - 29.0
3.2.3	NICKEL	0.5 - 1.0
3.2.4	ZINC	0.001 MAX.
3.2.5	CADMIUM	0.001 MAX.
3.2.6	LEAD	0.002 MAX.
3.2.7	PHOSPHORUS	0.002 MAX.
3.2.8	CARBON	0.005 MAX.
3.2.9	ALL OTHER METALLIC IMPURITIES HAVING V.P. HIGHER THAN 10^{-7} TORR AT 500°C	0.002 MAX. EA.
3.2.10	ALL OTHER METALLIC IMPURITIES HAVING V.P. LOWER THAN 10^{-7} TORR AT 500°C	0.05 MAX. EA.

3.3 CONDITION

3.3.1 WIRE - UNLESS OTHERWISE SPECIFIED, WIRE SHALL BE FURNISHED IN THE ANNEALED CONDITION SUITABLE FOR SEVERE BENDING AND FORMING.

3.3.2 SHEET - UNLESS OTHERWISE SPECIFIED, SHEET SHALL BE FURNISHED IN THE AS ROLLED CONDITION SUITABLE FOR STAMPING, RINGS, AND PREFORMS.

3.4 WORKMANSHIP - THE MATERIAL SHALL BE UNIFORM IN QUALITY, CLEAN, BRIGHT, AND FREE OF FOREIGN INCLUSIONS, OXIDE, OR OTHER DEFECTS THAT MAY CAUSE UNSOUND OR NON-VACUUM TIGHT BRAZE JOINTS.

3.5 DIMENSIONAL TOLERANCES, INCHES

3.5.1 WIRE - AVAILABLE IN EVEN THOUSANDTHS OF AN INCH DOWN TO 0.002".

3.5.1.1

DIAMETER	TOLERANCE PLUS OR MINUS
.001 TO .005 INCL.	.0001
OVER .005 TO .010 INCL.	.0002
OVER .010 TO .025 INCL.	.0005
OVER .025 TO .050 INCL.	.001
OVER .050 TO .080 INCL.	.002

3. REQUIREMENTS (CONT'D)

3.5 DIMENSIONAL TOLERANCES, INCHES (CONT'D)

3.5.2 SHEET - AVAILABLE IN ONE-HALF THOUSANDTHS OF THICKNESS DOWN TO 0.001".

3.5.2.1 WIDTH

	TOLERANCE PLUS OR MINUS
SLIT UNDER 2"	0.005

3.5.2.2 THICKNESS

.0005 TO .001 INCL.	.0001
OVER .001 TO .002 INCL.	.00015
OVER .002 TO .005 INCL.	.00025
OVER .005 TO .010 INCL.	.0005
OVER .010 TO .020 INCL.	.001
OVER .020 TO .040 INCL.	.0015
OVER .040 TO .060 INCL.	.002
OVER .060 TO .080 INCL.	.003

4. QUALITY PROVISIONS

4.1 CERTIFICATION - AT THE DISCRETION OF THE PURCHASING AGENCY, THE SUPPLIER SHALL SUBMIT WITH EACH SHIPMENT OF MATERIAL: (1) A STATEMENT OF COMPLIANCE TO THIS SPECIFICATION AND ISSUE LETTER AND/OR (2) VARIABLES TEST DATA AS REQUESTED. THIS CERTIFICATION SHALL INCLUDE THE PURCHASE ORDER NUMBER, QUANTITY SHIPPED, AND ONE OR MORE OF THE FOLLOWING WHERE APPLICABLE: (1) LOT NUMBER, (2) BATCH NUMBER OR (3) MELT NUMBER.

4.2 TEST METHODS (MANDATORY ONLY IN CASE OF DISPUTE)

4.2.1 CHEMISTRY

4.2.1.1 SILVER AND COPPER---------- ASTM E56

4.2.1.2 PHOSPHORUS--------- ASTM E54 AFTER REMOVAL OF SILVER AND COPPER

4.2.1.3 CARBON---------- LECO LOW CARBON ANALYZER

4.2.1.4 OTHERS---------- FED STD 151

4.2.2 CONDITION - TESTING NOT REQUIRED

4.2.3 WORKMANSHIP - VISUAL USING MAGNIFICATION IF NECESSARY

4.2.4 DIMENSIONS - ASTM F16 OR INSTRUMENTATION WITH AT LEAST EQUIVALENT ACCURACY

5. PACKAGING AND HANDLING

5.1 PACKAGING - THE MATERIAL SHALL BE PACKAGED IN NON-CONTAMINATING CONTAINERS IN A MANNER TO ENSURE SAFE DELIVERY AND STORAGE AND COMPLY WITH CARRIER'S REGULATIONS.

5.2 MARKING - EACH CONTAINER SHALL BE LEGIBLY MARKED OR TAGGED WITH BUYER'S SPECIFICATION NUMBER, ISSUE NUMBER, AND SUPPLIER'S LOT NUMBER WHERE APPLICABLE. ADDITIONAL MARKING IS OPTIONAL.

5.3 WIRE - ALL WIRE SHALL BE PACKAGED ON STANDARD SIZE SPOOLS.

6. NOTES

NONE

FSCM NO. 14213
FCO: 880100GE
TQ Clinton, GEND
FMF: MC2041

SS277052
-200

Issue E
Date: 01/26/88

Title: Cleaning Process

SHEET INDEX

SHEET	1	2																
ISSUE	E	E																

Part# -200 Qty	Drawing or Part Number	Description	Item
AR	124A1219P1	Acetone	1
AR	SS384049-200	Amyl Acetate	2
AR	46A101581P1	Methylene Chloride	3
AR	46A101581P2	Methylene Chloride	4
X	46A100661	General Ultrasonic Cleaning	5

1. GENERAL.

1.1 Scope.

To remove and clean metallize from baked and unbaked ceramic parts prior to sintering.

2. DOCUMENTS.

2.1 Required Documents.

See sheet 1.

2.2 Reference Documents.

Not applicable.

2.3 Equipment.

Bendix Type UG-1B-2 or equivalent.

3. REQUIREMENTS.

3.1 Procedure for Unbaked Parts.

3.1.1 Ultrasonic clean per Item 5 for 3 minutes minimum in Item 2.

3.1.2 Repeat step 1, using fresh, clean Item 2.

3.1.3 Repeat step 1, using fresh, clean Item 1.

3.1.4 Dip rinse in fresh, clean Item 1.

3.1.5 Dry, preventing contamination.

3.2 Procedure for Baked Parts.

3.2.1 Ultrasonic clean per Item 5 for 3 minutes min. in Item 3 or 4.

3.2.2 Ultrasonic clean per Item 5 for 3 minutes min. in Item 2.

3.2.3 Repeat step 1, using fresh, clean Item 2.

3.2.4 Repeat step 1, using fresh, clean Item 1.

3.2.5 Dip rinse in fresh, clean Item 1.

3.2.6 Dry, preventing contamination.

SECTIONS 4, 5, AND 6 NOT APPLICABLE.

FSCM NO. 14213
FCO: 850166GE
DF Fernadez, GEND
Diskette 1540C-0055C

SS284775
See Below
Issue M

Date: 6/4/85

Title: Vacuum Firing

SHEET ISSUE INDEX

SHEET	1	2	3												
ISSUE	M	M	M												

CONTROL NO.	MATERIAL	FIRST MADE FOR
-200	See Para. 3.1	MC1238A MC1451A
-201	See Para. 3.1	MC1238A MC1451A
-202	See Para. 3.1	MC1238A MC1451A
-203	See Para. 3.1	MC1238A MC1451A
-204	See Para. 3.1	MC1081
-205	See Para. 3.1	MULTIPLE
-206	See Para. 3.1	MC2730
-207	See Para. 3.1	MC3140

1. GENERAL:

1.1 Scope - This specification covers a procedure for removing unwanted surface and internal gasses by vacuum firing.

2. DOCUMENTS:

46A101568P1; Argon

3. PROCEDURE:

3.1 Vacuum degas in accordance with the following schedule for two hours minimum and until pressure is equal to or less than that specified below. Maintaining temperature, vacuum fire for an additional one hour minimum at a pressure equal to or less than that specified below. Total time at temperature shall not exceed 5 hours. Items shall be maintained in a non-contaminating, non-oxidizing environment while above 50°C .

SS284775-200	800°C ± 25°C	1×10^{-6} Torr
-201	700°C ± 25°C	1×10^{-6} Torr
-202	575°C ± 25°C	1×10^{-6} Torr
-203	500°C ± 25°C	1×10^{-6} Torr
-204	400°C ± 25°C	1×10^{-6} Torr
-206	500°C ± 25°C	5×10^{-6} Torr
-207	650°C ± 25°C	1×10^{-6} Torr

Vacuum degas in accordance with the following schedule for 10-15 minutes. Items shall be maintained in a non-contaminating, non-oxidizing environment while above 50°C .

SS284775-205	800°C ± 25°C	1×10^{-6} Torr

3.2 Heat Up and Cool Down

3.2.1 After meeting the requirements of Para. 3.1, reduce the items temperature below 50°C in accordance with the following schedule:

SS284775-200	Uncontrolled cooldown
-201	Uncontrolled cooldown
-202	Uncontrolled cooldown
-203	Cool at 1°C per minute to 420°C (on the average, any 10 minute interval should not exceed 1°C per minute)
-204	Uncontrolled cooldown
-205	Uncontrolled cooldown
-206	Uncontrolled cooldown
-207	Uncontrolled cooldown

3.2.2 Clean dry argon per 46A101568P1 may be inlet below 300°C to facilitate and promote uniform piece item cooling.

Sections 4, 5, and 6 - NOT APPLICABLE.

FSCM NO. 14213
FCO840362GE
G.B. Mc Clellan, GEMD
Diskette 0510_-0416A
FMF: -200 MC1238A
-201 MC2649
-202 MC2965
-203 MC1081
-204 MC3140
SC/GE TIE

SS284790
See Parts List
Issue Y
Page 1 of 4
Date: 06/19/84

Metallize Specification

PART # -204 QTY	PART # -203 QTY	PART # -202 QTY	PART # -201 QTY	PART # -200 QTY	DWG/PART	DESCRIPTION	ITEM
AR	-	AR	-	AR	SS277044-200	Screen Print Metallize Media	1
-	AR	-	-	-	SS349248-200	Screen Print Metallize Media	2
X	X	X	X	X	46A100702	Handling and Storage	3
X	X	X	X		SS277052-200	Cleaning Process	4
X	X	X	X	X	46A115289	Hydrogen Firing Spec	5
-	-	-	AR	-	SS231343-000	Screen Print Metallize Media	6
X	X	X	-	X	46A100669G1	Cleaning Process	7
AR	AR	AR	AR	AR	124A1219P1	Acetone	8
AR	AR	AR	AR	AR	46A101582P1	Amyl Acetate	9
AR	-	AR	-	AR	SS306808-200	Hand Paint Metallize Slurry	10
AR	AR	AR	AR	AR	46A102309P1	Nitrogen	11
-	AR	-	-	-	SS349247-200	Hand Paint Metallize Slurry	12
-	-	-	-	X	SS349404-200	Cleaning Proc.	13
AR	-	-	-	-	46A101568P001	Argon, High Purity	14
AR	-	-	-	-	SS374607-200	Spray, Metallize Slurry	15

1. GENERAL

1.1 Scope. To establish a procedure for metallizing ceramics using metallizing slurry media.

2. DOCUMENTS AND EQUIPMENT.

2.1 Required Documents.

See Parts List

2.2 Reference Documents.

2.3 Equipment.

2.3.1 Tilted type mixer, Viscometer, or equivalent.

2.3.2 Semi-automatic screen printer (Weltek Model 68 or equivalent).

2.3.3 Micropump model 120 gear pump or equivalent, Badger model 100 XF or equivalent, Teflon tubing and fittings.

3. PROCEDURE.

3.1 Screen Print Application.

3.1.1 Using the equipment of paragraph 2.3.2 and freshly mixed screen print metallize media (Item 1 or Item 2 or Item 6), metallize piece parts as required.

3.1.2 Dry metallized parts in an air atmosphere at 110°C ± 10°C for two hours minimum.

3.1.3 If multiple screen printing is needed to meet the piece part metallize requirement, paragraphs 3.1.1, 3.1.2, and 3.5 may be repeated, except interim air drying may be at 85°C ± 10°C for 1 hour minimum. Only one metallize sinter (para. 3.5) is allowed for control -201 ceramics.

3.1.4 Source control screen printed rejects may be cleaned after para. 3.1.1 per Item 4 or 13 and reprinted as required.

3.2 Hand Paint Application.

3.2.1 Using the equipment of paragraph 2.3.1 and freshly mixed hand paint metallize media (Item 10 or Item 12) metallize piece parts as required, using a clean badger or sable hair brush. Item 11 may be used as required.

3.2.2 Source control hand painted rejects may be cleaned after para. 3.2.1 per Item 7 and repainted as required. Item 10, 11 or 12 may be used as required. Excessive metallize media may be removed using Item 8 or Item 9. Parts may be kept in Item 8 or Item 9 prior to cleaning per Item 7.

3.3 SPRAY APPLICATION

3.3.1 Using the equipment of paragraph 2.3.1 and 2.3.3 and freshly mixed spray metallic media per Item 15, metallized piece parts as required, using nitrogen per Item 11 or Argon per Item 14 as a propellant.

3.3.2 Source control hand painted rejects may be cleaned after para. 3.3.1 per Item 7 and repainted as required. Item 11 and 15 may be used as required. Excessive metallize media may be removed using Item 8 or Item 9. Parts may be kept in Item 8 or Item 9 prior to cleaning per Item 7.

3.4 SET FIRING:

Prior to metallize sinter (3.5), Control No. -200, -202 -203 and -204 ceramics may have a set firing performed with wet hydrogen per Item 5 for 10 minutes $\pm$ 2 minutes at 1495°C $\pm$ 40°C using molybdenum boats with molybdenum or ceramic rods and fixtures. A maximum of (3) set firings are allowed.

3.5 METALLIZE SINTER:

All metallized ceramic parts shall be wet hydrogen fired per Item 5 for 45 minutes $\pm$ 5 minutes at 1495°C $\pm$ 40°C in molybdenum boats with molybdenum or ceramic rods and fixtures. A maximum of (2) metallize sinter firings are allowed.

4. QUALITY PROVISIONS.

4.1 Unless otherwise specified on the applicable drawing, the following criteria applies:

4.1.1 Metallizing is acceptable if no inclusions or blisters greater than .015 diameter or equivalent area are evident in good light without magnification. Magnification may be used to verify limits.

4.1.2 Minimum penetration to be .010.

4.1.3 After firing metallize ceramics as in Para. 3.5, the maximum allowable storage time per Item 3 shall not exceed 60 days.

4.1.4 The number of temperature cycles and total time at temperature must be minimized and limited to that required to maintain the specific metallization pattern and thickness.

SECTION 5 NOT APPLICABLE.

6. NOTES:

6.1 Exposure to the high temperatures of paragraphs 3.4, 3.5 and the associated temperature cycling will degrade the strength of the ceramic body and the bonding surface due to grain growth, new phase generation, micro-crack generation and glass build-up on the surface.

FSCM NO. 14213
FCO: 8801GGGE
K.F. Moore, GEND
FMF: -200 MC1238A
-201 MC2649
-202 MC2965
-203 MC1081
-204 MC3140
-205 MC3578
SC/GE TIE

SS284790
See Parts List

Issue AC
Date: 01/26/88

Title: Metallize Specification

SHEET INDEX

SHEET	1	2	3	4											
ISSUE	AC	AB	AC	AB											

PART # -205 QTY	PART # -204 QTY	PART # -203 QTY	PART # -202 QTY	PART # -201 QTY	PART # -200 QTY	DWG/PART	DESCRIPTION	ITEM
AR	AR	-	AR	-	AR	SS277044-200	Screen Print Metallize Media	1
-	-	AR	-	-	-	SS349248-200	Screen Print Metallize Media	2
X	X	X	X	X	X	46A100702	Handling and Storage	3
X	X	X	X	X	X	SS277052-200	Cleaning Process	4
X	X	X	X	X	X	46A115289	Hydrogen Firing Spec	5
-	-	-	-	AR	-	SS231343-000	Screen Print Metallize Media	6
AR	AR	AR	AR	AR	AR	124A1219P1	Acetone	8
AR	AR	AR	AR	AR	AR	SS384049-200	Amyl Acetate	9
-	AR	-	AR	-	AR	SS306808-200	Hand Paint Metallize Slurry	10

PART # -205 QTY	PART # -204 QTY	PART # -203 QTY	PART # -202 QTY	PART # -201 QTY	PART # -200 QTY	DWG/PART	DESCRIPTION	ITEM
AR	AR	AR	AR	AR	AR	46A102309P1	Nitrogen	11
-	-	AR	-	-	-	SS349247-200	Hand Paint Metallize Slurry	12
-	-	-	-	-	X	SS349404-200	Cleaning Proc.	13
AR	AR	AR	AR	AR	AR	46A101568P001	Argon, High Purity	14
X	AR	-	-	-	-	SS374607-200	Spray, Metallize Slurry	15
AR	-	-	-	-	-	SS306808-201	Hand Paint Metallize Slurry	16

1. GENERAL

1.1 Scope. To establish a procedure for metallizing ceramics using metallizing slurry media.

2. DOCUMENTS AND EQUIPMENT.

2.1 Required Documents.

See Parts List

2.2 Reference Documents.

2.3 Equipment.

2.3.1 Tilted type mixer, Viscometer, or equivalent.

2.3.2 Semi-automatic screen printer (Weltek Model 68 or equivalent).

2.3.3 Micropump model 120 gear pump or equivalent, Badger model 100 XF or equivalent, Teflon tubing and fittings.

3. PROCEDURE.

3.1 Screen Print Application.

3.1.1 Using the equipment of paragraph 2.3.2 and freshly mixed screen print metallize media (Item 1 or Item 2 or Item 6), metallize piece parts as required.

3.1.2 Dry metallized parts in an air atmosphere at 110°C ± 10°C for two hours minimum.

3.1.3 If multiple screen printing is needed to meet the piece part metallize requirement, paragraphs 3.1.1, 3.1.2, and 3.5 may be repeated, except interim air drying may be at 85°C ± 10°C for 1 hour minimum. Only one metallize sinter (para. 3.5) is allowed for control -201 ceramics.

3.1.4 Source control screen printed rejects may be cleaned after para. 3.1.1 per Item 4 or 13 and reprinted as required.

3.2 Hand Paint Application.

3.2.1 Using the equipment of paragraph 2.3.1 and freshly mixed hand paint metallize media (Item 10/12 or Item 16) metallize piece parts as required, using a clean badger or sable hair brush. Item 11 may be used as required.

3.2.2 Source control hand painted rejects may be cleaned after para. 3.2.1 per Item 4 and repainted as required. Item 10, 11 or 12 may be used as required. Excessive metallize media may be removed using Item 8. Parts may be kept in Item 8 prior to cleaning per Item 4.

3.3 SPRAY APPLICATION

3.3.1 Using the equipment of paragraph 2.3.1 and 2.3.3 and freshly mixed spray metallic media per Item 15, metallized piece parts as required, using nitrogen per Item 11 or Argon per Item 14 as a propellant.

3.3.2 Source control hand painted rejects may be cleaned after para. 3.3.1 per Item 4 and repainted as required. Item 11 and 15 may be used as required. Excessive metallize media may be removed using Item 8. Parts may be kept in Item 8 prior to cleaning per Item 4.

3.4 SET FIRING:

Prior to metallize sinter (3.5), Control No. -200, -202 and -204, using Diamonite ceramics, and -203 and -205 ceramics may have a set firing performed with wet hydrogen per Item 5 for 10 minutes ± 2 minutes at 1495°C ± 40°C. Control No. -200, -202 and -204, using Wesco ceramics, may have a set firing performed with wet hydrogen per Item 5 for 10 minutes ± 2 minutes at 1400°C ± 30°C. All firing will use molybdenum boats with molybdenum or ceramic rods and fixtures. A maximum of (3) set firings are allowed.

3.5 METALLIZE SINTER:

Control No. -200, -202 and -204, using Diamonite ceramics, and Control No. -201, -203, and -205 metallized ceramic parts shall be wet hydrogen fired per Item 5 for 45 minutes ± 5 minutes at 1495°C ± 40°C. Control No. -200, -202 and -204, using Wesco ceramics, shall be wet hydrogen fired per Item 5 for 45 minutes ± 5 minutes at 1400°C ± 30°C. All firings will be in molybdenum boats with molybdenum or ceramic rods and fixtures. A maximum of (2) metallize sinter firings are allowed.

4. QUALITY PROVISIONS.

4.1 Unless otherwise specified on the applicable drawing, the following criteria applies:

4.1.1 Metallizing is acceptable if no inclusions or blisters greater than .015 diameter or equivalent area are evident in good light without magnification. Magnification may be used to verify limits.

4.1.2 Minimum penetration to be .010.

4.1.3 After firing metallize ceramics as in Para. 3.5, the maximum allowable storage time per Item 3 shall not exceed 60 days.

4.1.4 The number of temperature cycles and total time at temperature must be minimized and limited to that required to maintain the specific metallization pattern and thickness.

SECTION 5 NOT APPLICABLE.

6. NOTES:

6.1 Exposure to the high temperatures of paragraphs 3.4, 3.5 and the associated temperature cycling will degrade the strength of the ceramic body and the bonding surface due to grain growth, new phase generation, micro-crack generation and glass build-up on the surface.

MANUFACTURING AGENCY	DWG. CLASSIFICATION LEVEL	DWG STATUS
GENERAL ELECTRIC NEUTRON DEVICES DEPT.	UNCLASSIFIED	PRODUCTION

REVISIONS

ISSUE	DESCRIPTION	ISSUE	DESCRIPTION	ISSUE	DESCRIPTION	ISSUE	DESCRIPTION
A	740992 GE WR Wilkinson A-1-74	C	770309GE M. Cobo 6-7-77				
B	ASR 740789SC 740789SC	D	780500GE J. Bosse 10-19-78				

CONTROL NO			MATERIAL	FIRST MADE FOR
-200			SHEET	MC2965
-201			WIRE & ROD	MC2965
-202			TUBING	MC2965

1. GENERAL:

1.1 SCOPE - THIS SPECIFICATION COVERS 99.99% GOLD SHEET, WIRE, ROD AND TUBING.

2. DOCUMENTS: NONE

3. REQUIREMENTS:

3.1 MANUFACTURERS

3.1.1 WESTERN GOLD AND PLATINUM CO.

3.1.2 WILLIAMS PRECIOUS METALS.

3.1.3 THE WILKINSON CO.

3.2 MATERIAL:

3.2.1 QUALITY - MATERIAL SHALL BE CLEAN, BRIGHT AND FREE WITHIN BEST COMMERCIAL PRACTICE OF INTERNAL AND EXTERNAL DEFECTS.

3.2.2 PURITY, BY WT.----------99.99% MIN.

3.2.3 CONDITION - AS COLD FINISHED, NO REQUIREMENTS ON MECHANICAL PROPERTIES.

3.2.4 DIMENSIONAL TOLERANCES (INCHES):

APPLIED PRACTICES		DIST CODE: IVS			
UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING		DESIGN AGENCY APPROVAL			TITLE: GOLD, HIGH PURITY
SURFACES	TOLERANCES ON DIMENSIONS: DECIMALS ± PLACE; DECIMALS ± PLACE; ANGLES ±	ORG.	DATE	INITIALS	
✓					
MADE: R. Meade	DATE: MAR 1 '79	MFG. AGENCY APPROVAL			SIZE: A; CODE IDENT: 14213; SC GE
ORIGINATED AT: GEND	APPROVAL: [illegible] DATE: 4/13/79	DATE: 5-5-79	INITIALS: [illegible]		DWG NO.: SS302235
					SHEET 1 OF 3

3.2.4 Continued:

3.2.4.1 DIAMETER OF WIRE & ROD:

Diameter	Tolerance Plus or Minus
Up to 0.010, incl.	0.0002
Over 0.010 to 0.020 incl.	0.0003
Over 0.020 to 0.030 incl.	0.0005
Over 0.030 to 0.040 incl.	0.0007
Over 0.040 to 0.050 incl.	0.0008
Over 0.050 to 0.060 incl.	0.0010
Over 0.060 to 0.080 incl.	0.0015
Over 0.080 to 0.150 incl.	0.0020
Over 0.150 to 0.500 incl.	0.0025
Over 0.500 to 0.750 incl.	0.0030

3.2.5.2 THICKNESS OF SHEET OR STRIP:

Thickness	TOLERANCES Plus	Minus
Up thru 0.001	0.0002	0.0001
Over 0.001 thru 0.0018	0.0002	0.0002
Over 0.0018 thru 0.003	0.0003	0.0003
Over 0.003 thru 0.006	0.0004	0.0004
Over 0.006 thru 0.009	0.0008	0.0008
Over 0.009 thru 0.025	0.001	0.001

3.2.5.3 TUBING - DIMENSIONAL TOLERANCES SHALL BE AS DESIGNATED ON PART DRAWING.

4. QUALITY PROVISIONS:

4.1 CERTIFICATION - AT THE DISCRETION OF THE PURCHASING AGENCY, THE SUPPLIER SHALL SUBMIT WITH EACH SHIPMENT OF MATERIAL: (1) A STATEMENT OF COMPLIANCE TO THIS SPECIFICATION AND ISSUE LETTER AND/OR (2) VARIABLES TEST DATA AS REQUESTED. THIS CERTIFICATION SHALL INCLUDE THE PURCHASE ORDER NUMBER, QUANTITY SHIPPED, AND ONE OR MORE OF THE FOLLOWING WHERE APPLICABLE: (1) LOT NUMBER, (2) BATCH NUMBER, OR (3) MELT NUMBER.

4.2 TEST METHODS (MANDATORY ONLY IN CASE OF DISPUTE)

4.2 Continued:

4.2.1 PURITY - SUBTRACT FROM 100% THE SUM OF ALL IMPURITIES DETERMINED AS FOLLOWS:

4.2.1.1 OXYGEN, NITROGEN & HYDROGEN - VACUUM OR INERT GAS FUSION.

4.2.1.2 ALL OTHERS------SOLIDS MASS SPECTROMETER OR EQUIVALENT HAVING EQUAL OR GREATER ACCURACY AND SENSITIVITY.

4.2.2 DIMENSIONAL TOLERANCES - MEASURING INSTRUMENT CAPABLE OF BEING READ AT LEAST ONE-TENTH OF THE TOLERANCE.

5. PACKAGING AND HANDLING:

5.1 PACKAGING - THE MATERIAL SHALL BE PACKAGED IN A MANNER TO ENSURE SAFE DELIVERY AND STORAGE AND COMPLY WITH CARRIER'S REGULATIONS.

5.2 MARKING - EACH CONTAINER SHALL BE LEGIBLY MARKED OR TAGGED WITH BUYER's SPECIFICATION NUMBER, REVISION LETTER AND SUPPLIER'S NAME AND PRODUCT IDENTIFICATION. ADDITIONAL MARKING IS OPTIONAL.

6. NOTES:

NONE

DWG CLASSIFICATION LEVEL	
UNCLASSIFIED	PRODUCTION

DESIGN AGENCY PART OR CONTROL NO.	REVISIONS					
	ISSUE	DESCRIPTION	PREPARED BY	DATE	CHKR	ENGR
-200	A	780576GE	Gill Leung	10-6-78		
	B	780599GE	Gill Leung	10-29-78	EKS	
	C	790532GE	Gill Leung	9-13-79	JAB	

1. GENERAL:

1.1 Scope - The purpose of this specification is to clean quartz resonator parts.

2. DOCUMENTS: None

2.1 Equipment - Ultraviolet Cleaning Box,
Ultraviolet Prod. Corp.
Model R-51 or Equiv. Lamp

NOTE: Ultraviolet cleaner shall be fabricated from ALZAK Aluminum and shall contain no organic materials. Lamp(s) shall be quartz enclosed mercury vapor lamps with significant emission in the 2536 A° region.

3. PROCEDURE:

3.1 Insert parts in ultraviolet cleaner, close cover, energize lamp and clean for time specified.

3.2 Remove.

4. QUALITY PROVISIONS: NA

5. PACKAGING AND HANDLING: NA

AGENCY APPROVALS		
ORG	DATE	INITIALS
GC	9/14/79	EKS

PART CLASSIFICATION: UNCLASSIFIED

DWG CLASSIFICATION LEVEL: UNCLASSIFIED

TITLE: ULTRAVIOLET CLEANING

FMF SC RES

SIZE	CODE IDENT NO.	DWG NUMBER
A	14213	SS305131

SCALE

SHEET 1 OF 2

6. NOTES:

6.1 Ultraviolet cleaner shall be maintained, free of contamination and particles.

FSCM NO. 14213
FCO: 870420GE
J Degelleke, GEND
FMF: SC Reson.

SS328609
See Para 3
Issue T

Date: 06/15/87

Title: Adhesive, Polyimide

SHEET INDEX

SHEET	1	2	3												
ISSUE	T	S	T												

1. GENERAL:

1.1 Scope. This specification covers a high temperature electrically conductive silver filled polyimide adhesive and a high temperature electrically insulating unfilled polyimide adhesive.

1.2 Warning: This product may cause skin irritation to sensitive personnel. If contact with skin occurs, wash affected area immediately with soap and water.

2. DOCUMENTS:

2.1 ASTM D1002 - Strength properties of adhesives in shear by tension loading (metal-to-metal).

3. REQUIREMENTS:

3.1 Manufacturers and Product Designation

3.1.1 Ablestik Laboratories

3.1.1.1 -200 Ablebond 71-1 (Conductive silver filled) - FMF: SC Reson

3.1.1.2 -201 Ablebond 71-2 (Insulating unfilled)

3.2 Material

3.2.1 Volume Resistivity ---------- 0.0003 Ohm-cm max. (-200 only)

3.2.2 Lap shear strength to Alum. ---------- 500 psi minimum (-200)
1500 psi minimum (-201)

3.2.3 Viscosity check ------ 1.0-1.4 Grams/Minute @ 60 psi thru a #21 needle 1/2" long @ 25°C (-200 only).

4. QUALITY PROVISIONS:

4.1 Certification. The Supplier shall submit with each shipment of material: (1) a statement of compliance to this specification and issue letter, and (2) test data from para 3.2 or additional data as requested. This certification shall also include the purchase order number, quantity shipped, and one or more of the following if available: (1) lot number, (2) batch number, or (3) melt number.

4.2 Records.

4.2.1 Buyer - A historical summary containing the certification data in para 4.1 and the material properties test data as measured in para 3.2 shall be retained by the Buyer for 5 years from date of purchase.

4.2.2 Supplier - The supplier shall maintain historical records of each buyer lot of material for a period of 5 years. Volume resistivity (para 3.2.1), lap shear strength (para 3.2.2), viscosity (para 3.2.3) and any other pertinent manufacturing data shall be included in those records. Copies of this test data shall be available from the manufacturer for each purchased lot of material.

4.3 Test Methods (Mandatory only in case of dispute)

4.3.1 Requirements para 3.2 shall be tested at Buyer's option to verify material.

4.3.2 Volume Resistivity

a. Place two parallel strips of plastic tape .25 cm apart onto a glass slide for a length of several inches.

b. Next, place a dab of the adhesive on the slide between the tape strips and squeeze the adhesive into the slot using the edge of a flat blade at a 30-45° angle. Thickness is controlled by the edge of the blade riding on the tape.

c. Peel away the tape and place the specimen in a preheated oven to cure at 140°C - 160°C for 1/2 hour. Increase temperature to 275°C minimum and hold for an additional 1/2 hour.

d. After cooling to room temperature, attach leads from a Wheatstone or Kelvin Bridge to the adhesive strip 2.54 cm apart and read the resistance in ohms. If a Wheatstone Bridge is used, subtract the resistance of the leads.

e. Use the following calculation:

$$R(\text{ohm} - \text{cm}) = \frac{R(\text{ohm}) \times \text{Cross Sectional area } (\text{cm}^2)}{\text{Length (cm)}}$$

4.3.3 Lap Shear Strength - ASTM D1002 for reference only. Use 1/2 inch overlap with 1 inch wide aluminum strips. Cure specimen per schedule in para. 4.3.2.c.

5. PACKAGING AND HANDLING:

5.1 Packaging. The material shall be packaged in 1 cc syringes a manner to ensure safe delivery and storage and comply with carrier's regulations.

5.2 Marking. Each container shall be legibly marked or tagged with buyer's specification number, issue letter and supplier's name, product designation and date of manufacture. Additional marking is optional.

5.3 Storage Temperature: 5°C or less

5.4 Shelf Life - Six months from date of manufacture. material shall not be used after expiration date.

6. NOTES: None

DWG. CLASSIFICATION LEVEL: **UNCLASSIFIED**

DWG. STATUS: **PRODUCTION**

FIRST MADE FOR: SC RES

PART NO.: -200

REVISIONS

ISSUE	DESCRIPTION	ISSUE	DESCRIPTION	ISSUE	DESCRIPTION
A	780576GE 10-10-78				

QUANTITY REQ'D	DRAWING OR PART NUMBER	DESCRIPTION	ITEM
AR	46A100670P2	Deionized Water	1
AR	SS328541-200	Phosphonate (Acid)	2
AR	SS329824-200	Potassium Gold Cyanide	3
AR	SS329823-200	Potassium Hydroxide	4
AR	46A101567P1	Sulfuric Acid	5

MADE BY: [signature] DATE: 10-10-78

ORIGINATED AT: GEND

APPROVAL: [signature] DATE: 10/11/78

DIST CODE

DESIGN AGENCY APPROVAL

ORG	DATE	INITIALS

MFG AGENCY APPROVAL

DATE	INITIALS

TITLE: GOLD PLATING PROCESS (DEQUEST)

SIZE: A | CODE IDENT: 14213 | SC GE

DWG NO: SS329971

1 3

1. GENERAL

1.1 Scope. This specification covers a procedure for gold plating parts and assemblies.

2. DOCUMENTS

See Sheet 1

3. REQUIREMENTS

3.1 Equipment

3.1.1 Gold Plating Console

3.1.2 Containers for gold solution shall be polypropylene, polyethylene, tygon, rigid polyvinyl chloride, glass or fiberglass.

3.2 Tolerance

All tolerances shall be plus 5% minus 0% unless otherwise specified.

3.3 Definitions

All firing times specified are times at temperature. Parts to be sintered shall be preheated and precooled upon entering and leaving the heat zone of the furnaces to prevent blistering and cracking.

3.4 Solution Preparation and Maintenance

3.4.1 Mix plating solution, as follows, in desired multiples:

Mix 80 ml of Dequest 2000 (item 2) with 800 ml of deionized water (item 1). Adjust the pH to 5.0 - 5.3 with a 50% solution of potassium hydroxide (1G/ML of item 4). Add 24 g of gold as potassium gold cyanide (item 3) and stir to dissolve. Dilute to 1000 ml total volume with deionized water (item 1).

3.4.2 Maintain the solution at 70°C ± 5°C and strongly agitate or recirculate to assure a constant flow of solution across surface to be plated.

3.4.3 Maintain the solution at a gold metal concentration of 3 ± 1 troy oz/gal (16 to 32 G/L). Item 3 shall be used to raise the gold content as required.

3.4.4 Maintain the solution at a pH of 5.0 to 6.0 electrometrically. Items 2 and 4 shall be used to adjust pH as required.

3.4.5 Add Item 1 as required to maintain gold plating solution liquid level.

3.5 Procedure

3.5.1 Energize power supply and place fixtured parts into 10% by volume sulphuric acid, item 5, activation solution using low current density and a cathodic mode of operation.

3.5.2 Rinse in running item 1 for 10 to 20 seconds.

3.5.3 Plate parts at required current density for approximately 10% of time required to achieve desired plating thickness.

3.5.4 Rinse in running item 1 until all traces of plating solution are removed.

3.5.5 Dry to minimize contamination.

3.5.6 Sinter per applicable part drawing.

3.5.7 Replate to desired thickness.

3.5.8 Rinse in running item 1 until all traces of plating solution are removed.

3.5.9 Resinter per applicable part drawing.

4. DRAWING PROVISIONS

4.1 Unless otherwise specified on the applicable drawing the following criteria applies:

4.1.1 Blisters or lack of continuous coating greater than .010 diameter or equivalent area are not acceptable.

4.1.2 Plating purity shall be 99.9% minimum.

Sections 5 and 6 - NOT APPLICABLE.

DOD CLASSIFICATION LEVEL: **UNCLASSIFIED**

DOD STATUS: **PRODUCTION**

FIRST MADE FOR: SWSC

PART NO.: -200

QUANTITY REQ'D

REVISIONS

ISSUE	DESCRIPTION	ISSUE	DESCRIPTION	ISSUE	DESCRIPTION
A	790576GE J. Baggs 1-2-79	D	790805GE 1-18-80		
B	790646GE J. Baggs 1-19-79	E	800184GE 4-1-80		
C	790692GE J. Baggs 12-8-79				

QUANTITY REQ'D	DRAWING OR PART NUMBER	DESCRIPTION	ITEM
AR	46A102131P1	Detergent, Non-Ionic	1
AR	46A101756P1	Detergent, Anionic	2
AR	46A100670P2	Deionized Water	3
X	SS305131-200	UV Clean	4
AR	46A102309P1	Nitrogen	5
AR	46A101568P1	Argon	6
			7
X	FED-STD-209A	Clean Work Station Req.	8
X	46A100662G1	Cleaning	9

DIST IDF

DESIGN AGENCY APPROVAL

ORG	DATE	INITIALS

MFG AGENCY APPROVAL

DATE	INITIALS

TITLE: **HANDLING AND STORAGE**

SIZE: A | CODE IDENT: 14213 | SC GE

DWG NO: SS329986

MADE BY: J. Baggs DATE: 9-26-79

DATE: 1/9/80

1. GENERAL:

1.1 Scope - This drawing covers approved practices for handling and storage of crystal resonator parts and assemblies, except where otherwise specified.

1.2 NOTES: Referenced notes are listed on last sheet.

2. DOCUMENTS:

See Sheet 1.

3. REQUIREMENTS:

3.1 General:

Handling - Parts and assemblies shall not be handled unnecessarily even if approved methods are observed; and when they are handled, it shall be in a manner to ensure against contamination and minimal damage such as dents, nicks, scratches, chips, etc.

3.1.2 Furnace Materials - Container materials for high temperature furnace applications are not included in this drawing.

3.2 Handling Materials in Decreasing Order of Preference (See Para. 4.1

3.2.1

Containers Code	Manipulation Code
1 - Aluminum	A - Stainless steel tools (see Para. 4.3)
2 - Stainless Steel	B - Ceramic tipped tools (see Para. 4.3)
3 - Glass (see Para. 4.3)	C - Delrin/Celcon
4 - Delrin Celcon Tefzel C.T.F.E. Teflon LEXAN	D - Nylon gloves plus external finger cots E - Finger cots F - Nylon gloves
5 - Plastic (see para. 4.4)	G - Plastic tools (see Para. 4.5) H - Plastic gloves I - Cotton gloves J - Bare hands

3.2.1.1 All containers shall be adequately covered whenever it is necessary to protect material within from airborne contamination.

3.2.1.2 Patapar paper may be used in conjunction with other materials when cleanness is necessary without regard to scratching or slight paper particle contamination.

3.2.1.3 Lens tissue may be used where cleanness is necessary and where scratch protection from other parts or the container is desired.

	Code
3.3 Ceramic Parts (frames and covers)	
Caution: After gold plating extreme care should be exercised to avoid contact between gold plated surfaces and any metallic surfaces and to avoid scratching or damaging these surfaces.	
3.3.1 Prior to gold plate	4E
3.3.2 Gold plate thru vacuum fire	4E
3.3.3 Vacuum fire thru final seal	4E
3.3.4 After final seal	5J
3.4 Resonator Blanks	
All stages except etching	3A
Etching	4A
3.5 Braze Material	
Prior to use	5E
3.6 Gold Gaskets	
3.6.1 Incoming stock thru fabrication in shop	5J
3.6.2 Fabrication thru parts in stock	4C
3.6.3 Clean thru assembly	4C
3.7 Mounting Clips	
3.7.1 Incoming thru stock	5J
3.7.2 Clean thru assembly	4E
3.8 Gold Ribbon or Copper Strip, gold plated	
3.8.1 Incoming thru use	5J

Code

3.9 Polyimide

Caution: Store refrigerated when not in use.

3.9.1 All stages — 4D, E or H only

3.10 Tooling:

Unless otherwise noted all tooling shall be handled and stored under the same conditions as the parts or assemblies with which they are used to prevent damage or contamination.

3.11 Containers:

All containers shall be maintained in clean condition at all times using one or more of the following methods:

3.11.1 Hand Cleaning - Wash with Alconox (Item 2) and warm water followed by deionized water (Item 3) rinse and drying.

3.11.2 Machine Cleaning - Wash with Alcojet (Item 1) and warm water followed by deionized water (Item 3) rinse and drying.

3.11.3 U.V. clean per Item 4.

3.11.4 Clean anodized aluminum containers per Item 9, Schedule A.

3.12 Storage

3.12.1 In-Process Materials - All materials after inspection shall be stored within materials required per 3.2.1 and contained in covered containers.

3.12.2 Frame blank assemblies after cure & inspection shall be stored in an inert gas atmosphere.

4. NOTES:

4.1 Code number or letter without the word "only" means that material and any of the preceding materials in that table under para. 3.2.1 are acceptable for use.

4.2 After cleaning, parts shall be blown dry with clean dry Item 5, Item 6 or air, or spin dried as per applicable drawing.

4.3 Plastic covers are acceptable on glass containers.

4.4 The choice of plastics for handling of parts and assemblies is very important and each application shall be thoroughly studied to ascertain correct usage. Factors to be considered are as follows:

A. Marking - Plastics that will rub off on a part shall not be used if this marking will not be totally removed by cleaning, firing or blasting in accordance with subsequent cleanness requirements.

B. Stability - Thermal and chemical stability are required to the extent that the plastic will not deteriorate or deform nor in any way contaminate the material with which it comes in contact.

FSCM NO. 14213
FCO 820295GE
J. Leonard, GEND
Diskette 4814A-0225A
SC/GE

SS332871
Issue C

Date: 5/7/82

Gold Plating Process (Dequest)

PART #
-200

QTY	DWG/PART	DESCRIPTION	ITEM
AR	46A100670P2	Deionized Water	1
AR	SS328541-200	Phosphonate (Acid)	2
AR	SS329824-200	Potassium Gold Cyanide	3
AR	SS329823-200	Potassium Hydroxide	4
AR	46A101567P1	Sulfuric Acid	5
AR	SS332875-200	Lead Oxide	6

1. GENERAL:

1.1 Scope. This specification covers a procedure for gold plating parts and assemblies.

2. DOCUMENTS:

See Parts List

3. REQUIREMENTS:

3.1 Equipment

3.1.1 Gold Plating Console

3.1.2 Containers for gold solution shall be polypropylene, polyethylene tygon, rigid polyvinyl chloride, glass or fiberglass.

3.2 Tolerance

All tolerances shall be plus 5% minus 0% unless otherwise specified.

3.3 Solution Preparation and Maintenance

3.3.1 Mix plating solution, as follows, in desired multiples:

Mix 80 ml of Dequest 2000 (item 2) with 800 ml of deionized water (item 1). Adjust the pH to 5.0 - 5.3 with a 50% solution of potassium hydroxide (1G/ML of item 4). Add 24 g of gold as potassium gold cyanide (item 3) and stir to dissolve. Dilute to 1000 ml total volume with deionized water (item 1).

3.3.2 Maintain the solution at 60°C ± 5°C and strongly agitate or recirculate to assure a constant flow of solution across surface to be plated.

3.3.3 Maintain the solution at a gold metal concentration of 3 ± 1 troy oz/gal (16 to 32 G/L). Item 3 shall be used to raise the gold content as required.

3.3.4 Maintain the solution at a pH of 5.0 to 6.0 electrometrically. Items 2 and 4 shall be used to adjust pH as required.

3.3.5 Add Item 1 as required to maintain gold plating solution liquid level.

3.3.6 Add Item 6 as required to maintain plating brightness. Level of lead plated out of solution may be below or approx. 300 ppm. (nominal 0.1 gram/gallon).

3.4 Procedure

3.4.1 Plate parts at desired current density and time to obtain thickness required by applicable part dwg.

3.4.2 Rinse in running item 1 until all traces of plating solution are removed.

3.4.3 Dry to minimize contamination.

4. DRAWING PROVISIONS:

4.1 Unless otherwise specified on the applicable drawing the following criteria applies:

4.1.1 Blisters or lack of continuous coating greater than .010 diameter or equivalent area are not acceptable.

4.1.2 Plating purity shall be 99.7% minimum.

FSCM NO. 14213
FC0840336GE
D. Hardy, GEND
Diskette 1194B-0450A
FMF: SC/RESON
SC/GE

SS334182
-200
Issue E

Date: 07/23/84

Cleaning & Insp. Procedure

QTY	DWG/PART	DESCRIPTION	ITEM
AR	124A1105P1	Alcohol	1
AR	46A101581P2	Methylene Chloride	2
AR	SS302227-200	Trichloroethane, (Alt for Item 4)	3
AR	46A101584P1	Trichloroethylene	4
X	SS305131-200	Ultraviolet Clean	5
			6
AR	46A100670P2	D.I. Water	7
			8
			9
			10

1. GENERAL:

1.1 Scope. This drawing covers the process for cleaning, inspecting, and handling crystal blanks.

2. DOCUMENTS:

2.1 Required Documents

See Parts List

2.2 Equipment

3. PROCEDURE:

3.1 Insert blanks in a teflon fixture.

3.2 Immerse in liquid trichloroethylene Item 4, and agitate for (2) minutes minimum.

3.3 Immerse in methylene chloride, Item 2, and agitate for (2) minutes minimum.

3.4 Immerse in Alcohol, Item 1, and agitate for (2) minutes minimum.

3.5 Rinse in running D.I. Water, Item 7, for (2) minutes minimum. D.I. Water to be filtered thru a 1/2 micron millipore filter.

3.6 Clean in Alcohol, Item 1, and agitate for (2) minutes minimum.

3.7 Immerse in hot D.I. Water (65°C min.), Item 7, for 5 minutes minimum, that has been filtered thru a 1/2 millipore filter.

3.8 Spin dry for 15 sec. minimum, at a terminal velocity of 7650 ± 765 ft./min.

3.9 Ultraviolet clean per Item 5, for 5 minutes minimum per side in fixture within 1 cm of UV lamp.

3.10 Measure contact angle on one blank from each teflon fixture. Angle shall be less than 6°. Blanks used for this test shall be recycled thru cleaning before use in product and shall not be reused for test samples.

4. INSPECTION:

4.1 Inspect crystal blank at 30x magnification with edge illumination, to reveal any cracks, chips or channels. The crystal blank will also be inspected such that the surface topography is revealed.

4.2 Any channel (hole) will be cause for rejection. Any crack will be cause for rejection.

4.3 Any edge chip larger than 0.25 in the radial direction will be cause for rejection.

4.4 Any scratch which has not been etched will be cause for rejection.

4.5 The blank will be free of twinning.

5. HANDLING AND STORAGE: Not applicable

6. NOTES:

6.1 Minimum lot size is 6 units.

6.2 Unless otherwise specified, all dimensions are in millimetres.

FSCM NO. 14213
FCO: 870723GE
J. DeGelleke, GEND 10/6
FMF: SLA RES

343283
-200
Page 1 of 1
Issue B
Date: 09/19/87
Part Class: UNCL

Title: Gold Cleaned

Material: SS302235-201

NOTES:

1. Clean per 46A10066201, Sched. C.

SI METRIC

NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETRES.
2. INSPECT FOR MARKING (PREVIOUSLY APPLIED) LOCATED APPROXIMATELY AS SHOWN.

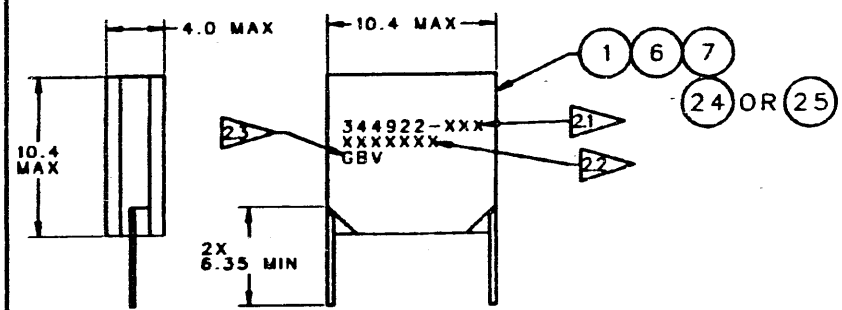
(21) NINE DIGIT PART NUMBER COMPOSED OF THE SIX DIGIT TOP DRAWING NUMBER AND THREE DIGIT SUFFIX.

(22) SEVEN DIGIT SERIAL NUMBER XXXXXXX, THE FIRST TWO DIGITS BEING THE CALENDAR YEAR DESIGNATION, THE THIRD AND FOURTH DIGITS BEING THE FISCAL WEEK DESIGNATION, FOLLOWED BY A THREE DIGIT SEQUENTIAL NUMBER.

(23) MANUFACTURER'S CODE, "GBV" DESIGNATES GENERAL ELECTRIC CO., NEUTRON DEVICES DEPARTMENT.

3. TEST PER ITEM 2.

PART OR CONTROL NUMBER	REVISIONS: RSS	SHEET ZONE	PREPARED BY	DESCRIPTION	DATE	CHKD	APVD
SEE PARTS LIST	J		A. HEIDNER	880760GE	7/28/88		



-20 QTY	-203 QTY	-302 QTY	-201 QTY	-300 QTY	PART/CONTROL NO	DESCRIPTION/MATERIAL	NOTE	SHEET ZONE	ITEM
1	–	–	–	–	344920-204	RESONATOR ASSEMBLY (20MHZ)			25
–	1	–	–	–	344920-203	RESONATOR ASSEMBLY (14.7MHZ)			24
X	X	X	X	X	SD382492-001	SOFTWARE DOCUMENTATION PT3419			23
–	1	1	1	1	UA2057-000	OSCILLATOR OVEN			22
X	X	X	X	X	AM382492-001	PT3419 MASTER DATA DISC			21
X	X	X	X	X	SD381046-000	SD FOR AM381046			20
X	X	X	X	X	AM381046-001	PT3419 AGER			19
X	X	X	X	X	AF379700-000	OP PT3419			18
1	1	1	1	1	PT3419-003	RESONATOR & CLOCK AGER			17
1	1	1	1	1	UA3830-000	CHARACTERIZATION FIXTURE			16
X	X	X	X	X	SD379783-000	SD FOR AM379783			15
X	X	X	X	X	AM379783-000	PT3416/MC3850			14
X	X	X	X	X	AF381234-000	OP PT3416			13
1	1	1	1	1	PT3416-002	RESONATOR SLEW TEST			12
X	X	X	X	X	SD379785-000	SD FOR AM379785			11
X	X	X	X	X	AM379785-000	PT3418/MC3850			10
X	X	X	X	X	AF-PT3418-002	OP PT3418			9
1	1	1	1	1	PT3418-002	CHARACTERIZATION TEST			8
–	–	1	–	–	344920-202	RESONATOR ASSEMBLY (16.38MHZ)			7
–	–	–	1	–	344920-201	RESONATOR ASSEMBLY (16.5MHZ)			6
X	X	X	X	X	372X333-001	MEAS STATION			5
X	X	X	X	X	9900000	GENL MFG REQT			4
X	X	X	X	X	TI372X333-000	TE OPER INSTR			3
X	X	X	X	X	PS344922-200	PS SC RESON 14.7/20			2
–	–	–	–	1	344920-200	RESONATOR ASSEMBLY (16MHZ)			1

SHEET 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27

ISSUE

PART CODE

SHEET 1 2 3 4 5 6

ISSUE J

(U) TITLE CLASSIFICATION: CRYSTAL RESONATOR

PART CLASSIFICATION: UNCLASSIFIED

FIRST MADE FOR MC3647 SC/GE TIE

SI METRIC

DRAWING CLASSIFICATION: UNCLASSIFIED

SIZE C | DRAWING NUMBER 344922

THIRD ANGLE PROJECTION

FSCM 14213 | SCALE 5X | SHEET 1 OF 1

STATUS | ORIGIN GE-CAL-41

FSCM NO. 14064
FCO840336GE
J. Leonard, GEND
Diskette 5702A-0265A
FMF: 20 MHz Reson.
SIMETRIC

46A923742
See Parts List
Issue L

Date: 07/23/84

Cleaning & Insp. Procedure

Part #
G1

Qty.	Dwg/Part	Description	Item
AR	124A1105P1	Alcohol	1
AR	46A101581P2	Meth. Chloride	2
AR	SS302227-200	Trichloroethane (Alt for Item 4)	3
AR	46A101584P1	Trichloroethylene	4
x	SS305131-200	Ultraviolet Clean	5
AR	46A100670P2	D.I. Water	7

1.0 GENERAL:

1.1 Scope. This drawing covers the process for cleaning and inspecting crystal blanks.

2.0 DOCUMENTS:

2.1 Required Documents

See Parts List

3.0 PROCEDURE:

3.1 Insert blanks in a teflon fixture.

3.2 Immerse in liquid trichloroethylene, Item 4, and agitate for (2) minutes minimum.

3.3 Immerse in methylene chloride, Item 2, and agitate for (2) minutes minimum.

3.4 Immerse in Alcohol, Item 1, and agitate for (2) minutes minimum.

3.5 Rinse in running D.I. Water, Item 7, for (2) minutes minimum. D.I. Water to be filtered thru 1a ½ micron millipore filter.

3.6 Clean in Alcohol, Item 1, and agitate for (2) minutes minimum.

3.7 Immerse in hot D.I. Water (90 - 100°C), Item 7, for 5 minutes minimum, that has been filtered thru a ½ millipore filter.

3.8 Spin dry for 15 sec. minimum, at a terminal velocity of 7650 ± 765 ft./min.

3.9 Ultraviolet clean per Item 5 for 5 minutes minimum per side prior to para. 3.10 for sample, and for parts loaded into evaporation paddles.

3.10 Measure contact angle on one blank from each Teflon fixture. Angle shall be less than 6°. Blanks used for this test shall be recycled thru cleaning before use in product and shall not be reused for test samples.

4.0 INSPECTION:

4.1 Inspect crystal blanks at 30X magnification with edge illumination, to reveal any cracks, chips or channels. The crystal blank will also be inspected such that the surface topography is revealed.

4.2 Any channel (hole) will be cause for rejection. Any crack will be cause for rejection.

4.3 Any edge chip larger than 0.25 in the radial direction will be cause for rejection.

4.4 Any scratch which has not been etched will be cause for rejection.

4.5 The blank will be free of twinning.

5.0 HANDLING AND STORAGE: N/A

6.0 NOTES:

6.1 Minimum lot size is 6 units.

6.2 Unless other wise specified, all dimensions are in millimeters.

FSCM NO. 14064
FCO830747GE
D. Hardy, GEND
Diskette 5705A-0265A
FMF: 20 MHz Reson.

46A923763
See Parts List
Issue K

Date: 11/15/83

Polyimide Application and Cure

PART #
G1

QTY	DWG/PART	DESCRIPTION	ITEM
AR	SS328609-200	Polyimide	1
AR	46A102309P1	Nitrogen	2
AR	46A101568P1	Argon	3

1. GENERAL:

1.1 The purpose of this process is to bond the resonator blank to the mounting clips.

2. DOCUMENTS AND EQUIPMENT:

2.1 See Parts List

3. PROCEDURE:

3.1 Apply Item 1 to clips using clean metal applicator.

3.2 Position resonator blank onto clips.

3.3 Perform initial polyimide cure in a flowing dry atmosphere, Item 2 or 3, with less than 75 ppm oxygen according to the following schedule:

a. Heat to 90°C max. at a rate of 1°C/minute max.

b. Hold at 90°C ± 10°C for 20 ± 5 minutes.

c. Heat to 180°C max. at a rate of 2°C/minute max.

3.3 Continued

d. Hold at 180°C ± 10°C for 20 ± 5 minutes.

e. Heat to 330°C max. at a rate of 2°C/minute max.

f. Hold at 330°C ± 10°C for 120 ± 15 minutes.

g. Cool to 75°C or below before introducing air to the chamber.

FSCM NO. 14064
FCO820349GE
DB Hardy, GEND
Diskette 0334B-0408A
20 MHz RESON
SC/GE

46A923912
See Parts List
Issue D

Date: 6/1/82

Evaporation Process Mo/Au

PART #
G1

QTY	DWG/PART	DESCRIPTION	ITEM
AR	124A1105P1	Alcohol	1
X	46A102298P1 or P5	Steel CRE 304	2
X	46A102297P1-P6	Molybdenum, Unalloyed	3
X	SS268095-200	Molybdenum	4
AR	46A100670P1	Deionized Water	5
X	SS205980-200	Tungsten	6
X	46A100853P1	Ceramic	7
X	SS329986-200	Handling	8
AR	46A101568P1	Argon	9
X	46A100662G1	Cleaning Process	10
X	46A115289	Hydrogen Fire	11
X	46A100667G1	Cleaning Process	12
X	SS284775-205	Vacuum Firing	13
X	SS284775-200	Vacuum Firing	14
AR	SS277000-200	Fluoroform (CHF_3)	15
AR	8003310	Gold	16
X	SS334182-200	Cleaning & Insp. Procedures	17
X	SS226817-000	Copper OHFC	18
AR	46A102309P1	Nitrogen	19

1. GENERAL:

1.1 Scope. The purpose of this process is the deposition of a Mo/Au film on a quartz substrate.

2. DOCUMENTS: See Parts List

3. REQUIREMENTS:

3.1 Equipment

3.1.1 Vacuum System. The vacuum system for Moly/Gold evaporation shall contain sorption pumps for rough pumping and a cryopump for fine pumping. This system shall be capable of attaining a pressure of 3×10^{-3} torr or less by means of the sorption pumps only and a further reduction to a pressure of 5×10^{-8} torr or less by means of the cryopump only. These requirements shall apply with the vacuum system empty and at room temperature.

3.1.2 Leak Detector. The system shall have a quadrupole type residual gas analyzer (RGA) and be capable of detecting an Item 15 (fluoroform) leak of 1×10^{-9} std cc/sec.

3.1.3 Bell Jar Furniture & Fixturing. The bell jar shall contain the following equipment:

a. A holder, with evaporation masks as necessary to support the substrates.

b. A molybdenum heater capable of heating the substrates to a temperature of 400°C.

c. An electron beam gun capable of simultaneously heating the moly and gold charges to the temperature required for evaporation.

d. A shutter capable of being operated under vacuum so as to shield the substrates from the charges.

e. Shields as necessary to minimize the deposition of evaporant on the vacuum chamber walls.

f. An evaporation monitor assembly for process control.

g. Rotation fixturing for rotating substrates between evaporations.

h. Flipping mechanism for turning parts, so as to evaporate both sides of substrates.

3.1.4 All internal system parts, fixtures, substrates, and support materials used in connection with this process shall be such that they will not contribute significantly to the system's inherent residual gas level. Copper and tungsten parts shall be made of Item 18 and Item 6.

3.2 Cleaning

3.2.1 Cleaning of Vacuum System. Vacuum system bakeout and ion pump cleaning shall be performed in accordance with equipment manufacturers recommendations or procedures developed at GEND.

3.2.2 Cleaning of Fixtures and Shields (Other than masks):

NOTE: Handle fixtures and shields as required by Item 8.

3.2.2.1 Prior to first use:

a. Clean Item 2 (stainless steel) and Item 3 and 4 (molybdenum) parts of the unassembled fixture per Item 10, Schedule A. Follow with an Item 1 rinse. Ultrasonic clean parts from Item 7 (ceramic) per Item 12. Air fire the ceramic parts at 1100°C ± 50°C for 60 minutes ± 2 minutes.

b. Parts made from Item 2 (stainless steel) shall be hydrogen fired, where physical dimensions permit, per Item 11 at 1140°C ± 25°C for 20 minutes ± 3 minutes.

c. Parts made from Items 3 and 4 (molybdenum) shall be hydrogen fired where physical dimensions permit, per Item 11 at 900°C ± 25°C for 20 minutes ± 3 minutes.

d. Parts made from Item 2 (stainles steel), Items 3 and 4 (molybdenum), and Item 7 (ceramic): vacuum fire per Item 14.

e. Procured fastening hardware made from Item 2 (stainless steel), clean per Item 12, followed by Item 10, Schedule A and vacuum fire per Item 13.

3.2.2.2 After a maximum of 50 process runs on the upper tooling:

a. Disassemble all fixturing that receives direct Mo/Au deposition.

b. Discard all fastening hardware made from Item 2 (stainless steel).

c. Cleaning schedule to be determined.

3.2.3 Cleaning of Masks

3.2.3.1 Prior to first use:

a. Degrease per Item 10, Schedule C.

3.3 Cleaning of Mo/Au:

a. Clean Item 4 (moly) and Item 16 (gold) per Item 10, Schedule C.

b. Dry in Item 19 (Nitrogen) oven for 30 minutes minimum.

c. Vacuum fire Item 16 (Gold) per Item 13.

3.4 Procedure:

3.4.1 Pump Down

3.4.1.1 Load system with proper fixtures, masks and the Mo/Au charges.

3.4.1.2 Load crystal blanks in fixture. UV clean blanks and fixture per Item 17.

3.4.1.3 Seal system and pump down to less than 1×10^{-6} torr.

3.4.1.4 After attaining a chamber pressure of 1×10^{-6} torr, verify that there are no external leaks. Leaks larger than 1.0×10^{-9} std cc/sec not allowed while using Item 15, fluoroform, (CHF_3) as a tracer gas.

3.4.2 Premelt:

3.4.2.1 Premelt the gold charge or addition to charge

3.4.2.2 Maintain gold and moly charges incandescent, but below significant evaporation temperature.

3.4.3 Substrate Degas:

3.4.3.1 Raise temperature of substrate to between 230°C and 270°C, and maintain for 30 minutes min. and until a pressure of 2×10^{-6} torr is reached. Maximum pressure during temperature rise shall not exceed 8×10^{-6} torr.

SIMETRIC

SEE PTS LIST	B	8006748E		82

NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETRES.
2. HANDLE PER ITEM 3.
3. PROCEDURE:

3.1 ULTRASONIC CLEAN PER ITEM 4, SCHEDULE C.

3.2 CLEAN PER ITEM 5.

3.3 METALLIZE PER ITEM 6.

3.4 WET HYDROGEN FIRE PER ITEM 7, PROC. 5 AT 1495°C ± 40°C FOR 45 MINUTES ± 5 MINUTES.

3.5 GOLD PLATE PER ITEM 8, TO A THICKNESS OF $3{\cdot}12 \times 10^{-3}$.

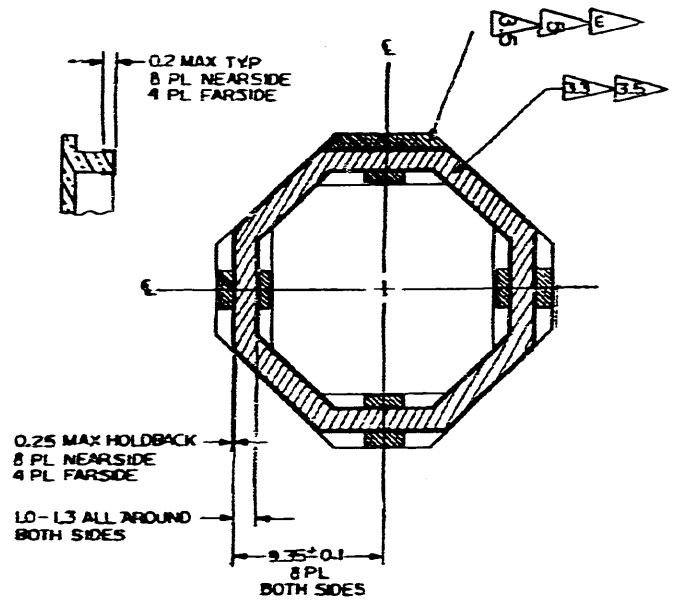
3.6 DRY HYDROGEN SINTER PER ITEM 7 BY INCREASING THE TEMPERATURE TO 575°C ± 25°C AT A RATE OF 5°C/MIN. MAXIMUM. THEN INCREASE THE TEMPERATURE TO 900°C ± 25°C AND FIRE FOR 10 MINUTES ± 1 MINUTE. A MAXIMUM OF (3) PLATING AND SINTERING CYCLES ARE ALLOWED.

OR:

AIR FIRE TO A TEMPERATURE OF 300/310°C AT A RATE OF 2°C/MINUTE MAX. STOP FIRING WHEN THE 300/310°C IS REACHED (NO HOLD).

DRY HYDROGEN FIRE ON A BELT FURNACE TO A TEMPERATURE OF 900 ± 25°C WITH A FIVE MINUTE MINIMUM ABOVE 825°C. NO RESTRICTIONS ON HEATING OR COOLING RATES.

4. STORE TO AVOID METAL TO METAL CONTACT.
5. ISOLATION CHECK BETWEEN PADS AND BETWEEN EACH PAD AND EACH SEALING SURFACE TO BE 10K OHMS MINIMUM.
6. EVIDENCE OF GOLD REQUIRED ON THESE AREAS. CONTACT MARKS ARE ACCEPTABLE



PART# SUBL QTY	DWG/PART	DESCRIPTION	ITEM
1	46C924935P001	LAMINATED FRM	02
X	46A9252726001	MARD ARD STOR	03
X	46A1006626001	CLEANING PROC	04
X	46A1006656001	CLEANING PROC	05
AR	SS284790 -202	METAL SPEC	06
X	46A115289	HYDROGEN FIRE	07
AR	SS329971 -200	GOLD PLT PROC	08
X	9900000 -	GEN MFG REQ	09

RELEASED DWG

THIRD ANGLE PROJECTION

UNCLASSIFIED

UNCLASSIFIED

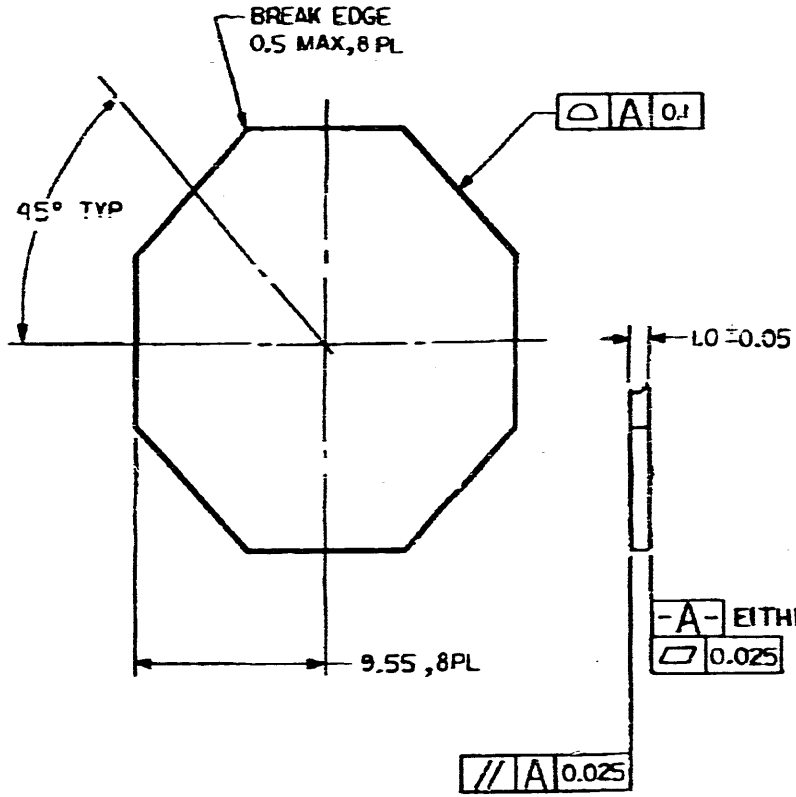
FRAME PROC

FMF SMH₂ RES

C | 14064 | 46C924934

5X

DESIGN AGENCY PART OR CONTROL NO.	REVISIONS					
	LTR	DESCRIPTION	PREPARED BY	DATE	CHKD	TRACE
P1	B			7-24-80		
	C	8005206E		8-22-80		B
	D	8006396E		11-19-80		C



NOTES:

1. MATERIAL: CERAMIC, 94% - 96% ALUMINA
2. APPLIED PRACTICES: 9900030
3. PARTS MUST BE FREE OF CRACKS AND PITS GREATER THAN 0.025 IN ANY DIRECTION.
4. HANDLE PER 5535536G-203.
5. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
6. APPROVED SUPPLIER: LDC

THIRD ANGLE PROJECTION

AGENCY APPROVALS		
ORG	DATE	SIGNATURE
GE	8-25-80	
GE	8/25/80	

UNCLASSIFIED

UNCLASSIFIED

TITLE: COVER

5MHZ RESON

SIZE	CAGE SHEET NO.	SHEET NUMBER
B	14064	46B924935

SCALE: 5/1 SHEET 1 OF

3925A-0187A

FC-305 (2-76)

SIMETRIC

G001	C	820988GE	G N YOUNG	5/83	WHB
	D	840208GE	DE CASTELLANO	4/17/84	

NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETRES. THREADS ARE SPECIFIED IN INCHES.
2. HANDLE PER ITEM 3.
3. PROCEDURE:

3.1 ULTRASONIC CLEAN PER ITEM 4.

3.2 AIR FIRE AT 1100°C±50°C FOR 60 MINUTES±10 MINUTES.

3.3 METALLIZE PER ITEM 6.

3.4 WET HYDROGEN FIRE PER ITEM 7, PROC. 5 AT 1495°C±40°C FOR 45 MINUTES±5 MINUTES.

3.5 GOLD PLATE PER ITEM 8, TO A THICKNESS OF $3-12 \times 10^{-3}$

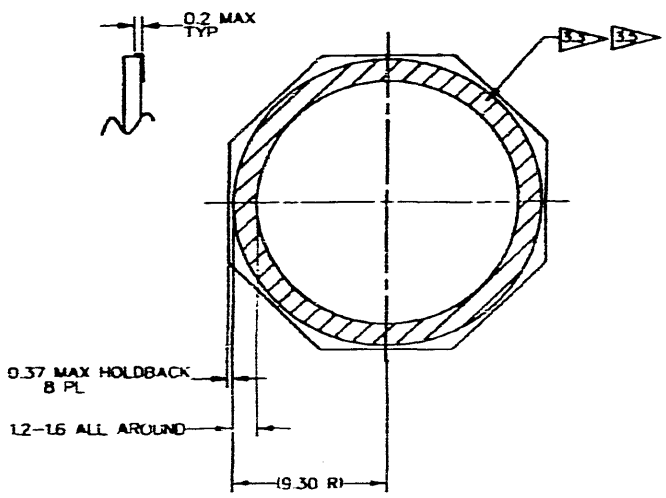
3.6 DRY HYDROGEN SINTER PER ITEM 7 BY INCREASING THE TEMPERATURE TO 575°C±25°C AT A RATE OF 5°C/MIN. MAXIMUM, THEN INCREASE THE TEMPERATURE TO 900°C±25°C AND FIRE FOR 10 MINUTES±1 MINUTE. A MAXIMUM OF (3) PLATING AND SINTERING CYCLES ARE ALLOWED.

OR

AIR FIRE TO A TEMPERATURE OF 300°C/310°C AT A RATE OF 2°C/MIN MAXIMUM. STOP FIRING WHEN THE 300°C/310°C IS REACHED (NO HOLD).

DRY HYDROGEN FIRE ON A BELT FURNACE TO A TEMPERATURE OF 900°C±25°C WITH A FIVE MINUTE MINIMUM ABOVE 875°C. NO RESTRICTIONS ON HEATING OR COOLING RATES.

4. STORE TO AVOID METAL TO METAL CONTACT.



QTY	PART NO.		DESCRIPTION	NOTES	SHT	ITEM
X	9900000		GEML MFG REQT			9
AR	SS329971-200	L	GOLD PLATING PROCESS			8
X	46A115289	L	HYDROGEN FIRE			7
AR	SS284790-202	✓	METALLIZE SPECIFICATION			6
X	46A100667G001	✓	CLEANING PROCEDURE			4
X	46A925072G001	✓	HANDLING & STORAGE			3
1	468924935P001	✓	COVER			2

THIRD ANGLE PROJECTION

DRN	8/10/83	TJL
CHKD	8/10/83	DS

UNCLASSIFIED

UNCLASSIFIED

TITLE: COVER PROCESSED
FMF RESON 5

SIZE	CAGE IDENT. NO.	DRAWING NO.
C	14064	46C924936

SCALE 5/1 SHEET 1 OF 1

FSCM. NO. 14064
FCO 330747GE
F. Leonard, GEND
Diskette 3479A-0173A
FMF: RESON 5
SIMETRIC

46A924940
P1

Issue N
Date: 11/15/83
PART CLASS: UNCL

Fundamental Mode 5 MHz SC-CUT
Crystal Blanks

1. GENERAL.

Scope: This document covers the requirements for Fundamental Mode 5 MHz SC-CUT Crystal Blanks made of swept quartz.

2. DOCUMENTS: Not Applicable

3. REQUIREMENTS:

3.1 Finished Blank Frequencies

P1 - The frequency of the C- mode shall be 5.1453 ± 0.0024 MHz when measured with an air gapper.

3.2. BLANK MATERIAL

Swept Cultured Quartz, suitable for high precision applications. (Q greater than 2.2×10^6).

3.3 Blank Angles of Cut

The blanks shall be cut at the SC-cut angles such that when resonators are fabricated from the finished blanks, the slope of the resonator frequency vs. temperature characteristic at the inflection temperature is between zero and -0.036 ppm per °C, and the inflection temperature is at 103°C ± 8°C.

4. QUALITY PROVISIONS:

4.1 BLANK GEOMETRY:

The blanks shall be plano-convex circular plates with contours between 1.25 and 3.0 diopter, with diameter 0.5495" + .0000" - .0015". The flat side shall be not beveled, and the blank shall not be marked with a flat. The blanks shall be contoured on the fast-etch side (i.e. the negative on compression side). Contour requirements are for tooling and processing purposes only.

4.2. BLANK SURFACE AND EDGE FINISH:

The blank surface shall be final lapped with 1 micrometer aluminum oxide. The blanks shall be chemically polished in a solution consisting of four parts, by volume, 40% NH_4F and one part 49% HF. After the final contouring, the blanks shall be etched between $\Delta f = 12\ f_o f_f$ and $\Delta f = 15\ f_o f_f$, where f_o = initial frequency in MHz, f_f = final frequency in MHz, and $\Delta f = f_f - f_o$ in KHz. The blanks shall be free of chips greater than 0.254 mm and scratches when inspected under intense light at 10X magnification.

5. PACKAGING AND HANDLING:

5.1 Crystal blanks are to be packaged to avoid scratches or chips. Parts should not be allowed to abrade each other during shipment. Packaging in Fluoroware trays is suggested. The blanks in each package shall be identified with the nominal angles of cut, and with one of the following three contour ranges: 1.25 to 1.75 diopter, 1.87 to 2.37 diopter, and 2.5 to 3.0 diopter.

6. NOTES:

6.1 APPROVED QUARTZ SUPPLIER:

Sawyer Research Products, Inc.
35400 Lakeland Blvd.
Eastlake, OH 44094

6.2 APPROVED BLANK SUPPLIER:

Piezo Crystal Co.
100 K Street
P.O. Box 619
Carlisle, PA 17013

6.3 SWEEPING:

The electrolytic sweeping process shall be performed by Piezo Crystal Co. or Sawyer Research Products, Inc.

FSCM NO. 14064
FCO 820520GE
D. Hard, , GEND
Diskette 3781A-0182A
FMF: RESONATOR 5
SIMETRIC

46A924943
P1
Page 1 of 1
Issue F
Date: 07/26/82
PART CLASS UNCLASS

Clip

LENGTH: 15.2 ± 0.2

WIDTH: 1.52 ± 0.02

NOTES:

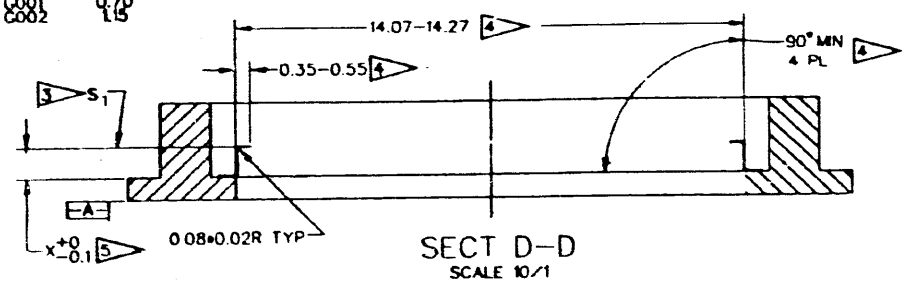
1. MATL.: 46A927253G1
2. Clean per 46A100662G1.
3. Unless otherwise specified all dimensions are in millimetres.

SIMETRIC

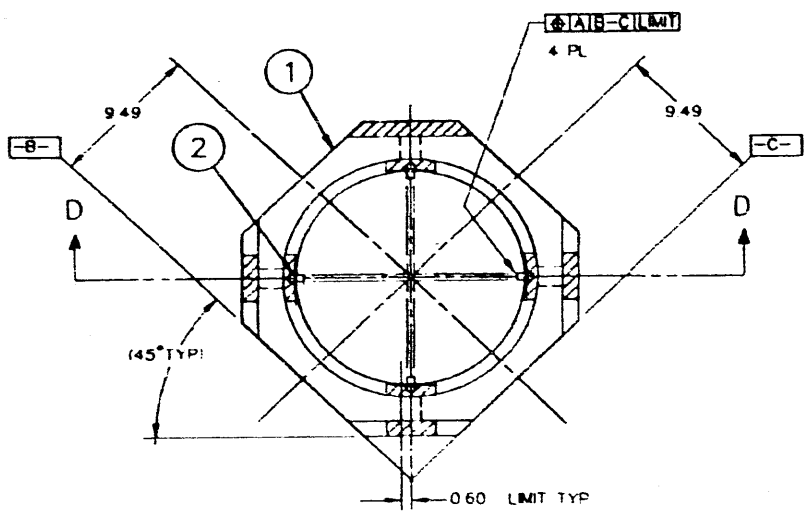
DESIGN AGENCY PART OR CONTROL NO.	ISSUE	DESCRIPTION	PREPARED BY	DATE	CHKD	ENGR
SEE PARTS LIST	G	820988GE	G N YOUNG	/4/83	WHB	

NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETRES. THREADS ARE SPECIFIED IN INCHES.
2. PROCEDURE:
   - 2.1 HANDLE PER ITEM 6.
   - 2.2 CENTER ITEM 3 AS SHOWN (2 PL) AND BRAZE PER ITEM 8 USING USING ITEM 4 AND ITEM 9 IF REQUIRED.
   - 2.3 CUT ITEM 3 AND FORM AS SHOWN IN SECTION D–D.
   - 2.4 VACUUM FIRE PER ITEM 7.
3. S_1 PORTION OF CLIPS TO BE COPLANER WITHIN 0.075.
4. FOR TOOLING PURPOSES ONLY.
5. PART # X
   G001 0.70
   G002 1.15



SECT D–D
SCALE 10/1



AR	AR	SS307737-200	BRAZE ADHESIVE			9
X	X	138A6012	HYD BRAZE & PLATE			8
X	X	SS284775-201	VACUUM FIRING			7
X	X	46A925072G001	HANDLING & STORAGE			6
X	X	9900000	GENL MFG REQT			5
AR	AB	SS268140-200	BRAZE ALLOY			4
2	2	46A924943P001	CLIP			3
1	1	46C926307G001	FRAME PROCESSED			2
QTY PER	QTY REQ	PART NO.	DESCRIPTION	NOTES	UNIT	ITEM

THIRD ANGLE PROJECTION

AGENCY APPROVALS

ORG	DATE	INITIALS
GENO	12/8/80	F.L.
QA-O	12/8/80	TRS

SHEET INDEX

PART CLASSIFICATION
UNCLASSIFIED

SEC. CLASSIFICATION OF ASSY.
UNCLASSIFIED

TITLE
FRAME CLIP ASSEMBLY
FMF RESON 5

SIZE	CAGE IDENT. NO.	DWG. NUMBER
C	14064	46C924944

SCALE 5/1 SHEET 1 OF 1

FSCM NO. 14064
FCO 810317GE
J. Leonard, GEND
Diskette 3780A-0182A
FMF: Reson. 5

46A924945
P1
Page 1 of 1
Issue C
Date: 06/10/81
PART CLASS UNCLAS

Gasket Processed

NOTES:

1. MAT.: 46A926271P1
2. Clean per 46A100662G1.

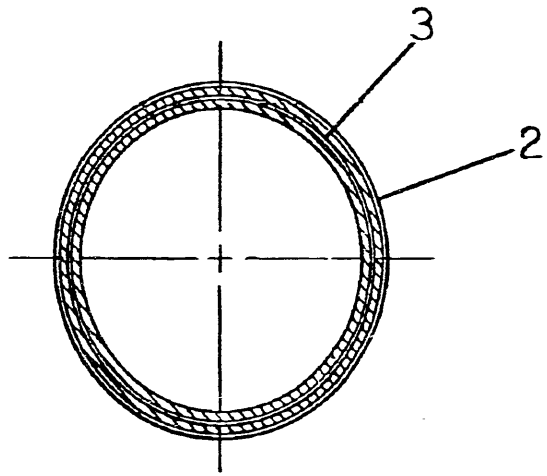
SI METRIC

DESIGN AGENCY PART OR CONTROL NO.
SEE PTS LIST

REVISIONS					
ISSUE	DESCRIPTION	PREPARED BY	DATE	CHKR	ENGR
B	800674GE	[illegible]	11-21-80	[illegible]	
C	810317GE	David L Carter	6-10-81	[illegible]	
D	810486GE	David L Carter	9-10-81	[illegible]	
E	820296GE	David L Carter	5-11-82	[illegible]	

NOTES:

1. PROCEDURE
   - 1.1 HANDLE PER ITEM 8.
   - 1.2 U.V. CLEAN ITEMS 2 & 3 PER ITEM 6.
   - 1.3 CENTER ITEM 3 APPROX. AS SHOWN, ON MET PATTERN.
   - 1.4 VACUUM FIRE PER ITEM 7.
2. DISCONTINUITIES AND SEVERE CUTS & SCRATCHES ARE NOT ALLOWED.



PART# GOOL QTY	DWG/PART	DESCRIPTION	ITEM
1	46CS26308G001 ✓	COVER PROC	02
1	46A924945P001 ✓	GASKET PROC	03
X	9900000 -	GEN MFG REQ	05
X	SS305131 -200 ✓	ULTRAVIOL CLN	06
X	SS284775 -200 ✓	VAC FIRING	07
X	46A925072G001 ✓	HAND AND STOR	08

THIRD ANGLE PROJECTION

AGENCY APPROVALS		
CAG	DATE	INITIALS
GE	12-8-80	[illegible]
GE	12/10/80	[illegible]

PART CLASSIFICATION: UNCLASSIFIED

DWG CLASSIFICATION LEVEL: UNCLASSIFIED

TITLE: COVER GASKET ASM FMF 5MHz RES

SIZE	CODE IDENT NO.	DWG NUMBER
B	14064	46B924946

SCALE 4X SHEET 1 OF

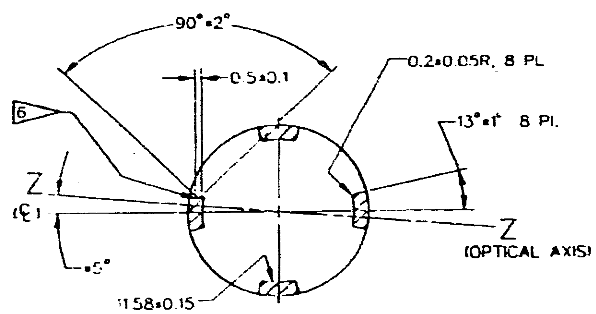
Design Agency Part or Control No.	Issue	Description	Prepared by	Date	Chkd	Engr
G001	G	820988GE	G N YOUNG	4/4/83	WHB	
	H	830747GE	LYNN WILSON	11/15/83	[illegible]	

SIMETRIC

NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETRES. THREADS ARE SPECIFIED IN INCHES.
2. PROCEDURE:
2.1 HANDLE PER ITEM 8.
2.2 PROCESS PER ITEM 9.
2.3 MOUNT IN MASK.
2.4 EVAPORATE PER ITEM 6 (BOTH SIDES).
3. EVAPORANT MUST BE FLUSH OR OVERLAP EDGE (4 PL).
4. SCRATCH TEST TO VERIFY ADHESION AND SCRAP SAMPLE.
5. ALL DIMENSIONS ARE TOOL CONTROLLED, EXCEPT THICKNESS:
   MOLY 500±256Å
   ALLOY MOLY/GOLD 500±256Å
   GOLD 5000±2500Å
   (COMBINED THICKNESS ONLY SHALL BE MEASURED).

6 ▷ NOTCH ON CONVEX SIDE OF CONTACTED PATTERN ON THE Z-Z AXIS; ORIENTATION ONLY.



2004 QTY	2003 QTY	2002 QTY	2001 QTY	PART NO.	DESCRIPTION	NOTE	UNIT	ITEM
–	1	–	–	46A928256P001	ALTERNATE ITEM 3			11
–	–	1	–	46A928257P001	ALTERNATE ITEM 2			10
X	X	X	X	46A923742G001	CLEAN & INSPECTION PROC	2.2		9
X	X	X	X	46A925072G001	HANDLING & STORAGE	2.1		8
X	X	X	X	9900000	GENL MFG REQT			7
AR	AR	AR	AR	46A923912G001	EVAPORATION PROC MO/AU	2.4		6
1	–	–	–	46A927146P001	CRYSTAL BLANK			4
–	1	–	–	46A926846P001	CRYSTAL BLANK			3
–	–	1	–	46A927[illegible]P001	CRYSTAL BLANK			2
–	–	–	1	46A924940P001	CRYSTAL BLANK			1

THIRD ANGLE PROJECTION

AGENCY APPROVALS	DATE	INITIALS
[illegible]	[illegible]	F.R.
[illegible]	[illegible]	TMS

PART CLASSIFICATION: UNCLASSIFIED

DWG. CLASSIFICATION LEVEL: UNCLASSIFIED

TITLE: BLANK CONTACTED

EMF RESIN 5

SIZE: C | CODE IDENT NO.: 14064 | DWG. NUMBER: 46B924954

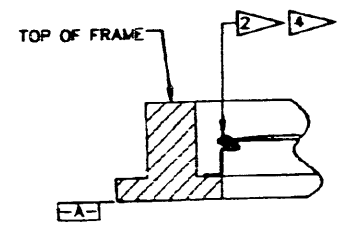
SCALE: 4/1 | SHEET 1 OF 1

DESIGN AGENCY PART OR CONTROL NO.	ISSUE	DESCRIPTION	PREPARED BY	DATE	CHKD	ENGR
SEE PARTS LIST	J	820988GE	G N YOUNG	4/5/83	WHB	

SIMETRIC

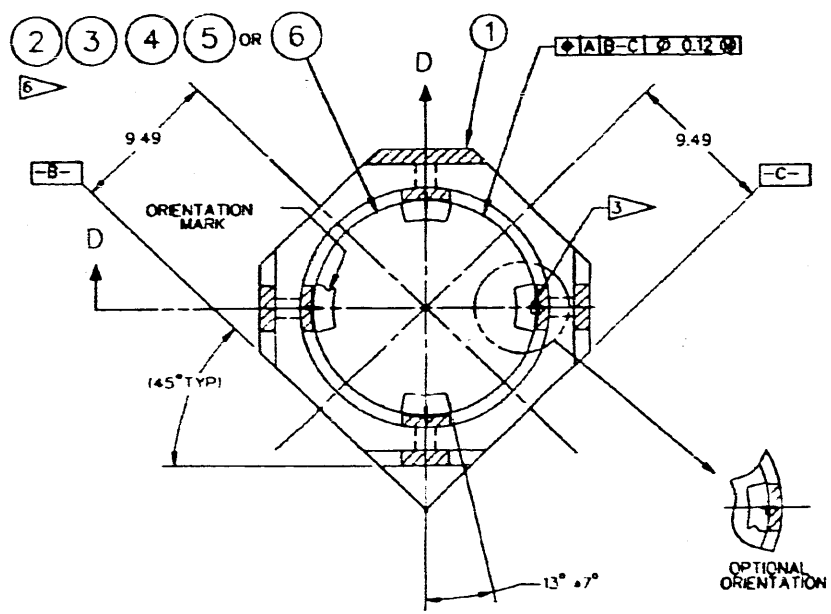
NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETRES. THREADS ARE SPECIFIED IN INCHES.
2. APPLY POLYIMIDE TO ITEM 1 AND ATTACH ITEM 2, 3, 4, 5 OR 6 AS SHOWN PER ITEM 7.
3. POLYIMIDE SHOULD NOT EXTEND BEYOND EVAPORATED AREA (BOTH SIDES).
4. POLYIMIDE SHALL ENVELOPE THE TOP AND BOTTOM OF THE CLIPS' MOUNTING SURFACE, ALL AROUND.
5. HANDLE PER ITEM 9.
6. CONVEX SIDE OF ITEM 2, 3, 4, 5 OR 6 TO BE TOWARD THE TOP OF FRAME.



SECT D-D

SCALE 10/1



	X	X	X	X	X	46A925072G001	-	HANDLING & STURAGE	5	9
	X	X	X	X	X	990000	0	GENL MFG REQT		8
	AR	AR	AR	AR	AR	46A923763G001	-	POLYIMIDE APPLICATION	2	7
	1	-	-	-	-	468924954G005	-	BLANK PROCESSED	2,6	6
	-	1	-	-	-	468924954G004	-	BLANK PROCESSED	2,6	5
	-	-	1	-	-	468924954G003	-	BLANK PROCESSED	2,6	4
	-	-	-	1	-	468924954G002	-	BLANK PROCESSED	2,6	3
	-	-	-	-	1	468924954G001	-	BLANK PROCESSED	2,6	2
	1	1	1	1	1	46C924944G002	-	FRAME CLIP ASSEMBLY	2	1
	CODE 0TY	CODE 0TY	CODE 0TY	CODE 0TY	CODE 0TY	PART NO.		DESCRIPTION	NOTE SHT	ITEM

AGENCY APPROVALS			SHEET
CODE	DATE	INITIALS	ISSUE
07140	9/8/80	JJL	SHEET INDEX
07140	9/10/80	DMS	PART CLASSIFICATION
			UNCLASSIFIED
			D.E. CLASSIFICATION LEVEL
			UNCLASSIFIED

3RD ANGLE PROJECTION

TITLE: FRAME BLANK ASSEMBLY

FMF RESON 5

SIZE	CODE IDENT. NO.	DWG. NUMBER
C	14064	46C924960

SCALE 5/1 SHEET 1 OF 1

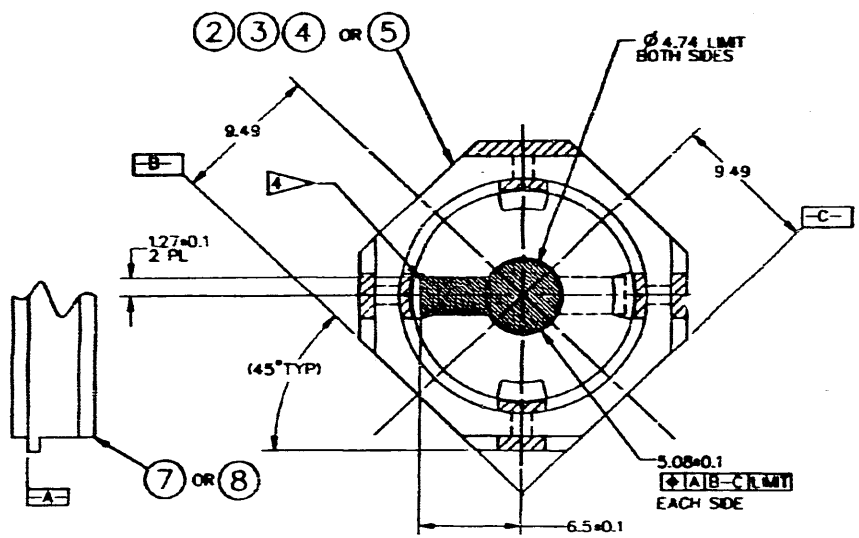
DESIGN AGENCY PART OR CONTROL NO.	ISSUE	DESCRIPTION	PREPARED BY	DATE	CHKD	ENGR
SEE PARTS LIST	G	820988GE	G N YOUNG	4/5/83	WHB	
	H	830747GE	LYNN WILSON	11/15/83		

SIMETRIC

NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETRES. THREADS ARE SPECIFIED IN INCHES.
2. HANDLE PER ITEM 9 AND PROCESS PER ITEM 10.
3. ALL DIMENSIONS ARE TOOL CONTROLLED.

4 ELECTRODE MUST OVERLAP EVAP. CONTACTS BOTH SIDES, 2 PL.



				PART NO.	DESCRIPTION	NOTE/SHT	ITEM
AR	AR	AR	AR	46A927742G001	PROCESS SPECIFICATION	2	10
X	X	X	X	46A925072G001	HANDLING & STORAGE	2	9
2	2	2	2	46B924946G001	ALTERNATE ITEM 7		8
2	2	2	2	46B927564G001	COVER GASKET ASSEMBLY		7
1	–	–	–	46C924960G004	FRAME BLANK ASSEMBLY		5
–	1	–	–	46C924960G003	FRAME BLANK ASSEMBLY		4
–	–	1	–	46C924960G002	FRAME BLANK ASSEMBLY		3
–	–	–	1	46C924960G001	FRAME BLANK ASSEMBLY		2
X	X	X	X	9900000	GENL MFG REQT		1

THIRD ANGLE PROJECTION

AGENCY APPROVALS		
	DATE	INITIALS
ORIG	12/8/80	PJL
CHKD	12/9/80	ERS

SECURITY CLASSIFICATION: UNCLASSIFIED

SUBJ. CLASSIFICATION LEVEL: UNCLASSIFIED

TITLE: FRAME BLANK ELECTRODED & SEALED

FMF:RESON 5

SIZE	CODE IDENT. NO.	SUBJ. NUMBER
C	14064	46C924972

SCALE 5/1 SHEET 1 OF 1

DESIGN AGENCY PART OR CONTROL NO.	ISSUE	DESCRIPTION	PREPARED BY	DATE	CHKD	ENGR
SEE PARTS LIST	G	820988GE	G N YOUNG	4/5/83	WHB	
	H	830747GE	LYNN WILSON	11/16/83	[illegible]	

SIMETRIC

NOTES:

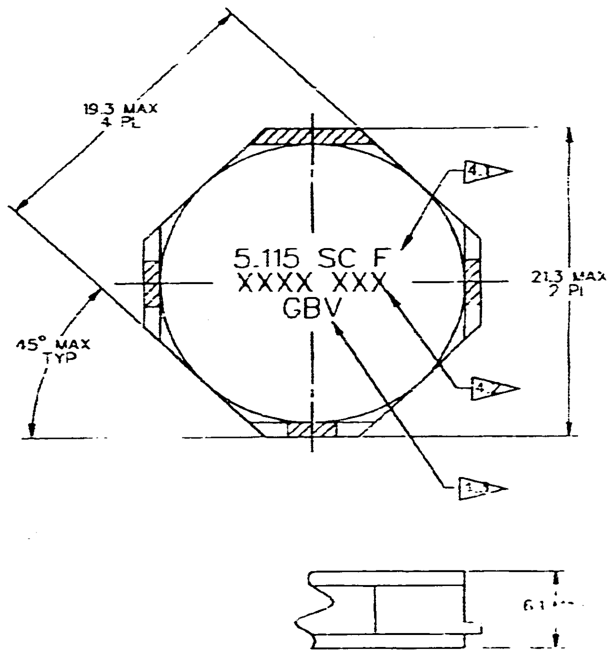
1. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETRES. THREADS ARE SPECIFIED IN INCHES.
2. TEST PER ITEM 6.
3. PACKAGE PER ITEM 7.
4. MARK PER ITEM 9, CLASS K-1 (LASER MARKING).

4.1 NOMENCLATURE

PART#	FREQUENCY	CUT	OVERTONE
G001	5.115	SC	F (EXAMPLE SHOWN)
G002	5.115	SC	3
G003	10.000	SC	3
G004	10.230	SC	3

4.2 SEVEN DIGIT SERIAL NO. XXXX XXX. THE FIRST TWO DIGITS BEING THE CALENDAR YEAR DESIGNATION. THE THIRD AND FOURTH DIGITS BEING THE FISCAL WEEK DESIGNATION. A SPACE, FOLLOWED BY A THREE DIGIT SEQUENTIAL NUMBER.

4.3 MANUFACTURER'S CODE, "GBV" DESIGNATES GENERAL ELECTRIC CO., NEUTRON DEVICES DEPT.



G004 QTY	G003 QTY	G002 QTY	G001 QTY	PART NO.	DESCRIPTION	NOTE	SHT	ITEM
X	X	X	X	9919100	GENL MARKING	4		9
X	X	X	X	9900000	GENL MFG REQT			8
X	X	X	X	46A925105G001	PACKAGE SPECIFICATION	3		7
X	X	X	X	46A926172	PRODUCT SPECIFICATION	2		6
1	–	–	–	46C924972G004	FRAME BLANK ELEC			4
–	1	–	–	46C924972G003	FRAME BLANK ELEC			3
–	–	1	–	46C924972G002	FRAME BLANK ELEC			2
–	–	–	1	46C924972G001	FRAME BLANK ELEC			1

THIRD ANGLE PROJECTION

AGENCY APPROVALS

PART CLASSIFICATION: UNCLASSIFIED

DWG. CLASSIFICATION: UNCLASSIFIED

TITLE: RESONATOR

FMF-RESON 5

SIZE C | CAGE IDENT. NO. 14064 | DWG. NUMBER 46C924975

SCALE 5/1 | SHEET 1 OF 1

Handling and Storage

PART #
G1

QTY	DWG/PART	DESCRIPTION	ITEM
AR	46A102131P1	Detergent, Non-Ionic	1
AR	46A101756P1	Detergent, Anionic	2
AR	46A100670P2	Deionized Water	3
X	88305131-200	UV Clean	4
AR	46A102309P1	Nitrogen	5
AR	46A101568P1	Argon	6
X	FED-STD-209A	Clean Work Station Req.	8
X	46A100662G1	Cleaning	9

1. GENERAL:

1.1 Scope. This drawing covers approved practices for handling and storage of crystal resonator parts and assemblies, except where otherwise specified.

1.2 NOTES: Referenced notes are listed on last sheet.

2. DOCUMENTS:

See Parts List

3. REQUIREMENTS:

3.1 General

Handling. Parts and assemblies shall not be handled unnecessarily even if approved methods are observed; and when they are handled, it shall be in a manner to ensure against contamination and damage such as dents, nicks, scratches, chips, etc.

3.1.2 Furnace Materials. Container materials for high temperature furnace applications are not included in this drawing.

3.2 Handling Materials in Decreasing Order of Preference (See Para. 4.1)

3.2.1

Containers	Manipulation
Code	Code
1 - Glass (see para. 4.3)	A - Stainless steel tools (see Para. 4.3)
2 - Stainless Steel	B - Deleted
3 - Anodized Aluminum	C - Delrin/Celcon
4 - Delrin Celcon Tefzel C.T.F.E. Teflon Lexan	D - Nylon gloves plus external finger cots E - Finger cots F - Nylon gloves
5 - Plastic (see para. 4.4)	G - Plastic tools (see Para. 4.5) H - Plastic gloves I - Cotton gloves J - Bare hands

3.2.1.1 All containers shall be adequately covered whenever it is necessary to protect material within from airborne contamination.

3.2.1.2 Patapar paper may be used in conjunction with other materials when cleanness is necessary without regard to scratching or slight paper particle contamination.

	Code
3.3 Ceramic Parts (frames and covers)	
Caution: After gold plating extreme care should be exercised to avoid contact between gold plated surfaces and any metallic surfaces and to avoid scratching or damaging these surfaces.	
3.3.1 Prior to gold plate	4E
3.3.2 Gold plate thru vacuum fire	4E
3.3.3 Vacuum fire thru final seal	4E
3.3.4 After final seal	5J
3.4 Resonator Blanks	
All stages except etching	3A
Etching	4A
3.5 Braze Material	
Prior to use	5E
3.6 Gold Gaskets	
3.6.1 Incoming stock thru fabrication in shop	5J
3.6.2 Fabrication thru parts in stock	4C
3.6.3 Clean thru assembly	2C
3.7 Mounting Clips	
3.7.1 Incoming thru stock	5J
3.7.2 Clean thru assembly	4E
3.8 Gold Ribbon or Copper Strip, Gold Plated	
3.8.1 Incoming thru use	5J

3.9 Deleted

3.10 Tooling. Unless otherwise noted all tooling shall be handled and stored under the same conditions as the parts or assemblies with which they are used to prevent damage or contamination.

3.11 Containers. All containers shall be maintained in clean condition at all times using one or more of the following methods:

3.11.1 Hand Cleaning. Wash with Alconox (Item 2) and warm water followed by deionized water (Item 3) rinse and drying.

3.11.2 Machine Cleaning. Wash with Alcojet (Item 1) and warm water followed by deionized water (Item 3) rinse and drying.

3.11.3 U.V. clean per Item 4.

3.11.4 Clean anodized aluminum containers per Item 9, Schedule A.

3.12 Storage

3.12.1 In-Process Materials. All materials after inspection shall be stored within materials required per 3.2.1 and contained in covered containers.

3.12.2 Frame blank assemblies after cure and inspection shall be stored in an inert gas atmosphere.

4. NOTES:

4.1 Code number or letter without the word "only" means that material and any of the preceding materials in that table under para. 3.2.1 are acceptable for use.

4.2 After cleaning, parts shall be blown dry with clean dry Item 5, Item 6, or air, or spin dried as per applicable drawing.

4.3 Plastic covers are acceptable on glass containers.

4.4 The choice of plastics for handling of parts and assemblies is very important and each application shall be thoroughly studied to ascertain correct usage. Factors to be considered are as follows:

a. Marking. Plastics that will rub off on a part shall not be used if this marking will not be totally removed by cleaning, firing or blasting in accordance with subsequent cleanness requirements.

b. Stability. Thermal and chemical stability are required to the extent that the plastic will not deteriorate or deform nor in any way contaminate the material with which it comes in contact.

FSCM NO. 14064
FCO830747GE
D. Hardy, GEND
Diskette 8529A-0356A
FMF: RESON 5
SIMETRIC

46A926172

Issue F
Page 1 of 20
Date: 11/15/83

Product Specification, 5 MHz and 10 MHz Quartz Crystal Resonator

1. SCOPE

1.1 This document covers the general requirements for ceramic flatpack enclosed SC -cut quartz crystal resonators. The detailed requirements are included as addendum sheets.

1.2 Type Designation. The type designation applies only to resonators meeting all of the requirements of the specification. The type designation shall be TBD.

2. REQUIRED DOCUMENTS

46C924934	Frame Processed
MIL-STD-202E	Elect. Test Methods
MIL-C-3098F	Crystal Units, Quartz, General Specifications for
MIL-STD-883B	Test Methods and Procedures for Microelectronics
NBS Monograph 140	Time and Frequency: Theory and Fundamentals
IEC Publication 302 (1969)	Standard Definitions and Methods of Measurement for Piezoelectric vibrators operating over the frequency range up to 30 MHz
IEC Publication 122-1 2nd Edition (1976)	Quartz Crystal Unit frequency and selection Part 1: Standard values and test conditions
IEC Publication 444 (1973)	Basic Method for the measurement of resonance frequency and equivalent series resistance of quartz crystal units by zero phase technique in a Pi-Network.

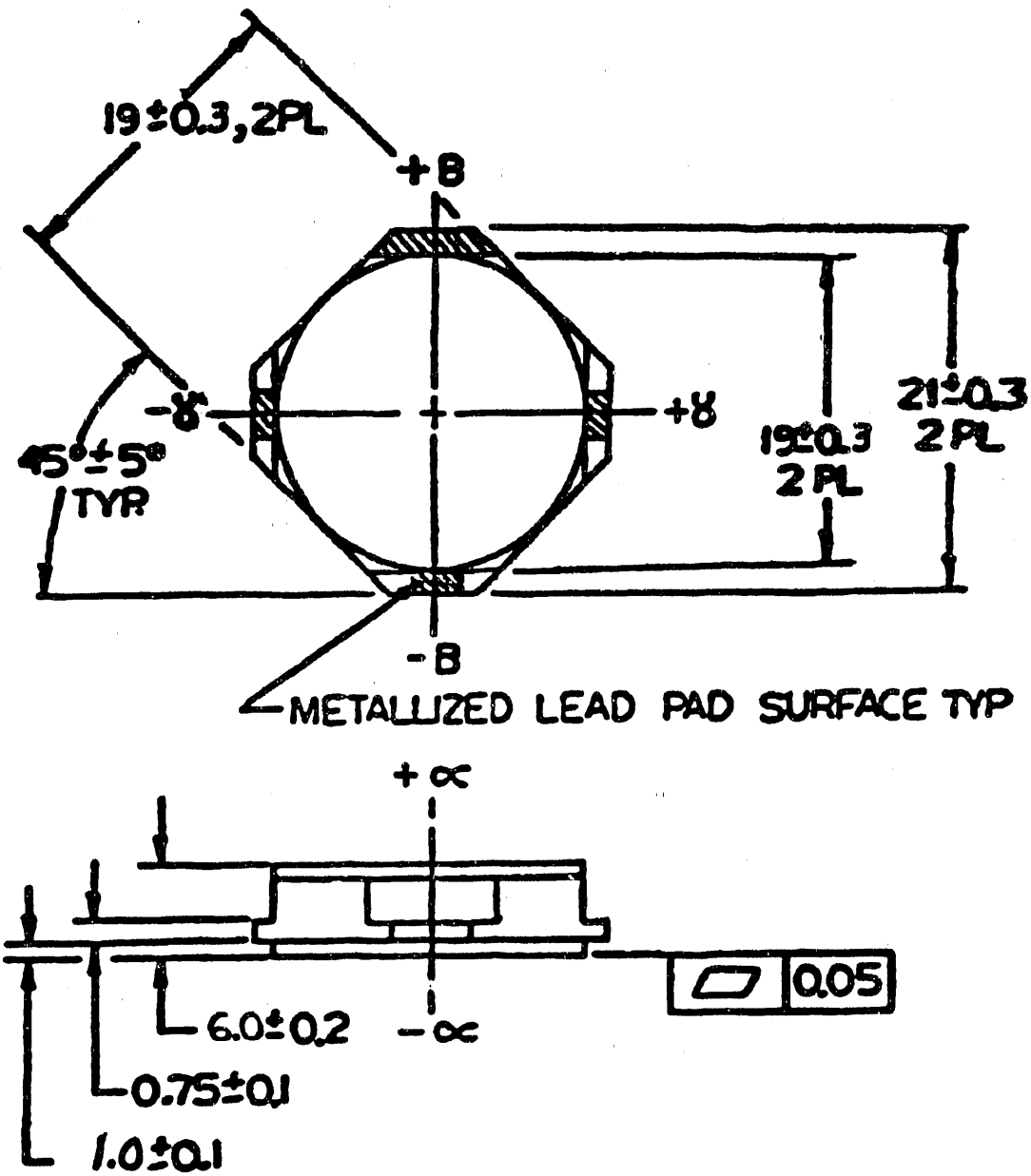

19±0.3, 2PL
+B
-B
-A-
+A
45°±5° TYP
19±0.3 2PL
21±0.3 2PL
METALLIZED LEAD PAD SURFACE TYP
+∝
-∝
6.0±0.2
0.75±0.1
1.0±0.1
0.05

FIG. 1

3. REQUIREMENTS

3.1 Addendum Sheets. The individual item requirements shall be as specified herein and in accordance with the applicable addendum sheets. In the event of any conflict between this specification and the addendum sheet, the latter shall govern.

3.2 Materials. All materials shall conform to a government approved set of product drawings.

3.3 Enclosure. The enclosure shall be a ceramic flatpack with outside dimensions as specified in figure 1.

3.4 Nominal Frequency. Unless otherwise specified, the term nominal frequency shall mean the frequency of resonance (of the "c-mode" for SC-cut resonators) when measured at the specified overtone and when in series with the specified load capacitor. The frequency of the resonator shall be within the range specified when it is excited with the specified drive current and is at the specified reference temperature.

3.5 Nominal Resistance. Unless otherwise specified, the term resistance shall mean the load resonance resistance of the resonant combination of the resonator in series with the specified load capacitor when measured under the drive conditions specified in paragraph 3.4. (See IEC 122-1, para. 3.3.8). The resistance shall not exceed the maximum specified at the temperature specified in para. 3.4.

3.6 Shunt Capacitance. The shunt capacitance, C_o, shall be defined as the capacitance from active terminal to active terminal at a frequency which is lower than the fundamental frequency of the resonator and at which the resonator shows no oscillation response. The shunt capacitance shall be within the range specified.

3.7 Motional Capacitance. The motional capacitance, C_1, shall be defined by the following relation

$$C_1 = \frac{2\Delta F}{F_s} (Co + C_L).$$

$$\Delta F = F_L - F_s$$

F_L = Frequency with load capacitor, C_L

F_s = Series resonant frequency

C_o = Shunt capacitance

C_L = Load capacitance

The motional capacitance shall be within the range specified.

3.8 Bondability. The contacts on the enclosure shall be suitable for the attachment of leads using the method specified in the addendum sheet. The test procedure shall be appropriate for the specified attachment method.

3.9 Shock. The frequency change due to the effects of shocks received as a result of rough handling, transportation and military operation shall be less than the specified value. The resistance shall not change by more than the specified value.

3.10 Vibration. When subjected to the specified test, the changes in frequency and resistance shall not exceed the specified value. The frequency modulation caused by vibration shall not exceed the specified value.

3.11 Thermal Time Constant. The thermal time constant shall be defined as the time required for the frequency to change to its static value at 63°C ± 1°C after a step change in ambient temperature from 0°C to 100°C. The thermal time constant shall not exceed the value specified. The frequency overshoot shall be defined as the maximum difference between the static and dynamic frequency vs. temperature characteristics. The frequency overshoot shall not exceed the specified value.

3.11.1 Thermal Shock. When subjected to rapid changes in temperature, changes in frequency and equivalent resistance shall not exceed specified values. Furthermore, there shall be no evidence of cracking, chipping, or breaking or any other damage.

3.12 Frequency vs. Temperature. The frequency vs. temperature characteristic shall be free from coupled modes over the specified temperature range as shown by the absence of deviations greater than the specified amount from the appropriate polynomial.

3.12.1 Inflection Temperature. The inflection temperature is that temperature at which the second derivative of the frequency with respect to temperature is zero.

3.12.2 Turnover-Temperature. The turnover temperatures are those temperatures where the first derivative of the frequency with respect to temperature is zero.

3.12.2.1 Upper-Turnover-Temperature. The upper-turnover-temperature (UTP) is the turnover temperature which is higher than the inflection temperature. (The second derivative is positive at the UTP.)

3.12.2.2 Lower-Turnover-Temperature. The lower-turnover-temperature (LTP) is the turnover temperature which is lower than the inflection temperature. (The second derivative is negative at the LTP.)

3.12.3 Operating Temperature. The operating temperature shall be defined as that temperature, in the specified region, at which the magnitude of the first derivative of the frequency with respect to temperature is a minimum.

3.12.4 SC-Cut. The inflection temperature (see para. 3.12.1) shall be within the range specified. The first derivative (slope) of the frequency with respect to temperature, when evaluated at the inflection temperature, shall be within the range specified.

3.13 Resistance vs. Temperature. The resistance vs. temperature characteristic shall not have deviations from a straight line which are larger than the value specified over the temperature range specified in para. 3.12. The maximum rate of change of resistance with temperature shall be specified.

3.14 Thermal Frequency Repeatability. After the specified temperature cycle, the maximum frequency difference between any two frequencies at operating temperature (see Fig. 2) shall be less than the specified value.

3.15 Unwanted Modes. Unwanted modes within 8% of the nominal frequency (see para. 3.4) shall have a resistance which exceeds the specified value.

3.16 Resistance Non-Linearity (Reduced Drive Level). The frequency and resistance shall not change by more than the specified amounts when tested as specified.

3.17 Seal. The leakage rate of the resonator enclosure shall not exceed 10^{-10} atm - cc/sec. of air.

3.18 Accelerated Aging. When tested as specified, the difference in frequency between the measurements made immediately prior to and immediately after conditioning shall not exceed the value specified, and the resistance shall not change by more than the value specified.

3.19 Aging. The aging rate at the end of the specified time period shall not exceed the value specified. The resistance change shall not exceed the value specified.

3.20 Short-Term Stability. The rms frequency deviation as defined by the Allan variance shall not exceed the specified value for all averaging times between and including the limits specified.

$$(\text{Allan Variance})^2 = \sigma_y^2(\tau) = \frac{1}{2(M-1)} \sum_{k=1}^{M-1} (\bar{y}_{k+1} - \bar{y}_k)^2$$

where τ = averaging time

$\bar{y}_k$ = fractional frequency deviation

M = Numbers of samples

The short term stability shall be measured during the second week of the aging cycle for informational purposes and during the final week of the aging cycle to show compliance with this requirement.

3.21 Marking. As per paragraph 3.24 of MIL-C-3098F.

3.22 Workmanship. As per paragraph 3.26 of MIL-C-3098F.

3.23 Quality Factor (Q). The quality factor, Q, shall be defined as

$$Q = \frac{1}{2\pi F_s C_1 R_s}$$

where R_s is the resistance of the resonator measured without a load capacitor, C_1 is the motional capacitance and F_s is the series resonance frequency.

3.24 Nuclear Survivability. The frequency change due to the specified exposure to radiation shall be less than the specified value. The resistance change shall not exceed the specified value.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection. Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the government. The government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

4.2 Classification of Inspection. Inspection shall be classified into three categories as follows:

a. Engineering Sample Inspection

b. Confirmatory Sample Inspection

c. Pilot Production Run Inspection

4.3 Test Plan. The contractor prepared, government approved test plans as mentioned herein are as specified in the contract. The test plan for each category of inspection itemized in 4.2 shall be delivered to the government at least 30 days prior to the scheduled commencement of inspection.

4.4 Engineering Samples. Unless otherwise specified in the contract, the engineering sample inspection shall be performed by the contractor prior to the initiation of fabrication of the confirmatory samples.

4.4.1 Engineering Sample Size. The contractor shall furnish the number of units as specified in the contract.

4.4.2 Engineering Sample Inspection. The engineering sample inspection shall include those inspections included herein to show compliance with the requirements of paragraph 3. Inspection results should reflect the technical progress made up to the time of manufacture and shall be evaluated accordingly. Failures shall be analyzed and remedial action shall be taken to improve the performance of subsequent units.

4.5 Confirmatory Samples. Unless otherwise specified in the contract, the confirmatory sample inspection shall be performed by the contractor prior to the initiation of the pilot production run.

4.5.1 Confirmatory Sample Size. The contractor shall furnish the number of units as specified in the contract.

4.5.2 Confirmatory Sample Inspection. The confirmatory sample shall be subjected to the inspections specified in Table I. All sample units shall be subjected to the inspections of group A. The sample shall then be divided as specified in the government approved test plan. The sample units shall then be subjected to the inspection for their particular group. The aging inspection shall be performed as early as possible so as not to delay the start of the pilot production run.

4.5.3 Failures. To minimize delays in the start of the pilot production run, failures shall be promptly analyzed and remedial action taken.

4.6 Pilot Production Run. Pilot production run inspection shall be performed by the contractor to provide data from which a realistic quality level may be determined.

4.6.1 Pilot Run Inspection Lot Size. An inspection lot for the pilot run shall consist of all units of the same type and frequency produced during the pilot production run.

4.6.2 Pilot Production Run Inspection. The pilot run units shall be subjected to the inspections specified in Tables II, III and IV. All sample units shall be subjected to the inspections in Table II. A random sample taken from all units which have passed the inspection in Table IV, of quantity as specified in the government approved test plan, shall then be selected and subjected to the tests of Table III. A second random sample, of quantity as specified in the government approved test plan, shall be taken from units which have passed the inspection in Table III. These units shall then be subjected to the inspection in Table IV.

4.6.3 Quality Level. Based on the inspections from 4.6.2, the contractor shall provide an estimate, to a 90% confidence level, of the percent defective of each pilot production run lot.

4.7 Methods of Inspection

4.7.1 Test Criteria

4.7.1.1 Measurements Before and After a Test. When frequency and equivalent resistance are measured before and after a test to determine the change during the test, the resonator shall be measured without a load capacitor with the frequency and resistance measurement normalized to the same temperature $\pm$ 0.1°C. The drive current shall be the same as the pre test condition $\pm$ 0.1 ma and the lead configuration shall be identical to the pre test condition $\pm$ 1.0 mm. Measurement at the reference temperature is preferred but is not required.

4.7.2 Visual and Mechanical Inspection

4.7.2.1 External. Resonators shall be examined to verify that the external design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements.

4.7.2.2 Internal. Contractor shall provide data and unsealed resonators, if necessary, to display that internal construction meets all applicable requirements.

4.7.3 Nominal Frequency. The nominal frequency shall be measured in accordance with IEC publications 302 and 444 or equivalent. Lead length and configuration shall be considered in the design of fixturing in order to maximize the accuracy and precision of all measurements. The temperature shall be maintained at the reference temperature $\pm$ 0.2°C.

4.7.4 Nominal Resistance. The resistance shall be measured in accordance with IEC publications 302 and 444 or equivalent at the temperatures specified in para 4.7.3.

4.7.5 Shunt Capacitance. Resonators shall be tested in accordance with method 305 of MIL-STD-202. The capacitance shall be measured from active terminal to active terminal, see figure 1.

4.7.6 Motional Capacitance. The motional capacitance shall be measured in accordance with IEC publication 302 or equivalent.

4.7.7 Bondability

4.7.7.1 Parallel-Gap Welding or Thermo-Compression Bonding. The contractor shall attach gold wires or ribbons to the ceramic enclosures using the specified method. Compliance with the bondability requirement shall be demonstrated by compliance with MIL-STD-883B, method 2011.2, test condition C.

4.7.7.2 Solder. The contractor shall solder the specified wires to the ceramic enclosure. Compliance with the bondability requirement shall be demonstrated by compliance with MIL-STD-883B, method 2004.2, test conditions A and B_2 (flexible leads).

4.7.8 Shock. The test will be performed in accordance with MIL-STD-202, method 213, condition G. The shock pulse shall be a sawtooth of 50G peak with a period of 11 msec per Figure 2. Three shocks in each direction shall be applied along 3 mutually perp. axes. The frequency shall be measured before and after the test at series resonance in a manner specified in the government approved test plan as per para. 4.7.1.2.

4.7.9 Vibration

4.7.9.1 Frequency and Resistance Offset. Resonators shall be tested in accordance with MIL-STD-202, using the method specified. The following details and exceptions shall apply:

a. Test and measurements before vibration. The frequency and equivalent resistance shall be measured as specified in 4.7.1.2.

b. Test method as specified:

Method 201 - 2 hours, or

Method 204 - Test condition A, 3 hours.

c. Direction of motion. Specimens shall be rigidly mounted on the horizontal platform of a vibration machine so that the applied vibration shall be as follows:

1. One-third of the units (to the nearest integral number) shall have the direction of vibration parallel to the line connecting the active terminals (along the Y axis in Fig 1).

2. The same number of units shall have the direction of vibration perpendicular to the plane of the resonator blanks (along the X axis in Fig 1).

3. The remainder of the sample units shall have the direction of vibration perpendicular to the directions specified in 1 and 2 above (along the B axis in Fig 1).

d. Time of traverse of frequency range. 1 to 2 minutes (method 201).

e. Tests and measurements after vibration. The frequency and equivalent resistance shall be measured as specified in 4.7.1.2.

4.7.9.2 "2-G" Tip-Over. The resonator, in a suitable oscillator, shall be rotated 180 degrees about its three major axis in increments of 22.5°. Data shall be taken in pairs with the oscillator orientation being shifted 180 degrees for the second measurement in a pair. Maximum frequency excursion shall be translated into parts per G.

4.7.10 Frequency vs. Temperature and Resistance vs. Temperature. The resonator shall be measured with the series load capacitor specified in a government approved test set. The load capacitor shall have a temperature coefficient less than 100 ppm/°C. The temperature of the resonator shall be varied so as to traverse the temperature range of +30°C to 140°C. The rate of change of temperature will not exceed 1.0°C/minute. Frequency, equivalent resistance, and temperature shall be recorded continuously or at intervals of not over 0.2°C. The inflection temperature and upper and lower turnover temperatures shall be determined by a least square fit to a cubic equation. The operating temperature (T_o) shall be determined from the least square fit coefficients.

4.7.11 Thermal Frequency Repeatability. The crystal resonators shall be subjected to the temperature cycle of Fig. 2. Thermal equilibrium shall be achieved at each operating temperature (see para. 4.7.10) segment of the cycle. The thermal frequency repeatability shall be defined as the difference between the highest and lowest of the operating temperature frequency measurements.

4.7.12 Unwanted Modes. Unwanted modes shall be measured on a government approved test circuit of the bridge or Pi type. The test shall be performed at room ambient temperature. A frequency of ± 12% of the nominal frequency shall be swept. The resistance of the "b-mode" shall be recorded for informational purposes.

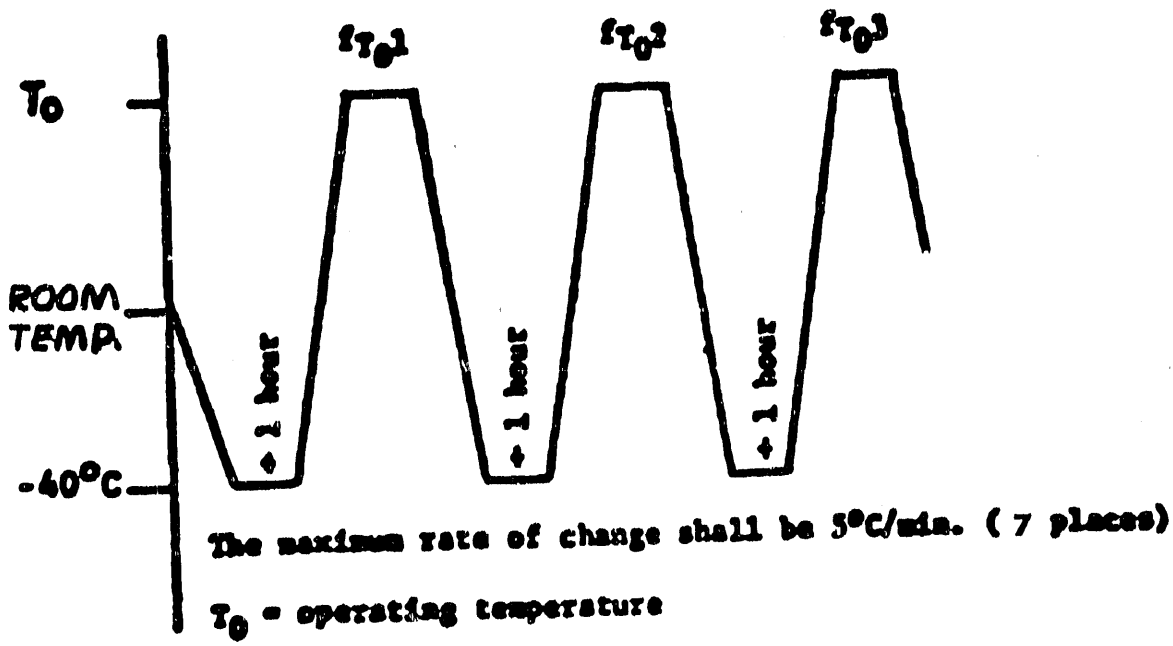

T_O
ROOM TEMP
-40°C
T_O1
T_O2
T_O3
+ 1 hour
+ 1 hour
+ 1 hour
The maximum rate of change shall be 5°C/min. (7 places)
T_O = operating temperature

Figure 2.

4.7.13 Thermal Time Constant/Thermal Shock. The resonator, in equilibrium at 0°C ± 1°C shall be rapidly (less than 0.5 sec) immersed in a suitable liquid bath held at 100°C ± 1°C. The frequency shall be recorded every 0.1 sec. The time required for the frequency to change to its value at 63°C ± 1°C shall be recorded as the thermal time constant. The difference between $(f_{max} - f^{w}_{100})$ and $(f_{ltp} - f^{s}_{100})$ shall be recorded as the frequency overshoot, where f_{ltp} is the frequency at the lower turnover point, f^{s}_{100} is the static frequency at 100°C, f^{w}_{100} is the frequency at 100°C, measured three minutes ± 10 sec after immersion into the 100°C bath, and f_{max} is the maximum frequency recorded during the warmup test.

4.7.14 Seal. The sealed resonators shall be tested for hermeticity according to MIL-STD-202, method 112, test condition C, procedure IIIb. The specimen in its completed state shall be placed in the sealed chamber which is then pressurized with Krypton 85 gas for the length of time prescribed in the government approved test plan. The specimen shall then be removed from the chamber and the internal content of radioactive gas shall be determined by the radioactivity counter, and then translated into terms of leakage rate. Upon completion of this procedure, the specimen shall be checked for gross leaks in the method specified in the government approved test plan.

4.7.15 Resistance Non-Linearity (Reduced Drive Level). The crystal units shall be conditioned at a temperature of at least 105°C for a duration of at least 1 hour. After conditioning, the units shall be stored at room temperature for 3-6 hours. Measurement of the resonant frequency and resistance shall be made at no fewer than 4 drive levels between 5 microamperes or less and the rated drive level. The levels shall be chosen at nominally equal intervals on a logarithmic scale. The sequence of measurements shall be from lowest drive current to highest drive current. The crystal unit shall not have been operated from the beginning of the conditioning period to the start of the frequency and resistance measurements at the lowest drive level.

4.7.16 Accelerated Aging. Resonators shall be measured at series resonance for frequency and equivalent resistance. The resonators shall then be conditioned at 120°C for 168 hours ± 4 hours. The units shall be measured again for frequency and resistance as per paragraph 4.7.1.2.

4.7.17 Aging. Only resonators having passed all previous inspections shall be included in this inspection. Equivalent series resistance measurements shall be made prior to inserting the crystal resonators into the oven and after removal from the oven on completion of the test. Each crystal resonator shall be operated at its operating temperature (see para. 3.12.3) for a frequency stabilizaton period before starting data collection. The stabilization period shall be 48 hours and the oscillator oven shall be stable to at least 0.01°C. The frequency of each resonator shall be measured immediately after the stabilization period. The resonators shall be operated at the operating temperature for an additional 4 weeks. The frequency of each resonator shall be measured daily. The data obtained shall be least squares fit to a TBD aging model. The aging rate per day at day 30 shall be determined from the first derivative of the aging expression.

4.7.18 Short Term Stability. The short term stability shall be measured in a manner specified in the government approved test plan. See NBS MONOGRAPH 140, Chapter 8.

4.7.19 Quality Factor. The quality factor, Q, shall be calculated using room temperature values for F_s, C_1, and R_s.

4.7.20 Nuclear Survivability. The crystal resonators shall be tested in accordance with MIL-STD-883B, method 1019 for resistance to steady state total dose irradiation. The total ionizing dose shall be delivered in as near as 10 seconds as practical. A steady state gamma ray source whose photon energy is approximately 1 mev, such as a ^{60}Co source shall be used. An acceptable option is an electron source whose beam energy is between 1 and 15 mev. The use of pulsed ionizing irradiation sources to accumulate the total ionizing dose is not acceptable. The total ionizing dose shall be 10^3 to 10^4 rads (S_i).

Confirmatory Sample

Inspection	Para.
Bondability	3.8
Materials	3.2
Enclosure	3.3
Seal	3.16
Characterize	3.4, 3.5, 3.6, 3.7, 3.23
Accelerated Aging	3.18
Characterize	3.4, 3.5, 3.6, 3.7, 3.23
*Unwanted Modes	3.15
*Frequency and Resistance vs. Temperature	3.12, 3.13
*Thermal Frequency Repeatability	3.14
Characterize	3.4, 3.5, 3.6, 3.7, 3.23
Thermal Time Constant and Shock	3.11
Inspect	3.11
Characterize	3.4, 3.5, 3.6, 3.7, 3.23
Charazterize in Env. Fixture	3.4, 3.5
Vibration	3.10
Characterize in Env. Fixture	3.4, 3.5
Shock	3.9
Characterize in Env. Fixture	3.4, 3.5
Aging	3.19
Short Term Stability	3.20
Nuclear Survivability	3.24
Characterize	3.4, 3.5, 3.6, 3.7, 3.23

*Tests may be combined where applicable.

Pilot Production

Inspection	Para.
Bondability	3.8
Materials	3.2
Enclosure	3.3
Seal	3.16
Characterize	3.4, 3.5, 3.6, 3.7, 3.23
Frequency and Resistance vs. Temperature	3.12, 3.13
Characterize	3.4, 3.5, 3.6, 3.7, 3.23
Group "A" Samples	
Accelerated Age	3.18
Frequency and Resistances	3.4, 3.5
Unwanted Modes	3.15
Frequency + Resistance in Env. Fixture	3.4, 3.5
Vibration	3.10
Frequency + Resistance in Env. Fixture	3.4, 3.5
Shock	3.9
Frequency + Resistance in Env. Fixture	3.4, 3.5
Characterize	3.4, 3.5, 3.6, 3.7, 3.23
Group "B" Samples	
*Thermal Frequency Repeatability	3.14
*Thermal Time Constant and Shock	3.11
Aging	3.19
Short Term Stability	3.20
Nuclear Survivability	3.24
Characterize	3.4, 3.5, 3.6, 3.7, 3.23

*These tests may be combined where applicable.

Req. Para.	Requirement	46C924975G001	46C924975G002	46C924975G003	46C924975G004	Assurance Para.
3.4	Nominal Frequency	5.115 MHz ± 1.5 ppm	5.115 MHz ± 1.5 ppm	10.0 MHz ± 1.5 ppm	10.23 MHz ± 1.5 ppm	4.7.3
	Overtone - Cut	fund - SC	3rd - SC	3rd - SC	3rd - SC	
	Load Capacitor	50 pF	30 pF	20 pF	20 pF	
	Drive Current	1.4 ma ± 0.25 ma	1.4 ma ± 0.25 ma	1.4 ma ± 0.25 ma	1.4 ma ± 0.25 ma	
	Reference Temperature	Upper Turnover	Upper Turnover	Upper Turnover	Upper Turnover	
3.5	Nominal Resistance	* Ohms	* Ohms	* Ohms	* Ohms	4.7.4
3.6	Shunt Capacitance	* pF ± * pF	* pF ± * pF	* pF ± * pF	* pF ± * pF	4.7.5
3.7	Motional Capacitance	* fF ± * fF	* fF ± * fF	* fF ± * fF	* fF ± * fF	4.7.6
3.8	Bond Method			Parallel Gap Welding		4.7.7
3.9	Shock - Δ F/F			± 1 x 10^{-7}		4.7.8
	Δ R			1 Ohm		
3.10	Vibration Δ F/F			± 1 x 10^{-7}		4.7.9.1
	Δ R			1 Ohm		
	Acceleration Sensitivity			2 x 10^{-9}/g		4.7.9.2

Req. Para.	Requirement	46C924975G001	46C924975G002	46C924975G003	46C924975G004	Assurance Para.
3.11	Thermal Time Constant	18 sec.	*sec.	*sec.	*sec.	4.7.13
	Overshoot	2 ppm	2 ppm	2 ppm	2 ppm	
3.11.1	Thermal Shock					
	F/F			$\pm 1 \times 10^{-7}$		4.7.8
	R			1 Ohm		
3.12	F vs T					4.7.10
	Deviation	± 1 ppm	± 1 ppm	± 1 ppm	± 1 ppm	
	Temperature Range	80° To 125°C	80° To 125°C	80° To 125°C	80° To 125°C	
	Inflection Temp (Ti)	99°C ± 7°C	99°C ± 7°C	99°C ± 7°C	99°C ± 7°C	
	Upper Turnover Temp.			Between T_i and 115°C		
3.13	R vs. T					4.7.10
	Deviation			± 10%		
	Max. Slope			± 1%/°C		
	Range			Upper Turnover Temperature ± 15°C		
3.14	Thermal Freq. Repeat			$\pm 3 \times 10^{-9}$		4.7.11
3.15	Unwanted Modes			1.5 x Nominal Resistance		4.7.12
3.16	Resistance Non-Linearity	*	*	*	*	4.7.15
3.17	Seal			10^{-10} atm - cc/sec		4.7.14

Req. Para.	Requirement	46C924975G001	46C924975G002	46C924975G003	46C924975G004	Assurance Para.
3.18	Accelerated Aging					4.7.16
	Δ F/F			0.1 ppm		
	Δ R			1 Ohm		
3.20	Short-Term Stability Allan Variance Avg. Times			τ Less than 5×10^{-11} = 1 sec., 10 sec., 100 sec.		4.7.18
3.19	Aging			3×10^{-10}/day		4.7.17
3.23	Quality Factor	2.0×10^6	2.0×10^6	1.0×10^6	1.0×10^6	4.7.19
3.24	Nuclear Survivability					4.7.20
	Δ F/F			$\pm 2 \times 10^{-9}$		
	Δ R			1 Ohm		

* To be determined by contractor such that all other specifications are met.

FSCM NO. 14064
FCO820120GE
J. Leonard, GEND
Diskette 4329A-0210A
FMF: RESON 5
SIMETRIC

46A926246
P1

Issue D
Date: 03/08/82

Cover

Dia.: 19.0 ± 0.1

Thickness: 1.0 ± 0.05

NOTES:

1. Material: Ceramic, 94% Alumina Typical (93% minimum for reference only)

2. APPLIED PRACTICES: 9900000

3. Parts must be free of cracks and pits greater than 0.025 in any direction.

4. Top and bottom surfaces to be flat and parallel within 0.025. Top and bottom surfaces to have a finish of 0.8 micrometres.

5. All dimensions are in millimetres unless otherwise specified.

6. Approved Supplier:

FSCM NO. 14064
FCO830151GE
D. Hardy, GEND
Diskette 4331A-0210A
FMF: ESON 5
SIMETRIC

46A926271
P1

Issue E
Date: 03/28/83
PART CLASS: UNCL

Gasket

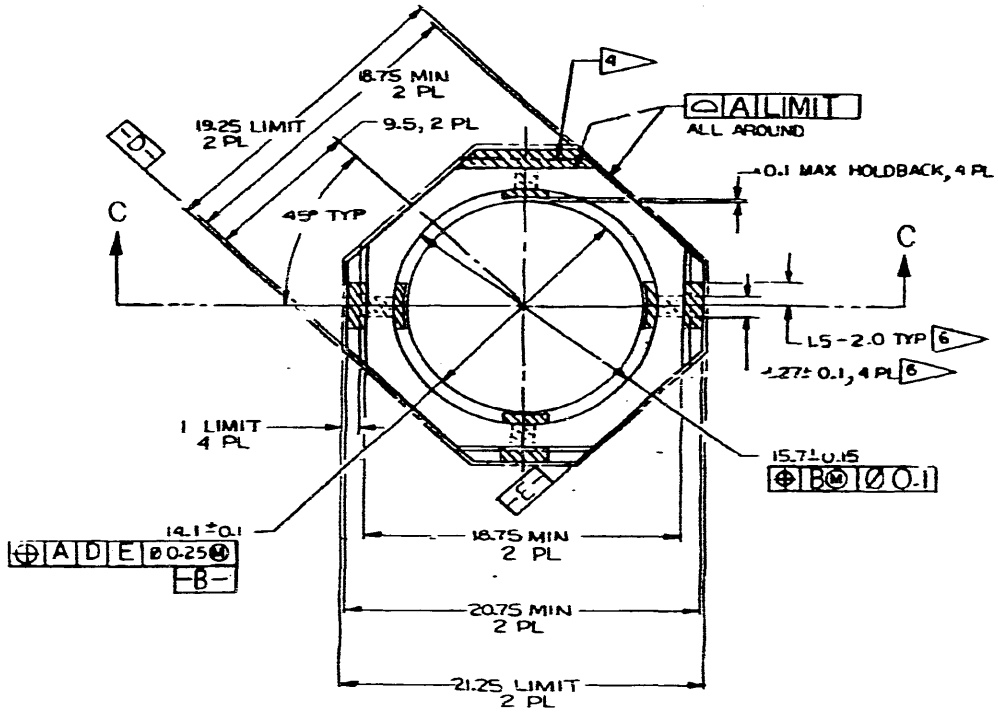
O.D.: 17.25 - 17.35

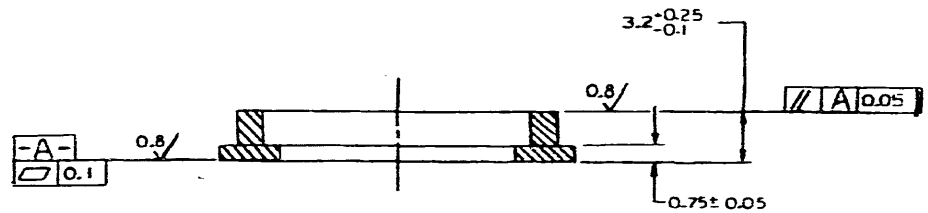
I.D.: 17.0 ± 0.1

NOTES:

1. Material: Per 8003310, .010 ± .001 inches thick.
2. Unless otherwise specified all dimensions are in millimetres.
3. Applied Practices: 9900000
4. All dimensions are for tooling purposes only. Severe twists, burrs, kinks and scratches are not allowed.
5. Package to prevent damage. Only corrosion resistant materials may contact gasket in storage.
6. O.D. to be concentric to I.D. within 0.025.
7. Approved Supplier:

   Williams Precious Metals
   Buffalo, NY





SECTION C-C

P1				
A			1-9-81	
B			3-26-81	
C	810376E (DIC)		4-30-81	
D	810486GE		9-10-81	
E	806656E		10-19-81	
F	810895GE		1-12-82	
G	820230GE		3-24-82	

SIMETRIC

NOTES:

1. MATERIAL: CERAMIC, 94% ALUMINA TYPICAL (93% MIN FOR REFERENCE ONLY).
2. APPLIED PRACTICES: 9900000
3. PARTS MUST BE FREE OF CRACKS AND PITS GREATER THAN 0.025 IN ANY DIRECTION.
4. INDICATED AREAS TO BE TUNGSTEN METALLIZED. METALLIZED AREAS MUST BE ELECTRICALLY CONTINUOUS. THE RESISTANCE THRU THE FRAME WALL MUST BE LESS THAN 0.05 OHMS. THE RESISTANCE BETWEEN METALLIZED AREAS SHALL NOT BE LESS THAN 500 MEGOHMS AT 100VDC. INTERNAL LAYERS MAY HAVE .075 MM PULLBACK FROM PROFILE.
5. PARTS MUST BE LEAK TIGHT TO 1×10^{-8} STD CC/SEC. (HELIUM).
6. TOOLING PURPOSE ONLY.
7. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SPECIFIED.
8. APPROVED SUPPLIER:

   CERAMIC SYSTEMS

THIRD ANGLE PROJECTION

UNCLASSIFIED

UNCLASSIFIED

LAMINATED FRAME
(RESON)
FMF 5MHz RESON

C 14064 46C926288

SIMETRIC

SEE PTS LIST	A			1-31-81	
	B	B10317GE		6-10-81	
	C	B1048GGE		9-10-81	
	D	82029GGE		6-11-82	

NOTES:

1. UNLESS OTHERWISE SPECIFIED. ALL DIMENSIONS ARE IN MILLIMETRES.
2. HANDLE PER ITEM 3.
3. PROCEDURE:

3.1 ULTRASONIC CLEAN PER ITEM 4. SCHEDULE C.

3.2 CLEAN PER ITEM 5.

3.3 METALLIZE PER ITEM 6.

3.4 WET HYDROGEN FIRE PER ITEM 7. PROC. 5 AT 1495°C ± 40°C FOR 45 MINUTES ± 5 MINUTES.

3.5 GOLD PLATE PER ITEM 8. TO A THICKNESS OF $3\text{-}12 \times 10^{-5}$.

3.6 DRY HYDROGEN SINTER PER ITEM 7 BY INCREASING THE TEMPERATURE TO 575°C ± 25°C AT A RATE OF 5°C/MIN. MAXIMUM. THEN INCREASE THE TEMPERATURE TO 900°C ± 25°C AND FIRE FOR 10 MINUTES ± 1 MINUTE. A MAXIMUM OF (3) PLATING AND SINTERING CYCLES ARE ALLOWED.

OR:

AIR FIRE TO A TEMPERATURE OF 300/310°C AT A RATE OF 2°C/MINUTE MAX. STOP FIRING WHEN THE 300/310°C IS REACHED (NO HOLD).

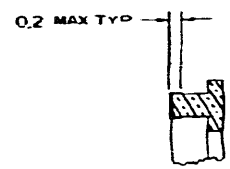
DRY HYDROGEN FIRE ON A BELT FURNACE TO A TEMPERATURE OF 900 ± 25°C WITH A FIVE MINUTE MINIMUM ABOVE 875°C. NO RESTRICTIONS ON HEATING OR COOLING RATES.

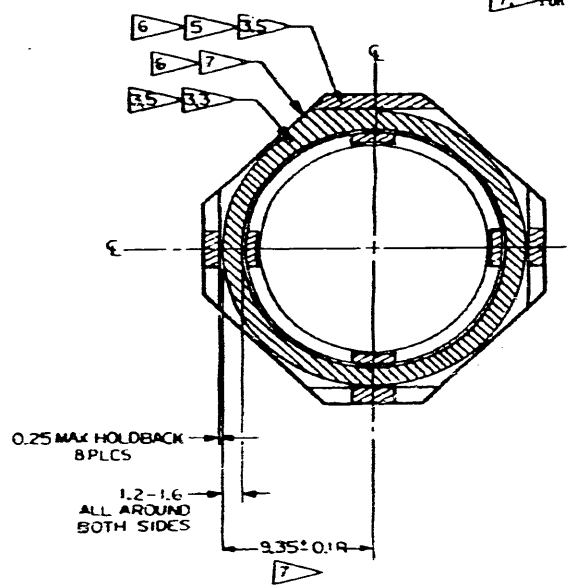
4. STORE TO AVOID METAL TO METAL CONTACT.

5. ISOLATION CHECK BETWEEN PADS AND BETWEEN EACH PAD AND EACH SEALING SURFACE TO BE 10M OHMS MINIMUM.

6. EVIDENCE OF GOLD REQUIRED ON THESE AREAS. CONTACT MARKS ARE ACCEPTABLE.

7. FOR TOOLING PURPOSES ONLY.





PART# QUI QTY	DWG/PART	DESCRIPTION	ITEM
I	46C926288P001	LAMIN FRAME	02
X	46A9250726001	WAND AND STOR	03
X	46A1006626001	CLEANING PROC	04
X	46A1006636001	CLEANING PROC	05
AR	SS284790 -202	METAL SPEC	06
X	46A115289	HYDROGEN FIRE	07
AR	SS379971 -200	GOLD PLT PROC	08
X	9900000 -	GEN MFG REQ	09

THIRD ANGLE PROJECTION

UNCLASSIFIED

UNCLASSIFIED

FRAME PROCESSED

FMF 5MHz RESON

C | 14064 | 46C926307

SIMETRIC

DESIGN AGENCY PART OR CONTROL NO.	ISSUE	DESCRIPTION	PREPARED BY	DATE	CHKD	APPD
G001	G	840208GE	DE CASTELLANO	--13-84		

NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETRES. THREADS ARE SPECIFIED IN INCHES.
2. HANDLE PER ITEM 3.
3. PROCEDURE:

3.1 ULTRASONIC CLEAN PER ITEM 4.

3.2 AIR FIRE AT 1100°C ± 50°C FOR 60 MINUTES ± 10 MINUTES.

3.3 METALLIZE PER ITEM 6.

3.4 WET HYDROGEN FIRE PER ITEM 7 . PROC. 5 AT 1495°C ± 40°C FOR 45 MINUTES ± 5 MINUTES.

3.5 GOLD PLATE PER ITEM 8, TO A THICKNESS OF 3-12 X 10-3.

3.6 DRY HYDROGEN SINTER PER ITEM 7 BY INCREASING THE TEMPERATURE TO 575°C ± 25°C AT A RATE OF 5°C/MIN MAXIMUM. THEN INCREASE THE TEMPERATURE TO 900°C ± 25°C AND FIRE FOR 10 MINUTES ± 1 MINUTE. A MAXIMUM OF (3) PLATING AND SINTERING CYCLES ARE ALLOWED.

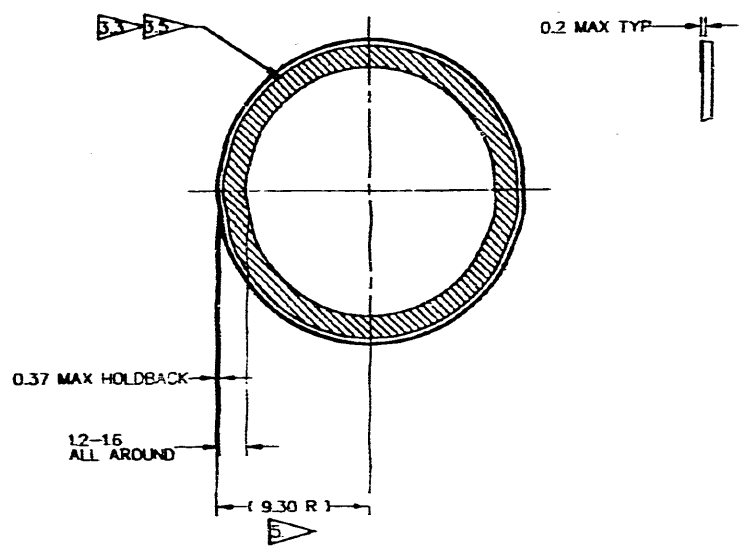
OR:

AIR FIRE TO A TEMPERATURE OF 300/310°C AT A RATE OF 2°C/MINUTE MAX. STOP FIRING WHEN THE 300/310°C IS REACHED (NO HOLD).

DRY HYDROGEN FIRE ON A BELT FURNACE TO A TEMPERATURE OF 900 ± 25°C WITH A FIVE MINUTE MINIMUM ABOVE 875°C. NO RESTRICTIONS ON HEATING OR COOLING RATES.

4. STORE TO AVOID METAL TO METAL CONTACT.

5. FOR TOOLING PURPOSES ONLY.



QTY	PART NO.		DESCRIPTION	NOTE	WT	ITEM
X	9900000		GENL MFG REQT			9
AR	SS329971-200	✓	GOLD PLATING PROCESS			8
X	46A115289	✓	HYDROGEN FIRE			7
AR	SS284790-202	✓	METALLIZE SPECIFICATION			6
X	46A100667G001	✓	CLEANING PROCEDURE			4
X	46A925072G001	✓	HANDLING AND STORAGE			3
1	46A926246P001	✓	COVER			2

AGENCY APPROVALS

	DATE	INITIALS
DE	1-30-84	FA

THIRD ANGLE PROJECTION

SHEET
SIZE
SHEET INDEX
PART CLASSIFICATION
UNCLASSIFIED
SPECIAL CLASSIFICATION LIMITS
UNCLASSIFIED

TITLE
COVER PROCESSED
FMF, SMH2 RESON
SIZE | CODE IDENT. NO. | DWG. NO.
C | 14064 | 46C926308
SCALE 5 X
SHEET 1 OF

FSCM. NO. 14064
FCO820033GE
D. Hardy, GEND
Diskette 7578A-0324A
SYMETRIC

46A926845
P1

Issue D
Date: 01/19/82
PART CLASS: UNCL

Third Overtone 5 MHz AT-CUT Crystal Blanks

1. GENERAL.

Scope: This document covers the requirements for third overtone 5 MHz AT-CUT Crystal Blanks made of swept quartz.

2. DOCUMENTS: Not Applicable

3. REQUIREMENTS:

3.1 Finished Blank Frequencies

P1 - The frequency shall be 5.1237 ± 0.0007 MHz when measured with an air gapper.

3.2. BLANK MATERIAL

Swept Cultured Quartz, suitable for high precision applications. (Q greater than 2.2×10^6).

3.3 Blank Angles of Cut

The blanks shall be cut at the AT-cut angles such that $\phi = 0^\circ \pm 20'$, and the θ- angle is such that when resonators are fabricated from the finished blanks, the upper turnover of the resonator frequency vs. temperature characteristic is between 91°C and 99°C.

4. QUALITY PROVISIONS:

4.1 BLANK GEOMETRY:

The blanks shall be plano-convex circular plates with 4.25 diopter contour and with diameter of 0.5495" + .0000". - .0015"
The flat side shall be not beveled, and the blank shall not be marked with a flat.

4.2. BLANK SURFACE AND EDGE FINISH:

The blank surface shall be final lapped with 1 micrometer aluminum oxide. After the final contouring the blanks shall be chemically polished in a solution of saturated ammonium bifluoride an amount that is between $\Delta f = 12$ $f_o f_f$ and $\Delta f = 15$ $f_o f_f$, where f_o = initial frequency in MHz, f_f = final frequency in MHz, and $\Delta f = f_f - f_o$ in KHz. The blanks shall be free of chips greater than 0.254 mm and scratches when inspected under intense light at 10X magnification.

5. PACKAGING AND HANDLING:

5.1 Crystal blanks are to be packaged to avoid scratches or chips. Parts should not be allowed to abrade each other during shipment. Packaging in Fluoroware trays is suggested. The blanks in each package shall be identified with the nominal angles of cut.

6. NOTES:

6.1 APPROVED QUARTZ SUPPLIER:

Premium Q Swept Quartz manufactured by:

Sawyer Research Products, Inc.
35400 Lakeland Blvd.
Eastlake, OH 44094

6.2 APPROVED BLANK SUPPLIER:

Colorado Crystal Corp.
2303 West 8th St.
Loveland, CO 80537

4.1 BLANK GEOMETRY:

The blanks shall be plano-convex circular plates with 2.5 diopter contour and with diameter of 0.5495" + .0000" - .0015"
The flat side shall be not beveled, and the blank shall not be marked with a flat. The blanks shall be contoured on the fast-etch side (i.e. the negative on compression side).

4.2. BLANK SURFACE AND EDGE FINISH:

P1: The blank surface shall be final lapped with 1 micrometer aluminum oxide. After the final contouring the blanks shall be chemically polished in a solution consisting of four parts, by volume, 40% NH_4F and one part 49% HF an amount that is between $\Delta f = 12\ f_o f_f$ and $\Delta f = 15\ f_o f_f$, where f_o = initial frequency in MHz, f_f = final frequency in MHz, and $\Delta f = f_f - f_o$ in KHz. The blanks shall be free of chips greater than .010" and scratches when inspected under intense light at 10X magnification.

P2: The blank surfaces shall be final lapped and contoured with 1 micrometer aluminum oxide and shall not be etched after lapping. The blanks shall be free of chips greater than .010" and scratches when inspected under intense light at 10X magnification.

5. PACKAGING AND HANDLING:

5.1 Crystal blanks are to be packaged to avoid scratches or chips. Parts should not be allowed to abrade each other during shipment. Packaging in Fluoroware trays is suggested. The blanks in each package shall be identified with the slopes at the inflection temperature (zero to -1×10^{-8}, or -1×10^{-8} to -2×10^{-8}, or -2×10^{-8} to -3×10^{-8}, or -3×10^{-8} to -4×10^{-8} per ^{o}C.)

6. NOTES:

6.1 APPROVED QUARTZ SUPPLIER:

Sawyer Research Products, Inc.
35400 Lakeland Blvd.
Eastlake, OH 44094

4.1 BLANK GEOMETRY:

The blanks shall be plano-convex circular plates with 2.5 diopter contour and with diameter of 0.5495" + .0000" - .0015". The flat side shall be not beveled, and the blank shall not be marked with a flat. The blanks shall be contoured on the fast-etch side (i.e. the negative on compression side).

4.2. BLANK SURFACE AND EDGE FINISH:

P1: The blank surface shall be final lapped with 1 micrometer aluminum oxide. After the final contouring the blanks shall be chemically polished in a solution consisting of four parts, by volume, 40% NH_4F and one part 49% HF an amount that is between $\Delta f = 12\ f_o f_f$ and $\Delta f = 15\ f_o f_f$, where f_o = initial frequency in MHz, f_f = final frequency in MHz, and $\Delta f = f_f - f_o$ in KHz. The blanks shall be free of chips greater than .010" and scratches when inspected under intense light at 10X magnification.

P2: The blank surfaces shall be final lapped and contoured with 1 micrometer aluminum oxide and shall not be etched after lapping. The blanks shall be free of chips greater than .010" and scratches when inspected under intense light at 10X magnification.

5. PACKAGING AND HANDLING:

5.1 Crystal blanks are to be packaged to avoid scratches or chips. Parts should not be allowed to abrade each other during shipment. Packaging in Fluoroware trays is suggested. The blanks in each package shall be identified with the slopes at the inflection temperature (zero to -1×10^{-8}, or -1×10^{-8} to -2×10^{-8}, or -2×10^{-8} to -3×10^{-8}, or -3×10^{-8} to -4×10^{-8} per ^{o}C.)

6. NOTES:

6.1 APPROVED QUARTZ SUPPLIER:

Sawyer Research Products, Inc.
35400 Lakeland Blvd.
Eastlake, OH 44094

6.2 APPROVED BLANK SUPPLIER:

Piezo Crystal Co.
100 K Street
P.O. Box 619
Carlisle, PA 17013

6.3 SWEEPING:

The electrolytic sweeping process shall be performed by Piezo Crystal Co. or Sawyer Research Products, Inc.

FSCM. NO. 14064
FCO830291GE
D. Hardy, GEND
Diskette 7867A-0329A
FMF: RESON 10
SIMETRIC

46A926922
P1

Issue E
Date: 05/05/83
PART CLASS: UNCL

Third Overtone 10 MHz AT-cut
Crystal Blanks

1. GENERAL.

Scope: This document covers the requirements for 10 MHz 3rd Overtone AT-cut Crystal Blanks made of swept quartz.

2. DOCUMENTS: Not Applicable

3. REQUIREMENTS:

3.1 Finished Blank Frequencies

P1 - The frequency shall be 10.0334 MHz ± 0.0027 MHz when measured with an air gapper on the 3rd overtone.

3.2. BLANK MATERIAL

Swept Cultured Quartz, suitable for high precision applications. (Q greater than 2.2×10^6).

3.3 Blank Angles of Cut

The blanks shall be cut at the AT-cut angles such that $\phi = 0^\circ \pm 20'$, and the θ angle is such that when resonators are fabricated from the finished blank, the upper turnover temperatures are at $95^\circ \pm 4^\circ C$.

4. QUALITY PROVISIONS:

4.1 BLANK GEOMETRY:

The blanks shall be plano-convex circular plates with a 0.5 diopter contour, and shall have a diameter of 0.5495" + .0000". The flat side shall be not beveled, and - .0015"
the blank shall not be marked with a flat. Contour requirement is for tooling and processing purposes only.

4.2. BLANK SURFACE AND EDGE FINISH:

The blank surface shall be final lapped with 1 micrometer aluminum oxide. After the final contouring, the blanks shall be chemically polished in a saturated solution of ammonium bifluoride (NH_4F HF), between $\Delta f = 12 f_o f_f$ and $\Delta f = 15 f_o f_f$, where f_o = initial frequency in MHz, f_f = final frequency in MHz, and $\Delta f = f_f - f_o$ in KHz. The blanks shall be free of chips greater than 0.254 mm and scratches when inspected under intense light at 10X magnification.

5. PACKAGING AND HANDLING:

5.1 Crystal blanks are to be packaged to avoid scratches or chips. Parts should not be allowed to abrade each other during shipment. Packaging in Fluoroware trays is suggested. The blanks in each package shall be identified with the nominal angles of cut.

6. NOTES:

6.1 APPROVED QUARTZ SUPPLIER:

Premium Q Swept Quartz manufactured by:

Sawyer Research Products, Inc.
35400 Lakeland Blvd.
Eastlake, OH 44094

6.2 APPROVED BLANK SUPPLIER:

Colorado Crystal Corp.
2303 West 8th St.
Loveland, CO 80537

FSCM NO. 14064
FCO820379GE
D. Hardy, GEND
Diskette 8088A-0339A
FMF: Reson. 5

46A926977
P1
Issue B

Date: 05/17/82
PART CLASS: UNCL

Molybdenum Ribbon

1. GENERAL

1.1 This specification covers a high purity powder metallurgy molybdenum ribbon.

2. DOCUMENTS

2.1 AMS 7800 - Molybdenum Sheet, strip, and plate powder metallurgy, sintered, stress relieved.

3. REQUIREMENTS

3.1 Material Producers

3.1.1 Amax Specialty Metals Corp.

3.1.2 General Electric Co., Lamp parts and equipment sales operation.

3.2 Fabricators. Fabricator shall use material from above producers only and shall meet all requirements of this specification.

3.3 Material - Per AMS 7800

3.4 Thickness - 0.0007 ± .0001 inches

3.5 Width - 0.060 ± .0008 inches

4. QUALITY PROVISIONS

4.1 Certification. At the discretion of the Purchasing Agency, the supplier shall submit with each shipment of material: (1) a statement of compliance to this specification and issue letter and/or (2) Variables test data as requested. This certification shall include the purchase order number, quantity shipped, and one or more of the following if available: (1) Lot number, (2) Batch number, or (3) Melt number.

4.2 Test Methods (Mandatory Only in Case of Dispute)

4.2.1 See AMS 7800

5. PACKAGING AND HANDLING

5.1 Packaging. The material shall be packaged in a manner to ensure safe delivery and storage and comply with carrier's regulations.

5.2 Marking. Each container shall be legibly marked or tagged with buyer's specification number, issue letter and supplier's name and product designation. Additional marking is optional.

6. NOTES: None

FSCM NO. 14213
FCO820112GE
D. Hardy, GEND
Diskette 9123A-0374A
FMF: RESON 4.
TIE SC/GE

46A927146
P1
Issue A
Page 1 of 1
Date: 2/24/82
PART CLASS: UNC

Crystal Blanks

NOTES:

1. Matl: 46A926846P1 Rejects

FSCM NO. 14064
FC0820331GE
DB Hardy, GEND
Diskette 9466A-0385A

46A927252
G1
Issue A

Date: 5/18/82

Gold Plating Process for Molybdenum Ribbon

QTY	DWG/PART	DESCRIPTION	ITEM
AR	46A100670P2	Deionized Water	1
AR	46A101576P1	Hydrochloric Acid	2
AR	46A115050P1	Nickel Chloride	3
AR	SS332871-200	Cyanide Gold Plating Spec.	4

1. GENERAL:

1.1 This specification covers the plating process used on molybdenum ribbon for use in resonator assemblies.

2. DOCUMENTS:

2.1 See Parts List

3. REQUIREMENTS:

3.1 Preparation of Materials

3.1.1 Prepare a nickel chloride strike bath of the following composition:

240 gms Nickel Chloride	Item 3
86 ml HCl Acid	Item 2
1000 ml DI Water	Item 1

Bath should be premixed prior to use so there is sufficient time for the bath to cool to room temperature at time of use.

3.2 Procedure

3.2.1 Plate in nickel chloride strike per 3.1.1 for 60 seconds ± 10 seconds at a current density of 100 ± 20 mA/cm^2.

3.2.2 Rinse in DI water per Item 1 for 1-2 minutes.

3.2.3 Plate in gold bath per Item 4.

FSCM NO. 14064
FCO820988GE
DB Hardy, GEND
Diskette 9536A-0385A

46A927253
G1
Issue B

Date: 3/16/83

Molybdenum Ribbon Plated

QTY	DWG/PART	DESCRIPTION	ITEM
AR	46A926977P1	Molybdenum Ribbon	1
X	46A100662G1	Cleaning Proc	2
X	46A115289	Hydrogen Fire	3
AR	46A927252G1	Gold Plating Proc	4
X	46A925072G1	Hand and Stor	5
X	9900000	Gen. Mfg. Req.	6

1. GENERAL:

1.1 This specification covers the preparation and plating of molybdenum ribbon for use as clips in resonator assemblies.

2. DOCUMENTS:

2.1 See Parts List

3. PROCEDURE:

3.1 Ultrasonic clean per Item 2, Schedule C.

3.2 Dry hydrogen fire per Item 3 at 900°C ± 25°C for 20 minutes ± 10 minutes.

3.3 Plate per Item 4 to a thickness of 20-80 microinches.

3.4 Dry hydrogen sinter per Item 3 by increasing the temperature to 575°C ± 25°C at a rate of 5°C/min. maximum, then increase the temperature to 900°C ± 25°C and fire for 10 minutes ± 1 minute.

4. QUALITY PROVISIONS:

4.1 General. Unless otherwise specified, all criteria apply to the composite plating (nickel and gold).

4.2 Visual. Plating shall be bright, smooth, and free from exposed base metal, blisters, pits, and indications of burning when examined by the unaided eye.

4.3 Purity. Gold shall be 99.7% gold min.

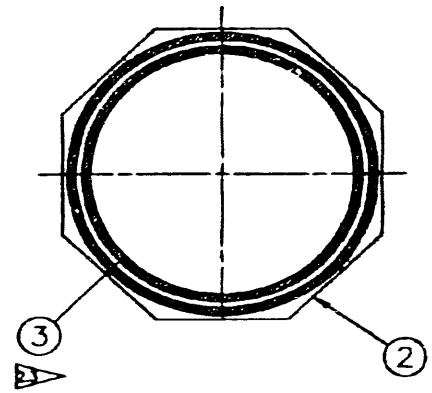
4.4 Thickness. 20-80 microinches

SIMETRIC

DESIGN AGENCY PART OR CONTROL NO.	CHANGE	DESCRIPTION	PREPARED BY	DATE	CHKD	APPD
G001	B	820988GE	G N YOUNG	7/6/83	WHB	

NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN MILLIMETRES. THREADS ARE SPECIFIED IN INCHES.
2. PROCEDURE:
   - 2.1 HANDLE PER ITEM 8.
   - 2.2 U.V. CLEAN ITEMS 2 & 3 PER ITEM 6.
   - 2.3 ▷1◁ CENTER ITEM 3 APPROX. AS SHOWN, ON METALLIZED PATTERN.
   - 2.4 VACUUM FIRE PER ITEM 7.
3. DISCONTINUITIES AND SEVERE CUTS & SCRATCHES ARE NOT ALLOWED.
4. STORE TO AVOID METAL TO METAL CONTACT.



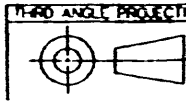
QTY	PART NO.	DESCRIPTION	NOTE	SHT	ITEM
X	46A925072G001	HANDLING & STORAGE			8
X	SS284775-200	VACUUM FIRING			7
X	SS305131-200	ULTRAVIOLET CLEANING			6
X	9900000	GENL MFG REQT			5
1	46A924945P001	GASKET PROCESSED			3
1	46C924936G001	COVER PROCESSED			2

AGENCY APPROVALS

	DATE	REVISED
DRN	6/16/83	
CHKD	6/16/83	TRS

SHEET / ISSUE

THIRD ANGLE PROJECTION



TITLE: COVER GASKET ASSEMBLY

FMF:RESON 5

PROP CLASSIFICATION: UNCLASSIFIED

SEC CLASSIFICATION LEVEL: UNCLASSIFIED

SIZE: C | SCHEM DRWG NO.: 14064 | DRG NUMBER: 46B927564

SCALE: 5/1 | SHEET 1 OF 1

FSCM NO. 14064
FCO820988GE
D. Hardy, GEND
Diskette 1991B-0462A
Part: 5 MHz Reson.

46A927742
G1

Issue A
Date: 03/16/83

Electroding & Sealing Process

1. GENERAL:

This document defines a procedure to clean, tune, and seal large format quartz crystal resonator flatpacks.

2. DOCUMENTS:

SS305131-200	Ultraviolet Cleaning
343283-200	Gold Cleaned
46A102309P1	Nitrogen
46A101568P1	Argon
46A101569P1	Oxygen

3. REQUIREMENTS:

3.1 Loading Chamber. The loading chamber shall be all metal (except O-rings in valves and pump) and contain a cryopump. It shall be capable of 5×10^{-8} torr or less. These requirements shall apply with the vacuum system empty, at room temperature.

3.1.1 UV clean cover gasket assemblies and each side of the frame/blank assemblies for 5-6 minutes per Dwg. SS305131.

3.1.2 Backfill the loading chamber with dry nitrogen, (46A102309P1), or argon, (46A101568P1).

3.1.3 Place parts into Loading Chamber.

3.1.4 Pump Loading Chamber to 1×10^{-5} torr or less within 40 minutes of first exposure of parts to atmosphere, after cleaning per paragraph 3.1.1.

3.1.5 Introduce 1.0 ± 0.25 Torr Oxygen, (46A101569P1) to the chamber. Subject the parts to 8.0 - 10.0 minutes short wave-length u/v, then 10.0 minutes min., long wave-length u/v to kill the O_3. Pump the chamber to 5×10^{-6} or less before transferring parts to the Bake Chamber.

3.2 Bake Chamber. The Bake Chamber shall be all metal (except O-rings in valves and pump) and contain a cryopump. It shall be capable of 5×10^{-8} torr or less. This requirement shall apply with the vacuum system empty, at room temperature. The heater shall be capable of baking the parts to 330°C.

3.2.1 With Bake Chamber at 5 x 10^{-6} torr or less, transfer parts from Loading Chamber to Bake Chamber.

3.2.2 Deleted

3.2.3 Increase part temperature to 330 ± 20°C and hold for 60 minutes minimum and to a pressure of 5 x 10^{-7} or less.

3.3 Deleted

3.4 Plating Chamber. The Plating Chamber shall be all metal (except O-rings in valves and pumps) and contain a cryopump. It shall be capable of 5 x 10^{-8} torr or less. This requirement shall apply with the vacuum system empty, at room temperature.

3.4.1 With Plating Chamber at 5.0 x 10^{-6} torr or less, transfer parts from Bake Chamber to Plating Chamber.

3.4.2 Allow parts to restabilize at 225 ± 25°C in mask head with shutter closed.

3.4.3 Adjust the power to the two nozzle beam sources until the rate of evaporation is approximately equal.

3.4.4 Open shutters and evaporate gold, 343283-200, to rough plate the resonators. Maximum pressure during rough plating not to exceed 5 x 10^{-6} torr.

3.4.5 Remove plated crystal and repeat for other crystals to be rough plated.

3.4.6 Fine plate resonator to final frequency with resonator assembly at 90 ± 5°C. Maximum pressure during fine plating not to exceed 1 x 10^{-6} torr.

3.5 Deleted

3.6 Sealing Chamber. The Sealing Chamber shall be all metal (except O-rings in valves and pump) and contain a cryopump. It shall be capable of 5 x 10^{-8} torr or less. This requirement shall apply with the vacuum system empty, at room temperature.

3.6.1 With Sealing Chamber at 1 x 10^{-6} torr or less, transfer the Cover/Gasket and Frame/Resonator assemblies from the Fine Plate Chamber to the Sealing Chamber.

3.6.2 Increase temperature of the assemblies to 320 ± 20°C. Hold parts at this temperature for 60 minutes minimum and to a pressure of 5 x 10^{-7} torr or less.

3.6.3 Decrease temperature to 310 ± 10°C and apply a pressure of 700 ± 10 psi to the sealing fixture by increasing pressure to 100 psi and in 50 psi increments thereafter, waiting 60 ± 10 seconds between steps, until reaching 690 - 710 psi. Upon reaching maximum pressure, turn off the heaters and hold at pressure for 15 ± 1 minutes.

3.7 Exit Chamber. The Exit Chamber shall be all metal (except O-rings in valves and pump) and contain a cryopump. It shall be capable of 5×10^{-8} torr or less. This requirement shall apply with the vacuum system empty, at room temperature.

3.7.1 With the Exit Chamber at 1×10^{-6} torr or less, transfer the Resonator Assemblies to the Exit Chamber.

3.7.2 Resonator Assembly shall be below 75°C.

3.7.3 Backfill the Exit Chamber with dry nitrogen, (46A102309P1), or argon, (46A101568P1).

3.7.4 Remove parts from Exit Chamber.

APPENDIX F

AGING RESULTS

This information was provided by:

Dr. Raymond L. Filler
U. S. Army LABCOM
Fort Monmouth, New Jersey

AGING RESULTS

Sixty-nine (69) units were operated in individual ovenized test oscillators[1] at each resonator's upper turnover temperature for a period of 30 days. The drive current was set to 1 ma. Frequency measurements were taken every six hours (4 times/day) with a 100 second gate.

The frequency vs. time data was fit to the expression[2]

$$f(t) = f(0) + K_a \log(t/t_a + 1)$$

using a least squares algorithm.[3]

Figure 1 is an example of the output from the algorithm. The upper curve is a plot on a linear scale of the data and the curve resulting from the least squares fit. The lower curve is the data and the fit on semi-log axes starting from day 1 and showing the extrapolation out to 10 years.

The actual least squares algorithm used fractional frequency normalized to the frequency measured at time t=0, $f_m(0)$. The calculated coefficients A, B, and C on Figure 1 are related to K_a, t_a, and f(0) by

$$K_a = A * f_m(0) * 10^{-9}$$

$$t_a = 1/B$$

$$f(0) = f_m(0)(1 + C*10^{-9})$$

The coefficients A and t_a are used to determine the fractional frequency shift for 30 days, 1 year, and 10 years. The values for the aging rate, df/dt, at 30 days, 1 year, and 10 years is determined from

$$df/dt = (A/2.303)/(t + t_a)$$

The rms Error in Figure 1 is the square root of the variance (mean square error) given by

$$\text{rms Error} = [(1/N) \quad (f_m(i) - f(t_m(i))^2]^{1/2}$$

where $f_m(i)$ are the measured frequencies at the times t_i, and N is the number of data points.

Table I is a compilation of all of the coefficients from the 69 units. Positive aging was displayed by 55% of the units. One of the units reversed sign from positive to negative. Figure 2 is a histogram of the coefficient A, (for clarity the single outlier with a value of +339 has been omitted.) The sample deviation is about 14 ppb. A Gaussian curve with its amplitude adjusted to the peak is plotted on the same histogram in Figure 3.

Figure 4 is a histogram of the characteristic time t_a. There are four units with values of t_a greater than 60 days which have been omitted because values of t_a over 30 days, the measurement duration, are of questionable validity. The calculated sigma is about 11 days, but, as can be seen in figure 5, the data is skewed to the right by the questionable larger values.

Figure 6 is a histogram of the total frequency shift from day 0 to day 30 given by

$$df/f = A \log(30/t_a + 1)$$

The sign distribution is clearly the same as that of A. The sample deviation is 7.7 ppb and is plotted in Figure 7.

A histogram of the aging rate at day 30 is shown in Figure 8. The sign distribution is again identical to that of A since

$$df/dt = A/(t_a + 30)$$

and t_a is positive definite. The sample deviation of the aging rate is 127 x 10^{-12}/day and is shown in Figure 9.

Figure 10 is a plot of t_a vs. the absolute value of A, |A|. There is very little correlation between the magnitude and the characteristic time.

The specified aging rate for these units was 200 x 10^{-12}/day. Of the 69 units 58 (84%) passed.

REFERENCES

1. H. W. Jackson, "Update on the Tactical Miniature Crystal Oscillator Program," Proc. 36th Annual Symposium on Frequency Control, 1982.

2. A. W. Warner, D. B. Fraser, C. D. Stockbridge, "Fundamental Studies of Aging in Crystal Resonators," IEEE Trans Sonics & Ultrasonics, SU-12,2,1965.

3. R. L. Filler, "Aging Specification, Measurement, and Analysis," Proc. 7th Quartz Devices Conference, EIA, 1985.

Table 1

	S/N	Mag(ppb)	Time	Con	dF	dF/dT
1	3P-005	+2.68	.1		+6.6	+38.6
2	10P_39	-1.67	2.0		-2.0	-22.7
3	10P-40	+6.80	3.7		+6.6	+87.7
4	10P-48	-7.96	7.9		-5.4	-91.2
5	10P-49	-15.61	2.8		-16.6	-206.4
6	10P-50	+21.21	13.9		+10.6	+209.8
7	10Q_02	+48.48	13.2		+25.0	+487.7
8	10Q_08	+.52	3.8		+.5	+6.7
9	10Q_10	-7.19	2.4		-8.1	-96.4
10	10Q-34	-5.65	8.1		-3.8	-64.4
11	10R-13	-.75	1.3		-1.0	-10.5
12	10R-21	-1.32	2.1		-1.6	-17.8
13	10R-23	+10.19	27.7		+3.2	+76.7
14	10R-25	+6.82	4.4		+6.1	+86.0
15	10R-36	+35.58	39.5		+8.7	+222.2
16	10R-38	-12.58	28.8		-3.9	-92.9
17	10S-15	+27.64	8.6		+18.0	+311.1
18	10S-16	+39.60	12.1		+21.5	+408.9
19	10S-32	+6.04	.8		+9.4	+85.0
20	10S-34	.63	.8		+1.0	+8.9
21	10T-55	-1.04	.8		-1.6	-14.7
22	10T-56	+7.52	21.4		+2.9	+63.5
23	10T-57	+60.57	196.7		+3.7	+116.0
24	10T-58	-1.60	2.5		-1.8	-21.3
25	10V-03	+3.39	.4		+6.4	+48.4
26	10V-07	+6.71	.7		+10.8	+94.8
27	10V-10	+1.05	.4		+1.9	+14.9
28	10V-13	+4.01	1.9		+4.9	+54.6
29	10V-25	+24.85	8.3		+16.5	+281.5
30	10V-32	+.84	4.8		+.7	+10.5
31	10V-33	+16.06	3.4		+16.0	+208.9
32	10V-39	-1.73	1.6		-2.3	-23.8
33	10W-08	+.32	37.1		+.1	+2.1
34	10W-10	+13.16	49.9		+2.7	+71.5
35	10W-11	+2.35	1.5		+3.1	+32.3
36	10W-13	-10.43	42.9		-2.4	-62.1
37	10W-14	+3.51	.4		+6.5	+50.1
38	10W-16	+4.64	.2		+10.0	+66.7
39	10W-25	+17.75	13.8		+8.9	+176.2
40	10W-28	+19.67	7.1		+14.1	+230.2
41	10W-29	-6.12	140.3		-.5	-15.6
42	10W-34	+3.95	7.8		+2.7	+45.4
43	10W-35	-2.56	5.0		-2.2	-31.7
44	10W-39	+22.31	177.8		+1.5	+46.6
45	10W-40	+5.31	7.4		+3.7	+61.7
46	10W-41	-2.50	1.0		-3.7	-35.0
47	10W-44	+12.61	3.7		+12.1	+162.5
48	10W-45	-1.35	1.4		-1.8	-18.7
49	10X-05	+5.33	7.8		+3.6	+61.2
50	10X-08	+339.62	137.3		+29.2	+881.5

51	E10X-8	+17.31	16.3	+7.8	+162.3
52	E10X-9	-3.30	2.0	-4.0	-44.8
53	10X-10	-20.30	7.1	-14.6	-237.8
54	10X-11	-6.57	5.5	-5.3	-80.5
55	10X-20	-7.89	7.7	-5.4	-90.9
56	10X-24	+5.54	7.3	+3.9	+64.4
57	10X-25	-.57	2.9	-.6	-7.5
58	10X-26	-.87	2.7	-.9	-11.6
59	10X-27	-.12	8.0	-.1	-1.4
60	10Y-24	-8.39	7.5	-5.9	-97.2
61	10Y-12	-1.03	.2	-2.3	-14.8
62	10Y-24	+8.73	10.8	+5.0	+92.9
63	10Y-25	-2.25	1.6	-2.9	-30.9
64	10Y-26	-10.15	3.1	-10.4	-133.1
65	10Y-29	-7.93	5.7	-6.3	-96.5
66	10Y-30	-3.33	2.1	-3.9	-45.0
67	10Y-34	+13.46	9.0	+8.6	+149.9
68	10Y-35	-11.39	20.5	-4.5	-97.9
69	10Y-37	-4.00	1.8	-5.0	-54.7

Outliers rejected A)65, Time Const)60

Avg A	= +4.7	Avg Ta	= 8.3
SIGMA A	= +14.2	SIGMA Ta	= 10.7
Avg |A|	= +9.6		
Max |A|	= +339.6	Max Ta	= 196.7
Min |A|	= +.1	Min Ta	= .1

38 are positive agers
31 are negative agers

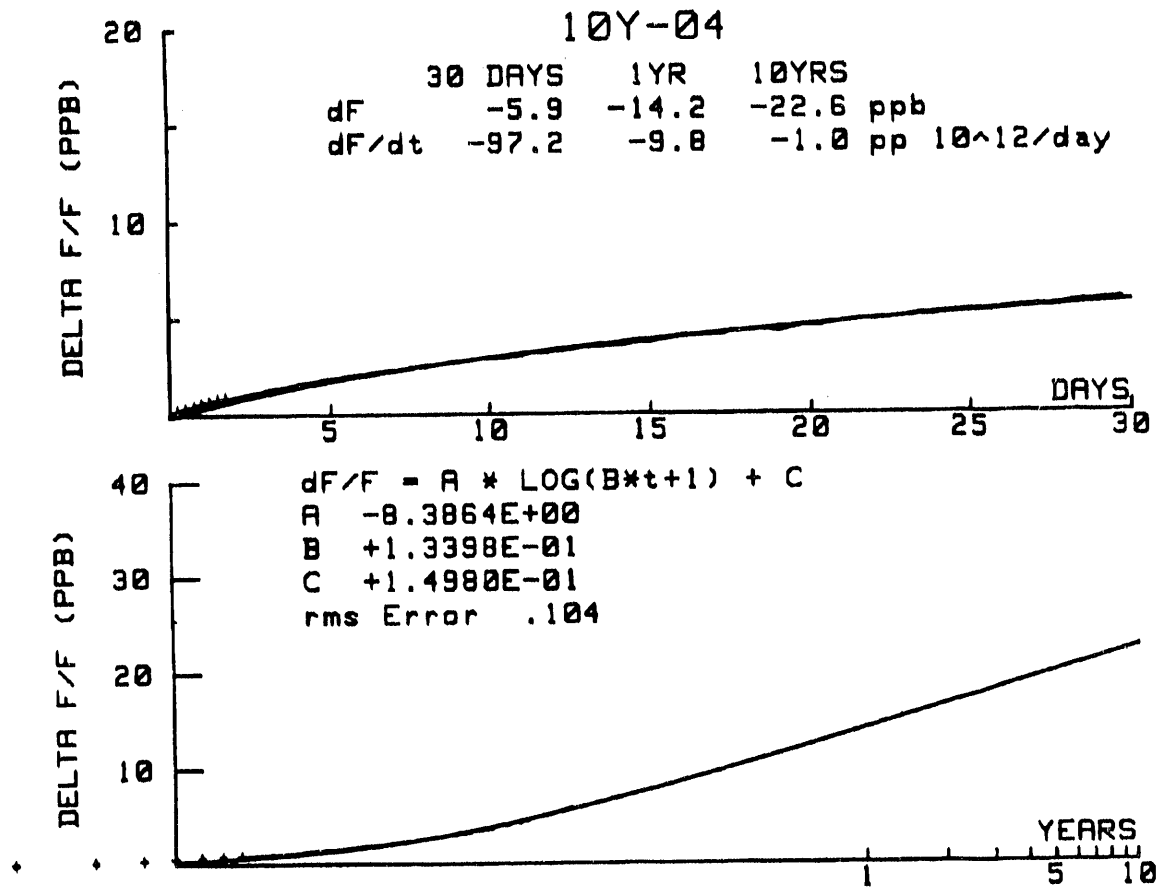
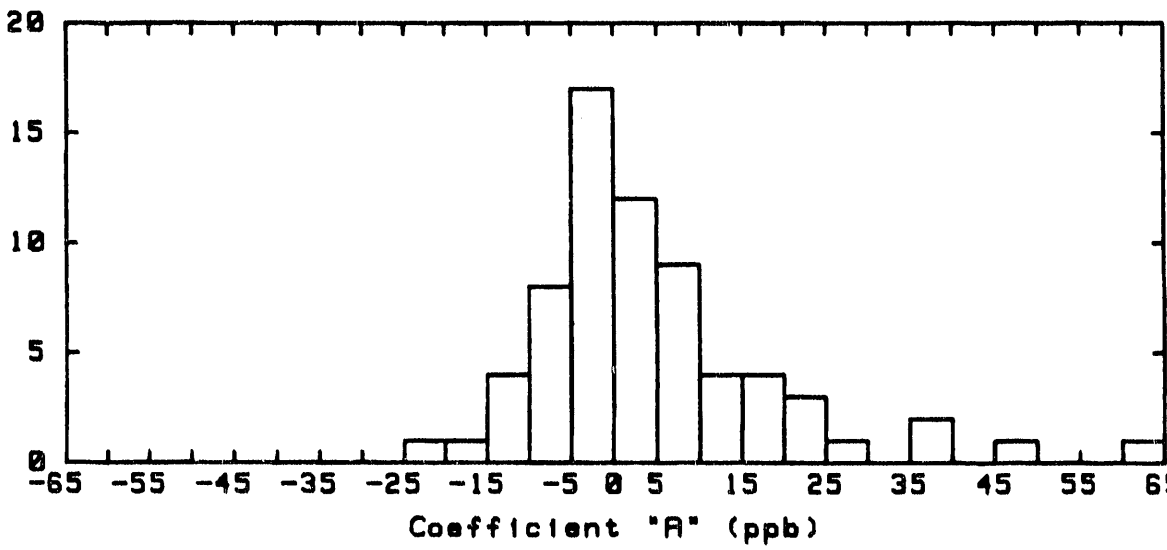


Figure 1.



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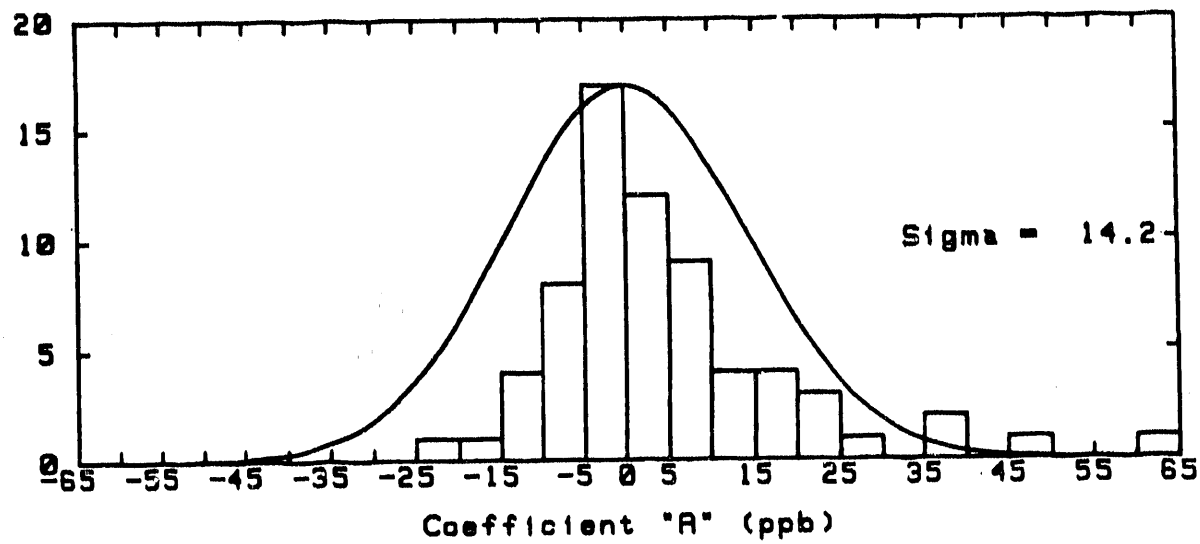

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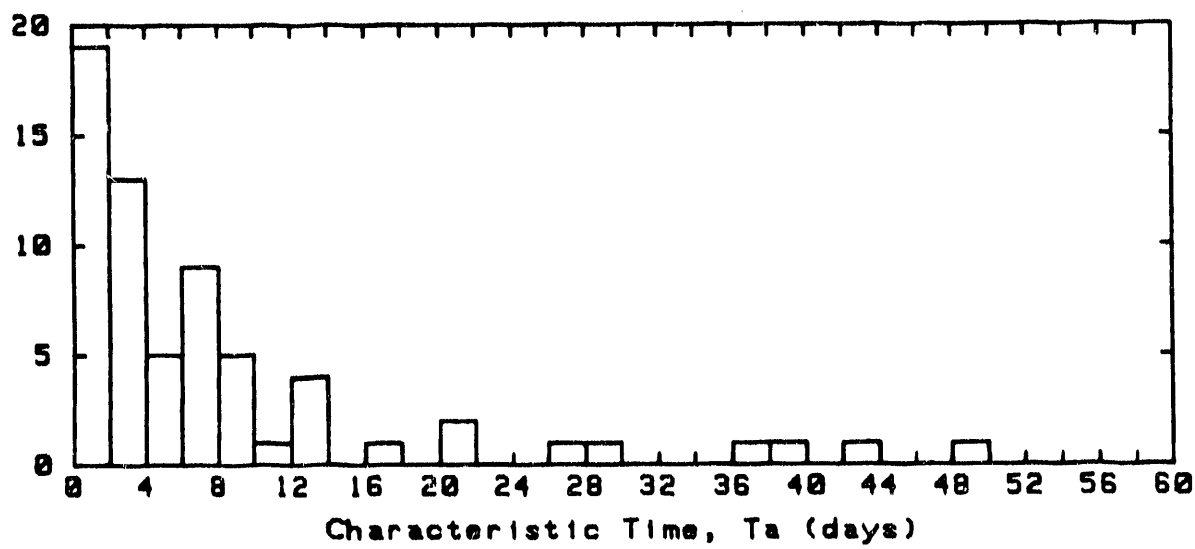

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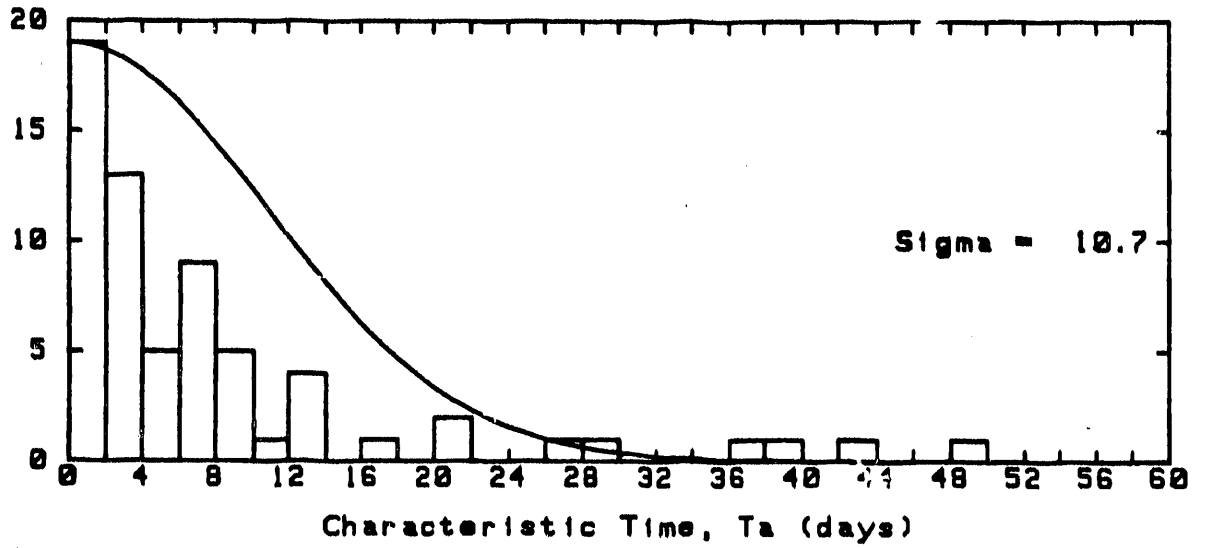

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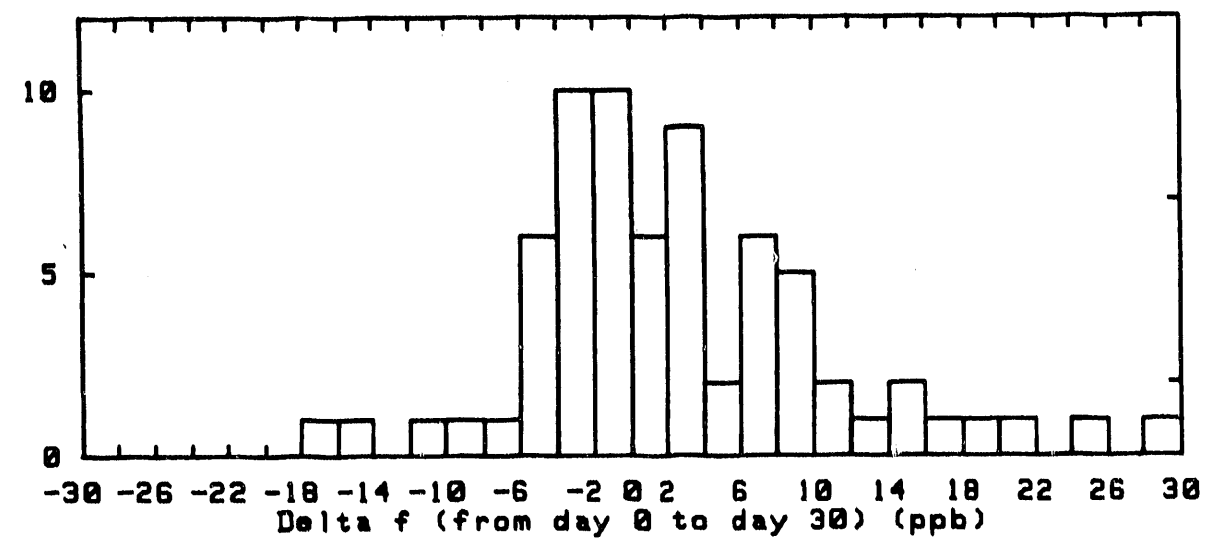

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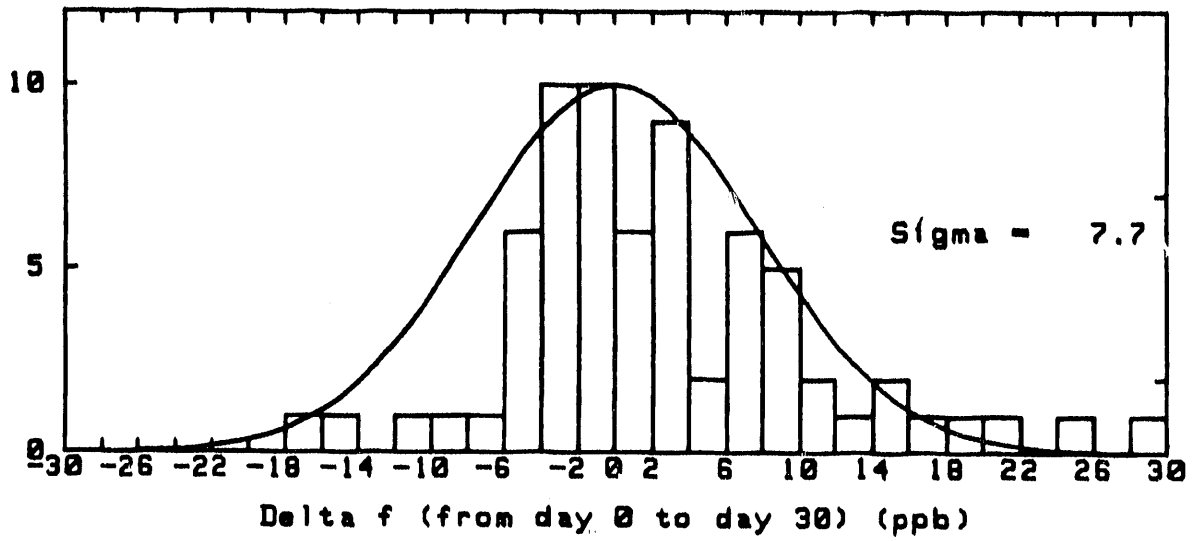

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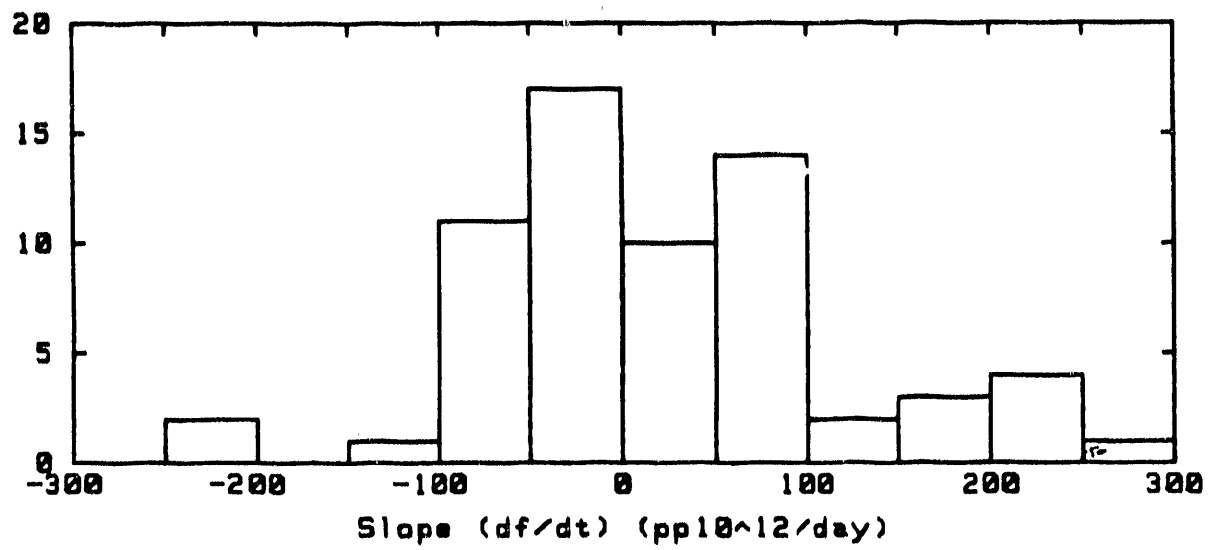

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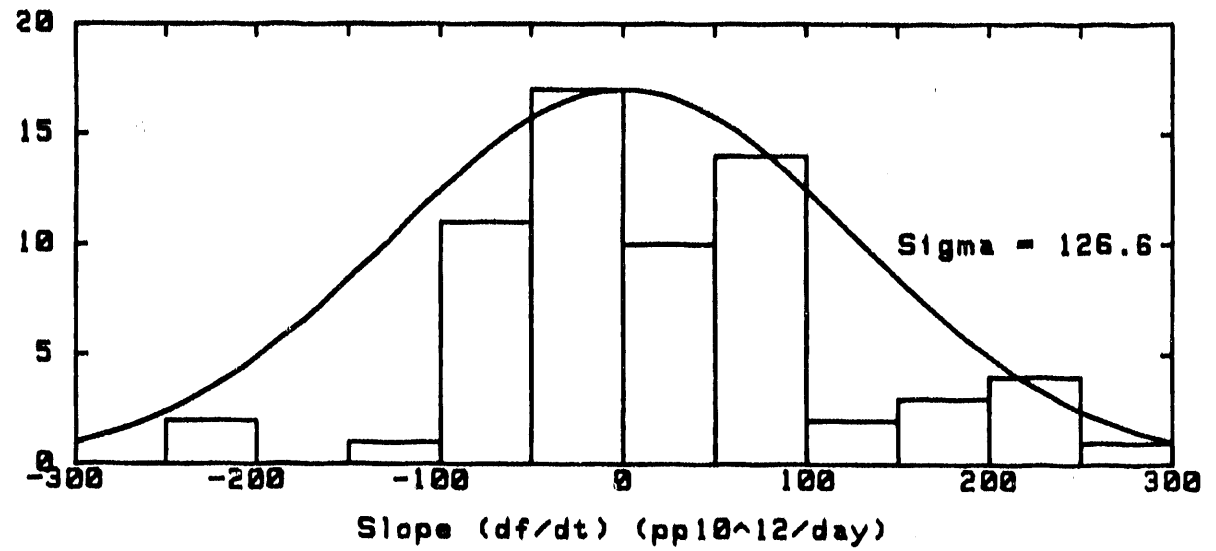

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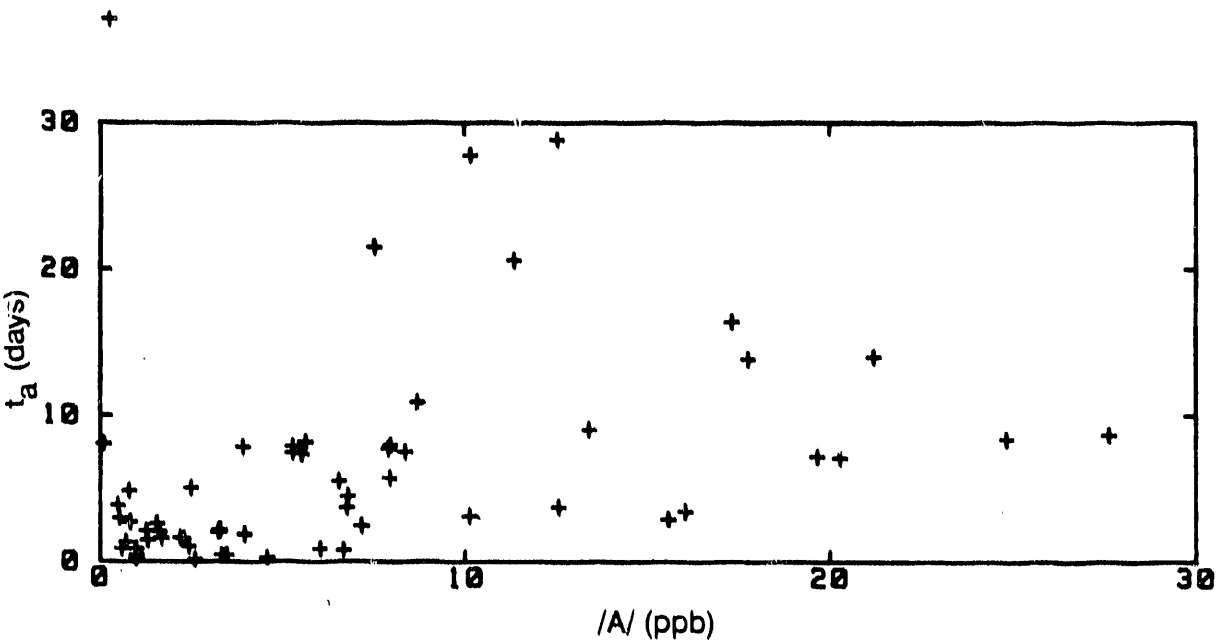

Figure 10.

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