QUARTZ CRYSTAL RELIABILITY STUDIES

REPORT NUMBER 2

CONTRACT DA 36-039 SC-89199

ORDER NUMBER 1048-PM-62-93-93 (4805)

SECOND QUARTERLY PROGRESS REPORT

5 JULY 1962 to 5 OCTOBER 1962

U.S. ARMY SIGNAL RESEARCH AND DEVELOPMENT

LABORATORY, FORT MONMOUTH, NEW JERSEY

INLAND TESTING LABORATORIES DIVISION
COOK ELECTRIC COMPANY
1482 Stanley Avenue
Dayton 4, Ohio

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QUARTZ CRYSTAL RELIABILITY STUDIES

REPORT NUMBER 2

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SIGNAL CORPS TECHNICAL REQUIREMENTS

NUMBER SCL-7003/84, 5 SEPTEMBER 1961

DEPARTMENT OF THE ARMY PROJECT NUMBER 991500401

SECOND QUARTERLY REPORT, 5 JULY 1962 to 5 OCTOBER 1962

The objectives of this study are:

1. - The determination of the causes of failure in quartz crystal units.

2. - The formulation of accelerated tests for the determination of "time to first failure", "meantime between failures", and "life time".

3. - The evaluation of such factors as elevated temperatures, and drive levels other than the recommended drive levels, in causing failure of quartz crystal units.

4. - The determination of a satisfactory definition of failure in terms of performance.

This report was prepared by Carleton E. Jones.

TABLE OF CONTENTS

Statement of Purpose

This study is an investigation of factors that produce failures of quartz crystal units. The work is divided into five phases, which are not necessarily to be performed in chronological order.

Phase I: The contractor will procure, from industry, military quartz crystal units in the types and quantities specified in Signal Corps Technical Requirement SCL-7003/84. Each of these quartz crystal units will be subjected to all preproduction tests required by Specification MIL-C-3098C, and such other tests as may be required to establish that the crystal units are of a quality suitable for the study. Any crystal units which fail these tests will be eliminated from further study.

Phase II: The crystal units that conform to all specification requirements during Phase I testing will be subjected to tests as listed below.

(a) All crystal units that are normally operated under controlled temperature conditions will be stored at their specified operating temperatures.

(b) One-fourth of the crystal units that are normally operated under non-controlled temperature conditions will be stored at plus 85 degrees centigrade. The remaining three-fourths of these units will be operated in oscillators at room ambient, one-third of them at 25 percent of rated drive level, one-third at 100 percent of rated drive level, and one-third at 500 percent of rated drive level.

(c) Measurements of series resonant frequency and resistance will be made at the end of each of the following periods of time after the start of the test: 24 hours, 125 hours. 225 hours, 500 hours, 1000 hours, 2000 hours, and 5000 hours.

Phase III: The frequency versus temperature characteristics of the crystal units will be redetermined.

Phase IV: Those crystal units which still meet the requirements of MIL-C-3098C at the end of Phase III will be divided into two lots, one of which will be subjected to shock tests, the other to vibration tests. The frequency and effective resistance of the crystal units will then be redetermined.

Phase V: A final report will be prepared, analyzing the data generated in Phases I through IV with regard to: (a) determination of causes of failure; (b) the formulation of tests to determine "time to first failure", "mean time between failures", and "life time"; (c) the effects of elevated temperatures, and high and low drive levels in inducing failure; (d) a workable definition of failure in terms of crystal performance; and (e) determination of a reliability figure for quartz crystals.

Abstract

Phase I (the preproduction testing of the crystal units) is progressing well. Two hundred ten of the six hundred crystal samples involved in this study have completed Phase I and are now in Phase II testing.

No problems of any significance have been encountered in performing either Phase I or Phase II tests. Slow delivery of the crystal units by the manufacturers continues to be the major element slowing progress with the study.

Publications, Lectures, Reports, and Conferences

During the period covered by this Quarterly Report, there were no publications issued, and no lectures delivered.

The First Quarterly Report of this study was prepared and distributed, the distribution being accomplished during the week ending 8 September 1962. The third and fourth monthly reports were also submitted during this period.

A conference was held 10 July 1962, at the U.S. Army Research and Development Laboratories, Fort Monmouth, New Jersey. The Signal Corps representatives present were Mr. M. Bernstein, Mr. J. Stanley, and Mr. P. Mulvihill. The contractor was represented by Mr. W. Ingling, Mr. C. Jones, and Mr. E. Roeger. The discussions held were of a general nature, and led to some clarification of the statement of work. A consensus was reached regarding both the terminology and the methods to be employed in performing the work outlined in Signal Corps Technical Requirement SCL-7003/94.

FACTUAL DATA

During the period covered by this report several partial shipments of sample crystals were received. Manufacturer "A" has delivered all the CR-18A/U units, all the CR-32A/U units, and 79 of the 120 CR-67/U units that were ordered. No CR-74/U samples have been received from manufacturer "A".

Manufacturer "B" has delivered 90 of 120 CR-18A/U units ordered, as well as 103 of 120 CR-67/U units, 9 of 30 CR-32A/U units, and all 30 CR-74/U units. All the crystal units that have been received are now undergoing, or have completed, the preproduction tests.

The following identification system has been established for use during the study of the crystals supplied by manufacturer "A":

Lot 1 - Type CR-18A/U, numbered from 1 through 30
Lot 2 - Type CR-18A/U, numbered from 31 through 60
Lot 3 - Type CR-18A/U, numbered from 61 through 90
Lot 4 - Type CR-18A/U, numbered from 91 through 120
Lot 5 - Type CR-67/U, numbered from 1 through 30
Lot 6 - Type CR-67/U, numbered from A1 through A30
Lot 7 - Type CR-67/U, numbered from T1 through T30
Lot 8 - Type CR-67/U, numbered from L1 through L30
Lot 9 - Type CR-32A/U, numbered from 1 through 30
Lot 10 - Type CR-74/U, numbered from 1 through 30

A parallel identification system has been established for the crystals supplied by manufacturer "B".

Lot 11 - Type CR-18A/U, numbered from 1 through 30
Lot 12 - Type CR-18A/U, numbered from 31 through 60
Lot 13 - Type CR-18A/U, numbered from 61 through 90
Lot 14 - Type CR-18A/U, numbered from 91 through 120
Lot 15 - Type CR-67/U, numbered from 1 through 30
Lot 16 - Type CR-67/U, numbered from A1 through A30
Lot 17 - Type CR-67/U, numbered from T1 through T30
Lot 18 - Type CR-67/U, numbered from L1 through L30
Lot 19 - Type CR-32A/U, numbered from 1 through 30
Lot 20 - Type CR-74/U, numbered from 1 through 30

All crystal samples that have been received have been identified according to this system. As the balance of the crystal samples are received, they will also be marked in accordance with this system.

During this report period, Lots 1, 2, 3, 4, 5, 6, and 9 completed the preproduction tests of Specification MIL-C-3098C, and entered Phase II testing. Lots 11, 12, 13, 15, 16, and 17 completed the preproduction tests through Low Temperature Storage. Lot 20 completed the preproduction tests through the initial measurement of series resonant frequency and effective resistance.

Descriptions of the manner of performing the visual and mechanical examinations, and the insulation resistance, shunt capacitance, overall frequency tolerance, and unwanted modes were included in the First Quarterly Report. The remainder of the preproduction tests were perfromed as described below:

(a) Reduced Drive Level

A fixed resistor, whose resistance is equal to the maximum allowable resistance for the crystal under test, is connected to the crystal socket of the test set. The screen voltage control of the test set is then adjusted to provide a grid-current meter deflection 2.5 microamperes greater than the non-oscillating reading of the grid-current meter. The meter shunt control is at its maximum clockwise setting when this adjustment is made. The fixed resistor is then removed from the crystal socket of the test set, and the crystal under test is plugged into the socket. The grid-current meter shall show a deflection of at least 2.5 microamperes from the non-oscillating grid-current meter indication. The crystal must also operate on frequency.

(b) Shock

The series resonant frequency and the effective resistance of the crystals are determined and recorded. The crystal units are then mounted in the specified shock machine and subjected to three impact shocks, each of 100 Gravity units intensity. One impact shock is applied along each of the three mutually perpendicular axes of each crystal unit. Following this, the series resonant frequency and the effective resistance of the crystals are again determined.

(c) Vibration

The series resonant frequency and the effective resistance of the crystal units are measured and recorded prior to vibration. The crystal units are then rigidly mounted on the table of a low-frequency vibration machine, so that the applied vibration will be as follows:

One-third of the units will have the vibratory motion applied parallel to the vertical axes of the crystal holders.

One-third of the units will have the vibratory motion applied parallel to the major horizontal axes of the crystal holders.

One-third of the units will have the vibratory motion applied parallel to the minor horizontal axes of the crystal holders.

The vibration consists of a simple harmonic motion having an amplitude of 0.03 inch (total excursion of 0.06 inch) and is applied continuously for a period of two hours. The frequency of the vibration is varied uniformly from 10 to 55 cycles per second, and returned to 10 cycles per second, once each minute. At the conclusion of the two hour period, the crystal units are removed from the low-frequency vibration machine, and then rigidly mounted to the table of a high-frequency vibration machine. The method of mounting and the orientation of the crystals units is the same as that for the low-frequency portion of the test.

The vibration consists of a simple harmonic motion having the necessary amplitude to provide the specified acceleration throughout the range of frequencies from 50 to 500 cycles per second. The frequency of vibration is automatically changed, at a logarithmic rate, from 50 to 500 and back to 50 cycles per second in a period of 12 minutes. The test is continued for a period of three hours.

At the conclusion of the three hour period, the crystal units are removed from the vibration machine, and the series resonant frequency and effective resistance are measured and recorded.

(d) Heat Cycling

Prior to the heat cycling test, the series resonant frequency and the effective resistance of the crystal units are measured and recorded. Following these measurements, the crystal units are placed in a well-ventilated oven equipped with an automatic program controller and subjected to the following temperature cycle:

From an initial temperature of approximately plus 25 degrees Centigrade, the temperature within the oven is increased to approximately plus 100 degrees Centigrade. The rate of change of temperature is less than 2 degrees per minute. After the temperature reaches the 100 degree level, it is maintained at that level for a period of 30 minutes. At the conclusion of the 30 minute period, the temperature within the oven is decreased to approximately plus 25 degrees Centigrade, with the rate of temperature change less than 2 degrees per minute. This completes one cycle. The test is continued, without interruption, until three cycles have been completed. At the conclusion of the third cycle the series resonant frequency and the effective resistance of the crystal units are again measured and recorded.

(e) Low Temperature Storage

The series resonant frequency and effective resistance of the crystal units are measured and recorded. The crystal units are placed in a refrigerator, and starting from a temperature of approximately plus 25 degrees Centigrade, the temperature within the refrigerator is reduced to approximately minus 65 degrees Centigrade, and then maintained at that level for a period of one hour. At the end of the one hour period, the temperature is increased to approximately plus 25 degrees Centigrade, the rate of temperature change being less than 10 degrees per minute. This completes one cycle. The test is continued, without interruption, until three cycles have been completed. At the conclusion of the third cycle, the crystal units are removed from the refrigerator, and their series resonant frequency and effective resistance are again measured and recorded.

(f) Leakage

The crystal units are immersed in a quantity of distilled water (containing a wetting agent) in an open glass container. The glass container is then placed in an altitude chamber, the chamber is closed and sealed, and the air pressure within the chamber is reduced to from 1.30 to 1.34 inches of mercury, absolute. This pressure is maintained for a period of five minute. During this period the crystal units are observed for leakage, as evidenced by a continuous formation of bubbles from the crystal units. At the conclusion of the five minute test period, the air pressure within the chamber is returned to room ambient, and the crystal units are removed from the test container and dried. The series resonant frequency and effective resistance of the crystal units are then measured and recorded. (This check of frequency and resistance is not required by Specification MIL-C- 3098C, but is performed because of the possibility that leakage might occur which is not visually detected.)

(g) Immersion

The crystal units are subjected to an immersion test, performed as follows: The crystal units are placed in a wire mesh basket, and then completely immersed in a hot bath of fresh (tap) water. The temperature of the hot bath is kept between plus 65 and plus 70 degrees centigrade, and duration of the immersion is 15 minutes. The crystals are next lifted from the hot bath, and immediately immersed in a saturated solution of sodium chloride and water, the temperature of this bath being between plus 20 and plus 25 degrees Centigrade. The duration of this immersion is also 15 minutes. This procedure is performed twice, then the crystal units are rinsed in running tap water, dried, and the insulation resistance, series resonant frequency, and effective resistance are measured and recorded.

(h) Salt Spray (Corrosion)

The crystal units are subjected to the following salt spray test: The crystal units are suspended within the salt spray chamber by means of chemically insert cords. The chamber is then closed, the temperature within the chamber is increased to between plus 92 and plus 97 degrees Fahrenheit, and the specified salt spray is introduced into the chamber. The test is continued for a period of 48 hours, then the crystal units are removed from the test chamber, washed in running tap water, dried, and examined for evidence of corrosion. Finally, the series resonant frequency and the effective resistance are measured and recorded.

(i) Aging

One-half of the crystal units of each type are subjected to the aging test. The crystal units are mounted in an oven, in crystal sockets, and leads are brought out of the oven to the test set. The oven is closed, and the temperature within it is increased to the temperature specified in MIL-C-3098C for aging the type of crystal being tested. The oven used is capable of maintaining any selected temperature (in its range) within plus or minus one-tenth of a degree centigrade. After 24 hours, and again after 96, 192, 264, 360, 432, 528, 600, 672, and 720 hours, the series resonant frequency of the crystal units was measured and recorded. The crystal units were not removed from the test chamber for the performance of these measurements.

(j) Moisture Resistance

The one-half of the crystal units of each type that are not subjected to the aging test are subjected to the mositure resistance test. The crystal units are dried, at a temperature of plus 50 degrees Centigrade, for a period of 24 hours. The crystal units are then transferred to the mositure resistance test chamber, where they are subjected to 10 continuous 24 hour cycles, as follows: During the first two and one-half hours, the temperature is raised from approximately plus 25 degrees Centigrade to plus 65 degrees Centigrade. This temperature is maintained for a period of three hours. The temperature falls to plus 25 degrees Centigrade during the next two and one-half hour period, and is again increased to plus 65 degrees Centigrade in the succeeding two and one-half hours. The temperature is maintained at that level for three hours, and is then gradually reduced to plus 25 degrees Centigrade during a period of two and one-half hours. The temperature is maintained at plus 25 degrees Centigrade for a period of eight hours. This completes one cycle. Throughout the 24 hour cycle the relative humidity was maintained between 90 and 98 percent, with the following exception:

In five of the first nine cycles, during the eighteenth through the twenty-first hours of the 24 hour cycle, the temperature is reduced to minus 10 degrees Centigrade. The humidity is not controlled during this portion of the test.

At the conclusion of the 10 cycles, the crystals are removed from the test chamber, stored 24 hours at room conditions, and then the insulation resistance, series resonant frequency, and effective resistance are measured and recorded.

(k) Temperature Run for Extended Temperature Ranges

All crystal units designed for operation under noncontrolled temperature conditions are tested for conformance with the provisions of MIL-C-3098C through their specified temperature range. The test equipment employed includes the following items:

(1) Crystal Impedance Meter, TS-683/TSM
(2) Vacuum tube Voltmeter, Hewlett-Packard Model 410-B
(3) Standard frequency source, General Radio Type 1101-A piezo-electric oscillator and Type 1102-A multivibrator and power supply
(4) Multi-band radio receiver, Hammarlund Model SP-600
(5) Electronic Frequency Meter, Hewlett-Packard Model 500B
(6) Temperature Recorder, Brown, Model 153 X 10V-K-26
(7&8) Recording Meters, Esterline-Angus Model AW
(9) Test slug, aluminum
(10) Oven, and auto-transformer
(11) Cold storage box
(12) Platinum wire temperature sensor
(13) Interpolation Oscillator, General Radio Type 1107-A

The setup and test procedure are as follows: All equipment is energized, and allowed to "warm-up" for a period of one hour. The drive adjustment of the crystal impedance meter is set near its low extreme, one of the test crystals is plugged into the crystal impedance meter, and the tuning control of the crystal impedance meter is adjusted to approximately the crystal frequency. The crystal impedance meter tuning and drive controls are adjusted until the grid-current meter indicates that the crystal is oscillating. The receiver is then tuned to the crystal frequency. The crystal is removed from the crystal impedance meter, the appropriate calibrating resistor is plugged into the crystal socket, and the vacuum tube voltmeter is used to adjust the drive level, as detailed in the instruction manual for the crystal impedance meter. The calibrating resistor is removed from the crystal impedance meter, a crystal plugged in, and the receiver tuning is adjusted for optimum reception of the signal from the crystal.

The output of either the 100 kilocycle or the 10 kilocycle multivibrator, depending on the nominal frequency of the crystal being tested, is coupled to the input of the receiver. The two signals are heterodyned in the receiver. The output of the receiver is an audio signal equal in frequency to the difference, in cycles per second, between the two R.F. signals.

The output of the interpolation oscillator is connected to the input of the electronic frequency meter, and the output from the frequency meter is connected to one of the recording meters.

Since the output of the electronic frequency meter is proportional to the input frequency, it is possible to cause the pen of the recorder to deflect in proportion to the frequency set up on the interpolation oscillator. The interpolation oscillator is set to the nominal frequency difference between the crystal and the standard harmonic signal. The recorder pen is adjusted to make this frequency fall at the center of the recorder chart, and the chart is advanced, leaving a mark at the nominal difference frequency point.

The output frequency of the interpolation oscillator is then adjusted, in turn, to the audio difference that marks the lower and upper frequency limits allowed the crystals, and the chart is marked at these two limits. This completes the calibration of the frequency test equipment. The interpolation oscillator is disconnected from the frequency meter, and the output from the receiver is connected to the input of the frequency meter. The pen of the recorder will trace out any changes in the difference between the two frequencies fed to the receiver, and since the stability of the signal from the standard oscillator is of a high order, any variations in the difference frequency can logically be attributed to a change in the frequency of the crystal being tested.

The crystal is removed from the socket of the crystal impedance meter, and a calibrating resistor, equal in resistance to the maximum effective resistance specified for the crystals being tested, is plugged into the meter. The circuit to the grid-current meter of the crystal impedance meter is opened, and the meter current is fed into a D.C. amplifier. The output of the D.C. amplifier is connected to a recording meter. The D.C. amplifier gain and the mechanical adjustments of the recorder are set to give a convenient deflection on the recorder chart, this deflection is marked on the chart, and its ohmic equivalent is noted. A series of resistors having less resistance are then plugged into the test set, and the meter deflection caused by each is marked on the chart. Thus, when a crystal is plugged into the crystal impedance meter the position of the recorder pin gives, at any instant, an indication of the effective resistance of the crystal unit at that instant.

The temperature monitoring system functions as follows: The temperature sensor is a platinum resistance element, which is built into a crystal holder of the same size as the holder of the crystal to be tested. An aluminum slug, such as that illustrated in Figure 1, is used to hold the crystal and the temperature sensor. The leads of the temperature sensor are connected to the electronic temperature recorder, which is a resistance-bridge type. The chart drive mechanism of the temperature recorder is inoperative, and the chart is marked, at five degree Centigrade increments above and below zero degrees, with a narrow strip of conductive paint. A series circuit is established from a plate circuit relay (on an auxiliary chassis), through the pen of the recorder, the conductive paint, and back to the relay. As the temperature changes and the recorder pen moves along the chart, the plate relay closes momentarily each time a five degree temperature increment is reached. The marker pens at the edges of the charts of the Esterline-Angus recorders are connected to a circuit which includes the contacts of the plate circuit relay. Thus, as each five degree increase or decrease in temperature occurrs, the edge of the frequency and resistance charts are marked.

In testing a crystal through its operating temperature range, the procedure is as follows: A crystal is put into the well in one end of the aluminum test slug, and the temperature sensor is put into a corresponding well in the other end of the slug. The assembly is put into a cold storage box which contains finely divided dry ice, and the temperature of the assembly is reduced to a point a few degrees below the minimum specified operating temperature of the crystal.

A small oven, which was made by winding asbestos-covered resistance wire around a length of copper tubing whose inside diameter was a close fit over the test slug, is mounted on the front of the crystal impedance meter, so positioned that when the slug is inserted into the oven, the crystal pins are connected with the crystal socket in the impedance meter. The winding of the oven is connected to the output of an auto-transformer. The output voltage of the auto-transformer is pre-set to a level that will cause the temperature of the crystal to increase at the rate required for the test.

The slug is removed from the cold box, inserted in the oven, and the recorders and auto-transformer are energized. As the temperature reaches minus 55 degrees Centigrade, the marker pens of the recorders mark a temperature pip on the frequency and resistance charts. A continuous recording of the series resonant frequency and effective resistance of the crystal are produced through the operating temperature range, with temperature reference marks at 5 degree intervals along the edge of the chart. This procedure is repeated for each crystal of the same type and frequency.

For testing crystals of the temperature-controlled type, the cold box is eliminated, and the temperature of the crystal is raised from room temperature through its maximum operating temperature at a controlled rate. Temperature markers are put on the charts at five degree intervals throughout the specified operating temperature range.

PHASE II:

Performance of Phase II testing was begun on 12 September 1962. On that date, Lot 1 was placed in non-operating storage, at a temperature of plus 85 degrees Centigrade, in accordance with the provisions of Paragraph 3.2.2b, Signal Corps Technical Requirement SCL-7003/84. The oven in which the Lot 1 crystals are stored is fitted with racks which contain crystal sockets. The crystal sockets are connected, by coaxial cable, to bulkhead R.F. connectors (BNC series) which are mounted in a feed-through panel in the wall of the oven. Thus, the crystals which are stored in this oven can be connected to the crystal impedance meter for test without removing them from the oven, as a short length of coaxial cable can be run from the BNC connector to the crystal socket in the crystal impedance meter.

On 13 September 1962, at the end of the first 24 hours of storage, Lot 1 was tested to determine the series resonant frequency and effective resistance of each of the crystal units, and the measured values of frequency and resistance were recorded. This procedure was repeated 125 hours, 225 hours, and 500 hours after initiation of the storage test. It will also be repeated 1000, 2000, 3000, 4000, and 5000 hours after initiation of the test.

Lot 2 also entered Phase II testing 12 September 1962. This lot of crystals is being operated in oscillators, at room ambient temperature. All Lot 2 crystal units are being driven at 25 percent of the rated drive level specified for 15 to 20 megacycle CR-18A/U crystals in specification MIL-C-3098C.

On 13 September 1962, at the end of the first 24 hours of storage, the Lot 2 crystals were removed from the oscillators, and placed in an oven which had been previously stabilized at a temperature of plus 30 degrees Centigrade. After a period of 24 hours at plus 30 degrees Centigrade, the series resonant frequency and effective resistance of each of the 30 crystals was determined and recorded. The crystals were then returned to operation in their respective oscillators. This entire procedure, including the 24 hour storage period, will be repeated at the same periods of time after initiation of the test as were listed above for Lot 1.

Lot 6 was put into storage, at plus 85 degrees Centigrade, on 13 September 1962. Lot 6 is being subjected to the same test procedures, performed at the same time intervals after initiation of the storage program, as were described above for Lot 1.

Lot 5 was put into operation, in oscillators, at room temperature, on 14 September 1962. The drive level for Lot 5 crystals was set to 100 percent of the drive specified for CR-67/U crystals. The crystals comprising Lot 5 are being subjected to the same test procedures, performed at the same time intervals after initiation of the storage program, as were described above for Lots 2, 3, and 4.

To the end of this report period, Lots 1, 2, 3, 4, 5, and 6 completed 500 hours of the storage tests. Lot 9 was put into the storage test at the close of the report period.

PHASES III, IV, and V:

The performance of these three Phases of the program cannot be initiated until completion of Phase II. As any Lot of crystals completes Phase II testing, that Lot will move into Phase III immediately. If no malfunctions of test equipment occur, Lot 1 should enter Phase III approximately 10 April 1963.

TEST DATA:

Test data, showing the series resonant frequency and the effective resistance of the various crystal units at stated times during preproduction and storage testing, is presented on pages 26 through 62 of this report. The information on each Lot of crystal is discussed and explained in the pages preceeding the data sheets.

TEST DATA

Pages 26 and 27 contain the test data on Lot 1 crystals The nominal frequency of these crystal units is 19,990,700 cycles per second. The maximum effective resistance allowed for CR-18A/U crystals of this frequency is 20 ohms. The overall frequency tolerance is plus or minus 0.005 percent, the permitted frequency change due to shock or vibration is plus or minus 0.0005 percent, and the permitted resistance change due to shock vibration is plus or minus 10 percent. Thus, at any time in any preproduction test, the frequency of the crystals must be within plus or minus 1000 cycles per second of nominal frequency, and the resistance must not exceed 20 ohms, for the crystal to be in compliance with the requirements of specification MIL-C-3098C. The change in series resonant frequency due to shock or vibration must not exceed plus or minus 100 cycles per second, and the resistance must neither exceed 20 ohms, nor change more than 2 ohms due to shock or vibration. A review of the Lot 1 data reveals that each of the 30 units conformed to the specification requirements throughout the preproduction tests. The figures recorded on page 26 are the last five digits of the series resonant frequency, in cycles per second. Thus, the 90804 entered for sample number 1 in the column headed "Initial Frequency" indicates that the measured frequency of this crystal was 19,990,804 cycles per second. There are no entries in the column headed "After Mois. Res.", as aging, rather than moisture resistance, was performed on this lot of crystals. The figures on page 27 are the resistance, in ohms, of the samples, as measured after the various preproduction tests.

Pages 28, 29, 30, 31, 32, and 33 record the same information for the crystals comprising Lots 2, 3, and 4. The sole failure to date among the crystals in Lots 1, 2, 3, and 4, was the failure of unit #120, in Lot 4, during vibration. The following four pages contain the equivalent data for Lots 5 and 6. The frequency tolerances for Lots 5 and 6 are plus or minus 1,250 cycles per second overall, and plus or minus 250 cycles change from shock or vibration. The maximum allowable equivalent resistance is 40 ohms. The permitted change in resistance from shock or vibration is plus or minus 4 ohms. Failures to date in these four lots include:

Lot 6: Units A3 and A13 stopped oscillating during the aging test. Unit A27 would not oscillate when tested at the end of 225 hours of high-temperature storage.

Pages 38 and 39 contain data on the performance of the crystals in Lot 9. These type CR-32A/U crystal units have an overall frequency tolerance, in the range from plus 70 degrees Centigrade to plus 80 degrees Centigrade, of plus or minus 0.002 percent. The required stability within this temperature range is plus or minus 1000 cycles per second of the nominal frequency of 49,997,000 cycles per second (in this ten degree range) and in addition, cannot vary more than plus or minus 250 cycles per second at any point in that temperature range from any other frequency measured in that range. Thus, if a crystal is 500 cycles per second above the nominal frequency at a temperature of 75 degrees Centigrade, the frequency, throughout the temperature range from plus 70 to plus 80 degrees Centigrade, must be between 250 and 750 cycles per second above the nominal frequency of the crystal. The maximum acceptable change in series resonant frequency from shock, vibration, or aging is also plus or minus 250 cycles per second. The maximum resistance is 40 ohms, the permitted change in resistance from shock or vibration is plus or minus 4 ohms. Failures to date in Lot 9 include:

Units 21 and 27 would not oscillate after vibration. The crystal holders were opened, and it was discovered that in each of these units the support wire for the crystal plate had broken from one of the pins in the base of the holder, at a point adjacent to the pin.

Unit 28 would not oscillate after low-temperature storage.

Units 15 and 19 would not oscillate after the salt spray test.

Lots 11, 12, 13, pages 40 through 45, are CR-18A/U samples from manufacturer "B". The same tolerances apply to this data as were listed for Lots 1, 2, 3, and 4. There have been no failures to date among the samples comprising Lots 11, 12, and 13. (The crystals for Lot 14 have not yet been received from the manufacturer.)

Lots 15, 16, and 17, pages 46 through 51, are CR-67/U samples from manufacturer "B", and are subject to the same tolerances as were listed above for Lots 5, 6, and 7. The sole failure to date is unit 25 of Lot 15. The failure was entirely mechanical, one of the leads of the crystal breaking off flush with the base of the crystal holder during the shock test. Electrically, this unit still performs satisfactorily. (The crystals which will make up Lot 18 have not been received from the manufacturer.)

Data on Lot 20 crystals is presented on pages 52 and 53. There have been no failures with these crystals.

The shunt capacitances of the crystals are recorded on data pages 54 through 62. Lot identifications and specification requirements are included on each data page. No crystal tested has failed to conform to the specification requirements for shunt capacitance.

For some Lots of crystals, the data presented in this report does not cover all tests that have been performed, as time limitations prevented reducing all the data taken to date to a format suitable for inclusion in this report.

Sample Number	Initial Frequency	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Aging	After Mois. Res.	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
1	90804	90868	90791	90775	90873	90019	90960		90916	90916	90926	90932	90932	1
2	90875	90920	91003	91238	91099	91450	91414		91310	91338	91330	91326	91325	2
3	91549	91600	91621	91648	91421	91296	91207		91245	91236	91236	91228	91226	3
4	90874	90965	91058	90892	90975	91108	91156		91090	91083	91083	91066	91075	4
5	90101	90195	90278	90236	90207	90158	90188		90148	90136	90142	90150	90153	5
6	90854	90929	91063	90936	90921	91065	91088		91060	91058	91044	91040	91032	6
7	90131	90137	90178	90166	90127	90167	90198		90208	90214	90222	90227	90224	7
8	90832	90875	91010	90814	90870	90837	90817		90803	90786	90791	90797	90794	8
9	91165	91165	91209	91206	91160	91123	91107		91088	91089	91078	91082	91085	9
10	91048	91061	91073	91055	91060	91047	91052		91027	91020	91028	91017	91010	10
11	90983	90963	91004	91009	91064	91122	91116		91100	91114	91108	91111	91113	11
12	90047	90062	90075	90055	90056	90078	90084		90063	90065	90063	90062	90065	12
13	91525	91547	91564	91476	91500	91590	91650		91613	91618	91620	91623	91625	13
14	91052	91058	91115	91122	91070	91038	91050		91021	91014	91025	91020	91016	14
15	91391	91471	91581	91424	91476	91428	91461		91382	91377	91375	91360	91356	15
16	91308	91368	91500	91315	91380	91425	91525		91455	91455	91455	91455	91455	16
17	91229	91391	91422	91304	91371	91425	91574		91521	91523	91524	91526	91530	17
18	91186	91163	91175	91192	91147	91147	91149		91123	91120	91120	91121	91121	18
19	91265	91215	91364	91255	91230	91370	91409		91380	91377	91375	91375	91373	19
20	91045	91072	91109	91194	91164	91135	91178		91152	91129	91130	91130	91132	20
21	91058	91119	91154	91074	91115	91127	91138		91068	91068	91070	91074	91075	21
22	91570	91606	91667	91528	91602	91703	91627		91558	91555	91553	91550	91543	22
23	91531	91549	91579	91583	91632	91698	91595		91531	91530	91530	91533	91533	23
24	91018	91077	91029	90980	91060	91024	91069		91022	91023	91028	91033	91035	24
25	90461	90498	90423	90418	90460	90433	90458		90443	90443	90444	90448	90449	25
26	90105	90161	90193	90103	90114	90130	90130		90136	90137	90135	90130	90116	26
27	90755	90761	90845	90864	90768	90799	90853		90801	90805	90817	90827	90833	27
28	90988	90953	90976	90965	90949	90953	90916		90888	90880	90883	90897	90908	28
29	90224	90222	90308	90342	90324	90372	90381		90345	90344	90355	90362	90365	29
30	90613	90584	90562	90504	90514	90554	90586		90549	90553	90553	90553	90553	30

Lot 1, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
1	4.0	4.5	5.0	4.5	4.5	6.0		7.0	7.0	7.0	7.0	7.0						1
2	4.5	5.0	5.0	5.0	5.5	7.0		6.5	6.5	7.0	6.5	6.5						2
3	10.0	12.0	12.0	10.0	10.0	12.5		14.0	13.0	14.0	12.0	11.0						3
4	8.0	6.5	8.5	8.0	8.5	10.5		11.0	11.5	14.0	13.0	14.0						4
5	7.0	5.5	4.5	5.5	6.0	7.0		9.0	11.0	9.0	8.5	10.0						5
6	4.5	5.0	4.0	5.5	6.0	6.0		7.5	9.0	11.0	12.0	14.0						6
7	8.0	6.5	7.0	7.0	6.0	7.0		8.5	10.0	12.0	14.5	18.0						7
8	7.0	5.0	4.5	5.0	6.0	7.0		8.0	10.5	11.0	13.0	14.0						8
9	7.0	5.0	4.5	5.5	5.0	6.5		7.5	8.5	9.5	10.0	9.5						9
10	8.0	6.5	6.0	5.5	7.0	6.5		7.0	8.5	8.5	8.5	9.0						10
11	9.5	7.5	7.0	7.0	8.5	7.0		9.0	11.0	12.5	10.0	10.0						11
12	9.5	8.0	6.5	6.5	6.0	6.0		8.0	9.5	10.5	13.5	14.0						12
13	7.0	5.0	4.5	5.0	5.5	5.0		6.5	9.0	10.0	14.0	12.5						13
14	8.0	6.5	6.5	6.5	5.5	6.5		6.5	7.0	10.5	12.0	12.0						14
15	4.5	4.5	4.5	5.0	4.5	6.0		7.0	7.5	8.0	8.0	8.5						15
16	9.5	7.5	6.5	7.0	8.0	9.5		9.5	8.0	8.0	8.5	8.0						16
17	20.0	18.5	19.0	17.0	17.0	15.5		16.0	13.0	13.0	12.0	10.5						17
18	8.0	6.0	6.0	6.0	7.0	8.0		9.5	10.0	7.5	9.0	10.5						18
19	16.0	14.0	12.0	11.0	13.0	11.5		11.5	11.5	10.5	10.5	10.5						19
20	9.5	7.5	6.5	6.5	6.0	8.0		9.0	10.5	11.0	12.0	11.0						20
21	9.5	7.5	6.5	6.5	6.5	8.5		9.5	10.0	10.5	8.5	8.5						21
22	8.0	6.5	8.5	10.0	9.5	11.5		11.5	12.5	14.0	10.0	11.0						22
23	16.0	14.0	13.5	15.5	17.0	16.0		15.5	14.0	13.0	11.5	10.0						23
24	13.0	11.5	13.0	14.0	15.0	14.5		14.5	13.5	13.5	13.0	12.5						24
25	4.5	4.5	4.5	6.0	6.0	7.0		7.5	7.0	7.5	7.5	6.5						25
26	4.0	4.5	4.0	4.0	4.5	5.0		6.5	8.0	9.0	9.5	8.5						26
27	9.5	7.5	8.0	9.0	7.0	7.0		6.5	8.5	8.5	8.5	8.5						27
28	8.0	6.0	7.5	8.5	8.5	9.0		9.0	8.5	10.0	10.0	10.5						28
29	10.0	8.5	10.0	11.0	9.5	10.5		10.5	10.5	11.0	11.5	9.5						29
30	9.8	8.5	10.0	11.5	10.0	12.0		13.0	12.0	12.0	12.0	12.0						30

Lot 1, Effective Resistance

Sample Number	Initial Frequency (See Note)	After Shock	After Vibration	After Heat Cycling	After Low-Temp. Storage	After Immersion	After Salt Spray	After Moisture Resistance	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Sample Number
31	90789	90798	90777	90786	90789	90774	90747	This lot of samples was subjected to the Aging Test and not to the Moisture Resistance test.	90741	90741	90741	90741	90741	31
32	90084	90040	90060	90093	90081	90084	90084		90039	90030	90034	90038	90043	32
33	91419	91475	91452	91384	91415	91472	91475		91460	91460	91485	91483	91485	33
34	91539	91527	91543	91471	91533	91535	91552		91518	91510	91503	91500	91502	34
35	91169	91154	91116	91138	91133	91165	91100		91046	91040	91030	91008	91000	35
36	90543	91115	91142	91052	91113	91163	91133		91118	91104	91124	91104	91104	36
37	90796	90723	90731	90726	90754	90791	90792		90730	90730	90732	90732	90736	37
38	91439	91456	91496	91486	91585	91611	91682		91631	90634	90630	90636	90633	38
39	91734	91769	91774	91752	91853	91695	91680		91650	91659	91656	91658	91560	39
40	91393	91385	91390	91387	91380	91389	91325		91321	91314	91325	91320	91320	40
41	91190	91142	91176	91084	91137	91191	91240		91238	91236	91234	91230	91224	41
42	90970	90937	90982	90854	90855	90870	90934		90912	90919	90920	90920	90920	42
43	91048	91097	91123	91107	91113	91131	91163		91200	91215	91220	91220	91221	43
44	90892	90803	90839	90748	90801	90850	90899		90825	90828	90830	90830	90830	44
45	91265	91217	91276	91157	91130	91135	91107		91046	91046	91037	91037	91040	45
46	90985	90927	90910	90902	90994	90942	90913		90854	90853	90850	90838	90833	46
47	91498	91451	91468	91384	91345	91358	91336		91304	91304	91290	91284	91284	47
48	91396	91389	91401	91392	91388	91525	91508		91504	91507	91497	91497	91487	48
49	91379	91288	91252	91159	91244	91280	91288		91233	91242	91256	91259	91254	49
50	90874	90894	90870	90879	91006	90989	91117		91107	91107	91107	91107	91100	50
51	90896	90815	90789	90862	90844	90809	90795		90763	90745	90748	90758	90739	51
52	90832	90896	90915	90798	90862	90944	91090		91105	91115	91129	91132	91138	52
53	90990	91065	91090	91073	91073	91135	91104		91065	91077	91074	91078	91070	53
54	90714	90709	90723	90628	90700	90734	90782		90820	90811	90800	90815	90830	54
55	91305	91282	91302	91275	91271	91290	91305		91300	91299	91298	91280	91250	55
56	90598	90558	90580	90462	90562	90507	90594		90575	90565	90563	90595	90588	56
57	91339	91339	91348	91348	91334	91376	91354		91348	91258	91329	91320	91308	57
58	91564	91511	91514	91490	91515	91547	91543		91544	91521	91516	91500	91498	58
59	91397	91328	91320	91309	91300	91283	91271		91256	91241	91221	91201	91188	59
60	90886	90858	90844	90803	90796	90731	90724		90713	90700	90688	90663	90640	60

Note: The nominal frequency of these crystal units is 19,990,700 cps. The first three digits were dropped from the frequency measurements recorded above.

Lot 2, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
31	8.0	6.5	6.0	6.5	5.5	6.0		6.5	7.0	7.0	6.0	6.0						31
32	19.5	15.0	15.0	13.5	12.0	14.5		16.0	14.0	11.0	13.0	14.5						32
33	16.0	11.0	20.0	19.0	19.0	18.5		16.5	13.5	10.0	11.0	12.0						33
34	9.5	6.5	8.0	10.0	10.0	14.5		12.0	14.0	10.5	13.0	13.0						34
35	7.0	4.5	6.0	6.8	7.0	8.5		8.0	10.0	8.0	8.0	9.5						35
36	16.0	15.0	16.0	16.5	14.0	16.0		16.0	14.0	11.0	12.5	14.0						36
37	10.0	8.5	7.0	6.5	5.0	10.0		11.5	13.0	13.0	13.0	13.0						37
38	9.8	7.0	9.0	8.5	6.5	7.5		8.0	10.5	9.5	10.0	11.0						38
39	18.5	15.0	16.0	15.0	11.5	10.5		10.0	12.0	14.0	14.0	13.5						39
40	7.0	5.0	6.5	5.0	4.0	6.0		6.5	7.0	6.0	6.5	7.0						40
41	16.0	14.0	13.5	13.0	10.0	10.0		10.5	11.0	13.0	14.0	14.0						41
42	14.0	11.0	11.0	11.5	8.5	8.5		8.5	9.0	10.0	13.5	13.0						42
43	7.0	5.0	5.0	5.0	3.0	5.5		4.5	6.5	9.0	9.0	9.5						43
44	7.0	6.5	5.5	5.0	3.0	4.5		4.5	6.5	6.5	6.5	6.5						44
45	10.0	8.5	5.0	9.5	11.5	11.5		13.0	13.5	14.0	16.0	17.5						45
46	9.5	5.5	10.0	6.5	5.0	5.5		5.0	5.5	10.0	12.5	14.0						46
47	4.0	4.5	7.8	4.5	4.5	4.5		4.0	6.5	6.0	7.5	7.5						47
48	9.5	6.0	7.0	6.5	5.5	6.5		7.5	8.0	10.0	12.5	12.0						48
49	4.0	4.0	4.5	4.0	4.0	4.5		4.5	4.5	4.5	6.0	6.5						49
50	8.0	5.5	7.5	6.5	5.0	5.0		5.5	7.0	6.5	6.5	6.5						50
51	9.8	8.5	9.0	10.0	8.0	9.0		10.0	10.0	12.0	13.0	14.0						51
52	14.0	11.0	12.0	11.5	10.0	14.0		14.5	13.0	10.0	14.0	13.0						52
53	19.5	18.0	16.0	18.5	15.5	19.0		19.0	18.0	16.5	14.0	14.0						53
54	8.0	5.5	6.0	6.5	5.5	6.0		6.5	7.5	9.0	9.0	9.5						54
55	8.0	5.5	7.5	6.5	5.0	5.5		5.5	5.0	5.0	5.5	5.0						55
56	9.5	6.5	7.0	6.5	5.5	6.5		5.0	6.0	9.0	7.5	7.5						56
57	3.9	5.0	6.5	5.5	5.5	5.5		5.0	5.0	4.5	5.5	5.5						57
58	3.9	5.0	5.0	5.0	4.5	6.0		5.0	7.5	7.5	7.5	8.0						58
59	4.3	5.5	8.5	10.5	8.5	10.0		8.5	9.0	9.0	10.5	10.0						59
60	4.3	5.0	6.0	5.5	5.0	10.5		10.0	12.0	11.0	10.5	10.5						60

Lot 2, Effective Resistance

Sample Number	Initial Frequency (See Note)	After Shock	After Vibration	After Low-Temp. Storage	After Immersion	After Salt Spray	After Moisture Resistance	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
61	90788	90719	90755	90753	90890	90952								61
62	90734	90775	90736	90711	90849	90956								62
63	91159	91152	91130	91115	91270	91319								63
64	90946	90924	90935	90907	91075	91101								64
65	91471	91443	91472	91440	91594	91255								65
66	91335	91305	91316	91445	91450	91269								66
67	91618	91586	91594	91332	91275	91643								67
68	91007	90980	90984	91585	91128	91171								68
69	90562	90528	90547	90990	90676	90744								69
70	90482	90442	90472	90558	90599	90633								70
71	90902	90872	90878	90869	91015	91064								71
72	90746	90715	90722	90721	90864	90919								72
73	90804	90773	90764	90790	91119	91195								73
74	90867	90838	90849	90861	90991	90972								74
75	91681	91627	91568	91490	91179	91298								75
76	91161	91123	91131	90861	91275	91292								76
77	91365	91335	91335	91481	91471	91494								77
78	91660	91686	91624	91330	91371	91570								78
79	91607	91634	91700	91354	91374	91688								79
80	91656	91663	91620	91620	91679	91418								80
81	91033	91006	91026	91696	91411	91138								81
82	91226	91198	91219	91624	91345	91331								82
83	90990	90962	90983	90612	91124	91151								83
84	91386	91358	91353	91378	91492	91520								84
85	91557	91537	91553	91562	91691	91506								85
86	91151	91130	91039	91084	91261	91292								86
87	91033	91007	91007	91016	91155	91180								87
88	91582	91625	91601	91315	90779	90807								88
89	91643	91560	91554	91576	91570	91376								89
90	90802	90757	90782	90771	90905	90947								90

Note: The nominal frequency of these crystal units is 19,990,700 cps. The first three digits were dropped from the frequencies recorded above.

Lot 3, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
61	4.0	8.5	11.0	11.0	13.0	13.5	14.0											61
62	5.8	5.0	10.0	8.5	9.5	9.0	9.0											62
63	5.1	8.5	5.0	5.0	5.0	13.0	8.5											63
64	4.0	8.5	6.5	6.0	6.0	9.5	9.0											64
65	4.0	5.5	7.0	7.0	6.5	5.0	6.0											65
66	4.0	5.0	4.5	8.0	5.0	5.0	6.0											66
67	2.7	5.8	9.0	5.0	8.0	6.0	6.0											67
68	5.2	6.5	10.0	7.0	12.0	7.0	6.0											68
69	4.5	7.0	7.0	10.0	7.0	6.5	6.0											69
70	3.4	5.5	6.0	7.0	6.5	6.5	8.0											70
71	3.4	5.0	4.5	5.0	5.5	5.0	5.5											71
72	3.5	6.5	9.0	10.0	10.0	9.0	10.0											72
73	4.5	6.5	7.0	10.0	9.0	9.5	10.0											73
74	4.0	4.5	4.0	4.0	4.0	4.0	5.0											74
75	4.0	5.0	5.0	5.5	5.5	5.0	6.5											75
76	3.5	6.5	7.5	6.5	8.0	6.5	6.5											76
77	6.0	7.0	8.0	8.0	9.0	6.5	7.0											77
78	6.0	6.5	6.5	6.5	6.5	6.5	9.0											78
79	5.5	6.0	7.0	7.0	8.0	7.0	9.0											79
80	5.5	10.0	10.5	8.5	11.0	12.0	12.5											80
81	3.5	5.5	6.5	7.5	12.5	8.5	8.5											81
82	5.0	5.5	6.0	6.0	6.5	8.5	9.0											82
83	4.0	5.5	6.0	5.5	6.5	8.5	9.5											83
84	4.0	5.0	6.0	5.5	6.5	6.0	10.0											84
85	4.0	6.0	6.5	6.5	7.0	14.0	14.5											85
86	5.5	6.5	16.5	16.0	12.5	10.5	10.5											86
87	3.8	7.0	9.0	8.5	9.0	10.0	10.0											87
88	14.0	14.5	16.5	18.5	19.0	17.0	15.5											88
89	6.0	8.5	9.0	8.0	9.5	12.0	10.5											89
90	6.0	5.0	6.0	5.5	6.5	12.0	12.0											90

Lot 3, Effective Resistance

Sample Number	Initial Frequency (See Note)	After Shock	After Vibration	After Low-Temp. Storage	After Immersion	After Salt Spray	After Moisture Reistance	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
91	91231	91234	91270	91256	90999	90999								91
92	91259	91238	91260	91360	91090	91126								92
93	90490	90464	90600	90500	90310	90130								93
94	91042	91010	91144	91058	90840	90870								94
95	91222	91135	91114	91260	90999	91072								95
96	91544	91529	91560	91632	91632	91300								96
97	91565	91550	91630	91650	91366	91438								97
98	90959	90931	91004	91060	90958	90800								98
99	91286	91248	91310	91300	91288	90900								99
100	90655	90613	90541	90770	90740	90722								100
101	90730	90688	90712	90830	90525	90499								101
102	91037	91007	90996	91060	90090	90060								102
103	91200	91267	91214	91233	91250	91297								103
104	90955	90912	91000	91004	91000	91092								104
105	90925	91004	91025	91000	90978	90723								105
106	90818	90842	90905	90660	90850	90755								106
107	90628	90700	90731	90675	90652	90428								107
108	91300	91272	90192	90300	90362	90241								108
109	90944	90935	90950	91020	91002	90977								109
110	91044	91055	91150	91100	91090	90850								110
111	90700	90612	90700	90765	90771	91200								111
112	90400	90368	90358	90480	90469	90421								112
113	90645	90620	90604	90700	90695	90643								113
114	90976	90936	90957	91000	90991	90845								114
115	90487	90400	90367	90500	90500	90566								115
116	90759	90780	90850	90800	90803	90835								116
117	90694	90712	90750	90750	90700	90419								117
118	90815	90822	90920	90851	90850	90836								118
119	90312	90270	90333	90403	90370	90201								119
120	90354	90285	*											120

Note: The nominal frequency of these crystal units is 19,990,700 cps. The first three digits were dropped from the frequencies recorded above.

Lot 4, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
91	6.5	8.5	8.5	10.5	12.0	14.0		17.5	19.0									91
92	6.0	5.5	4.8	6.0	6.5	5.5		5.0	4.5									92
93	6.2	5.0	5.5	10.0	3.9	7.1		5.5	5.5									93
94	9.1	11.0	10.0	10.0	12.0	10.0		10.0	10.0									94
95	7.5	6.5	6.0	6.5	7.0	7.0		9.0	10.0									95
96	6.8	7.0	6.5	7.0	7.5	9.0		8.0	7.5									96
97	14.5	15.0	14.0	16.0	14.0	13.5		13.5	13.0									97
98	4.0	5.5	5.0	7.5	5.5	9.0		9.0	8.5									98
99	8.0	6.5	11.3	13.0	14.0	12.6		14.5	16.0									99
100	6.0	6.0	4.5	4.0	8.5	7.0		8.5	10.0									100
101	6.0	6.0	6.5	4.0	5.0	5.0		5.0	5.0									101
102	12.7	13.0	16.0	16.0	16.0	16.0		15.0	15.0									102
103	9.0	10.4	11.0	10.0	12.0	14.5		14.0	14.0									103
104	12.3	12.3	12.8	10.8	12.0	20.0		19.0	18.5									104
105	14.0	17.0	19.0	17.5	18.0	17.0		17.0	17.5									105
106	6.0	6.5	6.0	9.0	6.8	7.0		7.5	8.0									106
107	7.0	7.0	6.0	6.0	8.0	11.0		9.0	6.5									107
108	5.0	7.0	7.0	6.6	12.0	12.0		10.5	10.0									108
109	7.5	6.5	6.0	6.0	7.0	7.5		7.5	7.5									109
110	13.3	18.0	14.7	14.0	11.5	15.0		14.0	14.0									110
111	7.5	7.0	6.5	6.5	6.0	8.5		8.0	7.0									111
112	5.0	5.0	5.5	4.8	6.5	6.7		6.5	6.5									112
113	8.0	8.0	9.0	8.5	9.0	12.0		11.0	11.0									113
114	6.4	6.0	6.0	7.0	6.0	9.0		12.5	15.0									114
115	10.0	10.0	10.5	14.0	11.0	12.0		12.0	10.0									115
116	4.0	4.0	5.0	7.0	5.5	6.0		6.0	6.0									116
117	9.0	10.0	10.0	11.5	13.0	15.0		17.0	17.0									117
118	10.0	10.5	9.0	8.0	10.7	10.7		12.0	12.5									118
119	5.5	12.0	9.0	8.5	6.5	6.0		9.8	10.0									119
120	11.0	11.0	*															120

Lot 4, Effective Resistance

Sample Number	Initial Frequency	After Shock	After Vibration	After Low-Temp. Storage	After Immersion	After Salt Spray	After Moisture Resistance	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
1	97627	97533	97671	97800	97639	97810								1
2	97503	97498	97600	97700	97603	97697								2
3	97239	97217	97345	97463	97341	97300								3
4	97258	97207	97319	97400	97328	97400								4
5	97430	97448	97556	97688	97533	97600								5
6	97559	97478	97489	97625	97544	97620								6
7	97362	97230	97388	97500	97388	97480								7
8	96748	96642	96781	96850	96776	96858								8
9	96873	96759	96900	96900	96830	96786								9
10	97725	97645	97719	97800	97714	97802								10
11	97600	97586	97733	97850	97815	97888								11
12	97439	97393	97462	97555	97534	97576								12
13	97015	96990	97083	97015	97000	97030								13
14	97392	97388	97464	97566	97500	97563								14
15	97532	97460	97600	97778	97676	97777								15
16	97388	97418	97500	97573	97530	97590								16
17	97395	97389	97550	97669	97625	97676								17
18	97326	97238	97300	97384	97327	97385								18
19	97263	97200	97300	97200	97134	97212								19
20	96869	96750	96800	96800	*									20
21	98121	98040	98075	98000	97910	97880								21
22	97365	97250	97300	97200	97132	97199								22
23	98208	98150	98050	98059	98036	98005								23
24	97600	97500	97380	97515	97437	97492								24
25	97478	97400	97425	97400	97300	97300								25
26	97555	97475	97450	97440	97334	97430								26
27	97514	97400	97300	97450	97365	97450								27
28	96892	97007	96905	96666	96640	96701								28
29	97382	97280	97300	97100	97050	96900								29
30	97165	97000	97070	97100	97005	97005								30

Lot 5, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
1	18.2	17.5	18.0	20.0	18.0	18.0												1
2	18.7	18.5	19.6	21.2	19.6	19.6												2
3	22.0	20.5	22.0	24.5	22.0	22.0												3
4	22.0	20.0	21.3	25.0	21.3	21.3												4
5	34.0	32.5	34.0	34.0	33.0	21.3												5
6	23.0	23.0	24.5	28.7	24.5	24.0												6
7	18.7	18.0	18.0	21.0	18.0	24.0												7
8	22.0	22.0	22.0	25.0	22.0	19.5												8
9	27.7	25.0	27.0	29.7	26.4	23.3												9
10	22.0	21.5	22.0	29.0	25.0	28.0												10
11	22.0	22.0	22.0	25.0	22.0	25.0												11
12	28.7	28.0	28.0	34.0	28.0	22.6												12
13	33.3	31.5	31.5	36.0	28.7	28.7												13
14	28.7	26.0	28.0	29.7	27.5	30.0												14
15	23.3	23.0	25.5	27.0	25.5	28.0												15
16	28.7	27.0	28.0	33.3	28.0	25.5												16
17	28.7	26.0	27.0	29.0	25.5	27.0												17
18	22.0	20.5	21.0	24.4	22.0	25.0												18
19	23.3	25.0	24.4	27.0	24.4	24.4												19
20	34.0	34.0	36.5	40.0	*													20
21	34.0	33.3	33.3	37.0	34.0	34.0												21
22	31.0	30.0	33.3	35.0	30.0	32.0												22
23	28.7	27.0	27.5	30.5	28.7	30.5												23
24	28.0	27.0	28.0	31.4	28.7	28.7												24
25	25.0	25.0	25.0	28.0	25.0	26.0												25
26	22.0	20.0	20.0	23.4	21.0	21.0												26
27	28.7	29.0	30.0	33.3	28.0	29.0												27
28	34.0	28.7	30.0	28.7	29.0	30.0												28
29	27.7	25.0	28.0	30.0	28.0	34.0												29
30	34.0	34.0	31.5	34.0	35.2	35.0												30

Lot 5, Effective Resistance

Sample Number	Initial Frequency (See Note)	After Shock	After Vibration	After Heat Cycling	After Low-Temp. Storage	After Immersion	After Salt Spray	After Moisture Resistance	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Sample Number
A1	96960	96796	96730	96746	97158	97000	97046	This lost of samples was subjected to the Aging test and not to the Moisture Resistance test.	96832	97000	96890	97064	96985	A1
A2	97040	96966	96835	96901	97223	97255	97293		97186	97075	97091	97098	96924	A2
A3	97589	97581	97513	97499	97890	97840	97886		*					A3
A4	96831	96831	96698	96824	97232	97130	97191		96941	96941	97045	97033	97065	A4
A5	97398	97339	97208	97307	97208	97115	97168		97300	97400	97525	97500	97500	A5
A6	97042	96954	96900	96950	97291	97267	97302		97231	97131	97038	96993	96946	A6
A7	97551	97511	97464	97464	97848	97796	97845		97600	97473	97575	97591	97574	A7
A8	97336	97293	97180	97158	97580	97577	97542		97418	97397	97097	97068	97019	A8
A9	96204	96154	96049	96040	96447	96369	96181		96169	96098	96118	96169	96169	A9
A10	97383	97341	97168	97221	97631	97629	97641		97413	97396	97542	97490	97434	A10
A11	97590	97554	97443	97420	97775	97850	97824		97939	97871	97934	97976	97937	A11
A12	97151	97059	96994	96965	97359	97385	97343		97517	97761	97769	97258	97826	A12
A13	97477	97433	97371	97389	97777	97720	[illegible]		**					A13
A14	97237	97213	97064	97138	97534	97535	97533		97371	97348	97453	97519	97395	A14
A15	97442	97393	97270	97308	97733	97722	97710		97500	97436	97322	97329	97366	A15
A16	97170	97117	97012	97032	97403	97400	97466		97262	97265	97300	97347	97110	A16
A17	97563	97566	97463	97459	97843	97810	97840		97851	97657	97637	97642	97442	A17
A18	97314	97352	97156	97129	97559	97600	97620		97394	97332	97412	97416	97315	A18
A19	97264	97212	97116	97134	97526	97530	97523		97300	97290	97377	97308	97260	A19
A20	97029	96945	96833	96830	97249	97235	97215		96997	96990	97160	97116	96893	A20
A21	96797	96744	96638	96636	96710	97040	97054		96985	96922	96868	96703	96685	A21
A22	96599	96519	96425	96438	96806	96791	96810		96632	96604	96585	96590	96598	A22
A23	97288	97265	97151	97162	97375	97577	97572		97455	97300	97464	97423	97405	A23
A24	97564	97543	97435	97450	97483	97621	97876		97636	97649	97670	97556	97520	A24
A25	97381	97542	97240	97102	97104	97214	97508		97345	97245	97167	97272	97163	A25
A26	97626	97612	97518	97514	97587	97670	97642		97624	97644	97693	97656	97568	A26
A27	97026	97091	96944	97012	97157	97356	97428		97243	97214	97311	**		A27
A28	97668	97685	97592	97637	97801	97979	98065		98086	97986	97837	97773	97141	A28
A29	97145	97113	96960	97019	97072	97209	97297		97400	97373	97380	97421	97500	A29
A30	97559	97337	97456	97461	97590	97587	97658		97578	97550	97628	97658	97640	A30

Note: The nominal frequency of these crystal units is 19,997,000 cps. The first three digits were dropped from the frequency measurements recorded above.

Lot 6, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
A1	24.7	20.5	20.0	20.0	20.5	21.0		22.0	22.0	22.0	21.3	22.4						A1
A2	24.7	25.0	21.4	20.4	22.0	21.0		24.0	22.0	21.4	22.0	22.0						A2
A3	23.2	23.2	21.0	22.0	27.6	22.0		*										A3
A4	26.0	25.0	25.0	26.0	27.3	26.7		28.3	27.0	26.0	28.3	28.3						A4
A5	23.8	20.0	24.5	24.5	25.0	24.5		26.0	26.0	25.0	27.0	27.6						A5
A6	26.0	19.5	25.0	25.2	27.0	25.3		28.0	26.3	26.0	27.4	27.4						A6
A7	20.9	31.5	21.0	21.5	22.6	21.5		23.4	22.8	20.0	24.0	22.7						A7
A8	20.9	23.5	19.5	21.0	21.0	21.0		24.6	24.6	22.9	24.0	24.0						A8
A9	31.9	30.0	30.7	32.0	34.3	36.3		38.0	38.2	39.0	40.0	40.0						A9
A10	24.7	18.5	24.5	24.6	24.5	24.5		27.0	25.3	24.6	25.0	25.0						A10
A11	31.1	27.0	30.0	30.0	32.0	32.2		25.6	25.0	25.0	27.0	27.0						A11
A12	20.1	18.0	26.0	19.5	21.5	21.0		24.0	23.0	22.0	24.1	25.3						A12
A13	18.2	20.0	17.8	18.2	24.5	18.0		**										A13
A14	21.5	22.0	25.3	19.0	19.5	19.5		25.7	20.0	19.6	21.3	20.0						A14
A15	22.0	20.5	21.5	22.7	23.0	24.0		24.8	24.6	23.0	25.0	25.3						A15
A16	24.4	17.5	22.6	22.6	24.5	24.5		25.0	24.8	24.0	25.0	25.0						A16
A17	24.4	31.5	21.0	22.0	27.6	24.0		22.8	30.0	30.1	31.0	31.0						A17
A18	26.4	23.6	18.0	18.5	20.2	18.0		18.0	18.0	17.0	18.0	18.0						A18
A19	32.7	20.6	30.0	32.7	32.0	32.7		34.3	33.0	30.6	33.3	33.3						A19
A20	26.0	29.5	23.5	24.5	25.0	26.0		26.5	27.4	24.4	27.0	26.3						A20
A21	22.8	30.0	22.0	23.0	24.0	24.0		28.3	27.5	25.8	29.7	27.0						A21
A22	32.0	19.4	30.0	30.0	31.1	31.0		38.0	38.0	35.0	34.5	37.0						A22
A23	31.5	29.5	30.0	30.0	31.5	30.0		32.2	30.2	30.6	32.1	36.4						A23
A24	21.0	20.5	19.5	21.0	22.0	20.0		25.0	23.6	21.3	23.3	24.0						A24
A25	31.0	24.5	33.6	32.8	32.0	32.5		33.1	33.1	33.1	33.1	33.1						A25
A26	21.4	24.5	21.5	21.5	23.5	23.6		24.2	24.0	21.0	21.7	24.2						A26
A27	21.4	24.5	24.5	25.3	28.6	25.0		27.0	27.0	27.6	***							A27
A28	21.4	24.5	25.3	25.3	28.0	24.5		23.0	22.5	20.0	20.5	22.0						A28
A29	19.7	19.5	20.0	20.7	21.0	21.0		27.5	26.8	28.0	27.6	26.6						A29
A30	32.8	33.4	30.1	30.0	30.5	30.0		32.0	33.0	29.7	33.1	32.9						A30

Lot 6, Effective Resistance

Sample Number	Initial Frequency (See Note)	After Shock	After Vibration	After Low-Temp. Storage	After Immersion	After Salt Spray	After Moisture Resistance	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
1	96681	96560	96555	96833	96890	97016	97028							1
2	97086	96992	96968	97210	97235	97378	97388							2
3	96426	96315	96252	96507	96656	96741	96825							3
4	97234	97110	97109	97406	97474	97462	97450							4
5	96883	96789	96780	97043	97120	97241	97258							5
6	96105	96032	96012	96171	96300	96411	96414							6
7	97764	97656	97664	98057	98100	98226	98229							7
8	96886	96775	96769	97020	97117	97235	97264							8
9	97156	97050	97022	97287	97139	97187	97185							9
10	97262	97113	97125	97434	97435	97372	97377							10
11	97371	97240	97262	97523	97604	97714	97717							11
12	96803	96672	96650	96925	97027	96245	96240							12
13	96867	96765	96751	96924	97012	96909	96914							13
14	96762	96611	96647	96944	97000	96894	96885							14
15	97310	97202	97212	97284	97137	*								15
16	96933	96836	96819	97070	97222	97325		97322						16
17	96995	96879	96833	97096	96700	97327		97328						17
18	96474	96413	96352	96658	96700	96855		96843						18
19	97248	97154	97133	97373	97382	*								19
20	97058	96972	96954	97130	97333	97567		97567						20
21	96563	96478	*											21
22	97100	97029	97007	97267	97282	96853		96850						22
23	96493	96411	96396	96673	96787	96564		96544						23
24	97316	97241	97290	98105	97575	97567		97570						24
25	97079	97001	96997	97288	97369	97453		97462						25
26	96273	96186	96185	96444	96565	96667		96685						26
27	96063	96174	*											27
28	96624	96535	96495	*										28
29	96114	96054	96022	96200	96403	96543		96530						29
30	97058	96947	96821	96985	96840	96891		96804						30

Note: The nominal frequency of these crystal units is 49,997,000 cps. The first three digits were dropped from the frequencies recorded above.

Lot 9, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
1	25.0	26.2	24.6	25.0	24.0	26.0	24.0											1
2	25.0	25.0	25.3	26.5	25.6	27.3	25.2											2
3	26.5	27.0	24.0	26.5	25.0	26.0	25.0											3
4	32.0	29.5	30.4	31.0	31.0	30.0	34.0											4
5	28.4	30.4	28.4	28.0	28.3	29.6	28.3											5
6	30.0	32.0	31.0	33.3	32.0	33.1	32.6											6
7	29.2	29.2	31.0	31.6	31.6	32.4	31.0											7
8	26.5	28.3	29.5	27.0	27.2	27.2	26.0											8
9	29.0	30.0	28.6	30.0	30.0	31.6	33.0											9
10	32.5	33.5	29.8	32.2	31.5	30.2	30.4											10
11	32.1	32.0	30.5	30.5	29.0	31.0	33.0											11
12	32.1	32.1	32.0	32.0	31.1	31.9	34.6											12
13	27.3	30.0	32.0	28.0	29.6	31.6	32.0											13
14	31.8	33.5	32.5	32.0	32.0	32.4	30.9											14
15	26.4	28.0	27.0	30.0	28.6	*												15
16	24.0	23.6	26.5	27.8	27.0	28.3		26.0										16
17	34.4	35.0	36.2	37.0	37.0	38.0		37.0										17
18	34.4	35.6	35.6	34.4	37.0	37.4		36.0										18
19	27.3	24.9	28.0	28.0	30.8	*												19
20	27.3	24.0	28.0	28.6	27.0	29.0		28.3										20
21	37.1	34.3	*															21
22	31.2	31.2	35.0	36.0	32.0	35.4		37.2										22
23	31.2	33.0	32.4	33.3	30.4	32.0		33.0										23
24	23.0	27.0	30.5	32.3	33.0	36.3		40.0										24
25	35.0	35.0	34.3	34.6	34.0	38.0		36.2										25
26	29.0	32.4	30.8	27.9	30.0	28.0		30.2										26
27	29.5	31.3	*															27
28	37.5	35.0	36.3	*														28
29	37.5	36.5	36.0	37.0	35.5	37.0		35.0										29
30	30.0	30.5	30.4	30.7	31.3	34.4		34.3										30

Lot 9. Effective Resistance

Sample Number	Initial Frequency (See Note)	After Shock	After Vibration	After Low-Temp. Storage	After Immersion	After Salt Spray	After Moisture Resistance	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
1	90538	90559	90530	90563										1
2	90485	90525	90431	90500										2
3	90657	90725	90782	90666										3
4	90415	90430	90405	90413										4
5	90738	90520	90545	90715										5
6	90365	90444	90463	90437										6
7	90325	90300	90245	90329										7
8	90474	90500	90422	90393										8
9	90369	90450	90379	90385										9
10	90478	90509	90488	90467										10
11	90719	90803	90710	90700										11
12	90640	90709	90668	90663										12
13	90479	90555	90551	90469										13
14	90320	90400	90315	90336										14
15	90380	90475	90395	90400										15
16	90500	90554	90505	90528										16
17	90545	90470	90372	90385										17
18	90400	90598	90507	90560										18
19	90577	90609	90553	90567										19
20	90206	90219	90129	90101										20
21	90363	90405	90363	90376										21
22	90759	90824	90768	90790										22
23	90418	90468	90398	90417										23
24	90150	90269	90198	90222										24
25	90779	90825	90781	90800										25
26	90270	90307	90323	90243										26
27	90480	90524	90429	90512										27
28	90214	90245	90202	90242										28
29	90420	90466	90409	90442										29
30	91260	91300	91253	91225										30

Lot 11, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
1	5.0	3.0	4.0	4.0														1
2	6.0	5.0	6.0	6.0														2
3	6.0	5.5	5.0	6.0														3
4	5.5	4.0	4.0	5.0														4
5	6.0	5.0	5.0	6.5														5
6	5.0	5.0	3.5	5.0														6
7	5.0	4.5	4.5	6.0														7
8	5.0	3.5	4.0	3.0														8
9	4.5	3.5	3.0	4.0														9
10	4.0	3.0	4.0	4.0														10
11	5.0	4.0	5.0	4.5														11
12	3.5	4.0	5.0	5.5														12
13	5.0	5.0	6.0	5.5														13
14	6.0	5.5	6.0	6.0														14
15	3.5	3.0	3.5	3.5														15
16	4.0	3.5	3.5	3.0														16
17	5.0	4.5	5.0	4.5														17
18	5.0	4.5	5.0	5.0														18
19	5.0	5.5	4.0	6.0														19
20	5.0	5.0	5.3	5.5														20
21	3.5	3.5	3.8	3.5														21
22	7.0	6.0	6.0	6.0														22
23	3.0	3.5	3.5	3.0														23
24	5.0	4.5	4.5	5.0														24
25	5.5	5.0	4.5	5.5														25
26	5.5	5.0	5.3	5.5														26
27	4.0	4.0	5.3	4.5														27
28	6.5	5.5	5.4	6.5														28
29	4.0	5.0	5.3	4.0														29
30	6.0	6.0	7.5	6.5														30

Lot 11, Effective Resistance

Sample Number	Initial Frequency (See Note)	After Shock	After Vibration	After Low-Temp. Storage	After Immersion	After Salt Spray	After Moisture Resistance	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
31	90145	90212	90200	90204										31
32	90516	90600	90554	90575										32
33	90440	90524	90480	90484										33
34	90873	90970	90895	90880										34
35	90617	90705	90639	90654										35
36	90500	90568	90527	90527										36
37	90633	90717	90681	90665										37
38	90365	90457	90415	90423										38
39	90270	90355	90318	90326										39
40	90350	90411	90397	90389										40
41	90300	90303	90351	90370										41
42	90215	90315	90285	90291										42
43	90500	90600	90570	90563										43
44	90594	90571	90635	90648										44
45	90380	90450	90445	90439										45
46	90322	90400	90378	90360										46
47	90425	90499	90478	90483										47
48	90283	90350	90313	90330										48
49	90650	90730	90690	90700										49
50	90152	90250	90200	90215										50
51	90160	90237	90233	90207										51
52	90400	90454	90431	90448										52
53	90420	90500	90472	90480										53
54	90450	90511	90487	90474										54
55	90535	90601	90581	90580										55
56	90346	90413	90378	90350										56
57	90400	90470	90434	90452										57
58	90360	90402	90354	90373										58
59	89810	89904	89877	89899										59
60	90637	90680	90665	90693										60

Lot 12, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
61	3.5	4.0	3.5	4.5														61
62	4.0	4.0	4.0	5.0														62
63	6.0	4.5	4.5	4.0														63
64	5.0	3.5	3.5	5.0														64
65	6.0	4.5	4.5	5.0														65
66	5.5	5.0	5.0	4.5														66
67	7.0	6.0	6.0	7.0														67
68	3.5	3.5	3.5	4.5														68
69	7.5	6.5	6.0	6.0														69
70	5.0	5.0	3.5	5.0														70
71	5.0	5.0	5.0	4.5														71
72	5.0	4.5	4.5	3.0														72
73	5.0	5.5	5.0	4.0														73
74	4.5	5.0	5.0	4.0														74
75	6.0	6.5	6.5	5.0														75
76	6.0	5.0	5.0	6.5														76
77	5.0	4.5	4.5	3.5														77
78	5.0	4.0	4.5	3.5														78
79	4.5	3.0	3.5	3.5														79
80	6.5	4.5	4.0	4.0														80
81	4.5	4.5	3.5	3.5														81
82	6.5	6.0	6.0	6.5														82
83	5.5	5.5	5.5	4.5														83
84	6.5	4.5	4.0	5.0														84
85	6.5	5.5	6.0	6.0														85
86	6.5	6.0	6.0	6.0														86
87	4.5	4.0	4.0	3.5														87
88	6.5	6.0	6.0	4.0														88
89	5.5	4.5	4.0	4.0														89
90	4.0	4.0	4.0	5.0														90

Lot 12, Effective Resistance

Sample Number	Initial Frequency (See Note)	After Shock	After Vibration	After Low-Temp. Storage	After Immersion	After Salt Spray	After Moisture Resistance	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
61	90245	90313	90226	90330										61
62	90255	90332	90236	90329										62
63	89775	89858	89868	90822										63
64	90690	90756	90669	90748										64
65	90346	90433	90351	90348										65
66	90523	90600	90597	90600										66
67	90900	90977	90997	90933										67
68	90550	90628	90541	90607										68
69	90220	90304	90206	90040										69
70	90413	90482	90407	90484										70
71	90075	90069	90058	90126										71
72	90242	90327	90234	90300										72
73	90170	90233	90155	90189										73
74	90552	90610	90563	90409										74
75	90620	90691	90629	90673										75
76	90374	90447	90381	90424										76
77	90563	90628	90574	90630										77
78	90811	90819	90831	90960										78
79	90729	90793	90734	90765										79
80	90357	90371	90262	90295										80
81	90199	90266	90216	90263										81
82	90127	90194	90163	90204										82
83	90460	90543	90468	90519										83
84	90364	90439	90405	90438										84
85	90740	90784	90756	90765										85
86	90269	90330	90267	90323										86
87	90304	90319	90299	90341										87
88	90573	90634	90590	90612										88
89	90499	90561	90528	90569										89
90	90562	90667	90627	90628										90

Lot 13, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
31	4.0	3.5	3.5	4.0														31
32	5.0	4.0	3.5	4.0														32
33	5.0	4.0	3.0	4.0														33
34	4.0	5.5	5.0	4.0														34
35	4.0	3.5	3.0	4.5														35
36	5.5	5.5	3.5	4.5														36
37	5.0	4.5	4.0	5.0														37
38	6.5	4.5	4.0	5.0														38
39	5.5	5.0	3.5	4.5														39
40	6.0	5.0	3.5	5.0														40
41	5.0	5.0	4.0	4.0														41
42	7.5	6.0	4.5	6.0														42
43	6.5	6.5	6.0	6.0														43
44	4.5	4.0	3.5	3.5														44
45	5.0	4.0	4.5	5.0														45
46	6.5	5.0	4.5	6.0														46
47	6.0	5.0	4.5	5.0														47
48	6.0	5.0	4.5	5.3														48
49	5.0	4.5	4.5	4.5														49
50	5.0	5.5	4.5	4.5														50
51	4.5	3.5	4.0	4.0														51
52	4.5	4.0	4.0	4.5														52
53	5.5	4.5	4.0	5.0														53
54	4.0	4.0	3.5	3.5														54
55	3.5	3.5	3.5	4.0														55
56	4.0	3.5	3.0	4.0														56
57	3.5	3.5	3.0	5.0														57
58	6.0	5.5	3.5	4.5														58
59	4.0	4.5	3.5	4.0														59
60	4.0	3.5	4.0	4.0														60

Lot 13, Effective Resistance

Sample Number	Initial Frequency	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
1	97282	97240	97159	97270										1
2	97400	97340	97347	97388										2
3	97150	97100	97024	97101										3
4	97123	97000	96951	97024										4
5	97240	97220	97164	97234										5
6	97445	97383	97319	97317										6
7	97444	97359	97344	97368										7
8	97290	97222	97130	97212										8
9	97120	96919	96756	96738										9
10	97255	97210	97137	97200										10
11	96857	96590	96458	96448										11
12	97074	97000	96837	96984										12
13	97500	97447	97335	97422										13
14	97256	97176	97114	97064										14
15	97200	97132	97137	97166										15
16	97361	97373	97316	97358										16
17	97068	97020	96908	96980										17
18	97376	97313	97236	97263										18
19	97183	97101	96970	97081										19
20	97086	96875	96659	96489										20
21	97222	97160	97034	97030										21
22	97160	97131	97062	97068										22
23	97230	97020	96853	96965										23
24	97356	97254	97186	97211										24
25	97000	*												25
26	97307	97265	97185	97166										26
27	97013	96814	96673	96705										27
28	97254	97050	96860	96800										28
29	97256	97065	96887	96868										29
30	97174	97128	97003	97075										30

Lot 15, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
1	22	21	22	22	22	24												1
2	20	20	21	20	19	20												2
3	18	17	19	19	18	19												3
4	20	19	20	21	19	19												4
5	18	18	18	19	18	18												5
6	32	30	30	30	30	30												6
7	32	30	32	32	30	32												7
8	19	18	19	19	18	18												8
9	24	22	24	22	25	27												9
10	16	15	16	17	16	17												10
11	22	22	22	22	20	21												11
12	17	17	17	18	16	18												12
13	16	15	15	16	15	15												13
14	21	20	20	21	20	20												14
15	23	21	21	22	21	22												15
16	25	24	25	24	24	26												16
17	21	19	20	21	19	20												17
18	26	24	25	22	18	18												18
19	18	19	19	19	18	19												19
20	21	21	22	20	17	13												20
21	29	28	29	30	28	28												21
22	20	18	19	22	18	20												22
23	24	22	24	24	22	24												23
24	21	20	21	21	20	22												24
25	15	*																25
26	20	20	20	20	18	20												26
27	17	16	17	17	20	*												27
28	18	17	18	17	21	25												28
29	18	18	19	20	19	23												29
30	19	18	18	18	19	18												30

Lot 15, Effective Resistance

Sample Number	Initial Frequency	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
A1	97137	96999	96939	97026										A1
A2	97261	97162	96956	97150										A2
A3	97261	97162	97077	97134										A3
A4	97438	97381	97184	97310										A4
A5	97042	97010	96928	96945										A5
A6	97474	97381	97271	97360										A6
A7	97507	97347	97307	97408										A7
A8	97285	97221	97167	97153										A8
A9	97214	97179	97132	97180										A9
A10	97258	97179	97123	97186										A10
A11	97583	97472	97342	97370										A11
A12	97300	97266	97200	97245										A12
A13	97187	97134	97069	97093										A13
A14	97310	97266	97159	97200										A14
A15	97366	97472	97336	97379										A15
A16	97384	97381	97289	97300										A16
A17	97400	97300	97213	97300										A17
A18	97322	97221	97168	97201										A18
A19	97339	97300	97234	97298										A19
A20	97409	97300	97315	97350										A20
A21	97314	97200	97183	97229										A21
A22	96888	96795	96705	96776										A22
A23	96875	96733	96578	96730										A23
A24	97370	97266	97230	97244										A24
A25	97300	97179	97140	97128										A25
A26	97150	97070	97019	96969										A26
A27	97261	97251	97165	97146										A27
A28	97515	97472	97442	97447										A28
A29	97192	97134	97073	97030										A29
A30	97125	96999	96845	96817										A30

Lot 16, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
A1	18	18	18	18	19	18												A1
A2	25	24	24	25	25	25												A2
A3	18	18	18	18	18	17												A3
A4	21	20	21	21	21	20												A4
A5	25	24	26	25	24	24												A5
A6	19	20	22	22	19	18												A6
A7	23	24	22	22	22	21												A7
A8	20	20	20	22	22	19												A8
A9	16	17	17	16	17	15												A9
A10	17	17	18	17	18	17												A10
A11	22	21	21	22	25	22												A11
A12	20	19	19	18	19	18												A12
A13	28	24	25	25	23	23												A13
A14	18	18	19	18	18	18												A14
A15	22	22	20	19	20	19												A15
A16	18	18	18	18	18	17												A16
A17	20	20	20	19	20	19												A17
A18	17	16	16	16	17	16												A18
A19	24	22	22	22	24	27												A19
A20	25	25	25	25	25	25												A20
A21	25	25	25	25	25	24												A21
A22	25	25	25	24	24	22												A22
A23	39	37	40	36	34	35												A23
A24	18	18	18	18	18	18												A24
A25	18	17	18	17	18	17												A25
A26	22	22	22	22	21	20												A26
A27	19	18	18	18	18	18												A27
A28	24	24	24	23	24	22												A28
A29	18	18	18	18	18	18												A29
A30	22	21	21	21	24	22												A30

Lot 16, Effective Resistance

Sample Number	Initial Frequency	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
T1	97259	97240	97195	97189										T1
T2	97274	97260	97205	97258										T2
T3	97078	96960	96920	96934										T3
T4	96923	96856	96790	96850										T4
T5	97279	97200	97178	97213										T5
T6	97200	97145	97087	97115										T6
T7	97181	97100	97089	97084										T7
T8	97143	97000	97023	97072										T8
T9	97423	97347	97315	97354										T9
T10	96840	96670	96530	96580										T10
T11	97027	96960	96907	96969										T11
T12	97200	97200	97159	97189										T12
T13	97187	97070	97051	97097										T13
T14	97543	97400	97418	97340										T14
T15	97145	97070	97109	97111										T15
T16	97110	96856	96674	96672										T16
T17	97272	97200	97166	97216										T17
T18	97335	97145	97206	97217										T18
T19	97234	97100	97133	97060										T19
T20	97248	97200	97175	97200										T20
T21	97008	96960	96989	96929										T21
T22	97100	97000	96976	97017										T22
T23	97015	96900	96869	96900										T23
T24	97464	97391	97353	97337										T24
T25	97344	97260	97100	97200										T25
T26	97393	97333	97265	97285										T26
T27	97344	97145	97234	97222										T27
T28	97093	96856	96717	96728										T28
T29	97028	96960	96925	96875										T29
T30	97440	97391	97300	97347										T30

Lot 17, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
T1	18	18	18	18	18	17												T1
T2	18	19	19	18	19	20												T2
T3	19	18	18	18	20	13												T3
T4	30	30	30	30	30	30												T4
T5	28	28	28	28	28	28												T5
T6	19	19	20	19	20	19												T6
T7	18	17	18	18	18	16												T7
T8	26	27	26	25	25	24												T8
T9	18	18	18	18	18	17												T9
T10	17	16	18	18	18	16												T10
T11	30	30	30	30	30	28												T11
T12	16	16	16	16	16	20												T12
T13	21	19	20	19	20	19												T13
T14	25	24	25	22	22	21												T14
T15	24	22	23	22	22	21												T15
T16	17	17	17	18	18	17												T16
T17	17	17	18	18	17	16												T17
T18	19	18	19	18	19	18												T18
T19	20	19	20	21	20	19												T19
T20	22	21	21	22	21	21												T20
T21	18	18	18	18	18	18												T21
T22	17	17	17	17	17	16												T22
T23	22	22	22	22	22	22												T23
T24	28	27	27	27	28	27												T24
T25	19	19	19	18	19	18												T25
T26	30	28	30	30	30	28												T26
T27	30	28	28	28	28	27												T27
T28	24	24	25	22	25	24												T28
T29	19	18	18	19	19	18												T29
T30	20	24	20	19	20	19												T30

Lot 17, Effective Resistance

Sample Number	Initial Frequency	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Sample Number
1	97950													1
2	98000													2
3	97745													3
4	97855													4
5	97867													5
6	97927													6
7	98058													7
8	98212													8
9	97933													9
10	97943													10
11	97800													11
12	97715													12
13	97877													13
14	97703													14
15	97621													15
16	97814													16
17	97888													17
18	98100													18
19	97684													19
20	97952													20
21	98132													21
22	98035													22
23	98114													23
24	98068													24
25	97962													25
26	98000													26
27	97752													27
28	97700													28
29	97976													29
30	98057													30

Lot 20, Series Resonant Frequency

Sample Number	Initial Resistance	After Shock	After Vibration	After Low-Temp.	After Immersion	After Salt Spray	After Mois. Res.	After Aging	Storage 24 hours	Storage 125 hours	Storage 225 hours	Storage 500 hours	Storage 1000 hours	Storage 2000 hours	Storage 3000 hours	Storage 4000 hours	Storage 5000 hours	Sample Number
1	22																	1
2	22																	2
3	22																	3
4	27																	4
5	24																	5
6	26																	6
7	22																	7
8	24																	8
9	22																	9
10	23																	10
11	30																	11
12	25																	12
13	32																	13
14	30																	14
15	24																	15
16	30																	16
17	22																	17
18	25																	18
19	26																	19
20	27																	20
21	22																	21
22	22																	22
23	21																	23
24	20																	24
25	25																	25
26	22																	26
27	22																	27
28	25																	28
29	26																	29
30	20																	30

Lot 20, Effective Resistance

GENERAL DATA SHEET

TEST Capacitance, Shunt	SPEC: MIL-C-3098C	PAR: 4.7.3	TEST NO:
CONDITIONING: Room ambient			DATE:
MATERIAL: Crystal Unit, Quartz, Type CR-18A/U			TEMP: RH:
MANUFACTURER: "A"			M. NO:
INSTRUMENTS: Lots Number 1 and Number 2			TESTED BY: D. Switzer LAB SUP CHECK: H. Barrett ENGRG CHECK: C. F. J...

Sample Number	Capacitance, Pin-to-Pin, Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads
1	5.3	21	5.4	41	5.3
2	5.7	22	5.3	42	5.4
3	5.2	23	5.0	43	5.6
4	5.6	24	5.4	44	5.6
5	5.4	25	5.3	45	5.6
6	5.4	26	5.3	46	5.4
7	5.4	27	5.7	47	5.3
8	5.3	28	5.3	48	5.3
9	5.3	29	5.3	49	5.3
10	5.3	30	5.6	50	5.3
11	5.3	31	5.4	51	5.4
12	5.4	32	5.2	52	5.6
13	5.0	33	5.1	53	5.7
14	5.3	34	5.5	54	5.4
15	5.2	35	5.4	55	5.4
16	5.4	36	5.4	56	5.2
17	5.4	37	5.3	57	5.2
18	5.5	38	5.2	58	5.3
19	5.6	39	5.1	59	5.1
20	5.3	40	5.4	60	5.3

Required: The shunt capacitance of the crystal units shall not exceed 7.0 pf. pin-to-pin.

GENERAL DATA SHEET

TEST	SPEC:	PAR:	TEST NO:
Capacitance, Shunt	MIL-C-3098C	4.7.3	

CONDITIONING: Room ambient

DATE:

MATERIAL: Crystal Unit, Quartz, Type CR-18A/U

TEMP: **RH:**

MANUFACTURER: "A"

M. NO:

INSTRUMENTS:

Lots Number 3 and Number 4

TESTED BY: D. Switzer

LAB SUP CHECK: H. Barrett

ENGRG CHECK: C. E. Jones

Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads
61	5.5	81	5.5	101	5.5
62	5.3	82	5.3	102	5.6
63	5.3	83	5.4	103	5.3
64	5.5	84	5.4	104	5.1
65	5.4	85	5.4	105	5.4
66	5.3	86	5.5	106	5.1
67	5.6	87	5.4	107	5.2
68	5.6	88	5.0	108	5.2
69	5.6	89	5.3	109	5.1
70	5.7	90	5.4	110	5.3
71	5.7	91	5.7	111	5.4
72	5.6	92	5.3	112	5.3
73	5.3	93	5.6	113	5.3
74	5.4	94	5.4	114	5.4
75	5.2	95	5.5	115	5.4
76	5.3	96	5.3	116	5.3
77	5.4	97	5.2	117	5.3
78	5.2	98	5.4	118	5.3
79	5.1	99	5.5	119	5.4
80	5.5	100	5.6	120	5.2

Required: The shunt capacitance of the crystal units shall not exceed 7.0 pf, pin-to-pin.

GENERAL DATA SHEET

TEST Capacitance, Shunt	SPEC: MIL-C-3098C	PAR: 4.7.3	TEST NO:
CONDITIONING: Room ambient			DATE:
MATERIAL: Crystal Unit, Quartz, Type CR-67/U			TEMP: RH:
MANUFACTURER: "A"			M. NO:
INSTRUMENTS: Lots Number 5 and Number 6			TESTED BY: D. Switzer LAB SUP CHECK: H. Barrett ENGRG CHECK: C. E. J

Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads
1	5.5	21	6.4	A11	5.4
2	5.4	22	6.5	A12	5.4
3	5.5	23	6.4	A13	5.5
4	5.6	24	6.5	A14	5.4
5	5.5	25	6.5	A15	5.6
6	5.6	26	6.6	A16	5.3
7	5.5	27	6.4	A17	5.3
8	5.4	28	6.6	A18	5.6
9	5.6	29	6.4	A19	5.5
10	5.8	30	6.4	A20	5.6
11	5.8	A1	5.4	A21	5.5
12	5.7	A2	5.4	A22	5.4
13	5.6	A3	5.5	A23	5.3
14	5.9	A4	5.5	A24	5.5
15	5.5	A5	5.5	A25	5.4
16	5.6	A6	5.4	A26	5.7
17	5.7	A7	5.3	A27	5.9
18	5.6	A8	5.3	A28	5.6
19	6.6	A9	5.7	A29	5.7
20	6.3	A10	5.5	A30	5.6

Required: The shunt capacitance of the crystal units shall not exceed 7.0 pf, pin-to-pin.

GENERAL DATA SHEET

TEST: Capacitance, Shunt	SPEC: MIL-C-3098C	PAR: 4.7.3	TEST NO:
CONDITIONING: Room ambient			DATE:
MATERIAL: Crystal Unit, Quartz, Type CR-32A/U			TEMP: RH:
MANUFACTURER: "A"			M. NO:
INSTRUMENTS: Lot Number 9			TESTED BY: D. Switzer
			LAB SUP CHECK: H. Barrett
			ENGRG CHECK:

Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads
1	5.2	11	5.8	21	5.4
2	5.3	12	5.7	22	5.7
3	5.6	13	5.2	23	5.0
4	5.4	14	5.5	24	5.3
5	5.1	15	5.2	25	5.1
6	5.3	16	5.2	26	5.2
7	5.2	17	5.7	27	5.2
8	5.3	18	5.4	28	5.4
9	5.3	19	5.2	29	5.6
10	5.5	20	5.2	30	5.3

Required: The shunt capacitance of the crystal units shall not exceed 7.0 pf, pin-to-pin.

GENERAL DATA SHEET

TEST: Capacitance, Shunt	SPEC: MIL-C-3098C	PAR: 4.7.3	TEST NO:
CONDITIONING: Room ambient			DATE:
MATERIAL: Crystal Unit, Quartz, Type CR-18A/U			TEMP: RH:
MANUFACTURER: "B"			M. NO:
INSTRUMENTS: Lot Number 11 and 12			TESTED BY: D. Switzer
			LAB SUP CHECK: H. Barrett
			ENGRG CHECK:

Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads
1	5.8	21	5.9	41	6.0
2	5.7	22	5.8	42	5.8
3	5.8	23	5.8	43	5.9
4	5.8	24	5.8	44	5.8
5	5.8	25	5.8	45	5.8
6	5.7	26	5.8	46	5.7
7	5.7	27	5.9	47	5.7
8	5.8	28	5.8	48	5.8
9	5.8	29	5.9	49	5.9
10	5.8	30	5.8	50	5.9
11	5.7	31	5.7	51	5.9
12	5.7	32	5.8	52	5.9
13	5.7	33	5.8	53	5.8
14	5.8	34	5.9	54	5.9
15	5.7	35	5.8	55	5.8
16	5.8	36	5.9	56	6.0
17	5.8	37	5.9	57	5.9
18	5.8	38	5.7	58	6.0
19	5.9	39	6.0	59	6.0
20	5.9	40	5.9	60	6.0

Required: The shunt capacitance of the crystal units shall not exceed 7.0 pf, pin-to-pin.

GENERAL DATA SHEET

TEST	SPEC:	PAR:	TEST NO:
Capacitance, Shunt	MIL-C-3098C	4.7.3	
CONDITIONING: Room ambient			DATE:
MATERIAL: Crystal Unit, Quartz, Type CR-18A/U			TEMP: RH:
MANUFACTURER: "B"			M. NO:
INSTRUMENTS: Lot Number 13			TESTED BY: D. Switzer
			LAB SUP CHECK: H. Barrett
			ENGRG CHECK: C. E. Jones

	Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads	
	61	5.8	76	5.9	
	62	5.8	77	5.7	
	63	5.8	78	5.8	
	64	5.8	79	5.7	
	65	5.8	80	5.8	
	66	5.9	81	5.8	
	67	5.8	82	5.8	
	68	5.9	83	5.8	
	69	5.9	84	5.8	
	70	5.8	85	5.8	
	71	5.7	86	5.8	
	72	5.9	87	5.8	
	73	5.9	88	5.8	
	74	5.9	89	5.8	
	75	5.8	90	5.7	

Required: The shunt capacitance of the crystal units shall not exceed 7.0 pf, pin-to-pin.

GENERAL DATA SHEET

TEST Capacitance, Shunt	SPEC: MIL-C-3098C	PAR: 4.7.3	TEST NO:
CONDITIONING: Room ambient			DATE:
MATERIAL: Crystal Unit, Quartz, Type CR-67/U			TEMP: RH:
MANUFACTURER: "B"			M. NO:
INSTRUMENTS: Lots Number 15 and Number 16			TESTED BY: D. Switzer LAB SUP CHECK: H. Barrett ENGRG CHECK: C. E. Jones

Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads
1	4.4	21	4.4	A11	4.5
2	4.5	22	4.6	A12	4.5
3	4.5	23	4.4	A13	4.5
4	4.5	24	4.4	A14	4.5
5	4.4	25	4.6	A15	4.4
6	4.4	26	4.4	A16	4.4
7	4.5	27	4.5	A17	4.6
8	4.5	28	4.4	A18	4.5
9	4.4	29	4.4	A19	4.5
10	4.5	30	4.4	A20	4.5
11	4.4	A1	4.4	A21	4.4
12	4.4	A2	4.4	A22	4.5
13	4.5	A3	4.5	A23	4.4
14	4.4	A4	4.4	A24	4.5
15	4.5	A5	4.5	A25	4.5
16	4.6	A6	4.4	A26	4.5
17	4.4	A7	4.6	A27	4.6
18	4.5	A8	4.5	A28	4.4
19	4.4	A9	4.4	A29	4.6
20	4.4	A10	4.4	A30	4.4

Required: The shunt capacitance of the crystal units shall not exceed 7.0 pf, pin-to-pin.

GENERAL DATA SHEET

TEST Capacitance, Shunt	SPEC: MIL-C-3098C	PAR: 4.7.3	TEST NO:
CONDITIONING: Room Ambient			DATE:
MATERIAL: Crystal Unit, Quartz, Type CR-67/U			TEMP: RH:
MANUFACTURER: "B"			M. NO:
INSTRUMENTS: Lots Number 17 and Number 18			TESTED BY: D. Switzer LAB SUP CHECK: H. Barrett ENGRG CHECK: C. E. Jones

Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads
T1	4.5	T21	4.4	L11	
T2	4.5	T22	4.5	L12	
T3	4.6	T23	4.6	L13	
T4	4.4	T24	4.5	L14	
T5	4.4	T25	4.5	L15	
T6	4.6	T26	4.6	L16	
T7	4.5	T27	4.4	L17	
T8	4.5	T28	4.4	L18	
T9	4.5	T29	4.4	L19	
T10	4.6	T30	4.4	L20	
T11	4.6	L1		L21	
T12	4.6	L2		L22	
T13	4.6	L3		L23	
T14	4.6	L4		L24	
T15	4.6	L5		L25	
T16	4.6	L6		L26	
T17	4.5	L7		L27	
T18	4.5	L8		L28	
T19	4.6	L9		L29	
T20	4.5	L10		L30	

Required: The shunt capacitance of the crystal units shall not exceed 7.0 pf, pin-to-pin.

GENERAL DATA SHEET

TEST Capacitance, Shunt	SPEC: MIL-C-3098C	PAR: 4.7.3	TEST NO:
CONDITIONING: Room ambient			DATE:
MATERIAL: Crystal Unit, Quartz, CR-74/U			TEMP: RH:
MANUFACTURER: "B"			M. NO:
INSTRUMENTS: Lot Number 20			TESTED BY: W. Janney LAB SUP CHECK: H. Barrett ENGRG CHECK: C. E. Jan

	Sample Number	Capacitance Pin-to-Pin Picofarads	Sample Number	Capacitance Pin-to-Pin Picofarads	
	1	4.6	16	4.5	
	2	4.4	17	4.5	
	3	4.5	18	4.5	
	4	4.5	19	4.5	
	5	4.4	20	4.4	
	6	4.4	21	4.5	
	7	4.5	22	4.4	
	8	4.4	23	4.5	
	9	4.5	24	4.4	
	10	4.4	25	4.5	
	11	4.4	26	4.6	
	12	4.4	27	4.5	
	13	4.4	28	4.5	
	14	4.4	29	4.5	
	15	4.5	30	4.6	

Conclusions

Since only a small percentage of the sample crystals are in the storage portion of this program, and these have been in storage for only a relatively short period of time, not enough data has yet been accumulated that any useful evaluation and analysis can be performed. When the next Quarterly Report is prepared, there will be sufficient information recorded that a meaningful review and analysis can be made, and some conclusions drawn concerning the objectives of this study.

Program for the Next Interval

During the next report period, preproduction testing of all crystals required for this program will be concluded, and all the crystals will be in Phase II testing. The data presently on hand and the data accruing during the next period will be analyzed to determine if any particular factors that produce failures of quartz crystals can be identified and explained.

Identification of Personnel

During the period covered by this report, two people have been directly assigned to this contract. These are the Project Engineer, Mr. Carleton E. Jones, and a technician, Mr. Dixon Switzer. A description of their backgrounds was included in the First Quarterly Report.

A second engineer, Mr. Robert Pease, also worked on this contract during this report period, designing the printed circuit oscillators used for the program, and supervising the fabrication and initial operation of the oscillator boards.

Through the end of this report period, Mr. Jones has performed approximately 850 man-hours of work on this contract, Mr. Pease 470 man-hours, and Mr. Switzer 690 man-hours.

A brief description of the background of Mr. Pease is given below.

PEASE, ROBERT W. - Engineer

Years Actively Engaged in Profession - 24 Years

Academic Training

Ohio State University 1931-1936

Employment Record

Dates	Company	Duties
1960 - Present	Inland Testing Laboratories	Engineer
1958 - 1960	Jackson Electrical Instr. Co.	Engineer
1957 - 1958	Production Control Units, Inc.	Engineer
1954 - 1957	Frigidaire Div. G.M.C.	Process Engineer
1953 - 1954	Acro Mfg. Co.	Project Engineer
1939 - 1953	Ranco Inc.	Asst. Dir. of Lab.
1936 - 1938	Battelle Memorial Institute	Lab. Technician

Professional Experience

Inland Testing Laboratories - Engineer

Engaged in the designing of test fixtures and circuits; supervise technicians in the performance of electrical and environmental tests; prepare test procedures and reports.

Supervised test programs on aircraft transceivers; rescue transmitters; alarm receivers; oscilloscopes; Signal Corps transmitters and receivers; R.F. broad band transformers; crystal test circuits and fixtures.

Jackson Electrical Instrument Co. - Engineer

Engaged in design of electronic circuits and instruments.

Designed transistorized marine depth sounder and detergent mixture detector for commercial dish washers.

Production Control Units, Inc.

Engaged in design of special equipment.

Designed electrical circuits and requisitioned parts for automatic vacuum alarm and dehydration equipment for hermetically sealed refrigeration compressors.

Frigidaire Division, General Motors Corp. - Process Engineer

Responsible for design and construction supervision of process tools and equipment for use in manufacturer of motor starting relays. This included automatic control circuits and automated assembly and inspection. Also responsible for plant layout for this department.

Acro Manufacturing Co. - Project Engineer

Responsible for design of spring forming machine and water level control for automatic home washers and dish washers.

Ranco, Inc. - Asst. Director of Laboratory

Responsible for supervision of laboratory technicians during absence of Director. Designed and supervised construction of laboratory test equipment and production assembly and test equipment.

Battelle Memorial Institute - Lab. Technician

Performed tests necessary in study of the corrosion of various steel alloys.

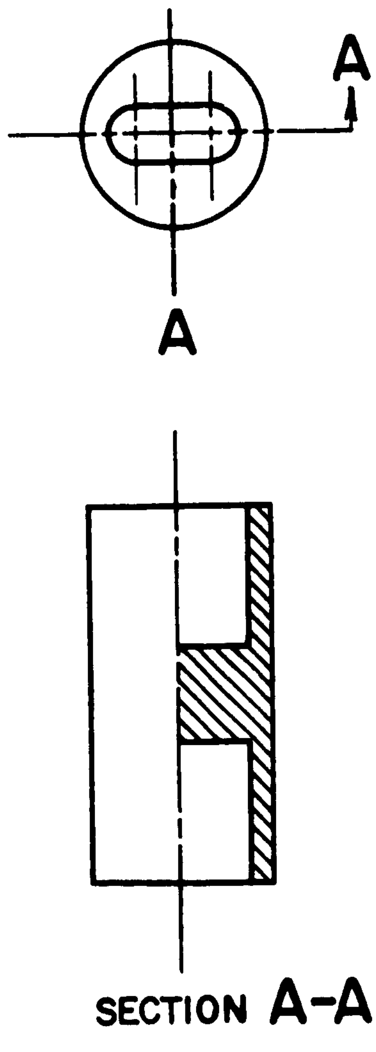

FIGURE 1.

Second Quarterly Progress Report, Contract DA 36-039 SC-89199

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