Automatic Aging Calculation for Transducer Piezoelectric Ceramic

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The "RING" computer program was developed to calculate the aging rate of piezoelectric ceramic materials. The program computes the percent aging rate for ceramic capacitance, resonant frequency, and coupling coefficient as a function of logarithmic time decades. Program options enable the user to store and edit data, perform statistical analyses, and display printed or plotted ceramic properties.

**Subject Terms**
- piezoelectric ceramic; ceramic
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New London, Connecticut 06320

Technical Memorandum

Automatic Aging Calculation for Transducer Piezoelectric Ceramic

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Prepared by: Richard Lamprecht
ABSTRACT

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ADMINISTRATIVE INFORMATION

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The author of this memorandum is located at the Naval Underwater System Center New London Laboratory, New London, CT 06320.

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INTRODUCTION

A computer program was developed to calculate the aging rate of piezoelectric ceramic materials. The program, called "RING", computes the percent aging rate for ceramic capacitance, resonant frequency, and coupling coefficient as a function of logarithmic time decades. The program is useful for predicting ceramic behavior over time.

Program applications include both circular ring and cylindrical tube ceramic shapes. The data to be entered includes the ceramic serial number, capacitance, dissipation factor, frequency data, and temperature for two different days since poling. Program options enable the user to store and edit data, perform statistical analyses, and display printed or plotted ceramic properties. A computer listing of the program is presented in the appendix of this technical memorandum.

PROGRAM INSTALLATION

The "RING" program operates on the Hewlett-Packard HP 9845 desktop computer. The tape cassette should be inserted into the right hand tape drive unit (from user perspective). The following executive commands are used to initialize, run, and terminate the program. Each example is divided into three parts. The first column lists the typed command. The second column shows the console key(s) to be pressed. The third column describes the action taken by the program.
The program operates from a main options list. Each time the user selects an option, the program performs the requested function and returns to the main options list. The following paragraphs discuss the usage of each of the main options.

1. **CREATE DATA FILE FOR RING STORAGE**

   This option creates a data file on tape on which ceramic ring data may be stored using Option 2. The user enters the file title (up to 6 characters in length) and the maximum number of rings for which storage is to be allocated. Up to 500 rings may be stored on a single file. The size of a data file should be specified greater than that used initially if subsequent ring data are added to the file.

   The program then attempts to create the file on the tape or disk. If no tape or disk error occurs, the user enters an up to 80 character file title/information string indicating the contents of the file. The ring original poling data is then entered (up to 32 characters in length). This data is stored in the file, and the program returns to the main options list. See the Option 1 example in the Appendix of this report for creating a data file.

2. **STORE RING DATA IN DATA FILE**

   Once a file has been created using Option 1, the user may store individual ring data in the file. First, the user selects the data file in which the ring data is to be stored. Then, provided that the file is not already filled, the user enters the ring serial number. The input data depends upon the types of measurements taken on the ceramic rings, which vary with transducer model. Currently the program is set up to accept data for the TR-317 or TR-155 transducers (ceramic ring or tube data). For the TR-317 transducer two sets of the following data are entered:
Days since poling
CAP - Capacitance in picofarads at 1 KHz
K - Coupling Coefficient (K₃₁, "Hoop Mode")
DF - Dissipation Factor at 1 KHz
FR - Ring Resonant Frequency, "Hoop Mode", KHz
TEMP - Air Temperature in degrees Fahrenheit

For the TR-155 transducer two sets of the following data are entered:

Days since poling
CAP - Capacitance in picofarads at 1 KHz
DF - Dissipation Factor at 1 KHz
FM - Frequency of Maximum Admittance KHz
FN - Frequency of Minimum Admittance KHz
TEMP - Air Temperature in degrees Celsius

The data is stored in the data file, and the program returns to the main options list. The Option 2 examples in the Appendix show data storage formats for both the TR-317 and TR-155 model transducers.

3. PRINT RING CATALOG FOR THE CURRENT DATA FILE

If the user wishes to print a catalog of the serial numbers of rings stored on the current data file, he selects Option 3. The catalog may be printed on the CRT or the printer. The file name, the title string, and the poling date string are printed, followed by a list of the ring serial numbers stored in the file (See the Appendix under the Option 3 example for displaying a ring catalog). The program then returns to the main options list.

4. EDIT DATA STORED IN DATA FILE

Data that has been previously stored in a data file may be changed using Option 4. A list of data edit options is printed as follows:

EDIT OPTIONS:
1. Print serial number catalog for file
2. Edit ring
3. Purge ring
4. Enter new title string
5. Enter new poling date
6. Return to main options

Any changes made are stored in the data file. Thus, if a ring is purged using edit Option 3, that data is no longer accessible for any purpose, because it is deleted from the data file, not just from the statistical calculation (see main Option 6). When edit Option 6 is selected, data editing is completed, and the program returns to the main options list. The Option 4 example located in the Appendix gives a few examples of this option.
5. CALCULATE STATISTICS AND PRINT RING DATA TABLE

This option calculates statistics and prints the file data on the CRT or
the printer. The user selects the file, and where the table is to be
printed. The mean, standard deviation, and minimum and maximum of CAP, K, and
FM are printed for both days since poling. If Option 6 has been exercised to
delete a ring from the statistical calculations, an asterisk is placed next to
the ring serial number. After the table has been printed, the program returns
to the main options list (See Option 5 example in the Appendix).

6. DELETE A RING FROM THE STATISTICAL CALCULATIONS

Once a table has been printed using Option 5, the user may delete a ring
from the statistical calculations. The user enters the ring serial number,
and the program returns to the main options list (See Option 6 example in the
Appendix).

7. RESTORE A RING TO THE STATISTICAL CALCULATIONS

A ring that has been deleted from the statistical calculations using
Option 6 may be restored to the calculations using Option 7. The ring serial
number is entered, and the program returns to the main options list. See the
Option 7 example in the Appendix of this report.

8. PLOT INDIVIDUAL RING DATA

This option plots on the CRT, the CAP, FR, and K data for an individual
ring on a logarithmic time scale. The user selects the file and ring serial
number, and the plot is automatically scaled and drawn on the CRT. The actual
CAP, FR, and K data points are denoted by an X. A line is drawn through the
data points, and the slope of the line is printed, indicating the percent
change per logarithmic decade for each data type (See Option 8 example in the
Appendix). After the plot is drawn, the program pauses. The user presses
CONT when he wishes to return to the main options list. A ring which was
deleted from statistical calculations using Option 6 may be plotted under this
option.

9. MAKE BAR PLOT OF COMPOSITE CAP, K, OR FR DATA

A bar graph of the CAP, K, or FR data for each data set is plotted on the
CRT. Rings which have been deleted from the statistical calculations do not
appear on the bar chart. When the plot for the first data set has been made,
the program pauses. When CONT is pressed, the plot for the second data set is
made, and the program pauses again. The user then presses CONT to return to
the main options list. See the Appendix under the Option 9 example for a
sample bar plot.
"RING" PROGRAM OPTION EXAMPLES

The following computer listing is a sample session illustrating the use of options with the "RING" program. Each program option is demonstrated. User responses are denoted with a caret (>) preceding the response. Additional comments are inserted to clarify the input data.

OPTION 1 EXAMPLE:

ENTER OPTION NUMBER (1-9)
> 1
ENTER FILE TITLE AND MASS STORAGE DEVICE
> RING1
ENTER NUMBER OF RINGS TO ALLOCATE STORAGE FOR (1-500)
> 6
ATTEMPTING TO CREATE FILE RING1,8,128
ENTER FILE TITLE STRING (UP TO 80 CHARACTERS)
> TR155G-80 SAMPLE DATA
ENTER POLING DATE (UP TO 32 CHARACTERS)
> 1-15-85
OPTION 2 EXAMPLE: TR-155

ENTER OPTION NUMBER (1-9)
> 2
PRESS CONT, OR ENTER NEW FILE NAME AND MASS STORAGE DEVICE
>
ENTER SERIAL NUMBER (NUMERIC ONLY, >0)
> 50830224
ENTER 1 FOR TR-317 DATA, 2 FOR TR-155 DATA
> 2
>
> Days since poling
?
> 30549 CAP
?
> .002 DF
?
> 16901 FM
?
> 18822 FN
?
> 22 TEMP
?
> DAYS SINCE POLING
?
> 29961 CAP
?
> .002 DF
?
> 16968 FN
?
> 18847 FN
?
> TEMP
>
PRESS CONT TO ENTER DATA FOR ANOTHER RING; ENTER 0 TO RETURN TO OPTIONS LIST.
OPTION 2 EXAMPLE: TR-317

<table>
<thead>
<tr>
<th>Enter Option Number (1-9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>Enter File Title and Mass Storage Device</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>Enter Number of Rings to Allocate Storage for (1-500)</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>Attempting to create file ring2,55,128</td>
</tr>
<tr>
<td>TR-317 Sample Data</td>
</tr>
<tr>
<td>Enter Poling Date (up to 32 characters)</td>
</tr>
<tr>
<td>4-12-85</td>
</tr>
<tr>
<td>Enter Option Number (1-9)</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>Press Cont, or enter new file name and mass storage device</td>
</tr>
<tr>
<td>Enter Serial Number (numeric only, &gt;0)</td>
</tr>
<tr>
<td>632148</td>
</tr>
<tr>
<td>Enter 1 for TR-317 Data, 2 for TR-155 Data</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Days since poling</td>
</tr>
<tr>
<td>129</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>CAP</td>
</tr>
<tr>
<td>1516</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>K</td>
</tr>
<tr>
<td>3291</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>DF</td>
</tr>
<tr>
<td>0013</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>FR</td>
</tr>
<tr>
<td>14729</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>TEMP</td>
</tr>
<tr>
<td>75</td>
</tr>
<tr>
<td>Days since poling</td>
</tr>
<tr>
<td>49</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>CAP</td>
</tr>
<tr>
<td>1536</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>K</td>
</tr>
<tr>
<td>3340</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>DF</td>
</tr>
<tr>
<td>0013</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>FR</td>
</tr>
<tr>
<td>14695</td>
</tr>
<tr>
<td>?</td>
</tr>
<tr>
<td>TEMP</td>
</tr>
<tr>
<td>75</td>
</tr>
</tbody>
</table>

Press Cont to enter data for another ring; enter 0 to return to Options List.

OPTION 3 EXAMPLE:

<table>
<thead>
<tr>
<th>Enter Option Number (1-9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
</tr>
<tr>
<td>Hardcopy printout (Y or N)?</td>
</tr>
<tr>
<td>Y</td>
</tr>
<tr>
<td>File: RING1</td>
</tr>
<tr>
<td>TR155G-B0 sample data</td>
</tr>
<tr>
<td>Poling Date: 1-15-85</td>
</tr>
</tbody>
</table>

File RING1 contains data for the following ring serial numbers:

<table>
<thead>
<tr>
<th>50830224</th>
<th>50830321</th>
<th>50880103</th>
<th>50880115</th>
</tr>
</thead>
<tbody>
<tr>
<td>50880413</td>
<td>50900202</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
OPTION 4 EXAMPLE:

a. Print ring serial number from RING 1 data file.

```
ENTER OPTION NUMBER 1-9
> 4
ENTER FILE NAME WITH MASS STORAGE DEVICE
> RING1
ENTER EDIT OPTION NUMBER (1-6)
> 1
HARDCOPY PRINTOUT (Y or N)?
> Y
FILE: RING1
TR155G-BQ SAMPLE DATA
POLING DATE: 1-15-85
FILE RING1 CONTAINS DATA FOR THE FOLLOWING RING SERIAL NUMBERS:
50830224 50830321 50880103 50880115
50880413 50900202
```

b. Create a new title string.

```
ENTER EDIT OPTION NUMBER (1-6)
> 4
ENTER NEW TITLE STRING UP TO 80 CHARACTERS)
> TR-155G/BQ EDIT
```

c. Make the following changes to the first data set of ring #50830224:

```
CAP = 30500
K = .20
FM = 17000
FN = 19000
```

```
ENTER EDIT OPTION NUMBER (1-6)
> 2
ENTER RING SERIAL NUMBER (ENTER 0 FOR RING CATALOG)
> 50830224
ENTER Y or N
> Y
PRESS CONT, OR ENTER A NEW VALUE
> CAP
PRESS CONT, OR ENTER A NEW VALUE
> K
PRESS CONT, OR ENTER A NEW VALUE
> .2
PRESS CONT, OR ENTER A NEW VALUE
> DF
PRESS CONT, OR ENTER A NEW VALUE
> FM
PRESS CONT, OR ENTER A NEW VALUE
> 17000
PRESS CONT, OR ENTER A NEW VALUE
> 19000
PRESS CONT, OR ENTER A NEW VALUE
> FN
PRESS CONT, OR ENTER A NEW VALUE
> TEMP
ENTER Y or N
> N
ARE VALUES CORRECT Y or N?
> Y
Change values for time 1?
Days since poling
Change values for time 2?
Updated values are listed on monitor.
OPTION 5 EXAMPLE:

ENTER OPTION NUMBER (1-9)
> 5
PRESS CONT, OR ENTER NEW FILE NAME AND MASS STORAGE DEVICE
> PRINT HARD COPY (Y or N)?
> Y

FILE: RING1
TR-155G/BQ EDIT
POLING DATE: 1-15-85

<table>
<thead>
<tr>
<th>RING</th>
<th>DAY</th>
<th>CAP</th>
<th>K</th>
<th>DF</th>
<th>FM</th>
<th>FN</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>50830224</td>
<td>008</td>
<td>30500</td>
<td>.2000</td>
<td>.0020</td>
<td>17000</td>
<td>19000</td>
<td>72</td>
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<tr>
<td></td>
<td>022</td>
<td>29961</td>
<td>.1895</td>
<td>.0020</td>
<td>16968</td>
<td>18847</td>
<td>72</td>
</tr>
<tr>
<td>50830321</td>
<td>008</td>
<td>31259</td>
<td>.1920</td>
<td>.0020</td>
<td>16961</td>
<td>18758</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>022</td>
<td>30546</td>
<td>.1877</td>
<td>.0020</td>
<td>16958</td>
<td>18816</td>
<td>72</td>
</tr>
<tr>
<td>50880103</td>
<td>008</td>
<td>30377</td>
<td>.1850</td>
<td>.0020</td>
<td>17011</td>
<td>18843</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>022</td>
<td>29819</td>
<td>.1815</td>
<td>.0010</td>
<td>17088</td>
<td>18888</td>
<td>72</td>
</tr>
<tr>
<td>50880115</td>
<td>008</td>
<td>30503</td>
<td>.1902</td>
<td>.0020</td>
<td>16971</td>
<td>18859</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>022</td>
<td>29919</td>
<td>.1851</td>
<td>.0010</td>
<td>17058</td>
<td>18896</td>
<td>72</td>
</tr>
<tr>
<td>50880413</td>
<td>008</td>
<td>30613</td>
<td>.1919</td>
<td>.0020</td>
<td>16971</td>
<td>18879</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>022</td>
<td>30046</td>
<td>.1868</td>
<td>.0010</td>
<td>17058</td>
<td>18916</td>
<td>72</td>
</tr>
<tr>
<td>50900202</td>
<td>008</td>
<td>30511</td>
<td>.1910</td>
<td>.0020</td>
<td>16981</td>
<td>18880</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>022</td>
<td>30022</td>
<td>.1867</td>
<td>.0010</td>
<td>17068</td>
<td>18926</td>
<td>72</td>
</tr>
</tbody>
</table>

**CAP**

**MIN** | 30377 | 31259 | 30844 | 313.72472
**MAX** | 30500 | 30546 | 30652.167 | 255.0415

**K**

**MIN** | .18499828 | .2 |
**MAX** | .1916989 | .19151538 |
**MEAN** | .19151538 | .18945552 |
**STD DEV** | .0048303313 | .0027126622 |

**FM**

**MIN** | 16661 | 17011 |
**MAX** | 16965.833 | 17033 |
**MEAN** | 16965.833 | 17033 |
**STD DEV** | 53.816039 | 55.407581 |
Verify ring # 50830224 deleted from ring statistical calculations

FILE: RING1
TR-155G/60 EDIT
POLING DATE: 1-15-85

<table>
<thead>
<tr>
<th>RING</th>
<th>DAY</th>
<th>CAP</th>
<th>K</th>
<th>DF</th>
<th>FM</th>
<th>FN</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>50830224</td>
<td>008</td>
<td>30500</td>
<td>.2000</td>
<td>.0020</td>
<td>17000</td>
<td>19000</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>022</td>
<td>29961</td>
<td>.1895</td>
<td>.0020</td>
<td>16968</td>
<td>18847</td>
<td>72</td>
</tr>
<tr>
<td>50830321</td>
<td>008</td>
<td>31259</td>
<td>.1920</td>
<td>.0020</td>
<td>16861</td>
<td>18758</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>022</td>
<td>30546</td>
<td>.1877</td>
<td>.0020</td>
<td>16958</td>
<td>18816</td>
<td>72</td>
</tr>
<tr>
<td>50880103</td>
<td>008</td>
<td>30377</td>
<td>.1850</td>
<td>.0020</td>
<td>17011</td>
<td>18843</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>022</td>
<td>29819</td>
<td>.1815</td>
<td>.0010</td>
<td>17088</td>
<td>18888</td>
<td>72</td>
</tr>
<tr>
<td>50880115</td>
<td>008</td>
<td>30503</td>
<td>.1902</td>
<td>.0020</td>
<td>16971</td>
<td>18859</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>022</td>
<td>29419</td>
<td>.1851</td>
<td>.0010</td>
<td>17058</td>
<td>18896</td>
<td>72</td>
</tr>
<tr>
<td>50880413</td>
<td>008</td>
<td>30613</td>
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<td>.0020</td>
<td>16971</td>
<td>18879</td>
<td>72</td>
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<tr>
<td></td>
<td>022</td>
<td>30046</td>
<td>.1863</td>
<td>.0010</td>
<td>17058</td>
<td>18916</td>
<td>72</td>
</tr>
<tr>
<td>50900202</td>
<td>008</td>
<td>30612</td>
<td>.1910</td>
<td>.0020</td>
<td>16981</td>
<td>18880</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>022</td>
<td>30022</td>
<td>.1867</td>
<td>.0010</td>
<td>17068</td>
<td>18926</td>
<td>72</td>
</tr>
</tbody>
</table>

CAP
- FIRST DATA SET: 30377
- SECOND DATA SET: 29419
- MEAN: 30672.8
- STD DEY: 341.77215

K
- FIRST DATA SET: 18495628
- SECOND DATA SET: 19151538
- MEAN: 19003868
- STD DEY: 0029142182

FM
- FIRST DATA SET: 16861
- SECOND DATA SET: 16356
- MEAN: 16959
- STD DEY: 57.183914

Ring #50830224 was omitted from the ring statistics calculations via Option 6. Compare the results with those in the Option 5 example.
OPTION 7 EXAMPLE:

ENTER OPTION NUMBER 1-9
> 7
ENTER RING SERIAL NUMBER (ENTER 0 FOR RING CATALOG)
> 50830224

OPTION 8 EXAMPLE:

ENTER OPTION NUMBER (1-9)
> 8
PRESS CONT, OR ENTER NEW FILE NAME AND MASS STORAGE DEVICE
> ENTER RING SERIAL NUMBER (ENTER 0 FOR RING CATALOG)
> 50830321
> DUMP GRAPHICS

![Graph](image)

FILE: RING1
RIN: 50830321
OPTION 9 EXAMPLE:

ENTER OPTION NUMBER (1-9)

9

ENTER 1 TO PLOT CAP; 2 TO PLOT K; 3 TO PLOT FR.

DUMP GRAPHICS
10 ! RING - 28 MAY 1985
20 OPTION BASE 1
30 DIM Ser(500),Dat(2,7),Dat$(7),Title$(80),Ckf(500,6),Stat(6,4),Hostat(500),Date$[32]
40 MAT READ Dat$
50 DATA DAYS SINCE POLING,CAP,K,DF,FM,FN,T
60 Opt: Opt=0
70 PRINT LIN(3);"MAIN OPTIONS:
80 PRINT " 1. CREATE DATA FILE FOR RING STORAGE;"
90 PRINT " 2. STORE RING DATA IN DATA FILE;"
100 PRINT " 3. PRINT RING CATALOG FOR THE CURRENT DATA FILE;"
110 PRINT " 4. EDIT DATA STORED IN DATA FILE;"
120 PRINT " 5. CALCULATE STATISTICS & PRINT RING DATA TABLE;"
130 PRINT " 6. DELETE A RING FROM THE STATISTICAL CALCULATIONS;"
140 PRINT " 7. RESTORE A RING TO THE STATISTICAL CALCULATIONS;"
150 PRINT " 8. PLOT INDIVIDUAL RING DATA;"
160 PRINT " 9. MAKE BAR PLOT OF COMPOSITE CAP, K, OR FR DATA."
170 INPUT "ENTER OPTION NUMBER (1-9)",Opt
180 IF (Opt<1) OR (Opt>9) THEN Opt=0
190 ON Opt GOSUB Createfile,Datastore,Rcat,Dataedit,Table,Statdelete,Statrestore,Plot,Call_barplot
200 GOTO Opt
210 Createfile: INPUT "ENTER FILE TITLE AND MASS STORAGE DEVICE",File$
220 CFOS: INPUT "ENTER NUMBER OF RINGS TO ALLOCATE STORAGE FOR (1-500)",Nring
230 IF Nring<1 THEN CF99
240 IF Nring>500 THEN CF05
250 Recplus=INT(Nring/16)+1+(Nring MOD 16)/0
260 DISP "ATTEMPT TO CREATE FILE ";File$;",";VAL$(Nrec);",";128"
270 ON ERROR GOTO CF10
280 CREATE File$,Nrec,128
290 GOTO CF15
300 CF10: PRINT "ERROR";ERRN;"DURING ATTEMPT TO CREATE FILE ";File$
310 OFF ERROR
320 GOTO CF99
330 CF15: OFF ERROR
340 PRINT "FILE ";File$;" CREATED"
350 INPUT "ENTER FILE TITLE STRING (UP TO 80 CHARACTERS)",Title$
360 INPUT "ENTER POLING DATE (UP TO 32 CHARACTERS)",Date$
370 ASSIGN #1 TO File$
380 REDIM Ser(Nring)
390 MAT Ser(1)=(-1)
400 PRINT #1;Nring,Title$,Date$
410 PRINT #1,2
420 PRINT "FILE ";File$;" READY FOR STORING CERAMIC RING DATA"
430 CF99: RETURN
440 ! -----------------------------------------------------------------
450 Datastore: CALL Fileselect(File#,#1,Nring,Title$,Date$,Ser(*),Recplus,Hostat(*)
460 Ds12: FOR P=1 TO Nring
470 IF Ser(P)=-1 THEN Ds15
480 NEXT P
490 PRINT "FILE ";File$;" IS FILLED - NO ADDITIONAL DATA CAN BE STORED"
500 GOTO Ds99
510 Ds15: INPUT "ENTER SERIAL NUMBER (NUMERIC ONLY, >0)",Ser(P)
520 IF Ser(P)<=0 THEN Ds15
521 Ds20: Kmode=0
522 INPUT "ENTER 1 FOR TR-317 DATA, 2 FOR TR-155 DATA",Kmode
523 IF Kmode<1 OR (Kmode>2) THEN Ds20
524 MAT Dat=(0)
530 FOR I=1 TO 2
540 PRINT LIN(2);"ENTER DATA SET":I;"FOR TRANSDUCER RING";Ser(P);LIN(1)
550 FOR J=1 TO ?
IF (J=3) AND (Kmod=2) OR (J=6) AND (Kmod=1) THEN Ds30

560 PRINT "ENTER DATA SET";I;Dat$(J)
570 INPUT Dat(I,J)
580 Ds30: NEXT J
581 IF Kmod=1 THEN Ds40
582 Ds(j,3)=(Dat(I,6)^2-Dat(I,5)^2)/Dat(I,6)^2
583 PRINT "CALCULATED K VALUE FOR DATA SET";I;="";Dat(I,3)
584 Dat(I,7)=Dat(I,7)*9/5+32
585 PRINT "TEMPERATURE CONVERTED TO";Dat(I,7);"deg F"
590 Ds40: NEXT I
600 PRINT #1,P+Recplus;Dat(*)
610 PRINT #1,2
620 PRINT #1;Ser(*)
630 READ #1,1;X
640 PRINT "DATA FOR RING";Ser(P);"HAS BEEN STORED IN FILE";File$
650 Ds90: X=1
660 INPUT "PRESS CONT TO ENTER DATA FOR ANOTHER RING; ENTER 0 TO RETURN TO OPTIONS LIST.";X
670 IF X=1 THEN Ds12
680 IF X THEN Ds90
681 ASSIGN #1 TO *
682 ASSIGN #1 TO File$
690 Ds99: RETURN

! ------------------------------------------------------------------
10 DATAEDIT: CALL Fileselsel(File$,#1,Nring,Title$,Date$,Ser(*),Recplus,Nostat(*))
20 De02: PRINT LIN(2);"EDIT OPTIONS:"
30 PRINT LIN(1);" 1. PRINT SERIAL NUMBER CATALOG FOR FILE";File$
40 PRINT " 2. EDIT RING"
50 PRINT " 3. PURGE RING"
60 PRINT " 4. ENTER NEW TITLE STRING"
70 PRINT " 5. ENTER NEW POLING DATE"
80 PRINT " 6. RETURN TO MAIN OPTIONS"
90 De05: Edopt=0
100 INPUT "ENTER EDIT OPTION NUMBER (1-6)",Edopt
110 IF (Edopt<1) OR (Edopt>6) THEN De05
120 ON Edopt GOTO De10,De20,De60,De70,De80,De99
130 De10: CALL Ringcat(File$,Nring,Title$,Date$,Ser(*),Nostat(*))
140 GOTO De02
150 De20: CALL Ringselsel(Nring,Ser(*),Ring,File$,Title$,Date$,Nostat(*))
160 IF Ring=0 THEN De02
170 READ #1,Ring+Recplus;Dat(*)
180 PRINT LIN(1);"CURRENT DATA FOR RING";Ser(Ring)
190 GOSUB De50
200 De28: FOR I=1 TO 2
210 De30: X$=""
220 PRINT "CHANGE VALUES FOR TIME";I;"(Y or N)?"
230 INPUT "ENTER Y or N",X$
240 IF X$="N" THEN De35
250 IF X$<"Y" THEN De30
260 PRINT LIN(1);"PRESS CONT TO MAINTAIN DISPLAYED VALUE, OR ENTER A NEW VALUE";LIN(1)
270 FOR J=1 TO 7
280 PRINT "TIME";I;Dat$(J);"=";Dat(I,J)
290 INPUT "PRESS CONT, OR ENTER A NEW VALUE",Dat(I,J)
300 NEXT J
310 De35: NEXT I
320 GOSUB De50
330 De40:X$=""
340 INPUT "ARE VALUES CORRECT (Y or N)?",X$
350 IF X$="Y" THEN De45
360 IF X$<"N" THEN De40
370 GOTO De28
380 De45: PRINT #1,Ring+Recplus;Dat(*)
390 MAT Dat=(0)
READ #1, Ring+Recplus; Dat(*)
PRINT "EDITED VALUES HAVE BEEN STORED IN FILE "; File$
GOTO De02
De50: PRINT LIN(1);" TIME 1","," TIME 2"
FOR I=1 TO ?
PRINT Dat(1,I), Dat$(I), Dat(2,I)
NEXT I
PRINT
RETURN
De50: CALL Ringselect(Nring, Ser(*), Ring, File$, Title$, Date$, Nostat(*))
IF Ring=0 THEN De02
PRINT "RING"; Ser(Ring); "PURGED"
Ser(Ring)=-1
PRINT #1, 2; Ser(*)
READ #1, 1, Nring
GOTO De02
De60: CALL RingselectCNring, Ser(*), Ring, File$, Title$, Date$, Nostat(*))
IF Ring=0 THEN
PRINT "RING"; Ser(Ring); "PURGED"
Ser(Ring)=-1
PRINT #1, 2; Ser(*)
READ #1, 1, Nring
GOTO De02
De70: PRINT "CURRENT TITLE STRING:"
PRINT Title$
PRINT "CURRENT TITLE STRING (UP TO 80 CHARACTERS)" ; Title$
PRINT #1, 1, Nring, Title$, Date$
READ #1, 1
GOTO De02
De80: PRINT "CURRENT POLING DATE: "; Date$
PRINT "ENTER NEW POLING DATE (UP TO 32 CHARACTERS) "; Date$
PRINT #1, 1
READ #1, 1
GOTO De02
De99: ASSIGN #1 TO *
ASSIGN #1 TO File$
RETURN
! --------------------------------------------------------------
Table: IF Opt=9 THEN Ta11
CALL Fileselect(File#, #1, Nring, Title$, Date$, Ser(*), Recplus, Nostat(*))
Ta10: X"=
INPUT "PRINT HARD COPY (Y or N)? "; X$
IF (X$<"Y") AND (X$<"N") THEN Ta10
PRINT Lin(2); "FILE: "; File$
PRINT Tit1e$
PRINT "POLING DATE: "; Date$
PRINT LIN(1);" RING DAY CAP K DF FM
FN TT "
Ta11: X=-1
MAT Ckf=(0)
Ckf=0
FOR I=1 TO 6
Stat(I,1)=1E35
Stat(I,2)=-1E35
Stat(I,3)=Stat(I,4)=0
NEXT I
Ta12: Y=1E35
FOR J=1 TO Nring
IF (Ser(J)<X) OR (Ser(J)>Y) THEN Ta13
I=J
Y=Ser(J)
Ta13: NEXT J
IF Y=1E35 THEN Ta20
X=Y
READ #1, I+Recplus; Dat(*)
IF NoStat(1) THEN Ta14
Ckf=Ckf+1
Ckf(Ckf,1)=Dat(1,2)
Ckf(Ckf,2)=Dat(1,3)
Ckf(Ckf,3)=Dat(1,5)
Ckf(Ckf,4)=Dat(2,2)
Ckf(Ckf,5)=Dat(2,3)
C kf (C kf, 6) = Dat (2, 5)
FOR K = 1 TO 6
IF C kf (C kf, K) < Stat (K, 1) THEN Stat (K, 1) = C kf (C kf, K)
IF C kf (C kf, K) > Stat (K, 2) THEN Stat (K, 2) = C kf (C kf, K)
Stat (K, 3) = Stat (K, 3) + C kf (C kf, K)
Stat (K, 4) = Stat (K, 4) + C kf (C kf, K) * 2
NEXT K
Ta14: IF Opt = 9 THEN Ta12
PRINT USING "#,10D"; Ser (< I >
PRINT USING "#:0.15s", CHR$ (32 + 10 * N ostat (< I >), Dat (< 1, 1>, Dat (< 1, 2), Dat (< 1, 3), Dat (< 1, 4), Dat (< 1, 5), Dat (< 1, 6), Dat (< 1, 7)
PRINT USING Ta15; "", Dat (< 2, 1>, Dat (< 2, 2), Dat (< 2, 3), Dat (< 2, 4), Dat (< 2, 5), Dat (< 2, 6), Dat (< 1, 7)
PRINT
GOTO Ta12
Ta15: IMAGE K, 3Z, 4X, 5D, 4X, D.4D, 4X, D.4D, 5X, 5D, 5X, 3D
Ta20: IF Opt = 5 THEN PRINT LIN(2)
FOR I = 1 TO 6
IF C kf #1 THEN Stat (< I, 4) = SQR ((Stat (< I, 4) - Stat (< I, 3)) ^ 2 / C kf) / (C kf - 1))
IF C kf = 1 THEN Stat (< I, 4) = 0
Stat (< I, 3) = Stat (< I, 3) / C kf
NEXT I
IF Opt = 9 THEN Ta99
FOR I = 1 TO 3
PRINT
IF I = 1 THEN PRINT USING "#,K"; " CAP"
IF I = 2 THEN PRINT USING "#,K"; " K"
IF I = 3 THEN PRINT USING "#,K"; " FM"
PRINT TAB (24); " MIN"; TAB (36); " MAX"; TAB (51); " MEAN"; TAB (66); " STD DEV"
FOR J = 0 TO 3 STEP 3
IF J = 0 THEN PRINT USING "#,K"; " FIRST DATA SET "
IF J = 3 THEN PRINT USING "#,K"; " SECOND DATA SET "
PRINT TAB (10); DROUND (Stat (< I + J, 1), 8); TAB (30); DROUND (Stat (< I + J, 2), 8); TAB (45);
DROUND (Stat (< I + J, 3), 8); TAB (60); DROUND (Stat (< I + J, 4), 8)
NEXT J
NEXT I
Ta95: PRINTER IS 16
PAUSE
Ta99: RETURN
! --------------------------------------------------------------
Call barplot: IF C kf THEN Cb10
PRINT "THERE IS NO DATA BASE FOR MAKING A BAR PLOT AT THIS TIME."
PRINT "ACCESS OPTION 5 TO CREATE A DATA BASE AND CALCULATE STATISTICS."
GOTO Cb99
Cb10: GOSUB Table
CALL barplot (C kf, C kf *, Stat (*), File $)
Cb99: RETURN
! --------------------------------------------------------------
Rcat: IF File $ <> "" THEN Rca10
PRINT "NO FILE HAS BEEN SELECTED."
GOTO Rca99
Rca10: CALL Ringcat (File $, N ring, Title $, Date $, Ser (*), N ostat (*))
Rca99: RETURN
! --------------------------------------------------------------
Statdelete: IF File $ <> "" THEN Sd10
PRINT "NO FILE HAS BEEN SELECTED FOR PRINTING AND STATISTICAL ANALYSIS."
GOTO Sd99
Sd10: CALL Ringsel ect (N ring, Ser (*), Ring, File $, Title $, Date $, N ostat (*))
IF Ring = 0 THEN Sd99
N ostat (Ring) = 1
PRINT "RING"; Ser (Ring); " DELETED FROM STATISTICAL CALCULATIONS."
Sd99: RETURN
! --------------------------------------------------------------
Statrestore: IF File $ <> "" THEN Sr10
PRINT "NO FILE HAS BEEN SELECTED FOR PRINTING AND STATISTICAL ANALYSIS."
GOTO Sr99
Sr10: CALL Ringselect(Nring,Ser(*),Ring,File$,Title$,Date$,Nostat(*)
Nostat(Ring)=0
PRINT "RING";Ser(Ring);"RESTORED TO STATISTICAL CALCULATIONS."
Sr99: RETURN
! --------------------------------------------------------------
Plot: CALL Fileselect(File$,#1,Nring,Title$,Date$,Ser(*),Recplus,Nostat(*)
CALL Ringselect(Nring,Ser(*),Ring,File$,Title$,Date$,Nostat(*)
PRINT PAGE
IF Ring=0 THEN Pl99
PLOTTER IS 13,"GRAPHICS"
GRAPHICS
LOCATE 18,118,8,98
SCALE 0,3,0,7
AXES 1,1,0,0
LORG 2
CSIZE 3,3
MOVE -.48,1.5
LABEL USING "K";"K"
MOVE -.48,3.5
LABEL USING "K";"FR (Hz)"
MOVE -.48,5.5
LABEL USING "K";"CAP (pF)"
LONG 6
FOR I=0 TO 3
MOVE I,-.05
LABEL USING "K";"1" & RPT$C"0",1)
NEXT I
MOVE 1.5,-.3
LABEL USING "K";"DAYS"
MOVE 0,-.4
LABEL USING "K","FILE: ",File$
LONG 9
MOVE 3,-.4
LABEL USING "K,10D";"RING: ",Ser(Ring)
FOR I=213 TO 90 STEP 113
FOR J=-1 TO 1
X=LGT(I)>+J
MOVE X,0
DRAW X,.05
NEXT J
READ #1,Ring+Recplus;Dat(*)
X0=LGT(DatC1,1))
X1=LGT(DatC2,1))
D0=X0/(X1-X0)
D1=(3-X1)/(X1-X0)
FOR I=1 TO 3
ON I GOTO Pl20,Pl25,Pl30
Pl20: J=3
P=-2
GOTO Pl35
Pl25: J=5
P=3
GOTO Pl35
Pl30: J=P=2
Pl35: D=DatC2,J)-Dat(1,J)
Y0=Dat(1,J)-D0*D
Y1=DatC2,J)+D1*D
P=INT(LGTABS(Y0-Y1)*.4)+1
Y=(Y0+Y1)/2
Y=Y(1,J)+Dat(2,J))/2
Y=10^P*INT(Y/10^P)
SCALE 0,3,Y-(2*I-1)*10^P,Y+(8-2*I)*10^P
2780 LORG 8
2790 MOVE -.03,Y
2800 LABEL USING "K";Y
2810 MOVE -.03,Y+10AP
2820 LABEL USING "K";Y+10AP
2830 LORG 5
2840 FOR K=1 TO 2
2850 MOVE LGT < Dat(K,1) ,Dat(K,J)
2860 LABEL USING "K";" X"
2870 NEXT K
2880 MOVE 0,Y0
2890 DRAW 3,Y1
2900 IF Y1+Y0<>0 THEN Perdecade=(Y1-Y0)/3/(Y1+Y0)/2)*100 ! CHANGE PER DECADE
2905 IF Y1+Y0=0 THEN Perdecade=0
2920 CSIZE 2.5
2930 CSIZE 2.5
2940 OPTION BASE
2950 IF X=1+<FileS сторне"") THEN Fs20
2960 Fs10: INPUT "ENTER FILE NAME WITH MASS STORAGE DEVICE",F$
2970 GOTO Fs30
2980 Fs20: PRINT PAGE;"CURRENT FILE: ";F$
2990 Fs=F$
3000 Fs=File$
3010 INPUT "PRESS CONT, OR ENTER NEW FILE NAME AND MASS STORAGE DEVICE",F$
3020 IF F$=Fs THEN Fs99
3030 Fs30: PRINT "ATTEMPTING TO OPEN FILE ";F$
3040 ON ERROR GOTO Fs40
3050 ASSIGN #1 TO F$
3060 ON ERROR
3070 READ #1;Nring,Title$,Date$
3080 REDIM Ser(* Nring)
3090 READ #1;Ser(*)
3100 Recplus=1+INT(Nring/16)+Nring MOD 16>0
3110 MAT Nostat=0
3120 GOTO Fs50
3130 Fs40: OFF ERROR
3140 PRINT LIN(1);"ERROR";ERRN;"DURING ATTEMPT TO OPEN FILE ";F$
3150 ON X GOTO Fs10,Fs20
3160 Fs50: FileS=F$
3170 Fs99: Recplus=1+INT(Nring/16)+Nring MOD 16>0
3180 SUBEND
3190 SUBEND
3200 !---------------------------------------------------
3210 Fileselect: SUB Fileselect(File#,Nring,Title$,Date$,Ser(*),Recplus,Nostat(*))
3220 OPTION BASE 1
3230 X=1+(File$"")
3240 IF X=2 THEN Fs20
3250 Fs10: INPUT "ENTER FILE NAME WITH MASS STORAGE DEVICE",F$
3260 GOTO Fs30
3270 Fs20: PRINT PAGE;"CURRENT FILE: ";F$
3280 Fs=F$
3290 Fs=File$
3300 Fs20: PRINT "PRESS CONT, OR ENTER NEW FILE NAME AND MASS STORAGE DEVICE",F$
3310 IF F$=Fs THEN Fs99
3320 Fs30: PRINT "ATTEMPTING TO OPEN FILE ";F$
3330 ON ERROR GOTO Fs40
3340 ASSIGN #1 TO F$
3350 ON ERROR
3360 READ #1,1;Nring,Title$,Date$
3370 REDIM Ser(Nring)
3380 READ #1,2
3390 READ #1;Ser(*)
3400 Recplus=1+INT(Nring/16)+Nring MOD 16>0
3410 MAT Nostat=0
3420 GOTO Fs50
3430 Fs40: OFF ERROR
3440 PRINT LIN(1);"ERROR";ERRN;"DURING ATTEMPT TO OPEN FILE ";F$
3450 ON X GOTO Fs10,Fs20
3460 Fs50: FileS=F$
3470 Fs99: Recplus=1+INT(Nring/16)+Nring MOD 16>0
3480 SUBEND
3490 SUBEND
3500 !---------------------------------------------------
3510 Ringcat: SUB Ringcat(File$,Nring,Title$,Date$,Ser(*),Nostat(*))
3520 OPTION BASE 1
3530 Rc10: X=""
3540 INPUT "HARDCOPY PRINTOUT <Y or N>?",X$
3550 IF X="Y" AND X="N" THEN Rc10
3560 PRINTER IS 16<"X=""N">
3570 PRINT LIN(2);"FILE ";File$
3580 PRINT Title$
3590 PRINT "POLING DATE: ";Date$
3600 PRINT LIN(1);"FILE ";File$;" CONTAINS DATA FOR THE FOLLOWING RING SERIAL NUMBERS:";LIN(1)
3610 X=-1
3620 Rc20: Y=1E35

23
FOR I=1 TO Nring
  IF (Ser(I)<X) OR (Ser(I)>Y) THEN Rc30
  J=I
  Rc30: NEXT I
  IF Y=1E35 THEN Rc90
  X=Y
  Z$="&VAL$(Ser(J))
  IF Mostat(J) THEN Z$[1,1]="*
  PRINT Z$,
  GOTO Rc20
  Rc90: PRINT
  Rs10: Ser=-1
  INPUT "ENTER RING SERIAL NUMBER (ENTER 0 FOR RING CATALOG)"; Ser
  ON SGN(Ser)+2 GOTO Rs10,Rs15,Rs20
  Rs15: CALL Ringcat(File$, Nring, Title$, Date$, Ser(*), Mostat(*))
  GOTO Rs10
  Rs20: FOR Ring=1 TO Nring
  NEXT Ring
  Ring=0
  PRINT LINE(1); "SERIAL NUMBER"; Ser; "NOT FOUND IN FILE "; File$
  Rs99: SUBEND
  ! ---------------------------------------
  Barplot: SUB Barplot(Ckf, Ckf(*), Stat(*), File$)
  OPTION BASE 1
  DIM Bins(25)
  PRINT PAGE
  Bp10: K=0
  INPUT "ENTER 1 TO PLOT CAP; 2 TO PLOT K; 3 TO PLOT FR"; K
  IF (K<1) OR (K>3) THEN Bp10
  Dataset=1 TO 2
  D=Dataset*3-3
  Dx=Stat(K+D,2)-Stat(K+D,1)
  Dtic=10^INT(LGT(Dx)-1)
  IF Dx/Dtic<20 THEN Bp20
  Dtic=Dtic*2
  IF Dx/Dtic>=20 THEN Dtic=Dtic*2.5
  Bp20: Bmin=PROUND(Stat(K+D,1)/Dtic,0)
  Bmax=PROUND(Stat(K+D,2)/Dtic,0)
  REDIM Bins(1+Bmax-Bmin)
  MAT Bins=C 0)
  Ymax=0
  FOR I=1 TO Ckf
  Bin=PROUND(Ckf(I,K+D)/Dtic,0)+1-Bmin
  Bins(B)=Bins(B)+1
  IF Bins(B)>Ymax THEN Ymax=Bins(B)
  NEXT I
  Ymax=MAX(5,Ymax)
  PLOTTER IS 13,"GRAPHICS"
  GRAPHICS
  LOCATE 15,110,25,95
  Xmin=Dtic*(Bmin-1)
  Xmax=Dtic*(Bmax+1)
  SCALE Xmin,Xmax,0,Ymax
  Ytic=1+(Ymax>50)
  AXES Dtic,Ytic,Xmin,0,5,5
  CSIZE 2.5
  NEXT I
MOVE (Bmin-1)*Dtic,-.028*Ymax
LABEL USING "K";(Bmin-1)*Dtic
FOR I=Bmin TO Bmax
CLIP (1-.5)*Dtic,(1+.5)*Dtic,0,Bins:-3min+1
FRAME
IF (I-Bmin+1) MOD 5 THEN Gr20
MOVE I*Dtic,-.028*Ymax
LABEL USING "K";I*Dtic
Gr20: NEXT I
MOVE Dtic<(Bmin+Bmax)/2,-.0654*Ymax
CSIZE 2.7,.8
Y$="FIRST"
IF Dataset=2 THEN Y$="SECOND"
X$="CAP"
IF K=2 THEN X$="K"
IF K=3 THEN X$="FR"
LABEL USING "K";"FILE \
&File$";"X$" (;"Y$" DATA SET)
CSIZE 2.5
LORG 8
FOR I=0 TO Ymax STEP 5*Ytic
MOVE Dtic*(Bmin-1)-.01*Dtic*(Bmax-Bmin+2),I
LABEL USING "K";I
NEXT I
LORG 5
MOVE Dtic*(Bmin-1)-.11*Dtic*(Bmax-Bmin),Ymax/2
LDIR 90
CSIZE 2.7,.8
LABEL USING "K";"NUMBER OF OCCURRENCES"
LDIR 0
PRINT "PRESS CONT WHEN READY"
PAUSE
NEXT Dataset
EXIT GRAPHICS
SUBEND