Information Note 102171

IMAGE ENHANCEMENT THROUGH DATA PROCESSING

by

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under the direction of

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INTRODUCTION

This work represents a continuation of that originated by Jack Derry and reported in LARS Information Note No. 052770: "A Preliminary Study of Image Quality Improvement Through Data Processing".

The basic problem considered was the reduction of the transient response "ring" produced by the sharp cutoff low-pass filter frequency response of the composite analog signal processing equipment employed in the recording and playing back of the airborne scanner data prior to digitizing and reformatting. This ring produces a train of "ghost" images each displaced in time and reduced in intensity compared to the preceeding image and overlaid on the original undistorted image. As shown in Fig. 1, this ring produces the multiple images or "ghosts" to the left of the road in the center of the photograph. It should be noted that the scanner movement with respect to time is from right to left.

In addition to reducing the optical quality of the scanner image, it is suspected that this transient ring may lead to data classification errors, particularly in regions immediately to the left of a discontinuity in luminance level. It should also be noted that any program which attempts to correct for variations in scene illumination resulting from cloud shadows must also correct for this transient ring which would occur at the cloud shadow boundaries.

DETERMINATION OF THE FREQUENCY RESPONSE OF THE COMPOSITE ANALOG SYSTEM

Since the distortion characteristics of each component in the analog signal chain are not available, it was decided to choose a signal of approximately 50% of the total dynamic range of the scanner data, assuming that distortion at this signal level is negligible, as a calibration reference signal to determine the composite analog system frequency response. In addition, this calibration signal must have been generated by a signal at the scanner output which can be described with reasonable accuracy by a minimum number of parameters, and must contain a sufficient data record length to include all significant oscillations of the transient ring without containing new data in the region of the ring. The calibration samples used by Derry from lines 701 to 705 and columns 340 to 390 of channel 5 of the color panels of Run 66005200, as shown in Fig. 2, seemed to match the desired criteria. It was assumed that the original analog signal at the scanner output for this area of the above run was composed of two rectangular pulses.

The basic approach used to determine an estimate of the frequency response of the composite analog system was to obtain the frequency spectrum for an average of lines 701 to 705 of the calibration samples, using the Fast Fourier Transform algorithm. FORT, choosing N=1024 so that a good approximation to the continuous spectrum is obtained, and dividing this spectrum by the frequency spectrum of the assumed rectangular-shaped input signal. Although this basic approach is fundamentally straight forward, a number of parameters had to be defined to obtain a good estimate of the system response.

Four parameters were chosen to describe the discrete estimate of each of the rectangular pulses assumed to have comprised the original analog scanner output signal for the calibration samples, which for the first rectangular pulse were defined as follows: the number of intermediate sample points between the "zero level" and the peak of the pulse (defining the leading edge of the pulse), defined as parameter N14; the number of sample points between the start of the record length of the data for the calibration area and the first data point on the peak of the first input pulse, defined as parameter N10; the number of sample points defining the duration of the peak of the pulse, defined as parameter N1; and the slope of the peak of the pulse, defined as DLTX1. The corresponding parameters for the second rectangular pulse were N27, N22, N28, and DLTX2.

Two criteria were used to determine the best set of parameters. First, since the discrete spectrum estimate of the frequency response of the analog system is defined as the ratio of the discrete frequency spectrum of the system output signal to that of the input signal for the chosen calibration sample, it is clear that if the poles and zeros of the numerator and denominator polynominals do not coincide at all frequencies, discontinuities will result in the frequency response estimate of the analog system. These discontinuities are clearly shown in Fig. 11 of Derry's report. If it is assumed that the frequency response of the composite analog system did not contain such discontinuities, which should be a reasonable assumption in view of the type of equipment employed, then the magnitude of the discontinuities in the resulting estimate of the system frequency response could be used as a measure of the accuracy of the parameters previously defined.

Second, if the estimate of the system impulse response is obtained from the inverse Fourier Transformation of the frequency components, two requirements must be satisfied. First, the impulse response must be casual; and second, the impulse response must decay essentially to zero after a finite time. After examination of the transient ring for many points in the run from which the calibration samples were chosen, it was found that the transient ring had significant values, greater than 0.5%, for the first 30 to 40 data points following the beginning of the transient.

After extensive analysis, the best parameter set for the assumed input signal was obtained. N1=12, N10=1, N14=0, DLTX1=0.0, DLTX2=0.0, N27=0, N22=31, N28=12, PK1=92.0, PK2= -7.5. Fig. 3, which shows the magnitude of the discrete estimate of the analog system frequency response, has discontinuities of at least an order of magnitude less than previously possible. Fig. 4 shows the corresponding discrete impulse response estimate of the composite analog system.

DETERMINATION OF THE DATA CORRECTION FUNCTION

The basic approach used to correct the data consisted of multiplying the frequency spectrum of a suitable impulse response correction function, based upon the estimate of the composite analog system impulse response, by the frequency spectrum of a line of uncorrected data.

Several criteria were used to determine a suitable impulse response correction function. First, ideally, the convolution of the composite analog system impulse response and the impulse response correction function should be a unit impulse. However, since the frequency spectrum of a unit impulse is a constant over the frequency range from zero to infinity, and since the composite analog system frequency response asymptotically approaches zero rapidly for normalized discrete frequency component estimates above about 230 as shown in Fig. 3, and since the spectral components of the output of the composite analog system, being shaped by the frequency spectrum of the composite analog system, are significant only for normalized discrete frequency components below about 230, the frequency spectrum of the ideal impulse response correction function must be approaching infinity for components above 230. From a practical standpoint, such a function could not be used; since it would enhance any noise introduced by the tape or the digital processing of the uncorrected analog data which had normalized spectral components in the region above about 230 in Fig. 3.

Thus, it was necessary to consider a "shaping" function in the frequency domain which would "weight" that spectral region occupied by the uncorrected data; or another way to state the same criterion, the ratio of the frequency spectra of the desired impulse correction function to that of the composite analog system must be equal to the "shaping" function instead of unity. Since the impulse response of this "shaping" function must be as close to that of the unit impulse as possible, i.e., not having any significant secondary lobes, and must be described by a small number of parameters, the Hanning and Hamming "shaping" functions were considered. It should be noted that as far as this first criterion is concerned, the Hamming function is the best choice.

The second criterion, and possibly more important than the first, is that the impulse response of the correction function decay as rapidly as possible. The significance of the criterion lies in the fact that if an error is made concerning the data which immediately preceeded the first data sample to be corrected, an oscillatory error will result in the "corrected" data having a magnitude proportional to the impulse response of the data correction function. Thus, if the impulse response of the correction function takes a long time to decay to insignificant levels, the "corrected" data will contain these oscillations which will propagate through the corrected data for approximately the same time duration as that of the impulse response of the correction function. Since spectrum analysis of numerous lines of uncorrected data indicated that significant components existed for about 236 discrete normalized components on a basis of 1024 total discrete spectral components, the Hanning frequency shaping function with a parameter of 236 produced a correction function with an impulse response which decayed in less than half the time required by the Hamming function.

The importance of the second criterion lies in the fact that the data points immediately preceeding the first data point to be corrected on a given scanner line are lost because of the digitizing procedure employed during reformatting.

The third criterion for the impulse response correction function is that it must be causal. Thus, once a correction function is obtained which satisfies the second criterion, its impulse response is sufficiently delayed in time so that it approximates a causal response. The resulting function is shown in Fig. 5.

Before the spectral components of the data correction function are multiplied by those of a line of uncorrected data, one additional procedure must be considered. As a means of minimizing the correction error introduced by not knowing what preceeded the first data point to be corrected, a ramp function beginning at the "dark level" calibration value and terminating 100 sample points later at the level of the first data point to be corrected was assumed to preceed each line of uncorrected data. This ramp function is an approximation to the actual function produced during the time that the scanner morror is partially covered by the scanner window, and its duration was approximated by examining line graphs of the digitized data before reformatting.

The effectiveness of this overall correction procedure is demonstrated by comparing Fig. 6 which represents a graph of the data on line 695 and Fig. 7 for line 705 of run 66005200 channel 5 to Fig. 8 and 9 respectively.

Conclusions:

Fig. 10 shows the results of the correction applied to the data of Fig. 1. More work is still required to obtain a better estimate of the original analog system impulse, or equivalently, frequency response characteristics upon which the data transient correction function is based. Much of the difficulty in obtaining a good correction function arises because of apparent analog system non-linearity and the limitations of the color panels as calibration standards.

Also, further work is necessary to determine if it is possible to generate a single correction function which would accurately correct all data channels and all runs made with the same basic analog recording equipment. Preliminary investigations have shown that the correction function generated from channel 5 of run 66005200 will correct the other channels of this run with essentially the same accuracy as was obtained for channel 5. In addition, this same correction function made an acceptable correction of the same channel and flight line taken 2 years later.

Although no classification of corrected data has been made to date, the necessary software exists; and it is felt that the present correction function would be suitable to perform an initial classification to determine the magnitude of accuracy improvement.

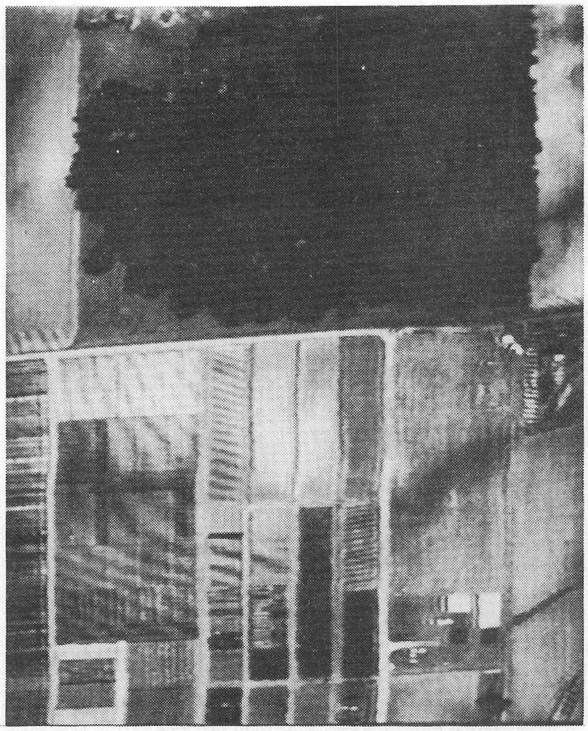


Figure 1. Scanner Image from Run 66005200, Lines 400-1000, Columns 1-450, Channel 5.

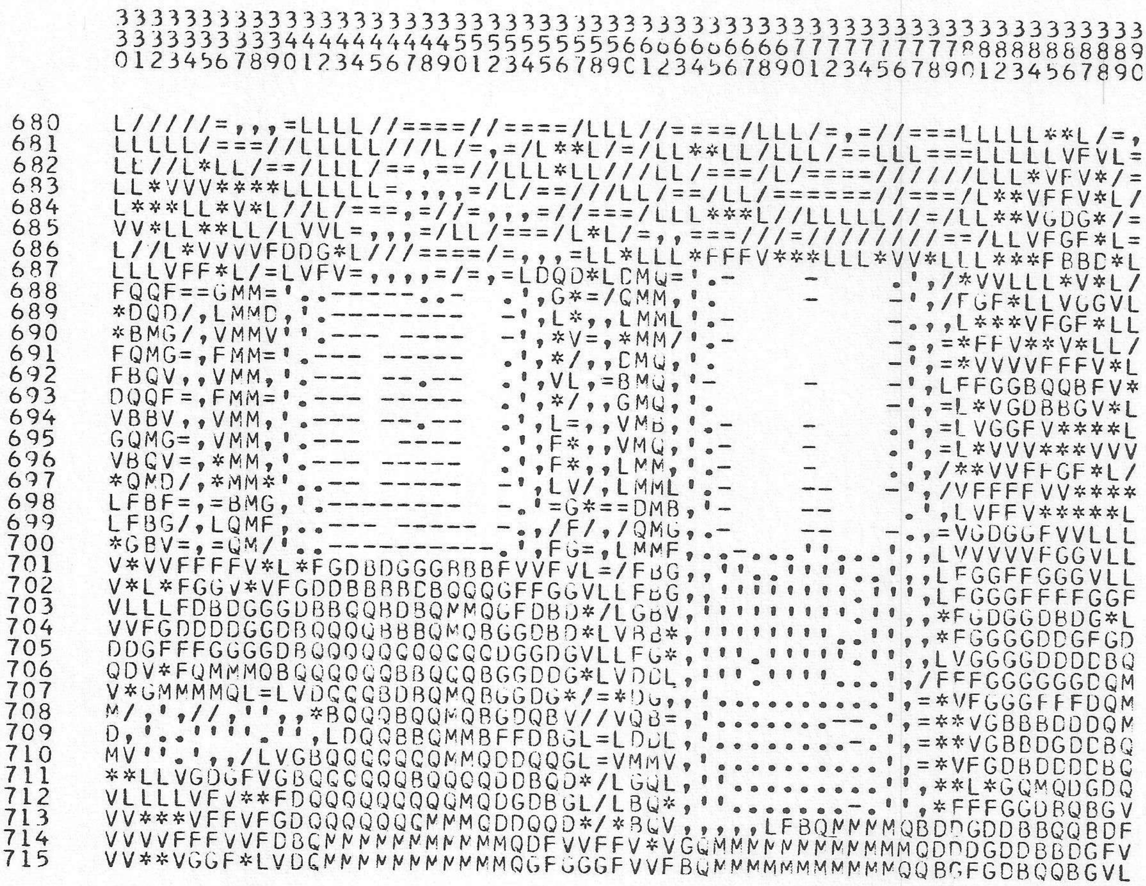


Figure 2. Gray Scale Printout from Run 66005200, Lines 680-715, Columns 330-390, Channel 5.

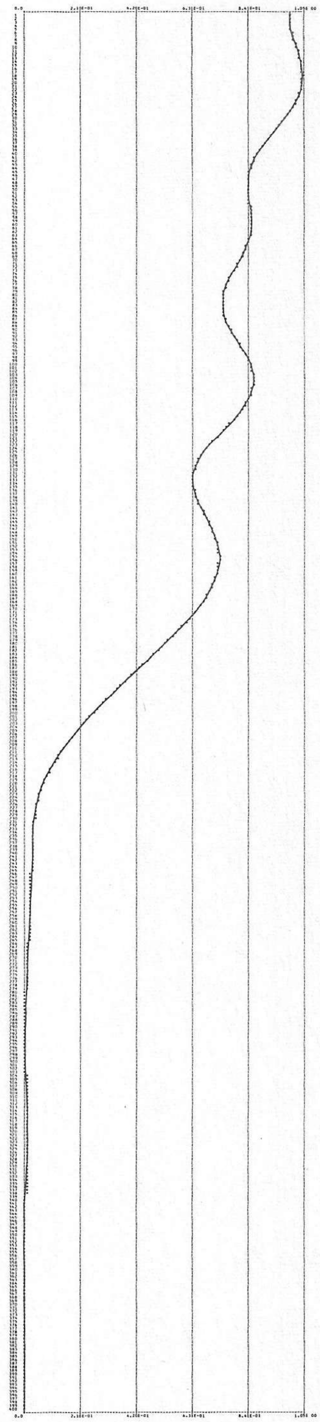


Figure 3. Frequency Response Estimate for Composite Analog System for Optimum Input Signal Parameter Set.

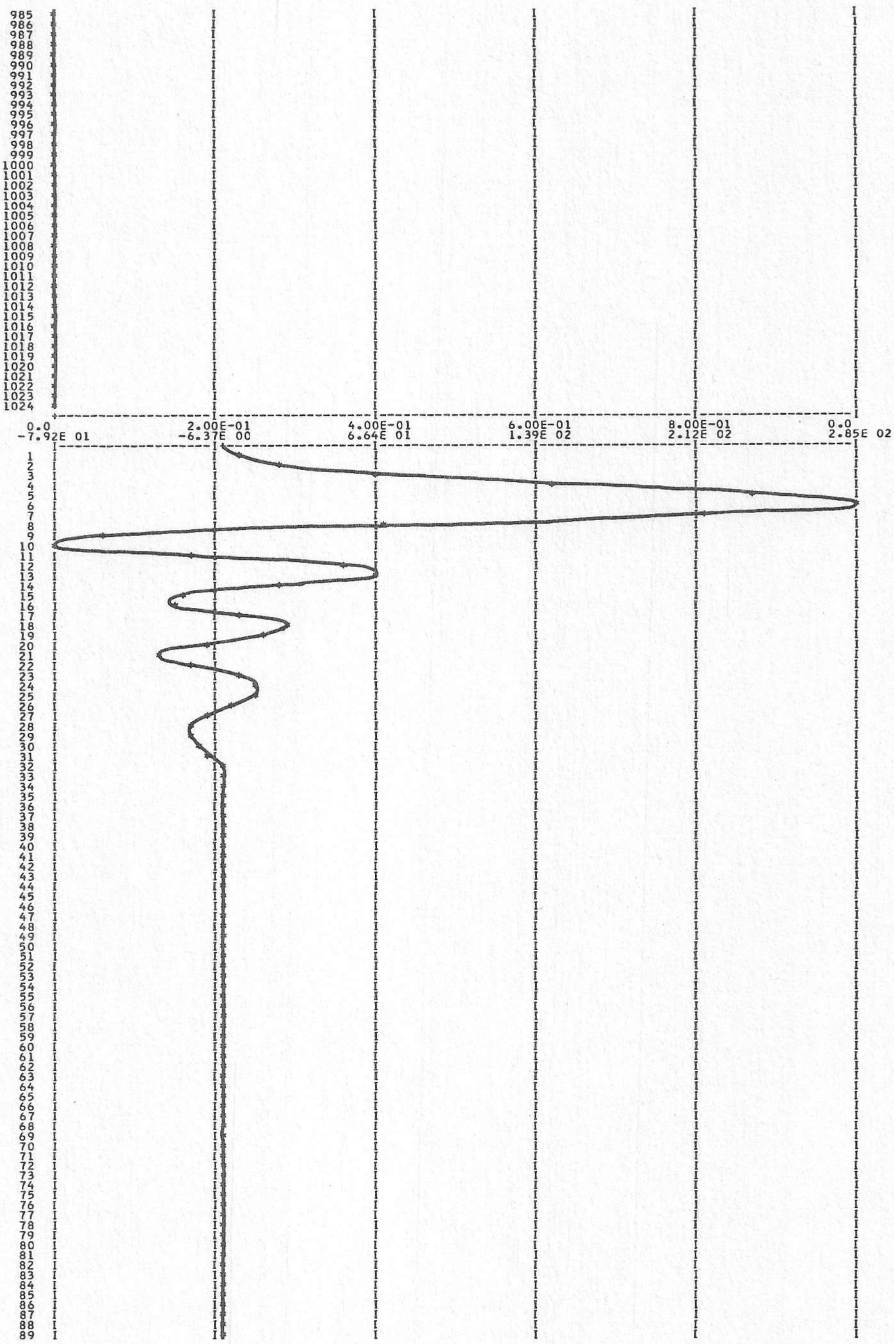


Figure 4. Estimate of Composite Analog System Impulse Response for Optimum Input Signal Parameter Set.

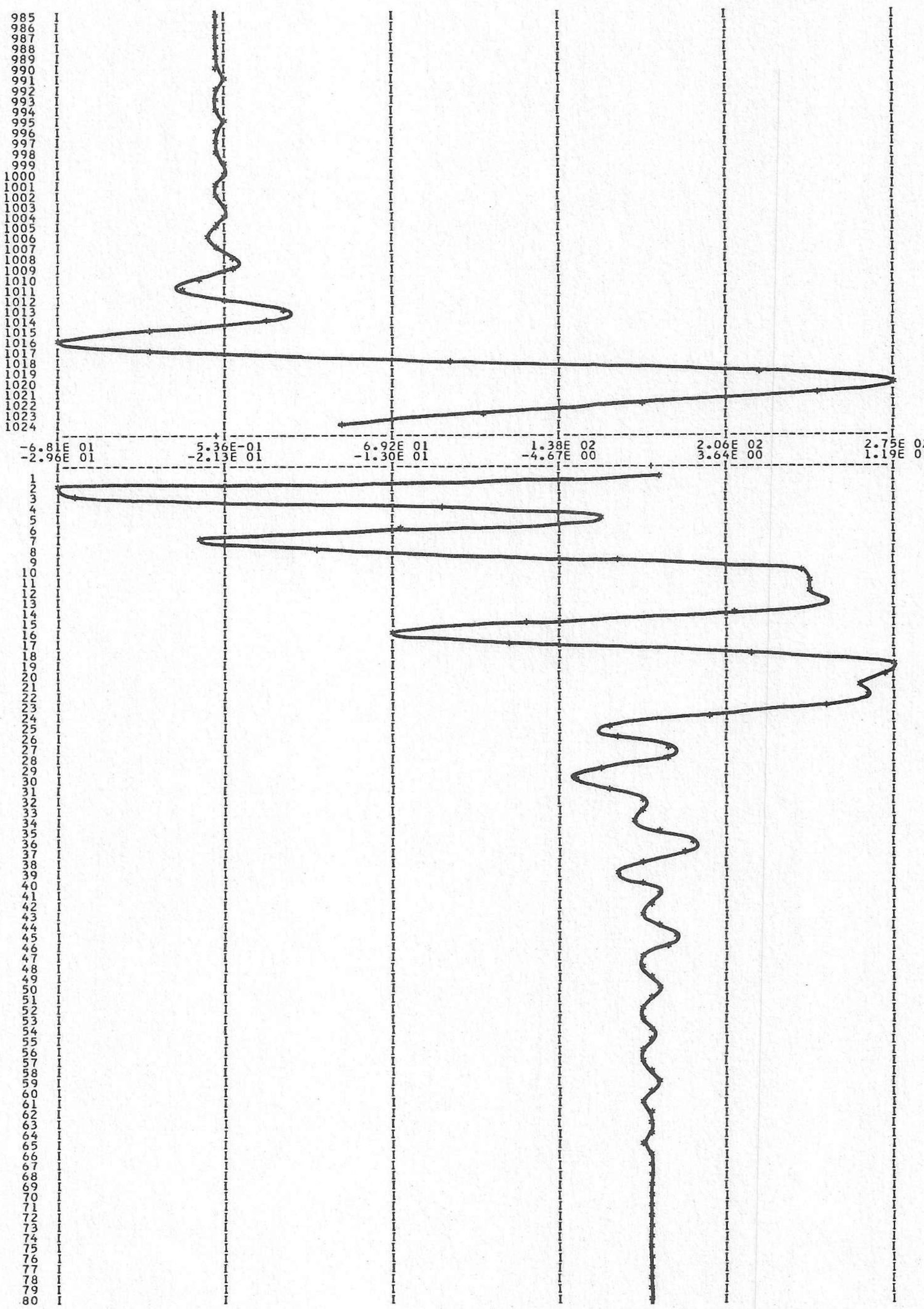


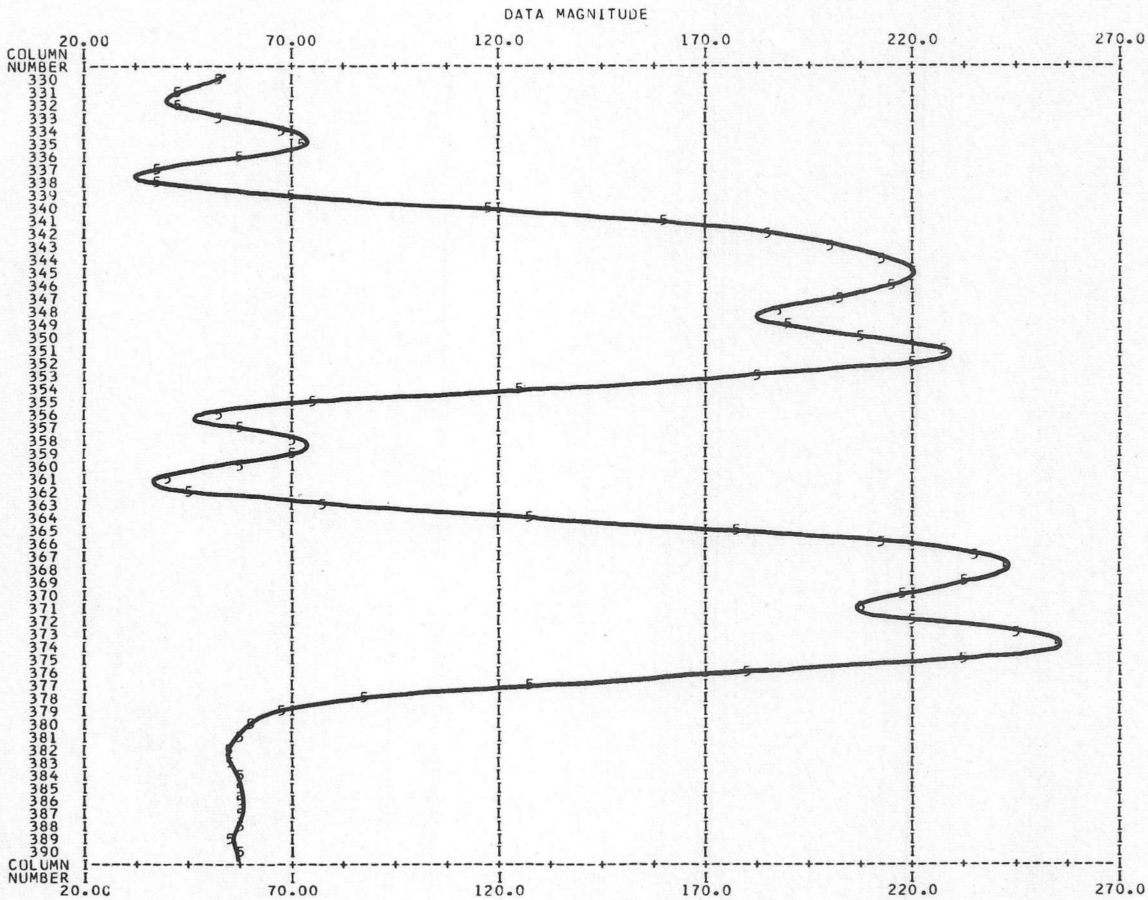
Figure 5. Impulse Response of Data Correction Function for a Hamming Frequency-Shaping Function of 236.

****** GRAPH OF LINE 695 ******

RUN NUMBER........... 66005200
FLIGHT LINE.. COLOR PANELS (F)
DATA TAPE................. 213
REFORMATING DATE. DEC 8,1969

DATE................. 6/30/66
TIME..................... 1400
ALTITUDE.............. 700
GROUND HEADING.... 270 DEGREES

CHANNEL 5 SPECTRAL BAND 0.62 TO 0.66 MICROMETERS DISPLAYED AS.. 5 CALCODE = 1 CO = 16.15



CALIBRATION FOR LINE 695

CHANNEL	C0 MEAN	C0 VARIANCE	C1 MEAN	C1 VARIANCE	C2 MEAN	C2 VARIANCE
5	16.2	1.0	73.2	7.0	195.2	4.0

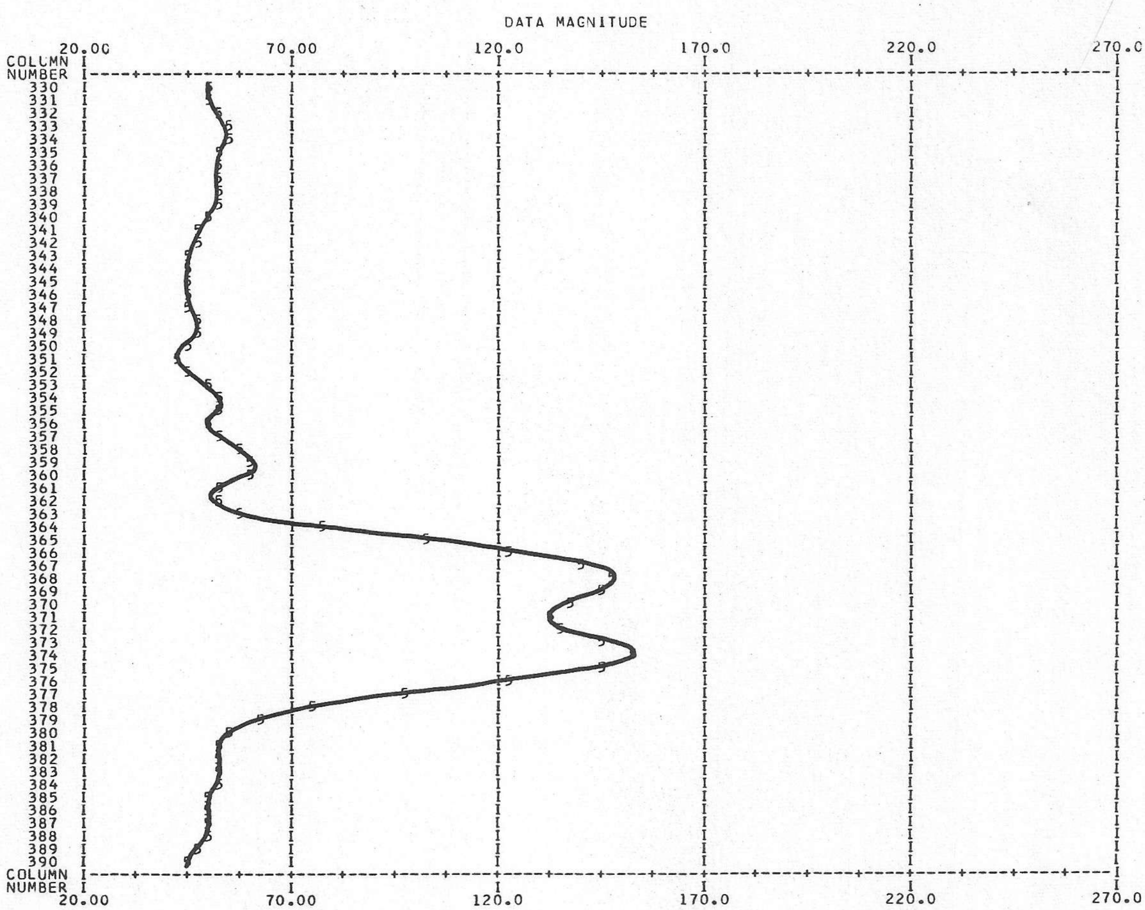
ROLL -11

Figure 6. Graph of the Corrected Data in Line 695, Channel 5, Run 66005200.

****** GRAPH OF LINE 705 ******

RUN NUMBER........... 66005200	DATE................. 6/30/66
FLIGHT LINE.. COLOR PANELS (F)	TIME..................... 1400
DATA TAPE................ 213	ALTITUDE............. 700
REFORMATING DATE. DEC 8,1969	GROUND HEADING.... 270 DEGREES

CHANNEL 5 SPECTRAL BAND 0.62 TO 0.66 MICROMETERS DISPLAYED AS.. 5 CALCODE = 1 CO = 16.15



CALIBRATION FOR LINE 705

CHANNEL	C0 MEAN	C0 VARIANCE	C1 MEAN	C1 VARIANCE	C2 MEAN	C2 VARIANCE
5	16.2	1.0	73.2	3.0	192.2	6.0

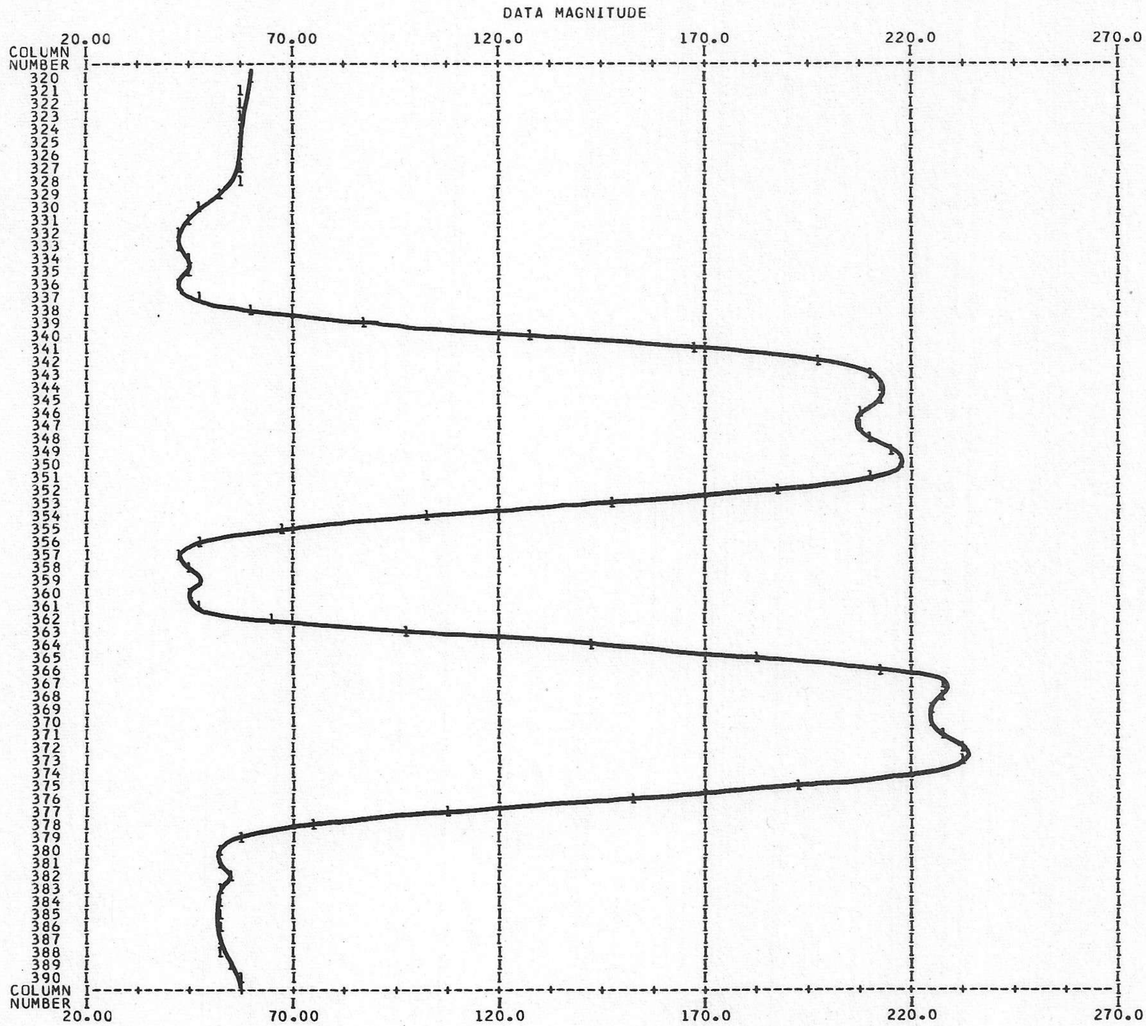
ROLL -12

Figure 7. Graph of Uncorrected Data in Line 705, Channel 5, Run 66005200.

****** GRAPH OF LINE 695 ******

RUN NUMBER...........	66005202	DATE.................	6/30/66
FLIGHT LINE.. COLOR PANELS (F)		TIME.....................	1400
DATA TAPE.................	213	ALTITUDE..............	700
REFORMATING DATE. DEC	8,1969	GROUND HEADING....	270 DEGREES

CHANNEL 1 SPECTRAL BAND 0.62 TO 0.66 MICROMETERS DISPLAYED AS.. 1 CALCODE = 1 CO = 16.15



CALIBRATION FOR LINE 695

CHANNEL	C0 MEAN	C0 VARIANCE	C1 MEAN	C1 VARIANCE	C2 MEAN	C2 VARIANCE
1	16.2	0.0	16.2	0.0	16.2	0.0

ROLL 0

Figure 8. Graph of Corrected Data of Figure 6, Run 66005202.

****** GRAPH OF LINE 705 ******

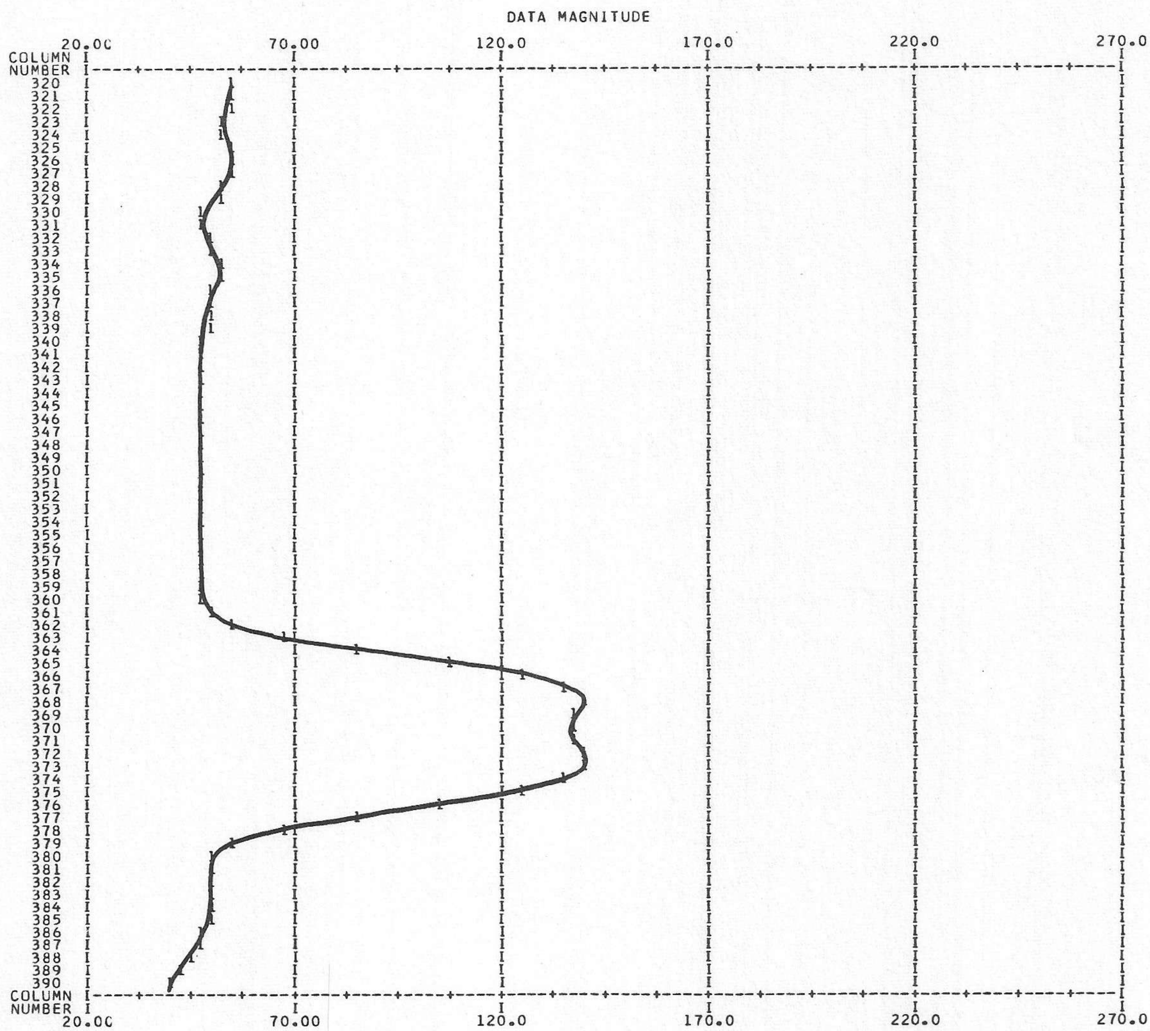
RUN NUMBER........... 66005202 DATE................. 6/30/66

FLIGHT LINE.. COLOR PANELS (F) TIME..................... 1400

DATA TAPE................. 213 ALTITUDE............. 700

REFORMATING DATE. DEC 8,1969 GROUND HEADING.... 270 DEGREES

CHANNEL 1 SPECTRAL BAND 0.62 TO 0.66 MICROMETERS DISPLAYED AS.. 1 CALCODE = 1 CO = 16.15



CALIBRATION FOR LINE 705

CHANNEL	C0 MEAN	C0 VARIANCE	C1 MEAN	C1 VARIANCE	C2 MEAN	C2 VARIANCE
1	16.2	0.0	16.2	0.0	16.2	0.0

ROLL 0

Figure 9. Graph of Corrected Data of Figure 7, Run 66005202.

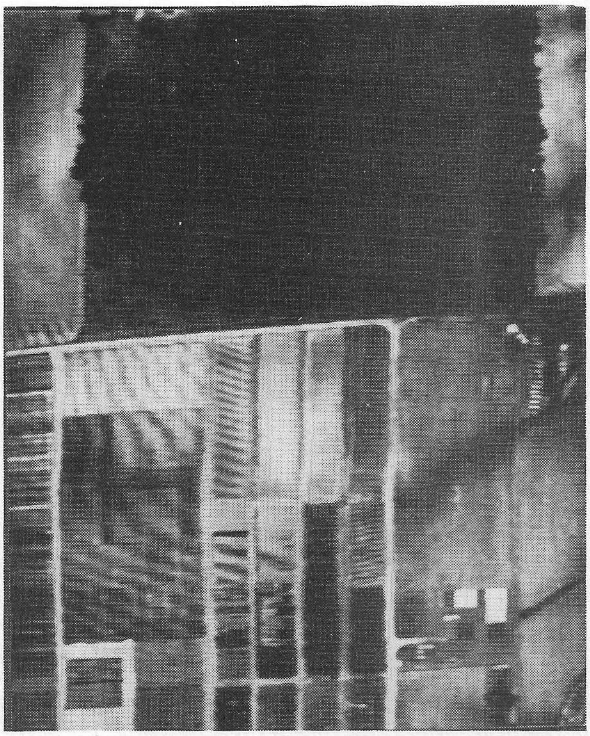


Figure 10. Scanner Image from Run 66005202, Lines 200--800, Columns 1-450, Channel 1.

APPENDIX A:

The follow listing is a program used to compute analog system frequency and impulse response and correction function frequency and impulse response.

```
FORTRAN IV    MODEL 44  PS       VERSION 3,  LEVEL 4   DATE  71143                    PAGE  0001

      C*********************************************************************
      C ***** THIS PROGRAM COMPUTES H(W) AND HI(W) *******
      C*********************************************************************
            DIMENSION RY(100),Y(1024), S(1024),X(1024),CMH(1024),ICONT(13),
           1CHCR(1024),CHCI(1024),HAM2(1024),HI(1024),CIHM(1024),HAMR(1024)
            DIMENSION THI(1024),CMTIH(1024),HWR1(1024),XC(1024)
            COMPLEX CTIH(1024),HW1(1024),CCTIH(1024)
            COMPLEX CY(1024), CX(1024), CH(1024), CHC(1024),HAM1(1024)
            COMPLEX HAM3(1024),CIH(1024),CCIH(1024),CHB(1024),CXC(1024)
            INTEGER PUN
            ICONT(1)=-1
            ICONT(13)=1
            DO 9 I=2,12
          9 ICONT(I)=0
      C   ************************************************************
      C        N1=NO OF DATA POINTS ON PULSE PEAK FOR PANEL 1
            N1=12
      C        N10= 1ST POINT ON FLAT TOP OF SQUARE WAVE  FOR PANEL 1
            N10=1
      C        N14= NO OF INTERM PCINTS BETWEEN MIN & MAX ON PANEL 1
            N14=0
      C        DLTX1=CHANGE IN X OVER WIDTH OF N1 FOR PANEL 1
            DLTX1=0.0
      C        DLTX2=CHANGE IN X OVER WIDTH OF N28 FOR PANEL 2
            DLTX2=0.0
      C        N27=NO OF INTERM POINTS BETWEEN MIN & MAX FOR PANEL 2
            N27=0
      C        N22=FIRST DATA PCINT ON PANEL 2
            N22=29
      C        N28=NO OF DATA POINTS CN PEAK OF PANEL 2
            N28=12
      C        PK1=PEAK OF PANEL 1
            PK1=92.0
      C        PK2=PEAK CF PANEL 2
            PK2=-2.5
      C        N29=POSITIVE TIME DURATION OF INVERSE IMPULSE
            N29=1024
      C          NBC=TIME DURATION OF IMPULSE RESPONSE
            NBC=33
      C          NLW CAN HAVE ANY VALUE BETWEEN 1 AND N2
            NLW=240
      C          PUN=0 FOR NO PUNCHED OUTPUT
      C          PUN=1 FOR PUNCHED OUTPUT
            PUN=0
      C   ************************************************************
            M=10
            N=1024
            N2=N/2
            N5=N2+1
            N11=N10+N1-1
            N13=N11+1
            N23=N22+N28-1
            N24=N23+1
            A2=N2
            P1=3.14159/A2
            READ(5,501) (RY(I), I=1,40)
        501 FORMAT(12F6.1)
            DO 1 I=1,40
          1 Y(I)=RY(I)-52.2
            DO 2 I=41,N
          2 Y(I)=0.0
            DO 3 I=1,N
          3 CY(I)=CMPLX(Y(I),0.0)
            CALL FORT(CY,M,S,-1,JACK)
            READ(5,502) NCH
        502 FORMAT(I2)
            N12=N10-(N14+1)
            IF(N12.LT.1) GO TO 22
            DO 21 I=1,N12
         21 X(I)=0.0
         22 N15=N12+1
            N16=N10-1
            IF(N16.LT.1) GO TO 24
            DO 23 I=N15,N16
            A3=I-N12
            B1=N14+1
         23 X(I)=(PK1/B1)*A3
         24 DO 5 I=N10,N11

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            A4=I-N10
            B2=N1-1
          5 X(I)=PK1+((DLTX1/B2)*A4)
            N17=N13+N14-1
            IF(N17.LT.N13) GO TO 26
            DO 25 I=N13,N17
            A5=I-N11
            B3=N14+1
         25 X(I)=X(N11)-((X(N11)/B3)*A5)
         26 N18=N17+1
            N19=N22-N27-1
            IF(N22.LT.N19) GO TO 41
            DO 34 I=N18,N19
         34 X(I)=0.0
            N20=N19+1
            N21=N22-1
            IF(N20.GT.N21) GO TO 19
            DO 35 I=N20,N21
            A6=I-N19
            B4=N27+1
         35 X(I)=(PK2/B4)*A6
         19 DO 36 I=N22,N23
            A7=I-N22
            B5=N28-1
         36 X(I)=PK2+((DLTX2/B5)*A7)
            N25=N24+N27-1
            IF(N25.LT.N24) GO TO 38
            DO 37 I=N24,N25
            A8=I-N23
            B6=N27+1
         37 X(I)=X(N23)-((X(N23)/B6)*A8)
         38 N26=N25+1
            GO TO 42
         41 N26=N18
         42 DO 4 I=N26,N
          4 X(I)=0.0
            DO 6 I=1,N
          6 CX(I)=CMPLX(X(I),0.0)
            CALL FORT(CX,M,S,-1,JACK)
            DO 16 I=1,N2
            A=I
         16 HAM1(I)=0.54+0.46*COS(A*P1)
            DO 17 I=N5,N
            N6=N-I+1
         17 HAM1(I)=HAM1(N6)
            DO 7 I=1,N
          7 CH(I)=(CY(I)/CX(I))*HAM1(I)
            CALL FORT(CH,M,S,1,JACK)
            NBC1=NBC+1
            DO 18 I=1,NBC
         18 HAM2(I)=1.0
            IF(NBC1.GT.N) GO TC 51
            DO 20 I=NBC1,N
         20 HAM2(I)=0.0
         51 DO 12 I=1,N
         12 CHCR(I)=REAL(CH(I))*HAM2(I)
            DO 14 I=1,N
         14 CHB(I)=CMPLX(CHCR(I),0.0)
            CALL FORT(CHB,M,S,-1,JACK)
            DO 47 I=1,N
         47 CHC(I)=CHB(I)/CHB(1)
            DO 15 I=1,N
         15 CMH(I)=CABS(CHC(I))
            B=NLW
            P2=3.14159/B
            NLW2=N-NLW+1
            NLW3=NLW2-1
            NLW1=NLW+1
            DO 27 I=1,NLW
            A=I
         27 HAM3(I)=0.50+0.50*COS(A*P2)
            DO 28 I=NLW2,N
            N6=N-I+1
         28 HAM3(I)=HAM3(N6)
            DO 29 I=NLW1,NLW3
         29 HAM3(I)=0.0
            C1=1.0E-10
            DO 30 I=1,N
```

(Appendix A: Continued)

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           IF(CABS(CHC(I)).LT.C1) CHC(I)=CMPLX(C1,C1)
           CIH(I)=HAM3(I)/CHC(I)
           CIHM(I)=CABS(CIH(I))
        30 CCIH(I)=CIH(I)
           CALL FORT(CCIH,M,S,1,JACK)
           DO 31 I=1,N
        31 HI(I)=REAL(CCIH(I))
           N30=N29+1
           DO 39 I=1,N29
        39 THI(I)=HI(I)
           DO 40 I=N30,N
        40 THI(I)=0.0
           DO 43 I=1,N
        43 CTIH(I)=CMPLX(THI(I),0.0)
           CALL FORT(CTIH,M,S,-1,JACK)
           DO 44 I=1,N
           CCTIH(I)=CTIH(I)/CTIH(1)
           CMTIH(I)=CABS(CCTIH(I))
        44 HW1(I)=CCTIH(I)*CHC(I)
           CALL FORT(HW1,M,S,1,JACK)
           DO 45 I=1,N
        45 HWR1(I)=REAL(HW1(I))
           CALL FORT(HAM3,M,S,1,JACK)
           DO 32 I=1,N
        32 HAMR(I)=REAL(HAM3(I))
           DO 48 I=1,N
        48 CXC(I)=CY(I)*CCTIH(I)
           CALL FORT(CXC,M,S, 1,JACK)
           DO 49 I=1,N
        49 XC(I)=REAL(CXC(I))
           N3=1
           N4=64
         8 CONTINUE
           WRITE(6,603)
       603 FORMAT(1H1)
           WRITE(6,611) NCH
       611 FORMAT( 55X,'CHANNEL NO ', I2)
           WRITE(6,607)
       607 FORMAT( 95H                                   SYSTEM RESPONSE
          1                        INVERSE RESPONSE )
           WRITE(6,602)
       602 FORMAT(112H   NO       REAL            IMAG           MAG       IMP RESP
          1       REAL             IMAG          MAG             IMP RESP   )
           WRITE(6,604)
       604 FORMAT(1H0)
           DO 10 I=N3,N4
        10 WRITE(6,601) I,CHC(I),CMH(I),CHCR(I),CIH(I),CIHM(I),HI(I)
       601 FORMAT(I5,1P2E13.4,1PE13.4,1PE13.4,1P2E13.4,1PE13.4,1PE13.4)
           WRITE(6,616)
       616 FORMAT(1H1)
           WRITE(6,617) NCH
       617 FORMAT(55X,'CHANNEL NO ',I2)
           WRITE(6,618)
       618 FORMAT(25X,'TRUNCATED INVERSE RESPONSE')
           WRITE(6,619)
       619 FORMAT(4X,'NO',6X,'REAL',10X,'IMAG',9X,'MAG',6X,'IMP RESP',2X,
          1'COMP IMP RESP',2X,'CORRECTED X')
           WRITE(6,620)
       620 FORMAT(1H0)
           DO 46 I=N3,N4
        46 WRITE(6,621) I,CCTIH(I),CMTIH(I),THI(I),HWR1(I),XC(I)
       621 FORMAT(I5,1P2E13.4,1PE13.4,1PE13.4,1PE13.4,1PE13.4)
           N3=N3+64
           N4=N4+64
           IF(N4.LE.N)  GO TO 8
        50 WRITE(6,605)
       605 FORMAT(1H1)
           CALL PLOTNR(CMH,ICONT,1,400,1)
           WRITE(6,606)
       606 FORMAT(1H1)
           CALL PLOTNR(CHCR,ICONT,924,N,1)
           CALL PLOTNR(CHCR,ICONT,1,200,1)
           WRITE(6,608)
       608 FORMAT(1H1)
           CALL PLOTNR(X,ICUNT,1, 60,1)
           WRITE(6,609)
       609 FORMAT(1H1)
           CALL PLOTNR(CIHM,ICONT,1,400,1)
```

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           WRITE(6,610)
       610 FORMAT(1H1)
           CALL PLOTNR(HI,ICONT,924,N,1)
           CALL PLOTNR(HI,ICONT,1,200,1)
           WRITE(6,612)
       612 FORMAT(1H1)
           CALL PLOTNR(HAMR,ICONT,974,N,1)
           CALL PLOTNR(HAMR,ICONT,1, 50,1)
           WRITE(6,613)
       613 FORMAT(1H1)
           CALL PLOTNR(THI,ICONT,974,N,1)
           CALL PLOTNR(THI,ICONT,1,200,1)
           WRITE(6,614)
       614 FORMAT(1H1)
           CALL PLOTNR(CMTIH,ICONT,1,400,1)
           WRITE(6,615)
       615 FORMAT(1H1)
           CALL PLOTNR(HWR1,ICONT,974,N,1)
           CALL PLOTNR(HWR1,ICONT,1, 50,1)
        52 WRITE(6,622)
       622 FORMAT(1H1)
           CALL PLOTNR(XC,ICUNT,924,N,1)
           CALL PLOTNR(XC,ICONT,1,100,1)
           WRITE(6,623)
       623 FORMAT(1H1)
           CALL PLOTNR(Y,ICONT,1,61,1)
           IF(PUN.EQ.0) GO TO 33
     C       PLACE WRITE 7 STATEMENT CARD DO-LOOP AFTER THIS CARD
           DO 11 I=1,N2
           I1=2*I
           I2=I1-1
        11 WRITE(7,701) CIH(I2),CIH(I1),NCH,I
       701 FORMAT(1P4E15.7,I6,I6)
     C       PLACE WRITE 7 STATEMENT CARD DO-LOOP BEFORE THIS CARD
        33 STOP
           END
```

APPENDIX B:

A program to correct digitized analog data.

```
//   JOB
//   EXEC  FORTRAN(BCD)
C          THIS PROGRAM CORRECTS ANY CHANNELS OF DATA FROM A LARS
C              DATA TAPE WHICH IS MOUNTED ON TAPE UNIT 180 AND GENERATES
C              A CORRECTED VERSICN WITH TAPE UNIT 181 AS OUTPUT
      IMPLICIT INTEGER(A-Z)
      INTEGER*2 CSEL(30),LINE,LNIDA(2),CHAN(30),ROLLH,KDATA( 700,10)
      INTEGER*2 IDATA(10000)
      INTEGER*2 BLOCK(4)
      INTEGER  ID(200),NID(200),BDATA(10000),JDATA( 2000),ROLL
      REAL CSET(3,10),RDATA( 500,10)
      REAL          Y(1024),S(1024)          ,XR(1300)
      REAL K,DCLV
      COMPLEX CY(1024), CX(1024),CIH(1024)
      EQUIVALENCE(LNID,LINE),(LNIDA(2),ROLLH),(LNIDA(1),LNID)
C ****************************************************************************
C         RUN= RUN NO TO BE CORRECTED
      RUN=66005200
C         FLINE= FIRST DATA LINE OF RUN
      FLINE=1
C         LLINE=LAST DATA LINE CF RUN
      LLINE=800
C         CHAN(I)= CHANNEL NO OF RUN TO BE CORRECTED
      CHAN(1)=5
C         NCHAN= NO OF CHANNELS ON CORRECTED VERSION
      NCHAN=1
C         TAPE= TAPE NO CF CORRECTED VERSION
      TAPE=175
C         FILE= FILE NO OF CORRECTED VERSION
      FILE=2
C         NRUN= RUN NO OF CORRECTED VERSION
      NRUN=66005203
C ****************************************************************************
C ************************************************************************
C     *****SHIFT CAN HAVE ANY INTEGER VALUE BETWEEN   + OR - 100
C  *****    NOTE..... A POSITIVE SHIFT WILL MOVE IMAGE TO THE RIGHT ON
C                               LARSPLAY
      SHIFT=-5
C ************************************************************************
C          ***** DCLV IS DC BIAS CORRECTION *****
      DCLV=-20.0
C   **************************************************************************
C******  SELK SELECTS THE SHAPE OF THE WAVEFORM PRECEEDING THE FIRST
C           DATA SAMPLE
C           SELK=0  PRODUCES A RAMP
C           SELK=1  PRODUCES A DC LEVEL EQUAL TO FIRST DATA SAMPLE
      SELK=0
C    ****************************************************************************
C******* KBD DETERMINES SAMPLE LENGTH OF WAVEFORM PRECEEDING FIRST DATA
C           SAMPLE(MUST BE BETWEEN 1 AND 200)
      KBD=100
C  ****************************************************************************
      UNIT=10
      OUTUNT=11
      ROLLH=ROLL
      NSD=500
      NCD=10
      CALL GADRUN(RUN,UNIT,ID,ERR)
      DO 810 I=1,30
  810 CSEL(I)=0
      FSAMP=1
      LSAMP=ID(6)
      ISAMP=1
      BLOCK(1)=FLINE
      BLOCK(2)=FSAMP
      BLOCK(3)=LSAMP
      BLOCK(4)=ISAMP
      DO 820 I=1,NCHAN
  820 CSEL(CHAN(I))=7
      M=10
      N=1024
      N2=N/2
      IDNS=ID(6)-6
      IDA=IDNS+1
      DO 16 I=1,N2
      I1=2*I
      I2=I1-1
   16 READ(5,502) CIH(I2),CIH(I1)
  502 FORMAT(1P4E15.7)
      DO 825 I=1,51
```

```
  825 NID(I)=ID(I)
      DO 824 I=51,200
  824 NID(I)=0
      DO 826 J=1,NCHAN
      M1=(J-1)*5+50
      N1=(CHAN(J)-1)*5+50
      DO 826 I=1,5
  826 NID(I+M1)=ID(I+N1)
      CALL TOPRW(OUTUNT)
      NID(1)=TAPE
      NID(2)=FILE
      NID(3)=NRUN
      NID(5)=NCHAN
      IF(FILE.EQ.1) GO TO 832
      NSKP=FILE-1
      DO 827 J=1,NSKP
  827 CALL TOPFF(OUTUNT)
  832 COUNT=800
      CALL TOPWR(OUTUNT,COUNT,ERR,NID)
  823 CALL GADLIN(BLOCK,CSEL,CSET,ID,UNIT,NCD,NSD,BDATA,RDATA,ROLL,
     1ERROR)
      DO 20 CHN=1,NCHAN
      LINE=BLOCK(1)
      FCAL=ID(6)-5
      LCAL=ID(6)
      NSAM=IDNS
      DO 830 I=FCAL,LCAL
  830 KDATA(I,CHN)=RDATA(I,CHN)
      DO 1 I=1,IDNS
      IF(KBD.LT.1) KBD=1
      I1=IDNS-I+KBD
    1 Y(I1)=RDATA(I,CHN)
      IF(KBD.LE.1) GO TO 21
      KBD1=KBD-1
      IF(SELK.EQ.1) GO TO 22
      DO 2 I=1,KBD1
    2 Y(I)=RDATA(IDA,CHN)+(((RCATA(IDNS,CHN)-RDATA(IDA,CHN))/(KBD1-1))*(
     1I-1))
      GO TO 21
   22 DO 23 I=1,KBD1
   23 Y(I)=RDATA(IDNS,CHN)
   21 KBD2=IDNS+KBD
      KBD3=KBD2+KBD-2
      IF(SELK.EQ.1) GO TO 24
      DO 28 I=KBD2,KBD3
   28 Y(I)=RDATA(1,CHN)-(((RDATA(1,CHN)-RDATA(IDA,CHN))/(KBD-2))*(I-KBD2
     1))
      KBD4=KBD3+1
      DO 26 I=KBD4,N
   26 Y(I)=RDATA(IDA,CHN)
      GO TO 27
   24 DO 25 I=KBD2,N
   25 Y(I)=RDATA(IDNS,CHN)
   27 DO 3 I=1,N
    3 CY(I)=CMPLX(Y(I),0.0)
      CALL FORT(CY,M,S,-1,JACK)
      DO 6 I=1,N
    6 CX(I)=CY(I)*CIH(I)
      CALL FORT(CX,M,S,1,JACK)
      DO12 I=1,N
      I1=100+I
   12 XR(I1)=REAL(CX(I))
      DO 18 I=1,100
   18 XR(I)=0.0
      I3=101+N
      I4=200+N
      DO 19 I=I3,I4
   19 XR(I)=0.0
      S1=SHIFT+KBD
      I5=101+S1
      I6=IDNS+100+S1
      DO 13 I=I5,I6
      I1=IDNS+100-I+S1+KBD
      K=XR(I)+DCLV
      IF(K.LT.0.0) K=0.0
      IF(K.GT.255.0) K=255.0
   13 KDATA(I1,CHN)=K
      LSBD=LSAMP+KBD
      KBD5=KBD+1
      DO 20 J=KBD5,LSBD
```

(Appendix B: Continued)

```
      I=(J-KBD)+(CHN-1)*ID(6)
   20 IDATA(I)=KDATA(J,CHN)
      INDIS=1
      ININC=2
      OUTDIS=4
      OUTINC=1
      NOBYTS=ID(6)*NCHAN
      OUTBYT=NOBYTS+4
      CALL MOVBYT(IDATA,INDIS,ININC,JDATA,OUTDIS,OUTINC,NOBYTS)
      JDATA(1)=LNID
      CALL TOPWR(OUTUNT,OUTBYT,ERR,JDATA)
      IF( LINE.GE.LLINE) GO TO 900
      BLOCK(1)=BLOCK(1)+1
      GO TO 823
  900 CALL TOPEF(OUTUNT,ERR)
      NID(2)=NID(2)+1
      DO 901 I=3,200
  901 NID(I)=0
      COUNT=800
      CALL TOPWR(OUTUNT,COUNT,ERR,NID)
      CALL TOPEF(OUTUNT,ERR)
      CALL TOPEF(OUTUNT,ERR)
      CALL TOPRW(OUTUNT)
      CALL TOPRW(UNIT)
      STOP
      END
/*
// EXEC LNKEDT
/*
// EXEC
   9.9995571E-01  0.0             9.9977595E-01  1.7198496E-02      5    1
   9.9939799E-01  3.4723703E-02   9.9876744E-01  5.2893139E-02      5    2
   9.9779701E-01  7.2000146E-02   9.9636525E-01  9.2302501E-02      5    3
   9.9431360E-01  1.1400908E-01   9.9145573E-01  1.3726884E-01      5    4
   9.8758411E-01  1.6216117E-01   9.8247319E-01  1.8868536E-01      5    5
   9.7590029E-01  2.1675634E-01   9.6766013E-01  2.4620420E-01      5    6
   9.5758581E-01  2.7677900E-01   9.4556820E-01  3.0816364E-01      5    7
   9.3157214E-01  3.3999139E-01   9.1564673E-01  3.7187201E-01      5    8
   8.9793748E-01  4.0341985E-01   8.7867290E-01  4.3428081E-01      5    9
   8.5815406E-01  4.6415752E-01   8.3674067E-01  4.9283159E-01      5   10
   8.1481946E-01  5.2017051E-01   7.9278570E-01  5.4613346E-01      5   11
   7.7101678E-01  5.7076418E-01   7.4985468E-01  5.9418046E-01      5   12
   7.2959030E-01  6.1655945E-01   7.1045941E-01  6.3812017E-01      5   13
   6.9263345E-01  6.5910864E-01   6.7622006E-01  6.7977816E-01      5   14
   6.6126692E-01  7.0037931E-01   6.4776206E-01  7.2114795E-01      5   15
   6.3563675E-01  7.4229258E-01   6.2476873E-01  7.6398671E-01      5   16
   6.1498487E-01  7.8636229E-01   6.0606050E-01  8.0949706E-01      5   17
   5.9772241E-01  8.3340710E-01   5.8965337E-01  8.5804296E-01      5   18
   5.8149338E-01  8.8327378E-01   5.7285184E-01  9.0888429E-01      5   19
   5.6332010E-01  9.3456990E-01   5.5248892E-01  9.5993054E-01      5   20
   5.3998005E-01  9.8448491E-01   5.2546954E-01  1.0076790E 00      5   21
   5.0872415E-01  1.0289135E 00   4.8963422E-01  1.0475883E 00      5   22
   4.6823096E-01  1.0631351E 00   4.4469780E-01  1.0750837E 00      5   23
   4.1936213E-01  1.0831003E 00   3.9266795E-01  1.0870275E 00      5   24
   3.6513549E-01  1.0869131E 00   3.3731186E-01  1.0829992E 00      5   25
   3.0972242E-01  1.0757103E 00   2.8282464E-01  1.0656080E 00      5   26
   2.5698602E-01  1.0533562E 00   2.3246181E-01  1.0396547E 00      5   27
   2.0939738E-01  1.0252123E 00   1.8783480E-01  1.0107002E 00      5   28
   1.6772479E-01  9.9673826E-01   1.4894468E-01  9.8387289E-01      5   29
   1.3131231E-01  9.7258061E-01   1.1459619E-01  9.6326268E-01      5   30
   9.8524570E-02  9.5625710E-01   8.2789063E-02  9.5184404E-01      5   31
   6.7044139E-02  9.5025200E-01   5.0901160E-02  9.5166218E-01      5   32
   3.3922080E-02  9.5620954E-01   1.5608095E-02  9.6397901E-01      5   33
  -4.6114437E-03  9.7498697E-01  -2.7392298E-02  9.8916453E-01      5   34
  -5.3481992E-02  1.0063190E 00  -8.3718240E-02  1.0260820E 00      5   35
  -1.1901212E-01  1.0478468E 00  -1.6029489E-01  1.0706806E 00      5   36
  -2.0842671E-01  1.0932493E 00  -2.6404011E-01  1.1137447E 00      5   37
  -3.2731313E-01  1.1298790E 00  -3.9769793E-01  1.1389885E 00      5   38
  -4.7365326E-01  1.1382990E 00  -5.5249649E-01  1.1253748E 00      5   39
  -6.3050836E-01  1.0986938E 00  -7.0337641E-01  1.0581608E 00      5   40
  -7.6692164E-01  1.0053463E 00  -8.1788814E-01  9.4328886E-01      5   41
  -8.5450882E-01  8.7589234E-01  -8.7664849E-01  8.0715132E-01      5   42
  -8.8554490E-01  7.4048930E-01  -8.8330871E-01  6.7837483E-01      5   43
  -8.7240797E-01  6.2225324E-01  -8.5527074E-01  5.7268929E-01      5   44
  -8.3404231E-01  5.2960145E-01  -8.1049412E-01  4.9251008E-01      5   45
  -7.8600889E-01  4.6072030E-01  -7.6163375E-01  4.3346995E-01      5   46
  -7.3813576E-01  4.1001016E-01  -7.1606255E-01  3.8965279E-01      5   47
  -6.9579875E-01  3.7178957E-01  -6.7760557E-01  3.5589361E-01      5   48
  -6.6165370E-01  3.4151208E-01  -6.4804792E-01  3.2825643E-01      5   49
  -6.3684279E-01  3.1578529E-01  -6.2805289E-01  3.0379385E-01      5   50

  -6.2166351E-01  2.9200047E-01  -6.1762911E-01  2.8013772E-01      5   51
  -6.1587572E-01  2.6794285E-01  -6.1629611E-01  2.5515461E-01      5   52
  -6.1874747E-01  2.4151105E-01  -6.2304109E-01  2.2675145E-01      5   53
  -6.2893713E-01  2.1062344E-01  -6.3613677E-01  1.9289511E-01      5   54
  -6.4427871E-01  1.7337263E-01  -6.5294462E-01  1.5192080E-01      5   55
  -6.6166162E-01  1.2848759E-01  -6.6992986E-01  1.0312629E-01      5   56
  -6.7724472E-01  7.6014340E-02  -6.8314260E-01  4.7457460E-02      5   57
  -6.8723452E-01  1.7883111E-02  -6.8925071E-01 -1.2186140E-02      5   58
  -6.8905938E-01 -4.2172372E-02  -6.8668383E-01 -7.1491003E-02      5   59
  -6.8228614E-01 -9.9601150E-02  -6.7613918E-01 -1.2604576E-01      5   60
  -6.6859239E-01 -1.5048212E-01  -6.6001958E-01 -1.7269039E-01      5   61
  -6.5078527E-01 -1.9257450E-01  -6.4120352E-01 -2.1014488E-01      5   62
  -6.3152242E-01 -2.2550231E-01  -6.2190664E-01 -2.3881322E-01      5   63
  -6.1243999E-01 -2.5029433E-01  -6.0312217E-01 -2.6019222E-01      5   64
  -5.9388566E-01 -2.6877362E-01  -5.8460385E-01 -2.7631152E-01      5   65
  -5.7510334E-01 -2.8307712E-01  -5.6518584E-01 -2.8933233E-01      5   66
  -5.5463207E-01 -2.9531461E-01  -5.4322547E-01 -3.0123264E-01      5   67
  -5.3075552E-01 -3.0724853E-01  -5.1703650E-01 -3.1347132E-01      5   68
  -5.0191164E-01 -3.1994563E-01  -4.8527157E-01 -3.2664877E-01      5   69
  -4.6705580E-01 -3.3349001E-01  -4.4726670E-01 -3.4031850E-01      5   70
  -4.2597532E-01 -3.4694004E-01  -4.0332085E-01 -3.5313386E-01      5   71
  -3.7951040E-01 -3.5868043E-01  -3.5480344E-01 -3.6338305E-01      5   72
  -3.2950062E-01 -3.6709249E-01  -3.0391753E-01 -3.6971891E-01      5   73
  -2.7836418E-01 -3.7124234E-01  -2.5311911E-01 -3.7170595E-01      5   74
  -2.2841626E-01 -3.7121308E-01  -2.0442700E-01 -3.6990631E-01      5   75
  -1.8125761E-01 -3.6795288E-01  -1.5894872E-01 -3.6553109E-01      5   76
  -1.3747764E-01 -3.6280835E-01  -1.1676878E-01 -3.5993564E-01      5   77
  -9.6699238E-02 -3.5703135E-01  -7.7110291E-02 -3.5417837E-01      5   78
  -5.7815254E-02 -3.5141277E-01  -3.8609870E-02 -3.4872425E-01      5   79
  -1.9282434E-02 -3.4604388E-01   3.7534884E-04 -3.4324497E-01      5   80
   2.0552907E-02 -3.4013361E-01   4.1401789E-02 -3.3644724E-01      5   81
   6.3012481E-02 -3.3185828E-01   8.5386336E-02 -3.2597905E-01      5   82
   1.0840541E-01 -3.1838989E-01   1.3180619E-01 -3.0866927E-01      5   83
   1.5516686E-01 -2.9645449E-01   1.7791516E-01 -2.8150237E-01      5   84
   1.9937330E-01 -2.6375937E-01   2.1882904E-01 -2.4340475E-01      5   85
   2.3563826E-01 -2.2086567E-01   2.4931896E-01 -1.9677490E-01      5   86
   2.5962514E-01 -1.7189205E-01   2.6657242E-01 -1.4699900E-01      5   87
   2.7041042E-01 -1.2279767E-01   2.7156568E-01 -9.9841177E-02      5   88
   2.7055842E-01 -7.8497589E-02   2.6793504E-01 -5.8954705E-02      5   89
   2.6420611E-01 -4.1243933E-02   2.5981826E-01 -2.5279354E-02      5   90
   2.5513357E-01 -1.0894466E-02   2.5043142E-01  2.1242669E-03      5   91
   2.4591273E-01  1.4014114E-02   2.4171036E-01  2.5018509E-02      5   92
   2.3789996E-01  3.5377804E-02   2.3450583E-01  4.5323193E-02      5   93
   2.3151082E-01  5.5074070E-02   2.2885358E-01  6.4836204E-02      5   94
   2.2643548E-01  7.4800432E-02   2.2411311E-01  8.5138142E-02      5   95
   2.2170061E-01  9.5995009E-02   2.1896070E-01  1.0747916E-01      5   96
   2.1561140E-01  1.1964679E-01   2.1132684E-01  1.3247734E-01      5   97
   2.0575416E-01  1.4585149E-01   1.9854873E-01  1.5952832E-01      5   98
   1.8941468E-01  1.7312884E-01   1.7817026E-01  1.8614894E-01      5   99
   1.6480511E-01  1.9799334E-01   1.4952707E-01  2.0805436E-01      5  100
   1.3276571E-01  2.1580255E-01   1.1512727E-01  2.2088575E-01      5  101
   9.7305715E-02  2.2318566E-01   7.9974055E-02  2.2282964E-01      5  102
   6.3693047E-02  2.2014999E-01   4.8853073E-02  2.1560323E-01      5  103
   3.5662208E-02  2.0969504E-01   2.4167351E-02  2.0290369E-01      5  104
   1.4293630E-02  1.9564641E-01   5.8890954E-03  1.8825281E-01      5  105
  -1.2395843E-03  1.8096918E-01  -7.2989091E-03  1.7396182E-01      5  106
  -1.2489911E-02  1.6733545E-01  -1.6998760E-02  1.6114193E-01      5  107
  -2.0992436E-02  1.5539426E-01  -2.4616737E-02  1.5007573E-01      5  108
  -2.7996078E-02  1.4514166E-01  -3.1236336E-02  1.4052945E-01      5  109
  -3.4422815E-02  1.3614625E-01  -3.7618935E-02  1.3188076E-01      5  110
  -4.0861420E-02  1.2758642E-01  -4.4149965E-02  1.2308574E-01      5  111
  -4.7431521E-02  1.1815643E-01  -5.0575122E-02  1.1254072E-01      5  112
  -5.3342536E-02  1.0594666E-01  -5.5354021E-02  9.8084986E-02      5  113
  -5.6082532E-02  8.8740289E-02  -5.4886259E-02  7.7845514E-02      5  114
  -5.1162254E-02  6.5601707E-02  -4.4593833E-02  5.2506637E-02      5  115
  -3.5482753E-02  3.9302170E-02  -2.4917062E-02  2.6812635E-02      5  116
  -1.4635772E-02  1.5861884E-02  -6.4498112E-03  7.2718821E-03      5  117
  -1.5251765E-03  1.8271799E-03   0.0            0.0                5  118
   0.0            0.0             0.0            0.0                5  119
   0.0            0.0             0.0            0.0                5  120
   0.0            0.0             0.0            0.0                5  121
   0.0            0.0             0.0            0.0                5  122
   0.0            0.0             0.0            0.0                5  123
   0.0            0.0             0.0            0.0                5  124
   0.0            0.0             0.0            0.0                5  125
   0.0            0.0             0.0            0.0                5  126
   0.0            0.0             0.0            0.0                5  127
   0.0            0.0             0.0            0.0                5  128
   0.0            0.0             0.0            0.0                5  129
   0.0            0.0             0.0            0.0                5  130
```

(Appendix B: Continued)

0.0	0.0	0.0	0.0	5	131
0.0	0.0	0.0	0.0	5	132
0.0	0.0	0.0	0.0	5	133
0.0	0.0	0.0	0.0	5	134
0.0	0.0	0.0	0.0	5	135
0.0	0.0	0.0	0.0	5	136
0.0	0.0	0.0	0.0	5	137
0.0	0.0	0.0	0.0	5	138
0.0	0.0	0.0	0.0	5	139
0.0	0.0	0.0	0.0	5	140
0.0	0.0	0.0	0.0	5	141
0.0	0.0	0.0	0.0	5	142
0.0	0.0	0.0	0.0	5	143
0.0	0.0	0.0	0.0	5	144
0.0	0.0	0.0	0.0	5	145
0.0	0.0	0.0	0.0	5	146
0.0	0.0	0.0	0.0	5	147
0.0	0.0	0.0	0.0	5	148
0.0	0.0	0.0	0.0	5	149
0.0	0.0	0.0	0.0	5	150
0.0	0.0	0.0	0.0	5	151
0.0	0.0	0.0	0.0	5	152
0.0	0.0	0.0	0.0	5	153
0.0	0.0	0.0	0.0	5	154
0.0	0.0	0.0	0.0	5	155
0.0	0.0	0.0	0.0	5	156
0.0	0.0	0.0	0.0	5	157
0.0	0.0	0.0	0.0	5	158
0.0	0.0	0.0	0.0	5	159
0.0	0.0	0.0	0.0	5	160
0.0	0.0	0.0	0.0	5	161
0.0	0.0	0.0	0.0	5	162
0.0	0.0	0.0	0.0	5	163
0.0	0.0	0.0	0.0	5	164
0.0	0.0	0.0	0.0	5	165
0.0	0.0	0.0	0.0	5	166
0.0	0.0	0.0	0.0	5	167
0.0	0.0	0.0	0.0	5	168
0.0	0.0	0.0	0.0	5	169
0.0	0.0	0.0	0.0	5	170
0.0	0.0	0.0	0.0	5	171
0.0	0.0	0.0	0.0	5	172
0.0	0.0	0.0	0.0	5	173
0.0	0.0	0.0	0.0	5	174
0.0	0.0	0.0	0.0	5	175
0.0	0.0	0.0	0.0	5	176
0.0	0.0	0.0	0.0	5	177
0.0	0.0	0.0	0.0	5	178
0.0	0.0	0.0	0.0	5	179
0.0	0.0	0.0	0.0	5	180
0.0	0.0	0.0	0.0	5	181
0.0	0.0	0.0	0.0	5	182
0.0	0.0	0.0	0.0	5	183
0.0	0.0	0.0	0.0	5	184
0.0	0.0	0.0	0.0	5	185
0.0	0.0	0.0	0.0	5	186
0.0	0.0	0.0	0.0	5	187
0.0	0.0	0.0	0.0	5	188
0.0	0.0	0.0	0.0	5	189
0.0	0.0	0.0	0.0	5	190
0.0	0.0	0.0	0.0	5	191
0.0	0.0	0.0	0.0	5	192
0.0	0.0	0.0	0.0	5	193
0.0	0.0	0.0	0.0	5	194
0.0	0.0	0.0	0.0	5	195
0.0	0.0	0.0	0.0	5	196
0.0	0.0	0.0	0.0	5	197
0.0	0.0	0.0	0.0	5	198
0.0	0.0	0.0	0.0	5	199
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0.0	0.0	0.0	0.0	5	201
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0.0	0.0	0.0	0.0	5	205
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0.0	0.0	0.0	0.0	5	207
0.0	0.0	0.0	0.0	5	208
0.0	0.0	0.0	0.0	5	209
0.0	0.0	0.0	0.0	5	210

0.0	0.0	0.0	0.0	5	211
0.0	0.0	0.0	0.0	5	212
0.0	0.0	0.0	0.0	5	213
0.0	0.0	0.0	0.0	5	214
0.0	0.0	0.0	0.0	5	215
0.0	0.0	0.0	0.0	5	216
0.0	0.0	0.0	0.0	5	217
0.0	0.0	0.0	0.0	5	218
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0.0	0.0	0.0	0.0	5	221
0.0	0.0	0.0	0.0	5	222
0.0	0.0	0.0	0.0	5	223
0.0	0.0	0.0	0.0	5	224
0.0	0.0	0.0	0.0	5	225
0.0	0.0	0.0	0.0	5	226
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0.0	0.0	0.0	0.0	5	228
0.0	0.0	0.0	0.0	5	229
0.0	0.0	0.0	0.0	5	230
0.0	0.0	0.0	0.0	5	231
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0.0	0.0	0.0	0.0	5	237
0.0	0.0	0.0	0.0	5	238
0.0	0.0	0.0	0.0	5	239
0.0	0.0	0.0	0.0	5	240
0.0	0.0	0.0	0.0	5	241
0.0	0.0	0.0	0.0	5	242
0.0	0.0	0.0	0.0	5	243
0.0	0.0	0.0	0.0	5	244
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0.0	0.0	0.0	0.0	5	246
0.0	0.0	0.0	0.0	5	247
0.0	0.0	0.0	0.0	5	248
0.0	0.0	0.0	0.0	5	249
0.0	0.0	0.0	0.0	5	250
0.0	0.0	0.0	0.0	5	251
0.0	0.0	0.0	0.0	5	252
0.0	0.0	0.0	0.0	5	253
0.0	0.0	0.0	0.0	5	254
0.0	0.0	0.0	0.0	5	255
0.0	0.0	0.0	0.0	5	256
0.0	0.0	0.0	0.0	5	257
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0.0	0.0	0.0	0.0	5	266
0.0	0.0	0.0	0.0	5	267
0.0	0.0	0.0	0.0	5	268
0.0	0.0	0.0	0.0	5	269
0.0	0.0	0.0	0.0	5	270
0.0	0.0	0.0	0.0	5	271
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0.0	0.0	0.0	0.0	5	275
0.0	0.0	0.0	0.0	5	276
0.0	0.0	0.0	0.0	5	277
0.0	0.0	0.0	0.0	5	278
0.0	0.0	0.0	0.0	5	279
0.0	0.0	0.0	0.0	5	280
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0.0	0.0	0.0	0.0	5	287
0.0	0.0	0.0	0.0	5	288
0.0	0.0	0.0	0.0	5	289
0.0	0.0	0.0	0.0	5	290

(Appendix B: Continued)

0.0	0.0	0.0	0.0	5	291
0.0	0.0	0.0	0.0	5	292
0.0	0.0	0.0	0.0	5	293
0.0	0.0	0.0	0.0	5	294
0.0	0.0	0.0	0.0	5	295
0.0	0.0	0.0	0.0	5	296
0.0	0.0	0.0	0.0	5	297
0.0	0.0	0.0	0.0	5	298
0.0	0.0	0.0	0.0	5	299
0.0	0.0	0.0	0.0	5	300
0.0	0.0	0.0	0.0	5	301
0.0	0.0	0.0	0.0	5	302
0.0	0.0	0.0	0.0	5	303
0.0	0.0	0.0	0.0	5	304
0.0	0.0	0.0	0.0	5	305
0.0	0.0	0.0	0.0	5	306
0.0	0.0	0.0	0.0	5	307
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0.0	0.0	0.0	0.0	5	319
0.0	0.0	0.0	0.0	5	320
0.0	0.0	0.0	0.0	5	321
0.0	0.0	0.0	0.0	5	322
0.0	0.0	0.0	0.0	5	323
0.0	0.0	0.0	0.0	5	324
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0.0	0.0	0.0	0.0	5	350
0.0	0.0	0.0	0.0	5	351
0.0	0.0	0.0	0.0	5	352
0.0	0.0	0.0	0.0	5	353
0.0	0.0	0.0	0.0	5	354
0.0	0.0	0.0	0.0	5	355
0.0	0.0	0.0	0.0	5	356
0.0	0.0	0.0	0.0	5	357
0.0	0.0	0.0	0.0	5	358
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0.0	0.0	0.0	0.0	5	363
0.0	0.0	0.0	0.0	5	364
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0.0	0.0	0.0	0.0	5	367
0.0	0.0	0.0	0.0	5	368
0.0	0.0	0.0	0.0	5	369
0.0	0.0	0.0	0.0	5	370

0.0	0.0	0.0	0.0	5	371
0.0	0.0	0.0	0.0	5	372
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0.0	0.0	0.0	0.0	5	379
0.0	0.0	0.0	0.0	5	380
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0.0	0.0	0.0	0.0	5	388
0.0	0.0	0.0	0.0	5	389
0.0	0.0	0.0	0.0	5	390
0.0	0.0	0.0	0.0	5	391
0.0	0.0	0.0	0.0	5	392
0.0	0.0	0.0	0.0	5	393
0.0	0.0	0.0	0.0	5	394
0.0	0.0	-1.3902085E-03	-1.7800597E-03	5	395
-6.0966052E-03	-7.3038042E-03	-1.4508825E-02	-1.6358074E-02	5	396
-2.6014049E-02	-2.8193377E-02	-3.8927265E-02	-4.1888684E-02	5	397
-5.1083945E-02	-5.6582693E-02	-6.0685653E-02	-7.1453810E-02	5	398
-6.6807806E-02	-8.5662901E-02	-6.9447994E-02	-9.8498464E-02	5	399
-6.9217443E-02	-1.0952383E-01	-6.6958249E-02	-1.1864722E-01	5	400
-6.3459873E-02	-1.2604135E-01	-5.9332900E-02	-1.3202876E-01	5	401
-5.4987520E-02	-1.3697928E-01	-5.0660230E-02	-1.4123577E-01	5	402
-4.6470128E-02	-1.4509916E-01	-4.2447310E-02	-1.4880764E-01	5	403
-3.8571764E-02	-1.5255582E-01	-3.4784183E-02	-1.5649092E-01	5	404
-3.1002823E-02	-1.6072971E-01	-2.7123418E-02	-1.6535771E-01	5	405
-2.3024686E-02	-1.7043781E-01	-1.8566813E-02	-1.7600650E-01	5	406
-1.3590105E-02	-1.8207544E-01	-7.9140961E-03	-1.8862402E-01	5	407
-1.3397189E-03	-1.9558799E-01	6.3458495E-03	-2.0285356E-01	5	408
1.5359480E-02	-2.1023542E-01	2.5902607E-02	-2.1747255E-01	5	409
3.8130637E-02	-2.2420949E-01	5.2117251E-02	-2.3000902E-01	5	410
6.7805052E-02	-2.3436290E-01	8.4968865E-02	-2.3674649E-01	5	411
1.0318965E-01	-2.3668134E-01	1.2187415E-01	-2.3383045E-01	5	412
1.4031309E-01	-2.2807044E-01	1.5777832E-01	-2.1953529E-01	5	413
1.7364085E-01	-2.0860845E-01	1.8745649E-01	-1.9585103E-01	5	414
1.9901967E-01	-1.8190801E-01	2.0834929E-01	-1.6740280E-01	5	415
2.1564788E-01	-1.5286475E-01	2.2123009E-01	-1.3868552E-01	5	416
2.2546458E-01	-1.2511444E-01	2.2872430E-01	-1.1227179E-01	5	417
2.3135006E-01	-1.0017312E-01	2.3364019E-01	-8.8757396E-02	5	418
2.3583990E-01	-7.7907085E-02	2.3814493E-01	-6.7468524E-02	5	419
2.4070156E-01	-5.7260454E-02	2.4361384E-01	-4.7083497E-02	5	420
2.4694163E-01	-3.6722388E-02	2.5070435E-01	-2.5949441E-02	5	421
2.5487322E-01	-1.4524754E-02	2.5937068E-01	-2.2000941E-03	5	422
2.6405853E-01	1.1275571E-02	2.6872689E-01	2.6146132E-02	5	423
2.7308929E-01	4.2630646E-02	2.7677011E-01	6.0898699E-02	5	424
2.7931136E-01	8.1037104E-02	2.8018636E-01	1.0301059E-01	5	425
2.7883655E-01	1.2662411E-01	2.7472711E-01	1.5149575E-01	5	426
2.6742476E-01	1.7705601E-01	2.5667530E-01	2.0258087E-01	5	427
2.4246860E-01	2.2726780E-01	2.2506231E-01	2.5033808E-01	5	428
2.0495433E-01	2.7114278E-01	1.8281114E-01	2.8924894E-01	5	429
1.5936470E-01	3.0447471E-01	1.3531286E-01	3.1688124E-01	5	430
1.1124164E-01	3.2672012E-01	8.7584019E-02	3.3436912E-01	5	431
6.4607918E-02	3.4026074E-01	4.2433299E-02	3.4482968E-01	5	432
2.1056805E-02	3.4847265E-01	3.8440619E-04	3.5152763E-01	5	433
-1.9740485E-02	3.5426408E-01	-3.9512746E-02	3.5687906E-01	5	434
-5.9146520E-02	3.5950446E-01	-7.8858614E-02	3.6220866E-01	5	435
-9.8858654E-02	3.6500418E-01	-1.1933696E-01	3.6785191E-01	5	436
-1.4045626E-01	3.7066895E-01	-1.6234112E-01	3.7333256E-01	5	437
-1.8506932E-01	3.7569064E-01	-2.0866263E-01	3.7757063E-01	5	438
-2.3308003E-01	3.7879241E-01	-2.5821275E-01	3.7918591E-01	5	439
-2.8388470E-01	3.7860483E-01	-3.0985880E-01	3.7694657E-01	5	440
-3.3584982E-01	3.7416607E-01	-3.6154372E-01	3.7028629E-01	5	441
-3.8661772E-01	3.6539763E-01	-4.1076845E-01	3.5965472E-01	5	442
-4.3373066E-01	3.5325652E-01	-4.5529687E-01	3.4642857E-01	5	443
-4.7532427E-01	3.3939391E-01	-4.9374384E-01	3.3235168E-01	5	444
-5.1055431E-01	3.2545495E-01	-5.2581668E-01	3.1879461E-01	5	445
-5.3964621E-01	3.1239522E-01	-5.5220026E-01	3.0620939E-01	5	446
-5.6367123E-01	3.0012757E-01	-5.7427144E-01	2.9398346E-01	5	447
-5.8422405E-01	2.8756654E-01	-5.9374928E-01	2.8063411E-01	5	448
-6.0305119E-01	2.7292168E-01	-6.1230582E-01	2.6415414E-01	5	449
-6.2163973E-01	2.5405413E-01	-6.3112420E-01	2.4235272E-01	5	450

(Appendix B: Continued)

-6.4075649E-01	2.2879958E-01	-6.5045458E-01	2.1317679E-01	5	451
-6.6004854E-01	1.9531560E-01	-6.6928977E-01	1.7511582E-01	5	452
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