Computer Program Useful for Quality Control of an Image-Processing Laboratory

by

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INTRODUCTION

Because one important product of an image processing laboratory is a photographic reproduction of an image and because the making of photographic images is complex, a quality control program is essential. The photographic image making process consists of two distinct steps: 1) the data are transformed from a digital format to a film format using a film writing machine, 2) the film is developed using an appropriate chemical process. Each of these steps must be subject to quality control, and appropriate tests must be devised that will make it possible to determine whether an incorrect film product is caused by problems with the film writing machine or the film processing. This report discusses the tests which were devised for quality control and presents the computer program which makes appropriate calculations. Although this report discusses the use of film transparencies, the same general procedures could be used for photographic prints.

FILM PROCESSING

Because both black and white and color images are made in the U.S. Geological Survey (USGS) image processing laboratory in Denver, Colorado, techniques to test both types of film processing are needed. A commonly used technique for controlling film processing is to expose test films with a calibrated light source which produces a series of uniformly exposed rectangular areas. The exposure of successive areas increases by fixed increments. This series of rectangular areas is called a step-wedge. The film density (defined as the logarithm of the ratio of light incident on a film to the light transmitted through the film) measured for each of the steps in the step-wedge gives a curve that can be used to judge the quality of the film processing. The film density is measured using a film densitometer. The film densitometer used in the Denver USGS image processing laboratory has red, green, blue, and visual filters (Kodak wratten filters 92, 93, 94, and 106, respectively) that provide a measurement of the spectral characteristics of the light transmitted through the film. The red, green, and blue filters are designed to approximate the spectral properties of the red, green, and blue emulsion used in many color films. The visual filter is designed to approximate the spectral response of the human eye. For black and white film, the visual filter is used to measure the step-wedge. For color film the red, green, and blue filters are used to provide a measure of the color reproduction.

Before the processing of a particular film can be judged, a standard for comparison must be defined. If all of the film to be used is from a single batch of film, a comparison standard can be defined as the average curve calculated from a number of films with similar data and which are qualitatively acceptable. Figure 1 presents the comparison standard used for a specific batch of black and white film, and Figure 2 presents the comparison standard used for a specific batch of color film. Comparison to
the standard can be done graphically or by using a goodness-of-fit calculation, which is the sum of the squares of the differences between the standard and the curve being tested divided by the number of data points. Because any problem with film processing will shift the film densities of the entire step-wedge, a goodness-of-fit parameter provides a reasonable measure for judging the quality of the film processing. Table 1 gives some typical goodness-of-fit values calculated to monitor film processing. Our experience has been that values less than 0.01 indicate an acceptable product, but a graphical presentation of the data is more useful, as described below.

Table 1. Typical values of goodness-of-fit parameters calculated to judge the quality of film processing.

<table>
<thead>
<tr>
<th>DATE</th>
<th>BLACK AND WHITE MACHINE</th>
<th>COLOR MACHINE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RED</td>
</tr>
<tr>
<td>01/25/82</td>
<td>.0013</td>
<td>.0018</td>
</tr>
<tr>
<td>02/01/82</td>
<td>.0006</td>
<td>.0025</td>
</tr>
<tr>
<td>02/08/82</td>
<td>.0002</td>
<td>.0002</td>
</tr>
<tr>
<td>02/16/82</td>
<td>.0130</td>
<td>.0034</td>
</tr>
<tr>
<td>02/22/82</td>
<td>.0026</td>
<td>.0003</td>
</tr>
</tbody>
</table>

FILM WRITING MACHINES

The film writing machines used in the Denver USGS image processing laboratory are designed to transform digital data in the value range 0-255 into variable light intensity. The transformation function is proportional to the exponential of the negative value of the data. The digital data are, therefore, proportional to the logarithm of the exposure and can be used to plot a curve used in photography called DlogE. The DlogE curve is film density plotted as a function of the logarithm of the exposure. We can obtain such a curve by defining a step-wedge of areas of constant exposure at intervals in the range 0-255. A standard for comparison would be defined in the same way the process control standards are defined. For black and white film the visual film density is used. For color film the visual film density is also used, but it is measured on a neutral color step-wedge made by overlapping step-wedges using red, green, and blue filters on the film writing machine. Figure 3 shows a comparison standard used for judging proper exposure of film by a black and white film writing machine. Figure 4 presents a comparison standard used for judging proper exposure of film by a color film writing machine. Table 2 lists some typical goodness-of-fit values calculated for exposure control. Values less than 0.01 generally indicate an acceptable exposure.
Table 2. Typical values of goodness-of-fit parameters calculated to judge the quality of film exposure by film writing machines.

<table>
<thead>
<tr>
<th>DATE</th>
<th>BLACK AND WHITE MACHINE</th>
<th>COLOR MACHINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/25/82</td>
<td>.0002</td>
<td>.0021</td>
</tr>
<tr>
<td>02/01/82</td>
<td>.0019</td>
<td>.0014</td>
</tr>
<tr>
<td>02/08/82</td>
<td>.0002</td>
<td>.0017</td>
</tr>
<tr>
<td>02/16/82</td>
<td>.0071</td>
<td>.0005</td>
</tr>
<tr>
<td>02/22/82</td>
<td>.0077</td>
<td>.0041</td>
</tr>
</tbody>
</table>

Because the color film used at the Denver USGS image processing laboratory has three emulsions with response functions for different parts of the visible light spectrum, the measurement to judge proper exposure is of no value if the neutral color step-wedge is not truly neutral color. The definition of neutral color used in the Denver laboratory is that the red, green, blue, and visual film densities must all be equal. To test that the step-wedge is neutral color, the red, green, and blue film densities of the step-wedge are measured in addition to the visual film density. By plotting curves of the differences between the visual film density and the red, green, and blue film densities as shown in Figure 5, the quality of the neutral color can be judged. Comparisons of the differences to the ideal values which are also shown in Figure 5 provide a basis analysis of any problems with the color balance. Curve values below the ideal values indicate that the color intensities are low and values above the ideal values indicate that the intensities are high. In the particular example given in Figure 5, both the red and blue light exposures are low. To correct the problem both red and blue exposures could be increased or green exposure could be decreased. In either case the comparison standard for exposure control may have to be redefined. Experience over a period of almost two years suggests that adjustments are not necessary until one or more of the curves deviate from the ideal by as much as 0.1.

COMPUTER PROGRAM

A computer program was written to do the goodness-of-fit calculations and graphically display the data. The program is written in BASIC and uses internal graphics of the Hewlett-Packard 9845T for which it was designed. The program does require that the computer have the graphics and mass-storage ROM's. The basic design of the program provides for permanent storage of the comparison standards as well as selective zeroing of any specific standard to allow for changes in the performance of the film writing machines. Provision is also made for the use of special transfer functions allowed by the machines. In general, these special functions are called film factors and are designed to linearize the film response functions as well as modify the slope of the exposure curve. The program is completely interactive with prompts from the computer for required data or decisions. Appendix I contains a listing of the program.
APPENDIX I

10 ! ****************************************** QCCTRL ******************************************
20 ! ***
30 ! *** QUALITY CONTROL PROGRAM
40 ! ***
50 ! *** This program is designed to make any of the various calculations used for quality control of the Optronics machines. The machines are designated as:
60 ! ***
70 ! *** BW = old black & white machine
80 ! ***
90 ! *** CO = old color machine
100 ! ***
110 ! *** HSBW = new high speed black & white machine
120 ! ***
130 ! *** HSCO = new high speed color machine
140 ! ***
150 ! *** The program is completely interactive and will prompt the user for all required data.
160 ! ***
170 ! *** Options available are to calculate a chi-squared value for either the intensity curve (film density versus DN) or the Sensomat step wedge. These calculations can be made for no film factor or any of five film factors in the case of the intensity curves.
180 ! *** You can also calculate the color balance data which is the difference from the ideal case where the color film densities are equal to the visual film density.
190 ! ***
200 ! **********************************************
210 ! ** OPTION BASE 1
220 ! **
230 ! ** DIM Stdcrv(4,27,6),Stpwdg(4,11,3),Red(27),Green(27)
240 ! **
250 ! ** DIM Blue(27),Visual(27)
260 ! **
270 ! ** DIM Dred(27),Dgrn(27),Dblu(27),Ncrvd(4,6),Ncrvw(4,3)
280 ! **
290 ! ** DIM Crv(27),Tmp(27)
300 ! **
310 ! ** DIM Wdg(11),Stdtot(4,27,6),Stptot(4,11,3),T$(4)
320 ! **
330 ! ** DIM File$(15),Ptmp(54)
340 ! **
350 ! ** STDRCV(I,J,K) - I SELECTS MACHINE TYPE (1=BW, 2=CO, 3=HSBW, 4=HSCO), J SELECTS THE DN VALUE WHERE "X" CORRESPONDS TO UNEXPOSED FILM, AND K SELECTS THE FILM FACTORS
360 ! **
370 ! ** STPWDG(I,J,K) - IS THE STEP WEDGE ON THE FILM MADE USING THE SENSOMAT CALIBRATED LIGHT SOURCE, I SELECTS THE MACHINE TYPE
380 ! **
390 ! ** K SELECTS THE COLOR (1=RED OR BLACK AND
Assign the data file to unit # 1

Assign_it:  ON ERROR GOSUB Chk_file

Assign #1 TO File$
OFF ERROR
GOTO Read_dat

Check for errors on the file assignment. If no
*** file exists, create one.

Chk_file: PRINT ERRM$
BEEP
IF ERRN=56 THEN S100
PAUSE
RETURN

Create a data file, initialize the arrays, and
*** write the data out to the file

S100: CREATE File$,80
ASSIGN #1 TO File$
MAT Stdcrv=ZER
MAT Stpwdg=ZER
MAT Ncrvd=ZER
MAT Ncrvw=ZER
MAT Stdtot=ZER
MAT Stptot=ZER
MAT PRINT #1;Stdcrv,Stpwdg,Ncrvd,Ncrvw,Stdtot,Stptot
ASSIGN #1 TO *
ASSIGN #1 TO File$
RETURN

Read in the comparison standards

Read_dat:MAT READ #1;Stdcrv,Stpwdg,Ncrvd,Ncrvw,Stdtot,Stptot
ASSIGN #1 TO *
Ans$="N"
INPUT "WANT TO DO ANY SELECTIVE ZEROING OF ARRAYS ?
(Y/N) DEFAULT=N", Ans$
IF Ans$="Y" THEN GOSUB Sel_zero
PRINTER IS 16
PRINT PAGE,SPA(25),"QUALITY CONTROL PROGRAM"
PRINT "THIS PROGRAM CALCULATES QUALITY CONTROL DATA FOR
OPTRONICS MACHINES."
PRINT "YOU WILL BE PROMPTED FOR ALL INPUT DATA"
800 Start: INPUT "TYPE OF MACHINE ? (1=BW, 2=CO, 3=HSBW, 4=HSCO) (DEFAULT=1)", Ntype
810 Ncalc = 1
820 Ncalc: INPUT "TYPE OF CALCULATION ? (1=STD CURVE, 2=STEP WEDGE, 3=COLOR BALANCE) (DEFAULT=1)", Ncalc
830 IF ((Ntype = 1) OR (Ntype = 3)) AND (Ncalc = 3) THEN Bad_select
840 GOTO Okay
850 Bad_select: BEEP
860 PRINT LIN(2), "NO COLOR BALANCE ON BLACK & WHITE FILM"
870 GOTO Ncalc
880 Okay: ON Ncalc GOTO Std_curve, Step_wedge, Color_balance
881 Std_curve: PRINT PAGE, "ENTER VALUES FOR THE STANDARD CURVE"
890 INPUT "", Crv(*)
900 ! *** Transfer to subroutine which permits the user to verify that he has entered the data correctly.
910 ! ***
920 GOSUB Chk_crv
930 PRINT PAGE
940 INPUT "DATE OF THE FILM ? (MM/DD/YY)", Date$
950 Ff = 0
960 INPUT "FILM FACTOR NUMBER ? (0=NONE, OR 1-5 FOR FACTORS 1 to 5) (Default=0)", Ff
970 Ff = Ff + 1
980 ! *** Check to see whether a comparison standard exists. If not, transfer down to ask whether this curve is to be used in the averaging to get a standard.
990 IF Ncrvd(Ntype, Ff) = 0 THEN No_std
1000 Nchi = 27
1001 ! ***
1002 ! *** Go to subroutine which calculates the goodness-of-fit parameter
1003 ! ***
1010 GOSUB Nchi
1020 GOTO S110
1030 Nchi: Chi = 0
1040 FOR I = 1 TO Nchi
1050 IF Ncalc = 1 THEN Chi = Chi + (Stdcrv(Ntype, I, Ff) - Crv(I))^2
1060 IF Ncalc = 1 THEN Dred(I) = Stdcrv(Ntype, I, Ff) - Crv(I)
1070 IF Ncalc = 2 THEN Chi = Chi + (Stpwdg(Ntype, I, Ff) - Wdg(I))^2
1080 NEXT I
1090 Chi = Chi / Nchi
1100 RETURN
1110 S110: PRINT PAGE, LIN(10), "CHI-SQUARED FOR "; T$(Ntype); " DN CURVE = "; Chi
1120 PRINTER IS 0
1130 PRINT LIN(2),T$(Ntype);" MACHINE - FILM FACTOR ";
   FF-1;" -- ";Date$
1140 PRINT "CHI-SQUARED FOR DN CURVE = ";Ch1
1141 ! ***
1142 ! *** Transfer to plotting subroutine
1143 ! ***
1150 GOSUB Pltem
1160 F6: IMAGE 3(7(3D,1X,MD.2D,1X)/),6(3D,1X,MD.2D,1X)
1170 MAT Ptmp=ZER
1190 J=0
1200 FOR I=1 TO 27
1201 J=J+1
1210 Ptmp(J)=Tmp(I)
1220 J=J+1
1230 Ptmp(J)=Dred(I)
1231 NEXT I
1232 PRINT USING F6;Ptmp(*)
1240 PRINTER IS 16
1250 Ans$="A"
1251 ! ***
1252 ! *** Subprogram to add or subtract step-wedges to the
1253 ! *** comparison standards for exposure control.
1254 ! ***
1260 No_std:INPUT "IS THIS CURVE TO BE ADDED TO, REMOVED FROM
THE STANDARD OR NOT ? (A/R/N)(DEF=A)",Ans$
1270 IF Ans$="N" THEN Query
1280 Xm=l
1290 IF Ans$="R" THEN Xm=-l
1300 Ncrvd(Ntype,Ff)=Ncrvd(Ntype,Ff)+Xm
1310 FOR I=1 TO 27
1320 Stdtot(Ntype,I,Ff)=Stdtot(Ntype,I,Ff)+Crv(I)*Xm
1330 Stdcrv(Ntype,I,Ff)=Stdtot(Ntype,I,Ff)/Ncrvd(Ntype,Ff)
1340 NEXT I
1350 GOTO Query
1351 ! ***
1352 ! *** Section to compare the film processing step-wedges
1353 ! *** to the comparison standards for film processing
1354 ! ***
1360 Step_wedge:PRINT PAGE,"INPUT DATA FOR THE STEP WEDGE"
1370 PRINT "11 VALUES ARE EXPECTED"
1380 PRINT "DATA CAN BE ON ONE OR SEVERAL LINES"
1390 INPUT ",",Wdg(*)
1400 GOSUB Chk_wdg
1410 PRINT PAGE
1420 INPUT "DATE OF THE FILM ? (MM/DD/YY)",Date$
1430 Ff=l
1440 INPUT "RED, BLK&W, GREEN, OR BLUE DENSITY ?
(1=RED OR B&W, 2=GREEN, 3=BLUE)(DEFAULT=1)",Ff
1450 IF Ncrvw(Ntype,Ff)=0 THEN No_stp
1460 Nchi=11
1470 GOSUB Nchi
1480 PRINT PAGE,LIN(10),"CHI-SQUARED FOR ";T$(Ntype);" STEP WEDGE = ";Ch1
1490 PRINT IS 0
IF (Ntype=1) OR (Ntype=3) THEN X$="B&W"
1510 IF ((Ntype=2) OR (Ntype=4)) AND (Ff=1) THEN X$="RED"
1520 IF ((Ntype=2) OR (Ntype=4)) AND (Ff=2) THEN X$="GREEN"
1530 IF ((Ntype=2) OR (Ntype=4)) AND (Ff=3) THEN X$="BLUE"
1540 PRINT LIN(2),T$(Ntype);" MACHINE ";X$;" STEP WEDGE ";Date$
1550 PRINT "CHI-SQUARED = ";Chi
1560 PRINTER IS 16
1570 Ans$="A"
1571 ! ***
1572 ! *** Subprogram to add or subtract step-wedges to the
1573 ! *** comparison standards for film processing.
1574 ! ***
1580 No_stp:INPUT "ADD, REMOVE CURVE TO STANDARD OR NEITHER ?
(A/R/N) (DEFAULT=A)",Ans$
1590 IF Ans$="N" THEN Query
1600 Xm=1
1610 IF Ans$="R" THEN Xm=-1
1620 Ncrvw(Ntype,Ff)=Ncrvw(Ntype,Ff)+Xm
1630 FOR I=1 TO 11
1640 Stptot(Ntype,I,Ff)=Stptot(Ntype,I,Ff)+Stptot(Ntype,I,Ff)
1650 Stpwdg(Ntype,I,Ff)=Stptot(Ntype,I,Ff)/Ncrvw(Ntype,Ff)
1660 NEXT I
1670 GOTO Query
1671 ! ***
1672 ! *** Section to perform calculations related to color
1673 ! *** balance of color film.
1674 ! ***
1680 Color_balance:PRINT PAGE,"ENTER THE DATA FOR EACH OF
THE RED, GREEN, BLUE, AND VISUAL FILM DENSITIES"
1690 PRINT "ENTER ALL VALUES FOR EACH CURVE IN
THE ORDER GIVEN ABOVE"
1700 PRINT "27 VALUES ARE EXPECTED FOR EACH CURVE",
LIN(1),"FIRST 26 VALUES CORRESPOND TO DN'S (0,10,...,240,250)"
1710 PRINT "LAST VALUE CORRESPONDS TO UNEXPOSED FILM",
LIN(1),"THE DATA CAN BE ENTERED ON ONE OR SEVERAL LINES"
1720 INPUT "RED FILM DENSITY ON GREY WEDGE ?",Red(*)
1730 INPUT "GREEN FILM DENSITY ON GREY WEDGE ?",Green(*)
1740 INPUT "BLUE FILM DENSITY ON GREY WEDGE ?",Blue(*)
1750 INPUT "VISUAL FILM DENSITY ON GREY WEDGE ?",Visual(*)
1760 GOSUB Chk_bal
1770 PRINT PAGE
1780 INPUT "DATE OF THE FILM ? (MM/DD/YY) AND FILM FACTOR (0-5)",
Date$,Ff
1790 MAT Dred=Visual-Red
1800 MAT Dgrn=Visual-Green
1810 MAT Dblu=Visual-Blue
1820 PRINTER IS 0
1830 PRINT T$(Ntype);" MACHINE COLOR BALANCE CURVES - ";Date$
LIN(1)," FILM FACTOR ";Ff
1840 PRINT USING F1
1850 F1:IMAGE 2X,"DIFFERENCE FROM VISUAL DENSITY",/
5X,"DN",5X,"RED",5X,"GREEN",5X,"BLUE"
1860 F2: IMAGE 4X,3D,2X,MD.DD,5X,MD.DD,4X,MD.DD
1870 X=0
1880  FOR I=1 TO 27
1890  PRINT USING F2;X,Dred(I),Dgrn(I),Dblu(I)
1900  X=X+10
1910  NEXT I
1920  GOSUB Pltem
1930  PRINTER IS 16
1940  Query: Ans$="Y"
1950  INPUT "WANT TO DO SOMETHING ELSE ? (Y/N) (DEFAULT=Y)" ,Ans$
1960  IF Ans$="Y" THEN Start
1970  ASSIGN #1 TO File$
1980  MAT PRINT #1;Stdcrv,Stpwdg,Ncrvd,Ncrvw,Stdtot,Stptot
1990  ASSIGN #1 TO *
2000  STOP
2001  ! ***
2002  ! *** Subprogram to plot data
2003  ! ***
2010  Pltem:PLOTTER IS 13,"GRAPHICS"
2020  GRAPHICS
2021  ! ***
2022  ! *** Initialize the plot area and the curve plot area
2023  ! ***
2030  LIMIT 0,184,0,140
2040  LOCATE 30,130,25,95
2050  IF Ncalc<>3 THEN S200
2051  ! ***
2052  ! *** Prepare the blue and green color balance curves
2053  ! *** for plotting by putting in a zero offset.
2054  ! ***
2060  MAT Tmp=Dgrn+(.5)
2070  MAT Dgrn=Tmp
2080  MAT Tmp=Dblu+(1)
2090  MAT Dblu=Tmp
2100  S200: Redmn=0
2110  Grnmn=.5
2120  Blumn=1
2130  X=0
2140  FOR I=1 TO 27
2150  Tmp(I)=X
2160  X=X+10
2170  NEXT I
2180  Xmin=-10
2190  Xmax=270
2200  Ymin=-.5
2210  Ymax=1.5
2220  Xtick=10
2230  Ytick=.25
2240  IF Ncalc=3 THEN S210
2250  Ymax=.5
2260  Ytick=.1
2270  S210: FRAME
2280  SCALE Xmin,Xmax,Ymin,Ymax
2290  Xlen=(Xmax-Xmin)/100
2300  Ylen=(Ymax-Ymin)/50
2310  FOR Xpos=Xmin TO Xmax STEP Xtick
2320  MOVE Xpos,Ymin
2330  IPLOT 0,Ylen,-1
2340  MOVE Xpos,Ymax
2350  IPLOT 0,-Ylen,-1
2360  NEXT Xpos
2370  FOR Ypos=Ymin TO Ymax STEP Ytick
2380  MOVE Xmin,Ypos
2390  IPLOT Xlen,0,-1
2400  MOVE Xmax,Ypos
2410  IPLOT -Xlen,0,-1
2420  NEXT Ypos
2430  LINE TYPE 4
2440  MOVE 0,Redmn
2450  DRAW 260,Redmn
2460  IF Ncalc<>3 THEN S220
2470  MOVE 0,Grnmn
2480  DRAW 260,Grnmn
2490  MOVE 0,Blumn
2500  DRAW 260,Blumn
2510  S220:  LINE TYPE 1
2520  MOVE Tmp(1),Dred(1)
2530  FOR I=2 TO 27
2540  DRAW Tmp(I),Dred(I)
2550  NEXT I
2560  IF Ncalc<>3 THEN S230
2570  MOVE Tmp(1),Dgrn(1)
2580  FOR I=2 TO 27
2590  DRAW Tmp(I),Dgrn(I)
2600  NEXT I
2610  MOVE Tmp(1),Dblu(1)
2620  FOR I=2 TO 27
2630  DRAW Tmp(I),Dblu(I)
2640  NEXT I
2650  S230:  DEC
2660  CSIZE 3
2670  LDIR -90
2680  LORG 1
2690  FOR Xpos=Xmin TO Xmax STEP Xtick
2700  MOVE Xpos,Ymin
2710  LABEL USING "2X,3D"; Xpos
2720  NEXT Xpos
2730  LDIR 0
2740  LORG 8
2750  FOR Ypos=Ymin TO Ymax STEP Ytick
2760  MOVE Xmin,Ypos
2770  LABEL USING "MD.DDX"; Ypos
2780  NEXT Ypos
2790  LORG 1
2800  IF Ncalc<>3 THEN S240
2810  MOVE 245,.15
2820  LABEL "RED"
2830  MOVE 245,.65
2840  LABEL "GREEN"
2850  MOVE 245,1.15
2860  LABEL "BLUE"
2870 S240: SETGU
2880  MOVE 30,10
2890  LABEL "DN VALUES"
2900  MOVE 10,10
2910  LDIR 90
2920  IF Ncalc<3 THEN LABEL "STD CURVE - TEST CURVE"
2930  IF Ncalc=3 THEN LABEL "VISUAL DENSITY - COLOR DENSITY"
2940   " (GREEN AND BLUE OFFSET)"
2950  DUMP GRAPHICS
2960  EXIT GRAPHICS
2970  RETURN
2980  ! *** Subprogram for selective zeroing of arrays
2990  ! ***
3000 Sel_zero:PRINTER IS 16
3010  PRINT PAGE,LIN(10),"YOU CAN SELECTIVELY ZERO ANY"
3020  "OF THE ARRAYS",LIN(1),"ENTER Ntype,Ff,Dtype"
3030  PRINT "WHERE Ntype SELECTS THE MACHINE (1=BW, 2=CO,"
3040  "3=HSSW, 4=HSO)",LIN(1),"
3050  " Dtype SELECTS THE DATA TYPE -- (1=DN CURVES, 2=STEP WEDGES)"
3060  PRINT "Ff IS THE FILM FACTOR (0=None, OR 1,2,3,4,5"
3070  " FOR FACTORS 1 to 5)"
3080  PRINT "IF Dtype=2 AND THE MACHINE IS B&W, THE"
3090  "FILM FACTOR MUST BE 1"
3100  PRINT "IF Dtype=2 AND MACHINE IS COLOR, THE FILM FACTOR"
3110  "MUST BE 1,2, OR 3"
3120  PRINT "THE COMPUTER WILL CYCLE ASKING FOR NEW ARRAYS"
3130  "TO BE ZEROED",LIN(1),"UNTIL ALL ZEROS ARE ENTERED"
3140 Zeroem:INPUT "ENTER Ntype,Ff,Dtype",I,J,K
3150  IF I=0 THEN RETURN
3160  IF K=2 THEN Zero_step
3170   J=J+1
3180  FOR L=1 TO 27
3190   Stdtot(I,L,J)=0
3200   Stdcrv(I,L,J)=0
3210  NEXT L
3220  Ncrvd(I,J)=0
3230  GOTO Zeroem
3240 Zero_step:FOR L=1 TO 11
3250  Stptot(I,L,J)=0
3260  Stpwdg(I,L,J)=0
3270  NEXT L
3280  Ncrvw(I,J)=0
3290  GOTO Zeroem
3300 ! *** Subprogram for verifying that the data have been
3310 ! *** entered correctly. Changes can be made.
3320 ! ***
3330 Chk_crv:PRINT USING F4
3340  FOR I=1 TO 27
3350   PRINT USING F3;I,Crv(I)
3360 F3:IMAGE "POINT #",3D," CURVE VALUE = ",2D.2D
3370 F4: IMAGE "VALUES ENTERED ARE:"
NEXT I
   Ans$="Y"
   INPUT "ALL OKAY ? (Y/N) (DEFAULT=Y)",Ans$
   IF Ans$="Y" THEN RETURN
   Ans$="N"
   INPUT "MORE CHANGES ? (Y/N) (DEFAULT=N)",Ans$
   IF Ans$="N" THEN Chk_crv
   GOTO Crv_chg
!
*** Subprogram for verifying that step-wedge data
*** for checking film processing have been entered
*** correctly.
!
! *** Subprogram for verifying that color balance data
*** were entered correctly.
!
Chk_wdg:PRINT USING F4
   FOR I=1 TO 11
   PRINT USING F3;I,Wdg(I)
   NEXT I
   Ans$="Y"
   INPUT "ALL OKAY ? (Y/N) (DEFAULT=Y)",Ans$
   IF Ans$="Y" THEN RETURN
   Ans$="N"
   INPUT "POINT # AND NEW VALUE",I,Wdg(I)
   IF Ans$="N" THEN Chk_wdg
   GOTO Wdg_chg
!
*** Subprogram for verifying that color balance data
*** were entered correctly.
!
Chk_bal:PRINT USING F4
   FOR I=1 TO 27
   PRINT USING F5;I,Red(I),Green(I),Blue(I),Visual(I)
   NEXT I
   Ans$="Y"
   INPUT "ALL OKAY ? (Y/N) (DEFAULT=Y)",Ans$
   IF Ans$="Y" THEN RETURN
   Ans$="N"
   INPUT "ENTER POINT # AND NEW VALUES OF RED, GREEN, BLUE, AND VISUAL",I,Red(I),Green(I),Blue(I),Visual(I)
   IF Ans$="N" THEN Chk_bal
   GOTO Bal_chg
END

FIGURE 1. COMPARISON STANDARD USED FOR JUDGING BLACK AND WHITE FILM PROCESSING
FIGURE 2. EXAMPLE COMPARISON STANDARDS USED TO JUDGE COLOR FILM PROCESSING

RED FILTER  GREEN FILTER  BLUE FILTER

Curves for green and blue are offset by 0.5 and 1.0, respectively.
FIGURE 3. EXAMPLE COMPARISON STANDARD FOR JUDGING EXPOSURE OF BLACK AND WHITE FILM
FIGURE 4. EXAMPLE COMPARISON STANDARD FOR JUDGING EXPOSURE OF COLOR FILM
FIGURE 5. SAMPLE DIFFERENCE CURVES USED TO JUDGE COLOR BALANCE OF A FILM WRITING MACHINE

RED, GREEN, AND BLUE ZERO OFFSETS ARE 0.5, 1.0, AND 1.5, RESPECTIVELY