MEMORANDUM
RM-5297-PR
APRIL 1967

PSEUDO-COLOR PROCESSING OF ELECTRONIC PHOTOGRAPHS

C. Gazley, Jr., J. E. Rieber and R. H. Stratton

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PREFACE

RAND's recent concern with the enhancement of visual discrimination and the contact of staff members with advanced researchers in medicine combined to germinate the work reported here. The goal set was to improve and extend the medical pseudo-color technique used to study the distribution of radioactivity in a gland for the enhancement of visual discrimination in a black-and-white photograph. In the study reported here, one successful innovation was the use of the S-C 4020 computer-driven plotting system. Also the increase to 64 color gradations (instead of the earlier ten) was successful in substantially increasing the information visually available in a black-and-white photograph.

ABSTRACT

The ability to use "black-and-white" photographic information is limited by the observer's ability to distinguish shades of gray. This Memorandum describes a "pseudo-color" process which enhances visual discrimination by keying measured light intensity in a photograph to color. Test data obtained from the camera system of the Mariner IV have been processed as an example, and the resulting pseudo-color photograph is shown.

ACKNOWLEDGMENT

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PSEUDO-COLOR PROCESSING OF ELECTRONIC PHOTOGRAPHS*

The "photograph" reproduced on the facing page is actually a pseudo-color presentation of test data from the camera system of the Mariner IV. The original test photograph (black and white) was a Mariner's eye view of a relief map of a Southern California area. The reproduction is an offprint from the April cover of Astronautics and Aeronautics, a publication of the American Institute of Aeronautics and Astronautics.

A high-quality "black-and-white" photograph customarily records the graded intensities of light in a scene by means of a series of shades of gray ranging from near black to near white. In viewing such a record, the observer's ability to "use" the recorded gradations, i.e., to detect patterns, recognize objects, and discriminate between objects having different intensities, is limited by his ability to detect differences among various shades of gray.

Modern photographic techniques, whether chemical or electronic, can separate and record many more tonal values than can the eye. The Mariner's camera system can discriminate among 64 intensity levels,(1) but the human visual system can discriminate only about 15 shades of gray between black and white.(2)

Hence, for man to take advantage of the superior discrimination of a camera system, the information should be so presented that the observer can distinguish any recorded level of intensity from any other.

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*This work was supported by the United States Air Force under Project RAND.

**Original test data for the pseudo-color processing of the Mariner-Mars 1964 camera photographs were provided through the courtesy of the Jet Propulsion Laboratory, California Institute of Technology.

Accordingly we decided to make use of man's excellent color-discrimination.[3] The human eye can distinguish many thousands of colors, the exact number depending on the level of illumination. Thus by keying measured intensity level to color, pseudo-color can give an observer much more information than can a gray-scale. A recent example of the use of color coding to increase contrast is the work of Adams and Jaffe[4] who coded various levels of radioactive intensity to various colors for medical presentations. About ten colors are used in their process, and there are about as many colors in this pseudo-color transformation as there are discriminable shades of gray. The primary advantage thus gained is simply an enhanced effective contrast and an improved apparent resolution.

As a test of our pseudo-color presentation scheme, we used the data obtained from photographs of a relief map, made as a test of the Mariner's camera system. The digital output from the camera system consists of 200 lines of 200 elements each. Each picture element is coded with two octal digits representing an intensity level from 0 to 63, the 0 representing the lightest shade and the 63 the darkest. The information is coded line by line on magnetic tape, packed six elements to a standard 36-bit word.

By use of an IBM 7044 computer and a Stromberg-Carlson S-C 4020 peripheral plotting system, the information on the tape was converted into 64 successive black-and-white frames of 35-mm film. Each frame was used to mask out all the elements except those corresponding to a single intensity level. The processing consisted of three steps:
(1) the photo information on magnetic tape was unpacked and was used

to write 40,000 intermediate records, each containing a line number, an element number, and the corresponding intensity level; (2) the intermediate records were sorted by intensity level; and (3) the sorted records were processed to produce a control tape for the S-C 4020, which produced the 64 frames (the black-and-white frames accompanying this text are printed from the negative produced by the S-C 4020).

The 64 black-and-white frames were then copied successively onto a single frame (64 exposures) of 35-mm Kodachrome II daylight film. A different filter was used over the light source (electronic flash) for each exposure. Starting with shade number 0, the hue of the filter was red. Successive combinations of subtractive-wedge filters gradually shifted through orange, yellow, green, and cyan, and terminated with blue for shade 63. No nonspectral hues (magentas) were used. Thus, light areas in the original appear red, medium areas green, and dark areas blue. The accompanying color photograph is the result of this work. The two main problems in this transformation were (1) the frame-to-frame registration, both in the S-C 4020 camera system and in making the composite on color film, and (2) a magenta "wash" on the Kodachrome, which was caused by unwanted light passing through the dense areas of the black-and-white film.

A method is now being developed by which the 64 shades of gray may be re-formatted and masking areas added to make only four exposures necessary. These would be made through a minimum number of filters with obvious advantages for registration and fogging.

We hope soon to be able to apply the pseudo-color process to the Mariner's actual photographs of the Martian surface. We feel that the pseudo-color technique shows great promise in the presentation of television data from space-exploration vehicles and weather satellites, and in the presentation of electronic medical data.

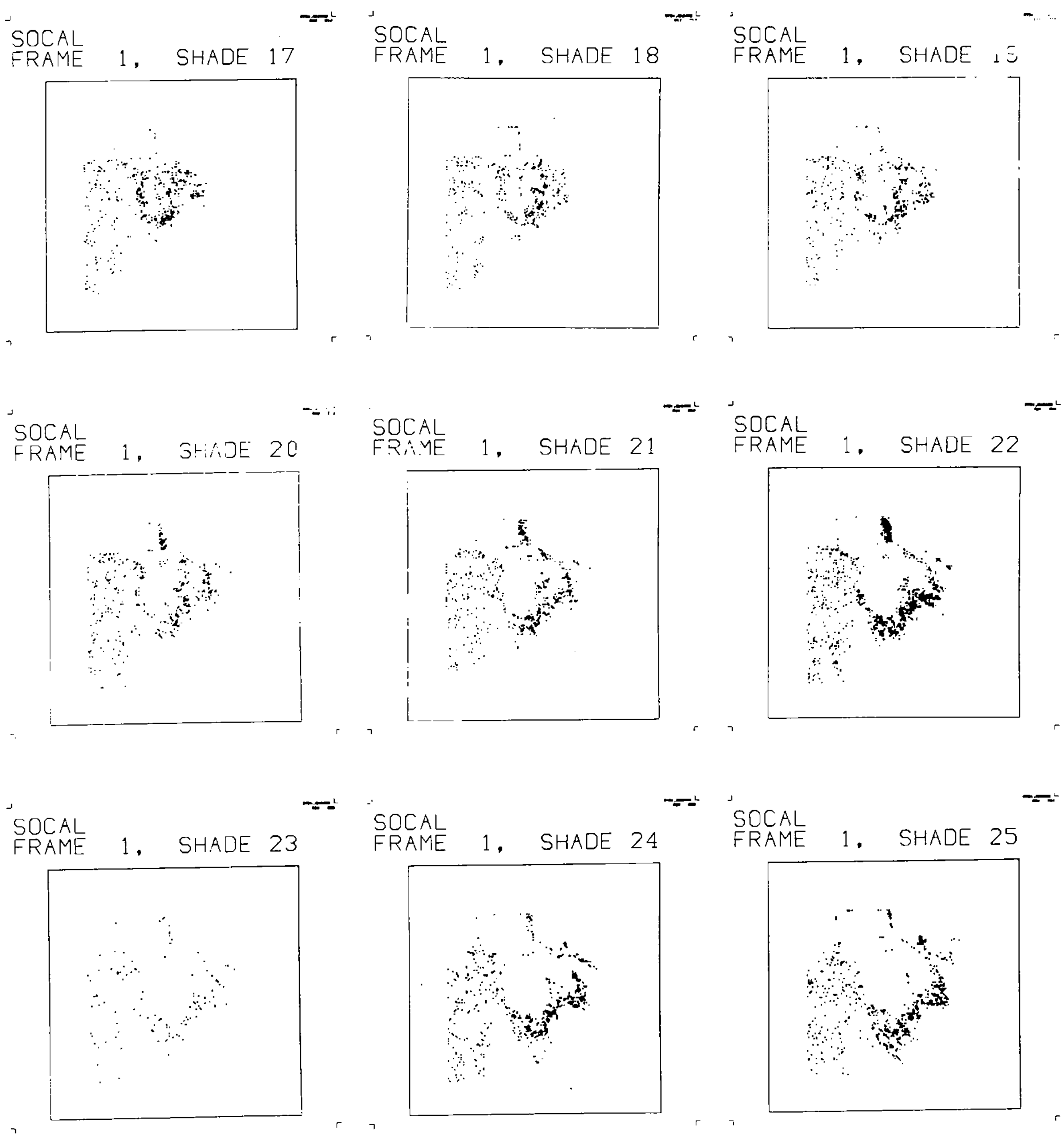

Fig. 2 -- This is part of the series of black-and-white masks made on the S-C 4020. A multiple exposure shot through each of these masks, using different colors, was used to make the color photograph.

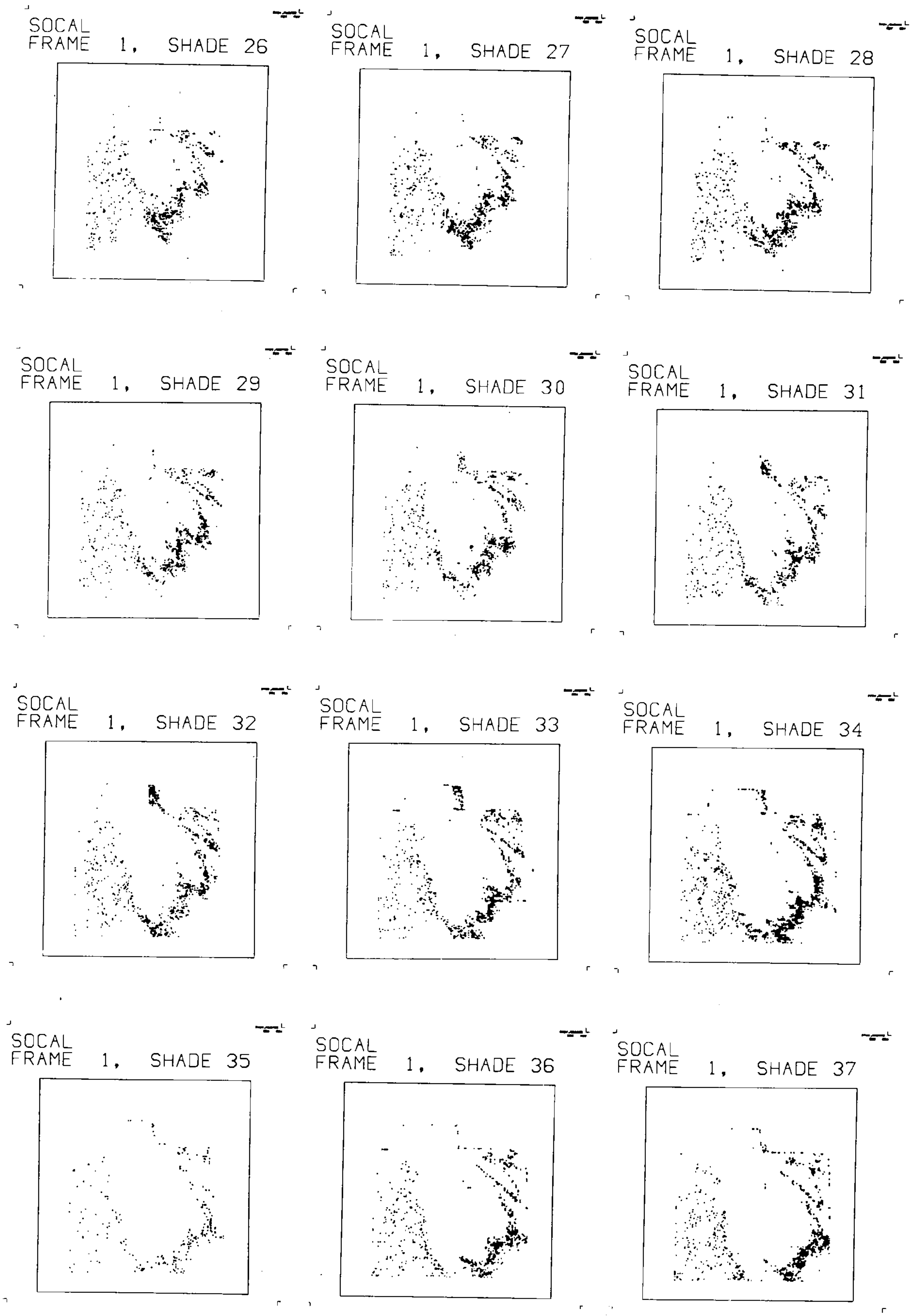

Fig. 2, continued

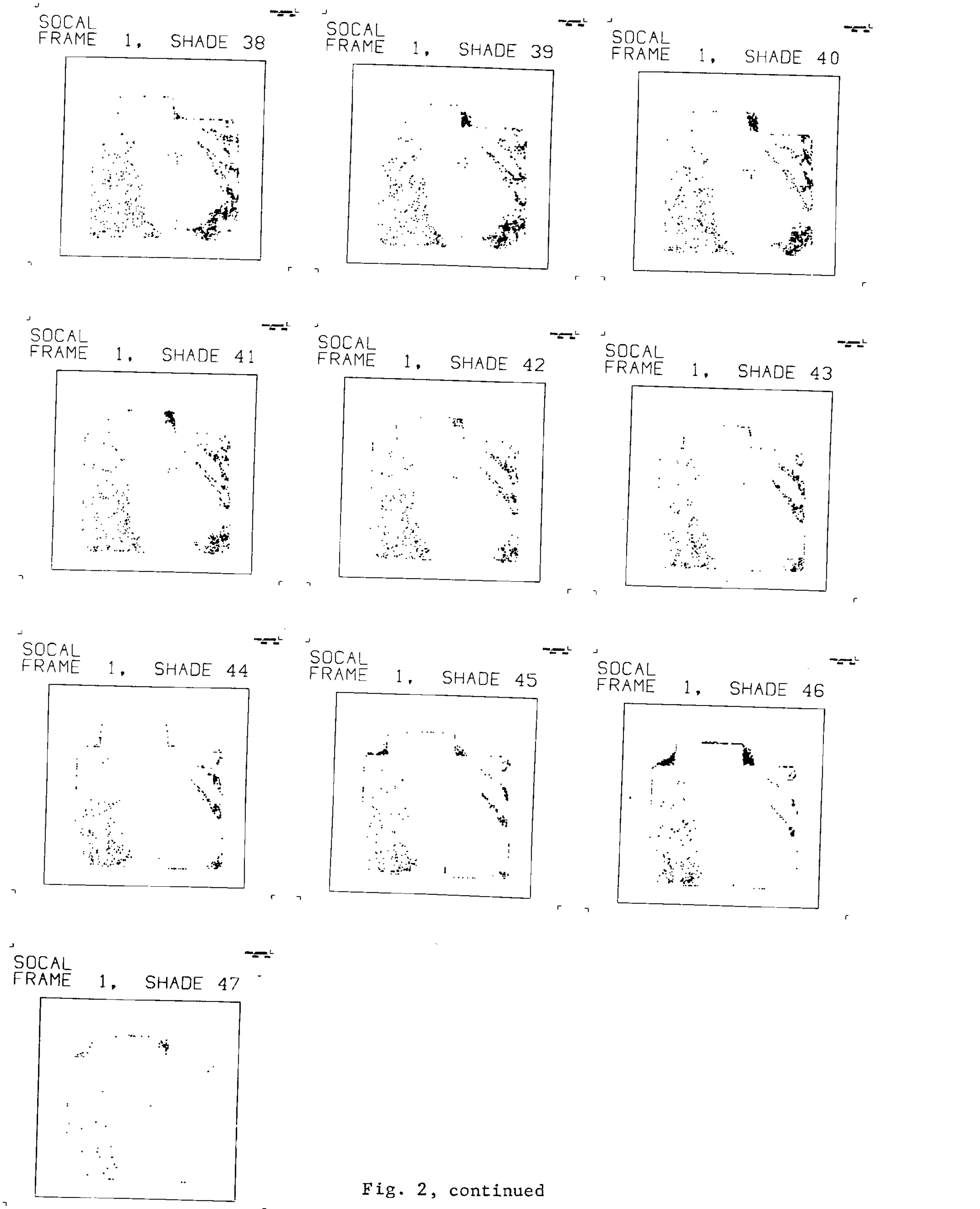

Fig. 2, continued

Appendix

COMPUTER PROGRAMS AND CONTROL CARDS USED TO PROCESS THE TEST TAPE FROM THE MARINER IV CAMERA SYSTEM

```
$JOB              5754,MARINR,R3500,15,250,130,P  PAL 25 USES SC-4020 SIMULATOR
$CLOSE            S.SU00,REWIND
$CLOSE            S.SU08,REWIND
$CLOSE            S.SU09,REWIND
$IBJOB  PRSORT    MAP
$FILE   PRSORT    'INTERM',U00,*,TYPE1,REEL,
$ETC    PRSORT    BLOCK=1950,LRL=3,RCT=650,
$ETC    PRSORT    ERR=RERRX.,EOF=REOFX.,EOR=REORX.
$FILE   PRSORT    'INPUT',U09,*,TYPE1,REEL,
$ETC    PRSORT    BLOCK=36,LRL=36,RCT=1,
$ETC    PRSORT    ERR=RERRX.,EOF=REOFX.,EOR=REORX.
```

```
$IBFTC PRSORT
C
C      UNPACK THE PHOTO INFORMATION FROM THE JPL TAPE AND PREPARE AN
C      INPUT TAPE FOR SORT.
C
       COMMON /PCOP/ INREC(36), OUTREC(210)
       DIMENSION TITLE(4)
       INTEGER OUTREC
       INTEGER CELLNO
C
C      CLOSE INPUT FILE AND OPEN WITH A REWIND.
C
                   CALL CLSEIN
                   CALL OPENIN
C
C      CLOSE INTERMEDIATE FILE AND OPEN WITH A REWIND.
C
                   CALL CLSINT
                   CALL OPNINT
C
C      READ IN A BCD ARRAY TO BE USED TO IDENTIFY EACH SLIDE.
C
                   READ 4000, TITLE
                   PRINT 2001, TITLE
C
C      READ IN THE FILE NUMBER (FRAME NUMBER) TO BE PROCESSED.
C
                   READ 3000, NFILE
                   PRINT3000, NFILE
C
C      N = NO. OF RECORDS ON FILE 'NFILE'.
C
                   READ  3000, N
                   PRINT 3000, N
C
C      SKIP TO THE FILE TO BE PROCESSED ('C' IS A DUMMY ARGUMENT).
C
                   CALL SKIPF(C, NFILE-1)
C
C      W060 ('SKIPF') CLOSES THE FILE WHEN SKIPPING.  IT MUST BE
C      RE-OPENED WITHOUT REWINDING.
C
                   CALL OPENNR
C
C      THE FIRST THREE RECORDS CONTAIN TITLE AND FILE NO. INFORMATION,
C      WRITTEN IN A FORM THAT WILL SURVIVE SORTING.
C
                   CALL PUTREC(-3, TITLE(1), TITLE(2))
                   CALL PUTREC(-2, TITLE(3), TITLE(4))
                   CALL PUTREC(-1, NFILE, ZERO)
C
             DO 100 LINENO = 1, N
C
C      READ IN A 36-WORD RECORD AND UNPACK IT TO MAKE A 200-WORD RECORD.
C      ARRAY 'OUTREC' HAS 10 EXTRA WORDS TO ALLOW FOR SPILLOVER IN
C      SUBROUTINE 'UNPACK'.
C
                   CALL GETREC
                   CALL UNPACK
C
```

```
C      NOW WRITE THE COLOR, LINE NUMPER, ANC CELL NUMPER (COLUMN) FCR
C      EACH CELL OF THE CURRENT LINE.
C
             DO 10 CELLNO = 1, 200
                   CALL PUTREC(OUTREC(CELLNO), LINENO, CELLNO)
   10        CONTINUE
C
  100        CONTINUE
C
C      CLOSE AND REWIND THE INPUT AND INTERMEDIATE FILES.
C      THE INTERMEDIATE FILE WILL NOW BE PROCESSED BY SORT.
C
                   CALL CLSEIN
                   CALL CLSINT
C
             STOP
C
 2001 FORMAT(1X, 4A6)
 3000 FORMAT(I4)
 4000 FORMAT(4A6)
      END
```

```
$IBMAP UNPACK
*      UNPACK THE 36 WORD MARINER RECORD INTO A 200 WORD RECORD.
*
       PMC
       CONTRL  POOP
       USE     POOP
INREC  BSS     36
*
*      SINCE 6*34 = 204, 'OUTREC' NEEDS 204 WORDS.  THE EXTRA SIX WORDS
*      ARE JUST FOR SAFETY.
*
OUTREC BSS     210
       USE
*
       ENTRY   UNPACK
UNPACK SAVE    1,2,4
*
       AXT     210,4
       AXT     34,1
*
LOOP1  CAL     INREC+35,1
       LDQ     INREC+36,1
       LGR     11
       AXT     6,2
*
LOOP2  LGL     6
       SAC     OUTREC+210,4,5
       TXI     *+1,4,-1
       TIX     LOOP2,2,1
*
       TIX     LOOP1,1,1
*
       RETURN  UNPACK
       END
```

```
$IBMAP INPRTN
*       NECESSARY ROUTINES FOR FILE 'INPUT'.
*
        CONTRL  POOP
        USE     POOP
INREC   BSS     36
OUTREC  BSS     210
        USE
*
        EXTERN  INPUT
*
*       GET A 36-WORD RECORD AND PLACE IT IN 'INREC'.
*
        ENTRY   GETREC
GETREC  SAVE
        TSX     S.GETL,4
        PZE     INPUT,,INREC
        RETURN  GETREC
*
*       OPEN THE INPUT FILE WITH A REWIND.
*
        ENTRY   OPENIN
OPENIN  SAVE
        TSX     S.OPEN,4
        PTW     INPUT                    REWIND,BINARY,INPUT
        RETURN  OPENIN
*
*       CLOSE THE INPUT FILE WITH A REWIND.
*
        ENTRY   CLSEIN
CLSEIN  SAVE
        TSX     S.CLSE,4
        PZE     INPUT                    REWIND,NOUNLOAD,END-OF-DATA
        RETURN  CLSEIN
*
*       OPEN THE INPUT FILE WITHOUT A REWIND.
*
        ENTRY   OPENNR
OPENNR  SAVE
        TSX     S.OPEN,4
        MTW     INPUT                    NOREWIND,BINARY,INPUT
        RETURN  OPENNR
        END
```

```
$IBMAP INPUTV
*       SPECIAL 'UTVAR.' DECK TO BE USED WITH W06C ('SKIPF').  IT RETURNS
*       THE ADDRESS OF FILE 'INPUT', REGARDLESS OF THE ARGUMENT SUPPLIED.
*
        EXTERN  INPUT
*
        ENTRY   UTVAR.
UTVAR.  NULL
        CLA     POINTR
        STO     2,4
        TRA     1,4
*
POINTR  PZE     FILINP
FILINP  PZE     INPUT
        END
```

```
$IBMAP CUTINT
*       OUTPUT ROUTINES FOR FILE 'INTERM' - INTERMEDIATE FILE WHICH WILL
*       BE PROCESSED BY SORT.
*
        EXTERN  INTERM
*
*       PLACE A THREE WORD RECORD CN FILE 'INTERM'.
*
        ENTRY   PUTREC
        PMC
PUTREC  SAVE
*
*       'SAVE' MACRO SETS XR4 TO COMPLEMENT OF CALLING ADDRESS.
*
        CLA*    3,4                      FIRST ARGUMENT
        STO     BUFFR
        CLA*    4,4                      SECOND ARGUMENT
        STO     BUFFR+1
        CLA*    5,4                      THIRD ARGUMENT
        STO     BUFFR+2
        TSX     S.PUTL,4
        PZE     INTERM,,BUFFR
        RETURN  PUTREC
        PMC
*
*       CLOSE INTERMEDIATE FILE WITH AN END-OF-FILE MARK AND REWIND.
*
        ENTRY   CLSINT
CLSINT  SAVE
        TSX     S.CLSE,4
        PZE     INTERM                   REWIND,NOUNLOAD,END-OF-DATA
        RETURN  CLSINT
*
*       OPEN INTERMEDIATE FILE WITH A REWIND.
*
        ENTRY   OPNINT
OPNINT  SAVE
        TSX     S.OPEN,4
        PTH     INTERM                   REWIND,BINARY,OUTPUT
        RETURN  OPNINT
*
BUFFR   BSS     3
        END
```

```
$ENTRY          PRSORT
SOUTHERN CALIFORNIA
  1
 200
$IBSYS
```

```
$CLOSE          S.SUC0,REWIND
$CLOSE          S.SUC9,REMOVE
$IBSRT
      FILE, INP/1, MOD/B, BLC/1950, REW
      FILE, OUT, MOD/B, BLC/1950, REW
      REC, LEN/(3), FIELD/(36BS, 72BS)
      SORT, FIL/1, SEC/S, ORD/2, FIELD/(1A)
      SYS, INP/S.SU00, MER/(C, 8), OUT/S.SU08, DISK/145
      OPT, NOCK
      END
$IBSYS
$CLOSE          S.SCK1,REWIND
$CLOSE          S.SU08,REWIND
```

```
$IBJOB MARINR   MAP
$FILE  MARINR   'INTERM',U08,*,TYPE1,REEL,
$ETC   MARINR   BLOCK=1950,LRL=3,RCT=650,
$ETC   MARINR   ERR=RERRX.,EOF=RECFX.,ECR=RECPX.
$IBFTC MARINR
C       JOB NO. 5754 - MARINER IV COLOR PHOTOS
C
C       READ THE SORTED PHOTO TAPE AND WRITE AN SC-4020 TAPE.
C
        INTEGER EOFRET, SHADE, OLDSHD, CELLNC, FRAMNC
        INTEGER BLSHDS(64, 2)
        DIMENSION TITLE(4)
        EXTERNAL TABLIV
C
C       CLOSE, REWIND AND OPEN THE INTERMEDIATE FILE (OUTPUT FROM SORT).
C
                   CALL CLSINT
                   CALL OPNINT
C
C       NECESSARY INITIALIZATION FOR SC-4020
C
                   CALL CAMRAV(935)
                   CALL CHSIZV(8, 8)
                   CALL RITSTV(48, 66, TABLIV)
                   CALL BRITEV
C
C       WRITE A 20-FRAME LEADER.
C
              DO 4 I = 1, 20
                   CALL FRAMEV
    4         CONTINUE
C
C       SET UP END-OF-FILE CONTROL TO TRANSFER TO STATEMENT 9000 WHEN
C       END-OF-FILE IS REACHED ON FILE 'INTERM'.  ('0' IS A DUMMY
C       ARGUMENT.)
C
                   ASSIGN 9000 TO EOFRET
                   CALL EOFCTL(0, EOFRET)
C
C       RETRIEVE TITLE AND FRAME NUMBER INFORMATION FROM THE INTERMEDIATE
C       FILE AND PRINT IT AS A CHECK.
C
                   CALL GETREC(JUNK, TITLE(1), TITLE(2))
                   CALL GETREC(JUNK, TITLE(3), TITLE(4))
                   CALL GETREC(JUNK, FRAMNC, JUNK)
C
                   PRINT 1000, TITLE, FRAMNC
C
C       GET FIRST RECORD FROM INTERMEDIATE FILE.
C
                   CALL GETREC(SHADE, LINENC, CELLNC)
                   NREC = 1
C
                   NBLANK = 0
C
C       TEST TO SEE IF FIRST SHADE IS =0.  IF NOT, MAKE APPROPRIATE
C       ENTRIES IN ARRAY 'BLSHDS'.
C
              IF(SHADE .EQ. 0)GO TO 5
C
```

```
                    NBLANK = NBLANK + 1
                    BLSHDS(NBLANK, 1) = 0
                    BLSHDS(NBLANK, 2) = SHADE - 1
C
    5         CONTINUE
C
C      ADVANCE THE FILM AND PRINT A TITLE, FRAME NUMBER, SHADE NUMBER,
C      AND BORDER.
C
                    CALL FRAME(TITLE, FRAMNO, SHADE)
C
   10         CONTINUE
C
C      PRINT THE CELL JUST READ ON THE SC-4020 FRAME, THEN READ IN A NEW
C      RECORD.  CONTINUE IN THIS FASHION UNTIL A NEW SHADE IS ENCOUNTERED
C
                    CALL PRCELL(LINENO, CELLNO)
C
                    OLDSHD = SHADE
                    CALL GETREC(SHADE, LINENO, CELLNO)
                    NREC = NREC + 1
C
              IF(SHADE .EQ. OLDSHD) GO TO 10
C
C      TEST FOR A GAP IN THE SHADES USED.  IF THERE IS A GAP, MAKE AN
C      APPROPRIATE ENTRY IN 'BLSHDS'.
C
              IF(SHADE .EQ. OLDSHD+1) GO TO 5
C
                    NBLANK = NBLANK + 1
                    BLSHDS(NBLANK, 1) = OLDSHD + 1
                    BLSHDS(NBLANK, 2) = SHADE - 1
C
              GO TO 5
C
C
C      RETURN HERE WHEN END-OF-FILE IS ENCOUNTERED BY 'GETREC'.
C
 9000         CONTINUE
C
C      PRINT THE TOTAL NUMBER OF RECORDS READ.
C      NREC SHOULD TOTAL 40,000.
C
                    PRINT 4000, NREC
C
C      TEST TO SEE IS LAST POSSIBLE SHADE WAS USED.  IF NOT, MAKE AN
C      ENTRY IN 'BLSHDS'.
C
              IF (OLDSHD .EQ. 63) GO TO 9010
C
                    NBLANK = NBLANK + 1
                    BLSHDS(NBLANK, 1) = OLDSHD + 1
                    BLSHDS(NBLANK, 2) = 63
C
 9010         CONTINUE
C
C      WRITE A 20-FRAME TRAILER.
C
              DO 9014 I = 1, 20
                    CALL FRAMEV
```

```
 9014       CONTINUE
C
C     WRITE A MESSAGE INDICATING WHICH SHADES WERE NOT USED.
C
                  CALL MESSGE(TITLE, FRAMNO, NBLANK, BLSHDS)
C
C     CLOSE AND REWIND THE INTERMEDIATE FILE.
C
                  CALL CLSINT
C
C     CLOSE AND WRITE OUT THE STANDARD OUTPUT BUFFER.  THIS ENSURES THAT
C     ALL INFORMATION ON THE STANDARD OUTPUT FILE APPEARS BEFORE THE
C     SC-4020 SIMULATION, WHICH DOES NOT USE A STANDARD FILE.
C
                  CALL CLEAN
C
C     A SPECIAL 'EXIT' ROUTINE CAN BE PROVIDED TO CALL THE SC-4020
C     SIMULATOR.
C
                  CALL EXIT
C
C     FORMATS FOR 'ECHO CHECK'.
C
 1000 FORMAT(1H1, 4A6, 7H  FRAME I4)
 4000 FORMAT(7H NREC=  I13)
      END
```

```
$IBFTC FRAME
C     4X4 CELLS - BRIGHT MODE
C
C     ADVANCE THE FILM TO A NEW FRAME AND PRINT BORDER AND TITLE
C     INFORMATION ON IT.
C
      SUBROUTINE FRAME(TITLE, FRAMNO, SHADE)
      DIMENSION TITLE(14)
      DIMENSION ALPHA(4)
      INTEGER FRAMNO, SHADE
C
C     ADVANCE FILM
C
                  CALL FRAMEV
C
C     PRINT BORDER.
C
                  CALL LINEV(913, 025, 913, 826)
                  CALL LINEV(112, 025, 112, 826)
                  CALL LINEV(112, 025, 913, 025)
                  CALL LINEV(112, 826, 913, 826)
C
C     PRINT TITLE.
C
                  CALL RITE2V(24, 957, 1023, 90, 1, 21, +1, TITLE,NLST)
C
C     CONVERT FRAME AND SHADE NUMBER TO BCD USING INTERNAL FILE 99.
C
                  CALL BCDCON(ALPHA)
                  WRITE(99, 2000) FRAMNO, SHADE
C
C     PRINT FRAME AND SHADE NUMBER.
C
                  CALL RITE2V(24, 891, 1023, 90, 1, 19, +1, ALPHA,NLST)
C
            RETURN
C
C     FORMAT FOR FRAME AND SHADE NUMBER.
C
 2000 FORMAT( 5HFRAME, I3, 8H,  SHADE, I3)
      END
```

```
$IBFTC PRCELL
C      PRINT A 4-DOT CELL AT THE APPROPRIATE LINE NUMBER AND CELL
C      (COLUMN) NUMBER.  THIS ROUTINE DIVIDES THE PHOTO AREA INTO 200
C      LINES AND 200 COLUMNS.
C
       SUBROUTINE PRCELL(LINENO, CELLNO)
       INTEGER CELLNO
C
                     IX = 109 + 4*CELLNO
                     IY = 826 - 4*LINENO
C
             DO 100 I = 1, 2
             DO 10  J = 1, 2
C
C      '42' IS THE CODE FOR THE CHARACTRON PLOTTING DOT.
C
                     CALL PLOTV(IX+J, IY+I, 42)
C
   10        CONTINUE
  100        CONTINUE
C
             RETURN
      END
```

```
$IBFTC MESSGE
C      PRINT A MESSAGE LISTING THE SHADES WHICH DO NOT APPEAR IN THE
C      PICTURE.
C
       SUBROUTINE MESSGE(TITLE, FRAMNO, NBLANK, BLSHDS)
       INTEGER FRAMNO, BS1, BS2, BLSHDS(64, 2)
       DIMENSION TITLE(4)
C
                     PRINT 1000, TITLE
                     PRINT 1001, FRAMNO
C
             IF(NBLANK .NE. 0) GO TO 10
C
                     PRINT 1004
             RETURN
C
   10        CONTINUE
C
             DO 100 I = 1, NBLANK
C
                     BS1 = BLSHDS(I, 1)
                     BS2 = BLSHDS(I, 2)
C
             IF(BS1 .EQ. BS2) PRINT 1002, BS1
             IF (BS1 .NE. BS2) PRINT 1003, BS1, BS2
C
  100        CONTINUE
C
             RETURN
C
 1000 FORMAT(1H1, 4A6)
 1001 FORMAT(44H0THE FOLLOWING SHADES DO NOT APPEAR IN FRAME I4/)
 1002 FORMAT (I4)
 1003 FORMAT(I4, 3H  -, I4)
 1004 FORMAT(46H0ALL SHADES FROM 0 TO 63 APPEAR ON THIS FRAME.)
      END
```

```
$IBMAP CLEAN
*       CLOSE AND UNBUFFER THE STANDARD OUTPUT FILE.
*
        ENTRY    CLEAN
CLEAN   TRA      **
        SXA      XR4,4
        TSX      S.CLSE,4
        MON      S.FBOU
XR4     AXT      **,4
        TRA*     CLEAN
        END
```

```
$IBFTC SCEXIT
C      SPECIAL 'EXIT' ROUTINE CALLS THE SC-4020 SIMULATOR BEFORE
C      RETURNING TO $IBSYS.
C
       SUBROUTINE EXIT
                CALL SCSIM
            STOP
       END
```

```
$IBMAP INPINT
*       INPUT ROUTINES FOR FILE 'INTERM' - INTERMEDIATE FILE WHICH HAS
*       BEEN PROCESSED BY SORT.
*
        EXTERN   INTERM
        PMC
*
*       GET A 3-WORD RECORD FROM FILE 'INTERM'.
*
        ENTRY    GETREC
GETREC  SAVE
*
*       'SAVE' MACRO SETS XR4 TO COMPLEMENT OF CALLING ADDRESS.
*       XR4 IS RESTORED TO THIS VALUE BY 'GXR4' AFTER TSX TO S.GETL
*
        SXA      GXR4,4
        TSX      S.GETL,4
        PZE      INTERM,,BUFFR
GXR4    AXT      **,4
        CLA      BUFFR
        STO*     3,4                 FIRST ARGUMENT
        CLA      BUFFR+1
        STO*     4,4                 SECOND ARGUMENT
        CLA      BUFFR+2
        STO*     5,4                 THIRD ARGUMENT
        RETURN   GETREC
        PMC
*
*       CLOSE INTERMEDIATE FILE WITH A REWIND.
*
        ENTRY CLSINT
CLSINT  SAVE
        TSX      S.CLSE,4
        PZE      INTERM              REWIND,NOUNLOAD,END-OF-DATA
        RETURN   CLSINT
*
*       OPEN INTERMEDIATE FILE WITH A REWIND.
*
        ENTRY    OPNINT
OPNINT  SAVE
        TSX      S.OPEN,4
        PTW      INTERM              REWIND,BINARY,INPUT
        RETURN   OPNINT
*
BUFFR   BSS      3
        END
```

```
$IPMAP INTUTV
*      SPECIAT 'UTVAR.' DECK TC BE USED WITH W061 ('ECFCTL').  IT
*      RETURNS THE ADDRESS OF FILF 'INTERM', REGARDLESS CF THE ARGUMENT
*      SUPPLIED IT.
*
       EXTERN   INTERM
*
       ENTRY    UTVAR.
UTVAR. NULL
       CLA      POINTR
       STD      2,4
       TRA      1,4
*
POINTR PZE      FILINT
FILINT PZE      INTERM
       END
```

```
$ENTRY          MARINR
$IBSYS
$CLOSE          S.SU08,REMOVE
$IBSYS          ENDJOB          TOTAL NUMBER OF CARDS IN YOUR INPUT DECK
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