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MAKING PMT HALFTONE PRINTS

Prepared by:
J. D. Corey

Published May 1977

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Department 554

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MAKING PMT HALFTONE PRINTS

BDX-613-1799, UNCLASSIFIED Report, Published May 1977

Prepared by J. D. Corey, D/554

In the printing process for technical reports presently used at Bendix Kansas City Division, photographs are reproduced by pasting up PMT halftone prints on the artwork originals. These originals are used to make positive-working plastic plates for offset lithography. This report gives instructions for making good quality halftone prints using Eastman Kodak's PMT materials and processes.

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CONTENTS

Section	Page
SUMMARY.	5
DISCUSSION	6
OFFSET PRINTING AND HALFTONES.	6
DENSITY.	6
PMT PROCESS.	8
MAKING THE PMT HALFTONE.	9
<u>Determining Copy Range</u>	9
<u>Normal Prints</u>	9
<u>Flat Prints</u>	16
<u>Very Flat Prints</u>	17
EVALUATING THE HALFTONE PRINT.	17
EFFECTS OF A BUMP EXPOSURE	18
GLOSSARY	21
APPENDIX. EXAMPLES OF COMPUTER SETTINGS	24
DISTRIBUTION	28

ILLUSTRATIONS

Figure		Page
1	Enlarged Halftone Showing Highlight and Shadow Dots.	7
2	Illustration of 15- and 85-Percent Halftone Dots	7
3	Using the Densitometer to Read the Print Density Limits	10
4	Placing the Original on the Camera Copyboard.	11
5	Camera Back and Controls	12
6	Carlson Exposure Computer.	13
7	Processing the PMT Print	16
8	Typical Gray Scale	19
9	Illustration of 50-Percent Halftone Dot.	19
10	Halftone of Flat Print Made Without Bump Exposure.	20
11	Halftone of Flat Print Made With Bump Exposure	20
A-1	Computer Settings for Normal Print	25
A-2	Computer Settings for Flat Print	26
A-3	Computer Settings for Very Flat Print.	27

SUMMARY

In the printing process presently used at the Bendix Kansas City Division, photographs are reproduced by pasting up Eastman Kodak's PMT halftone prints on the artwork originals, and these originals are used to make positive-working plastic offset printing plates. Little can be done to improve the quality of the halftone during the platemaking step other than ensuring that the original is reproduced faithfully. However, a great deal can be done when the halftone print is being made from a full tone print.

This report gives instructions for making PMT halftone prints using the following equipment: MacBeth RD-514 Reflection Densitometer, Brown Caravel Camera, Carlson Exposure Computer, Agfa-Gevaert Copyproof CP-53 Processor, Brown Southwind Film Dryer, Kodak PMT Contact Screen, and Kodak PMT Photographic Materials. Also included in the report are suggestions for improving the quality of halftones made from poor original prints and for adjusting the halftone to allow for the effects of the offset printing process and materials.

DISCUSSION

OFFSET PRINTING AND HALFTONES

The offset printing process is an either/or proposition. It either lays ink down on the paper or it doesn't. It is not capable of printing different shades of gray or continuous tones as in a regular photograph. In order to reproduce a photograph by offset printing, a halftone or screened print must be used. In a halftone, the continuous tones of a photograph have been converted into interspersed pure black and pure white elements, usually by copying the photograph through a screen especially made for this purpose. The more white in an area, the lighter the tone; the more black, the darker. Figure 1 shows an enlarged portion of a screened photograph.

The black and white elements in a photograph are generally called "dots." Small black dots on a white background will appear in the lighter tones and are called highlight dots. Small white dots on a black background will appear in the darker tones and are called shadow dots. The dots are measured in percentages, starting with about a 5-percent dot (the smallest highlight dot) through the 50-percent dot (black and white areas are equal) to the 95-percent dot (smallest shadow dot). Figure 2 shows 15- and 85-percent dots, the practical limits for the Bendix offset printing process.

DENSITY

Density is one of the most important concepts in photography, and especially in making halftones. In the context of this report, the density of a surface is essentially the absorptivity of the surface when illuminated with white light. In other words, the lower the density of the surface, the whiter it appears and the less light it absorbs. Density is measured in numbers from about 0.05 for an extremely white surface to about 2.50 for a very black surface (the numbers are a ratio and are unitless).

A photograph to be halftoned may have a large difference in density between the lightest and darkest tones (for instance 0.15 for highlight to 2.30 for shadow). This type of print would be called high-contrast or contrasty. Another print might have a low density difference (for instance, 0.35 to 1.35), and would be called a low-contrast or flat print. The offset printing process is much less versatile than the full-tone photographic printing process: the range in density that can be printed by offset lithography is much smaller. Therefore, to take advantage of the full offset capability, the density range of the full tone print should be adjusted during the process of making the screened

Figure 1. Enlarged Halftone Showing Highlight and Shadow Dots

Figure 2. Illustration of 15- and 85-Percent Halftone Dots

print to the density range of which the offset process is capable. For a particular screen, this range is known as the screen range.

The density range of the final offset printed photograph is also affected by factors other than the excellence of the halftone original. In the process at Bendix, the halftone originals are pasted up on master artwork. Positive-working plastic plates are made on the 3M platemaker in Duplicating Services, and the material is printed on a Multilith offset press. Somewhere in this process, either in the platemaker or the press, the dots in the halftone become smaller, and sometimes shadow dots fill in completely and highlight dots drop out completely. This can cause loss of detail, depending on the range of density over which the shadows fill in and the highlights drop out.

Another factor which affects the density range of the final product is the inking on the press. If the inking is lighter or heavier than normal, the density range of the photograph tends to be reduced. On the other hand, use of a whiter or more reflective paper tends to increase the density range.

The screen used to make the halftone also affects the density range which can be produced. In general, the more lines per inch (lines of dots in 1 linear inch measured in a direction normal to the lines of dots), the greater the density range the screen is capable of producing.

PMT PROCESS

The photomechanical transfer (PMT) process was developed by Eastman Kodak for the graphic arts and printing industries. The process uses an opaque negative sheet (not a true negative) on which the image (lines or dots but not full tones) is exposed. The negative sheet is then placed against a receiver sheet (image sides together) and run through a processor. The sheets pick up chemicals as they run through the processor and are subsequently left together for a period of time (about 30 seconds) for the chemicals to work. At the end of that time, the sheets are peeled apart and the image has been transferred to the receiver sheet. The negative sheet is then discarded and the receiver sheet is washed for a short time and then dried.

The advantages of the PMT process are the quickness with which the final product is produced and the reduced manhours required. The steps in the conventional method of processing the exposed negative, exposing a print, and then processing the print are eliminated. The total time from when the artwork is placed on the copyboard to the time the final print is ready can be less than five minutes.

MAKING THE PMT HALFTONE

Determining Copy Range

The copy range is determined by subtracting the highlight reading obtained on the densitometer from the shadow reading. A figure of 105 is currently being used as the screen range of the 85-line PMT screen. The copy range of a normal print is above the screen range; the copy range of a flat print is less than the screen range.

Normal Prints

Use the following procedure when making a halftone from a normal print (copy range equal to or greater than screen range).

1. Read the density in the lightest highlight and the darkest shadow on the image where you want to carry detail (Figure 3). Write the density readings down, preferably on the border of the print where they can be seen when the print is on the copyboard.

NOTE: Adjust the densitometer to read black, *not* magenta, cyan, or yellow. Always zero the densitometer before beginning to take readings. Sometimes a print will not have a large enough area in the desired density for the densitometer to read accurately. In these cases, the density value can be obtained by "eyeball" comparison with density values on a gray scale. For this purpose, a 25-step gray scale is preferred, but a 10-step scale can be used. It is helpful to have a hole punched in the middle of each tone area on the gray scale so that the desired density area on the print can be observed through a hole surrounded by a single density area.

2. Place the print on the copyboard, centered as nearly as possible (Figure 4). Turn the copyboard to the vertical position.

NOTE: Sometimes dirt particles and wax from pasteups get on the copyboard glass. These will affect your copy. Always make sure the glass is clean.

3. On the f16 scale above the camera lens, move the indicator to the percent of original to which the copy is to be reduced or enlarged.
4. Adjust the camera for the percentage of reduction or enlargement desired (Figure 5).

Figure 3. Using the Densitometer to Read the Print Density Limits (85-line)

NOTE: Always be sure the locking knob between the two percentage adjustment cranks is released before making the adjustment.

5. With the back of the camera down, pull the ground-glass focusing plate into position. With the FLASH/DENSITY switch on the computer (Figure 6) set to DENSITY, operate the FOCUS switch (the exposing lights should come on). Observe the position of the image on the focusing plate and, if necessary, center the image using the controls at the top of the camera back. Turn the FOCUS switch off and raise the focusing plate.

Figure 4. Placing the Original on the Camera Copyboard (100-line)

6. Enter the print highlight and shadow readings on the computer DENSITY and FLASH dials, respectively.

NOTE: Setting the DENSITY dial changes the reading on the FLASH dial. Always set the DENSITY dial first, and if the DENSITY dial reading is later changed, reset the FLASH DIAL. Pay no attention to the red numbers on the DENSITY dial, use the white numbers only. Set the tenths of your highlight density reading on the outer dial and the hundredths on the inner dial. On the FLASH dial, do not attempt to set numbers lower than 90 or higher than 200; for shadow density readings higher or lower, use the higher or lower limit. In most cases, you will not be able to set the exact number you want

Figure 5. Camera Back and Controls (85-line)

Figure 6. Carlson Exposure Computer (85-line)

on the FLASH dial; use the closest setting where the dial stops. An example of the computer settings for a normal print is shown in the Appendix.

7. Verify that the MAIN and FLASH digit switches are set to the proper values.

NOTE: These values are obtained during calibration of the computer and will change from time to time when other parameters of the process change. At the time this report was prepared, the calibrated values were approximately 400 and 50 units for the MAIN and FLASH switches, respectively.

8. Set the camera-back vacuum knob to 14 x 17.
9. Place a sheet of 10 x 12 PMT negative in the outlined area on the camera-back vacuum frame. Place the PMT grey contact screen (with borders for handling) on top of the negative in the 14 x 17 outline. Press the vacuum foot switch. With a chamois, wipe the top of the screen to remove air pockets between it and the negative. Close the camera back.

NOTE: Do not open any box of photographic paper unless *only* the safe lights are on. Do not touch the actual PMT screen with your hands; handle only by the border. These screens are very delicate and very expensive. They are easily damaged by skin oil, developing chemicals, water, and dirt particles (scratching).

10. With the computer FLASH/DENSITY switch set to DENSITY and the MAIN red pushbutton lighted, press the START pushbutton. The START pushbutton light will extinguish, and the CANCEL pushbutton light and the main exposure lamps beside the copyboard will light. When the exposure lights and the CANCEL light extinguish, the START pushbutton light will light again.

NOTE: The exposure can be stopped at any time by pushing the CANCEL pushbutton.

11. Leaving the vacuum on, lower the camera back. Press the FLASH pushbutton so that the MAIN light extinguishes and the FLASH pushbutton light comes on. Set the FLASH/DENSITY switch to FLASH. Press the START pushbutton. The CANCEL pushbutton will light and the flash exposure lamp (hanging over the camera back) will come on.

NOTE: The flash exposure is usually short. Sometimes, the density readings indicate that the print does not need a flash and the light does not come on at all. If the flash

exposure lamp does not come on when you press the START pushbutton, make sure that the FLASH/DENSITY switch is set to FLASH. If it is, then the computer has determined that the print does not need a flash and the exposure of the halftone is complete.

12. Release the vacuum on the camera back and take up the negative sheet after carefully removing the contact screen. Place a receiver sheet on the negative sheet so that the two are face to face.

NOTE: The receiver sheets should be face down in the boxes. If you look closely at the back of the opaque receiver paper, you can see the words "paper manufactured by Kodak."

13. Run the two sheets through the PMT processor (Figure 7), wait 30 seconds, peel the sheets apart, and put the receiver sheet in the wash.

NOTE: Make sure the negative goes under and the receiver sheet goes over the bar in the input slot of the PMT processor. The receiver sheet travels a shorter distance through the processor; to make both sheets come out of the processor even, position the leading edge of the receiver sheet about 20 mm (3/4 inch) back of the leading edge of the negative when feeding them into the processor. When the sheets come out of the processor, do not allow them to bend excessively: bending can create gaps between the negative and receiver sheets which will ruin the halftone. After the receiver is in the wash, the main lights can be turned on to allow the halftone to be examined. (Be sure all boxes of photopaper are closed.) The negative sheet cannot be used again and should be discarded. Make sure that negatives made from classified photos are put in a red burn barrel.

14. If the halftone is satisfactory, wash it and run it through the dryer.
15. If the halftone is not satisfactory, adjust the computer settings and try again. For a smaller highlight dot (whiter whites), increase the highlight setting on the DENSITY dial; for a larger dot, decrease the setting. For a smaller shadow dot (blackier blacks), decrease the shadow setting on the FLASH dial, and vice versa. The DENSITY and FLASH settings affect each other, so do not change both at the same time. However, when the DENSITY setting is changed, the FLASH dial will have to be reset to keep the same setting.

Figure 7. Processing the PMT Print (65-line)

Flat Prints

For flat prints (copy range up to 0.3 less than screen range), use the following procedure.

1. Set the HIGHLIGHT digit switch to approximately 5 percent of the MAIN digit switch reading.
2. When setting the highlight density reading on the DENSITY dial, set the tenths of the reading (outer dial) at the B pointer and the hundredths (inner dial) at the regular (fixed) pointer.

NOTE: Make sure that the A and B pointers are at the positions shown in Figure 6 (45° and 90° away from fixed pointer). An example of the computer settings for a flat print is given in the Appendix.

3. Set the vacuum to 10 x 12.
4. Place the negative sheet down in the 10 x 12 outline, and fix it in position with a small piece of masking tape at each of the two corners nearest the camera-back latch. Apply vacuum, smooth the sheet, and close the camera back.
5. With the FLASH/DENSITY switch set to DENSITY, press the HIGHLIGHT pushbutton switch. The switch should light up.
6. Press the START pushbutton switch. The CANCEL switch and the main exposure lamps should light.

NOTE: This exposure is called a "bump" exposure.

7. When the exposure is completed, release the vacuum, move the vacuum control to 14 x 17, let the camera-back down to the horizontal position, place the screen on the negative as in Step 9 for normal prints, and continue with the rest of the normal procedure.

Very Flat Prints

For very flat prints (copy range from 0.3 to 0.6 less than screen range), use the same procedure as for flat prints, with the following exceptions.

1. Set the HIGHLIGHT digit switch to approximately 15 percent of the MAIN digit switch reading.
2. Set the tenths of the highlight density reading at the A pointer on the DENSITY dial.

NOTE: An example of the computer settings for a very flat print is given in the Appendix.

EVALUATING THE HALFTONE PRINT

Using a magnifying glass, examine the dot structure of the halftone. In the lightest area of the highlight, the dots should be no smaller than 5 percent, and all dots should be sharp and black. In the darkest area of the shadow where you expect to hold detail, the dots should be no smaller than 85 percent.

In many cases, it is helpful to expose a gray scale (Figure 8) alongside the print. One of the main advantages of this technique is that the location of the 50-percent dot (Figure 9) in the density range of the original print can be determined. If the density range of the print is from 0.20 to 1.90, in general the 50-percent dot on the halftone should be in the 1.05 density areas of the original. If the density range of the original is 0.30 to 0.90, the 50-percent dot should fall in the 0.60 density areas. The location of the 50-percent dot in the density range of the print is, of course, a judgment decision. It can be affected by a predominance of high or low density areas on the print and by other factors as well.

The reason for such concern over the location of the 50-percent dot is the lack of versatility of the offset printing process with respect to the full tone photographic printing process. The screen range of the 85-line PMT screen is presently considered to be 1.05. This means that, considering both the PMT process and the offset printing process presently used, 1.05 is the maximum density range that can be reproduced with acceptable results. Thus, the halftone process, as set forth here, is intended to reduce the density range of a contrasty print to a range of about 1.05, and to increase the range of a flat print also to near the screen range. The location of the 50-percent dot and the locations of the 15- and 85-percent dots in the density range of the original almost completely define the quality of the halftone, and these values are immediately observable on the halftone if a gray scale has been exposed beside the original print.

EFFECTS OF A BUMP EXPOSURE

Figure 10 is a halftone of a very flat print. The print is a metallographic Polaroid made in the engineering laboratory and is the type of print that is almost always troublesome. Polaroid prints do not provide a great deal of contrast at any time, and many times the lighting on the microscope is insufficient or the subject just does not have a great deal of contrast. Figure 10 was made using the techniques for a normal halftone (that is, no bump exposure). Figure 11 was made using the technique described earlier for very flat prints. It is readily apparent that Figure 11 is a great improvement over Figure 10. Actually, use of this technique can bring out details in the halftone that are very hard to distinguish in the original print.

Figure 8. Typical Gray Scale

A 50-PERCENT DOT FROM THE CONVENTIONAL (SQUARE) DOT SCREEN GIVES THE FAMILIAR CHECKERBOARD PATTERN.

THE 50-PERCENT DOTS FROM AN ELLIPTICAL DOT SCREEN ARE JOINED TO EACH OTHER AT THE TWO OPPOSITE CORNERS. THE WIDTH AT THE JOIN (A) IS APPROXIMATELY EQUAL TO THE MINIMUM DISTANCE BETWEEN THE ROWS (B).

Figure 9. Illustration of 50-Percent Halftone Dot

Figure 10. Halftone of Flat Print Made Without Bump Exposure

Figure 11. Halftone of Flat Print Made With Bump Exposure
(Note how density variance across original print is increased, causing increased density at right side while some dots drop out completely in center.)

GLOSSARY

- BUMP.** A short, no-screen exposure sometimes added to the total exposure used in making a halftone. The bump exposure is used to increase the tonal reproduction of highlights; i.e., it spreads out the density range of the highlights.
- CONTRASTY.** This word is used to describe a full-tone print which has a large density difference; i.e., there is a high range in density between the highlight and the shadow. A contrasty print can have a density difference of more than 2.00.
- COPY RANGE (CR).** The numerical difference between the density of the lightest highlight area and that of the darkest shadow area of the print to be halftoned.
- DENSITY.** The density of a surface is essentially the absorptivity of the surface when illuminated with white light. In other words, the lower the density of the surface, the whiter it appears and the less light it absorbs. In the context of this report, density is measured using a reflection densitometer and ranges from about 0.05 for an extremely white surface to about 2.50 for a very black surface (the numbers are a ratio and are unitless).
- DENSITY DIFFERENCE (DD).** The density difference is the range in density from the lightest highlight to the darkest shadow of a print. It is calculated by subtracting the highlight density from the shadow density.
- DOT.** A dot is one of the elements that a full tone print is broken up into so that it can be printed by offset lithography. Dots can be of any shape, but most common screens create round dots in the highlight and shadow areas. The highlight dot is black on a white background, and the shadow dot is white on a black background.
- FLASH.** A flash exposure in this context is an unfocused exposure, through the screen, over the whole area of the negative. It shortens the density range of, or fills in, the shadow area. The flash burns the dots in normally clear areas to help maintain detail in shadow areas.
- FLAT.** A flat print has a low density difference; i.e., it has a short range between the density of the lightest highlight and that of the darkest shadow. The tones of a flat print generally range in the lighter density values; very high shadow densities generally do not occur on flat prints.

GRAY SCALE. A graduated series of tones. The tones increase in density from white to black, and each square tonal area is labeled with the density value for that tone. The gray scale is useful for calibrating and troubleshooting in the halftone printing system.

HALFTONE. A halftone or halftone print is a print that has been exposed through a screen created for halftoning. Thus, the halftone is broken up into small black and white elements rather than being shades of gray like a full tone photograph. Halftones are used in offset lithography where full tones cannot be printed but the illusions of tones are created by the ratios of black to white elements in the specific tonal areas.

HIGH-KEY. A high-key print has a large density difference; i.e., it has a high range between the density of the lightest highlight and that of the darkest shadow. In addition, a high-key print normally consists of predominantly light areas with a few dark shadow areas.

HIGHLIGHT. The highlights of a print are the lighter tones or the areas of lower density.

NEGATIVE. In the context of this report, a negative is a sheet of photographic paper, brownish on the image side, on which the image is exposed. When the image is chemically transferred to the receiver paper or film, the negative is no longer of value and is destroyed.

PMT. The photomechanical transfer (PMT) process was created by Eastman Kodak for the graphic arts and printing industries. In the PMT process, a negative sheet is exposed and run through a processor in contact with a receiver sheet, the sheets are left together for 30 seconds, and then the negative is discarded and the receiver sheet with the black and white image is washed and dried. The PMT process offers substantial savings in time and manpower over the conventional process using a true negative.

RECEIVER. The PMT receiver sheet is either photopaper or film. The image is chemically transferred to the receiver sheet from the negative sheet, and is a positive image ready to use in artwork masters.

SCREEN. A screen is a pattern of opaque and transparent areas created especially for making halftone prints. When an image is exposed through a screen, the tones are broken up into mixtures of black and white elements. The optical properties of screens are very complex and are different for different applications. The PMT contact screens are made especially for the PMT process.

SCREEN RANGE. The tonal range that can be reproduced with the correct dot size for a highlight and a shadow. The screen range can vary with the type of screen used, the lithographic process used to reproduce the halftone, and other factors, and indicates a density range to which the range of the original must be reduced or increased.

SHADOW. The shadows of a print are the darker tones or the areas of higher density.

Appendix

EXAMPLES OF COMPUTER SETTINGS

NORMAL PRINTS

The densitometer reading for the highlight area of a print turns out to be 0.14 and the shadow reading is 2.05. Then, the copy range is

$$CR = 2.05 - 0.14 = 1.91.$$

The difference between the copy range and the screen range is

$$CR - SR = 1.91 - 1.05 = +0.86 \text{ (normal print).}$$

The exposure computer settings would then be as shown in Figure A-1 (assuming that 350 and 50 are the calibrated values for the MAIN and FLASH digit switches, respectively).

FLAT PRINTS

The highlight density reading is 0.27 and the shadow reading is 1.14. The copy range is

$$CR = 1.14 - 0.27 = 0.87.$$

The difference between the copy range and the screen range is

$$CR - SR = 0.87 - 1.05 = -0.18 \text{ (flat print).}$$

The exposure computer settings would then be as shown in Figure A-2.

VERY FLAT PRINTS

The highlight density reading is 0.24 and the shadow reading is 0.82. The copy range is

$$CR = 0.82 - 0.24 = 0.58.$$

The difference between the copy range and the screen range is

$$CR - SR = 0.58 - 1.05 = -0.47 \text{ (very flat print).}$$

The exposure computer settings would then be as shown in Figure A-3.

Figure A-1. Computer Settings for Normal Print

Figure A-2. Computer Settings for Flat Print

Figure A-3. Computer Settings for Very Flat Print

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