ANA Tech
Eagle Color Scanner
User Guide

Revision F
September 2000

Foreword

This document covers the Eagle Color scanners. ANA Tech believes the information in this document is accurate as of its publication date. Software features are subject to change.

Document Conventions

The following typographical conventions are used throughout this manual:

Text to be entered via the keyboard appears in a monospaced font as follows:

`enter this text`

Emphasized text appears in italics:

this is emphasized text

Text that cautions the user about actions that may result in injury, equipment or software damage or malfunction, or may interfere with the proper operation of the scanner is preceded by the word **Warning**.

Text that presents useful information or valuable tips may be preceded by the word **Note**.

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The Eagle color scanners are roller type, large format digital scanning devices that output digital color data in industry standard file formats. Output can be either 24-bit RGB, or 8-bit or 4-bit classified color data. The scanners are designed with a minimal number of physical controls. Most scanner control is exercised through interface software. The scanners consist of a document transport system and cameras that focus light on tri-color CCDs (charge coupled devices), plus electronics to process the signals accumulated on the photosensitive CCDs. The scanners are designed primarily to capture large format, color documents, such as maps.

This document provides installation and calibration instructions. Also, an overview of color scanning technology is included. There are some troubleshooting tips and scanner specifications are listed in the Appendix. General operating instructions are provided, such as the scanner power on sequence and daily calibration procedure. Since the scanner is controlled primarily through its interface software, the documentation for this software should be studied. Also, scanning color classified data requires use of optional classification software to generate color lookup table files, so documentation for the classification software is also needed. The sketch below shows how the color scanning operation is structured.

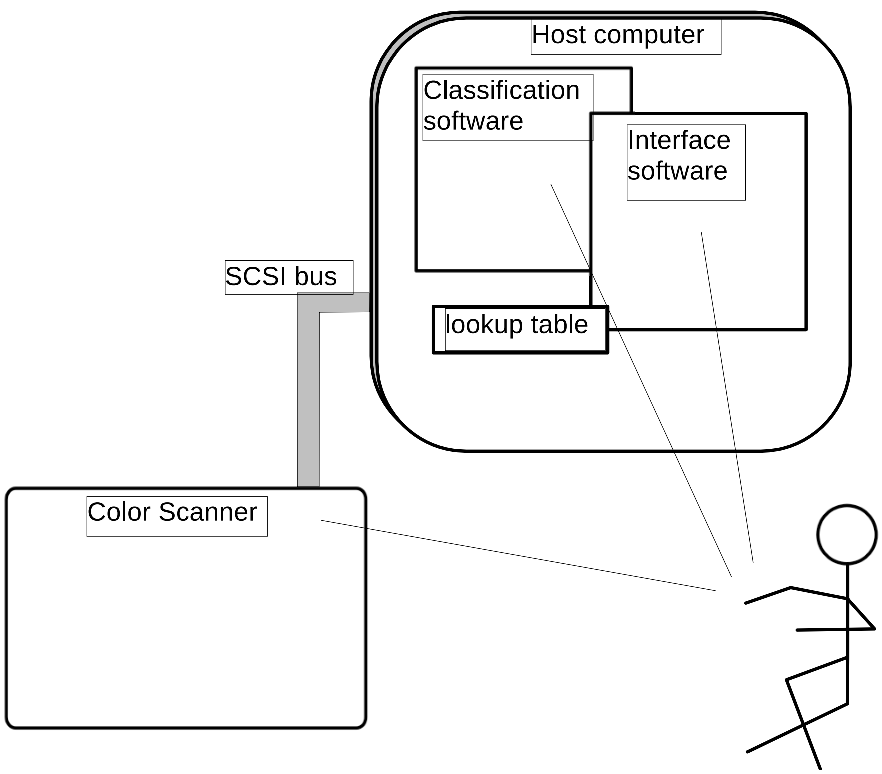


Figure 1.1 Operating Color Scanner

Color Scanning

Color scanning involves analyzing the color components of light reflected from a document surface. The red, green, and blue light components are captured by a tri-color CCD. After analog- to-digital conversion, color components must be collated to compensate for spatial separation of the different color elements on the CCD sensor. Additionally, various correction factors are applied to the data to adjust for light levels and camera overlap. The Eagle color scanner uses an all-digital approach to scanner electronics to minimize the effects of electrical noise and maximize scanner accuracy. "All-digital" means that the CCD signals are immediately converted to digital values on the camera board circuitry that contains the CCD. Thus, subsequent transfers of data within the system involve movement of digital values rather than vulnerable analog signals.

Once the red, green, and blue digital components for a pixel of color data have been collated and corrected, these values can be transferred to the host computer as a 24-bit RGB data file. A 24-bit RGB file uses three bytes for each pixel. One byte represents the red component, one represents the blue component, and one represents green. Each component contains 256 possible levels, so 24 bits indicates a total possible color range of 2563, or about 16.8 million possible colors. This color range is commonly called "true color," because there are enough color values to accurately represent images without color artifacts that are noticeable to the human eye.

A problem with 24-bit RGB data is the enormous disk and memory space it requires. Consider a small 8 x 10 inch color document scanned in 24 bits per pixel at 400 dpi. Each square inch of the document has 400 x 400 pixels, or 160,000 pixels. The 8 x 10 document has 80 square inches with 12,800,000 pixels. Since each pixel requires 3 bytes of data (24 bits = 8 bits x 3 = 3 bytes), this means the document will need 38,400,000 bytes, or 38.4 megabytes. Imagine the storage requirements for even larger documents, and it quickly becomes clear that alternate methods of representing color data are necessary.

To better manage color output, color classification schemes are used. Color classification works by sorting the observed color pixel values in a document into a set of color indices (256 or fewer colors). For instance, when classifying a map, all hues of blue might be sorted into a single "blue" classification, while all shades of pink, orange, vermilion, crimson, and rose, might become simply "red."

In addition to scanning color data, Eagle color scanners using PC host platforms and SCANSMITH SCAN-C PC can output black and white data, in bi-level and grayscale formats. To output black and white data, one of the black and white output formats is selected in the scanner interface software. For bi-level files, you can use thresholding options identical to those available for Eagle black and white scanners. The color scanner interface software also allows a choice of color channels for black and white scanning, which provides additional flexibility when scanning in bi-level or grayscale formats. Eagle color scanners using UNIX host platforms can use color lookup tables to output color classified data using grayscale colors or the colors black and white.

Other Documents

Refer to the software interface documentation and the color classification software documentation for more information about scanner operation. Also, check any README documents that come with the scanner software before operating the scanner.

2. Installation

Scanner installation should only be performed by qualified service personnel. Please read this section completely before unpacking or installing the scanner.

Unpacking and Inventory

The scanner is bolted to a pallet for shipping. Some units (air and international shipments) may be packed inside a crate. Here is the recommended unpacking procedure:

1. Inspect the Shockwatch and Tiltwatch indicators. See Figure 2-1. The indicators turn red if they have been activated. If any indicator has been activated, make a note on the bill of lading and inspect the scanner for damage. [Shockwatch and Tiltwatch are registered trademarks of Media Recovery, Inc.] Inspect the scanner for any apparent physical damage. If damage is noted, make a note on the bill of lading and request a hidden damage report from the shipper. Remove the crate cover, if the unit is in a crate.

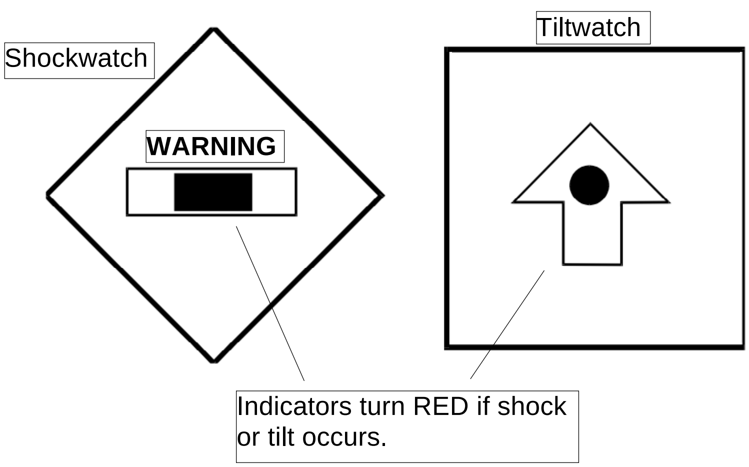


Figure 2-1. Shockwatch and Tiltwatch Indicators

2. Remove the four bolts that secure the scanner to the pallet.
3. Attach ramps to the pallet. Carefully roll the scanner from the pallet. The scanner should be positioned on a level surface capable of supporting more than 600 lbs. (273 kg.).
4. Inventory items shipped with the scanner. Locate the following items:

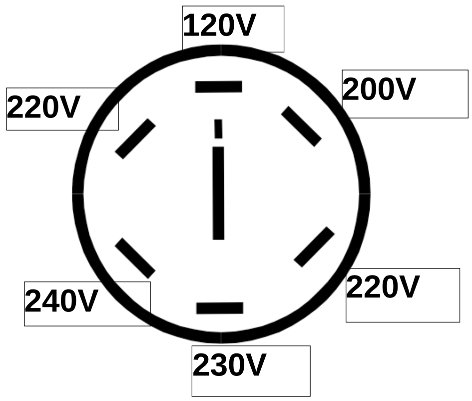
   Test targets
   - Laminated black and white target
   - Crosshatch target
   - Stitch target

   Factory information sheet

Document catcher and mounting hardware
Power cord
Diagnostics cable

Voltage Setting

The international power switch on the rear panel of the scanner must be set to the proper voltage level. Use a screwdriver or coin to select the power setting for your local voltage.



CAUTION The voltage *MUST* be set to the proper setting before powering on the scanner. Improper settings will damage the scanner electronics.

Power Cable Requirements

For units operating at 100-120V: The power cable is a UL-listed, CSA-certified, 18/3 AWG, type SVT or SJT, cable 15-foor (4.6 meter) maximum. It is terminated on one end by a 125V, 15A grounding-type attachment plug body. It is terminated at the other end by a 125V, 15A parallel blade, grounding-type attachment plug.

For units operating at 200-240V: The power cable is a UL-listed, CSA-certified, 18/3 AWG, type SVT or SJT, cable 15-foot (4.6-meter) maximum. It is terminated on one end by a 250V, 15A grounding-type attachment plug body. It is terminated at the other end by a 250V, 15A tandem blade, grounding-type attachment plug.

The power cable for international units is an 18/3 AWG, type SJT, cable 15-foot (4.6-meter) maximum. It is terminated on one end by a 250V, 15A grounding-type attachment plug body. It is terminated at the other end by a 250V, 15A grounding-type cord connector body. The cord set is marked HAR to signify appropriate safety approvals.

Installation and Connection to Host Computer

Scanner installation should only be performed by qualified service personnel.

1. Position the scanner so that you can access the rear panel.
2. Install the document catcher.
3. Ensure the scanner power switch is in the off position, then connect scanner power. See Specifications section for power requirements.
4. Power up the scanner once before it is connected to the host computer. Ensure that the scanner starts, then power it down.
5. Install the scanner interface hardware and software. Install the SCSI cable between scanner (SCSI IN) and host. Install the active SCSI terminator on the scanner SCSI OUT port.

Caution Be sure the host computer is turned off when connecting the interface cable. Refer to interface documentation for software installation instructions.

Scanner DIP Switch Settings

There is a set of DIP switches on the rear panel of the scanner. The switches set the SCSI ID setting for the scanner. The default SCSI ID is 2. These switches must be correctly set for proper scanner operation. During installation, switch settings should be checked to ensure that it is properly set. [*Black and white scanner users should note that the color scanner switch settings are different.*]

How to set the switch:

1. Power off the scanner.
2. Locate the switch on the rear panel of the V8000 electronics pod. See Figure 2-2.
3. Set switches 4-8 off.
4. Set switches 1-3 according to the following table:

SW3	SW2	SW1	SCSI ID
OFF	OFF	OFF	SCSI ID = 0
OFF	OFF	ON	SCSI ID = 1
OFF	ON	OFF	SCSI ID = 2
OFF	ON	ON	SCSI ID = 3
ON	OFF	OFF	SCSI ID = 4
ON	OFF	ON	SCSI ID = 5
ON	ON	OFF	SCSI ID = 6
ON	ON	ON	reserved for host

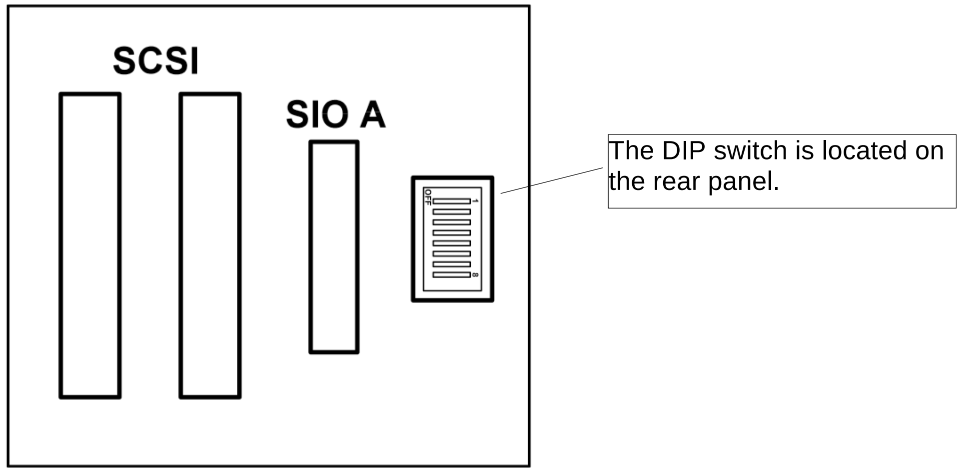


Figure 2-2. SCSI DIP Switch

Device ID

In addition to setting the DIP switch, software settings may be required to allow the host computer to recognize the scanner device. Refer to the documenattion that comes with the scanner interface software for detailed instructions.

SCSI Terminator

The SCSI terminator must be an active terminator.

Host-Scanner Communications

Host-scanner communications are established automatically by the scanner electronics. There are no actions required by the operator. When the scanner interface software is executed, the scanner host automatically downloads data contained in the scanner calibration files to the scanner.

Special Note on SCSI

Because the SCSI bus that is used for scanner communications is typically also used to run the host's hard disk drive, certain aspects of scanner installation and oparation are very important:

- ***Always*** follow the correct power on and power off sequence.
- ***Never*** modify the SCSI cable connection, unplug the SCSI cable, or move a terminator while the host is booted up and connected to the scanner.

Failure to follow the cautions listed above may cause spurious data to exist on the SCSI bus, possibly resulting in adverse effects on the host's hard drive, including potential data corruption.

Power On Sequence

The scanner uses a SCSI bus which, for some host computers, also serves the host's hard disk drive. This bus should not be interrupted while the computer is on. Do not power the scanner on or off while the system is running. Improper bus interruption can cause SCSI errors that may affect the hard disk drive. Moving a SCSI terminator with the scanner powered on, or plugging in a new device, may cause bus interruption.

— Power up scanner first.

— Then power up computer and complete the bootup procedure.

— Start the scanner interface software.

Caution Follow this sequence to prevent SCSI bus errors and potential hard disk drive data corruption.

If the scanner fails to respond, press the scanner Reset button and restart the interface software.

Power Off Sequence

When powering down, always shut down the computer first. After the computer is powered down, then power down the scanner. The scanner main power switch is located at the rear of the scanner. Normally, main power to the scanner is left on, and is turned off only when moving the scanner or performing service activities.

The Scanner Lamp

It is not necessary to power down the computer or scanner to turn off the scanner lamp. The scanner lamp may be turned off when the scanner is not in use for extended periods (more than several hours). To turn off the scanner lamp, use the lamp power switch in the scanner control panel.

The scanner lamps shuts off automatically if the scanner is not in use for more than two hours.

Note that once the scanner lamp has been turned off, it is necessary to repeat the daily calibration procedure (including the 20 minute warm-up period) if the scanner is used again. See the Calibration section.

3. Calibration

Certain calibration procedures are required at the time of installation and after certain service activities, such as replacing a camera. Also, there is a daily calibration procedure that should be performed before the scanner is used each day, to ensure best scan results. These calibration procedures *do not* involve any physical adjustments.

Installation Calibration

UNIX Host

This calibration should be performed after the scanner is installed at a new site and after service activities such as camera replacement. See the Calibration Routines section, below.

1. Run Calibrate by entering the command line command

   ```
   calibrate
   ```

2. The Calibrate routine runs the three tests Make Dacs, Make Cor, and Stitch, described below.

PC Host

This calibration should be performed after the scanner is installed at a new site and after service activities such as camera replacement:

1. Run Eagle Color Diagnostics. Pull down the Calibration menu. Select *Calibrate*.
2. The Calibrate routine runs the three tests Make Dacs, Make Cor, and Stitch, described below.

Calibration Routines

MAKEDACS Calibration [initial installation only]

The MAKEDACS calibration creates two files that compensate for the overall camera illumination level. These files are called hdacs.dat and ldacs.dat.

1. Ensure the scanner lamp is on and allow the lamp to warm up for at least twenty (20) minutes.
2. Insert the black and white target so the white portion of the target is positioned over the scanning area. Close the paper tension spring.
3. On UNIX machines, enter the command line command,
   ```
   makedacs  -white
   ```
   On DOS or NT machines, run the scanner interface software, pull down the Calibration menu and select,
   ```
   Make Dacs–White.
   ```
4. Position the black target and repeat the test. On UNIX machines, enter the command line command,
   ```
   makedacs  -black
   ```
   On DOS or NT machines, run the scanner interface software, pull down the Calibration menu and select,
   ```
   Make Dacs–Black.
   ```

MAKECOR Calibration [initial installation and daily]

The MAKECOR calibration creates correction files that compensate for small variations in light intensity. There are two makecor correction files:

pgain.dat	white light adjustment file
poffset.dat	dark adjustment file

Follow these steps to perform the makecor procedure:

1. Ensure the scanner lamp is on and allow the lamp to warm up for at least twenty (20) minutes.
2. Insert the white target. Close the paper tension spring.
3. On UNIX machines enter the command line command,
   ```
   makecor –gain
   ```
   On DOS or NT machines, run the scanner interface software, pull down the Calibration menu and select,
   ```
   Make Cor–Gain.
   ```
   This creates the pgain.dat file.
4. Insert the black target and repeat the test. On UNIX machines enter the command line command,
   ```
   makecor –offset
   ```

On DOS or NT machines, run the scanner interface software, pull down the Calibration menu and select,

```
Make Cor–Offset.
```

This creates the dark adjustment (poffset.dat) file.

If the Makecor test fails and generates error messages, be sure the correct target is installed and the lights have warmed up. If the test still fails, call Customer Support.

STEAGLE (Stitch) Calibration [initial installation only]

The STEAGLE calibration creates a file that compensates for overlap in the field of view of the cameras. This file is called a stitch file (pstitch.dat).

1. Ensure the scanner lamp is on and allow the lamp to warm up for at least twenty (20) minutes.
2. On UNIX machines, enter the command line command,

   ```
   steagle
   ```

   On DOS or NT machines, run the scanner interface software, pull down the Calibration menu and select,

   ```
   Stitch
   ```

3. When prompted, load the stitching target. The stitching target has several diagonal lines.

The best way to check the camera boundaries is to scan an image and check that there is no misalignment between the cameras. Camera boundaries on the 3640C scanner are at 12 and 24 inches, 4240C scanner are at 10.5, 21 and 31.5 inches.

Note that once initial calibration is accomplished, no further calibration is necessary for repeated scanning. It is not necessary to run makedacs, makecor and steagle every time the scanner is powered on. *Makedacs and steagle should only be performed during scanner installation.* Because the calibration results are stored in data files, the calibration remains valid until a change in scanner characteristics makes recalibration necessary. The files are downloaded on the scanner whenever the software interface is started. Also, if the calibration files are somehow erased or corrupted, these files can be reinstalled from a backup copy, without needing to recalibrate the scanner.

Help on Calibration Commands

Help for calibration commands running in the UNIX environment from the command line is available by typing "–help" after the command. For instance:
`makedacs -help`
`makecor -help`
`steagle -help`
Also, refer to cuurent README documents and applicable software interface documentation.

Caution All calibration targets must be maintained in undamaged condition to ensure proper calibration of the scanner. Targets should be stored in a protective tube. After daily calibration, the black and white target should be carefully rolled and stored in a protective tube. Any creasing, wrinkling, or other target damage may affect the calibration and result in scanning color errors. If a target becomes damaged, it should be replaced.

4. Maintenance

There are no user serviceable components in the Eagle color scanner. Routine maintenance consists only of cleaning the roller surface and maintaining the calibration test targets.

Cleaning the Roller

To clean the roller follow this procedure:

1. Lift the lid that covers the roller. Rest the lid in the open position so the roller is exposed.
2. Clean the roller with a soft, lint-free cloth or towlette and isopropyl alcohol. Do not use any other solvents.
3. Close the lid.
4. Use the interface software as needed to advance the roller for cleaning. This can be done by "scanning" and setting the Y axis scan distance to a small distance (e.g., two or three inches). Of course, you do not need to insert a document when simply advancing the roller. To avoid creating a large junk file, set the X window to a very small distance.

Storing the Targets

It is very important that the calibration targets are undamaged. Any fold or wrinkle in the target can produce calibration errors that affect the scanned data. The calibration targets should be carefully rolled when not in use and placed in a sturdy document tube when not in use.

Note Any wrinkle or crease in the targets can cause problems. If one of your targets become damaged, be sure to order a replacement target.

5. How to Scan

1. Follow the power on sequence described in the Installation section. Be sure to follow the prescribed power on sequence. Turn on the scanner lamp.
2. Run the scanner interface software. This procedure will vary with your scanner interface software and host platform. Refer to the interface software instructions for details.
3. Follow these steps:
   — Ensure that the scanner lamp is on and has warmed up for at least 20 minutes. (The lamp switch is in the recessed bay on the control panel to the right of the document entrance area.)

   — Insert the document to be scanned in the scanner with the ink side down.

   — Close the scanner paper tension spring switch to seat the document in the scanner (the paper tension spring switch is the multi-color pressure sensitive strip on the scanner lid).

   — Use the interface software to start the scan. When the scan is complete, open the scanner spring switch before removing the document.

Note Adjust software settings for scan density (resolution), speed, document area, etc., as needed before pressing the Scan button in the software.

4. When the scanner is not in use for extended periods (more than several hours), turn off the scanner lamp.

If the scanner needs to be moved, inspected, or requires a change in configuration, follow the power down sequence described in the Installation section.

Scanner Speed

Because of the data volume generated by color data, especially full color 24-bit color data, it is likely that you will need to slow down the scanner. If you encounter an overflow type error, just use the software interface to reduce scan speed. The larger the active scan area and the higher the resolution, the slower you may need to go.

6. Specifications

Document media	Opaque
Document type	Paper, photographic paper, vellum or linen
Document length	Roll length
Maximum scan width	Eagle 4080C 40 inches (101.6 cm) Eagle 3640C 36 inches (91.4 cm) Eagle 4240C 42 inches (106.7 cm) Eagle 6250C 62 inches (157.5 cm)
Maximum paper width	Eagle 4080C 44 inches (111.8 cm) Eagle 3640C 44 inches (111.8 cm) Eagle 4240C 44 inches (111.8 cm) Eagle 6250C 64 inches (162.6 cm)
Resolution	Eagle 4080C 1-800 dpi, variable Eagle 3640C 1-400 dpi, variable Eagle 4240C 1-400 dpi, variable Eagle 6250C 1-500 dpi, variable
Scanning technology	5,000 element tri-linear color CCD cameras Eagle 4080C 7 cameras Eagle 6250C 7 cameras Eagle 3640C 3 cameras Eagle 4240C 4 cameras
Illumination	Color balanced aperture fluorescent lighting
Scan Accuracy	0.020 inches (0.102 cm) over 40 inches (101.6 cm)
Paper Skew	0.1%
Dimensions (W x D x H)	4080C, 3640C, 4240C: 58 inches x 26 inches x 40 inches (147.3 cm x 66 cm x 101.6 cm)
(W x D x H)	6250C: 78 inches x 26 inches x 40 inches (198 cm x 66 cm x 101.6 cm)
Weight	4080C, 3640C, 4240C: 600 lbs (273 kg) 6250C: 750 lbs (340 kg)
Electrical	Auto sensing 120, 100, 200, 220, 230, 240 VAC 47-63 Hz, 4.5 or 3.0 A/480 W
Heat dissipation	985 BTU/Hr
Temperature range	65-85 degree Fahrenheit 18-30 degrees Celsius
Humidity range	15% to 90% (non-condensing)

7. Trouble Shooting

The Eagle color scanner is designed for self-contained operation, with no user serviceable components except for the roller, which can be cleaned. Some simple problems that may occur during installation or operation are described below. For more technical problems, it is recommended that a Customer Support representative be contacted.

Problem	**Cause/Solution**
Document slips through aperture and becomes trapped inside scanner.	Power off the scanner with the standard shutdown sequence. Open the access panel on rear of scanner by removing the two screws at top of panel. The grounding strap can stay attached. Open panel enough to remove the document. Replace the panel when complete.
Scanner operates, but all scanned data is black.	Check lamp switch and ensure lamp comes on when lamp switch is on. (Open paper tension spring and turn lamp off and on; you should see light coming from under the roller.)
Scanner does not run when powered on.	Scanner is not connected to power, or there is no power at the source. Check power connection and source. Check the international power switch setting on rear panel.
No response to software commands, or software interface cannot find the scanner.	Improper SCSI connection/termination, or SCSI device drivers are not properly configured.
Steagle (Stitch) calibration test fails.	Ensure the stitch target is inserted and paper tension spring engaged.

8. SCANSMITH Color Productivity Suite 98

The SCANSMITH Color Productivity Suite 98 software includes necessary software components to operate the scanner. These components are installed during installation of the Color Productivity Suite 98 software.

SCANSMITH SCAN-C

The scanner requires the SCANSMITH SCAN-C software interface to direct scanning operations. The interface lets you control scanner settings, such as scan resolution, classification mode or true color mode, scan speed, etc.

SCAN-C is described in the SCANSMITH SCAN-C User Guide.

SCANSMITH EASY SCAN-C

EASY SCAN-C is a simplified interface to SCAN-C designed to minimize the complexity of scanning operations. EASY SCAN-C is provided with several workspaces and you can use SCAN-C to create new workspaces.

EASY SCAN-C is described in the EASY SCAN-C User Guide.

SCANSMITH CLASS

To perform color classification, SCANSMITH CLASS is used. The classification software is necessary to create the color lookup file used by the scanner when scanning in color classification mode. SCANSMITH CLASS is included with the SCANSMITH SCAN-C interface.

CLASS is described in the SCANSMITH CLASS User Guide and the SCANSMITH CLASS Training Guide. (It is recommended that both of these documents be studied.)

SCANSMITH PREDITOR

SCANSMITH PREDITOR is a raster display and editing utility that works with color, grayscale, and bi-level images. PREDITOR is included with SCANSMITH SCAN-C. PREDITOR is only available for PC platforms. PREDITOR performs editing and drawing operations and can save color layers from color classified files as separate bi-level files. Also, PREDITOR can generate color and grayscale image adjust lookup tables which can be specified in SCANSMITH SCAN-C to adjust color or grayscale data at scan time (this is a different type of lookup table than the LUT used for color classification).

PREDITOR is described in the SCANSMITH PREDITOR User Guide.

SCANSMITH SCAN PLOT

SCAN PLOT provides scan-to-plot functionality for the scanner, printing through the Windows Print Manager or with Intergraph Plotting (if Intergraph Plotting software is installed).

The SCAN PLOT software is accessed automatically when you use the Print function in SCAN-C. SCAN PLOT functions are documented in the SCANSMITH SCAN-C User Guide, in the Print section.

SCANSMITH MATCH

SCANSMITH MATCH provides color matching to match scanned colors to output device colors.

SCANSMITH MATCH is described in the SCANSMITH MATCH User Guide.

9. Output Formats

The following formats are available as direct output of the Eagle color scanner:

RGB Color Formats

.TIF	TIFF 24 bit uncompressed
.T27	Intergraph Type 27, 24 bit compressed
.RGB	Intergraph Type 28, 24 bit uncompressed
.JPG	JFIF 24 bit JPEG
.BMP	Windows 24 bit bitmap

Palette Color Formats

.TIF	TIFF 8 bit uncompressed
.TIF	TIFF 8 bit PackBits
.TIF	TIFF 4 bit uncompressed
.COT	Intergraph Type 2, 8 bit uncompressed
.CRL	Intergraph Type 10, 8 bit compressed
.T29	Intergraph Type 29, 8 bit compressed
.PCX	Z-Soft color 8 bit compressed
.BMP	Windows 8 bit bitmap
.BMP	Windows 4 bit bitmap

Grayscale Formats (PC only)

.TIF	TIFF 8 bit uncompressed
.TIF	TIFF 4 bit uncompressed
.IGS	Image Systems Inc. (CAD Overlay), 8 bit uncompressed
.COT	Intergraph Type 2, 8 bit uncompressed
.T29	Intergraph 8 bit compressed
.GRY	ANA Tech 8 bit uncompressed
.JPG	JFIF 8 bit JPEG
.BMP	Windows 8 bit grayscale
.BMP	Windows 4 bit grayscale

Bi-level Formats (PC only)

.TIF	TIFF Group 4 FAX
.TIF	TIFF Group 3 FAX
.TIF	TIFF CCITT Group 3, Appendix B
.TIF	TIFF PackBits
.TIF	TIFF Group 3 2D
.TIF	TIFF Uncompressed
.CAL	CALS Type 1 Untiled Raster Data Format
.RLC	Image Systems Inc. (CAD Overlay), run length encoded
.RLE	Intergraph Type 9, run length encoded
.CIT	Intergraph Type 24, CCITT Group 4
.TG4	Intergraph Type 65, tiled CCITT Group 4
.PCX	Z-Soft Inc., compressed

.HRF	Hitachi Raster Format (Hitachi/CADCore)
.RST	Indigo Graphics RST MK-I
.RST	Indigo Graphics RST MK-II
.LRD	ANA Tech, run length encoded
.G4	ANA Tech, CCITT Group 4
.G3	ANA Tech, CCITT Group 3
.GTX	G4 Level 2
.GTX	G4 Level 3
.BMP	Windows 1 bit grayscale

Color Raster Files

Files contain headers and data. The data portion of a file represents the actual raster data. The header portion contains information about the data that applications may use when processing or displaying the data. For instance, TIFF headers contain a number of tags that specify the dimensions of the raster file and the type of raster data in the file — black-and-white, grayscale, full color, etc.

Not all software applications consistently recognize techniques used in file headers. For instance, the scan line orientation selection adjusts a header setting that indicates the orientation with which a raster file should be displayed. However, not all applications recognize scan line orientation settings in file headers. When such an application is encountered, it may be necessary to physically rescan the document with a different orientation, or to use a raster editor to resample the data so that proper orientation is represented in the data itself, rather than just the header.

The file format you choose should be suited to your application, costs of storage, and possible future uses for the data. A big decision for color data is whether to classify 24-bit full-color data into 8-bit data. Color classified data uses much less storage space than full color data, and some applications such as mapping may find classified data more useful than full color data.

You must create a color lookup table using classification software in order to capture color classified data. Once captured, the color classified data is saved in a file that contains palette information in addition to the data itself. The palette instructs software applications using the data what colors to display for assigned classification values. (The palette is not the same as the color classification lookup table.) Color classification is a one-way process that cannot be undone (except by rescanning).

Note A useful technique for image enhancement is to try randomly or selectively modifying the palette for color classified data — the images that result may reveal details about the data that would otherwise be unnoticed.

Compared to color classified data, 24-bit, full color data requires very large amounts of storage space. But if 24-bit color depth may be useful in the future, it may be worth investing in the extra storage requirements today and scanning documents in a full color format. Ultimately, there is no right or wrong answer about what color format to use — this decision must be made on a case by case basis.

10. System Overview

The Eagle color scanner is a large format, full color scanner. The scanner uses tri-color (red-green-blue) charge coupled devices (CCDs) and optical lenses to capture color data. A custom fluorescent lamp system provides document illumination. Conversion of analog CCD signals into digital data occurs on the camera boards at each camera assembly and all remaining processing of scan data is digital.

The physical enclosure for the Eagle color scanner consists of plastic-resin panels bolted to a structural frame. The panels can be removed by service personnel to access scanner internals for camera alignment or replacement, board replacement or upgrades in the V8000 card cage, or other diagnostics and repair operations.

A separate optical and external frame utilizes a three-point mounting concept to isolate the optics from external stresses. Document transport uses a roller, motor, and paper tension spring. Cameras are mounted on the optical frame using ANA Tech's patented mounting technique that eliminates vertical motion of the camera body and precisely positions the camera laterally. An alignment string is suspended just below the roller to act as a reference for the alignment procedure.

The three color channels (RGB) each generate 8 bits of data per pixel for a total of 24 bit color data. Hardware in the scanner can perform real time color classification on the data to output final data in 256 or fewer colors, as needed by the application software.

Most scanner control is exercised through application software. The control panel consists only of a lamp switch and a Reset switch. The power switch is on the rear panel. A strip switch on the scanner cover activates the paper tension spring. The scanner is designed to be left on continuously, with the lamp switched off during idle hours.

Features

The Eagle color scanners use the proven mechanical design of the Eagle black-and-white scanner models. The isolated optical subsystem ensures vibration-free scanning without mechanical distortion effects and reliable, trouble-free camera alignment. In addition, here is a list of some features that are especially relevant to color scanning:

- Single-pass scanning. Tri-linear CCDs, used for data capture, incorporate all three red, green, and blue sensor elements on the same integrated circuit, using built-in color filters. Single-pass scanning saves times and averts registration problems associated with multiple-pass color scanning.
- VME bus technology for easy board replacement and a viable upgrade path for future scanner electronics
- High accuracy process lenses for low-distortion data capture
- All-digital design for low noise scanning, enhancing color fidelity and dynamic range
- Full 24-bit color mode for 16.8 million colors (true color)
- Onboard real time color classification mode for efficient data transfer to host, better data compression, and applicability to mapping and other classification-intensive color processes
- Onboard real time color run-length encoding for color classification modes performs the initial compression of color data. This improves the efficiency of data transfer to the host computer. (Note that this internal run-length encoding is unrelated to the file format.)
- SCSI-II interface for fast transfer of large quantities of color data to the host computer

Theory of Operation

Scanning involves document transport, illumination and light capture, and electronic conversion and processing tasks. See Figure 10-1.

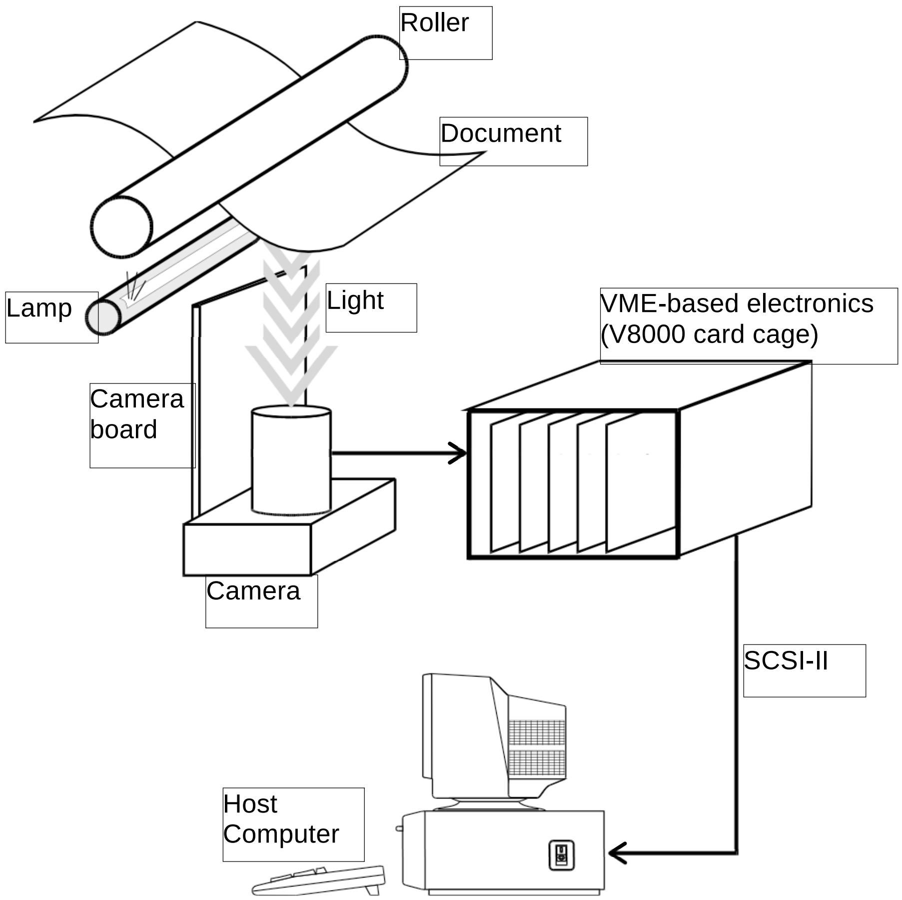


Figure 10-1. Scanner system

- A roller transports the document over a row of cameras. Document illumination is provided by a custom designed aperture fluorescent lamp.
- The CCD cameras capture analog signals that represent light levels. These signals are immediately converted into digital values in the camera board circuitry.
- Digital data from the cameras is routed by a ribbon cable to the V8000 enclosure.
- Data is passed through a series of circuit boards that perform processing tasks. The boards are modular in design and function. For instance, one board performs RGB collation, while another performs correction tasks. Another board monitors and controls functions such as roller movement and paper tension spring status.

- Data is transmitted from the scanner circuitry through a SCSI-II bus to the host computer, where it is saved as a data file.

CCD Basics

The Eagle color scanner is built around a single integrated circuit type — the charge-coupled device (CCD). Because the CCD is so essential to scanning with Eagle scanners, it may be useful to know a little about the CCD circuit.

Bell Laboratories developed the CCD in 1970. Since this time, a multi-billion dollar business has developed around CCD technology. Today, CCDs are used in digital photography, camcorders, and scanners such as the Eagle scanner series. There are many types of CCD circuits. The type used in Eagle scanners are linear CCDs. A linear CCD consists of a row of photosensitive cells. Eagle color scanners use tri-linear CCDs, which have three rows of cells. In the tri-linear CCD, each row is covered by a different color filter. The row covered by the red filter absorbs primarily red light, while the row covered by the green filter absorbs primarily green light, and the blue row absorbs blue light. Thus each row reacts to one of the three primary colors in white light. See Figure 10-2. When captured and saved as red-green-blue (RGB) data, these color components can later be recombined in application software to represent the original color of the document.

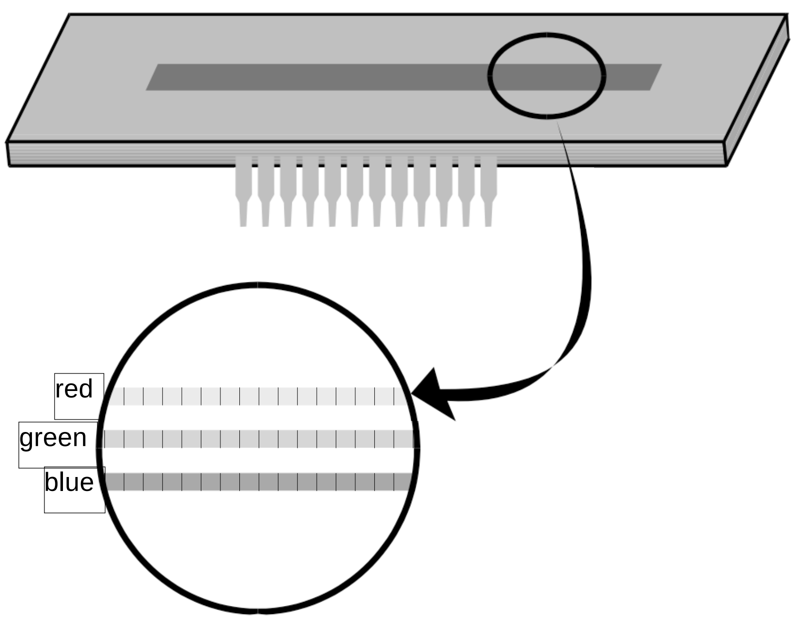


Figure 10-2. CCD Construction

CCD Principles

The scanner's optical system is designed to deliver light energy reflected from the document onto the CCD, while the electronic system is designed to collect and process electrical energy generated in the CCD chip. CCDs in Eagle scanners gather an entire scan line at a time. That is, a one-pixel-wide "snapshot" is taken across the entire width of the document. This line of pixels is called a scan line. As the roller spins and the document gets transported through the scanner, successive scan lines are captured and processed. Much of the scanner electronics and control circuitry and software are designed around the scan line concept. For instance, the CCD integration time is a key factor in all the timing and control circuitry of the scanner. Integration time is the time allotted for CCD light collection for a single scan line.

The CCDs used in Eagle color scanners include three major components (see Figure 10-3):

– A photo-sensitive region made up of a series of photodiode cells; in this region, light photons from the document excite the photodiode to enter a charged state, freeing some electrons. The number of free electrons is proportional to the intensity of the light source.

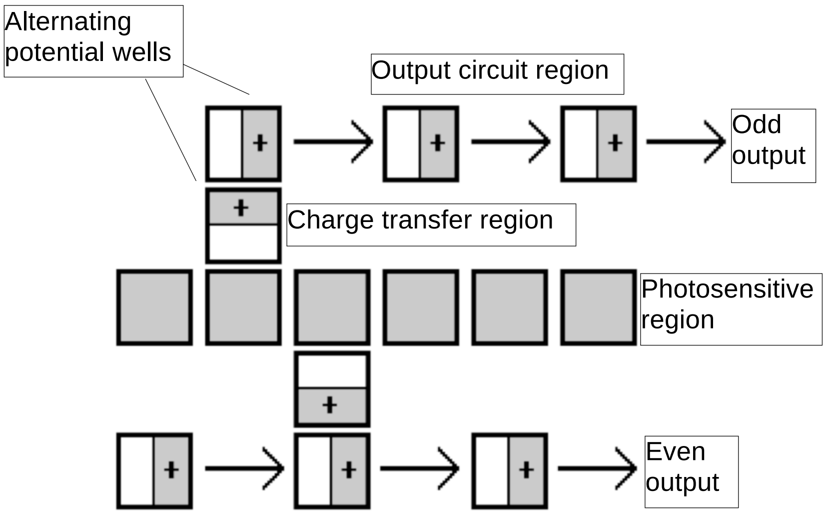
– A charge transfer region; in this section, charges generated by the photodiodes are transferred to the next region.

– The output circuit region; this section sequentially outputs the CCD charge data; this function can occur while the photo-sensitive region is integrating the next scan line.

Why are They Called CCDs?

CCDs use a photodiode effect to turn light energy into electrons, but they get their name from charge coupling. Charge coupling is the principle that allows CCDs to pass the information they collect to other circuits. After light is converted into electrical energy in the form of free electrons, the electrons are passed along a series of electrical potential wells — the electrical equivalent of a bucket brigade. By alternating the external voltages applied to adjacent regions of the output circuit, the charge packets collected by the photosensitive CCD cells are made to flow from well to well towards the output. This process is charge coupling. See Figure 10-3.

The potential wells that make up the CCD output channels are physically parallel to the photosensitive cells. The number of transfers required for a charge packet to exit the CCD depends on where it starts —if it starts at the end of the CCD, then it must be transferred through hundreds or thousands of wells, depending on the size of the CCD. Thus the transfer of electrons from well to well must be extremely efficient, because each charge must be transferred a number of times before it finally exits the CCD. If any electrons are lost or left behind in a transfer, this will degrade the accuracy of the observed light value that the charge packet represents. Therefore manufactured CCDs used in Eagle scanners have a well-to-well transfer efficiency of 99.999%.



10-3.   Charge Coupling Effect in Dual Output CCD

The dual output channel CCD is also designed to aid accuracy, by cutting in half the number of output channel steps through which each charge packet must travel to exit the CCD. For instance, in a 5,000-element CCD circuit, dual output saves as many as 2,500 charge coupling steps for the pixel at the far end of the scan line.

While the photosensitive elements are storing up electrical charges from one scan line, the transfer circuitry marches off the charges, in step fashion, from the previous scan line.

Note   It is not necessary to remember these details about CCD design in order to operate the scanner. However, it is hoped that this description may help readers understand the central importance of the CCD to the scanning system. The ultimate capabilities, and limitations, of a CCD-based scanning system stem from the type of CCD used in a system and its electronic and optical characteristics.

11. Scanner Description

This section describes the optical, electronic, and mechanical systems in the color scanner.

Optics

The Eagle color scanner optics consist of a high-quality process lens and lens extender mounted in a camera body so as to focus light on the color CCD circuit. Optics begin with a custom manufactured fluorescent lamp designed to generate light that balances the spectral response of the CCDs — because the CCDs respond strongly to red light and less strongly to blue light, the lamp is designed to generate more blue light. Thus the net effect of the lamp-CCD light system is balanced data capture for colors in the visible light spectrum.

Optics are direct path. That is, the light travels directly from the document surface, through the camera lens, to the CCD. There are no mirrors. The distance of the optical path, and hence, the height of the optical subsystem (and the height of the scanner) are determined by traditional optical formulas involving lens magnification and focus.

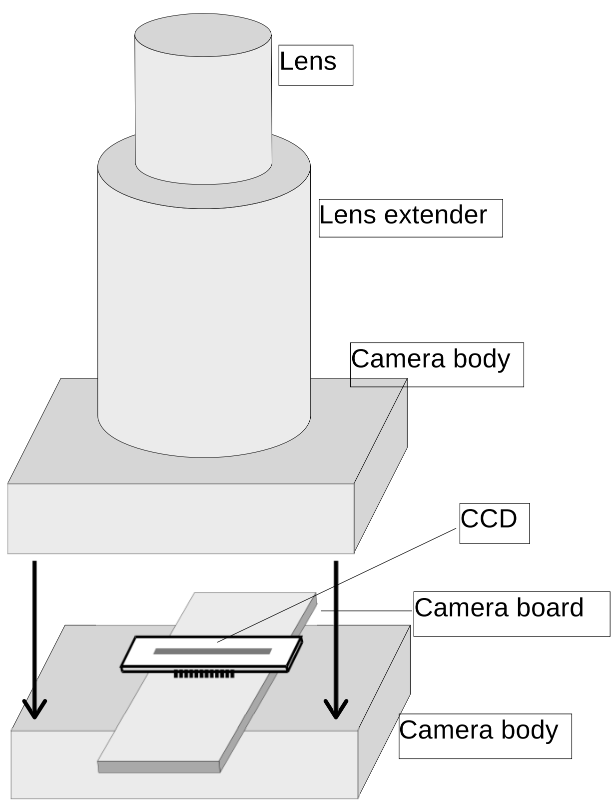


Figure 11-1. CCD Mounting Inside Camera

The CCD is mounted on a printed circuit board and housed inside the camera body, so that the CCD elements are parallel to the roller and the scan line.

A side view of the CCD, shown in Figure 11-2, reveals that different parts of the document are focused onto different CCD rows. The CCD color rows are separated by a distance of 12 pixels. This separation creates the need to collate scanned data (see Figure 11-4), because during each scan line integration, the CCD outputs pixel data for different scan lines.

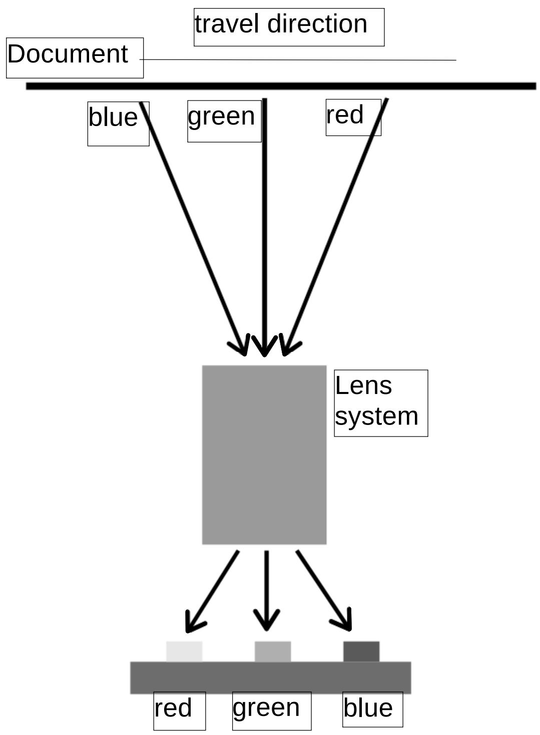


Figure 11-2. CCD Red, Green, and Blue Elements (cross-section)

Determining Resolution

The resolution, or scan density, of the scanner is determined by the amount of document width that gets imaged per unit width of the CCD. For instance, if a CCD camera is positioned so that it focuses on a 6.25-inch wide area, and there are 5,000 elements in the CCD circuit, then the resolution will be 5,000 pixels per 6.25 inches (5000/6.25), or 800 dpi. (In practice, some of the data from the 5,000 elements is discarded due to camera overlap — called the stitch process.) Vertical distance from the CCD to the document is precisely controlled in the camera mounting process to ensure proper scan resolution.

Electronics

The Eagle scanner electronics include a VME-type card cage with various circuit boards, camera electronics, and power and control circuits, referred to as the V8000. Only qualified service personnel should attempt to access or repair Eagle scanner electronics.

The small compartment on the right side of the scanner console conceals the reset and lamp switches. A strip switch that controls the paper tension spring is on top of the lid. On the rear of the scanner are SCSI in and out ports. (An active terminator should be installed on the SCSI out port in most cases — see the Installation section). The rear panel also has the power connection and international power option switch, and the main power switch.

Circuit Boards

The following circuit boards are installed in the Eagle color scanner:

- CCD and camera boards
- Camera control unit (CCU)
- Collator unit
- Correction unit
- Color look up table / Run-length encoder board (CLUT/RLE)
- CPU board

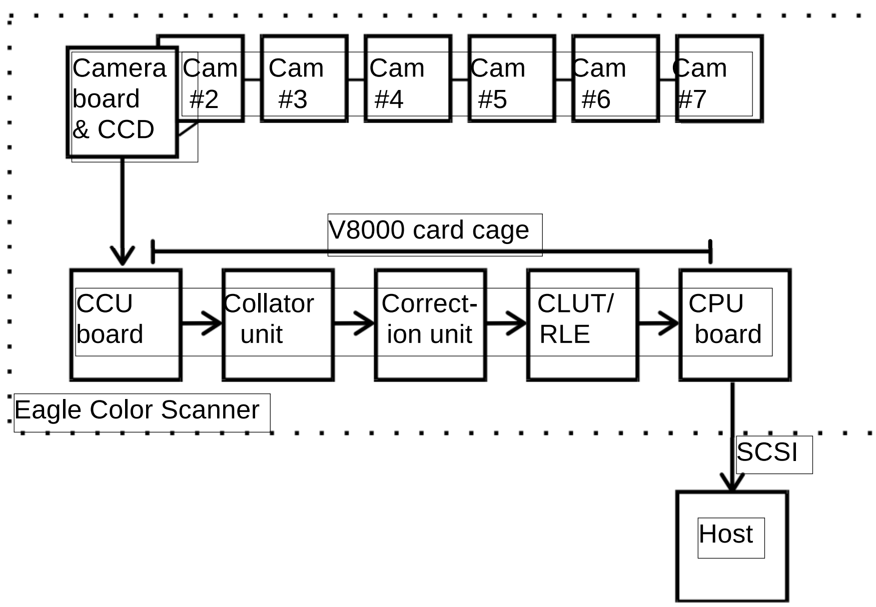


Figure 11-3. Eagle Color Scanner Electronics

Camera Control

The boards work together to capture and process color scan data. The CCD and camera boards are connected to each other and mounted to the camera assembly. Analog signals output by the CCD are immediately converted to digital values on the camera board. This early conversion to digital form minimizes the effects of electrical noise on scanned data. The camera board controls the response of Eagle color cameras to light from the document.

The camera control unit (CCU), inside the V8000 card cage, provides various control signals for the cameras and the roller motor. To use a human analogy, the CCU performs "lower brain" functions for the scanner.

Collating Pixels

The collator unit faces the difficult task of sorting out which pixel components go with which pixels. In the Optics section, we saw that different parts of the document get captured at the same time on the color sensor rows. But for a pixel to make sense, it must have the red, green, and blue components from its particular location — mixing the red light from one spot with green from another and blue from yet another would produce garbage for data. The collator also must keep track of when a pixel component was scanned, because the scanner can operate at different speeds. Figure 11-4 shows the nature of the collation problem.

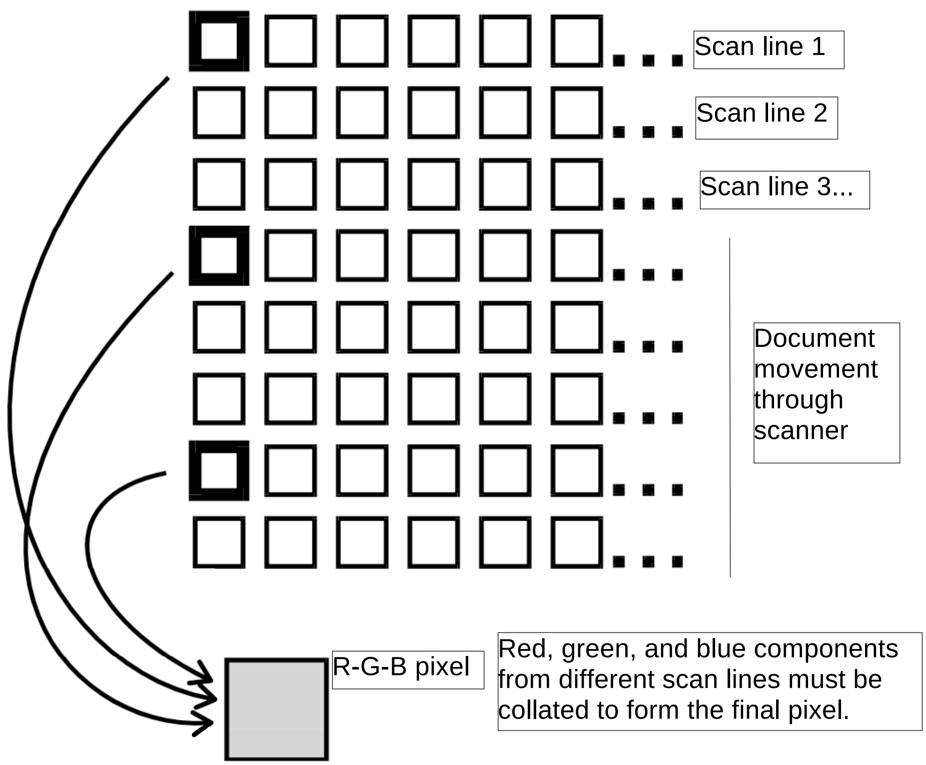


Figure 11-4. Collating R-G-B Pixel Components

Depending on how fast the scanner roller is moving the document, the collator joins pixel components separated by a variable number of scan lines.

After passing through the collator unit, the raw color data consists of 24-bit pixel data, often called R-G-B triplets. A triplet has three parts: a red value, a green value, and a blue value. The raw, uncorrected R-G-B triplets are sent from the collator to the correction unit.

Pixel Correction

The correction unit compensates for variation in light intensity and pixel responsivity. It also compensates for the optical overlap between adjacent cameras in the scanner. The scanner calibration procedure saves special data files that supply information to the correction unit. These files are saved on the host computer and loaded into the correction unit each time the scanner control software starts. The correction board also eliminates pixels when scanning at less than true resolution.

The Eagle color scanner performs dark correction, as well as light correction. This means that the CCD response is calibrated so that black data is the darkest black seen by the CCD and white data is the brightest white seen by the CCD.

Color Classification

The next board the pixel data goes to is the color lookup table/run-length encoding board (CLUT/RLE). This board handles the color classification process and performs data compression of classified color data into run lengths.

Color classification involves taking a 24-bit RGB image with 16.8 million possible colors for each pixel and sorting each pixel into one of a limited number of possible colors (up to 256).

The sections on color classification and run-length encoding later in this document discuss the color lookup table, color classification, and run length encoding in more detail.

The CPU Board

The CPU board is the last circuit board that scanned data encounters before transfer to the host computer. The CPU board supervises the other boards in the V8000 card cage and handles the SCSI-II communications to the host computer.

The scanning engines and associated electronics are theoretically capable of a maximum data output rate, when scanning full color data at top speed, of about 5 MB per second.
Most host computers cannot process and store data at the rate the scanner's full speed, nor can the SCSI-II interfaces used by most hosts keep up with this data rate. Therefore, when scanning large, full color (24 bit) documents, you will probably need to use the scanner control software to reduce scanner speed somewhat, in order to prevent a communications overflow condition.

Mechanics

The mechanical aspects of the scanner include components for document transport, plus the stationary mounting and frame components. The frame is really a frame-inside-a frame. The inner frame helps to isolate the scanner optics from external vibration and stress. Document transport is accomplished with a single roller and spring arrangement. The document travels under a Polyurethane-coated, high friction roller. A flat paper tension spring holds the document against the roller to ensure good focus and prevent document skew. The roller is a precision component designed to ensure stable and proper document motion. Any slippage or irregular travel of the document would be reflected in the captured data, causing unwanted skewing effects.

The paper tension spring can be released or engaged by the Hold switch (the rainbow-colored strip on the top of the scanner). This switch must be engaged for the document to be scanned.

12. Color Data Concepts

It is important to know some basics about color to understand the color scanning process. The most basic question is, "What is color?" To fully answer this, we would need to study the physiology of the human eye and optical nerve, pigmentation, color psychology, optics, physics, and other topics related to light and color. The study of color is complex, involving a number of scientific and technological disciplines. There are two aspects of color, however, that are relevant to scanning technology, the physical and the perceptive.

What is Color?

Color is a physical phenomenon consisting of light energy of various wavelengths. All documents reflect light which is color. Even white paper reflects color — the color white, which is a broad mixture of other colors. The color of reflected light depends on the source light and the pigmentation, texture, and other properties of a document. Documents do not originate or create colors (unless they are glowing or burning); rather they reflect colors present in the source light. Eagle color scanners use a specially designed white light source with many wavelengths of light to reveal all the potential colors of a document.

Color is a perception created in our mind from the sensation of color light falling on photoreceptors in the human eye. As a perceptive phenomenon, color is a unique and individual experience for different persons. Thus, though we may use a scanner to capture and classify colors, the perception of scanned color data may differ from person to person.

Detecting Color

The physical detection of color by human eyes is somewhat similar to the detection process for the color CCDs in the scanner cameras. In a human eye, light of different wavelengths falls on photoreceptor cells. A chemical reaction occurs in the pigments of some photoreceptors, releasing electricity. This electricity is conveyed by the neuro-synaptic process through the optical nerve to the brain, where the color information is processed. The photoreceptor cells include rods and cones; the cones react to color and bright details, while the rods react to low-light objects. There are three types of cones that react to colors in three different ranges. Pigments in one set of cones react most strongly to blue light, while another type of cone reacts more to green, and another to yellow. Using three input detection colors, the brain is able to reconstruct and perceive any color encountered by the eyes. It is a general property of color that three colors of different wavelengths can be combined, at the correct intensity, to form the perception of a fourth color.

Red, green, and blue are excellent colors to use for a wide range of color detection and regeneration, because these colors are spaced well apart on the spectrum of visible light. See Plate 1.1. Using red, green, and blue as the basis for color description is also consistent with the way colors are generated in current RGB computer display technology.

CCDs and Eyeballs

Just as the human eye has three types of cone cells that detect color, the color CCD has three rows of photosensitive elements covered by three different color filters: red, green, and blue. The red filter passes a distribution of red light wavelengths, blocking other wavelengths of light, so the CCD elements covered by the red filter react primarily to the red component of light reflected from the document. Green and blue elements react primarily to those color components. The filters are designed so that any color of light visible to the human eye will also be detected by the CCD. Just as the photoreceptor cells in the human eye, CCD elements also generate electricity.

Note Though there are three types of color receptor cones in the eye, there are four psychological primary colors — red, green, blue, and yellow. Psychological primaries are primary colors that are perceived in our mind. This phenomenon of perception involves the neural wiring between the cones and the brain and the way channels of color information are sent to the brain. It is interesting, though, that the actual detection mechanism in the eye uses three colors, just like the CCD.

Color Space

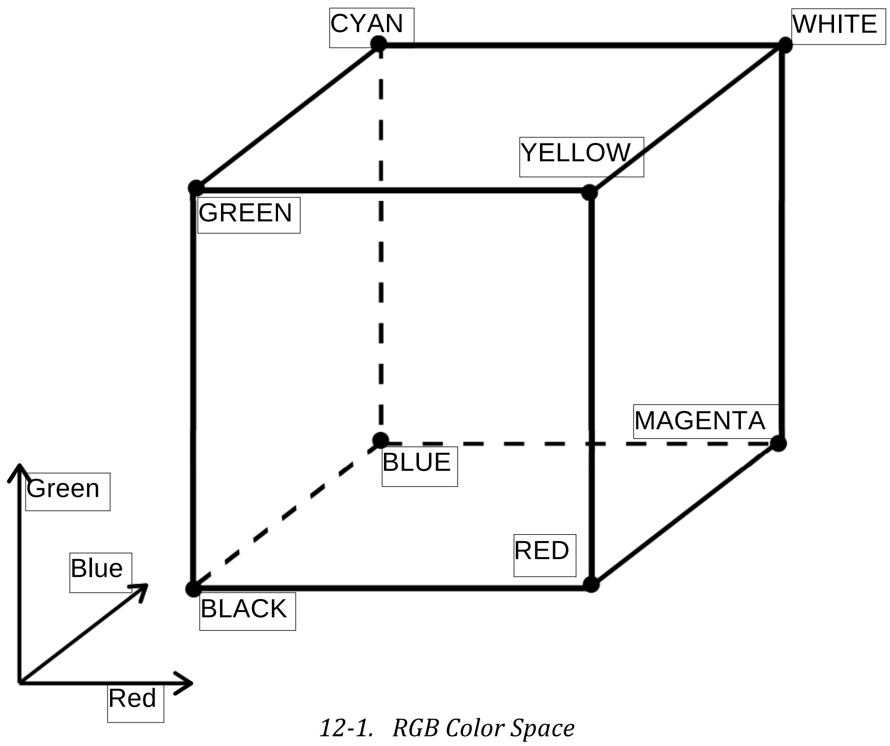
Because the Eagle color scanner CCDs use three element rows (red, green, and blue) to capture data, it is convenient to describe the scanned data in terms of the RGB levels captured by the CCD.

In RGB space, three color components, red, green, and blue, are mixed to form all the possible colors that can exist in RGB space. Using red, green, and blue is convenient in a computing environment, because this is the basis for color monitor technology and is thus a common frame of reference for describing color.

On a color monitor, color phosphors are driven at various levels to reproduce color. The three RGB signals drive separate electron guns which in turn excite color phosphors on the inner surface of the monitor screen. The colors we see for each screen pixel are not really unique monochromatic colors, but rather a combination of red, green, and blue that leads us to perceive some color. Just as the computer monitor is capable of producing only three original colors, the scanner captures only red, green, and blue components of light reflected from the document. These components can then be combined by applications software to re-create the perception of the original color of the scanned document.

Full levels of red, green, and blue produce white, while the absence of any color produces black. The advantage of the RGB model is that it is convenient for passing data to and from systems such as scanners and monitors.

We can define RGB color space as a cube. See Figure 12-1. One corner of the cube represents black, with RGB values of zero. One axis is red, another green, and another blue. All of the colors that the Eagle color scanner may capture can be represented in such a cube. To find a color, find the point inside the cube that corresponds to the red, green, and blue values for the pixel. Note that the "perfect," saturated colors lie along the outer edges of the cube. Black is the corner where red, green, and blue are zero, while the corner diagonally opposite black is white, with the maximum value of 255 for red, green, and blue. Red, green, and blue occupy three corners. The other three corners are used by cyan (blue+green), magenta (red+blue), and yellow (red+green). Gray values between black and white are inside the cube and lie along the line between the black and white corners. Plate 1.2 shows a more colorful rendition of the color space cube.



12-1. RGB Color Space

Color Models

The RGB color model is an additive color model. This means that colors are added to each other to make other colors. Red + green + blue = white. Red + green = yellow. Red + blue = magenta, etc.

Other models that describe color space exist, in addition to the RGB model. Intensity-Saturation-Hue (IHS) color space is a popular model based on a polar coordinate system, or color wheel. In this model, hue represents the color, while saturation represents the purity of the color — for instance, how blue a blue or how red a red. Intensity is the amount of energy, or brightness, in a color. Any hue with an intensity of zero is black.

For printing applications, color is described in terms of Cyan-Magenta-Yellow-Black (CMYK). This is a subtractive color model: Cyan + magenta + yellow = black. (In practice, a fourth ink color, black, is used for deeper black and to save the printing cost of mixing three inks everywhere that black is needed — hence the "K" designation in "CMYK.")

The standard specified by the National Television Systems Committee (NTSC) for television uses a luminance-chroma model to describe color. Still other models exist for other applications. Depending on the color model, color space may be designed to give greater emphasis to certain colors. For instance, the method of specifying color for television applications gives a greater range to flesh tone colors while other colors have less range.

A color space model provides a way of describing a set of colors. Any color that is not within the set does not exist, as far as that particular color model is concerned. Talking about color can be very tricky, because people use different color models for different applications. For instance, the term "intensity" in a color TV studio might have a different meaning than the same term has to an artist.

Sometimes it is necessary to convert data from one color model into another. For example, a user might need to manipulate the IHS values for a scanned document, changing the overall brightness for some artistic purpose. Another example is a video board that displays a television signal on a computer monitor. In this case the luminance-chroma information in the television signal is converted to an RGB form that the computer monitor can handle.

Color Data

Color data can exist in a number of formats, though there are two basic forms for color data, full color (unclassified 24 bit data) and classified. Full color data uses one byte to represent each of the red, green, and blue color components of a pixel. Each pixel requires 8+8+8 = 24 bits of data. Obviously, full color data files will be extremely large. Another basic form for color data is classified. Classified color data requires only 8 bits per pixel, and may be further compressed. The form you use will depend on your application and available storage space. These basic forms are discussed more in the following sections.

Full Color Data

The red, green, and blue components obtained from the CCD cells together describe the color of a pixel. See Plate 1.2. Each component is a number between 0 and 255. In binary, 0 is 0000 0000 and 255 is 1111 1111. This is a one-byte binary number, which consists of 8 bits. Thus, to save the values for a whole pixel, we need three one-byte binary numbers. Full color data, called true color, requires 24 bits of data per pixel. For example, the brown color in Plate 1.3 uses decimal RGB numbers 85-43-0. The binary equivalent of 85-43-0 is:

```
0101 0101   0010 1011   0000 0000
```

Although full color data requires a lot of storage space, it is very good at displaying scanned documents with subtle color variations, such as photographs. Plate 2.1 shows a close-up of full color data.

Color Classified Data

Color classification is very important for many applications. It allows us to greatly reduce the file size for scanned data. Additionally, certain applications benefit directly from color classification. For example, mapping applications can use color classification to separate scanned data into color layers. By scanning and classifying a color map, particular features can be extracted and separated.

How to Do Color Classification

Classification is performed automatically by the scanner during the scanning process. The typical color classification workflow is:

1. First you scan a representative sample of the color document in a 24-bit color format. The sample should have all the colors that need to be captured.
2. Run the classification software SCANSMITH CLASS and load the sample data. Operate the program to create and save a color classification file for your data.
3. Restart the scanner control software. Select an output format that uses color classification. Select the color classification file. Then scan the document. The document is saved as color classified data.

Classified color data consists of pixels values between 0-255 and a color palette, or map, that indicates what specific colors are assigned to the values between 0-255.

The scanner performs color classification by means of a look up table. The table has two "columns" — one column represents the raw, 24-bit, unclassified colors, while the other column represents the classification values assigned to each color:

Input R-G-B Value (18 bits)	Output Color (8 bits)
168-248-4 (yellow-green)	1 “green”
96-252-8 (light green)	1 “green”
0-244-0 (green)	1 “green”
0-168-252 (sky blue)	3 “blue”
4-0-212 (navy blue)	3 “blue”

Plate 2.2 also shows how color classification reduces ranges of full color values into a limited number of discrete output colors.

Note that even documents that appear at first glance to have only a few colors, such as topographic or thematic maps, will exhibit many subtle shades in the 24-bit, full color format. See Plate 3.1. The variety of colors is not apparent from a distance, but when you zoom in, is quite obvious. This color range results from slight differences in ink saturation, ink distribution patterns, wear and tear on the document, irregularities in paper texture, shininess or dullness, and so forth. Classification simplifies the color range into a small set of discrete colors.

The particular assignment of colors in the color classification scheme is arbitrary and can be set as needed in the classification software. A palette in the classified data file associates the values 0-255 with the selected color. The lookup table has 256,000 entries, one for each of the possible input colors. The scanner uses the most significant six bits of each raw color pixel as input to the color look up table ($2^6 * 2^6 * 2^6$ = 256,000 entries).

Note Once data has been classified, it cannot be converted back into full color data.

How to Do Color or Grayscale Adjustment

You can use a color or grayscale image adjust lookup table generated in SCANSMITH PREDITOR to adjust color or grayscale data at scan time:

1. Run SCANSMITH PREDITOR. Load a representative sample of color or grayscale data.
2. Pull down the Image menu and select Adjust. In the Adjust dialog that appears, make brightness, contrast, gamma, and high/low adjustments as needed. For color files, you can adjust individual color channels. Setting both high and low settings to zero turns off that color channel. Press the button *Save LUT File*. Save the image adjust LUT to disk.
3. Run SCANSMITH SCAN-C. Pull down the Custom menu. Select Image Adjust. In the Image Adjust dialog, select RGB or Grayscale LUT. Enter the name of the image adjust LUT you saved in Step 2. Press OK.
4. Scan normally. The image adjustment LUT is applied to the data while it is scanned. Note that using an image adjust LUT at scan time in this manner permanently affects the scanned data.

The Run-Length Concept

The initial compression of color classified data into run lengths is performed in the scanner during the scanning process. This occurs on the CLUT/RLE board, immediately after color classification.

A run length is a contiguous sequence of pixels with the same value. A run length is a space-saving way to describe pixel (raster) data. For instance, we can say "36 contiguous pixels with a value of 200," or we can spell out the values explicitly, "200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200 200." Clearly, it is more efficient to use the run length concept to describe such contiguous data. All color classified data is coded in the basic run length format on the CLUT/RLE board. The run length data may be then used in some data formats as the basis for even further compression, which occurs on the host computer, depending on which file format is selected with the scanner control software. Run length encoded data is more compact and easier to transfer to the host computer, thus easing the communications burden on the scanner when scanning large color documents.

Black and White Data

On PC platforms, SCANSMITH SCAN-C outputs grayscale and bi-level formats directly.

13. Color in Documents

This section provides some general information about color in documents. Whenever scanning a document, it is best to know as much as possible about the document — is it a photograph or printed matter, what type of printing process was used, how big are the halftone dots, and so forth.

Printed Documents

The Eagle Color scanner is capable of scanning flat, flexible documents such as paper or vellum. Most documents used by the scanner are printed documents that contain color information in the form of color inks on a document, or color papers or other document media.

There are different techniques used to create color documents. To get the most out of the scanner, it is essential to understand some basic document characteristics that result from different printing techniques.

Solid Color Printing

In this printing method, a document is printed with regions of solid ink colors. Different colors are obtained on the document by passing it through a printing press multiple times, each time using different specific ink colors. Topographic maps and road maps are typical of this printing method. Documents printed with this method usually have features with just a few colors — black for roads, blue for water, green for forest, etc. In this method of printing, the color of ink used is also the intended color of perception for a document feature. For instance, if there are purple lines on the document representing a dirt road, then we know that purple ink was used for this feature. This printing method is also called spot color. See Plate 3.1.

Halftones

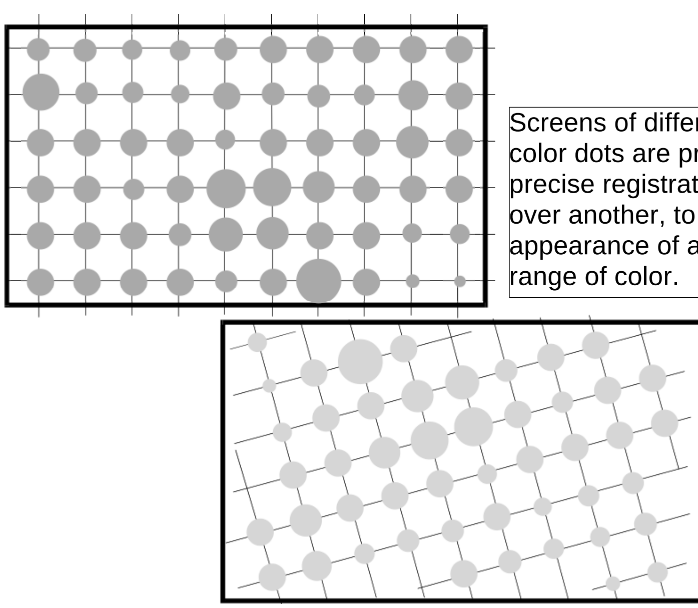
Halftones are commonly used in black and white printing, to depict photographs. A halftone creates the illusion of light and dark areas in a black and white photo with halftone dots of varying sizes. The eye blends the dots, so only the light and dark areas are noticed.

In color printing, halftones can be used the same way. For instance, a photograph can be represented as a monotone with an ink color other than black. Also, halftones are useful in color printing to shade areas with a color. United States Geological Survey (USGS) topographic maps often use halftones to fill in regions such as lakes or forest with a color. Plate 3.2 shows the use of a color halftone in a USGS topographical map.

It is possible to scan color halftones, though color classification of halftone features is more difficult than classification of solid color areas. The problem is that the scanner, unlike the human eye, will capture and record the separate halftone dots. At higher scan resolutions, the dots are more well defined. The pixels in between the dots may be very different in color from the dots themselves. Plate 3.3 shows a close-up of the scanned halftone pattern from Plate 3.2. When classifying such data, it may be difficult to distinguish between the very light areas in between the halftone dots and the white portions of the document outside the halftone region. As a result, the finished, classified data for the blue lake may appear blue with some white speckles.

Process Color Printing

The process color method differs significantly from solid, or spot color, in that a few ink colors are used to generate the visual appearance of many colors. This is achieved through the use of combining halftone screens of different ink colors. The screens have different orientations to prevent unattractive moire patterns from the dot combinations. The patterns that do result from the halftone combinations are meant to be unobtrusive, so the viewer notices the colors rather than the dot patterns. This printing method is often called four-color process printing, because printers use three color inks and black ink. The color inks are cyan, magenta, and yellow. Black is also used to obtain a deeper black than can be obtained by mixing of the three process color inks. These colors are abbreviated CMYK. In some cases, printers will use even more than four colors, such as when printing high quality art. The procedure graphic artists and printers use to prepare color artwork and photographs for printing is called color separation.



Screens of different size and color dots are printed in precise registration, one over another, to create the appearance of an infinite range of color.

Figure 13-1. Four Color Process Printing

In four-color process printing, color halftones, or screens, combine visually to produce the entire range of apparent printed colors. Where dots are adjacent to each other, our perception blends adjacent colors additively. Where dots overlap, the inks act like overlapping filters, passing only light that can travel through all the ink colors. (Light travels through the inks, reflects off the paper surface, and travels back through the inks to the viewer; also, some light is reflected directly from the inks surface back to the viewer.) For example, cyan ink (blue-green) passes blue and green light; yellow ink (red-green) passes red and green light. Thus a cyan dot overlapping a yellow dot would pass only green light. Plate 3.4 shows how colors mix subtractively in a simulated set of overlapping halftone dots. The overall effect of all the halftone dots is to create a color image in our visual perception.

Scanning documents printed with process colors is very difficult. Unlike a living person, the scanner lacks a psychological perceptive system to combine the color dots in order to create an appropriate perception of color. The scanner sees the dots and makes no automatic perceptive judgements, as our human visual senses do. Scanning single color halftones is difficult — scanning process color halftone screens may be impractical, depending on the quality of data you need. Classification of such data is extremely difficult, because all parts of a document may contain some amount of cyan, magenta, and yellow.

Color Photos

Unlike printed material, color photos are continuous — photos are not made up of separate dots, instead, photo images are unbroken. There is some granularity in photographs, which varies based on the type of film. This granularity, though, is not an obstacle to scanning, as halftone dots used in printed documents are.

Scanning color photographs is usually a 24-bit scanning operation. 24-bit data usually does a better job of capturing the photo's subtle variations in color than classified 8-bit data does.

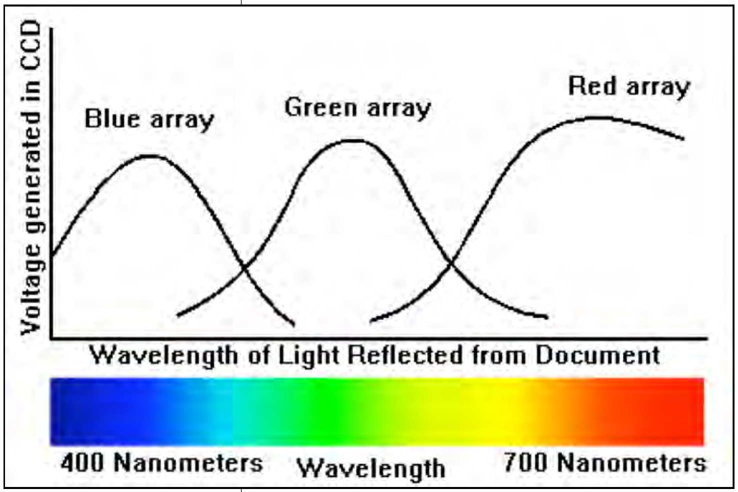


Plate 1.1 CCD Spectral Response

The CCD element rows respond to ranges of red, green, and blue wavelengths of light. Thus all parts of the visible spectrum have sensor coverage.

In the spectrum, note the absence of purple (magenta). Magenta is a perceived color we see when blue and red wavelengths are combined -- it is not in the natural spectrum of monochromatic light wavelengths.

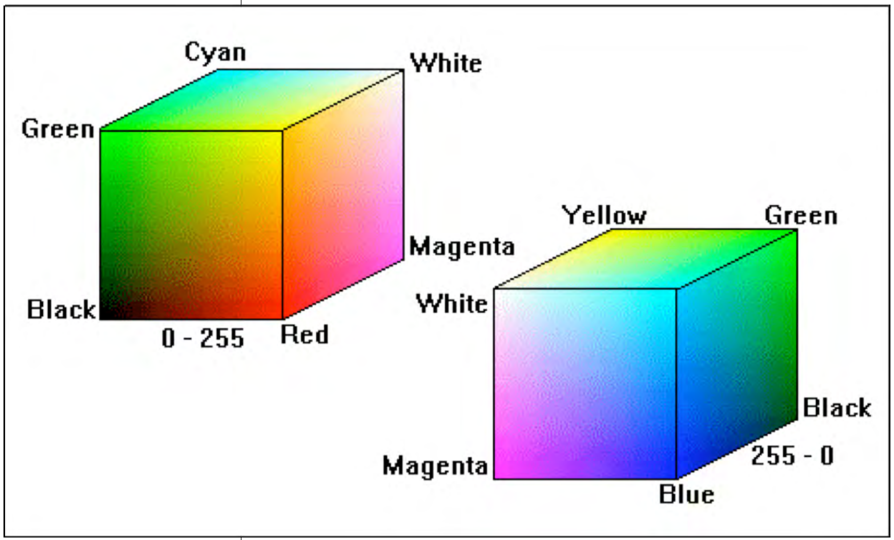


Plate 1.2 RGB Color Space

RGB color space is a cube, seen here from both sides.

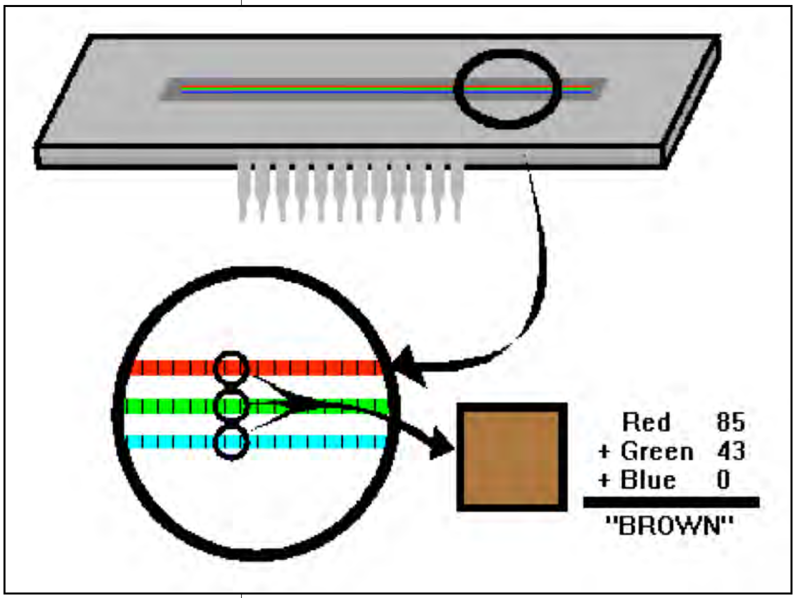


Plate 1.3 Tri-linear CCD

The CCD rows have built-in filters. The filters pass only red, green, or blue light.

This allows the CCD to generate three color signals during a single pass of the document.

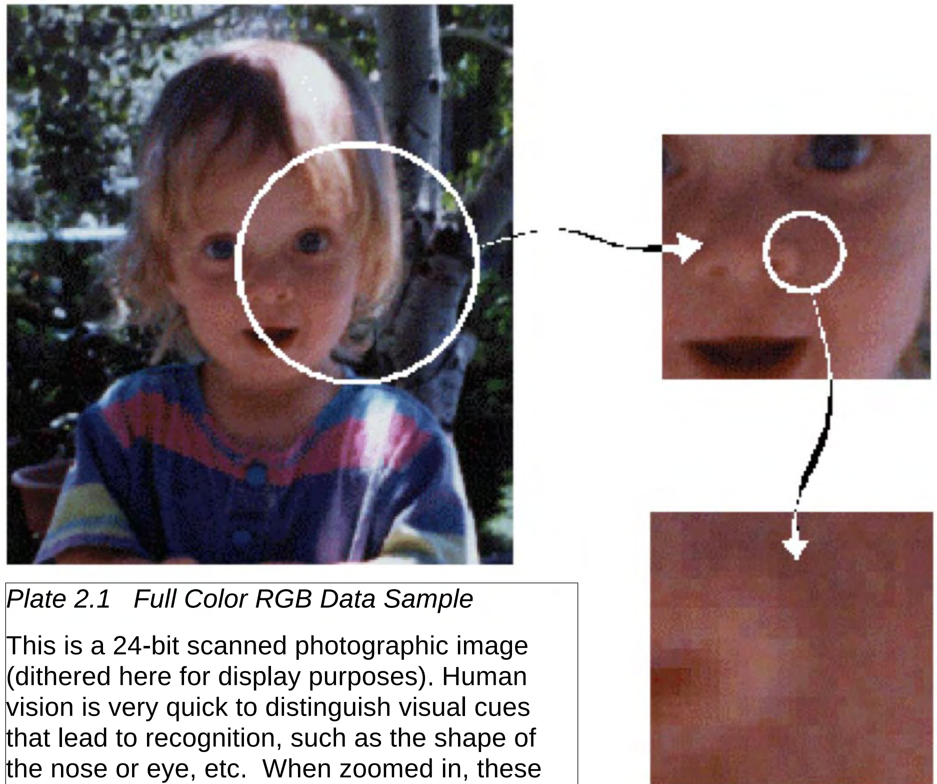


Plate 2.1 Full Color RGB Data Sample

This is a 24-bit scanned photographic image (dithered here for display purposes). Human vision is very quick to distinguish visual cues that lead to recognition, such as the shape of the nose or eye, etc. When zoomed in, these details are more difficult to recognize, because we lack visual cues and the color transitions are extremely subtle. Such documents are better scanned in full color (24-bit) than in classified mode. Classification tends to "posterize" images like this.

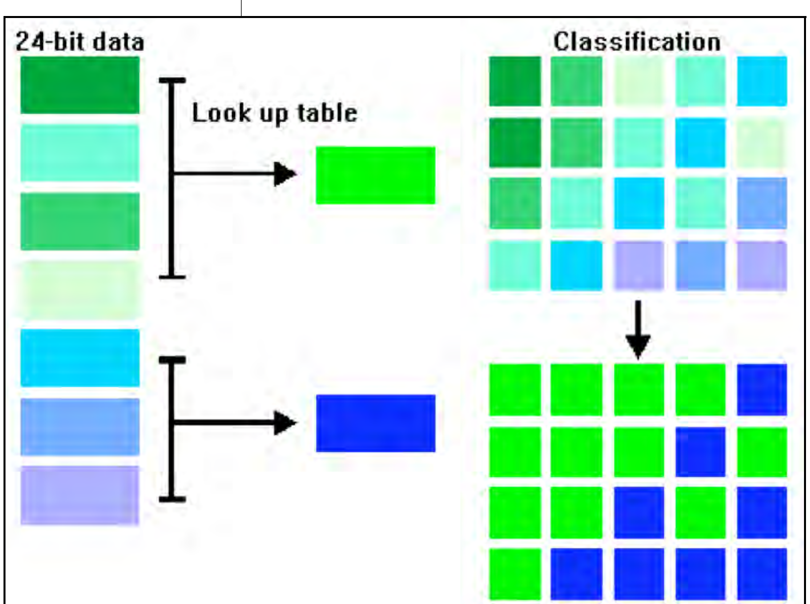


Plate 2.2 Classification

Color classification converts full color, 24-bit RGB data into classified, 8-bit data. The classification process uses a look up table to assign new 8-bit values to the full color data. The classified data includes a palette, or map that links each 8-bit value with some color. Note that the classification process is irreversible.

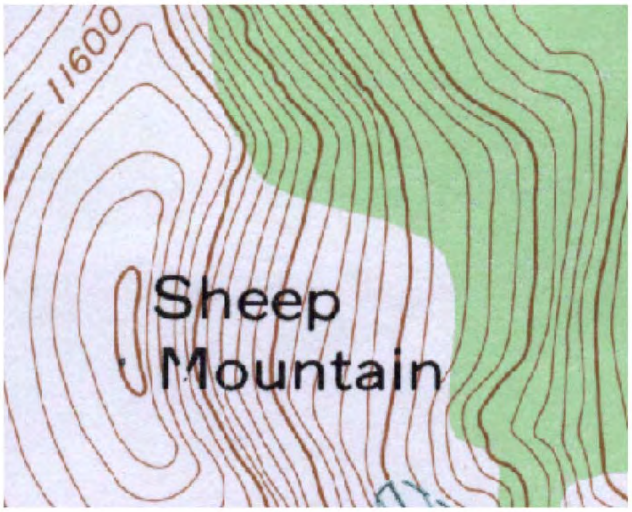
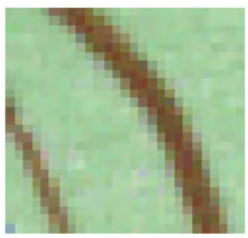


Plate 3.1 Solid Colors

The contour lines and forest from this map demonstrate solid color printing. There are subtle color variations in the scanned data, but no halftone dots are evident.



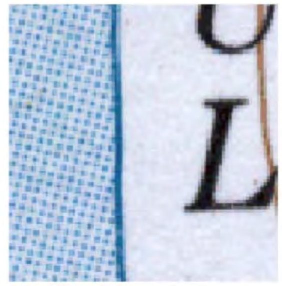


Plate 3.2 Color Halftone

In this map section, note the clear indication of halftone dots in the blue color of the lake. This piece of scanned data is from the same document as Plate 3.1 -- in this map, both solid color printing and halftoning are used.

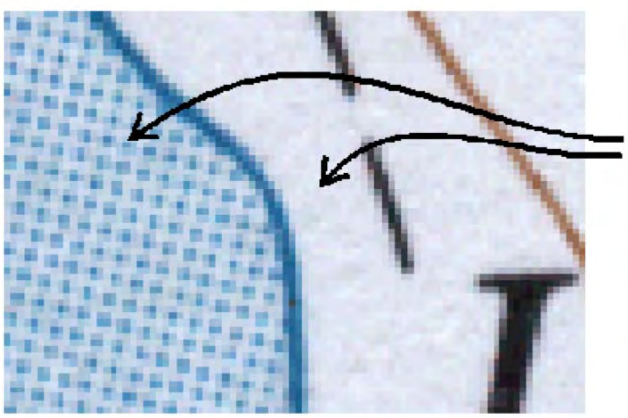
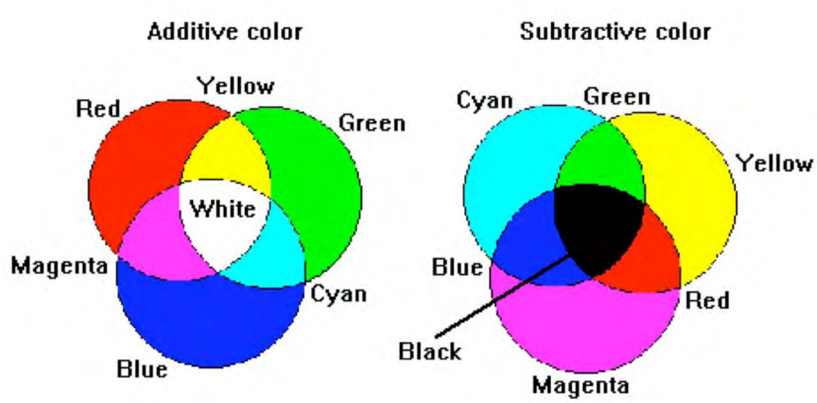


Plate 3.3 Classifying Halftones

Classifying halftones is difficult. In the lake at left, white pixels between the halftone dots may have the same value, when classified, as the white document where there is no printing. This will result in a speckled appearance in the classified data.

Plate 3.4 Additive vs. Subtractive Color

Adjacent RGB color dots in a computer monitor combine additively in human vision to create the perception of many colors. Red + blue + green = white. On the other hand, printer's inks used in four color process printing overlap and act as subtractive light filters. For example light reflects from a paper surface and passes through cyan (blue/green) and yellow (red/green), so only the green component is passed through the filter of ink.



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