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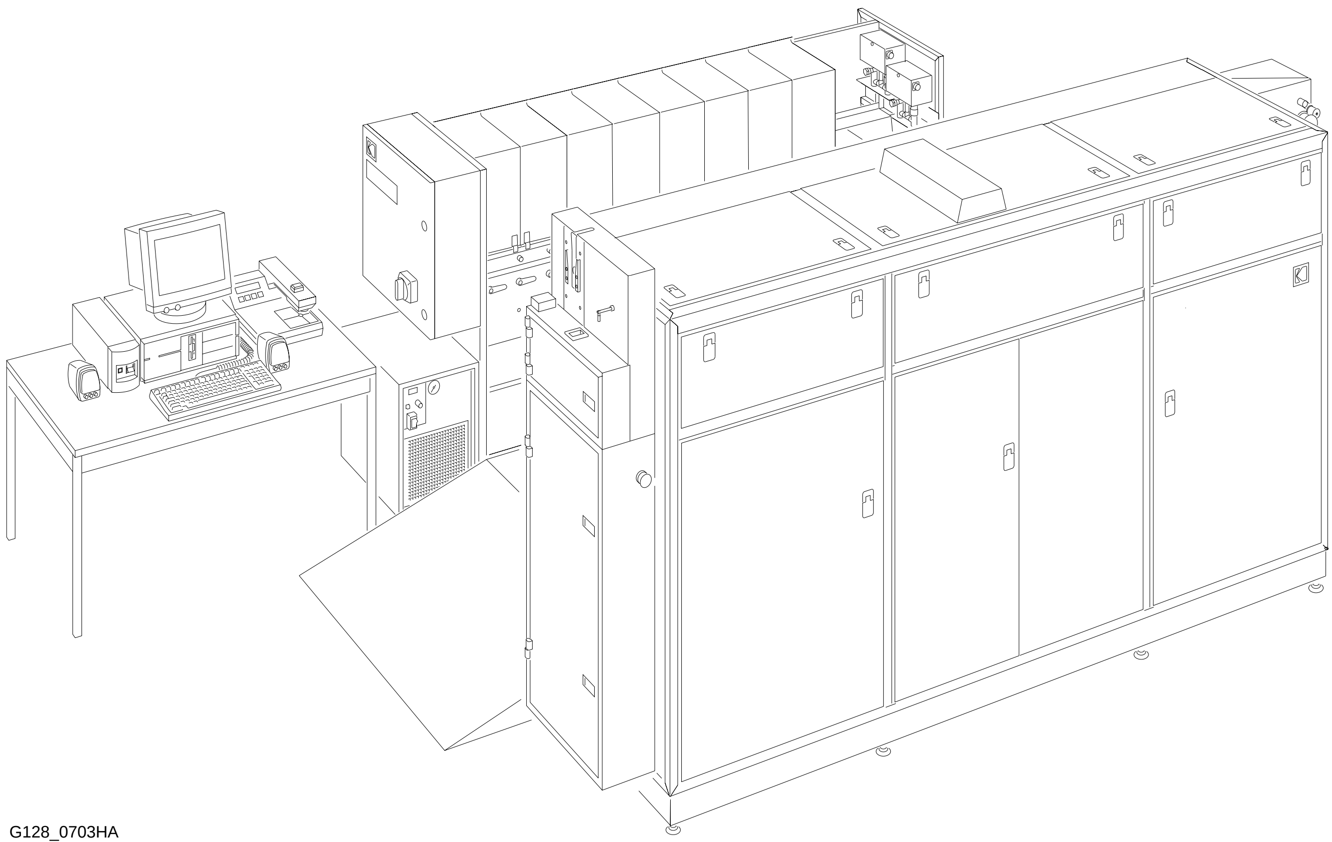
THEORY GUIDE
for the
Kodak K-Lab PROCESSOR
Service Code: 2044
for
Kodachrome FILM, PROCESS K-14M



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GLOBAL CUSTOMER SERVICE AND SUPPORT

This equipment includes parts and assemblies sensitive to damage from electrostatic discharge. Use caution to prevent damage during all service procedures.

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Section 1: Introduction

Product Description

The *Kodak K-Lab* PROCESSOR for *Kodachrome* FILM, PROCESS K-14M, processes 35 mm *Kodachrome* FILM using specially packaged chemicals.

The PROCESSOR is a white-light, continuous magazine feed, floor-standing machine, with 5 major components:

- MAIN CONTROL COMPUTER (MCC)
- PROCESSOR
- REPLENISHER RACK
- CHILLER
- SPLICER (stand-alone, optional)
- FILLING STATION

A FEED MAGAZINE of exposed film is assembled at the SPLICER. After it is spliced onto a leader, the FILM MAGAZINE contents are transported into the FEED ELEVATOR. Then the film transports through a series of tanks containing the film processing solutions. After development, the film goes through the DRYING CHAMBER and onto a REEL in the take-off section of the PROCESSOR. The film is ready for mounting or finishing.

The *Kodak K-Lab* PROCESSOR for *Kodachrome* FILM, PROCESS K-14M provides:

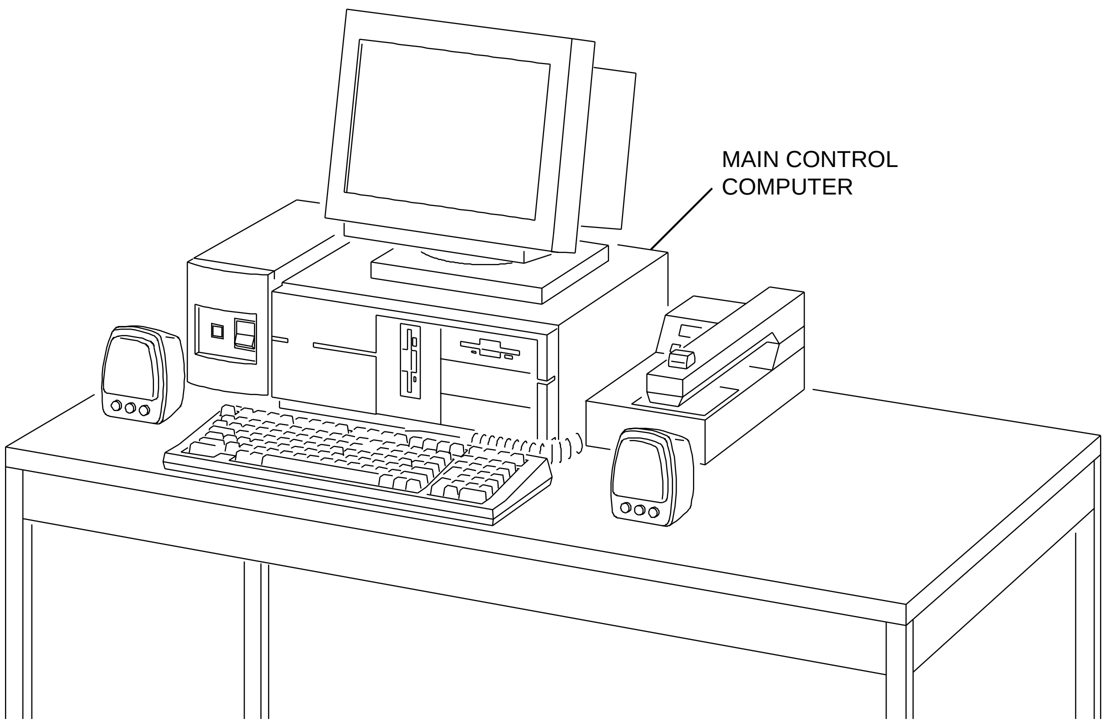
- DEVELOPER TANKS that hold 17.5 - 18.5 liters of developer solution
- Air process to regenerate the bleach
- DEVELOPER TANKS with a tube-within-a-tube-style construction, with the inner-tube easily removed for service
- MAGAZINE SHOE compatible with the 400 ft Source Two, Inc. MAGAZINE
- High-velocity impingement agitation in the developers
- "Demand" system, with a center pacer, DRIVE design:
  1. Specification: 2% of set transport speed
  2. Film tension: (0.5 - 1.0 lbs)
- CHILLER system that achieves temperature specifications within the DEVELOPER TANKS
- INTELLIFAUCETS that mix house water to provide 29.5 - 38°C (85 - 100°F) water
- System of SWITCHES that monitor, alarm, and maintain the process
- Built-in push processing at three levels: ½ , 1⅓ , and +2 stops

Product Safety

As a safety precaution, whenever the PROCESSOR is put in the Standby Mode, the HEATERS remain de-energized until the “Heater Control” command is enabled by the CPU. The “Heater Control” command enables the HEATER outputs unless a flow alarm condition occurs.

Section 2: Components

MAIN CONTROL COMPUTER (MCC)



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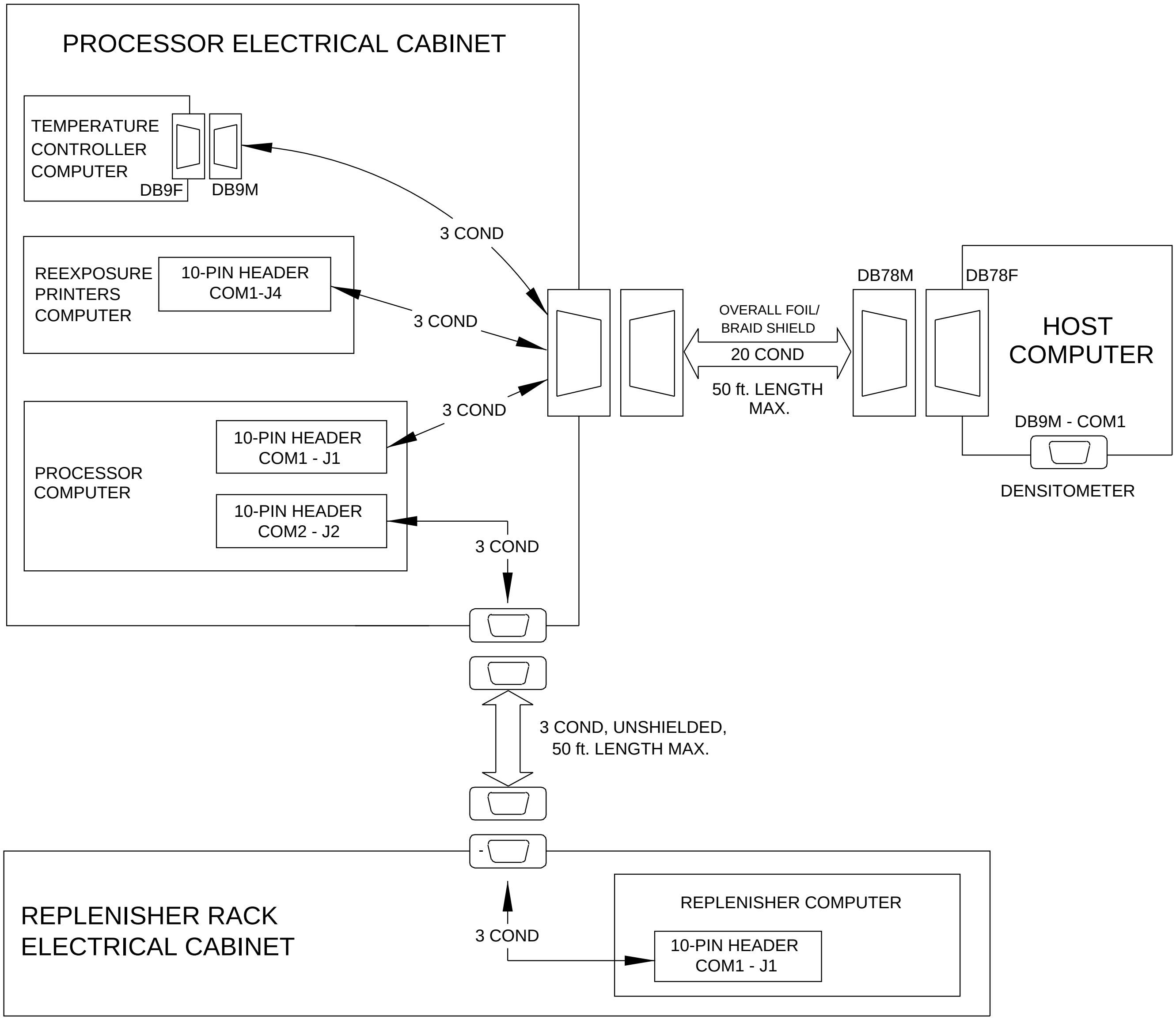
The MAIN CONTROL COMPUTER (MCC) is the "brain" of the PROCESSOR. It controls all of the components and is the only interface for the operator to view the status of the PROCESSOR. The MCC can be separated from the PROCESSOR by up to 50 ft. The MCC is a commercially available IBM-compatible computer, that has been modified, running a Microsoft Windows software-based machine-control program. Use the MCC to:

- Energize and de-energize the PROCESSOR
- Monitor all electronic and mechanical subsystems through a network of SENSORS
- Gather and analyze chemical, mechanical, and sensitometric data acquired during film processing
- Respond to emergencies such as film breaks

An UNINTERRUPTIBLE POWER SUPPLY (UPS) allows the MCC to continue operating in the event of a power failure.

System Communications



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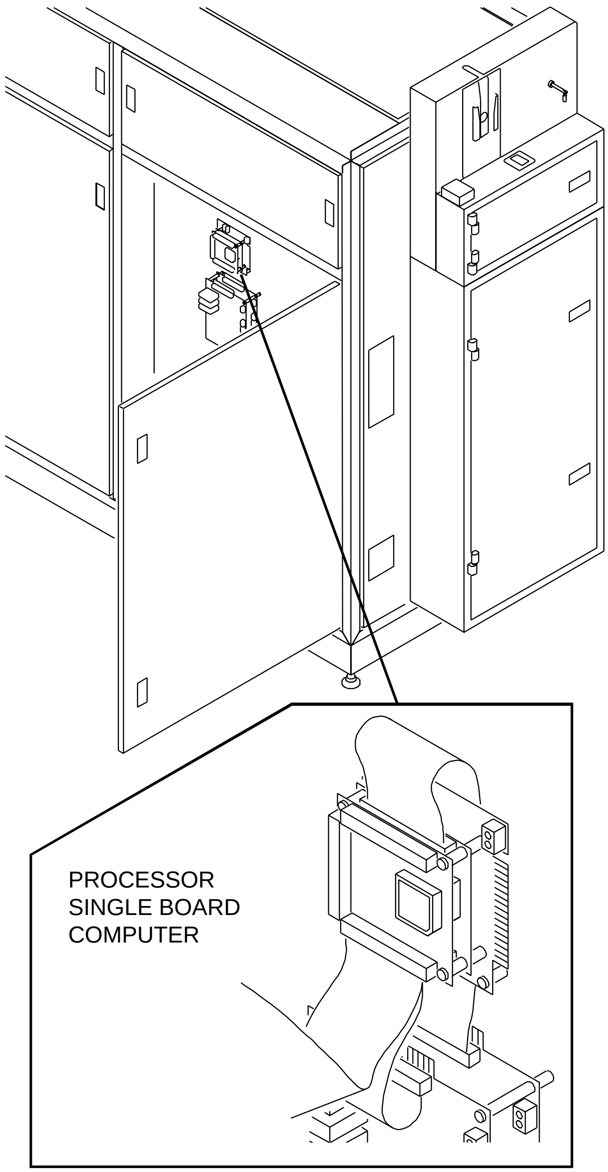
The HOST COMPUTER communicates with the PROCESSING COMPUTER and the REPLENISHER COMPUTER through serial communications. The HOST COMPUTER and REPLENISHER COMPUTER can be separated from the PROCESSOR by up to 50 ft.

PROCESSOR SINGLE BOARD COMPUTER (PSBC)



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The PROCESSOR SINGLE BOARD COMPUTER (PSBC) is located inside the PROCESSOR Electrical Cabinet.

The PSBC monitors and controls the individual SENSORS and components located within the PROCESSOR and reports their status to the MAIN CONTROL PROGRAM (MCP). It also alerts the MCP when a SENSOR or component malfunctions or does not respond as anticipated.

The PSBC receives commands for data and control from the main control program through a serial connection between the PROCESSOR and the MAIN CONTROL COMPUTER. The PSBC passes the appropriate commands to the REPLENISHER RACK SINGLE BOARD COMPUTER (RSBC) through a serial connection.

The PSBC communicates with 3 SOLID STATE RELAY BOARDS which accept input from various SENSORS, thereby allowing the PSBC to control various PUMPS and SOLENOIDS.

The PSBC is a small IBM-compatible, SINGLE-BOARD COMPUTER with Microsoft MS-DOS programmed into a ROM CHIP. The program it runs is contained on another CHIP on the BOARD and executes automatically when the RSBC energizes.

The PSCB has 5 primary functions:

1. Energizes and de-energizes the PROCESSOR components for Sleep, Standby, and Processing Modes
2. Monitors the operating condition of each component in the PROCESSOR and sounds an alarm if it detects a malfunction
3. Initiates the command for chemical replenisher
4. Monitors the condition of all the components in both the PROCESSOR and the REPLENISHER RACK and provides the operator with status information
5. Monitors the serial port for the REPLENISHER COMPUTER for messages and requests for chemical replenisher

PROCESSOR

The PROCESSOR consists of 7 different wet sections:

1. Rem-jet
2. First developer and wash
3. Cyan developer and wash
4. Yellow developer and wash
5. Magenta developer and wash
6. Conditioner and bleach
7. Fix, wash, and final rinse

The PROCESSOR also includes a DRYER tank that is similar in construction to the wet section tanks. The temperature in the DRYER tank is controlled to be within the range of 41° ± 3°C (105° ± 5°F).

The PROCESSOR has the following 4 modes of operation:

- Power Off Mode

  During this mode, the MAIN CONTROL COMPUTER and PROCESSOR are inactive. The PROCESSOR is in this mode during installation or when all chemicals have been removed for a long shutdown, such as over weekends.

- Sleep Mode

  During this mode, only the MAIN CONTROL COMPUTER (MCC) and the components in the PROCESSOR ELECTRICAL CABINET are energized. All mechanical components of the PROCESSOR are de-energized.

  It takes approximately 5 minutes to reach Sleep Mode after being in Power Off Mode.

- Standby Mode

  This mode is used as a system check when you first energize the PROCESSOR and between batches of film runs. During this mode, all components of the PROCESSOR are energized and monitored and all chemicals are maintained at their setpoint temperatures.

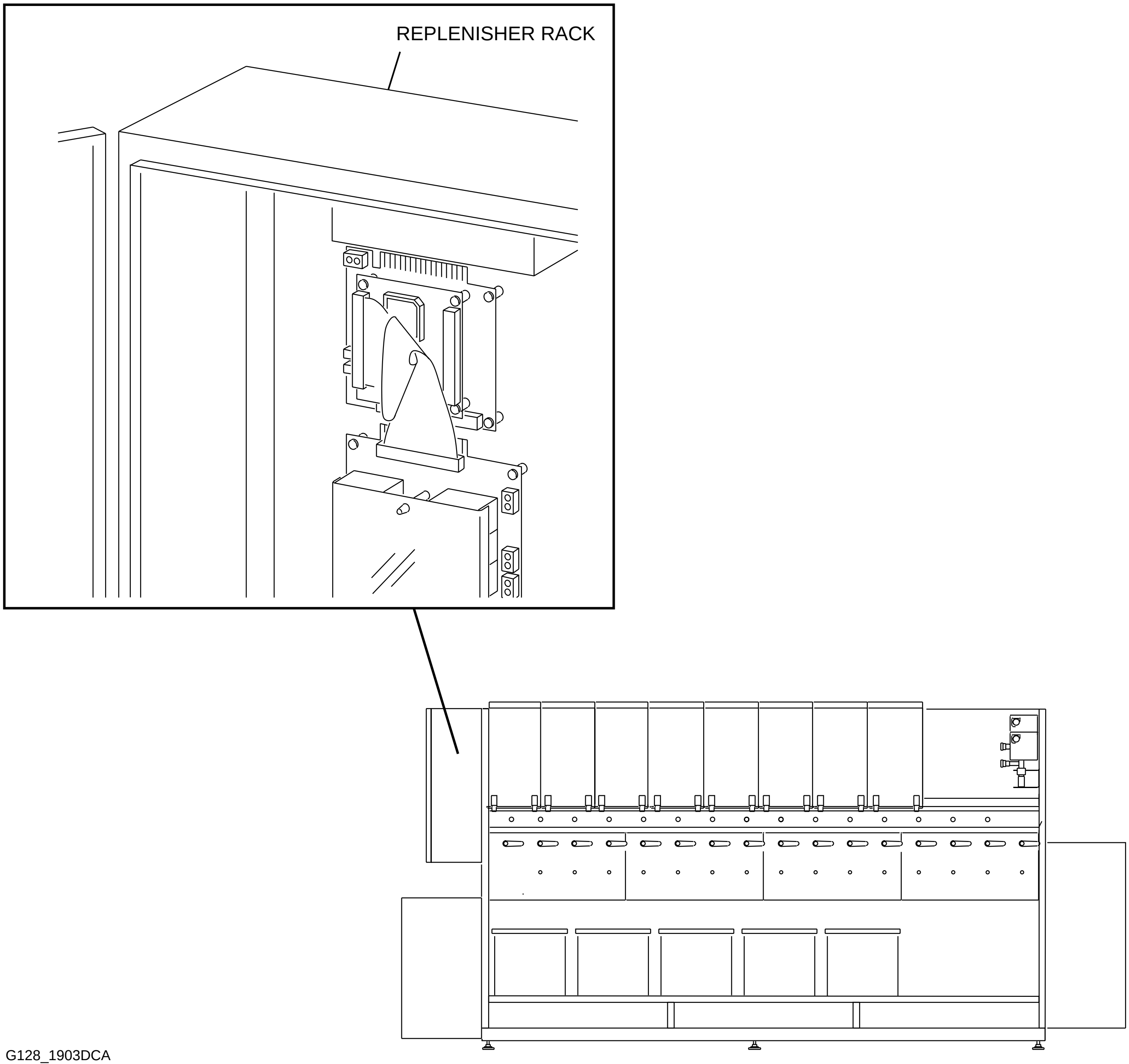
  It takes approximately 30 - 45 minutes for the PROCESSOR to reach Standby Mode after being in Sleep Mode.

- Processing Mode

  During this mode, the PROCESSOR actively processes film, and all chemicals are at a stable temperature. The PROCESSOR should be set back to Standby Mode if no additional batches are waiting for processing. You may select to process film or a control/scratch film strip.

  It takes approximately 2 minutes for the PROCESSOR to reach Processing Mode after being in Standby Mode.

REPLENISHER RACK



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The REPLENISHER RACK is a module connected to the PROCESSOR with plastic tubing for automatic chemical replenisher. The REPLENISHER RACK ASSEMBLY consists of:

- REPLENISHER RACK COMPUTER
- WASH WATER INTELLIFAUCETS
- REPLENISHER PUMPS
- RACK FRAME ASSEMBLY for holding Bag-In-Boxes (BIBs)
- 5 STORAGE TANKS
- All plumbing and electrical connections necessary to deliver replenisher and wash water to the chemical TANKS in the PROCESSOR
- 2 regulated air lines:
  - AIR SQUEEGEE at the red LAMP
  - AIR SQUEEGEE at the DRYER and supplies bleach aeration

The REPLENISHER RACK SINGLE BOARD COMPUTER (RRSBC), located in the ELECTRICAL CABINET of the REPLENISHER RACK, controls all the electronics.

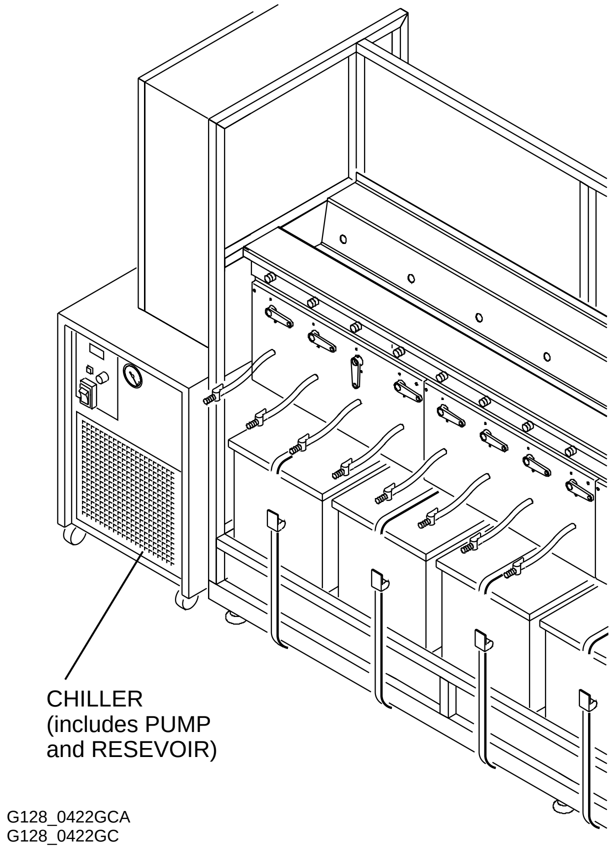
Physically, the RSBC is identical to the PSBC. The RSBC, however, runs a different program that monitors the SENSORS and PUMPS in the REPLENISHER RACK.

When a malfunction occurs in the REPLENISHER RACK, or the PSBC requests the status of a SENSOR, the RSBC transmits its data to the PSBC through a serial port connection.

The RSBC:

- Monitors the serial port to the PROCESSOR COMPUTER for commands and data
- Energizes and de-energizes the components in the REPLENISHER RACK for Sleep, Standby, and Processing Modes
- Calculates the correct energize and de-energize times for the REPLENISHER PUMPS COMPUTER

CHILLER



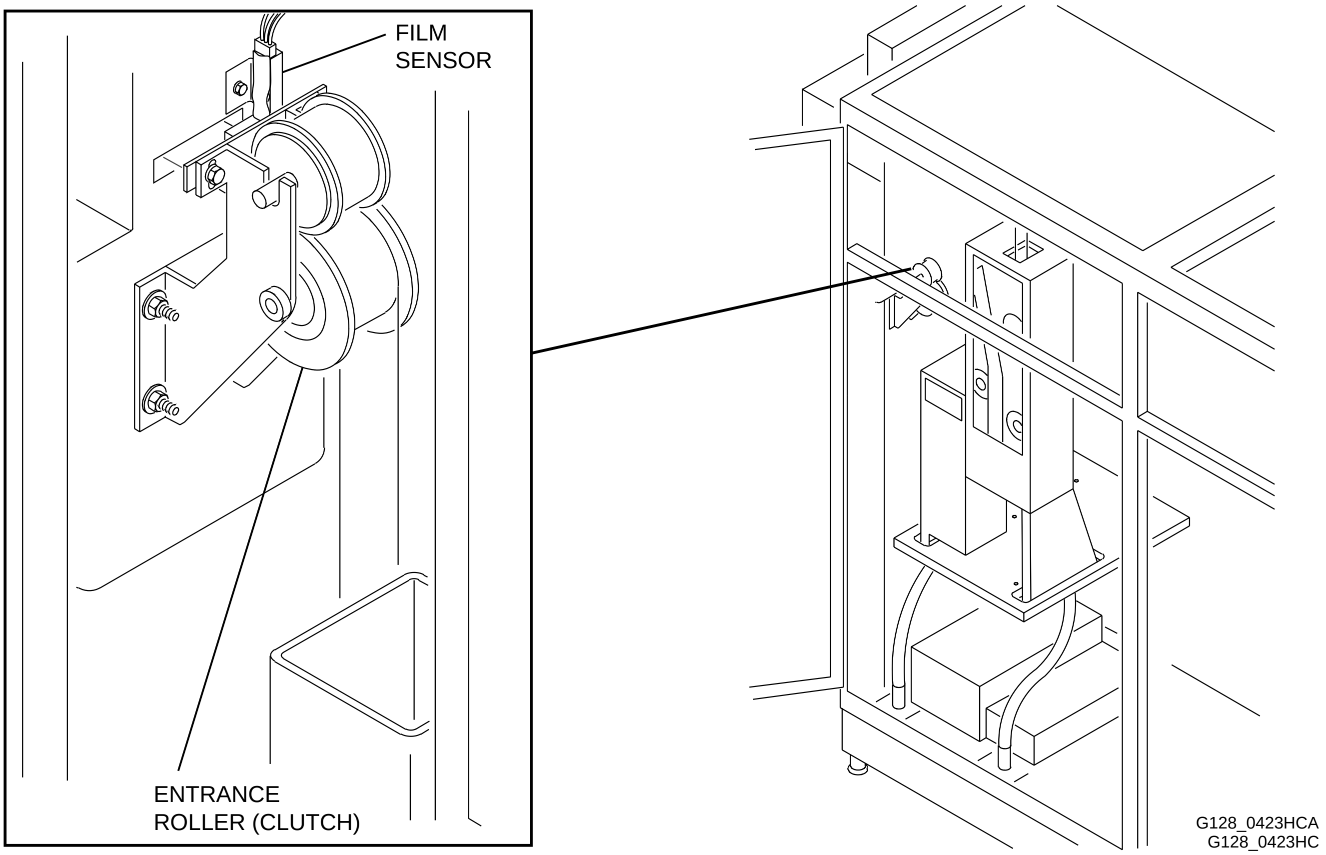
Caution

De-energize the CHILLER before removing any HOSES.

The CHILLER SYSTEM provides a constant thermal load to work against the HEATERS. This increases the stability of the developer solutions. The CHILLER cools the water to 24°C (75°F) and recirculates this water through metal CHILLER TUBES in the bottom of the DEVELOPER TANKS. This is a closed-loop system with a small reservoir. Any time the CHILLER energizes, water PUMPS through the system. The PUMP drains the CHILLER in a very short time. When reassembling the CHILLER SYSTEM during servicing, check that the RESERVOIR is filled correctly.

The CHILLER delivers 25°C (77°F) water to cool the 4 developers in the PROCESSOR. The circulation of the chilled water helps the TEMPERATURE CONTROLLER maintain the setpoint temperatures of the processing solutions.

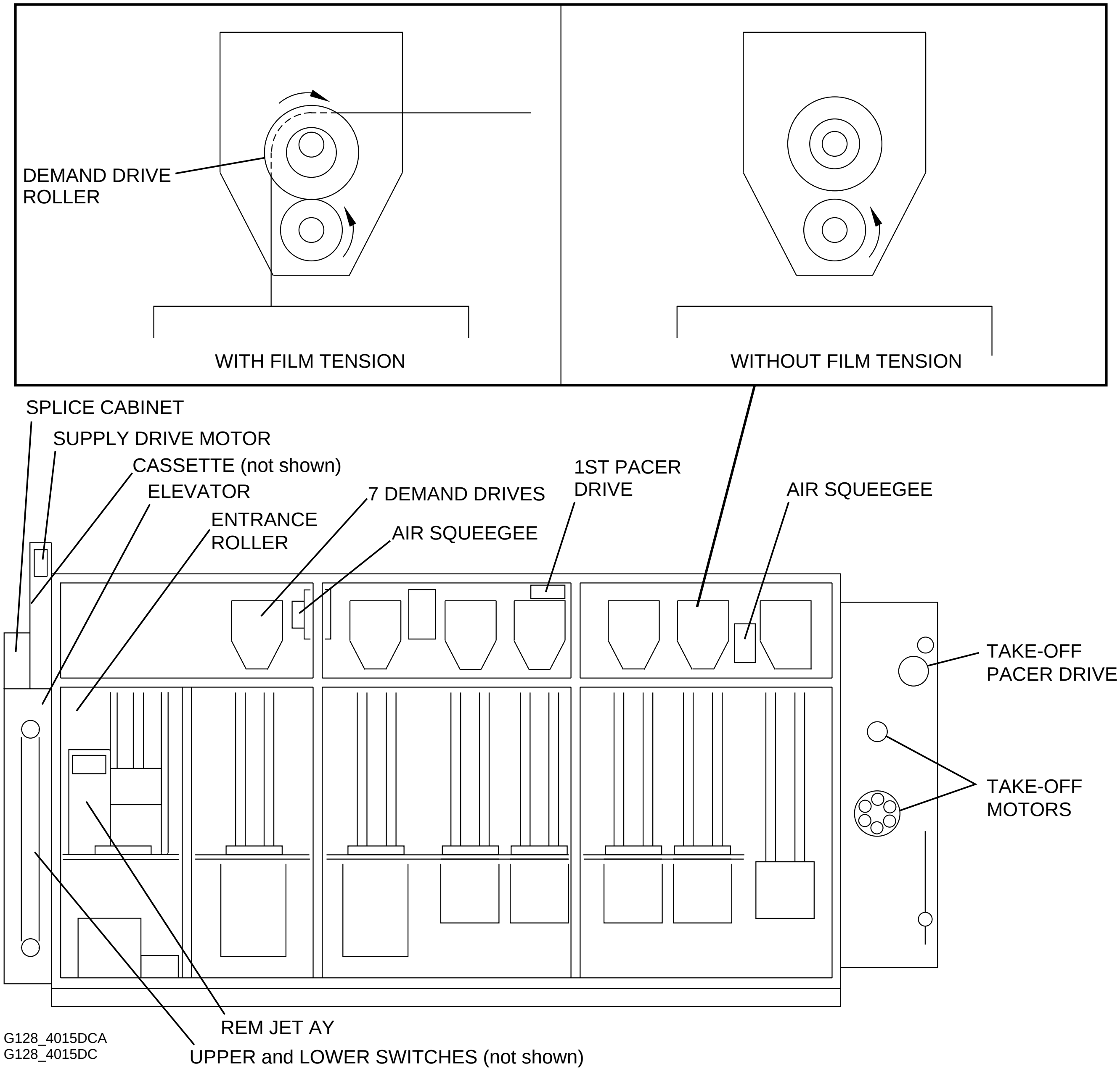
Section 3: Film Transport and Drive System



The SUPPLY DRIVE MOTOR pulls either the film or leader out of the CASSETTE into the SPLICE CABINET. The UPPER and LOWER SWITCHES in the ELEVATOR CABINET energize and de-energize the MOTOR. The excess film is taken up in the ELEVATOR.

A CLUTCH on the ENTRANCE ROLLER, between the ELEVATOR and the REM JET ASSEMBLY, prevents the wet film from going back into the ELEVATOR. When there is tension on the film, the ROLLERS on the DEMAND DRIVE RACK contact the DEMAND DRIVE ROLLER to RELIEVE THE TENSION.

The film is pulled from the ELEVATOR through the cyan developer by the CENTER PACER DRIVE. The TAKE-OFF PACER DRIVE pulls the film through the rest of the PROCESSOR. The film is then taken up by either TAKE-UP MOTOR that the TAKE-OFF ELEVATOR controls.There are 2 AIR SQUEEGEES in the PROCESSOR. The first is located before the red REEXPOSURE PRINTER. The second is located at the DRYER entrance. The air pressure at the REGULATOR, and the gaps between the BLADES of the AIR SQUEEGEE must be correct or excess tension on the leader material may cause the film to break.


DEMAND DRIVE ROLLER
WITH FILM TENSION
WITHOUT FILM TENSION
SPLICE CABINET
SUPPLY DRIVE MOTOR
CASSETTE (not shown)
ELEVATOR
ENTRANCE ROLLER
7 DEMAND DRIVES
AIR SQUEEGEE
1ST PACER DRIVE
AIR SQUEEGEE
TAKE-OFF PACER DRIVE
TAKE-OFF MOTORS
REM JET AY
UPPER and LOWER SWITCHES (not shown)
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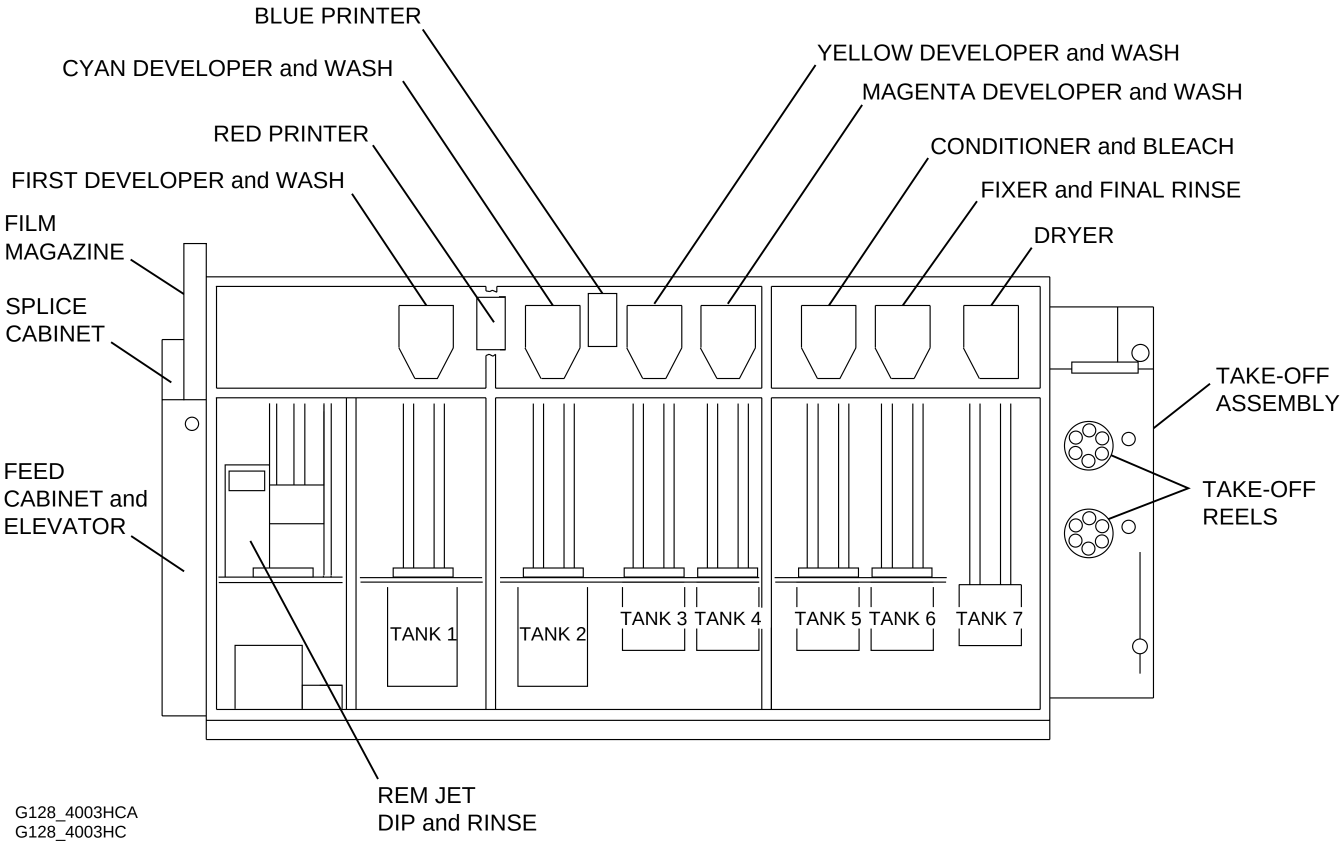
G128_4015DC


BLUE PRINTER
CYAN DEVELOPER and WASH
RED PRINTER
FIRST DEVELOPER and WASH
FILM MAGAZINE
SPLICE CABINET
FEED CABINET and ELEVATOR
YELLOW DEVELOPER and WASH
MAGENTA DEVELOPER and WASH
CONDITIONER and BLEACH
FIXER and FINAL RINSE
DRYER
TAKE-OFF ASSEMBLY
TAKE-OFF REELS
TANK 1
TANK 2
TANK 3
TANK 4
TANK 5
TANK 6
TANK 7
REM JET DIP and RINSE
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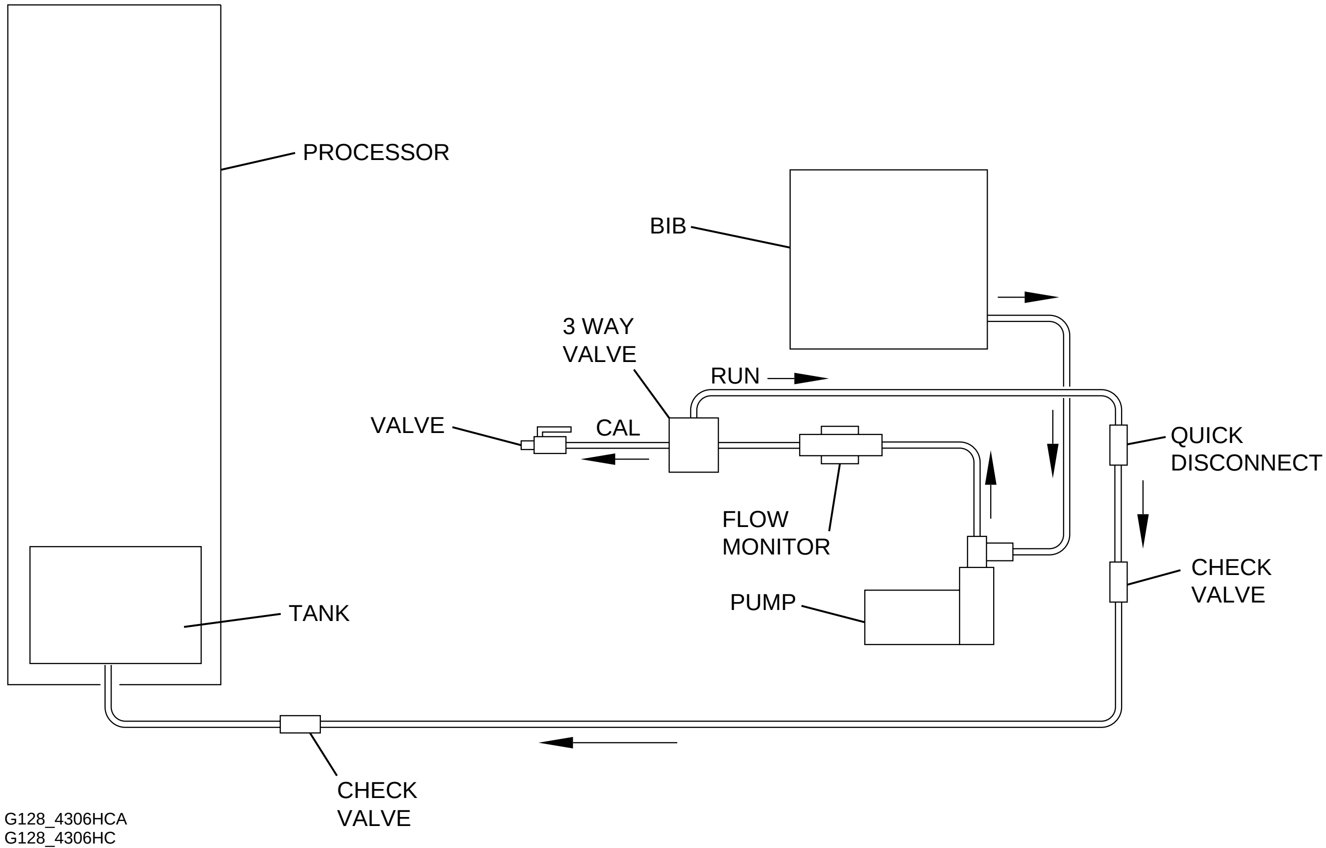
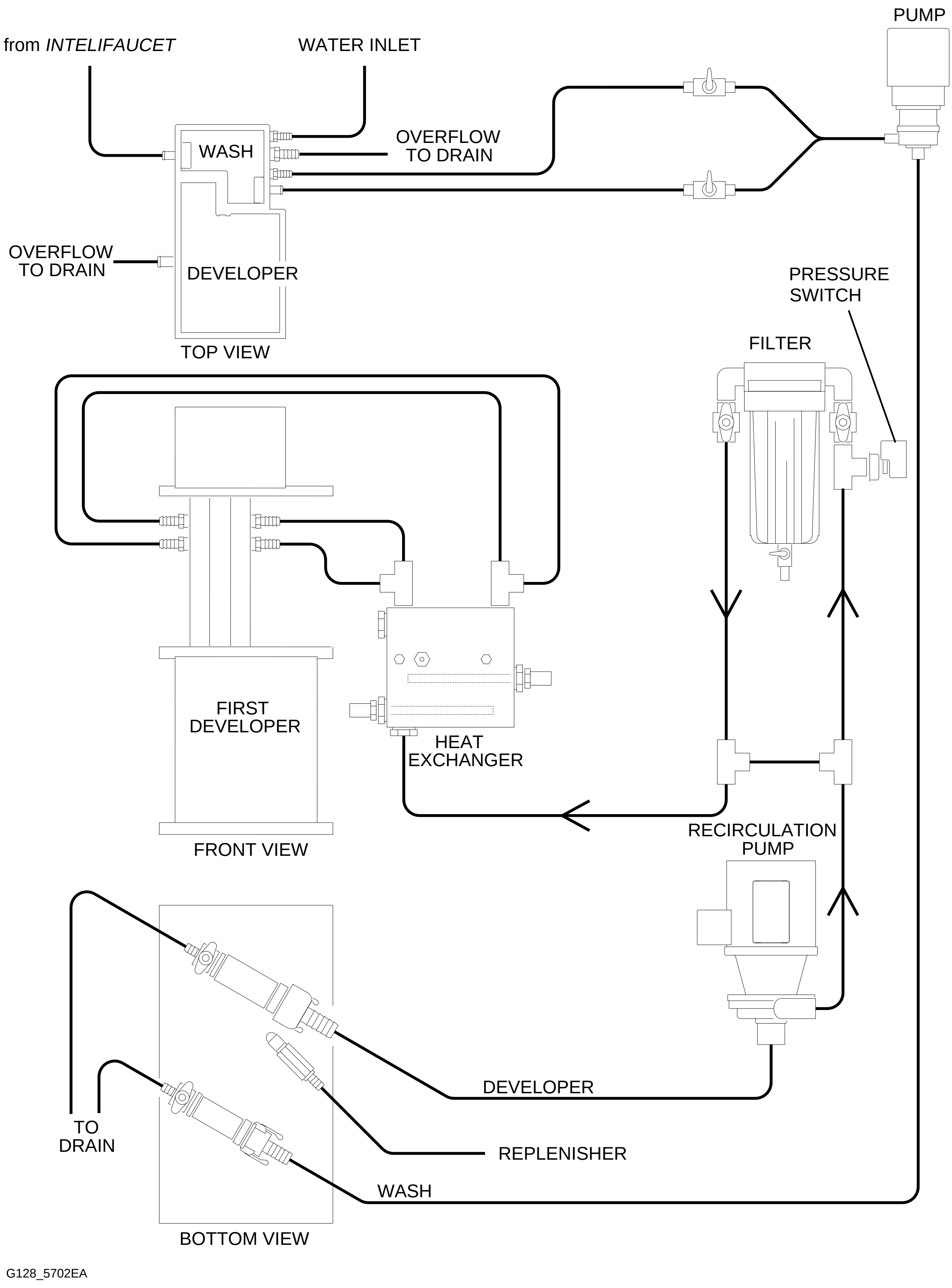
G128_4003HC

Section 4: Replenisher System



The REPLENISHER SYSTEM maintains chemistry at the correct strength in relation to the film that runs through the PROCESSOR. A single-board computer in the REPLENISHER RACK determines replenisher rates. Depending on the amount of film and film type, the appropriate REPLENISHER PUMP energizes. The PUMP pumps the REPLENISHER chemistry from the BIB through the PUMP, through a FLOW MONITOR, through 3-WAY VALVE and QUICK DISCONNECT, through a series of CHECK VALVES and HOSES, and into the bottom of the TANK. The FILM DETECTOR, at the entrance of the wet section, detects the amount of film. The FILM DETECTOR sends a signal to the SBC as to whether the PROCESSOR is transporting film or leader. When the film is spliced, the type of film is detected. This data is input into the computer at the start of a film batch.

Section 5: Recirculation System



The recirculation system contains:

- RECIRCULATION PUMP
- PRESSURE SWITCH
- FILTER POT
- HEAT EXCHANGER
- IMPINGEMENT TUBES in the DEVELOPER TANKS

The PUMP operates when the PROCESSOR is in the standby and processing modes. The PRESSURE SWITCH de-energizes the HEATER in the HEAT EXCHANGER if the pressure is too low. A BYPASS HOSE and SHUT OFF VALVES on each side of the FILTER POTS allow the FILTER to be changed when the system operates.

Section 6: REEXPOSURE PRINTERS

Description

The PROCESSOR requires 2 REEXPOSURE PRINTER modules:

- one filtered to reexpose the blue layer on the film
- one filtered to reexpose the red layer on the film

Each REEXPOSURE PRINTER module consists of a LAMP and a LAMPHOUSE that deliver filtered light to an exposure plane positioned to expose the moving film web. A PHOTO DETECTOR collects the filtered exposure energy data as the sample is exposed.

An embedded computer controls the 2 reexposure printers. The computer measures the exposure energy with the PHOTO DETECTORS and controls the exposure energy (brightness of the LAMP) by adjusting the voltages of the LAMPS.

Red Reexposure Printing

The red reexposure printing exposes all of the remaining silver halide in the red sensitive (bottom) emulsion layer so that the silver halide develops completely in the cyan developer solution. During this step, exposure of any remaining silver halide in the blue- and green-sensitive layers must be avoided to prevent unwanted cyan dye development in these layers. This selective reexposure is obtained by printing through the base side of the film, using a properly selected red glass filter in the light beam. The green and blue sensitive emulsion layers have no intentional sensitivity to red light and should, therefore, remain unaffected by the red-light exposure. However, some green-sensitive emulsion layers do have a slight, but significant, red-sensitivity, making accurate control of the red printing intensity necessary.

Blue Reexposure Printing

The blue reexposure printing exposes all the remaining silver halide in the blue-sensitive emulsion layer so that the silver halide develops completely in the yellow developer solution. During this step, exposure of the remaining silver halide in the green- sensitive layer must be avoided to prevent unwanted yellow dye development in the green-sensitive layer. This selective reexposure is obtained by printing through the emulsion surface of the film, using a properly selected blue glass filter in the light beam. The yellow filter layer between the blue- and green-sensitive layers limits passage of the blue light from the emulsion side. However, the filter layer does not protect the green-sensitive layer from any stray blue printing light that may strike the base of the film.

Overprinting and Underprinting

Once an optimum printing intensity is established for each PRINTER, the process should be controlled carefully to avoid either overprinting or underprinting.

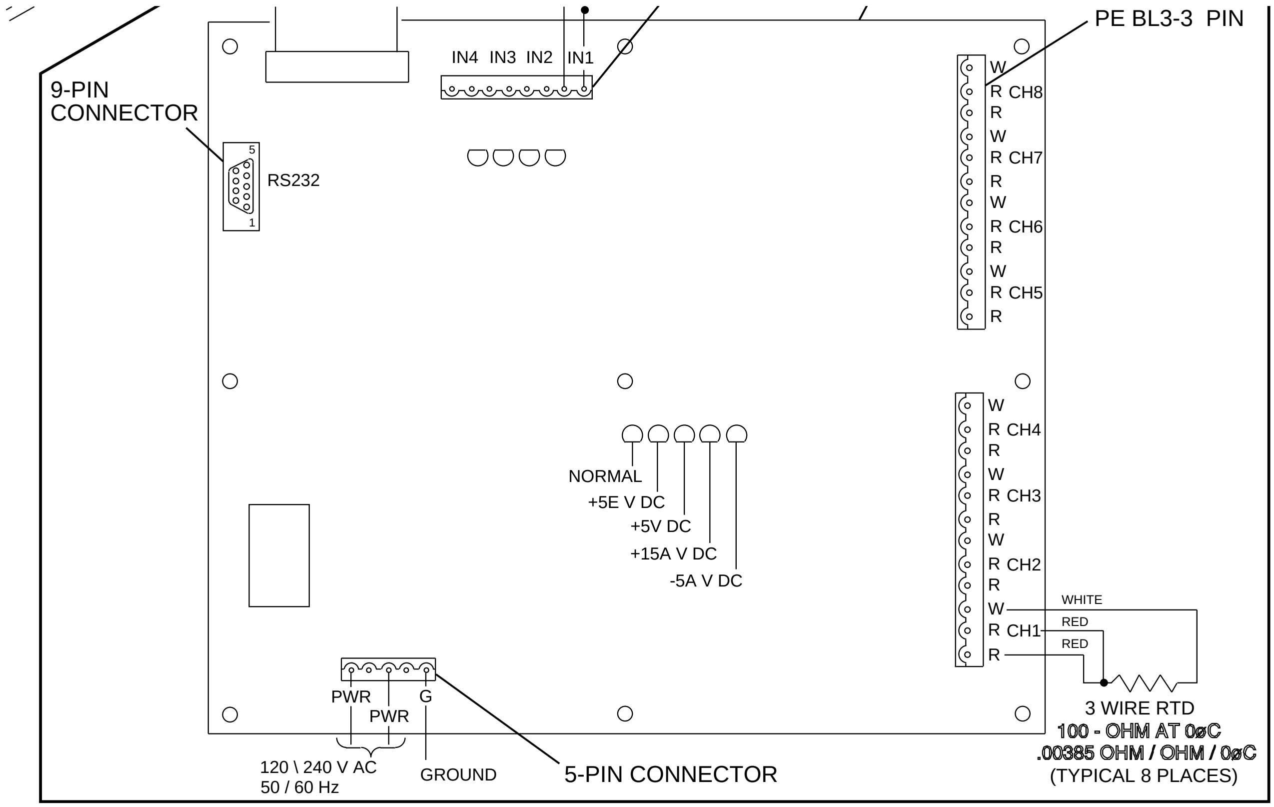
Overprinting can result in unwanted reexposure and subsequent yellow development of silver halide in the green-sensitive (magenta) layer. Underprinting leaves some of the silver halide in the yellow layer unexposed and subject to chemical reexposure and development in the magenta developer. Either situation can cause some degradation in quality.

Calibrating the REEXPOSURE PRINTERS

When the PROCESSOR energizes, the REEXPOSURE PRINTERS automatically perform a LAMP calibration sequence. During the sequence, exposure energy is monitored while the LAMPS cycle from the lowest to the highest voltages. The data collected is put into a table and used to find voltage levels needed to obtain exposure levels requested by the MCP.

The calibration sequence takes several minutes to perform. During the sequence all messages from the SERIAL PORT are ignored. When the sequence completes, both LAMPS are set to a nominal value and a message is sent to the HOST COMPUTER that the REEXPOSURE PRINTERS are ready.

Section 7: TEMPERATURE CONTROL BOARD



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The TEMPERATURE CONTROL BOARD is mounted in the ELECTRICAL CABINET of the PROCESSOR. The unit is a MICROPROCESSOR-based CONTROLLER that can control 8 different temperatures simultaneously.

The unit consists of 2 CIRCUIT BOARDS. The main CIRCUIT BOARD contains:

- 3 POWER SUPPLIES
- digital MICROPROCESSOR CIRCUITS
- 8 analog input conditioning circuitry

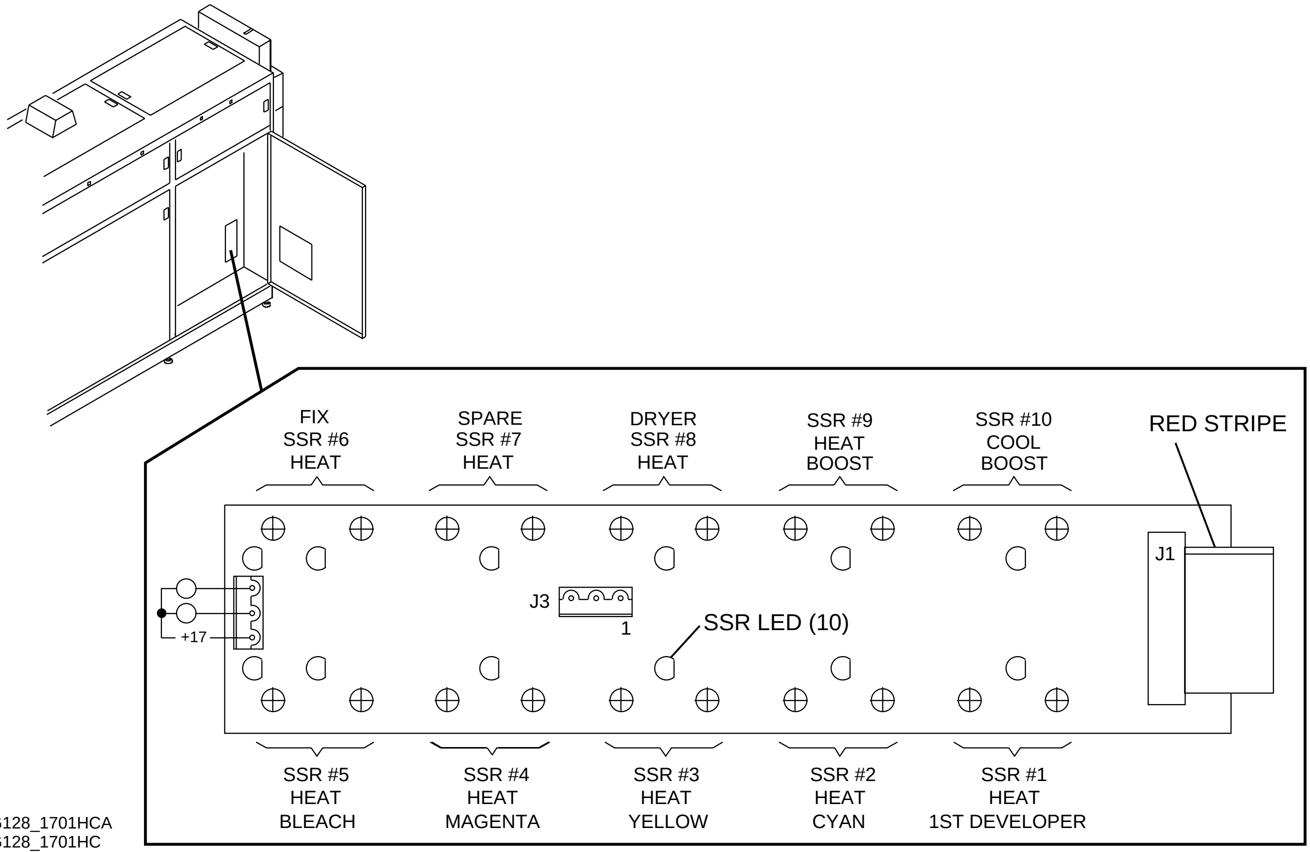
The 3 POWER SUPPLIES generate the necessary DC voltage to control the PROCESSOR. Separate POWER SUPPLIES generate power for the analog circuitry and the digital circuitry. The third POWER SUPPLY generates power for the RS232 serial interface and the SOLID STATE RELAY DRIVERS. By using the separate POWER SUPPLY, electrical noise and possible static damage can be kept to a minimum.

The digital circuitry consists of:

- Programmable Read Only Memory (PROM)
- Analog-to-digital CONVERTERS
- Light Emitting Diode (LED)

The analog circuitry consists of:

- RESISTANCE TEMPERATURE DETECTOR (RTD), which is a component that varies the voltage it outputs depending on the temperature to which it is exposed
- INSTRUMENTATION AMPLIFIER
  - converts the low level signal from the RTD to a usable level, which is converted to a digital value by the analog-to-digital CONVERTERS
  - the converted digital value can then be read as a temperature by the MICROPROCESSOR



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G128_1701HC

The second BOARD, which is attached to the MAIN BOARD by a RIBBON CABLE, contains drive circuitry to energize the SOLID STATE RELAYS (SSRs) that control:

- HEATERS
- SUPER HEATER
- SUPER CHILLER

The BOARD can control 10 SSRs, but only 9 SSRs are used. The first 7 SSRs control the HEATERS for each of the chemical TANKS in the PROCESSOR. The other 2 SSRs control the SUPER HEATER and SUPER CHILLER.

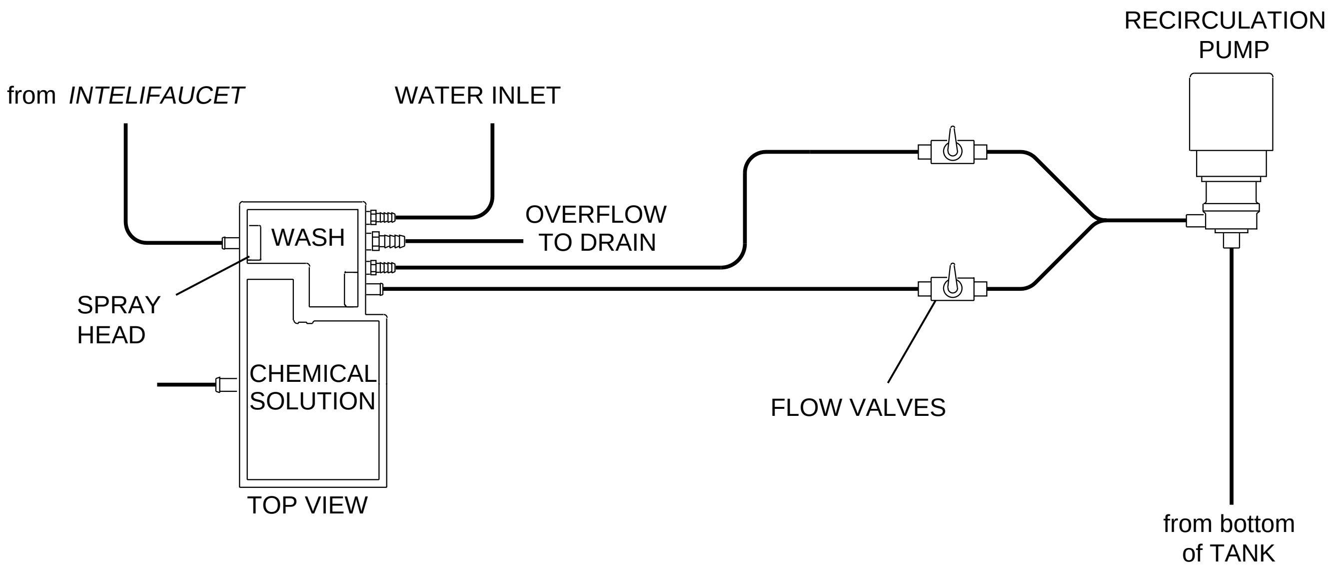
The relay board channels for the TEMPERATURE CONTROLLER are assigned as outlined below:

Channel	Solution or Component
1	First Developer
2	Cyan Developer
3	Yellow Developer
4	Magenta Developer
5	Bleach
6	Fixer
7	unused
8	DRYER
9	HEATER BOOST
10	CHILLER BOOST

The RS232 communication link controls the operation of the MICROPROCESSOR. The user can:

- Program all variables, setpoints, and alarms through the RS232 communication link.
- Check the status and obtain alarm information through the RS232 PORT.

Section 8: Wash System



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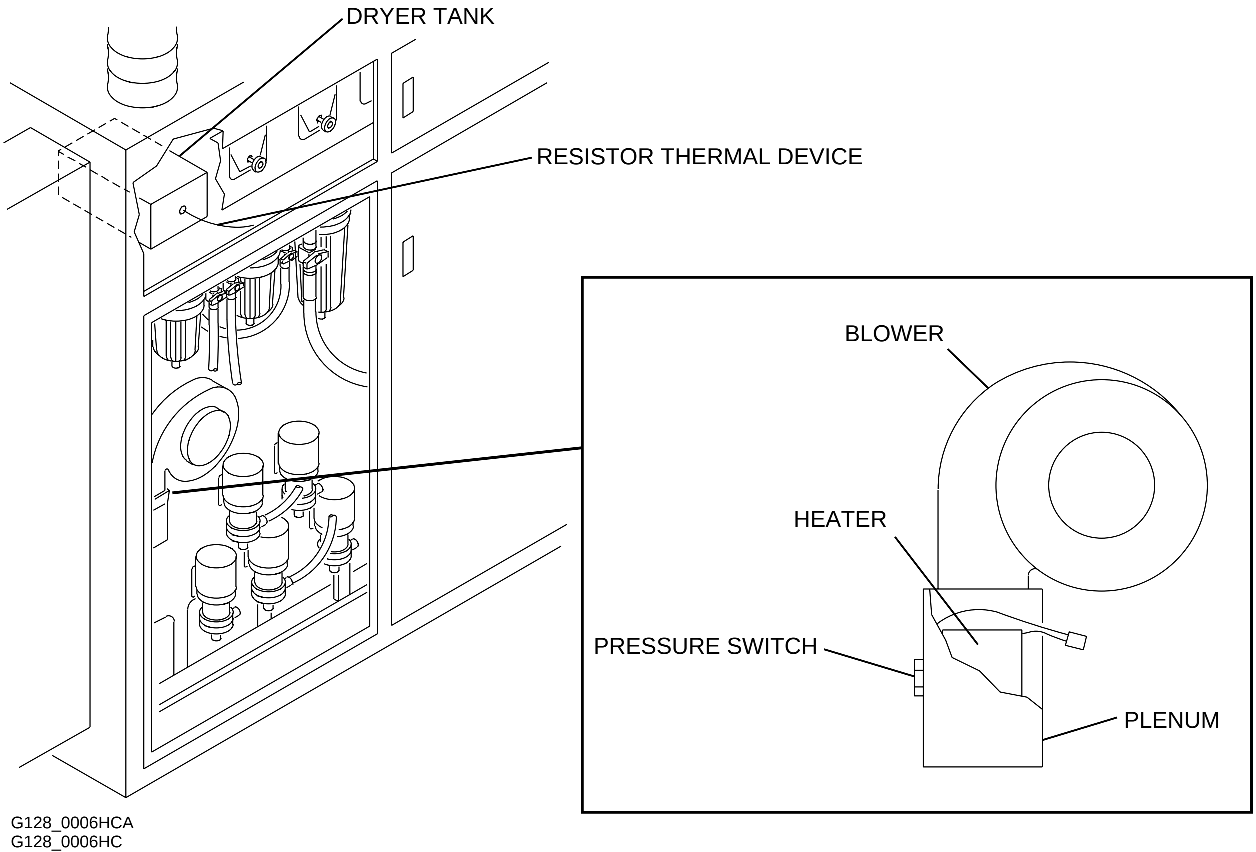
G128_4500DC

The recirculation system consists of:

- RECIRCULATION PUMP
- FLOW VALVES
- SPRAY HEADS

Another part of this system is a FLOW CONTROL FITTING on the SUPPLY WATER MANIFOLD and an OVERFLOW FITTING. Fresh water is supplied at the top of the WASH TANK. Wash water is drawn off the bottom of the TANK, through the PUMP, through the FLOW VALVES that regulate the flow through the SPRAY HEADS. Excess water goes through the OVERFLOW FITTING and through a HOSE to the WASTE MANIFOLD.

Section 9: DRYER System



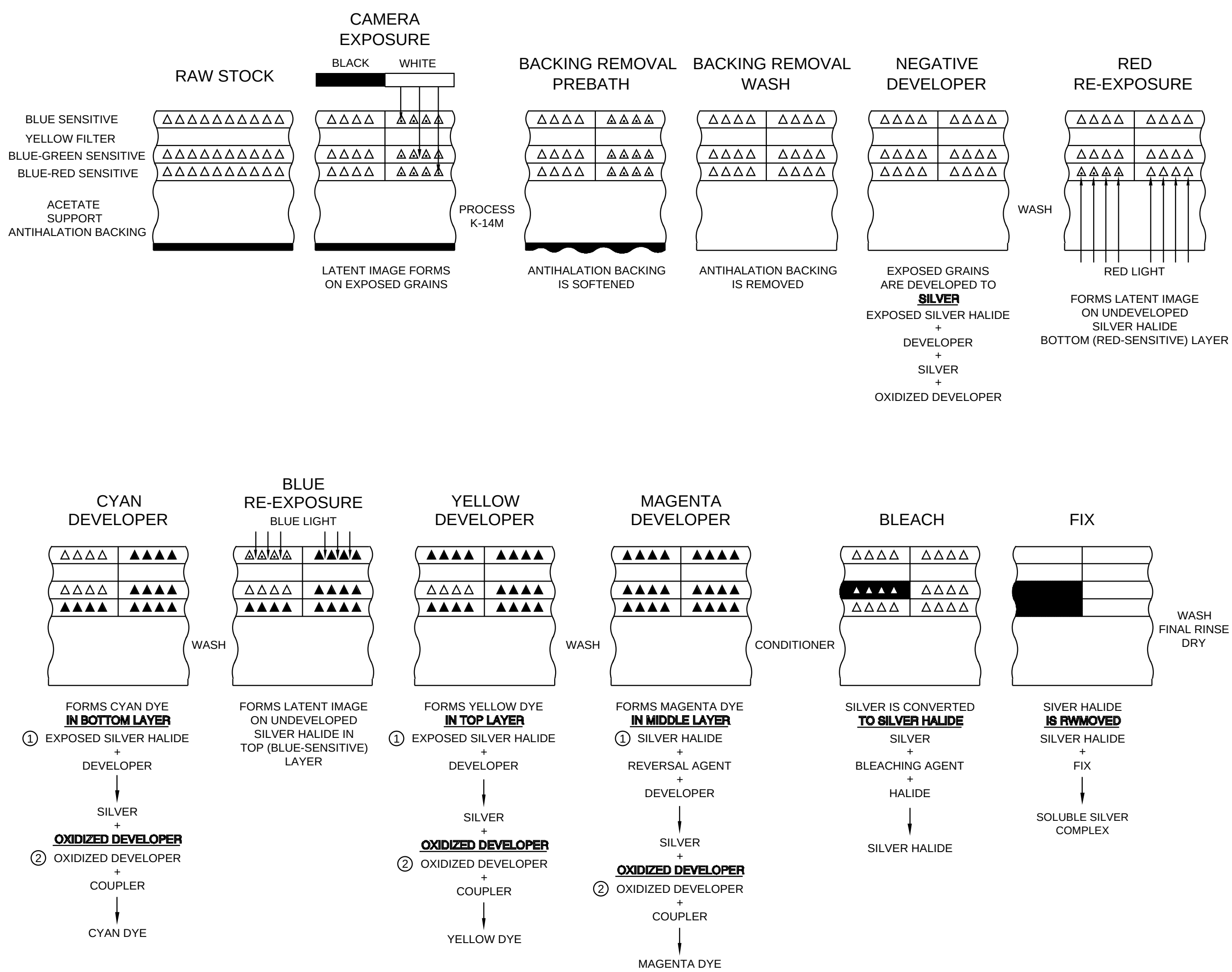
The DRYER system consists of:

- BLOWER
- HEATER
- PRESSURE SWITCH
- PLENUM
- RESISTOR THERMAL DEVICE (mounted in the DRYER TANK)

The TEMPERATURE CONTROLLER and the No. 8 SSR on the SOLID STATE RELAY BOARD control the temperature. As a safety precaution, the HEATER does not operate unless the PRESSURE SWITCH senses air flow from the BLOWER.

Section 10: Processing Cycle

Film Properties



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Kodachrome FILMS are reversal, subtractive color materials. When properly exposed and processed, they yield direct positive color images.

The figure above is a cross section (not to scale) of *Kodachrome* FILM that illustrates changes to the film during the process sequence. The transparent support (film base) has an antihalation backing layer called rem-jet. The rem-jet minimizes reflections of exposing light off the inner surface of the support, once it has passed through the film layers. These reflections cause "halo" images and loss of apparent sharpness in the processed films. The rem-jet backing is removed during the processing cycle.

The film base has a substratum (subbing layer) that provides adhesion of the light-sensitive emulsion layers to the film base. Following the subbing layer is a blue-red-sensitive emulsion, an interlayer, a blue-green-sensitive emulsion, an interlayer, a yellow filter layer, a blue-sensitive emulsion, and finally, a protective gelatin overcoating. Although the blue-red-sensitive layer is mainly sensitive to red light and the blue-green-sensitive layer to green light, both of these emulsion layers are sensitive to blue light. The yellow filter layer absorbs the blue component of exposing light, preventing blue-light exposure of the blue-green-sensitive and blue-red-sensitive emulsion layers.

Film Exposure

The best photographic results are obtained when the film is exposed as recommended in the film instructions. The processing laboratory must then have a well-controlled process to provide the customer with the best possible slide or transparency.

During film exposure, latent images form in each of the three emulsion layers. The blue-sensitive emulsion layer contains a record of the image created by the blue component of the exposing light; the green-sensitive layer contains the image formed by the green component; and finally, the red-sensitive layer contains the image formed by the red component of the exposing light. The records of the images all form simultaneously and are exactly superimposed.

Processing Steps

Backing Removal Solution

The alkaline backing removal solution converts the rem-jet antihalation backing on the film base into a water-soluble form. The backing removal wash removes this backing.

Backing Removal Wash

This wash performs 2 functions:

1. Removes the backing removal solution from the film
2. Completely removes the solubilized antihalation backing from the base by a combination of water action and mechanical buffing.

First Developer Solution

In the first, or negative, developer solution, only the exposed silver halide grains (latent images) are reduced to metallic silver by the action of Phenidone* and hydroquinone developers.

$$Ag^{+} + \text{Developer} \longrightarrow Ag^{\circ} + \text{Oxidized Developer} + X^{-}$$

Ag^{+} (Exposed Silver Halide)	+	Developer	$\longrightarrow$	Ag° (Negative Silver Images)	+	Oxidized Developer	+	X^{-} (Halide Ions)

The resulting silver grains form three superimposed negative images of the original scene, one image in each of the red-, green-, and blue-sensitive emulsion layers. The remaining (unexposed and undeveloped) silver halide in the three emulsion layers constitutes the positive (reversal) images that are later converted to full-color images in the color-development phases of the process.

*Phenidone is a trademark of Ilford Limited.

First Developer Wash

This wash stops the negative development and removes the first developer solution from the film.

Red Reexposure Printing

The red reexposure printing step completely reexposes all of the remaining silver halide in the red sensitive (bottom) emulsion layer so that the silver halide develops completely in the cyan developer solution. At the same time, exposure of any remaining silver halide in the blue- and green-sensitive layers must be avoided to prevent unwanted cyan dye development in these layers. This selective reexposure is obtained by printing through the base side of the film, using a properly selected red glass filter in the light beam. The green and blue-sensitive emulsion layers have no intentional sensitivity to red light and should, therefore, remain unaffected by the red-light exposure. However, some green-sensitive emulsion layers do have a slight, but significant, red sensitivity, and accurate control of the red printing intensity is necessary.

Cyan Developer Solution

The cyan developer solution forms a positive silver image in the red-sensitive layer by the action of the color developing agent on the silver halide that was exposed during the red printing step.

$Ag^{+}X^{-}$ (Reexposed Silver Halide)	+	Color Developer	→	Ag° (Positive Silver Images)	+	Oxidized Color Developer	+	X^{-} (Halide Ions)

Simultaneously, the resulting oxidized color developer combines with the cyan coupler to form a positive cyan dye image. This image is deposited only in the red-sensitive emulsion layer.

Oxidized Color Developer	+	Coupler	→	Colored Dye Image

The simplified equations given above typify the development and coupling reactions that also take place in the yellow and magenta developer solutions. Actually, the reactions are more complex than indicated.

If any red-sensitive halide is left undeveloped, unwanted dyes are produced in the red-sensitive layer during later color development stages.

Cyan Developer Wash

This wash stops cyan development and removes the cyan developer solution from the film.

Blue Reexposure Printing

In this printing step, all the remaining silver halide in the blue-sensitive emulsion layer is reexposed so that the silver halide develops completely in the yellow developer solution. At the same time, exposure of the remaining silver halide in the green-sensitive layer (which is also blue-sensitive) must be avoided to prevent unwanted yellow dye development in the green-sensitive layer. This selective reexposure is obtained by printing through the emulsion surface of the film, using a properly selected blue glass filter in the light beam. The yellow filter layer between the blue- and green-sensitive layers limits passage of blue light from the emulsion side. However, the filter layer does not protect the green-sensitive layer from any stray blue printing light that may strike the base of the film.

An optimum printing intensity for each printer should be established and then carefully controlled. Overprinting can result in unwanted reexposure and subsequent yellow development of silver halide in the green-sensitive (magenta) layer. Underprinting leaves some of the silver halide in the yellow layer unexposed and subject to chemical reexposure and development in the magenta developer. Either situation causes some degradation in quality.

The selected levels of reexposure for both the red and blue printing steps are based on the results of actual photographic tests, including each of the film types that are processed. These printer settings are computer controlled. For anything other than a lamp failure, call Kodak for service. Processing film with an inoperative printer produces unacceptable customer film.

Yellow Developer Solution

In the yellow developer solution, a positive silver image is formed in the blue-sensitive layer by the action of the color developing agent on the silver halide that was exposed during the blue printing operation. Simultaneously, a positive yellow dye image is formed by the reaction between the oxidized color developing agent and the yellow coupler. See the section, "Cyan Developer Solution" for the generic equations.

During the yellow development step, the blue-sensitive layer must be developed to completion while unwanted yellow development (fogging) of the green-sensitive layer is kept to a minimum. Any undeveloped silver halide in the blue-sensitive layer is developed in the magenta developer solution, causing magenta dye contamination in the yellow layer. Conversely, fogging of the green-sensitive layer during yellow development causes yellow dye contamination in the magenta layer and a significant reduction in the magenta dye yield. A normal process K-14M yellow developer solution provides the required yellow and magenta separation.

Normally, all of the exposed silver halide in the red-sensitive layer is developed in either the first or the cyan developer solution. If any exposed silver halide in this layer remains undeveloped after the cyan developer solution, it is developed in the yellow developer solution, and results in yellow dye contamination in the cyan layer.

Yellow Developer Wash

This wash stops the yellow development and removes the yellow developer solution from the film.

Magenta Developer Solution

At this stage in the processing sequence, only the green-sensitive layer should contain any unexposed silver halide. Therefore, selective reexposure is unnecessary. The reversal agent in the magenta developer solution nucleates (chemically reexposes) all the remaining silver halide.

During magenta development, a positive silver image is formed in the green-sensitive layer by the action of the color developing agent on the silver halide. Simultaneously, a positive magenta dye image is formed by the reaction of the oxidized color developing agent with the magenta coupler. See the section, "Cyan Developer Solution" on the previous page.

Magenta development is somewhat less critical than cyan and yellow development, because if the preceding steps were properly carried out, no silver halide should remain in the red- and blue-sensitive layers. Therefore, no unwanted magenta dye development should occur. However, if any silver halide is present in the red- or blue-sensitive layers, it is nucleated and developed in the magenta developer solution, producing magenta dye contamination of the cyan or yellow dye image.

The silver halide in the green-sensitive layer is the most difficult to develop completely, and incomplete development results in an inadequate magenta dye image, especially in the maximum-density areas.

Magenta Developer Wash

This wash removes the magenta developer solution from the film. This is the most critical of all the wash steps because it is more difficult to remove the components of the magenta developer solution.

Conditioner

The conditioner prepares the metallic silver developed in the first and color developers for oxidation to silver halide in the bleach step. It helps preserve the acidity of the bleach solution by reducing carryover of magenta developer into the bleach. An oxidized conditioner solution is ineffective and may cause silver to be retained in processed film.

Bleach

The bleach converts the metallic silver image back to silver halide; the silver halide is later removed in the fixer.

During bleaching, iron III is reduced to iron II. Iron II must be converted back to iron III by aeration so that satisfactory bleaching can continue. Aerate the bleach by bubbling air through it.

Inadequate aeration, underreplenishment, low temperature, and over-dilution of the bleach by conditioner can cause silver retention, which causes all densities to increase. The silver may be removed by bleaching and fixing the film again, if necessary.

Fixer

The fixer converts all of the silver halide into soluble silver compounds. Most of the silver compounds are removed in the fixer and can be recovered.

Underreplenishment, or fixer dilution, causes silver halide retention, increased blue density, or yellow D-min. The silver halide may be removed by bleaching and fixing the film again.

Final Wash

The final wash removes chemicals remaining in the film emulsion. Complete washing at this stage is important for image stability; any chemicals remaining in the film may deteriorate the image dyes.

Final Rinse

The final rinse contains a wetting agent to reduce water spotting and provide uniform drying. To help prevent water spots and streaks, replace the final rinse solution daily.

Mechanical Specifications

The table below outlines the durations and temperatures of each step in the processing cycle.

Solution or Step	Time (min:sec)	Temperature (°F)	(°C)	Wash Rates (L/min)
Rem-Jet Removal	0:10	Room temperature		
Rinse	0:15	85 (-2, +15)	29 (-1, +8)	2.8
First Developer	2:00	99.0 ± 0.05*	37.2 ± 0.3	
Wash	0:45	85 ± 2	29 ± 1	1.4
Red Reexposure Printer	*CORNING* 2403 FILTER, (nominal 2.5 mm); or *FISH-SCHURMAN* IR15 FILTER, (nominal 1.4 mm) 1000 micro-watt-seconds per square centimeter			
Cyan Developer	2:00	100 ± 0.1	37.8 0.06	
Wash	2:00	100 ± 2	38 1	1.4
Blue Reexposure Printer	*FISH-SCHURMAN* LB3 FILTER, (nominal 2.2 mm) 230 micro-watt-seconds per square centimeter			
Yellow Developer	3:00	100 ± 0.1	37.8 ± 0.06	
Wash	2:00	100 ± 2	38 ± 1	1.4
Magenta Developer	4:00	100 ± 0.1	37.8 ± 0.06	
Wash	2:00	100 ± 2	38 ± 1	
Conditioner	1:00	Room temperature		
Bleach	5:00	100 ± 2	38 ± 1	1.4
Fixer	3:00	100 ± 1	27 ± 3	
Wash	2:00	100 ± 2	38 ± 1	1.4
Final Rinse	1:00	Room temperature		
Dryer	6:00	105 ± 5	40 ± 3	

Section 11: Process Control

Introduction

The processing cycle of each PROCESSOR requires regular monitoring to ensure that the chemical process is in control. To check if the process is in control, process a control strip and evaluate the results.

All control strips, provided by Kodak, receive a calibrated exposure to a test target. Therefore, the expected density values of the processed strips are predetermined. By comparing the actual density readings to expected density readings, you can evaluate the current film processing conditions in the PROCESSOR.

If all the plots of the control strip fall within the established control limits, the process is said to be in control. However, when the control limits are exceeded, the processing is considered to be out of control and unable to produce acceptable quality processed customer film. The monitoring procedure allows you to detect an out-of-control process and to take corrective action in order to maintain optimum customer film quality.

Making Density Measurements

The work area must have tables with smooth, easily cleaned, top surfaces. Include several drawers or storage cabinets. Provide ample work space for recording and plotting the density measurements.

Provide a color transmission densitometer that gives Status A densitometric response. Include spare densitometer lamps, and an illuminator for visual inspection of processed control strips and customer film. The illuminator may be built into a worktable or mounted on the wall. This room should be large enough to accommodate equipment for evaluating the physical quality of processed film and for storing other control equipment.

Note

Check that the densitometer has good operational stability and provides the required precision (calibrated annually). For any color densitometer, adopt a rigid instrument maintenance and control program. Check the densitometer calibration at least once per day to make sure that it does not change during use. Use your densitometer check plaque and refer to the instructions included with the plaque.

Since some densitometers have some variation in optical gain, you must calibrate the densitometer used at the site against the Kodak densitometer used to calculate the expected density readings.

1. Compare the readings obtained on the Kodak DENSITOMETER with the readings obtained using the site densitometer for the same 3 control strips.
2. Check for consistent behavior of the customer's DENSITOMETER.
3. Calculate a set offsets for each of the 18 readings on the control strips.

Note

- The offsets calculated, along with the expected values, represent a set of aims for that process.
- New aim values must be set any time you begin using a new set of control strips.
- To allow for easy transition between aim values, the software maintains multiple sets of values.

Control Strip Exposure

All sensitometrically exposed control strips are assumed to have identical exposure. This requires a sensitometer in which the light intensity and color quality can be held extremely constant. It also requires that the sensitometer gives precise and repeatable exposures. The sensitometer at Kodak is carefully designed to provide this necessary precision, and is carefully maintained.

Control Strip Film

The film used for making control strips is assumed to be of uniform quality throughout. This is a valid assumption for a single full-length roll of film from one specific emulsion. When the supply of strips from a specific emulsion number and unit number have been depleted, different sensitometric standards are required for strips from the next emulsion number.

Control Strip Stability

Under ordinary conditions of temperature and humidity, film characteristics of unexposed film do not remain constant. Furthermore, the latent image of exposed film also changes with time. With high heat or humidity, the film changes are accelerated, causing unpredictable sensitometric effects. These changes are greatly minimized by storing the film in taped cans at a temperature of -18[deg]C (0[deg]F) or lower. With proper storage, you can purchase several rolls of control strips (with the same code number) at one time and use as needed.

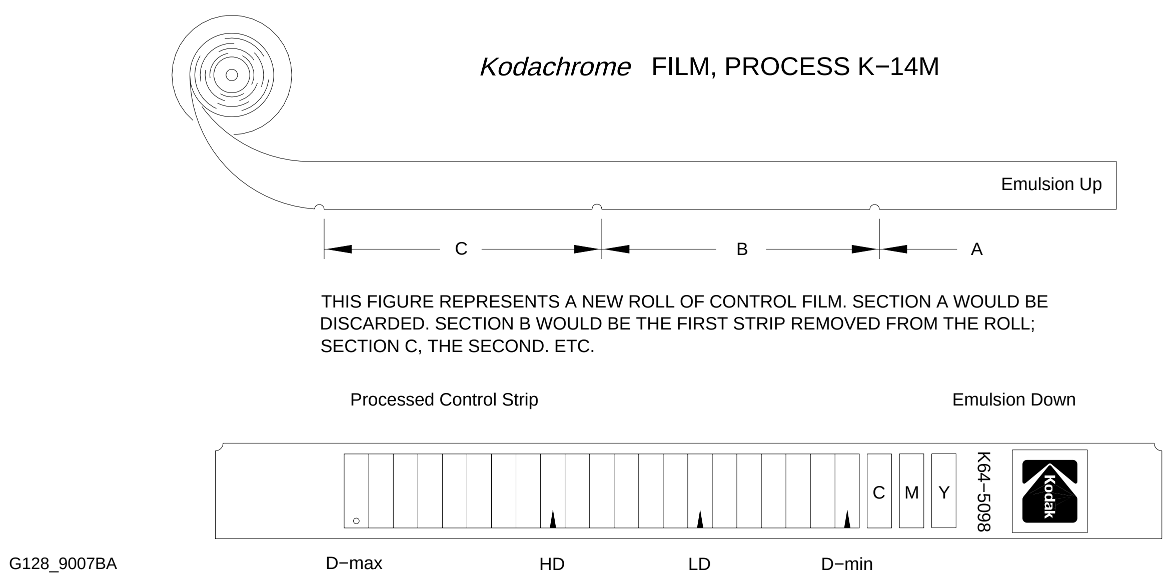
Standard Aim Values

Standard Aim Values for each unit of a particular batch of *Kodachrome* 64 Control Film is provided with each box of control strips. These standards are supplied in the form of red, green, and blue density values for the D-min, Ld, Hd, and D-max Steps (Steps 1, 7, 13, and 21) and the color patches of the control film.

Densitometer Correlation Strips

Each time a new control film code is released, you receive densitometer correlation strips, each with its own Status A density reading for that batch. These strips and their densities enable you to correlate the densitometer to the instrument on which the standard aim values were derived. Each strip is labelled “Densitometer Correlation” and identified by a 4-digit number. Each strip comes with pertinent information such as film width, code number, and process date.

Using 35 mm x 100 ft Roll Film Control Strips



The control film is pre-exposed and unprocessed in 100-ft continuous rolls, notched every 15 inches to yield approximately 80 control strips. The illustration shows the control film. Each strip has the same pre-exposed identifying number, unique for each batch of control film. The strips are exposed to a 21-step gray (neutral) scale, and to cyan, magenta, and yellow patches. Successive strips in the gray scale are exposed to give an increment of ½ camera stop, the equivalent of 0.15 log E exposure.

Storing and Handling Control Strips

To guard against erroneous process monitoring actions caused by spoiled strips, follow these recommendations for storage and handling.

Note

Do not use an oven, drying cabinet, or any heat to warm up the can. Do not leave a supply roll of control strips out of the freezer for an entire shift or work day.

- Estimate the usage rate of the control strip, and order a supply of strips to last one year or less.
- The box of control strips is shipped in a sealed can under refrigerated conditions. Immediately after receiving the control strips (and whenever they are not being used for monitoring the process), store them in a freezer at -18°C (0°F) or lower, in order to minimize latent image changes.
- The first time you are ready to use the control strips for the day, remove the taped can containing the supply roll from the freezer. Before removing the tape, allow it to warm up to room temperature (no moisture appears on the can); otherwise, moisture may collect on the strips and cause undesirable sensitometric effects.
- In total darkness, remove the tape from the can, and remove only enough strips from the supply roll for the day's operation. Place these strips in a second can and tape the can. Put the remainder of the supply roll back into the original plastic bag, put the bag in the can, and re-tape the can with black tape. Immediately return the can to the freezer and take the day's supply of strips to the location where they are spliced onto reels for processing. Discard any control strips that are not used by the end of the day. Repeat this procedure if more strips are needed than were anticipated. Place this supply roll near the front of the freezer and use it up before removing any strips from a new supply roll.
- Handle control strips by the edges to avoid fingerprints or other handling damage.
- Do not use control strips that have been improperly stored, mishandled, or light fogged.
- Discard control strips that have exceeded the expiration date.

Processing and Evaluating Control Strips

Frequency of Processing Control Strips

Caution

Process and evaluate a control strip to check that the process is in control before processing any customer films. It is good practice to process a control strip at the occurrence of any of the following conditions:

- During the daily start-up procedure
- Every hour during an extended run
- At the end of each work shift
- Whenever you suspect that the process is out of control
- Immediately after any chemical or mechanical change
- When using fresh processing solutions, especially developer

Processing Monitoring Procedure

[1] In total darkness, remove a control strip from the can containing the day's supply.

[2] Splice the control strip to the leader with the emulsion side up, so the minimum density end feeds first.

Caution

To avoid damage to the control strip or false densitometer readings, follow the guidelines below:

- Use a label or a grease pencil to mark on the strip.
- Do not place a label or mark on the front or back of the color or density patches.

[3] As soon as the strip has been processed, identify it with the following information:

- Date
- Hour
- Control number
- Machine number

Evaluating the Processed Control Strips

[4] Visually inspect each control strip using an ILLUMINATOR. Look for physical problems on the control strip that might indicate an malfunction in the process:

- Color contamination in the color patches
- Stains
- Unbleaching
- Incomplete fixing
- Light or fog streaks
- Dirt
- Scratches
- Digs or emulsion reticulation

[5] Evaluate each control strip by density measurement.

(a) Check that the DENSITOMETER is:

- Calibrated correctly
- Correlated with the DENSITOMETER correlation strip

Note

A densitometer is supplied and will be calibrated yearly.

(b) Check that the appropriate FILTERS are in the DENSITOMETER:

- Red
- Green
- Blue

(c) Compare the control strip readings and process aim values from film that has the same:

- Code number
- Unit number

(d) Check that the control strip density readings are in the center of the step or color patch.

Note

- Increases in density values indicate more dye; decreases in density values indicate less dye.
- Red density measurements indicate the amount of cyan dye.
- Green density measurements indicate the amount of magenta dye.
- Blue density measurements indicate the amount of yellow dye.

Section 12: Sequence of Operation

Energizing the PROCESSOR

The following actions occur when the PROCESSOR energizes:

1. The HOST COMPUTER energizes and initiates the main control program which controls all the functions and the maintenance of the PROCESSOR.
2. The main computer program checks the status of:
   - HOST
   - PROCESSOR
   - REPLENISHER RACK
   - TEMPERATURE CONTROLLER
   - REEXPOSURE PRINTERS
   - COMPUTERS
3. The PROCESSOR COMPUTER energizes and initiates the PROCESSOR program.
4. The REEXPOSURE PRINTERS de-energizes and waits for commands from the main computer program.
5. The processor program sets the CHILLER BYPASS SOLENOID VALVE to the bypass position to keep the chilled water out of the PROCESSOR.
6. The following components in the PROCESSOR de-energize:
   - TEMPERATURE CONTROLLER
   - REEXPOSURE PRINTERS
7. The REPLENISHER RACK COMPUTER energizes and initiates the replenisher program.
8. The REPLENISHER program stops the flow of water from the INTELLIFAUCET to the WASH TANKS in the PROCESSOR.
9. The REPLENISHER program de-energizes all PUMPS.

Entering Sleep Mode

The PROCESSOR can enter the Sleep Mode from:

- Initial energizing
- Standby Mode
- Processing Mode

Note

The state of the components during Sleep Mode is not affected by how the PROCESSOR entered the Sleep Mode.

While the PROCESSOR is in the Sleep Mode, the major components are in the following states:

Component	State
HOST COMPUTER	Sleep Mode
PROCESSOR COMPUTER	Sleep Mode
REPLENISHER RACK COMPUTER	Sleep Mode
CHILLER SOLENOID VALVE	Bypass Position
INTELLIFAUCET Water Flow	Off
All other components	Off

When the main computer program enters the Sleep Mode, it downloads the following default settings:

Default Condition	Downloaded To:
Processing Conditions	REPLENISHER RACK COMPUTER
Replenisher Rates	REPLENISHER RACK COMPUTER
Temperature Setpoints	TEMPERATURE CONTROLLER

Operator Actions

While the PROCESSOR is in the Sleep Mode, the operator may:

- Change settings or setpoints
  - REEXPOSURE PRINTER setpoints
  - TEMPERATURE CONTROLLER setpoints
  - Replenisher rates for different films and processing solutions
  - Default processing conditions
  - Time of day
- Enter Standby Mode
- De-energize the PROCESSOR
- View current status screens
- Replace a chemistry BIB
- Calibrate a REPLENISHER PUMP

Entering Standby Mode

When the PROCESSOR is in the Standby Mode, the main computer program initiates:

- Calibrates the REEXPOSURE PRINTERS
- Resets the REEXPOSURE PRINTERS to their setpoints
- Energizes the RECIRCULATION PUMPS
- Energizes the BLEACH AIR VALVE to begin oxidation
- Energizes the DRYER FAN
- Energizes the REM JET SCRUBBER MOTORS
- Communicates the temperature setpoints to the TEMPERATURE CONTROLLER
- Energizes the TEMPERATURE CONTROLLER HEATERS
- Monitors the SENSORS

Entering Processing Mode

When the PROCESSOR is in the Processing Mode, the main computer program initiates:

- Checks that the temperature of the processing solutions are still at their setpoints
- Checks that the REEXPOSURE PRINTERS are still set at the correct brightness
- Energizes all DRIVE MOTORS
- Monitors the film leader DETECTOR and communicates replenisher information to the REPLENISHER RACK COMPUTER
- Monitors the state of several SENSORS
- Monitors the temperature of the processing solutions
- Monitors the intensities of the REEXPOSURE PRINTERS

Operator Actions

The operator must replace empty FILM MAGAZINES and select the processing conditions for each new MAGAZINE or film batch. While the PROCESSOR is in the Processing Mode, the operator may:

- Enter Standby Mode
- Enter Sleep Mode
- View the Status Screens
- Replenish solutions

Entering Power Off Mode

The operator can only reach the Power Off Mode by first selecting the Sleep Mode. Selecting Power Off Mode is the last step the operator performs before de-energizing the PROCESSOR Management System.

Operator Actions

The operator can now de-energize:

- PROCESSOR
- REPLENISHER RACK
- CHILLER

Section 13: Glossary of Terms, Acronyms, and Abbreviations

BIB	BAG-IN-BOX; a method of storing, transporting, and using processing solutions in a plastic bag contained in a cardboard shipping box.
CPU	CENTRAL PROCESSING UNIT
MCC	MAIN CONTROL COMPUTER
MCP	Main Control Program; the software used to control all functions and all maintenance of the PROCESSOR. The HOST COMPUTER executes this program.
PPMS	Professional Production Mounting System; a database system that receives sensitometric monitoring data from *Kodachrome* labs supported by the marketing technical support group.
PP	PROCESSOR Program; the software that runs on the PROCESSOR COMPUTER.
PSBC	PROCESSOR SINGLE BOARD COMPUTER
RPP	REEXPOSURE PRINTERS Program; the software that runs on the REEXPOSURE PRINTERS COMPUTER.
RP	REPLENISHER RACK Program, the software that runs on the REPLENISHER COMPUTER.
RSBC	REPLENISHER RACK SINGLE BOARD COMPUTER
RTD	RESISTANCE TEMPERATURE DETECTOR
SBC	SINGLE BOARD COMPUTER; a small IBM PC-AT compatible COMPUTER within the PROCESSOR and REPLENISHER RACK used to acquire data from the SENSORS and format it for transmission to the HOST COMPUTER.
SSR	SOLID STATE RELAY
TPC	TEMPERATURE CONTROLLER Program; the software that runs on the TEMPERATURE CONTROLLER COMPUTER.

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