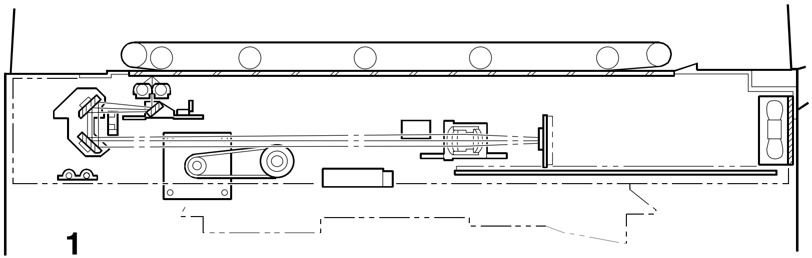
Photocopying Processes

Overview



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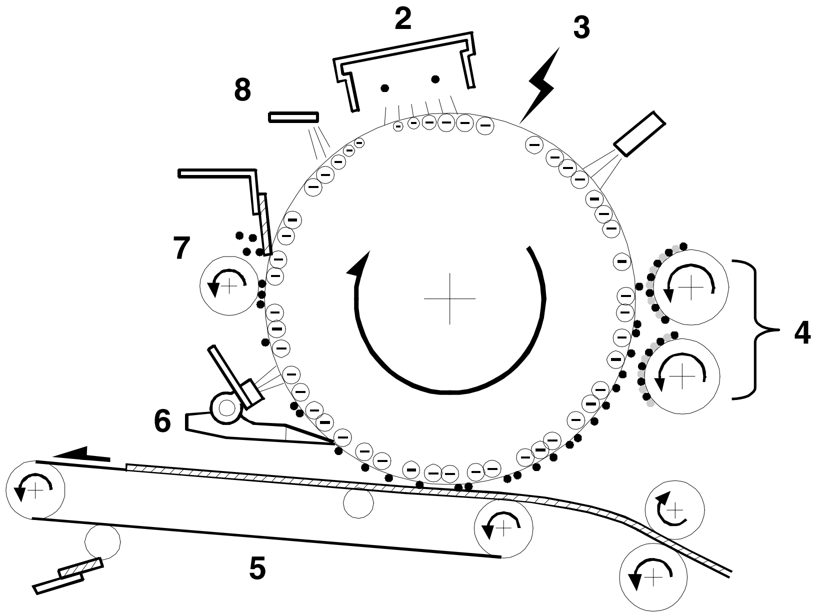
1. ***Scanning***
   An exposure lamp illuminates the original. Light reflected off the original is used to create the image on a drum*. In analog machines, the light is reflected through a series of mirrors, eventually striking the drum directly. For multi-copy runs, the original must be scanned for each copy.
   In digital machines, the reflected light is passed to a *CCD* or *CIS*, where it is converted into an analog data signal. This data is further converted to a digital signal, processed, and stored in memory. To print, the data is retrieved and sent to a laser diode. For multi-copy runs, the original is scanned only once and stored to a hard disk.
   * In this overview section we refer to the *photoconductor* as a ***drum*** just for simplicity. However, be aware that the photoconductor is often an OPC belt rather than a drum.

2. *Charging*

A charge is applied to the photoconductor drum. There are a variety of methods for this. Some machines apply a positive charge, others apply a negative. Most use a non-contact corona wire—though some use a contact, charge roller. The drum holds the charge because the photoconductive surface of the drum has a high electrical resistance–unless exposed to light.



3. *Exposure*

In an analog machine, the light reflected off the original is redirected to the drum. In a digital machine, the processed data from the scanned original is retrieved from memory or from a hard disk and transferred to the drum by one or more laser beams. In both cases, the areas exposed to light lose some or all of their charge. This writes an electrostatic image on the drum.

4. ***Development***
Toner is attracted to the latent image on the drum. The exact process varies depending on whether the drum holds a positive or negative charge. Most analog machines are Write to White—the toner is attracted to unexposed areas on the drum. Most digital machines are Write to Black—the toner is attracted to exposed areas.

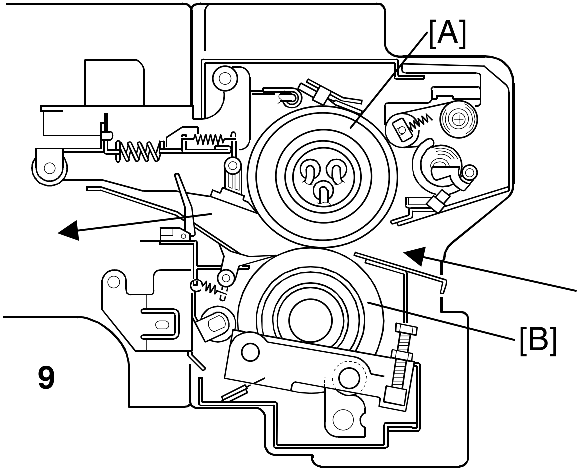
5. ***Transfer***
The image is transferred to paper. Some machines transfer the image directly from the drum. Others use an intermediary transfer belt. Transfer belts are particularly common in color machines. The four colors are layered onto the belt, and then the final image is transferred to the paper in one step.

6. ***Separation***
The paper can be separated from the drum (or image transfer belt) electrostatically or mechanically. Charge coronas, discharge plates, pick-off pawls and sharply curved paper paths are all used. Often a machine will combine two or more methods.

7. ***Cleaning***
The remaining toner is cleaned off the drum. Most machines use a cleaning blade to wipe off the excess toner. Some add a cleaning brush or cleaning roller to improve efficiency.

8. ***Quenching***
Light from a lamp neutralizes the remaining charge on the drum's surface.

9. *Fusing*
Heat and pressure are used to melt the toner and attach it to the page. The hot roller [A] is usually heated by one or more *halogen lamps*. The pressure roller [B] may or may not be heated.

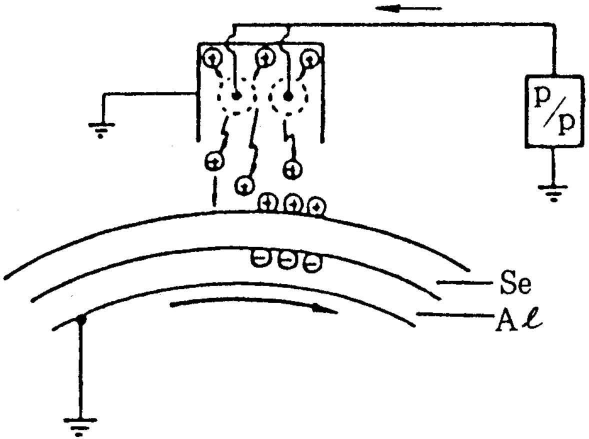


Charge

Overview

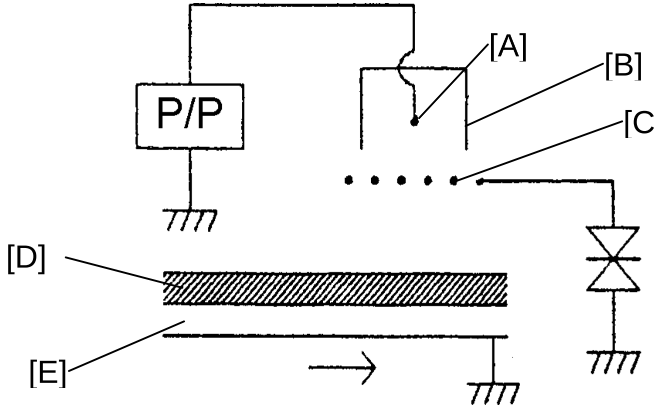
Charge refers to the application of a uniform electrostatic charge to a photoconductor in darkness. At present, two kinds of electrostatic charge methods are widely used in Ricoh products. The most common is the corona electrostatic charge method (non-contact type), which takes advantage of the corona discharge produced when a high voltage is applied to a fine wire. The other is the electrostatic charge roller method (contact type), which provides an electrostatic charge by applying a high voltage to a roller and contacting the roller to the photoconductor.

Corona Charge



Corotron Method—Positive charge (Se)

A power pack applies several thousand volts of electricity to a charge wire and a corona discharge is generated from the charge wire. The corona discharge ionizes air particles and the positive ions concentrate around the charge casing and photoconductive surface (Selenium). The photoconductor (insulator in darkness) stops the positive ions. The positive ions induce a negative electrostatic charge in the aluminum base, retaining the electrostatic charge.



Scorotron Method—Negative charge (OPC)

When several thousand volts of electricity are applied to a charge wire [A], a corona discharge is generated from the charge wire. The corona discharge ionizes air particles and the negative ions concentrate around the charge casing [B] and grid [C]. The negative ions adhere to the photo-conductor [D] (insulator in the darkness), causing positive electrostatic charge in the aluminum base [E], retaining the electrostatic charge.

Scorotron Grid

The quantity of the current of discharged electricity along the wire length changes as shown by the chart on the right. As this suggests, a negative corona is less uniform than a positive corona.

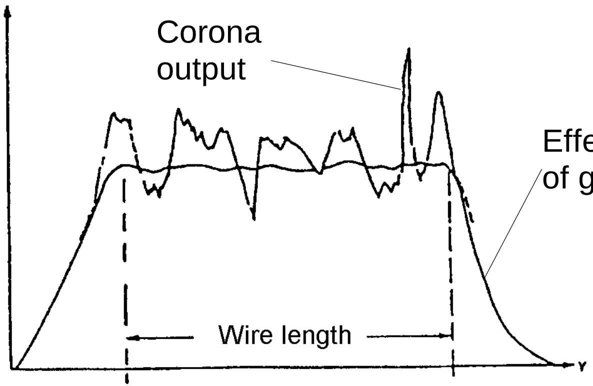
Therefore, the scorotron method uses a grid to even out the electric potential on the photosensitive surface.

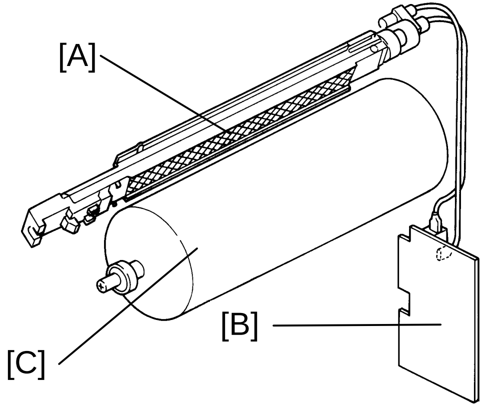
The grid is located at +1 or +2 millimeters away from the photosensitive surface, and the grid material is either stainless steel or tungsten wire.

[A]: Grid

[B]: Power pack

[C]: Drum





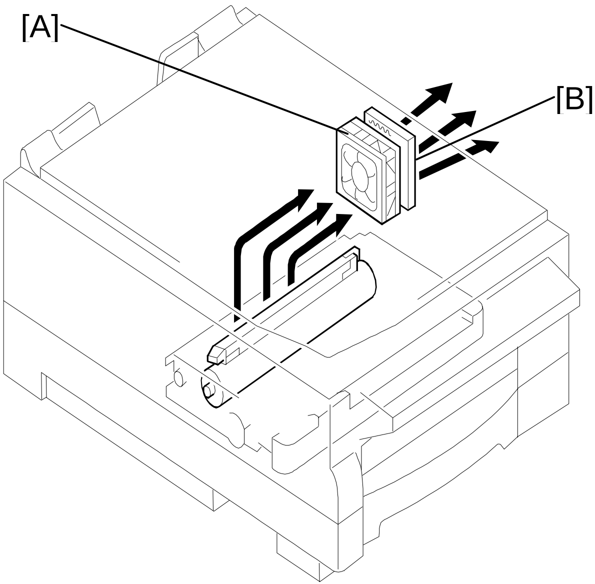
Corona Charge Power Pack

A rated current power pack is used for corona charging. In comparison to a rated voltage power pack, a rated current power pack provides a more stable image quality. It does this by stabilizing the total wire current even when the charge wire deteriorates or the wire resistance increases due to staining caused by dust.

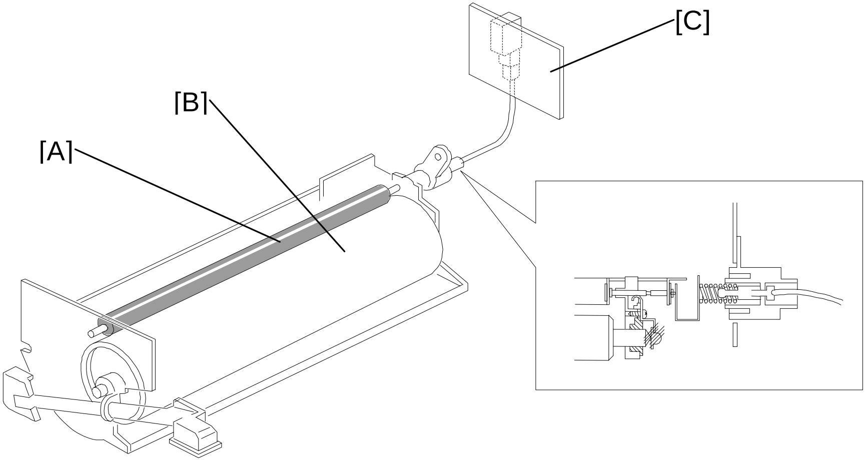
Uneven Charge Prevention

To prevent an uneven build-up of charge on the photoconductor, a flow of air is supplied to the electrostatic charge section. In the machine illustrated (*model A184*), the exhaust fan [A] causes a flow of air through the charge corona section.

Generally, an ozone filter [B] is also installed in the charge section to adsorb ozone (O3) generated by the charge corona.



Charge Roller Method



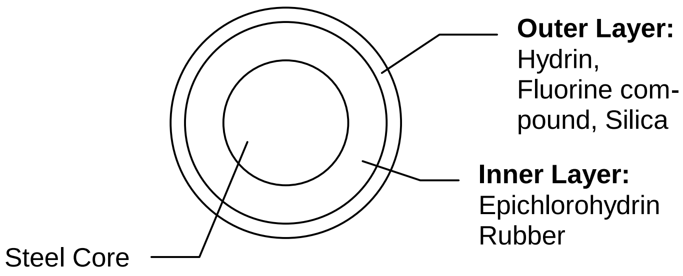
An electrostatic charge is applied to the photoconductor by applying several thousand volts of electricity to the drum charge roller [A]. The drum charge roller contacts the surface of the OPC drum [B] to give a negative charge

The DC power pack [C] for the electrostatic charge is a constant voltage type. This is because, in comparison to constant current power packs commonly used for coronas, the constant voltage type is better able to supply a uniform electrostatic charge on the drum surface when using a roller.

The amount of ozone generated during drum charging is much less than the amount made by a corona wire scorotron system. Therefore, there is no need for an ozone filter

Drum Charge Roller Construction

The charge roller consists of a steel core, surrounded by layers of rubber and other material.



Charge Roller Cleaning

If the charge roller becomes dirty, uneven charge may be applied to the photoconductor. This would decrease drum charge efficiency and cause spots and streaks on the output image. For this reason, the charge roller must be cleaned.

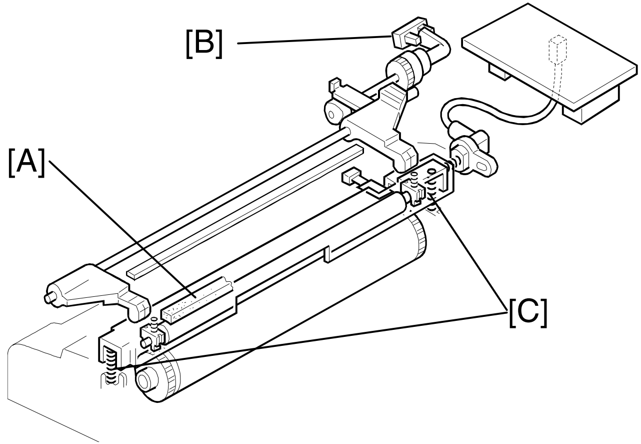
The charge roller cleaning may be done periodically (see example 1) or, if space is limited, the cleaning pad may be constantly in contact with the charge roller (example 2).

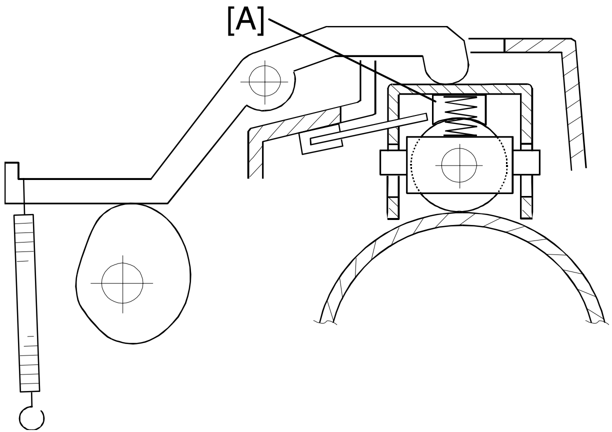
Example 1: Model A193—Contact and release

This machine has a contact and release mechanism with which it cleans the charge roller periodically.

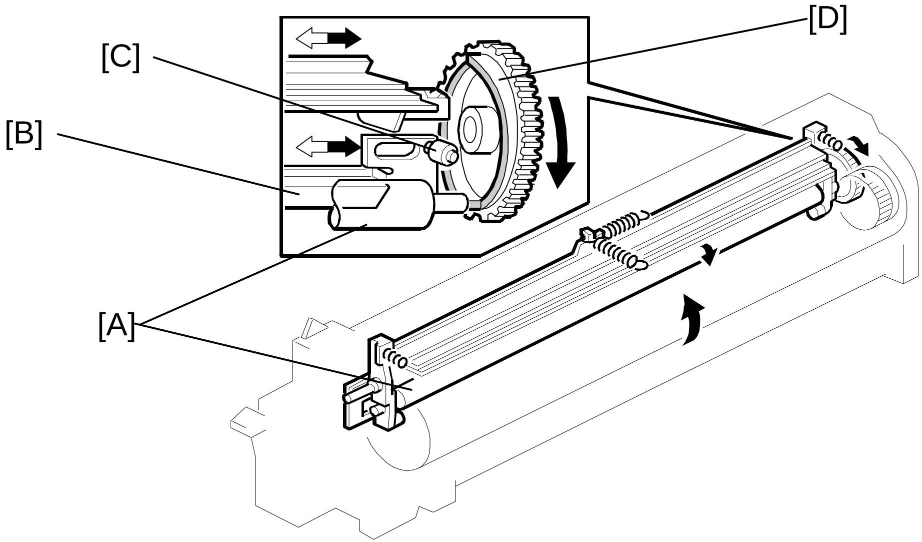
Drum charge roller cleaning is done for 2 seconds after every copy job. After the copy job, the charge roller contact clutch is driven another third of a rotation. The pressure lever presses down more, so that the cleaning pad [A] contacts the charge roller.

After charge roller cleaning, the clutch is driven the final third of the rotation (until the charge roller H.P sensor [B] is activated) to release the charge roller from the drum. The pressure lever moves away from the charge roller unit. Then the charge roller unit is released from the drum by the springs [C].





Example 2: Model A230/A231/A232—Constant contact



Because the drum charge roller [A] always contacts the drum, it gets dirty easily. So, the cleaning pad [B] also contacts the drum charge roller all the time to clean the surface of the drum charge roller.

The pin [C] at the rear of the cleaning pad holder rides on the cam [D] on the inside of the gear. This cam moves the cleaning pad from side to side as the gear turns. This movement improves cleaning efficiency.

Exposure

Overview

Exposure refers to a process where light is applied to a photoconductor to create a latent reverse image in the form of a charge pattern on the surface of the photoconductive material. Depending on the brightness of the image, the electric potential on the photoconducutor's surface is attenuated; thus, forming an electrostatic latent image

Ricoh products use three main exposure methods—flash exposure, strip exposure (sometimes called slit exposure), and laser exposure. The analog methods—flash and strip exposure—are covered in this chapter. Strip exposure is further divided into exposure using moving optics and exposure with fixed optics. Laser exposure is covered in the *Digital Processes* chapter

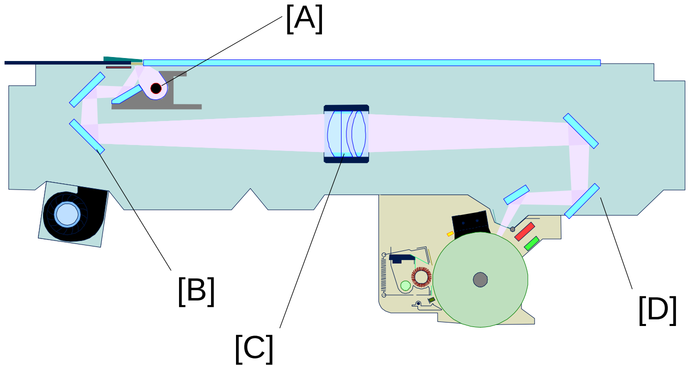
Strip Exposure With Moving Optics

Strip exposure with moving optics scans a strong light source across a fixed original. The strip of the image illuminated during this scanning, is continuously projected to the photoconductor by an optical assembly (mirrors and lens).

This method makes it easy to obtain even illumination distributions and it is well suited to projecting images onto cylindrical drums. Also, it is easy to change magnification by repositioning the optical components. However, it has speed limitations. Due to these characteristics, strip exposure is the most common exposure method used for low and medium speed models.

Example: Models A095/A096/A097

The illustration to the right shows the optics unit of the A095 series. This copier uses six mirrors to "fold" the optic path and thus make the optics unit smaller and obtain a wide reproduction ratio range (50 ~ 200%). A *halogen lamp* [A] mounted in the scanner is the light source. The 2nd and 3rd mirror carrier [B] moves at half the speed of the scanner to maintain a constant optical distance between the original and the lens [C] during scanning. The lens and the 4th and 5th mirrors [D] can be repositioned to change the reproduction ratio. A toner shield glass prevents toner and paper dust from leaking through the exposure slit into the optics cavity.



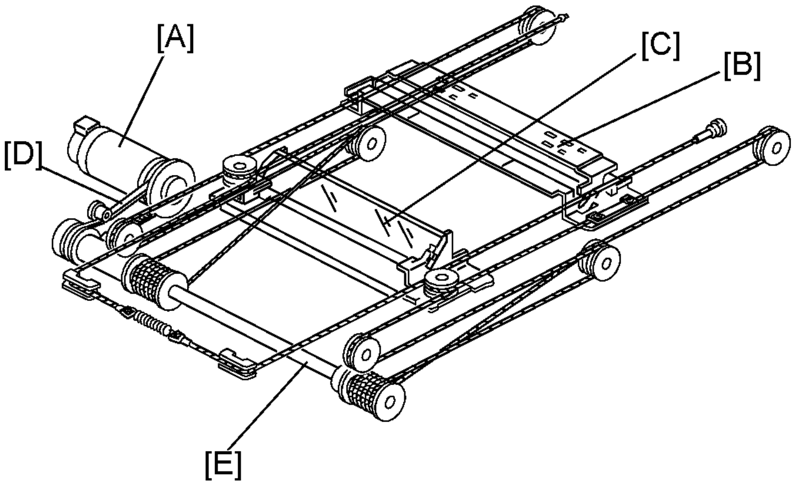
Scanner Drive

Here we will look at a couple of examples of scanner drive mechanisms in analog machines.

The illustration to the right shows a typical drive mechanism for an analog process photocopier. (*Model A095*)

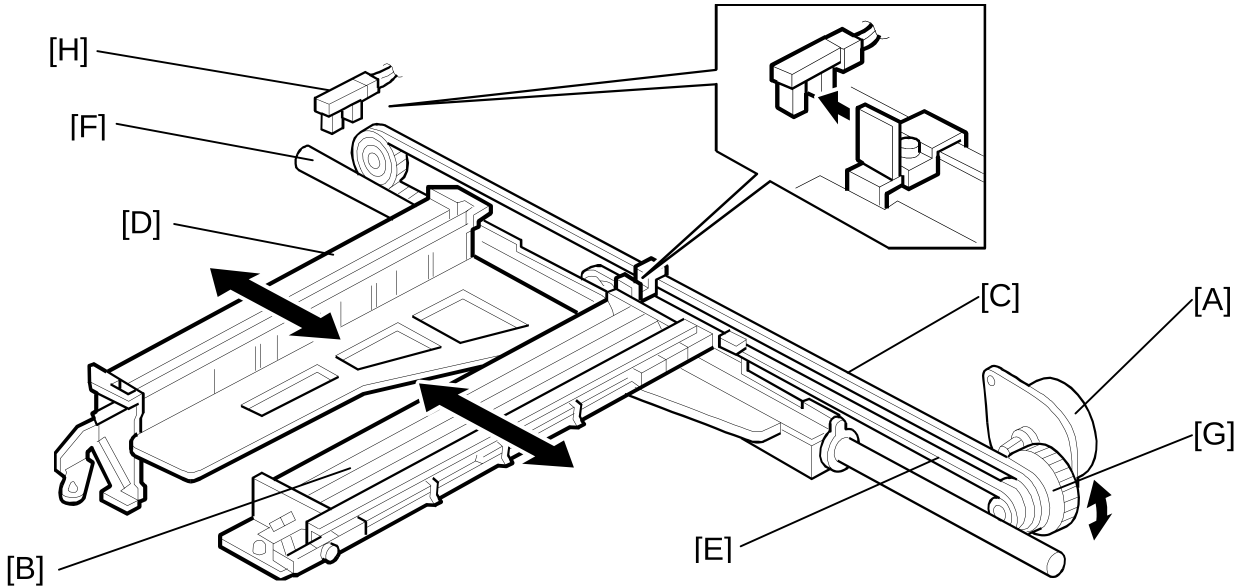
A dc servomotor is used as the scanner drive motor [A]. Scanner drive speed during scanning depends on the reproduction ratio. For a 100% copy, the scanning speed is 330mm/s.

The scanner drive motor drives the first [B] and second scanners [C] using two scanner drive wires via the timing belt [D] and the scanner drive shaft [E]. The second scanner speed is half of the first scanner speed. The scanner drive wire is not directly wound around the pulley on the scanner drive motor.



The second scanner drive example (*model A219*) shows scanner drive using belts rather than wires.

A stepper motor [A] drives the scanners. The first scanner [B], which consists of the exposure lamp and the first mirror, is connected to the first scanner belt [C]. The second scanner [D], which consists of the second and third mirrors, is connected to the second scanner belt [E]. Both the scanners move along the guide rod [F].



There are no scanner drive wires, and only one side of the scanner is supported (by a rod and guide rail).

The pulley [G] drives both the first and second scanner belts. The 2nd scanner moves at half the speed of the first scanner. This maintains the focal distance between the original and the lens during scanning.

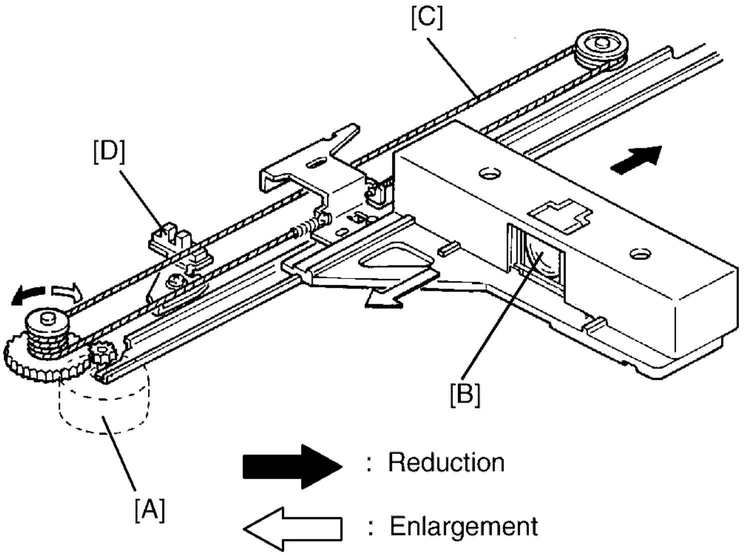
The scanner home position is detected by a home position sensor [H]. The scanner return position is determined by counting the scanner motor drive pulses.

Lens Drive

For a copier to make reduced or enlarged copies, the lens must be moved to achieve the proper optical distance between the lens and the drum surface for the selected reproduction ratio.

There are many ways this can be done. The illustration (from *model A152*) shows a typical arrangement. In this case, a stepper motor [A] changes the lens [B] position through the lens drive wire [C].

The rotation of the lens drive pulley moves the lens back and forth in discrete steps. The home position of the lens is detected by the home position sensor [D]. The main board keeps track of the lens position based on the number of pulses sent to the lens motor.

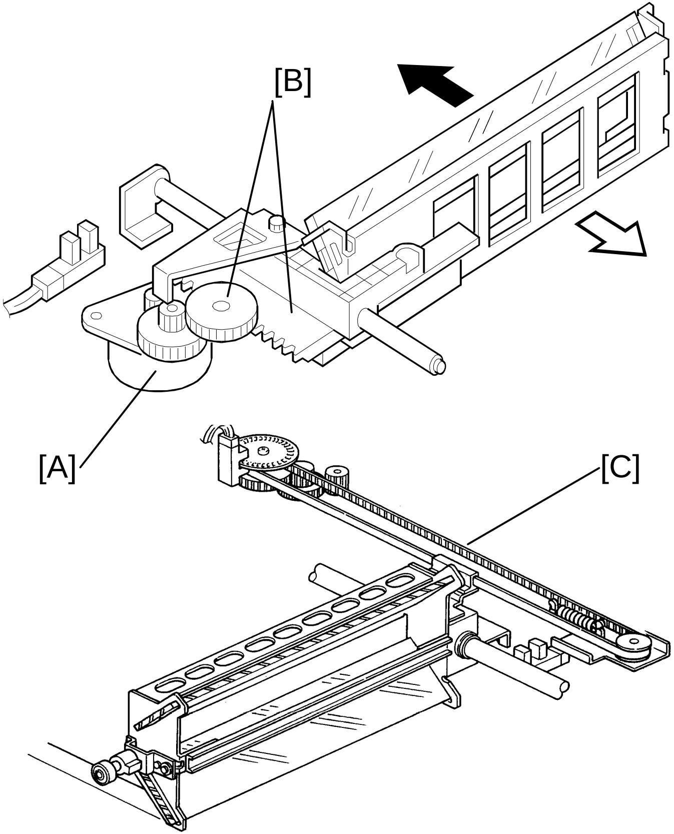


Mirror Positioning

To make reduced or enlarged copies, it isn't enough to just move the lens. To maintain focus, analog copiers must move mirrors also. For the typical 6-mirror exposure system, the 4th/5th mirror assembly is repositioned. (This is sometimes referred to as "third scanner drive"; however, that actually isn't an accurate name because the mirrors are stationary during scanning.)

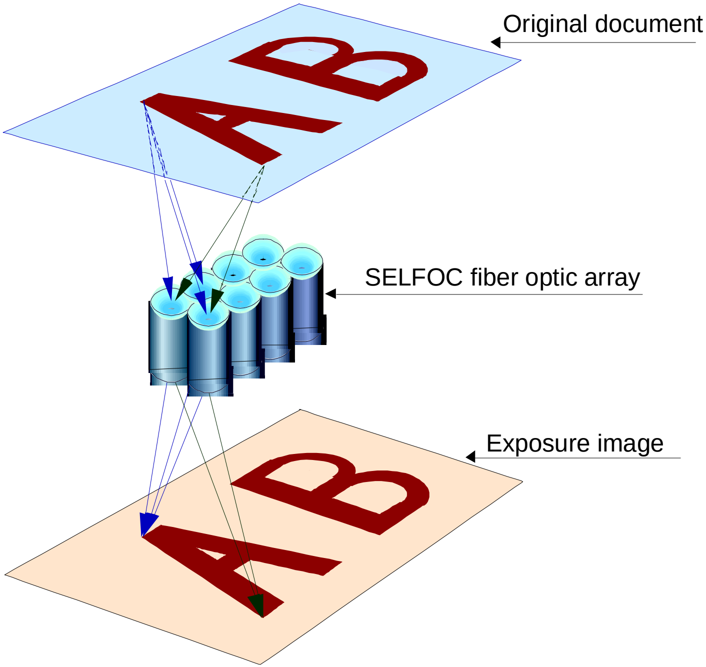
The illustrations to the right show two examples. In the upper illustration, a stepper motor [A] changes the 4th/5th mirror assembly position through a rack and pinion drive system [B].

The lower illustration shows a system where the mirror assembly is repositioned using a drive belt [C].



Strip Exposure With Fixed Optics

Strip exposure with fixed optics is a system where the original moves and the optics and light source are fixed. A strip of the original image is illuminated as it moves past the optics, and the optics continuously project this strip image to the photoconductor. While several types of optics could be used for this system, Ricoh uses a SELFOC fiber optic array. The fiber optic array has the advantage of being very compact. For that reason it is used mostly in large format copiers, where lens and mirror optics are impractical, and in small, low speed personal copiers, where compact size is important.



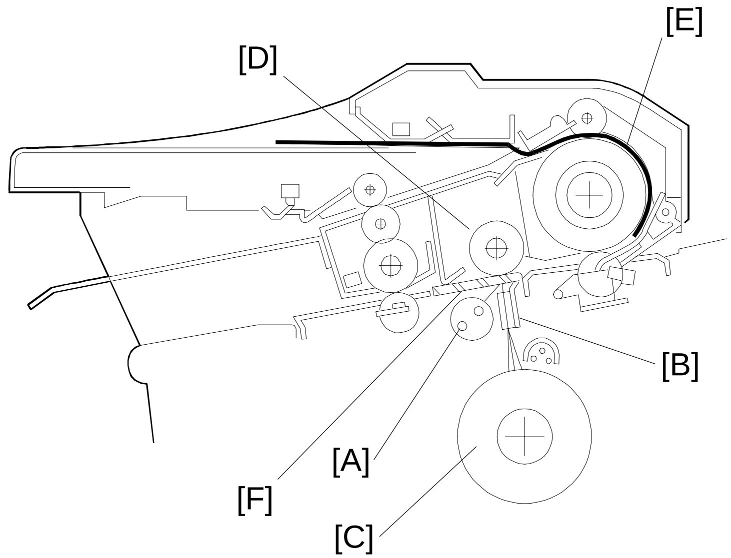
Example: Model A174 (Whale)

The illustration to the right shows the exposure mechanism of the model A174.

Light from the exposure lamp [A] reflects off the original and through the fiber optics [B] to the OPC drum [C]. During exposure, the original moves across the exposure glass at the same speed as the drum's peripheral velocity.

The platen roller [D] presses the original [E] flat against the exposure glass [F] just above the fiber optic array. This ensures that the image is properly focused. (The original must be within 0.2 mm of the exposure glass surface.)

The exposure lamp is a *fluorescent lamp*.



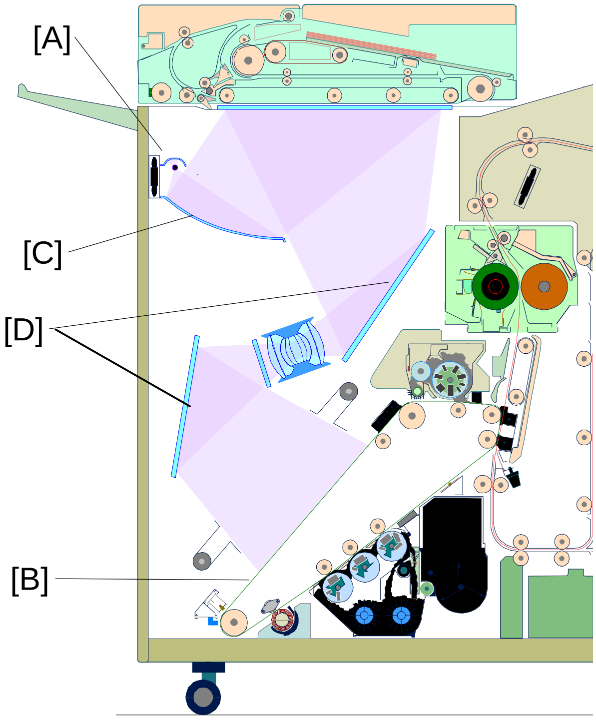
Flash Exposure

Flash exposure is an overall exposure method, which projects the document image onto the photoconductor, by exposing the entire document surface at once. As this method does not require a scanning mechanism, it enables high speed copying. However, it requires the photoconductor's surface to be flat and it requires an optics cavity that is quite large compared to standard scanner optics.

Example: Models A112/A201 (Big Bird)

The illustration to the right shows the exposure mechanism of the FT9101/9105. A *xenon flash lamp* [A] illuminates the entire document in a single flash of light. The flash is of such short duration (170 ms) that the opc belt [B], which moves at 430 mm/s, does not have to stop during exposure.

Reflectors [C] provide even light intensity to the original. Even though mirrors [D] are used to 'fold' the light path, most of the interior of the main body of the copier is taken up by the optics cavity.



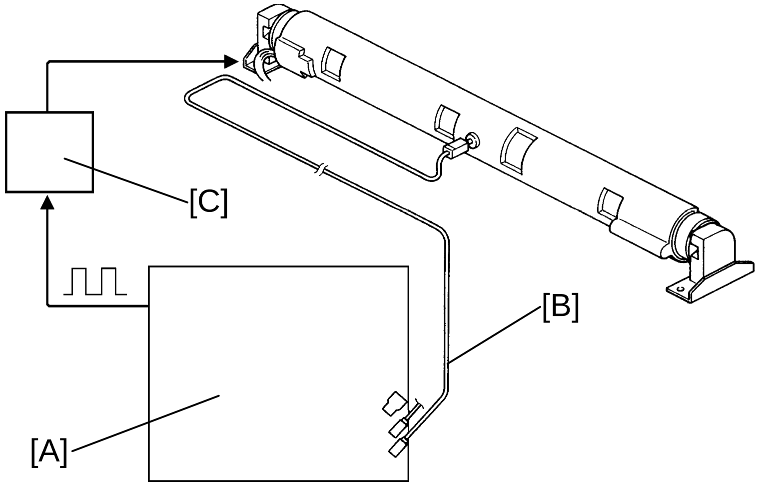
Exposure Lamp Control

Fluorescent Lamp

Feedback Control System

Light from a *fluorescent lamp* tends to fluctuate. For this reason, exposure lamp intensity must be stabilized during the copy cycle to get a constant latent image on the drum. To accomplish this the actual light output by the lamp is fed back to a control circuit.

The illustration to the right (from model A171) shows a typical control system. The main PCB [A] monitors the light intensity through a fiber optics cable [B]. based on this input, a lamp power signal (pulse width modulated signal) is sent to the fluorescent lamp regulator [C].

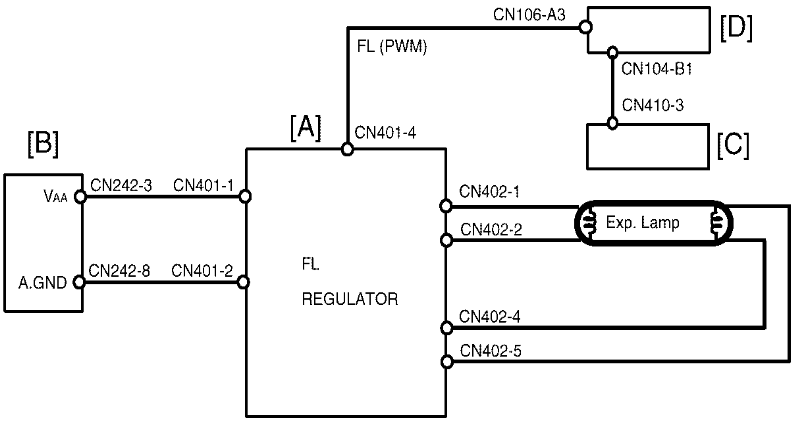


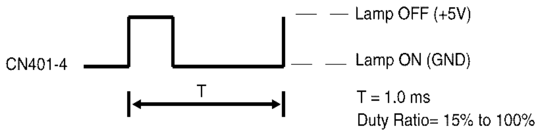
Fluorescent Lamp Regulator

The fluorescent lamp regulator (also called “FL stabilizer”) converts the power input to a stable, high-frequency ac output to the fluorescent lamp. A fluorescent lamp operates more efficiently with high frequency power input.

The percentage of the time that the lamp receives power—the duty cycle—is controlled by a pulse width modulated control signal.

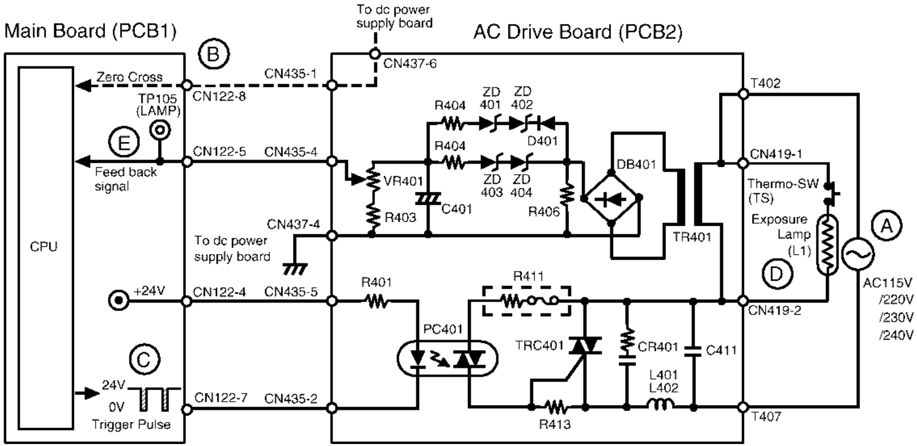
In the illustration to the right (from model A163), the lamp regulator [A] receives 24 volts dc at CN401-1 from the PSU [B]. The control signal, which is a pulse width modulated (PWM) signal, is received at CN401-4. The PWM signal has a period (T) of 1 millisecond and a duty ratio of 15% to 100%.





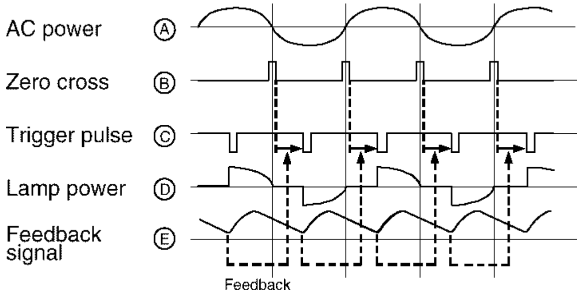
Halogen Lamp

The illustration to the right (from *model A110*) shows a typical control circuit for a *halogen lamp* used for exposure.



The main board sends lamp trigger pulses to the ac drive board from CN122-7. PC401 activates TRC401, which provides ac power to the exposure lamp, at the trailing edge of each trigger pulse.

The voltage applied to the exposure lamp is also provided to the feedback circuit. The feedback circuit steps down (TR401), rectifies (DB401), and smoothes (zener diodes and capacitors) the lamp voltage. The CPU monitors the lowest point of the smoothed wave (feedback signal), which is directly proportional to the actual lamp voltage.



The CPU changes the timing of the trigger pulses in response to the feedback voltage. If the lamp voltage is too low, the CPU sends the trigger pulses earlier so that more ac power is applied to the exposure lamp. This feedback control is performed instantly; so, the lamp voltage is always stable even under fluctuating ac power conditions.

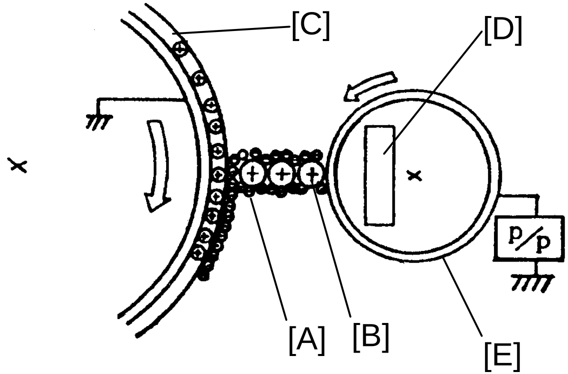
Development

This section covers standard systems for latent image development that are commonly used in Ricoh products. These development systems are divided into the dual-component development method and the mono-component development method.

Dual-Component Development (Magnetic Brush)

Overview

The two-component development process uses developer made of mixed toner [A] and carrier [B]. These two components rub against each other in the develop-ment unit and take on opposite charges. When a selenium photoconductor (drum) [C] is used, the toner takes a negative charge and the carrier takes a positive charge.



The carrier consists of resin-coated metallic particles, and they align with magnetic lines of force from magnets [D] inside the development roller, [E] forming a magnetic brush. The rotating drum contacts the magnetic brush, and the charged latent image areas of the drum attract the oppositely charged toner particles.

Features

Advantages

- Achieves high speed development
- Allows relatively wide scope in terms of accuracy

Disadvantages

- The development section is complex and large
- Deterioration of developer over time (difficult to achieve maintenance free operations)
- Requires toner concentration control

Developer Composition

Carrier

Carrier consists of roughly spherical metallic particles ranging in size from 50 to 200 μm. The particles have a resin coating with specific characteristics which determine the polarity and strength of the carrier's *triboelectric charge*.

Toner

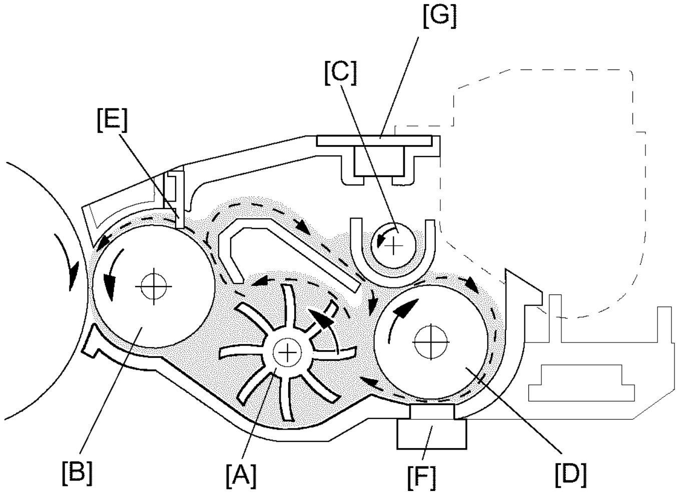
Several weight percent of *toner* (weight ratio) is mixed with the carrier. Toner particles have a diameter of 5 to 20 μm. Toner particles are made of a thermosetting carbon black resin in which an electrostatic charge agent is mixed. The triboelectric characteristics ensure that the toner always takes on a charge that is opposite to the carrier.

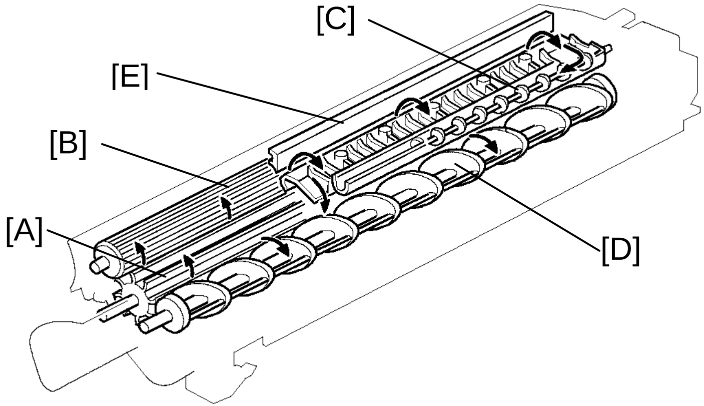
Example 1: Model A153

Model A153 has a typical dual component development unit. The parts shown in the illustrations are standard to most dual component systems.

When main motor rotation is transmitted to the development unit, the paddle roller [A], development roller [B], auger [C], and agitator [D] start turning. The paddle roller picks up developer in its paddles and transports it to the development roller. Internal permanent magnets in the development roller attract the developer (the carrier particles are about 70 micrometers in diameter) to the development roller sleeve.

The turning sleeve of the development roller then carries the developer past the doctor blade [E]. The doctor blade trims the developer to the desired thickness and creates developer backspill into the *cross-mixing* mechanism. The development roller continues to turn, carrying the developer to the OPC drum. When the developer brush contacts the drum surface, the negatively





charged areas of the drum surface attract and hold the positively charged toner. In this way, the latent image is developed.

Negative bias is applied to the development roller to prevent toner from being attracted to the non-image areas on the drum, which may have a residual negative charge.

A toner density sensor [F] directly measures the amount of toner in the developer mixture.

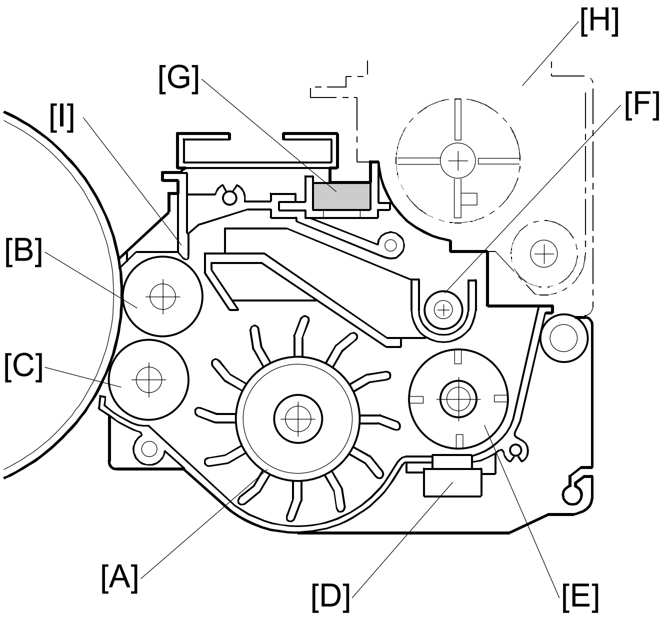
Example 2: Model A229

Model A229 uses a double roller development system. Each roller has a diameter of 20 mm which is somewhat narrower than single development roller systems.

This system differs from single roller development systems in that each development roller develops the image in a narrower area and the image is developed twice. Also, generally, the peripheral velocity of the development rollers relative to the drum is less than with single rollers.

The internal parts are basically the same as those of the single roller system.

The operation is explained on the next page.



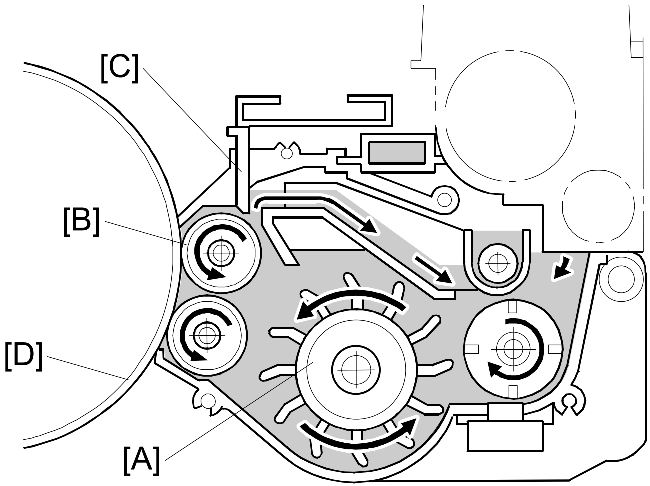
Paddle Roller [A]
Upper Development Roller [B]
Lower Development Roller [C]
Toner Density Sensor [D]
Developer Agitator [E]
Toner Auger [F]
Development Filter [G]
Toner Hopper [H]
Doctor Blade [I]

The paddle roller [A] picks up developer and transports it to the upper development roller [B]. Internal permanent magnets in the development rollers attract the developer to the development roller sleeve. The upper development roller carries the developer past the doctor blade [C]. The doctor blade trims the developer to the desired thickness and creates backspill to the cross mixing mechanism.

In this machine, black areas of the latent image are at a low negative charge (about –150 V) and white areas are at a high negative charge (about –950 V).

The development roller is given a negative bias to attract negatively charged toner to the black areas of the latent image on the drum.

The development rollers continue to turn, carrying the developer to the drum [D]. When the developer brush contacts the drum surface, the low-negatively charged areas of the drum surface attract and hold the negatively charged toner. In this way, the latent image is developed.



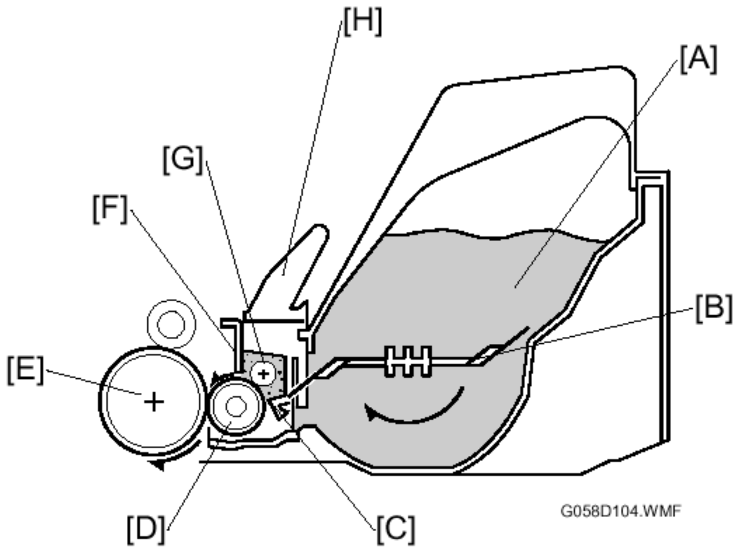
Example 3: G056 series printers

This double-component system requires no TD or ID sensors.

Toner density is mechanically controlled, using the gap between the pre-doctor blade and the development roller, the rotation of the rollers, pre-doctor blade and doctor blade.

The magnetic attraction of the toner to the development roller is also a factor in the control of toner supply. This is because the toner contains ferrite (attracted by magnetism), rather like the toner in a single-component system.

The gap between the pre-doctor blade and the development roller is adjusted at the factory. There is no field adjustment.



[A]: Toner tank
[B]: Agitator
[C]: Pre-doctor blade
[D]: Development roller
[E]: Drum
[F]: Doctor blade
[G]: Reverse roller
[H]: Developer tank

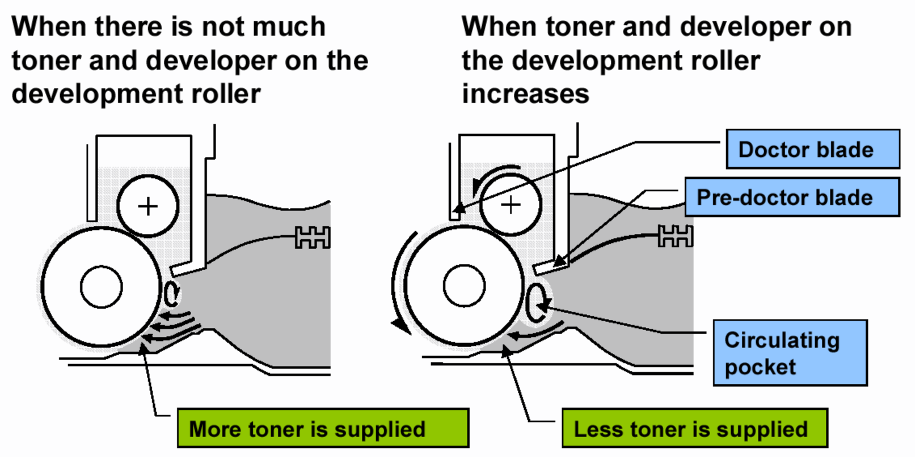
How does it work?

The agitator is always pushing toner towards the development roller, and the development and reverse roller are always turning. The reverse roller is magnetic.

The result of this is that toner and developer mix in a small circulating pocket just below the developer tank, at the pre-doctor blade. The size of this pocket depends on how much toner/developer there is on the development roller.

When toner on the development roller has been used up, the coating on the roller is thinner (diagram at the bottom left), and the circulating pocket of developer shrinks. This allows more toner to reach the development roller.

If the coating on the development roller is thick (diagram at the bottom right), the circulating pocket of developer is larger, and it does not allow toner arriving from the toner tank to reach the development roller.



Mono-Component Development

Overview

The monocomponent development process uses toner only with no carrier. Monocomponent development systems are used mainly in small photocopiers with a low copy rate.

Advantages:

- Development unit structure is simple and compact.
- Toner density control is unnecessary.

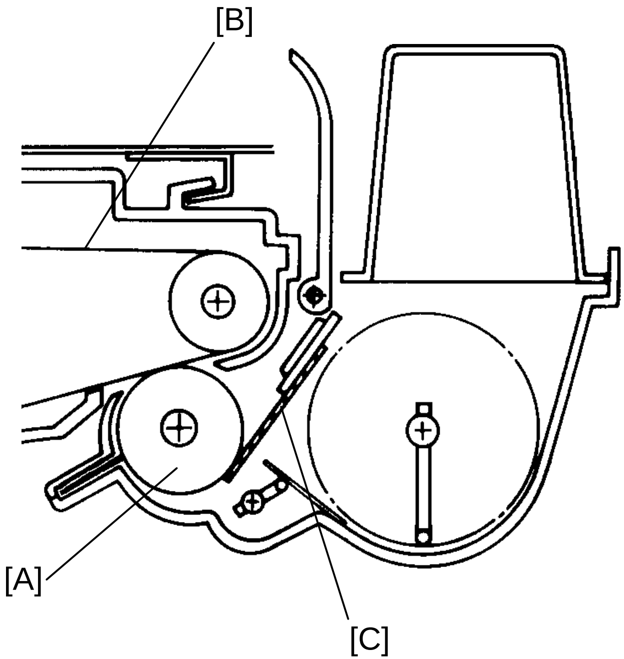
Disadvantages:

- Unsuitable for high speed developing
- Suitable for low-volume copying only because the development unit parts wear out relatively quickly.

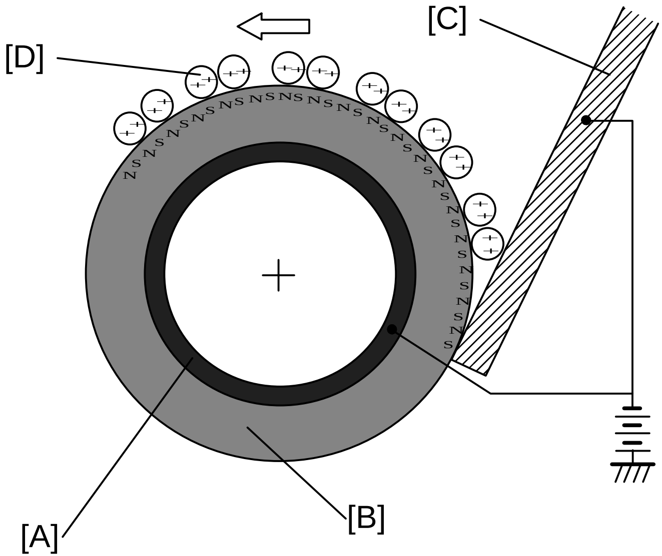
Basic Process

The illustration to the right (from *model A027*) shows a typical monocomponent development system. This system does not use a magnetic brush, and as a consequence, there isn't a doctor gap or photo-conductor gap. The development roller [A] directly contacts the OPC belt [B] and the toner metering blade [C].

As the development roller turns past the toner metering blade, only a thin coating of positively charged toner particles stays adhered to the development roller. After that, the development roller turns past the OPC belt. The negatively charged latent image on the OPC belt's surface attracts the toner from the development roller, making the image visible on the OPC surface.



Development Roller and Toner Metering Blade



The typical development roller used in the mono-component process has two layers. At the core there is a conductive layer [A] to which the *development bias* is applied. Around that, there is a magnetic rubber layer [B], which has closely spaced, alternating north and south magnetic poles. The development roller rotates at a high speed—typically greater than 300 rpm.

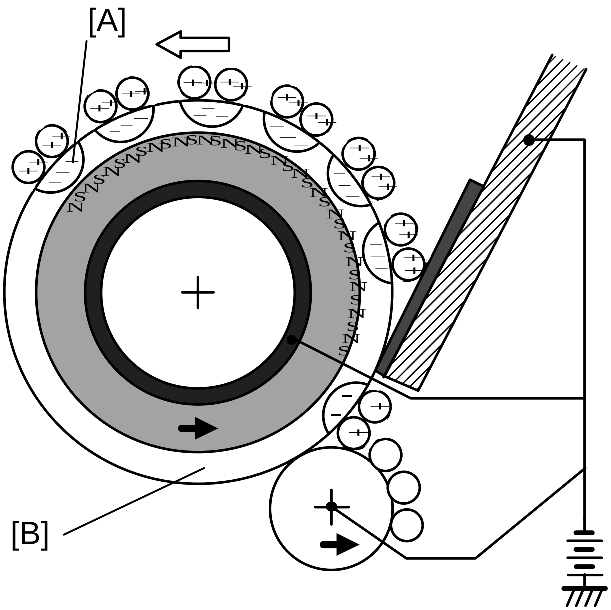
The toner metering blade [C] is made of an iron based material. It is attracted against the development roller by the magnetic field of the magnetic rubber layer. The toner metering blade vibrates because of rapid changes in the magnetic field as the roller turns. The vibration allows toner to pass by and prevents foreign matter from being caught on the edge of the metering blade.

Toner particles [D] receive a positive *triboelectric charge* as they move past the toner metering blade. This charge is created by the rubbing action of the development roller, toner, and toner metering blade.

The monocomponent toner used with this type of roller is composed of resin and ferrite. Attraction between the ferrite and the magnetic rubber layer causes the toner to adhere to the development roller. (Typically, this kind of toner also has high electrical resistance, which gives it good development and image transfer characteristics, even under high humidity conditions.)

FEED Development Roller

Some monocomponent development units use the FEED development technique. (FEED stands for “floating electrode effect development”.) This system is similar to that discussed in the previous section; however, the development roller has an insulating layer over the magnetic rubber layer. Floating electrodes [A] are embedded in the insulating layer [B]. (They are called floating electrodes because they “float” electrically in the insulating layer.)



This type of system is suitable for use with toners containing little or no ferrite (for example color toners). The floating electrodes take on a triboelectric charge opposite to that of the toner, and thus, attract the toner to the development roller.

Double Development Roller Process

The development of the double development roller method for monocomponent development was in two stages. The double development roller process was originally developed as an adaptation of the normal monocomponent process for use with an OPC drum. Since the development roller was a metal roller with magnetic strips, it wasn't suitable for direct contact with a hard OPC surface.

Because of this, a rubber roller was placed between the drum and the metal roller. This rubber roller was called the development roller, and the old metal-and-magnet roller was called the toner application roller. This is the type of development system used in model H523. (See example 1 below for details.)

In the second stage, the double roller process was modified for use in replaceable cartridges. In such cartridges, the toner application roller is a sponge. It is not magnetic. It just picks up toner and applies it to the development roller. The development roller is similar to the one used in the first stage. The toner-metering blade was moved to the development roller, because the application roller does not apply an even layer to the development roller.

Also, the potential difference (bias) between the application roller and development roller was reduced in the second stage. Less potential difference is required because it isn't necessary to overcome the attraction of the magnets. This is the type of development system used for models H545 and G026/G036. (See example 2 below for details.)

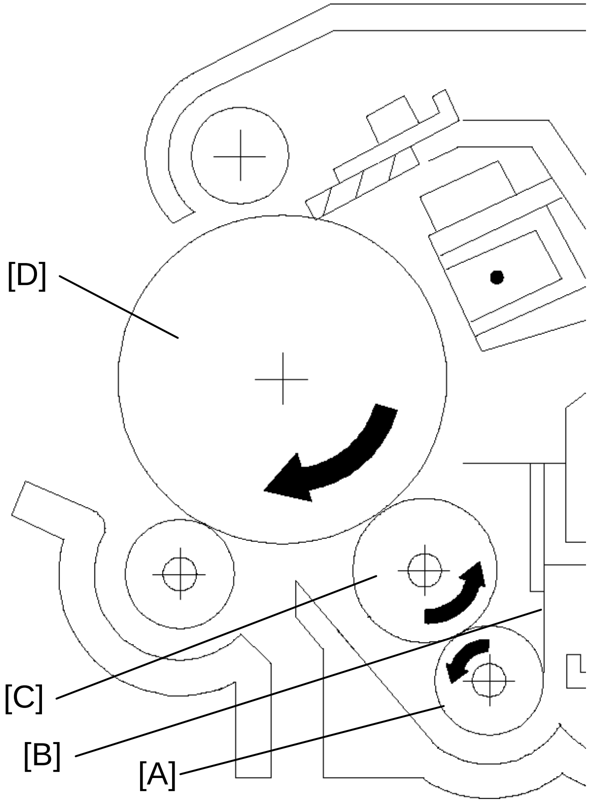
Example 1: Model H523

Toner is attracted to the toner application roller [A] because it has a magnetic layer. A thin coating of negatively charged toner particles adheres to the toner application roller as it turns past the toner metering blade [B].

During image development, a bias voltage of -700 V is applied to the toner application roller and another bias voltage of -400 V is applied to the development roller [C]. This 300 volt difference in electric potential moves the toner from the toner application roller to the development roller.

The development roller and OPC drum touch each other with a slight amount of nip and rotate in the same direction. The exposed areas on the drum [D] are at –100 volts. The development roller applies toner to these areas of the latent image as the drum and development roller rotate. The development roller is made of a soft rubber so it does not damage the surface of the drum.

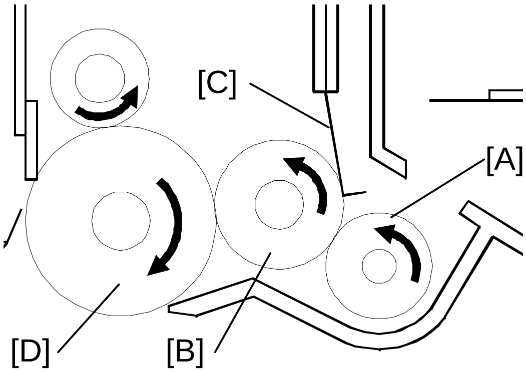
The speed ratio (peripheral velocity) between the drum, development roller, and the toner application



roller is 1 : 1 : 3. The toner application roller rotates three times as fast as the development roller, so it deposits a layer of toner three times as thick on the development roller. This leads to a clearer image. Also, the toner application roller rotates in the opposite direction to the development roller, which helps to keep the toner level on the development roller.

Example 2: Models G026/G036

The toner application roller [A] supplies toner to the development roller [B]. The toner application roller is a sponge roller. (Unlike the magnetic metal roller in example 1.) A thin coating of negatively charged toner particles adheres to the development roller as it turns past the toner metering blade [C].



During printing, a bias voltage of –650 volts is applied to the toner application roller and another bias voltage of -400 volts is applied to the development roller. This 250-volt difference in electric potential moves the toner from the toner application roller to the development roller. The exposed area on the drum [D] is at –200 volts. The development roller applies toner to these areas of the latent image as the drum and development roller rotate in contact with each other.

Since the development roller carries a thin layer of toner, it has to turn faster than the drum in order to supply sufficient toner. Peripheral velocity is 1.38 times the peripheral velocity of the drum.

Development Bias

When a photoconductor (photosensitive drum or belt) is exposed, the charge decreases in the sections that receive light, corresponding to the white sections of the document. However, exposure does not eliminate the charge completely, and there is always a small residual charge on the photoconductor. To prevent toner from being attracted to the non-image areas and thus causing toner background on copies, the development roller is charged with a bias voltage greater than the residual voltage on the photoconductor. This bias voltage is opposite in polarity to that of the toner; so, its attraction is greater than that of the residual voltage on the photoconductor.

In some machines, the bias voltage is also used to control image density. The higher the development bias voltage is, the less toner is attracted to the drum surface.

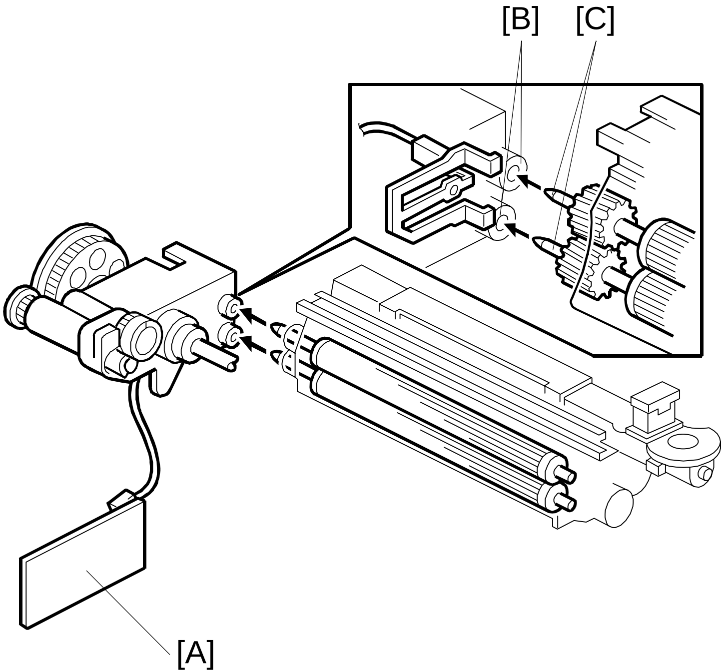
In the past, the most common copy process used a positively charged *selenium* drum photoconductor, negatively charged toner, and a positive development bias. However, recent products use a negatively charged *organic photoconductor (OPC)* and positively charged toner; so, the development bias is negative.

NOTE: The calculation of the actual value of the development bias can be quite complex and varies from machine to machine. Various compensating factors—for example for residual voltage changes, temperature, original background, drum wear, magnification, and many other factors—may be calculated by the machine's CPU depending on the details of the machine's process control. (For more details, see the *Process Control* section or refer to the service manual of the product you are interested in.)

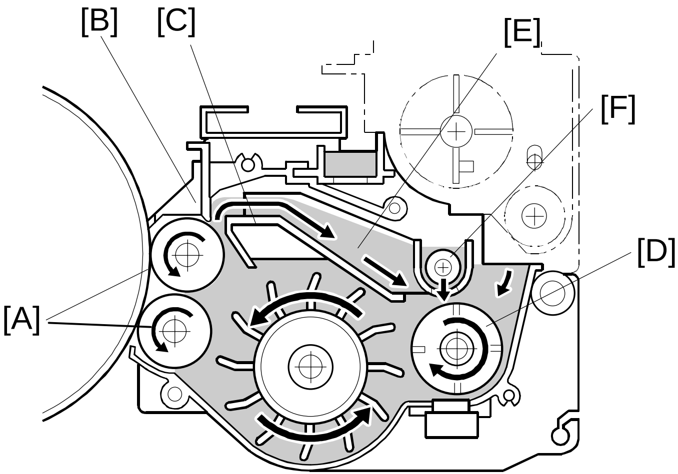
Example: Model A246

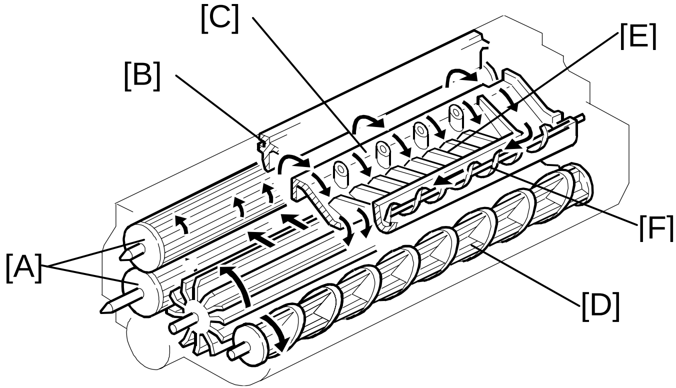
The high voltage control Board [A] applies the negative development bias to both the lower sleeve roller and upper sleeve roller through the receptacles [B] and the sleeve roller shaft [C].

The development bias prevents toner from being attracted to the background of the non-image areas on the OPC drum where there is residual voltage. In addition, the development bias adjusts image density according to the conditions the customer selected.



Crossmixing





The illustrations above show a standard cross-mixing mechanism. Most dual component development systems use a mechanism like this to keep the toner and carrier evenly mixed. This mechanism also helps agitate the developer to prevent developer clumps from forming and helps create the triboelectric charge (an electric charge generated by friction) on the toner and carrier.

The developer on the turning development rollers [A] is split into two parts by the doctor blade [B]. The part that stays on the development rollers forms the magnetic brush and develops the latent image on the drum. The part that the doctor blade trims off goes to the backspill plate [C].

As the developer slides down the backspill plate to the agitator [D], the mixing vanes [E] move it slightly toward the rear of the unit. Part of the developer falls into the auger inlet and the auger [F] transmits it to the front of the unit.

The agitator moves the developer slightly to the front as it turns, so the developer remains evenly distributed in the development unit.

Development Seal

Development units have several seals to prevent toner from spilling out into the copier. Usually there are an upper (or inlet) seal, a lower seal, and side seals. In some cases, the upper seal is a brush seal and actually contacts the drum. In other development units, the upper seal is positioned close to the drum to prevent particles from scattering upward. The development unit side seals, are in contact with the drum ends (out of the image area) preventing toner scattering from the ends of the unit. The lower seal is positioned to catch falling particles.

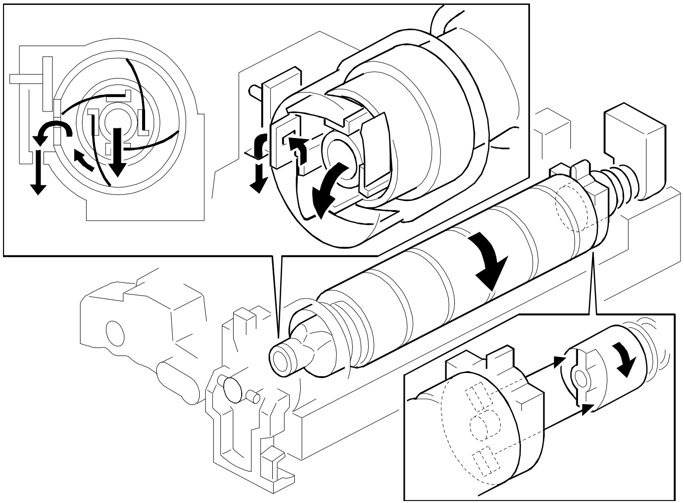
Toner Supply

In order to keep the toner density (ratio of toner to carrier) constant the development mechanism must have a way of adding toner to the developer. This is called the toner supply mechanism.

The toner supply mechanism cannot just dump toner into the development unit. To avoid fluctuations it must add small, measured amounts of toner in response to the *toner density control* system. (Also see *Toner Supply Control* in the Color Development section.)

There are many ways of designing a toner supply system. Here we will look at a couple of standard mechanisms.

Example 1: Model A193



This machine uses a toner bottle that has a spiral groove in it. When the toner supply drive mechanism is activated, the toner bottle rotates and the groove moves toner to the mouth of the bottle, where toner spills into a small hopper. Turning mylar blades move the toner to an opening in the side of the hopper and the toner drops into the development unit. The amount of toner added depends on the length of time that the toner supply mechanism rotates.

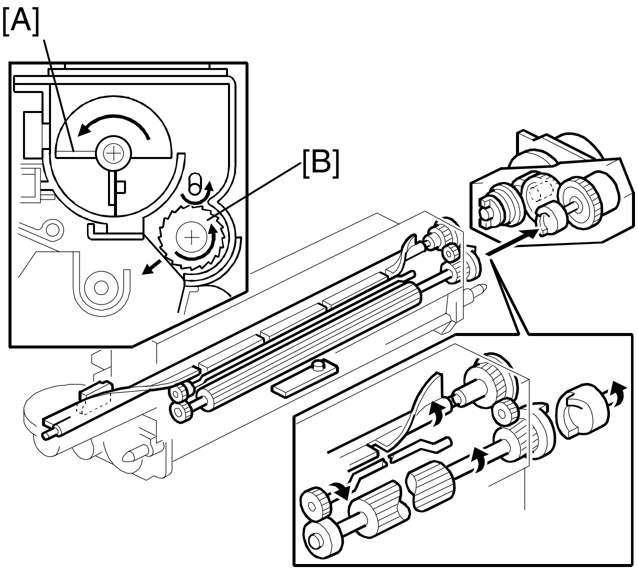
Toner supply mechanisms similar to this one are used in many machines.

Example 2: Model A246

The illustration to the right is an example of the most common structure for a toner supply system. The toner hopper, which is larger than the one in the previous example, is mounted on top of the development unit and runs the full length of the development unit.

An agitator [A] inside the toner hopper stirs the toner to prevent clumps from forming.

The toner supply roller [B] blocks the opening to the development unit. When the toner supply roller rotates, the grooves on the toner supply roller catch the toner. Then, as the grooves turn past the opening, the toner falls into the development unit.



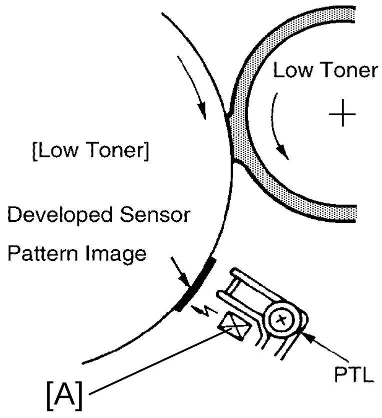
Toner Density Control

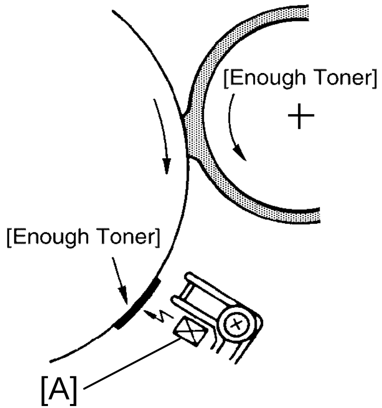
The toner density control system senses the density of toner in the developer mixture and activates the *toner supply* mechanism to add toner when the ratio of toner to carrier becomes too low. Some machines measure the toner density directly, others use an indirect sensing method, and still other machines use a combination of direct and indirect sensing.

Indirect Sensing

The CPU indirectly checks toner density by sensing the image density of a sensor pattern developed on the photoconductor.

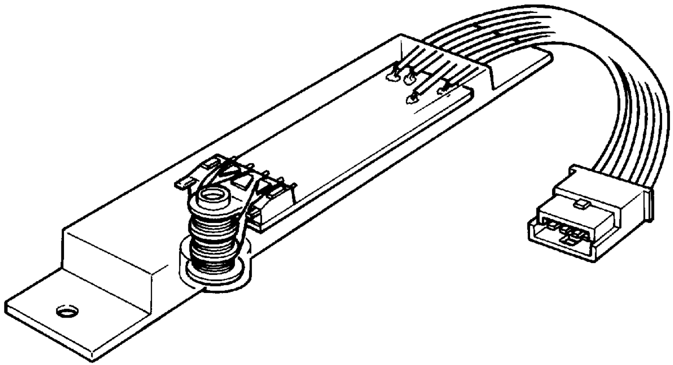
During image density check cycles, the sensor pattern is exposed prior to exposure of the original. After the sensor pattern is developed, its reflectivity is checked by the image density sensor [A] (which is a photosensor). The CPU notes the strength of reflectivity. If the reflected light is too strong, indicating a too low toner density condition, it adds toner to the development unit.



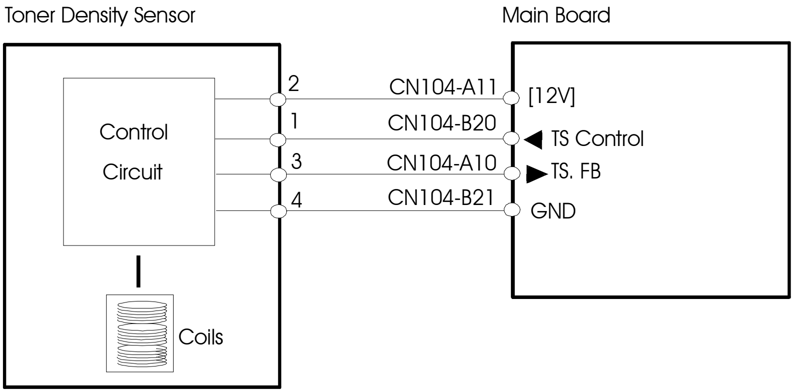


Direct Sensing

The illustration to the right is an example of a sensor used to directly measure the amount of toner in developer. (From *model A163*)



The active sensor element is a very small transformer with three coils. When iron ferrite (carrier) is near the sensor element, the inductance of the coils changes, causing the current through the transformer to change. As the amount of toner in the developer increases, the effect of the carrier particles decreases and the voltage applied to CN104-A10 decreases. Conversely, when the toner concentration drops as toner is used up, the effect of the carrier on the sensor coils increases and the voltage at CN104-A10 increases.



The CPU monitors the output at CN104-A10 and when the voltage at CN104-A10 reaches a level that indicates toner density is too low, the toner supply mechanism adds an appropriate amount of toner to the developer.

Toner End Detection

Some machines detect the toner end condition directly using a sensor or mechanical detection mechanism. Others detect toner end indirectly based on the toner density.

Indirect Toner End Detection

Some machines use the output of the image density sensor to determine when it is time to add toner. (Examples are models A166 and A110.) Other machines use the output from the toner density sensor. (An example is model A219.)The details of how the CPU decides when toner has run out depend on the control program and vary from machine to machine. However, there are some overall similarities.

Toner end detection proceeds in two steps. First, if toner density stays too low for a certain number of machine cycles, the CPU decides that a toner near end condition exists. In this condition, the CPU generally monitors the toner density more closely and increases the amount of toner supplied to the developer. Copying or printing is possible during the near end condition, but generally an Add Toner indicator blinks.

The machine proceeds to the second step if the toner near end condition persists for more than a predetermined number of cycles—typically 50 copies. The CPU then determines (based on the control program) that a true toner end condition exists, and it inhibits copying and lights an Add Toner indicator.

Example 1: Model A110 (Image density sensor)

Toner Near End Condition

When (Vsp/Vsg x 100) becomes greater than 22.5, the toner density detection cycle changes from every 10 copies to 5 copies. When this condition is detected three times consecutively, the toner supply ratio becomes two times the amount of toner supply level 4. The resulting toner supply ratio is 60%, and the ID sensor data is 236. Then, when this condition is detected five times consecutively, the CPU determines that it is the near end condition and starts blinking the Add Toner indicators.

Toner End Condition

After the Add Toner indicator starts blinking (Near Toner End Condition), the operator can make 50 copies. If the toner cartridge is not replaced within 50 copies, copying is inhibited and a toner end condition is determined. In this condition, the Add Toner indicator lights.

Example 2: Model A219 (Toner density sensor)

Toner Near End Condition

If the CPU detects toner supply level 6 (VT ³ VTS + 4S/5) five times consecutively, the toner end indicator blinks and the machine goes to the toner near end condition.

In this condition, the toner supply motor is energized for 10 seconds for every copy (this time can be changed using SP35). Also, the toner supply motor stays on continuously between pages of a multi-copy job.

If a toner sensor voltage lower than VTS + 4S/5 is detected twice consecutively while the toner supply motor is on, the machine recovers from the toner near end condition. Also, if this condition is detected during the normal copy cycle, the toner near end is canceled.

Toner End Condition

If toner supply level 6 is detected, the machine supplies toner between copies and for 10 seconds after the copy job is finished (as explained above). While the toner supply motor is on, if the CPU detects toner supply level 7 (VT ^{3} VTS +S) three times consecutively, a toner end condition is detected and copier operation is disabled.

If the toner sensor voltage stays at level 6 after the toner near end condition is detected, 50 more copies can be made. After 50 copies, the toner end indicator lights and copying is disabled.

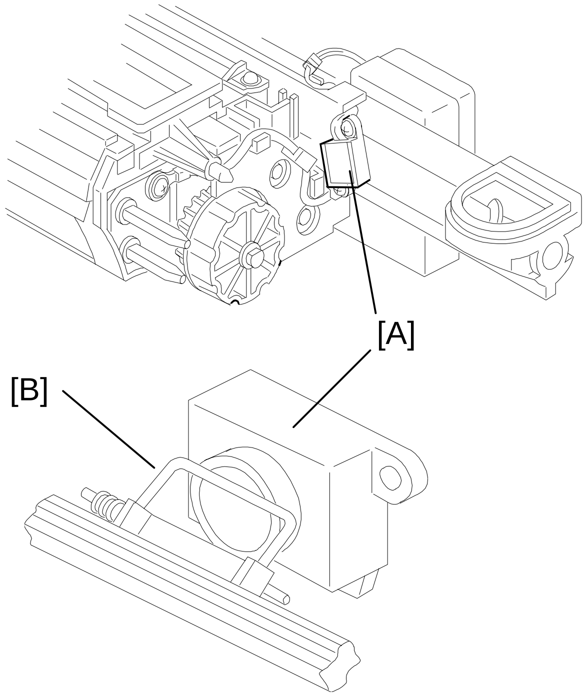
Direct Toner End Detection

Toner end is sensed directly using either a sensor or a mechanical mechanism. Here we will look at one example of each

Toner end sensor

Many machines use a piezoelectric sensor [A] to detect whether or not there is sufficient toner in the toner supply unit. This type of sensor is sensitive to pressure. Pressure from toner in the toner supply unit causes the sensor to output a high signal. When there is not much toner in the unit, the pressure of toner on the toner end sensor becomes low and the sensor outputs a low signal (0V). To prevent false readings, the toner end sensor is cleaned by a spring [B] on the toner agitator shaft.

The details of what happens when the sensor outputs a low signal vary depending on the machine; however, there are three major steps. First; the toner bottle turns to add toner to the toner supply unit. Then, if the sensor still has a low output after a specified interval, the machine changes to the toner near-end condition and the Add Toner indicator starts blinking. Finally, if the toner near-end condition persists for a programmed number of machine cycles (generally 50 copies), the machine enters the toner end condition and operation is disabled.



Mechanical Toner End Detection

Several mid and high volume photocopiers use the mechanism shown to the right to check the amount of toner remaining in the toner tank.

The toner near end feeler [A] has a magnet [B] and is installed on the toner mixing vane drive shaft [C]. The toner near end sensor [D] is located underneath the toner tank (outside) and has a sensor actuator [E], which also has a magnet. When the toner tank has enough toner, the toner near end feeler does not lower due to the resistance of toner.

When the to amount of toner remaining in the toner tank becomes below approximately 250 grams, the near end feeler lowers and magnetic repulsion pushes down the sensor actuator. This actuates the toner near end sensor. When the main PCB senses the toner near end sensor actuation three times in a row, the toner near end condition is displayed on the CRT screen to let the operator know to replace the toner cartridge. In the toner near end condition, copies can be made until the ID sensor detects toner end.

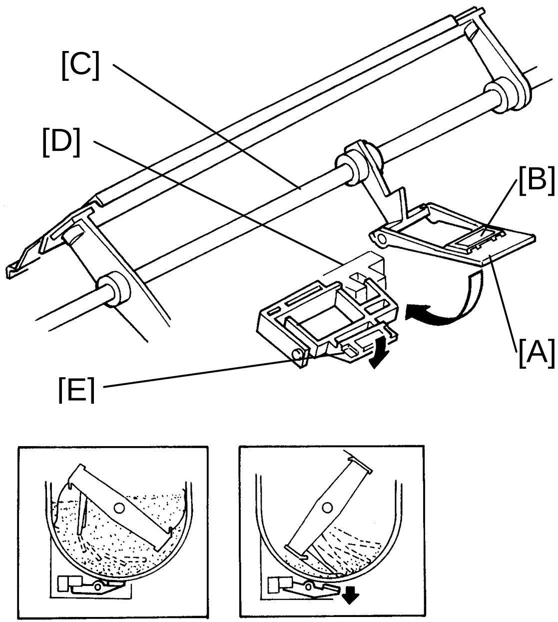
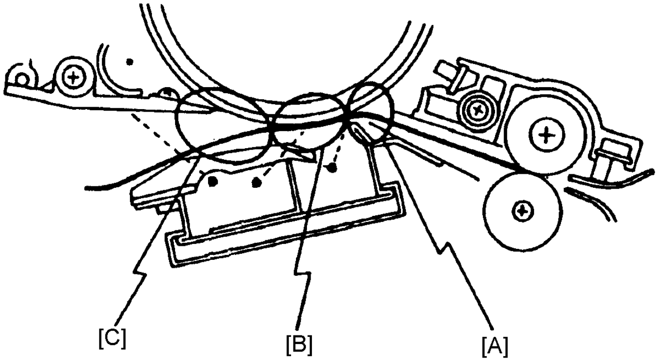


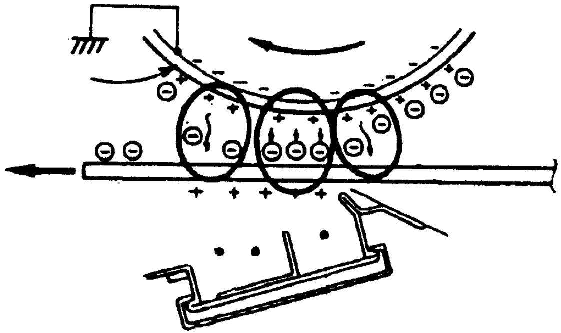
Image Transfer And Paper Separation

Overview

The transfer and separation process can be broken down into the three areas shown to the right.



Area A: Pre-transfer
Just before the image transfer process starts, guides direct the paper against the photosensitive surface of the drum (or belt). The mechanism is structured so that the transfer charge does not reach this area, and therefore, the paper can achieve complete contact with the photoconductor before image transfer starts.



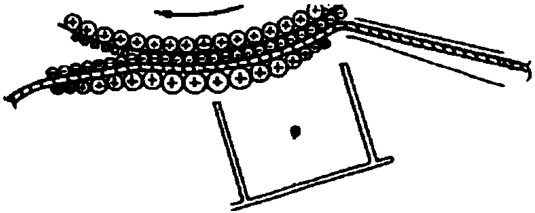
Area B: Image Transfer
This is the area where the image is actually transferred from the photoconductor to the paper. Generally, an electrostatic charge is applied to the back of the paper to pull the oppositely charged toner from the photoconductor to the paper.

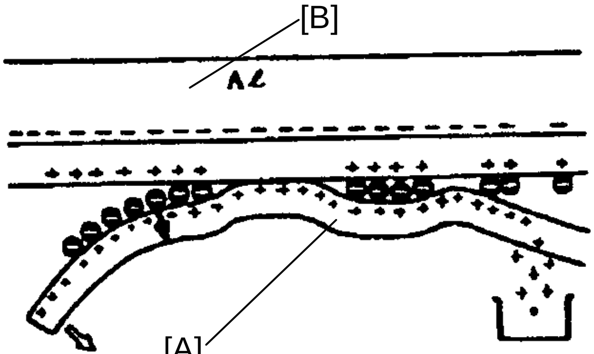
Area C: Paper Separation
The paper separates from the photoconductor after the toner image is transferred. This is usually

achieved by applying an ac corona to the back of the paper to eliminate the previously applied transfer charge. Pick-off pawls are also used to physically separate paper of low stiffness from the drum.

Corona Transfer And Separation

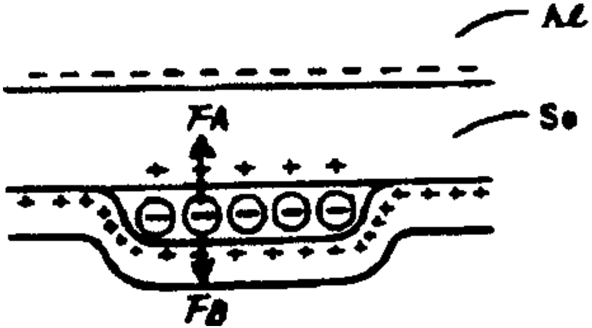
Image Transfer





In the image transfer process, the toner image on the photosensitive material (drum surface) is moved onto the copy paper.

As the paper enters the transfer area, a corona applies a charge to the reverse side of the copy paper [A]. This charge induces an opposite electrostatic charge in the drum's substrate [B] (usually aluminum) The resulting electrostatic force holds the paper close against the drum. This helps the transfer process.

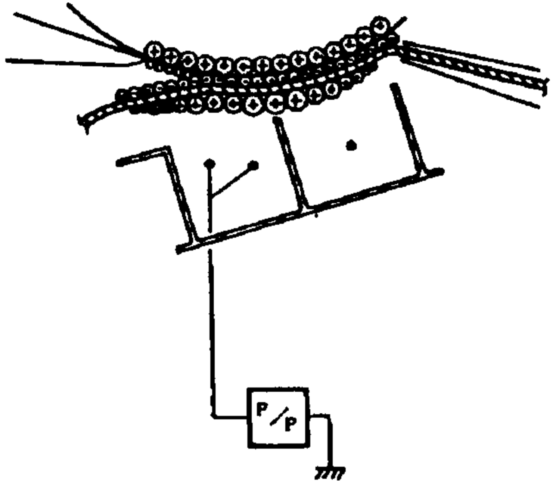


The charge on the reverse of the paper also attracts the toner because the polarity is opposite to the charge on the toner. Since, this attractive force (F_A) is designed to be greater than the attractive force holding the toner to the drum (F_B), the toner attaches to the paper

Paper Separation

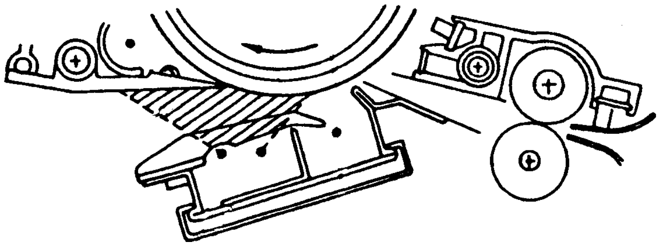
During the separation process, the copy paper with the toner image on it separates from the photoconductor. The paper can be separated either mechanically or electrostatically (or by a combination of both). Recent Ricoh copiers use the electrostatic method.

The charge given to the paper during the image transfer process causes the paper to cling to the photosensitive material. This makes it difficult to strip the paper from the drum. Therefore, an AC corona applied by the separation corotron neutralizes the charge on the paper in order to break the attraction between the drum and the copy paper. The paper then separates from the drum because of the rigidity and the weight of the paper.



The pick-off pawls provide a mechanical backup for the separation process. Normally, they are not needed. However, when the corona separation function is not sufficient for some unknown reason, they force paper separation.

The section with the diagonal lines in the illustration on the right shows the areas where the charge on the paper is eliminated by the separation corotron. This requires the use of two wires to create a wide-angle corona.



Belt Transfer and Separation

Advantages Of The Transfer Belt System

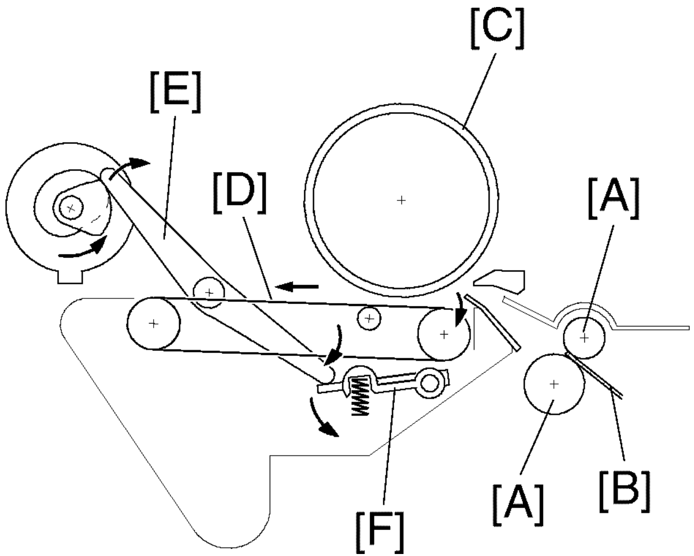
Many models use a transfer belt unit instead of a transfer and separation corona unit. The transfer belt process has the following advantages:

- Since the copy is held closely against the transfer belt, there is little chance of the paper lifting off of the belt during transport, making it less likely that creases and jams will be produced at the fusing unit inlet, and also reducing image blurring.
- As the paper adheres to the belt during transport, the transport performance is stable, even with smaller paper sizes, such as postcards.
- Because the belt and printing paper maintain close contact, an excellent separation performance over a wide range of paper types is ensured.
- As high voltage charge wires are not used, there is no problem with electrical leaks from charge wires.
- There is no trailing edge white margin on copies.
- It improves the printing efficiency and also enhances the printing performance on paper with a higher moisture content.
- A transport fan is not required.

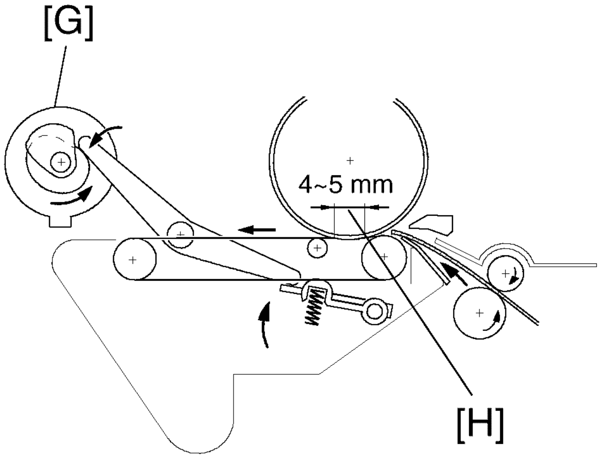
Belt Transfer and Paper Separation Mechanism

The following is a discussion of the operation of a typical transfer belt mechanism. This example is based on the Phoenix series (*model A156*).

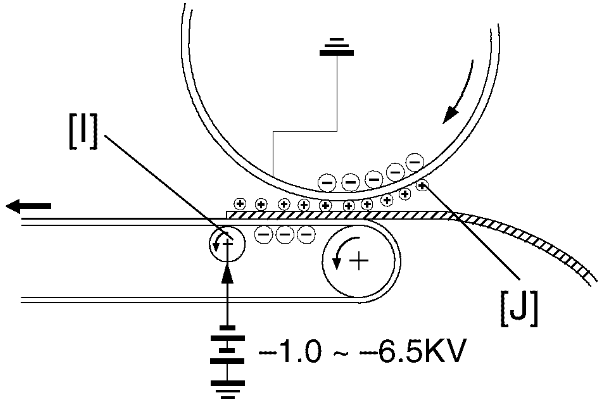
1. The registration rollers [A] start feeding the paper [B] to the gap between the OPC drum [C] and the transfer belt [D] at the proper time to align the leading edges of the paper and the image on the drum. The transfer belt does not contact the OPC drum at this moment (the on-off lever [E] pushes down the transfer belt lift lever [F]).



2. Before the leading edge of the paper reaches the gap between the transfer belt and the OPC drum, the transfer belt contact clutch [G] rotates one third of a complete rotation to release the on-off lever. Then, the transfer belt lift lever pushes up the transfer belt as a result of spring pressure. The contact width [H] is about 4 ~ 5 mm.

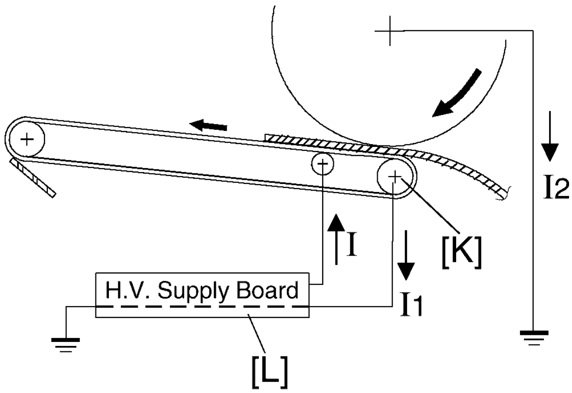


3. Then a negative potential of –1.0 ~ –6.5 kilovolts is applied to the transfer bias roller [I]. The negative charge attracts the positively charged toner [J] from the OPC drum. It also attracts the paper and separates the paper from the OPC drum.

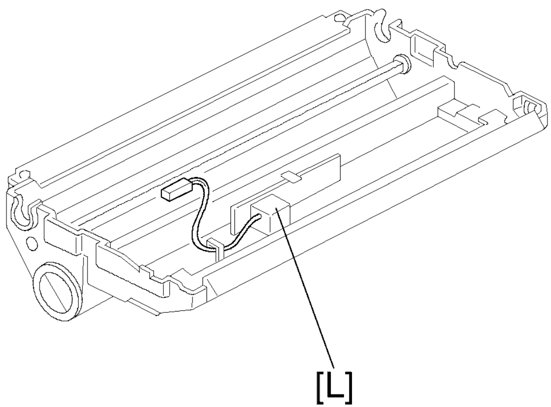


4. After the image transfer is completed, the charge on the transfer belt holds the paper on the transfer belt. Excess charge on the paper and the transfer belt is discharged during rotation via the grounded idle roller [K].

When the transfer high voltage supply board [L] inside the transfer belt unit provides high voltage to the transfer bias roller, a small current ($I2$) flows to ground via the transfer belt, the paper, and the OPC drum. It is important that this current stays constant even if the paper, environmental conditions, or the transfer belt surface resistance change. The positive feedback of $I1$ to the power supply board causes the voltage to increase and decrease with $I1$ so that ($I2$) remains constant. (The relationship is $I2 = I - I1$.)



$$I2 = I - I1 = \text{constant}$$



Drum Transfer

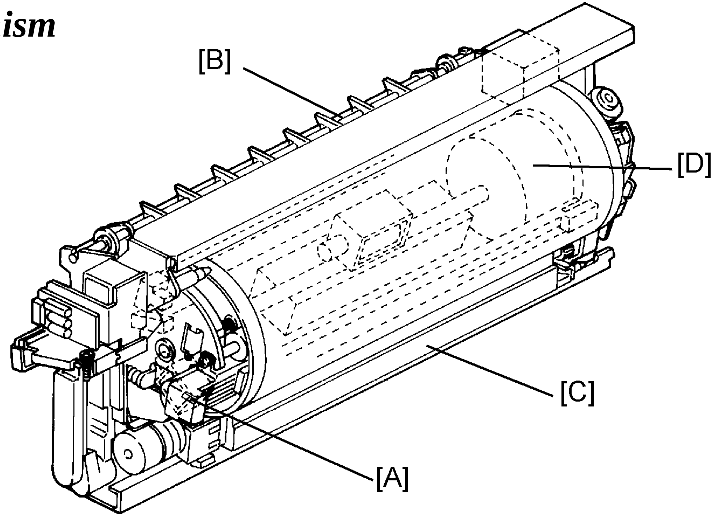
Basic Concept

Some color copiers (models *A072*, *A030*) use a drum to transfer the image from the photoconductor to the paper. This is actually a variation of the corona transfer and separation process
This process uses a second drum, the transfer drum, which rotates in contact with the OPC drum (photoconductor). The copy paper is held on the surface of the transfer drum, which makes several rotations to transfer the various colored toners. The image is transferred electrostatically using a corona.

Drum Transfer And Paper Separation Mechanism

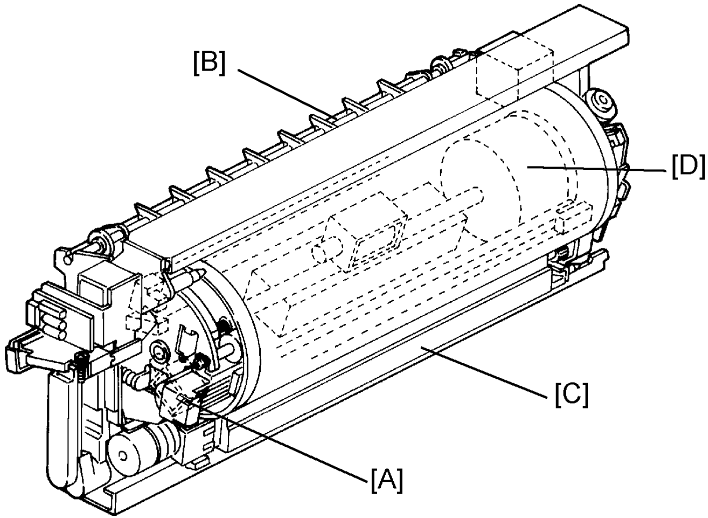
Example: Model A072

The registration rollers feed the copy paper to the transfer drum, where the leading edge of the paper is secured by a clamp. The transfer corona unit [A] is located inside the transfer drum unit. A high negative charge is applied to the transfer corona wire and the corona wire generates negative ions. The negative ions are applied to the copy paper and the negative charge attracts the positively charged toner away from the drum and onto the paper. At the same time, the copy paper is electrostatically attracted to the transfer sheet.



The transfer drum motor [D] drives the transfer drum directly. The number of transfer cycles depends on the number of colors being copied and the copier mode.

After the necessary number of transfer cycles, the clamp releases the leading edge of the paper and lifts it slightly. The leading edge of the paper catches on the pick-off pawls [B], which separate the paper from the transfer drum. The separation corona wire applies an AC charge to the paper in order to break the attraction between the paper and transfer drum.



The cleaning unit [C] for the transfer drum is located at the bottom of the transfer drum. During the copy cycle, the cleaning unit is not in contact with the transfer drum. After the copying sequence is completed, the cleaning unit moves against the transfer drum. This cleaning unit removes toner that gets on the transfer sheet as the result of paper misfeeds.

Note: The "transfer sheet" is a thin sheet of polyester film that forms the surface of the transfer drum.

Pre-Transfer Potential Reduction

Purpose

To improve image transfer efficiency, prevent *offset images* and improve cleaning efficiency, the electric potential on the photosensitive material surface is reduced, after the development process. There are two commonly used methods—the pre-transfer lamp method and the pre-transfer corona method.

Pre-Transfer Lamp (PTL)

After the latent image is developed but before the image is transferred to the copy paper, the photoconductor surface is illuminated by a lamp. This illumination functions in much the same way as the exposure process. The light neutralizes some of the charge on the photoconductor, and thus reduces the attraction of the toner to the photoconductor. This prevents the toner particles from being re-attracted to the photoconductor during the paper separation process. It also makes image transfer and paper separation easier.

Pre-Transfer Corona (PTC)

Some copiers use an alternating current corona prior to image transfer. This is referred to as the pre-transfer corona unit or PTC. The ac charge decreases the charge on the drum and makes paper separation easier.

Ricoh uses the PTC process only in higher speed copiers that require quick image transfer and paper separation.

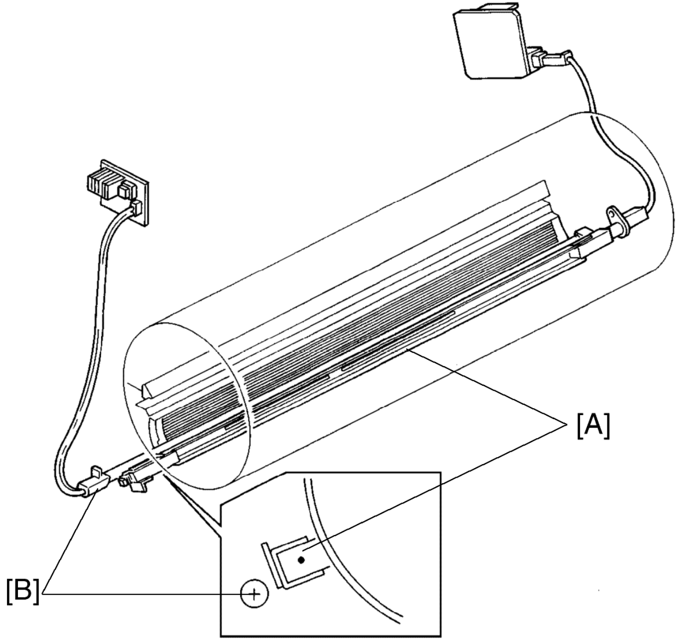
Example: Models A170/A171

Model A170/A171 (Thunderbird) copiers use both a PTC and a PTL.

The pre-transfer corona (PTC) [A] and pre-transfer lamp (PTL) [B] are used to prevent incomplete toner transfer and pick-off pawl marks on the copy.

To prevent incomplete toner transfer, the PTC reduces drum potential by applying an ac corona. The PTC also applies a dc negative charge at the same time to keep the toner potential negative.

The PTL further reduces the drum potential. Since the PTC gave a negative charge not only to the toner but also to the non-image (no toner) areas on the drum, PTL reduces the negative charge on the drum, which may attract copy paper and cause pick-off pawl marks.



Pick-off Pawls

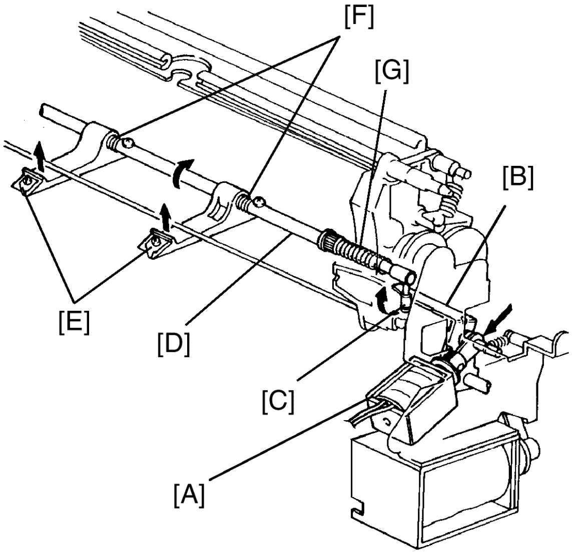
Purpose

Pick-off pawls are mechanical “fingers” that forcibly strip copy paper off of the photoconductor. In Ricoh photocopiers they are usually employed as a safety device to prevent paper from wrapping around the drum.

Example: Model A053

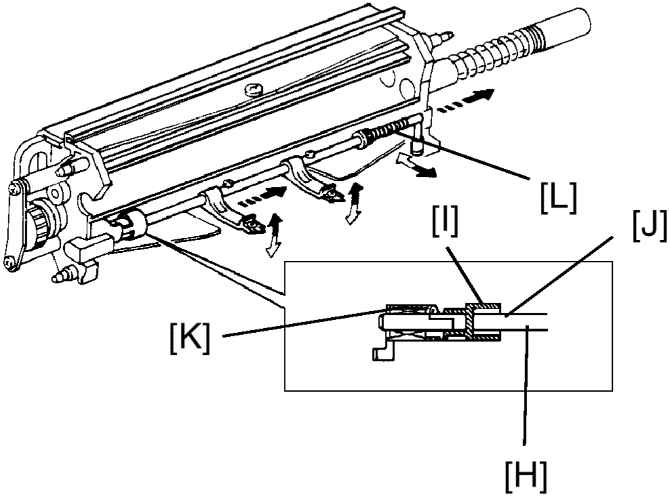
Touch-and-Release Mechanism

The pick-off solenoid [A] energizes just after the registration rollers turn on. The pick-off lever [B] rotates counterclockwise (rear view) and pushes the pawl shaft pin [C]. The pawl shaft [D] then rotates clockwise and the pick-off pawls [E] touch the drum. The pawl springs [F] hold the pick-off pawls on the shaft and prevent them from touching the drum too strongly. When the leading edge of the paper passes the pick-off area and just before it reaches the fusing unit, the pick-off solenoid turns off. The pick-off shaft spring [G] then rotates the pick-off lever to move the pick-off pawls away from the drum.



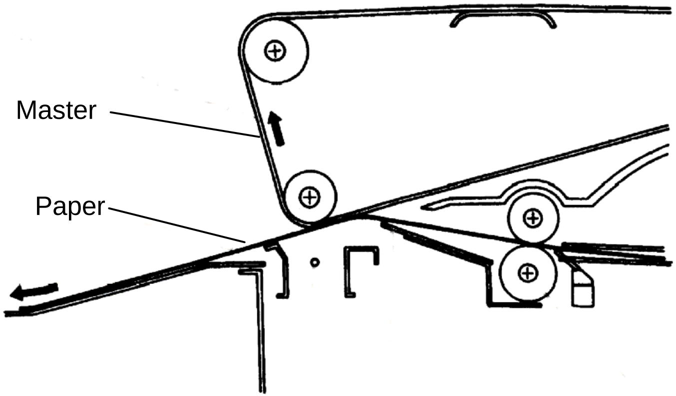
Side-to-Side Movement

The pick-off pawls do not always contact the drum in the same place but instead move slightly to the side on each copy cycle. The pick-off pawl shaft [H] and the cam rider [I] are joined by a one-way bearing [J]. Each time the pick-off pawl solenoid turns on, the one-way bearing causes the cam rider to turn together with the pick-off pawl shaft. As the cam rider turns, it and the pawl shaft are forced to move laterally by a cam [K]. When the pawl shaft rotates the pawls away from the drum, however, the cam rider does not turn. Pawl lateral movement is 0.1 to 0.2 millimeter per copy cycle. After moving about 8 millimeters, the cam rider passes the lobe of the cam and the pawl shaft is returned to its start position by the pawl shaft spring [G].



Curvature Separation

Some machines do not have a paper separation mechanism. In the illustration to the right (*model A027*), the master (OPC belt) turns at a sharp angle (approximately 90 degrees) just after the transfer point. Due to the paper's stiffness, it cannot make this sharp turn and separates without any assistance.



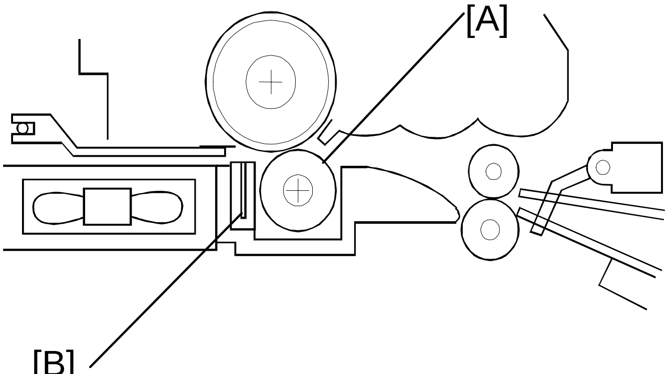
Transfer Roller + Discharger

Process Principles

Some machines use a transfer roller rather than a corona or belt to transfer the image to the copy paper.

Copy paper is fed between the transfer roller and the surface carrying the toner image (either a drum or a transfer belt). The transfer roller is given a charge opposite to the charge on the toner; so, the toner is attracted to the paper. After image transfer, a discharger removes the charge given to the paper by the transfer roller, and this allows curvature separation to take place.

Example 1: Model A193



Instead of using a transfer wire or a transfer belt, this machine uses a transfer roller [A], which touches the drum surface.

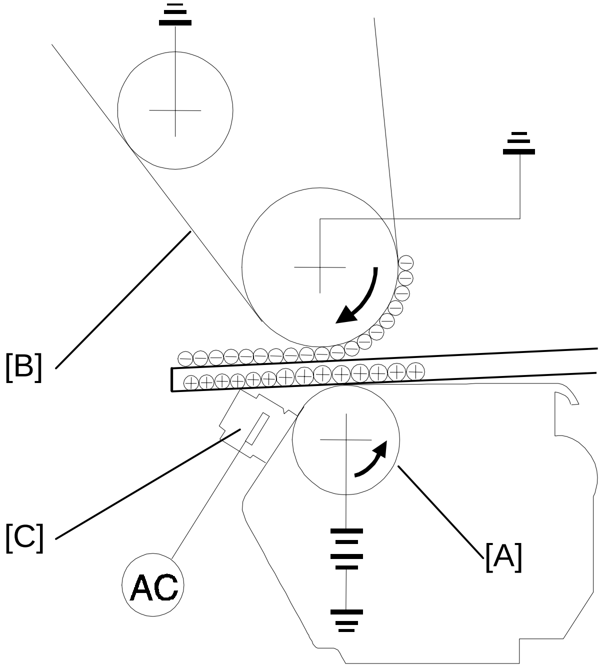
The high voltage supply board supplies a positive current (approximately +15 mA) to the transfer roller. The roller has a high electrical resistance, so it can hold a high positive electrical potential to attract toner from the drum onto the paper.

There is a discharge brush [B] after the transfer roller. The curvature of the drum and the discharge brush help the paper to drop away from the drum.

Example 2: Models A172/A199

The transfer roller [A] contacts the transfer belt [B] and starts rotating at the same speed as the transfer belt. Copy paper is fed to the nip band between the transfer belt and transfer roller aligned with the lead edge of the full color image. A high positive voltage is applied to the transfer roller to attract toner onto the paper.

A high ac voltage is applied to the discharge plate [C]. This discharges the remaining electricity on the paper to help the paper separate from the transfer belt.



Cleaning

Overview

Cleaning refers to the process of removing any toner remaining on the photoconductor (drum or OPC belt) after the imaging process is complete to prepare the photoconductor for the next copy/print cycle. The cleaning step also removes any paper dust on the photoconductor surface.

Cleaning is necessary before a new copy cycle or print cycle can start. If the cleaning step were not included in the copy process, the background of images would become progressively darker and dirtier.

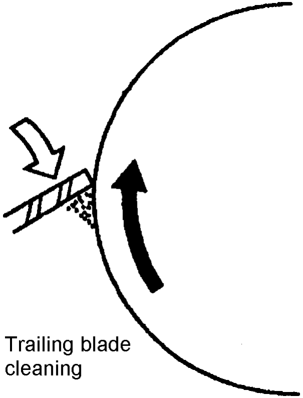
All cleaning systems use a cleaning blade or a cleaning brush or both. Additionally, all cleaning systems have a mechanism for collecting and storing (or recycling) the toner cleaned from the photoconductor.

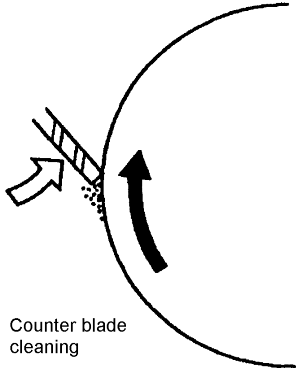
The most common cleaning systems use blades, and these are further divided into trailing-blade cleaning and counter-blade cleaning systems.

Cleaning brushes all rotate in contact with the photoconductor. There are also two types of cleaning brushes—fiber brushes and magnetic brushes.

Some cleaning systems also use a corona (pre-cleaning corona) to prepare the drum and toner for cleaning.

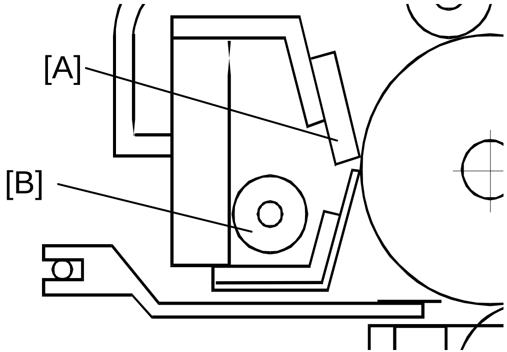
We will look at examples of all of these mechanisms in this section.





Counter Blade

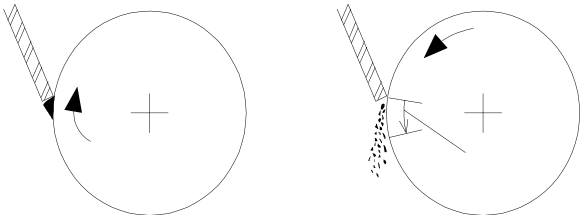
Counter blade cleaning is the most common method used in modern copiers. In comparison to the trailing blade method, counter blade cleaning causes less wear on the cleaning blade. Also, the blade has less of a tendency to ride over toner particles, significantly improving the cleaning performance.



Example: Model A193

The illustrations to the right show a typical counter blade cleaning mechanism.

The cleaning blade [A] removes any toner remaining on the drum after the image is transferred to the paper. The cleaning blade scrapes off the toner remaining on the drum and it falls onto the toner collection coil [B].



To remove the toner and other particles that are accumulated at the edge of the cleaning blade, the drum turns in reverse for about 5 mm at the end of every copy job,

Counter Blade + Brush

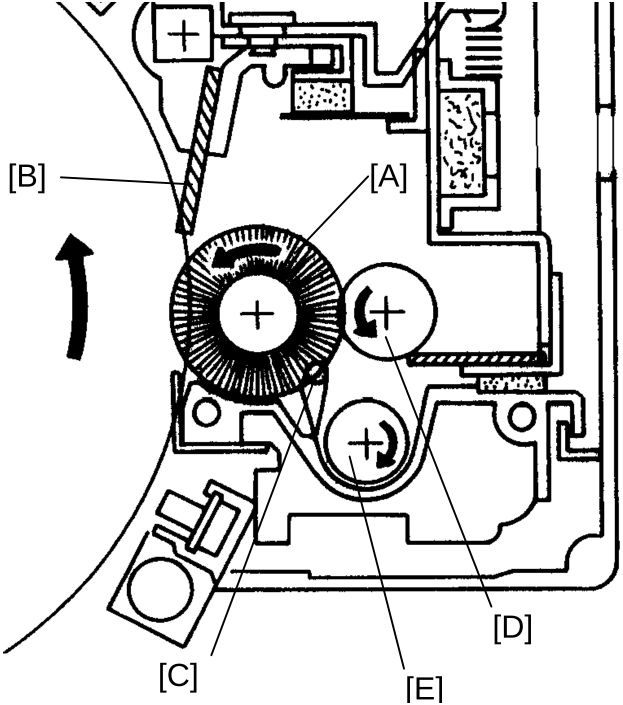
Some copiers, especially high-speed models, use a cleaning brush in combination with a counter cleaning blade. This increases the cleaning efficiency compared to systems using only a counter blade. The cleaning brush has a support function. The counter blade is the main cleaning component.

Example: Model A171

A cleaning brush [A] supports the cleaning blade [B] to improve cleaning. A looped-type brush is used for better efficiency.

The brush removes some of the toner from the drum surface and collects the toner wiped off the drum by the cleaning blade. The flick bar [C] and the flick roller [D] mechanically remove toner on the cleaning brush. Toner is transported to the toner cartridge by the toner collection coil [E].

To remove the accumulated toner at the edge of the cleaning blade, the drum turns in reverse for about 20 mm at the end of every copy job.



Trailing Blade + Brush

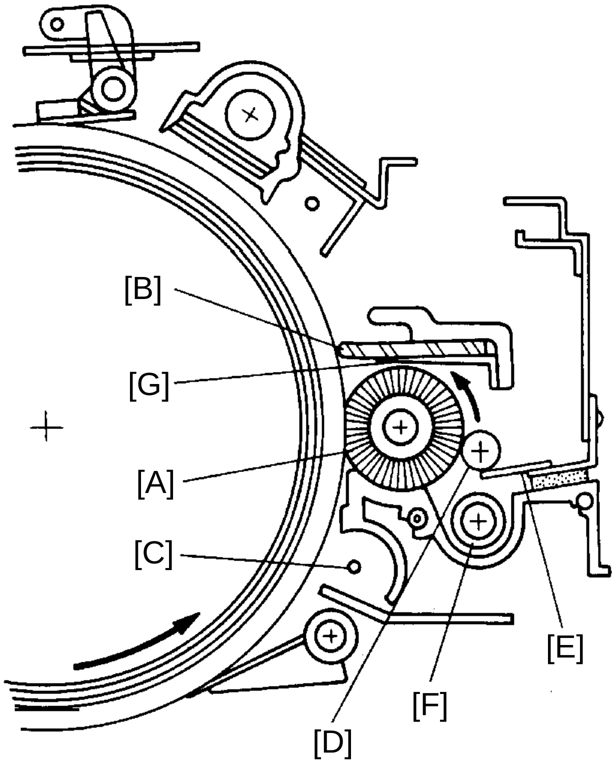
Many older copiers use a cleaning brush in combination with a trailing cleaning blade. Typically, in such systems, the brush does most of the cleaning with the cleaning blade as a supporting cleaning mechanism.

Electrostatic attraction is an important part of this type of cleaning system. A pre-cleaning corona is used to prepare the toner for removal and a bias is applied to attract the toner.

Example: Model A029

The illustration to the right shows the major components in a cleaning unit that uses a brush [A] and a trailing type blade [B] for cleaning.

The first step in the drum cleaning process is the application of the pre-cleaning corona [C]. The pre-cleaning corona has both ac and dc components. The ac component makes drum cleaning more efficient by reducing the drum's potential and weakening the electrical attraction between toner and the drum. The dc component of the corona gives a uniform negative



charge to the toner particles.

Next, the drum rotates past the cleaning brush. The brush moves in the opposite direction to the drum at the contact point. The brush, which is made of conductive acrylic carbon, receives a positive charge from the bias roller [D]. The brush removes the toner from the drum by both rubbing action and electrostatic attraction. The bias roller has a charge of +300 volts which attracts the negatively charged toner from the brush. The bias roller blade [E] scrapes off the toner from the bias roller.

Finally, the cleaning blade scrapes off any toner, paper dust, or other foreign material remaining on the drum. The toner collection coil [F] transports the toner to the rear end of the cleaning unit, From there, a collection mechanism returns the toner to the toner cartridge.

Paper dust or toner build up on the blade edge decreases the efficiency of the cleaning blade. To prevent this problem, the blade cleaner [G] (a strip of mylar) cleans the edge of the blade each time pressure is released.

Magnetic Brush

Magnetic brush cleaning is basically “development in reverse”. This method uses a magnetic roller and carrier to electrostatically lift the toner off of the photoconductor.

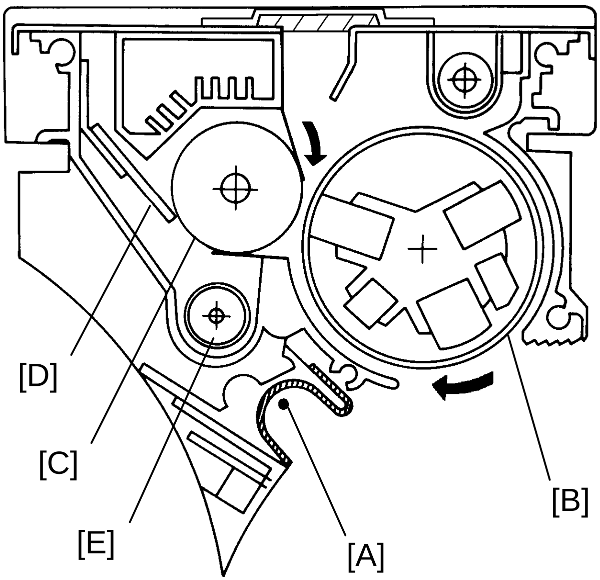
Example: Models A030 and A072

The illustrations to the right and on the next page show the cleaning unit used in models A030 and A072.

To ensure OPC drum cleaning, the pre-cleaning corona [A] applies an ac voltage with a positive dc bias to the surface of the drum. This gives the residual toner a uniform positive charge and neutralizes the negative charge on the drum.

The cleaning roller [B] looks like and operates similarly to a magnetic brush development roller. However, the attractive forces work in reverse. Internal permanent magnets in the cleaning roller attract cleaning carrier to the cleaning roller sleeve. The cleaning roller sleeve turns and carries the cleaning carrier to the OPC drum.

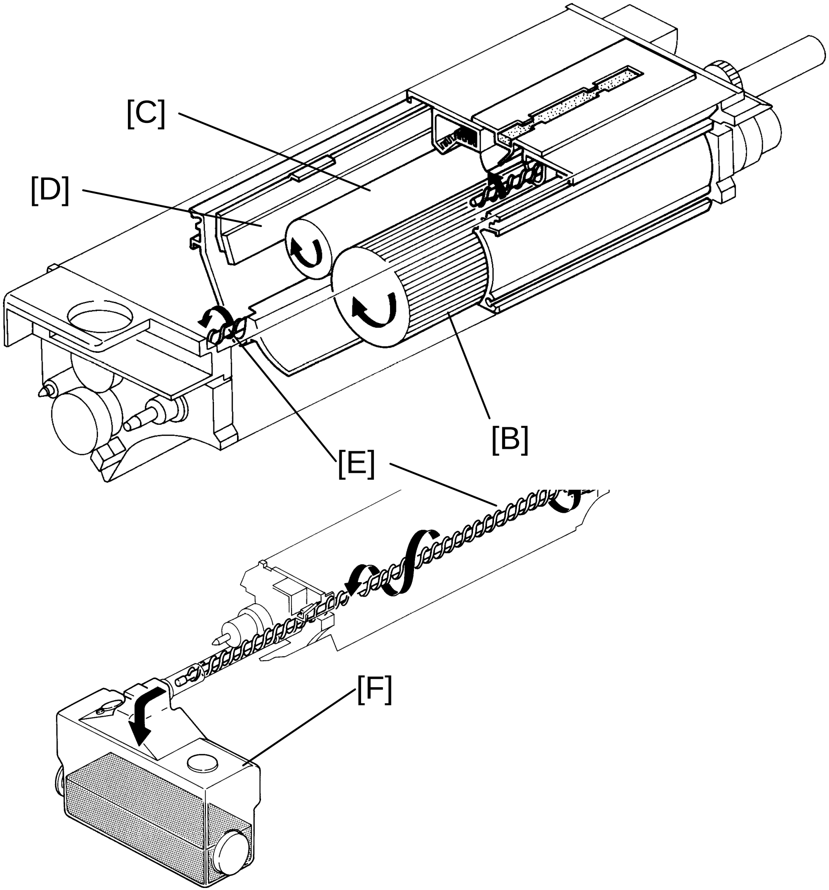
The cleaning carrier has a negative triboelectric charge as the result of contact between the carrier and toner particles in the carrier. (New cleaning carrier contains



1% toner.) This negative charge attracts the positively charged toner particles from the drum surface. A –150 V DC bias is applied to the cleaning roller to attract more toner particles from the drum.

The cleaning bias roller [C] (called a “scavenging roller” in some machines) is near the cleaning roller. The cleaning bias roller receives a –500 V charge, which is strong enough to separate the toner particles from the cleaner carrier on the cleaning roller and attract them to the cleaning bias roller. The cleaning carrier remains on the cleaning roller for the next cleaning cycle.

The bias roller blade [D] scrapes toner off the bias roller. The toner collection coil [E] transports the toner to the rear side of the cleaning unit, where it drops into the toner collection bottle [F].



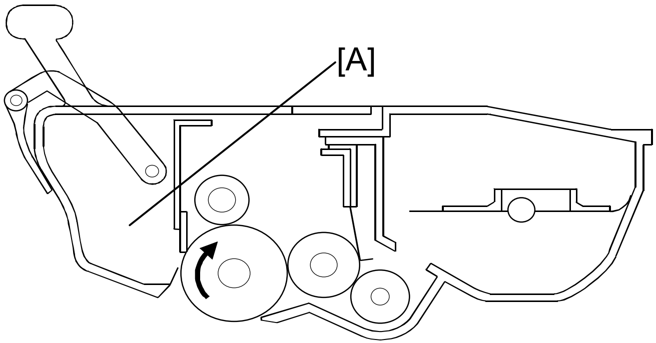
Used Toner Collection and Recycling

Once toner is cleaned from the photoconductor, something must be done with it. There are two options— (1) collect the used toner for later disposal or (2) recycle it. There is a cost versus image quality trade-off between the two options.

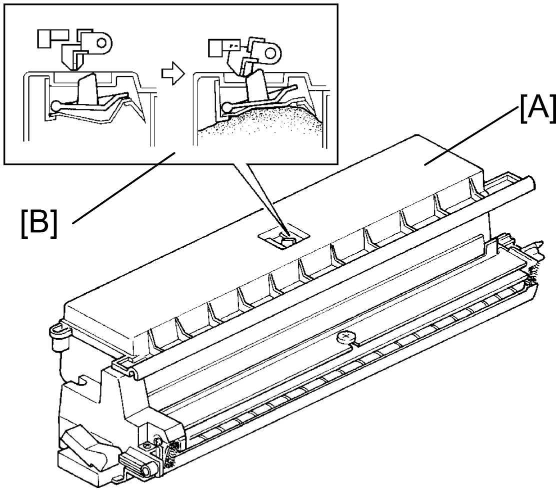
Recycling has the obvious advantage of reducing toner consumption and thus reducing cost per copy/print. However, even if it is carefully done, recycling to some extent damages the toner and degrades its triboelectric characteristics. Also, recycled toner tends to stick together and form clumps, and paper dust is collected along with the toner. For these reasons, image quality tends to be a problem in machines that recycle toner. This presents a challenge for engineers.

On the other hand, simply collecting the used toner prevents fewer design problems and makes it easier to maintain copy quality. However, the copy per cost increases. Also, the used toner container takes up space inside the machine, and some provision must be made for periodic disposal of the used toner.

Used Toner Collection



The location of the toner collection unit or used toner bottle varies. Smaller machines tend to have simple designs. For example, machines that use all-in-one cartridges such as *model G026* (shown to the right) have the used toner tank inside the cartridge. Such machines do not have a used toner overflow detection mechanism because the used toner tank [A] is large enough for the lifetime of the toner cassette.

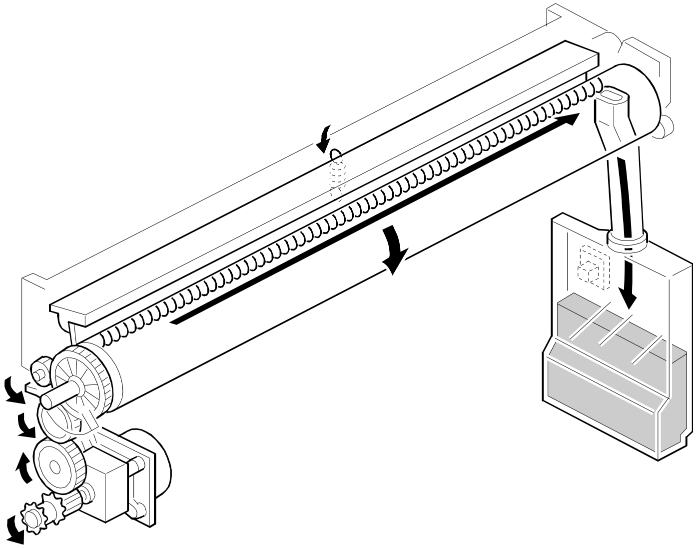


Other machines, especially low volume and mid volume products, mount the used toner tank directly on the cleaning unit. An example is *model A110*, shown to the right. The used toner tank [A] of this machine must be emptied periodically. The tank has a toner overflow detection mechanism [B] that stops copier operation when the used toner tank gets full. When the tank gets full, the pressure of the used toner pushes up a movable plate mounted in the top of the used toner tank. As this plate moves up, it raises the toner overflow actuator. When the actuator moves into the toner overflow sensor.

Larger machines have to transport used toner to a toner collection bottle. Typically, a helical coil does this.

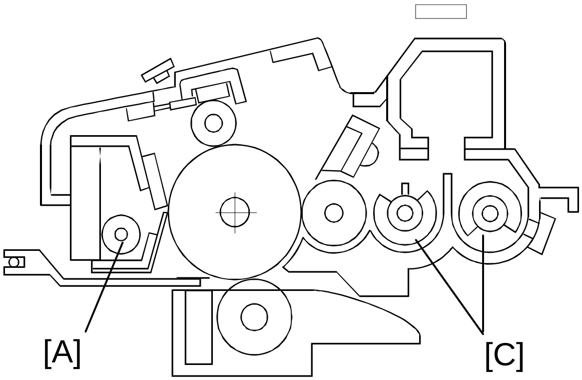
For example the toner recover mechanism of *model A174* (pictured to the right) has a toner collection coil [A], which moves used toner from the cleaning unit to the toner collection bottle [B]. The toner collection bottle capacity is enough to hold used toner from making 6 km (capacity: 4000 ml) copies. (This is a large format copier.)

A toner overflow sensor [C] detects when the used toner tank is full.



Recycling Used Toner

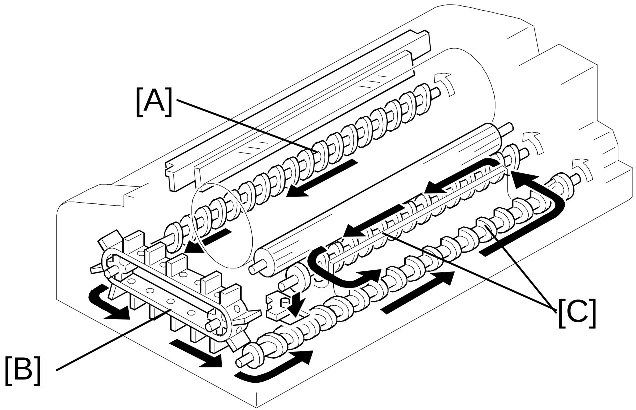
There are many configurations for toner recycling systems. All of them use helical coils to collect and transport the toner from the cleaning unit. Some of them return the used toner directly to the development unit. Others, mix the old toner with new toner first. We will look at a few examples.



Example 1: Model A193

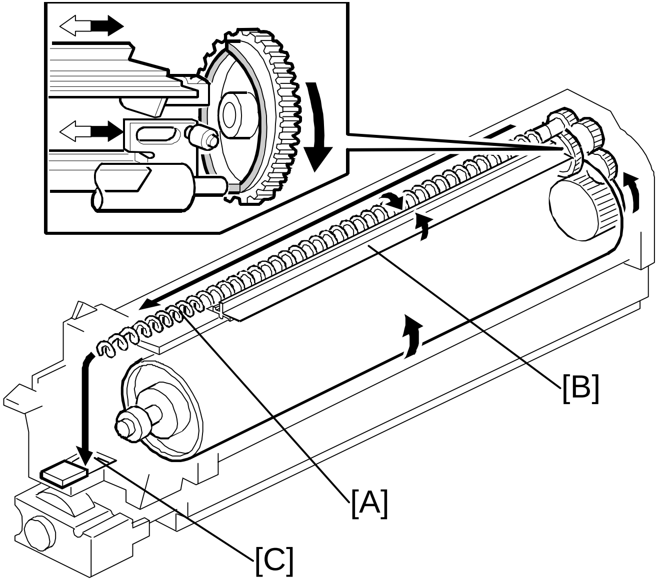
In this model, toner recycling is completely internal to a photoconductor unit (PCU). See the illustrations.

The cleaning blade removes any toner remaining on the drum after the image is transferred to the paper. This model uses a *counter blade* system. The toner removed by the cleaning blade falls onto the toner collection coil [A].



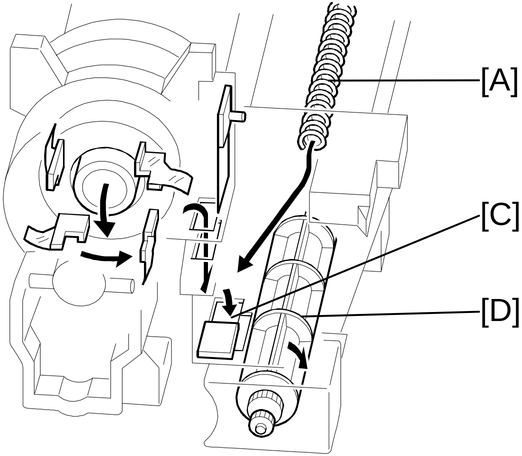
The toner collection coil transports the recycled toner to the transport belt [B] at the front of the PCU. The transport belt carries the toner to mixing auger 2. The two mixing augers [C] combine the recycled toner with the developer and new toner from the toner bottle.

Example 2: Models A230/A231/A232



The cleaning blade removes any toner remaining on the drum after the image is transferred to the paper. This model like the previous example uses a *counter blade* system. The toner is transferred to the toner collection coil [A] by the toner collection plate [B].

The toner collection coil transports the used toner to the opening [C] in the bottom of the PCU. Then, this toner falls into the development unit with new toner coming from the toner bottle and it is all mixed into the developer by the paddle roller [D].

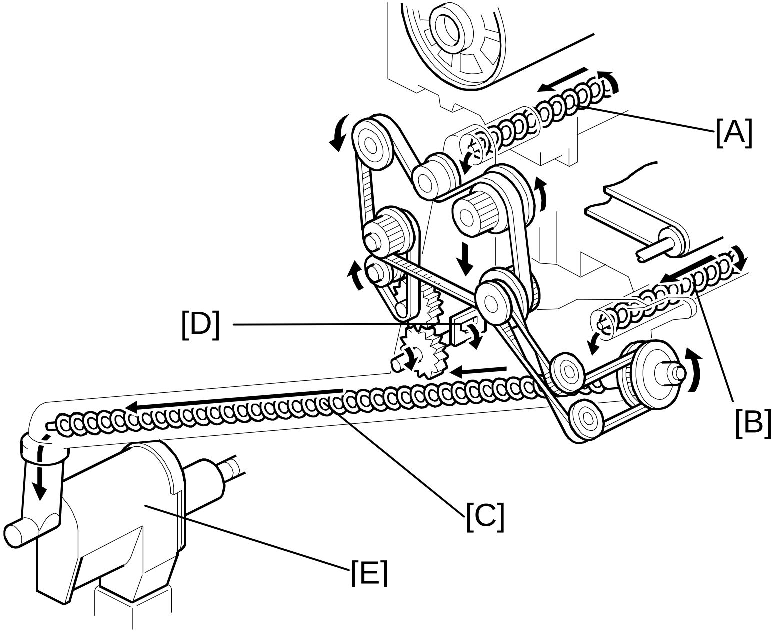


Example 3: Models A246/A247/A248

The toner recycling system of this model has a couple of unusual features. First, it recycles not only the toner cleaned from the drum but also toner cleaned from the transfer belt. Second, it filters the recycled toner.

Toner collection coils in the drum cleaning unit [A] and in the transfer belt cleaning unit [B] transport used toner to the toner transport coil [C]. To ensure good toner flow, a fin [D] breaks up the toner that drops from the tube of the drum-cleaning unit. The toner transport coil moves the toner through a tube to the filtering unit [E].

The filtering unit separates useable toner from toner that has adhered together into clumps. The useable toner is returned to the development unit, and the waste toner goes to a used toner bottle.



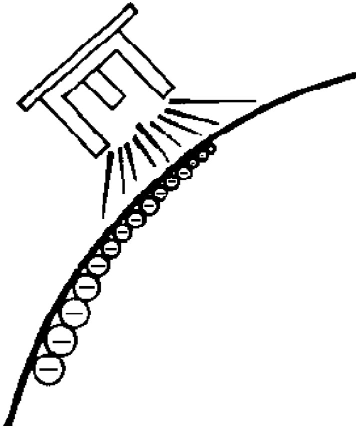
Quenching

Overview

Quenching is the process that eliminates any residual electric charge remaining on the photoconductor after the cleaning process. Quenching prepares the photoconductor for the charge step of the next copy or print cycle.

Several different methods are used to quench the photoconductor. The most common method is photo quenching using a lamp. Some machines use a combination of a dc corona and photo quenching. A few machines use an ac corona for quenching. The choice of quenching method depends on the type of photoconductor used and the details of the other steps of the copy process.

Photo Quenching



As the name implies, photo quenching uses the application of light to reduce the resistance of the photoconductor and thus eliminate the electrical charge. Photo quenching also stabilizes the drum sensitivity from the first cycle by pre-illuminating the drum.

Various types of lamp have been used for quenching lamps. LED arrays are the most common; however, cold cathode tubes, neon tubes, and fluorescent lamps have also been used.

- *LEDs* are inexpensive and compact, and it is easy to match the wavelength of the light to the spectral sensitivity of the photoconductor. However, LEDs output a relatively weak light.

- The *cold cathode lamp* has the characteristics of low power consumption and low heat output combined with strong, even light output covering a broad spectrum. However, it is more expensive (special power supply) than LEDs.
- The *neon tube* is cost effective; however, there is significant unevenness in the amount of light output.
- *Fluorescent lamps* output a strong, wide spectrum light, but they are the most expensive. Fluorescent lamps are used for quenching only in very high-speed photocopiers.

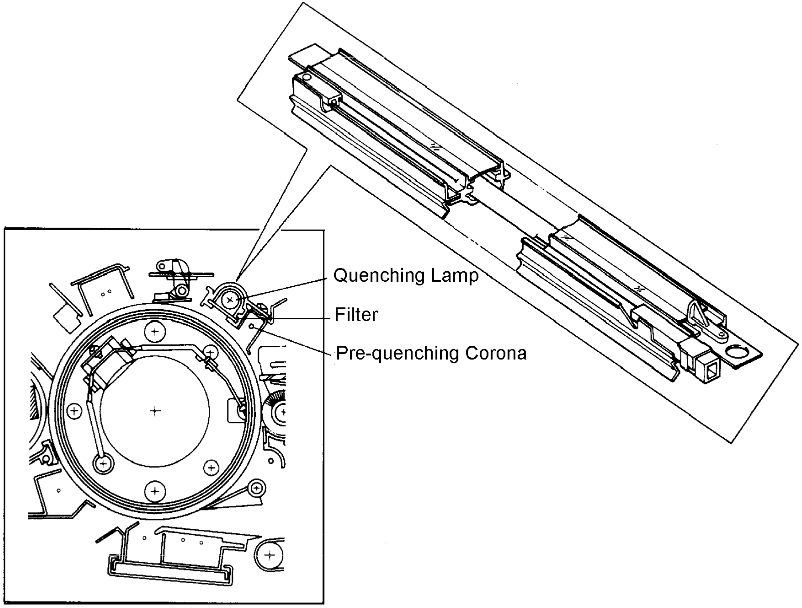
Various types of filters may be used depending on the copy process and photoconductor characteristics. For example when using a cold cathode lamp and an OPC drum, a yellow filter is usually used to reduce ultraviolet light which would cause light fatigue on the OPC drum.

DC Corona and Photo Quenching

This type of quenching involves two steps. First, the pre-quenching corona (PQC) applies a positive charge to the drum. This neutralizes any negative charge remaining on the drum from the pre-cleaning corona. Then, the quenching lamp neutralizes the positive charge. Two steps are required because the quenching lamp is less effective against negative charges than positive charges.

The quenching lamp also stabilizes the drum sensitivity from the first cycle by pre-illuminating (pre-fatiguing) the drum. The machine illustrated (*model A029*) uses a cold cathode lamp as the quenching lamp. The cold cathode lamp has characteristics of low power consumption and low heat output combined with strong light output.

In some machines (for example model A053), the PQC and quenching lamp are applied simultaneously.



Fusing

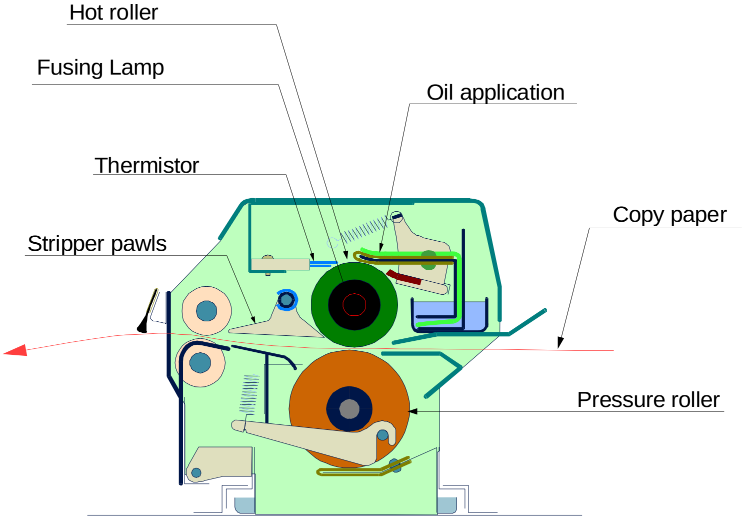
Overview

After the *image transfer and paper separation* steps, the image must be bound or "fixed" to the paper. Modern photocopiers and other machines (fax, printer) that use photocopier imaging processes, use resin based toners. To form a stable permanent image, the toner is heated to cause it to melt and soften. Simultaneously, pressure is applied to cause the toner to fuse with the fibers of the paper.

Heat-Roll Method

The heat-roll method is the most common way that Ricoh products use to fuse the toner image to paper. It is used in all types of machines from the lowest speed to high speed.

In the heat-roll fusing method, paper with dry toner particles on it moves between two rollers, the hot roller and the pressure roller. A quartz *halogen lamp* heats the hot roller from inside. When the paper comes in contact with the hot roller, the heat of the roller melts the toner. The pressure between the two rollers forces the melted toner into the fibers of the paper.



The Hot Roller

The hot roller is a hard-surfaced, hollow, metal tube with a halogen lamp at its axis. Toner tends to stick to the hot roller as well as the paper. To minimize this tendency, the hot roller is coated with non-stick Teflon.

Even with the non-stick coating, a small amount of toner still sticks to the hot roller. This toner contamination must be removed or it will be applied to subsequent copies, giving an offset image or dirty copies. This is usually done with a cleaning pad or with a cleaning roller. In many machines silicone oil is applied to the hot roller. The silicone oil acts as a lubricant and helps to prevent toner from sticking. (Refer to *Oil Supply* and *Cleaning* below.)

The Pressure Roller

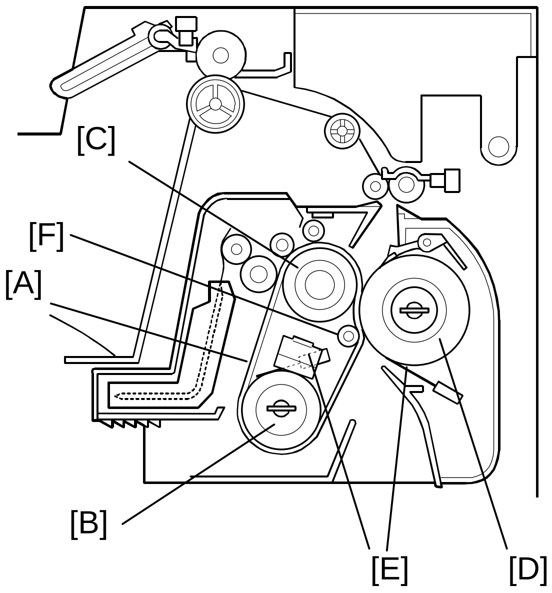
The pressure roller is a relatively soft roller made of silicone rubber. Silicone rubber is used because it is not easily damaged by the heat of the hot roller. Sometimes the roller surface is coated with Teflon. Since the pressure roller is soft, the pressure between the two rollers causes the pressure roller to deform slightly and creates a zone of contact called the “nip band”. The nip band extends the time that the rollers are in contact with the paper and helps to force the melted toner into the copy paper. If the pressure roller were a hard roller, the paper would contact the hot roller at only one point and the toner would not completely bond with the paper.

The hot roller and pressure roller are very slightly concave (spindle shaped) so that the pressure between them is a little greater near the ends than in the middle. This tends to pull the paper outward slightly at the edges and helps to prevent creasing of the paper.

Fusing Belt Method

The fusing belt method is similar to the heat roll method in that it uses heat and pressure to fuse the toner image to the paper. Although somewhat more costly than the heat-roll method, the fusing belt method is often used in color copiers and printers as it has less of a tendency to disturb or smear the layers of colored toner on the copy or print. Compared to the heat-roll method it has the following characteristics:

- The fusing belt [A] heats up quicker than a Teflon roller because it is heated by an aluminum heating roller [B]. (Fast-heating aluminum can be used because it does not touch the paper.)
- During a multi-page print job, the belt does not cool as quickly as a Teflon roller.
- The belt applies less pressure to the paper than a heat-roll system, so there is less chance of toner smearing on the copy or print.



Example: Model G071

The illustration to the right shows the fusing unit of model G071. The key components are the heating roller, hot roller [C], pressure roller [D], and fusing belt. The heating and pressure rollers each have a fusing lamp. (770W and 350W respectively) However, the hot roller has no fusing lamp; instead, it is heated by the belt. Thermistors [E] control the temperature of the rollers.

A small idle roller [F] increases the nip width between the belt and the pressure roller, so more of the paper is heated at any one time. At the start of the fusing nip (area of contact between the pressure roller and the fusing belt), toner begins melting. When the paper comes between the hot and pressure rollers, the toner has already melted, and at that point it is pressed into the fibers of the paper.

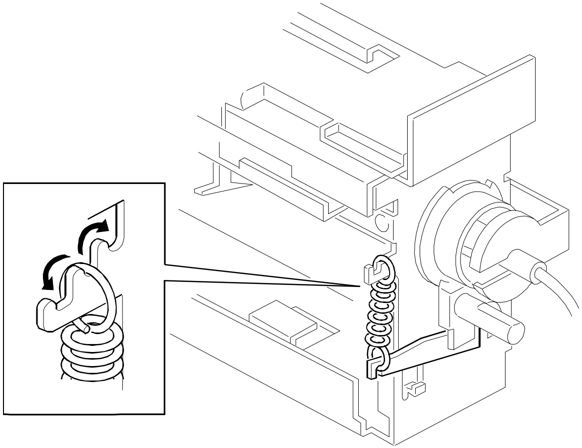
Fusing Pressure Mechanism

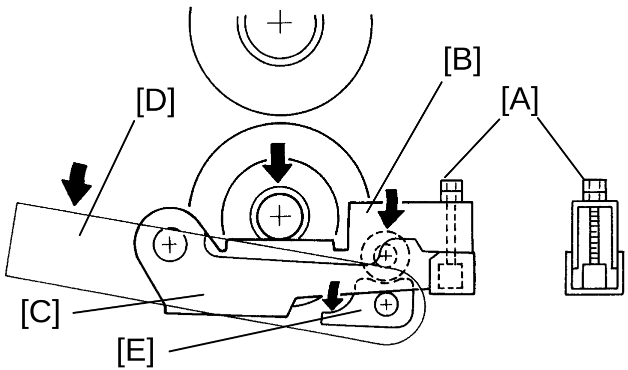
The pressure mechanism is a critical part of the fusing unit. The fusing pressure must be sufficient to form a proper nip band (see previous page). The pressure must also be even so that the paper feeds smoothly between the rollers without creasing or wrinkling.

The most common method of applying fusing pressure is with a spring. The illustration to the right (*model A219*) is a typical example. The fusing pressure can be adjusted by changing the point where the spring is attached. In this case fusing pressure is applied constantly.

Some copiers, especially higher-speed models, use screws to apply fusing pressure. The mechanism shown in the lower picture (*model A171*) allows precise pressure adjustment using adjustment screws [A].

This model allows the user to release fusing pressure to help clear paper jams. This is done by the upper pressure lever [B] and lower pressure lever [C] which are lifted up by the fusing unit release lever [D] via the pressure cam [E].





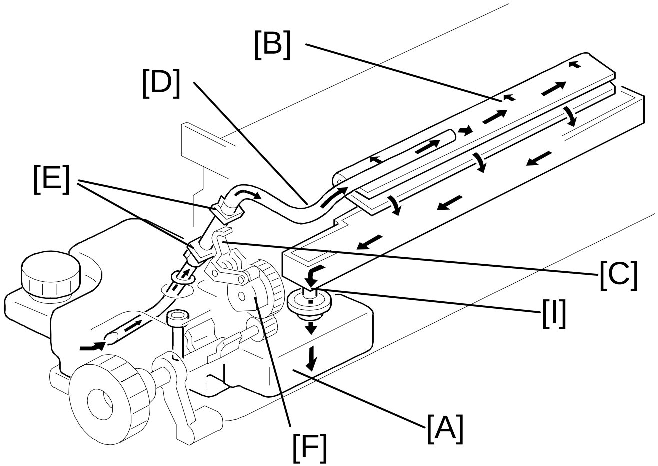
Oil Supply

Silicone oil is applied to the hot roller to help prevent toner and paper from sticking to the hot roller, to reduce paper curl, improve hot roller durability, and to help in roller cleaning. With such benefits you would expect that all photocopiers would have an oil supply system. This used to be the case. However, advances in design and composition of fusing rollers and toner have made oil application less important. Recently, many products do not have an oil supply mechanism. But, oil supply systems are generally used in products that have a critical fusing function—typically high-speed or color machines.

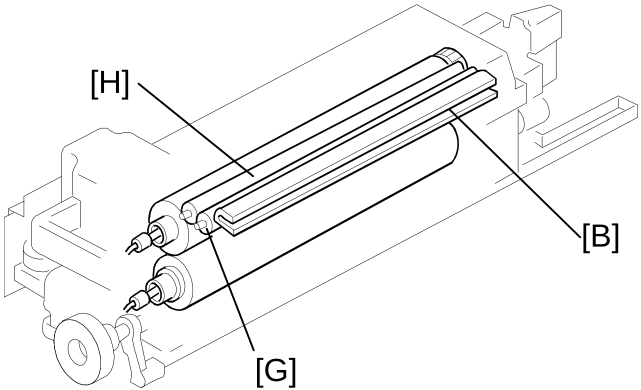
Example: Models A166/A187/A189

The A166 series (Azalea) has a rather complex oil supply system.

A small pump with a one-way valve moves the oil from the oil tank [A] to the oil supply pad [B]. The oil pump lever [C] alternately presses and releases the rubber tube [D] between two one-way valves [E] as the oil cam [F] turns.



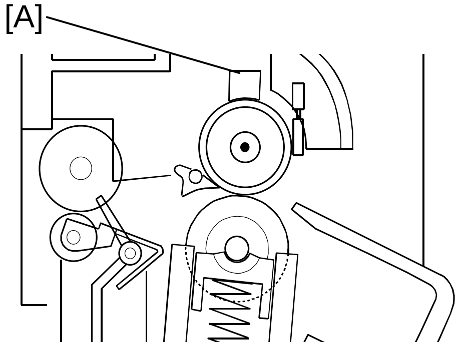
To keep oil use to at a minimum, two oil supply rollers are used. One is in contact with the oil supply pad and the other contacts the hot roller. The oil supply pad applies oil to the first oil supply roller [G]. If there is not enough oil on the hot roller, friction between the second oil supply roller [H] and hot roller increases, and the oil supply roller turns. As it turns the second oil supply roller supplies oil to the hot roller and picks up more oil from the first oil supply roller.



Excess oil flows out through the hole [I] in the bottom of the oil sump and returns to the oil tank.

Cleaning

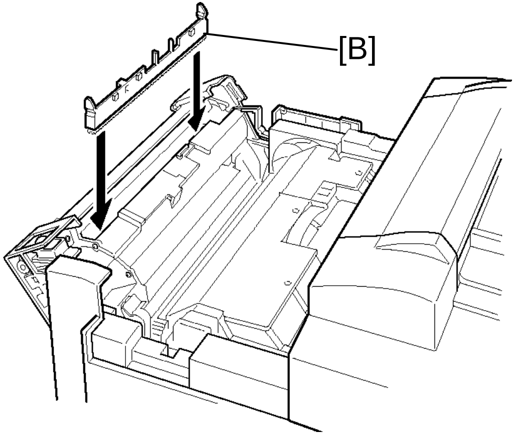
The hot roller has a non-stick coating and toner is formulated to help prevent it from sticking to the hot roller; but even with that, a small amount of toner still sticks to the hot roller. This toner is removed by a cleaning pad or a cleaning roller. In many machines silicone oil is applied to the hot roller. The silicone oil acts as a lubricant and helps to prevent toner from sticking. (See the preceding section.)



Cleaning Pad

Fusing roller cleaning pads are not as common now as in the past, but they are still commonly used in low speed copiers and fax machines. The upper illustration shows the position of the cleaning pad [A] in the fusing unit of *model G026*.

The chief advantages of a cleaning pad are low cost and simple design.



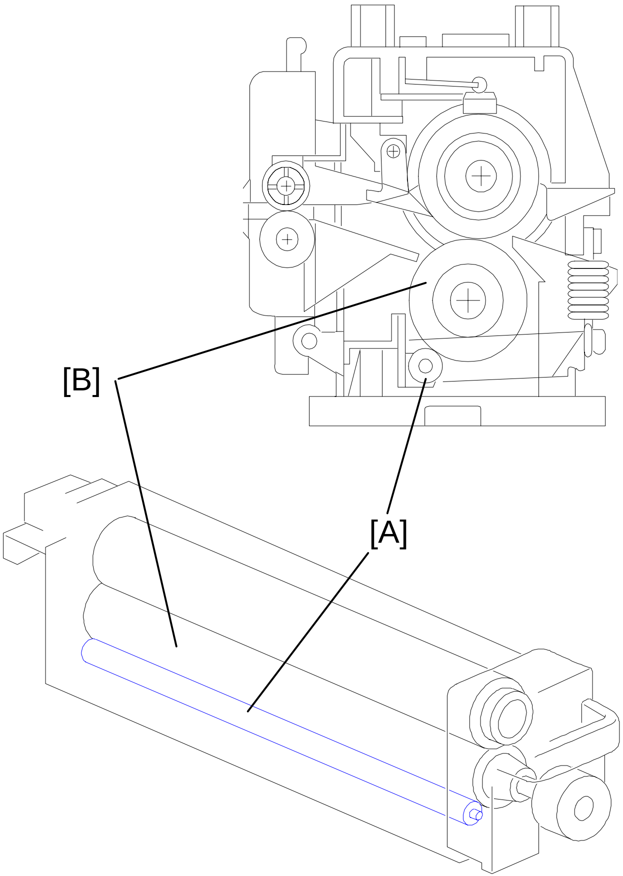
The major drawback of the cleaning pad is that it must be replaced periodically. To reduce service cost, recently machines have been designed with user replaceable cleaning pads. The illustration to the right shows replacement of the fusing cleaning pad in *model H523*.

Cleaning Roller

The cleaning roller is the most common way of removing toner and paper dust from the fusing rollers. The principle of operation is simple. Any toner that sticks to the hot roller preferentially transfers to the pressure roller. The pressure roller may also pick up some toner from the reverse side of the paper (from duplex copies). The toner and paper dust transfer to the cleaning roller due to adhesion. The toner preferentially sticks to the cleaning roller because it is made of metal.

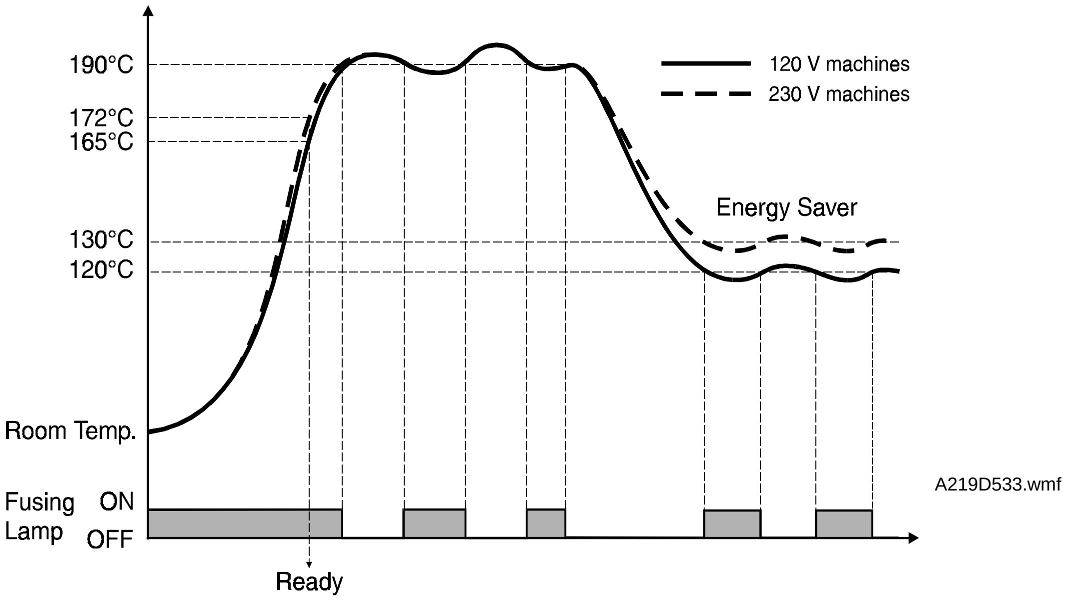
Example: Model A133

The cleaning roller [A] is always in contact with the pressure roller [B]. It collects toner and paper dust adhering to the surface of the pressure roller. This is because the cleaning roller is made of metal and collects any adhering matter more easily than the pressure roller (which has a Teflon coating).



Fusing Temperature Control

The CPU uses a thermistor to sense the temperature of the hot roller surface. Based on the input from the thermistor, it turns the fusing lamp on and off to keep the hot roller surface at the target temperature. Due to differences in copy rate, toner composition, and fusing unit construction, the target temperature varies from machine to machine but is generally in the 180°C to 200°C range. The target temperature may also change depending on the machine condition. For example temperature is controlled in *model A219* as shown in the following diagram.



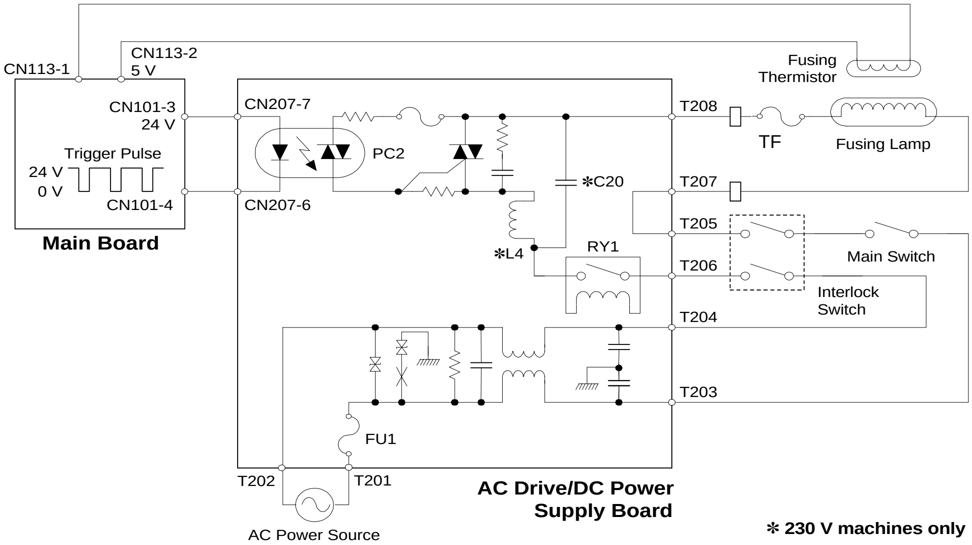
The following table explains the conditions shown by the above diagram.

Machine Condition	Fusing Lamp ON/OFF Threshold	Remarks
Ready	165°C: 120 V machines 172°C: 230 V machines	—
After the main switch is turned on, until one minute has passed after the hot roller temperature reaches the Ready condition.	190°C	After the fusing temperature reaches the ready temperature the fusing lamp is kept on until it reaches 190°C.
After the above time period, the copier enters the energy saver mode.	120°C: 120 V machines 130°C: 230 V machines	When the Print key is pressed, the red indicator blinks and copying starts after the fusing temperature reaches the Ready condition.
During copying	190°C	—

Fusing Lamp Control Circuit

The diagram (*model A219*) is a typical fusing lamp control circuit. While circuit details vary depending on power requirements and machine design, certain features are common to most machines.

First, all machines monitor the fusing temperature using a thermistor. The thermistor is either in contact with the hot roller or positioned very close to it. Also, a zero cross signal generated from the ac power supply is used to generate the trigger pulse and control the applied power accurately.



Since the fusing lamp is a high temperature heat source, safety is an important consideration. Interlock switches cut power to the fusing circuit whenever a cover is opened. Also, all machines have an overheat protection circuit which automatically cuts off the fusing power and stops machine operation if the temperature detected by the thermistor gets too high. Backup overheat protection is provided by a thermofuse (TF). Even if the thermistor overheat protection fails, the thermofuse opens if the heat gets excessive, removing power from the fusing lamp.

On/Off Control

When the main switch is turned on, the main board starts to output a trigger pulse, which has the same timing as the zero cross signal, to the ac power supply circuit. This trigger pulse allows maximum ac power to be applied to the fusing lamp. When the operating temperature is reached, the CPU stops outputting the trigger pulse (the trigger stays HIGH) and the fusing lamp turns off.

Phase Control

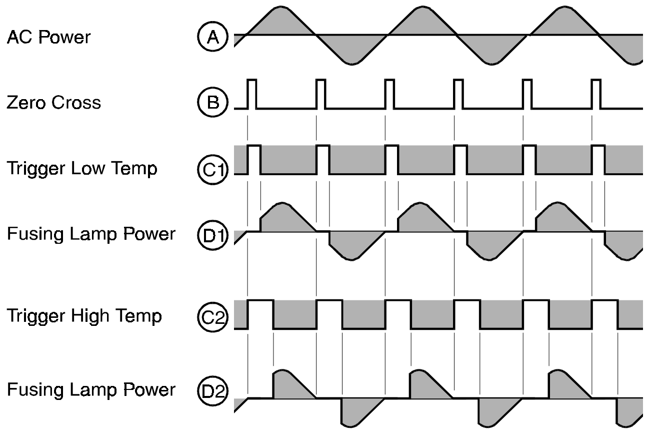
Normally, the voltage applied to the lamp is the full duty cycle of the ac waveform. However, many machines have an alternate method of fusing power control called phase control. Generally, phase control is used only if the customer has a problem with electrical noise or interference on the power line. Phase control is selected using a service program.

Example: Model A219

The main board sends the fusing lamp trigger pulse (LOW active) to the ac drive/dc power supply board, which provides ac power to the fusing lamp at the falling edge of each trigger pulse. The trigger pulse goes HIGH when the main board receives the zero cross signal.

The amount of time that power is applied to the fusing lamp depends on the temperature of the hot roller.

The trigger pulse (LOW part) is wider [C1] and power is supplied for longer [D1] when the hot roller temperature is lower. It is narrower [C2] and power is supplied for a shorter time [D2] when the hot roller is near the operating temperature.

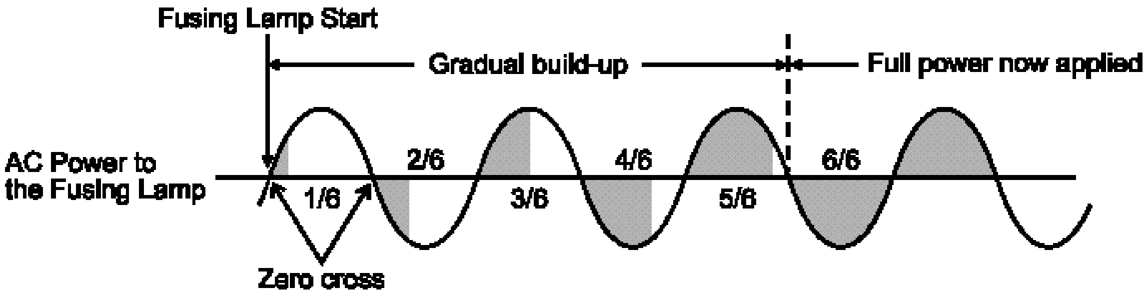


Soft Start

Soft start is a type of phase control mode.

In phase control mode, power is only applied to the lamp for a part of each ac cycle. This is to prevent sudden drops in room power supply when the copier starts to warm up.

In soft start mode, phase control is used for the first few ac cycles (a fraction of a second); power is gradually applied from zero to full power over these first few ac cycles.



The above diagram shows full power being applied to the lamp gradually over the duration of 6 zero-cross cycles. (This is the number of cycles taken to reach application of full ac power, not for reaching the required fusing temperature.)