

# CARTRIDGE PRINTING THEORY

By Mike Josiah and the Technical Staff at UniNet

Over the years we have compiled quite a bit of information on cartridge printing theory from a number of sources; OEM service manuals, patents, and OEM training manuals to name a few. Much of this has been included in various cartridge articles, but much was also left out, or never written about at all. While knowing cartridge theory is not really necessary to remanufacture a cartridge, it is really helpful when trying to troubleshoot a problem. The ability to troubleshoot a cartridge that is new to your production line fast and correctly is, as the saying goes: "Priceless."

**We have broken down the various cartridge types into six separate categories:**

- 1. MAGNETIC TONER (Monochrome HP LaserJet)**
- 2. NON-MAGNETIC TONER (Monochrome Lexmark & Samsung)**
- 3. NON-MAGNETIC SINGLE-PASS COLOR TONER (HP Color LaserJet 4600)**
- 4. NON-MAGNETIC CAROUSEL COLOR TONER (HP Color LaserJet 1500/2500)**
- 5. BROTHER HL-1240 TONER (Brother HL-1240)**
- 6. DUAL COMPONENT SYSTEMS (Analog Sharp Copiers)**

Some of the sections are specific to a single cartridge, and some are very broad. In either case, the information will hopefully help the next time you have a problem you may not have seen before. While technology is improving cartridge components and their printers at a very fast rate, the basis that they work on has changed very little. The biggest change I have seen was when HP and Canon moved from corona wires, to charge rollers. Other than that, toner particle size has gotten smaller, melt points are lower, the charges needed are less, and of course chips have been added but the cartridges all basically work the same as they did when their basic style was first released. While it is impossible to see what will happen in the future, from the patents I have seen, this trend will continue for a while longer.

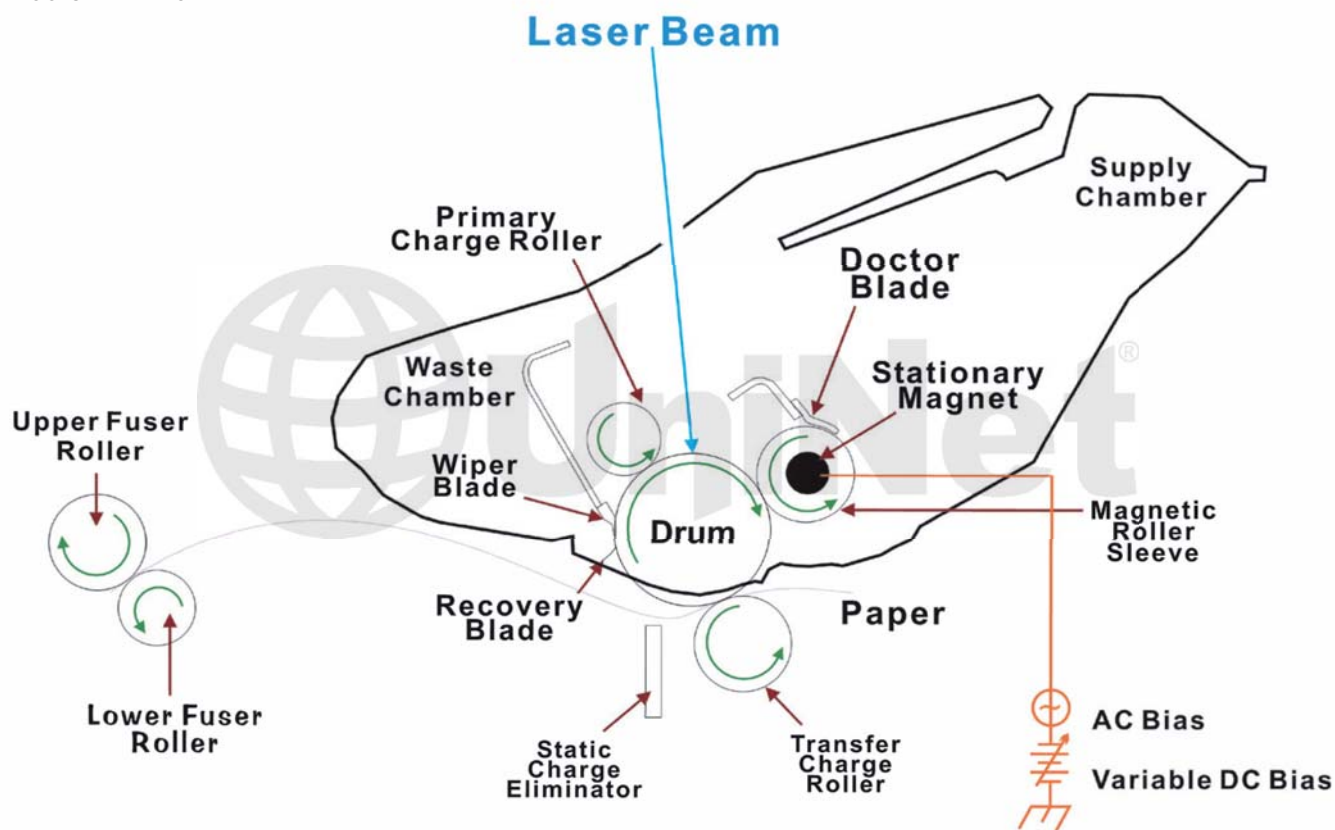
## **1. MAGNETIC TONER (MONOCHROME HP LASERJET)**

The magnetic toner cartridge printing process is best explained as a series of steps or stages. In the **first stage**, the primary charge roller (PCR) places a uniform negative DC bias voltage on the OPC drum surface. The amount of the negative DC bias placed on the drum is controlled by the printer's intensity setting. This process is called conditioning.

In the **second stage** (also called the imaging section), the laser beam is fired onto a rotating mirror (called the scanner). As the mirror rotates, the beam reflects into a set of focusing lenses. The beam then strikes the OPC's surface, leaving a latent electrostatic image on the drum. In most cartridges, the OPC drum makes approximately three revolutions for each 11-inch printed page.

The **third stage** (developing stage) is where the toner image is developed on the drum by the developing section, (or supply chamber), which contains the toner particles. The toner is held to the magnetic roller sleeve by the stationary magnet inside the sleeve, and a DC bias voltage supplied by the high-voltage power supply. This DC bias voltage is controlled by the printer's intensity setting, and causes either more or less toner to be attracted to the drum. This in turn will either increase or decrease the print density. Both the primary charge roller and magnetic roller DC bias voltages are controlled by the printer's intensity setting. The amount of toner on the magnetic roller sleeve is controlled by the rubber doctor blade, which uses pressure to keep the amount of toner on the magnetic roller sleeve constant. This blade also causes a static charge to build up on the toner, which helps keep the coating of toner even, and allows easy transfer to the OPC drum. At the same time an AC signal is also placed on the magnetic roller sleeve. This signal decreases the attraction of the toner to the Magnetic Roller sleeve, and increases the repelling action of toner against the areas of the drum that was not exposed to the laser beam. This AC potential improves the density, and contrast of the toner on the printed page. As the laser exposed areas of the OPC drum approach the magnetic roller, the toner particles are attracted to the drums surface due to the opposite voltage potentials of the toner, and laser exposed surface of the OPC drum.

## HP 4100 CARTRIDGE:



In the **fourth stage** (transfer stage), the toner image is then transferred to the paper as it passes below the drum by the transfer charge roller, which places a positive charge on the back of the paper. This positive charge causes the negatively charged toner on the drum's surface to be attracted to the page. The small diameter of the drum, combined with the stiffness of the paper causes the paper to peel away from the drum.

In the **fifth stage** (separation stage), the paper separates from the drum. The static charge eliminator weakens the attractive forces between the negatively charged drum surface, and the positively charged paper. This prevents toner dropouts onto the paper at low temperatures and humidity and also prevents paper from wrapping around the drum.

In the **sixth stage** (fusing stage), the image is then fused on to the paper by the fuser assembly, which is comprised of the upper and lower fuser rollers. The paper passes between a heated upper fusing element and a soft lower rubber roller that presses the page up into the upper roller. The upper heated element then melts the toner into the paper. The upper roller can be either a hard Teflon-coated heated roller with a halogen lamp inside, or a Teflon sleeve with a ceramic heating element inside. The newer machines all have the ceramic heaters because they use less energy, and are instant-on which allows faster printing.

In the **seventh stage** (drum cleaning stage), the OPC drum is cleaned. On average, approximately 95% of the toner is transferred to the paper during the print cycle. As the drum rotates during printing, the remaining 5% of the toner that is on the OPC drum is cleaned off the drum by the wiper blade. It is then guided into the waste chamber by the recovery blade, and stored in the waste chamber. Once the print cycle has been completed, the primary charge roller will then place an AC voltage across the drum surface that erases any residual charges left on the drum surface. The OPC drum is now ready to be conditioned by the primary charge roller using the negative DC bias voltage, and start the print cycle again.

In older systems, the PCR and transfer roller are replaced by a primary corona wire, and a transfer corona wire. These wires do the same job, but demand much more power to do it. The advantages of the primary charge roller systems are that they: operate at a lower voltage than the old style corona wire, do not generate ozone, and replace the erase lamps that were present in the older style laser printers.

**MAGNETIC TONER STYLE CARTRIDGE COMPONENTS**

- Magnetic Toner:** A combination of carbon, powdered iron, and other additives which control the flow and charge of the toner. Magnetic toner is used in all HP/Canon laser printers.
- Magnetic Roller:** This is the most important component for producing solid print density. As the magnetic roller rotates it attracts toner to it by a permanent magnetic axle which is fitted inside the sleeve, and electrical signals from the high-voltage power supply in the printer.
- Doctor Blade:** Physically regulates the amount of toner on the magnetic roller by using pressure from its silicon rubber blade rubbing against the magnetic roller sleeve. This friction also helps statically charge the toner so that an even layer of toner is on the magnetic roller sleeve.
- Primary Charge Roller:** The primary charge roller (PCR) has two functions. The first is to apply a DC signal to the surface of the drum so that the laser from the printer can write to it. The second is where an AC signal is applied to the drum to help erase any residual charges left on the drum surface after printing.
- Drum:** Drums used in disposable cartridges are OPC or “organic photoconductors” that refer to the type of chemicals used to coat the aluminum tube that is the drum base. All drums are light sensitive. There are normally three different layers of chemicals used to make the drum. The first is an insulator, the second is the reactive layer that reacts to light, and the third is a protective layer. It is this protective layer that determines how long a drum will last.
- Wiper Blade:** The rubber edge of a wiper blade cleans the drum of any toner that was not transferred to the paper. The blade rides directly on the drum, and is one of the main causes of drum wear.
- Recovery Blade:** The recovery blade is a very thin Mylar blade that guides toner that was wiped off the drum by the wiper blade into the waste chamber. If this blade were not present, or damaged, toner would drop from the cartridge onto the printed pages.
- Waste Chamber:** Collects and holds all the waste toner. It also usually contains the drum, PCR, recovery blade and wiper blade.
- Supply Chamber:** Contains all the new un-used toner, the magnetic roller assembly and the doctor blade.

**2. NON-MAGNETIC TONER (MONOCHROME LEXMARK & SAMSUNG)**

The non-magnetic toner cartridge printing process is best explained as a series of steps or stages. The **first stage** in the printing process is the conditioning stage. The primary charge roller places a uniform negative DC voltage on the OPC drum surface. The amount of the negative DC voltage placed on the drum is controlled by the printer’s intensity setting.

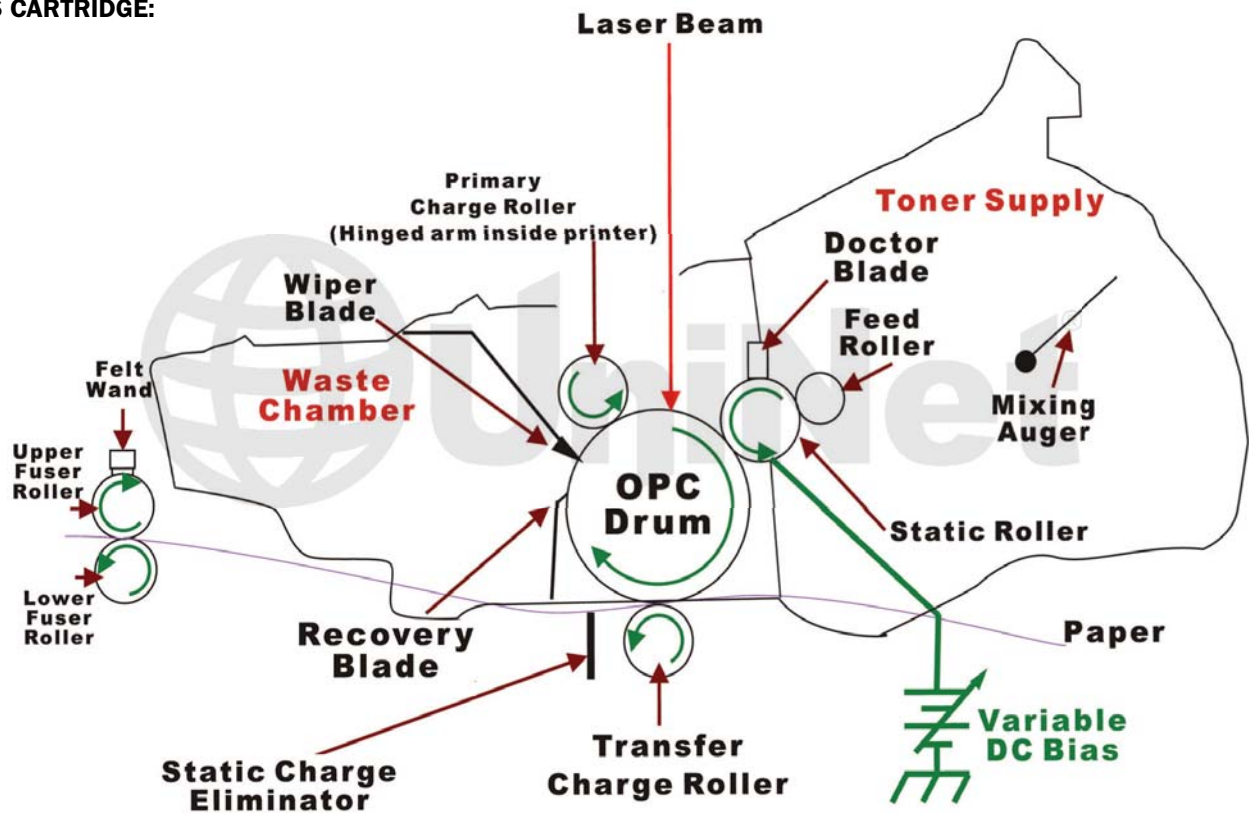
In the **second stage** (also called the imaging section), the laser beam is fired onto a rotating mirror (called the scanner). As the mirror rotates, the beam is reflected into a set of focusing lens. The beam then strikes the OPC’s surface, leaving a latent electrostatic image on the drum. In most cartridges, the OPC drum makes approximately three revolutions for each 11-inch page.

The **third stage** (developing stage) is where the toner is developed on the drum by the developing section (or supply chamber) which contains the toner particles. The toner is held to the developer roller by a DC voltage supplied by the high-voltage power supply. This voltage is controlled by the printer's intensity setting, and causes either more or less toner to be attracted by the developer roller. This in turn will either increase or decrease the print density. The toner is first fed to the developer roller by the feed mechanism, which is usually an open-cell foam roller. The amount of toner on the developer roller is controlled by the metal doctor blade, which uses pressure to keep the amount of toner on the roller constant. As the laser exposed areas of the OPC drum approach the developer roller, the toner particles are attracted to the drum's surface due to the opposite voltage potentials of the toner, and laser exposed areas of the OPC drum. This image is then transferred to the paper as it passes below the drum by the transfer charge roller, which places a positive charge on the back of the paper. This positive charge causes the negatively charged toner on the drum's surface to be attracted to the page. The small diameter of the drum, combined with the stiffness of the paper causes the paper to peel away from the drum. The static charge eliminator weakens the attractive forces between the negatively charged drum surface and the positively charged paper. Without this help, thin paper may wrap itself around the drum. The image is then fused on to the paper by the fuser assembly, which is comprised of the upper and lower fuser rollers. The lower rubber roller presses the page up into the upper roller which then melts the toner into the paper. The upper roller is a hard Teflon-coated heated roller which is kept clean by a felt wand.

The **fourth stage** is where the OPC drum is cleaned. On average, approximately 90% of the toner is transferred to the paper during the print cycle. The remaining 10% remains on the OPC drum that is cleaned off by the wiper blade, guided into the waste chamber by the recovery blade and stored into the waste chamber by the recovery blade and stored into the waste chamber.

The **final stage** is completed by the primary charge roller. This roller now places an AC signal across the OPC drum surface, which will erase any residual charges left on the OPC drum surface. The OPC drum is now ready to be conditioned by the PCRs DC signal and start the printing process all over again.

**OPTRA S CARTRIDGE:**



## NON-MAGNETIC TONER STYLE CARTRIDGE COMPONENTS

- Non-Magnetic Toner:** Used in non-magnetic single-component systems. Either very small amounts or none at all of powdered iron are used in these toners. Most Lexmark printers use non-magnetic toner systems. The advantage of non-magnetic toner is yield. 500g of non-magnetic toner can yield as much as 20,000 pages, where 500g of magnetic toner will yield at most 10,000 pages.
- Developer Roller:** The developer roller consists of a metal shaft with molded rubber around it and a conductive sleeve on the outside. Toner is attracted to the roller by electrical signals from the high-voltage power supply in the printer. No magnets or anything else is used to attract the toner.
- Doctor Blade:** Physically regulates the amount of toner on the developer roller by using pressure from its metal blade rubbing against the developer roller surface. This friction also helps statically charge the toner so that an even layer of toner is on the magnetic roller sleeve. Non-magnetic toner cartridges will almost always have a metal doctor blade.
- Primary Charge Roller:** The primary charge roller (PCR) has two functions. The first is to apply a DC signal to the surface of the drum so that the laser from the printer can write to it. The second is where an AC signal is applied to the drum to help erase any residual charges left on the drum surface after printing. For many non-magnetic cartridge machines, the PCR is actually installed in the printer, not the cartridge.
- Drum:** Drums used in disposable cartridges are OPC or “organic photoconductors” that refer to the type of chemicals used to coat the aluminum tube that is the drum base. All drums are light sensitive. There are normally three different layers of chemicals used to make the drum. The first is an insulator, the second is the reactive layer that reacts to light, and the third is a protective layer. It is this protective layer that determines how long a drum will last.

### 3. NON-MAGNETIC SINGLE-PASS COLOR TONER (HP COLOR LASERJET 4600)

Single-pass color printing is where the paper runs by each color cartridge one time, and the cartridges are all lined up in a row. This is a much faster and more accurate system as opposed to a carousel style system. It also tends to be used only in the more expensive machines.

The single-pass color toner cartridge printing process is best explained as a series of stages or steps. The **first stage** in the printing process is the primary exposure stage. Light from the primary exposure LED (which is located inside the cartridge), strikes the drum. This eliminates any residual charges on the drum surface, and ensures a consistent charge density.

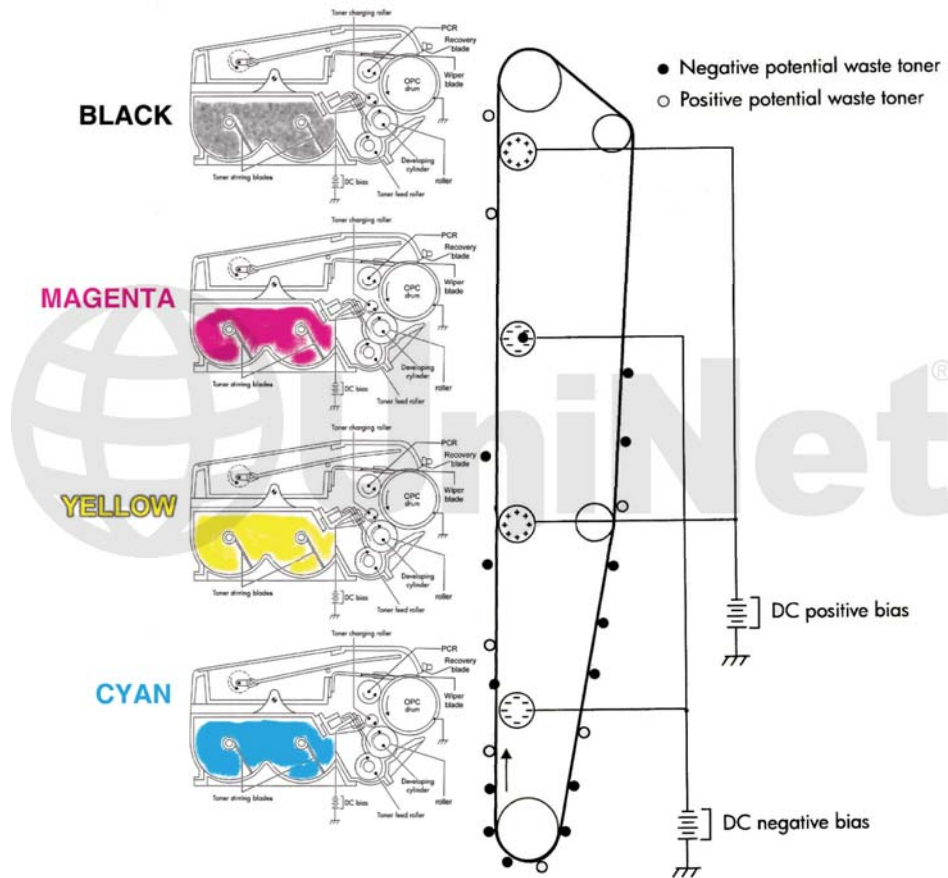
In the **second stage**, the primary charge roller (PCR) places a uniform negative DC voltage on the OPC drum surface. The amount of the negative DC voltage placed on the drum is controlled by the printer’s intensity setting.

In the **third stage**, the laser beam is fired onto a rotating mirror (called the scanner). As the mirror rotates, the beam is reflected into a set of focusing lenses. The beam then strikes the drums surface, neutralizing the negative charge and leaving a latent electrostatic image on the drum. The areas where the laser did not strike the drum will retain the negative charge. Each color cartridge has its own laser and scanner units.

The **fourth stage** (developing stage) is where the toner is developed on the drum by the developing section (or supply chamber) which contains the toner particles. The development stage is actually made up of two steps: toner charging and the actual development. In the toner charging stage, the toner stirring blade turns inside the hopper. As it turns, friction causes a negative potential to develop on the toner. In addition, a toner charging roller also places a negative voltage on the toner. These two charges ensure a uniform charge on the toner. Once the toner is properly charged, the toner will coat the developer roller. The toner will also be held onto the developer roller by another negative DC bias voltage. This voltage is controlled by the printer's intensity setting, and causes either more or less toner to be attracted by the developer roller. This in turn will either increase or decrease the print density. The toner is first fed to the developer roller by the feed mechanism, which in this case is an open-cell foam roller. The amount of toner on the developer roller is controlled by the doctor blade, which uses pressure to keep the amount of toner on the roller constant. As the laser exposed areas of the OPC drum approach the developer roller, the toner particles are attracted to the drum's surface due to the opposite voltage potentials of the toner, and laser exposed areas of the OPC drum.

The **fifth stage** is the transfer block. This is where there are some large differences from monochrome printers. The first step in the transfer block is where the attaching roller places a positive charge on the paper. The attaching roller sits just after the paper pick up roller. The attaching roller also pushes the paper up against the electrostatic transfer/transport belt or ETB. A positive DC bias voltage is placed on the transfer charging roller which is located directly opposite the OPC drum, and on the back side of the ETB. Each toner cartridge has a separate transfer charging roller. As the ETB passes the transfer charging roller, the positive charge is picked up, and draws the negatively charged toner off the drum onto the paper. This process is repeated for each color cartridge. As the toner piles onto the paper, the positive charge on the paper weakens as the paper runs through each cartridge. For this reason, the charge is increased on the transfer charging roller for each successive color. The paper separates from the ETB belt as the belt reaches the top of its path and turns back down to start the process again.

In the **sixth stage**, the image is then fused onto the paper by the fuser assembly. The fuser assembly is comprised of the upper heating assembly and lower pressure roller. The lower pressure roller presses the page up into the upper heating assembly which then melts the toner into the paper. The upper heating assembly consists of a flexible sleeve with an induction type heating coil inside. This type of fuser affords instant-on fusing with little to no wait time, and low power consumption.



The **final stages** are where the ETB belt and drum are cleaned:

**ETB Cleaning:** The ETB Belt is cleaned whenever the printer is turned on, when the printer's covers are closed, at the start of a print job, and after a specific number of pages. Both positive and negative bias voltages are applied to the transfer charge rollers. These voltages repel any residual toner off the ETB and onto the OPC drum where it is cleaned off by the wiper blade. After a print cycle, there is toner with both a negative potential, as well as toner with a positive potential left on the ETB. This is why both voltages are needed. Since the developer roller is always in contact with the OPC drum, precautions are needed in order to make sure that the toner supply chambers are not contaminated with old toner. During ETB cleaning as well as pure monochrome printing, the developer roller should not be in contact with the drum. To accomplish this, the bottom half of the cartridge has been designed to pivot so that the developer roller is moved away from the drum. A small block is located under the back edge of each cartridge that pushes up to disengage the developer roller.

**OPC Drum Cleaning:** The drum is cleaned after the image is transferred to the paper by the wiper blade. This part is fairly standard; the wiper blade scrapes the toner off the drum, and the recovery blade guides it into the waste chamber. The waste toner is then moved to the back of the waste chamber by the waste toner transfer plate. The difference here is that other rollers need to be cleaned as well. During normal printing, toner will stick to the PCR and the toner charging roller. Negative DC bias voltages are applied in varying values to both rollers so that the toner moves from the rollers onto the drum, where the wiper blade will remove it. The PCR and toner charging roller cleaning process occurs whenever the printer is turned on, when the printer's covers are closed, at the start of a print job, and after a specific number of pages.

**Printer Calibration:** At the start of all this is the calibration cycle. The printer will calibrate itself whenever the printer is turned on, when a new toner cartridge is installed, after 8 hours of run time, and at specific page intervals. Calibration consists of a solid block and halftone of each color being printed to the ETB. As the printed areas get to the top of the belt, a sensor will detect them, measure the density, and adjust the printer accordingly. There are also physical calibrations of the gear train, and various rollers.

## COLOR NON-MAGNETIC TONER STYLE CARTRIDGE COMPONENTS

**Non-Magnetic Color Toner:** Used in all the newer HP Color Systems. Unlike traditional pulverized toner, these color toners are polymerized toner or chemically grown. Polymerized toners have extremely uniform round particles that cause less wear, and allow for a more accurate color calibration. Either very small amounts or none at all of powdered iron are used in these toners.

**Developer Roller:** The developer roller consists of a metal shaft with molded rubber around it, and a conductive sleeve on the outside. Toner is attracted to the roller by electrical signals from the high-voltage power supply in the printer. No magnets or anything else is used to attract the toner.

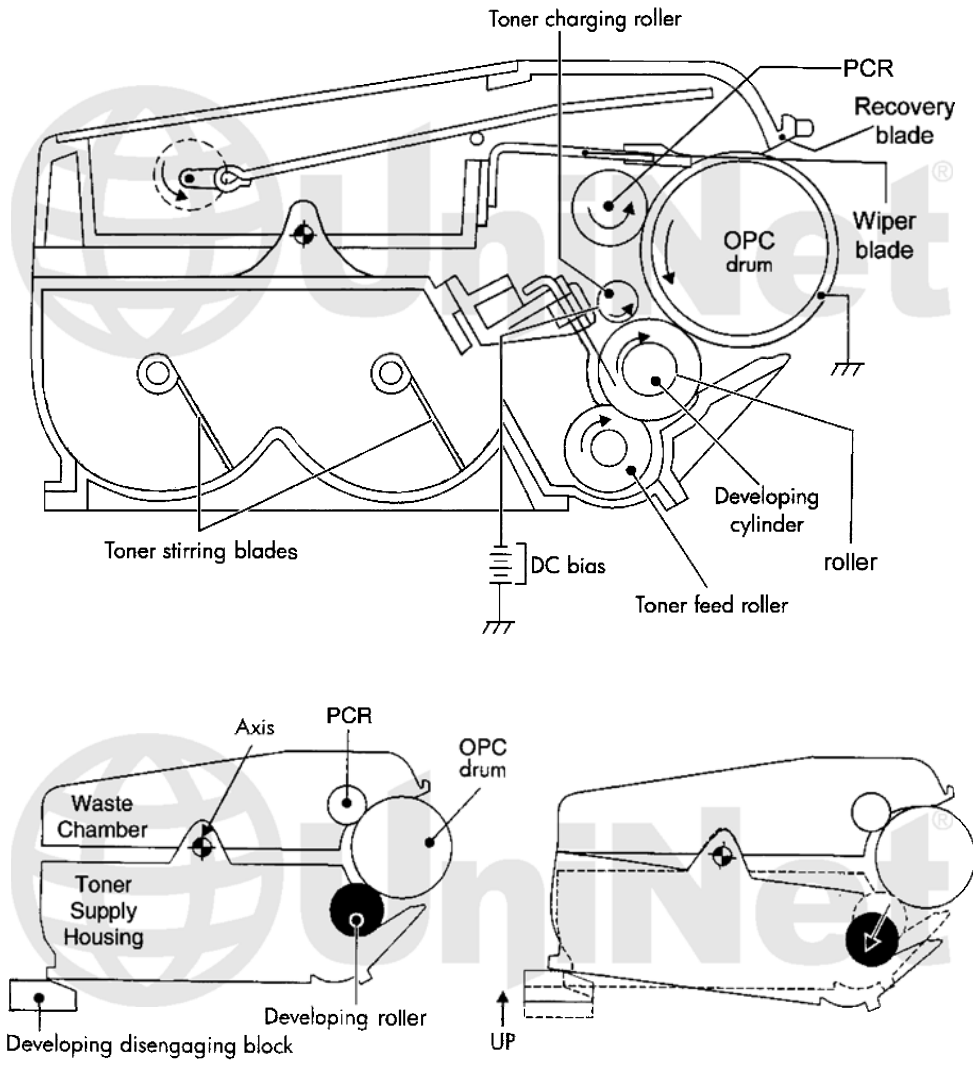
**Toner Charge Roller:** The toner charge roller actually imparts a charge into the toner as it is fed from the feed roller to the developer roller. This extra charge ensures a more uniform charge on the developer roller, giving more accurate color prints.

**Doctor Blade:** Physically regulates the amount of toner on the developer roller by using pressure from its metal blade rubbing against the developer roller surface. This friction also helps statically charge the toner so that an even layer of toner is on the magnetic roller sleeve. Color toner cartridges will almost always have a metal doctor blade.

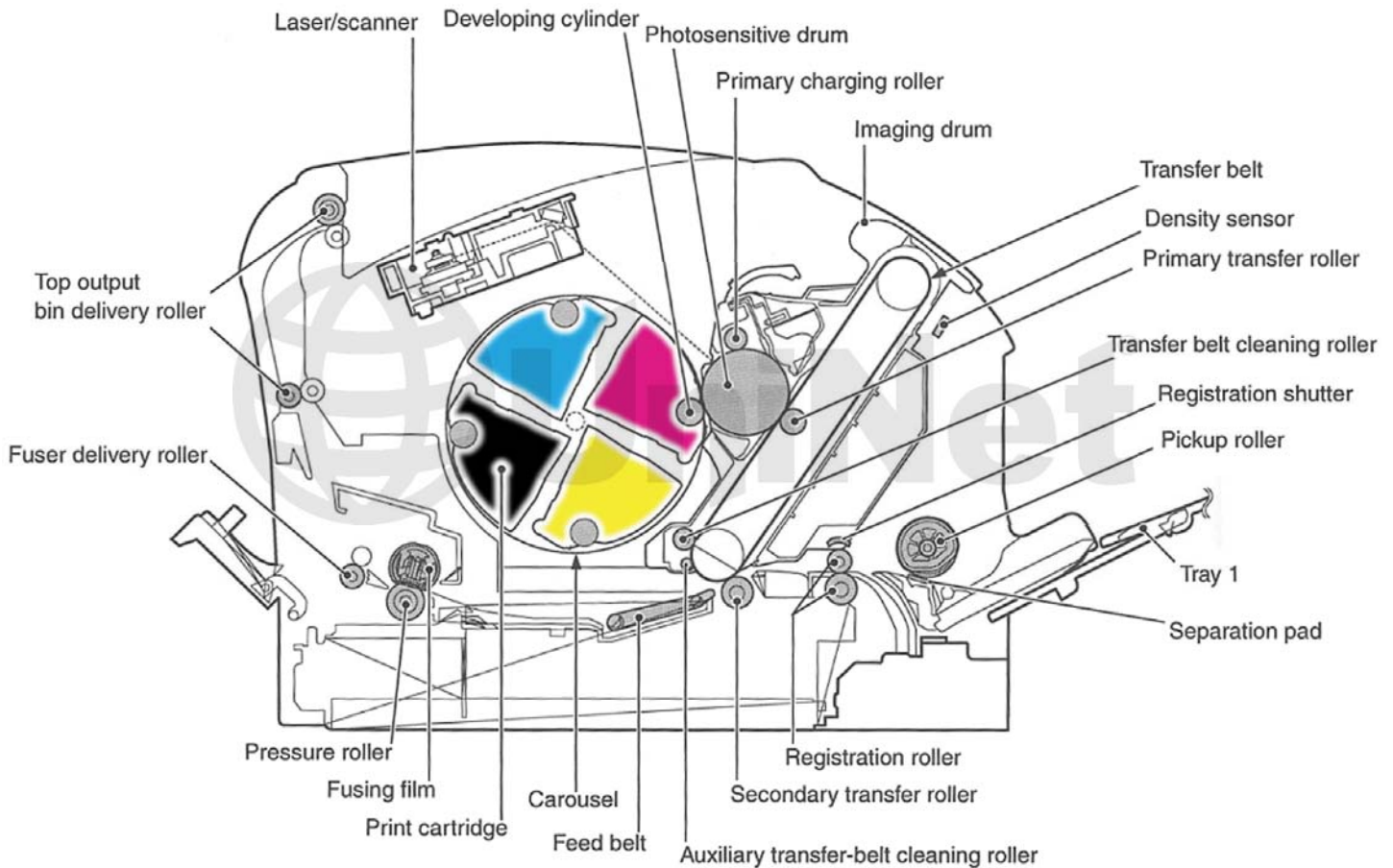
**Primary Charge Roller:** The primary charge roller (PCR) has two functions. The first is to apply a DC signal to the surface of the drum so that the laser from the printer can write to it. The second is where an AC signal is applied to the drum to help erase any residual charges left on the drum surface after printing.

- Drum:** Drums used in disposable cartridges are OPC or “organic photoconductors” that refer to the type of chemicals used to coat the aluminum tube that is the drum base. All drums are light sensitive. There are normally three different layers of chemicals used to make the drum. The first is an insulator, the second is the reactive layer that reacts to light, and the third is a protective layer. It is this protective layer that determines how long a drum will last.
- Wiper Blade:** The rubber edge of a wiper blade cleans the drum of any toner that was not transferred to the paper. The blade rides directly on the drum, and is one of the main causes of drum wear.
- Recovery Blade:** The recovery blade is a very thin Mylar blade that guides toner that was wiped off the drum by the wiper blade into the waste chamber. If this blade were not present, or damaged, toner would drop from the cartridge onto the printed pages.
- Waste Chamber:** Collects and holds all the waste toner. It also usually contains the drum, PCR, recovery blade and wiper blade. In the case of the HP 4600 it also contains the primary exposure LED bar.
- Supply Chamber:** Contains all the new unused toner, developer roller assembly, toner charge roller and doctor blade.

**COLOR HP COLOR LASERJET 4600 CARTRIDGE:**





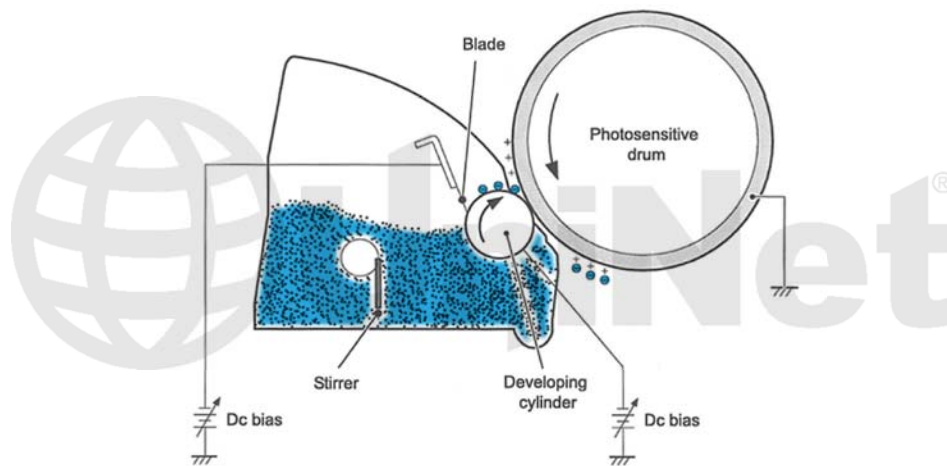


#### 4. NON-MAGNETIC CAROUSEL COLOR TONER (HP COLOR LASERJET 1500/2500)

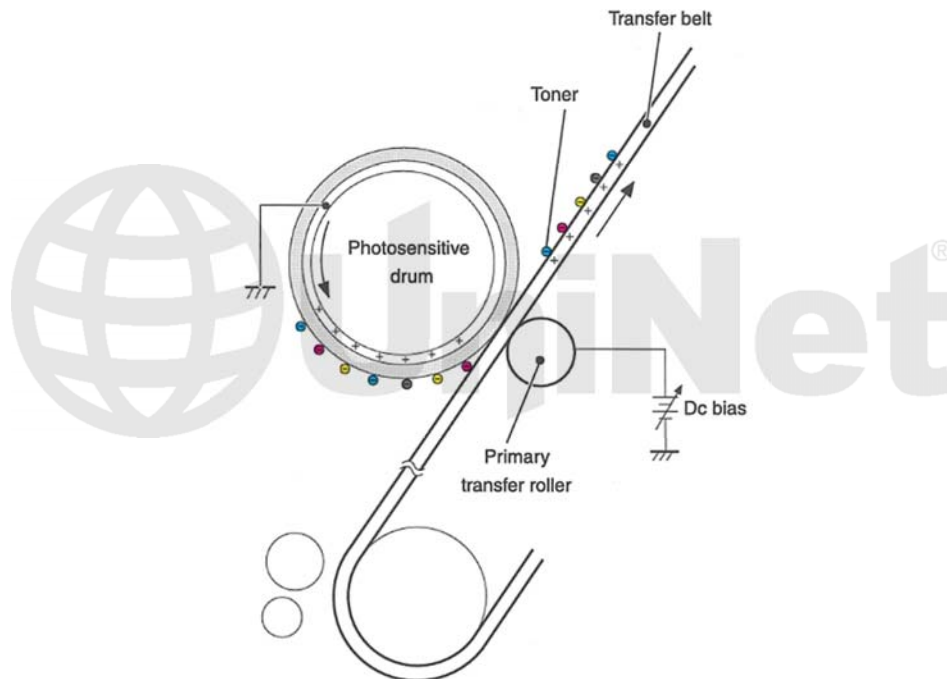
Another type of color printing engine other than the single-pass type (HP CLJ 4600) is the carousel type. The carousel system is much less expensive to manufacture than the single-pass systems. Probably one of the main reasons for this is that the single-pass systems have a separate laser-scanner unit and all the associated circuitry for each color cartridge. The carousel system has one for all of them. While this system is not as complicated as a single-pass, there is still quite a bit going on that has to happen in a very precise way. The carousel hold all four cartridges and rotates as each cartridge is needed. As technology improves, this type of system tends to be used in the less expensive machines. The HP CLJ 1500/2500 system is similar to the HP CLJ 4500, but much more advanced.

The HP CLJ 2500 color printing process is best explained as a series of stages. In the **first stage**, the primary charge roller (PCR) places a uniform negative DC voltage on the OPC drum surface. The amount of the negative DC voltage placed on the drum is controlled by the printer's intensity setting.

In the **second stage**, the laser beam is fired onto a rotating mirror (called the scanner). As the mirror rotates, the beam is reflected into a set of focusing lenses. The beam then strikes the drums surface, neutralizing the negative charge and leaving a latent electrostatic image on the drum. The areas where the laser did not strike the drum will retain the negative charge.

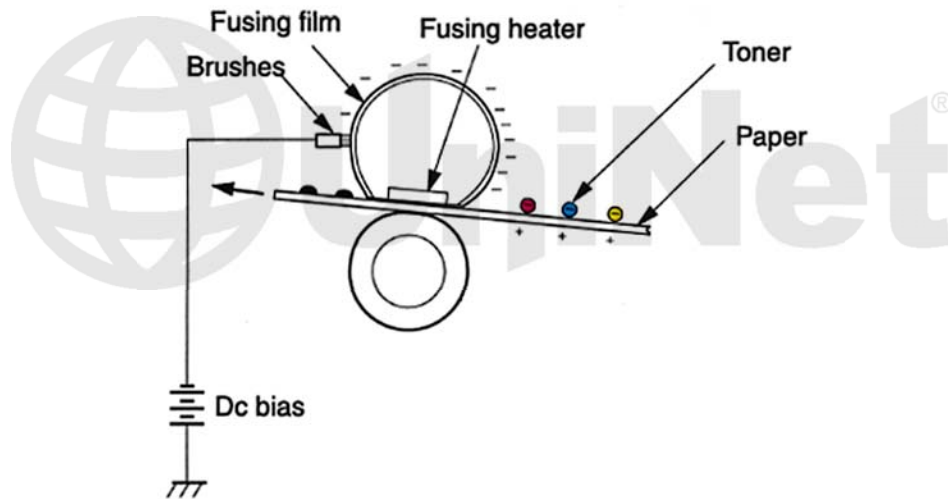


The **third stage** or developing stage (above illustration) is where the toner is developed on the drum by the developing section (or supply chamber) which contains the toner particles. As the toner stirring blade turns inside the hopper it pushes the toner towards the develop roller. The friction from this process causes a negative potential to develop on the toner. The toner will start to coat the developer roller. At the same time, a negative DC bias voltage is applied to the developer roller. This voltage is controlled by the printer's intensity setting, and causes either more or less toner to be attracted by the developer roller. This in turn will either increase or decrease the print density. The final amount of toner on the developer roller is controlled by the doctor blade, which uses pressure and a second DC bias voltage to keep the amount of toner on the roller constant. As the laser exposed areas of the OPC drum approach the developer roller, the toner particles are attracted to the drum's surface due to the opposite voltage potentials of the toner, and laser exposed areas of the OPC drum.

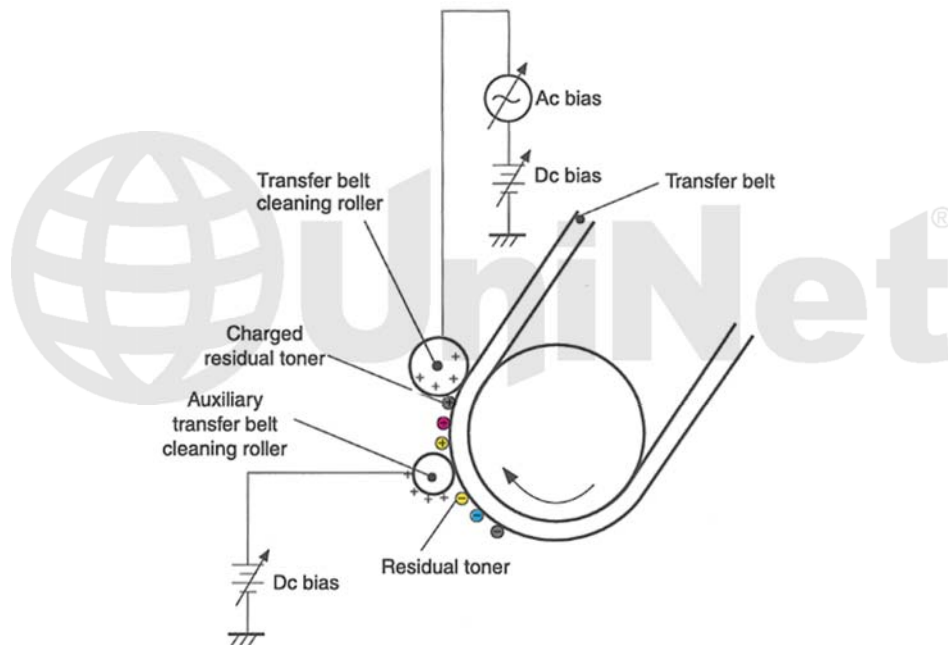


The **fourth stage** is the primary transfer stage. This is where there are some large differences from monochrome printers and even the HP 4600. The first step in the primary transfer stage is where the transfer roller places a positive charge on the back side of the transfer belt. The negatively charged toner on the drum is then transferred to the positively charged transfer belt. This process is repeated for each color. The positive DC bias voltage is increased for each successive color to make sure that all the toners stay in place on the belt.

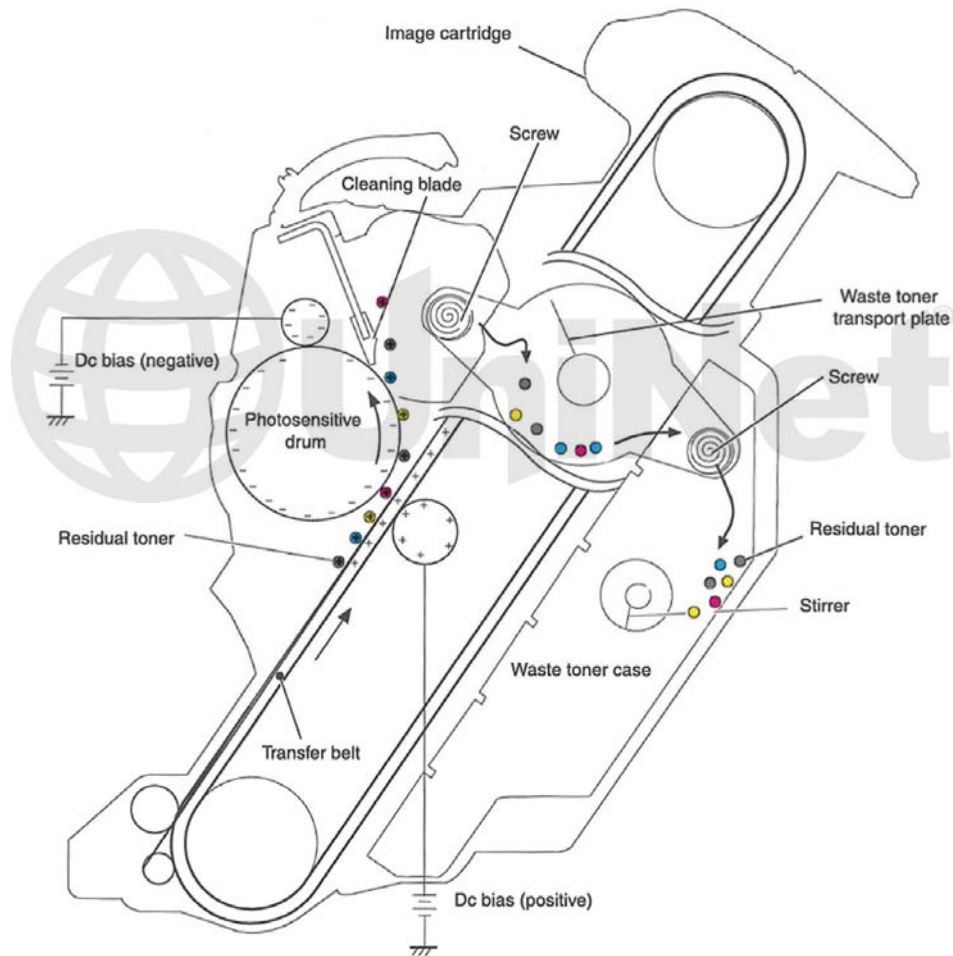
The **fifth stage** is the secondary transfer stage. As the paper reaches the transfer belt, it also runs by the secondary transfer roller. This roller places a positive charge to the paper which causes the toner to transfer from the belt to the paper. After the transfer process is complete, another DC bias voltage is placed on the secondary transfer roller to prevent any toner from sticking to it. The paper separates from the transfer belt with the help of the static charge eliminator and the stiffness of the paper.



In the **sixth stage** (above illustration), the image is then fused onto the paper by the fuser assembly. The fuser assembly is comprised of the upper heating assembly and lower pressure roller. The lower pressure roller presses the page up into the upper heating assembly which then melts the toner into the paper. The upper heating assembly consists of a flexible sleeve with an induction type heating coil inside. This type of fuser affords instant-on fusing with little to no wait time, and low power consumption. This sleeve also has a DC bias voltage on it to help hold the toner to the paper, and prevent it from scattering.



The **seventh stage** is where the transfer belt is cleaned. The transfer belt is cleaned whenever the printer is turned on, when the printer's covers are closed, at the start of a print job, and after a specific number of pages. The auxiliary transfer belt cleaning roller has a positive DC bias voltage placed on it. This voltage actually keeps the toner on the transfer belt to prevent toner from falling off into the printer. At this point, another DC bias voltage is placed on the transfer belt cleaning roller. These charges are stronger than the charge previously applied by the auxiliary transfer belt cleaning roller, so the earlier charge now behaves like a negative charge. Another DC bias voltage is placed on the transfer belt by the transfer roller to produce a difference between the belt and OPC drum. Another DC bias voltage is placed on the OPC drum cleaning roller. This causes the transfer of the residual toner to the drum.



The **last stage** is the drum cleaning stage (see above). The drum is cleaned after all the above takes place by the wiper blade. This part is fairly standard; the wiper blade scrapes the toner off the drum, and the recovery blade guides it into the waste chamber. The difference here is the movement of the waste toner to the waste toner case. The waste toner is picked up from the drum unit by an auger or waste toner screw as HP calls it. The toner moves across the waste toner transport plate to another auger which moves it finally to the waste toner case. This waste toner case is part of the transfer belt.

As you can see, the DC power supply (DC bias voltages) is extremely busy during the entire printing process. Although these machines have proved very reliable, it is possible to see where even a small deviation from this power supply can cause major issues.

**Printer Calibration:** At the start of all this is the calibration cycle, The printer will calibrate itself whenever the printer is turned on, when a new toner or drum cartridge is installed, and at specific page intervals determined by the total number of pages printed. Calibration consists of a solid block and halftone of each color being printed to the transfer belt. As the printed areas get to the top of the belt, a sensor will detect them, measure the density, and adjust the printer accordingly.

**Reset Chips:** Reset chips (or “memory tags” as HP tends to refer to them as) function the same as other HP chips. They control the TONER LOW, TONER OUT and REPLACE (COLOR) CARTRIDGE messages. Each color cartridge has a specific chip. Be careful not to mix them up. As stated earlier, the chips do not need to be replaced for the cartridge to function, but all the TONER LOW functions will be disabled if not. When a used chip is utilized, the CANCEL button must be pressed to clear it. At this point a NON-HP PRINT CARTRIDGE message will appear. This message appears for the first time only. The SUPPLIES STATUS page will print, but no cartridge information will be listed.

**NON-MAGNETIC CAROUSEL COLOR TONER COMPONENTS**

- Non-Magnetic Color Toner:** Used in all the newer HP Color systems. Unlike traditional pulverized toner, these color toners are polymerized toner or chemically grown. Polymerized toners have extremely uniform round particles that cause less wear, and allow for a more accurate color calibration. Either very small amounts or none at all of powdered iron are used in these toners.
- Developer Roller:** The developer roller consists of a metal shaft with molded rubber around it, and a conductive sleeve on the outside. Toner is attracted to the roller by electrical signals from the high-voltage power supply in the printer. No magnets or anything else is used to attract the toner.
- Toner Charge Roller:** The toner charge roller actually imparts a charge into the toner as it is fed from the feed roller to the developer roller. This extra charge ensures a more uniform charge on the developer roller, giving more accurate color prints.
- Doctor Blade:** Physically regulates the amount of toner on the developer roller by using pressure from its metal blade rubbing against the developer roller surface. This friction also helps statically charge the toner so that an even layer of toner is on the magnetic roller sleeve. Color toner cartridges will almost always have a metal doctor blade.
- Primary Charge Roller:** The primary charge roller (PCR) has two functions. The first is to apply a DC signal to the surface of the drum so that the laser from the printer can write to it. The second is where an AC signal is applied to the drum to help erase any residual charges left on the drum surface after printing.
- Drum:** Drums used in disposable cartridges are OPC drums or “organic photoconductors” that refer to the type of chemicals used to coat the aluminum tube that is the drum base. All drums are light sensitive. There are normally three different layers of chemicals used to make the drum. The first is an insulator, the second is the reactive layer that reacts to light, and the third is a protective layer. It is this protective layer that determines how long a drum will last.
- Wiper Blade:** The rubber edge of a wiper blade cleans the drum of any toner that was not transferred to the paper. The blade rides directly on the drum, and is one of the main causes of drum wear.
- Recovery Blade:** The recovery blade is a very thin Mylar blade that guides toner that was wiped off the drum by the wiper blade into the waste chamber. If this blade were not present or damaged, toner would drop from the cartridge onto the printed pages.
- Waste Chamber:** Collects and holds all the waste toner. It also usually contains the drum, PCR, recovery blade and wiper blade. In the case of the HP 4600 it also contains the primary exposure LED bar.
- Supply Chamber:** Contains all the new un-used toner, the developer roller assembly, toner charge roller, and the doctor blade.

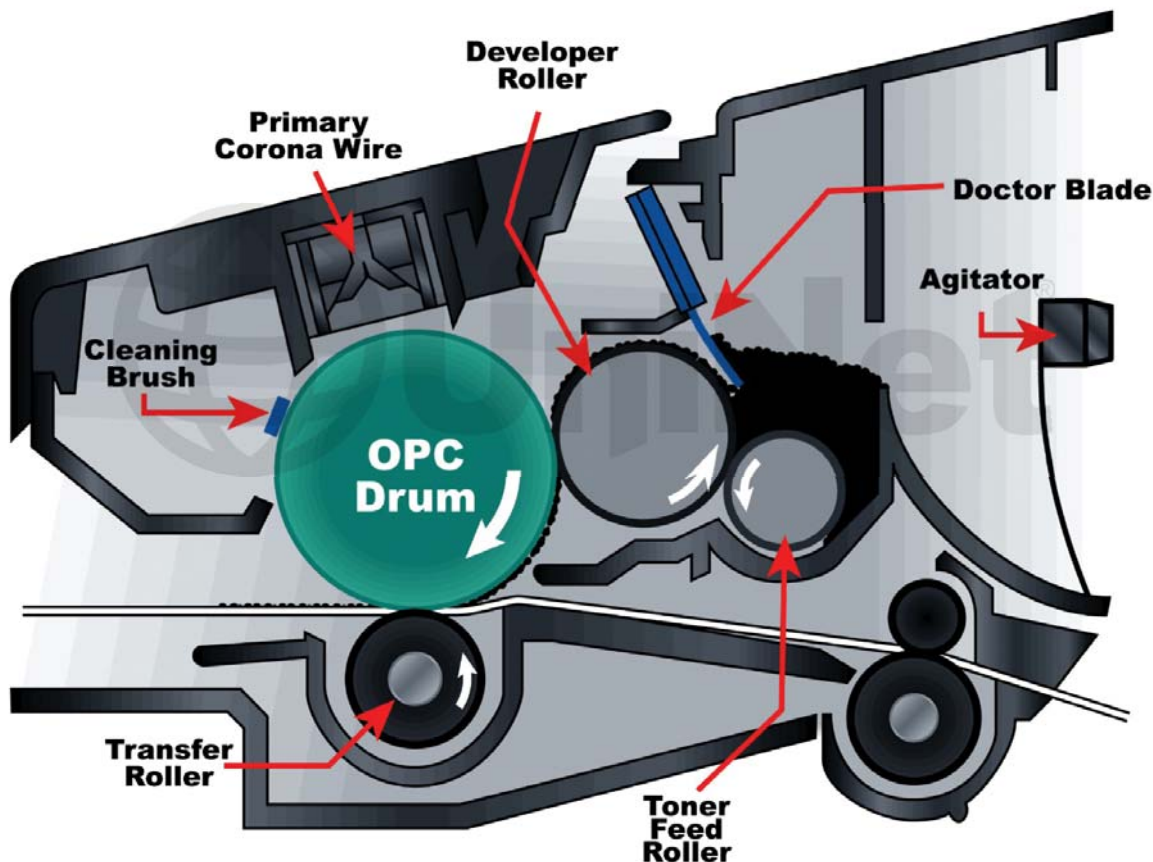
## 5. BROTHER HL-1240 TONER

This section is based on the Brother TN-460 (TN-6600), but also covers the TN-350 (TN-2000), TN-360 (TN-2120, TN-2150), TN-560 (TN-7600), TN-570 (TN-3060), TN-670 (TN-4100), TN-750 (TN-5500), TN-580 (TN-3160/TN-3185) and their associated drum cartridges. The Brother toner is non-magnetic, but the operating principles are so unique, we feel it deserves a special section here. Because of the uniqueness of these cartridges, we have also included general troubleshooting tips. Please note that while the theory for all the above cartridges is basically the same, the toners are not. In fact the toner used from one cartridge model to the next can be very different. Always check to make sure you have the proper toner for your cartridge.

This cartridge system is unique in a number of ways; the waste toner from the drum cartridge is recycled back into the toner supply chamber, the drum cartridge uses a cleaning felt (or brush) instead of a wiper blade or roller, and it also has both a primary corona wire and transfer roller. This is the first cartridge we have seen with both a wire and a roller for charging/transferring. The primary corona wire has a built in cleaner that should be on the left side of the cartridge when not in use (the home position for the cleaner).

This engine is also unique in the sense that the developer roller in the toner cartridge actually touches the drum. There is not an air gap as in other cartridges. In other words, this engine does not use what is commonly known as "jumping technology" to transfer the image from the developer roller to the drum. This unusual fact doesn't change how the cartridge is recycled, but can lead to some interesting problems if BOTH the Toner and OPC cartridges are not cleaned properly. If you are to do these cartridges successfully, throw out any pre-conceived notions you may have based on other cartridges, and read the following carefully. The diagram below will also help show how these cartridges work.

### BROTHER HL-1240 CARTRIDGE:



When an "empty" cartridge is returned for remanufacturing, the remaining toner (80g or so) must be completely removed from the supply chamber before adding new toner. Failure to do this will cause backgrounding. In addition to contaminating the toner cartridge, this will also contaminate the cleaning section of the drum cartridge, which in turn will contaminate the toner cartridge again (a vicious cycle)! The remaining 80g of toner is actually the waste toner and a small amount of new toner combined. There is not enough new toner to work or "charge up" left. Not cleaning this toner out completely is the largest cause of cartridge failure.

The cleaning section of the drum cartridge consists of a "cleaning brush" and a recovery blade. The cleaning brush has two opposite charges placed on it during the print cycle. The first attracts any remaining toner off the drum. The second repels the toner off the brush back onto the drum where it then transfers back into the toner cartridge. This is all done in a timing sequence that does not interfere with the printing process. If the cleaning brush becomes contaminated with bad toner that will not accept the proper charge, the brush will not be able to clean itself, and backgrounding will occur. It seems to be the nature of contaminated toner that it will accept most of the charge to be cleaned off the drum, but it will not accept the charge that would allow the brush to clean itself off at all. A properly working cleaning brush will at any given time have only a small amount of toner on it. Once contaminated, toner will accumulate, which will only cause the problems to get worse. The drum cartridge does not have a waste chamber; all the waste toner is recycled back into the toner cartridge.

Since the developer roller actually contacts the drum, the waste toner is transferred back into the supply of the toner cartridge. As stated above, once you print with a bad toner cartridge the drum unit will become contaminated. Even when you change out the toner with a good properly recycled or new OEM cartridge, the drum unit will transfer some of the bad toner back into the good toner cartridge, which will again cause backgrounding. Both cartridges will be contaminated again. Basically, once you have backgrounding, both cartridges need to be cleaned out.

The remaining 80g or so of "toner" in the toner cartridge is just below the bare minimum that can maintain the proper charge level. When the change toner light comes on, the toner will not charge up to the proper level and will cause the backgrounding. As the toner cartridge reaches the end of its useful life, the printer senses the low charge level in the toner supply and will try to keep the charge level up. This constant charging keeps an almost "empty" cartridge from backgrounding. Once the printer cannot get the remaining toner up to the minimum charge, the change toner light comes on. The cartridge at this point will still be printing properly. If you were to take that same cartridge out of the machine for a few days, and then put it back in the printer with out doing anything to it, the cartridge will background. This will happen because the charge level that the printer was trying so hard to keep up has dissipated out and the materials left can no longer accept a proper charge.

#### **WHAT DOES THIS ALL MEAN?**

1. Make sure that your cartridge technicians thoroughly clean out the supply chamber of the toner cartridge. Dry and clean compressed air is the best method.
2. In the event that they forget, and you have a backgrounding cartridge. The toner must be completely cleaned out again (do not use the toner over) and new fresh toner must be installed. At this point, the drum unit has to be taken apart and cleaned out with emphasis on the cleaning brush area. This is a very simple process but very necessary once contaminated.
3. Only fully tested, dedicated chemicals should be used to clean the developer roller in these cartridges. The blue-white film that builds up on the roller should be removed for proper printing. Never use anything except a dedicated fully tested brother developer roller cleaner. Other chemicals may seem like they cleaned the roller, but will cause a chemical reaction that may not happen right away and can potentially cause damage to the cartridge/machine when used.
4. When rebuilding the drum unit, alcohol can be used to clean the drum, but no other chemicals anywhere else. This is especially true of the cleaning brush. This brush has a conductive coating on it that will be removed if any solvents get on it. Once the conductive coating is gone, the cartridge is useless.

## CARTRIDGE TROUBLESHOOTING

### Backgrounding: Toner and Drum Cartridge

By far the most common problem with these cartridges. There are three common causes:

1. The first is contaminated toner. If the old toner in the toner cartridge was not fully cleaned out, a shaded background will result usually over the entire page. Can also be caused by a contaminated cleaning brush in the drum cartridge, which is directly related to a bad toner cartridge.
2. If the developer roller in the toner cartridge is worn, it will tend to pull too much toner, and backgrounding will result. This normally happens only on cartridges that have been recycled a few times. A normal roller will have a somewhat mottled look, and the texture should be smooth. If the roller has lines, small cracks, or just doesn't look right, don't use it.
3. Another backgrounding issue can result from the toner being used. Not all aftermarket toners will work together. This is because there is always a small amount of toner left on the drum cartridge cleaning brush. Most aftermarket toners will work over the OEM, but not all will work over another aftermarket toner. If your cartridges work in house but background out in the field, it can be that the drum unit has failed, or that another aftermarket toner was used previous to yours. Check with your vendor to make sure that your toner will work on top of another (all) aftermarket brand(s).

### Clicking: Toner Cartridge

On the left side of the cartridge there is a series of gears with very fine teeth. If any toner gets on these teeth during the cleaning process, and is not cleaned off, the toner can cause a tooth to break, and clicking will result. We have found it easy to keep one hand over the gear train when blowing the cartridge out and when filling it, that way the gears stay clean. If they do get toner on them, clean the gears and the shafts with alcohol, and lubricate with fine grease. Both the shafts and teeth need to be lubricated. Clicking gears can also result from toner not specifically designed for the TN-460 being used. If the toner particles are not uniform, the toner will not flow easily, and the mixing auger inside the toner cartridge can bind, causing a tooth to break.

### Vertical speckled toner pattern on right side of page: Toner Cartridge

This is a common problem. There is a small plastic clip on the right side of the developer roller that is held on only by double sided tape. It is very common for it to fall off. In fact we have seen as much as 35% of the cores come in with out these clips. The purpose of the clip is to keep the toner from building up on the edge of the developer roller. If it is missing, the toner will build up and eventually start to fall off and cause a speckled vertical streak. The left side of the cartridge also has a clip, but it is permanent and does not fall off. New clips are available.

### Dark black vertical streaks: Drum Cartridge

This is normally caused by either a dirty primary corona wire, or the blue corona wire cleaner is not in its "home" position on the left side of the cartridge.

### Gray vertical streaks down side of page: Toner Cartridge

This is normally caused by a groove in the developer roller. When this happens, the roller should either be replaced with a new one or repaired and recoated. Both solutions are available.

### Light print: Drum Cartridge

Can be caused by a dirty or worn transfer roller. These rollers are located inside the cartridge. In our tests, they should last at least 2 to 3 cycles.



**Black or white horizontal lines: Toner and Drum Cartridge**

Black lines normally appear when there is a build up of toner. White lines appear when there is a dead spot, or contamination of the roller. If the lines repeat every 94.1mm (approx. 3 3/4"), the drum is bad, or dirty. If they appear every 39mm (approx. 1 9/16"), the developer roller in the toner cartridge is bad or dirty.

**Solid black pages: Drum Cartridge**

Bad drum ground contact, probably from the drum axle shaft to the contact gear inside the drum.

**Perfectly straight thin black lines down page: Drum Cartridge**

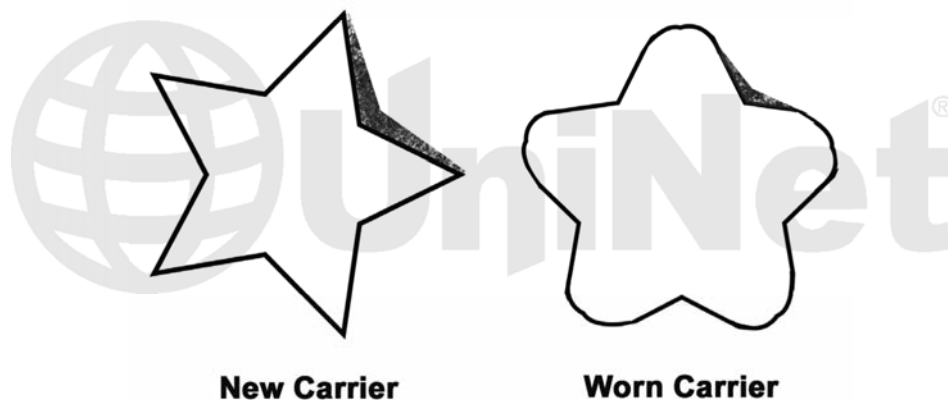
Scratched drum.

**Black dots that repeat every 94.1mm (3 3/4"): Drum Cartridge**

Bad drum, or something is stuck to the drum surface.

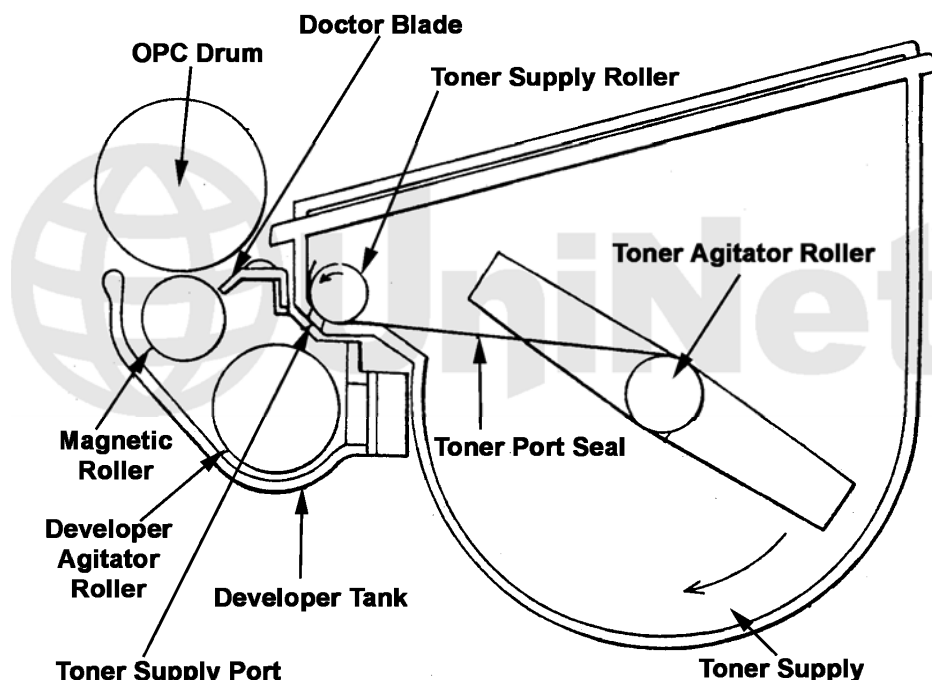
**6. DUAL COMPONENT SYSTEMS (ANALOG SHARP COPIERS)**

This section is loosely based on the Sharp Z Series of copiers. Dual component machines are usually analog copiers that use an exposure lamp as a source of light. The cartridges used in this type of machine can come in two styles. One is where they have both developer and toner in a single cartridge (Z Series), and the other is where the toner is in one cartridge (or tube) and the developer is in another. In both cases the drum cartridge is separate. As this technology has been around for quite a while, there are many versions in the field. The theory however is basically the same for all. Developer is actually made up of two components: metal filings (carrier) and toner. When developer is manufactured, the correct toner is mixed with the carrier at a specific percentage. As long as everything is running correctly, developer never actually leaves the cartridge. It picks up the toner from the supply chamber, brings it out to be transferred to the drum, and returns to the developer section where it will pick up more toner and start over again. The mixture of the toner and developer is controlled by a sensor which is normally located in the toner/developer cartridge. This sensor looks for a specific mixture. When it does not see the proper mix, it will cause the machine to cycle, and bring more toner into the developer section until it does. That is why when a new cartridge is installed in a Sharp machine, it will cycle for a while before the ready light comes on. The best explanation I have ever heard on why developer must be replaced is this: Think of a single metal filing as having the shape of a five-point star (it doesn't, but it makes it easier to explain). When the developer is new, the points of the star are sharp and there is a considerable amount of surface area between the points for the toner to sit. As copies are run, the friction of the toner and the magnetic roller will start to wear the points down. As the points get dull, the surface area for the toner to sit in is less. This will cause light prints and if let go long enough, the toner low sensor will never see the correct mixture and will not allow the machine to go to the ready state. The Sharp Z series of machines use developer that normally lasts at most two cycles. Other machines can have developer that last longer, it depends on the toughness of the carrier.



**New Carrier**

**Worn Carrier**

**DUAL COMPONENT STYLE CARTRIDGE:**

The **first stage** in the copy process starts when you press the start button. At that point the scanner starts to move across the glass and the exposure lamp lights up. The OPC drum gets charged from the primary corona wire which has about 5000 VDC on it (actual charge is roughly 800VDC when it gets to the drum). The light from the exposure lamp is reflected off the paper to be copied, and is reflected through a series of mirrors and lenses (or fiber optics in some machines) to the OPC drum. In the normal copy mode, the speed of the scanner and the drum are locked together so that they move in a 1:1 ratio. As the reflected light strikes the drum, it discharges the blank (white) areas of the copy. No light was reflected from the printed areas, so these areas remain charged. The charged area is actually a mirror image of the original copy and is known as a latent image. Some people call this a “write white system.” HP lasers can be considered a “write black system.” NOTE: This process is the opposite of what happens in a digital copier or laser printer. In most of those machines the image is drawn on the drum by a laser. This is the discharged part of the image. The non-printed or white areas of the image remain charged. This is also why most analog dual component machines use a positive toner system, and lasers use a negative toner system.

In the **second stage**, as the drum turns, the magnetic roller in the toner/developer cartridge is also turning. The developer has a full load of toner which is attracted to the charged areas of the drum. The attraction is enough to draw off the toner, but not the developer. The new toner is fed to the developer section by the toner agitator which pushes the toner up under the toner port seal and to the toner supply roller. The supply roller pushes the toner out the toner feed port, where it mixes with the developer. When the developer mixture sensor senses the proper mixture, it sends a signal to stop the agitator and supply rollers from turning. As all this is happening, the paper has been picked up, and is now coming to meet the drum. The transfer corona wire places another 5000V DC charge on the paper, and the image is transferred from the drum to the paper. The residual charge on the drum is enough to cause the paper to wrap around it, so there is usually some type of separation belt. This can be in the machine or on the drum cartridge.

The transfer of the image to the paper is the **third stage**. The image is then fused on to the paper by the fuser assembly, which is comprised of the upper and lower fuser rollers. The lower rubber roller presses the page up into the upper roller which then melts the toner into the paper. The upper roller is a hard Teflon-coated heated roller which is kept clean by a felt wand. The roller is usually heated by a high wattage halogen lamp.

The **fourth stage** is where the OPC drum is cleaned. On average, approximately 90% of the toner is transferred to the paper during the print cycle. The remaining 10% remains on the OPC drum and is cleaned off the drum by the wiper blade, guided into the waste chamber by the recovery blade, and stored in the waste chamber. The Sharp Z drum cartridges do not have a waste storage area. They have a series of augers that move the waste toner away from the wiper blade, and into the waste chamber located on the toner cartridge.

The **final stage** is completed by the erase lamps in the machine. These lamps bathe the drum in a red light that neutralizes the residual electrical charges left on the OPC drum surface. The OPC drum is now ready to be conditioned by the primary corona wire start the printing process all over again. If one of these red lights is not functioning, you will get what looks like a bad wiper blade problem gray vertical streaks down the page. In the first stage we talked about the drum and scanner being locked in a 1:1 ratio. In reduction and enlargement modes, the speed of the scanner is changed, and the image is run through a different set of lenses to produce the desired result.

## DUAL COMPONENT STYLE CARTRIDGE COMPONENTS

- Developer:** Developer is metal filings precisely mixed with toner. The developer carries the toner out to the drum and returns back to the supply section to pick up more toner. The developer never leaves the unit, it just wears out over time.
- Magnetic Roller:** This is the most important component for producing solid print density. As the magnetic roller rotates it attracts the developer/toner mixture to it by a permanent magnetic axle which is fitted inside the sleeve and electrical signals from the high-voltage power supply in the printer.
- Toner Low Sensor:** This sensor is usually located in the toner cartridge. This sensor looks for a specific mixture of toner to developer. When it does not see the proper mix, it will cause the machine to cycle, and bring more toner into the developer section until it does. That is why when a new cartridge is installed in a Sharp machine, it will cycle for a while before the READY light comes on. These sensors are easily damaged by static charges. Care should be taken if vacuuming the cartridge clean, to avoid damaging this sensor. We recommend that the cartridge be dumped out, and blown clean with compressed air to help avoid these issues.
- Toner Supply Port:** A damaged sensor can cause overtoneing. Overtoneing is too much toner on the developer, and is another way of saying, "backgrounding." A severely damaged sensor will cause the machine to continuously cycle, and never get to READY.
- Doctor Blade:** This port is a small slot that only allows a regulated amount of toner into the developer section. Toner is fed to this port by the toner agitator roller, and the toner supply roller. When the toner low sensor detects the proper mixture of toner and developer, a signal is sent to the machine that stops the toner agitator and feed rollers from turning. The toner port seal then effectively closes off the port to prevent extra toner from falling into the developer area.
- Primary Corona Wire:** Physically regulates the amount of toner on the magnetic roller by using a metal blade at a fixed distance from the magnetic roller sleeve.
- Transfer Corona Wire:** The primary corona wire applies approximately a 5000V DC signal to the surface of the drum so that the reflected light from the exposure lamp can discharge the non printed areas of the copy. The transfer corona wire applies approximately a 5000V DC signal to the surface of the paper so that the latent image on the drum is drawn to the paper as it passes underneath. This image is held on the paper by a static charge until it is melted into the paper by the fuser assembly.

- Drum:** Drums used in disposable cartridges are mostly OPC drums or “organic photoconductors” that refer to the type of chemicals used to coat the aluminum tube that is the drum base. All drums are light sensitive. There are normally three different layers of chemicals used to make the drum. The first is an insulator, the second is the reactive layer that reacts to light, and the third is a protective layer. It is this protective layer that determines how long a drum will last.
- Wiper Blade:** The rubber edge of a wiper blade cleans the drum of any toner that was not transferred to the paper. The blade rides directly on the drum, and is one of the main causes of drum wear.
- Recovery Blade:** The recovery blade is a very thin Mylar blade that guides toner that was wiped off the drum by the wiper blade into the waste chamber. If this blade were not present, or damaged, toner would drop from the cartridge onto the printed pages
- Waste Chamber:** Collects and holds all the waste toner. It can be located in the drum cartridge, as a separate chamber on the toner/developer cartridge, or as a separate replaceable chamber in the machine.
- Supply Chamber:** Contains the developer, all the new un-used toner, the magnetic roller assembly, miscellaneous feed rollers and the doctor blade.