Standard Components

Light Sources

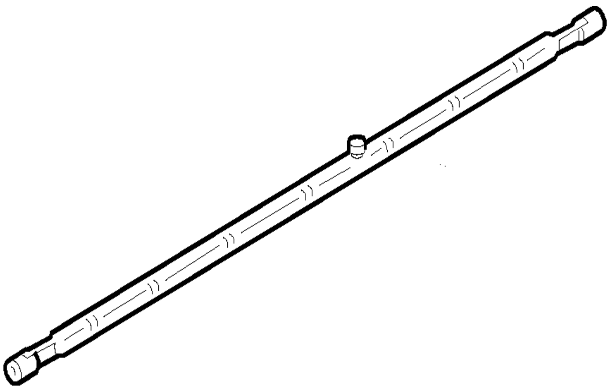
Our products use a variety of different light sources. These range from intense sources such as halogen lamps to relatively weak sources such as LED arrays. The light source selected depends on the function—original *exposure*, *quenching*, etc.—and the machine design. The most important light sources from a design point of view are those commonly used for original exposure (scanning)—the halogen lamp, the fluorescent lamp, and the xenon lamp. The most basic characteristics of these three lamps are summarized in the following table.

	Halogen	**Fluorescent**	**Xenon**
Light Intensity	High	Low	Low
Spectrum	Wide	Narrow	Narrow
Temperature dependency*	Small	Large	Large
Stability at start-up	Good	Poor	Good
Heat output	Large	Small	Smallest†
Cost	High	Low	Lowest†

*Dependency of light intensity on temperature †of these three lamp types.

Halogen Lamp

A Halogen lamp is an incandescent lamp filled with halogen gas (iodine or bromine). The halogen gas suppresses filament evaporation using a chemical regeneration process known as the "halogen cycle" (see below). Halogen lamps have a long effective life and strong light output.



Characteristics

- Extensive spectrometric distribution
- High illumination level
- Small changes resulting from the temperature of the light source and small transient changes
- Long lead time to lighting
- Large electricity consumption
- Large heat output

Halogen Cycle

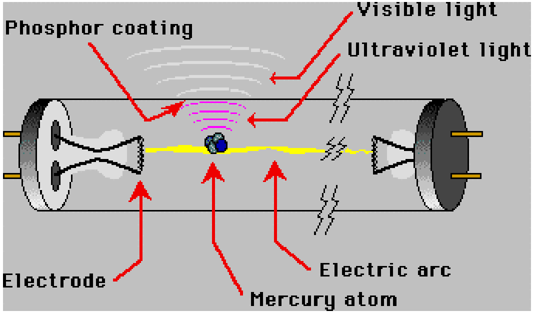
During lamp operation, the halogen gas combines with tungsten molecules that have evaporated off the filament. The evaporated tungsten molecules are then deposited back onto the filament, instead of on the lamp wall. Consequently, there is almost no reduction of light output from lamp wall darkening. Some light reduction from filament degradation does occur, but it is significantly lower than in other incandescent lamps. The halogen regenerative process requires that tungsten-halogen lamps operate at an extremely high temperature, which slightly increases lamp efficiency, and produces bright light and high temperatures. To withstand these high temperatures, tungsten-halogen lamps usually have quartz glass walls. Halogen lamps with quartz walled bulbs must be handled carefully. Quartz materials are extremely sensitive to oil and dirt from human skin, which can cause bulb wall deterioration, and premature lamp failure.

Applications

The intense light and wide spectral output of the halogen lamp suit it to color copiers and high-speed copiers. However, as it consumes a lot of electricity and undergoes drastic rises in temperature, it is generally not used for low-speed copiers and single scanner models. Since halogen lamps output a large amount of heat, they are also commonly used as a heat source in fusing units.

Fluorescent Lamp

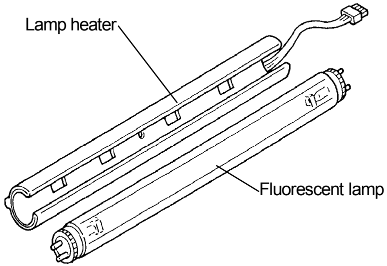
A fluorescent lamp is a closed glass tube that has electrodes at each end and an internal coated surface of a phosphorous material. The tube is filled with argon gas (or argon/krypton gas) mixed with a small amount of mercury vapor. When a suitable high voltage is applied across the electrodes, an electric arc forms and the resulting current ionizes the mercury vapor. The ionized mercury emits ultraviolet radiation, which strikes and excites the phosphor coating, causing it to glow and produce visible light.



FL operation (Illustration source unknown)

Characteristics

- Has a medium luminance
- Produces excess heat from filaments
- Short lead time to lighting
- The exact makeup of the phosphor coating determines the color properties of a fluorescent lamp’s light output.
- The intensity of illumination changes depending on the tube temperature.
- Uneven illumination at the ends of the tube requires shading plates.



Applications

Fluorescent lamps are suited for use in low-speed color copiers as well as medium-speed black and white copiers. They are the most commonly used type of lamp in fax machines. However, the light quantity changes depending on the tube temperature; and a lamp heater may be included to solve this problem.

Some Ricoh machines use a variation of the fluorescent lamp, called the cold cathode fluorescent lamp (sometimes called CFL or CCFL), as a *quenching* lamp or pre-transfer lamp. CFLs are also sometimes used as the exposure lamp in image scanners.

Xenon Lamps

A xenon lamp is a tube filled with xenon gas. When a voltage is applied across the lamp terminals, the xenon gas ionizes and current flows through the gas, which emits light. The terminals do not have to be preheated, unlike in fluorescent lamps.

There are different kinds of xenon lamp. The xenon lamps used in black and white digital machines output a yellowish-green light with a peak at 543 nm. The xenon lamps used with color machines utilize fluorescence as well as gas discharge to produce white light.

The xenon lamp used in ***model A250***

Characteristics

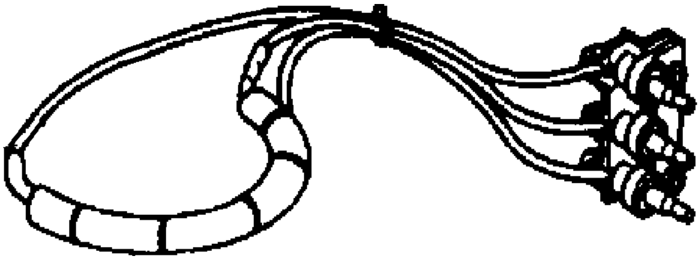
- Medium brightness light output
- Less expensive than fluorescent or halogen lamps
- Good durability—generally can be expected to last the life of the machine
- Low heat output—exposure cavity cooling isn't required
- More compact than fluorescent lamps

Applications

Xenon lamps can be used as exposure lamps for printers, lower speed copiers, fax machines, and scanners.

Recently, xenon lamps have been increasingly used in digital products. This is mainly due to improvements in the spectral sensitivity of *CCDs*, which allows use of the more economical xenon lamp.

Xenon Flash Lamp



xenon.pcx

The xenon flash lamps used in office machines are basically the same as the flash lamps used in photography—only larger. A xenon flash lamp has main electrodes at both ends of a gas tube, which contains xenon (Xe) gas. (Generally, any noble gas will work in a flash lamp. However, gases other than xenon are rarely used.) The lamp also has trigger electrodes, generally in the form of a wire, or conductive coating in the lamp tube wall.

The typical xenon flash lamp circuit consists of four parts: (1) power supply, (2) energy storage capacitor, (3) trigger circuit, and (4) the flash lamp itself. It operates as follows:

- The energy storage capacitor connected across the flash lamp is charged by the power supply. (The energy storage capacity is quite large.)
- A separate small capacitor is charged to generate a trigger pulse.
- The charge on the trigger capacitor to is dumped into the primary of a pulse transformer whose secondary is connected to the trigger electrodes. The pulse generated by this trigger is enough to ionize the xenon gas inside the flash lamp.

- The resistance of the ionized xenon gas is very low and the energy storage capacitor discharges through the flash lamp, which then emits a brilliant burst of light.

Characteristics

- Produces an intense peak of radiant energy.
- Since flash lamps use a high voltage, precautions must be taken against electric shocks.

Applications

Xenon flash lamps are suited for use in high-speed black-and-white copiers. They are also occasionally used as the heat source for flash fusing.

Neon Lamps

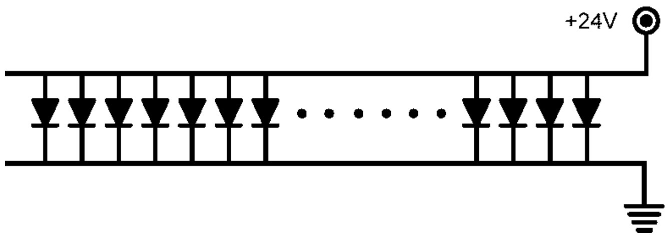
Like the cold cathode fluorescent lamp, a neon lamp uses a cold cathode to excite the atoms of a gas in an enclosed tube. However, the light is emitted by the neon gas in the tube rather than by a phosphorous coating inside the tube. The neon gas gives an orangish-red light.

Applications

In Ricoh products, neon lamps are used only as *quenching* lamps.

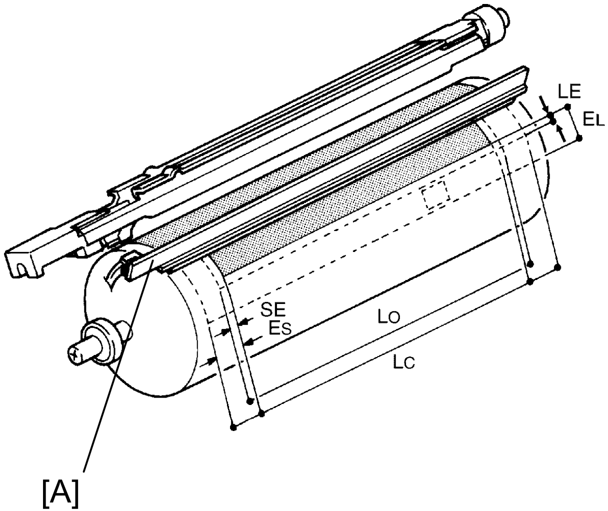
LED Arrays

LED stands for *light emitting diode*. As the name implies, an LED is a diode that emits light when a small electric current passes through it. LEDs are commonly used as display devices and indicators (see the next section), but they can also be mounted together in an array and used as a light source.



Characteristics

- LED arrays can be wired so that the LEDs can be turned on/off in blocks to provide precise illumination.
- LED arrays are useful where compact components are required.



Applications

In Ricoh products, LED arrays are used for document exposure in small fax machines and scanners. They are commonly used as quenching lamps in analog and digital copiers. Also, most analog copiers use them for erase lamps. The illustration to the right shows an LED array [A] used as an erase lamp in a copier.

Semiconductor Components

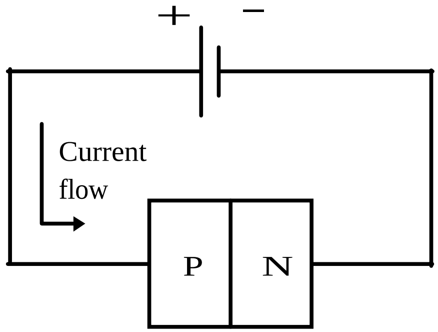
This section deals with components that are based on semiconductors.

Diodes

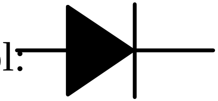
Normal Diodes

A diode consists of a p-type semiconductor joined to an n-type semiconductor. A diode only passes current in one direction. If it is connected up as shown opposite, current will flow.

However, if the power source is connected up the opposite way around, current will not flow.

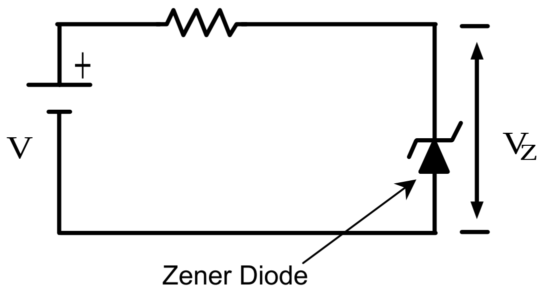


Symbol:

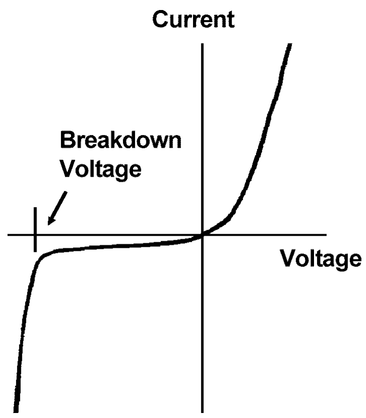


Zener Diodes

A zener diode is connected the opposite way around from a normal diode. Normal diodes cannot pass any current if connected up in this way, and may be destroyed. However, zener diodes connected in reverse will pass current, if the voltage across the diode exceeds a certain value, known as the breakdown voltage. After the breakdown voltage has been reached, the voltage across the diode will not change much, even if the current is greatly increased.



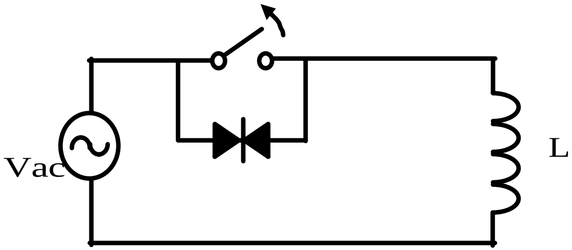
Zener diodes can be used to make sure that the voltage at a certain point in a circuit (Vz in the above-right diagram) does not exceed a certain value. The diagram below right is the typical diode characteristic curve. While normal diodes should operate below the breakdown voltage and may be damaged if it is exceeded, the zener diode is intended to operate at that voltage.

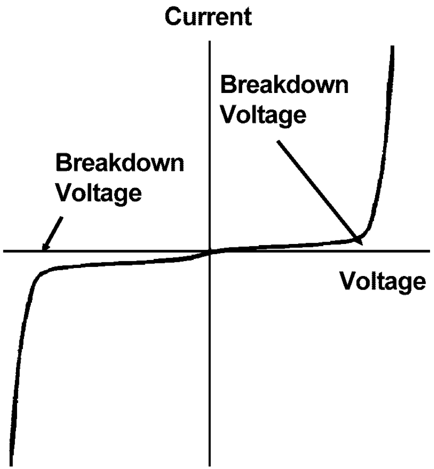


Varistors

A varistor acts like two zener diodes connected back to back. This means that it has positive and negative breakdown voltages. A single zener diode only has a negative breakdown voltage. Varistors are used in similar ways to zener diodes. They are also useful in protecting circuits against voltage spikes. The example to the right shows a varistor connected across a switch to eliminate sparking.

The illustration below right shows the characteristic double-breakdown curve of the varistor.





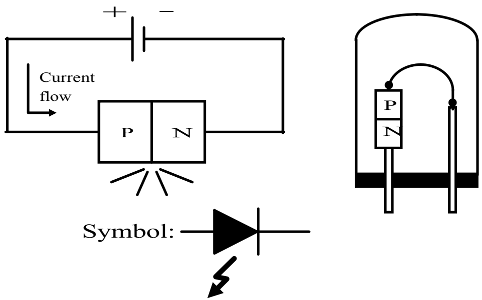
Light Emitting Diodes

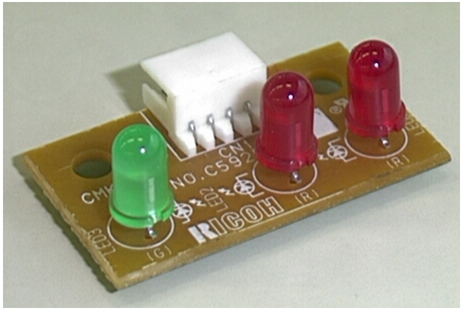
A light emitting diode (LED) is a kind of diode that emits photons (light particles) when a small electric current passes through it. When current flows across the pn junction in diodes, energy is released in the form of heat. However, the material used to make LEDs is selected so that some of the energy is emitted as light.

Light emitting diodes have some special characteristics. They convert electrical current directly into light; therefore, the LED is more efficient than many other light sources. Also the light emitted by an LED has a narrow wavelength range.

The LED is enclosed in a transparent case of epoxy resin or plastic. The typical LED produces red or infrared light; however, there are varieties to produce many colors. Alternately, as shown in the illustration, a colored case can be used to modify the light output.

LEDs can be used to form large displays and are often the lighting elements in information displays used in public places such as highways and airports. In office machines, LEDs are used to light indicators on operation panels, as indicator lights on circuit boards, and in *LED arrays*.





A small PCB with indicator LEDs on it.

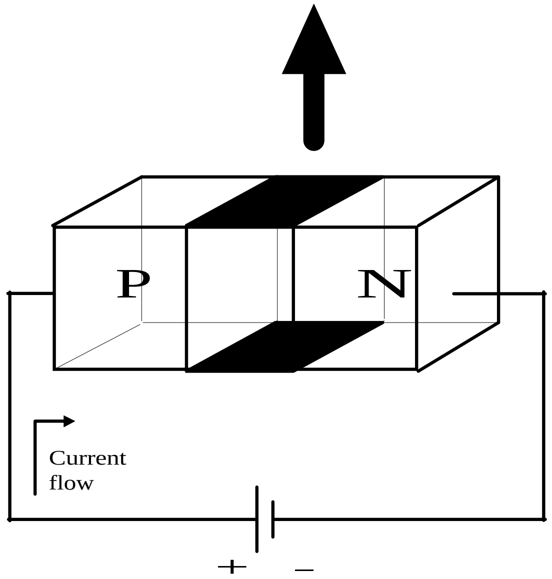
Laser Diodes

Natural light is a mixture of light of different wavelengths. However, a laser beam consists of light at one wavelength, and the waves are all in phase (the peaks and troughs in the waves all coincide).

As the waves are all in phase, the light is very intense (if peaks and troughs do not coincide, they tend to cancel each other out, reducing the power of the beam).

Natural light can be focused, but it cannot be focused to so fine a point as laser light can. This is because a lens at the same angle does not refract the different components of natural light, having different wavelengths.

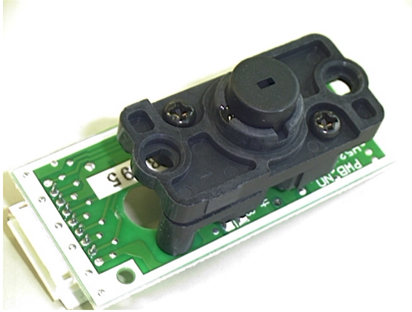
To the right is a simplified diagram of a laser diode. Laser diodes can be considered as similar to LEDs in operating principle; current flowing across the pn junction causes energy to be emitted in the form of light. LEDs emit light in all directions. However, the pn junction in laser diodes has a mirror at each end, reflecting the light back into the diode. When the current



passing through the diode reaches a threshold value, the light reflected back into the junction stimulates more atoms in that region to emit more radiation of the same wavelength. Some of this light passes out of the diode through one of the mirrors, which is partially transparent. The light beams emerge from the mirror parallel to each other.

The wavelength of the laser depends on the composition of the semiconductor material. The lasers used in most printers emit red light. Engineers are trying to develop lasers that emit green or blue light; the shorter wavelengths of this light would allow smaller dots to be written to the photoconductor, leading to higher resolution printouts.

Laser diode



LD Unit

For More Information

For a brief introduction to laser theory and more information on laser diodes we suggest you reference *A Brief Introduction to Laser Diodes* at the University of Washington web site (http://www.ee.washington.edu/class/ConsElec/Chapter6.html)*.

*We have no control over this web page. The content or location may change at any time.

Transistors

Bipolar Junction Transistors

A bipolar junction transistor contains two junctions between p and n type semiconductor, and three electrodes (the collector, the base, and the emitter). The most common use of a transistor is as a switch. They are also used in amplification and rectification. There are two types of transistor: the npn transistor, and the pnp transistor. The npn transistor is the most commonly-used of these.

The diagrams to the right show the symbols for both types of transistor, their construction, and the direction of current flow. Notice that the batteries in the pnp transistor circuit are connected up the opposite way round from the npn transistor.

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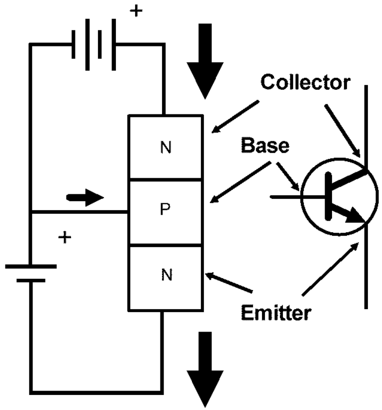
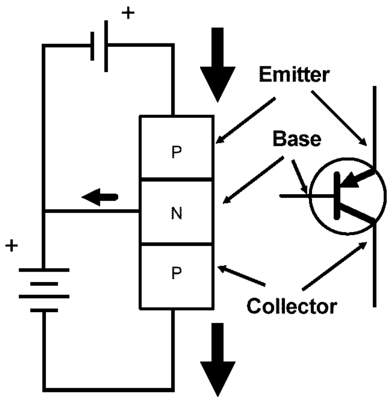
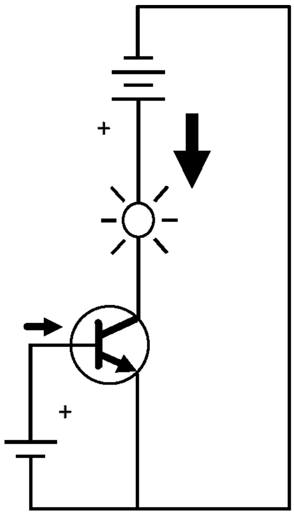
NPN Type



PNP Type



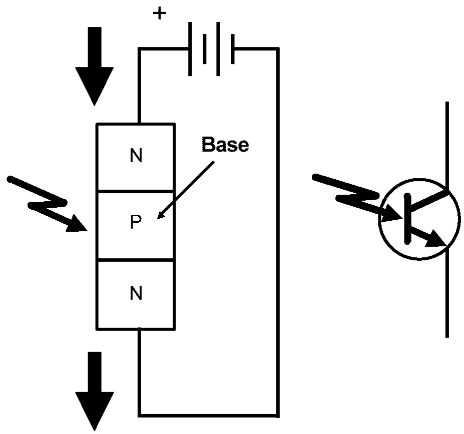
In the diagram on the right, an npn transistor is controlling a lamp. A positive voltage is applied between the collector and the emitter. The lamp cannot switch on unless a voltage is also applied between the base and the emitter.



Phototransistors

A phototransistor works like an ordinary bipolar transistor, except that the transistor is switched on by light shining on the base region of the transistor. The diagram on the right shows an npn-type phototransistor.

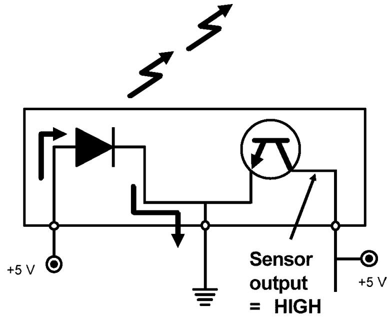
In office machines, phototransistors are used in *photointerrupters*, optoisolators, and *reflective photosensors*.



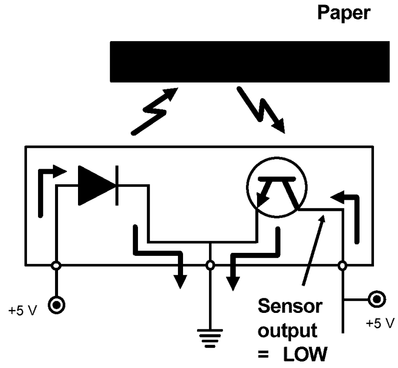
Sensors and Switches

Reflective Photosensors

Reflective photosensors are short range sensors that have a light emitting element (usually an LED) and a light sensitive element (usually a phototransistor). Reflective photosensors work by bouncing light off of an object.



There are two main types of reflective photosensor. The simplest type signals the presence or absence of an object or condition—the presence of paper, the presence of a belt reference plate, the presence of a cassette or cartridge. The illustration to the right is an example. This type of sensor has a binary output; it is either activated or deactivated.



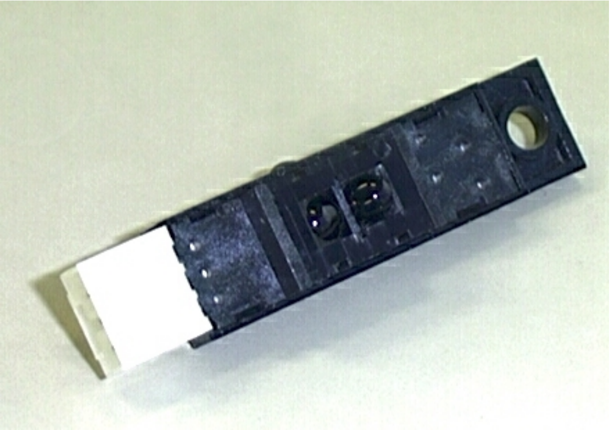
The other type of reflective photosensor is used to gather information about the surface being sensed. It has a variable output that depends on the strength of the light striking the light sensitive element. The primary example is the image density sensor (or ID sensor) used in copiers and other products.

Characteristics

- Small, inexpensive, rugged
- Available in many different types (size, shape, sensitivity, specifications).

Applications

Reflective photosensors are used for detecting paper in the paper path, paper size detection, master belt position detection, and a number of other functions.



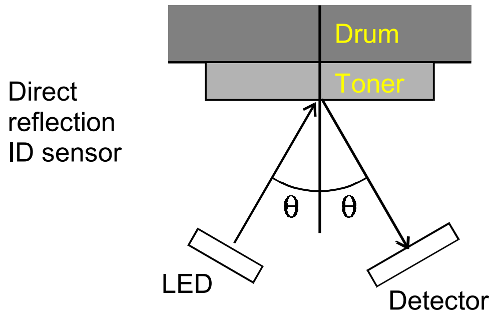
A reflective photosensor

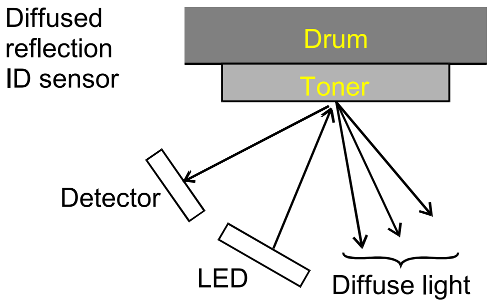
ID Sensor

The ID sensor is a special application of the reflective photosensor. Two types of ID sensor are used as part of the *process control* system in photocopiers.

One type is a direct reflection ID sensor. It is positioned so that light from the LED reflects directly to the detector. This is the commonly used type of ID sensor.

The other type is a diffused reflection ID sensor. In addition to the light reflected at a direct angle, diffuse light reflects at all angles from the toner on the drum. This sensor detects image density by receiving some of this diffused light. Using this type of sensor improves the measurement accuracy of the sensor pattern densities—particularly for yellow, cyan, and magenta toners.





Photointerrupters

A photointerrupter consists of an LED and a phototransistor separated by a slot. The sensor detects when something enters or leaves the slot, such as an actuator, a part of the machine, or a sheet of paper.

When there is no actuator in the slot, light from the LED activates the phototransistor, and current flows through it. However, if an actuator enters the slot, light from the LED is blocked and current cannot pass through the phototransistor.

Photointerrupters have a variety of uses in office machines. They are commonly used as home position detectors for moving parts such as lenses and scanners and to detect paper as it moves through the paper feed path. In machines such as photocopiers that handle a variety of feed stock photointerrupters are generally preferred over reflective photosensors because photointerrupters are not affected by the reflectivity of the paper.

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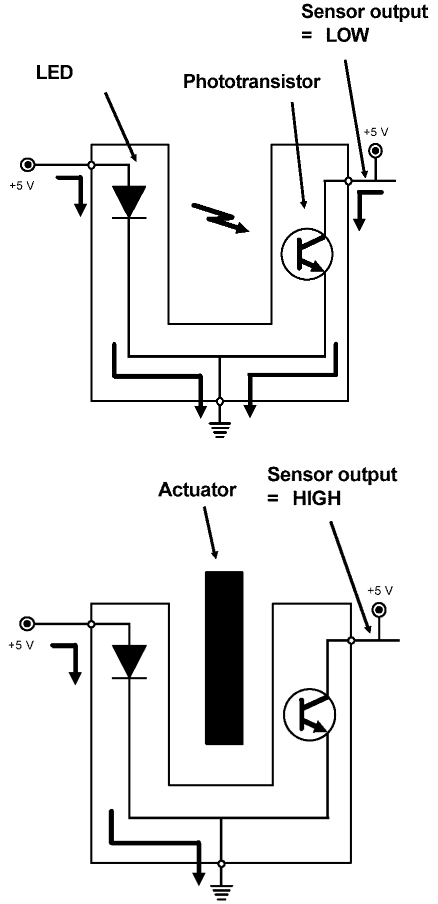
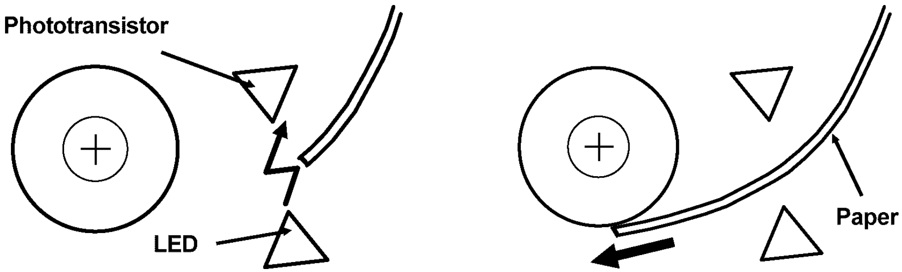
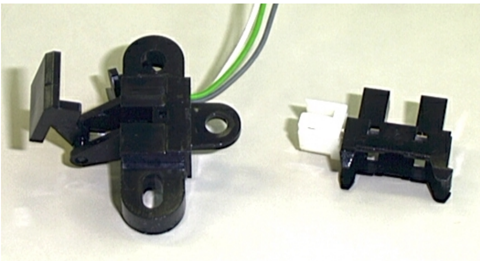


Characteristics

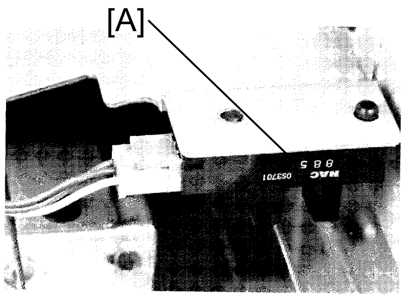
- Small, inexpensive, rugged
- Available in many different types (size, shape, sensitivity, specifications).



Most photointerrupters that are used as paper detectors use a "feeler" type plastic actuator. However, a photo-interrupter is occasionally installed across a paper feed path, as shown above. This type of photointerrupter may become dirty and will need cleaning periodically.

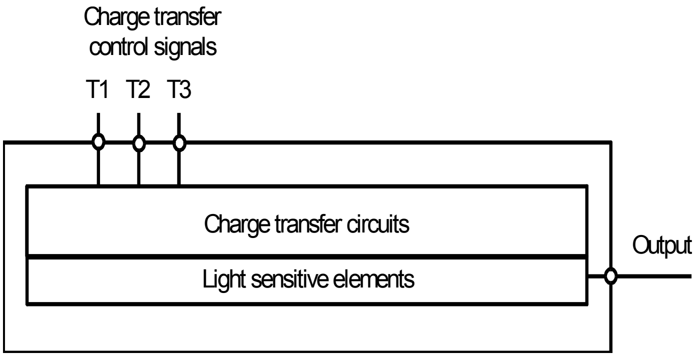


Photointerrupters: The one on the left has a weight operated actuator built on it.



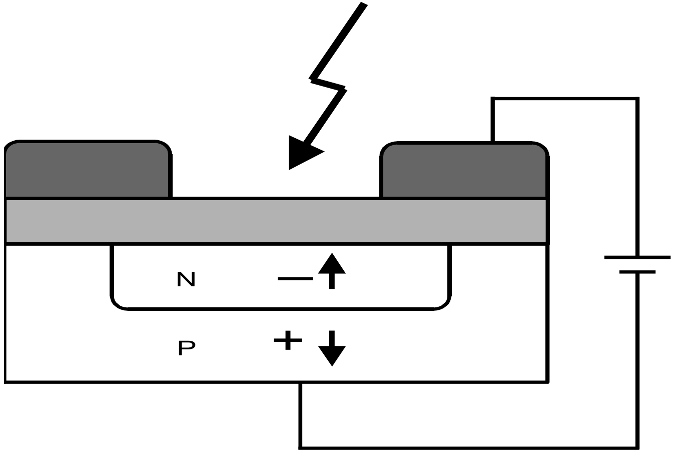
A photointerrupter [A] used as a home position sensor. Notice the scanner drive wire below the slot of the photointerrupter.

CCDs



A CCD (Charge Coupled Device) is a semiconductor chip with light receiving elements etched onto it. In a digital machine that scans documents, the CCD is a row of these elements; each element on the CCD corresponds to one pixel on one main scan line across the original. The CCD also contains circuits for transferring the accumulated charges out of the elements and into the video processing circuits.

The diagram on the right shows a simplified cross-section of a CCD element. When applying the appropriate voltage across the element, any light hitting the element liberates electrons from the silicon at the boundary between the n and p type semiconductors. Positive charges can flow out, but an insulating layer traps the electrons, and gathers them under the electrodes. The brighter the light shining on the element, the more electrons generated in that element.



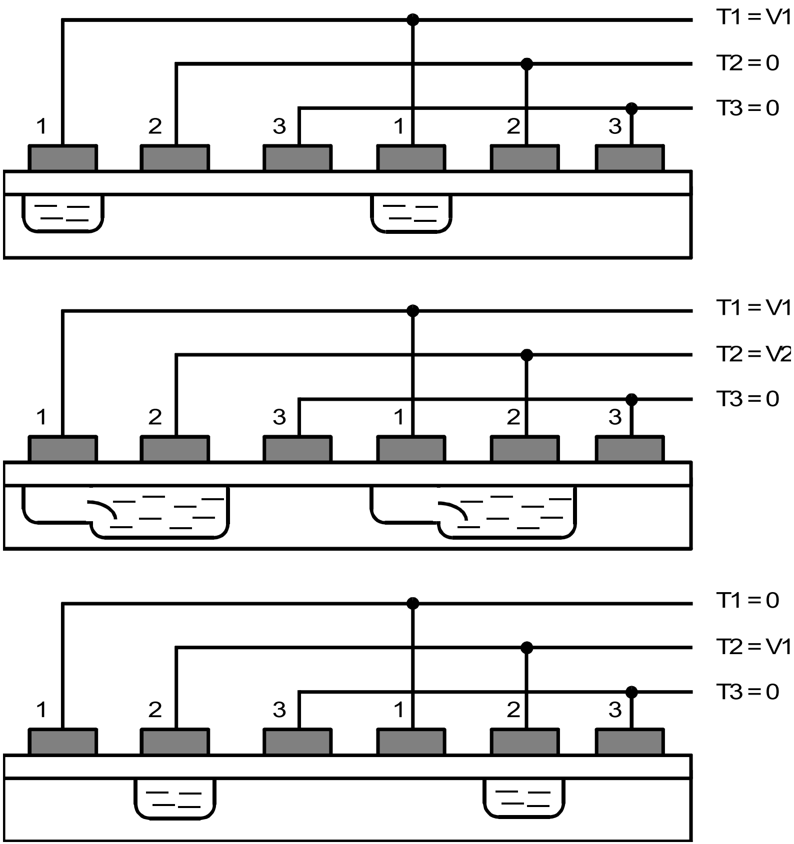
After scanning a line, the charges trapped in each element must be moved out of the CCD and into the video signal processing circuits so that the next line can be scanned. The diagram shows how this is done.

The diagram shows two adjacent elements. Each element has three electrodes attached to it. After scanning a line of data, the electrons are under electrode 1, as shown in the top diagram.

A voltage V2, higher than V1, is then applied to electrode 2. The electrons are attracted to the area beneath electrode 2, as shown in the middle diagram.

Then, the voltage at electrode 1 switches off and the voltage at electrode 2 is set to V1, as shown in the bottom diagram. The electrons all gather under electrode 2.

By repeating the above procedure, but using electrodes 2 and 3 instead of electrodes 1 and 2, the electrons move to

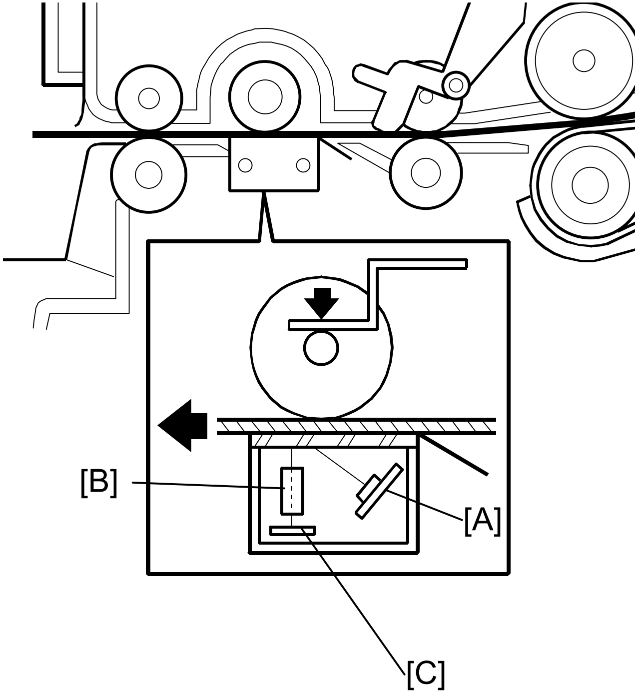


electrode 3. The result of this is that one element shifts all the charges along, and the element charges at the end of the CCD shift out of the CCD. By continuing this process, all the charges shift out of the CCD. The series of charges appears on the CCD output line as a serial analog video signal. This signal passes to the video processing circuits, allowing the next line of the original to be scanned.

Contact Image Sensors (CIS)

The contact image sensor (CIS) is a compact image reading assembly containing an *LED array*, an array of self-focusing optic fibers (SELFOC), and a strip of light detectors, such as *phototransistors*. The CIS is used instead of the *CCD* in the most compact of fax machines.

The illustration to the right (from *model H545*) shows a typical CIS. Light from the LED array [A] reflects off of the document, through a row of self-focusing optic fibers [B], and onto a strip of phototransistors [C]. The entire assembly is located directly below the document, so a long light path is not necessary.

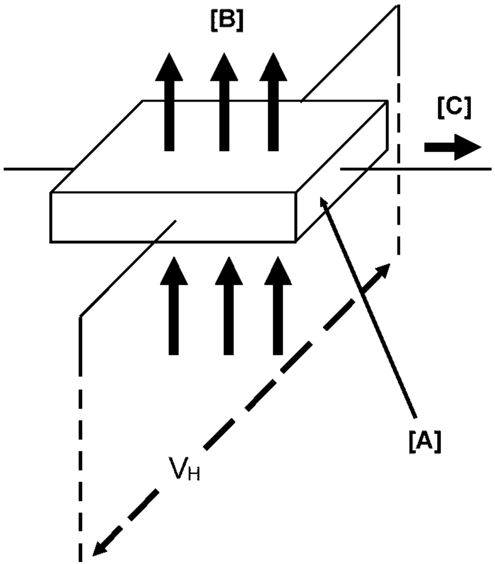


When using a fluorescent lamp/lens/CCD arrangement, the light path is typically about 300 to 500 mm. However, with a CIS, the light path can be reduced to about 15 to 50 mm; with the most recent types, the CIS is positioned less than 0.1 mm from the surface of the document.

Hall Effect Sensors

Hall effect sensors are used in some network control units (NCU) of fax machines to detect line current. The output of a Hall effect sensor is called the Hall voltage. If a conductor [A] is placed in a magnetic field [B], and current [C] flows through this conductor perpendicularly to the magnetic field, a Hall voltage (V_H) is generated across the conductor.

The conductive material in Hall effect sensors is normally a semiconductor, as the Hall effect is too small to measure accurately in metallic conductors.

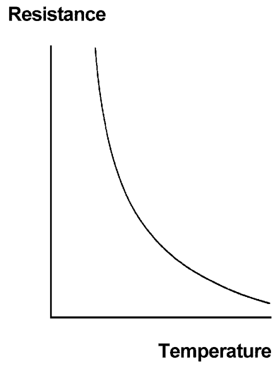


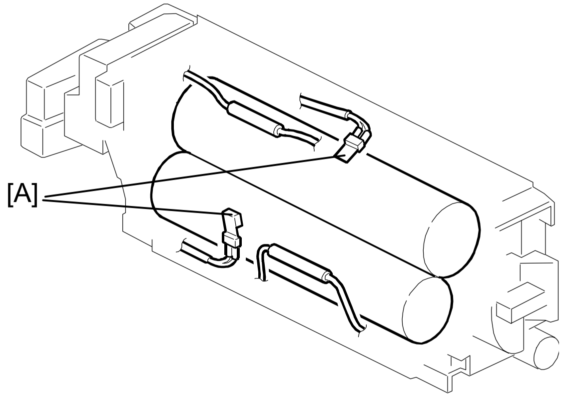
Thermistors

A thermistor is a device that undergoes a very large change of resistance with temperature. The name is derived from ***therm***ally sensitive res***istor***. Typically, a thermistor is made from a semiconductor or sintered metal oxides.

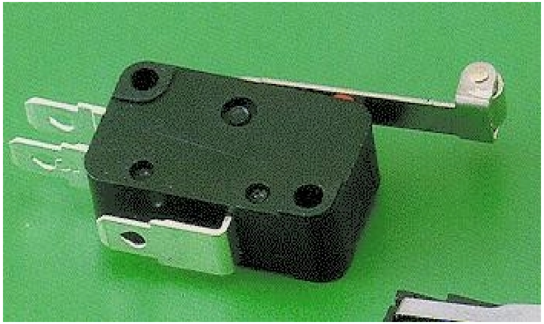
Most types have a negative temperature coefficient—that is, the resistance decreases as the temperature increases. However, some positive temperature coefficient varieties are also available. The material can be formed into rods or small beads, but for sensing purposes the small bead shape is generally used in order to get the fastest possible response.

Thermistors have a large variety of uses. In office machines, they are used mainly to measure the temperature at critical points—for example inside fusing units or optic cavities.



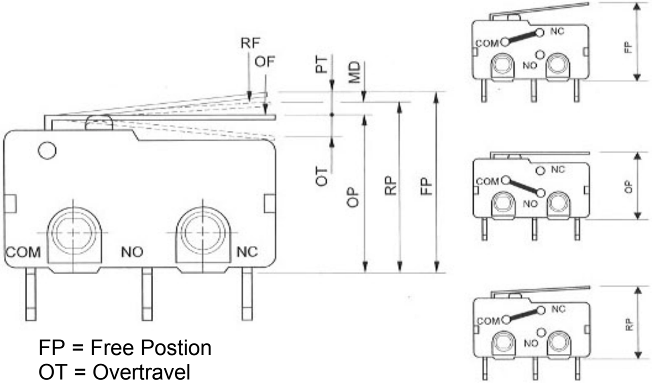


Thermistors [A] used to measure the temperature of fusing rollers (*model G024*)



Microswitches

Microswitches are electromechanical devices, which contain two contacts. They are modular, inexpensive, resistant to dust and contamination as well as metered. This means that any time the actuator is depressed, the contacts of the switch will close at the same point each time. These switches have a characteristic sound or click when the contacts close. The main advantage of a microswitch is its durability and its consistency.



The “normally open” terminal of this switch has been removed so that it cannot be connected incorrectly.

FP = Free Postion
OT = Overtravel
OP = Operating Position
PT = Pretravel
RP = Release Position
MD = Movement Differential
OF = Operating Force

Above pictures courtesy of Zippy USA Inc.

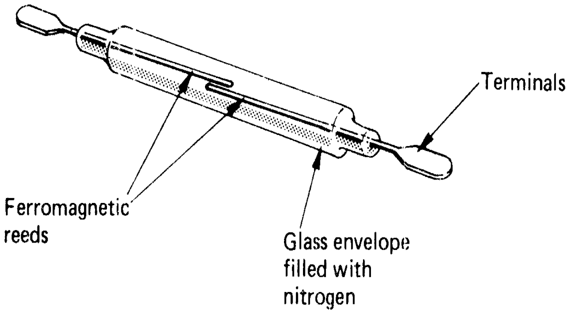
Reed Switches

Reed switches are magnetically operated components with contacts hermetically sealed in a glass capsule. Bringing a permanent magnet to the switch or placing the switch in or near an electromagnet causes the contact “reeds” to flex and touch, completing the circuit. Either protective inert gas or a vacuum within the capsule keeps the contacts clean, protecting them for the life of the device.

Due to their lack of mechanical parts, reed switches are maintenance-free and remain unaffected by temperature change, moisture, chemicals, dust, abrasive fluids and other hostile surroundings.

Features:

- Reliable
- Non-mechanical
- Long operating life
- Compact
- Rugged



Reed switch

Thermoswitches

As the name implies, a thermoswitch (also known as thermal switch or thermostat) is a temperature controlled switch.

Thermoswitches have contacts made of two dissimilar metals molecularly bonded together. These are called bi-metal contacts. The two metals expand and contract at different rates with changes in temperature. As the temperature rises the bi-metal contacts start to flex, and at a certain temperature, the contacts will open. At a lower, temperature, the contacts will close again.

The difference between the opening and closing temperature of a thermoswitch is the "hysterisis" or "differential" of the device. Some thermoswitches, such as those used in deep fat cookers or popcorn machines, have a narrow hysterisis. However, In Ricoh products, thermoswitches are usually overheating safety devices with a large hysterisis. For example, the thermoswitch used in the 1st scanner of *model A257* opens at 140ºC but will not close again until its temperature drops to -35ºC!

A collection of thermoswitches. (Photo courtesy of Elmwood Sensors, Inc.)

Note: Thermoswitch and thermostat are often used interchangeably. In fact, thermostat is the term used in our parts catalogs. However, here we use thermoswitch to avoid confusion with adjustable control devices such as room temperature thermostats.

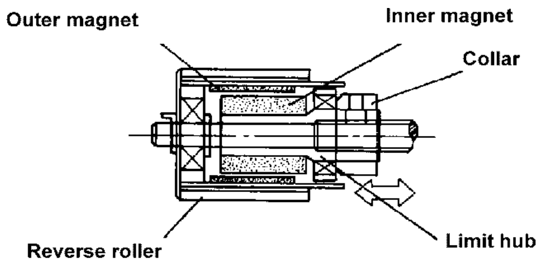
Clutches, Motors, And Solenoids

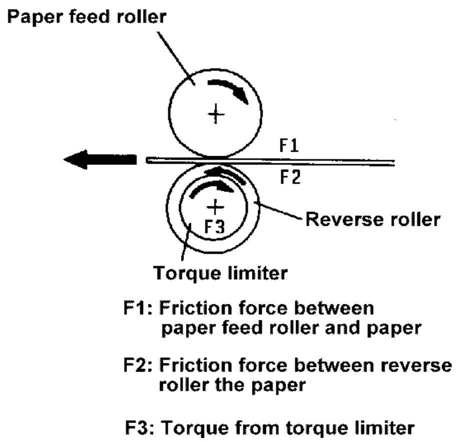
Clutches

Torque Limiter Clutches

In Ricoh products, torque limiter clutches are often in reverse rollers of *feed and reverse roller* paper feed mechanisms. In concept, torque limiter clutches (also called slip clutches) are simple. They transmit rotation to a drive component (usually a roller, pulley, or gear mounted on a rotating shaft). As long as the resistance to rotation is less than the torque (twisting force) limitation of the clutch, the roller turns with the shaft. If the resistance exceeds the torque limitation, the roller stops turning—it slips. In fact, it may turn in the opposite direction if sufficient counter force is applied.

Torque limiter structures vary: some use springs as slip mechanism, while others use magnetic force or powder filling. Compared to those that use springs, torque limiters that use magnets and/or powders do not need to be lubricated with





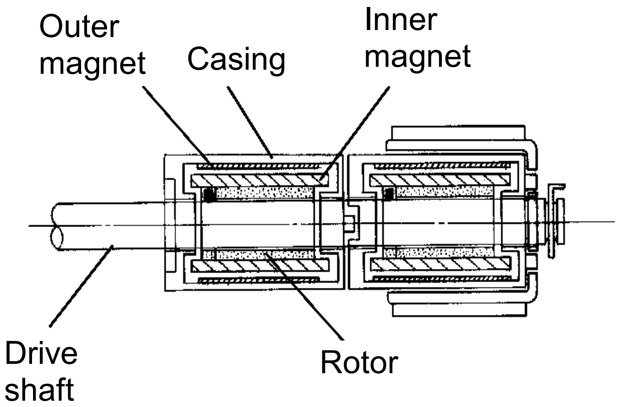
grease or other lubricants, so that they are easier to maintain. In addition, the magnet-type torque limiter does not generate much heat, even after extended use, because it does not come in contact with other components. Consequently, it ensures stable torque. The torque limiter of the *model A112* reverse roller, shown on the previous page, is a magnetic type.

Here are some other examples of torque limiter clutches:

The clutch used in *Model A084*, illustrated to the right, uses two coupled magnetic type clutches. (Two coupled clutches have a stronger total torque than a single clutch.)

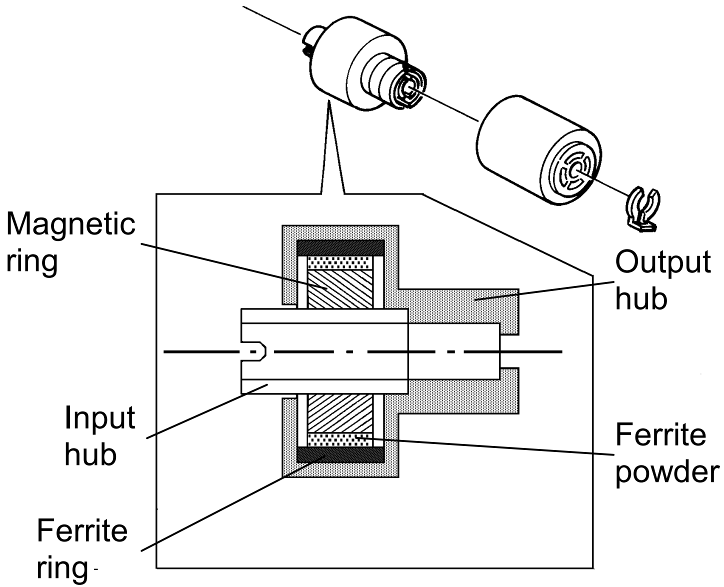
Continued on the next page.

Model A084 (magnet)



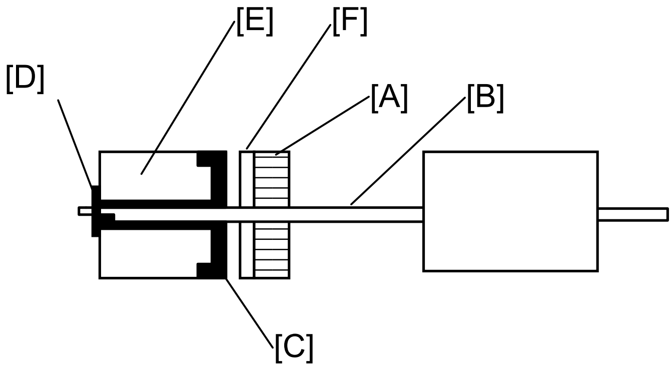
Model A133 uses a magnet and ferrite powder type slip clutch.

Model A133 (magnet + ferrite powder)



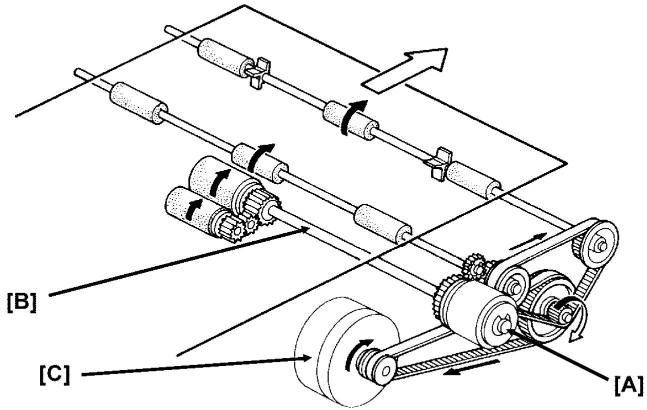
Electromagnetic Clutches

The illustration to the right diagrams the basic parts of an electromagnetic clutch. Gear [A] is driven by a motor. This gear is an idle gear; it does not drive the roller shaft [B]. Shaft [B] is attached to the rotatable part [C] of the clutch, and held in place by an E-ring [D].



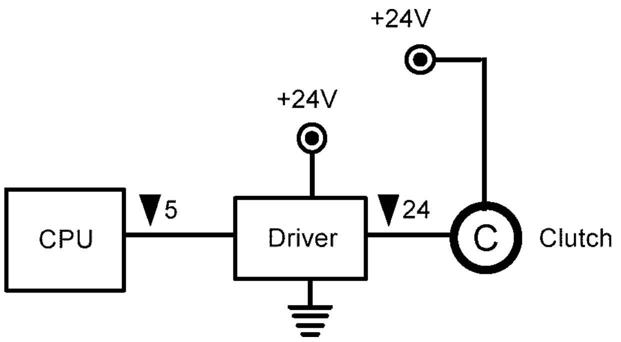
When the clutch is switched on, current flows through the coil [E]. The magnetic field generated by this coil attracts plate [F], which is connected to gear [A]. The motor is still turning gear [A], and when plate [F] comes into contact with the rotating part of the clutch [C], the roller shaft begins to turn.

A typical application is shown to the right, where a clutch [A] switches on to connect shaft [B] to the drive from motor [C].



Continued on the next page.

An electromagnetic clutch requires + 24 or + 12 volts to drive it, but a CPU cannot output this high a voltage, so the CPU controls the clutch through a driver. When the clutch is off, the driver is holding the control signal to the clutch high, preventing current from going to ground. When the CPU drops the control signal low, + 24V flows through the coils in the clutch, and through the driver to ground.

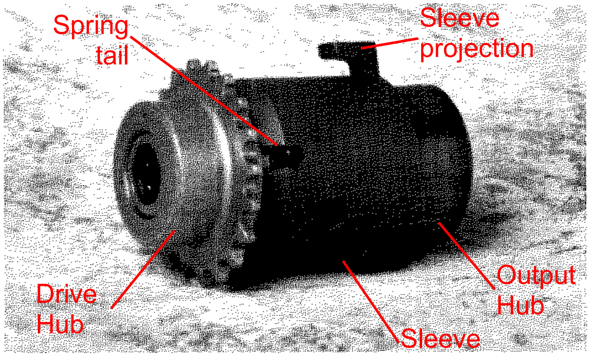


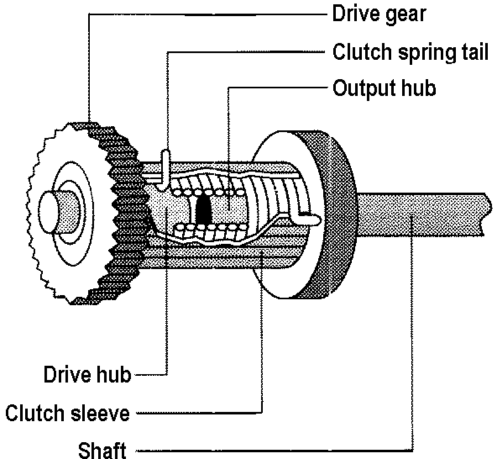
Spring Clutch

A spring clutch is purely mechanical clutch. It is a simple device that consists of two separate pieces fitted inside a coiled spring. One piece called the drive hub, supplies rotation from a motor. The other piece, called the output hub, delivers the rotation of the drive hub to a shaft. Under normal circumstances, the spring grips both pieces very tightly, so they function as one unit and pass on the rotation from the motor. The clutch's release mechanism is a sleeve that surrounds the spring. The sleeve is attached to one end of the spring—the clutch spring tail. The other end of the spring is engaged with the output hub. When the sleeve is kept from turning, the spring expands away from the drive hub, disengaging the drive.

The sleeve of a spring clutch either has a ratchet surface for a pawl to engage with or one or more projections for a stopper to engage with.

Typically, spring clutches are engaged and disengaged by some kind of electronic control—usually a *solenoid*.





Magnetic Spring Clutch

A magnetic spring clutch is a hybrid of the electromagnetic clutch and the spring clutch. Unlike the normal spring clutch, the spring is loose while idling. When the electric coil is energized, it causes the spring to tighten around the output element.

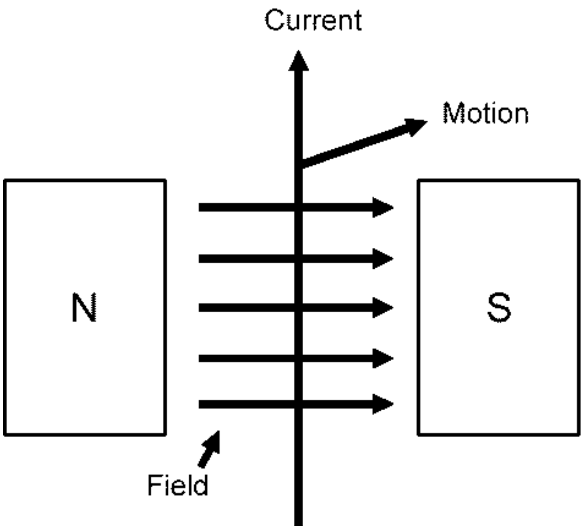
DC Motors

Electric motors are based on the following two observations:

- When current flows along a wire, a magnetic field develops about that wire.
- When two magnetic fields are close to each other, an attractive or a repulsive force is felt.

So, if a wire carrying current is placed in a magnetic field, a magnetic field develops around the wire, and a force is exerted on the wire. The force is strongest if the wire is at 90° to the magnetic field. The force is also at 90° to the wire. If there is no angle between the wire and the field, there is no force. This is summarized in the diagram opposite; the wire would be forced directly upwards, away from the plane of the paper.

If a loop of wire is placed in a magnetic field, the current direction is opposite on each side of the loop. This means that one side has an upward force on it, and the other side has a downward

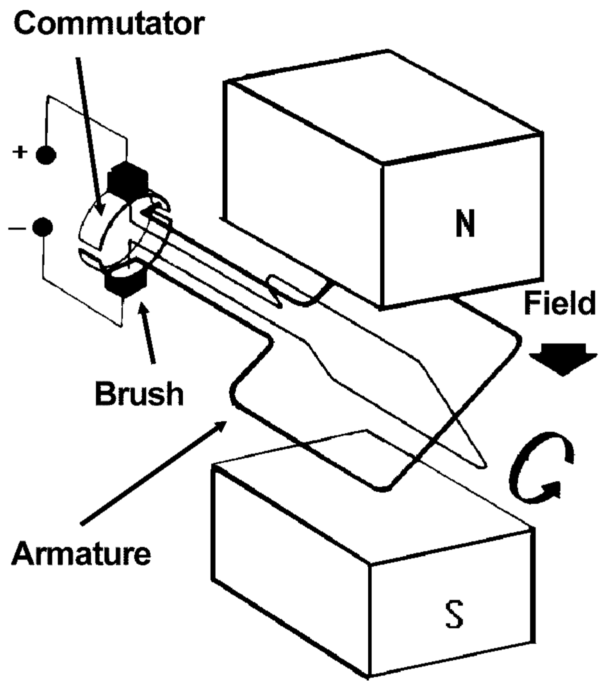


force on it. This causes the loop to rotate, as shown opposite.

The part of the motor containing the loop of wire is called the armature. It is normally in the form of a drum, with many loops of wire wound around it for increased motor power.

The armature is connected to the drive current by a split metal ring called the commutator, and a pair of brushes made from a low-resistance material such as graphite.

Each segment of the commutator is insulated from the other. The commutator is split in a dc motor so that the polarity of the current flowing through the loop is reversed every 180° of rotation. This allows the rotation of the coil to continue; if there were no reversal of current, the coil would not rotate constantly.



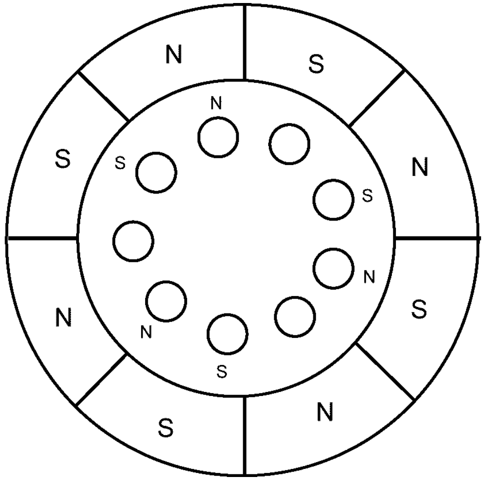
Brushless DC Motors

In the dc motor described above, the magnet is stationary while the coil rotates. In the brushless dc motor, the coil is stationary and the magnet moves.

In a typical example, nine coils are attached to the motor drive board, arranged in a circle around the shaft. A circular magnet, com-posed of eight alternating north and south polarized segments, fits around the outside of these coils. The magnet is bonded to a metal cover, which is bolted to the motor shaft.

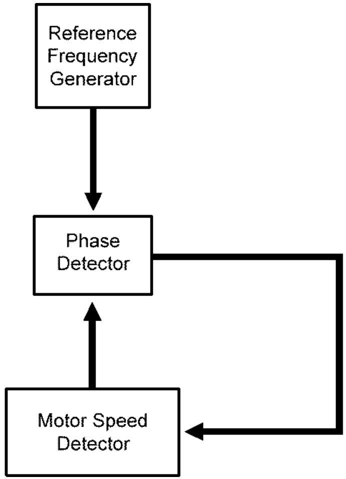
As shown in the diagram, the coils are wired up so that there are three north poles, three south poles, and three neutral positions around the center. To rotate the magnet, the motor drive board switches the positions of the poles in such a way that the magnet is always pulled around in the same direction.

Ricoh products primarily use two types of brushless dc motors—servomotors and stepper motors.

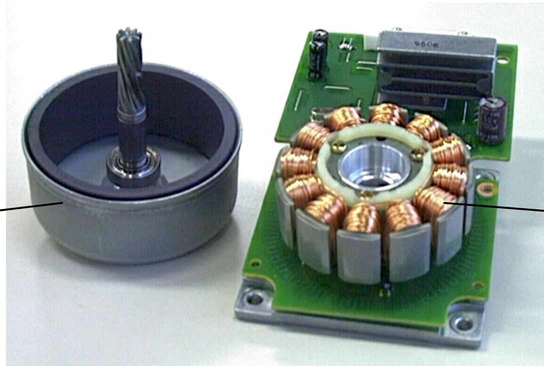


Servomotors

Servomotors use feedback to maintain a constant rotating speed. To check that a dc servomotor is running at the correct speed, the drive board contains a circuit known as a phase-locked loop. An oscillator generates a reference frequency. The circuit board contains a detector that converts the motor's rotation into another frequency signal. The phase detector compares both signals; a feedback signal is sent to the motor drive board to adjust the motor speed until it reaches the correct value. When the motor is at the correct speed, the two frequencies are the same.



A servomotor mounted on its controller board.



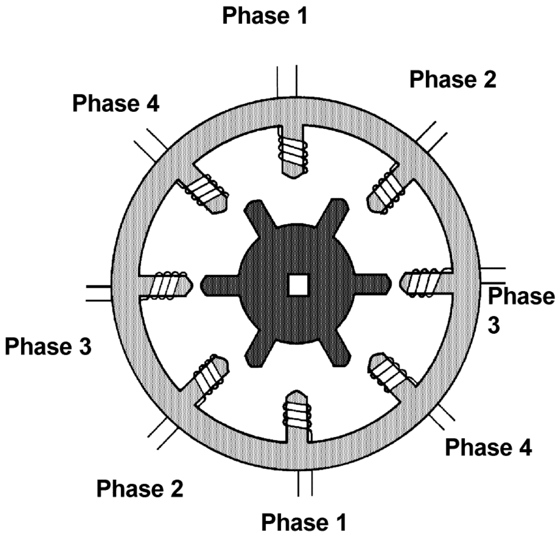
The same motor disassembled to show stator and rotor.

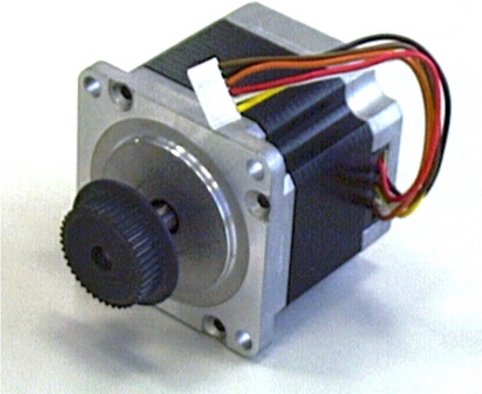
Stepper Motors

Stepper motors are used whenever accurate positioning of a component is required.

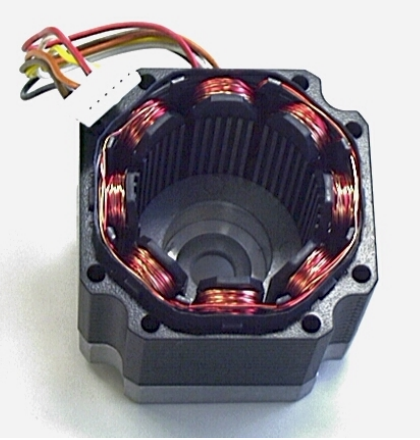
The outer shell of the motor is stationary. Coils are wound around teeth attached to this shell. The core of the motor, made of iron, can rotate. The arrangement of the teeth is such that, if pulses are applied to the coils in the correct timing sequence, the core of the motor can be rotated in stepwise increments of a few degrees.

In the example shown here, when phase 1 is energized, two of the teeth on the motor core will align with the coils on the outer shell, but the other four teeth will be out of alignment. Then, if phase 2 is energized, the core rotates by 15 ° to align two of the other teeth. If phases 1, 2, 3, and 4 are energized in sequence continuously, the motor will drive the shaft in increments of 15 °. The order of activating the coils can be varied to give different effects, such as reverse motion, or coarser steps.

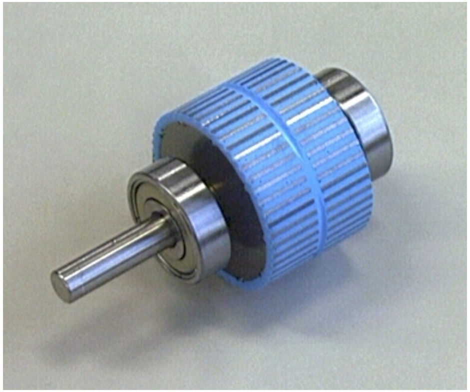




A typical stepper motor

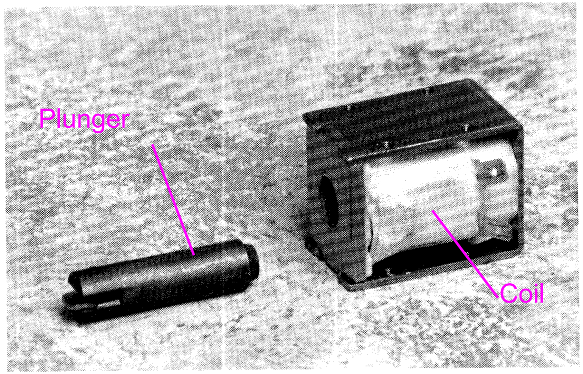


The stator

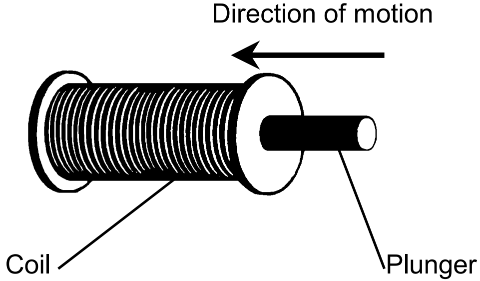


The Rotor

Solenoids



The solenoid is one of the oldest, simplest and most commonly used electromagnetic devices. It consists of a hollow electromagnet (coil) and a movable plunger that fits inside. When an electric current energizes the coil, it creates an electromagnetic force around the coil. This force causes the plunger to move into the coil. The picture to the right shows a disassembled solenoid.

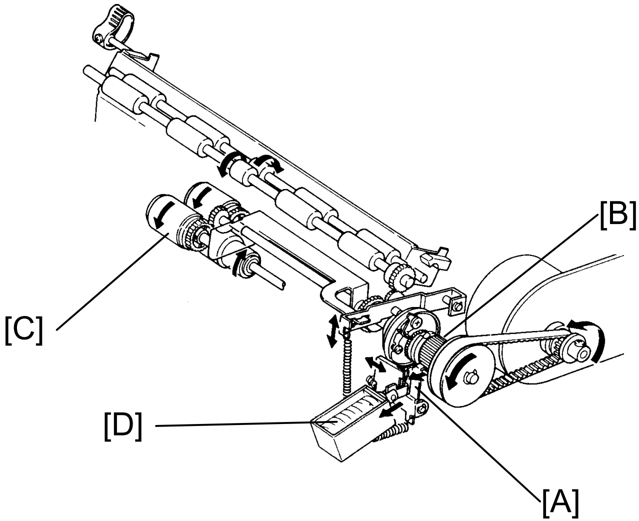


The amount of force created by a solenoid is in direct proportion to the amount of current applied. Some other factors, such as the number of turns in the coil, the magnetic character of the steel, and the stroke of the solenoid affect the amount of force produced.

The solenoid drive circuit is similar to the drive circuit for and *electromagnetic clutch* as explained on an earlier page.

Continued on the next page.

A typical application is shown to the right, where the solenoid's plunger is activating a mechanical paper feed mechanism. A pawl [A] is gripping the ratchet sleeve of a *spring clutch* [B], preventing motor drive from reaching the feed rollers [C]. When the solenoid [D] turns on, the plunger pulls the pawl away from the ratchet sleeve, and the rollers start to rotate.



For More Information

For more information on solenoid theory, operation, and design, we suggest you reference *What is a Solenoid* at the web site of the Detroit Coil Company. (http://www.detroitcoil.com/whatis.htm)*.

*We have no control over this web page. The content or location may change at any time.

Other Electrical Components

Thermal Heads

Operation

The thermal head is the central component of the thermal printer. A thermal head consists of a row of heating elements. If a heating element is turned on, it will heat up. The heat from the element will make a dot on the thermosensitive printer paper.

Roughly speaking, each element on the thermal head reproduces what was scanned by the corresponding element of the CCD at the transmitter.

There are 8 heating elements for each mm across the thermal head. A4 [8.5"] thermal heads have 1728 elements, B4 [10.1"] thermal heads have 2048 elements, and A3 [11.7"] thermal heads have 2368 elements.

Basically, the CPU clocks a line of data into a shift register in the thermal head. When the line is complete, the CPU sends a latch signal, then prints the line. Then the paper is fed forward one line, and the next line is printed in the same way.

When printing a line, the CPU divides the line into 4 blocks. It prints the blocks one at a time. Each of these blocks is transferred to the printing elements using a strobe signal. Each block has a separate strobe signal.

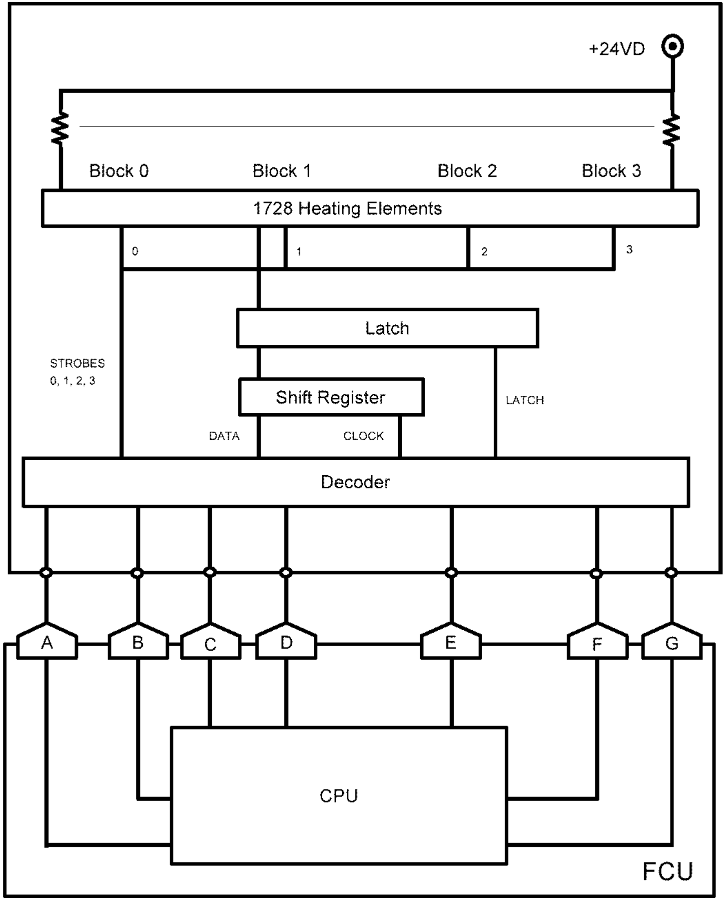
The blocks are usually adjacent on the thermal head, but they do not have to be. In fact it is even possible to interleave the blocks, having an element from block 0 next to an element from block 1, then one from block 2, followed by one from block 3, then back to block 0 again, and so on across the thermal head.

Data, latch, and strobe signals reach a decoder in the thermal head from the CPU. The + 24VD supply comes directly from the power supply; it is a separate channel from the + 24VD supply used by the rest of the machine.

Serial data comes from the CPU on pin A (see the diagram on the previous page). In most models, for a black dot, A is high. The data is clocked into the shift registers (the clock is on pin B).

When a line of data has been fed to the shift registers, the CPU sends a latch pulse (pin C) and the data moves into the latches.

To print the line of data, the CPU sends strobe signals to the thermal head. First, the strobe signal for block 0 (pin D goes low) is sent to



block 0, and the data in the block 0 elements passes from the latch to the heating elements (for a black dot, the element is heated). After all elements for block 0 have been printed, pin D goes high again. Then blocks 1 (pin E), 2 (pin F), and 3 (pin G) are sent in sequence, in the same way as block 0.

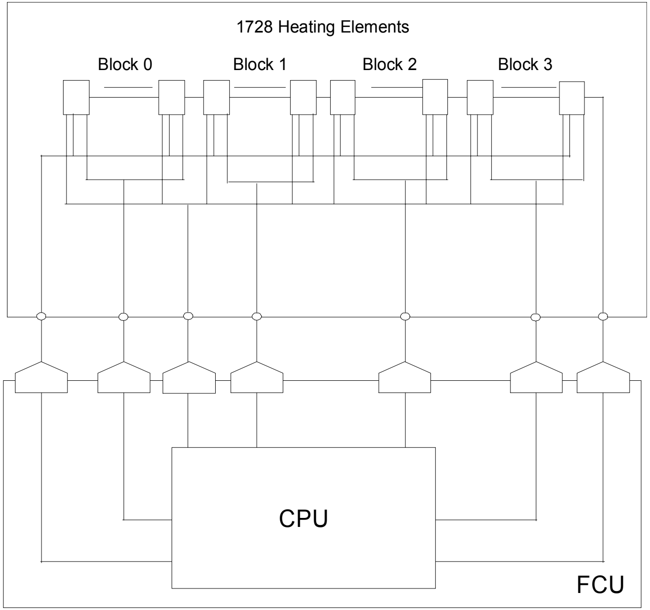
The duration of the strobe pulse determines how much an element is heated to make a black dot. The CPU monitors the thermistor on the thermal head (see section 3-5-4). The CPU calculates the strobe pulse width based on the thermistor reading and on the value for the pulse width entered using service mode when the head was installed.

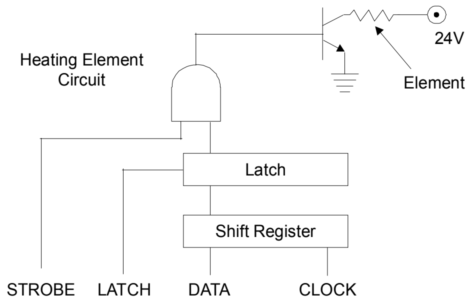
NOTE: In most models, the pulse width must be programmed using a service function after installing a new thermal head or system RAM board (called the MBU in most fax models). In a few models, the pulse width is programmed automatically.

Internal Structure

The internal structure of the thermal head varies from model to model. However, two basic types have been used so far. These are the discrete-element control type and the block control type.

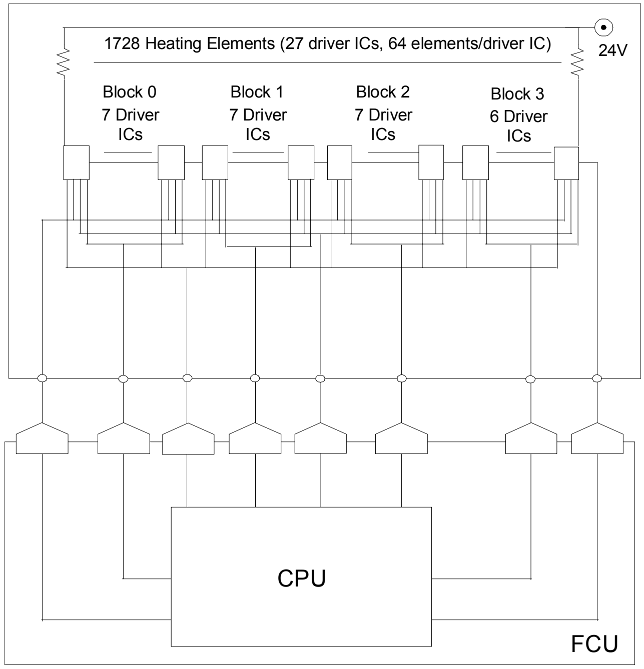
In a thermal head using discrete-element control, each element has its own discrete clock, latch, and switching circuits. Each element also receives the strobe signal.

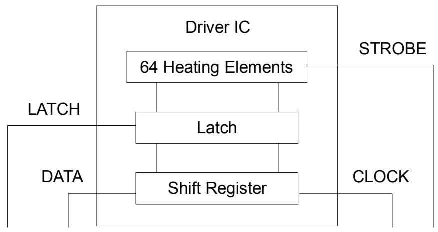




In a block control type thermal head, driver ICs control a group of elements. For example, one driver IC may control 64 elements. The decoder sends a clock, latch, and strobe signal to each driver IC. Each driver IC contains shift register, latch, and switching circuits for the elements that it controls.

A good thermal head will have a conductive cover that is grounded to prevent build-up of static, which would damage the driver ICs inside the thermal head.

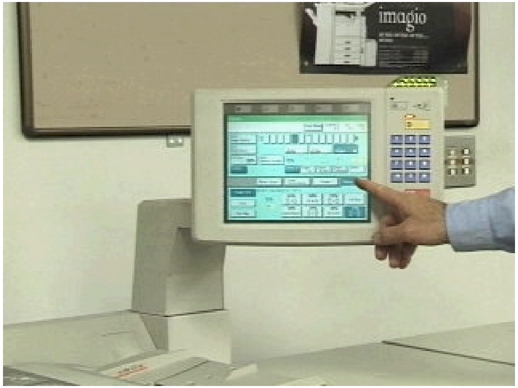




LCDs

LCD is an abbreviation for *Liquid Crystal Display*. An LCD is a digital display that consists of two sheets of glass separated by hermetically sealed liquid crystal material. The liquid crystal is normally transparent. The outer surface of each glass sheet has a transparent conductive coating, forming front and back electrodes. On the viewing side, the conductive coating is arranged as either a matrix of dots (for example for a computer display) or character forming segments (for example the 7-segment display elements of a calculator). Leads at the edge of the display attach to the segments or the lines of the matrix. A voltage applied between the front and back electrodes, causes the liquid crystal molecules to change alignment and thus become reflective. The reflectivity of the liquid crystal segments can vary depending on the amount of voltage applied.

Some LCDs depend on the reflection of ambient light for viewing. However, most larger displays use a backlight. The illustrations to the right show LCD displays used on model ***A201*** (upper picture) and model ***A246*** (lower picture).



Characteristics

- Lightweight and thin construction
- Not naturally radiant, a light source is required.
- More expensive than CRTs (Still true … but prices are dropping.)

Applications

LCDs are used as display screens.

For More Information

For more information on LCD theory, operation, and design, we suggest you reference the following web pages:
LCD Frequently Asked Questions.
(http://margo.student.utwente.nl/el/misc/lcd_faq.htm)*
Liquid Crystal And Other Non Emissive Displays
(http://itri.loyola.edu/displays/c3_s1.htm)*
*We have no control over these web pages. The content or location may change at any time.

Consumables

Photoconductors

The photoconductor—a photoconductive drum or belt is the heart of most imaging processes. The photoconductor's surface is where the latent image is formed and then developed. Photoconductors have the following characteristics:

- They are able to accept a high negative electrical charge in the dark. (The electrical resistance of a photo-conductor is high in the absence of light)
- The electrical charge dissipates when the photoconductor is exposed to light. (Exposure to light greatly increases the conductivity of a photoconductor.)
- The amount of charge dissipation is in direct proportion to the intensity of the light. That is, where stronger light is directed to the photo-conductor surface, a smaller voltage remains.

Our products use two types of photoconductors. One type is a selenium based inorganic photoconductor. That type was used in the past for analog copiers. The other type is an organic photoconductor (OPC) that is used for analog and digital copiers, plain paper facsimiles, and laser printers. Recently, all such products use OPCs instead of inorganic photoconductors.

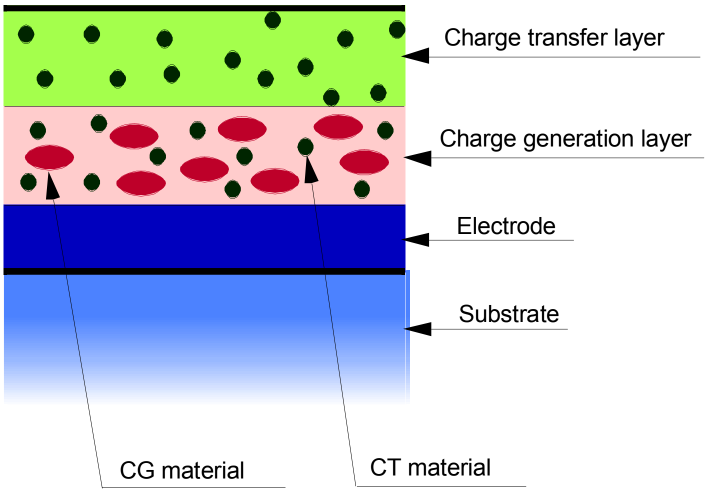
Organic Photoconductors (OPC)

An OPC consists of a CTL (charge transfer layer), CGL (charge generation layer), electrode layer, and a substrate to which the layers are bonded. (The electrode layer is also called the under layer.)

Ricoh made OPCs have charge generation pigments and charge transfer compounds imbedded in the charge generation layer. These materials greatly improve the response characteristics of the OPC.

For more information on OPCs, refer to *Appendix 2-OPC*.

Cross section of OPC layer



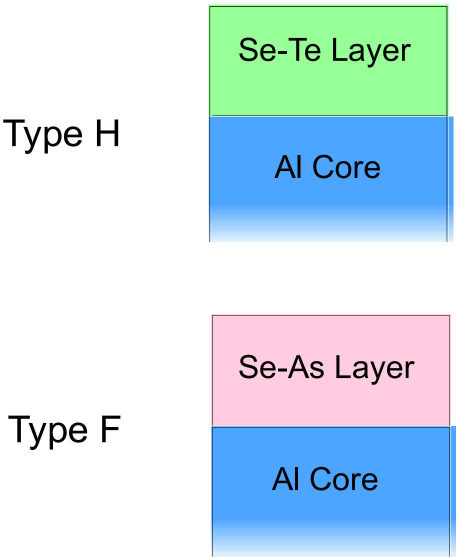
Selenium

Many of the copiers in the field use selenium drum photoconductors. These drums consist of a layer of selenium or a selenium alloy bonded to an aluminum base.

Selenium drums have gone through several generations of development. However, the only types that you are likely to encounter in the field at present are types H and F. Type H has a layer of selenium-tellurium alloy bonded to an aluminum core. Type F has a layer of selenium-arsenic (actually Arsenic-Triselenide) bonded to an aluminum core.

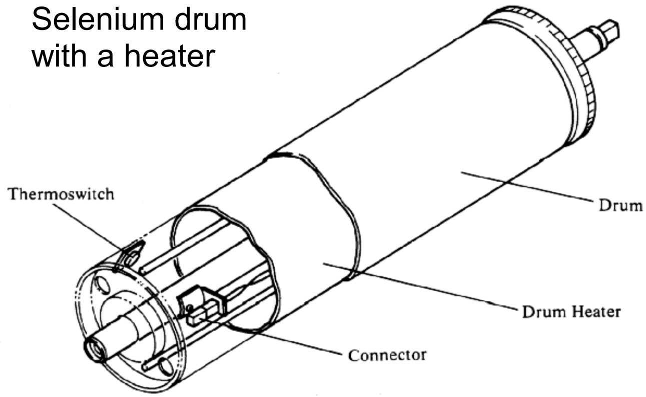
The F type drum is more durable and has greater spectral sensitivity. However, it is more expensive to make.

Selenium photoconductor types



The sensitivity of selenium changes slightly with variations in the temperature around the drum. This is especially true of type F drums. Under cool conditions, the drum may be excessively charged, resulting in drum has an internal over-toning of the copy image. To prevent this, many machines have a heater to warm the drum if it becomes too cool.

Selenium drum with a heater

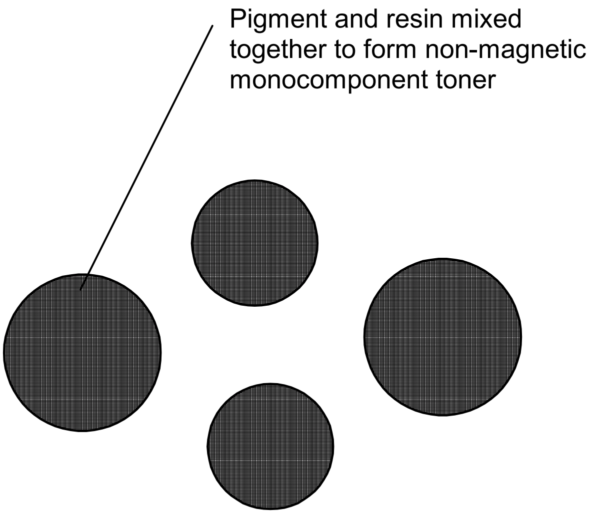


Toner (Black)

Toner is a combination of plastic resins, dyes, waxes, flow agents, charge agents, and particles with magnetic characteristics (if magnetic toner). The plastic resins are the base ingredients of toner. They combine with some or all the other parts (sometimes with other additives) in a precise mixture with the proper charge, transfer, and fusing characteristics required for each type of toner.

Non-Magnetic Monocomponent

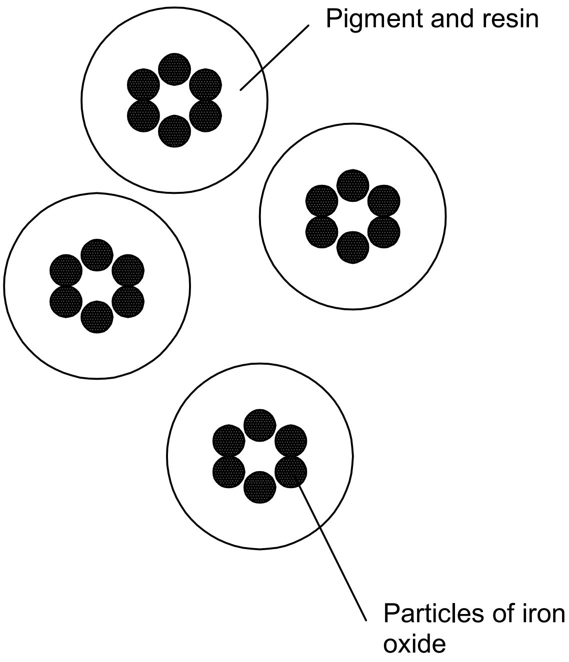
All-in-One toner that contains blackened pigments for printing in a matrix of resin. This kind of toner usually comes in a cartridge and is used with non-magnetic rollers. For this type of toner, a static charge picks up and holds the toner on the roller surface.



Magnetic Monocomponent

Similar to the non-magnetic toner, this type has iron oxide particles encapsulated in the resin matrix of each individual particle of toner.

The toner itself isn't actually magnetic, but the iron particles in the toner make it possible for magnetic rollers to easily pick up and hold the toner particles. All monocomponent systems that use magnetic rollers must use this type of toner.



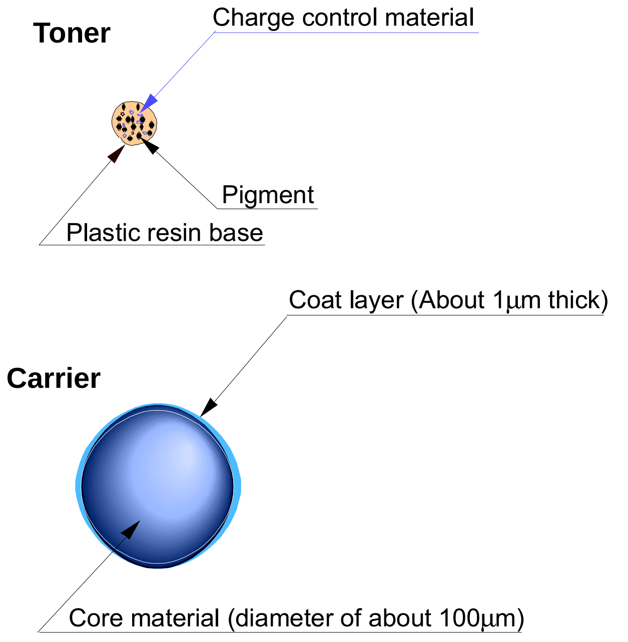
Dual Component

The toner used in *dual component development* systems is similar to the non-magnetic type monocomponent toner. This type of toner works with a separate particle known as a carrier. The mixture of toner and carrier is known as developer. The toner and carrier particles are held together by triboelectric charges. They develop opposite triboelectric charges due to mixing action in the development unit.

The carrier rides on magnetic rollers and carries the toner with it to the photoconductor. The carrier itself is not transferred to the photoconductor, but merely releases the toner onto the photoconductor (which the toner is electrostatically more attracted to) and then returns to the hopper to pick up more. The carrier is normally an iron or iron oxide particle with a coating to improve durability.

The illustration to the right shows the toner and developer particles used in F-type developer.

Toner and carrier of F developer



Characteristics

There are three main characteristics of toner: its charge properties, fusing ability, and image capabilities.

Charge Properties

The charge is what enables toner to transfer from its container to the drum. If the toner is not charged properly, dirty background, toner blasting, or light prints may occur.

The characteristics of toner charge depend on the toner particle size, shape, and composition. Friction generates a triboelectric charge on the toner particles. The charge generated for each particle depends on the surface area to mass ratio of each particle. This is determined by the size and shape of the particle. The smaller the particle the larger the ratio. The result is a stronger triboelectric charge for smaller particles. Particle sorting or printing defects can occur if toner particles are not uniformly sized. Therefore, the toner requires sifting several times after it is ground into a powder. Charge control material or "charging agents" are also important in that they help determine how well particles charge and if that charge is negative or positive.

Fusing Ability

Fusing requires very specific adhering and melting properties. Toner must melt at the correct temperature to be compatible with the fusing system it is in. The fusing rate is also an important part of fusing.

Toner must fuse quickly for high speed printers and slowly for lower speed ones. If the toner cannot meet these standards cold or hot offset may occur. This is a ghost image picked up on the fusing rollers. The plastic resins and various additives determine the fusing properties of the toner.

Flow rate is also important because it determines the density of print. A toner that flows well produces higher density copies. Therefore, an optimum flow rate, where the toner is neither too much nor insufficiently fluid, is necessary. Toner composition, particle size and additives determine this rate.

Image Capabilities

If all of the previous characteristics are correct, a problem may still occur. This problem concerns resolution. High-resolution printers require micro fine toner, usually around 6 microns or less. If the toner particles are larger than this, the resulting image will not have the razor-sharp quality the user desires from their high-resolution printer. The size of the particle will also effect the density of the image and limit the number of shades the printer can produce.

Printing black dots in white areas produces shades. The blackness of the dots is always the same; they appear darker or lighter depending on how closely grouped. For example, if the user selects 100 dpi as the desired shading, but the particles are too large, the toner will not stay within the boundaries of the dot size. This results in an overflow past the boundaries, filling in more of the area. Consequently, this produces a shade darker than desired by the user. This is how large sized toner particles limit the shading spectrum of high-resolution printers. The production of smaller, micro fine particles create new challenges. The smaller particles will have different charge and flow characteristics that must be handled properly.

Paper

Paper isn't a consumable part of office machines, but as copiers, printers, and fax machines all have to handle paper in various ways, paper is an integral part of their operating processes. In this section we will take a look at the properties of paper that effect the operation of our machines.

Except where stated otherwise, we will use the term *copier paper* to include paper for plain paper faxes and office printers.

Summary

Properties important in copier papers include weight, size, stiffness, smoothness, electrical resistivity, porosity, coefficient of friction, and moisture content. Some properties are important to copy quality others affect paper handling reliability. Image density and fusing are improved on smoother papers. Paper handling reliability and less background toning are obtained with rougher papers. Increasing resistivity improves density but also increases the tendency toward static, background toning, and feathering.

Paper Weight

There are three commonly used systems for classifying paper weight. They are summarized in the following table. Papers with weights at the extreme low and extreme high levels of a machine's specified tolerance range will tend to jam more frequently.

System	Paper weight definition	Where it is used
International (ISO) system	The weight in grams of a single one square meter sheet of paper. The units are grams per square meter (g/m^2)	Most of the world
US (lb) system	The weight of 500 17" x 22" sheets of paper. The units are pounds (lb).*	USA
Japan (kg) system	The weight in kilograms of 1000 788 mm x 1091 mm sheets of paper. The units are kilograms (Kg).	Japan

*This applies to Bond paper only. See the discussion of US paper weights below.

Since the paper weights are defined differently, you cannot convert directly between them. The conversion factors are as follows:

lb → g/m^2	x 3.760	g/m^2 → Kg	x 0.860	Kg → g/m^2	x 1.163
lb → Kg	x 3.233	g/m^2 → lb	x 0.266	Kg → lb	x 0.309

Paper Weights in the United States

In the United States, paper weight specification is a real dog's dinner. Weight depends on classification. Sheets of paper that are actually exactly the same can have different weight specifications if they are from the different classes.

The problem is that paper weight is measured by weighing 500 *full sheets* of paper. This is referred to as the "standard ream weight". So far so good, but now the fun begins. The size of a *full sheet* of paper is different for different types of paper! Some commonly used paper types are bond paper, book paper, card stock (or index stock), and cover stock. Lets take for example bond paper and book paper. A *full sheet* of bond paper is 17 x 22 inches. (A *full sheet* of bond is the equivalent of four sheets of 8½ x 11 inch paper.) A *full sheet* of book paper is 25 x 38 inches. So if you took 500 *full sheets* of book paper that was the equivalent of 20 lb Bond paper, it would weigh more. Standard 20 lb bond paper is actually the same as 50 lb book paper.

For copiers, paper specifications are written in bond weights. So, if a machine can copy on 14 to 42 lb bond paper, it will accept from 40 to 100 lb book paper.

Confusing isn't it?

Paper Sizes

International Paper Sizes (ISO)

The ISO (International Organization for Standardization) paper sizes, which were based on the earlier DIN (Deutsche Industrie Norm) sizes, are commonly used everywhere in the world except Canada and the United States. The following table lists the sizes that can commonly be expected to be used in copiers.

ISO A Series		ISO B Series		ISO C Series	
A0	841 x 1187	B0	1000 x 1414	C0	917 x 1297
A1	594 x 841	B1	707 x 1000	C1	648 x 917
A2	420 x 594	B2	500 x 707	C2	458 x 648
A3	297 x 420	B3	353 x 500	C3	324 x 458
A4	210 x 297	B4	250 x 353	C4	229 x 324
A5	148 x 210	B5	176 x 250	C5	162 x 229
A6	105 x 148	B6	125 x 176	C6	114 x 162
A7	74 x 105	B7	88 x 125	C6	81 x 114

Sizes are in millimeters

For More Information

For a detailed discussion of the concepts behind ISO paper sizes refer to Markus Kuhn's web page on international standard paper sizes. (http://www.cl.cam.ac.uk/~mgk25/iso-paper.html)*

*As we have no control over this web page, The content or location may change at any time.

Multiplying the 0 sizes creates large format sizes. For example, 2A0 = 1189 x 1682 and 4A0 = 1682 x 2378

Paper Sizes in the USA

Many paper sizes are in use in the United States. Copy paper sizes are defined in inches; the most commonly used sizes also have a name (letter, ledger, etc.). US paper sizes are also used in Canada; however, there they are usually defined in millimeters. The table to the right gives the copier paper sizes most commonly used in the USA.

Size in Inches	Size in mm	Common Name
4¼ x 5½	108 x 140	
5½ x 8½	140 x 216	Statement
8 x 10½	203 x 267	Government letter
8 x 13	203 x 330	Government legal
8½ x 11	216 x 279	Letter
8½ x 14	216 x 356	Legal
11 x 14	280 x 356	Computer
11 x 17	279 x 432	Ledger
17 x 22	432 x 559	
22 x 34	559 x 864	
34 x 44	864 x 1118	

Japan JIS B Sizes

Japan has developed its own standards for paper sizes. While the JIS (Japan Industrial Standard) A series of sizes is identical to the ISO A series of sizes, the JIS B series is not. Also, Japan has no series of envelope sizes comparable to the ISO C series.

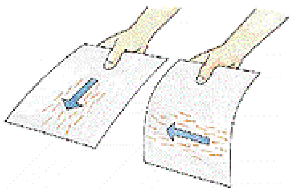
JIS B Series	
B0	1030 x 1456
B1	728 x 1030
B2	515 x 728
B3	364 x 515
B4	257 x 364
B5	182 x 257
B6	128 x 182
B7	91 x 128

Paper Characteristics

The following table summarizes the most important paper characteristics (other than weight and size).

Brightness	The brightness of a paper is a measure of its light reflectivity. A high grade paper usually has a brightness in the 85 ~ 90% range. Low grades would be in the 70 ~ 75% range. A high grade looks bright (white) and a low grade dull (gray). This is a measurement of the incident light that is reflected from the paper's surface.
Coefficient of friction	The coefficient of friction directly affects the efficiency of paper feeding. It must be high enough that the feed and transport rollers can get a good grip. However, it must be low enough that the sheets of paper slip over each other. Also, the coefficient of friction should not vary from sheet to sheet as variations in friction could cause multi-feeds and jams.
Curl	Curl in paper is a major cause of transport problems resulting in misfeeds. Basically, copier paper should be manufactured to remain as nearly flat as possible while It is subjected to varied temperatures and humidity changes as it proceeds through the copy making process. Paper in a copier's paper tray tends to curl as it picks up moisture from the air. Some machines, especially higher speed models, have heaters in the paper trays to prevent such curling.
Electrical Resistivity	If paper resistivity is too high it can cause static build-up that results in double feeding and jams. Too low an electrical resistivity (= higher conductivity) can cause image deletion (blank areas) as well as jams. Resistivity is affected by moisture and paper composition.

Moisture content	Moisture content directly affects paper transport, copy quality, and curl. The generally acceptable range is 4 ~ 6 percent moisture. A higher moisture content will cause curl, a higher jam rate, poor image transfer (due to lower resistivity), and poorer image fusing. A lower moisture content causes static that results in misfeeds and double sheet feeding.
Opacity	Paper must be sufficiently opaque to prevent image show through. This is especially important in paper used for duplexing. Most brands of paper use some kind of filler to enhance opacity. The composition of the filler can affect copier performance and durability of parts. Some common fillers are clay, chalk, and marble.
Porosity	Mottling and smearing can result from excess porosity. Low porosity paper tends to have more curl and is prone to image smearing.
Shade	Shade will vary from a pure white to tints in the blue, pink, or yellow ranges. Shade is a personal preference but also may vary between lots of paper or within a brand. Close control of shade is most important for papers used in color printing and copying.
Smoothness	Smoother papers increase electrostatic adhesion at the image transfer step. This is because closer contact with the photoconductor makes the paper more difficult to strip from the photoconductor. Smoother papers are also more likely to have background toning. Too rough a paper may cause image mottling, poor image fusing, and high toner consumption.

Stiffness	Paper stiffness is classified by *cross grain* and *with grain*. The stiffness is a result of the orientation of the fibers within the paper. In most copier papers, the fibers are orientated in the length direction of the paper Stiffness affects paper feeding and transport in copiers and laser printers. Paper is generally two or three times stiffer in the *with grain* direction than in the *cross grain* direction. 
Surface condition	Paper finishing and surface properties have an impact on long-tern satisfactory performance of copier equipment. Copier papers should be tightly controlled to eliminate such problems as: • Dirt and dust—which can cause reduced machine reliability, misfeeds, and copy quality defects. • Surface inclusions—which can result in poor copy quality, sheet weakness, and transport problems. • Torn and wrinkled sheets—which can cause poor transport, misfeeds, and machine damage.
Thickness	Paper thickness is measured in micrometers. Typical copy paper has a thickness of about 95 micrometers. For copy paper, thickness is a direct function of paper weight; so, for our products, generally only paper weight is specified.

The following table gives Ricoh Standards (= ideal paper) for some selected paper characteristics. (Not all possible paper characteristics are included.)

Item	Units	Standard	
		B/W	**Color**
Weight	g/m^2	69.5 ±4.0	80.0 ±4.0
Thickness	µm	92 ±6	95 ±6
Stiffness	—	With grain: ≥55 Cross grain: ≥28	With grain: ≥55 Cross grain: ≥28
Brightness	%	≥80	≥82
Smoothness	S	Front: 60 ±20 Back: 50 ±20	120 +40/-35 (front and back)
Ash content	%	1 ~ 5	—
Moisture	%	4.0 ~ 6.0	4.0 ~ 6.0
Resistivity	Ω·cm	8×10^9 $\sim 2 \times 10^{11}$	8×10^9 $\sim 6 \times 10^{10}$