Classes of Fluorescent Lamps

Preheat Lamps

Early fluorescent systems were all of the preheat type, requiring separate starters. A few seconds of heating time were necessary between the time current to the lamp was turned ON and the time the lamp lighted. Sometimes called general line lamps, the preheat fluorescent types all have bipin bases. Some rapid start lamps and a few of the instant start types are manufactured with bipin bases, also. Sizes of preheat lamps range from 4 to 90 watts, in lengths from 6 inches to 5 feet. The 40-watt size is the most widely used of the preheat types.

The cathodes of the preheat lamp are preheated to emit electrons before the arc strikes; this is where the name "preheat" comes from. This type of lamp operation is also referred to as switch-start or starter-start.

The preheating process requires a few seconds. It is usually accomplished by an automatic starter which applies current to the cathodes of the lamp for sufficient time to heat them, and then automatically removes the current from the cathodes causing the voltage to be applied between the cathodes — and striking the arc. In some preheat systems, such as typical fluorescent desk lights, the preheating is accomplished by pushing a manual start button. This button is held down for a few seconds. During this time, the cathodes heat. When the button is released, the arc strikes. Preheat lamps are usually identified by wattage, bulb diameter (in eighths of an inch), and color. Thus a lamp marked F15T8/CW is a 15-watt, 1-in. diameter, Cool White fluorescent lamp. With preheat lamps designed for appliance service, wattage varies widely depending on the ballast. These lamps are identified by length instead of wattage. For example, F26″T8 for a lamp 26 inches long, 1-in. diameter.

Ballasts are available to operate certain preheat lamps without using starters. These ballasts use the rapid start principle of starting and operation. They are designed around the characteristics of the preheat lamps involved. These ballasts are popularly called "trigger start" ballasts. Full rated lamp life will be obtained with these rapid start ballasts if they are designed to meet published specifications.

Instant Start Lamps

To overcome the slow starting of the preheat system, General Electric introduced instant start lamps in 1944.

In addition to starting as soon as current to the lamp is turned on, instant start lamps also eliminate the need for starters, and thus simplify the lighting system and maintenance.

In instant start lamps, sufficient voltage is applied between the cathodes to break down the resistance of the lamp and strike the arc. The arc quickly heats up the fine wire cathodes, which then supply electrons to sustain the arc.

With the instant start system also came the introduction of lamps up to 8 feet long. Because no preheating is required with instant start lamps, only a single pin on each end of the lamp is required. Lamps with single pin bases are called "slimline" lamps. A few instant start lamps use bipin bases; however, the lead wires from the pins are connected together inside the lamp. To eliminate the possibility of mistaking these lamps as preheat lamps, the lamps are marked "instant start." Instant start lamps with bipin bases cannot be used in preheat or rapid start circuits and vice versa.

Since slimline lamps can be operated at more than one current and wattage, they are identified by lamp length. The number following the F in the designation is the nominal lamp length in inches, rather than the lamp wattage as with most preheat lamps. For instance, a lamp marked F96T12/WW is a 96-in. long, 1½-in. diameter, Warm White fluorescent lamp. The lamp is identified as a slimline lamp by the fact that it has a single pin base on each end. Instant start lamps with bipin bases are identified by the letters IS at the end of the designation. With these lamps, the number following the F in the designation is the lamp wattage. For example, the identification F40T17/CW/IS means that the lamp is a 40-watt, 2⅛-in. diameter, Cool White, instant start lamp. It has a mogul bipin base.

Rapid Start Lamps

The rapid start principle is the most recent basic development in fluorescent types. Introduced by General Electric in 1952 in the 40-watt size, rapid start lamps start quickly without starters. Rapid start ballasts are smaller and more efficient than instant start ballasts for the same wattage lamp. Lamps in rapid start circuits start almost as quickly as instant start lamps, and in a much shorter time than the older preheat lamps.

The rapid start principle utilizes low resistance cathodes which can be heated continuously with very low losses. Today, rapid start systems are the most popular and important fluorescent lighting systems in new installations. The rapid start principle also extends the use of fluorescent lamps into applications that were previously not possible — dimming and flashing.

Today's GE F40 Mainlighter* combines the advantages of both into a single lamp and gives more light and longer life at a lower operating cost than ever before possible in a single Standard 40-watt fluorescent. The Mainlighter can be used in rapid-start and preheat-start circuits.

The F40 Staybright* solves end-blackening — one of fluorescent lighting's oldest problems. An exclusive electrode design eliminates end-blackening permitting higher initial light output and better lifetime lumen maintenance. Both the Mainlighter and the Staybright are available in a variety of white colors.

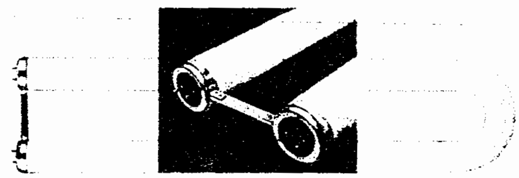
Circline lamps are now of the rapid start design. These lamps also work satisfactorily in former preheat and trigger start systems.

The rapid start principle provided the opportunity to increase fluorescent lamp loading with good system efficiency beyond the level of about 10 watts per foot, which is achieved at lamp current of 430 mA. Previously this was not practical due to the size, cost, and losses in the ballast.

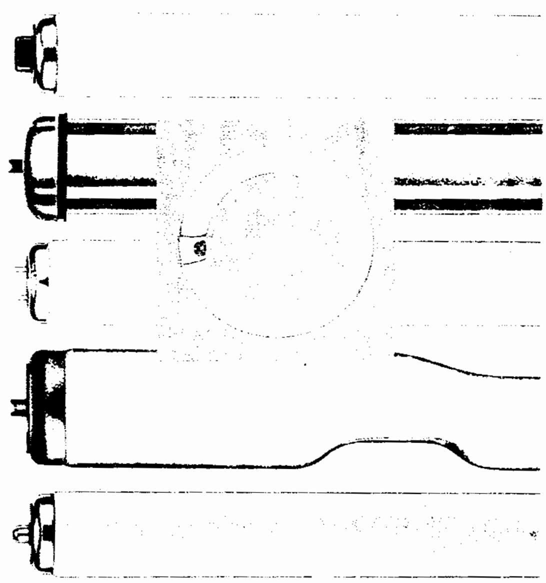
The high output lamp was the first higher current rapid start lamp. High output lamps usually operate at 800 mA, an energy loading of about 14 watts per foot. At 800 mA these lamps produce about 45% more light than slimline lamps of corresponding physical size. For street lighting applications, high output lamps usually operate at 1000 mA to provide high light output at colder temperatures. High output lamps are identified by lamp length, bulb diameter, color, and HO (e.g., F96T12/CWX/HO).

Power Groove lamps also operate on the rapid start principle. Operating at 1500 mA, they are loaded to approximately 25 watts per foot. The unique bulb shape of the Power Groove lamp permits the higher loading without the use of special filling gases which can reduce life. The grooved bulb places a large portion of the phosphor near the arc to minimize internal losses. The double grooves actually increase the effective length of the arc 1 foot in an 8-foot lamp. Two of the grooves — one on each side near the center — are shaped to operate cooler than the rest of the lamp to keep the internal mercury pressure near the point for maximum output. The Power Groove lamp provides the highest light output of any fluorescent lamp available today. Power Groove lamps are identified by lamp length, bulb designation and color (e.g., F96PG17/CW).

All-Weather fluorescent lamps are rapid start lamps which also operate at 1500 mA. These lamps are designed to provide best performance in specific applications under low temperature conditions. See Page 19.



Newest in the General Electric line of rapid start fluorescent lamps is the 40-watt Mod-U-Line* fluorescent lamp. Blending compact, U-shape design with rugged construction, this lamp satisfies growing architectural demands for compact lighting fixtures in today's modular building design. Leg spacing of 3⅝ inches permits two or three lamps per 2-foot by 2-foot fixture, achieving flexible illumination levels while maintaining uniform brightness distribution. Using standard cost-comparing methods, two 40-watt Mod-U-Line lamps yield more light at 30 percent lower cost per footcandle than four 20-watt fluorescent lamps. Further savings are realized because all wiring and lampholders are at one end of the fixture reducing the number of system parts.



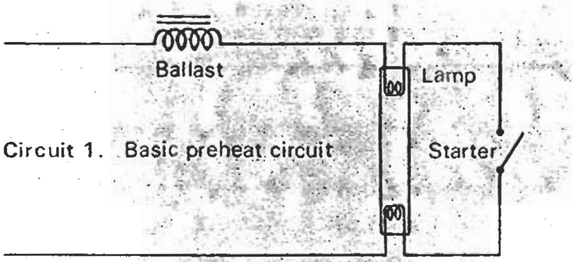
Preheat Circuits

The components of a preheat fluorescent lamp system include a ballast, starter, starter socket, lamp and lampholders. When power is first applied to the circuit, the starter switch is closed and the lamp cathodes are connected in series with the ballast. The current which flows preheats the lamp cathodes. After sufficient preheat time elapses the starter switch is opened. This causes a high transient voltage between the cathodes which is sufficient to start the lamp.

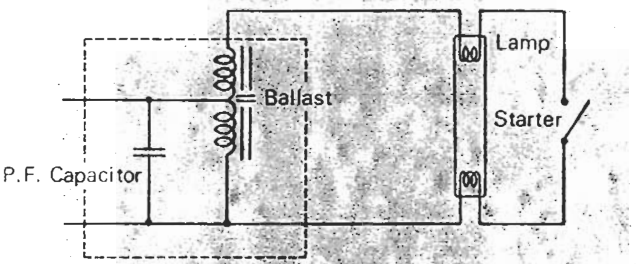
Preheating is used to help ionize gases in the tube, reducing the voltage required to strike the arc. While it is possible to start a preheat lamp without cathode heating by simply applying sufficient voltage, ballasts would be larger and more expensive and lamp life would be short because the cathodes sputter each time the lamp starts.

The starter switch may be manual, as shown in Circuit 1, or automatic. The manual starter is often used with small desk lamps. Three types of common automatic starters are described below.

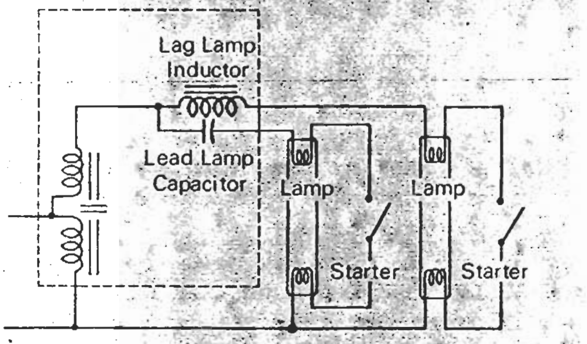
Circuit No. 1 uses only a choke to limit lamp current. Two other representative preheat circuits (No. 2 and 3) are shown at right, these circuits use autotransformers to limit current and increase voltage. The capacitor across the line in Circuit No. 2 corrects the power factor. In Circuit No. 3, a lead-lag system, the lamp circuit controlled by the capacitor has a leading power factor while the lamp circuit controlled by the inductor has a lagging power factor. Together the two circuits result is essentially unity power factor.



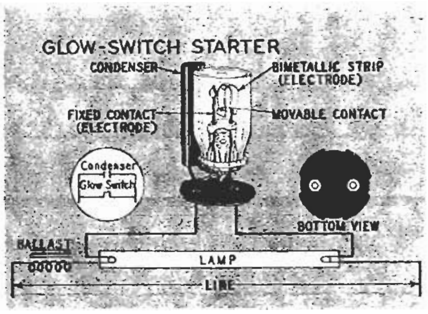
Circuit 1. Basic preheat circuit



Circuit 2. Preheat circuit with autotransformer to step up voltage and capacitor to correct power factor

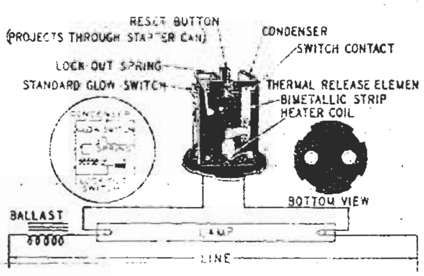


Circuit 3. Lead-lag preheat circuit



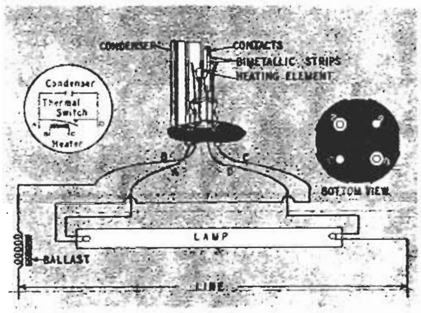
GLOW-SWITCH STARTERS. On starting, voltage at the starter produces a glow discharge. Heat from the glow discharge actuates the bimetallic strip, the contacts close, extinguishing the glow, and cathode preheating begins. When the bimetal cools sufficiently due to the elimination of the glow, the contacts open, and the lamp starts. During operation, voltage across the starter is too low to produce further glow, the contacts remain open.

WATCH DOG STARTER



WATCH-DOG* STARTERS. This type of starter automatically removes the glow switch from the circuit if the lamp fails to start after 15 or 20 seconds. This eliminates annoying lamp blinking, and conserves the life of the ballast. A new metal glow switch in the G.E. FS-400 Watch-Dog starter reduces instant-starting tendencies of the 40 watt lamp on lead circuits. This tends to increase lamp life.

*Registered T.M.



THERMAL-SWITCH STARTERS. This type of starter is useful in operating conditions involving low temperature, direct current, or widely varying line voltage. It has a heating coil in series with the ballast and lamp. When voltage is first applied to the circuit preheating occurs immediately since the thermal switch is closed. The heating coil actuates the bimetallic strip in the starter switch. After sufficient preheat time elapses, the thermal switch opens, and the lamp starts. During lamp operation a small amount of energy is consumed by thermal starters.

Instant Start Circuits

Instant start systems are composed simply of a ballast, lamp and lampholders. The ballast contains a transformer that provides sufficient open-circuit voltage to attract electrons from the cathodes without preheating. Instant start lamps are made with cathodes specially designed to reduce the loss of electron-emitting materials caused by this method of starting. During lamp operation, a few turns of wire on each cathode become red hot to continue to provide free electrons efficiently.

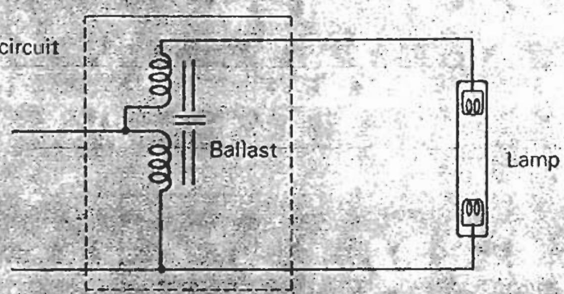
Slimline lamps, with single-pin bases, are the most common instant start types, although some bipin-based lamps are designed for this service. They may be operated at different lamp currents (and wattages) with appropriately designed ballasts. T-6 and T-8 slimline lamps are usually operated at 200mA lamp current; the T-12 slimlines are usually operated at 425mA. Operation at higher currents usually increases output, while slightly decreasing efficiency. At lower currents, light output is decreased, but efficiency is slightly increased. A minimum current of about 120mA is necessary for sufficient cathode heating to maintain reasonable lamp life. Systems for continuously varying current (dimming) are not practical with instant start lamps; generally, separate ballasts are required for each level of lamp current desired.

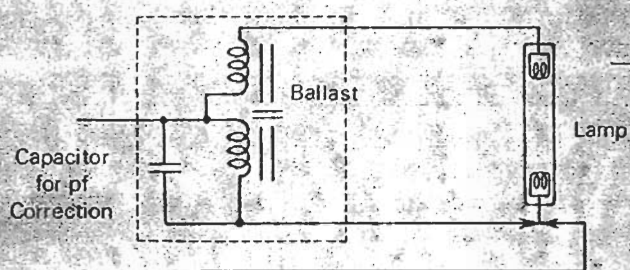
Because slimline lamps require relatively high voltages to start, lampholders are designed to reduce the hazard to maintenance personnel when the lamps are removed and installed. This is generally accomplished by having push-pull lampholders wired in the circuit so that the ballast is disconnected unless both ends of the lamp or lamps it serves are properly seated in position.

Circuit 4 shows the basic instant-start circuit, while Circuit 5 adds the disconnecting lampholder and power factor correction used in most common single-lamp circuits. Circuit 6 shows a two-lamp circuit designed to operate the lamps in series.

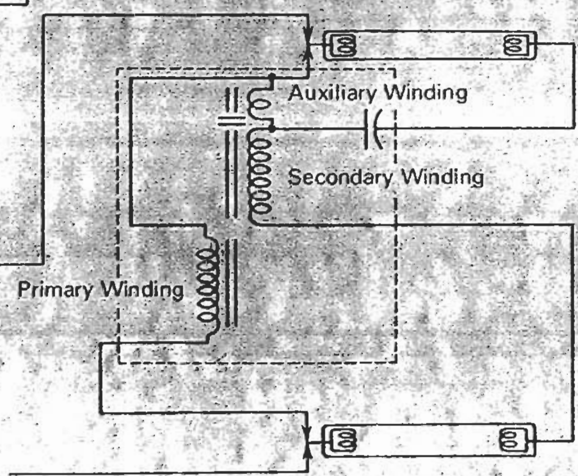
Originally, two-lamp slimline circuits were of the lead-lag type, operating lamps in parallel: one lamp was connected with a reactance having leading power factor, and the other with a lagging reactance, with the combination having a net high power factor. Today, most two-lamp slimline ballasts are designed to start the lamps in sequence a few thousandths of a second apart, and operate the lamps in series with a combination of reactances that has a slightly leading high power factor. The design of series-sequence ballasts has significantly reduced ballast size, cost and sound level, thus improving economics and pleasantness of lighting with instant-start lamps.

Circuit 4. Basic instant start circuit





Circuit 5. Instant start circuit showing disconnect lampholder



Circuit 6. Typical series instant start circuit

Rapid Start Circuits

Ballasts for rapid start systems have separate windings to heat the lamp cathodes continuously. When the circuit is energized, these windings quickly heat the electrodes, causing sufficient ionization in the lamp for the arc to strike from the voltage of the main ballast windings. The immediate heating of the cathodes reduces the voltage necessary to strike the arc. This reduces ballast size and losses, and thus improves the efficiency of the system. The rapid start circuit eliminates the annoying flicker associated with starting of preheat systems. It also simplifies system maintenance since the starter and its socket are eliminated.

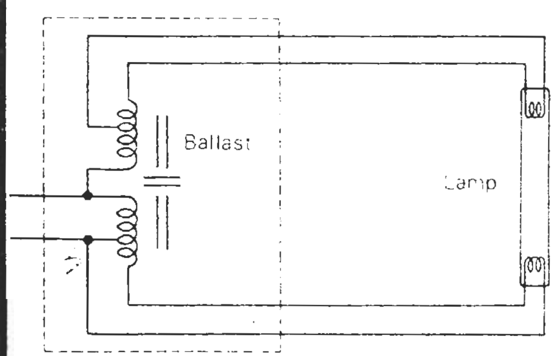
Rapid start circuits are used in the vast majority of new fluorescent installations today. High output, Power Groove®, Circline, All-Weather™ and the new Mod-U-Line™ lamps are all designed specifically to operate in rapid start systems.

All rapid start lamps are coated with Dri-Film® silicone coating to aid reliable starting under conditions of high humidity.

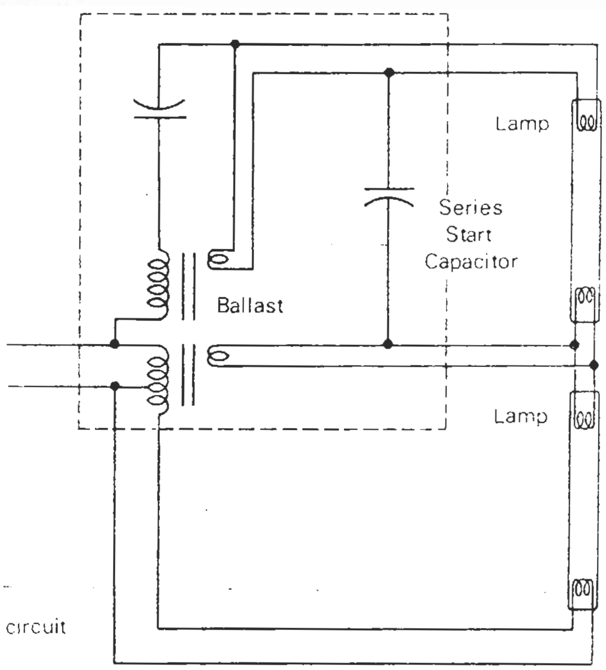
To assure reliable starting of rapid start lamps, an external starting aid is needed. This consists of an electrically grounded metal strip extending essentially the full length of the lamp. In most cases, the wiring channel or a reflector is used as the starting aid. For lamps of 500 mA or below, including circline, the starting aid should be within ½ inch of the bulb wall. For all other lamps, the starting aid should be not more than 1 inch from the bulb wall.

Typical rapid start circuits are shown. Circuit 7 is the simplest; note the tapped windings for heating the electrodes continuously.

The series circuit (Circuit 8) is the most common for multiple lamp ballasts. The capacitor across the top lamp aids in starting the lower lamp first; the voltage drop across the lower lamp after starting is very low; this places virtually the entire ballast voltage across the upper lamp for reliable starting. With this system, the starting voltage for both lamps need be only slightly higher than for one lamp.



Circuit 7. Basic rapid start circuit



Circuit 8. Two-lamp series lead circuit

Special Fluorescent

Dimming

The light output of rapid start fluorescent lamps may be adjusted or dimmed by a number of special circuits. All of these circuits incorporate one essential principle: The ballast must keep the cathodes of the lamp energized at the proper voltage regardless of the amount the lamp may be dimmed.

Current passing through the lamp or lamps in the dimming system may be controlled by a number of methods. The methods used include thyratrons, silicon-controlled rectifiers and other solid-state devices, variable inductors, autotransformers, saturable core reactors, magnetic amplifiers, etc.

Dimming systems vary widely in performance. Some systems can dim lamps no lower than 20% of normal full output, while others can dim lamps as low as 0.2%.

The limitations of some dimming systems cause undesirable operating characteristics toward the lower end of the dimming range which should be expected. Lamps may flicker or go out entirely. Marked non-uniformity in output from one lamp to another may be observed. On the other hand, the better systems produce a wide range of dimming without exhibiting any of these less desirable performance features.

In most dimming systems, the lamp can be started at any setting of the dimmer control. However, in some systems it is necessary to turn the control to nearly full brightness to start the lamp; once started the brightness can again be reduced.

Dimming systems for 40-watt fluorescent lamps are made commercially by several manufacturers. Many systems can dim either 30-watt rapid start or 40-watt lamps with the same ballast. However, 30-watt and 40-watt lamps should not both be used on the same dimmer control.

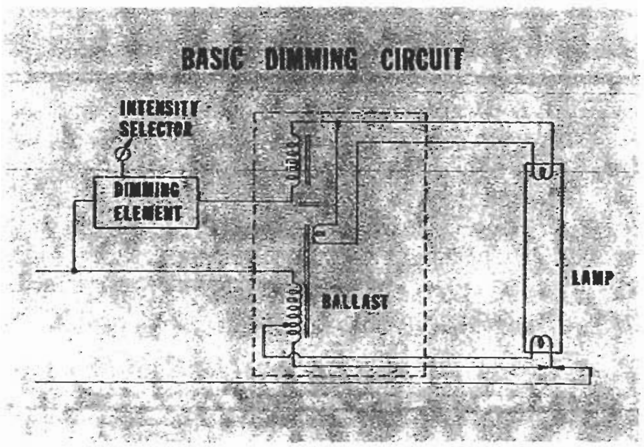


Diagram of a fluorescent lamp dimming system. The ballast heats the cathodes of the lamp to the proper operating temperature. the control and dimmer, in conjunction with the ballast, vary current in the arc

Flashing

The life of fluorescent lamps is seriously reduced by turning them ON and OFF frequently when ordinary ballasts are used. However, it is possible to flash rapid start type lamps and maintain satisfactory life by using a special flashing ballast.

Similar to dimming ballasts, the flashing ballasts heat the lamp cathodes continuously even when the lamp arc is in the off portion of the flashing cycle. Flashing is accomplished by interrupting current to the arc only. One-, two-, and three-lamp flashing ballasts are available for most high output lamps. In addition, "Hi-Low" two-level flashing ballasts are available for certain lamp lengths.

In addition to the special ballast, a flasher designed for this specific application is also required. Plastic sign manufacturers utilize flashing fluorescent lamps of various colors to create many interesting and attractive advertising effects.

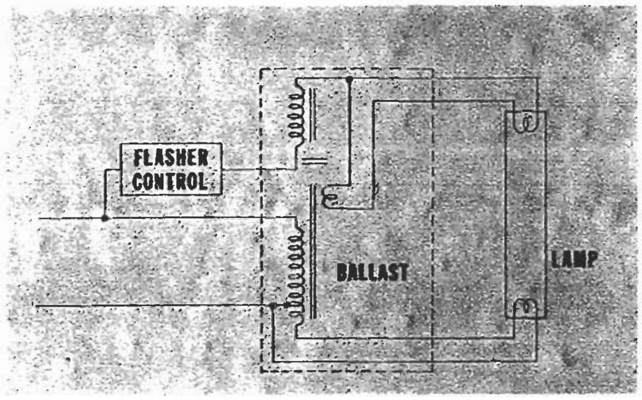


Diagram of a fluorescent lamp flashing system. The flasher interrupts arc current without affecting cathode heating.

TDR Sign Ballasts

High output fluorescent lamps, when operated on low temperature ballasts, will instant-start at all but the lowest commonly encountered ambient temperatures. This has a detrimental effect on lamp life. For typical sign applications operated at 6 hours per start, average lamp life is reduced about 25% compared with operation on indoor ballasts.

If the cathodes are preheated at least 2 seconds before the high voltage is applied, lamp life will be increased substantially. The combined effects of instant starting and starting frequency are virtually eliminated, and lamp life is comparable to that obtained on continuous burning, regardless of temperature (within normal limits) or number of starts. For this reason it is suggested that for some outdoor applications where lamp maintenance is unusually difficult and/or costly, it is economically sound to provide a time-delay device to allow the cathodes to be fully heated before the high voltage is applied.

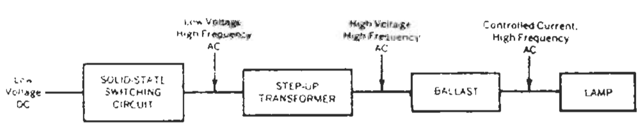
The circuit for the TDR ballast is basically the same as the flashing circuit shown above. The external flasher device is replaced by a time-delay switch which is enclosed in the ballast case.

Inverter Ballast

Inverter ballasts are compact solid-state devices which convert low-voltage dc to high-frequency ac. Their use permits high efficiency, low-glare fluorescent lighting where formerly only incandescent was possible. Typical applications include boats, automobiles, recreational vehicles, buses, trains, standby emergency lighting systems, hand lanterns and portable applications of all kinds. Fluorescent fixtures and hand lanterns, which make use of inverter ballasts, are now available commercially.

Inverter ballasts may be designed to operate lamps in any of the three basic circuit configurations; preheat, instant start, or rapid start. Circuits for portable applications often are designed to operate the fluorescent lamp at less than its rated wattage, thus reducing current drain from the battery.

A fortunate consequence of operation of the lamp at high frequency is that fluorescent lamps become more efficient. For example, the F6T5 and F40 increase about 7% in efficacy at 3000 Hertz as compared with their operation at 60 Hertz. The result at 20,000 Hertz (often used because it is not audible to humans) is even more impressive: efficacy of the F40 is more than 12% higher and efficacy of the F6T5 is more than 18% higher than at 60 Hertz.



Functional block diagram of a typical inverter ballast. Actual circuits may operate the lamp in a preheat, instant start or rapid start mode.

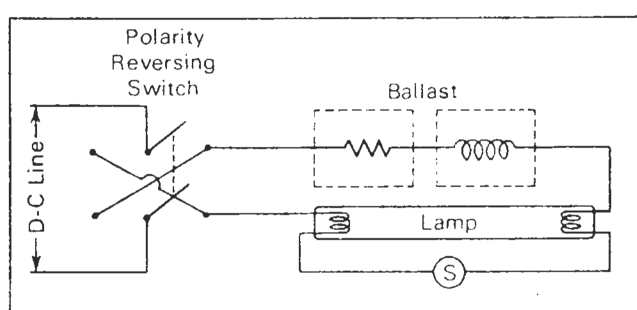
Direct Current

Fluorescent lamps are intended primarily for use on ac circuits; however, operation on dc circuits is possible with proper auxiliary equipment. For dc operation, two components make up the ballasting equipment:

1. A resistor to limit current to the desired value.
2. A choke type ballast to supply an inductive voltage "kick" for starting the lamp.

When a fluorescent lamp is operated in an ac circuit, an inductive ballast limits current to the lamp without consuming an appreciable amount of power. This is possible because of characteristics exhibited by inductance in an ac circuit. However, the resistance ballast used for dc operation consumes about the same amount of power as the lamp. Therefore, over-all efficiency of fluorescent lamps operated on dc circuits is much lower than for operation on ac circuits.

When operated on direct current, the longer fluorescent lamps have a tendency to become dim at one end after several hours' operation. This is caused by the fact that the current flows continuously in one direction, causing the mercury to accumulate at the negative (cathode) end of the lamp. A line-reversing switch is often used to reverse the electrode functions periodically (every few hours of operation), thus overcoming the tendency to dim more at one end. Even for the shorter lamps, which do not exhibit this mercury migration, a reversing switch is recommended. Reversing the current flow from time to time evens the wear in the cathodes, resulting in longer life. A ratchet relay, which reverses current each time the lamps are lighted, is a good device for the purpose. Lamp life ratings are based on ac operation. When lamps are operated on dc, life may be somewhat reduced.



Typical circuit for direct-current operation of fluorescent lamps. The resistor limits current to the lamp, and the inductor provides a surge of high voltage to aid in starting the lamp.

Special Lamp Characteristics

Fluorescent lamps are highly reliable in their operation. However, they have certain unusual characteristics which may be observed from time to time.

SPIRALING AND FLICKERING

Early in life, fluorescent lamps occasionally exhibit a condition called spiraling, i.e., the brightness varies from end to end. This condition is often caused by loose materials knocked off the cathode. Normally, this condition disappears after the lamps have been burned for a few hours.

On 60-Hz operation, fluorescent lamps all develop a 120-Hz fluctuation. However, this is not perceptible to the human eye. Sometimes a lamp flickers at lower frequencies (which is perceptible) when the lamp is first turned ON or when it is cooled to too low temperature by a draft. Ordinarily, this type of flicker stops when the lamp warms up.

UNDER AND OVERVOLTAGE

Ballasts are usually designed for operation on 120-volt circuits. In general, operation is satisfactory with voltage as low as 110 volts, or as high as 125 volts. Similarly, ballasts for 208-volt service operate satisfactorily from 200 to 215 volts; 240-volt service from 220 to 250 volts; 277-volt service from 250 to 290 volts; and 480-volt service from 440 to 500 volts.

If the circuit voltage is too high, operating current is excessive. This overheats the ballast, and causes premature ballast failure. If lower than rated voltage is applied, current may be too low for satisfactory heating of the cathodes, causing unreliable or delayed starting, and reduced lamp life. Curves on Page 16 show how varying line voltage affects typical lamp characteristics.

STROBOSCOPIC EFFECTS

When a fluorescent lamp is operated on alternating current, the current passes through zero twice each cycle and reverses in direction. As this occurs, the light from the lamp dips momentarily to a low value. On 60-Hz power this occurs 120 times per second. No flicker is visible since the eye does not respond to a frequency this high. However, an interesting phenomenon called *stroboscopic effect* may sometimes be observed on rapidly moving or rotating objects. Instead of a uniform blur, evenly spaced shadows along the path of the moving object may be observed. These occur at the points occupied by the object when the current in the lamp is passing through zero.

The stroboscopic effect from fluorescent lamps may occasionally be useful to judge the speed of an object moving at synchronous or near synchronous speed. However, fluorescent lamps will not produce the sharp stroboscopic images obtained on moving pictures or television or with a special stroboscopic light made for the purpose. The characteristic blur of motion is always plainly visible. There is no danger of mistaking a rotating object for a stationary one.

RADIO INTERFERENCE

Fluorescent lamps produce detectable radio interference on the standard AM broadcast band (500-1700 kHz). Although radiation can be detected in the 2-200 MHz region, interference with broadcasting services in this frequency range (FM radio, TV, etc.) is rare.

Most modern radios have built-in antennas. Moving the radio a short distance away from fluorescent lamps and associated electric supply lines (see table) is helpful. If the radio cannot be moved, install an outdoor antenna with shielded or twisted lead-in. Also, grounding the radio is often helpful.

Radio noise may also enter the receiver from the fluorescent lamps through a common power supply circuit. The wiring supplying the fluorescent lamps can act as an antenna to broadcast the noise where nonmetallic cable or knob-and-tube wiring is used. Line filters placed in the fluorescent fixtures can relieve these problems. Such filters are available from radio parts suppliers.

For special laboratory, military, and industrial applications, fluorescent fixtures may be equipped with appropriate metal louvers or conducting glass lenses. In this way, the radio noise may be almost completely screened and prevented from leaving the fixture. Equipped with high quality commercial line filters, such fixtures have tested below the noise limitations of the most stringent military specifications.

Recommended Distance from Lamp to AM Radio Antenna

LAMP SIZE	DISTANCE (feet)
14, 15, 20-watt	4
32-watt circline	5
30-watt	6
40-watt	8
90-watt, 72 and 96-in. slimline	10

Trouble Shooting

Although this publication is not intended to be a service manual, a few basic troubleshooting procedures are worthy of mention. For more complete troubleshooting procedures, see *Maintenance Guide for Fluorescent Lighting*, General Electric publication No. 60F-140R. The following procedures will restore most systems to operation.

PREHEAT CIRCUITS

Lamp blinks ON and OFF. Usually this is a normal end-of-life lamp failure. However, if the lamp has not been in service long, the starter may be defective, and should be replaced. Lamp replacement is the next logical step. Low circuit voltage, low ballast rating, low temperature, and cold drafts can also cause blinking.

Lamp makes no starting effort or starts slowly. Be certain that the lamp makes proper contact in the lampholders.

Ends of lamp remain lighted. The trouble may be a shorted capacitor in the starter, or the switch contacts may be welded together. In either case, the starter must be replaced.

INSTANT START CIRCUITS

Because instant start and rapid start circuits do not use starters, there are fewer components to cause trouble. Virtually the only thing that goes wrong with these circuits is that the lamps fail at normal end of life, and occasionally ballasts fail.

The ballast open-circuit voltage is about three times the normal lamp voltage. Therefore, on some ballast designs, these lamps may start and operate even when one cathode is completely de-activated at the end of normal life. In this condition, the lamp may spiral violently; sometimes orange-colored flashes occur. Such lamps or any lamps which become quite black at one end should be replaced promptly because there is little life left. The end of life spiraling results in abnormally high peak voltages and ballast overheating; if the lamp is not replaced, the ballast may fail.

RAPID START

Completely reliable starting in rapid start circuits depends on the presence of a suitable starting aid, as discussed on Page 14.

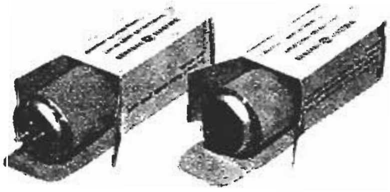
If, under high humidity conditions, rapid start lamps start slowly or do not start at all although the cathodes are properly heated, this may be due to dirt on the lamp which is offsetting the Dri-Film coating. In this case, the lamps should be cleaned.

Satisfactory starting and lamp life of lamps in rapid start circuits depend on proper heating of both cathodes when lamps start. With heating current at only one cathode, either the lamp fails to start or the lamp starts slowly (about 5 seconds). In either case, lamp life is reduced drastically.

Heating current at only one cathode can be caused by improper contact in the holder, broken holder, open cathode, shorted leads in the lamp base, corroded or dirty base pins or holder contacts, defective ballast, improper wiring, etc. Inexpensive testers are available to check cathode heating voltage in rapid start circuits.

Lamps started many times without being operated for reasonable periods of time become hard to start. This situation can be corrected by operating hard-to-start lamps for several hours.

On most two-lamp 40-watt ballasts, if one lamp fails, both go out or are quite dim. The good lamp is not damaged because heating current still flows through the cathodes. At normal failure, lamps simply fail to start, and are black at one or both ends. There usually is no flashing, spiraling, or ballast overheating at the end of lamp life.



Rapid start tester for bipin fixtures, another for Power Groove, High Output and All-Weather fixtures. Help locate fixture troubles.

FLUORESCENT DISPOSAL

Since 1949, the basic phosphor used by the General Electric Company in the manufacture of fluorescent lamps has been a relatively inert phosphate found to be safe in the ordinary handling of either the intact or broken lamp.

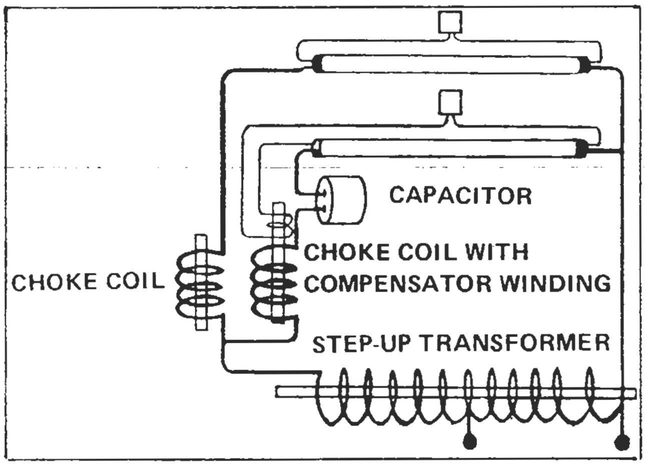
As for any product containing glass and chemicals, reasonable care should be observed when burned out lamps are discarded.

Fluorescent lamps are filled to a very low gas pressure (almost a vacuum), and implosions may occur when lamps are broken. Thus, if lamps are to be broken or crushed prior to disposal, certain precautions should be taken. Proper equipment should be worn to protect the eyes and skin from flying glass fragments. As in the case of any fine dust, excessive exposure to the phosphor dust should be avoided. Unbroken lamps should not be thrown into fires or domestic types of incinerators.

The following additional precautionary measures are recommended where large quantities of fluorescent lamps are to be broken, either regularly or intermittently:

1. Break lamps outdoors or in a well-ventilated indoor area. The use of waste container and local exhaust ventilation will minimize the dispersed dust and mercury vapor.
2. It is not to be expected that the small amount of mercury contained in each lamp will cause any difficulty. However, under unusual conditions where large quantities are being broken in an enclosed, poorly ventilated area, mercury vapor concentrations should periodically be measured. Most local health authorities have proper measuring equipment. If values exceed established standards or criteria, corrective steps should be taken. This may be through the use of increased ventilation, enclosure, or by providing workers with suitable respirators. Employees should also be provided with adequate protection against flying glass (goggles, face shields, etc.).
3. Disposition of crushed lamps in a properly designed and maintained land-fill area presently appears to be the most feasible means of disposal.

FIGURE 4



A two-lamp, switch-start circuit with compensator winding.

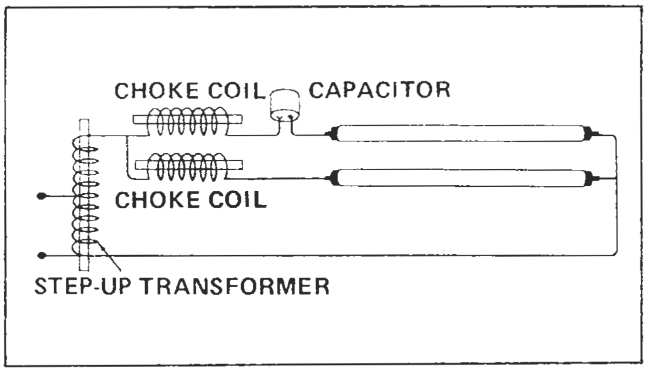
INSTANT START

All slimline lamps are classified as "instant-starting". They are easily identifiable by their single pin base. Ballasts for these lamps are built with a large step-up transformer to strike the starting arc without pre-heating the cathodes.

This means the starter and compensator winding can be eliminated. However, lamp cathodes must be strongly constructed to withstand the shock of this "brute-force" type of starting. Two lamp ballasts in lead lag construction for instant-start lamps are bulky and heavy. These disadvantages have been largely overcome in the series-sequence design shown in figure 6.

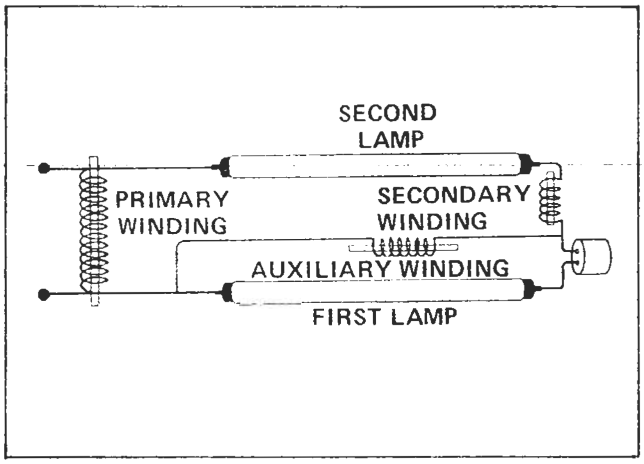
The trick with series operation is to put a high voltage auxiliary winding in parallel with the first lamp. This winding gets lamp cathodes up to operating temperature fast. As a result the ballast starts the lamps one after the other with the open circuit voltage normally required for only one lamp.

FIGURE 5



A two-lamp ballast for instant start lamps (lead lag construction).

FIGURE 6



Series operation of two instant start lamps achieves substantial reductions in size, weight, wattage loss and cost.

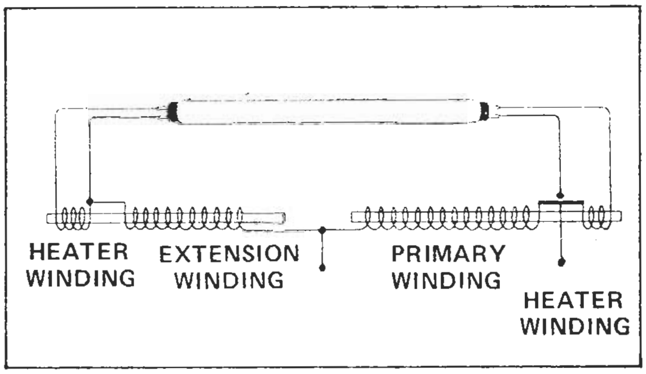
RAPID START

This system combines the desirable features of switch start and instant start systems. The ballast supplies a small voltage (approx. 4 volts) to the lamp cathodes continuously to help strike the arc when open circuit voltage is applied. No external starter is required.

As a starting aid the rapid start ballast utilizes the potential difference that exists between the lamp cathodes and the metal in the fixture. ALL RAPID START FIXTURES MUST BE GROUNDED FOR THAT REASON. Here again series sequence starting of two lamps is used to achieve economies in construction of the ballast. Since a lower open circuit voltage may be used due to continuous heating of the cathodes further reductions are possible in size and weight.

Since rapid start ballasts apply a low voltage (3 to 4 volts) to lamp cathodes throughout operation, it has been possible in recent years to introduce fluorescent dimming systems.

FIGURE 7



The rapid start ballast supplies a small voltage continuously to the cathodes.

3 Noise

USE OF SOUND RATING NOMOGRAPH

Even though noise in varying degrees is to be expected with fluorescent installations, many complaints are still heard. However, if the room's purpose, size and construction, the ballast's sound rating and the number of ballasts required are taken into consideration during layout, this sometimes bothersome hum can be reduced to a minimum.

BALLAST IS A NOISE SOURCE

Audible hum originates with the ballast and is a normal operating characteristic. Whether or not it will bother its user depends on the total lighting system of ballast, fixture, lamp, the room and its purpose.

Ballasts using copper and iron are required to operate a fluorescent lamp. These metals, in conjunction with a 60 Hertz power source, inevitably generate noise. Its magnitude is minimized by design and manufacturing techniques.

Every CGE ballast has a catalogue number with only one sound rating since a given amount of copper and iron is used.

FIGURE 13

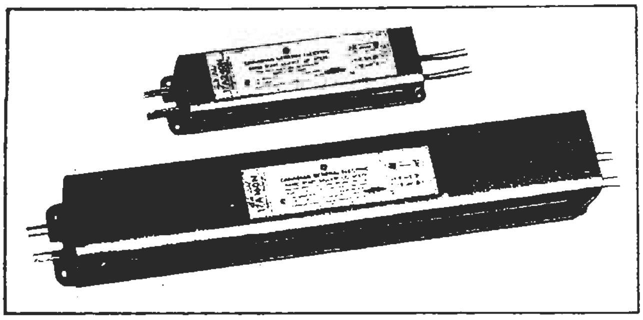


Illustration shows varying size of ballasts according to wattage required. Top unit is sound rated "A", bottom ballast is rated "E".

FIXTURES CAN AMPLIFY SOUND

The fixture itself can be an additional noise source if not carefully constructed and installed because its metal is sensitive to vibrations caused by electrical forces within the ballast.

If fixture components are flimsy or loose, they will vibrate in unison with ballast vibration, causing additional noise. If the fixture is well made and correctly installed, it should transmit ballast sound without amplification.

LAMP RATING DETERMINES BALLAST SIZE

Fluorescent lamps themselves do not generate noise but their rating determines ballast size — iron and copper content of the ballast increases with lamp wattage rating and results in more noise.

It does not necessarily follow, however, that smaller lamps should be used in the interest of quieter operation. Fewer ballasts are needed with high wattage lamps because fewer lamps are required to achieve the desired lighting level.

AMBIENT NOISE LEVEL AND ROOM SIZE

Construction and furnishing of the room have a considerable bearing on its ability to absorb or reflect noise from lighting. Acoustical tiles and drapes absorb noise; plaster ceilings, hard walls and floors reflect it.

Fluorescent lighting for a room where sedate activities will be conducted must be carefully considered from a sound stand-point. Soft materials in these rooms, such as rugs and drapes, dampen noise from normal activities and from lighting equipment to the same degree. Their advantage in reducing awareness of hum from lighting equipment is therefore negligible.

In addition, these materials have a poor reflectance factor so more lamps are required to achieve the desired illumination level. Extra lamps mean extra ballasts, hence, more unwanted noise. Activities in the room determine whether or not sound will be detected. The combination of ballast noise and sounds made by people and equipment produce the actual noise level.

FIGURE 14

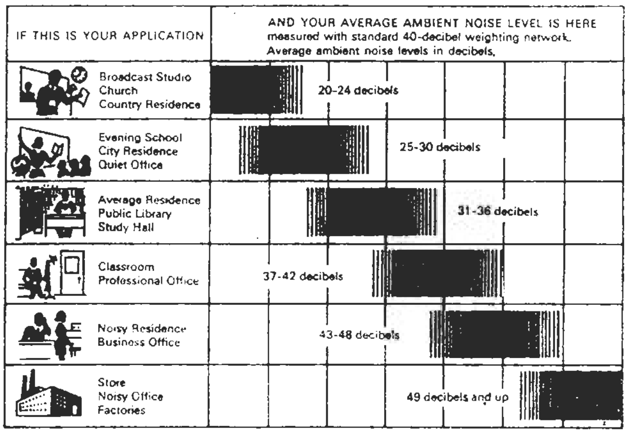
50 DB	+	50 DB	=	53 DB

If all noise energy in two industrial rooms of 50 DB each be placed in one room the total ambient would increase only 3 DB.

Noise levels do not add arithmetically. (Adding two noise sources of 50 decibels each produces a total noise level of only 53 decibels. Refer to Figure 14. Adding 50 db and 40 db equals 50 db — the louder noise drowns out the quieter one).

Consequently, if activity noise was 50 db and lighting equipment noise 40 db, the lighting equipment noise would not be noticeable. The reverse is also true.

FIGURE 15



HOW TO CALCULATE NOISE

Sound generated by CGE ballasts is carefully measured and statistically analysed. The quietest are given an "A" rating and noisier units are graduated from "B" to "F". This rating is meaningful only when used in conjunction with the CGE nomograph which in turn is applicable only to installations using CGE Fluorescent Ballasts.

1. Once preliminary lighting layout is complete, determine the ballast's sound rating and the number of ballasts required.
2. Determine room constant from figure 16. Use the figures in light face type for rooms with plaster ceilings and the figures in bold type for acoustical tiled ceilings.
3. Determine the ambient sound level created by normal activities in the room (see figure 15 for guide). Assuming 64 sound rated "A" ballasts are to be used, and that the room constant is 2.0 and normal ambient sound level is 35 db: –
4. Draw a line on the nomograph from 64 to "A".
5. From the point where this corsses index line 1, draw a second line to room constant 2.0.
6. From where this line intersects index line 2, draw a third line through the normal ambient noise level and project it through the system evaluation.
7. Read whether or not the lighting installation is acceptable from an acoustical standpoint, assuming use of well-made, correctly-installed fixtures.

FIGURE 16

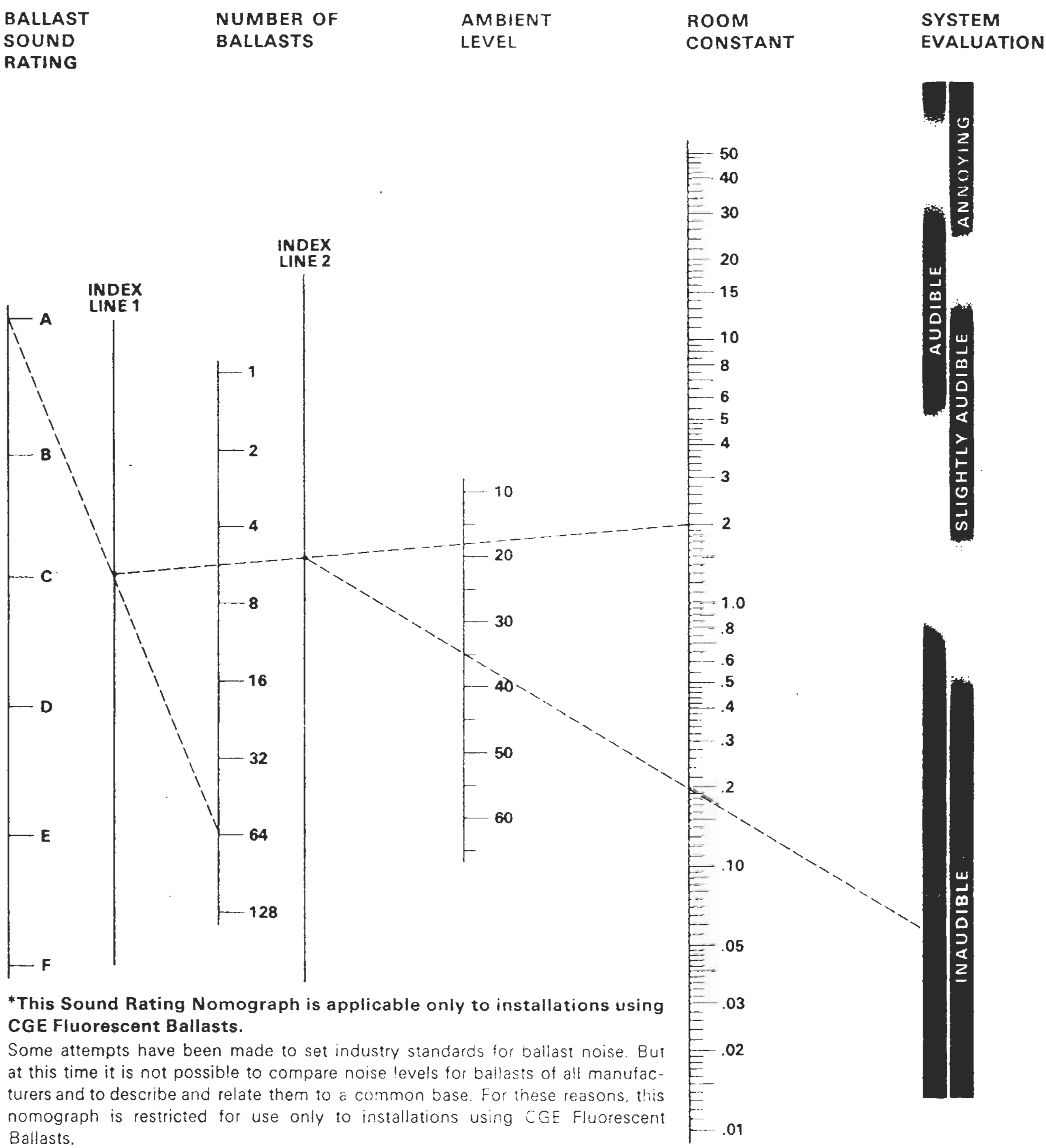
TABLE 1 ROOM CONSTANT IN THOUSANDS

CEILING = HARD PLASTER CEILING
CEILING = ACOUSTIC TILE ON CEILING

ROOM - FT		CEILING HEIGHT - FT																	
Width	Length	8		10		12		14		16		20		24		28		34	
	10	.01	.07	.01	.07														
	14	.01	.1	.01	.1	.02	.1												
	18	.01	.1	.02	.1	.02	.1												
8	24	.02	.2	.02	.2	.02	.2	.03	.2										
	30	.02	.2	.03	.2	.03	.2	.03	.2										
	40	.03	.3	.03	.3	.04	.3	.04	.3										
	50	.04	.4	.04	.4	.05	.4	.05	.4	.05	.4								
	10	.01	09	.01	.09	.01	.09												
	14	.01	.1	.02	.1	.02	.1	.02	.1										
	18	.02	.2	.02	.2	.02	.2	.02	.2										
10	24	.02	.2	.02	.2	.03	.2	.03	.2	.03	.2								
	30	.03	.3	.03	.3	.03	.3	.04	.3	.04	.3								
	40	.03	.4	.04	.4	.04	.4	.05	.4	.05	.4								
	60	.05	.6	.05	.6	.06	.6	.06	6	.07	.6								
	12	.01	.1	.02	.1	.02	.1	.02	.1										
	16	.02	.2	.02	.2	.02	.2	.02	.2										
	20	.02	.2	.02	.2	.03	.2	.03	.2	.03	.2								
12	30	.03	.3	.03	.3	.04	3	.04	.3	.04	.3								
	50	.05	6	.05	6	.06	6	.06	.6	.07	6	.08	.6						
	70	.06	.8	.07	.8	.07	.8	.08	8	.09	.8	.1	.8						
	100	.09	1.1	.1	1.1	.1	1.1	.1	1.1	.1	1.1	.1	1.1						
	14	.02	2	.02	.2	.02	.2	.02	2	.03	.2								
	20	.02	.3	.03	.3	.03	.3	.03	.3	.03	.3	.04	.3						
	30	.03	.4	.04	.4	.04	.4	.04	.4	.05	4	.05	.4	.06	4				
14	40	.04	5	.05	.5	.05	.5	.05	.5	.06	.5	.07	.5	.08	5				
	60	.06	.8	.06	.8	.07	.8	.08	.8	.08	8	.1	.8	.1	.8	.1	.8		
	90	.08	1.1	.08	1.1	.09	1.1	.1	1.0	.1	1.0	.1	1.0	.1	1.0	.2	1.0		
	100	.09	1.3	.1	1.3	.1	1.3	.1	1.3	.1	1.3	.2	1.3	.2	1.3	.2	1.3		
	15	.02	.2	.02	.2	.03	.2	.03	.2	.03	.2	.04	.2						
	20	.03	.3	.03	.3	.03	.3	.03	.3	.04	.3	.04	.3						
	30	.04	.5	.04	.5	.04	.4	.05	.4	.05	.4	.06	.4	.07	.4				
16	40	.04	.6	.05	.6	.05	.6	.06	.6	.06	.6	.07	.6	.08	.6	.09	.6		
	60	.06	.9	.07	.9	.08	.9	.08	.9	.09	.9	.1	.9	.1	.9	.1	.9		
	80	.08	1.2	.09	1.2	.1	1.2	.1	1.2	.1	1.2	.1	1.2	.1	1.2	.2	1.2		
	100	.1	1.6	.1	1.5	.1	1.5	.1	1.5	.1	1.5	.2	1.5	.2	1.5	.2	1.5		
	20	.03	3	.03	.3	.03	.3	.04	.3	.04	3	.05	.3	.05	.3				
	30	.04	5	.04	.5	.05	.5	.05	.5	.05	.5	.06	.5	.07	.5				
	40	.05	.7	.05	.7	.06	.7	.06	.7	.07	.7	.08	.7	.09	.7	.1	.7		
18	60	.07	1.0	.08	1.0	.08	1.0	.09	1.0	.1	1.0	.1	1.0	.1	1.0	.1	1.0	.2	1.0
	80	.09	1.4	.1	1.4	.1	1.4	.1	1.4	.1	1.3	.1	1.3	.2	1.3	.2	1.3	.2	1.3
	100	.1	1.8	.1	1.7	.1	1.7	.1	1.7	.2	1.7	.2	1.7	.2	1.7	.2	1.7	.2	1.7
	120	.1	2.1	.1	2.1	.2	2.1	.2	2.0	.2	2.0	.2	2.0	.2	2.0	.2	2.0	.3	2.0
	20	.03	4	.03	.4	.04	.4	.04	.4	.04	.4	.05	.4	.06	.4				
	30	.04	6	.05	.6	.05	.6	.05	.6	.06	.6	.07	.6	.07	.6	.08	.6		
	40	.05	8	.06	.8	.06	.8	.07	.7	.07	.7	.08	.7	.09	.7	.1	.7		
20	60	.08	1.2	.08	1.2	.09	1.1	.1	1.1	.1	1.1	.1	1.1	.1	1.1	.1	1.1	.2	1.1
	80	.1	1.6	.1	1.5	.1	1.5	.1	1.5	.1	1.5	.1	1.5	.2	1.5	.2	1.5	.2	1.5
	100	.1	2.0	1	1.9	.1	1.9	.2	1.9	.2	1.9	.2	1.9	.2	1.8	.2	1.8	.3	1.8
	120	.1	2.4	.2	2.3	.2	2.3	.2	2.3	.2	2.3	.2	2.2	.2	2.2	.3	2.2	.3	2.2
	30	.05	.7	.05	.7	.06	.7	.06	.7	.07	.7	.08	.7	.08	.7	.09	.7		
	40	.06	1.0	.07	1.0	.07	1.0	.08	.9	.08	.9	.09	.9	.1	.9	.1	.9	.1	.9
	60	.09	1.5	.1	1.5	.1	1.4	.1	1.4	.1	1.4	.1	1.4	.1	1.4	.2	1.4	.2	1.4
25	80	.1	2.0	.1	2.0	.1	1.9	.1	1.9	.2	1.9	.2	1.9	.2	1.9	.2	1.9	.2	1.8
	100	.1	2.5	.2	2.5	.2	2.4	.2	2.4	.2	2.4	.2	2.3	.2	2.3	.2	2.3	.3	2.3
	120	.2	3.0	.2	3.0	.2	2.9	.2	2.9	.2	2.9	.2	2.8	.3	2.8	.3	2.8	.3	2.8
	140	.2	3.5	.2	3.5	.2	3.4	.2	3.4	.3	3.3	.3	3.3	.3	3.3	.3	3.2	.4	3.2
	30	06	.9	.06	.9	.07	.9	.07	.8	.08	.8	09	.8	.1	.8	.1	.8	.1	.8
	40	.07	1.2	.08	1.2	.08	1.2	.09	1.1	.1	1.1	.1	1.1	.1	1.1	.1	1.1	.2	1.1
	60	.1	1.8	.1	1.8	.1	1.7	.1	1.7	.1	1.7	.1	1.7	.2	1.7	.2	1.7	.2	1.7
30	80	.1	2.4	.1	2.4	.2	2.3	.2	2.3	.2	2.3	.2	2.3	.2	2.2	.2	2.2	.3	2.2
	100	.2	3.0	.2	3.0	.2	2.9	.2	2.9	.2	2.9	.2	2.8	.3	2.8	.3	2.8	.3	2.8
	120	.2	3.6	.2	3.6	.2	3.5	.2	3.5	.2	3.5	.3	3.4	.3	3.4	.3	3.4	.4	3.3
	140	.2	4.3	.2	4.2	.3	4.1	.3	4.1	.3	4.0	.3	4.0	.3	3.9	.4	3.9	.4	3.8

FIGURE 17

Dotted lines (- - - -) shown are for typical example as described on previous page.



***This Sound Rating Nomograph is applicable only to installations using CGE Fluorescent Ballasts.**

Some attempts have been made to set industry standards for ballast noise. But at this time it is not possible to compare noise levels for ballasts of all manufacturers and to describe and relate them to a common base. For these reasons, this nomograph is restricted for use only to installations using CGE Fluorescent Ballasts.

7 Rapid Start Ballasts

NEED FOR PROPER GROUNDING

All rapid start systems, whether 430 milliamp, 800, 1000, or 1500 milliamp, require a starting aid voltage between the full length of the lamp and the lamp electrodes to help initiate the lamp ionization. *This requires metal sheet, strip or mesh, the full length of the lamp at least one inch in width spaced no further than 1/2 inch from the lamp for 430 milliamp lamps and 1 inch for all others.*

A minimum voltage difference must exist between the lamp electrodes and this metal. This voltage difference can be established in at least two ways:

(a) Grounded Fixtures and supply circuit (see Fig. 21)
This is the usual system in Canada as the Canadian Electrical code requires grounded fixtures and usually grounded supplies. Industrial and commercial fixtures naturally provide the metal and the spacing, and we have a connection between the metal fixture and the ballast white lead through the fixture ground connection back to the point where supply line is grounded.

(b) Ungrounded fixtures and/or ungrounded supply (see Fig. 22)
In some fluorescent applications such as street lighting, the fixtures are ungrounded. Supply systems may be ungrounded also; such as 480 and 600 volt – 3-phase – line-to-line connected fixtures.

For these installations, we have no starting aid voltage because there is no connection between the ballast windings, fixture metal and hence lamp electrodes. For reliable starting for such installations an alternative approach has to be taken. This is usually provided by means of a 2 megohm resistor mounted in the ballast and connected between the windings and the ballast case. The ballast case in turn is connected to the fixture metal by the mounting screws.

There are some applications such as plastic signs, where the metalic starting aid has to be provided and connected to the sign frame. This can be provided by running a strip of metal or a wire mesh the full length of the lamp and connecting to the sign frame which is grounded.

FIGURE 21

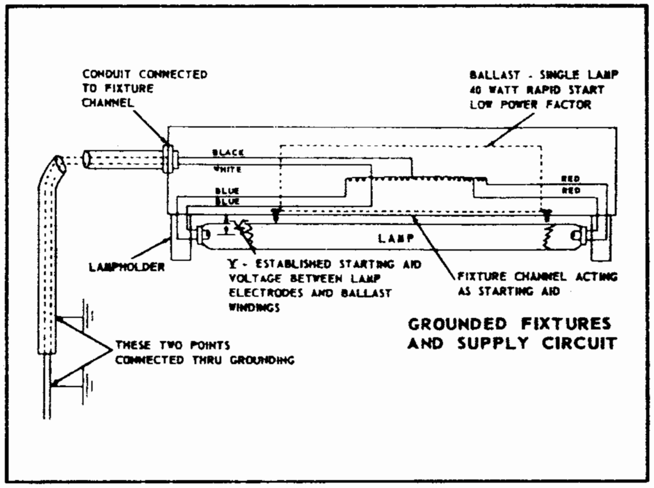
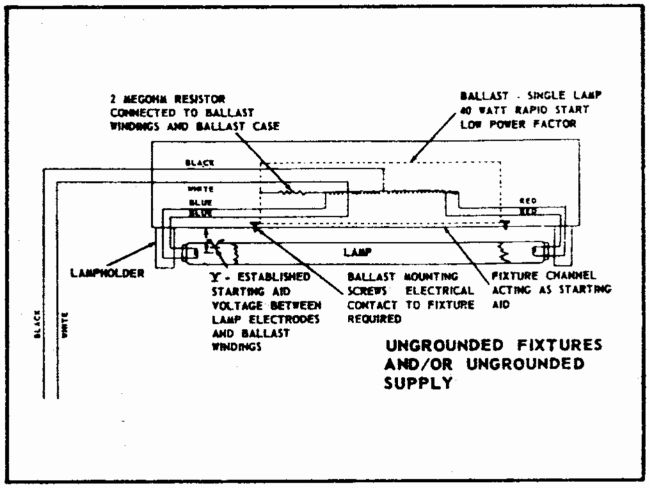


FIGURE 22



9 Fluorescent Dimming

PRINCIPLE OF OPERATION

Canadian General Electric's DS5000 and DS4020 dimming systems utilize solid-state devices. The heart of the system is a silicon controlled rectifier (SCR). This is included in a separate auxiliary (6G5008) for the DS5000 system. The 13A4020 dimmer control for the DS4020 system includes the SCR. By switching on and off at a high rate of speed the SCR controls the amount of current flowing.

It is possible to control the period that lamp current is conducted and thus the average value of current flowing through the lamp by controlling the point in the voltage cycle at which the SCR is switched on. If the SCR is switched on at the beginning of each half-cycle of voltage, the lamps will operate at a high intensity. Conversely if the SCR is switched on later during the half-cycle the lights become dimmer.

Control of the SCR is achieved by the intensity selector which transmits a series of voltage pulses to the SCR. Each of these pulses switches the SCR on. At the end of each half-cycle of voltage the SCR switches off automatically.

The function of the dimming ballast is to provide adequate starting voltage to the lamp *at all intensity settings* and to maintain smooth and stable operation throughout the dimming range.

DS 5000 APPLICATION DATA

Manual and/or motorized control — single phase — up to 1200 lamps

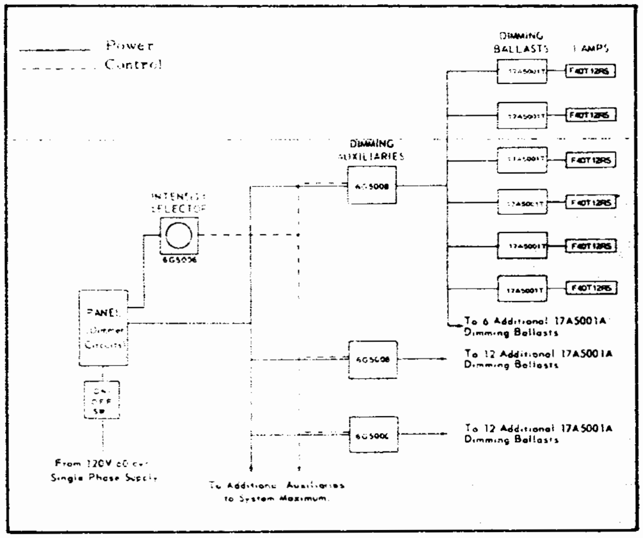
FIGURE 24

SYSTEM SCOPE

Lamp Type:	F40T12/RS ONLY
System line voltage:	120V single phase, line to neutral only
system capacity:	4 to 1200 lamps
Light output control:	Infinite variations from full brightness down to 0.3% of maximum light intensity.

BASIC COMPONENTS		REQUIRED:
a. Dimming ballast cat.	17A5001T	1 per lamp
b. Dimming auxiliary cat.	6G5008	1 per 4 - 12 ballasts
c. Intensity selector cat.	6G5006	for manual control — 1 per location
d. Knobless intensity selector cat.	6G5009	for motorized control— 1 per system
e. Motorized master potentiometer cat.	6G5011	for motorized control— 1 per system

FIGURE 25



WHAT LAMPS SHOULD BE USED?

The DS-5000 System and DS4020 System are listed by CSA for use with 40-watt rapid-start fluorescent lamps only. Fluorescent lamps of different brands and different colours (such as warm white, cool white, etc.) have different dimming characteristics. Use lamps of one brand and one colour preferably seasoned for 100 hours at maximum intensity selection for best results.

LOW-INTENSITY STRIATIONS

When fluorescent lamps are dimmed to extremely low current levels (very low light levels), a condition can exist where a stream of luminescent slugs may appear to be travelling the length of the lamp. These slugs are actually small volumes of ionized gas, called striations. They are noticeable only when the lamp is viewed directly.

If striations are objectionable, the low trimmer potentiometer should be set at a higher light level.

DS-5000 SYSTEM TRIMMER ADJUSTMENT

The 6G5006 intensity selector is equipped with two trimmer potentiometers for fine adjustments to high or low line voltage conditions which may exist on the job. This is accomplished as follows:

a. turn light off.
b. remove knob and plastic face plate
c. turn master potentiometer fully clockwise
d. turn lights on (lights should now be at full intensity)
e. turn HI trimmer potentiometer slowly clockwise until lights begin to flicker — then turn back 1/8 turn. This completes the high end adjustment
f. turn master potentiometer fully counter-clockwise (lights will now be very dim)
g. adjust LO trimmer potentiometer until the lowest stable light level is reached; this will be the minimum light level of the system in operation

h. reassemble face plate and knob.

NOTE: In new installations the lamps should be burned at full intensity for 100 hours before final trimming. Occasionally it may be necessary to retrim for an unbalanced condition which could result from normal lamp replacement or variations in supply voltage.

TEMPERATURE RESTRICTIONS

Due to the temperature rating on the solid-state components used in the DS-5000 System, the hottest spot on the dimming auxiliary case should not exceed 70°C. (Hot spot location is approximately one inch from green/yellow lead end of the auxiliary case.)

TROUBLESHOOTING GUIDE FOR DS-5000 SYSTEM

If a problem occurs, the following troubleshooting guide may help you to quickly locate the source of trouble in minimum time and with the least expense.

For more complete application information on the DS-5000 dimming system including typical wiring diagrams ask for:
NEWSLETTER NO. 153 – Single phase
NEWSLETTER NO. 154 – Three phase

DS-4020 DIMMING SYSTEM

Components

The system consists of the 13A4020 dimmer control (controls 4 to 20 lamps) and the required number of 17A5001A single lamp dimming ballasts. Auxiliaries are *not* required.

PERFORMANCE

The DS-4020 system offers smooth, continuous dimming over a wide range from full brightness down to effectively zero light output. It will start the lamps at any intensity selection and is stable over the entire dimming range.

INSTALLATION

The 13A4020 dimmer control fits into a standard two-gang wall box (minimum 2-1/2" deep) and is connected directly to 17A5001T dimming ballasts (mounted in fixture) using standard building wire.

RATING

The control and ballasts operate from 120 volt, 60 cycle, single phase grounded system. The dimmer control and all ballasts must be connected to the same single phase supply. Maximum current is 10 amperes for 20 lamps.

FIGURE 26

If a problem occurs, the following troubleshooting guide may help you to quickly locate the source of trouble in minimum time and with the least expense.

CONDITION	LAMPS WON'T START	SHORT LAMP LIFE	POOR LAMP TRACKING (Lamps won't dim & brighten in unison)	LAMP FLICKER SPIRALING OR SWIRLING EFFECT	SHORT AUXILIARY LIFE	SHORT BALLAST LIFE	AUDIBLE BALLAST HUM
POSSIBLE CAUSES TO INVESTIGATE	1. Lamp failure 2. Poor lamp-to-lamp-holder contact 3. Low supply voltage 4. Incorrect wiring or loose connections 5. System not properly grounded 6. Inadequate starting aid 7. Defective ballast, auxiliary, or intensity selector	1. Improper supply voltage 2. Incorrect wiring 3. Poor lamp-to-lamp-holder contact 4. Extremely short duty cycles (greater than average number of starts per day; check lamp manufacturer) 5. Shorted or open cathode leads 6. Defective lamp-holders, lamps, or ballasts	1. Poor lamp-to-lamp-holder contact 2. Dissimilar lamps 3. Uneven starting-aid spacing 4. Incorrect wiring or loose connections 5. Low lamp bulb-wall temperature 6. Pinched or grounded leads 7. Defective lamps 8. Defective ballast or auxiliary	1. New lamps (should be operated 100 hours for proper seasoning 2. Improper adjustment of trimmer potentiometers (at maximum and minimum settings) 3. Drafts on lamp bulb 4. Defective lamp 5. Defective ballast 6. Unstable supply voltage (check with utility) company)	1. Excessive heating (over 70C case temperature) 2. High supply voltage 3. Operation in excess of auxiliary ballast capacity 4. Incorrect wiring	1. Excessive heating (over 90C case temperature) 2. High supply voltage 3. Incorrect wiring 4. Defective lamp-holders	1. Too many ballasts in installation (Refer to CGE Ballast Sound Rating Nomograph) 2. Amplification by loose fixture louvers, panels or 3. Amplification by insecure ballast mounting 4. Defective ballast

WIRE SIZE

AWG No. 14 wire size will be sufficient regardless of the distance between control and ballasts. Connecting wire to be 75°C minimum.

DIMMING BALLASTS

17A5001T – high power factor dimming ballast to operate one 40-watt rapid start lamp at 120 volts, 60 cycles.

STARTING AIDS

To provide proper starting potentials, a metal starting aid at least one inch wide (usually the lighting fixture) must be placed within one-inch of the lamp along its entire length. For a multiple-lamp fixture, the distance from the starting aid to the lamp must be the same for each lamp. If not, the lamps may dim unevenly, the lamp closest to the starting aid being the brightest.

The ballast case must be electrically connected to the ground (usually the lighting fixture). In addition, the lighting fixture must be electrically connected to ground. The white lead on the 13A4020 dimmer control must be connected to the grounded side of the 120 volt supply system (normally the white lead of the power supply).

OPERATING TEMPERATURE

The 13A4020 is designed to operate fully loaded (20 lamps) in a maximum room ambient of 77°F. This temperature restriction will prevent damage to the solid state components. Under normal operating conditions, the plastic faceplate of the control will reach a temperature that feels warm to the touch. This is normal and should not be interpreted as a faulty unit. The actual temperature sensed will be a function of the number of lamps being controlled. Care should be taken to avoid mounting the 13A4020 dimmer control in walls which are heated due to internal heating ducts or proximity to room heating elements.

RADIO INTERFERENCE SUPPRESSION

The 13A4020 dimmer control incorporates a line filter to reduce interference with radio reception which may be caused by line feedback from the dimmer. Fluorescent lamps are essentially electrical discharge light sources and as such may also cause radio interference, either by direct radiation, line feed back, or line radiation.

Following are suggested "good practices" which should be followed during installation of the DS-4020 dimming system to minimize possible interference with radios and/or intercom systems.

1. keep dimmer installation at least six feet away from radio or intercom system
2. intercom leads should be at least six to eight feet away from A.C. lines feeding dimmer control
3. wire intercom or radios and the dimming installation on separate circuits.
4. when intercom wires and A.C. lines feeding the dimmer installation must cross be sure they cross at right angles
5. wire intercom connection with shielded wire. Ground shielding at intercom only
6. use line filters, such as CGE cat. no. 13A635, if interference from line radiation and line feedback is encountered with existing wiring.

SYSTEM ADJUSTMENTS

The 13A4020 dimmer control is pre-set at the factory for a nominal line voltage of 120 volts. The dimmer control is equipped with a trimmer to compensate for nominal line voltage variations. Trimmer instructions are visible after removing knob and face plate.

FUSING

Each dimmer control should be fused at 15 amps, either by circuit breaker or plug fuse, regardless of the number of dimming ballasts and lamps controlled.

WIRING CONNECTIONS

The 17A5001T dimming ballasts are normally supplied by the fluorescent fixture manufacturer. To complete the wiring of the installation a layout drawing should be prepared and the sequence of wiring should be as follows:

1. Connect all white ballast leads together and bring a common lead to the two-gang wall box. (The box must be at least 2-1/2" deep). *Clearly identify this as the white lead.*
2. Connect all black ballast leads together and bring a common lead to the wall box. *Clearly identify this as the black lead.*
3. Connect all yellow/black ballast leads together and bring a common lead back to the wall box. *Clearly indicate this as the yellow/black lead.*
4. To check the wiring of the fixtures install all lamps and temporarily jumper the black ballast lead to the yellow/black ballast lead.

Connect the white ballast lead to the grounded neutral side of the 120 volt power supply.

Temporarily connect black ballast lead (which is now jumpered to yellow/black) to the hot side of the 120 volt power.

At this point the system is that of a conventional fluorescent installation. All lamps should operate at full brilliance. If any lamps fail to operate, trouble shoot the installation in the same manner as a standard installation. Check for broken sockets, wiring errors, defective lamps, etc.

Once all lamps operate satisfactorily turn off the power, then remove the temporary jumper between the black ballast lead and yellow/black ballast lead. Disconnect both power lines.

5. Install the 13A4020 dimmer control (includes ON-OFF switch) in the wall box. Connect the neutral wire of the

power supply to the common white lead for the ballasts *and* to the white lead of the dimmer control.

6. Connect the hot side of the 120 volt power supply to the terminal for the black lead of the dimmer control.
7. Connect the yellow-green dimmer control wire to the yellow/black ballast lead CAUTION: Do not connect this lead to ground or the dimmer control will be *destroyed.*
8. Connect the black/white dimmer control lead to the common black lead for the ballasts.
9. Turn on the power to the dimmer control and make sure the ON-OFF switch is in the ON position. The dimming installation is complete.

SPECIAL NOTICE

CGE also offers a dimming auxiliary 13A929T and dimming ballast 17A718T for use with other manufacturers' dimmer controls.

Due to the variety of these controls and their operating characteristics we recommend that you consult with the control manufacturer for application details involving our components.

FIGURE 27

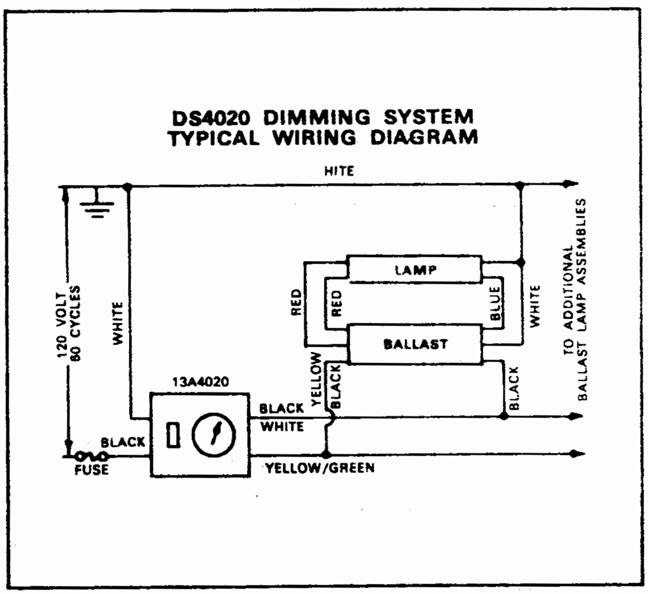


FIGURE 28

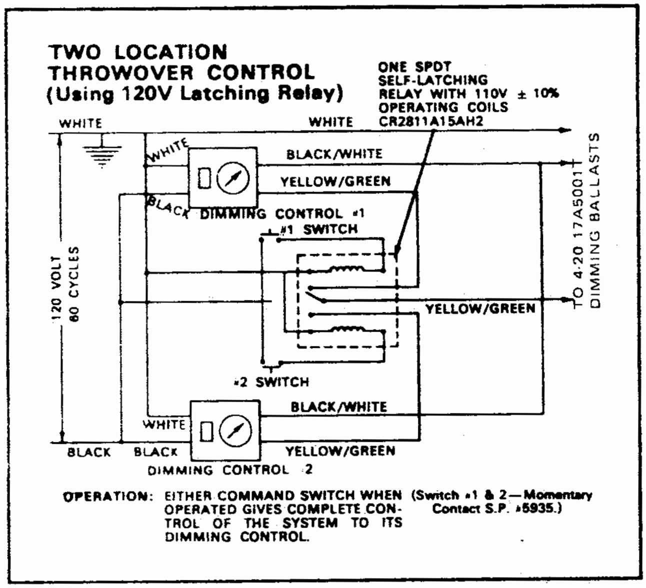
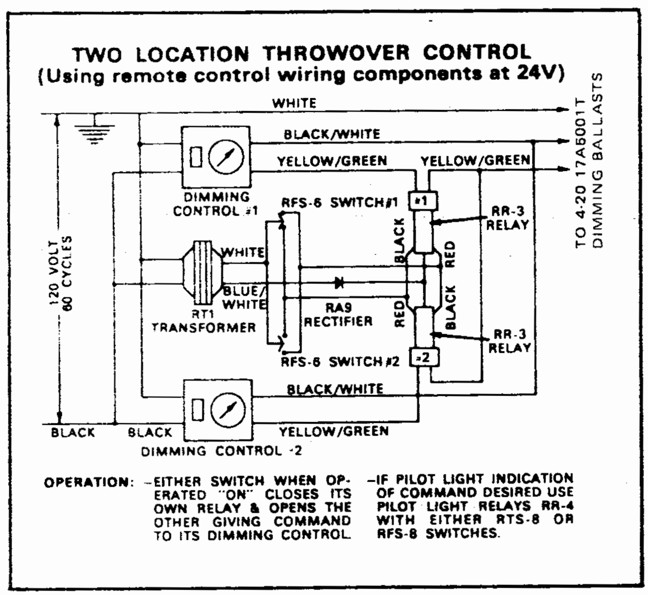


FIGURE 29



12 Radio Interference

FLUORESCENT LAMPS AND RADIO RECEPTION

Since the fluorescent lamp is essentially a mercury-arc discharge lamp, it may produce radio interference. Here are some facts on the nature of the phenomenon and some recommendations for suppressing interference.

We have all heard the crackling or frying sound in a radio, when someone turns off a switch and generates an electric spark. The fluorescent lamp during its operation on a 60 Hertz alternating current is automatically turned on and off 120 times per second. The mercury arc within the glass tube causes a sputtering or sparking action at the lamp electrodes, thus setting up a continuous series of high frequency radiation which under some conditions may reach the radio and interfere with reception. The radio frequency energy is, therefore, propogated by the lamp electrodes and this energy may reach the radio in one or all of the following ways:

1. Direct radiation from the bulb to the radio aerial circuit.
2. Direct radiation from the electric supply line to the aerial circuit.
3. Line feedback from the lamp through the service line to the radio.

FREQUENCY OF INTERFERENCE

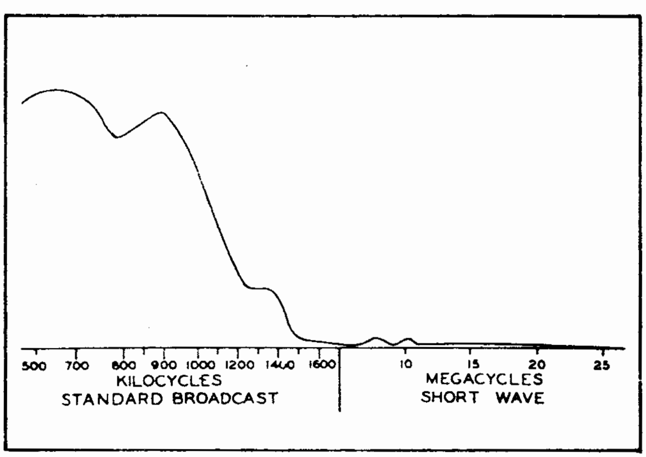
The broadcast frequences from 550 to 1600 kilocycles are most affected. Figure 34 illustrates the approximate level of interference corresponding to various frequences for the 40-watt lamp.

Other lamps generate interference at frequencies which approximate these curves but at a lower level.

AMOUNT OF INTERFERENCE

In general the radio noise is not additive and therefore the total amount of interference from any fluorescent installation will correspond to the single lamp producing the most interference.

FIGURE 34



Potential level of interference with 40-watt fluorescent lamp at various frequencies if filters are not used.

The amount of radio noise varies considerably even among lamps of the same type and wattage. The particular 40-watt lamp used in plotting the curve in Figure 34 was the one which produced more line feedback interference (with no filters attached) than that produced by any other 40-watt lamp in a group tested.

BULB RADIATION

The radio energy transmitted by the bulb of the lamp is dissipated within a few feet, and therefore, can be controlled by moving the radio and its aerial out of range. The following table shows the minimum recommended distance between lamp and radio.

LAMP TYPE	MINIMUM RECOMMENDED DISTANCE
14-W	4 feet from radio
15-W	4 feet from radio
20-W	4 feet from radio
32-W (Circline)	5 feet from radio
30-W	6 feet from radio
40-W	8 feet from radio
85-W	10 feet from radio
72" and 96" slimline	10 feet from radio

In case the radio must remain within the bulb radiation range, it will be necessary to take the following precautions:

1. Connect the aerial to the radio by means of a shielded lead-in with the shield grounded or install a "doublet" type aerial with twisted pair leads.
2. Provide a good ground for the radio.
3. Aerial proper must be out of bulb radiation range. Radios equipped with built-in aerials present a more difficult problem when located within the bulb or line radiation range. However, some radios of this design are also equipped with separate aerial and ground connections so that an outside aerial can be used.

In some instances it will be noted that bulb radiation apparently travels a greater distance than shown for various lamps in the table. This may be due to extended metal work such as beams, wireways, and pipes located near the lamp.

Where the radio is of necessity located near the lamp (such as in a radio service shop using bench-type units), it is possible to reduce bulb radiation to a low level by applying a metal screen to the bottom of the fixture. In most cases the screen should be grounded. Obviously, the screen will absorb some light, and it will be necessary to choose a mesh for maximum reduction of interference and minimum absorption of light.

Bulb radiation is not reduced through the use of line filters. Consequently, it is suggested that the proceding recommendations be specified in addition to those which follow.

LINE RADIATION

The electric service lines may act as an antenna to radiate interfering radio waves to the radio's aerial circuit or they may transmit the energy directly to the radio through its power supply. The field of radio energy surrounding the service lines is known as line radiation. With fluorescent lamps the field of interference around the lines corresponds roughly to that of bulb radiation. Thus, if the aerial circuit is properly protected against bulb radiation, line radiation will also be eliminated.

LINE FEEDBACK

The radio energy transmitted from the bulb through the service line is known as line feedback. This energy is often dissipated before it reaches the radio due to the impedance of the line. Accordingly, the shorter the line from the lamp to radio, the greater will be the possibility of line feedback.

In view of the wide variety of applications of fluorescent lamps and the variation in radios and antennas, it is impractical to attempt a blanket recommendation covering all types of radio interference. The ideal method for reducing both line radiation and line feedback is at the point of origin. This can be accomplished through proper application of line filters at each lamp or fixture. The function of the filter is to suppress radio energy and by-pass it to the ground.

In many installations, the capacitor type of filter provides satisfactory reduction of line noise. *It is recommended that one capacitor-type filter CGE cat. no. 13A214 for 120V be installed in each fixture as close to the ballasts as possible and with the metal case grounded.* Where a continuous row of lamps is installed, one filter should be used for each 8-foot section. This method of installing the filters will eliminate the possibility of line radiation between fixtures.

For installations in radio stores, radio service shops, electronic laboratories and radio and television studios where maximum reduction of interference is necessary, we recommend that the CGE cat. no. 13A635 filter should be used (up to 600V).

F.M. RECEPTION

The maximum line noise at any point on the FM band is a small percentage of the maximum for the broadcast band. Therefore, if the FM radio receives a signal of normal strength, it will not be necessary to apply filters to the fluorescent installation for frequencies in the FM band.

TELEVISION RECEPTION

In general, television receiving sets will not pick up continuous interference from fluorescent lamps if the incoming station signal strength is adequate for normal reception.

CONCLUSION

The preceding recommendations have been made following several years of laboratory and field tests. The results clearly show that fluorescent lighting installations can be made without sacrifice of good radio reception.

13 Fluorescent System Troubleshooting

TROUBLE SHOOTING THE FLUORESCENT BALLAST

The ballast is usually the first item checked when a lighting fixture doesn't work properly. However, many times the problem must lie elsewhere as a large number of ballasts that are returned to the factory as defective are perfectly good units.

The purpose of this section is to give assistance in locating the trouble. Listed below are common system problems as well as suggested procedures for checking the fixture *plus* data for testing CGE fluorescent ballasts.

TROUBLE SHOOTING TIPS

I. Lamps won't start

Investigate:—

1. Lamp failure
2. Poor lamp-to-lampholder contact
3. Incorrect wiring
4. Low voltage supply
5. Dirty lamps or lamp pins
6. Defective starters*
7. Low or high lamp bulb-wall temperature
8. High humidity
9. Inadequate grounding
10. Improper ballast application
11. Defective ballast
12. Wrong lamps

II. Short lamp life

Investigate:—

1. Improper voltage
2. Improper wiring
3. Poor lamp-to-lampholder contact
4. Extremely short duty cycles (greater than average number of lamp starts per day. Check with lamp manufacturer.)
5. Defective starters*
6. Defective lamps
7. Improper ballast application
8. Defective ballast

III. Lamp flicker
(spiraling or swirling effect)

Investigate:—

1. New lamps (should be operated 100 hours for proper seasoning)
2. Defective starters*
3. Drafts on lamp bulb (lamp too cold)
4. Defective lamps
5. Improper voltage
6. Improper ballast application
7. Defective ballast

IV. Very slow starting

Investigate:—

1. Improper voltage — too low
2. Inadequate lamp-starting-aid strip** (Refer to fixture manufacturer)
3. Poor lamp-to-lampholder contact
4. Defective starter*
5. Defective lamp
6. Improper circuit wiring
7. Improper ballast application
8. High humidity
9. Bulb-wall temperature too low or too high

V. Excessive ballast heating
(over 90C ballast case temp.)

Investigate:—

1. Improper fixture design or ballast application
2. High voltage
3. Improper wiring or installation
4. Defective ballast
5. Poor lamp maintenance (instant-start and preheat systems)
6. Wrong type lamps

*Applies only to preheat (switch-start) circuits.

**Applies only to rapid start circuits (including 430 milliamp, 800 and 1500 milliamp).

A suggested procedure to follow for checking a fixture is as follows:

1. Check to make sure there is correct voltage at the fixture. This can be done with a voltmeter between the black lead and the white lead to be certain there is 110 to 125 volts present in the fixture (assuming a 120-volt input). If power is not there check the branch circuit protection for a blown fuse or a tripped breaker.
2. A blown fuse or a tripped breaker suggests a short or a ground in the line or
   in the fixture or
   in one of the ballasts or
   the wiring of the black and white leads.
   To determine if it is a ballast, disconnect the ballasts from the input voltage one at a time to see if the fault disappears.
3. If rated line voltage is measured in the fixture but lamps will not light check lamps one at a time by inserting a new lamp. (Use a lamp that is known to be good.) Lamps showing end-blackening should be checked first. As you replace lamps, make an inspection of the lampholders for any evidence of arcing, loose or misaligned lampholders, broken lampholders, incorrect spacing, etc.

4. If lamps still do not come on and you are testing a rapid start fixture (430, 800 and 1500 milliamp) remove lamps that are unlighted plus any others on the same ballast. (Note: This check does not apply to slimline, instant-start systems.) Check for filament voltage at the lampholders. This can be done with a voltmeter and should read approx. 4 volts. This check can also be made with a filament voltage tester available from CGE Lamp Dept. (either exposed bipin or recessed bipin for high output and Power Groove). If voltage is low or at zero, or if the lamp in the tester is dim or does not light the trouble could be
   - incorrect wiring (check wiring diagram to see that correct connections have been made)
   - a faulty lampholder
   - a defective ballast.

INSTANT START AND SLIMLINE LAMPS

The general characteristics of these two lamp types are the same. Neither requires starters. To insure starting under high humidity conditions both are provided with a dry film coating. Since the ballast open circuit voltage is about three times the normal lamp voltage, these lamps will usually start and operate even when one cathode is completely deactivated (end of normal life). In this condition the lamps usually show rather violent spiraling, sometimes occasional orange colored flashes. Such lamps or any lamps which have become quite black at one end should be promptly replaced, as there is little life left. This end of life spiraling results in high peak voltages and overheating that may cause ballast failure.

RAPID START LAMPS

Satisfactory starting and life depends on proper heating of both cathodes when lamp starts. With heating current at only one cathode, one of two things will happen: (1) failure to start and lamp will be ruined in a few hours or, (2) slow starting (5 sec.) and lamp failure may occur within 50 such starts.

Heating current at only one cathode may be due to improper contact in holder, broken holder, open contact in base pin, broken base pin, open cathode, shorted leads in base, corrosion or foreign material on base pins or holder contacts, defective ballast, improper wiring, etc.

Lamps started many times without operation become hard starters. This is corrected by leaving the lamp lighted for a few hours. On most tulamp ballasts, if one lamp fails, both go out or are quite dim. The good lamp is not damaged as heating current still flows through the cathodes. At normal failure the lamp simply fails to start, and is black at one or both ends. There is no flashing, spiraling or overheating of the ballast at end of life.

5. If filament voltage is present at all lampholders but the lamp or lamps still do not light check open circuit voltage available between red and blue lead lampholders. (See Table 2 following.) In the event that neither filament nor open circuit voltages can be measured look for a disconnected or loose terminal connection to lampholder. Also check continuity between black and white leads. Should continuity be broken one of the reasons may be an open circuited thermal device. This means the ballast has been operating at higher than normal temperature due to excessive line voltage, poor fixture ventilation or a failing insulation system in the ballast.

Generally speaking, when a thermal device trips, the ballast's insulation system is breaking down and the ballast should be replaced. Should the device be a resetting type, power will be restored when the ballast cools off. In a new installation, it is possible to obtain extra ballast life by taking corrective measures to improve operating temperatures (e.g. venting the fixture, lowering the fixture from ceiling for better air circulation). If the thermal device is a fuse type protector it de-energizes the ballast permanently. The fuse type of device only operates when final failure is in progress and the ballast's insulation system has no useful life remaining.

FACTORS AFFECTING BALLAST LIFE

Ballast Type	Line Voltage Fluctuation	Dead or Burned out Lamp	Rectifying Lamp	Shorted Starter
22, 30, 32 or 40 WATT RAPID START (CIRCLINE AND STRAIGHT LAMP)				
one light LPF	X	▲	O	▲
one light HPF (lag type)	X	X	O	▲
one light HPF (lead type)	O	▲	▲	▲
two light HPF (series lead type)	O	▲	▲	▲
SLIMLINE—HPF				
one light (lag type)	X	X	X	▲
one light (lead type)	▲	▲	▲	▲
two lamp (seq.-start-lead type)	X	X	O	▲
two lamp (lead-lag type)	X	X	X	▲
HIGH OUTPUT RAPID START—HPF, POWER GROOVE—HPF, VHO—HPF, SHO—HPF				
one light (lag type)	X	X	X	▲
one light (lead type)	O	▲	▲	▲
two light (series-lead type)	O	▲	▲	▲
two light (series-lag type)	XX	XX	X	▲
three light (series lead type)	O	▲	▲	▲
PREHEAT TYPE				
one light LPF	X	▲	O	X
two light LPF	X	▲	O	X
one light HPF	X	▲	O	X
two light HPF	X	▲	O	X

X Indicates overheating under normal condition.
▲ Indicates ballast not affected by specific condition.
O Indicates overheating to a lesser extent at specified condition.
XX Indicates critical condition.

To assist you in testing for open circuit voltage, the attracted table has been prepared. The indicated voltages are minimum readings taken at 90% rated line voltage.

To determine open circuit voltage supplied by ballast

(a) remove lamps from fixture

(b) use a voltmeter to measure voltage between ballast leads identified below.

TABLE 2
OPEN CIRCUIT VOLTAGE WHICH MUST BE SUPPLIED BY THE BALLAST TO OPERATE FLUORESCENT LAMPS SHOWN

BALLAST TYPE	LAMP TYPE	WATTS	LENGTH	Measure Open Circuit Voltage Between Leads Shown Below	MINIMUM OPEN CIRCUIT VOLTAGE SHOULD BE	FILAMENT VOLTAGE
Preheat	F30T8 single	30	36"	red and blue	176 volts	Not required
Preheat	F40T12 single	40	48"	red and blue	176 volts	Not required
Preheat	F90R17 two	90	60"	red and white	132 volts	Not required
	lamp			blue and white	132 volts	Not required
Slimline	F42T6 single	25	42"	red and white	405 volts	Not required
	two lamp			blue and white	405 volts	Not required
Slimline	F64T6 single	37	64"	red and white	540 volts	Not required
	two lamp			blue and white	540 volts	Not required
Slimline	F72T8 single	37	72"	red and white	540 volts	Not required
	two lamp			blue and white	540 volts	Not required
Slimline	F96T8 two	49	96"	red and white	675 volts	Not required
	lamp			blue and white	675 volts	Not required
Slimline	F48T12 single	38.5	48"	red and white	385 volts	Not required
	Lead-lag two	38.5	48"	red and white	385 volts	Not required
	lamp			blue and white	385 volts	Not required
	Series sequence two lamp	38.5	48"	red and white *only*	385 volts	Not required
Slimline	F72T12 single	57	72"	red and white	475 volts	Not required
	Lead-lag two	57	72"	red and white	475 volts	Not required
	lamp			blue and white	475 volts	Not required
	Series sequence two lamp	57	72"	red and white *only*	475 volts	Not required
Slimline	F96T12 single	73.5	96"	red and white	565 volts	Not required
	Lead-lag two	73.5	96"	red and white	565 volts	Not required
	lamp			blue and white	565 volts	Not required
	Series sequence two lamp	73.5	96"	red and white *only*	565 volts	Not required
Rapid Start	single lamp					
	F14T12, F15T8	14, 15	15" 18"	a red and a blue	105 volts	8
	F15T12, F20T12	15, 20	18" 24"	a red and a blue	105 volts	8
Rapid Start	F20T12 two lamp	20	24"	a red and a blue	157 volts	8
Rapid Start	F30T12 single	30	36"	a red and a blue	150 volts	3.4 to 3.9
	F30T12 two lamp	30	36"	red and blue	215 volts	3.4 to 3.9
	F40T12 single	40	48"	a red and a blue	200 volts	3.4 to 3.9
	F40T12 two lamp	40	48"	a red and a blue	256 volts	3.4 to 3.9

BALLAST TYPE	LAMP TYPE	WATTS	LENGTH	Measure Open Circuit Voltage Between Leads Shown Below	Minimum Open Circuit Voltage		FILAMENT VOLTAGE
					Indoor	Cold Temp.	
High Output	F24T12/HO	30	24″	a red and a blue	200 volts	225 volts	3.4 to 4.3
	F36T12/HO	45	36″	a red and a blue	200 volts	260 volts	3.4 to 4.3
	F48T12/HO	60	48″	a red and a blue	256 volts	310 volts	3.4 to 4.3
	F60T12/HO	70	60″	a red and a blue	220 volts	310 volts	3.4 to 4.3
	F60T12/HO two lamp	70	60″	a red and a blue	325 volts	365 volts	3.4 to 4.3
	F64T12/HO	75	64″	a red and a blue	240 volts	330 volts	3.4 to 4.3
	F64T12/HO two lamp	75	64″	a red and a blue	345 volts	385 volts	3.4 to 4.3
	F72T12/HO	85	72″	a red and a blue	275 volts	340 volts	3.4 to 4.3
	F72T12/HO two lamp	85	72″	a red and a blue	395 volts	420 volts	3.4 to 4.3
	F96T12/HO	105	96″	a red and a blue	295 volts	360 volts	3.4 to 4.3
	F96T12/HO two lamp	105	96″	a red and a blue	465 volts	490 volts	3.4 to 4.3
Power Groove	F48PG17	110	48″	a red and a blue	160 volts	240 volts	3.4 to 4.3
	F48T10J	105	48″	a red and a blue	160 volts	240 volts	3.4 to 4.3
	F48PG17 two lamp	110	48″	a red and a blue	250 volts	300 volts	3.4 to 4.3
	F48T10J two lamp	105	48″	a red and a blue	250 volts	300 volts	3.4 to 4.3
	F72PG17	160	72″	a red and a blue	225 volts	310 volts	3.4 to 4.3
	F72T10J	160	72″	a red and a blue	225 volts	310 volts	3.4 to 4.3
	F96PG17	215	96″	a red and a blue	300 volts	400 volts	3.4 to 4.3
	F96PG17 two lamp	215	96″	a red and a blue	470 volts	500 volts	3.4 to 4.3