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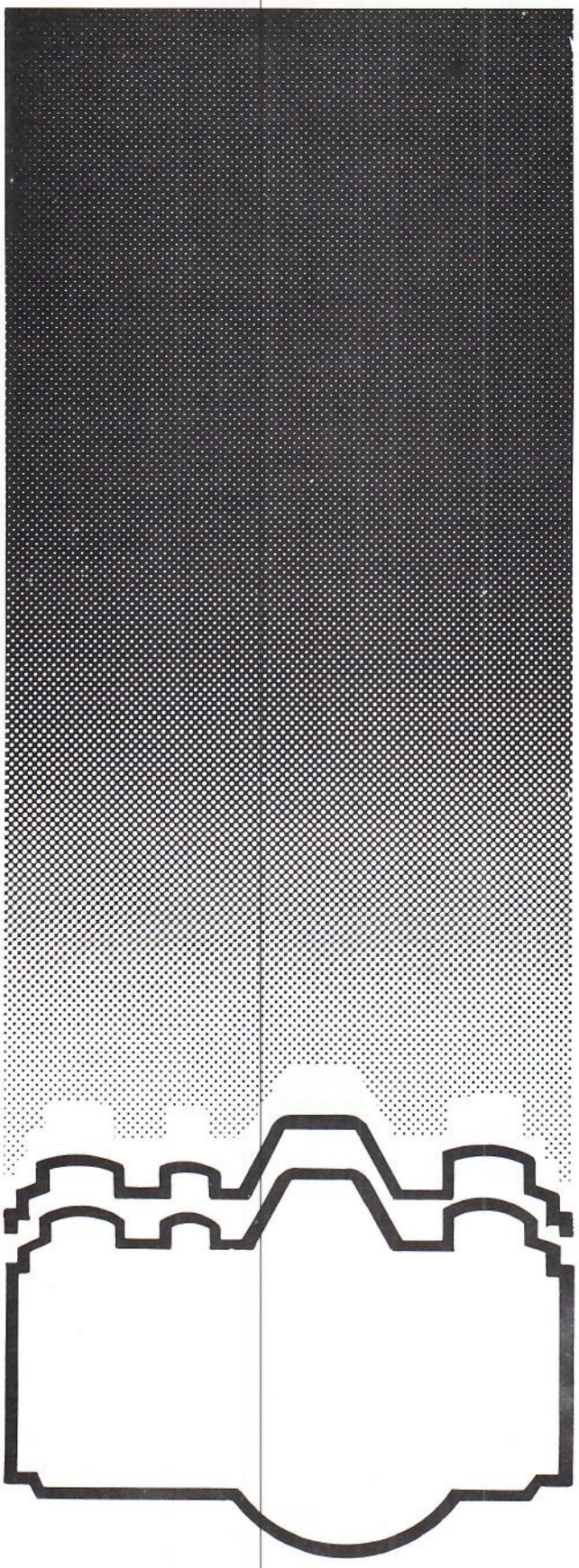

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The Slide Projector

contents

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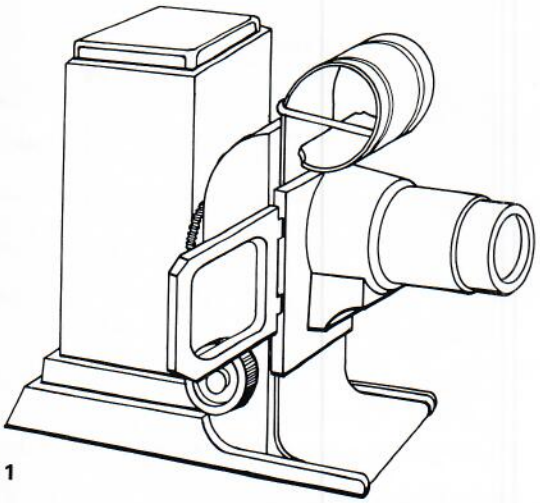


FIGURE 1

The Slide Projector

THE SLIDE PROJECTOR

The 35mm slide projector is a relative newcomer to the photographic marketplace. Although transparencies and projectors for them have been around almost as long as transparent film base, it took the 35mm camera and color film to give slide making mass popularity. Toward this end, the introduction of Kodachrome film was a big step. Kodachrome, then Agfacolor used in any of the quality 35's of the day could produce high quality and inexpensive slides.

While a transparency shot in a view camera on 5 x 7 or 8 x 10 Autochrome or Dufaycolor could be held close to a light source for easy viewing, a 35mm slide could not. So, for viewing convenience a slide projector became a necessity. The first slide projectors to become available to the amateur were simple and crude in design, Fig. 1. Often the projector was not much more than a sheet metal housing over a lamp, diffuser, slide holder and a lens. But advances in optics, in camera design and in films made a projector of higher quality a necessity to the serious slide maker.

From the first models produced in the 1930's, the slide projector has evolved into today's high quality and sophisticated machine. Today's slide projector represents a combination of technologies directed toward the goal of the best possible results. Optics, electronics and mechanics are used in combination in a modern slide projector.

In order to make the operation and maintenance of a complex slide projector easier to understand, let's create and evolve a simple projector design.

To project a slide we'll need a light source to illuminate the slide and a lens to project the image. To prevent stray light from escaping we'll enclose the projector in a lighttight housing. Our simple slide projector would work, but it could certainly use some refinements, Fig. 2.

Our light source is not very bright nor is it uniform. Our single element lens is uncorrected, slow and lacks a convenient focus adjustment. There is no simple way of changing slides, nor is there an accurate way of positioning slides, plus the whole works is awkward to set up. So let's improve the design. First, for the sake of economy, let's convert to AC operation. By using AC we'll be able to use a more powerful light source as well as save on batteries. We'll put a switch in the circuit in order to give the projector operator convenient control of the lamp.

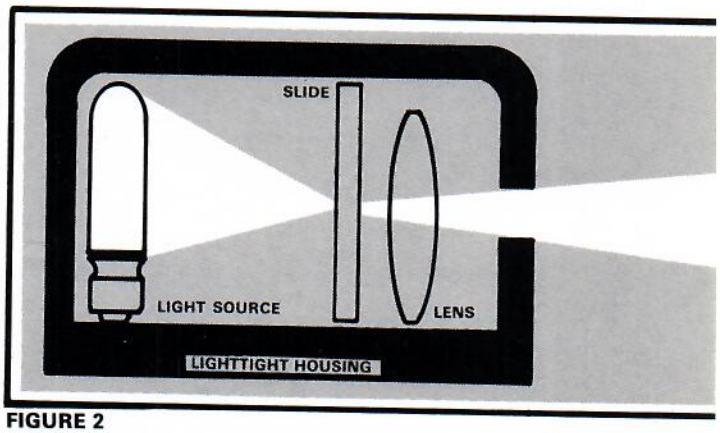


FIGURE 2

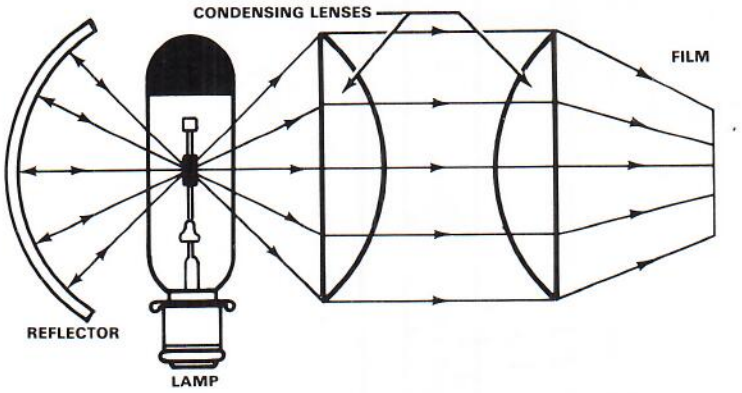


FIGURE 3 Condensing lenses funnel more light to the film.

Next, let's even out the illumination. By using a simple lens, or better yet, a pair of lenses, we can make a condenser assembly. The condenser takes the light rays, leaving the lamp - going every which way - and directs them toward the slide, Fig. 3. To complement the condenser, we'll add a reflector behind the lamp.

Now for a better lens. A multiple element lens, color corrected and corrected for flatness of field. A corrected lens is designed so that the projected image is sharp in the center as well as in the corners. In addition, corrections will keep the lens from color fringing.

For a slide holder, we'll need a simple device which allows rapid changing of slides yet assures that each slide is positioned accurately in relation to the projection lens. We'll surround the mechanism with a housing designed to keep bright light from escaping and interfering with the projected image, add a focus mechanism for the lens and we'll be ready to roll. Well, almost. One more thing we'll have to add - a cooling system. That AC operated lamp is going to generate a fair amount of heat, and although we could design a convection cooled projector, we're better off adding a motor driven fan. We'll rig the lamp switch so that the fan turns on before the lamp and off after the lamp. That way the fan must be running while the lamp is switched on. By adding a heat absorbing filter between the lamp and slide, we'll increase the protection from heat for slides being projected. Now we have a simple, yet complete slide projector. In fact, the projector we've just built is similar to many of the economy model projectors in use today.

Using our simple projector as an example, let's look at each component in more detail, paying attention to its maintenance and repair.

THE ILLUMINATION SYSTEM

The conventional illumination system in use since the 1930's relies upon a high wattage tungsten filament lamp as its light source. The projection lamp, which is operated by line current, is typically a 300 to 500 watt bulb. More recent projectors have dropped the conventional lamp and switched to a halogen lamp system. We'll cover the conventional illumination system first -- age before beauty.

The conventional system consists of a lamp and reflector directing light toward the condenser assembly. In many cases, the reflector will be an integral part of the projection lamp, although a few projectors use a separate reflector behind the

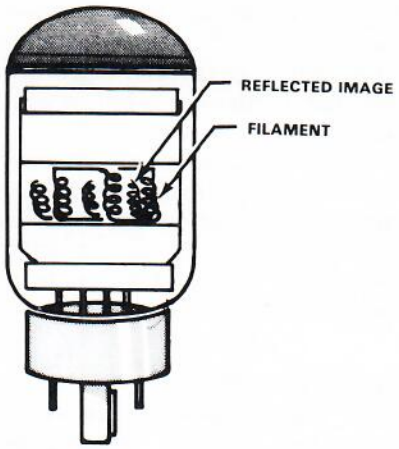


FIGURE 4

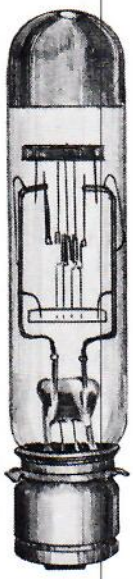
lamp. Related to the illumination system is the cooling system. The cooling system removes heat generated by the lamp from the projector. In most conventional systems not much can go wrong, but there are some common repairs and adjustments which may have to be made.

By far the most common complaint related to conventional illumination system projectors is premature lamp burn out. More often than not, premature burn out of a conventional lamp is due to overheating of the projector. Overheating may be caused by blocked or clogged air passageways inside the projector, but a more common cause is operator carelessness. Operating a projector with its vents blocked or covered is a careless yet common practice. Most projectors must be operated on a hard, clean surface as they depend upon air circulation from beneath for proper cooling. Too, a slow running, dirty or damaged fan could be causing overheating. A dirty fan or dirty air passageway will cut down the air circulation through a projector. Obviously,cleaning of a dirty cooling system is in order. A damaged fan must be replaced. But what if the slow turning fan is caused by a motor fault? As we'll see in a little while, you'll probably have to replace the motor.

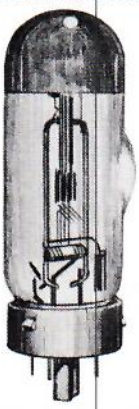
A few older projector designs rely upon a reflector positioned behind the lamp to redirect light which would otherwise be wasted. If the reflector is adjustable, you'll want to be certain that it's positioned accurately. Ideally, the reflector should return light striking it in the way shown in Fig. 4. To position an adjustable reflector, operate the projector so that it projects white light. Then, focus the projector's lens until the lamp's filament is visible on your screen and finally adjust the reflector. An improperly adjusted reflector most often makes it s presence known by causing softening and deformation of the lamp's glass envelope and leads to the lamp blowing up.

Although premature lamp burnout is a common complaint, the rated life of a projector lamp is not all that long. Most conventional lamps have a rated life of around 25 hours. Because a projection lamp which burns for its full rated life or longer may only operate 25 or 30 hours, you may encounter projectors for lamp-problem repairs with nothing wrong with them. A projection lamp which has burned for its full rated life has certain characteristics which you can easily recognize. The most noticeable characteristic is internal blackening. You can

In a horizontally burning lamp, the blackening which is the indication that the lamp operated for its normal life will be on the side of the envelope.



Lamps, which use a bridge to support the filament, will blacken in the area of the bridge. A blackened bridge is a sign that the lamp has been used for its normal expected life.



In addition to blackening, most lamps will bulge or blister after a number of hours of use. Blistering is a good indication of end of normal life failure in lamps where a colored top hides blackening.

FIGURE 5

see this here, Fig. 5. Very seldom does a projector lamp burn out during operation; most often the lamp dies when it's first switched on and drawing high current. Once the lamp is at projection brightness and its filament is hot, it will probably continue to operate.

Projection lamp manufacturers are aware that sometimes a defective or weak bulb slips through their inspection system. Most lamp manufacturers will replace at no charge a lamp which has burned out prematurely due to a defect. Bulbs which have burned out prematurely and would be replaced at no charge are shown here, Fig. 6.

HALOGEN CYCLE LAMPS

Up until now, the only light source we've discussed has been the conventional tungsten filament lamp, but the tungsten filament lamp is losing favor as the standard light source for projectors. In its place, the **tungsten-halogen cycle,** or just halogen for short, lamp is being used. The halogen lamp offers several advantages over the conventional lamp:

- The halogen lamp is more efficient. It requires less current to produce a light output equal to a conventional lamp.
- A halogen lamp of the same brightness is often 2/3 to 1/2 the size of a conventional projection lamp, Fig. 7.
- The halogen lamp has a long life. It's not uncommon for a halogen lamp to have a normal life of more than twice the equivalent brightness of a conventional lamp.
- A halogen lamp's output remains constant throughout its life because the glass envelope does not darken with use.

Let's take a closer look at the halogen lamp to see what makes it so unusual. The halogen lamp, unlike a conventional lamp which contains a vacuum or an inert gas such as nitrogen or argon, contains a halogen. The halogen used in most lamps is either iodine or bromine gas. It's the halogen gas inside the lamp envelope which makes the lamp so special. During operation, any lamp's filament gradually evaporates, but in the halogen lamp the evaporated filament is recycled. You can see the four steps of a halogen cycle: *evaporation, combination, convection,* and *redepositon* in the diagrams of the halogen cycle, Fig. 8. Because the halogen cycle is very efficient, halogen lamps would last forever, except for one thing--the filament will not necessarily be redeposited on the areas from which it evaporated. It's uneven evaporation and redeposition that eventually ends the life of the halogen cycle lamp.

For all its advantages, the halogen lamp has one major disadvantage. The halogen lamp and its halogen cycle work at a high temperature. In operation, the envelope of the halogen lamp must reach 250°C before the halogen cycle can begin. Meanwhile the lamp's filament is operating at 1250°C or higher. Unlike a conventional lamp, which will quickly destroy itself if it gets this hot, the halogen lamp can get quite a bit hotter without any serious consequences to itself. So, if the cool-

ing system in a halogen-lamp-system projector malfunctions, heat from the lamp can do serious damage. Consequently, proper maintenance of the cooling system in a halogen-lamp-equipped projector is essential.

The fact that the halogen cycle does not begin the moment the lamp is switched on sometimes contributes to shortened lamp life. The halogen cycle doesn't begin until the lamp has heated up. This usually requires a minute or two of operation, so, if you're working on a halogen lamp equipped projector, be sure that when you run the lamp, you run it long enough for the halogen cycle to do its job.

Because of the high temperature encountered in halogen lamp systems, special materials are used and special handling techniques are necessary. The lamp envelope,which was at one time made of quartz and now is mostly made of high strength glass, can withstand very high temperature. However, dirt, grease and fingerprints can do it real damage so halogen lamps are supplied in protective packaging which allows the lamp to be installed without your touching its envelope. It's very important that the lamp be installed in this manner, as a fingerprint could result in blackening of the lamp envelope or even in a fracture of the envelope caused by heat build up in the fingerprinted area. A halogen lamp which has been accidentally touched or is greasy or dirty must be cleaned before it's used. A good cleaner is ammonia and water. After you clean the lamp, make absolutely certain that it's dry before you use it. Most operating halogen and conventional lamps, for that matter, will explode violently if subjected to thermal shock or unequal temperatures such as might be generated by evaporating water.

THE CONDENSERS

Most condenser system problems are shock or impact related. Being made of glass and being quite heavy, the condensers are easy to damage if the projector is handled carelessly. In addition to mechanical shock, the condensers are sensitive to thermal shock. A rapid change in temperature can very easily shatter a condenser lens.

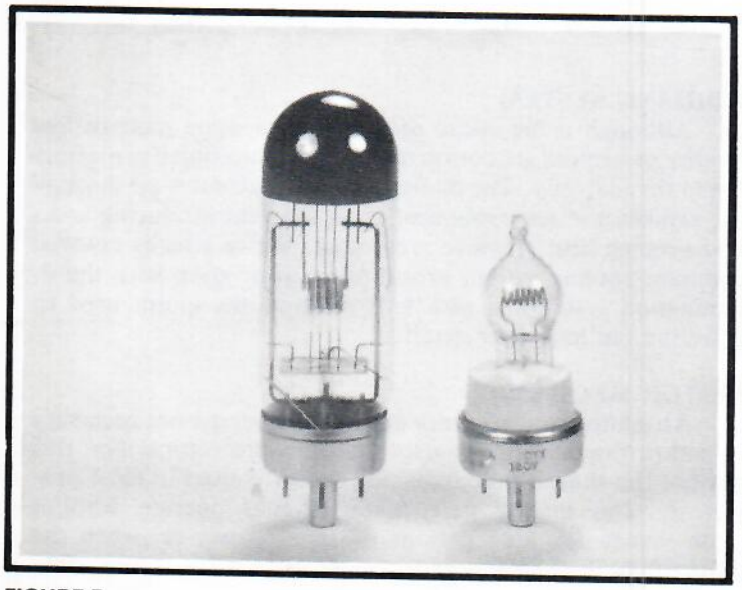
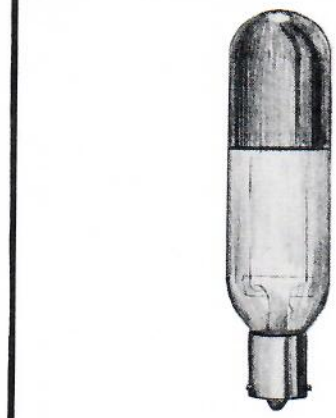
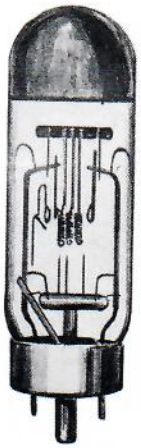


FIGURE 7



A leaking bulb in which a tiny hole in the envelope has allowed air to enter will be milky or cloudy.



An early failure is clear and appears to be okay except for a broken filament. This lamp has not been operated for very long, if at all.

FIGURE 6

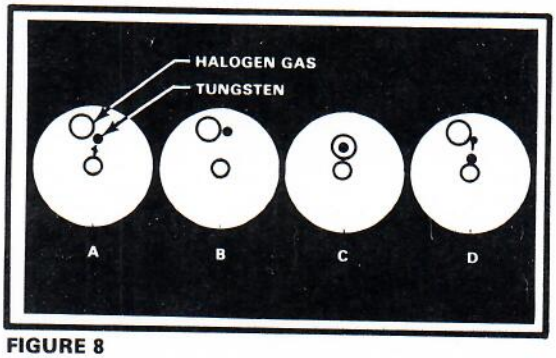


FIGURE 8

These are the four stages of the halogen cycle: A. The tungsten particle from the filament evaporates. B. The tungsten particle collides with a halogen molecule. C. The tungsten and halogen combine chemically. D. Convection within the bulb brings the tungsten-halogen combination back to the filament where the tungsten is deposited on the filament and the halogen is freed for another combination.

Related to the condenser-assembly is the heat-absorbing glass. The heat absorbing glass, which is often located between the condenser lenses for space saving reasons, keeps slides which often remain in the projection aperture for a long period of time from being destroyed by heat given off by the lamp,

The heat absorbing glass is easy to spot because unlike the condenser, it is flat surfaced. Also, the heat absorbing glass is pale green in color. While in theory the heat absorbing glass should be colorless, economics dictate the slight color cast. Although the heat absorbing glass absorbs some visible red light in addition to infrared, a color shift is not seen because the projection lamp's light is heavy in red to begin with.

Because it absorbs large amounts of heat, the heat absorbing glass is subjected to great stress. With the projector in operation, the heat absorbing glass will expand as it absorbs heat from the lamp. It's for this reason that the heat absorbing glass is not firmly fixed in place within the projector. Not allowing the heat absorbing glass room to expand would result in its shattering on first use. Because the condensers being near the lamp also absorb some heat and expand, they are often mounted loosely too.

Extra care is in order when handling heat absorbing glass. Due to the stresses which the glass undergoes, it may become brittle and if jarred, shatter or explode. Always be sure to use extra care in handling heat absorbing glass so if the glass does break or explode, you won't be injured.

TEST YOURSELF QUIZ #1

1. Internal blackening of a projection bulb which has burned out indicates normal life (normal life, premature burnout).
2. Two advantages of halogen lamps are more efficent and longer life.
3. Why is the failure of a projector's cooling system a serious problem in halogen-lamp equipped projectors? it will over heat and cause a black out
4. Always use extra care when handling heat-absorbing glass because they can break or explode.

COOLING SYSTEM

Although a few older projectors and some modern low quality projectors are convection cooled, fan cooled projectors are in the majority. The motor drive fan circulates air through the projector -- removing heat from the heat producing areas and keeping heat sensitive areas cool. We've already covered common cooling system problems in association with the illumination system, so now let's examine the motor used to drive the fan in greater detail.

MOTOR MECHANICS

Absolute speed accuracy and high power are not necessary in motor-fan assemblies used in slide projectors. For this reason, the shaded pole induction motor is used in most projectors. The shaded pole motor should operate without maintenance for long periods of time. However, when the motor fails, it is seldom economical to repair it. More often than not, the motor must be replaced.

Almost without exception, **life lubricated bearings** are used in shaded pole motors. Life lubricated bearings are oil impregnated during manufacture and so should not be more than surface cleaned. When a bearing fails, short of machining another bearing, there is little you can do except replace the motor. On the other hand, in cases of moderate bearing wear, which sometimes shows up as noise from the fan striking its housing, you may be able to reposition the motor or fan slightly and so continue using the same motor.

Besides bearings, the other cause of motor failure is a bad coil. An induction motor coil should be of fairly low resistance. A resistance measurement of the coil of more than a few ohms indicates an open coil. Sometimes a motor coil will fail due to a short circuit in the coil. This usually is an easy malfunction to detect. Smoke, then the discovery of burned insulation in the motor points toward a new motor. A coil which is shorted to the motor frame may be detected using your ohmmeter. Connect one ohmmeter level to a lead from the motor winding in question and the other meter lead to the motor frame. You should read infinite resistance. If you don't, current can pass from the coil to the motor frame and a new motor is called for.

Once in awhile a foreign substance will enter a projector and crud up the bearings. In this case, cleaning the bearings may be practical. To clean the bearings, a mild solvent such as alcohol is desirable. A more powerful cleaner will tend to remove the impregnated lubricant, shortening the bearing's life. Use a light, external application of cleaner, then immediately dry the cleaned area. Follow cleaning with a light application of 10 to 20 weight non-detergent motor oil. If this cleaning method is ineffective, the bearings have probably been damaged and the motor must be replaced.

MOTOR ELECTRICS

In more sophisticated projectors such as the Kodak Carousel and Sawyer's Autofocus projector which we'll study soon, the motor coil may serve a dual purpose.

Frequently, voltages lower than the line voltage are needed to operate convenience features. Power focusing and auto focusing are commonly operated at less than line voltage. Rather than install a separate, costly transformer to power the low voltage circuits, a second and sometimes third coil is added to the motor. These additional coils serve as transformer secondaries, providing the required lower voltages.

LENS AND FOCUS

The slide projector's function is to project an enlarged image of the slide illuminated by the lamp and condensers. Toward that end, a projection lens and a focusing system are necessary.

Because of the space available inside a projector, rack and pinion focusing is by far the most common system. It's common practice for the manufacturer to mold a focus rack into the lens housing. Then, when the lens assembly is installed in the projector, the focus rack on the lens engages a pinion coupled to an external focus knob.

Some older projectors employed helical focus mounts. Often this was a lens barrel with a spiral groove cut in it which engaged a fixed pin in the projector. Thus, by rotating the lens

barrel, the projector operator could bring the projected image into sharp focus. Rack and pinion focusing has almost completely replaced helical focusing mounts in projectors for two reasons. First, the rack and pinion focus mount operates more easily, and second, motor driven focus. Operating a helical focus mechanism by motor drive would be difficult and require a fairly powerful motor or involved gearing, so power focus and auto focus projectors use rack and pinion focusing. The specifics of auto focus are covered just ahead in the text.

THE SLIDE CHANGER

In a simple projector, the slide changer is usually manually operated. Because of their variety of design, we'll briefly cover the principles of their operation rather than specifics. You'll be able to apply these principles to the variety of different changers which you will see. Obviously, this description has left out the very simplest slide changes.

The slide changer does several things: 1. It removes the previous slide from the projector aperture; 2. it closes a shutter to prevent white light from flooding the screen; 3. it advances the slide tray or selects the next slide; 4. it inserts the new slide into the projector aperture, and 5. it reopens the shutter.

In our simple projector, all these operations are carried out manually. The projector operator moves a changer lever on the side of the projector by hand. In more complex projectors, most changer actions are motorized. We'll be seeing the specifics of two systems soon.

TEST YOURSELF QUIZ #2

1. The shaded-pole induction motor used in most slide projectors has life lubricated bearings.

2. If it's necessary to clean the bearings in a shaded-pole induction motor, cleaning should be followed by a light application of mild solvent.

3. Rather than install a separate, costly transformer to power low voltage circuits in a projector, additional coil are added to the motor.

4. Motor driven focus is made easier through the use of rack and pinion focusing.

AUTOFOCUS PRINCIPLES

Although it might seem at first thought that an autofocus system would require a complicated electronic circuit, this is not the case. Let's examine the principles of operation of an autofocus circuit to see how it works. The key to the simplicity of present autofocus systems is that the autofocus circuit does not focus the projector initially; the projector operator does this. Once correct focus has been established by the projector's operator, the autofocus projector maintains that focus. The autofocus circuit will precisely maintain an out-of-focus condition just as readily as it will maintain an in-focus condition because the autofocus circuit can't see the projected image. Then how does the autofocus circuit keep the projected image sharp? To understand this, let's examine what could affect screen sharpness.

- Screen Position: Moving the projection screen toward or away from the projector will throw the projected image out of focus.
- Projector Position: Like the screen position, changing it affects focus.
- Slide Position: A change in the position of the slide within the projection aperture will relocate the plane of sharpness of the projected image

Since it's unlikely that the position of the screen or projector will change during use, that leaves slide position. A warped slide in a group of slides or a slide which "pops" during projection is what the autofocus projector must correct for.

A variety of methods could be used to determine slide position and correct for changes in it. The simplest method, the one used in autofocus projectors, is to bounce a tiny beam of light off the surface of the slide and then reposition the projector's lens if the position of the reflected light changes. This keeps the lens a fixed distance from the slide.

To detect a change in the light's reflection, two CdS cells are used. The accuracy of the autofocus mechanism depends upon detecting small changes in the position of the reflected light, so having the two cells close together is necessary. As a rule, the two CdS cells are combined in a single housing so that their light sensitive elements are close together. Now let's look at a simple autofocus system in block form, Fig. 9.

In the autofocus system shown here, a feedback system couples the movement of the projection lens back into the circuit through the positioning of the CdS cell and lamp. As the projection lens returns to the position of sharp focus, the cell and lamp move too. Autofocusing stops when the position of the reflected light on the CdS cell is the same as it was before a focusing correction was needed. Once the focus has been restored, the autofocus circuit stops the lens motion.

The electronic circuits used to control the autofocus motor may take a variety of forms, but in operating principle they are all similar to the circuit shown here. This circuit is

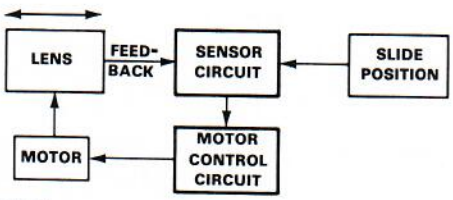
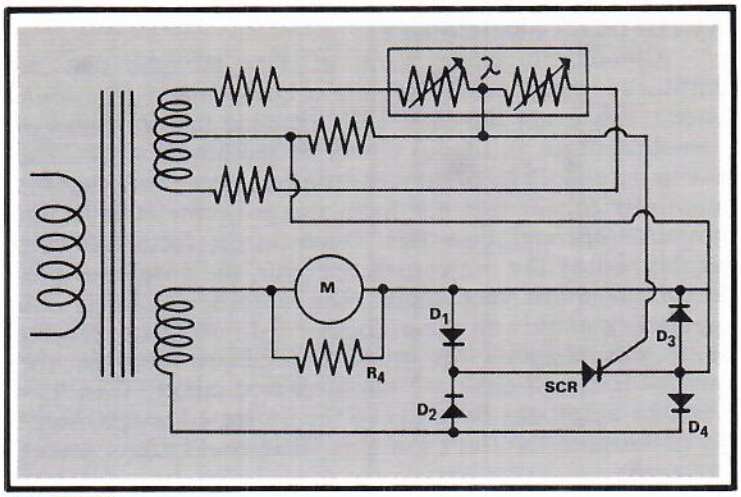
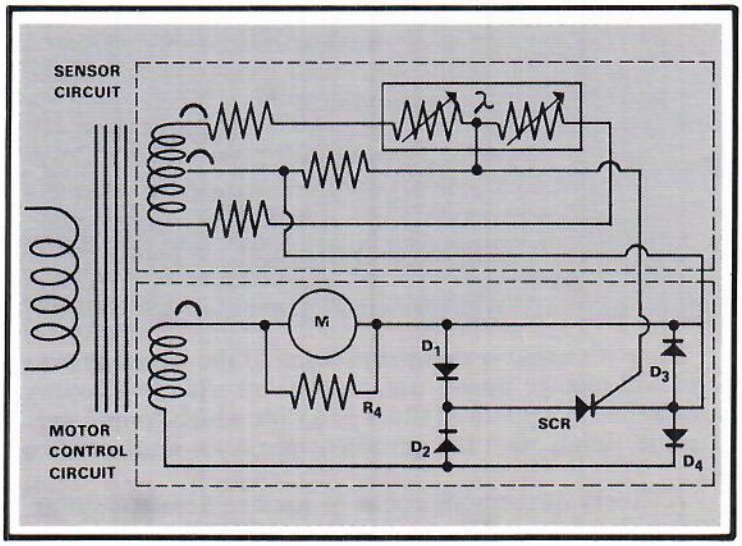


FIGURE 9
In a simplified cycle-of-operations form, this is how an autofocus system works.



The circuit used by Sawyer's in their autofocus projectors.

FIGURE 10



Dividing the autofocus circuit into two parts makes understanding its operation much easier.

FIGURE 11

one used in Sawyer's Rotomatic projectors. Let's examine the circuit to see how it works, Fig. 10.

AUTOFOCUS MOTOR CONTROL

First we'll divide the circuit into two parts: the position **sensor (or sensor circuit)**, and the **motor control circuit.** Although the circuits are powered by separate transformer windings on the motor frame, the winding's outputs are in phase. This means that when a positive half cycle is being fed to the sensor circuit, a positive half cycle is being fed to the motor control circuit as well, Fig. 11.

Now let's take a look at the motor control circuit, Fig. 12. The motor control circuit uses an SCR to allow or to block current flow through the focus motor. The focus motor is a DC motor so the motor's running direction depends on the direction of current flow through the motor. Changing the direction of current flow causes the motor to reverse direction. The SCR turns on when a positive signal is applied to its gate, then remains on until power is removed from it. Diodes D_1 through D_4 provide two current paths through the SCR. One path for the positive half of the AC cycle and another path for the negative half of the cycle, Fig. 13. In this circuit, R_4 is used to

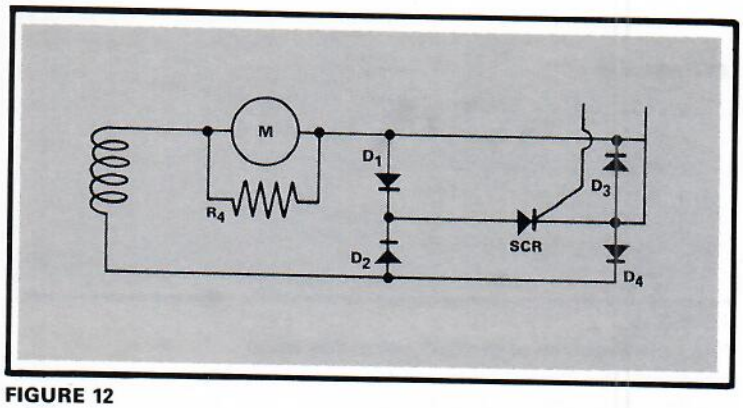


FIGURE 12

An SCR is the heart of the motor control circuit.

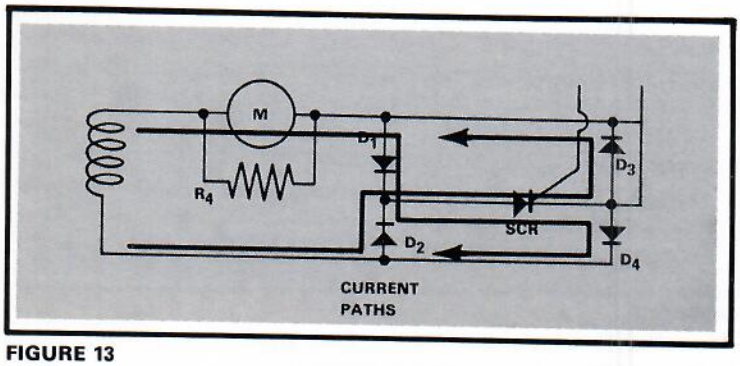


FIGURE 13

There are two current paths through the SCR and the diode array. Depending upon the current path which is open, the focus motor will run in one direction or in the other.

regulate the focusing speed. By itself, the motor control will supply no operating current to the motor. It takes the addition of the sensor circuit to provide the SCR with "turn on" and "turn off" signals.

TEST YOURSELF QUIZ #3

1. Autofocus systems generally use two *part* in a single housing to detect slide position.

2. The two basic components of an auto circuit are the *motor* control circuit and the *position* sensor circuit.

3. The solid state components of an autofocus circuit are an *focus motor* and four *SCR's*.

4. The focus motor used in autofocus circuits is a *DC* motor.

THE SENSOR CIRCUIT

The circuit is a bridge like circuit operated by alternating current, Fig. 14. The circuit is made up to two current paths or current loops. The first loop contains R_1, half of the CdS cell and R_3. The second loop contains R_2, the other half of the CdS cell and R_3. Depending upon the resistances of the CdS cell elements, the loops will be of equal resistance or one loop will be higher and the other loop of lower resistance.

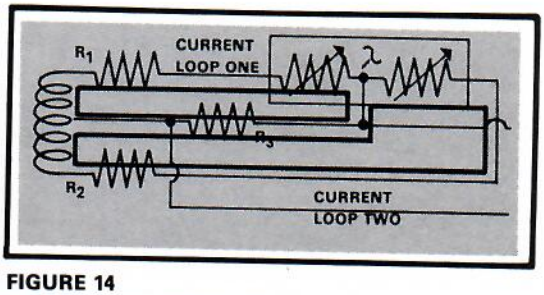


FIGURE 14

Both current loops in the sensor circuit contain R_3. It's the voltage drop across R_3 that controls the motor control circuit.

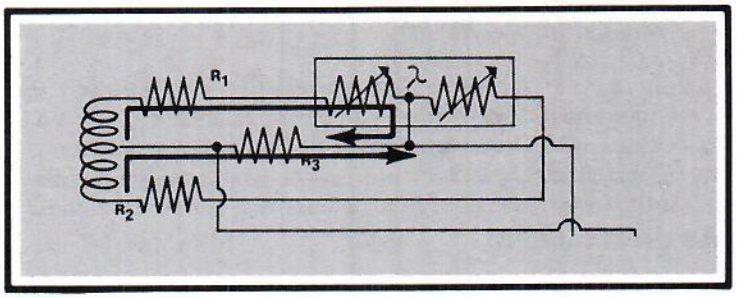


FIGURE 15
When the elements of the CdS cell are of equal resistance, the current loops are equal in strength and there is no voltage drop across R_3.

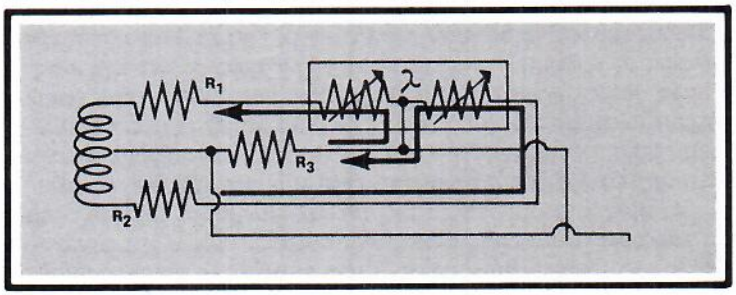


FIGURE 16
When the current changes direction there is still no drop across R_3 as long as both elements of the CdS cell are equal in resistance.

Right now, let's look at the loops when the elements of the CdS cell are of equal resistance, Fig. 15. Here a current is passing through the sensor circuit. Because the resistance of the first loop is equal to the resistance of the second loop, current in the first loop is equal to the current in the second loop. Loop 1 is passing through R3 in one direction while loop 2 is passing through R3 in the other direction. This means that the voltage drop created across R3 by the first loop is cancelled by the second loop. When the AC provided by the transformer winding switches direction in the circuit, the current changes direction. But the loops are still equal and so cancel each other's voltage drop, Fig. 16. This means that on both the positive and negative half cycle there is no measurable voltage dropped across R3 and so no signal is sent to the SCR to turn on.

In the next diagram, a change of slide position has been simulated. Now the CdS cell elements have unequal resistance so there is a current flow through R3, Fig. 17.

Low resistance of the CdS cell element in the first loop is allowing more current to flow in the first loop. Because the first loop is stronger than the second, the first loop determines the polarity of the voltage drop across R3. In this case, R3's gate connection is positive so a positive signal goes to the SCR's gate. This condition will continue to exist for half of an AC cycle, or until the autofocus motor corrects the out-of-focus condition. If one half of an AC cycle isn't enough time for a correction, the next positive half cycle in the circuit will again send a turn-on signal to the SCR, and another slight correction of the focus will be made. In fact, the motor will continue to make tiny corrections - 60 each second - until the out-of-focus condition is corrected.

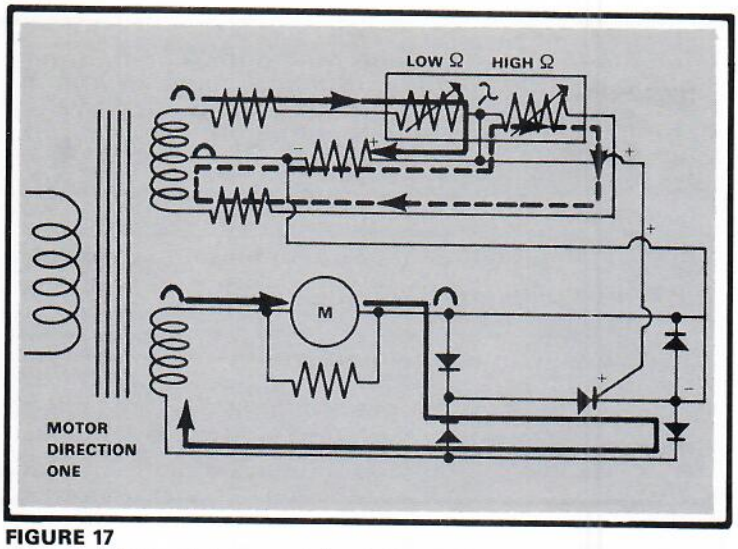


FIGURE 17
Here the left-hand element of the CdS cell has dropped in resistance. This would occur due to more light striking the left-hand element than is striking the right-hand element.

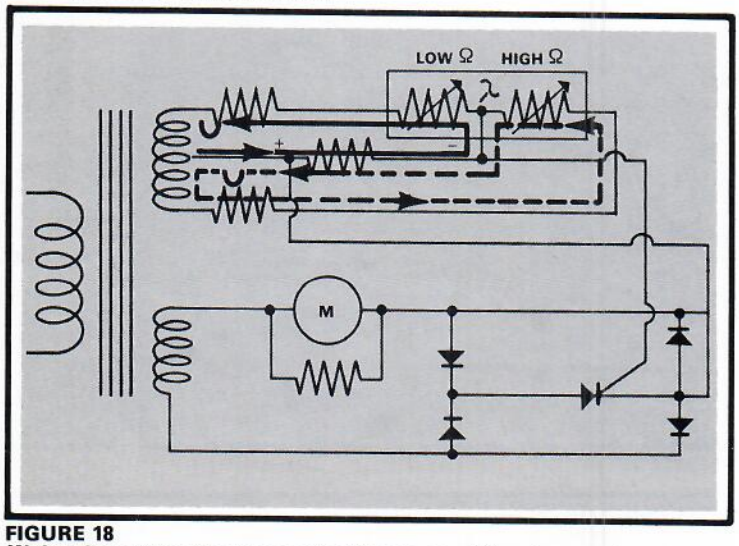


FIGURE 18
We're simulating the same out-of-focus condition here as in Fig. 17, only on the negative half of an AC cycle.

After a positive signal from the positive half cycle turns the motor on, why doesn't the SCR remain on for the negative half cycle too? Because, when the AC cycle reaches its zero voltage point between negative and positive half cycles, current flow through the SCR stops. As soon as the current to the SCR stops, the SCR turns off. Now let's look at the negative half cycle, Fig. 18.

Both current loops have changed direction, but their relative strengths have remained the same. Current loop 1 still controls the polarity of the voltage drop across R_3, but since current direction has changed, the polarity of the voltage drop has changed, too. Now a negative signal is fed to the SCR's gate and a positive signal is sent to the SCR's cathode. The negative signal to the SCR's gate can't turn on the SCR, so it stays off. So on the negative half cycle, the SCR is off and no focusing correction is made.

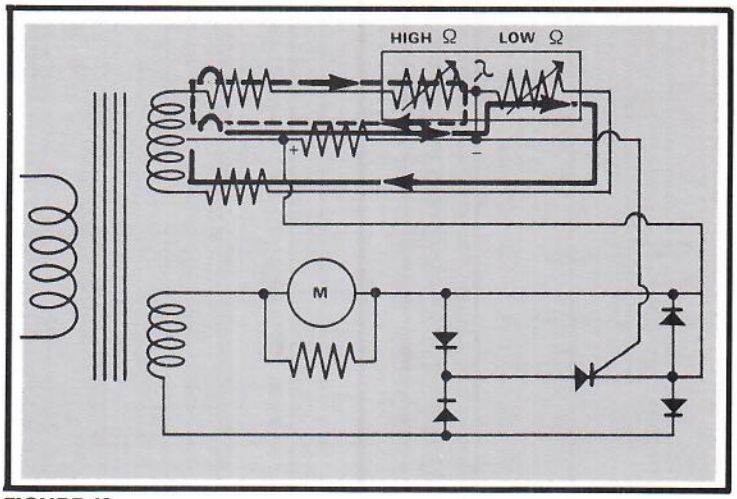


FIGURE 19
Here the right-hand element of the CdS cell has a lower resistance than the left-hand element. This drawing shows the positive half cycle.

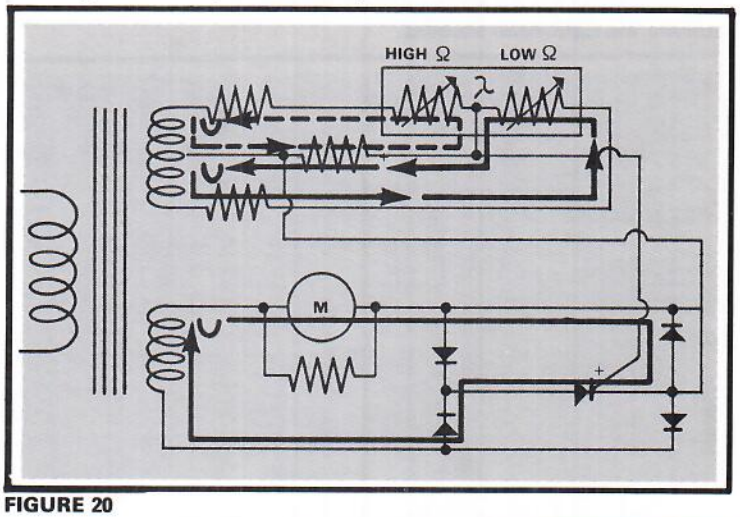


FIGURE 20

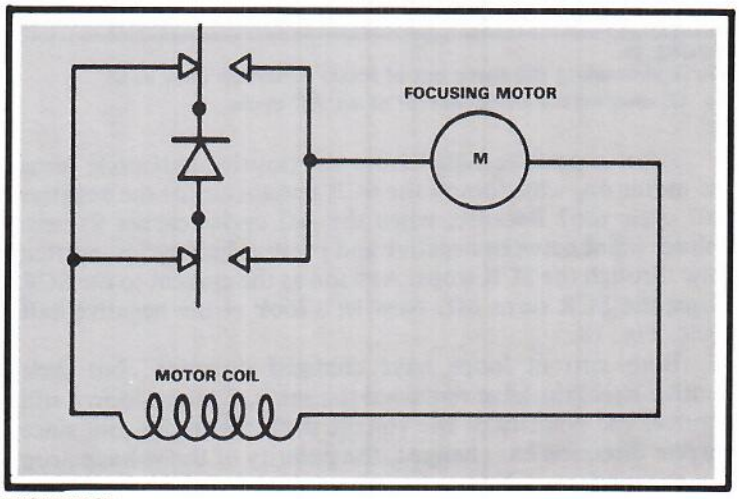


FIGURE 21
Single diode controlled power focusing rectifies AC from a motor coil and uses the resulting pulsating DC to drive a direct current focusing motor.

Now we've switched the high and low resistance CdS cell elements, Fig. 19. This simulates a slide which has warped or popped in the opposite direction from the one in our first examples.

Once again we're in the positive half cycle. In this case, current loop 2 is stronger than current loop 1. So, current loop 2 determines the polarity of the voltage drop across R_3, making the gate lead end of R_3 negative. With its gate negative, the SCR won't turn on so the autofocus motor doesn't run.

Now let's switch to the negative half cycle and see what happens, Fig. 20. Remember, we're simulating a slide which requires the opposite focusing correction from the first one. In the negative half cycle, the current loops change direction and make the gate end of R_3 positive. With a positive signal fed to its gate, the SCR is on. So now the SCR turns on during the negative half cycle. The current direction through the motor is reversed, and the projector's lens is moved in the opposite direction from that in the case of the first slide.

You may be wondering what happens when the out-of-focus condition is corrected during a cycle, that is while the SCR is on. In this case, the motor will probably overshoot a little bit, but because the autofocus motor receives 60 pulses per second when moving, a portion of one pulse isn't much error. In fact, the error can't be detected by the eye. It's in minimizing the overshoot that R_4 comes into play. R_4 is a current shunt around the motor used to control the motor's speed. If R_4 were removed, the autofocus motor would run faster and its tendency to overshoot noticeably would increase.

Power focus, which is a simplified autofocus mechanism in which the projector operator provides the feedback to the focusing motor, does away with much of the autofocus circuitry. In a typical power focus circuit, Fig. 21, a motor coil and single diode provide motor control. This is done by rocking the diode to control current direction through the motor.

We have now covered the fundamentals of slide projector design. In order to put these fundamentals to work, let's look at two common projector designs, the Kodak Carousel and Sawyer's Rotomatic.

TEST YOURSELF QUIZ #4

In the autofocus circuit shown here describe what would happen if:

1. The SCR is shorted and so is always on motor won't work.
2. The SCR is burned out and so is always off auto focus won't turn
3. D_1 is shorted and so is always on would turn in one direct.
4. D_4 is open and so is always off only turn in one direction.

FIGURE 22

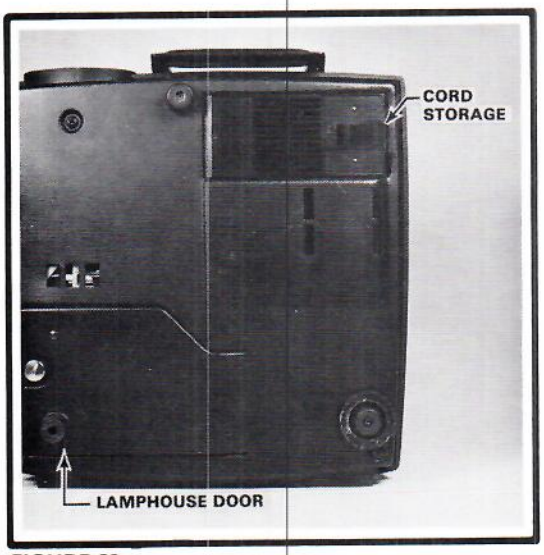


FIGURE 23

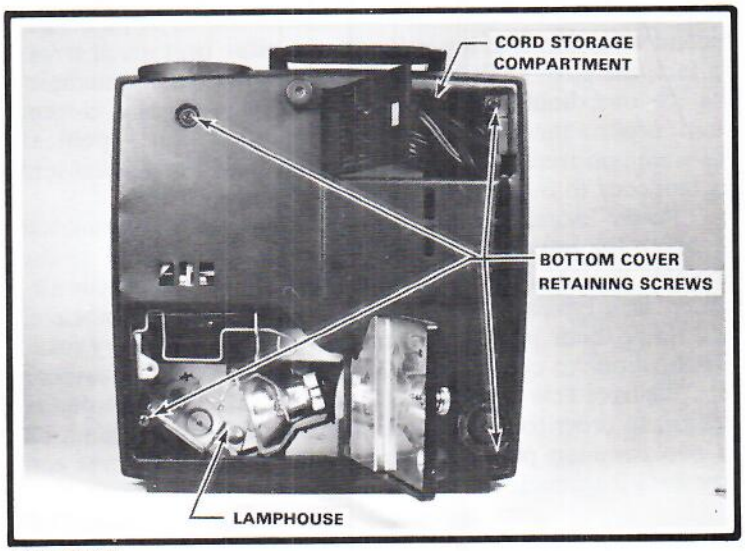


FIGURE 24

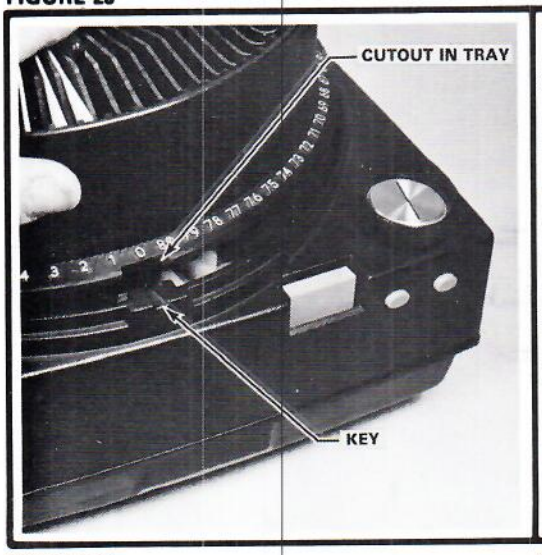


FIGURE 25

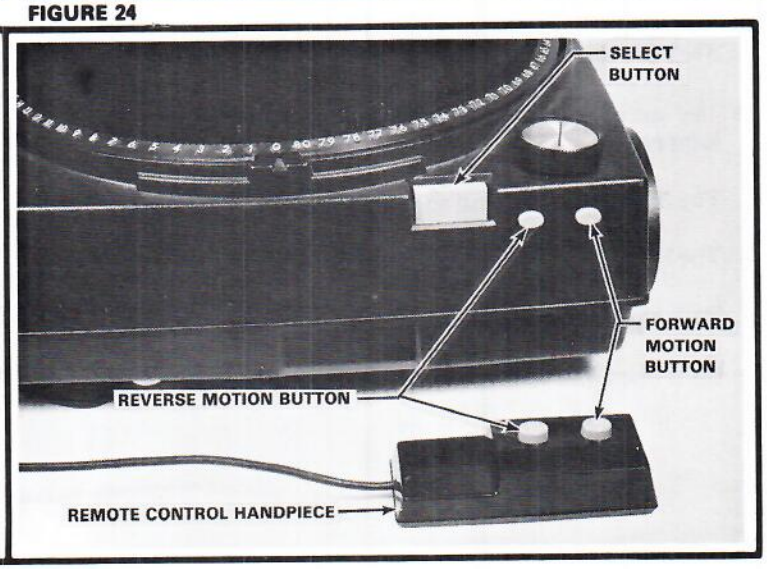


FIGURE 26

THE CAROUSEL PROJECTOR OPERATION AND FEATURES

The Kodak Carousel projector is one of today's most popular projector designs. Much of the Carousel's popularity is due to its functional, compact and nearly troublefree design.

Before examining the Carousel's mechanism, let's go over its features and operation. The projector shown is a model 760H Carousel. Other Carousel projectors, even those which differ in their external appearance are similar in operation. This particular Carousel, Fig. 22, is one of Kodak's newer models. It's a hushed model; that's what the "H" in 760H stand for. In addition to being quieter than earlier Carousels, the 760H also uses a halogen lamp and has an autofocusing system.

The 760H and Kodak's other Carousel projectors share a common round slide tray. The Carousel's standard tray holds 140 slides. In addition to the standard tray, the Carousel projector accepts a special tray holding 80 glass-mounted slides and a stack loader. The stack loader eliminates the tray and accepts a stack of 40 slides. While Carousel slide trays allow slides to be shown in a forward sequence, a reverse sequence and randomly, the stack loader shows slides only in forward sequence.

On the bottom of the Carousel are two compartment doors, one for access to the projection lamp, condenser and heat absorbing glass, the other for cord and accessory storage, Fig. 23, 24. Open the cord storage compartment and remove the power cord and remote control cord. Connect the power cord to the projector's AC terminal and plug the remote control cord. On the remote control cord plug is a colored dot to be indexed against another dot on the projector. The dots must match in color; on the Kodak 760H, they're yellow. Also, never leave cords in the storage compartment during operation as they will interfere with proper cooling of the projector.

Now, install a slide tray so that its cutout lines up with the tray key in the housing, Fig. 25. The projector will now be throwing out white light unless the projector's owner has placed an opaque slide in the projection aperture.

To select the first slide, depress the "Forward" motion button, Fig. 26. The projector will select the first slide and project it. Each time the "Forward" motion button is depressed, the slide in sequence is projected. Depressing the "Reverse" motion button will back the projector up a slide at a time. When you reverse the Carousel projector, you'll have to hold the Reverse motion button down for a moment. Not holding the Reverse motion button down long enough will cause the projector to go through a forward cycle. By pressing the "Select" button and holding it down, you'll unlock the slide tray so that it may be turned by hand and the slides may be shown in any sequence.

When slides are being shown in a forward sequence, they pass over a prewarmer opening before they reach the projection aperture, Fig. 27. The purpose of warming slides before they get to the projection aperture is to keep them from popping during projection.

Once a slide is being projected, you'll probably have to focus the projector to get the sharpest image. The focus knob

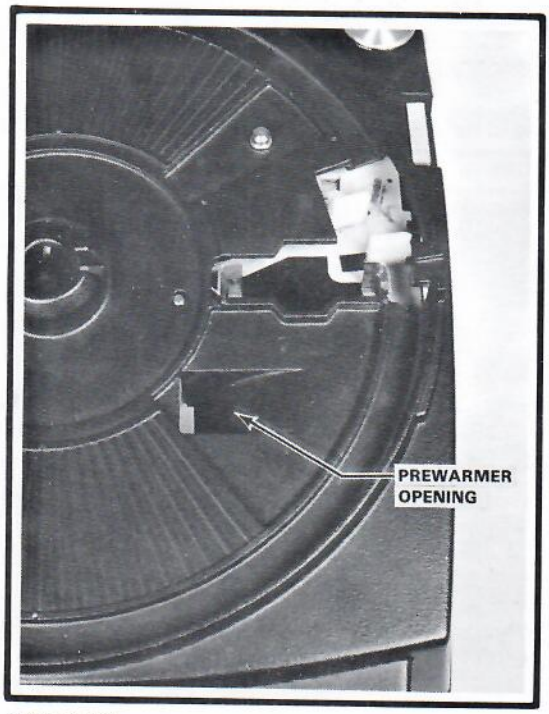


FIGURE 27

is located in the projector's upper right hand corner, Fig. 28. After you've focused the projector, its autofocus mechanism will keep the projected image sharp. If you're projecting onto a screen which is higher than the projector, or if your projector is not on a perfectly level surface, use the elevation control and the leveling foot, Fig. 29, to adjust the projector's position.

A big advantage of autofocus projectors is that they lend themselves to a variety of remote control devices. The 760H has a remote control jack which will accept a hand operated remote control as well as additional accessories such as a tape/slide synchronizer. Other Carousel slide projectors offer a wide variety of different accessory features.

After you've shown the last slide, move the slide tray until its cutout lines up with the key on the projector. Then lift off the tray. When you shut off the projector, you don't need to run the fan to cool the projector down. A pause of a second or two in the switch's "Fan" position to allow the projection lamp to stop glowing is all that is needed. In fact, by running the fan alone, you'll be shortening the useful life of the projector's motor, without increasing the life of the lamp.

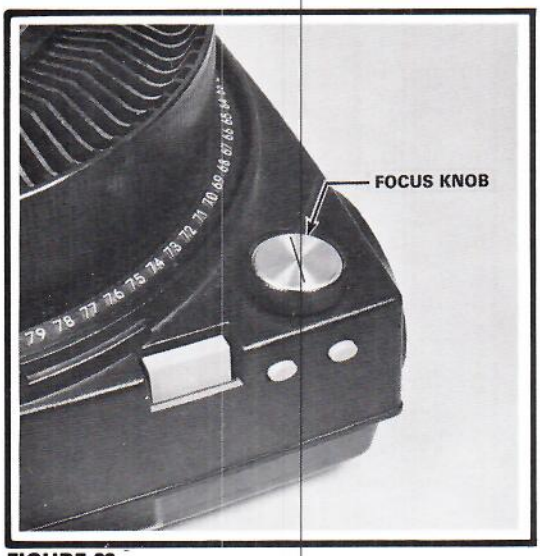


FIGURE 28

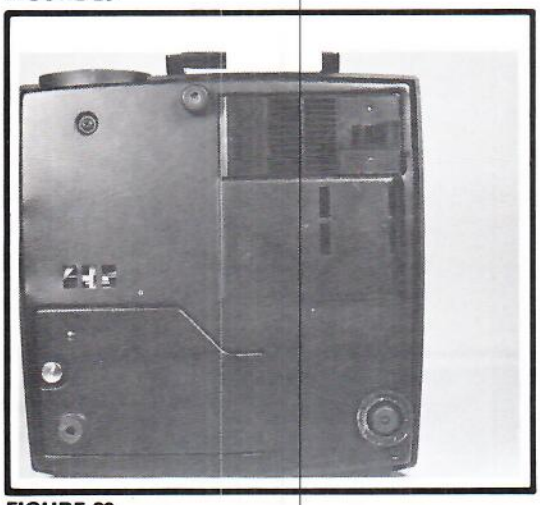


FIGURE 29

PRELIMINARY DISASSEMBLY

Before beginning disassembly of the Carousel projector, remove its projection tray. To do this, run the projector with the SELECT button, or if you can't plug the projector in, or the projector won't run, you can use a coin or other suitable tool to manually operate the tray lock, Fig. 30. Following manual operation of the tray lock, remove the slide still in the projection aperture, then turn the slide tray upside down and replace the slide. Now, since the slide tray's bottom plate isn't holding the slide in place, pull back on the tray's bottom plate locking spring and rotate the bottom plate until the tray index lever lines up, Fig. 31, as we've shown.

DISASSEMBLY FOR REPAIR

Begin disassembly of the Carousel projector by turning the projector over and opening its cord storage compartment. Remove the remote control cord and power cord. Next open

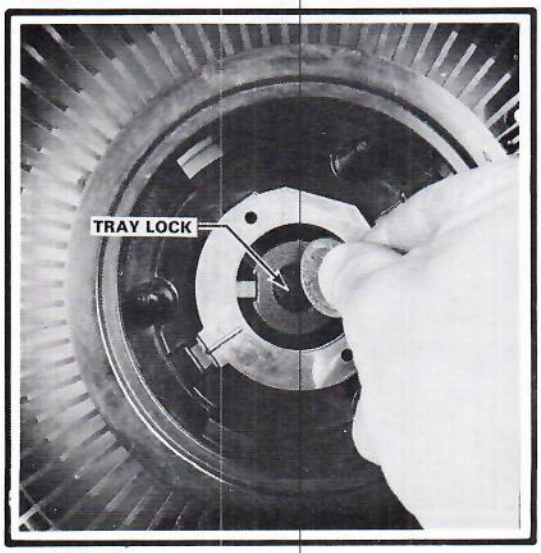


FIGURE 30

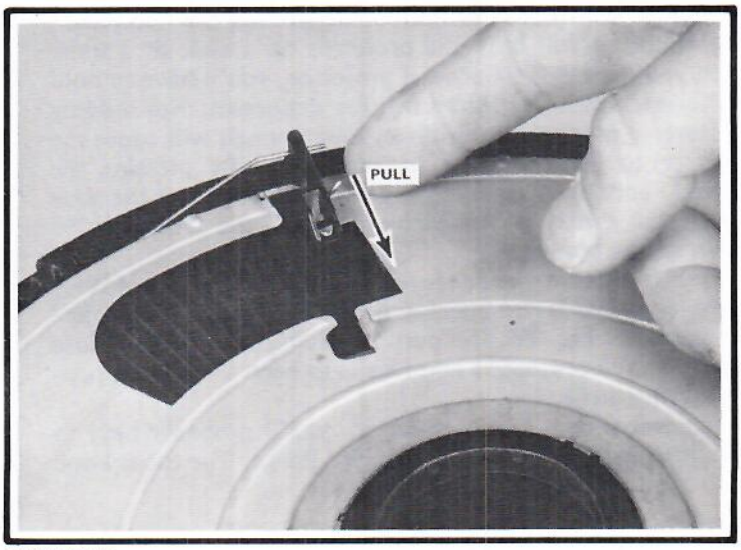


FIGURE 31

the lamphouse door and remove the projection lamp, condenser lens(es) and heat absorbing glass to protect them from accidental damage, Fig. 32. Be especially careful when handling the heat absorbing glass in this and all other projectors. Remember, heat absorbing glass contains very high internal stresses introduced during manufacture; so you'll probably want to keep the heat absorbing glass wrapped up once it's out of the projector as an added protection. Now remove the Carousel's projection lens. To do this, use the focus knob to extend the lens about 1/2 inch out of the projector housing. Then, pull outward on the focus knob and slip the lens out of the projector, Fig. 33.

Finally, use the elevation control to pull the elevation foot against the projector's housing, remove the screw holding the rubber foot and washer, and lift them off. You can now remove the four screws retaining the projector's bottom cover. One of these screws is inside the cord storage compartment and another is inside the lamphouse. Notice that three of the screws are sheet metal screws while the fourth has a finer thread. Once you've removed the bottom cover screws, you'll have to slip the bottom cover a little bit forward before it will lift off. With the Carousel's bottom cover off, you can see all of its major subassemblies, Fig. 34.

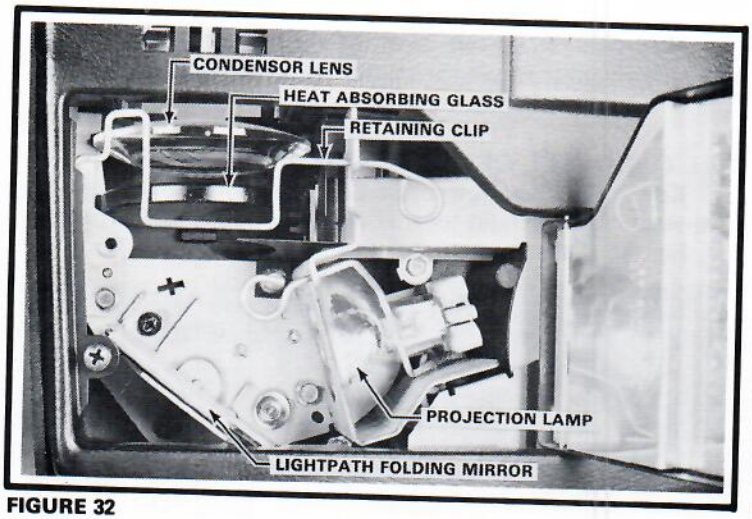


FIGURE 32
The lamp, condenser lens and heat absorbing glass should be removed before disassembly of the projector.

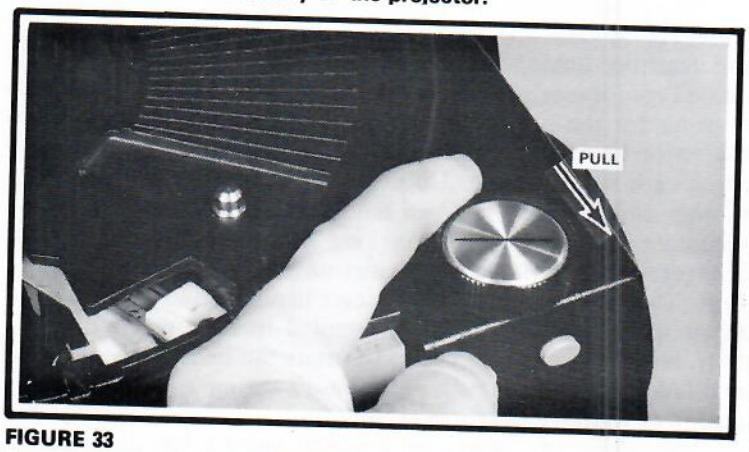


FIGURE 33
To remove the lens, pull outward on the focus knob.

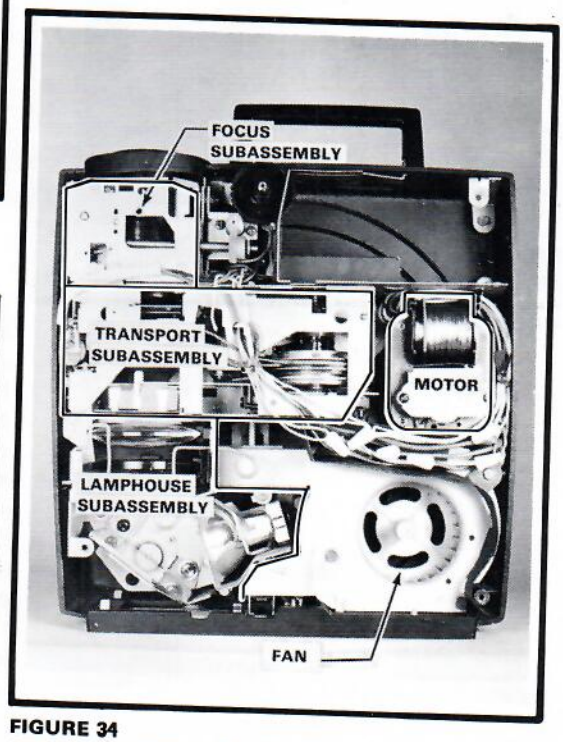


FIGURE 34
Major subassemblies in the Carousel projector.

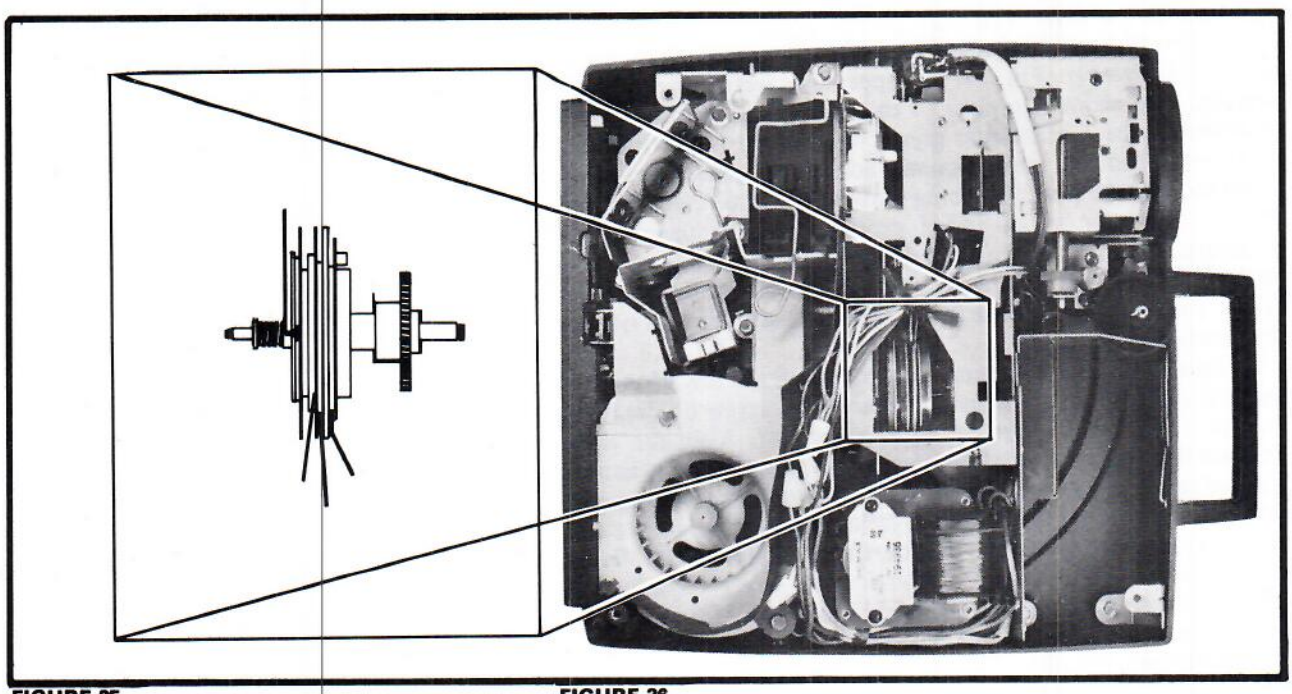


FIGURE 35
The cam stack is the key to Carousel projector operation.

FIGURE 36

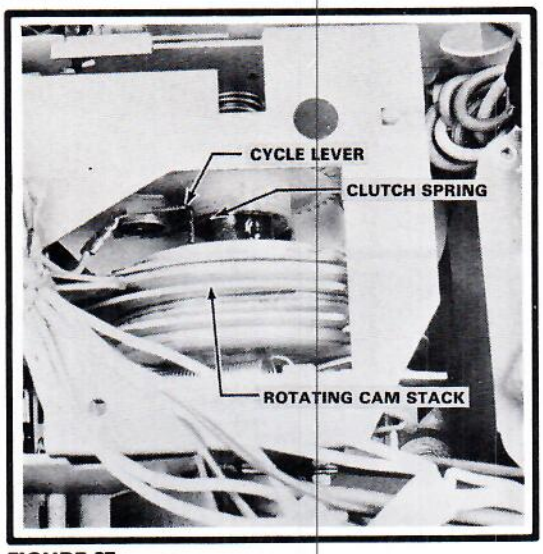


FIGURE 37

Now that the bottom cover of the projector is out of the way, it's possible to see the operation of the Carousel projector.

THE CAROUSEL OPERATING SEQUENCE

Key to the operation of the Carousel's mechanism are the cam stack and solenoid located near the center of the projector, Fig. 35. During one revolution, the cam stack will:

1. Close the shutter
2. Remove the slide from the projection aperture
3. Open the pressure pads
4. Move the slide tray one step
5. Lower the next slide into the aperture
6. Close the pressure pads and
7. Open the shutter

The **rotating cam stack** performs these functions through a number of cam followers. Here we've identified the cams, and described the followers functions, Fig. 36. If the cam stack rotated continuously, slides would be shown in rapid sequence. In order for the projector operator to be able to control the projection interval, the cam stack is arrested by the **cycle lever** engaging a spring clutch. Until the projector operator selects another slide, the cycle lever holds the clutch spring in its released position, Fig. 37. As long as the spring clutch is disengaged, the cam stack remains uncoupled from its drive shaft. Then, as soon as the cycle lever is pulled away from the clutch spring, the cam stack is coupled to its rotating drive shaft. Now the cam stack begins to rotate but because the cycle lever has re-entered the path of the clutch spring, the cam stack is allowed to make only one revolution.

Because the projector operator may wish to view slides out of sequence, the projector also has a half cycle provision. By

pressing the projector's external SELECT button all the way down and holding it there, the operator causes the slide changer to stop after removing the slide just projected from the projection aperture. Now the operator can turn the slide tray by hand, selecting the next slide of his choice. We'll be covering the forward cycle, reverse cycle and half cycle and how they differ as soon as we've disassembled the projector far enough to see the parts involved.

LAMP AND THERMAL FUSE

The next step of disassembly is to remove the lamp house. In this projector, four 1/4 inch hex head screws hold the lamp house in place. Notice that the two screws nearest the projection lamp are nickel plated. This is what gives them their shiny appearance, Fig. 38.

As part of the lamp house, "H" series carousels use a mirror to fold the light path. The purpose of folding the light path is to allow a halogen lamp and its socket assembly to fit into the projector conveniently.

Once the lamp housing assembly has been removed, you'll have access to the projector's **thermal fuse,** Fig. 39. The thermal fuse is in series with the projector's electrical circuit to provide an extra safety margin in case the projector should overheat. If the internal temperature of the projector gets too high, the thermal fuse becomes an open circuit cutting off electrical power to the projector.

A blown thermal fuse is relatively common in a projector which has been operated carelessly. Covering the projector's vents during operation, or operating the projector on a carpeted surface or with cords in the storage compartment will almost certainly result in the thermal fuse blowing. Unfortunately for the projector owner, the thermal fuse isn't readily accessible. To remove the thermal fuse, remove its mounting screw and lift out the thermal fuse bracket. Next unsolder the thermal fuse leads at the ON/OFF switch. Soldering the new fuse into the circuit and remounting the fuse and bracket to the fan cover completes replacement of the thermal fuse.

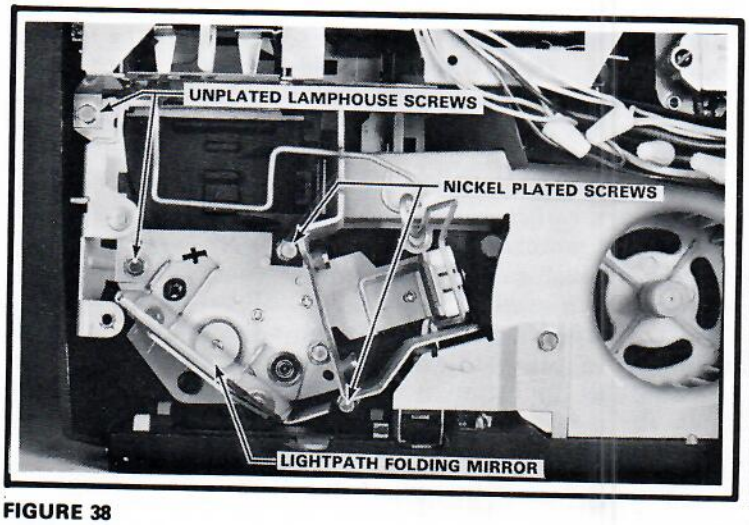


FIGURE 38

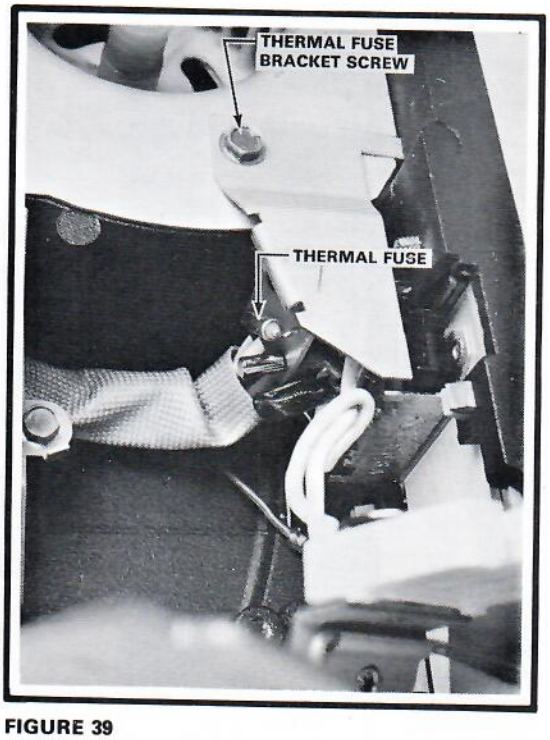


FIGURE 39
You'll have to replace the thermal fuse if a Carousel projector overheats.

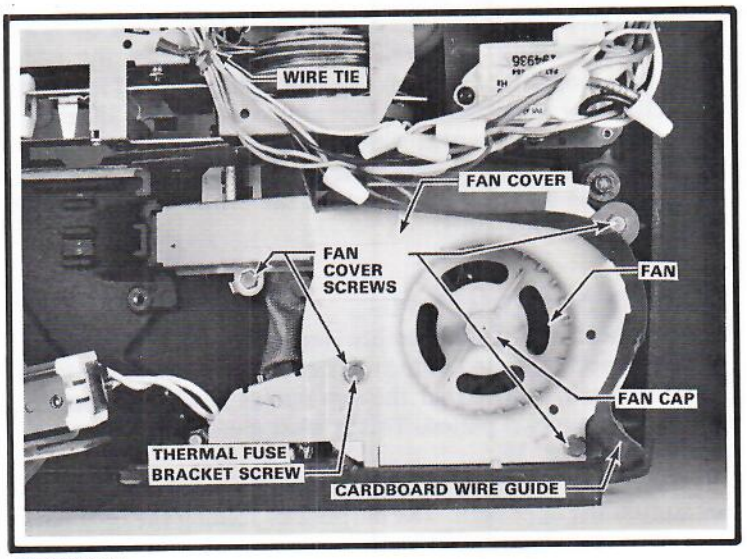


FIGURE 40

FIGURE 41
An E-ring holds the fan in place. Be careful, there's a spring beneath the E-ring.

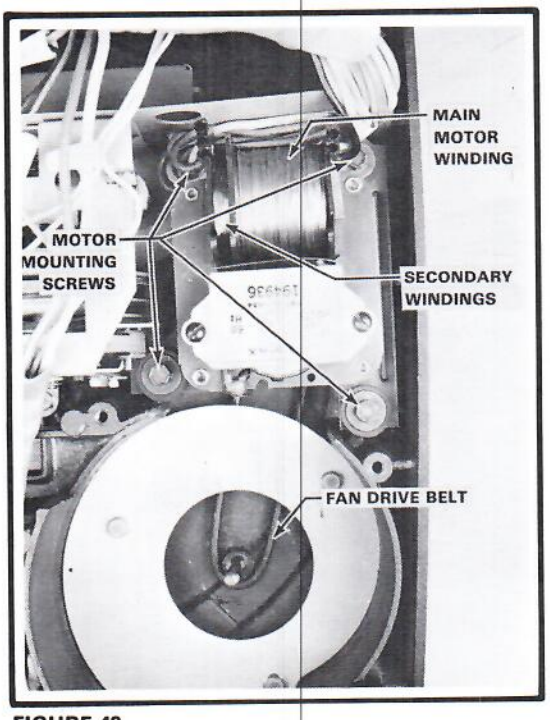


FIGURE 42
Extra windings on the 760's motor provide power to the autofocus and solenoid circuits.

FAN AND COOLING

Proceeding with the disassembly, remove the cardboard wire guide and metal fan cover. These are held in place by four 1/4 inch hex head screws, Fig. 40. One of the retaining screws is hidden beneath wiring in a wire guide made from the cardboard air guide. You'll have to lift the wires out of the way to uncover this retaining screw. In order for the fan cover to clear the projector housing, you may have to push back one of the plastic locking tabs for the projector's rear grill if it interferes. Now pull off the fan cap. Notice before you remove the fan from the projector how the fan's spring is hooked up. At its E-ring end, the spring has an upturned end which passes through the E-ring. At its other end there is extension on the spring which rests against a small metal clip, Fig. 41. It's important during reassembly that the spring be installed correctly. Now, you can lift off the fan cap, remove the E-ring and spring and lift the fan away from its drive belt, off of its shaft and out of the projector. Reaching through the cutouts in the base of the fan with a wooden or plastic probe to guide the fan belt away from the fan while turning the fan by hand will make its removal easier. On the fan shaft beneath the fan are two washers. These washers should remain in place while you're working on the projector, but you may wish to remove them to insure against their loss. Once the fan has been lifted out of the way, it's an easy step to remove the motor.

The Carousel projector uses a shaded-pole motor which we discussed earlier. Notice that in addition to having a coil to operate the motor, the motor frame carries additional coils serving as transformer secondaries providing power to operate the projector's solenoid circuit and autofocus circuit, Fig. 42. You'll probably find it easier to remove the motor if you first remove the paper wire tie located beside the cam stack. If you are replacing the motor, twist off the wire connectors which hook the motor into the projector's electrical system and disconnect the motor from the circuit.

FOCUS AND TRANSPORT

Only two subassemblies remain in the housing, the slide changer subassembly and the focus subassembly, Fig. 43.

These two parts must be removed together but once out of **the projector,** they may be separated. Before you can remove the slide changer and focus subassemblies from the projector, you'll have to disconnect the wires linking the control switch on the back of the projector with the subassemblies. These wires, like those used to connect the motor to the projector's circuits, are fastened using a twist-on connector. To separate the wires, just unscrew the cap holding them together and lift the cap away. Following unhooking the wires from the switch, be sure to replace the caps on the remaining wires so that reassembly of the projector is simplified. Before the focusing subassembly will come free of the projector housing, you'll have to remove the focus knob. The focus knob is usually tight, so you may have to use the rounded end of tweezers or other suitable tool to pry the knob off of the focus shaft. Once you've removed the focus knob, 9 screws inside the housing hold the changer and focusing subassemblies in place. Removing these screws, shown in Fig. 44, will allow you to lift both assemblies out of the projector together. Use both hands when performing this step to prevent the subassemblies from separating while they are being removed.

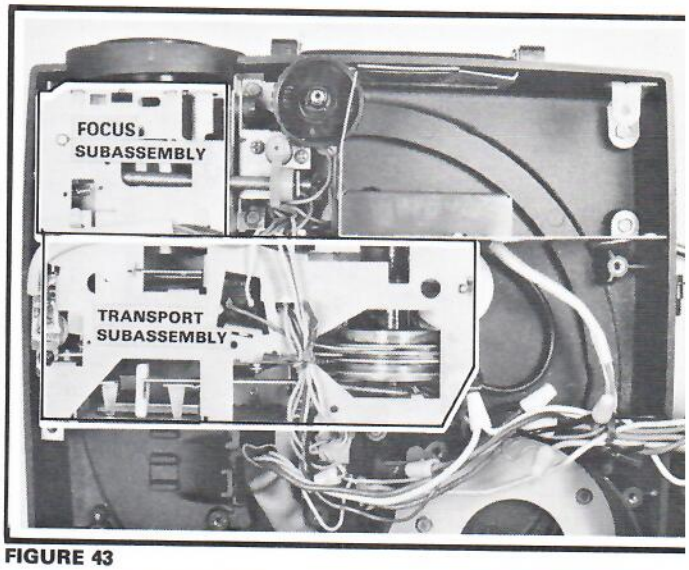


FIGURE 43

TRANSPORT OPERATION

Once the focusing subassembly and the slide changer subassembly have been removed from the projector, you can see how the transport operates. First, unhook the spring on the feedback arm, Fig. 45 then separate the assemblies. By rotating the transport worm's drive pulley, you can make the **cam shaft drive gear** turn. Then by either depressing the select lever or simulating the relay's operation by using a tool to hold its core in, you'll be able to see the projector operate in the select, forward and reverse modes of operation, Fig. 46.

While turning the drive pulley on the worm, momentarily depress the select lever to start a forward cycle. Now, notice what happens. The cycle lever disengages from the clutch spring and the cam shaft begins turning. After a portion of its rotation, **the shutter and pressure pad control cam** begin to close the projector's shutter. Closing the shutter prevents the slide being removed from the projection aperture from appearing on the projection screen while in motion. As soon as the shutter is fully closed, the **slide lifter** cam begins to move the slide lifter arm. The slide lifter arm begins pushing the slide from the projection aperture; closed pressure pads in the projection aperture act as guides at this point to insure that the slide being removed from the aperture travels straight up and into its slot in the projection tray. As soon as the slide lifting arm has removed the slide from the projection aperture, the pressure pads open. Now, while the slide lifting arm remains up, preventing the slide that's just been removed from falling back into the aperture, the **tray locking arm** moves back allowing tray motion. If you're holding down the select lever, the tray must be moved manually. But, in either forward or reverse motion, the tray motion lever pushes the tray to select the next slide in sequence. Then, as soon as the tray's motion is complete, the tray locking arm once again engages the slide tray to

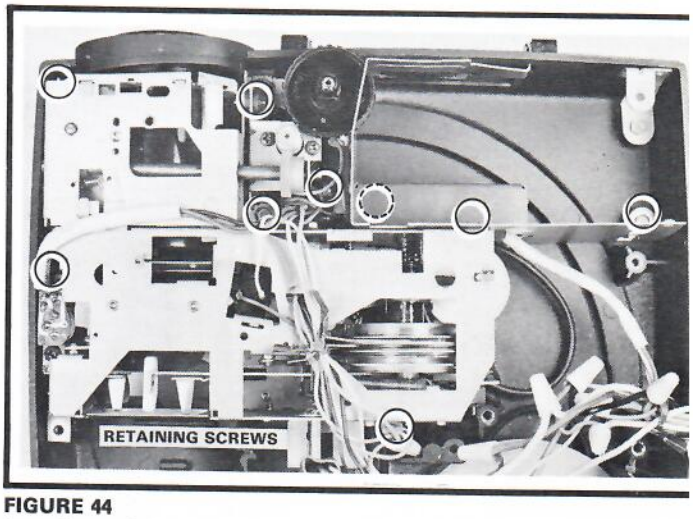


FIGURE 44
Locations of the screws holding the transport and the focus subassemblies.

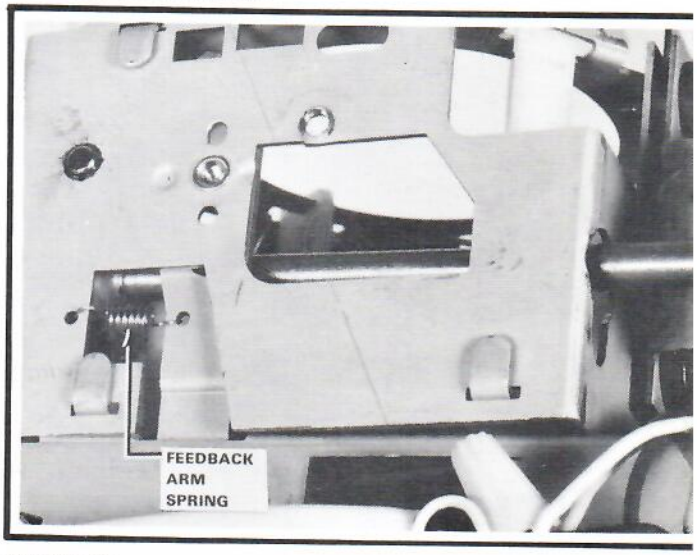


FIGURE 45

prevent its movement and the slide lifting arm begins to drop back down into the projection aperture lowering the next slide with it. Once the slide is in position in the projection aperture, the pressure pads close on the slide holding it in place. Finally, the shutter reopens and the slide is projected onto the screen.

HALF CYCLE OPERATION

What happens if the projector operator presses down on the select lever and holds down? When the operator does this, it's because he wishes to select a slide other than the next one in a forward or reverse sequence. Holding down on the select lever does two things: it positions the second half of the cycle lever approximately 180 degrees from where the clutch spring was released and it disengages the tray motion lever from the tray motion cam after the cam stack has moved a small distance. By shifting the **tray motion cam follower** from its control cam, and placing it instead on a smooth cam, the tray motion lever will be prevented from moving. This insures that the projector will not move the tray forward or backward a step when the operator wishes to select slides manually.

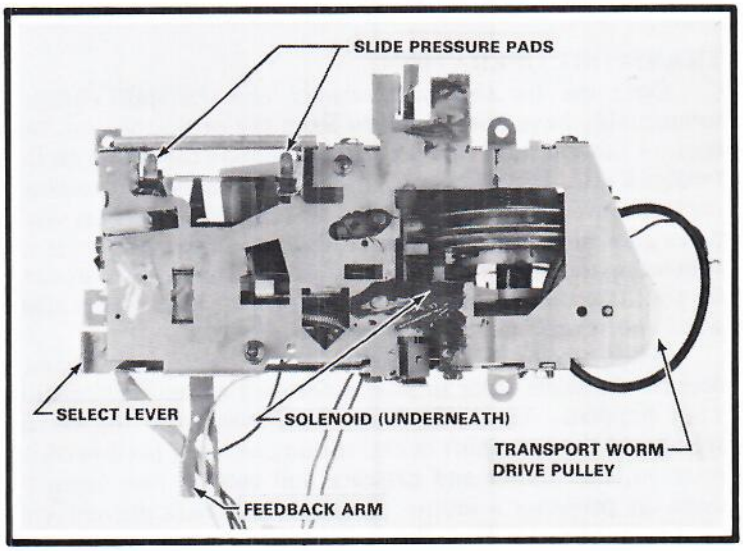


FIGURE 46
The transport subassembly.

TEST YOURSELF QUIZ #5

1. Cords left in the storage compartment of a Carousel Projector during operation will result in the projector _____ overheating.

2. The key to the Carousel's mechanical operation is its rotating cam stack and solenoid.

3. If the internal temperature of a Carousel projector gets too high, a thermal fuse blows.

4. The tray motion cam follower tracks a smooth cam in half cycle operation.

THE SOLENOID CONTROL

For either forward or reverse operation, the cycle lever is operated by the projector's internal solenoid rather than by the select lever. In the case of forward motion, the cycle lever and clutch spring act as electrical contacts. For forward operation, the solenoid is momentarily energized. This is done by momentarily supplying electrical power to operate the solenoid through a circuit with the clutch spring and cycle lever in series with the solenoid and acting as a switch, Fig. 47. What this means is that as soon as the solenoid has pulled in far enough to disengage the cycle lever from the clutch spring, power is removed from the solenoid so the solenoid core once again drops out and allows the cycle lever to drop back into a position to intercept the clutch spring. The cam stack now goes through one complete revolution and in doing so selects the next slide from the slide tray and projects it. When the reverse button is pressed, Fig. 48, the projector behaves in a similar manner except now the cycle lever and clutch spring are not acting as electrical contacts. The solenoid is directly energized by the reverse contacts. Now, the solenoid pulls in and remains in. In addition to pulling the cycle lever out of the way, the solenoid also rocks the forward/reverse selector arm and holds it. In the case of forward operation, the forward/reverse selector arm momentarily selects reverse

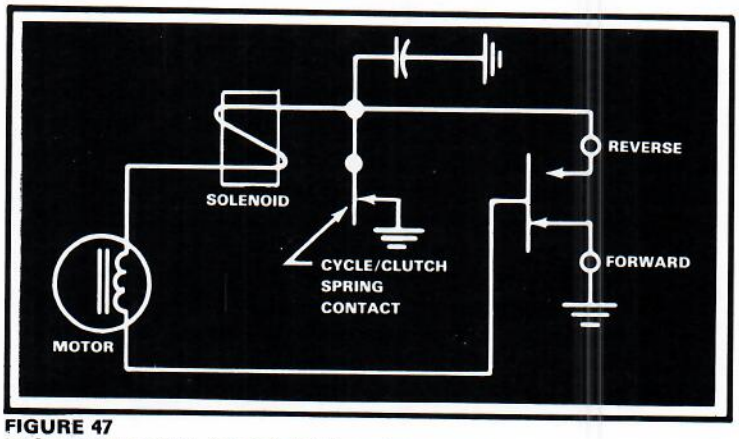


FIGURE 47
In forward motion, the solenoid receives power through the cycle lever and clutch spring.

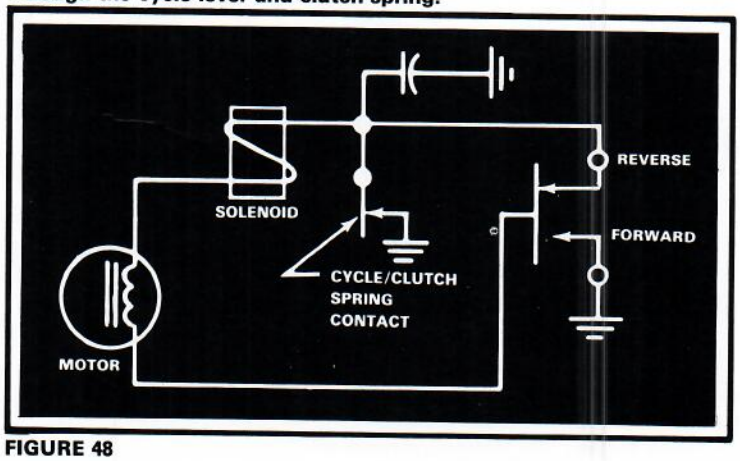


FIGURE 48

In reverse motion, the reverse contacts directly energize the solenoid.

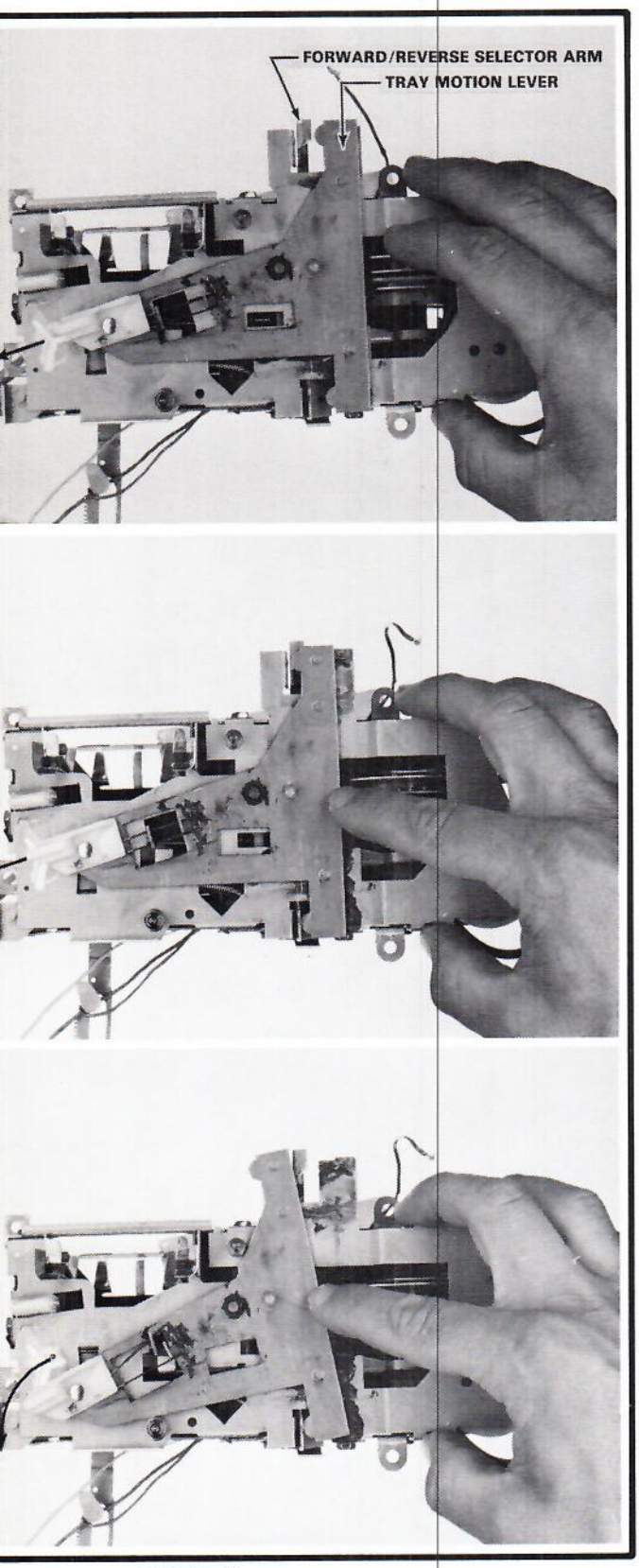


FIGURE 49
For forward motion, the tray motion arm is rocked by the forward/reverse selector arm so that the slide tray is pushed forward.

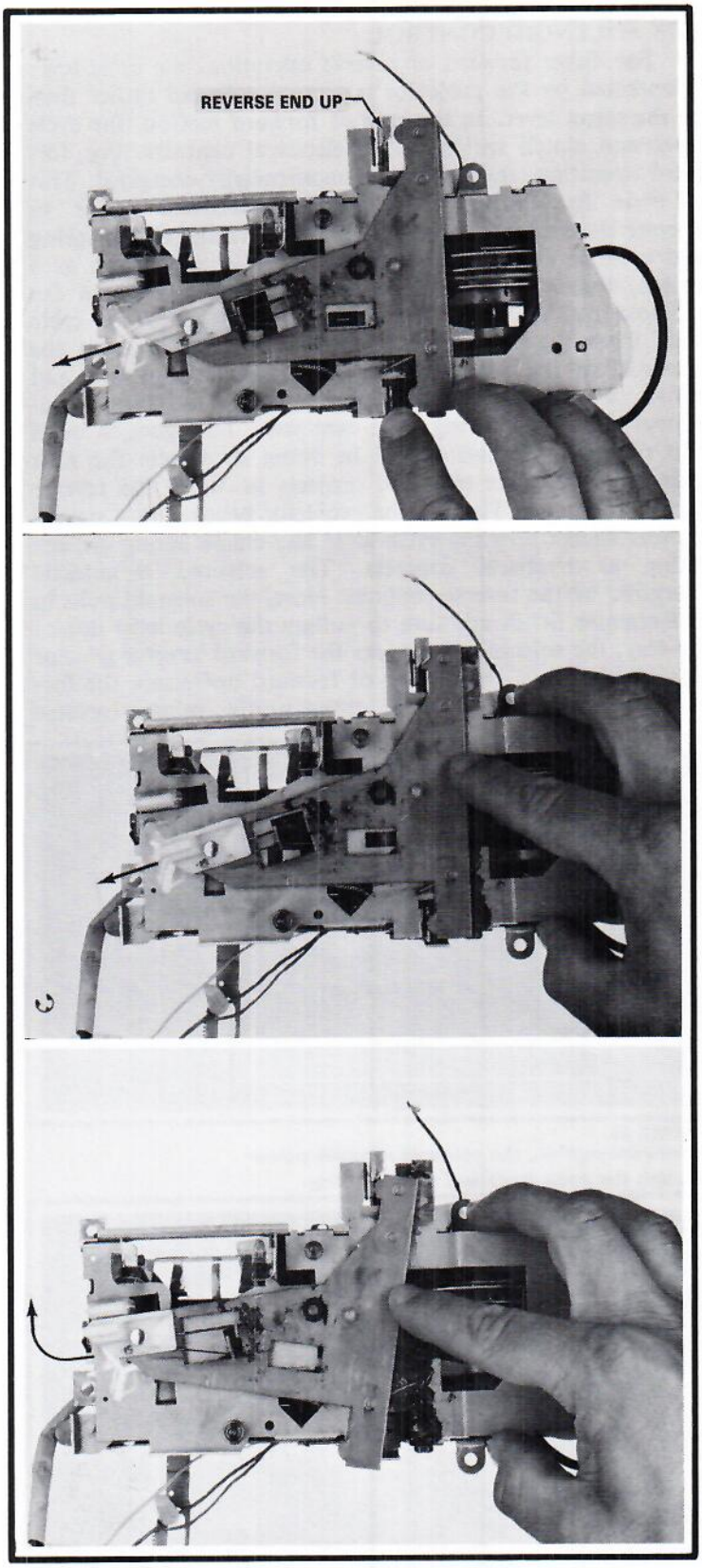


FIGURE 50
In reverse motion, the forward/reverse selector arm rocks the tray motion arm so that it pushes the tray backwards.

operation, but by the time the tray motion lever is actuated by its control cam, the forward/reverse lever has moved back out of the way so the projector goes through a forward cycle. In reverse operation, however, with the solenoid energized for the entire cycle, the reverse tab on the forward/reverse control arm remains in the path of the tray motion lever, so that now instead of pushing the slide tray one slide forward, the tray motion arm pushes the tray one slide back, Fig. 49, 50.

DRIVE PULLEY BELT REPLACEMENT

Although it's not a common repair, from time to time the Carousel's slide changer drive belt will have to be changed. Although this is not difficult, it does require some care. To free the changer belt from the changer drive pulley and shaft, bend the tab at the upper end of the shaft so you can pivot the shaft from the projector and slip the belt off, Fig. 51.

REASSEMBLY NOTES

When reinstalling the focusing subassembly and transport subassembly, you'll have to be careful to prevent the tray motion arm from falling off of the transport subassembly. In addition, when the transport subassembly is reinstalled, you must make sure that the select lever engages the select button and that the forward and reverse motion control buttons on the side of the projector contact their respective switch contacts. When replacing the compartment wall which carried the autofocus circuit board, be careful not to pinch the drive belt which is still attached to the transport subassembly. You'll probably find it most convenient to replace the fan at this point. By replacing the fan now, you'll make hooking the belts up, a little later on in reassembly, a much easier procedure. If you've made any adjustments or repairs to the autofocusing mechanism which have involved moving the photocell or lamp assembly, do not complete reassembly of the fan. Fix the fan to its shaft using the spring and E-ring, but don't reinstall the fan cap. The fan cap will be needed to check for proper positioning of the photocell assembly in relation to the autofocus lamp.

Rehooking the drive belts in the Carousel projector requires a bit of dexterity. Notice that the drive belt for the slide changer mechanism rides on the pulley closest to the motor, Fig. 52. The other pulley carries the belt which operates the fan. Of course, you'll have to hook the changer mechanism belt first. Before you replace the fan's metal cover plate, be sure that the wiring within the protective sleeve will pass below the metal cover and air guide. If you're sure this is the case, replace the cover and the cardboard air guide. Make sure that you do not pinch any wires between the metal fan cover and the projector housing because although you probably won't do any immediate damage, eventually through use of the projector, the wire's insulation will be cut and a serious electrical problem will present itself.

The next step is to replace the thermal fuse with its single mounting screw. Then add a lamp housing and fix it into position. Again, be sure that you don't pinch any of the wires when re-installing the lamp housing.

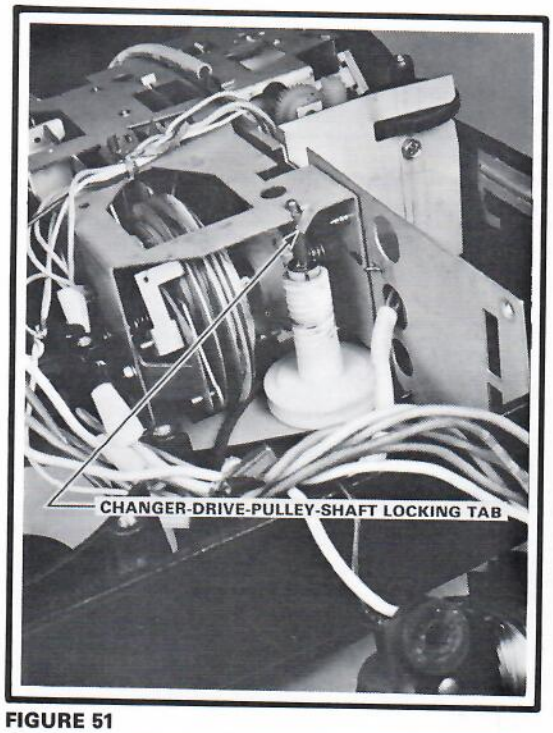


FIGURE 51
Replacing a slipping drive belt requires removing the changer drive pulley.

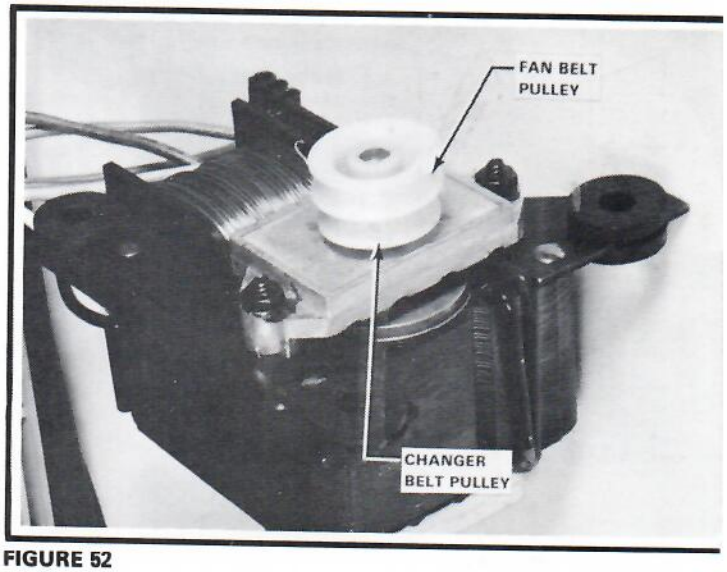


FIGURE 52

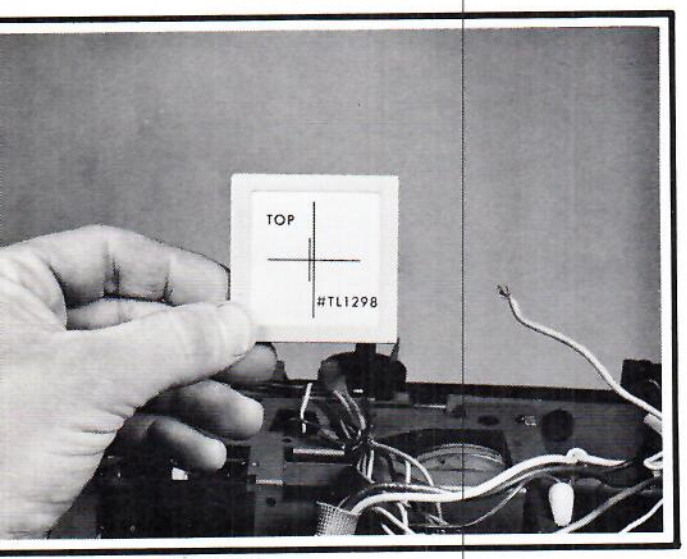


FIGURE 53
Kodak's test slide, TL 1298 is used to check the alignment of the autofocus lamp.

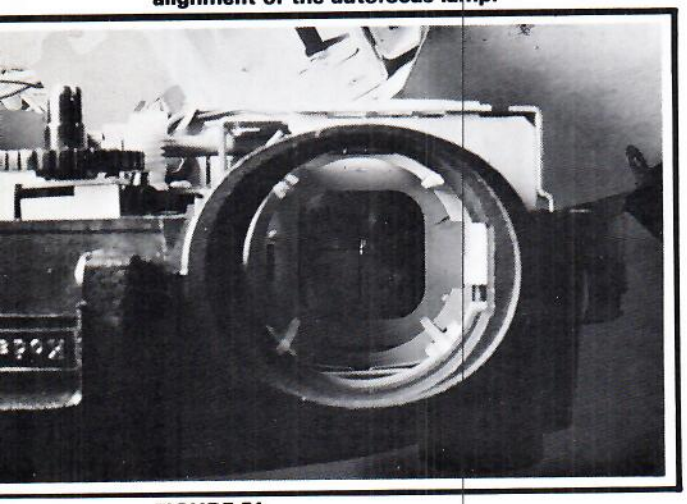


FIGURE 54
This is what you should see if the lamp is adjusted properly.

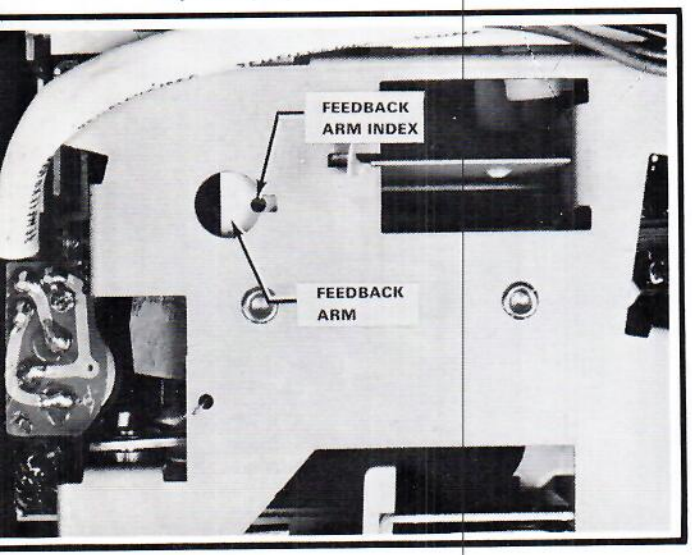


FIGURE 55

ADJUSTING THE AUTOFOCUSING SYSTEM

If you've disturbed the position of the autofocus cell assembly or of the autofocus lamp, you'll have to recalibrate the autofocus system. Although it's not likely that you'll have to reposition the autofocus lamp, there are cases when a lamp alignment must be made. For example, if a new lamp is installed. If the autofocus lamp's position has been disturbed, you'll have to realign the lamp before aligning the photocell. To reset the lamp's position, you'll need a Kodak test slide.

To use the test slide, install it in the projection aperture with its top side up when the projector is right side up. Turn the projector on to "Fan," but do not turn on the projection lamp. Then observe the image of the autofocus lamp's filament; the filament should be in focus and positioned within the .050" space and centered on the horizontal axis, Figs. 53, 54.

To adjust the autofocus lamp's position, bend the lamp mounting end of the autofocus lamp until the filament's image falls with the tolerance lines.

HOUSING ALIGNMENT

Now proceed to the photocell housing alignment. To do this you will need a glass-mounted slide or a 2 x 2 inch piece of glass which can be inserted into the projection aperture. You'll also need the projector's fan cap. The first step in the calibration procedure is to place the glass-mounted slide in the projection aperture and switch the projector to the fan position. When set to "Fan" the projector's autofocus circuit will be operating. Now observe the motion of the autofocus feedback arm. The feedback arm has a small, round hole in it which should line up in its index in the focus assembly mechanism plate, Fig. 55. If the hole does not line up, then you'll have to shift the position of the photocell bracket until it does. Loosen the screw holding the photocell mounting bracket, and shift its position in and out until you line the hole on the feedback arm up with its index. Check the accuracy of your adjustment by shifting the glass slide in the projection aperture. First, the projector should correct for the out-of-focus condition. Then when you allow the glass slide to move back into the projection position, the hole in the feedback arm should realign with its notch. Failure to make this adjustment if it's needed may cause the autofocus mechanism to drive the lens in or out continuously when there is a slide in the projection aperture.

The next adjustment to be made is to the cell. To do this, you will have to lift the photocell from its housing. Because removing the photocell and re-installing it correctly is a somewhat tricky procedure, check the autofocus by projecting slides before you adjust cell alignment. If the autofocus checks out, that is, it keeps the image being projected on the screen in focus, there is no need to make a cell alignment.

PHOTOCELL ALIGNMENT

Once again, place the glass-mounted slide in the projection aperture. Recheck the position of the feedback rack. Then with the rack in the proper position, disconnect the focus motor from the autofocus circuit. The easiest way to do this is to unhook either the red or blue wire leading to the autofocus motor. Then you'll have to remove the photocell.

The photocell and the circuit board are held to their housing by plastic posts which have had one end melted and then flattened over to prevent the circuit board and cell from slipping from the mount, Fig. 56. To remove the board and cell, use a low wattage soldering iron to soften the plastic where it has been flattened over to hold the circuit board. Once the plastic is soft, you can slip the circuit board and photocell away from the housing. Next, lift the filter and mask from the CdS cell housing.

The Carousel and a number of other projectors incorporate a filter which passes primarily infrared light in order to keep the light from the projector lamp from interfering with autofocusing, so be sure you replace the filter during reassembly.

Once the mask and the filter have been removed from the cell housing, you can insert the fan cap the way we've shown, Fig. 57. Now with the projector switch on, you should see an S or C-shaped image projected on the end of the fan cap. The image should be aligned so that it is centered and passes through a small hole in the end of the cap, Fig. 58. If it does not, it will be necessary to reposition the housing. To reposition the housing, first loosen its mounting screw and bring the housing and fancap alignment gage in along axis #1. Then, snug down the housing's retaining screw. To bring the housing in on axis #2, it will be necessary to bend the tab on which the housing is mounted up or down until the image is properly centered. Once these adjustments have been made, reassemble the mask, the filter and the photocell. Heat seal the two posts and then reconnect the focus motor. Once again, check for the proper position of the feedback rack and make a minor position adjustment if necessary. Now tighten the screw holding the CdS cell housing and apply locking paint to the screw.

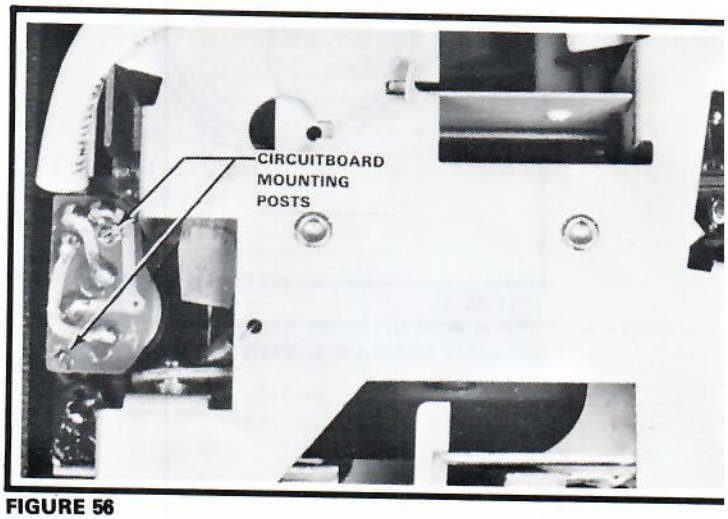


FIGURE 56
Plastic mounting posts hold the photocell circuit board in place. To remove the board, soften the posts and slip the board off.

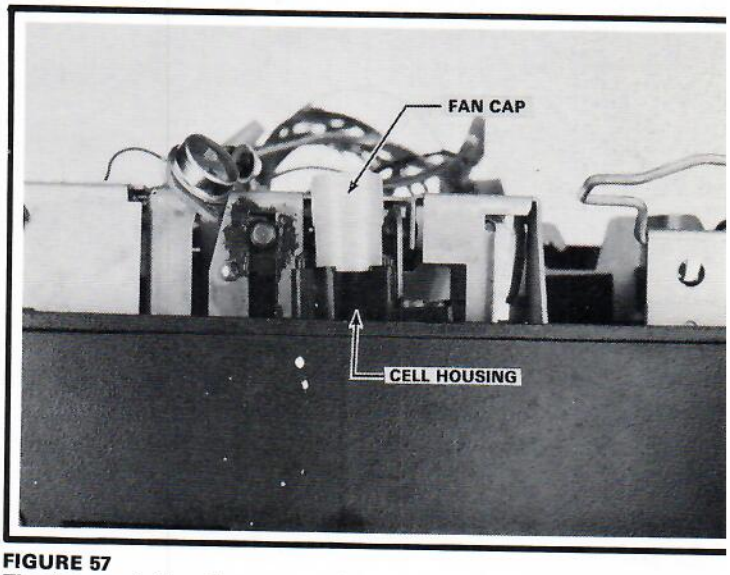


FIGURE 57
The fan cap is the alignment tool for adjusting the photocell housing position.

TEST YOURSELF QUIZ #6

1. The clutch lever and clutch can act electrically as a switch.

2. With a slide in the projection aperture, the autofocus motor drives continuously. out of alignment position could cause this problem. photocell bracket

3. To adjust the photocell position, use the fan cap as an alignment tool.

4. An S or C-shaped image should pass through the small hole in the fan cap when the photocell housing is properly adjusted.

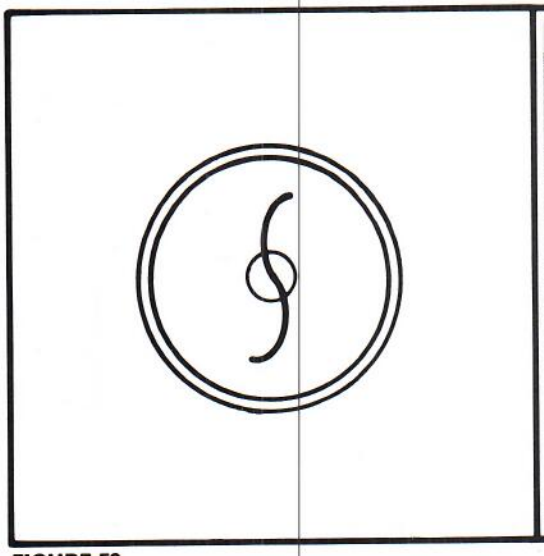


FIGURE 58
This is what the image should look like when the photocell housing is properly adjusted.

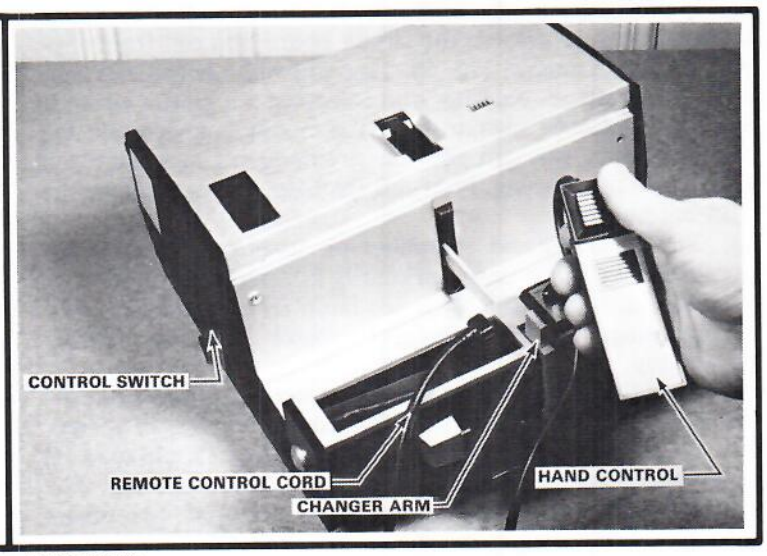


FIGURE 59

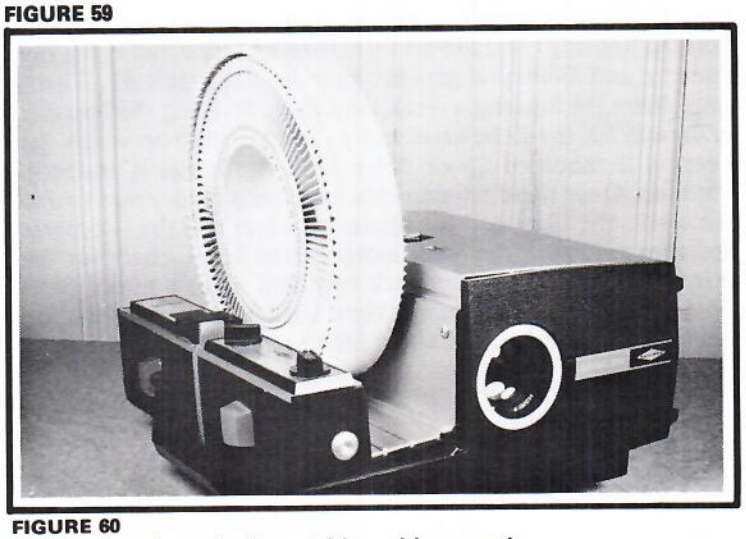


FIGURE 60
Changer arm in projection position with a round tray in place.

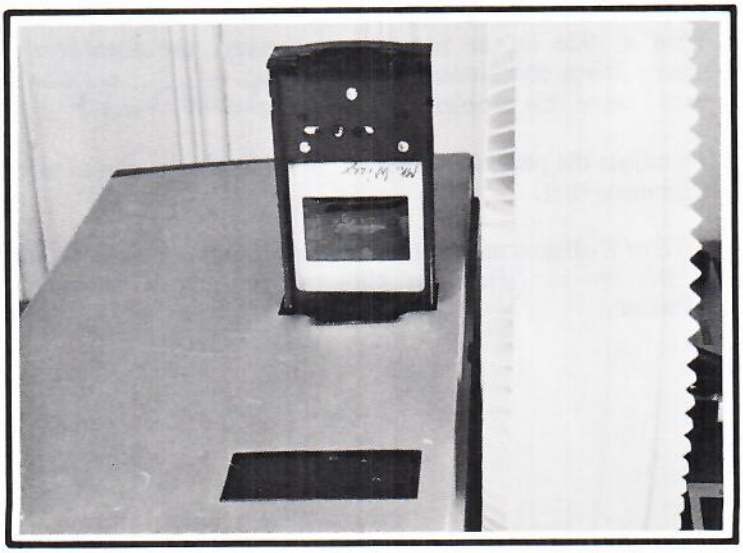
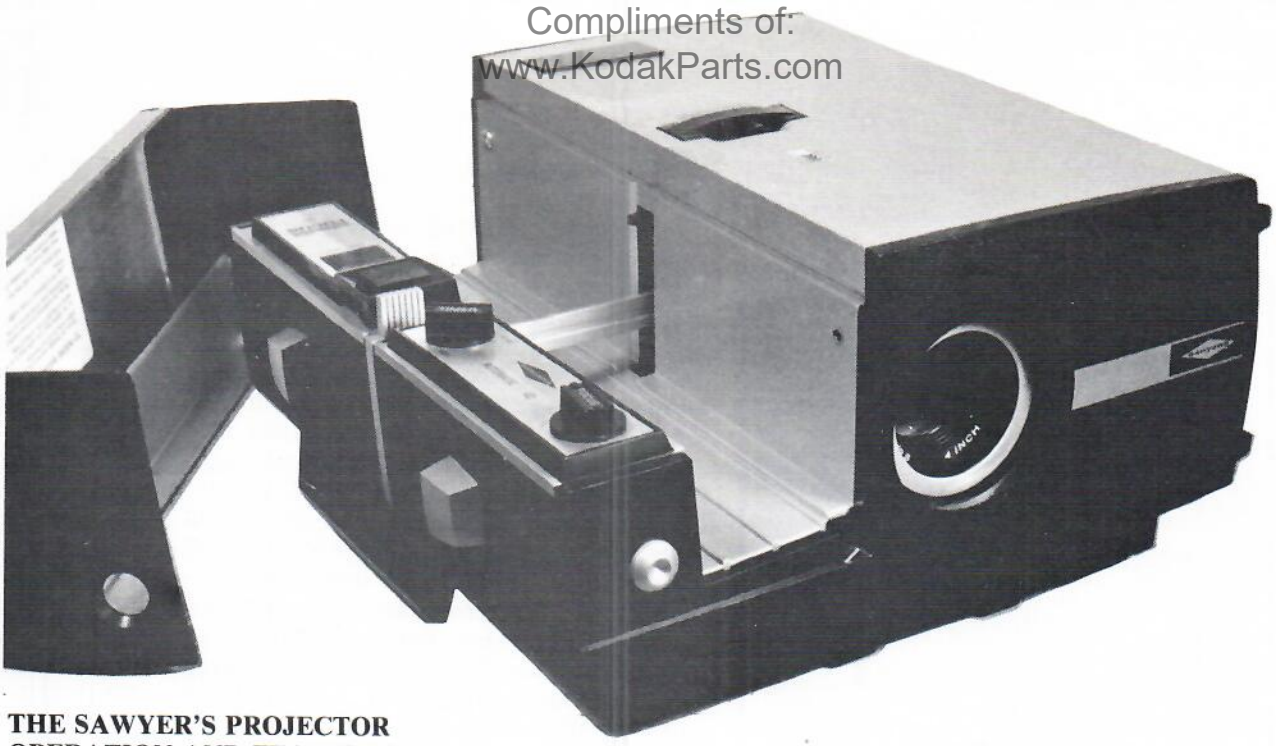


FIGURE 61



THE SAWYER'S PROJECTOR
OPERATION AND FEATURES

To prepare the projector for operation, first lift off the top cover. Do this by pressing in on the lock button at either end of the top cover and then lifting. This exposes the projector's tray guide and control panel. If the door covering the projection lens was closed, removing the top cover unlatched the lens door, which allowed the lens door to spring out of the way. Inside the top cover on the 747AQ is the remote control cord. On other Sawyer's projectors, both the remote control cord and power cord are stored inside the top cover; however, the power cord is on a spring operated reel on the bottom of the 747AQ. If the projector operator prefers, he can sit back away from the projector and still control the projector by using the remote control cord. The hand control snaps out of the projector's control panel, then the remote control cord links the projector to the hand control, Fig. 59.

Before a slide tray will fit into the tray guide, you'll have to extend the changer arm until the tray guide is unobstructed. Round trays drop into the tray guide from the top and are supported by two plastic tray guides, Fig. 60. Straight trays must be inserted through the front or rear opening to the tray guide.

Once the slide tray is in position, gently move the changer arm to its projection position. By manually operating the changer arm for the first slide, you'll avoid accidental damage to the first slide which could be caused by tray misalignment.

Now turn the switch on the back of the projector to the "Fan" position. In this position, all the projector's circuits except the lamp circuit will operate. Turning the switch to the "lamp" position, activates the lamp -- now you're projecting an image. If you had plugged a room light into the accessory outlet at the back of the projector, the room light would switch off as the projector lamp came on. So, use the focus control to adjust the projected image to its sharpest. Should the slide be in the projector backwards, or upside down, the pop-up editor will allow the slide to be conveniently positioned without having to remove the slide tray. Simply pull up the editor, Fig. 61, slip the slide out, correct the slide's position and then replace the slide in the editor. Pressing the editor back into the projector puts the slide back in the projector aperture. For addi-

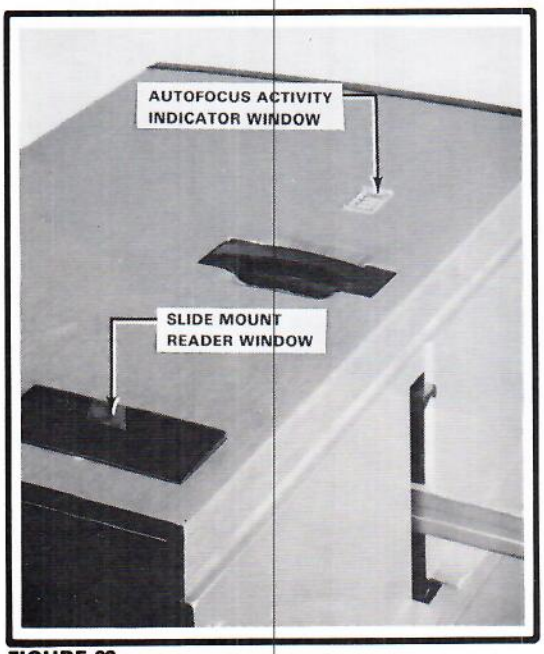


FIGURE 62

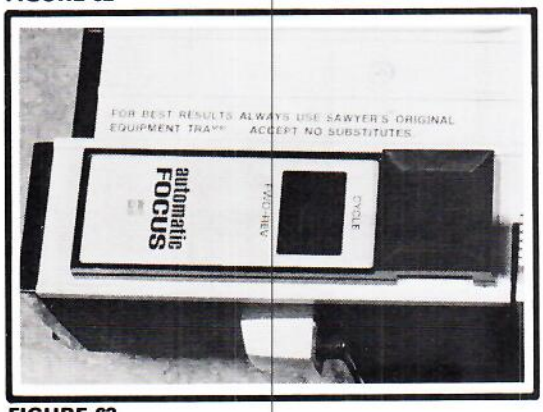


FIGURE 63
The "Cycle" and the "FWD-REV" buttons are used to control tray motion.

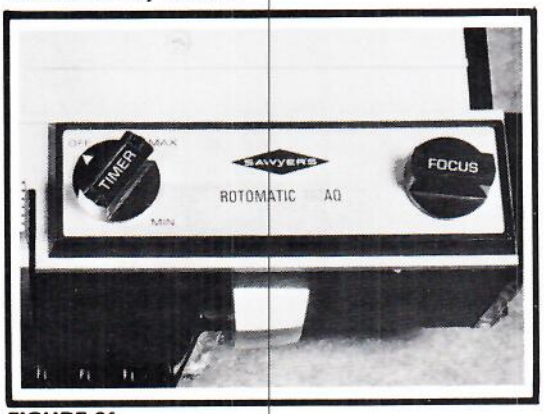


FIGURE 64
The 747AQ and other Sawyer's projectors have a built-in timer to allow them to show slides unattended.

tional editing, there is a small illuminated window in the back of the projector.

Once the projected image is in focus, it will remain in focus due to the built-in autofocus circuit. A window on the mechanism cover of the projector lights up to indicate that the autofocus circuit is operational. A moving pattern appears in the same window as the autofocus circuit restores proper focus, Fig. 62. Another window on the mechanism cover allows the projector operator to read information written on the slide mount, you can see this in Fig. 62 also.

Depressing the "Cycle" button will cause the projector to change slides. Depressing the "FWD-REV" button will cause the projector to switch the direction in which it is showing slides. If the projector is showing slides in a forward sequence, pressing the "FWD-REV" button causes the projector to change over to reverse-order projecting, but it doesn't cause the projector to change slides -- it still takes a touch of the cycle button to do that. Now the projector continues to show slides in reverse sequence until another touch of the "FWD-REV" button switches the projector to forward operation, Fig. 63.

The 747AQ can project slides unattended, too. By switching on the timer, Fig. 64, the projector operator can set the projector to show slides on a five second to thirty second interval.

Following projection, switch the projector to "lamp" and allow the fan to run for a moment or two so the projector can cool down. While the fan is running, cooling the projector, remove the slide tray. To remove the tray, pull out the changer arm, then lift out a round tray or push out a straight one.

DISASSEMBLY OF THE 747AQ

Begin disassembly by removing the slide tray, if one is installed. Now lift off the projector's mechanism cover, Fig. 65. If you're going to replace a condenser lens or the projection bulb, you'll have to lift out the lamp chimney-condenser assembly, Fig. 66. Notice that the condenser lens nearest to the projection lamp is green. This is because the heat absorbing glass is combined with the rear condenser. The heat absorbing glass/condenser lens is held in place by a spring clip. Should you need to install a replacement lens, the spring clip may be unhooked and slipped out freeing the lens. Some Sawyer's projectors use spring clips which are riveted to the chimney. In this case, rotate the clips aside to replace the condenser lens.

Most of your repairs will be more complicated than this, so let's proceed with the disassembly. First, snap out the hand control unit and then remove the four screws in the bottom of the tray guide. Then use a closed end wrench to hold the nut inside the projector at each end of the tray guide while removing the corresponding screws, Fig. 67.

Now the control deck and tray guide assembly is free. So, pull the changer arm all the way out and then lift the tray guide away from the projector. You'll have to be careful while doing this because the timer is still connected to the projector by three wires.

The projector we've used for our illustrations uses a **thermal timer** which relies upon a bimetallic strip and heating coil

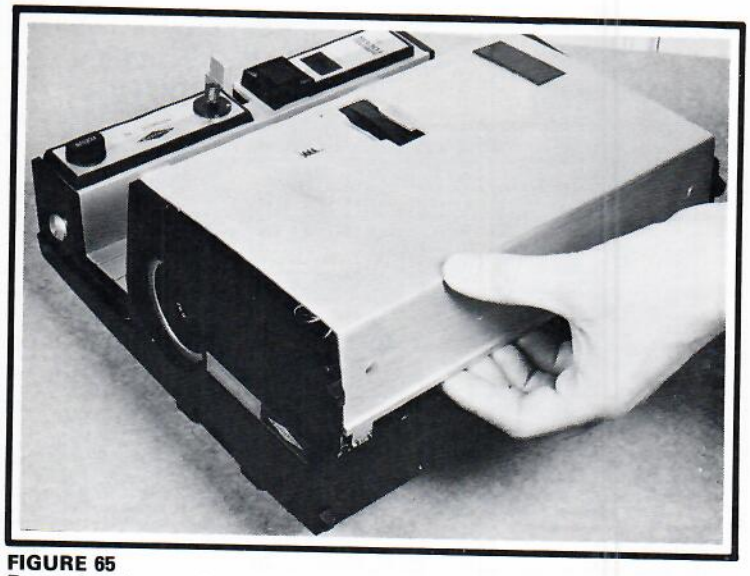


FIGURE 65
Removing the mechanism cover is the first step in disassembly.

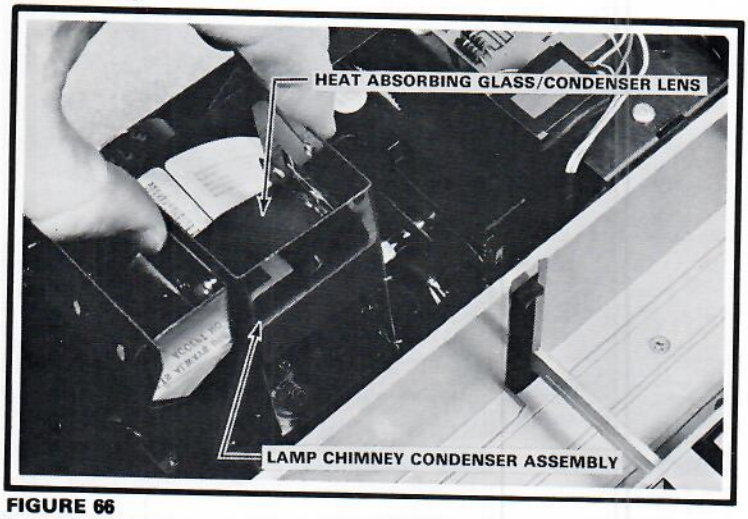


FIGURE 66

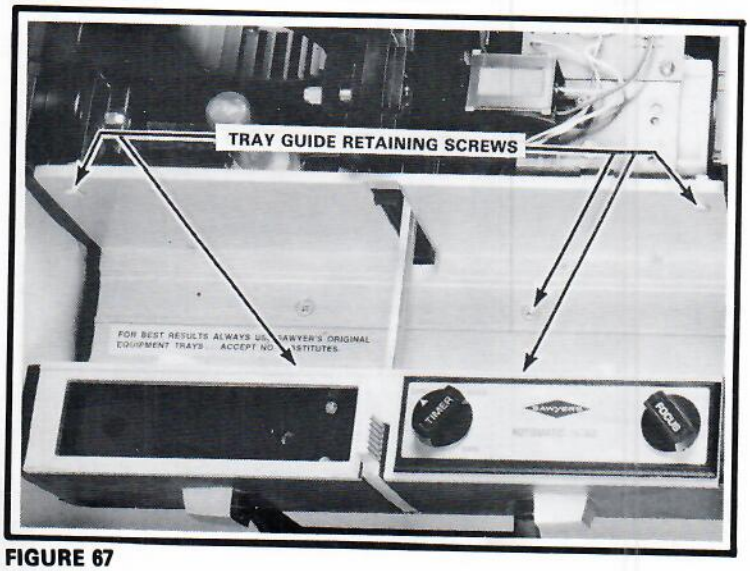


FIGURE 67
The Slide Projector

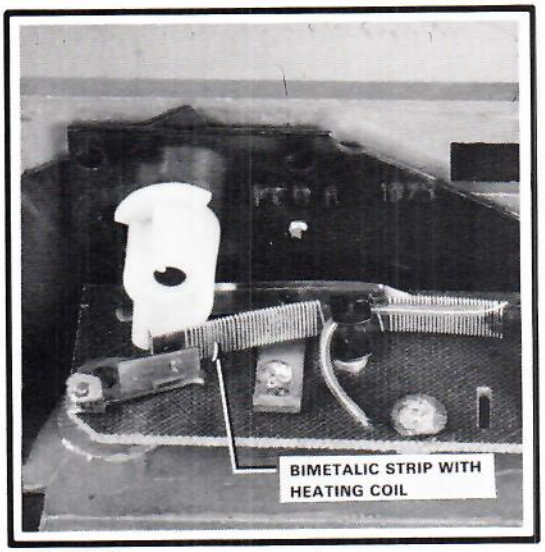


FIGURE 68
The thermal timer used in many Sawyer's projectors.

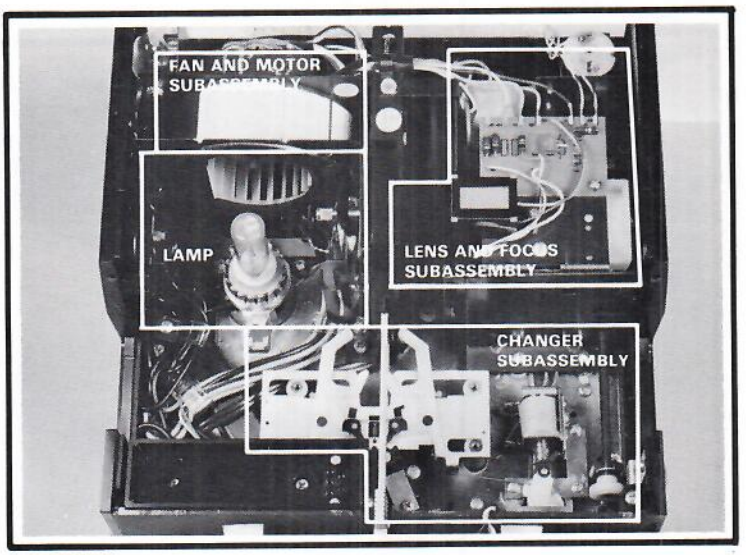


FIGURE 69
The Sawyer's mechanism is divided differently than the mechanism in the Carousel.

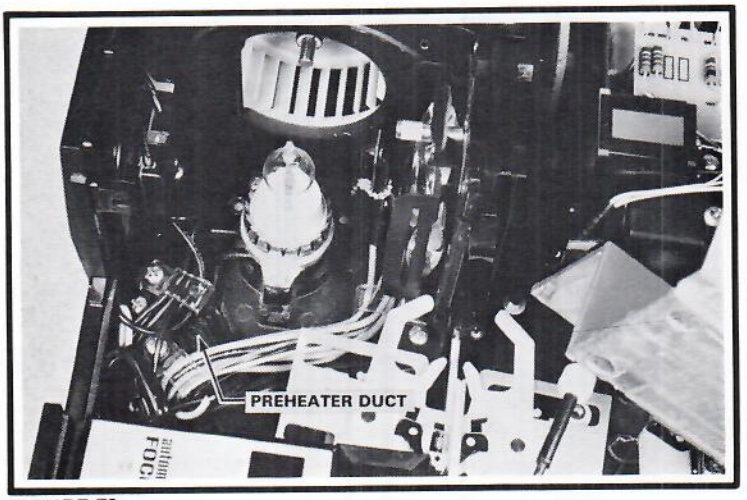


FIGURE 70

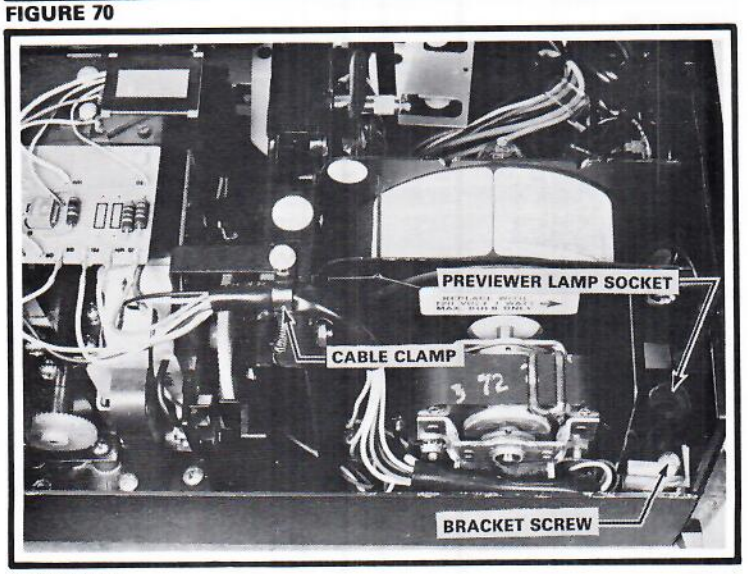


FIGURE 71

for its timing interval, Fig. 68. This is not the only timer used in Sawyer's projectors however, many Sawyer's projectors incorporate a solid state timer which uses an RC timing circuit to activate a transistor switch.

Now that the tray guide is out of the way, Fig. 69, you can see almost all of the projector's mechanism. This is the point of disassembly to which you would have to proceed for most routine cleaning and lubrication jobs. However, if a specific section of the projector requires more extensive repair, you'll probably find that additional disassembly is necessary.

One of the most often heard complaints about slide projectors is too much noise. More often than not the noise is being generated in the motor or fan area of the projector. Because motor-fan noise is so frequently a problem, let's look at this area of the Sawyer's projector first.

If you haven't removed the lamp-chimney condenser assembly, do so now. Notice that passing below the lamp-chimney condenser assembly there is an air duct taken from the fan cage. The fan pulls warm air from the lamp chimney and then diverts some of the air through the duct to preheat slides headed for projection, Fig. 70. Preheating the slides cuts the temperature change slides go through when they enter the projection gate. Since the slides are already warm, they have less tendency to "pop" in the gate.

Now, with the chimney out of the way you can see how the fan fits into its housing. Because of this "squirrel cage" fan design it's easy for the fan to move a little or warp and start to rub against the housing. Sometimes firm pressure applied to the fan housing is all that's needed to restore clearance. But, in some cases the noisy contact between fan and housing also slows the fan down and causes overheating. Overheating very often results in the fan impeller warping. Once the impeller warps, it will have to be replaced -- to do that the fan and motor must be removed from the projector.

Begin the disassembly for access to the fan by unscrewing the previewer lamp, then remove the screw from the previewer lamp bracket. Now, loosen the screw holding the cable clamp to the top of the changer arm housing and slip the cable from underneath the clamp. Now you can free the wiring held down by the previewer lamp bracket. Don't unhook this wiring. Just lift it out of the way for now, Fig. 71.

The rear plate of the fan housing is held by two screws to the projector base and by one additional screw to the changer arm housing. Remove these screws, then locate the motor-mount screw and remove it, too. Pull off the switch knob and remove the hex nut from the switch so that the switch can be removed from its bracket. Now free the handpiece socket by removing its two screws. Located beneath the handpiece socket and at two other points on the projector's baseplate are rear panel retaining screws, Fig. 72. Loosen these screws and slip the rear panel away from the projector.

Now locate the three long cotter pins which hold the fan frontplate and the backplate to the scroll. Straighten and remove the cotter pins but save them, as they'll be needed for reassembly. Pull the scroll key out and then gently slip the scroll from the fan housing, Fig. 73. Now you can lift the fan

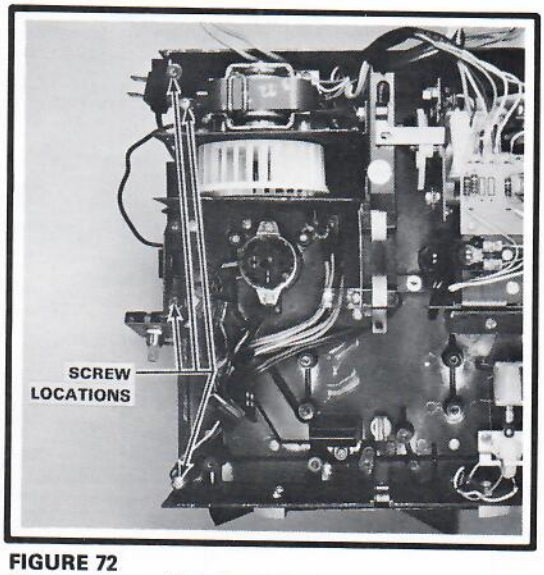


FIGURE 72
The locations of the rear panel retaining screws are shown with the rear panel removed for clarity.

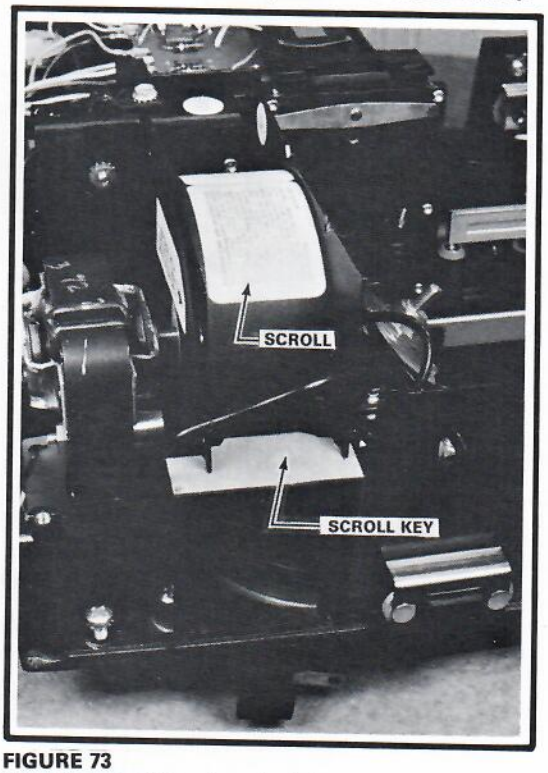


FIGURE 73
Once the scroll key is out of the way, you can remove the scroll.

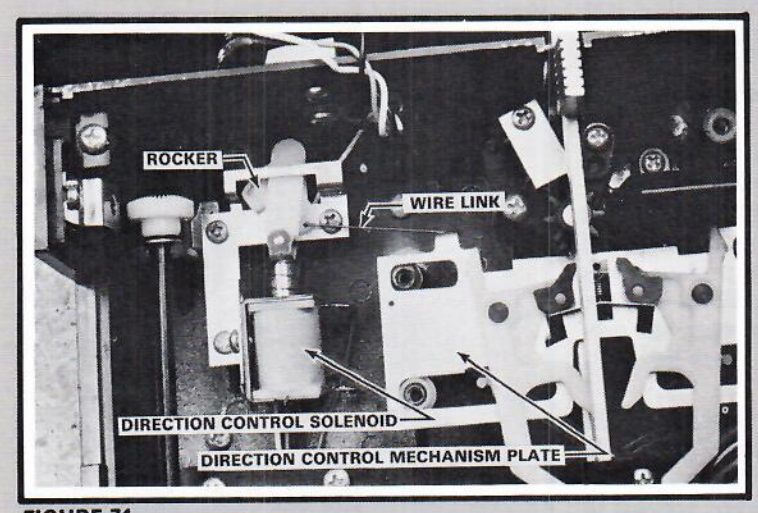


FIGURE 74

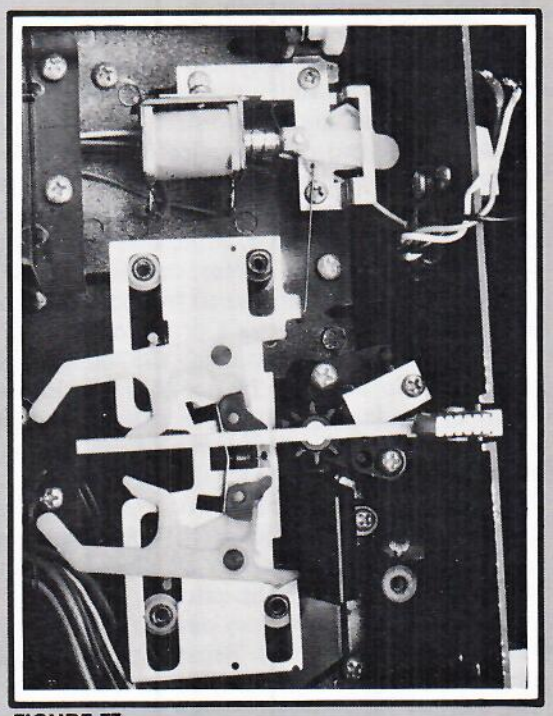


FIGURE 75
Here the direction control mechanism plate is in the forward motion position.

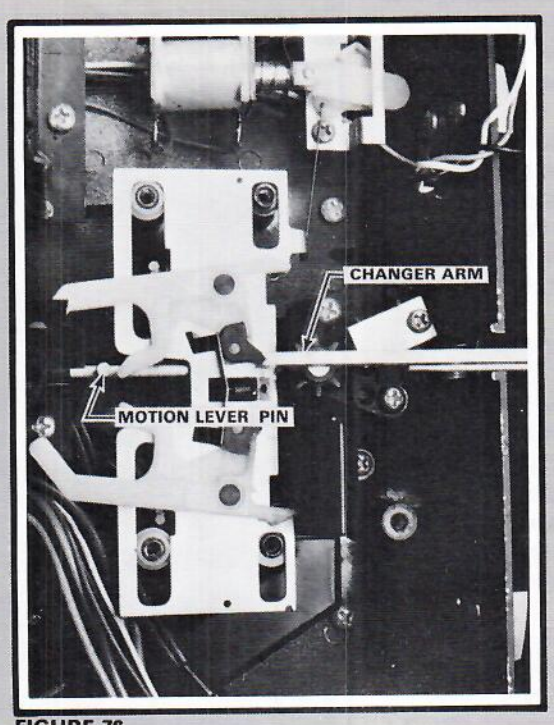


FIGURE 76

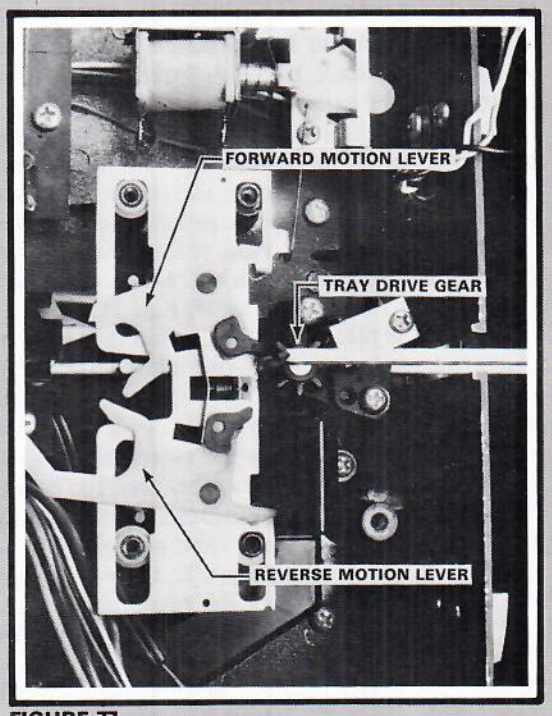


FIGURE 77

and motor assembly away from the projector. To remove the fan from the motor shaft, use a pair of retaining ring pliers to spread the fan retaining clip while slipping the fan off the motor shaft. If you need additional clearance or if the motor must be replaced, remove the wire connectors from the group of red, the group of white and the group of black wires which you lifted out from underneath the previewer lamp earlier, and separate the motor leads from their respective groups. Also pull the connectors for the orange, yellow, white and purple wires from the autofocus circuit board and slip them from their protective sleeve.

TRAY MOTION AND DIRECTION CONTROL

In order to see the operation of the tray motion and direction control mechanism, push the tray motion and direction control plate to either limit of its travel. Now, using your finger, pull in the armature of the **direction control solenoid.** Notice how the solenoid moves a rocker which shifts the direction control mechanism plate back and forth, Fig. 74. The projector operator controls the position of the direction control mechanism plate by applying power to the direction control solenoid. Each time the operator presses the "FWD-REV" button, its switch contacts close supplying power to the solenoid. The solenoid pulls in its armature which moves the rocker and shifts the position of the **tray-motion and direction-control-mechanism plate.**

Push the direction control mechanism plate all the way toward the rear of the projector, Fig. 75, this is the forward motion position of the plate. Now each time the changer arm is fully extended, a tray motion lever will move the tray drive gear one tooth, and each time the tray drive gear is moved a tooth the slide tray moves forward one slide. Let's see how this happens.

As the changer arm is extended, Fig. 76, it empties the projection aperture. Continuing its motion, the changer arm brings its motion lever pin into contact with the **forward motion lever.** Additional movement of the changer arm rocks the forward motion lever so that a tooth on it moves the **tray drive gear,** Fig. 77,78. Since the tray drive gear is coupled to the slide tray, the slide tray is advanced to the next slide. At this point, the changer arm has reached the limit of its outward travel.

Pushing the changer arm back in causes the motion lever pin to recontact the forward motion lever. This time the pin pushes the forward motion lever back toward its rest position. A spring which rests against the forward motion lever causes the lever to snap back into place, Fig. 79.

The forward motion lever doesn't move the tray drive gear while on its return trip because the tooth which operates the tray drive gear rocks and slips past the tray drive gear. Once it's past the tray drive gear, the tooth is pushed back to its drive position by the tray-motion-lever detent spring.

In reverse operation, the changer arm operates the **reverse motion lever** instead of the forward motion lever. This is accomplished by shifting the position of the tray-motion and direction-control-mechanism plate so that the reverse motion lever intercepts the motion lever pin on the changer arm. Otherwise, the action of the mechanism is the same in reverse as it is in forward operation.

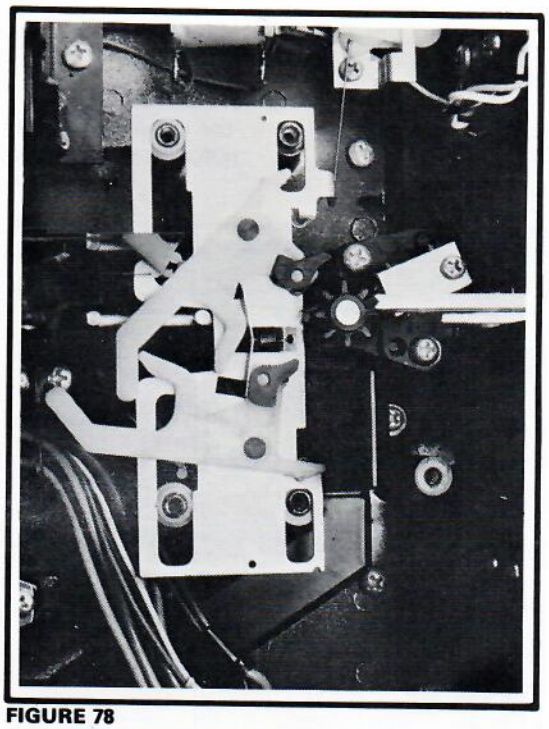


FIGURE 78

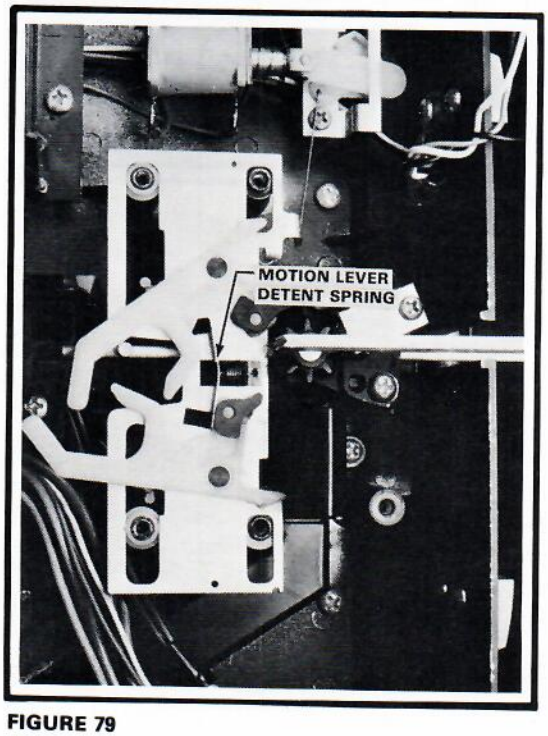


FIGURE 79

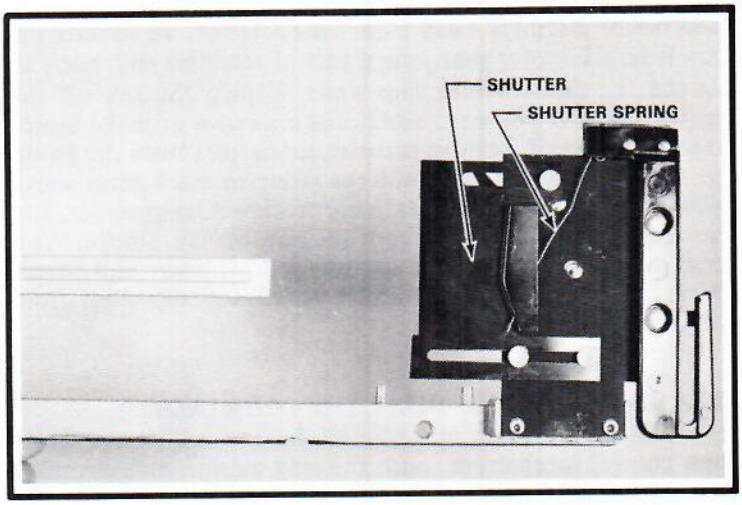


FIGURE 81
The complete changer arm removed from the projector.

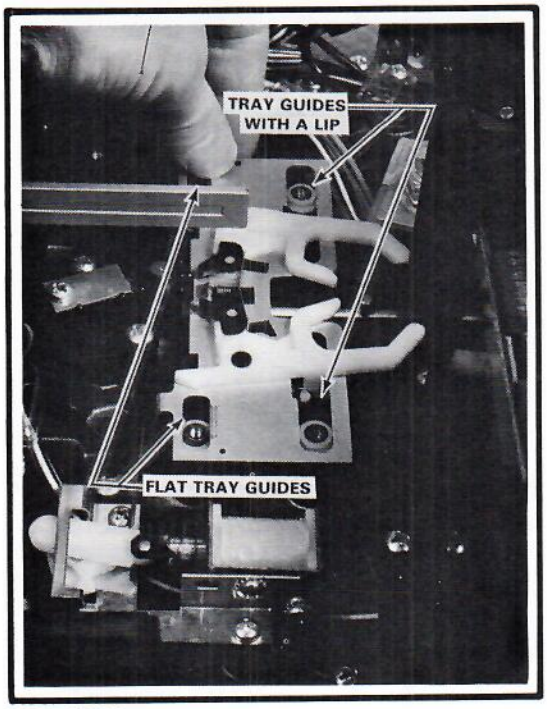


FIGURE 80

ARM AND SHUTTER

Next we'll remove and examine the changer arm and shutter assembly. To remove the assembly, first lift the tray-motion and direction-control-mechanism plate assembly off of its four locating posts and four plastic guides. Notice that two of the guides have a shoulder on them. These are the guides toward the center of the projector, Fig. 80. Once the tray-motion and direction-control-mechanism is out of the way, remove the two screws holding the tray drive gear plate in place. Then, lift the tray drive gear assembly out of the projector. The slide changer arm will now pull straight out from the projector.

Notice that the front side of the changer arm carries the projector's movable shutter, Fig. 81. The spring-loaded shutter is designed to close off the projection aperture while slides are being changed.

When the changer arm is fully extended, the movable shutter is pushed back along the changer arm. Then as the changer arm is moved back into the projector, the shutter is re-extended by its spring. Before we examine the operation of the changer arm, notice the **changer-drive-gear follower.** The changer-drive-gear follower is located on the innermost end of the changer arm, Fig. 82, and it's in the form of a flat surface and a slot which is controlled by a drive pin coupled to the changer drive motor.

TEST YOURSELF QUIZ #7

1. Unlike the Carousel Projector which has separate forward and rear motion buttons, the 747 AQ uses a FWD / REV and a cycle button for tray motion.

2. In the Sawyer's Projector, the condensor lens nearest the lamp is green. This is because the condensor doubles as heat glass.

3. A _____ editor allows changes to be made in a slide's position in the Sawyer's Projector.

4. In the Sawyer's Projector, the _____ area carries the shutter.

CHANGER ARM OPERATION

To see the operation of the slide ejector and changer-drive-gear follower, reinstall the changer arm being sure that the changer arm engages both its top and bottom guides. To limit the travel of the changer arm, replace the tray motion and direction control assembly. Now move the changer arm in and out. Notice that as the arm nears its fully extended position that the top of the slide ejector is intercepted and that this causes the free end of the ejector to move in the direction of the changer arm's travel, Fig. 83. This motion of the slide ejector clears the slide from the projection aperture and insures that the slide is fully inside of the slide tray before tray motion begins.

Now, let's examine the operation of the changer-drive-gear follower. First, push the changer arm in all the way. Notice, Fig. 84, that resting just above the opening in the changer-drive-gear follower is a pin coupled to the changer drive gear. When the changer arm is operated manually, the pin is above the slot so there is no interference, but when the

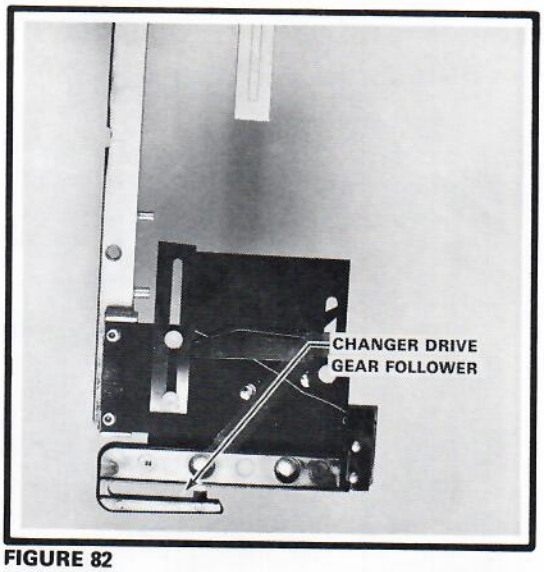


FIGURE 82

FIGURE 83
The slide ejector insures that each slide is completely removed from the projection aperture before the slide tray is moved to the next slide. Notice that the ejector swings faster than the travel of the slide changer arm.

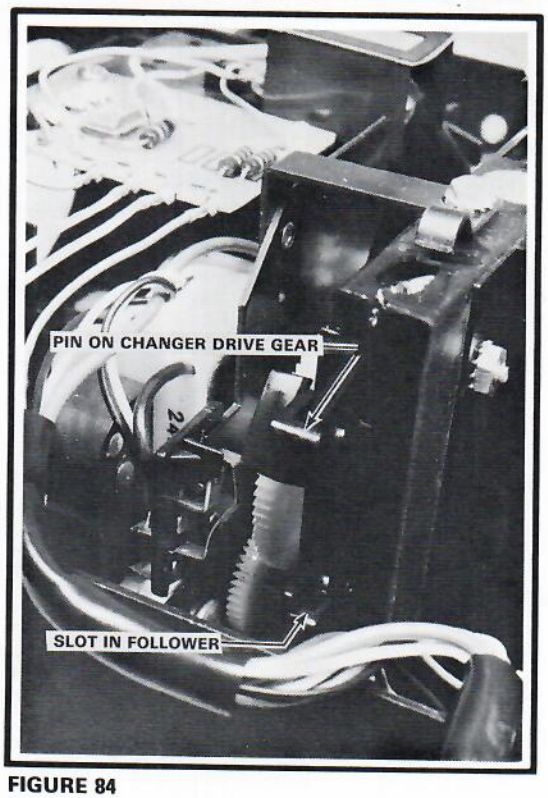


FIGURE 84

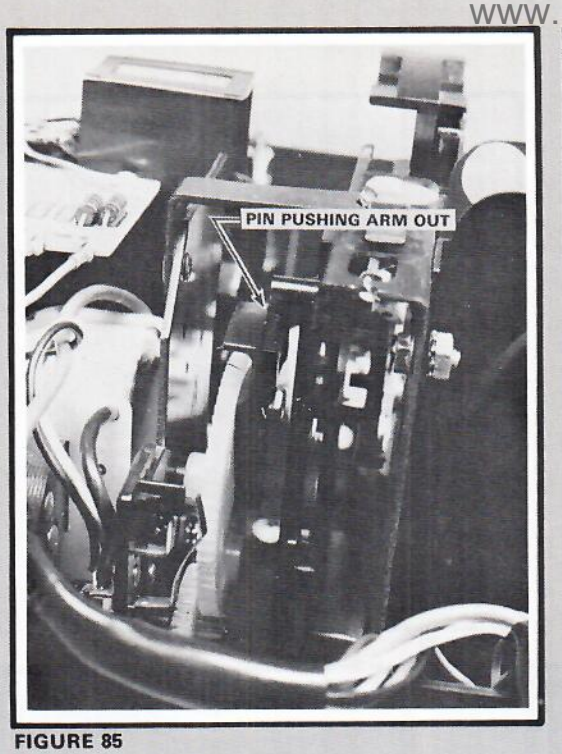


FIGURE 85

FIGURE 86

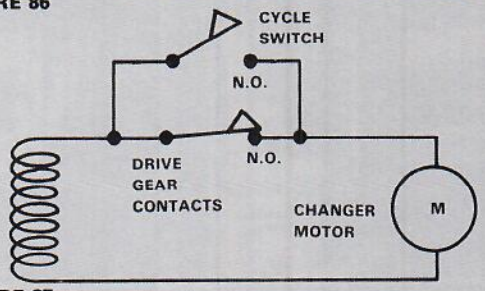


FIGURE 87

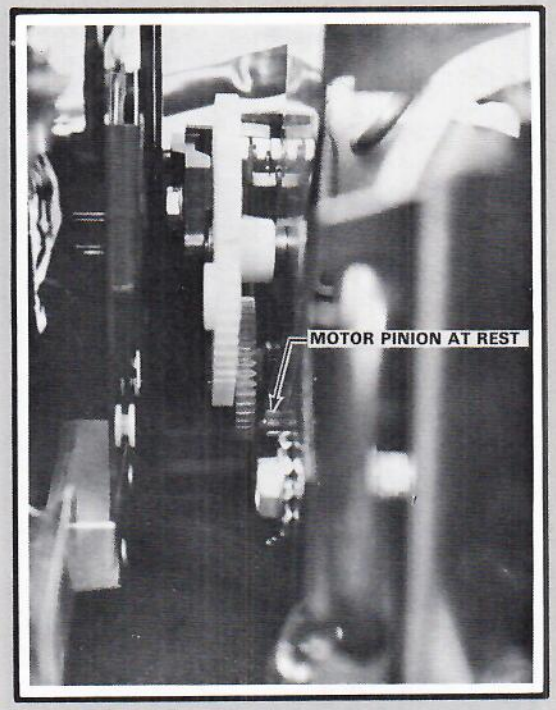


FIGURE 88
When power is removed, the pinion retracts.

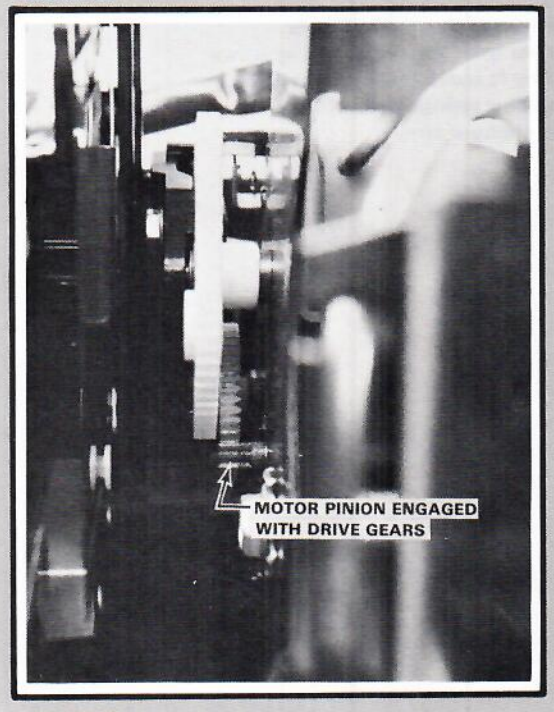


FIGURE 89
With power applied, the pinion extends engaging the drive gear.

projector's internal slide changing mechanism is used, the changer drive gear and pin operate the changer arm. To operate the arm, first the changer drive gear and pin push the arm out using the flat surface of the changer drive gear follower, then continuing its rotation, the pin picks up the slot in the follower and pulls the arm back to its rest position. You can see this in Fig. 85.

The drive gear would rotate the changer drive gear continuously except that each time the changer arm reaches its projection position, the drive gear breaks an electrical contact in series with the drive motor, Fig. 86. To initiate changer operation the projection operator, or the timer, momentarily supplies power to the drive motor. Externally this is done by pressing the "cycle" button. The "cycle" button bypasses the drive gear contacts long enough for the drive gear to rotate slightly, allowing the drive gear contacts to close. Schematically, the circuit looks like Fig. 87. Once closed, the drive gear contacts continue to supply power to the motor even though the projector operator is no longer depressing the cycle button. As soon as the projector has completed a slide change, the drive gear contacts are once again interrrupted and the drive gear motor stops.

To insure that the changer drive gear doesn't overshoot, the drive motor is made as a combination motor and solenoid. With power applied the armature is pulled into the motor frame. When the armature is in this running position,the motor gear engages the intermediate drive gear. As soon as power is removed from the motor, the armature spring pulls the armature out of the motor frame and so disengages the motor gear from the intermediate drive gear, Figs. 88, 89. Disengaging the motor gear at the end of each cycle prevents motor coasting from causing the changer drive gear to rotate too far and reclose the changer gear contacts, starting a new cycle.

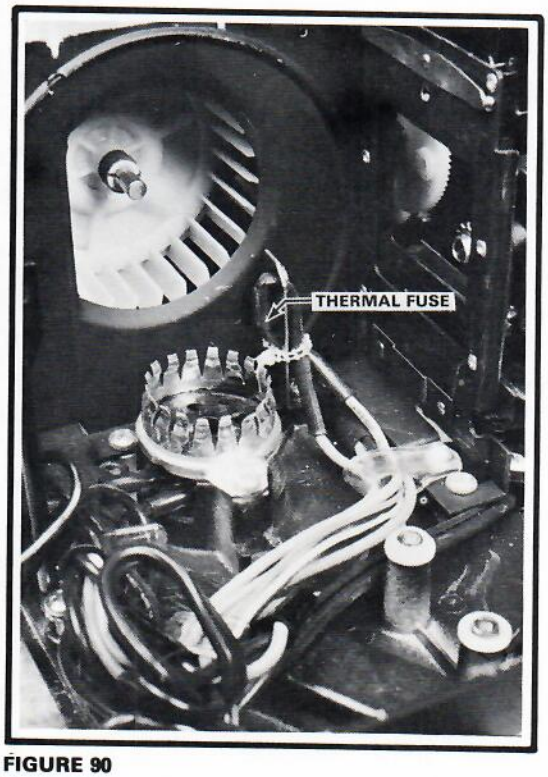


FIGURE 90

CHANGING THE THERMAL FUSE

In order to protect the projector from overheating, a thermal fuse is wired in series with the projector. The thermal fuse is designed to open and remove power from the projector if the projector's internal temperature goes too high. In the 747AQ, the thermal fuse is located close to the lamp socket, Fig. 90. If the thermal fuse blows, it must be replaced, not bypassed. To remove the thermal fuse, first trace its leads back to where they are connected to the line cord and to the switch. Remove the twisted on wire connectors fastening the leads and pull the fuse's leads free. Then replace the wire nuts temporarily. Pull the leads from their plastic clamps back to where the fuse is fastened and then remove the fuse bracket. Remove the old fuse from the bracket and replace it with the new fuse. Then reroute the wiring finally reconnecting the leads and re-mounting the fuse bracket.

Although replacing the fuse will restore the projector to operation, the repair may only be a temporary one. Unless operator carelessness was the cause of the fuse's blowing, you'll need to find out why the projector overheated and correct the problem before you consider the repair complete.

To see the mechanics of Sawyer's autofocus mechanism, the front panel must be removed. Four screws hold the front panel; their location is shown in Fig. 91 with the front panel

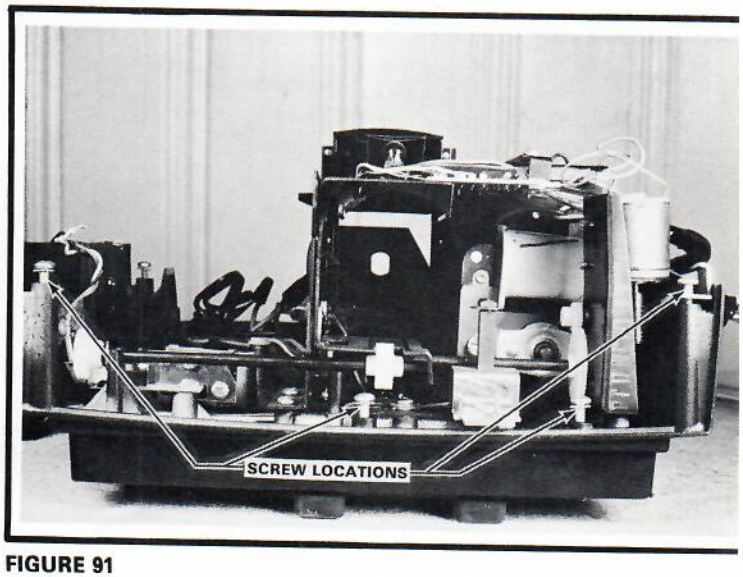


FIGURE 91

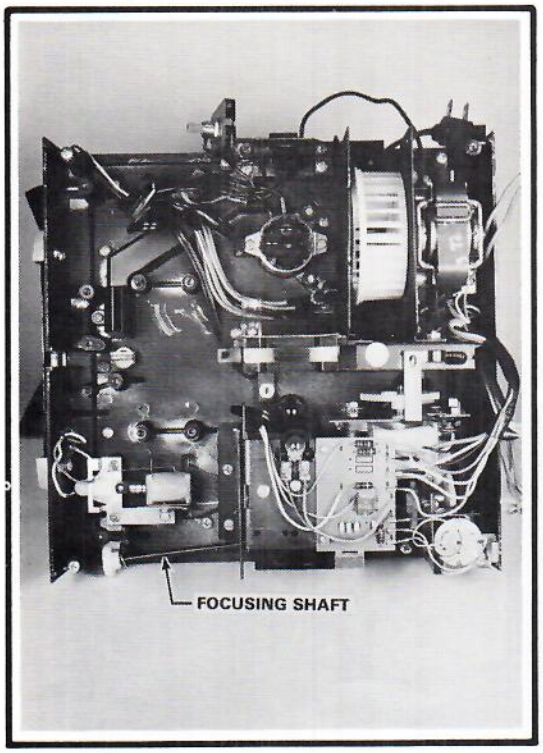


FIGURE 92

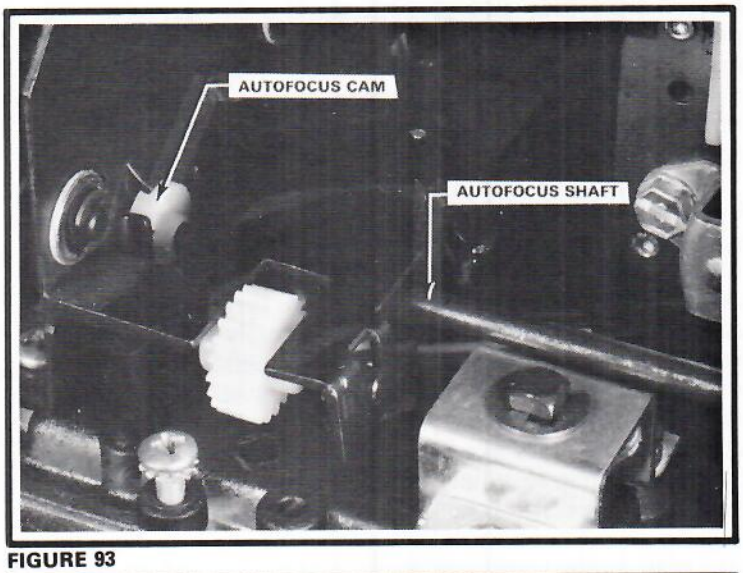


FIGURE 93

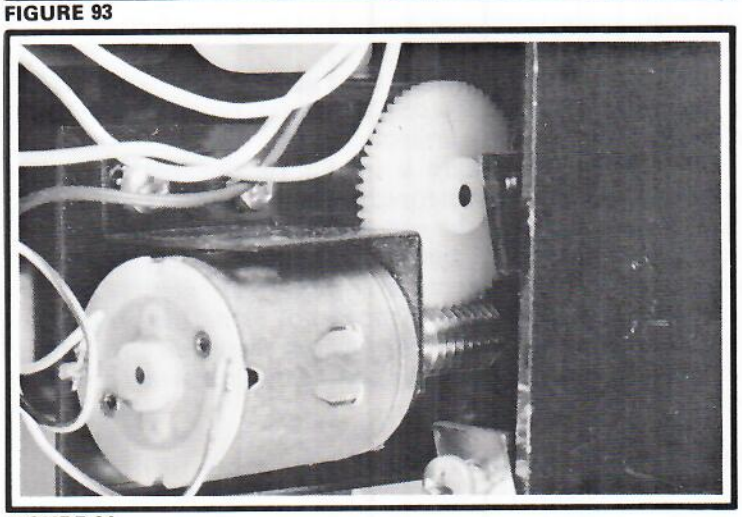


FIGURE 94

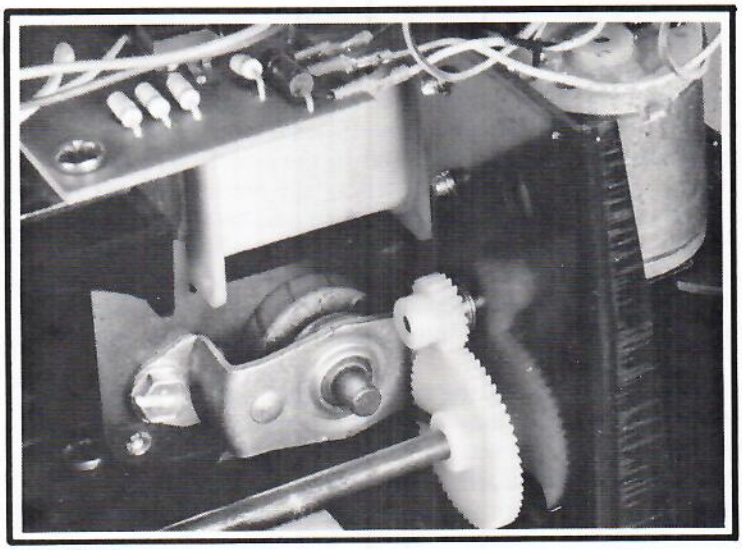


FIGURE 95
Reduction gearing used to drive the autofocus shaft.

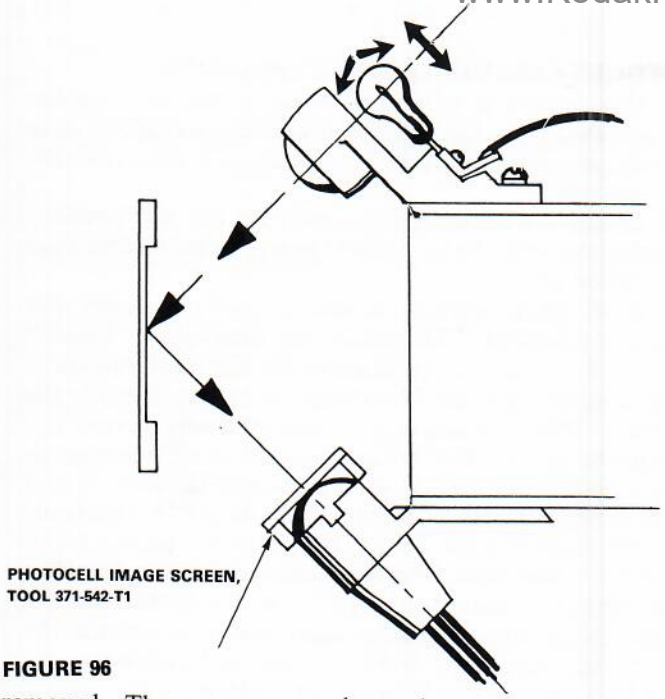


FIGURE 96

removed. These screws need not be removed in order to remove the front panel as the panel mounting tabs are slotted to allow the panel to be slipped off. (Also pull off the elevation lock button at this time so it won't be lost.)

Notice the focusing shaft running across the front of the projector, Fig. 92. The focusing shaft is used to drive the lens through a rack which is part of the lens housing. On its focus knob end, a bevel gear engages a second bevel gear on the focus knob shaft. So rotating the focusing knob moves the lens back and forth on the lens mount.

When the autofocusing circuit comes into play, the entire lens mount moves carrying the lens with it. This is accomplished through the autofocusing shaft, Fig. 93, which rotates an eccentric cam in a cutout in the mount. In turn, the cam shifts the entire lens mount back and forth for autofocusing operation. In order to have sufficient torque to shift the lens mount, the autofocus motor is geared down, Figs. 94, 95. As the lens mount moves during autofocusing, the housing shaft used for manual focusing pivots at its bevel gear end to follow the mount's motion.

ADJUSTING THE SAWYER'S AUTOFOCUS

A special adjusting screen which fits over the autofocus photocell is necessary in order to set the position of the autofocus and photocell to factory specifications. This tool, #371-542-T1, is used much the same way as the Kodak test slide, Fig. 96. To use the tool you'll need to have a slide in the projection aperture. A good quality cardboard mounted slide will work, or you can use Sawyer's "test slide B."

With a slide in the projection aperture, turn the projector on to "Fan" and allow the autofocus circuit a moment to stabilize, then disconnect one autofocus motor lead. Now you can establish proper lamp position by adjusting the lamp bracket and the lamp until the filament image is positioned properly on the adjusting screen, Figs. 97, 98. Finally, reconnect the autofocus motor and then project a group of slides to establish that the autofocus mechanism is operating correctly.

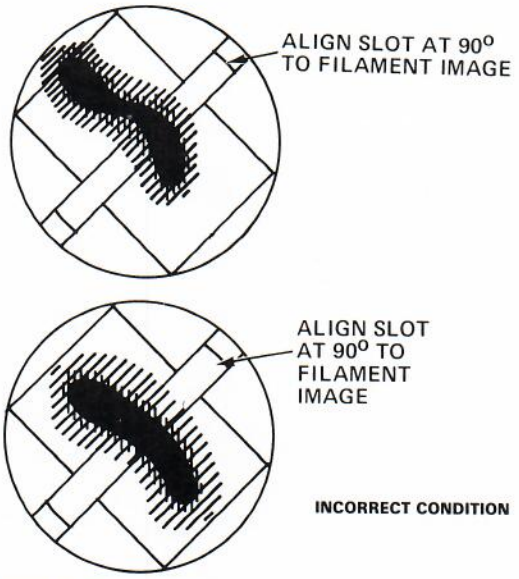


FIGURE 97

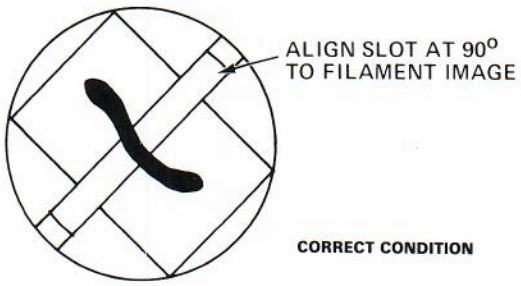


FIGURE 98

AUTOFOCUS CIRCUIT TROUBLESHOOTING

If, after alignment of the autofocus system in either the Kodak or Sawyer's projector, the autofocus mechanism does not operate properly there may be a problem in the autofocus circuit.

Of course it's impossible to cover all the malfunctions which could occur in the autofocus circuit, so we'll cover only some common problems.

A small direct current motor is used to power the autofocus mechanism. This motor can wear out or become dirty and fail. Check the operation of the Carousel autofocus motor by connecting a variable voltage DC power supply to the motor leads. Then, starting at zero volts gradually increase the voltage to the motor. The motor should start up smoothly as you're increasing the voltage. Do not exceed 12 volts.

Use a similar procedure for the Sawyer's autofocus motor, only do not exceed 3 volts. Be sure to try running either motor in both directions. That is, repeat your motor test with the leads from the power supply reversed. Remember that the autofocus motor must operate in both directions when in the projector. Any hesitation, shaking or uneven running may indicate a faulty motor which should be replaced.

Sometimes a component on the autofocus circuit board will fail, most often this is a diode and the symptom of failure is either the motor runs continuously or the motor won't run in one direction. Because a misaligned autofocus lamp or photocell can also create the same symptoms, make sure that the autofocus lamp and cell are correctly positioned before attempting circuit repairs.

If you are checking for a faulty diode, you must disconnect the diode from the rest of the circuit. Do this by unsoldering a diode lead from the circuit. Leaving the diode connected to the circuit can make your test results meaningless. Check each diode with a VOM; you should read a fairly low resistance in one direction and a high resistance in the other. In addition, all the diodes should give similar readings. A diode which reads low in both directions, high in both directions or gives a reading a lot different from the other diodes should be replaced. You can probably find a replacement diode at an electronic parts store. The replacement should be rated at least 75 PIV at 1 amp.

If your motor is good, and your diodes test good, it could be the SCR causing trouble. An SCR may be tested with an ohmmeter, too. You'll find an SCR testing procedure in your lesson "Semiconductor Electronics-2." A bad SCR will probably require a manufacturer's replacement although you may be able to locate a replacement using the code number on the SCR. Other components of the circuit may be tested and compared against their marked values if necessary -- or you may prefer to replace the entire circuit if components are suspects.

CLEANING AND LUBRICATION

Some of the most common slide projector repairs are those requiring cleaning and relubrication. We've already covered motor bearings earlier in the lesson, so now let's take a look at the other bearing areas in a projector which must be clean and properly lubricated in order to operate correctly.

Cleaning a projector is not difficult as flush cleaning is applicable to most projector mechanisms. In general, a flush

cleaning should remove accumulated dirt along with any surface grease or oil. If you're careful, you can flush clean without having to relubricate. When a more thorough cleaning is needed, it's probably best to disassemble the area to be cleaned, then clean and relube.

Selecting a lubricant for use in a slide projector requires different considerations than selecting a lubricant for a camera. There are several reasons for this: slide projectors get hot, projector bearings are high load bearings and projector bearings often operate continuously. For these reasons and others, most projector manufacturers recommend their own oils and greases. However, in many cases commonly available lubricants work as well as the manufacturers'.

Here are the common types of bearing surfaces found in projectors and some general lubrication suggestions: Where oil is called for a 10 or 20 weight non-detergent motor oil may be used. A suitable grease for most projector applications is Plastilube #1, available from Eastman Kodak. Other oils and greases work, too, just be sure that they will provide lubrication when the projector gets hot.

LUBRICATE		LUBRICANT	QUANTITY
ROTATING BEARINGS	Motor Bearings	oil	2 or 3 drops
	High Speed Bearings	oil	2 or 3 drops
	Plastic on Metal	grease	light coat
	Plastic on Plastic	grease	light coat
SLIDING BEARINGS	Plastic Cam Surfaces	grease	light coat
	Plastic on Metal	grease	light coat
	Plastic on Plastic	grease	light coat
	Metal on Metal	grease	light coat
GEARS	Plastic, Low Power	oil (none)	light coat
	Plastic, High Power	grease	light coat
	Plastic, High Speed	oil	light coat
	Metal	grease	light coat

A firm brush about 1/4" wide works well for applying a light coat of either oil or grease. If you don't have a brush, there is nothing wrong with using your finger as an applicator -- it's just messier.

Bearings requiring packing haven't been included in the table. A bearing which should be packed will be one which has a cavity to hold grease as well as a bearing cover to keep the grease in and dirt out. An example of this type of bearing is the fan shaft bearing in the Carousel projector.

You will encounter plastics and plastic bearings in projectors. In general the plastic won't be harmed by either grease or oil; however, you'll have to be careful with some cleaning solutions. Cleaning with acetone, methyl ethyl ketone, ether and some solvents can severely damage many plastics.

The vinyls, like PVC, which are often used for electrical insulation are not affected by most lubricants or cleaners, but because leaving excess oil or grease on insulators will trap dust and dirt, it's a good idea to be careful when working around insulation.

A final caution concerning a particular plastic: you may encounter TFE bearings in projectors. TFE is the generic name for plastics like Teflon, which is made by DuPont. Most often these bearings will be a misty white color. TFE bearings are designed to be self lubricating, so using a lubricant is unnecessary, although an oil or grease won't damage the TFE bearing. But as a rule of thumb, a TFE bearing should be left dry. This is because the use of TFE indicates that a sticky oil or grease in the bearing could be a trouble causer.

TEST YOURSELF QUIZ #8

1. Shutter oil is not suitable for use in a slide projector due to high heat. A good oil to use is _____.

2. In general, a light coating of lubricant is better than a heavy deposit because there is less sticky lube around to pick up dust and dirt. One useful tool for applying a light coat of lube is _____.

3. When cleaning areas with plastic parts in or near them, you'll have to be careful if you're using solvents like acetone because _____.

4. TFE bearings are designed to be self-lubricating and in general should be left alone. This is because the use of a TFE bearing indicates that _____.

This wraps up our coverage of slide projectors. We haven't covered every model of projector. We haven't done a complete disassembly of a projector or tried to provide complete troubleshooting information. Rather, we've tried to provide you with a general understanding of slide projectors which you can apply and add to.

SUMMARY

Most slide projector repairs require an understanding of the fundamentals of slide projector operation. Because of the wide variety of different mechanisms in use, learning one or two projectors is of limited value. Rather, understanding the sequence of operation of projectors, the functions of the tray, tray guide, shutter, lamp, heat-absorbing glass and the other projector parts will enable you to analyze a projector mechanism and repair it due to your understanding of it. Likewise, the autofocus circuits in common use in slide projectors are all different, however, the operating principle behind the circuits is the same between makes. So understanding how an autofocus mechanism is designed to operate should help you to repair an unfamiliar circuit.

You can break most projectors down into an illumination system, a condenser system, a cooling system with motor, a slide changer and a focusing system which may include autofocus components. This systems package is designed to project the image in a slide onto a screen. The projected image must be bright and sharp and the slides must not be damaged during the projection. Since most of the problems with projectors are associated with a breakdown in the cooling system, you should pay particular attention to the cooling system in a projector.

In terms of reliability, proper lubrication of a projector is very important. While there are very few hard and fast rules for lubrication, there are some important "don'ts." The lubrication used in a projector must be suitable for use in high-heat areas. In this sense, shutter oil and some light greases can cause a problem, so it's better to use an approved lubricant in a projector than to use a lube you are uncertain of at high temperatures.

Overall, projectors are relatively high-powered mechanisms and must be treated as such. They need appropriate care and lubrication for their intended use, they must be kept clean and be operated correctly. If you pay attention to the proper maintenance and proper operation of a projector, it will operate correctly for long periods of time.

SUMMARY

ANSWERS TO TEST YOURSELF QUIZZES

QUIZ #1

1. Internal blackening of a projection bulb which has burned out indicates **normal life.**

2. Two advantages of halogen lamps are **longer life** and **greater light** output.

3. Because the **higher heat** of the halogen lamp can cause damage to the projector very quickly.

4. Extra care is necessary when handling heat-absorbing glass because of the glass **high internal stress.**

ANSWERS

QUIZ #2

1. **Life lubricated,** oil impregnated bearings are used in most projector motors.

2. Use **10 to 20 weight, non-detergent motor oil** to relubricate projector motor bearings.

3. **Additional coils** on the motor are used instead of a separate transformer.

4. Motor driven focus is made easier through the use of **rack and pinion focusing.**

QUIZ #3

1. **Two CdS cells in a single housing** are used in most autofocus systems to detect slide position.

2. A **motor control circuit** and a **position sensor circuit** make up an autofocus circuit.

3. An **SCR and four diodes** are the solid state components of a basic autofocus circuit.

4. A **direct current** motor is used to focus the lens in autofocusing projectors.

QUIZ #4

1. If the SCR in an autofocus circuit was shorted on, **the motor would not turn,** but it might vibrate due to the alternating current passing through it.

2. If the SCR in an autofocus circuit has burned out and won't conduct current, the **autofocus motor will not turn** because there is no current path through it.

3. If a diode shorts, **the autofocus motor will turn continuously in one direction.**

4. If a diode opens up, **the autofocus motor will turn in only one direction.**

QUIZ #5

1. Leaving cords in their storage compartment in the Carousel will result in the projector **overheating.**

2. The Carousel depends upon its **rotating cam stack and a solenoid** for its mechanical operation.

3. A **thermal fuse** will blow if the internal temperature of a Carousel projector gets too high.

4. In **half cycle operation** the tray motion cam follower tracks a smooth cam.

QUIZ #6

1. The clutch lever and clutch spring form an **electrical switch.**

2. Continuous operation of the autofocus motor can be the result of an **out of alignment photocell bracket.**

3. Photocell position is adjusted using the **fan cap** as an alignment tool.

4. When the photocell housing is properly adjusted, an S or C shaped image will pass through the **small hole** in the fan cap.

QUIZ #7

1. The 747AQ uses a separate **FWD/REV** and a **CYCLE** button to control tray motion.

2. The green condenser lens in a Sawyer's projector is also the **heat-absorbing glass.**

3. A **pop-up editor** allows for slide editing in the Sawyer's projector.

4. It's the **changer arm** that carries the shutter in a Sawyer's projector.

QUIZ #8

1. A suitable oil for use in slide projectors is a **10 to 20m weight, non-detergent motor oil**

2. To apply a light coat of lube, **a brush** works well and **a finger** will do, too.

3. You must be careful when working with solvents in a projector because a great **many plastics which are used in projectors are harmed by acetone** and other solvents.

4. When you encounter a TFE bearing this indicates that **a conventional, lubricated bearing was not suitable** in the bearing area.

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SLIDE PROJECTOR QUIZ

Name Mel Chow

No. 114-57 Grade ~~50%~~ 65%

1. The purpose of condensers in the optical system of a projector is to:
   A. Store an electrical charge for the flash.
   B. Remove stray light from the projector.
   C. Direct light from the lamp to the slide.
   D. Absorb heat before it gets to the lens.

2. One noticeable characteristic of a projection lamp which has burned for its full rated life is:
   A. The bulb is cloudy white inside.
   B. The bulb envelope is clear, but there is a tiny break in the filament.
   C. A bulge has started to form on the top of the envelope.
   D. There is internal blackening of the envelope and filament support.

3. Although halogen lamps have a very long life, they do eventually fail. Quite often the failure is the result of:
   A. Uneven evaporation and redeposition of the filament.
   B. The envelope reaching 250° C while the filament is at 1250° or higher.
   C. A halogen lamp's light output remains constant throughout its life because the envelope does not darken with use.
   D. Evaporation, combination, convection and redeposition.

4. In a projector using a shaded pole induction motor, fan noise could be the result of:
   A. A short circuit in the coil.
   B. Moderate wear of the motor bearings.
   C. An additional coil could be added to act as a transformer secondary.
   D. Use an ohmmeter to check for coil continuity.

5. The autofocus system in use in projectors is designed to:
   A. Perform the initial focusing of the projector accurately.
   B. Maintain proper focus of the projected image once it has been set correctly.
   C. Allow positive and negative pulses from the CdS cell to pass through the SCR and go to the focus motor.
   D. Turn off the SCR when the current flow through the SCR stops.

6. A current shunt is often added around an autofocus motor. The purpose of the current shunt is to:
   A. Increase the resistance of the autofocus motor circuit so that the autofocus motor runs slowly.
   B. Decrease the resistance of the autofocus motor circuit so that the autofocus motor runs faster.
   C. Allow current to pass through the motor in one direction only.
   D. Help prevent motor overshoot.

7. When you work on the Carousel and other projectors which contain heat absorbing glass you should remove the heat absorbing glass from the projector and then cover or wrap the glass. The reason for this is:
   A. Heat absorbing glass is easy to lose. By keeping the glass wrapped you will make it easier to find for reassembly.
   B. Heat absorbing glass can shatter without apparent reason. Keeping the glass wrapped is a safety precaution.
   C. Fingerprints can cause blackening of the envelope, however the fingerprints can be removed with ammonia and water.
   D. Heat absorbing glass is green in color and so absorbs some visible light in addition to infrared radiation.

8. Key to the operation of the Carousel projector is a part which rotates 360° per cycle of the projector. The rotating part is the:
   A. Slide tray
   B. Focus knob and lens
   C. The Forward and Reverse buttons
   D. The rotating cam stack.

9. In half cycle operation, the Carousel operates normally except that:
   A. The slide lifter arm doesn't remove the slide from the aperture.
   B. The tray motion lever pushes the slide tray to the next slide position.
   C. The tray motion cam follower is shifted to a smooth cam.
   D. Closed pressure pads in the aperture act as guides for the slide being removed.

10. The forward/reverse selector arm rocks its reverse end up for reverse operation of the Carousel. To accomplish this,
   A. The reverse contacts act as the switch for the solenoid.
   B. The clutch spring and cycle lever act as switch contacts for the solenoid.
   C. The solenoid is not used in obtaining reverse operation.
   D. The cycle lever is used to lock the solenoid into the reverse position

11. Before performing any adjustments on the autofocus system in the Carousel projector you should:
   A. Use a low wattage soldering iron to remove the photocell from its housing.
   B. Align axis #1 and #2 so that they line up with the fan cap hole.
   C. Check autofocus operation. If it's okay, no adjustment is necessary.
   D. Check for an S or C shaped image in the film plane of the projector.

12. Before a slide tray may be installed on a Sawyer's 747AQ projector,
   A. The projector must be switched on to the "fan" position.
   B. The changer arm must be extended.
   C. The autofocus window must show a moving pattern so you know the autofocus is working
   D. The "FWD/REV" button causes the projector to change over to reverse order projection.

13. The 747AQ uses a squirrel-cage type of fan, so if the fan is rubbing on its housing you can often reposition the fan slightly. However, if the fan has melted:
   A. You will have to replace the thermal timer.
   B. You should caution the projector operator about operating the projector without proper air circulation but leave the fan as it is.
   C. You will have to replace the fan.
   D. You will have to adjust the thermal fuse.

14. The selection of forward and reverse operation in the Sawyer's 747AQ is accomplished through the:
   A. Position of the tray motion and direction-control mechanism plate.
   B. Position of the changer arm and the forward motion lever.
   C. Position of the changer arm and the reverse motion lever.
   D. Spring which rests against the forward motion lever causes the lever to snap back into position.

15. The function of the slide ejector in the 747AQ is to:
   A. Allow the projector operator to edit slides during projection.
   B. Cause the shutter to close if there is no slide in the aperture.
   C. Break an electrical connection in series with the changer motor.
   D. Insure that slides are in the slide tray before the tray moves.

16. The type of design used in the Sawyer's slide changer might be susceptible to overshoot. To prevent this the Sawyer's projector:
   A. Uses a motor in which the armature is spring loaded.
   B. Has a switch in series with the motor to turn the motor off.
   C. Uses a "cycle" button to bypass the drive gear contacts.
   D. Engages the motor gear at the end of each cycle.

17. When you replace a thermal fuse in any projector, you cannot consider the repair complete until:
   A. You also replace the projection lamp and heat absorbing glass.
   B. You run the projector for a moment or two to see if it works.
   C. You return the projector to your customer and the projector doesn't come back for a redo.
   D. You determine what caused the fuse to blow and correct the problem.

18. By applying around 12 volts to the Carousel's motor, or 3 volts to the Sawyer's you can test the motor. If the motor doesn't work under these conditions,
    A. You should increase the voltage
    B. You should replace the motor.
    C. You should reverse the polarity of the power and try again.
    D. You should replace the autofocus circuit board.

19. Shutter oil is too lightweight for use in a slide projector. A good choice of oil for a projector would be:
    A. No oil -- oil is not suitable for use in projectors.
    B. 10 or 20 weight motor oil.
    C. Vegetable oil.
    D. An oil designed to cut rust.

20. Plastic bearings are sometimes used in projectors. These bearings are often made of plastics like TFE. When you encounter a TFE bearing, you should:
    A. Clean it with acetone, methyl ethyl keytone, ether or some other solvent.
    B. Lubricate it with a heavy grease to give it damping properties.
    C. Leave grease or oil around the bearing to trap dust and dirt.
    D. Leave the bearing unlubricated, as a general rule.