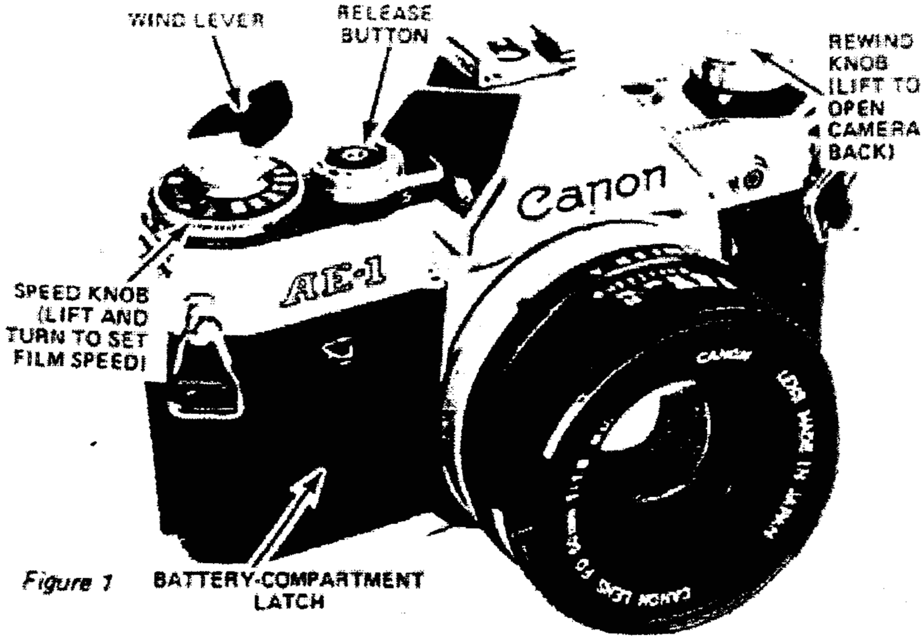


Figure 1

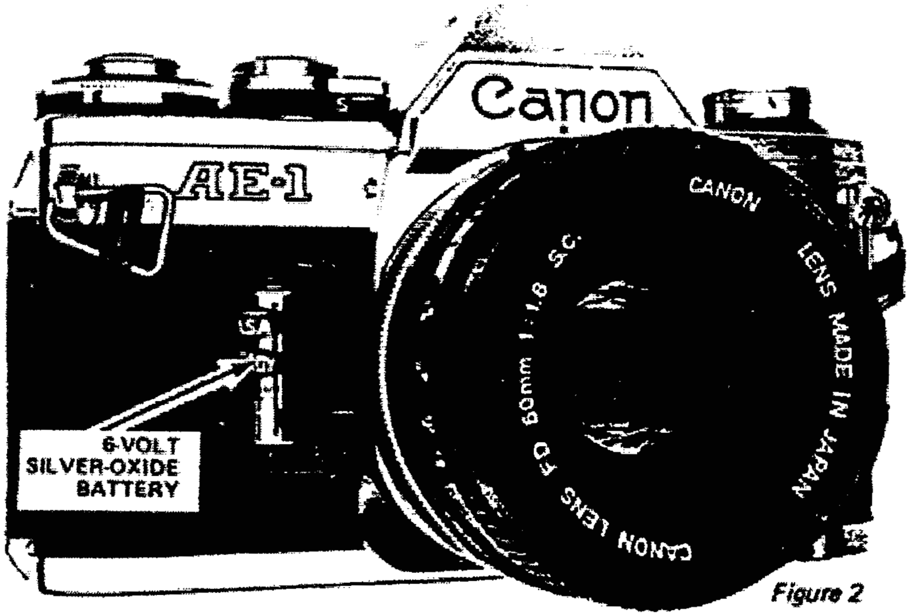


Figure 2

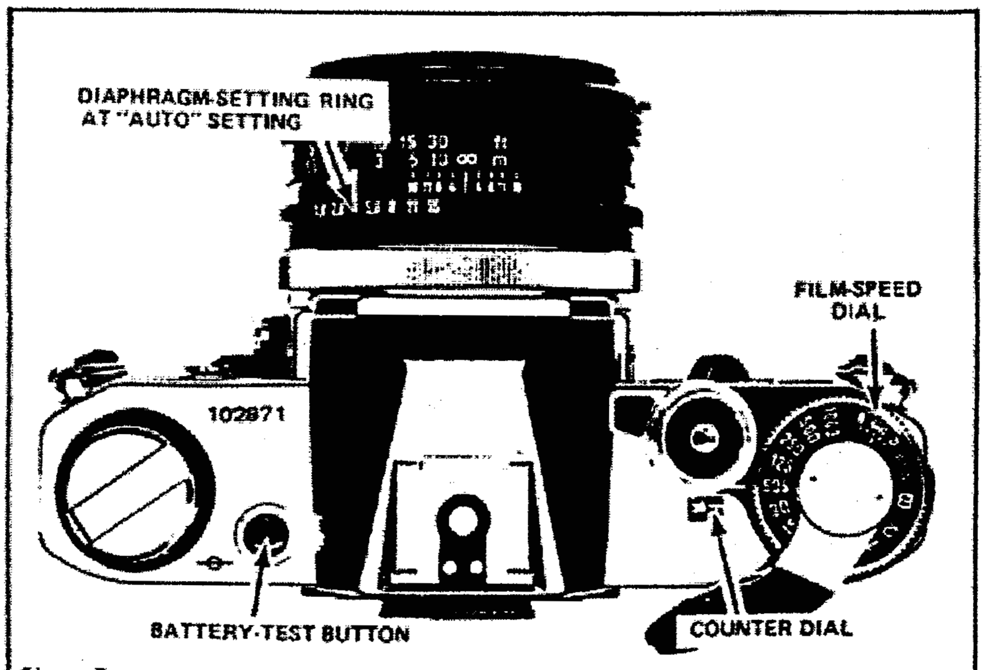


Figure 3

Canon AE-1

THE AE-1 SALES SENSATION

Few new cameras have caused as much of a sensation as has the Canon AE-1. Complete shutter-speed-preferred automation in a compact package—digital-logic memory—super-sophisticated integrated-circuit design. All this in a camera that sells for a surprisingly affordable price.

Canon's marketing department introduced the AE-1 with full-scale promotion. Fortunately, the service department kept pace. Canon first presented an excellent series of repair seminars for its warranty people. Yet the factory wanted to reach the independent repair technicians as well. So Canon provided the practice equipment for the 1977 National Camera Area Workshops covering the AE-1 and its partners in automation, the Speedlite 155A and the Power Winder A.

To help us put together the Workshop program, Canon invited us to participate in one of the warranty semina This was the first seminar-type facto session we've had the privilege to attend. And we're grateful to Canon for the information they presented.

Yet despite the hands-on programs, we've received several requests for a complete *Craftsman* article on the AE-1. True, our policy has always been to avoid duplicating technical information in the *Craftsman*. That's why we haven't been doing articles on equipment covered in Workshops.

So why the exception? Well, the AE-1 has been enjoying a wildfire sales record. And it puts into practice our series of articles on digital electronics (concluded last issue). For those who would rather not read through all the details, we suggest you get a copy of the Canon AE-1 workbook, the Speedlite 155A workbook, and the Power Winder A workbook. These workbooks, used as training aids in the National Camera Area Workshops, include complete explanations of the electronic operation as well as all the adjustments. You can also get Canon's service and parts manual on microfiche.

OPERATOR CONTROLS IN THE AE-1

Canon designed the AE-1 to be error-proof in operation—so automated that the camera could make a professional photographer out of a tennis player (at least, according to the TV ads). Yet despite the many ingenious concepts in the AE-1, Canon says the main problem has been operator error. People think the camera is malfunctioning when it isn't.

Why this problem? For one thing, many of the AE-1 controls are unique. Also, the full-scale promotion may lead people to believe they can't make a mistake using the camera. So people shop prices, discovering that large distributors and discount houses sell the camera for amazingly low prices (under $300 in some places). The buyers get bargains, but they receive no personalized instructions on using the camera.

When an AE-1 owner thinks his camera is "jammed," first check the battery. The AE-1 depends on battery power for just about everything—even the shutter release. So, without a battery, nothing works. The compartment for the 6-volt silver-oxide battery sits at the front of the camera, Fig. 1. You can use a small screwdriver to push in the battery-compartment latch (the owner's manual says to use the insulator cover that goes over the accessory shoe), Fig. 2.

From the technician's viewpoint, the battery compartment has an ideal location. You don't have to remove the battery to take off the top and bottom cover plates. So you can operate the camera under its own power for tests and adjustments.

Test the battery by pushing the battery-test button at the top of the camera, Fig. 3. The needle visible through the finder should swing to or below the battery-test mark on the focusing screen—the mark next to the f/5.6 calibration, Fig. 4.

Just a look at the focusing-screen calibrations in Fig. 4 tells you that the camera provides automatic diaphragm control. You set the electronically controlled shutter speed you want—the camera sets the diaphragm opening automatically. Turn the diaphragm-setting ring to the automatic position (marked with a green "A" in the current lenses, a green circle in the older lenses). Pushing the release button part way turns on the exposure-control system. And the needle moves to the f/stop you're going to get automatically.

Here, as in the EF, Canon shows its ingenuity in designing an automatic camera to use the existing FD lenses. However, as we mentioned in an earlier Craftsman article, Canon introduced a new FD lens with the AE-1. The new FD lens, shorter in overall length and a lot lighter in weight, allows the AE-1 to compete in the "smallest, lightest full-frame 35mm SLR" competition (a title now held by Pentax). But the AE-1 will accept any of the older FD lenses as well.

You can even use the FL series of lenses with the AE-1. Since the FL lenses aren't equipped for full-aperture metering or automatic control, you must use stopped-down metering. First, push in the stop-down lever on the front of the camera, Fig. 5. The stop-down lever latches in the stopped-down posi-

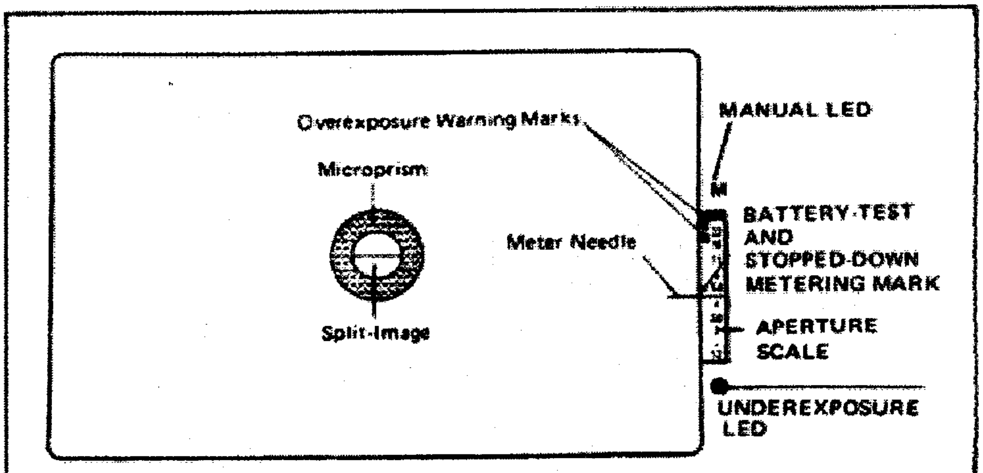


Figure 4 *Focusing Screen*

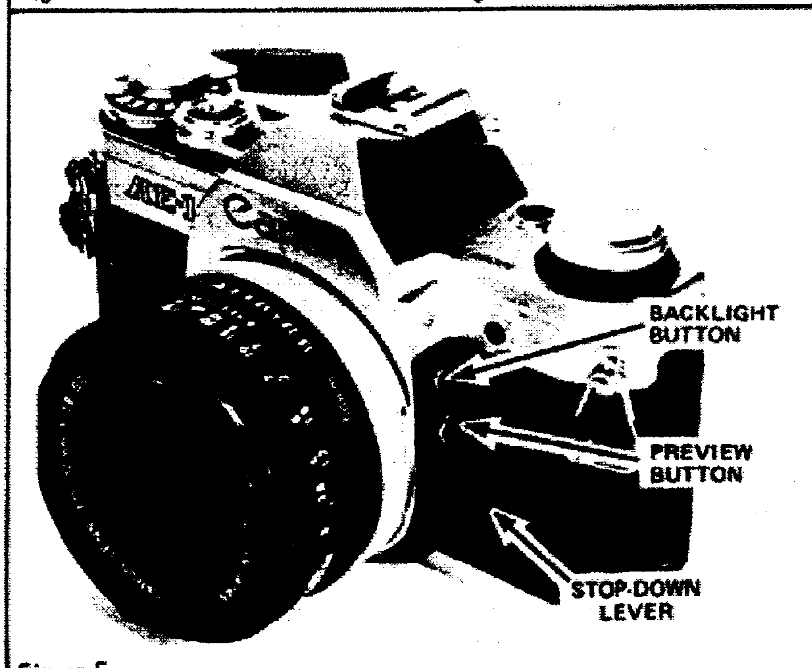


Figure 5

tion, Fig. 6, simultaneously closing the diaphragm to the f/stop you've selected. You can now change your shutter speed or your diaphragm setting until the needle centers on the battery-test mark.

However, you can't use stopped-down metering with the FD lenses. Nor can you push in the stop-down lever with the diaphragm-setting ring at the automatic position. An internal blocking lever prevents you from pushing in the stop-down lever far enough to latch.

So the AE-1 doesn't allow a depth-of-field preview at the automatic setting. And that's where one of the operator problems comes in. If you want to see the depth of field, you must first select one of the manual f/stops on the diaphragm-setting ring. Then, cock the shutter and push in the stop-down lever to close the diaphragm. Pushing in the stop-down lever releases the auto-control mechanism. And the diaphragm closes to whatever f/stop you've selected.

But, since you've disengaged the auto-control mechanism, you can't simply return to the automatic setting. If you do, you'll get the smallest aperture —not an automatically controlled exposure. You must first set the auto-control mechanism.

The auto-control mechanism resets automatically when you cock the shutter. Yet the shutter's already cocked—you cocked the shutter to use the depth-of-field preview. So how can you reset the auto-control mechanism? Just turn the diaphragm-setting ring to the largest f/stop. You can then go back to the auto position and get fully automatic diaphragm control.

What if you forget and leave the diaphragm-setting ring at a manual f/stop setting? Canon has an answer for that one too. As you start depressing the release button at a manual f/stop setting, a red LED (light-emitting diode) starts flashing at the top of the diaphragm scale, Fig. 4. The LED illuminates the letter "M" to warn that you're at a manual f/stop setting.

Notice in Fig. 4 that the smaller f/stops are at the top of the diaphragm scale. As the needle deflects, it moves down. And the lower the light level, the further the needle moves. If the AE-1 needle moves below the largest f/stop calibration of the lens you have installed, another LED flashes on and off. This LED, at the bottom of the diaphragm scale, Fig. 4, provides either an underexposure or an out-of-range indication. Both the underexposure LED and the manual LED flash on and off four times a second (4 Hz.).

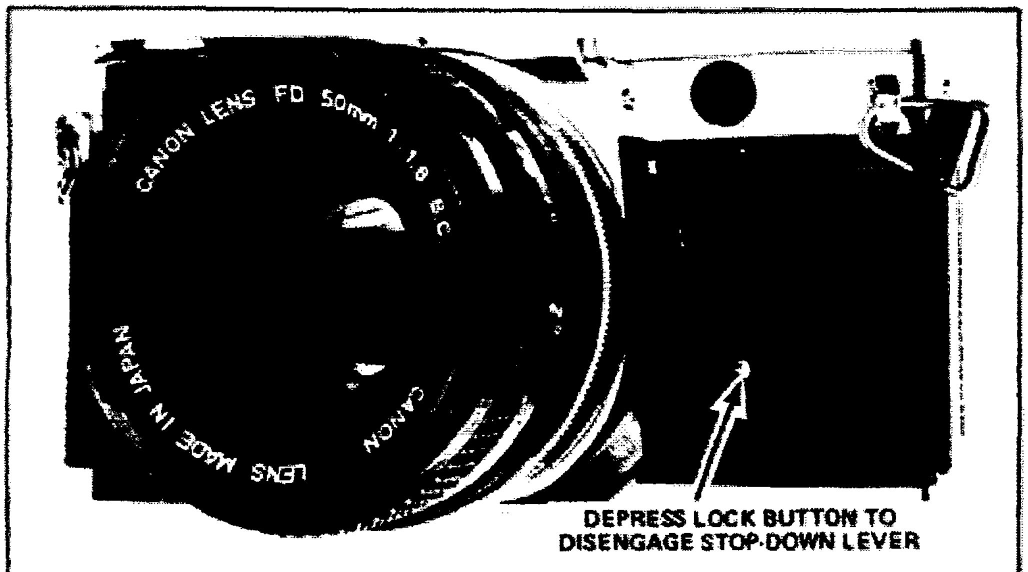


Figure 6

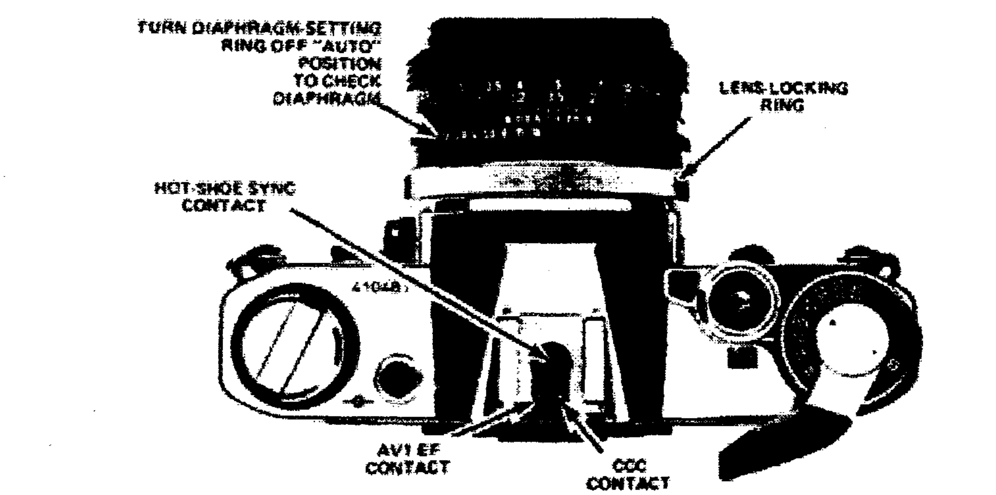


Figure 7

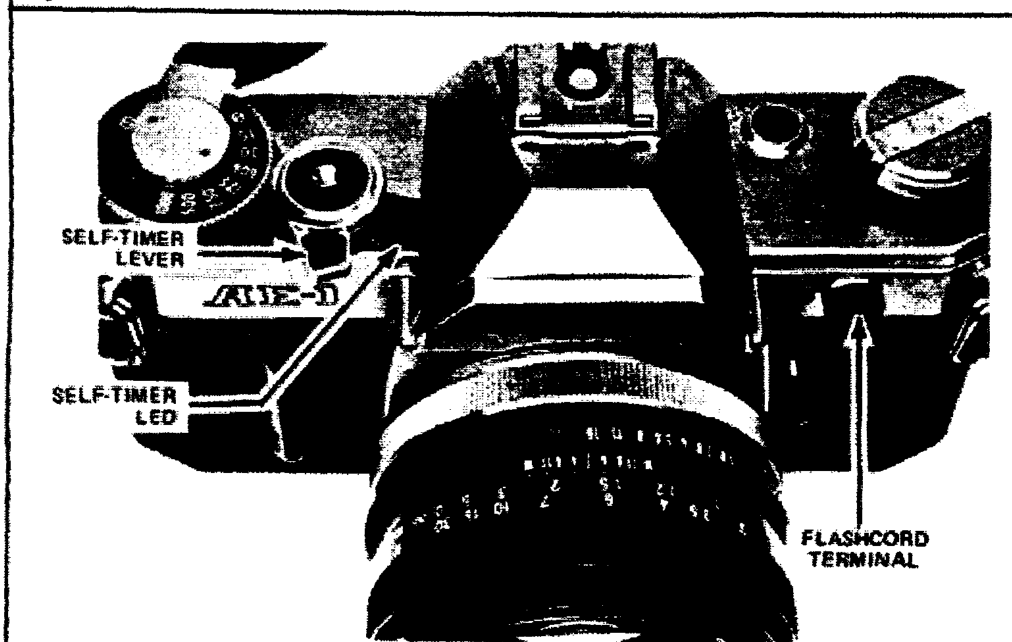


Figure 8

CHECKING THE DIAPHRAGM OPENING

Using the stop-down lever as a depth-of-field preview may be a little awkward. But the unique operation provides a bonus to the technician—you can conveniently check the diaphragm to see that you're getting the proper aperture automatically.

The reason is that the diaphragm-setting controls remain at the last aperture programmed automatically—until you recock the shutter. Differing from most shutter-speed-preferred systems, the galvanometer in the AE-1 plays no part in actually setting the diaphragm opening. Rather, the galvanometer serves strictly as an indicator. So it's possible for the needle to be indicating the proper aperture while the diaphragm stops down to a completely different opening. You have adjustments in the camera for both the needle reading and the actual diaphragm closure.

To check the diaphragm closure, turn the diaphragm-setting ring to the automatic position. Then, cock the shutter and look through the finder as you push the release button part way. And note the f/stop indicated by the needle. You may have to change the shutter-speed setting to get a usable f/stop indication.

Then, without moving your eye from the finder, press the release button the rest of the way to release the shutter. The diaphragm should stop down automatically to the same f/stop indicated by the meter. But how do you know it does? To find out, turn the diaphragm-setting ring just off the automatic position—toward the manual f/stop settings, Fig. 7. You can then push in the stop-down lever until it latches.

Pushing in the stop-down lever disengages the auto-control mechanism and allows the diaphragm to close. The diaphragm should now stop down to the last aperture programmed automatically—to the diaphragm setting you noted while looking through the finder.

It's still tough to look at the diaphragm leaves and say, "That's a good f/5.6." Yet you can find the exact diaphragm opening by watching the leaves as you slowly turn the diaphragm-setting ring toward the larger apertures. When the diaphragm leaves just start to open, stop turning the diaphragm-setting ring. The f/stop you now read on the diaphragm-setting ring is the aperture programmed automatically by the lens.

Using this test, you can check the operation with nothing more than a calibrated light source—you don't have to actually measure the light transmission. Check first to see that the needle indicates the proper f/stop for the light conditions. Then, check to see that the diaphragm actually stops down to the indicated f/stop.

OTHER OPERATOR CONTROLS IN THE AE-1

Some of the other operator controls are equally unique. The preview button sits above the stop-down lever, Fig. 5. Pushing in the preview button does the same thing as does pushing the release button part way—it turns on the exposure-control system, moving the meter needle to the appropriate f/stop calibration.

Why two controls that do the same thing? Well, you might want to change the shutter-speed control to get the automatically programmed diaphragm opening you want. And it's pretty tough to turn the shutter-speed control while you're holding the release button partially depressed. So instead, you can hold in the preview button while you turn the shutter-speed control. Also, the preview button allows you to preview the aperture without the danger of accidentally releasing the shutter.

The backlight button above the preview button, Fig. 5, provides an intentional overexposure. Hold the release button partially depressed and push in the backlight button—the needle should move down (toward the larger f/stops) an additional 1 1/2 f/stops. To get the intentional overexposure automatically, you must hold the backlight button depressed as you release the shutter.

Even the self timer in the AE-1 features electronic control. To use the self timer, push forward the self-timer lever, Fig. 8 (pushing the self-timer lever in the other direction locks the release button). When you then push the release button, the self timer electronically delays the release of the mirror for 10 seconds.

Since the self timer works electronically, there's no familiar buzzing during the delay. So you have yet another flashing LED. Moving the self-timer lever forward uncovers the self-timer LED, Fig. 8. The LED flashes on and off twice a second during the delay. If you want to know exactly when the shutter's going to release, you can simply count the LED flashes. After 20 flashes, the mirror should release.

If you change your mind about using the self-timer feature—or if you forget and leave the self-timer lever in the forward position—you can cancel the function. The battery-test button also serves as a cancel button. Pushing the battery-test button energizes the battery-test circuit and simultaneously deprives the other circuits of power.

Suppose that the self timer is now at work, delaying the release of the opening curtain. If you then push the battery-test button, everything stops. You can push the release button again and the self timer will start timing from scratch. Or, you can return the self-timer lever to its normal position. Pushing the release button then releases the shutter without the self-timer delay.

HOT-SHOE CONTACTS

Like so many Canon SLR's, the AE-1 has three contacts in the hot shoe. The large contact in the center provides the X-sync contact. You also get X sync at the flashcord terminal, Fig. 8—there's no M or FP sync.

Those other two contacts in the hot shoe, Fig. 7, provide automatic flash control. But the action here is completely different from that in Canon SLR's using CATS (Canon Auto Tuning System) automation.

Canon's new Speedlite 155A, introduced with the AE-1, provides series-thyristor flash control. In this respect, there's little difference between the 155A and other series-thyristor flash units. The Speedlite 155A gives you a choice between two different f/stops. Just set the film-speed dial according to your film speed. You can then use the f/stop shown by the calculator's red indicator or the f/stop shown by the calculator's green indicator. A selector switch at the back of the flash unit allows you to set either the green f/stop or the red f/stop, providing you with some depth-of-field control.

Using the Speedlite 155A with any other camera, you just set the diaphragm to the f/stop indicated on the calculator. And the flash unit shuts itself off according to the flash-to-subject distance. Nothing to it. Yet the operation becomes even easier with the AE-1.

Here, you just leave the diaphragm-setting ring at the automatic position. And the flash unit automatically sets the diaphragm opening. If you've set the flash unit to the red setting—and if the red indicator calls for a diaphragm opening of, for example, f/2.8—the camera programs an aperture of f/2.8. If you then select the green setting for a smaller f/stop, the camera programs the aperture shown by the green indicator—

in this example, f/5.6.

The flash unit sends the aperture information through the AV1 EF (aperture value/electronic flash) hot-shoe contact, Fig. 7. But if the flash unit hasn't recycled and the ready lamp isn't on, there's no signal applied. And the camera programs the aperture according to the available-light conditions.

If the camera's meter doesn't indicate the proper aperture—the aperture shown on the calculator—the problem is probably with the flash unit, not with the camera. The National Camera workbook on the Speedlite 155A describes the tests and adjustments.

So, with the Speedlite 155A, it's nearly impossible to make a mistake in setting the aperture. Yet there's another mistake people frequently make when using electronic flash with a focal-plane shutter—they set too fast a shutter speed. Canon's amazing Speedlite even takes care of that. Once the ready lamp turns on, the Speedlite 155A automatically programs a shutter speed of 1/60 second, the fastest full-aperture speed, regardless of the speed-knob setting (except "bulb"). It sends the shutter-speed information through the second hot-shoe contact, the CCC contact, Fig. 7. And if the ready lamp isn't on? Then, you get whatever shutter speed you've selected on the speed knob.

COUPLING TO THE LENS

Remove the lens by turning the lens-locking ring in a counterclockwise direction (as seen from the front of the camera). You can then see the coupling controls between the camera and the lens, Fig. 9. At first glance, the linkages look typically Canon. But the AE-1 controls that linkage in a very unique manner.

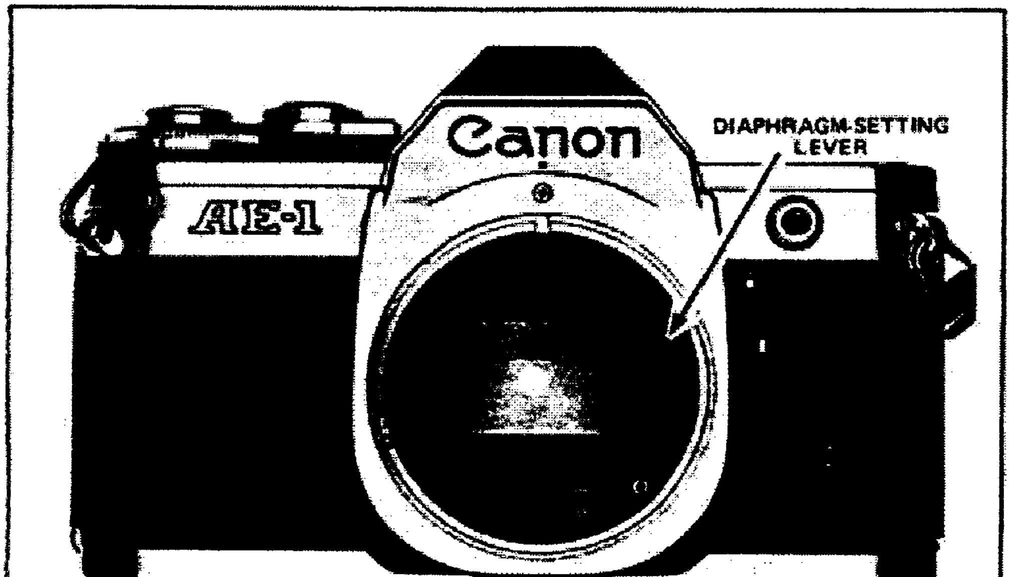


Figure 9

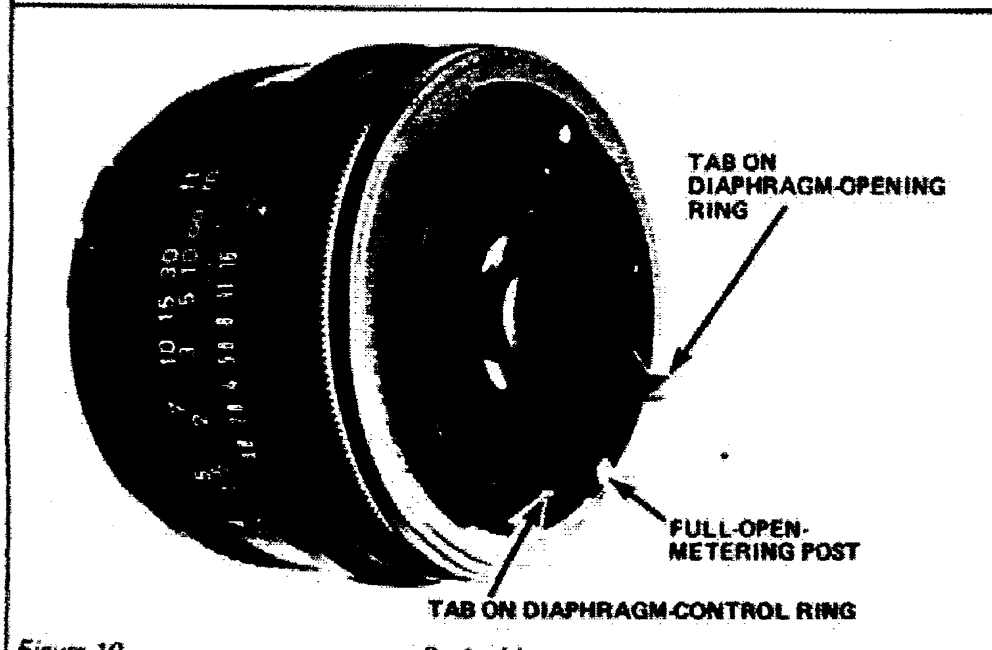


Figure 10

Back of lens

The diaphragm-setting lever controls the diaphragm closure. With the lens installed, the tab on the diaphragm-control ring, Fig. 10, sits on top of the diaphragm-setting lever. So, as the diaphragm closes, the spring-loaded diaphragm pulls the diaphragm-setting lever toward the bottom of the camera.

In the Canon EF, the diaphragm-setting lever couples to trap-needle linkage. When a stepped cam engages the exposure-meter needle, the diaphragm-setting lever latches in position. That's what prevents the diaphragm from closing beyond the proper f/stop. But, as we mentioned earlier, the AE-1 meter has nothing to do with setting the aperture.

Instead, the diaphragm-setting lever in the AE-1 controls a sensing mechanism—a variable resistor which detects the actual position of the diaphragm leaves. As the leaves close, the resistance of the diaphragm-sensing resistor decreases. This resistance value tells the auto-control system when the diaphragm has reached the proper f/stop.

The diaphragm-setting lever can move down as long as an electromagnet remains energized. The energized diaphragm-control electromagnet holds its armature out of engagement with a ratchet gear. But as soon as the diaphragm-sensing resistor reaches the right value, the sensing circuit de-energizes the diaphragm-control electromagnet. The electromagnet then releases its armature. And the armature latches the diaphragm-setting lever.

On a manually set f/stop, the diaphragm-control electromagnet remains energized until the diaphragm reaches the f/stop you've selected. And now, with the lens removed, the camera thinks you've set a manual f/stop. So you can quickly check the action of the diaphragm-setting lever.

Say, for example, you get the complaint that the diaphragm isn't stopping down—it always remains at the largest opening. That means the diaphragm-control electromagnet de-energizes immediately—the armature locks the diaphragm as soon as the mirror releases. Or, you could have a mechanical malfunction.

Try using your tweezers or a small screwdriver to put downward pressure on the diaphragm-setting lever, Fig. 11. You're now simulating the action of the spring-loaded diaphragm. Then, release the shutter. The diaphragm-setting lever should move down freely.

At the end of the exposure, the diaphragm-setting lever should remain latched in the down position, Fig. 12. It should return to the up position when you cock the shutter. That's why the camera remains at the last aperture programmed automatically, a test we described earlier.

Slowly cocking the shutter allows you to examine the overtravel of the diaphragm-setting lever. At the end of the cocking stroke, the diaphragm-setting lever should move up slightly and then down slightly. This overtravel assures that the diaphragm-control system latches properly.

Another linkage system in the lens mount compensates for the maximum aperture of the lens. As with other Canon SLR's, the full-open-metering post on the back of the FD lens supplies the maximum-aperture information, Fig. 10. The larger the maximum aperture, the longer this post.

When you install the lens, the full-open-metering post comes against the maximum-aperture correction pin, Fig. 12. In the Canon EF, pushing in the maximum-aperture correction pin moves the finder's diaphragm scale. But that's not the case with the AE-1—the diaphragm scale never moves. Instead, the maximum-aperture correction pin in the AE-1 controls a pair of variable resistors on the side of the mirror cage. One of the variable resistors provides information to both the aperture-control and readout systems. The other provides information to the readout (meter) only.

Despite the unique operation, the maximum-aperture correction pin has a typical Canon adjustment. The outer cylinder of the maximum-aperture correction pin threads onto a shaft—the other end of the threaded shaft comes against a wiper lever that controls the variable resistors.

So you can adjust the distance between the front surface of the maximum-aperture correction pin and the front surface of the lens-mounting ring. Canon specifies that this distance should be 5.7 mm (+0, -0.2 mm). To increase the distance, first loosen the lock screw in the center of the maximum-aperture correction pin. Then, use a screwdriver

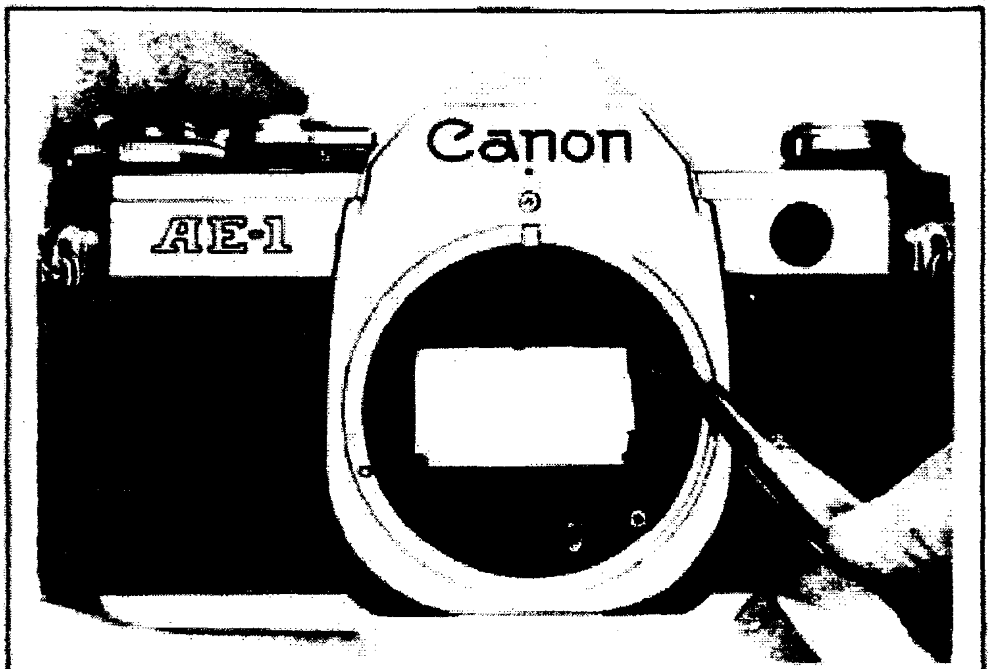


Figure 11

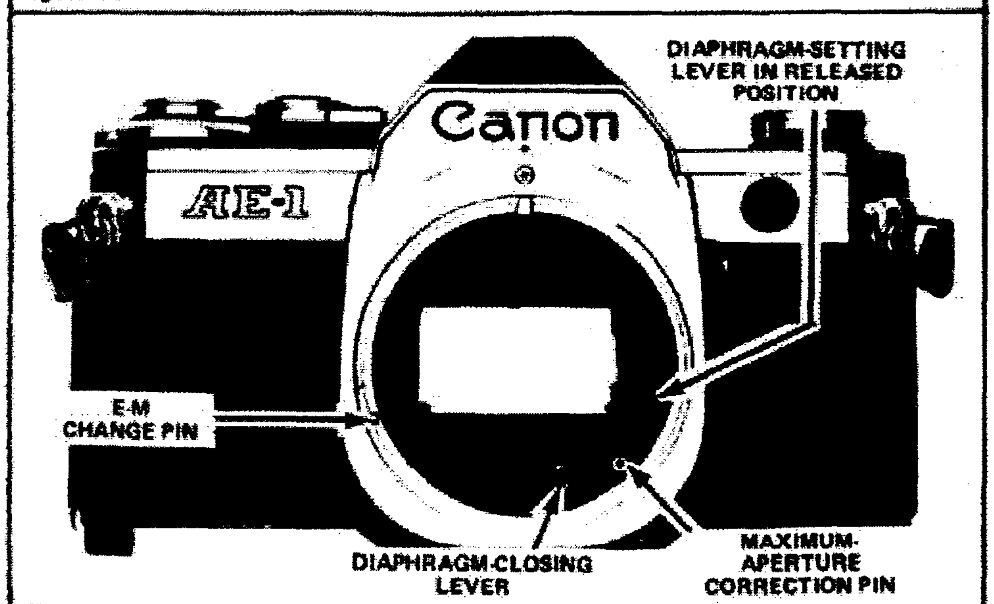


Figure 12

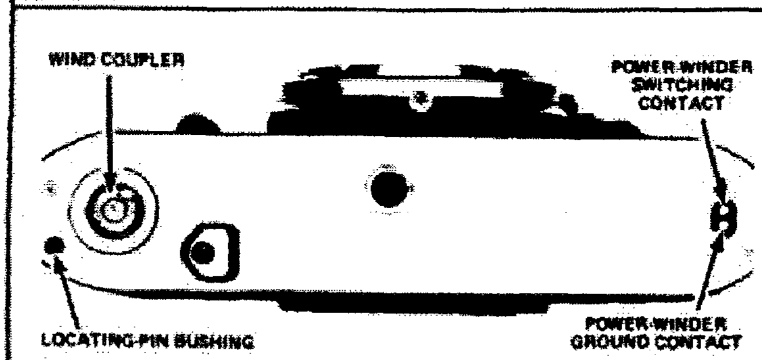


Figure 13

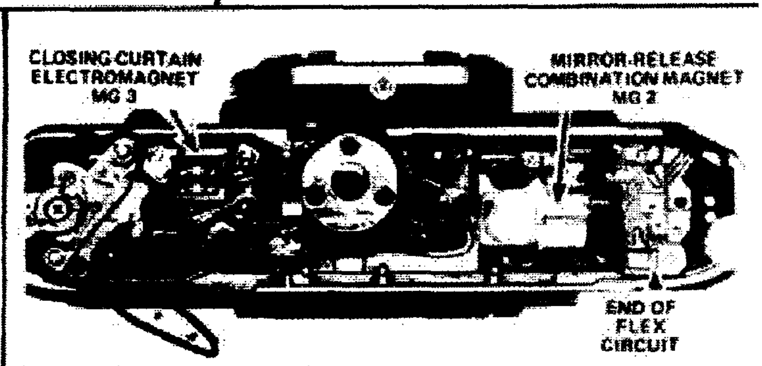


Figure 14 *Shutter released*

to turn the maximum-aperture correction pin clockwise—that screws the outer cylinder further onto the threaded shaft.

To decrease the distance, turn the maximum-aperture correction pin counterclockwise. And tighten the lock screw to hold the adjustment. The tough part of the whole biz is measuring the distance between the lens-mounting ring and the maximum-aperture correction pin. That's because the spring-loaded maximum-aperture correction pin moves down when you apply any pressure.

The E-M change pin (electronic-manual) at the other side of the lens mount senses the position of the diaphragm-setting ring—whether you're at a manual f/stop setting or at the automatic position. When you turn the diaphragm-setting ring to the automatic position, the auto pin at the back of the lens moves out (toward the camera). That depresses the E-M change pin. And depressing the E-M change pin opens a switch at the bottom of the mirror cage.

There's one more lever visible through the lens opening—the diaphragm-closing lever, Fig. 12. The diaphragm-closing lever swings from right to left as the mirror moves to the taking position. So the diaphragm-closing lever drives the lens' diaphragm-opening ring in a counterclockwise direction, Fig. 10. And the diaphragm-opening ring moves away from the spring-loaded diaphragm-control ring, allowing the diaphragm leaves to close.

There's no difference between this operation in the AE-1 and that in other Canon SLR's. Yet it's one thing that's easy to overlook as a problem area. With all the electronic sophistication in the AE-1, it's natural to start your troubleshooting in the electronic circuitry.

But if the diaphragm isn't closing, check the action of the diaphragm-closing lever. You could simply have a mechanical malfunction. And it's best to look for the simple things first. Make sure the camera functions mechanically before you start troubleshooting and adjusting electronic systems.

TESTS AND CONTROLS AT THE BOTTOM OF THE AE-1

Along with the Speedlite 155A, Canon introduced another sophisticated accessory for the AE-1—the Power Winder A. Unscrewing the coin-slotted cover disc at the bottom of the camera reveals the wind coupler, Fig. 13. The Power Winder A engages this coupler to automatically advance the film and cock the shutter.

But the controls that tell the Power Winder A to go into action are inside the camera. Notice the two power-winder contacts at the other end of the bottom plate, Fig. 13. The contact closer to the back of the camera connects to ground. The other contact connects to ground only when the shutter is in the released position.

The shutter's closing curtain controls the switching action. With the shutter released, an internal switch connects the front motor-drive contact to ground. Consequently, the two bottom-plate contacts act as a closed switch. And the closed switch tells the Power Winder to advance the curtains and cock the shutter.

When the closing curtain reaches the cocked position, it disconnects the power-winder switching contact from ground. That shuts off the Power Winder. The Power Winder remains off until you release the shutter. Then, the closing curtain crosses the aperture and once again connects the switching contact to ground.

All this may sound like typical motor-drive action. Yet, since the camera contains the release and switch controls, Canon could make the Power Winder A exceptionally light and compact. The Power Winder contains little more than a master on/off switch, drive motor, and a timing circuit whic shuts off the motor after one second The timing circuit brings things to a hal when you reach the end of the film roll— a red LED on the side of the Powe Winder then glows.

There's only one precaution in re moving the camera's bottom plate—th black bushing for the Power Winder' locating pin may be loose, Fig. 13 Normally, though, a dab of cemen holds the bushing to the bottom plate.

Remove the two screws visible in Fig 13 and lift off the bottom plate. Yo can now reach quite a bit of the contro circuit. Notice in Fig. 14 that you'v uncovered two of the camera's thre electromagnets. As yet, you still can' see the electromagnet which control the diaphragm opening—the diaphragm control electromagnet Mg1 mounts t the bottom of the mirror cage.

The two electromagnets at the bot tom of the camera control the shutte release and the closing curtain. Mg3, th closing-curtain electromagnet, sits at th wind-lever end of the camera, Fig. 14 And the mirror-release magnet, Mg2 connects to the flexible circuit board a the rewind end of the camera. You ca just see the end of the flex circuit i Fig. 14—the complete board extends t the top of the camera and houses mos of the electronic components.

When you cock the shutter, th charge cam pushes the charge lever fro left to right, Fig. 15. The end of th charge lever then pushes the Mg2 arma ture against the magnet's core. As yet there's no current being drawn from th battery. Yet the Mg2 armature remain against the core when the charge leve returns, Fig. 16.

That's because the two cores of Mg are permanent magnets. So the core hold the armature magnetically withou drawing battery current. When you pus the release button all the way down, capacitor discharges through the coil

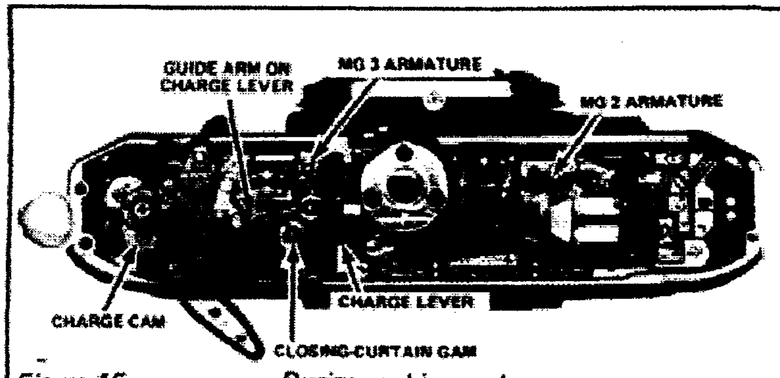


Figure 15 *During cocking cycle*

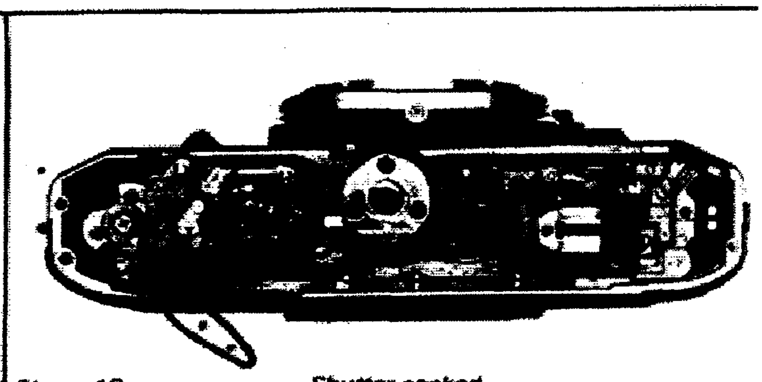


Figure 16 *Shutter cocked*

wound around the Mg2 cores. That surge of current temporarily disables the permanent magnets. As a result, the spring-loaded armature shoots toward the front of the camera and releases the mirror.

Since Mg2 combines a permanent magnet with an electromagnet, it's a "combination magnet." And that's just one of the unique battery-conservation techniques used in the AE-1. With other cameras using an electromagnetic release, the current surge normally energizes a standard electromagnet. The electromagnet must then pull its armature against the core. So using a standard electromagnet requires quite a bit of current.

Even the Mg3 closing-curtain electromagnet has a battery-conserving circuit. Mg3, Fig. 17, draws no current until the capacitor discharges through the coil of Mg2. A sensing circuit detects this current surge. And it simultaneously energizes Mg3.

Until that current surge, a mechanical control holds the Mg 3 armature against the magnet's core. During the cocking cycle, the *charge lever tensions the* mirror. The mirror-tensioning lever on the side of the mirror cage then comes against the Mg3 armature (you can just see the end of the mirror-tensioning lever in Fig. 17). In the shutter-cocked position, the mirror-tensioning lever remains latched. So it continues to hold the Mg3 armature.

Notice the guide arm on the charge lever, Fig. 15—the guide arm comes against an upturned tab on the Mg3 armature as you cock the shutter. So the guide arm prevents the Mg3 armature from touching the closing-curtain cam during the cocking cycle.

The closing-curtain cam attaches to the bottom of the closing-curtain winding roller. With the shutter cocked, Fig. 17, the Mg3 armature is in position to engage the latching surface of the closing-curtain cam. As the mirror rises, the mirror-tensioning lever moves away from the Mg3 armature. But the Mg3 armature remains against the magnet's core—the energized electromagnet now holds the armature magnetically.

Consequently, the Mg3 armature latches the closing-curtain cam. The mirror releases the opening curtain. Yet the shutter remains open as long as the circuit supplies current to the Mg3 coil. In effect, the Mg3 armature just replaces the closing-curtain latch used in conventional focal-plane shutters.

Selecting the shutter speed decides how long the Mg3 armature holds the closing curtain. The speed selector connects a certain resistance value in series with a timing capacitor—in this respect, conventional circuitry for an electronically controlled shutter. When the timing capacitor (under the top cover) reaches a certain voltage, a sensing circuit shuts off the current flowing through Mg3. Mg3 then releases its armature to disengage the closing-curtain cam. And the closing curtain crosses the aperture to end the exposure.

There should be a slight overtravel between the latching surface of the Mg3 armature and the latching surface of the closing-curtain cam, Fig. 17. Canon specifies a 0.05 to 0.15mm space gap. To make the overtravel adjustment, you must first loosen the two allen-head setscrews on the side of the closing-curtain cam. These setscrews hold the closing-curtain cam to the closing-curtain winding roller.

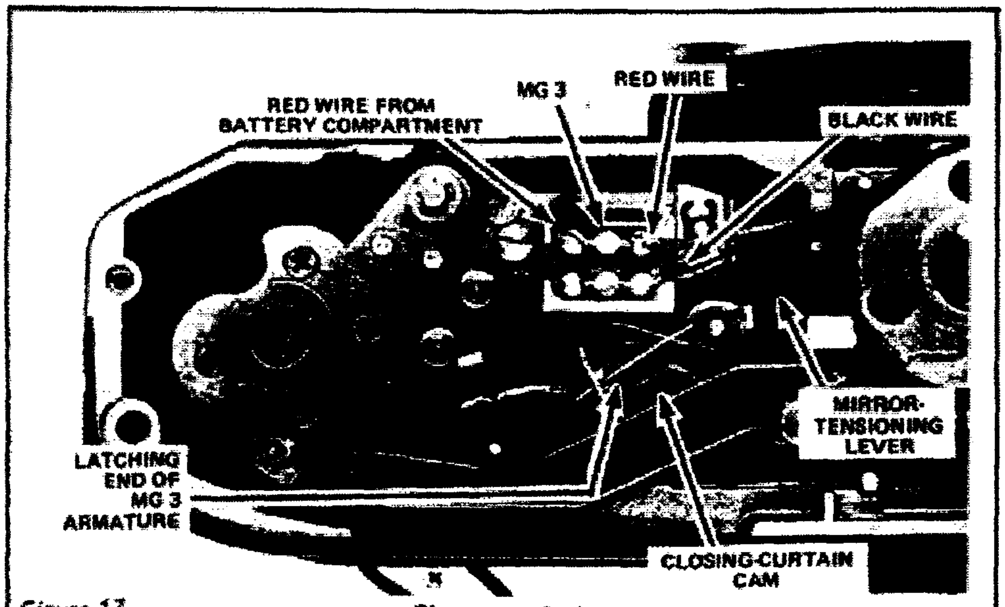


Figure 17 *Shutter cocked*

After loosening the setscrews, you can rotate the closing-curtain cam. But those setscrews are tough to reach. Fortunately, you'll probably never have to make the overtravel adjustment. An exception may arise if you're replacing shutter parts. Yet in that case, you'll have removed the shutter module. It's then much easier to reach the setscrews.

CHECKING THE MG2 COMBINATION MAGNET

You might at first suspect that servicing the AE-1 involves replacing modular circuit boards. While that's true in many electronically controlled cameras, it's not the case in the AE-1. Replacing the flex circuit requires an almost complete camera disassembly.

Since it takes a lot of time to replace the flex circuit—and because the flex circuit, complete with components, is pretty expensive—some technicians have expressed the opinion that the AE-1 isn't economical to service. That may be true in rare cases. But most of the "common" repairs we've encountered in AE-1 cameras have been relatively simple. And, if you're willing to troubleshoot the circuit, you'll probably never replace a complete assembly—rather, you'll replace individual components.

Fortunately, three IC's at the top of the AE-1 contain the most sophisticated circuitry. When you have an electronic malfunction, the IC's are the last components to suspect. That's because you have no solder connections inside an IC. And solder connections are probably the main troublespots in an electronically controlled camera.

The fine coil of wire making up an electromagnet may also be a logical suspect. Temperature extremes can cause this tiny wire to expand and contract—and sometimes break. You then have an open coil.

For example, say you have an open Mg3 coil. In that case, the coil can't develop the electromagnetic field to hold the closing curtain. And you'll get no aperture—both curtains will cross the aperture together. Or, if the Mg2 coil is open, the shutter won't release.

You can check both magnets after pulling the bottom plate. Suppose the customer complains that the shutter won't release. You check the battery and find that it's o.k. The next logical step would be to pull the bottom plate and check the combination magnet Mg2.

Fig. 18 shows the connections from the Mg2 coil at the flex circuit. You may have a piece of insulating tape over this section of the board—that tape insulates the flex circuit from the bottom plate. Pull off the insulating tape to check the Mg2 coil.

First, though, check the mechanical releasing action—just use your screwdriver to push the Mg2 armature toward the front of the camera. The shutter should release. If the shutter releases, you know there's no mechanical problem.

So you could have an open Mg2 coil—or you could have a bad capacitor (the capacitor that discharges through the coil to disable the permanent magnet). You can check both the coil and the capacitor in one shot. Cock the shutter. Then, use your tweezers to short between the negative lead of the Mg2 coil, Fig. 19, and ground (the edge of the camera body or the ground screw on the flex circuit). The armature should spring away from the Mg2 core and release the mirror.

This shorting test bypasses the electronic switch that routes the spurt of current through the Mg2 coil. The partial schematic, Fig. 20, shows how the release circuit normally works. Notice that capacitor C47 (for 47 microfarads) connects in series with the Mg 2 coil. When the electronic switch closes, it allows capacitor C47 to discharge through the Mg2 coil.

If shorting across the switch doesn't release the shutter, check for battery power at the flex circuit. Locate the red wire that runs from the flex circuit to the Mg3 electromagnet—this red wire connects the flex circuit to positive battery. So measuring between the red-wire connection and ground, you should read the full battery voltage (around 6.35 volts without drawing battery current).

Similarly, you can check the voltage at each of the Mg2 combination magnet leads—you should measure the full battery voltage at each lead. If you do, you know that you don't have an open coil.

Now, let's assume that your shorting test doesn't release the shutter. Yet you measure the proper voltage at the flex circuit. There may still be a question as to which component is defective—the coil or the capacitor. Measuring the voltages to the coil leads tells you the coil must be complete. But for a final check, you can use a power supply to release the shutter.

Set the power supply between 2 and 4 volts. Then, touch the negative power-supply lead to the negative Mg2 lead, Fig. 18. And simultaneously touch the positive power-supply lead to the positive Mg2 lead. That sends current through the Mg2 coil. And the mirror should release. If it does, you can suspect a bad capacitor.

You can replace either the combination magnet or the C47 capacitor from the bottom of the camera. The capacitor hooks to the flex circuit at the points shown in Fig. 18. But a word of caution—be extremely careful when handling the flex circuit. Mishandling the flex circuit can result in breaks within the board. Those breaks can be tough to find. And about the only way to correct them is to use jumper wire, a technique we'll later describe.

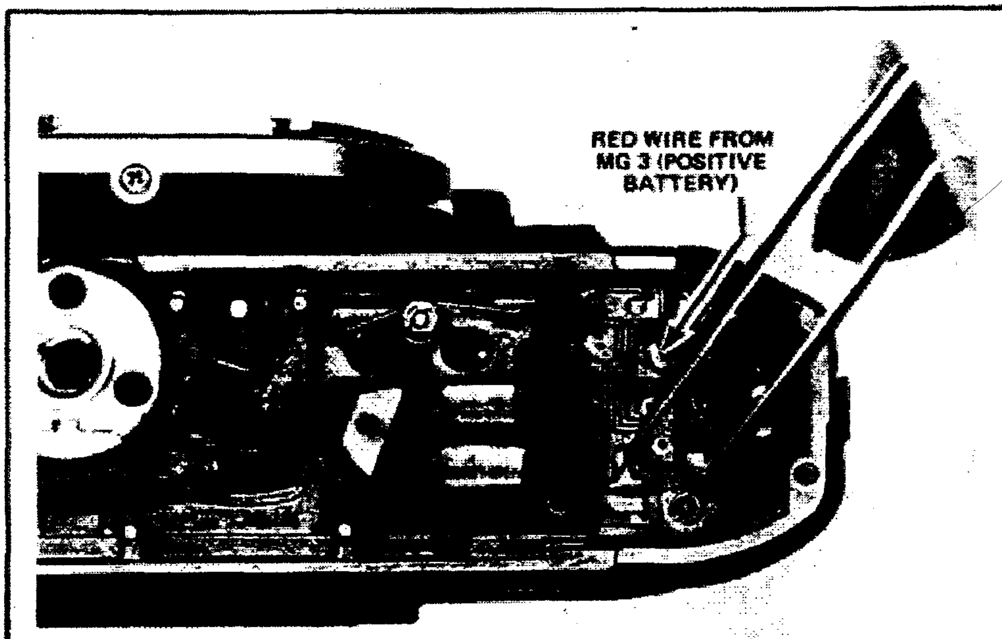


Figure 19. Shorting the negative Mg 2 lead to ground should release the shutter

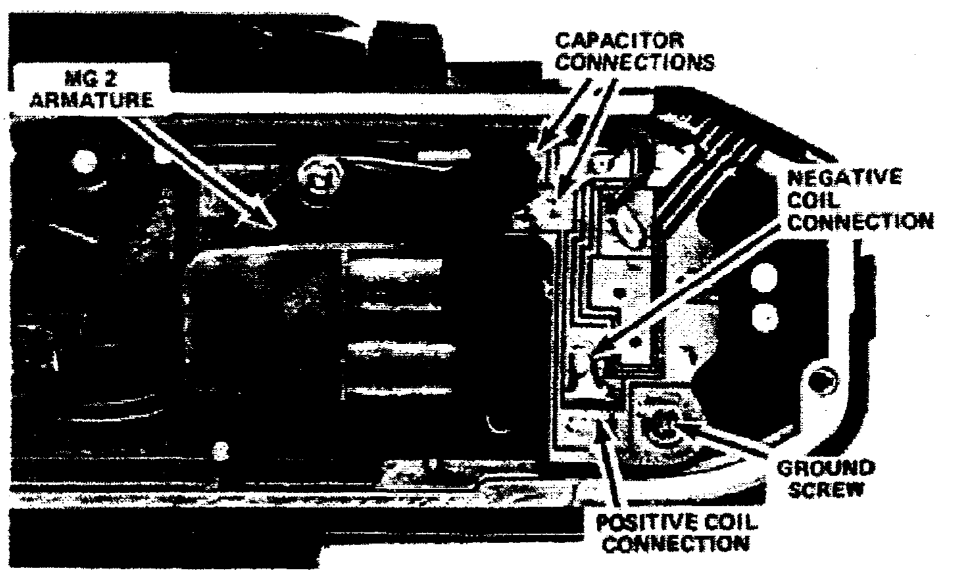


Figure 18 *Shutter cocked*

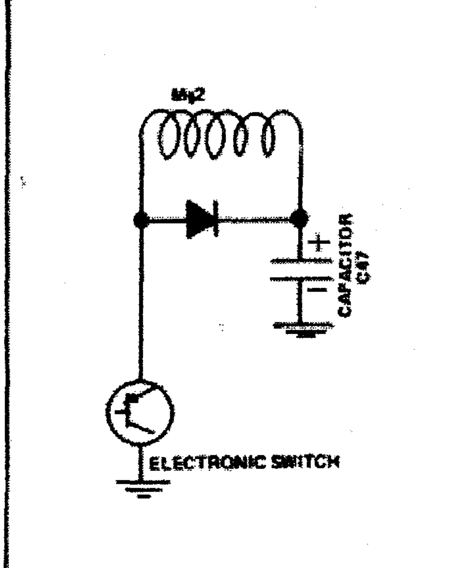


Figure 20

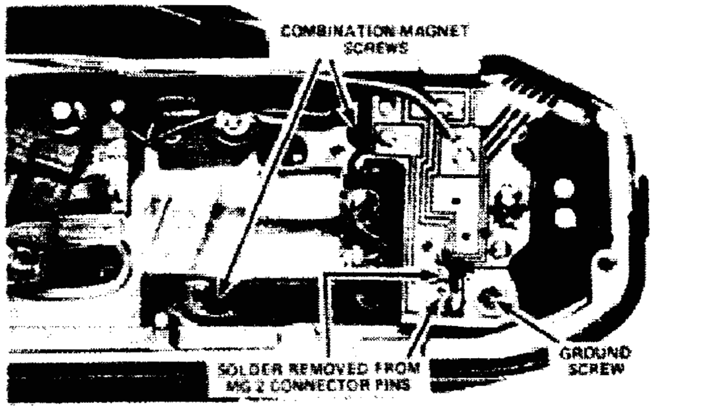


Figure 21

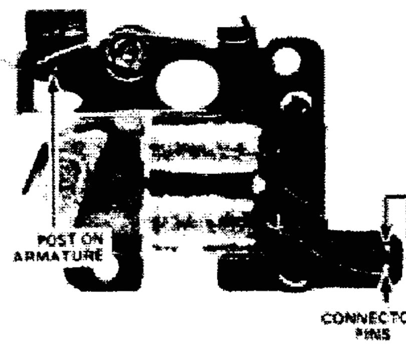


Figure 22 *Combination-magnet assembly*

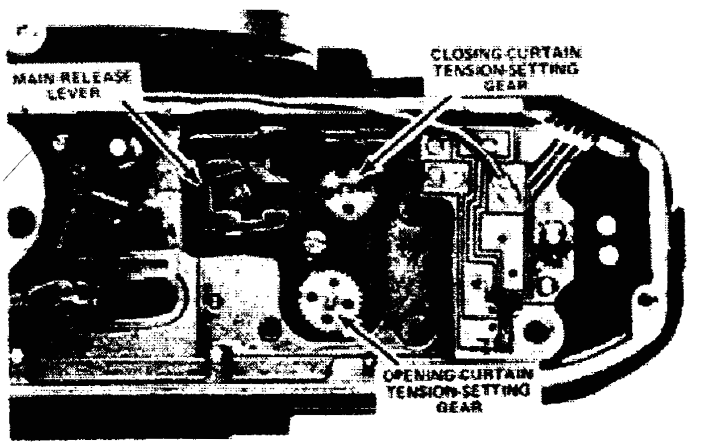


Figure 23

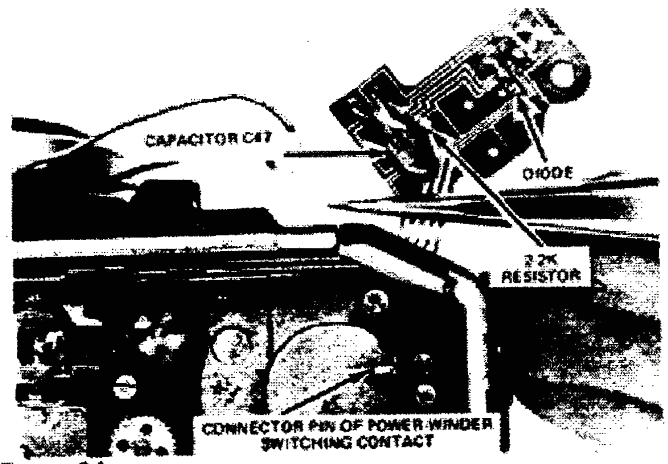


Figure 24

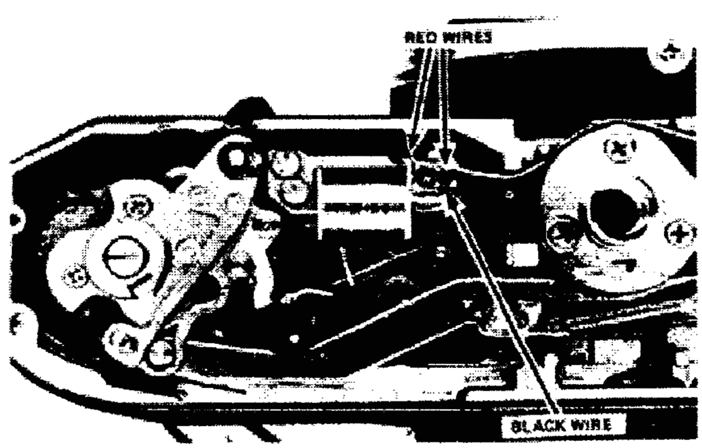
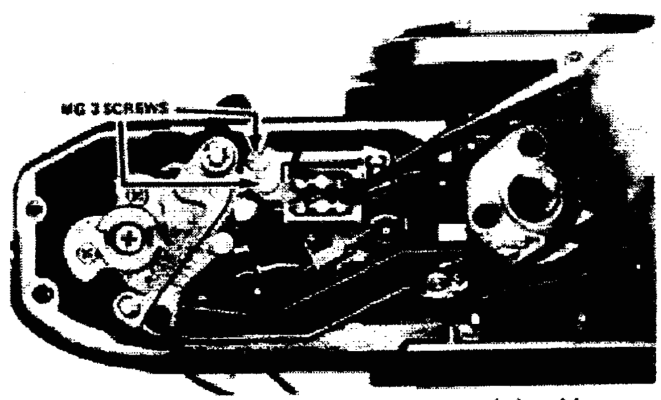


Figure 25 *Mg 3 variation*



Shorting the black wire to ground should hold open the shutter

Figure 26

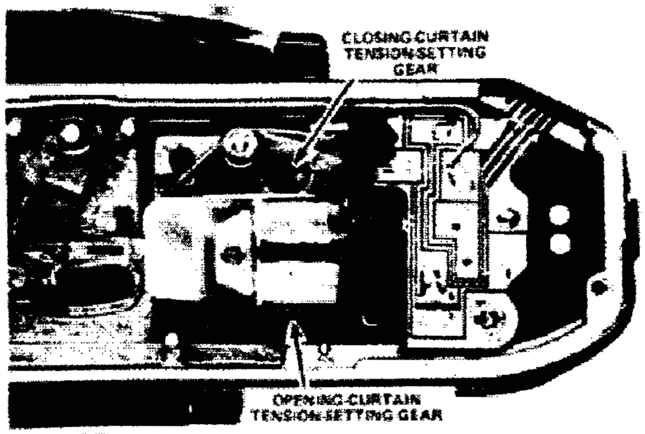


Figure 27

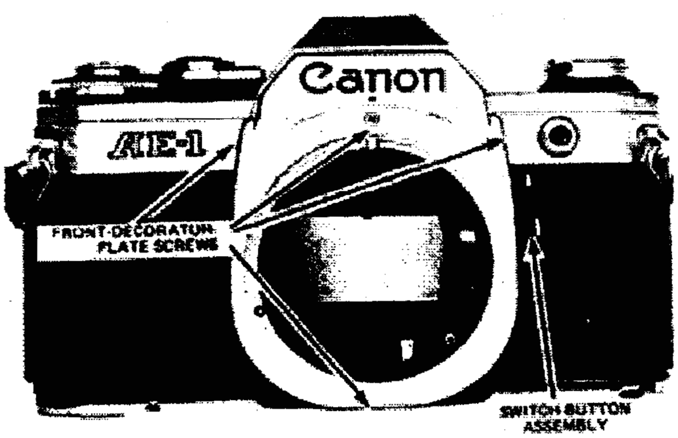


Figure 28

Suppose that you have to replace the Mg2 combination magnet. First, use desoldering wick to remove the solder from the two connector pins, Fig. 21. Then, remove the ground screw shown in Fig. 21—a washer under the ground screw provides good contact between ground and the flex circuit. You can now lift the flex circuit from the connector pins of the Mg2 combination magnet.

Remove the complete combination-magnet assembly by taking out its two screws, Fig. 21. Similarly, you can remove the capacitor C47 by pulling the solder from its two leads, Fig. 18.

Fig. 22 shows the combination-magnet assembly removed from the camera. Notice the connector pins which pass through the holes in the flex circuit—the Mg2 coil leads wrap around these connector pins. Also notice the post on the underside of the Mg2 armature. When the Mg2 armature shoots toward the front of the camera, the post strikes the main-release lever, Fig. 23. The main-release lever releases both the mirror and the auto-control mechanism.

In Fig. 24, we've pulled the bottom section of the flex circuit to show the parts on its underside. Here, we've disconnected the two wires (one red and one black) from the flex circuit contacts. And we've pulled the solder from the power-winder switching contact.

Capacitor C47, Fig. 24, charges to the battery voltage through the 2.2K resistor. The diode shown in Fig. 24 protects one of the IC's from the counter EMF of the Mg2 coil.

CHECKING THE CLOSING-CURTAIN ELECTROMAGNET MG3

You can also check the closing-curtain electromagnet Mg3 with a shorting test. Notice that the closing-curtain electromagnet has three wires connected to it—two red wires and a black wire, Fig. 17. Here, you'll encounter a couple of design variations. In some cameras, like the one illustrated in Fig. 17, there's a small PC board cemented to the top of the Mg3 coil. The two red wires and the black wire solder to the PC board. Also, the two coil leads connect to the PC-board contacts, the contacts closer to the wind-lever end of the camera body.

The other type of Mg3 electromagnet, Fig. 25, has a small PC board at the side of the coil. The coil leads connect to the same contacts as do the insulated wires. It's a little tougher to work with this type of electromagnet—when unsoldering the red wires and the black wire, you're running the risk of disconnecting the coil leads.

But there's no electrical difference between the two types of electromagnets. And the two variations are interchangeable. One of the red wires connected to Mg3 comes directly from the positive terminal of the battery compartment. The black wire and the other red wire connect Mg3 to the flex circuit at the other end of the camera. So, measuring between ground and either terminal of Mg3, you should measure the full battery voltage.

Reading the battery voltage at both coil terminals tells you that the coil is complete. You don't have an open. But to make the quick shorting test, just short between the black-wire contact of Mg3 and ground, Fig. 26. When you then release the shutter, you're running battery current directly through the coil. And the shutter should stay open as long as you maintain the short.

You can also measure the resistance of the coil. The Mg3 coil, measured between the red wire and the black wire, should be around 224 ohms. If you have an open or shorted coil, just remove the two screws shown in Fig. 26. And replace the complete Mg3 electromagnet.

ADJUSTING THE CURTAIN TENSIONS

Fig. 23 points out the tension-setting gears for the opening and closing curtains. However, you can reach both adjustments through clearance holes in the Mg2 plate, Fig. 27. Except for parts replacement, you'll never have to remove the Mg2 combination magnet as we've done in Fig. 23.

The tension-setting adjustments in the AE-1 are especially convenient. You can turn the tension-setting gears in either direction without disengaging the locking wire. Just insert the points of your tweezers into the gear holes. Then, turn the gear in either direction—counterclockwise to increase the tension, clockwise to decrease the tension.

Canon specifies the curtain-travel times as 11.3 milliseconds using Kyoritsu test equipment. New cameras we've checked with National Camera's Auto-System-7 (measuring in 1mm from each edge) have varied from 11.5 to 12.6 milliseconds. So there's some latitude which may help in adjusting the fast shutter speeds. As you'll see a little later, you don't have convenient shutter-speed adjustments in the AE-1.

REMOVING THE FRONT DECORATOR PLATE

Remove the front decorator plate by taking out five screws—one at the front, one at the bottom, and one at each side, Fig. 28. The switch-button assembly should stay with the front decorator plate.

You'll now notice that the front decorator plate is made of metal-plated plastic. The top cover is also plastic. Using plastic for these and other parts partially accounts for the exceptionally light weight of the AE-1.

Notice also the two switches at the side of the camera, Fig. 29. The two switch blades are formed from one piece, a piece that connects to ground. So

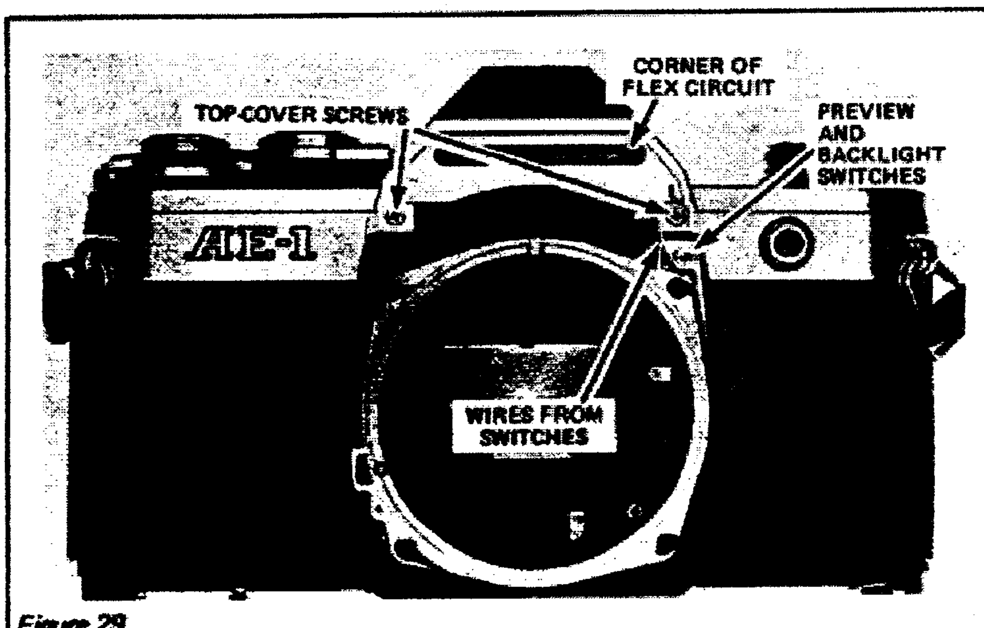


Figure 29

when you're closing the preview switch, you're just connecting the purple-wire contact to ground. And when you close the backlight switch, you're connecting the white-wire contact to ground.

The purple wire and the white wire both pass through a special cutout to reach the top of the camera, Fig. 29. On reassembly, make sure the wires take the route shown in Fig. 29—otherwise, you can cut off the wires when you replace the top cover.

Another precaution—note the portion of the flex circuit visible through the cutout in the top cover, Fig. 29. The cutout provides clearance for the front edge of the pentaprism. When you're lifting off the top cover, there's a danger of catching and tearing the flex circuit. So, while removing the top cover, push in the edge of the flex circuit that's visible through the cutout.

In Fig. 29, you can also see the four screws holding the lens-mounting ring. Here, you have a typical Canon adjustment for the flange-focal distance. Washers under the lens-mounting ring allow you to adjust the flange-focal distance and the parallelism. The distance between the front of the lens-mounting ring and the film-guide rails should be 41.9mm—between the lens-mounting ring and the pressure-plate rails, 42.14mm.

REMOVING THE TOP COVER

Removing the front decorator plate is a necessary step in disassembly—the front decorator plate conceals two of the top-cover screws, Fig. 29. Remove the two screws shown in Fig. 29. Then, remove the other four top-cover screws—one on each side of the eyepiece and one on each end of the top cover.

Next, open the camera back by pulling up the rewind knob. Notice that you can remove the camera back completely—just push down the locking hinge pin. The removable back allows you to attach another special AE-1 accessory, a data back. You'll probably find it's easier to work on the camera if you now remove the camera back and get it out of your way.

Wedge the rewind shaft and unscrew the rewind knob. That gets you to the snap ring holding the plastic cover over the rewind-shaft opening, Fig. 30. You'll find snap rings throughout the AE-1, one of Canon's techniques for cutting production costs. Using the snap rings eliminates many of the endplay washers you normally expect to find in Canon SLR's.

It's a little tricky to remove the snap rings—unless you have a special snap-ring plier. Canon has an excellent snap-ring plier for the job, but it sells for around $30. For a lot less money, you can get the special snap-ring plier for the Polaroid SX-70—it's available through Polaroid and through National Camera. Or you can modify a standard pair of external snap-ring pliers to do the job. With most standard pliers, you'll have to grind the tips to a smaller size. But investing in a special tool might be a good idea—it's likely we'll be seeing more snap rings used in future designs.

Once you remove the snap ring, lift off the plastic cover ring. That exposes the functional resistor, Fig. 31. The functional resistor turns as you set either the film speed or the shutter speed. Setting a slower shutter speed or a faster film speed allows the spring-loaded functional resistor to rotate in a clockwise direction. That decreases the resistance value supplied to the exposure-control system.

Canon's service materials call the functional resistor the "SV—TV" resis-

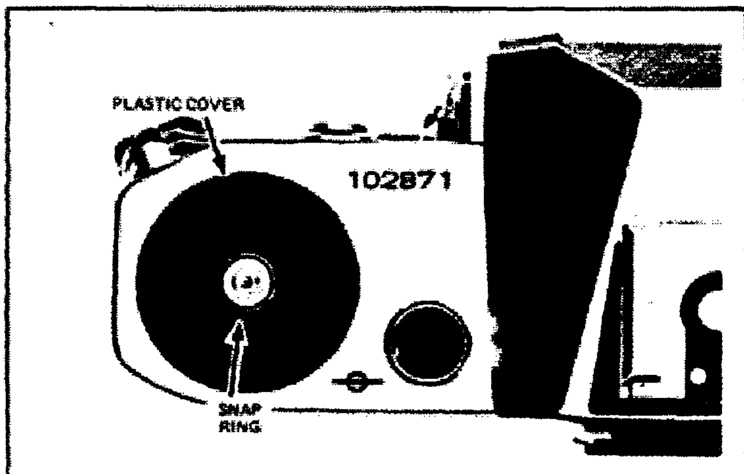


Figure 30

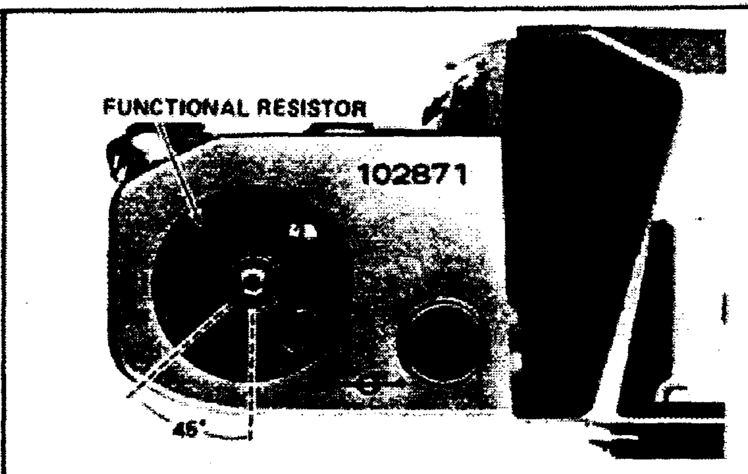


Figure 31 *Functional resistor*

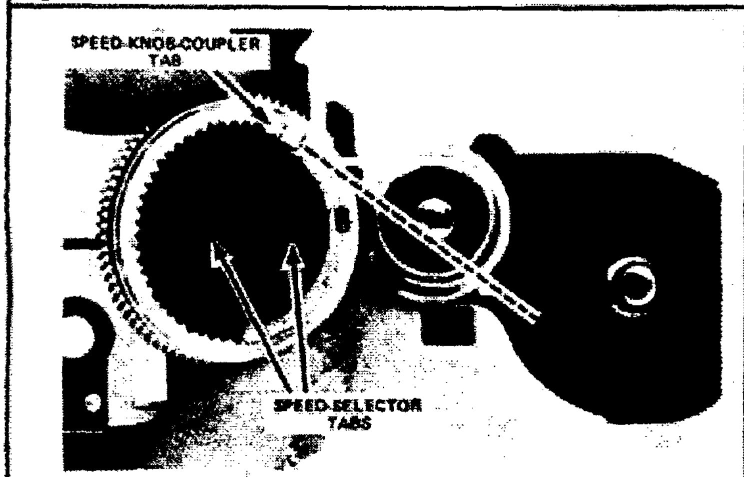


Figure 32

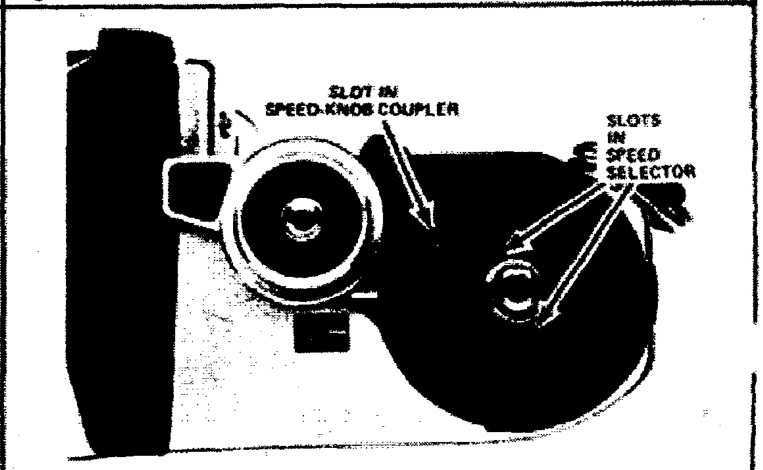


Figure 33

tor. In fact, the service materials make extensive use of the Apex system for designating the variables which affect exposure. "SV" stands for "speed value," a number in the Apex system referring to the ASA film speed. And "TV" stands for "time value," the Apex designation of the shutter speed. In effect, the functional resistor substracts the time value from the speed value.

In Fig. 31, we've set the shutter speed to "B" and the film speed to ASA 3200—the combination of settings for maximum exposure. These settings allow the functional resistor to turn as far as it can in a clockwise direction.

Always set this combination of settings before removing the speed knob. You want to let off as much of the spring tension as you can. Otherwise, you run the risk of breaking the fine coupling wire that connects the speed knob to the functional resistor.

Also note the position of the functional resistor in Fig. 31. Here, we've drawn two imaginary lines—one running perpendicular to the rewind shaft and one running through the center of the cover tab. At "B" and ASA 3200, there should be a 45° angle between these two imaginary lines. As yet, you aren't so concerned with timing the functional resistor—you'll see the precise timing after pulling the top cover. But noting the position of the functional resistor now gives you a check on the proper speed-knob installation.

The reason for the concern is that there are a couple of speed-knob variations. To remove the speed knob, first take off the wind lever. As you unscrew the wind-lever retaining screw, watch for the loose spring washer and teflon washer underneath. Lift off the wind lever and the wind-lever coupler. Now, making sure you're set to "B" and ASA 3200, unscrew the speed-knob retaining ring (there should be a brass washer under the ring) and lift off the speed knob.

Notice the tab on the underside of the speed knob, Fig. 32. Here's where you'll find the variation—that tab may be in a different location at the same combination of settings. The tab fits into a slot in the speed-knob coupler.

A mechanical-coupling system joins the speed-knob coupler to the functional resistor. So, when you remove the speed knob, the spring-loaded functional resistor turns the speed-knob coupler a little further in a clockwise direction. And the tab on the underside of the speed knob no longer aligns with the speed-knob-coupler slot.

To replace the speed knob, start the large tab, Fig. 32, in the speed-knob-coupler slot. Then, turn the speed knob in a counterclockwise direction. When the "B" calibration aligns with the index, the speed knob should drop into place. Two small tabs on the underside of the speed knob then align with two slots in the speed selector. And your functional resistor should be at the 45° angle.

But not all of the speed-knob couplers you'll see have the slot in the same position. Some have the slot closer to the front of the camera, Fig. 33. And others have two slots. If your speed-knob coupler has two slots, there may be some question as to which slot you should use. Here's where it's handy to know the timing of the functional resistor.

Normally, you should use the speed-knob-coupler slot that's closer to the front of the camera. So first try the speed-knob tab in this slot. And, after seating the speed knob, check the timing of the functional resistor. If the functional resistor isn't at the 45° angle, you know that you used the wrong slot.

Now, with the speed knob removed, lift off the top cover. You can then see the top of the flex circuit—and most of the circuit components, Fig. 34.

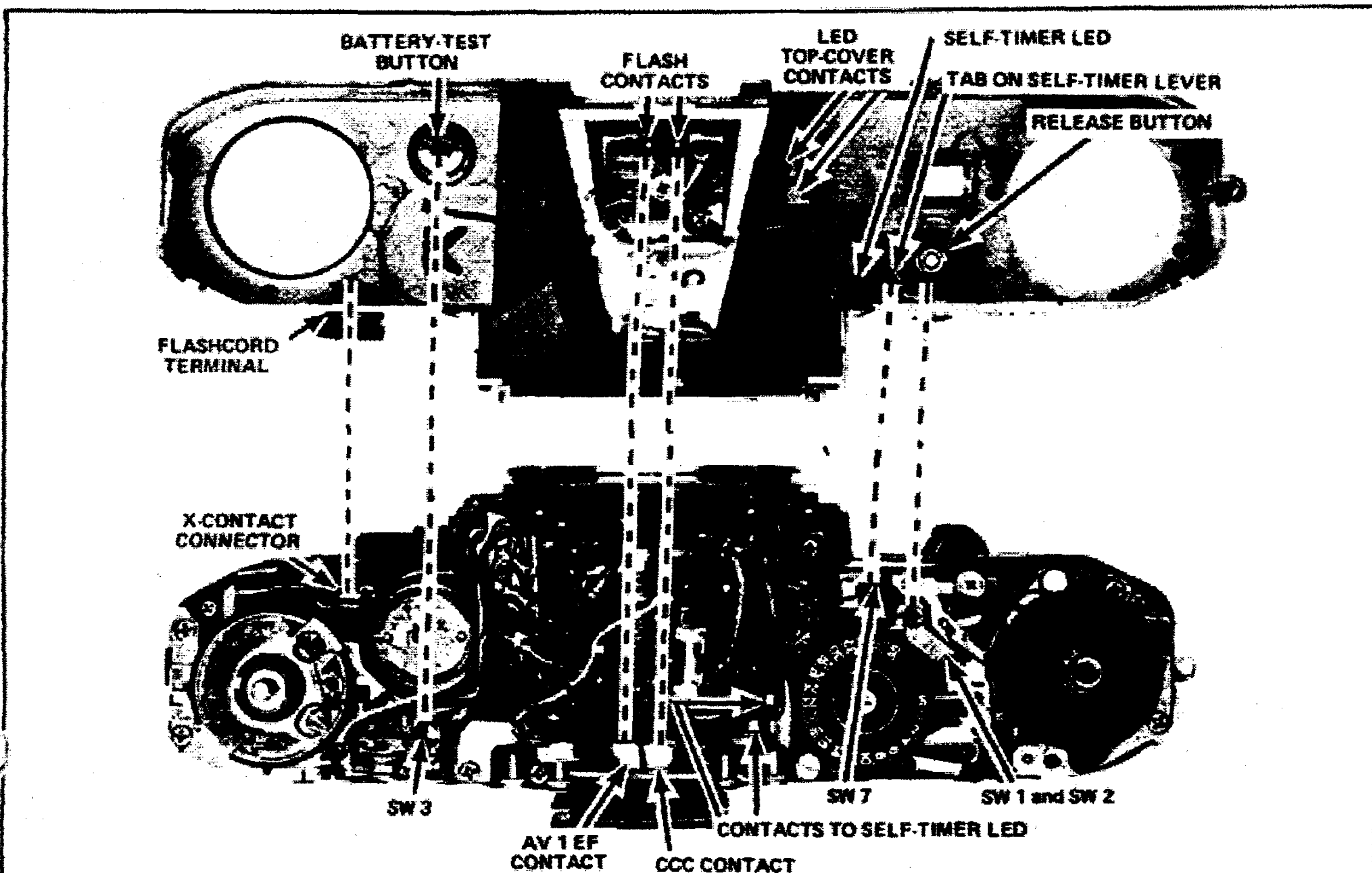


Figure 34

COUPLING BETWEEN THE TOP COVER AND THE CAMERA BODY

Fig. 34 points out the parts in the top cover which align with points in the camera. Starting at the wind-lever side, notice the switches labeled "SW1" and "SW2." These are the release-button switches—the switches that close when you push the release button.

Three blades make up the SW1 and SW2 switches. The top blade is a ground contact. When you push the release button part way, the ground contact moves down and touches the second

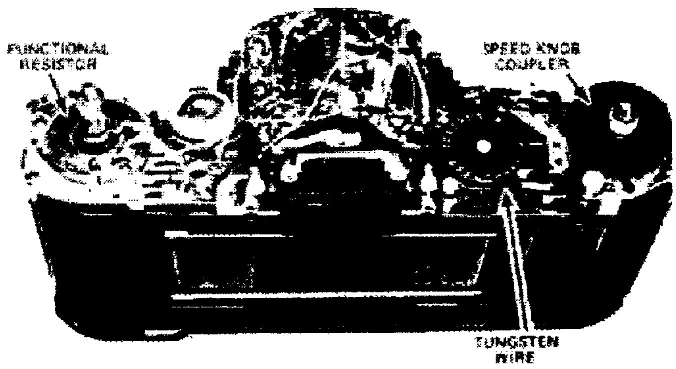


Figure 35

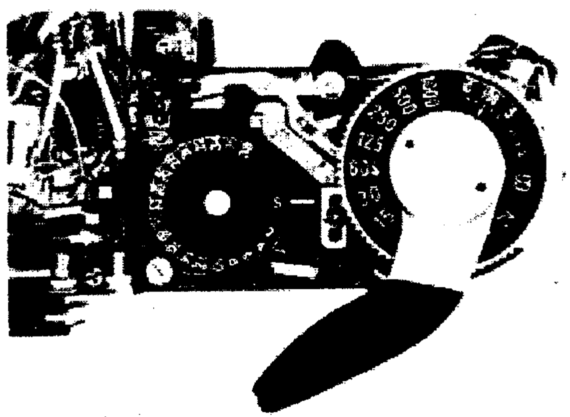


Figure 36 *Test settings for timing functional resistor*

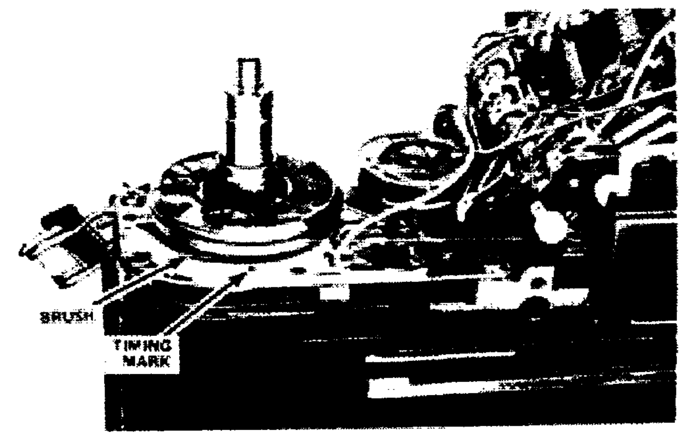


Figure 37 Functional-resistor timing at ASA 100, 1/60 second

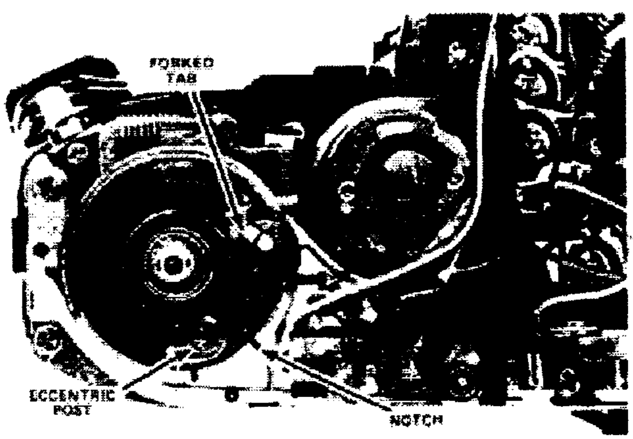


Figure 38 *Speed knob removed*

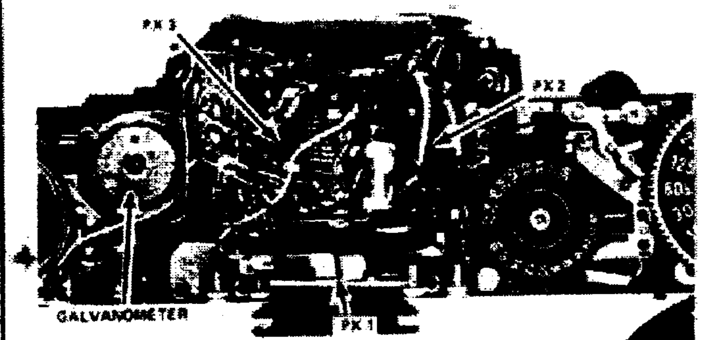


Figure 39

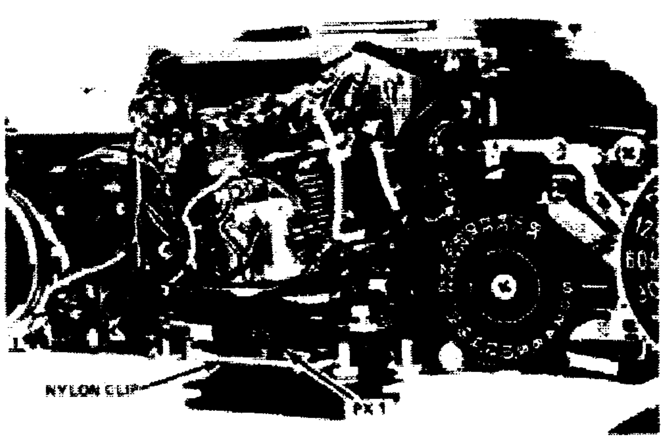


Figure 40

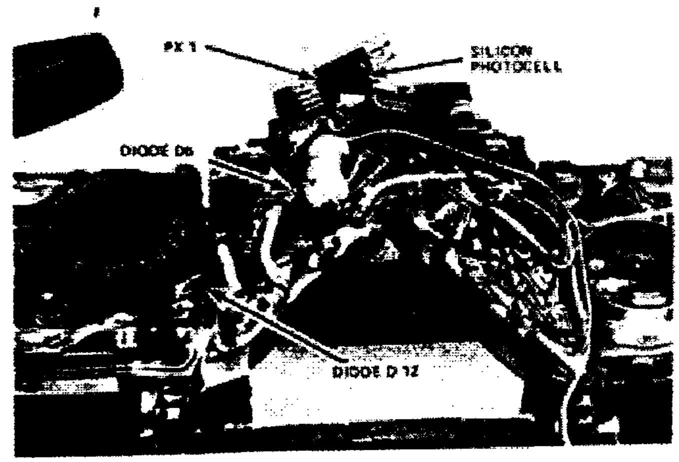


Figure 41

blade—the SW1 blade. That turns on the circuit. Pushing the release button the rest of the way connects the bottom blade, SW2, to ground. And that releases the shutter.

A tab on the self-timer lever sits next to the release-button pin, Fig. 34. When you push forward the self-timer lever, the tab comes against a thin wire. This wire is the blade of SW7, the self-timer switch. So the self-timer lever just pushes the SW7 blade against a ground tab, closing the self-timer switch SW7 to provide the 10-second delay.

Two vertical contact blades next to the counter dial send the self-timer signal to the self-timer LED. The LED, remaining with the top cover, connects to the two lands shown in Fig. 34. And the two contact blades come against these lands.

Another switch sits under the hot shoe in the top cover. This switch, normally open, closes when you install a flash unit. So you don't get contact to the hot shoe unless you have a flash unit mounted to the camera. If you've hooked a flash unit to the flashcord terminal at the front of the camera, there's no danger of getting a shock at the hot shoe.

The two contacts in the hot shoe engage the two contact blades above the eyepiece. The shorter of the two contact blades, the one on top, receives the f/stop signal from the flash unit. And the longer, lower blade—the CCC contact—receives the signal to switch the shutter speed to 1/60 second.

At the other end of the top cover, locate the long pin on the battery-test button, Fig. 34. This pin passes through a hole in the functional-resistor circuit board. And the battery-test switch SW8 sits beneath the circuit-board hole.

Finally, locate the X-contact connector next to the galvanometer, Fig. 34. A wire joins the X-contact connector to the X-sync contacts at the other end of the camera. When you install the top cover, the X-contact connector comes against the end of the flashcord terminal.

COUPLING TO THE FUNCTIONAL RESISTOR

A thin tungsten wire connects the speed-knob coupler to the functional resistor, Fig. 35. Although the tungsten wire looks delicate, you'll find that it's exceptionally strong—stronger than steel. And it rarely presents problems (unless someone removes the speed knob at the wrong settings, leaving too much tension on the functional-resistor spring).

Replace the speed knob to check the timing of the functional resistor. Seat the speed knob at the "B" and ASA 3200 settings. Then, set the speed knob to 1/60 second and ASA 100, Fig. 36.

Now, look at the underside of the functional resistor. The brush that comes against the resistance path should align with the circuit-board timing mark, Fig. 37. The exact portion of the brush that aligns with the timing mark may vary from camera to camera. But you should note the timing in the event you have to replace the tungsten wire.

REPLACING THE TUNGSTEN WIRE

Suppose, then, that you do have to replace the tungsten wire. Notice the route of the tungsten wire in Fig. 35. A knot at one end of the tungsten wire hooks in a slot at the underside of the speed-knob coupler (with some cement helping to secure the connection). The tungsten wire passes around a nylon pulley next to the speed-knob coupler and around four nylon pulleys above the eyepiece.

Notice that the tungsten wire wraps clockwise around the functional resistor—a slot in the side of the functional-resistor spring barrel guides the tungsten wire. The tungsten wire then passes through a notch in the top of the spring barrel and passes around an eccentric post, Fig. 38. And the end of the tungsten wire ties to a forked tab on the spring-barrel cap.

You can get the tungsten wire as a replacement part—it's not necessary to buy complete assemblies. Tie a knot in one end of the wire (don't use too much of the wire for your knot—you don't have much excess length with which to work). Then, stuff the knot into the slot at the underside of the speed-knob coupler. And use some cement to secure the connection.

Seat the speed-knob coupler and replace the speed knob at the "B" and ASA 3200 settings. Next, route the tungsten wire around the nylon pulleys.

With the original tungsten wire disconnected, there's no initial tension remaining on the functional-resistor spring. But this spring should have 1 to 1 1/2 turns of initial tension. You'll normally find that the eccentric post now points toward the back of the camera. So turn the functional-resistor spring barrel a complete turn in a counterclockwise direction—that applies the initial tension.

Hold the functional resistor at the 45° angle (shown in Fig. 31) as you connect the free end of the tungsten wire. Wrap the tungsten wire clockwise around the outer edge of the spring barrel. Bring the tungsten wire through the barrel notch and around the eccentric post. And pass the free end of the tungsten wire through the slot in the forked tab. Finally, wrap the excess wire around the tab.

Now, set your speed knob to 1/60 second and ASA 100. And check the position of the functional-resistor brush, Fig. 37. If the brush aligns properly with the timing mark, apply a dab of cement to the forked tab. But what if the brush doesn't align with the timing mark? If it's close, you can make the fine adjustment by turning the eccentric post, Fig. 38.

However, you can't get too much adjustment out of the eccentric post. So, if the brush isn't close to the timing mark, it's best to disconnect the end of the tungsten wire from the forked tab. And turn the complete spring barrel until the brush aligns properly. Then, reconnect the tungsten wire and apply some cement to the forked tab.

CUSTOM IC'S IN THE AE-1

Most of what you've read or heard about the AE-1 probably concerns the advanced IC technology. Here, Canon packs a myriad of functions into three tiny IC's. You can see all three IC's at the top of the camera, Fig. 39.

The two IC's on the sides of the pentaprism look alike. But they're completely different inside. PX2, the IC on the wind-lever side of the pentaprism, contains the digital-logic circuitry—the mini-computers. And PX3, on the rewind side of the pentaprism, processes information received from other components to control the shutter speed, meter readout, and diaphragm setting.

How about PX1? It's a little more difficult to see. PX1 mounts to the section of flex circuit that curls up near the eyepiece, Fig. 40. PX1 contains the silicon photocell and the MOSFET (metal oxide semiconductor field effect transistor) amplifier for the photocell.

A white nylon clip holds PX1 in place. The clip passes over the top of the IC at the back of the flex circuit, Fig. 40. To reach the IC, you can simply remove the clip. And carefully lift out the section of flex circuit containing PX1, Fig. 41.

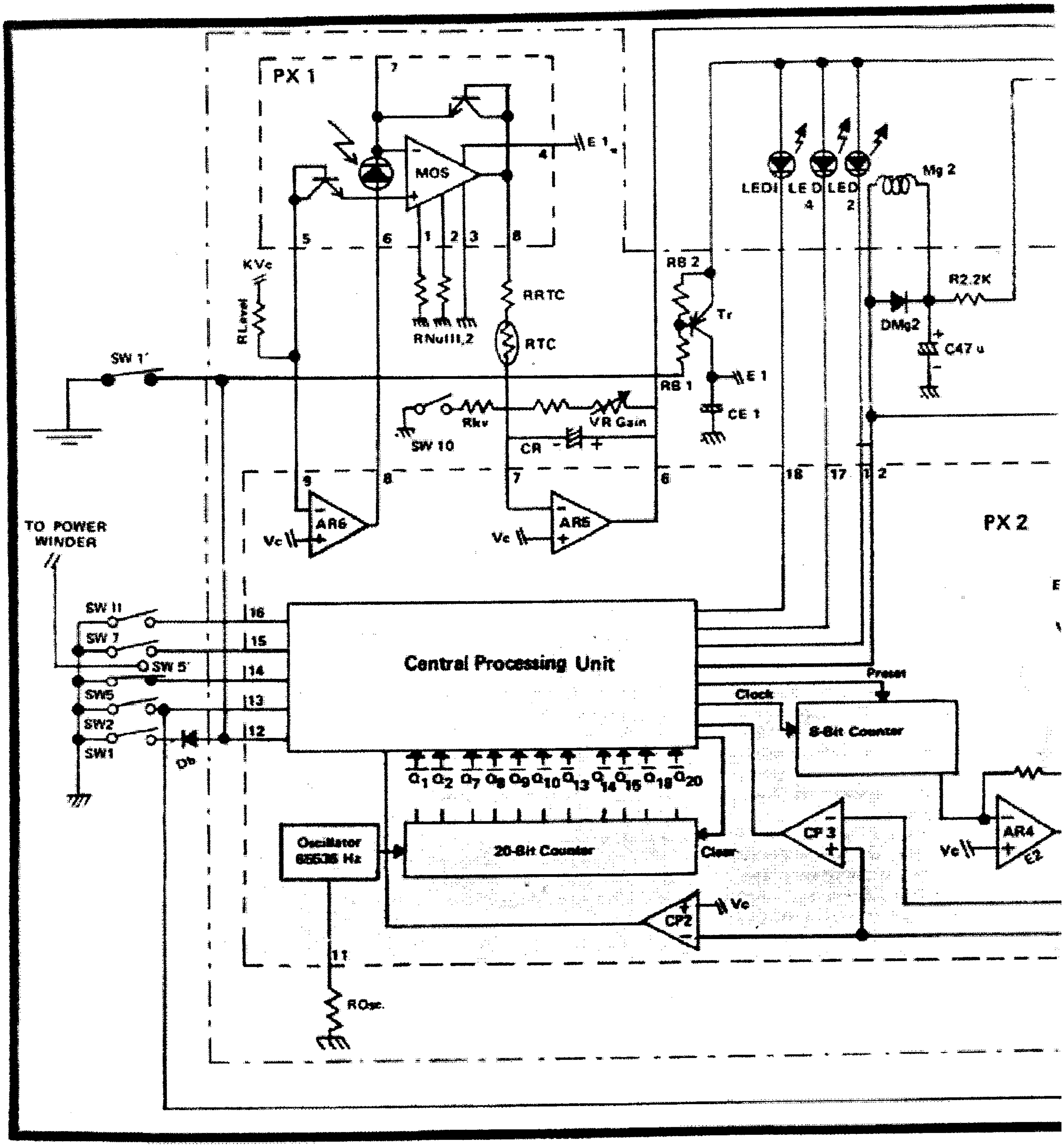
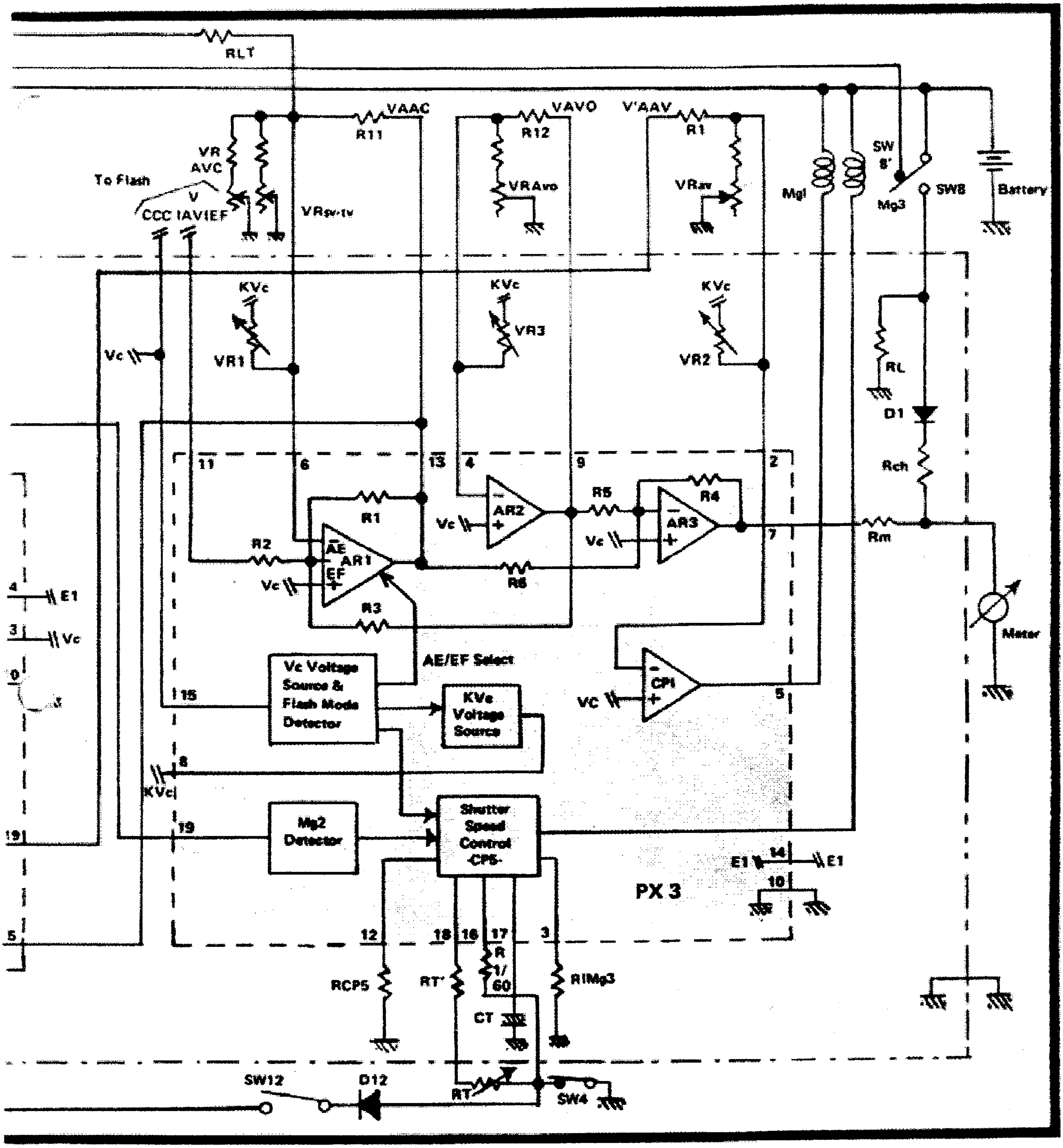


Figure 42

Part 2

Canon AE-1



CIRCUIT FOR THE CANON AE-1

Fig. 42 shows the complete schematic for the AE-1. Here, we've just made some slight changes to the schematic published in Canon's service materials. If you're using Canon's service manual, here are the changes we've made:

1. We've added diode Db to input No. 12 of the central processing unit. Early versions of the camera don't have this diode. Diode Db sits on the top of the flex circuit, Fig. 41.
2. We've added diode D12 at the bottom of the schematic. Early AE-1 models have a resistor R12 rather than the diode. Fig. 41 also points out diode D12. If you have a resistor in this position, you're working on an early version of the circuit.
3. We've reversed the positions of thermistor RTC and resistor RRTC at the output of the MOSFET amplifier. The resistor—not the thermistor—hooks to pin 8 of the MOSFET.
4. We've reversed the positions of resistors RT and RT' at the bottom

(right-hand side) of the schematic. Resistor RT'—not resistor RT—hooks to pin 18 of the shutter-speed control.

5. We've added switch SW1' at the left-hand side of the schematic. SW1' is the preview switch, the switch at the front of the camera connected to the flex circuit by a purple wire.

At first glance, the circuit of Fig. 42 may appear overwhelming—that's a lot more than you normally expect to see inside a camera. So we'll break down the various circuit operations to make the whole thing more digestible. However, keep in mind that Canon's complete schematic, Fig. 42, provides your most valuable troubleshooting tool for the AE-1. So we'll first cover some of the basics.

Locate the battery in the upper right-hand corner of the schematic, Fig. 42. And notice that the battery has a negative ground. So all the test and adjustment voltages we'll be describing will be positive with respect to ground. In making your voltage measurements, hook your negative voltmeter lead to any metal portion of the camera body. And touch the positive voltmeter lead to the test points.

The dash-dot line around the outside of the schematic indicates the flex circuit—everything within the dash-dot line mounts to the flexible circuit board. And the inner dashed lines (dashes with no dots) indicate the three IC's.

PX1, the MOSFET amplifier, is in the upper left-hand corner of the schematic. Here, you can see the symbol for the silicon photocell hooked to the input of the MOSFET, Fig. 43. PX2, in the lower left-hand corner, Fig. 42, contains the digital circuits. Locate the 20-bit counter (20 flip-flops) and the 8-bit counter (8 flip-flops). The 8-bit counter serves as the memory circuit.

The third IC, PX3, is at the lower right-hand corner of Fig. 42. PX3 controls the galvanometer and two of the three electromagnets—Mg1, the diaphragm-control electromagnet, and Mg3, the closing-curtain electromagnet. The shutter-speed-control circuit sits just below PX3 in Fig. 42.

There's a lot more inside the IC's than the schematic indicates. But the schematic breaks down the IC's enough to show what's going on—and to show the inputs and outputs. Although there may literally be thousands of transistors inside the IC's, there's only one discrete (individual) transistor in the camera—a PNP transistor (marked "TR") just above the box indicating PX2. The transistor sits on the top of the pentaprism, Fig. 44. Transistor TR has one function—it supplies operating voltage for all three IC's. Pushing the release button far enough to close SW1 turns on the transistor. And battery voltage E1 appears at the transistor's collector.

The schematic doesn't show all the connections between the collector of the transistor and the IC's. Rather, the schematic simplifies things a little by

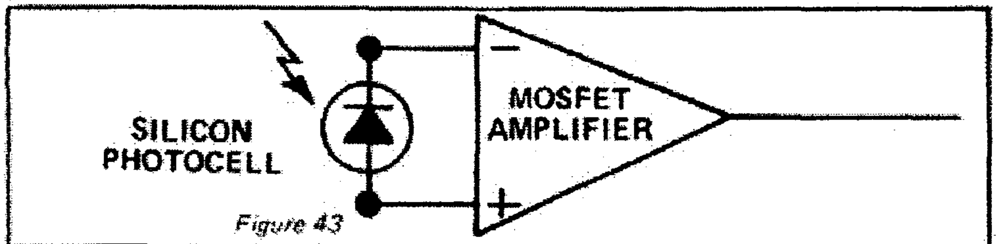


Figure 43

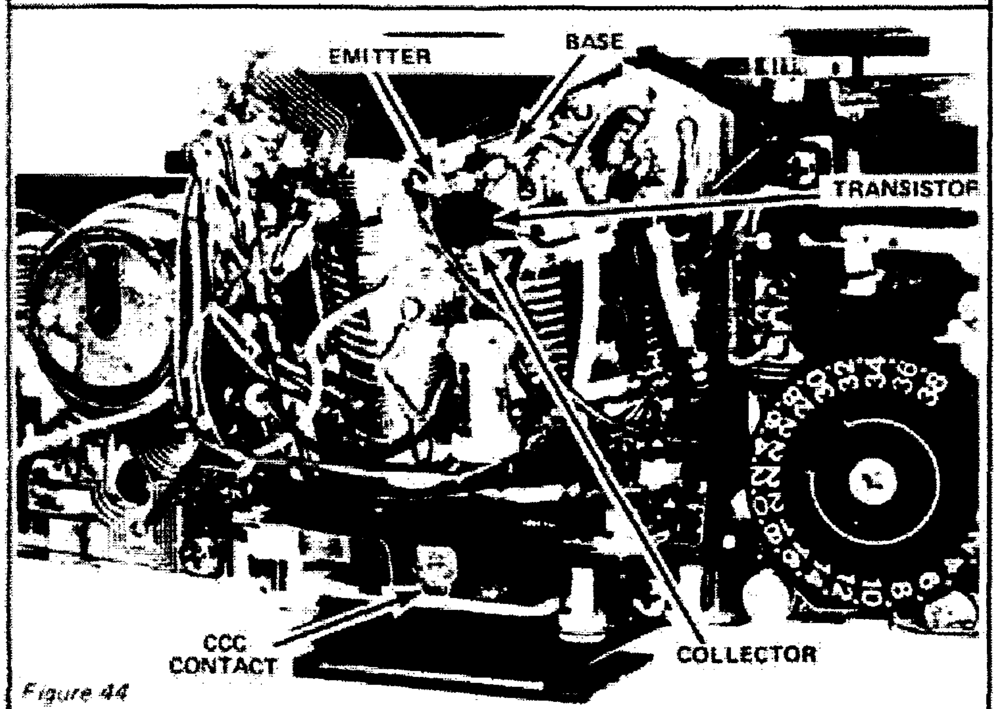


Figure 44

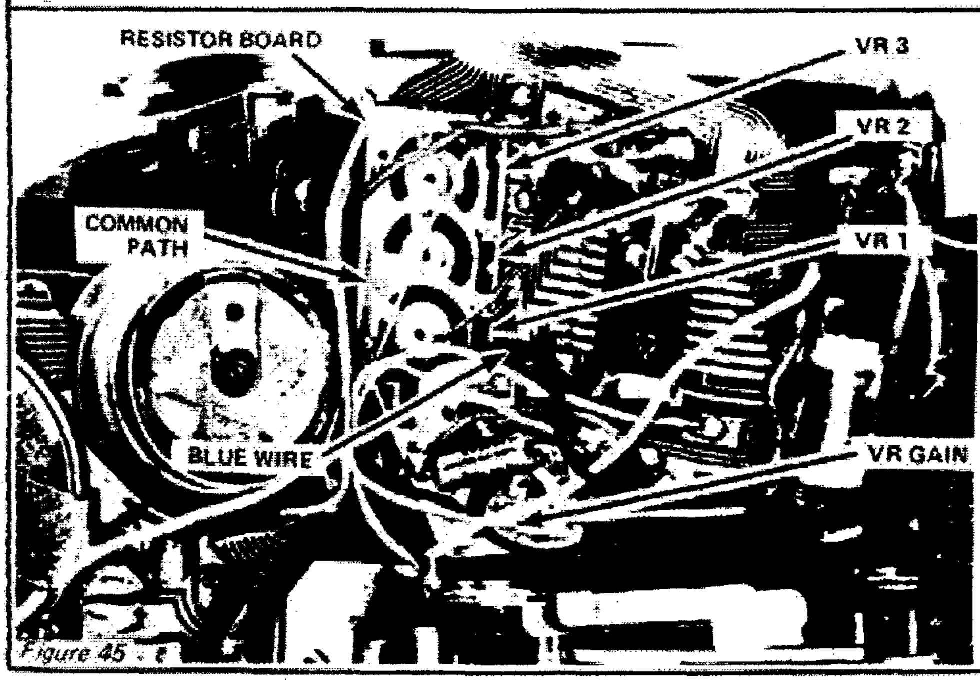


Figure 45

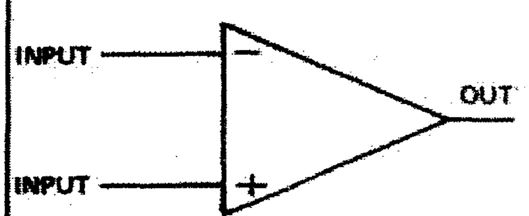


Figure 46

just indicating where voltage E1 appears. Notice that the IC leads are numbered. And the collector voltage of TR appears at pin 4 of each IC.

To the right of PX1 in Fig. 42, you can see the three LED's and the mirror-release combination magnet Mg2. LED 1 is the underexposure LED, LED 2 the self-timer LED, and LED 4 the manual LED. Strangely, there's no LED 3.

CONSTANT-VOLTAGE SOURCES IN THE AE-1

The AE-1 generates two constant voltages within PX3. Even though the battery voltage may change, these two constant voltages remain the same. However, the two constant voltages may vary slightly from camera to camera.

One of the constant voltages provides a reference for each amplifier stage. That's Vc, appearing at pin 15 of PX3. Notice that the CCC hot-shoe contact also connects to pin 15 of PX3. So, when closing the release-button switch SW1, you should measure the Vc voltage at the CCC contact, Fig. 44. The Vc voltage should be 1.2 volts plus or minus 0.06 volt. We'll talk more about the Vc voltage later—it's very important in setting up your adjustments.

The other constant voltage, KVc, provides the adjustment capability. KVc appears at pin 8 of PX3. And PX3 applies the KVc voltage to one end of the variable resistors VR1, VR2, and VR3. Adjusting these three variable resistors just regulates the amount of KVc applied to amplifier inputs.

Again, the schematic doesn't show the connections between the KVc voltage source (pin 8 of PX3) and the variable resistors. But you can see the three variable resistors we mentioned on the resistor circuit board, Fig. 45. A common circuit path joins one end of each of the resistors. And a blue wire connects to the common path—it's this blue wire that carries the KVc voltage to the variable resistors.

KVc may vary between 1.8 and 2 volts, depending on the particular camera. But, like Vc, it remains constant within the camera. So you can measure the KVc voltage between the blue wire, Fig. 45, and ground. Checking your Vc and KVc voltages should be one of your first steps in troubleshooting the camera.

OPERATIONAL AMPLIFIERS IN THE AE-1

If you followed the series of *Craftsman* articles on digital electronics, you already have the theory background for understanding the AE-1. So we can now put that theory to work and see how it applies specifically to the schematic of Fig. 42.

All those triangle symbols in Fig. 42 indicate amplifiers—more specifically, operational amplifiers. The operational amplifier, "op amp" for short, is a high-gain DC amplifier with many applications. You can use the same op amp to do a number of things—it just depends on the components you hook to the op amp.

Other than the MOSFET, you can see two types of op amps in Fig. 42. Several of the op amps are labeled "AR" for "amplifier." Another group uses the label 1 "CP" for "comparator."

Each amp labeled "AR" provides linear amplification. The op amp takes a certain DC input signal and provides a proportional—but amplified—output. Fig. 46 shows basically how the op amp does the job. Notice that you have two inputs—one marked "-" and one marked "+." And there's one output at the opposite corner of the triangle.

The input marked "-" is the inverting input. That means any signal applied to the "-" input appears amplified but inverted at the output. So suppose you apply a signal that's going more positive at the inverting input. The signal, amplified at the output, goes more negative (or less positive).

The other input, marked "+," provides the noninverting input. Any signal applied to the noninverting input appears amplified and in phase at the output. So a more positive signal at the noninverting input appears as a more positive signal at the output.

But notice in the AE-1 schematic that every op amp serves as an inverting amplifier. Each input signal goes to an inverting input. You'll frequently see inverting op amps with the noninverting input connected to ground. However, in the AE-1 each noninverting input ties to the Vc voltage source. Consequently, the Vc voltage regulator supplies a 1.2-volt reference signal to every amplifier stage.

Also, part of the output is returned to the input through a feedback resistor, Fig. 47. That's because the gain of an op amp is so high (in an ideal op amp the gain would be infinite). You can't really use all that gain. But taking part of the inverted output signal—and returning that signal to the input through the feedback resistor Rf—reduces the gain to a usable amount.

Why? Because the output signal is opposite in phase to the input signal. Consequently, the feedback partially cancels the input. You can then control the gain of the amplifier just by changing the value of the feedback resistor.

The input signal is applied through another resistor—Rin (for "resistor input"). Again assuming a perfect op amp, the input impedance is infinite. And with infinite input impedance, no signal flows into the op amp. Rather, all of the input signal appears across Rin. Of course, no op amp can be perfect. Yet, for measurement purposes, you can consider that the op amps in the AE-1 have these ideal characteristics.

In fact, you can consider that the feedback signal completely cancels the input because of the high gain. That can't actually be the case—if it were, the op amp would be completely useless. Still, for measurement purposes, just figure that the entire input appears across Rin and the entire output appears across Rf. The feedback signal then drives the inverting input to the same potential as the noninverting input.

So suppose you're checking an op amp which has the noninverting input connected to ground. Measuring between the inverting input and ground, you should then measure 0 volt. But in the AE-1, each noninverting input hooks to the 1.2-volt Vc reference. So you should measure 1.2 volts at each inverting input. Changing the light conditions,

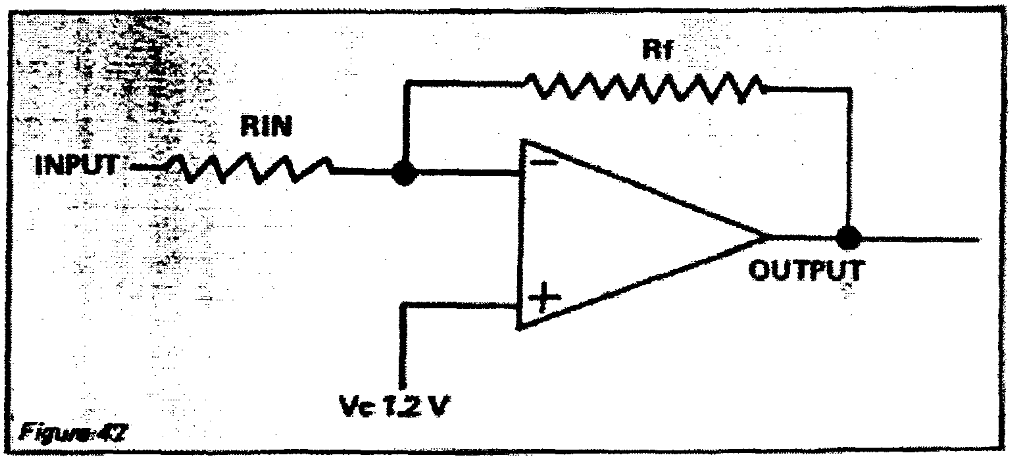


Figure 42

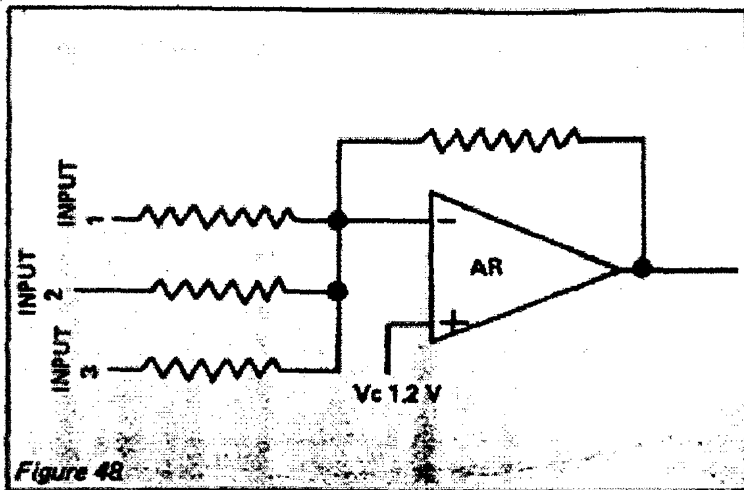


Figure 48

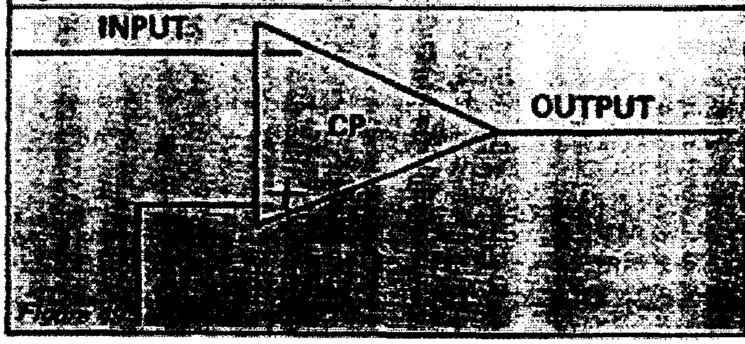


Figure 49

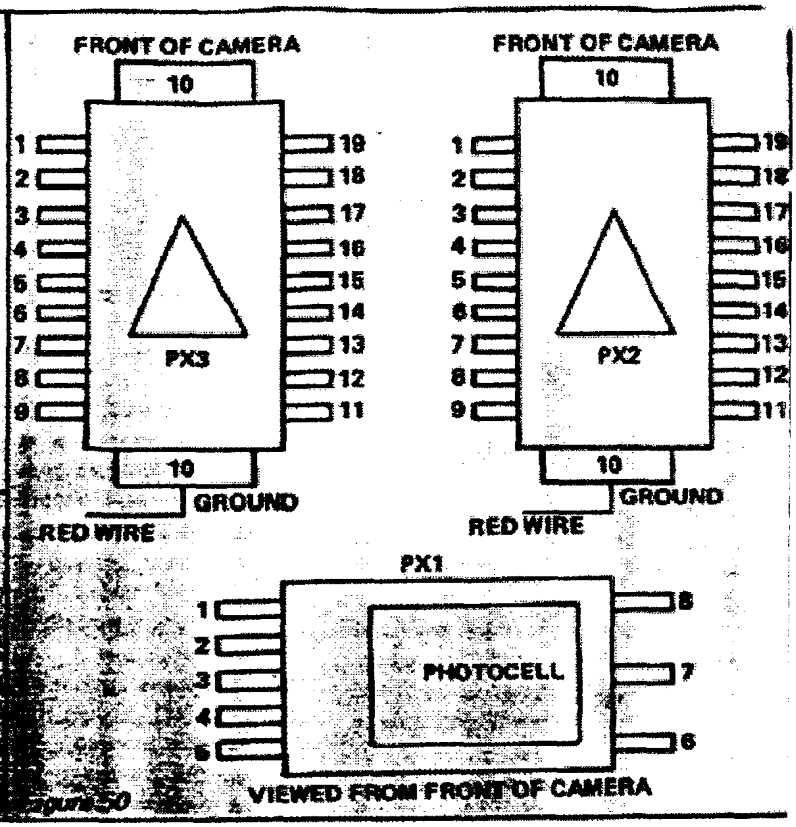


Figure 50

shutter speed, film speed, etc., normally won't give you a difference you can measure.

Since we're assuming perfect op amps—infinite input impedance, zero output impedance—you can figure the gain of the amplifier by the input and feedback resistances:

$$\text{Gain} = \frac{Rf}{Rin}$$

Taking one example from the AE-1, you have an op amp with a feedback resistance of approximately 800 ohms. And you have an input resistance of approximately 400 ohms. Dividing the feedback resistance by the input resistance gives you a gain of 2. If the input signal then goes 1 volt more positive, the output goes 2 volts less positive.

THE SUMMING AMPLIFIER

Each op amp marked "AR" in Fig. 42 serves as a summing amplifier. Fig. 48 shows an example. Here, you have more than one input resistor. An input signal appears across each input. The summing amplifier then sees the algebraic sum of these inputs—it adds them all together. And the algebraic sum of the inputs determines the output.

How could you then use the summing amplifier? As an example, you could make one input the scene brightness, one the shutter speed, and the third the film speed. The summing amplifier would then add these variables to determine the exposure at its output.

THE COMPARATOR

All the op amps marked "CP" in Fig. 42 function as comparators. Here, you'll notice that there's no feedback resistor, Fig. 49. So the comparator isn't a linear amplifier—rather, it functions strictly as a switch.

You can think of the comparator as an analog-to-digital device. It receives an analog voltage signal at the inverting input. And it compares this signal with a constant reference at the noninverting input. In the AE-1, that constant reference is again the 1.2 volts Vc.

If the input voltage is above the reference, the output of the comparator goes to a saturated negative state. For example, say the input voltage is 1.5 volts. It's more positive than is the Vc voltage of 1.2 volts. So the output of the comparator is close to ground.

But if the input voltage is below the reference, the output of the comparator goes to a saturated positive state. So suppose our input of 1.5 volts drops below the reference 1.2 volts. Then, the comparator switches states. And the output goes close to +6 volts, the battery voltage.

Since the comparator serves strictly as a switch, you might think of it another way—it just turns on or turns off, according to the input signal. Think of the output as being negative when the input voltage is above the reference voltage (even though all voltages in the AE-1 are positive with respect to ground). And think of the output as being positive when the input voltage is below the reference voltage. In the AE-1,

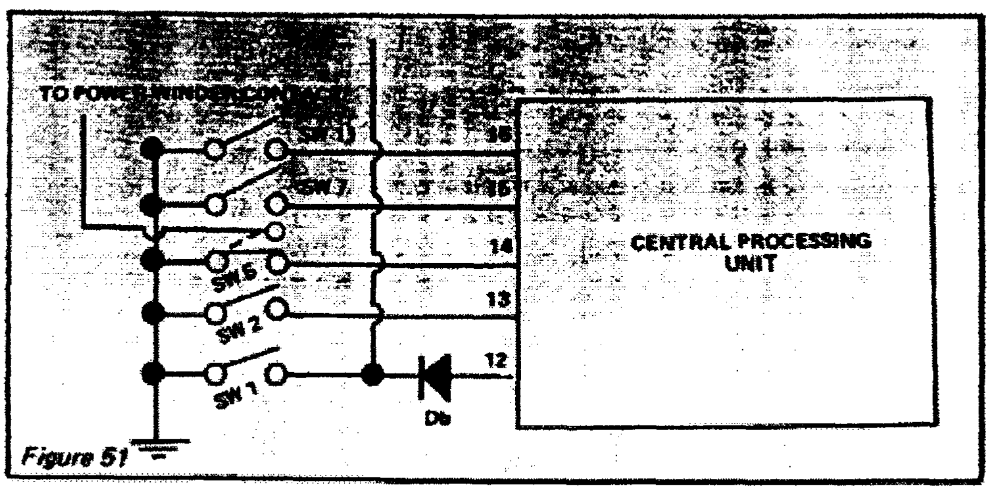


Figure 51

the comparators act as switches for the LED's, the memory circuit, and the electromagnets.

CIRCUIT BOARD REPAIRS

When you're troubleshooting the AE-1, here's one clue to keep in mind—has the camera been worked on before? You can usually tell by looking at the solder connections, screwheads, etc. If it's obvious the camera hasn't been worked on, breaks in the flex circuit are unlikely.

But if someone has worked on the camera, a break in the flex circuit becomes a strong possibility. You may then have to jumper between components, bypassing the break. Here, Canon recommends that you use brown wire. Why? Because there aren't any brown wires in the camera. So when the next technician sees a brown wire, he knows it's a jumper.

Of course, not everyone is going to use brown wire. Most people will use whatever they have handy. Consequently, you can't depend on all jumper wires being brown.

The most difficult part in repairing the flex circuit, though, is locating that break. Now, the schematic, Fig. 42, becomes essential. Using your ohmmeter, you can trace out circuit paths to find a break.

For example, suppose that you aren't getting the E1 voltage to pin 4 of PX2. Yet, checking the voltage at the collector of the discrete transistor with SW1 closed, you measure the battery voltage. You then check for continuity between the collector of the transistor and pin 4 of PX2. And you find an open circuit.

You'll then have to jumper the break in the flex circuit. Solder one end of your jumper wire directly to the transistor's collector, Fig. 44. And solder the other end of the jumper wire to pin 4 of PX2.

Fig. 50 shows the numbering system for the leads of the three IC's. If there's a wire soldered to any of these leads, you know it's a jumper (except for the ground tabs—a red wire connects the ground tabs of PX2 and PX3 to ground).

TROUBLESHOOTING THE SWITCHES IN THE AE-1

Several of the switches in the AE-1 connect to the central processing unit inside PX2, Fig. 42. And mechanical switches are logical places to start troubleshooting for certain types of malfunctions. Remember, it's much more likely to have a problem with a mechanical switch than with an IC.

Fig. 51 shows just the section of PX2 which receives the inputs from the mechanical switches. And Fig. 52 points out the switches themselves. Notice that closing the release-button switch SW1 connects pin 12 of PX2 to ground through the diode Db. And when you push the release button all the way to close SW2, you're connecting pin 13 of PX2 directly to ground.

Suppose, then, that you have a shutter which won't release. You've already checked the combination magnet Mg2 at the bottom of the camera. And you've found that the shutter releases properly during your shorting test.

Try hooking one ohmmeter lead to ground. And touch the other ohmmeter lead to pin 13 of PX2. You should read an open circuit—no continuity. Then, push down the release switches to close SW2. You should now read a short circuit.

Also, with the shutter cocked, check for continuity between pin 14 of PX2 and ground—you should read a direct short. Notice in Fig. 51 that pin 14 connects to switch SW5. And SW5 must make good ground contact before the shutter will release.

Switch SW5, Fig. 52, also has the job of signaling the Power Winder A to cock the shutter. The forked end of the SW5 blade straddles a pin on the SW5 control lever. The SW5-control lever extends into the shutter mechanism where it's controlled by the closing curtain.

With the shutter cocked, the SW5 blade moves to the position shown in Fig. 53. Here, it contacts the land closer to the back of the camera. That connects pin 14 of PX2 to ground. But when the

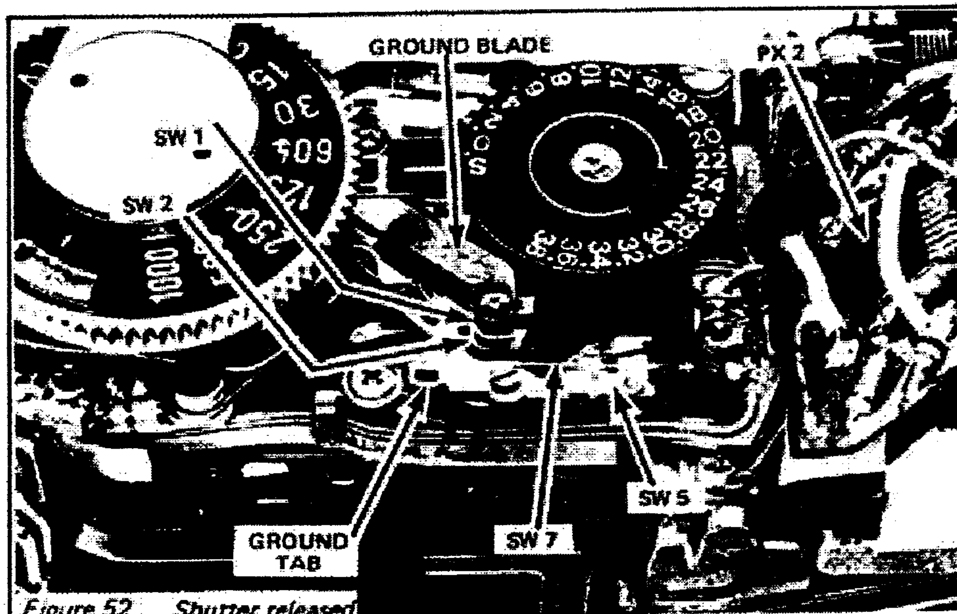


Figure 52 Shutter released

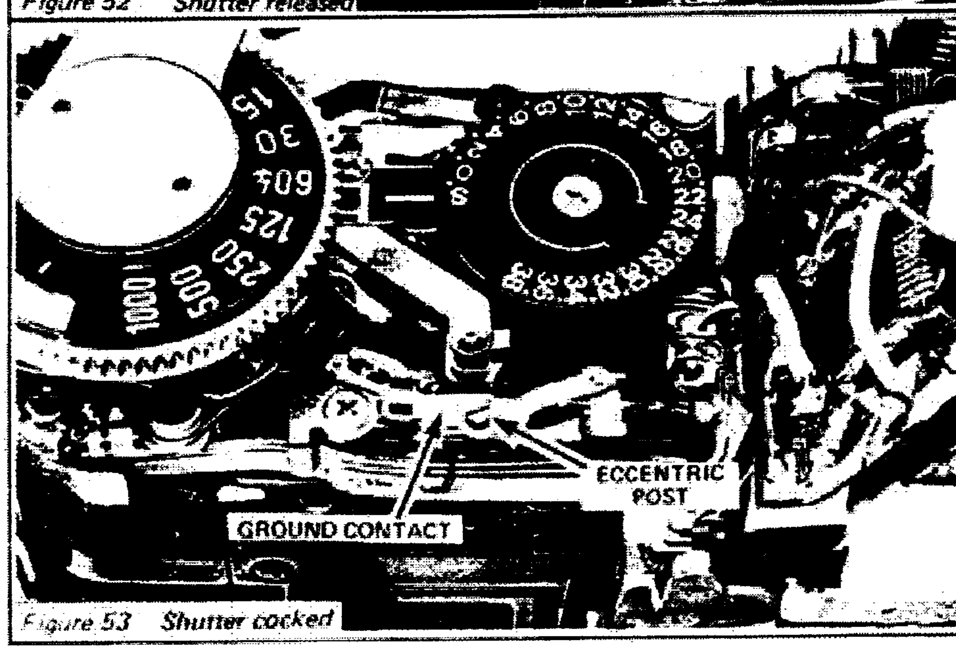


Figure 53 Shutter cocked

closing curtain causes the aperture to end the exposure, the SW5 blade swings toward the front of the camera. It then disconnects pin 14 of PX2 from ground. And instead it connects the Power-Winder switching contact to ground. In the schematic, Fig. 51, the dashed line shows the position of the SW5 blade with the shutter released.

SW5 has one other job in the camera–it maintains the ground contact when you allow the release button to return. When the release button returns, it allows switches SW1 and SW2 to open. Yet the shutter should still time out properly–it's not necessary to hold down the release button for the full exposure.

Suppose, then, you get an AE-1 which doesn't time out at the slow speeds. Perhaps you've set the speed knob to the 1-second or 2-seconds setting. And you find that the shutter closes as soon as you allow the release button to return. Yet the shutter times out properly when you hold down the release button for the full exposure.

This condition indicates a problem with SW5–the switch isn't maintaining a good ground contact. Possibly you have dirty contacts. In that case, use either a soft eraser or a commercial contact-cleaning solution. Or you may have to reform the SW5 blade, providing a firmer contact with the land.

Another solution is to reform the ground contact that sits above the SW5 blade. The ground contact pushes down the SW5 blade for firm contact. In some cameras, you'll find a washer between the forked end of the ground contact and the SW5 blade. This washer increases the downward pressure applied by the ground contact. Also, you may find that the post supporting the SW5 blade is eccentric (if the post has a screwdriver slot, it's an eccentric). You can then turn the eccentric for better switch contact.

The ground contact, Fig. 53, also provides the ground for the self-timer switch SW7, Fig. 51 and Fig. 53. Remember, the self-timer lever just pushes the self-timer switch SW7 against the vertical tab of the ground contact. That connects pin 15 of PX2 to ground.

You can check the self-timer action by holding the SW7 blade against the ground contact. Or, to make things easier, just lift the SW7 blade up and over the ground-contact tab, Fig. 54. With the SW7 blade against the front of the tab, the switch stays closed. You can then cock the shutter and push down the release-button switches–you should get the 10-second self-timer delay.

Here, there's no flashing LED indication to tell you the self timer is at work. So you'll have to wait patiently. Or you can monitor the voltage between the two self-timer LED contacts, Fig. 55. Hook the positive voltmeter lead to the LED contact which has a red wire–hook the negative voltmeter lead to the LED contact which has a black wire. You should then see the voltage pulsate from around 1.7 volts to around 1.2 volts during the self-timer delay.

If the self-timer delay fails to work during this test–and instead the shutter releases as soon as you depress the release-button switches–check for continuity between pin 15 of PX2 and ground. No continuity with the self-timer switch closed indicates a break in the flex circuit. On the other hand, if the shutter fails to release–even after the 10-second delay–you could have a problem with SW5. SW5 must still maintain that good ground contact when SW1 opens.

What if you have a break in the flex circuit? Then, you can jumper between the end of the SW7 blade (the end that solders to the flex circuit) and pin 15 of PX2. But if there's no break, and you still have no self-timer delay, PX2 may be defective.

The release-problem possibilities we've described can't really be called "common" malfunctions. But [illegible]

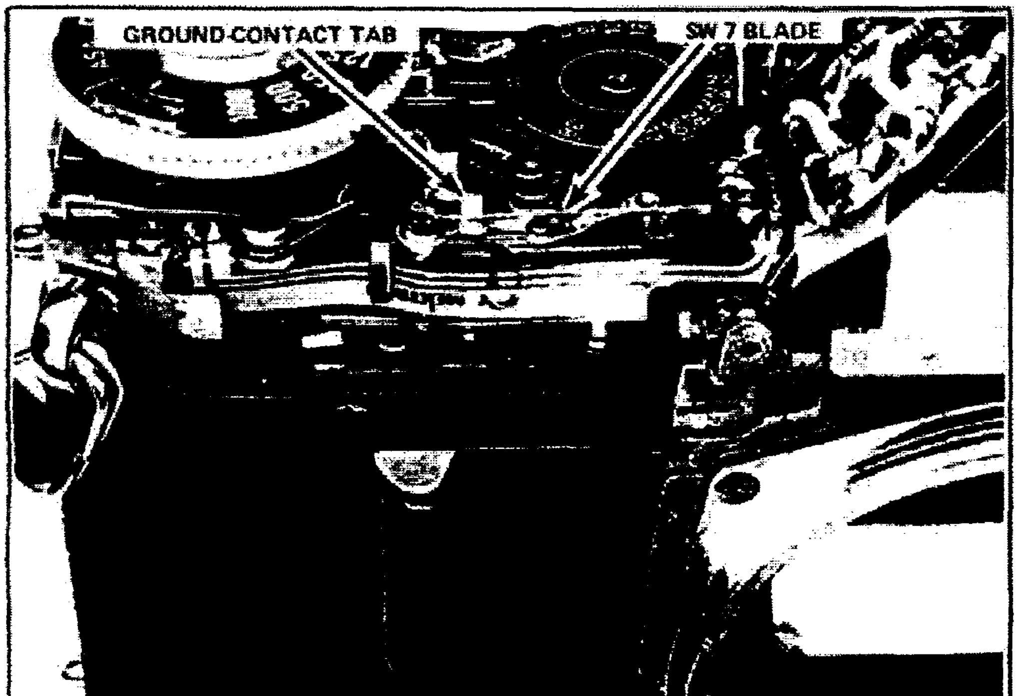


Figure 54

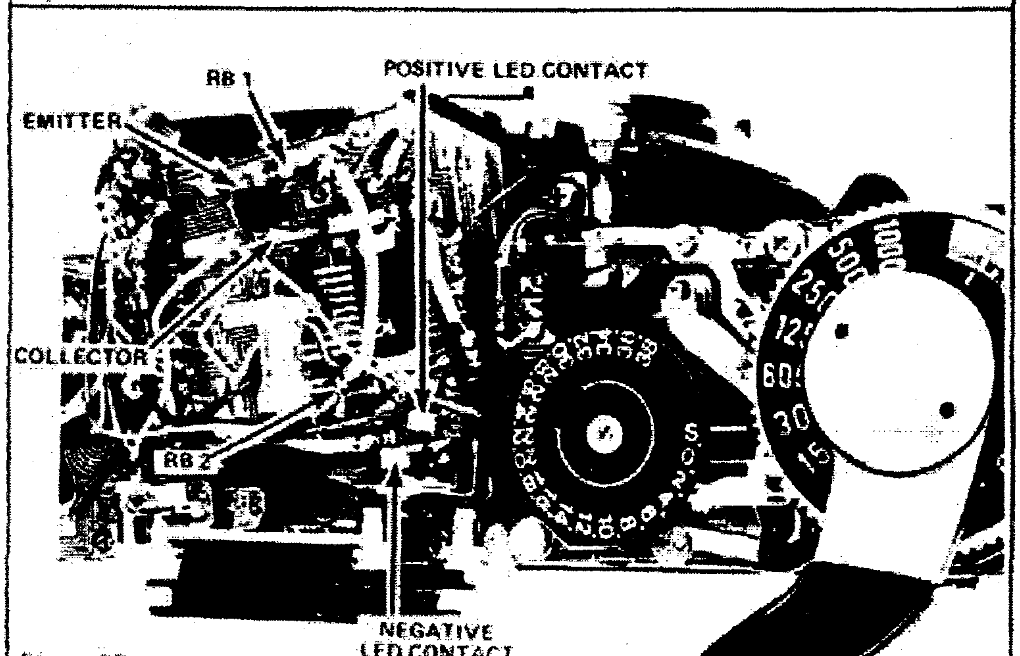


Figure 55

one release problem that may fall into this category—the SW7 switch remains in constant contact with the ground-contact tab. When that happens, you have an "easy" repair. Just pull the top cover and reform the SW7 blade, bending the blade away from the ground-contact tab.

There's one more switch shown in Fig. 51—the auto-manual switch SW11. As yet, you can't see SW11—it's the switch behind the front plate that's controlled by the E-M change pin. SW11 opens when you set the diaphragm-setting ring to the automatic position. Setting a manual f/stop allows SW11 to close, connecting pin 16 of PX2 to ground.

PHOTOMETRIC SYSTEM IN THE AE-1

Probably the most unique part of the AE-1 involves the photometric system—the system that reads the light, provides the meter indication, and controls the diaphragm closure. Since Canon uses the Apex system in its service materials, we've put the Apex symbols in Fig. 56.

"BV" means the brightness value—a certain amount of light entering the lens system. The brightness value has nothing to do with the shutter speed, film speed, or any other variable. It's strictly a fixed amount of light.

Some of that light is lost in passing through the lens system. So, once through the lens, BV becomes BVO—the brightness value out of the lens. The silicon photocell sees BVO as the light falling on the focusing screen. And it responds to the light level by developing a voltage that's proportional to the BVO.

The brighter the light (the higher the BVO), the more voltage the silicon photocell puts out. The MOSFET then amplifies the voltage across the photocell. This amplified version of BVO goes to summing amplifier No. 1 in Fig. 56.

Notice that summing amplifier No. 1 has several inputs. It adds the BVO to the film-speed-setting information (SV), the shutter-speed information (TV), and the aperture-correction information (AVC). The value of AVC (aperture value correction) depends on the lens installed. One of the resistors on the side of the mirror cage (controlled by the maximum-aperture correction pin) determines the value of AVO.

The output of summing amplifier No. 1 is now AV—the aperture value, a diaphragm opening which will provide proper exposure with all the variables considered. But for the meter readout, the system must add one more factor—the maximum-aperture information AVO. A second variable resistor on the mirror cage, also controlled by the maximum-aperture correction pin, provides the maximum-aperture information. Summing amplifier No. 2, Fig. 56, then adds the maximum-aperture information to the AV information from summing amplifier No. 1. And it provides an output which drives the galvanometer needle to the proper f/stop reading.

So far, all we've done is get a meter readout. However, the same AV information at the output of summing amplifier No. 1 also controls the diaphragm-closing system. Notice that the two lower outputs from summing amplifier No. 1, Fig. 56, go to comparators.

Comparator No. 1 in Fig. 56 controls the underexposure LED in the finder. First, it compares the AV signal from summing amplifier No. 1 to the constant voltage reference Vc. If AV is below 1.2 volts, the comparator switches into positive saturation. And the underexposure LED flashes on and off, telling you that you're outside the metering limits.

The third AV output of summing amplifier No. 1 goes to comparator No.

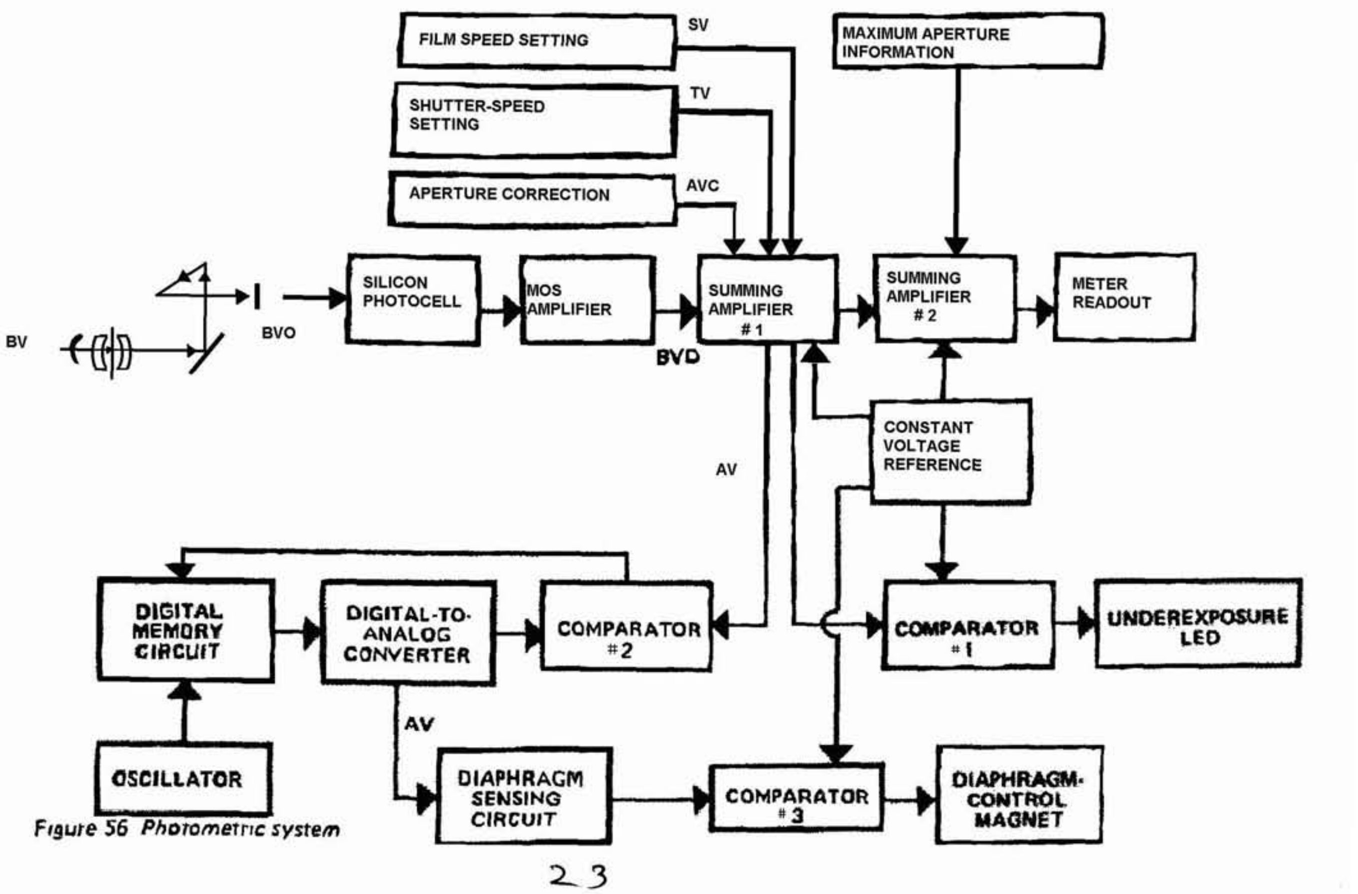


Figure 56 Photometric system

2. And comparator No. 2 controls the memory circuit. When you depress the release button to close SW2, the oscillator shown in Fig. 56 starts feeding pulses to the digital memory circuit.

Earlier, we mentioned that the memory consists of an 8-bit counter—a series of 8 flip-flops. The counter starts at 0. It then counts the pulses supplied by the oscillator.

A digital-to-analog converter constantly monitors this count. And it turns the digital count into an analog voltage. As the count increases, the voltage output of the digital-to-analog converter decreases. This voltage then provides the second input to comparator No. 2 in Fig. 56—the other input, you'll recall, is the AV signal from summing amplifier No. 1.

When the output of the digital-to-analog converter drops to the AV signal, the comparator shuts off the digital counter. But the counter holds its count as long as it has operating power. That's how it serves as a memory circuit. The AV output of summing amplifier No. 1 now appears as the output of the digital-to-analog converter.

Naturally, all this counting takes some time—around 8 milliseconds for the counter to reach its maximum count. So the release circuit has a built-in 10 ms delay. It takes 10ms between the time you close SW2 and the time the capacitor discharges through the combination magnet Mg2. This time delay assures that the counter can reach its maximum count.

After the 10ms delay, the mirror releases. And, as the mirror rises, the diaphragm starts closing. Now, the silicon photocell can no longer see the light passing through the lens. So you lose the AV output from summing amplifier No. 1. But it doesn't matter—that same AV signal has been memorized at the output of the digital-to-analog converter.

Consider that the diaphragm is now closing. That means the diaphragm-control electromagnet Mg1 remains energized. As the diaphragm closes, it lowers the resistance in the diaphragm-sensing circuit, Fig. 56.

So the diaphragm-sensing circuit modifies the AV output of the digital-to-analog converter. And it supplies this changing output to comparator No. 3, Fig. 56. When the diaphragm-sensing circuit drops the AV input below the VC reference signal, comparator No. 3 switches into positive saturation. That shuts off the current flowing through the diaphragm-control electromagnet Mg1.

As a result, the diaphragm-control electromagnet releases its armature. The armature then drops into engagement with a ratchet gear to arrest the diaphragm-setting lever. So the diaphragm-setting lever stops the diaphragm at the proper f/stop—the proper AV.

TROUBLESHOOTING THE PHOTOMETRIC SYSTEM

In a moment, we'll go through the same operations using the actual circuit. You'll then be able to see the test points and troubleshooting procedures. But you'll notice in Fig. 56 that you have a natural dividing point for troubleshooting—the output of summing amplifier No. 1.

For example, suppose that you get a camera in which the meter doesn't work. Perhaps the needle always stays at the top of the scale. Or perhaps the needle always pegs to the bottom of the scale. Yet you check the diaphragm on automatic operation and find that it stops down to the proper f/stop.

You then know that the AV output of summing amplifier No. 1 must be o.k. If it weren't, the diaphragm system wouldn't be working. So the problem must be to the right of the first summing amplifier. Perhaps there's a problem in the maximum-aperture resistor. Or maybe the galvanometer itself is defective.

Or, suppose that the diaphragm fails to stop down properly. It always remains at the largest aperture or it always stops down to the smallest aperture, regardless of the light conditions. Yet the meter reads correctly. Again, you know that the output of the first summing amplifier must be correct. Why? Because the meter reads properly. So the problem must be in the lower part of Fig. 56—most likely, the diaphragm-sensing resistor.

Possibility number three—neither the meter nor the diaphragm works properly. Now, you can be pretty sure you aren't getting the proper AV output from summing amplifier No. 1. So the problem must be between the first summing amplifier and the photocell.

LIGHT-MEASURING CIRCUIT

We can now go through the schematic step-by-step to locate the test points. In Fig. 57, we're showing just the light-measuring circuit. This is the portion in the upper left-hand corner of the complete schematic, Fig. 42.

Fig. 57 also shows the circuit through which the preview switch SW1' turns on the transistor TR. Closing SW1' allows current to flow through the two base-bias resistors of TR. This bias current makes the base of the PNP transistor around 0.8 volt negative with respect to the emitter. And that turns on the transistor. Closing the release-button switch SW1 does the same thing.

The forward bias is more than enough to drive the transistor into saturation. As a result, very little voltage drops across the transistor. The transistor serves strictly as a switch—it turns on when you close SW1 (or SW1') and it turns off when SW5 removes the ground contact.

What if the transistor failed to turn on? Then, none of the IC's would operate—none would have operating power. As a result, the shutter would not release and the meter needle would not deflect. The only circuit still operational would be the battery-test circuit.

So one of your standard tests in the AE-1 is to check the discrete transistor. Without closing SW1 or SW1', measure the voltage between the emitter of the transistor, Fig. 55, and ground. You should measure the full battery voltage. Then, measure the voltage at the collector. Here, you should measure 0 volt—the transistor should be off.

Now, close SW1. And again measure the collector voltage. This time, you should measure close to the full battery voltage. Your reading will probably be just under 6 volts, depending on the battery's condition. When you're drawing current, there's a voltage drop across the battery's internal resistance.

If you don't get the battery voltage E1 at the collector, the transistor isn't turning on. Possibly you have a bad transistor. Or maybe the transistor isn't getting the bias it needs.

You can then check the voltage between the base and emitter of the transistor, Fig. 55. If you're getting the proper forward bias, you evidently have a bad transistor. And if you're not getting the forward bias, there may be a problem in the bias circuit. Check the two base-bias resistors, Fig. 55.

Turning on the transistor applies the collector voltage to the E1 input of the MOSFET. So the MOSFET amplifies the signal from the silicon photocell. The negative lead of the photocell connects to the MOSFET's inverting input. Consequently, increasing the light level causes the inverting input to go more negative. And, since the MOSFET is an inverting amplifier, the output at pin 8 goes more positive.

Notice that the MOSFET doesn't use

a resistor as the feedback component—instead, it uses a transistor connected as a diode (the base and emitter leads are tied together). A diode's resistance changes as the current changes. So the MOSFET has a changing feedback signal—a signal that varies according to the input.

As a result, the MOSFET serves as a log converter—it amplifies the log of the input. The reason is that EV's (exposure values) aren't linear with respect to BV's (brightness values). So the MOSFET changes the gain according to the input signal to provide a linear output.

There's one problem with using a semiconductor as a feedback component—semiconductors are heat-sensitive. That means changes in temperature also affect the gain of the MOSFET. To take care of this problem, the AE-1 uses temperature-compensating circuitry.

A tracking transistor, also connected as a diode, connects to the MOSFET's noninverting input. The tracking transistor tracks temperature variations and makes needed compensations in the reference voltage. Also, a thermistor hooks to the MOSFET output, Fig. 57.

You can see the thermistor RTC (resistor temperature control) near the top of the pentaprism in Fig. 58. It's a coil of wire. With all the advanced semiconductor electronics in the AE-1, it's somewhat surprising to see a coil of wire for temperature stability. But there's a reason. As the temperature of the wire increases, the resistance increases—a positive temperature coefficient. A semiconductor thermistor normally has a negative temperature coefficient, meaning the resistance decreases as the temperature increases.

The thermistor and its series resistor serve as the input resistance for amplifier AR5. Consequently, the gain of AR5 varies according to the temperature to make compensations. AR5, as you can see in the complete schematic, is inside PX2. This amplifier stage once again inverts the signal. Since the output of the MOSFET goes more positive with increased light, the output of AR5 goes less positive.

Notice that the feedback path of AR5 includes a variable resistor—VR Gain. VR Gain is one of the resistors on the resistor board—the one nearest the back of the camera, Fig. 58. Changing the setting on VR Gain changes the gain of AR5—turning the wiper clockwise increases the gain, turning the wiper counterclockwise decreases the gain. VR Gain provides one of the standard adjustments you'll use in setting up the camera.

The capacitor hooked in the feedback circuit of AR5 just serves as a filter. It compensates for fluctuations in the light source, such as would result from fluorescent lighting.

When you close the backlight switch SW10, Fig. 57, AR5 becomes a summing amplifier. It now has two input resistances. SW10 hooks the inverting input of AR5 to ground through the backlight resistor Rkv. So closing SW10 causes the output of AR5 to go more positive for the same light level, giving you the intentional overexposure.

There's one more op amp shown in Fig. 57—AR6. AR6 holds the noninverting input of the MOSFET at a constant value. And R level sets the operating point of the MOSFET. Here, it looks as though R level may originally have been intended as an adjustment—it's on the resistor board, connected to the KVc adjustment voltage. However, R level is a fixed resistance path.

Let's now trace the BVO signal through the circuit of Fig. 57. If you're checking the signal with a voltmeter, you should see a changing voltage at the MOSFET output (pin 8)—a voltage that goes more positive as the light level increases. This changing voltage provides the input to amplifier AR5.

But measuring the voltage at pin 7 of PX2, you should read 1.2 volts (again, the high gain drives the inverting input of AR5 to the same voltage as the noninverting input). And at the output of AR5 (pin 6 of PX2), you should again read a changing voltage. The voltage should decrease—go less positive—as you increase the light level. The output of AR5 then goes to the next amplifier stage through input resistor RLT, Fig. 57.

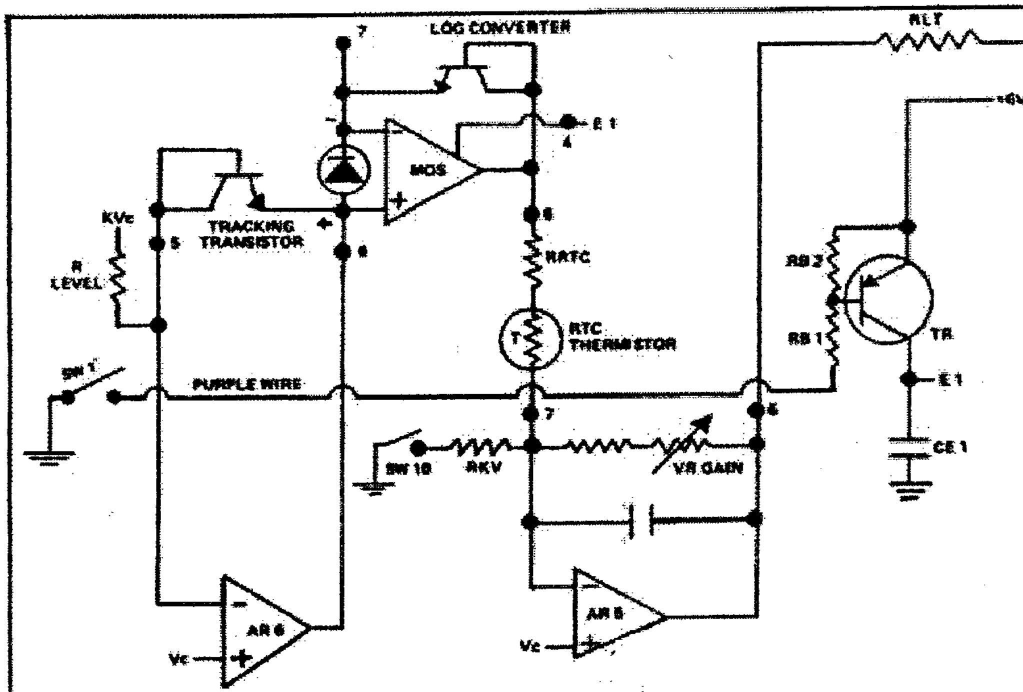


Figure 57. *Light-measuring circuit*

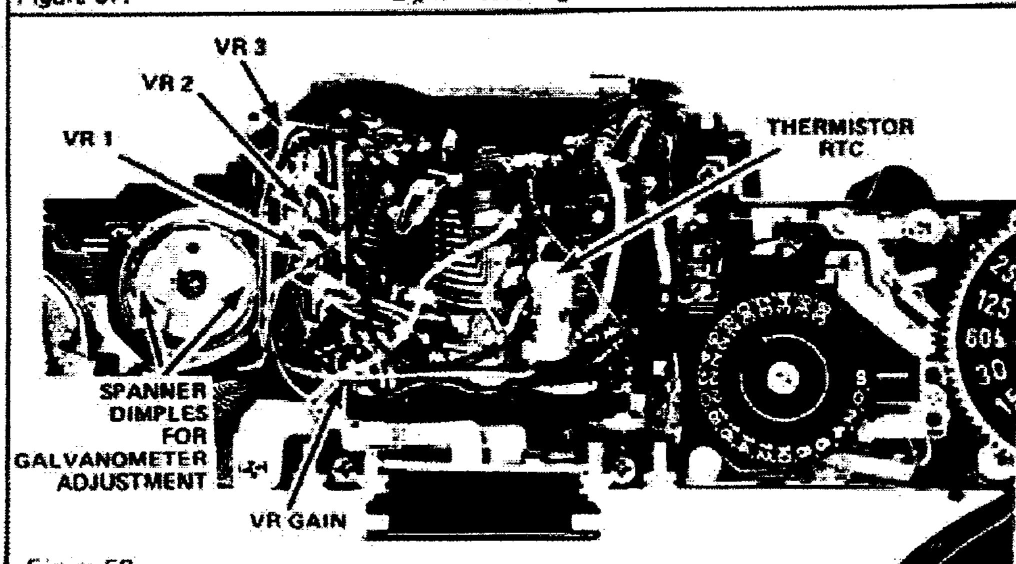


Figure 58

THE SUMMING AMPLIFIER AR1

Amplifier AR1 inside PX3, Fig. 59, corresponds to summing amplifier No. 1 in the block diagram, Fig. 56. AR1 adds the shutter-speed information, the lens information, and the film-speed information to BVO.

Notice in Fig. 59 that AR1 has two inverting inputs. Input resistor RLT hooks to the AE (automatic exposure) input. And input resistor R2 hooks to the EF (electronic flash) input. The other end of R2 connects to the hot-shoe contact that automatically sets the aperture.

With the Speedlite 155A installed, AR1 gets its input through resistor R2 to the EF input. The Speedlite provides the input signal and resistor R1 provides the feedback. But for available-light functions, AR1 uses the AE input.

In Fig. 60, we've omitted the EF input to AR1. Here, you can see how AR1 serves as a summing amplifier for automatic exposure control. The BVO signal from AR5, Fig. 57, is applied to the AE input of AR1 through resistor RLT. Since the output of AR5 goes less positive with increasing light, the output of AR1 goes more positive with increasing light—another phase inversion.

But remember, AR1 adds the other variables to the BVO signal. It gets the film-speed and shutter-speed information from the functional resistor. In the schematic, Fig. 60, variable resistor VR SV-TV indicates the resistance set by the functional resistor.

AR5 also adds a correction factor for the particular lens. Installing the lens selects the resistance of VR AVC, one of the two variable resistors on the side of the mirror cage. So RLT, VR AVC, and VR SV-TV all serve as input resistors for amplifier AR1.

There's one more input resistor—VR1, Fig. 60. VR1, one of the variable resistors on the resistor board, Fig. 58, provides your adjustment for the AR1 output. For a particular combination of film speed, shutter speed, light level, and maximum lens aperture, you should have a certain output from AR1. Adjusting VR1 requires actually measuring the output of AR1 at pin 13 of PX3.

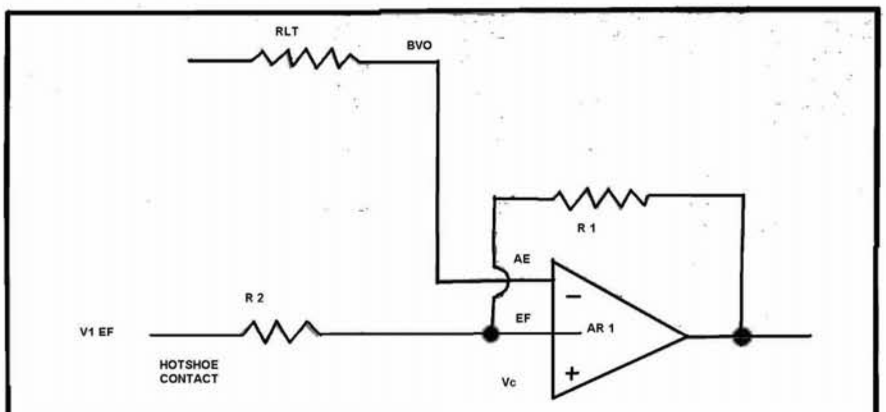
For most of the troubleshooting tests we'll describe, just about any voltmeter will do the job. But you're expected to make the adjustments to the millivolt. That means a 3 1/2 digit voltmeter practically becomes a necessity for adjusting the AE-1. You just can't read an analog meter to this kind of precision.

CONTROLLING THE METER READOUT

The output of AR1 now contains the actual diaphragm information— the AV (aperture value). This AV, you'll recall, has two functions: it controls the meter readout and it sets the actual diaphragm opening. But to provide the proper f/stop indication, the meter needs one more bit of information—the maximum aperture of the lens.

Installing the lens sets the resistance of VR AVO—that's the second variable resistor controlled by the maximum-aperture correction pin. The resistance of VR AVO, Fig. 60, controls the output of amplifier AR2.

Notice that you can adjust the output of AR2 with another of the resistors on the resistor board—VR3. VR3, then, provides your maximum-aperture adjustment. Here, you'll install a lens.



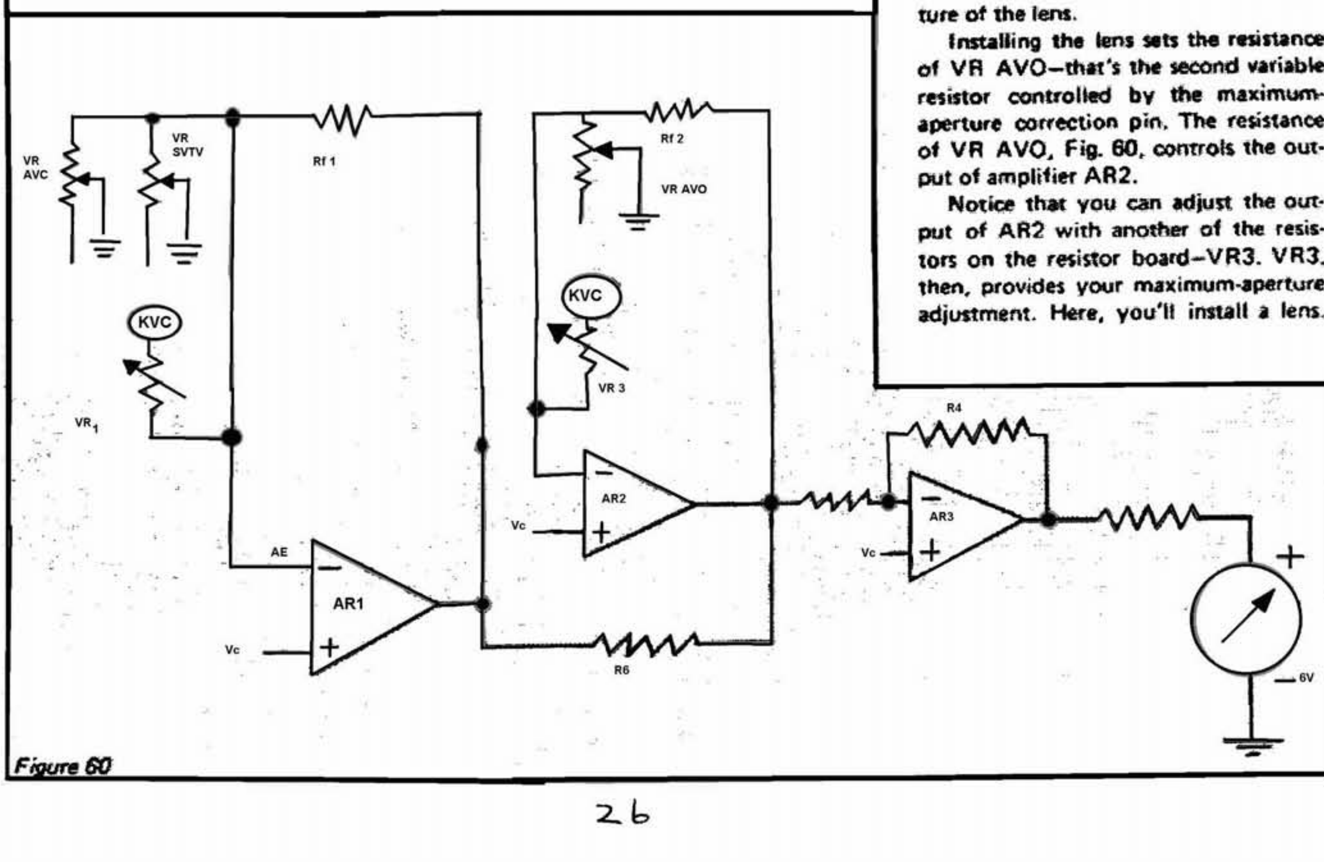


Figure 60

And you'll adjust the voltage output of VR3 to get the proper voltage at pin 9 of PX3.

Amplifier AR3 now adds the AV information from AR1 to the maximum-aperture information from VR AVO. And the output of AR3 drives the galvanometer. The output of AR3 makes the top of the galvanometer more positive or less positive, depending on the input signals.

You've seen that the galvanometer needle deflects further for a lower light level. Tracing through all those phase inversions, you can now see why. Consider again that you have an increasing light level. The output of the MOSFET then goes more positive, the output of AR5 goes less positive, the output of AR1 goes more positive, and the output of AR3 goes less positive. And the end result—the top of the galvanometer goes less positive.

Making the top of the galvanometer less positive, Fig. 60, lowers the potential difference across the meter. That's because the bottom of the meter connects to ground. So you have less current flowing through the meter's coil. And the needle doesn't move as far.

The adjustment for the needle reading may provide a surprise—you simply rotate the complete galvanometer housing. Notice the two spanner-wrench dimples on top of the galvanometer, Fig. 58. A pressure spring holds the galvanometer movement in a mounting plate. So, using a spanner wrench, you can turn the galvanometer until you get the proper f/stop reading.

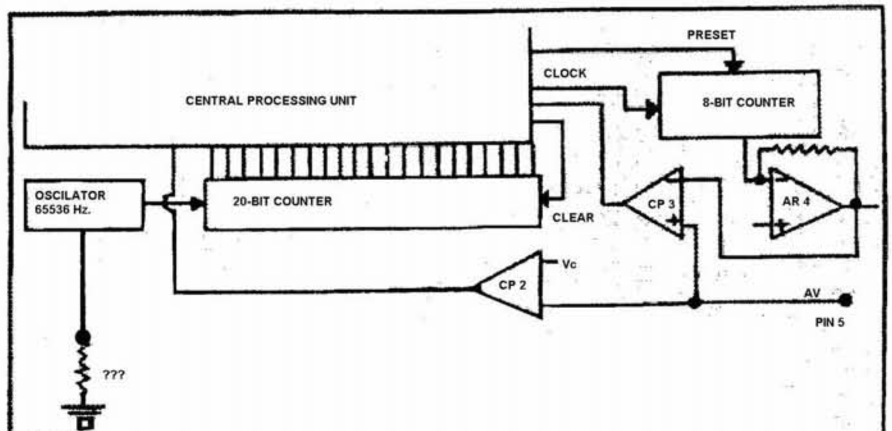
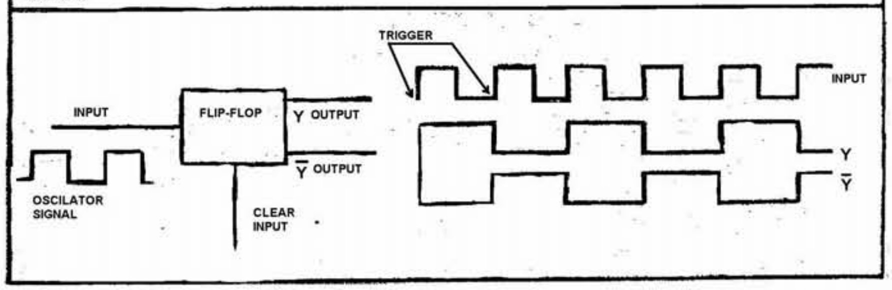


FIGURE 61



THE MEMORY SYSTEM

Most automatic SLR's with electronic controls store the exposure information in a memory capacitor. If the AE-1 used a memory capacitor, it would simply charge the capacitor with the AV information from AR1. The charge on the memory capacitor would then determine the diaphragm opening.

But Canon engineers decided the memory-capacitor system lacked the precision they wanted. So instead, they adapted a computer concept for retaining information—a digital counter. And the AE-1 became the first camera to use digital logic.

Integrated circuit PX2 contains the digital system, Fig. 61. PX2 receives the input of AR1 at pin 5. So you can measure the changing AV signal at two IC's—pin 5 of PX2 and pin 13 of PX1.

Inside PX2, the AV signal goes to two separate comparators, Fig. 61. Comparator CP2 controls the underexposure LED. And comparator CP3 controls the memory circuit.

Earlier, we mentioned that the AV signal from AR1 is more than 1.2 volts in the usable metering range. Comparator CP2 compares the AV with the 1.2-volt Vc reference. And if the AV signal drops below 1.2 volts, the comparator turns on the underexposure LED. The underexposure LED then flashes on and off at an eye-grabbing rate—4Hz.

Since the LED flashes (rather than glowing steadily), you know the AE-1 must have a built-in oscillator. The oscillator shown in Fig. 61, an astable multivibrator, supplies the oscillations needed for several applications. When you close SW1, the oscillator sends a 65536 Hz. signal to the 20-bit down counter.

The 20-bit down counter serves as a frequency divider. It has 20 separate flip-flops (bits). And each bit divides its input frequency in half. So at the first bit, you get a frequency of 32768 Hz., half the oscillator frequency. At the second bit, you get 16385 Hz., at the third bit 8192 Hz., etc. Keep dividing the frequency in half and you'll reach 4 Hz. at the 14th bit—that's the frequency that drives the underexposure and manual LED's. At the 15th bit, you get the 2 Hz. signal for the self-timer LED.

Fig. 62 shows the operation of the frequency divider. We've simplified the drawing to show just one bit—the first flip-flop stage. Depending on the flip-flop design, it takes either a positive-going pulse or a negative-going pulse to trigger the flip-flop. A change in the input pulse tells the flip-flop to switch its outputs to opposite states.

So suppose in Fig. 62 that the Y output of the flip-flop is at 0—it's set to 0 by a pulse applied to the "clear" input. The other output, $\overline{Y}$ (not Y) must then be in the opposite state—1. A flip-flop has only two states, 0 and 1. And the two outputs must always be at opposite states.

A positive-going pulse applied to the input triggers the flip-flop. So the flip-flop changes states—the $\overline{Y}$ output goes to 1 and the Y output goes to 0. The square-wave input pulse then drops back to 0. But the flip-flop doesn't change conditions until the input starts increasing again.

As a result, the signal taken from the Y output looks like the input signal. But the frequency has been divided in half. Same with the signal at the $\overline{Y}$ output—it's just opposite in phase to the Y output. So the 65536 Hz. signal applied to the input becomes a 32768 Hz. signal at the outputs. It's this signal that drives the memory circuit.

An 8-bit up counter provides the memory. The 8-bit counter isn't much different from the 20-bit counter. But it's used for a different purpose—it counts the pulses from the first bit of the frequency divider.

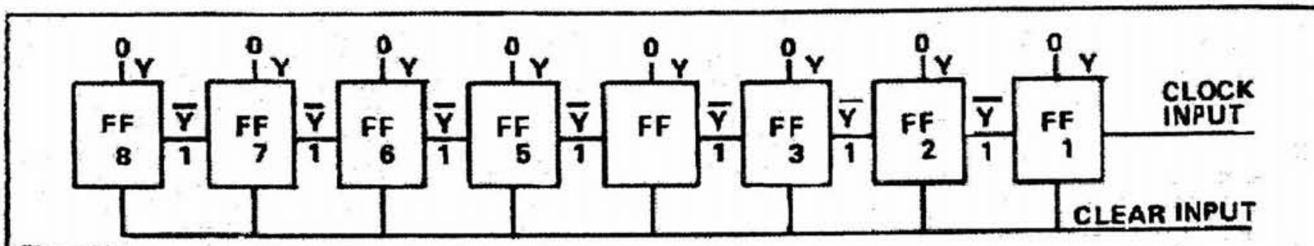


Figure 63

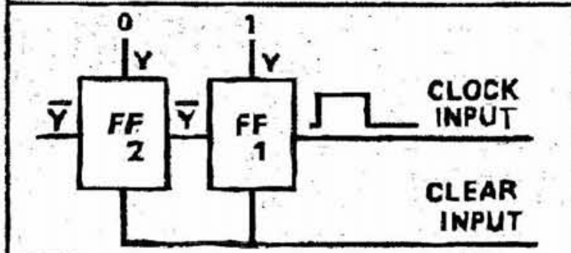


Figure 64

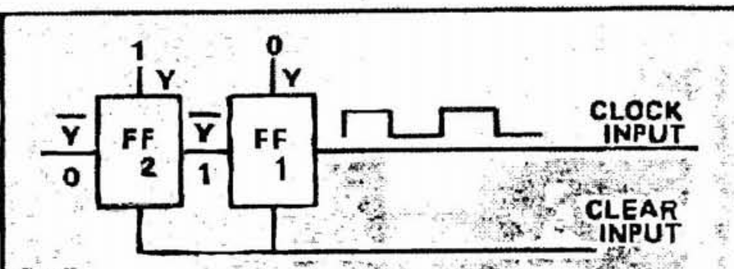


Figure 65

Closing the release-button switch SW2 applies a "clear" pulse to the 8-bit counter through the "preset" lead, Fig. 61. That sets the Y outputs to 0 (and the $\bar{Y}$ outputs to 1). Now, the 8-bit counter can count the 32.768 KHz. signal applied to its "clock" input.

The simplified diagram, Fig. 63, shows how the 8-bit counter can count the clock pulses. Consider that you've just applied the "clear" signal. So all the Y outputs are at 0. And each flip-flop requires a positive-going pulse—a 1—to change states.

When the input starts going positive, flip-flop No. 1 changes states—the Y output goes to 1 and the $\bar{Y}$ output goes to 0, Fig. 64. How about flip-flop No. 2? It doesn't change states. Flip-flop No. 2 requires a 1 at its input before it'll change. But it now sees a 0 input from the $\bar{Y}$ output of flip-flop No. 1.

So, after the first clock pulse, the 8-bit counter reads "00000001." Translating the binary system to the decimal system, that's a count of "one."

The next clock pulse again triggers flip-flop No. 1. The Y output of flip-flop No. 1 goes to 0 and the $\bar{Y}$ output goes to 1. The 1 at the $\bar{Y}$ output of flip-flop No. 1 triggers flip-flop No. 2, Fig. 65. Consequently, flip-flop No. 2 also changes states. And the count, taken from the Y outputs, reads "00000010." In the decimal system, that's a count of "two."

When the flip-flop reaches the maximum count, each Y output goes to the 1 state. So you have a digital count of "11111111," a count that translates to "255." Yet you can stop the counter at any point between "00000001" and "11111111." The 8-bit counter remains at whatever count it has reached as long as it has operating power.

USING THE DIGITAL COUNT

The camera, though, can't do much with a digital count—it must first convert that count to a voltage. It then compares the voltage to the AV signal from AR1.

From the schematic, you can't really see how the digital count gets converted to a voltage. All that takes place inside PX2. But you can see amplifier AR4, Fig. 61, which provides the analog voltage at its output.

The voltage at the output of AR4 decreases as the count increases. Comparator CP3 then sees this decreasing voltage at one input. And it compares the voltage with the AV signal from summing amplifier AR1. When the two voltages are equal, CP3 shuts off the clock pulses.

For example, suppose you have a low-light condition. That means there's a low AV signal applied to the noninverting input of comparator CP3—a low reference. Then, as the 8-bit counter starts counting, the output of AR4 is quite a ways above the reference. And this output, applied to the inverting in-

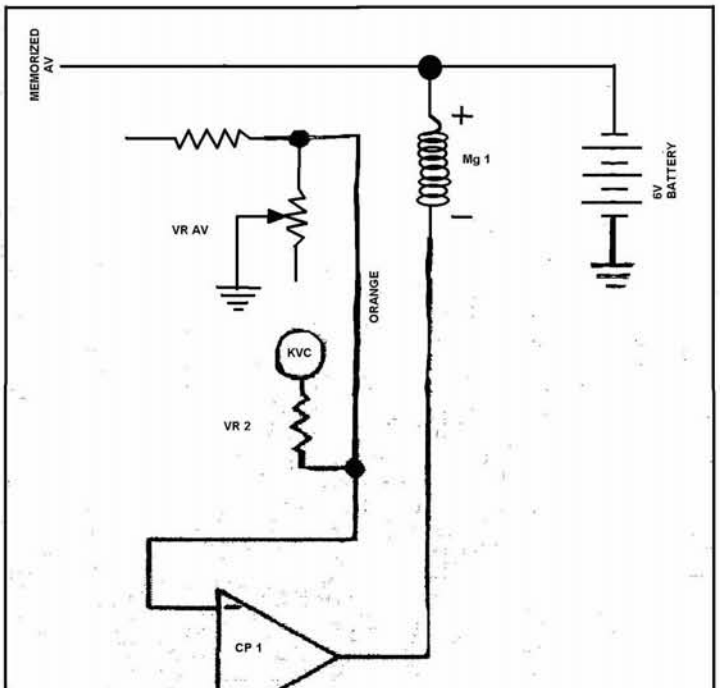


Figure 66

put of CP3, keeps the comparator saturated in the negative state.

But as the 8-bit counter continues to count clock pulses, the output of AR4 creases. The output of AR4 keeps ...pping, getting closer and closer to the AV input.

Finally, the output of AR4 drops low enough to match the AV signal from AR1. Comparator CP3 then switches to the saturated positive state and shuts off the memory circuit. The AV output of AR4 now matches the AV input to comparator CP3.

What has all this accomplished? It's just taken the changing AV signal from AR1 and memorized it at the output of AR4. The memorized AV signal goes back to PX3 to determine the actual diaphragm opening.

TRANSLATING THE MEMORIZED AV TO THE DIAPHRAGM OPENING

The memorized AV signal from AR4 goes to the inverting input of comparator CP1, Fig. 66. And the output of CP1 controls the diaphragm-control electromagnet Mg1. In the usable metering range, the memorized AV signal is higher than the Vc reference voltage 1.2 volts.

As long as this condition exists, CP1 remains in a saturated negative state. So CP1 connects the lower end of the electromagnet Mg1 to ground. That allows current to flow through the electromagnet.

The oscillator in Fig. 61 provides the 10 ms delay that allows the 8-bit counter to reach its maximum count. After this delay, an electronic switch inside PX2 closes. Capacitor C47 then discharges through the coil of the combination magnet Mg2.

Now, the combination magnet Mg2 releases the mirror. And, as the mirror rises, the diaphragm closes. The diaphragm can continue closing as long as current flows through the diaphragm-control electromagnet Mg1. It's up to the diaphragm-sensing system to tell comparator CP1 when the diaphragm has reached the proper f/stop.

The diaphragm-sensing resistor VR av on the side of the mirror cage provides the needed information—it relates the position of the diaphragm to the AV signal. As the diaphragm closes, the diaphragm-setting lever moves a wiper along the diaphragm-sensing resistor. And that decreases the resistance of VR av.

Lowering the resistance of the diaphragm-sensing resistor lowers the memorized AV input to CP1. Or, looking at the operation another way, it brings the inverting input closer to ground. When the AV signal drops low enough to match the 1.2-volt reference, CP1 switches to the positive state. And that shuts off the current to the diaphragm-control electromagnet Mg1. Mg1 then releases its armature to stop the diaphragm at the right opening.

For example, let's again assume that you're shooting under a low-light condition. So there's a low AV signal applied to CP1—perhaps very close to the 1.2-volt reference. As a result, the diaphragm-sensing resistor must only move a small distance to match the AV signal to the reference signal. And the diaphragm-control electromagnet stops the diaphragm at a large f/stop.

But under a high-light condition, there's a large AV signal. Consequently, the diaphragm has to stop down further in bringing down the AV signal to the reference signal. The Mg1 electromagnet remains energized longer, allowing the diaphragm to close to a smaller f/stop.

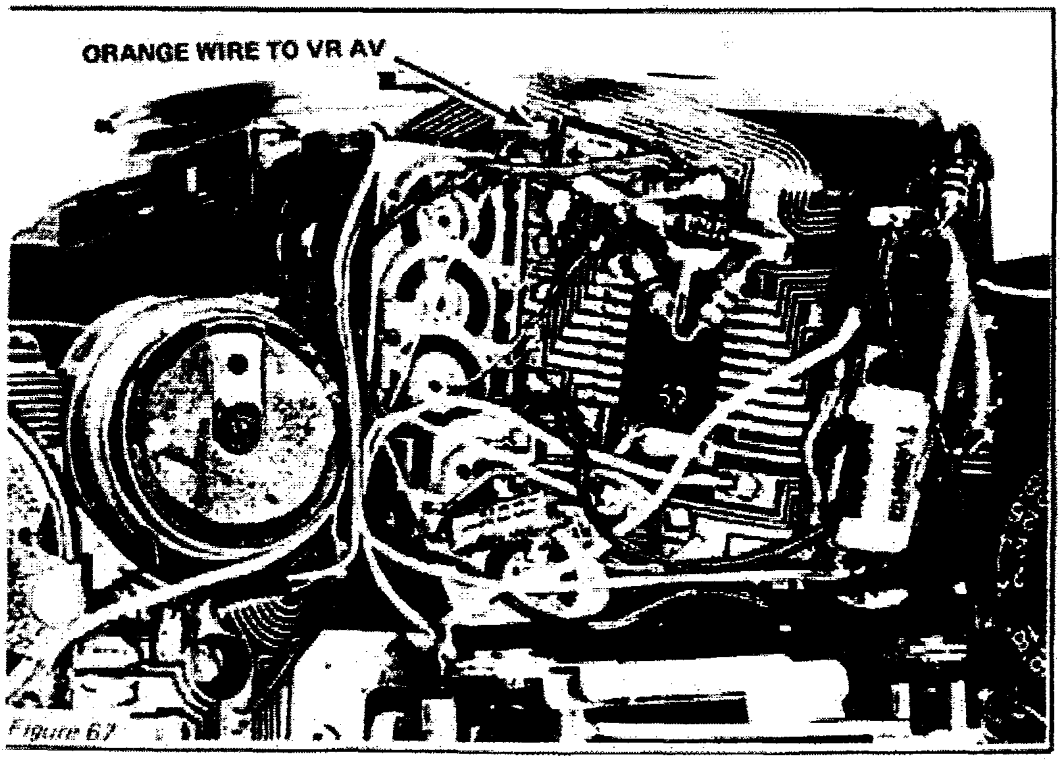


Figure 67

CHECKING THE DIAPHRAGM-SENSING RESISTOR

Suppose, then, you have a situation where the meter reads the proper f/stop. But the diaphragm fails to stop down properly—it always stops down to the smallest f/stop or it always remains at the largest f/stop.

Since the meter reads properly, you know that you're getting the right AV signal from AR1. So the problem must be in something that affects only the diaphragm closure. Your first suspect—the diaphragm-sensing resistor VR av.

We've mentioned that VR av sits on the side of the mirror cage. But you can check the operation without removing the mirror cage—wires from VR av connect the diaphragm-sensing resistor to the top of the flex circuit.

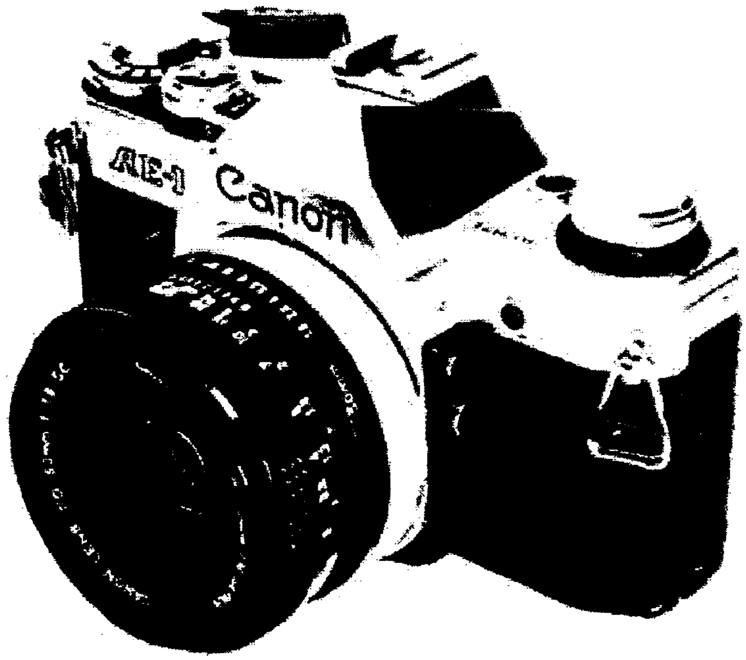
Locate the orange wire connected to the flex circuit, Fig. 67. This is the wire that connects VR av to pin 2 of PX3. If you close SW1 and measure the voltage to the orange-wire connection, you should measure around 1 volt.

But probably the easiest way to check VR av is to use an ohmmeter. Cock the shutter and push in the stop-down lever—that frees the diaphragm-setting lever. Now, measure the resistance between the orange-wire connection and ground—you should measure around 1.3K-2K. Then, slowly push the diaphragm-setting lever toward the bottom of the mirror cage. And note the resistance change. The resistance between the orange-wire connection and ground should smoothly decrease to less than 1K.

If you get erratic readings while moving the diaphragm-setting lever, you have a problem with the diaphragm-sensing resistor VR av. And you're going to have to pull the mirror cage. Poor contact, resulting in an open, could cause the diaphragm to stop down fully. A short could cause the diaphragm to remain fully open.

Canon AE-1

Part 3



CHECKING THE DIAPHRAGM-CONTROL ELECTROMAGNET

There's another likely culprit if the diaphragm remains fully open—the diaphragm-control electromagnet Mg1 could be defective. If the electromagnet has an open, it won't hold its armature. The armature then latches the diaphragm-setting lever immediately, giving you the largest aperture. The same symptom could also result from a mechanical malfunction.

You can't as yet get to the diaphragm-control electromagnet. It's at the bottom of the mirror cage. And removing the mirror cage requires quite a bit of disassembly. Fortunately, you can check the diaphragm-control electromagnet and the mechanical operation without removing the mirror cage. All you have to do is take off a cover plate at the rewind side of the camera body.

First, remove the front-plate leatherette from the rewind side. You can now reach the three screws holding the end cover plate, Fig. 68.

Remove the cover-plate screw at the front of the camera, Fig. 68. But be careful in removing the two screws at the end of the cover plate—these screws pass through spacers for the back latch. And the spacers will be loose once you remove the cover plate. After removing the screws and the cover plate, replace the screws through the spacers as shown in Fig. 69—that holds the spacers in place.

From the front of the camera, you can now see three connections to the flex circuit, Fig. 70. The green wire at the top connection goes to the auto-manual switch, the switch controlled by the E-M change pin. The red wire and the black wire go to the coil of the diaphragm-control electromagnet Mg1.

Fig. 71 shows a variation, an earlier version of the flex circuit. Here, you can see five (rather than three) contact

Figure 68

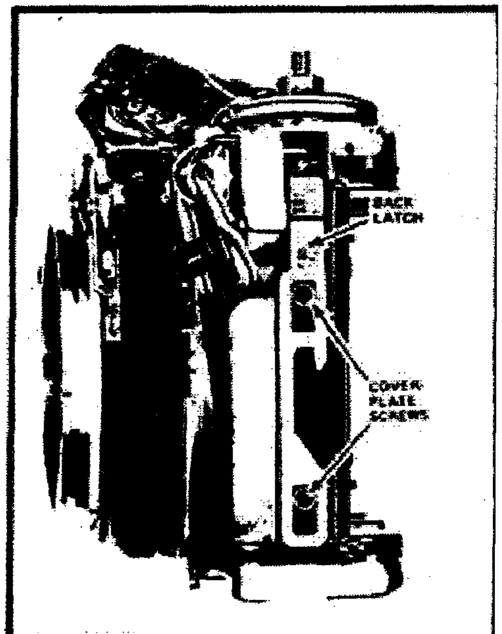


Figure 69

points. The three wires connect to the top three contacts—the same sequence as shown in Fig. 70. And a shorting wire shorts the bottom two contacts together.

You can now check the mechanical action and the Mg1 electromagnet in one step. Replace the lens and set the diaphragm-setting ring to the automatic position. Then, short between the black electromagnet lead and the metal front plate (ground), Fig. 72. Watch the diaphragm leaves as you release the shutter—the diaphragm should stop down fully. If it does, you know the mechanical mechanism and the Mg1 electromagnet are o.k.—you don't have to pull the mirror cage.

All you're doing in this shorting test is running battery current directly through Mg1. You're shorting between the negative electromagnet lead and ground. That bypasses PX3.

If the diaphragm doesn't stop down, you could have an open Mg1 coil. Or you could have a mechanical malfunction. You can check the coil by measuring the resistance between the red-wire connection and the black-wire connection, Fig. 70—you should read around 357 ohms. But in either case—bad coil or mechanical problem—you're going to have to remove the mirror cage.

SHUTTER CONTROL CIRCUIT

Unlike the photometric system, the shutter-speed circuit is reasonably conventional. However, you can't get to the transistor-switching system—it's all inside the PX3 integrated circuit.

Fig. 73 shows the portion of the complete schematic that controls the shutter speeds. When you select a shutter speed, you're setting the resistance of resistor RT. RT isn't actually a variable resistor

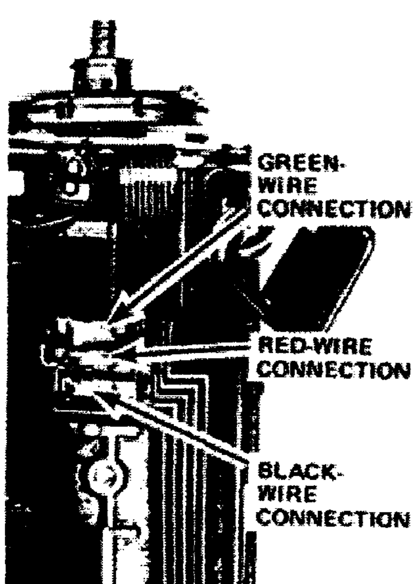


Figure 70

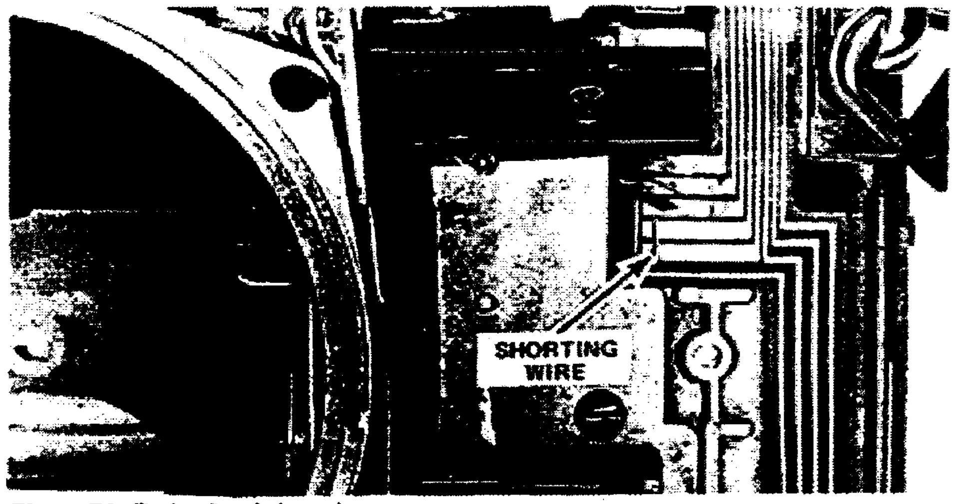


Figure 71. Early circuit board

Figure 72. Shorting to the black lead should cause the diaphragm to stop down fully when you release the shutter

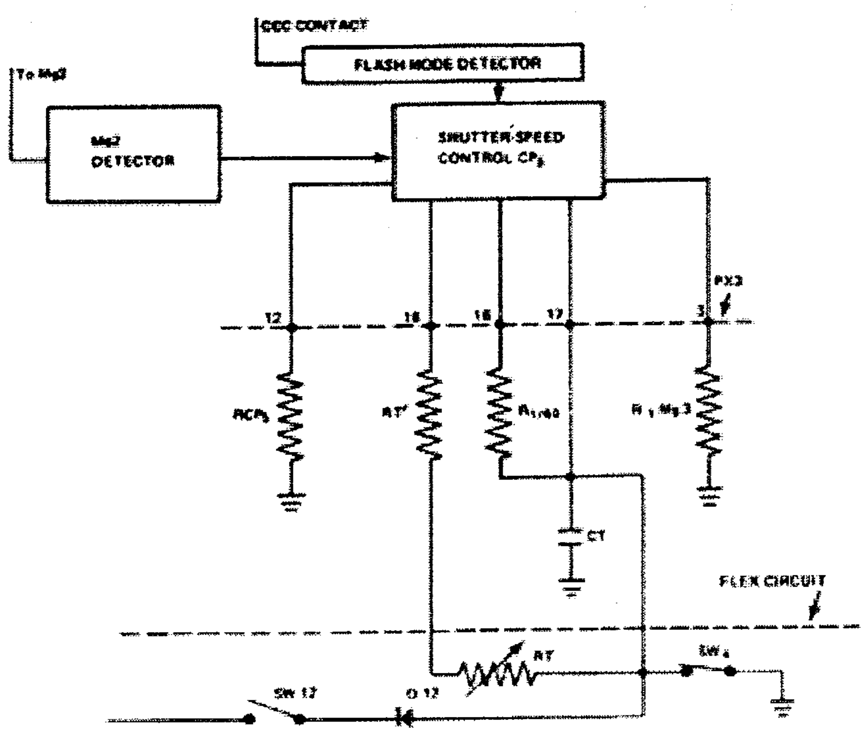


Figure 73

as the schematic would indicate. Rather, RT consists of a series of fixed resistors mounted around the RT circuit board, Fig. 74.

The speed selector, sitting under the speed-knob coupler, turns with the speed knob as you change shutter speeds. A brush on the underside of the speed selector then selects the resistance in series with the timing capacitor CT, Fig. 73 and Fig. 75.

So the resistance of RT determines how long it takes the timing capacitor to charge. When the timing capacitor reaches approximately 2.6 volts, it shuts off a switch to the closing-curtain electromagnet Mg3. Mg3 then releases its armature and frees the closing curtain.

You may recall that the Mg3 electromagnet doesn't start drawing current until capacitor C47 discharges through the Mg2 coil. In Fig. 73, you can see the Mg2 detector which senses this current flow. The Mg2 detector then energizes the closing-curtain electromagnet Mg3.

The shutter-speed-control circuit, Fig. 73, shuts off Mg3 according to the shutter speed you select. Notice in Fig. 73 that the shutter-speed-control circuit contains another comparator indication —CP5. Comparator CP5 serves as the switch for the closing-curtain electromagnet Mg3.

Although Fig. 73 indicates the proper connections for the various components, it doesn't really show how the circuit works. Redrawing the circuit, Fig. 76, makes the operation more apparent. You can now see that the timing resistors RT are in series with the timing capacitor CT.

The two transistors shown in Fig. 76 are inside PX3. Consider that transistor TR2, the Mg2 detector, turns on when you depress the release button. TR2 then acts as a closed switch. Driven into saturation, the transistor drops little voltage. As a result, TR 2 practically shorts across the base and emitter of TR1.

TR1 serves as the series switch for the Mg3 electromagnet. Thanks to TR2, TR1 now has insufficient base-emitter bias to conduct. So TR1 remains shut off. And no current flows through the Mg3 coil.

But the spurt of current through the Mg2 combination magnet turns off transistor TR2. Now, the high collector voltage of TR2 gives TR1 the forward bias it needs to conduct. The zener diode hooked to the TR1 base maintains a constant forward bias—a constant voltage between the TR1 base and emit-

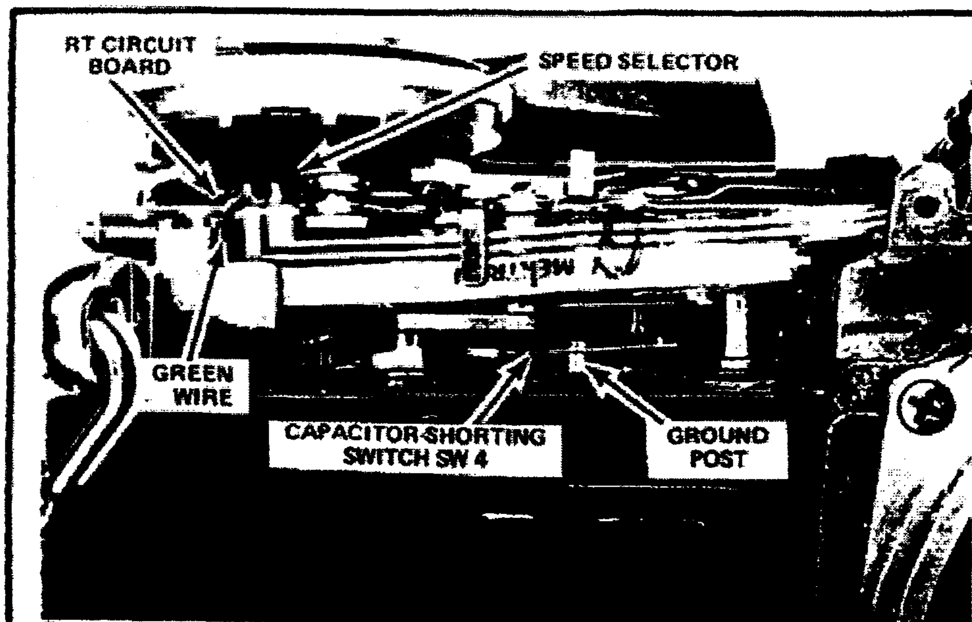


Figure 74

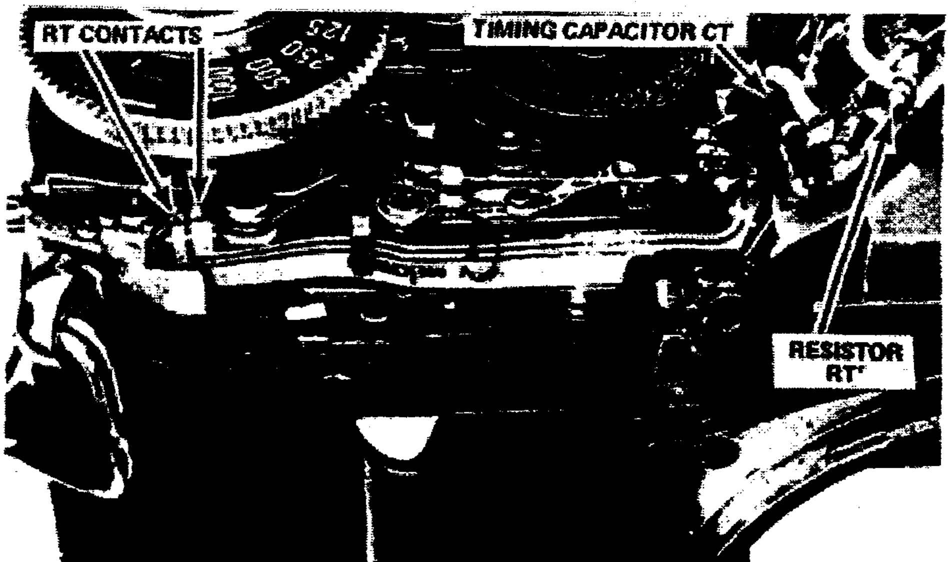


Figure 75

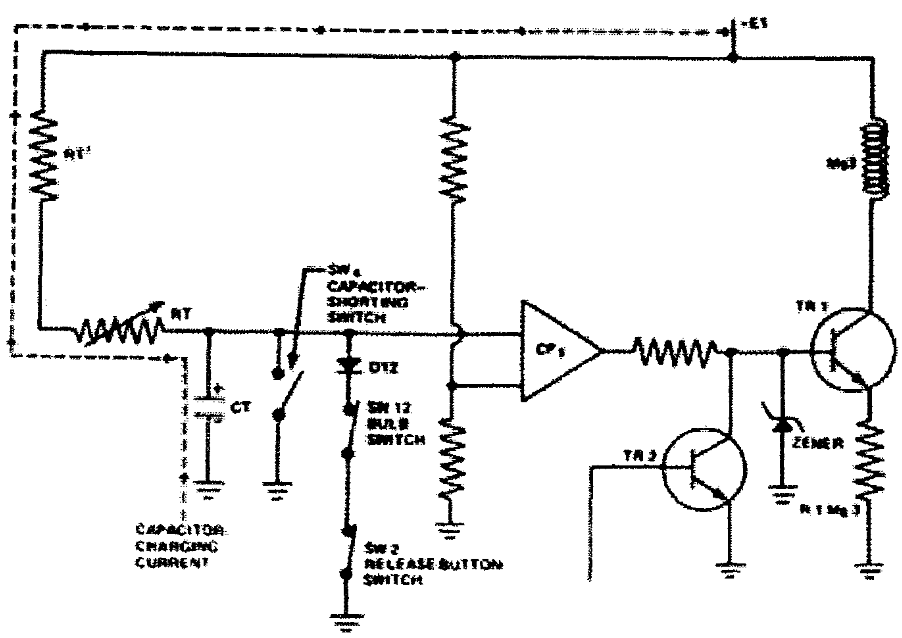


Figure 76

ter. So TR1 acts as a constant-current source. Despite variations in battery voltage, TR1 supplies a constant 8 milliamps through the Mg3 coil.

As long as TR1 continues to conduct, the closing-curtain electromagnet remains energized. And the Mg3 armature holds open the closing curtain. To shut off TR1 and end the exposure, the timing capacitor must charge to the cutoff voltage.

However, CT can't start charging until the mirror rises. That's because the capacitor-shorting switch SW4, Fig. 76, is closed. SW4 maintains a direct short across the timing capacitor.

When the mirror moves to the taking position, it disengages the opening-curtain latch. And the opening-curtain latch frees the opening curtain. At nearly the same time, an insulated post on the opening-curtain latch opens the capacitor-shorting switch SW4. You can see the capacitor-shorting switch from the front of the camera, Fig. 74. A green wire connects the capacitor-shorting switch to the shutter-speed resistors RT.

With SW4 open, the timing capacitor starts charging through the shutter-speed resistors RT and the fixed resistor RT', Fig. 76. Again, the shutter-speed setting determines how long it takes for the timing capacitor to charge to 2.6 volts. The slower the shutter-speed setting, the greater the resistance of RT. And, as a result, the longer it takes the capacitor to charge.

The top plate of capacitor CT, Fig. 76, goes more positive as the capacitor charges. When the top plate of the capacitor goes sufficiently positive, comparator CP5 switches to the negative state. That puts the base of TR1 nearly at ground potential—close to the same potential as the emitter. So TR1 no longer has the forward bias it needs to conduct. Shutting off TR1 stops the current flow through the Mg3 electromagnet and releases the closing curtain.

Setting the shutter to "B" closes the bulb switch SW12 and sets RT to a low resistance—the same resistance value as you have at the 1/60-second setting. Now, as long as you hold down the release button, the timing capacitor can't charge above the voltage dropped across diode D12. Holding down the release button keeps the release-button switch SW2, Fig. 76, closed.

So the shutter stays open on bulb until you allow the release button to return. SW2 then opens. And the timing capacitor charges through the RT resistance that's the same as the 1/60-second resistance (around 15.3K).

Earlier, we mentioned that the shutter delivers 1/60 second when you have the Speedlite 155A installed. Here, the timing capacitor CT doesn't charge through the RT resistance—rather, it charges through the fixed resistor R 1/60 (for 1/60 second). When the neon ready lamp turns on, the flash unit draws current through the flash-mode detector, Fig. 73. The flash-mode detector then switches resistor R 1/60 in series with the timing capacitor. As a result, you get a 1/60-second exposure regardless of your speed-knob setting (except "bulb," at which you'll still get "bulb").

SHUTTER-SPEED ADJUSTMENTS

You'll notice in Fig. 73 that you have no variable resistors to adjust the shutter speeds. Instead, you have a fixed resistor RT' in series with the RT timing resistors. You're expected to change this fixed resistor, Fig. 75, in adjusting the fast speeds.

The technique Canon describes is to install a variable resistor in place of RT'. Then, use the variable resistor to adjust 1/1000 second. When you get a proper exposure at 1/1000 second, measure the value of your variable resistor. And replace the variable resistor with a fixed resistor of the same value.

Obviously, this isn't a convenient adjustment. Resistor RT' normally varies within the range of 0.6K to 1K. And it could take quite a while to find a fixed resistor that perfectly matches the setting of your variable resistor. Fortunately, it's rarely necessary to adjust the shutter speeds. If your shutter's clean and in good operating condition, simply adjusting the curtain tensions should bring in your shutter-speed adjustments.

However, there's another adjustment for the fast speeds—one that isn't described in Canon's service manual. You can adjust the capacitor-shorting switch SW4. When SW4 closes, the wire blade contacts an eccentric ground post, Fig. 74. By turning the eccentric post, you can adjust the time the capacitor-shorting switch opens—the sooner the switch opens, the faster the resulting shutter speed. Although the eccentric-post adjustment affects the fast speeds, it has practically no effect on the slow speeds.

Resistor RCP5, Fig. 73, provides the intended slow-speed adjustment. But we've yet to see a camera that has this resistor. Fig. 77 indicates where the resistor would be connected—between the flex-circuit contact with the two red wires (ground) and the empty land.

Canon suggests making the slow-speed adjustment at 1/2 second. If your 1/2-second exposure's too slow, hook a 100K variable resistor in parallel with the timing capacitor. Adjust the variable resistor to bring in 1/2 second. Then, replace the variable resistor with a fixed resistor of the same value.

But if the 1/2-second exposure is too fast, hook a 0.1 microfarad capacitor in parallel with the timing capacitor CT. That increases the total capacitance of the timing capacitor. So it takes slightly longer for the timing capacitor CT to charge.

Either slow-speed adjustment affects the fast speeds as well. Yet the fast-speed adjustments have very little effect on the slow speeds. Consequently, you should make your slow-speed adjustments first. Then, adjust the 1/1000-second exposure.

Why doesn't Canon provide more convenient adjustments? Probably be-

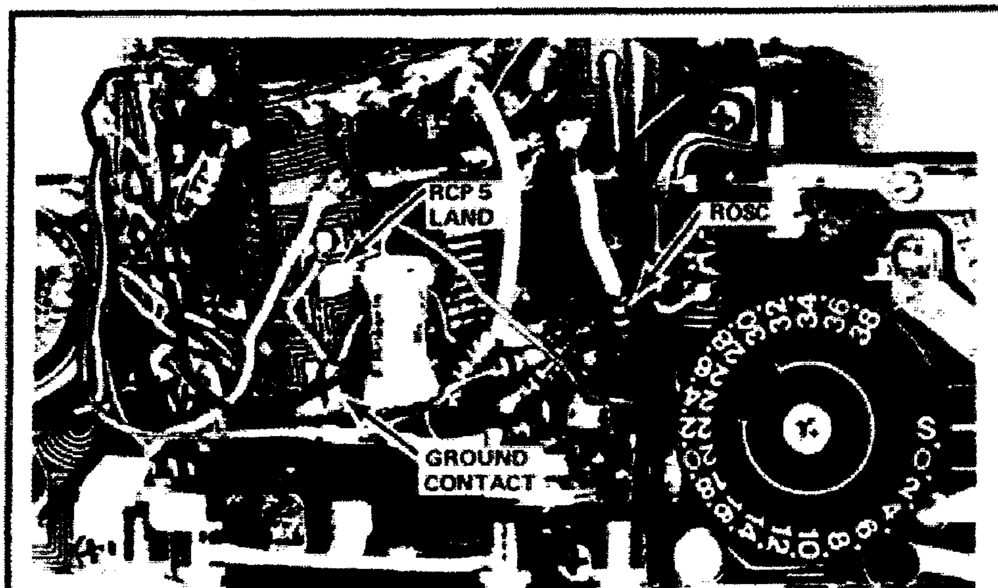


Figure 77

cause you'll rarely need them. Canon does provide variable-resistor adjustments for the exposure-control system. And these are the adjustments you'll be making with just about every repair.

SHUTTER PROBLEMS

Troubleshooting the AE-1 shutter follows about the same procedures as you'd use for any other electronically controlled shutter. Normally, the malfunctions you'll encounter fall into one of four categories:

- the shutter doesn't release
- the shutter stays open
- the shutter delivers the fastest speed only
- the shutter delivers no exposure

Let's say the shutter doesn't release. We've already described the techniques for checking the mirror-release combination magnet Mg2, the transistor, and the release switches. Another possibility—you aren't getting a connection between the mirror-release combination magnet and pin 2 of PX2.

So check the voltage at pin 2 of PX2—you should measure the full battery voltage. If you don't, you may have to jumper between the negative side of Mg2 (at the bottom of the camera) and pin 2 of PX2. That's a long way to run a jumper wire.

Also, you may not be getting the output of the oscillator. If the oscillator isn't working, the shutter won't release. And none of the LED's will flash on and off. Check then to make sure you have continuity between pin 11 of PX2 and the oscillator resistor Rosc, Fig. 77. And check the resistor itself.

If the shutter delivers the fastest speed only, you may have a short across the shutter-speed-resistor assembly RT—between the two contacts shown in Fig. 75. Shorting the shutter-speed resistors RT leaves only the high-speed adjustment resistor RT' in series with the timing capacitor. So the timing capacitor charges through RT'. And the shutter delivers an exposure that's close to 1/1000 second.

When the shutter hangs open, you may have a short across the timing capacitor CT. Or there could be an open in the capacitor-charging path. Something is preventing the timing capacitor from charging to 2.6 volts.

Check the capacitor-shorting switch SW4 first—make sure it's opening when the shutter releases. You can use an ohmmeter to check between ground and the green-wire contact of the RT resistors, Fig. 75. With the mirror down, you should measure a short. But when the mirror rises, you should read an open.

You might also disconnect the green wire from the RT circuit board. And check for a short between the camera body and the RT contact from which you disconnected the green wire. A connector pin passes through the RT circuit board to engage the flex circuit. This pin comes very close to the camera body. And, if the pin touches the camera body, you'll have a short across the timing capacitor CT—the same effect as when the capacitor-shorting switch fails to open.

Breaks in the flex circuit or poor solder connections may cause an open in the capacitor-charging path. Try measuring the resistance between the green-wire RT contact and the end of resistor RT', Fig. 75. You should read the resistance of the RT resistors according to the shutter-speed setting. The resistance should decrease as you set faster shutter speeds. The following table lists the resistance values measured from our evaluation camera:

B	15.3K	1/30	31K
2	2.07M	1/60	15.3K
1	1.02M	1/125	7.71K
1/2	510K	1/250	3.82K
1/4	253K	1/500	1.87K
1/8	124K	1/1000	947 ohms
1/15	63.1K		

But if you read an open circuit, check the continuity between the other RT contact and RT'. Here, you should measure a short—a direct connection. If there's no continuity, you may have a poor solder joint at the RT connector pin (the pin that doesn't have the green-wire connection, Fig. 75). Or you may have a break in the flex circuit between the RT connector pin and RT'.

Other breaks in the flex circuit or poor solder connections could cause the same malfunction. However, unless someone else has worked on the camera, these things are unlikely. A break between the RT green-wire contact and diode D12 would cause the shutter to hang open. So would a break between diode D12 and the timing capacitor CT. Poor solder connections at the RT connector pins, diode D12, or timing capacitor CT would have the same effect.

And finally, there's the possibility of component problems. Check the resistance between the two RT connector pins as you change the shutter speeds—your readings should be close to those shown earlier (in the chart). You may find an open at a particular speed setting, indicating a break in the series of RT resistors. In that case, you'll have to replace the RT circuit board. Other component possibilities—a bad timing capacitor CT, a bad diode D12, or, as a last resort, a bad integrated circuit PX3.

We mentioned one other possible shutter problem—the shutter delivers no exposure at all, both curtains crossing the aperture together. That indicates a problem with the closing-curtain electromagnet Mg3. For some reason, the electromagnet isn't holding its armature. You could have an open electromagnet (we described this test earlier). Or you could have a mechanical latching problem between the Mg3 armature and the closing-curtain cam.

Check the mechanical action by holding the Mg3 armature against the electromagnet. Then, release the shutter. The shutter should stay open as long as you hold the armature.

Also check the spring on the Mg3 armature and the adjustment on the closing-curtain cam. Problems here won't cause both curtains to cross the aperture together. But they will cause difficulties in adjusting the shutter speeds. If the armature spring is disconnected or broken—or the adjustment is incorrect—you won't be able to bring in your fast shutter speeds. The slow speeds may time correctly. But the fast speeds will be too slow.

BATTERY-TEST CIRCUIT

Fig. 78 shows the battery-test circuit in the AE-1. Here's a very straightforward circuit—nothing fancy. When you push the battery-test button, switch SW8 moves from the solid-line position to the dashed-line position, Fig. 78.

When switch SW8 moves away from the solid-line position, it opens the contact to the rest of the circuit. That's why the battery-test button also serves as a cancel feature.

Current then flows from the battery, through the galvanometer, and through resistor Rch (for resistor check). Resistor RL provides a dummy load for the battery test—it draws battery current to simulate the normal load. And diode D1 protects against damage if you install the battery upside down. The diode also prevents the load resistor RL from drawing current in normal circuit operation. Without the diode, current could flow through the grounded side of RL, through Rch, and through resistor RM (resistor meter) to the positive output of amplifier AR3.

Notice in Fig. 78 that there's no variable-resistor adjustment for the battery test. As with the shutter-speed circuit, you're expected to change the

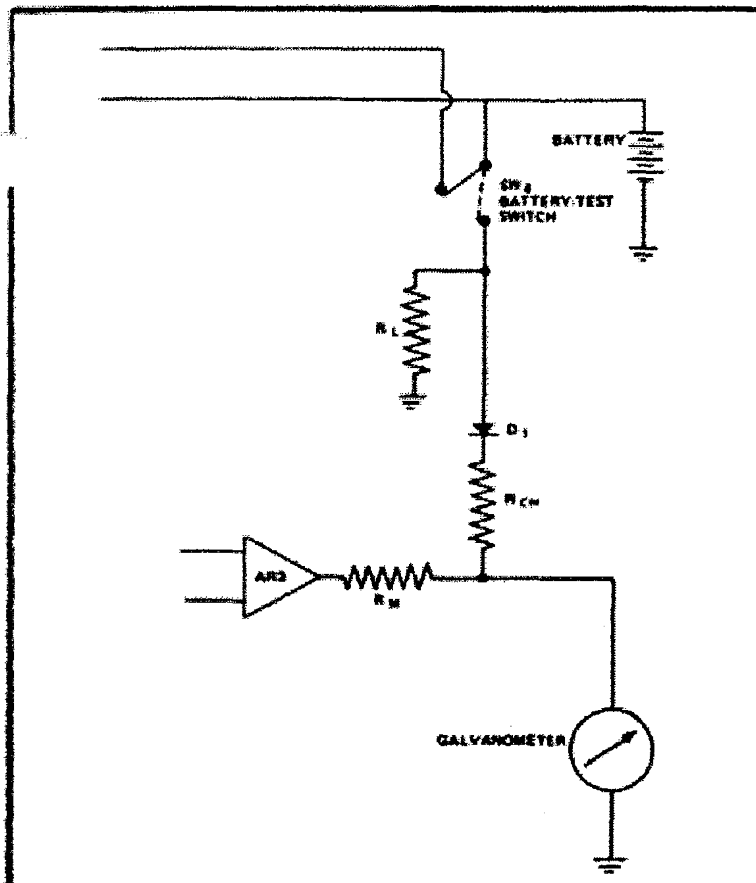


Figure 78

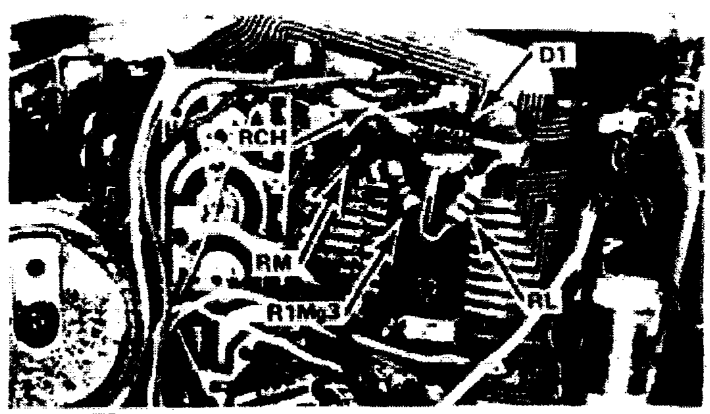


Figure 79

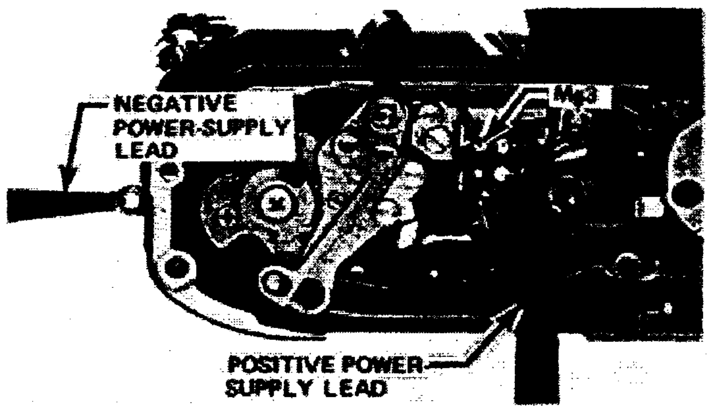


Figure 80

value of a fixed resistor—in this case, resistor Rch, Fig. 79. Since Canon intends both RT' and Rch as technician adjustments, a new flex circuit comes without these two resistors.

Canon's technique for adjusting the battery-test circuit is certainly unique. As with most battery-test adjustments, you need a continuously variable power supply. But you use that supply to discover the voltage at which the shutter releases.

Remove the camera's battery and connect the power supply to the battery terminals. It's probably easiest to hook the negative power-supply lead to ground and the positive power-supply lead to the positive Mg3 lead, Fig. 80. Use a mini-clip to hold the release-button switches SW1 and SW2 closed. Then, cock the shutter. And slowly increase the power-supply voltage from 0 volt until the shutter releases.

The shutter should release at a voltage setting between 4 and 5 volts. When the shutter does release, measure the power-supply output. And record this voltage.

You then use the recorded voltage in setting the battery-test adjustment. If the shutter released at a setting between 4.2 volts and 4.39 volts, set the power supply to 4.6 volts—between 4.4 volts and 4.59 volts, set the power supply to 4.7 volts—and between 4.6 volts and 4.8 volts, set the power supply to 4.8 volts.

So far, you've found and set the proper power-supply setting for the particular camera. Now, close the battery-test switch. The needle should center in the battery-test indicator. If it doesn't, you can change the value of Rch, Fig. 79.

Canon's technique is to use a variable resistor that can be adjusted to either side of 4.7K. Hook the variable resistor in place of Rch. And adjust the variable resistor to center the needle. Measuring the value of the variable resistor then tells you the proper value for Rch. Again, you're faced with an awkward adjustment (especially when it comes to finding a fixed resistor with the same value as your variable resistor). But it's an adjustment you'll rarely have to make.

CHECKING THE AV OUTPUT

We've described the common problems if you have a diaphragm that doesn't stop down properly and if you have a meter that doesn't read properly. But what if you have both problems—if neither the diaphragm nor the meter works? In that case, you probably aren't getting the proper AV output from amplifier AR1.

Use your voltmeter to check the changing AV output. Here, you want to measure the output of AR1 as you vary the light striking the photocell. But you don't have to measure directly to pin 13 of PX3 or pin 5 of PX2—the changing AV appears at the flex-circuit contact shown in Fig. 81.

So you can hook your negative voltmeter lead to ground. And touch the positive voltmeter lead to the AV contact, Fig. 81. Close switch SW1 (again, you can use a mini clip to hold the switch closed). Then, check the voltage as you vary the light reaching the photocell.

You should be able to make the AV signal change from around 1.2 volts to 2 volts. And the voltage should increase as you increase the light level. If you don't get a change in your AV voltage, try checking the output of the MOSFET. Just hook the positive voltmeter lead to pin 8 of PX1, Fig. 82. Again, you should see an increasing voltage as you increase the light striking the photocell—from around 0.8 volt to 1.2 volts.

Suppose, then, you get the change at pin 8 of PX1. Yet you don't get a change at the AV contact. Checking to pin 6 of PX2, you should also measure a changing voltage. But here, the voltage should decrease as the light level increases.

And if you don't get the change at pin 6 of PX2? Then, check the battery input to PX2—you should measure the battery voltage at pin 4. Also, check the resistance between pin 8 of PX1 and pin 7 of PX2. You're now measuring the resistance of the thermistor and resistor Rrtc in series—around 400 ohms, depending on the temperature.

An open in this input circuit could cause the problem. Perhaps the thermistor is open. Or perhaps one of the components isn't making good connection to the flex circuit. But if the inputs check properly, you may have a bad IC.

On the other hand, suppose you aren't getting the changing output from pin 8 of PX1. In that case, check the voltages to the other leads. Fig. 82 shows what you should measure at each pin. If you're getting 0 volt at any pin (other than the ground pin), you may have a break in the flex circuit.

Or, suppose you measure your Kvc rather than Vc at pin 5. You know from your understanding of op amps that you should be measuring 1.2 volts here—this is the inverting input of AR6 which should be driven to the same voltage as the noninverting input. But if you measure something like 1.88 volts (Kvc), you know there must be a problem in the feedback circuit—perhaps a break between pin 8 of PX2 and pin 6 of PX1.

Again, if you're getting the proper inputs—but not the changing output—you probably have a bad IC. The same applies to PX3. If you aren't getting the changing AV signal—yet you have the proper signals from PX1 and PX2—PX3 could be at fault.

REPLACING AN IC

Fig. 83 indicates the proper voltages measured to the pins of PX2 and PX3. As we've mentioned, the IC's should be your last suspects in the event of component failure. So, before replacing an IC, check everything else that could cause the problem—especially solder connections. If you encounter a new problem after reassembling the camera—one that didn't exist before disassembly—double-check the solder joints of the wires you disconnected.

Let's now say that you've isolated a problem to a defective IC. For example, suppose that you aren't getting the Vc voltage output from pin 15 of PX3. Yet you are getting the 6 volts input at pin 14. From this, you can determine that PX3 is defective.

As you can imagine, replacing the IC requires a delicate touch. You must be careful to avoid damaging the flex circuit when you pull the old IC. And you must be careful to avoid bridging connections when you solder in the new IC.

First, unsolder the components that connect to the IC. If you're replacing PX 3, Fig. 84, unsolder the resistors that connect to the ground tab (pin 10) closer

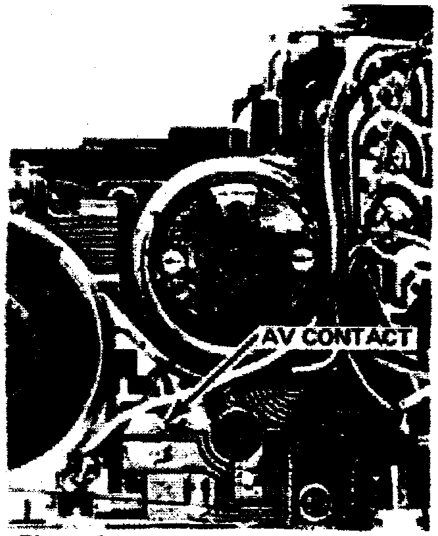


Figure 81

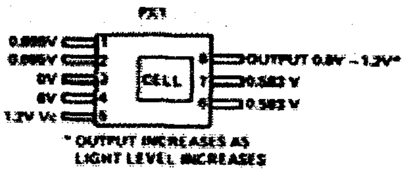
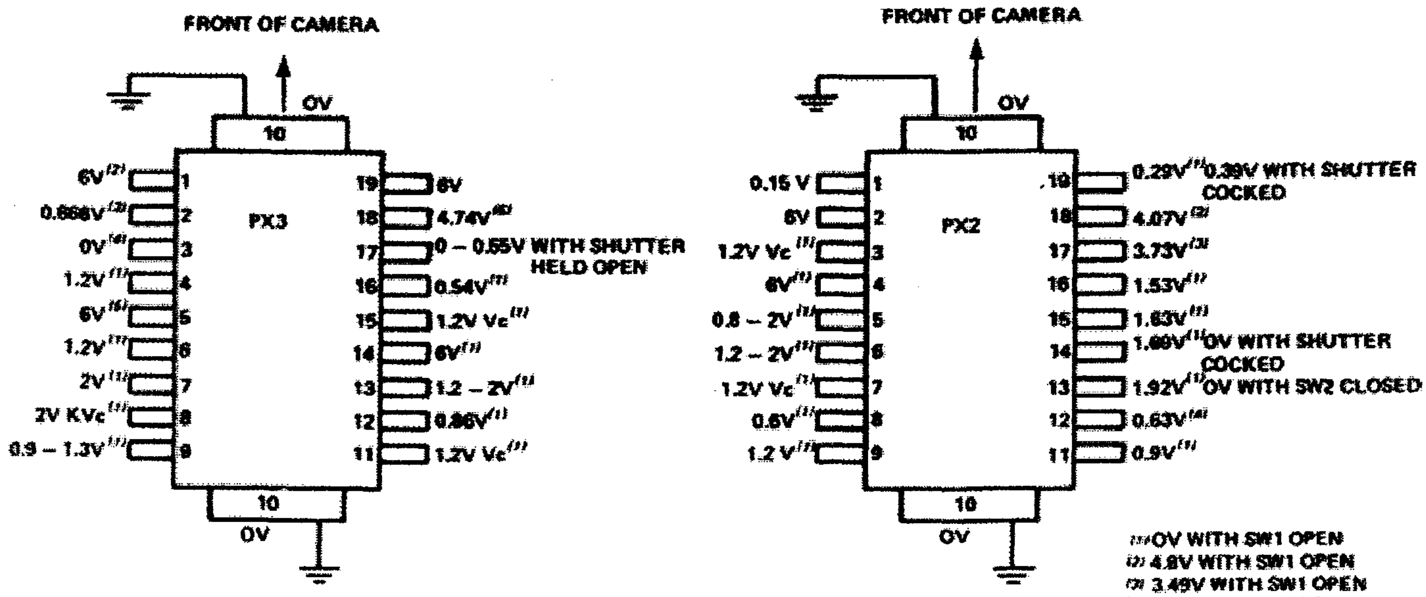


Figure 82



(1) 0V WITH SW1 OPEN
(2) 3.33V WITH SHUTTER HELD OPEN
(3) DECREASES TO 0.494 V AS DIAPHRAGM-SETTING LEVER MOVES DOWN
(4) 0.383V WITH SHUTTER HELD OPEN
(5) 0.19V WITH SHUTTER HELD OPEN
(6) 5.38V WITH SW1 OPEN

(1) 0V WITH SW1 OPEN
(2) 4.8V WITH SW1 OPEN
(3) 3.49V WITH SW1 OPEN
(4) 6V WITH SW1 OPEN

Values measured from sample camera using fresh battery with SW1 closed. All voltages measured with respect to ground.

Figure 83

Figure 84

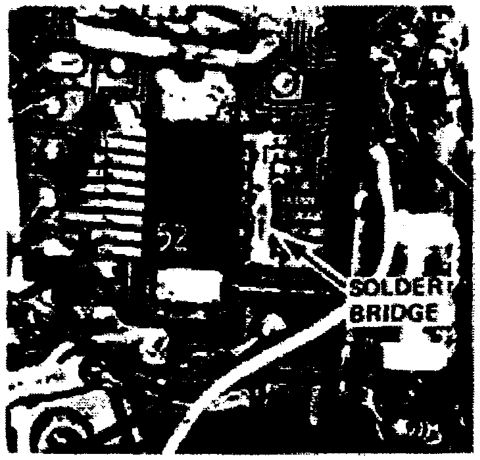


Figure 85

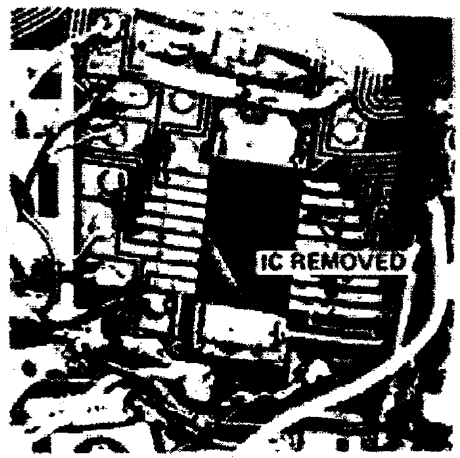


Figure 86

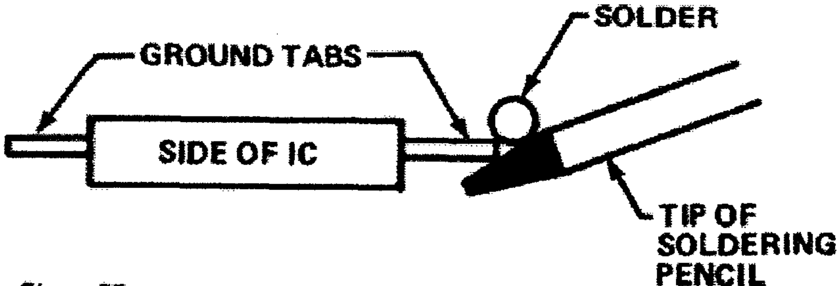


Figure 87

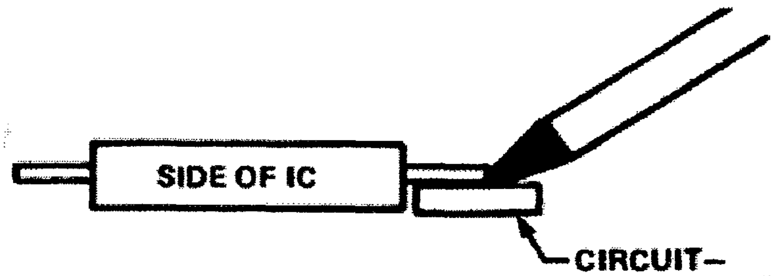


Figure 88

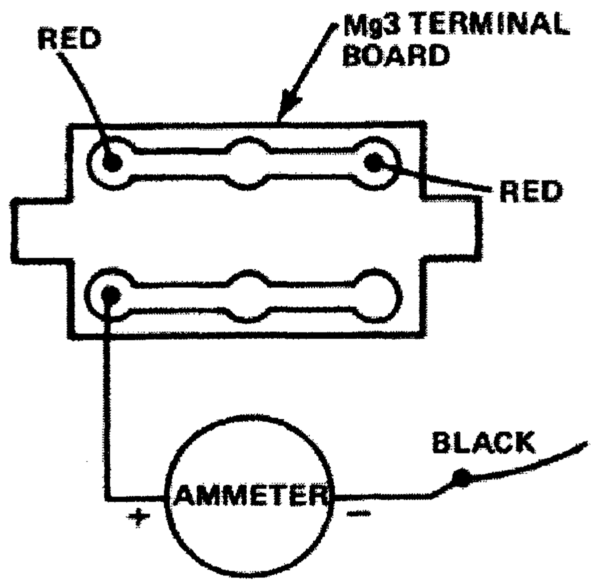


Figure 89

to the front of the camera. And unsolder the red wire that connects to the other ground tab.

Next, use desoldering wick to remove the solder from the two ground tabs, Fig. 84. Make sure both ground tabs are free from the flex circuit. That part of the procedure isn't so bad. The real trick is in disconnecting the 9 pins along each side of the IC.

You could unsolder and disconnect each lead individually. But there's an easier, faster way. Just flow solder over *all 9 pins on one side*, Fig. 85. Use your soldering iron to keep the solder melted. And lift all 9 pins at the same time. Use the same technique *to disconnect the 9* pins at the other side of the IC.

It's critical that you keep the solder melted on all 9 pins. If one pin isn't free, you'll pull loose a circuit-board land, Fig. 86. Then, you'll have to use a jumper wire to repair the circuit board.

Before installing the new IC, tin all the leads. Tin the ground leads first, Fig. 87. Here, you want a light coat of solder on both sides of the ground tabs. Then, tin each of the 9 pins on both sides of the IC.

Notice the triangle symbol that indicates the *top of the IC case*, Fig. 85. Make sure this symbol goes up, pointing toward the front of the camera, as you seat the IC. Also make sure each IC lead contacts its respective land. Finally, touch your soldering iron to each lead as shown in Fig. 88. Since you've already tinned the leads, you shouldn't have to apply any more solder.

ADJUSTMENTS INVOLVED WHEN YOU CHANGE AN IC

Changing any of the three IC's requires checking some adjustments. Suppose that you've replaced PX3. You've seen that PX3 contains the constant-current source for Mg3. So, after changing the IC, you should measure the current through the closing-curtain electromagnet.

Disconnect the black (negative) lead from Mg3. Then, hook an ammeter in series with the electromagnet as shown in Fig. 89. And measure the current while you're holding open the shutter on bulb. You should measure 8 ma (8.01 ma in our evaluation camera, indicating Canon is pretty fussy about this adjustment).

You can adjust the current through Mg3 by changing resistor R1Mg3, Fig. 79. R1Mg3 is the resistor in the emitter circuit of TR1, the electromagnet switch, Fig. 73. Increasing the resistance decreases the current through Mg3. In our evaluation camera, R1Mg3 measured 468 ohms. But this value may vary from camera to camera.

If you replace PX2, check the frequency of the oscillator. Here, all you have to do is count the self-timer LED pulses on the self-timer function. Or, simply time the self-timer delay. Again, you should get 20 pulses if you're checking between the two LED contacts with a voltmeter. And you should get a 10-second self-timer delay.

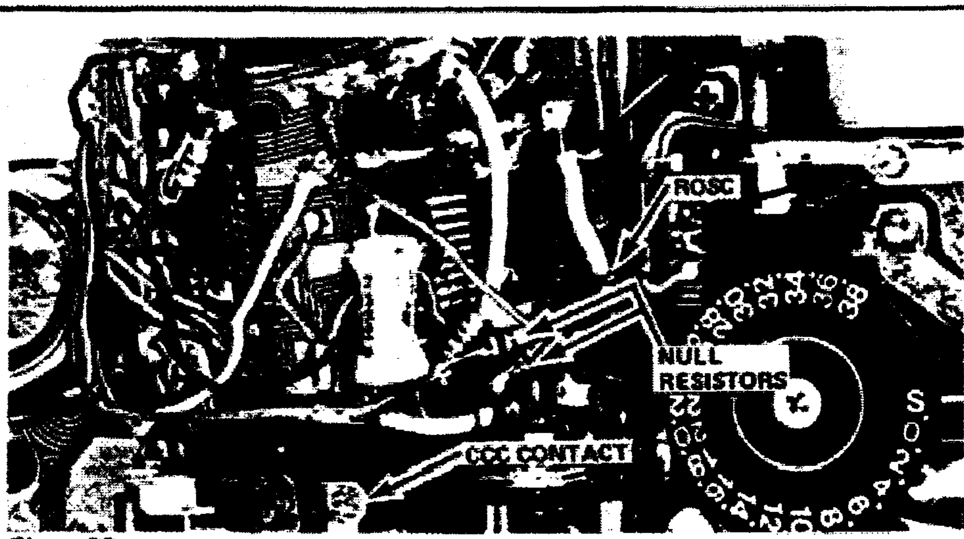


Figure 90

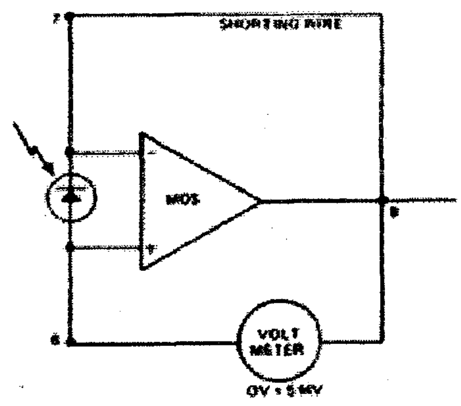


Figure 91

Adjusting the oscillator frequency requires changing the oscillator resistor Rosc, Fig. 90. A higher resistance increases the self-timer delay time. In our evaluation camera, Rosc measured 100K.

Finally, suppose you replace PX1. You may then have to make the offset—or "null"—adjustment. You'll normally find two null resistors connected to PX1, Fig. 90. But you may also find resistors hooked in parallel with the ones shown to get the right resistance value.

Changing the null resistors allows you to null the MOSFET—so there's no output when you short the input. To check the null adjustment, first short the output of the amplifier to the inverting input—pin 8 to pin 7, Fig. 91. And measure the voltage between the output and the noninverting input—between pin 8 and pin 6. When you close SW1, you should measure 0 volt with a tolerance of + 5 mv.

And if you have an output of more than 5 mv? Canon then suggests hooking a 30K pot in place of the larger of the two null resistors (if the resistors have different values). Adjust the variable resistor until your output is within tolerance. Then, install a fixed resistor of the same value in place of the variable resistor. If you still can't bring in the null adjustment, follow the same procedure using the smaller of the two null resistors.

EXPOSURE-CONTROL ADJUSTMENTS

All of the electronic adjustments we've described so far sound inconvenient. But again, you may never have to change fixed resistors. If you replace a flex circuit, all but two of the fixed-resistor adjustments have already been made at the factory.

The only fixed-resistor adjustments you're expected to make with a new board are the fast-speed adjustment using RT' and the battery-check adjustment using Rch. Still, you may not have to go through the whole adjustment procedure—it may be sufficient to simply transfer these fixed resistors from the old board to the new board.

But plan on making the variable-resistor adjustments with every repair. In fact, many of the AE-1's you'll service need only the exposure-control adjustments. Owners sometimes discover that they're getting a slightly different exposure on a manually set f/stop than on the same f/stop programmed automatically. By following Canon's adjustment procedure, these cameras become "easy" repairs.

Your first step in the adjustment technique—as well as your first step in most troubleshooting—is to check the discrete transistor TR. We described this test earlier. Just measure the voltage at the collector of the transistor without closing switch SW1—you should read 0 volt. Then, close SW1 and again measure the collector voltage. This time, you should read close to the battery voltage.

Next, measure and record your Vc voltage. As mentioned earlier, the Vc voltage varies slightly from camera to camera. But it remains constant in the particular camera—despite variations in battery voltage. The Vc voltage should be 1.2 volts ± 0.06 volt.

Again, the CCC contact, Fig. 90, provides a convenient place to measure the Vc voltage. Hook the positive voltmeter lead to the CCC contact; and hook the negative voltmeter lead to ground. Then, close SW1 and note your Vc voltage to the millivolt.

MAXIMUM-APERTURE ADJUSTMENT

Your first variable-resistor adjustment is to set AVO, the maximum-aperture correction. Remember, the full-open-metering post on the back of the lens pushes in the maximum-aperture correction pin. That sets a resistance value which compensates for the maximum aperture of the particular lens.

The resistance of the AVO resistor determines the output of amplifier AR2. And the output of AR2 provides one of the inputs to amplifier AR3, the amplifier that drives the galvanometer. By turning variable resistor VR3, Fig. 92, you can set the AR2 output.

Install the lens and note the largest aperture. The AE-1 comes with either the 50mm f/1.4 lens or the 50mm f/1.8 lens. Of the two, the f/1.8 lens is probably the more popular.

The lens you have installed makes a difference in the voltage you should measure at the output of AR2. But there's another factor—your measured Vc voltage. So you first have to calculate the correct output. Use the following formula:

$$AVO = \frac{\text{Aperture Value} - 4.5}{16} \times Vc + Vc$$

For example, suppose you're using an f/1.8 lens. And your Vc voltage measures 1.2 volts. The formula then appears:

$$AVO = \frac{1.7 - 4.5}{16} \times 1.2 + 1.2$$

Or, $AVO = -0.175 \times 1.2 + 1.2 = 0.99$

So, in this example, you should measure 0.99 volt at the output of AR2—pin 9 of PX3, Fig. 92. However, since it's a little tough to measure directly to the tiny IC pins, you can measure to the white-wire contact, Fig. 92—this contact connects to pin 9 of PX3.

Close switch SW1 as you measure between the white-wire contact and ground. And adjust VR3 until you get your calculated AVO (0.99 volt in our example) to a tolerance of ± 0.020 volt. Turning the VR3 wiper clockwise increases the voltage.

The adjustment itself normally goes very smoothly. But all that math takes time. Since you must also figure out the correct voltages for the other adjustments, a pocket calculator becomes a valuable special tool.

THE GAIN ADJUSTMENT

The gain adjustment VR Gain, Fig. 92, sets the output of amplifier AR5. In checking the gain, you must measure the response at two different light levels. You then adjust the gain for the proper difference between the two outputs.

But you don't measure the output of AR5. Rather, you measure the output of AR1. At AR1, the exposure-control system takes into consideration the shutter speed, the film speed, and the lens' maximum aperture. You can check the AR1 output at the AV contact, Fig. 81.

There's one problem in measuring the gain—ambient light spills onto the photocell, affecting the response (especially at the lower light level). So you must shield the photocell from light. Here, it's almost essential to make a "dummy" top cover that you can use for making the adjustments.

Canon doesn't supply the dummy top cover as a special tool. But you can make your own quite easily out of a replacement top cover (fortunately, the replacement top covers aren't too expensive). Just cut a slot on one side of the pentaprism "hump" to provide access to the variable resistors. And cut away the wind-lever side of the top cover—that eliminates having to remove the wind lever and speed knob when installing the dummy top cover. Canon also recommends putting a cloth "flap" over the resistor cutout. However, you can simply cover the cutout with your finger when you're taking a reading.

There's still the problem of reaching the AV contact, Fig. 81, when you have the dummy top cover installed. Canon's solution is to simply solder a wire to the AV contact, Fig. 93. Then, run the wire through the resistor cutout as you install the dummy top cover, Fig. 94. You can now make your measurements between the wire and ground (any metal portion of the camera).

When making the gain adjustment, your shutter-speed setting and film-speed setting aren't important. However, in

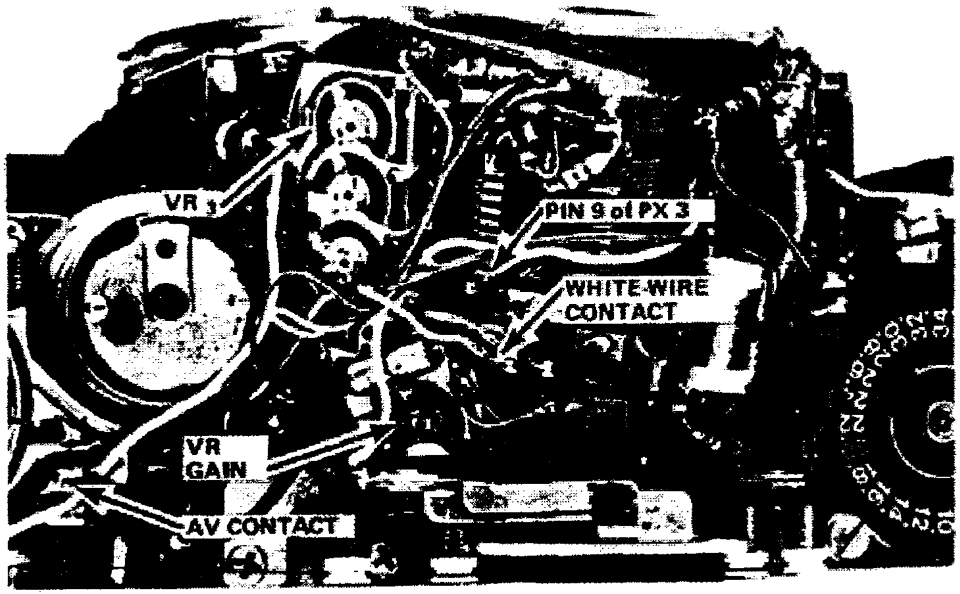


Figure 92
Notice how we've used the small white wire to hold the other wires wrapped together. That keeps the wires away from the variable resistors, allowing easy access to all adjustments.

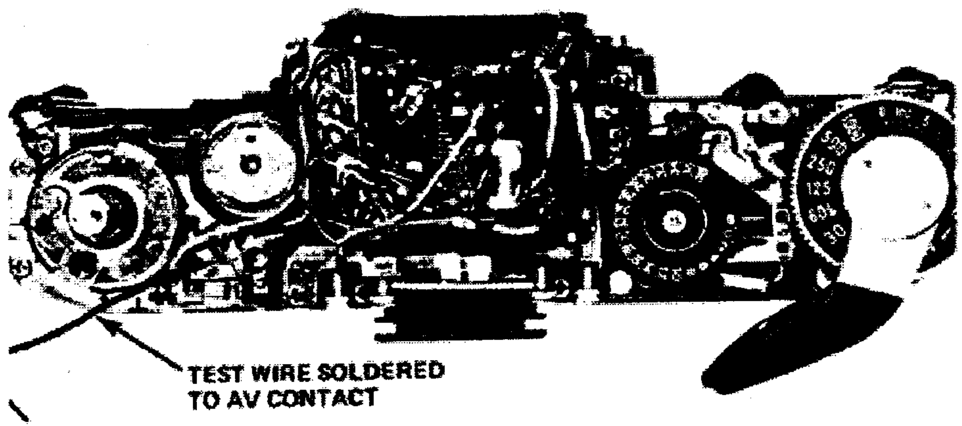


Figure 93

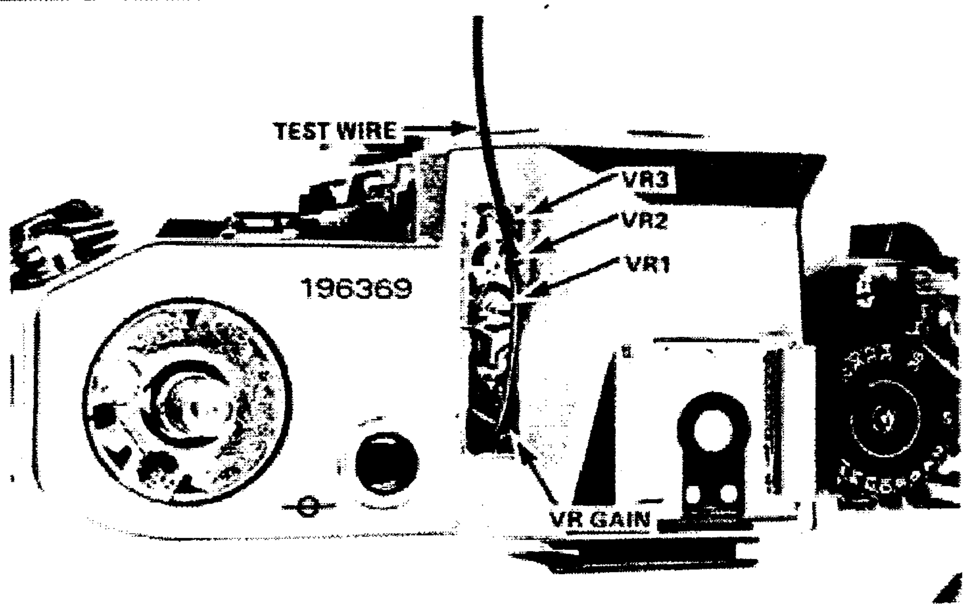


Figure 94 Dummy top cover installed.

the other adjustments, you'll need a film-speed setting of ASA 100 and a shutter-speed setting of 1/125 second. So you can set the speed knob to these settings now. Then, you won't have to change the settings for the adjustments that follow the gain adjustment.

Again, you must start with a calculation—what your gain should be depending on your Vc voltage and your two light levels. Use the following formula:

$$\frac{Vc}{16} \times \text{EV RANGE}$$

The EV range depends on the difference between your two light levels. For example, suppose you're using National Camera's AutoLumen—CV or Comparalumen. You can make one measurement at the f/16 light level. And you can make the other measurement at the f/2 light level. That gives you a difference of 6 EV's (or 6 brightness values).

But you don't have to use National Camera test equipment. Whatever light source you're now using should do the job. Just put the EV range of your light source into the formula. The greater the EV range, the greater the accuracy of your adjustment.

As an example, assume again that your Vc voltage is 1.2 volts. And your EV range is 6, a difference of 6 EV's between your high-light level and your low-light level. The formula then appears:

$$\frac{1.2}{16} \times 6 = 0.450$$

The difference between your voltage reading at the high light level and the voltage reading at the low light level should then be 0.450 volt.

So measure between the AV wire and ground as you expose the lens to the high-light level. And record your reading. Then, record your reading at the low-light level. Subtracting your second reading from your first reading should give you the calculated voltage difference—0.450 volt in our example.

Again, you aren't concerned with what the voltages are at those two light levels—you're just concerned with getting the proper *difference* between the two readings. Fig. 95 illustrates what you're actually setting, again using the Comparalumen as an example. At the f/2 light level you get one voltage. You get a higher voltage (more positive) at the f/16 light level. By adjusting the gain control VR Gain, you're establishing the difference between these two readings.

Turning the wiper of VR Gain clockwise increases the gain—increases the difference between your two readings. Each time you make an adjustment, you must again take two separate readings and subtract. Your tolerance is ± 0.012 volt.

THE AV LEVEL ADJUSTMENT

With your gain adjustment, you set the proper difference in AV's between two light levels. But you weren't concerned with setting a specific AV level—exactly where those lines in Fig. 95 should be. The gain control just makes sure the lines in Fig. 95 are the proper distance apart.

Now it's time to set the actual position of the AV—the proper voltage output for a set of conditions. Here, you just need one light level—EV 12 (the f/5.6 light level on the AutoLumen-CV and Comparalumen). Set your shutter speed to 1/125 second, your film speed to ASA 100, and your diaphragm-setting ring to the automatic position. You can then use the AV level adjustment to set the precise height of the line in Fig. 95.

VR1, Fig. 94, provides the level adjustment. As you can see in the schematic, Fig. 42, VR1 affects the output of amplifier AR1. So make your AV voltage level measurement at the same place as you made your voltage measurements for the gain adjustment—between the AV wire and ground, Fig. 94.

But once more, you must calculate what the voltage should be. Use the following formula for the f/1.4 lens:

$$AV = \frac{4.5\ Vc}{16} + Vc$$

For any other lens, you must subtract a value from your previous calculation. Calculate this value by the formula:

$$(0.075\ (\text{aperture value} - 1))$$

An f/1.8 lens, as mentioned earlier, has an aperture value of 1.7. So the formula becomes:

$$0.075 \times (1.7 - 1) = 0.0525$$

If you're using the f/1.8 lens, subtract 0.0525 from the value you obtained in the first formula.

Let's again consider an example using a Vc of 1.2 volts. Putting 1.2 into the first formula, you get:

$$AV = \frac{4.5 \times 1.2}{16} + 1.2$$

$$AV = 1.5375$$

Rounded off to the millivolt, the value becomes 1.538—that's the AV voltage you want using the f/1.4 lens. But if you're using the f/1.8 lens, subtract 0.0525 from 1.5375. Our example then becomes 1.485 volts.

Now, hold the lens against the f/5.6 light level (EV 12). While measuring between the AV wire and ground, close SW1. You should read your calculated voltage within 0.020 volt. If you're out of tolerance, adjust VR1. Turning the VR1 wiper clockwise increases the voltage.

THE COMPARATOR ADJUSTMENT

You've now completed your voltage-level adjustments. So you can disconnect the voltmeter. But leave your dummy top cover in place—it's still possible that the diaphragm isn't stopping down to the proper f/stop for the light conditions.

Comparator CP1 controls the actual diaphragm closure. And variable resistor VR2, Fig. 94, affects the comparator's action—when the comparator switches states. By adjusting VR2, you can set the actual f/stop programmed by the lens.

In the previous adjustment, you set the shutter speed to 1/125 second and the film speed to ASA 100. And you used a light level of EV 12. At this combination, the diaphragm should stop down to f/5.6.

So all you have to do is release the shutter while holding the lens to the EV 12 light level. If you're using a test instrument that measures light transmission, you can simply read the result. For example, the AutoSystem-7 reads the light transmission in aperture values. At EV 12, a proper f/5.6 has an aperture value of AV 5. When you release the shutter, then, you should read AV 5 on the AutoSystem-7.

And if you don't have an instrument that measures light transmission? Then, you can check the diaphragm opening by using the visual test we described earlier.

In either case, adjust variable resistor VR2 for the proper diaphragm opening. Turning the VR2 wiper clockwise results in a larger aperture, counterclockwise in a smaller aperture.

Earlier, we mentioned that AE-1 owners sometimes notice a difference in exposure between a manually set aperture and the same aperture programmed automatically. If that's the case, VR2 may be the only adjustment you need.

Using VR2, you can "fine-tune" the camera—set the automatically programmed f/stop to match the manually set f/stop. For example, assume again that you're using the AutoSystem-7. Adjusting VR2 for an aperture of AV 5 is correct as far as the instrument's concerned. Yet the manually set f/5.6 may not be a perfect AV 5—some light is lost through the lens system.

So you can set f/5.6 on the diaphragm-setting ring. And note the aperture-value reading on the AutoSystem-7—the reading will normally be slightly less than

40

AV 5. Then, set the diaphragm-setting ring to the automatic position. Adjust VR2 until you get the same reading.

THE GALVANOMETER ADJUSTMENT

There's only one exposure-control adjustment left—the galvanometer adjustment. You've adjusted the diaphragm to stop down properly according to the light conditions. But the galvanometer may not be indicating the same f/stop.

Remember that the galvanometer provides only an indicator—it has nothing to do with actually programming the aperture. Yet, for the photographer's sake, it's still important that the galvanometer read accurately.

At the settings you've been using, the camera programs f/5.6. So the exposure-meter needle should read f/5.6 on the focusing screen. Close SW1 while you're holding the lens against the EV 12 light level. Looking through the finder, check the needle indication.

If the needle isn't reading f/5.6, you'll have to pull the dummy top cover. Then, use a spanner wrench to rotate the galvanometer housing. Turn the galvanometer housing until the needle reads f/5.6 at the EV 12 light level.

REMOVING THE FRONT-PLATE/ MIRROR-CAGE ASSEMBLY

You've seen that replacing an IC requires a delicate touch with the soldering iron. For that matter, so does further disassembly. To remove the front plate, you must unsolder several wires from the flex circuit.

In the AE-1's we've seen, the wire color coding has been very consistent. But, as always, be on the alert for variations. We'll note the standard color codes during disassembly. Yet you never know when someone has replaced a wire with one that has a different color code.

Most of the disassembly problems, though, result from using too much heat. It's pretty easy to damage the flex circuit. Some technicians prefer to use around a 47-watt soldering pencil—that allows them to get on and off the solder joint very fast. However, unless you're a real whiz at soldering, you should use a smaller soldering pencil—around 27 watts.

Also, you must be careful to avoid burning the wire insulation—especially on reassembly. The insulation should come right to the flex-circuit land, Fig. 96. If you burn the insulation, you'll have a bare section of wire extending from the land—that could cause shorting problems. You can use your tweezers to hold the wire against the land while you're making the solder connection. But keep your tweezers quite a ways from the solder joint. Then, there's less chance of burning the insulation.

Another critical point on soldering these wires—the wire should lie in contact with the land, Fig. 97. And the solder should flow over the top of the wire (as indicated in Fig. 97) to hold the wire in place. You don't want a big glump of solder holding the wire away from the land, Fig. 98. That could give you problems with poor electrical connections.

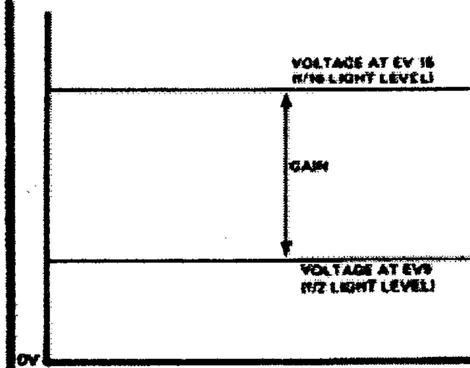


Figure 95

Figure 96

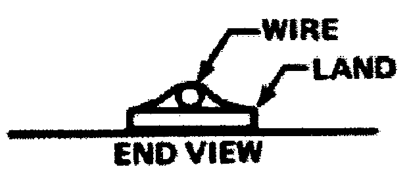


Figure 97

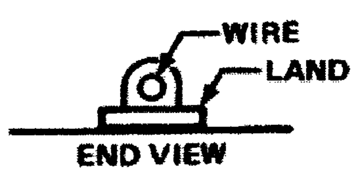


Figure 98

The main problem people have in working on the AE-1 results from poor solder joints. Remember, you're dealing with tiny voltages and currents. So the additional resistance introduced by a cold solder joint can cause a complete failure. If something fails to work properly on reassembly, check first the solder joints of the wires you had to disconnect and resolder.

Using a liquid soldering flux, such as 1544, can really improve your solder joints. Just apply a drop of the flux to the circuit-board land. Then, solder the wire in place. The liquid flux cleans the solder joint as it's burned off by the soldering iron. And you'll get a bright, shiny connection.

With those precautions in mind, let's proceed to the removal of the front-plate/mirror-cage assembly. When would you have to remove this assembly? One, to get to the shutter. Also, you'll have to remove the front-plate/mirror-cage assembly to reach the diaphragm-sensing resistor and the diaphragm-control electromagnet. Earlier, we've described how you can trouble shoot these components without pulling the front plate. Yet, to replace the components, you'll have to remove the front-plate/mirror-cage assembly.

Canon recommends removing the battery before doing any soldering or unsoldering. Then, unsolder the purple wire from resistor RB1, Fig. 99. The other end of the purple wire connects to the preview switch on the front plate. And unsolder the white wire from the functional-resistor circuit board, Fig. 100—this is the wire that goes to the backlight switch on the front plate.

There's one problem in disconnecting the white wire—the ceramic circuit board for the functional resistor likes to soak up heat. The circuit board then tends to draw the heat away from the solder joint faster than the solder will melt. Here's one place a larger soldering iron (around 47 watts) comes in handy.

You can now unsolder the three wires—red, black, and green—from the front of the flex circuit, Fig. 101. These wires, you'll recall, come from the diaphragm-control electromagnet and from the auto-manual switch (green).

Also unsolder the red galvanometer wire that hooks to Rch on the flexible circuit board, Fig. 102. The galvanometer wire sometimes passes under the resistor—that makes disconnecting the wire a little more difficult. But you should have no trouble locating the galvanometer wire; it's a larger wire gage than are the other wires in the area.

The other five wires you'll have to unsolder come from the diaphragm-sensing and maximum-aperture resistors on the side of the mirror cage. Unsolder the orange wire from the flex circuit, Fig. 102. And unsolder the red wire from the VR3 land, also shown in Fig.

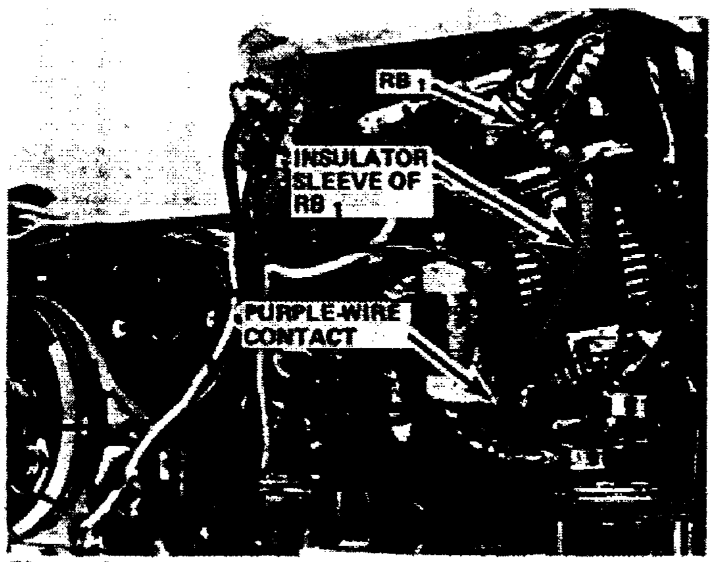


Figure 99

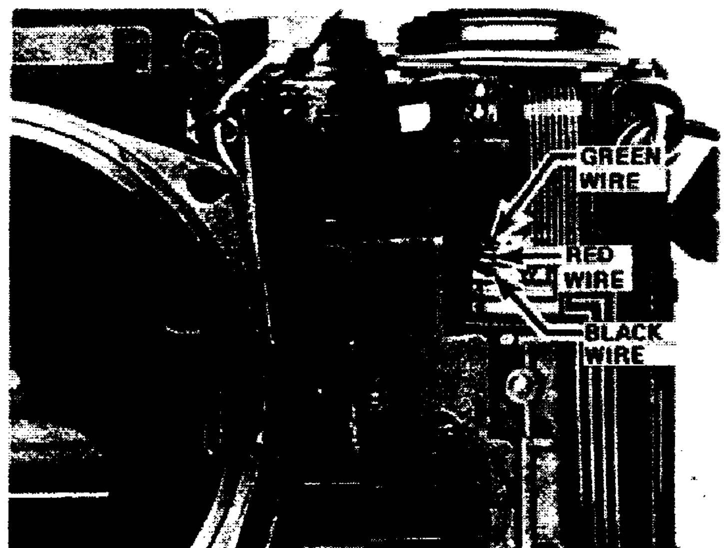


Figure 101

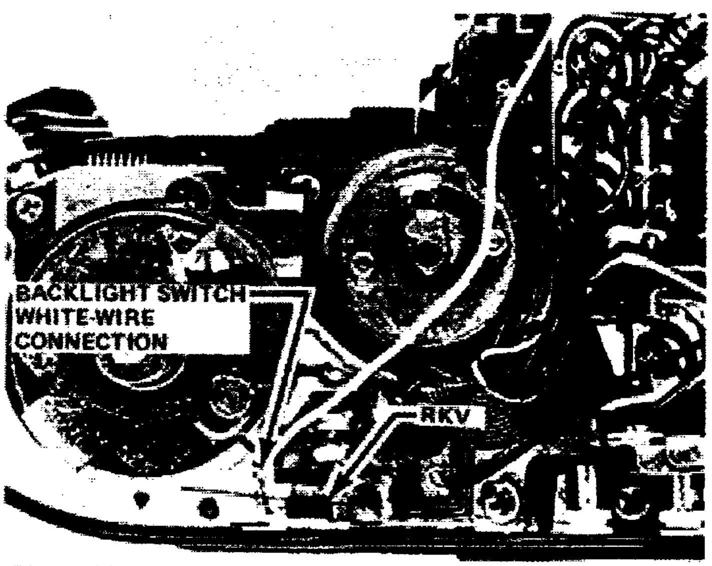


Figure 100

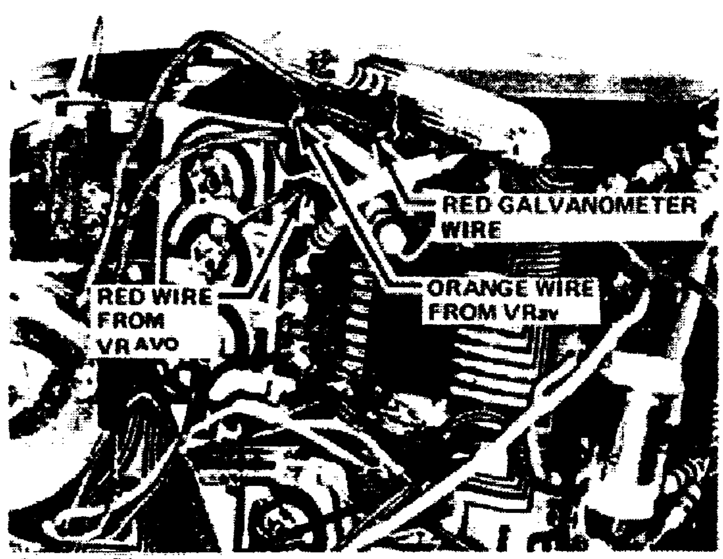


Figure 102

102.

Next, unsolder the white wire from the flex circuit, Fig. 103. And unsolder the green wire from the functional-resistor circuit board, Fig. 104. Notice that all the wires you're now disconnecting pass through the slot behind the galvanometer.

The last of the five wires is the toughest to unsolder—that's the blue wire coming from one end of the diaphragm-sensing resistor VRav. The blue wire connects to a flex-circuit land that's almost hidden by the resistor circuit board, Fig. 105. Be sure you unsolder the right blue wire. In some variations, there's another blue wire connected right next to the one you want.

If you have two blue wires, notice that one passes over the top of the resistor circuit board. Don't unsolder this wire—it connects pin 5 of PX3 to the Mg1 electromagnet through the flex circuit (in other cameras, a bare wire passing under the resistor circuit board makes the connection). Rather, unsolder the blue wire that connects to the land closer to the back of the camera. That's the wire passing through the slot with the other four mirror-cage wires.

You should now have five disconnected wires passing through the slot behind the galvanometer. To facilitate reassembly, it helps to twist the wires together as shown in Fig. 106.

DISCONNECTING AND TESTING THE LED'S

In Fig. 106, you can see the solder connections for the viewfinder LED's. The LED leads pass through holes in the flex circuit. And, since the LED's stay with the mirror cage, you'll have to remove the solder from the leads.

The two connections closer to the front of the camera are for the manual LED (the LED that flashes when you're set to a manual f/stop). And the two connections closer to the back of the camera are for the underexposure LED. Since you can now see the LED contacts in the illustrations, this might be an appropriate time to describe some test procedures.

Suppose that one of the LED's fails to flash. The problem could be in the circuit. Or you could have a bad LED. If the manual LED isn't working, there's most likely a problem with the auto-manual switch. So use your ohmmeter to check between the disconnected green wire, Fig. 101, and ground. You should read a short—a direct connection. But when you push in the auto-manual pin, you should read an open circuit.

Your ohmmeter test tells you whether or not the auto-manual switch works properly (if it doesn't, you'll have to remove the front-plate/mirror-cage assembly). To check the LED's, though, just replace the battery. Using a voltmeter, you should then read the full

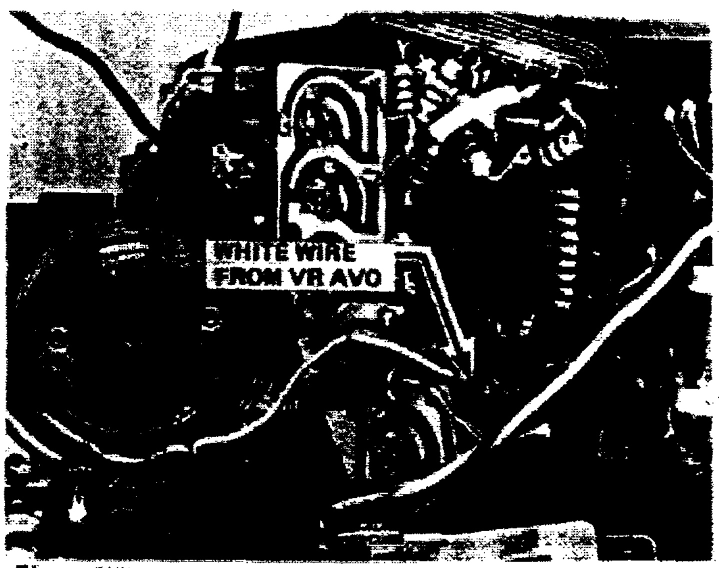


Figure 103

Figure 105

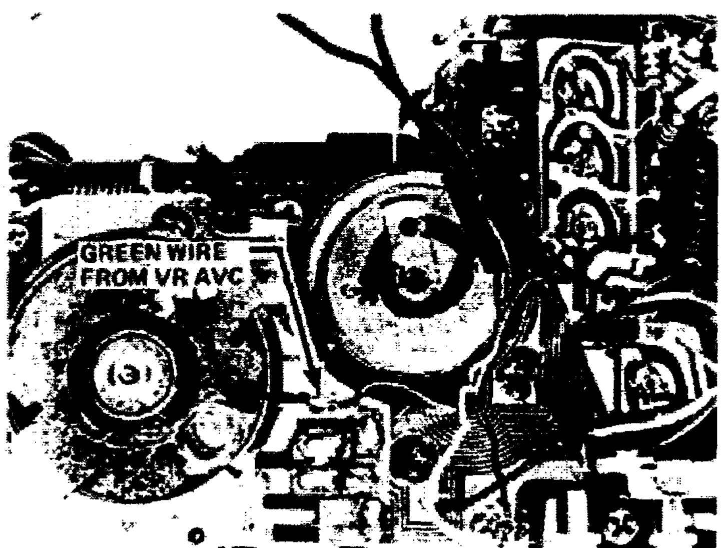


Figure 104

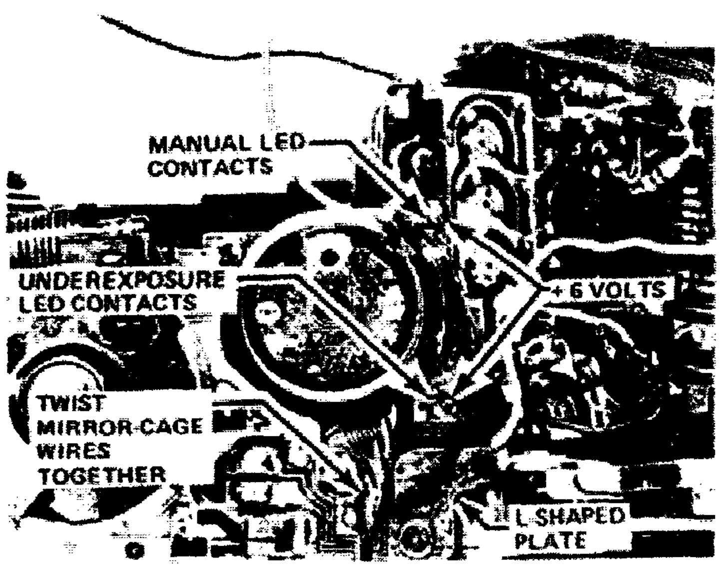


Figure 106

battery voltage at each LED.

Measure between ground and the manual-LED lead closer to the front of the camera—you should measure 6 volts without closing the release-button switches. You should also measure 6 volts at the underexposure-LED lead closer to the back of the camera, Fig. 106. If you don't get a reading at these two connections, you evidently have a break in the flex circuit.

To test the LED itself, just short the negative LED lead to ground, Fig. 107. The LED should glow steadily (no flashing because you're bypassing the oscillator). If the LED doesn't glow—yet you measure 6 volts at the positive lead—you evidently have a bad LED. You can replace either LED individually. But that's easier to do with the mirror cage removed.

COMPLETING THE FRONT-PLATE REMOVAL

As mentioned earlier, removing the front-plate/mirror-cage assembly requires disconnecting the LED pins from the flex circuit. Here, you must be especially careful to avoid damage. Applying too much heat when you pull the solder can damage the flex-circuit connections.

You can remove the solder from the LED pins by using a solder-removing tool. But it's usually better to use desoldering wick. Most solder-removing tools have relatively large tips—too large for such cramped quarters.

So use the desoldering wick to remove the solder from all four LED leads. Fig. 108 shows the LED leads after removing the solder. Notice how the LED leads pass through the circuit-board holes. As you remove the front-plate/mirror-cage assembly, you'll have to lift the flex circuit over these leads.

You do need some play in the flex circuit to clear the LED leads. So remove the ground contact shown in Fig. 106. The screw holding the L-shaped ground plate connects the flex circuit to ground. Earlier cameras may not have the ground plate—there may just be a washer under the screw for the ground contact. And some cameras have a washer under the L-shaped plate.

Now, remove the other section of front-plate leatherette. And cock the shutter—that usually makes it easier to remove the mirror cage. Take out the two mirror-cage screws by the eyelens, Fig. 109, and the five front-plate screws at the front of the camera, Fig. 110.

Notice the different shapes of the front-plate screws, Fig. 110. Two of the screws have slotted (rather than cross-point) heads—these are shoulder screws

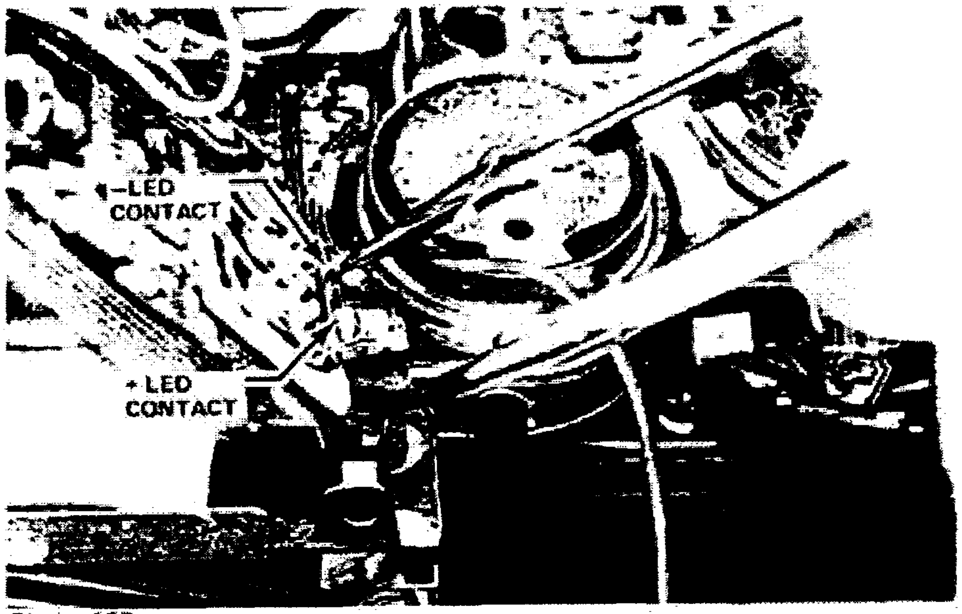


Figure 107

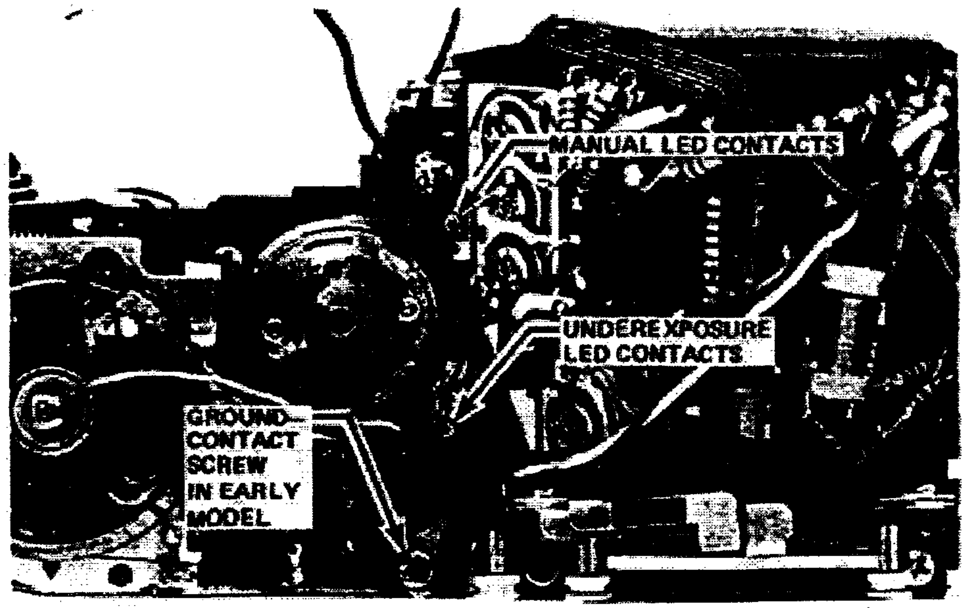


Figure 108

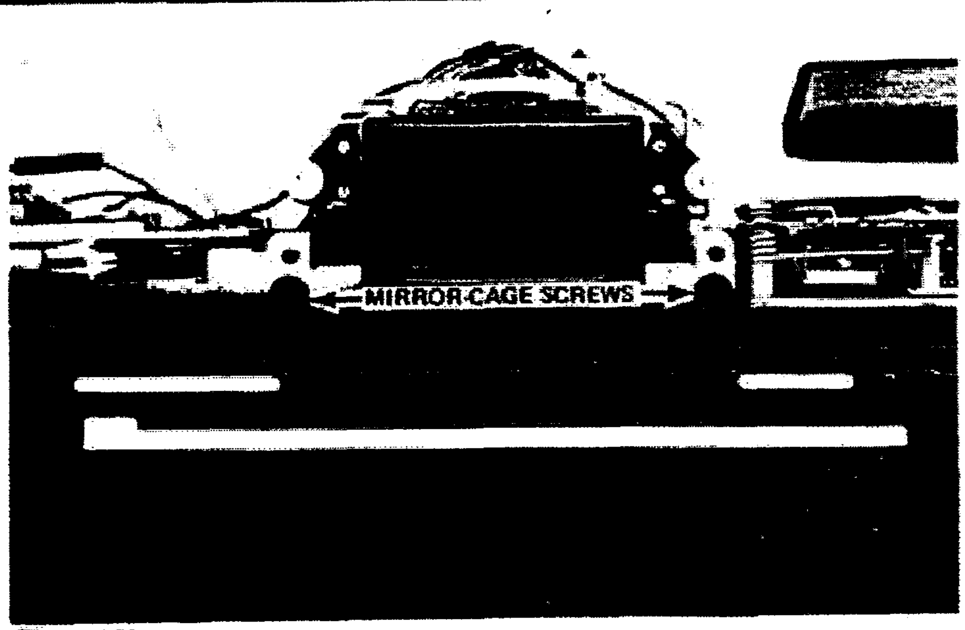


Figure 109

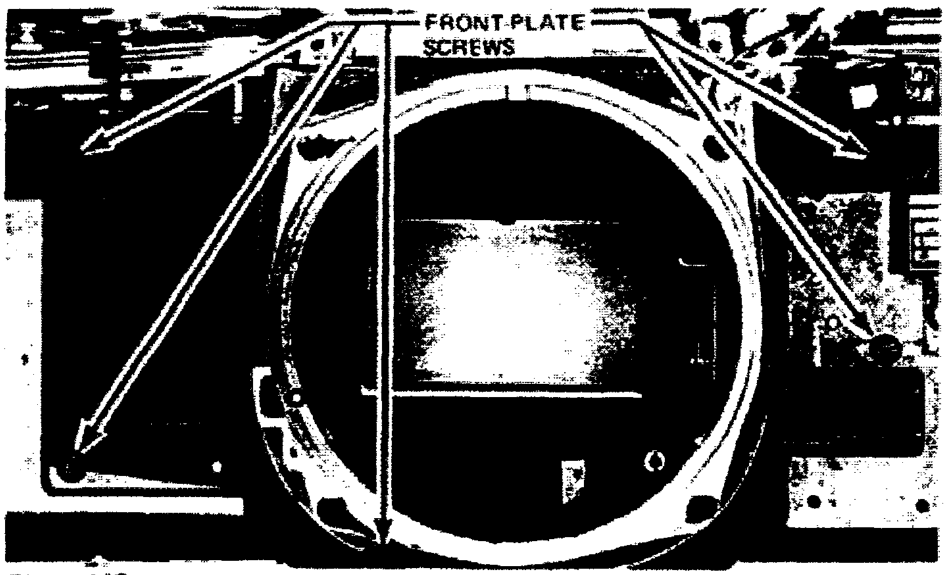


Figure 110

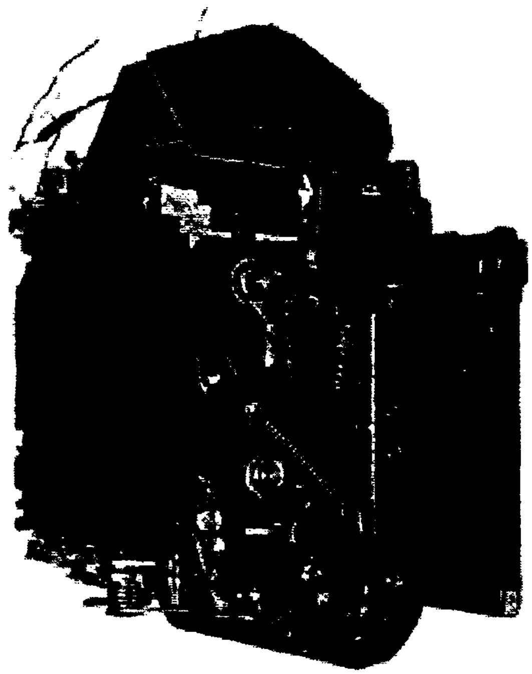


Figure 111 Mirror-Cage/Front-Plate Assembly

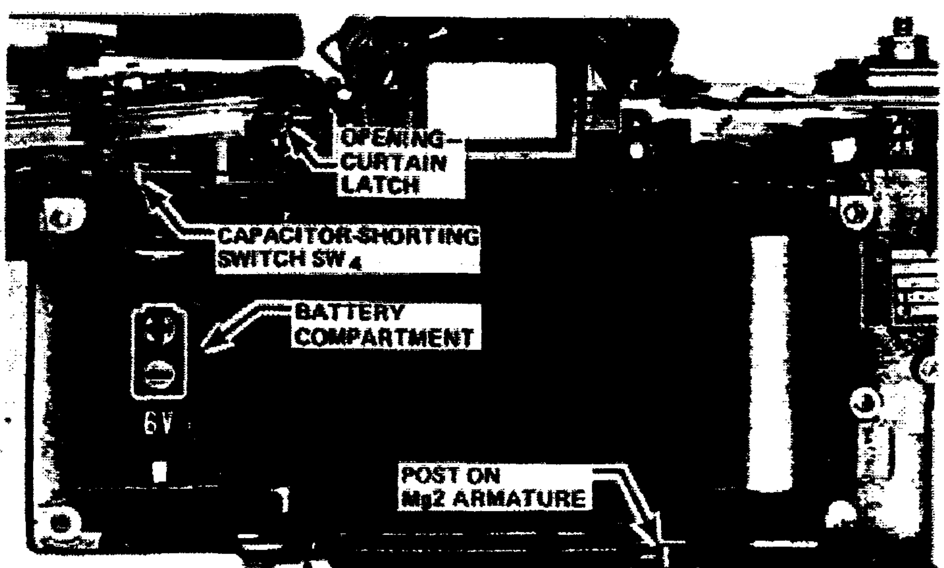


Figure 112

which help position the front plate. Also, the screw that goes in the cavity below the lens-mounting ring is the same as the two screws you removed from the back of the camera.

It's still a little tricky to remove the front-plate/mirror-cage assembly. For one thing, *there's nothing to hold on to.* So you might try opening the battery compartment—that gives you a "handle" to grasp. Then, with a little manipulation—and being extremely careful to avoid catching the flex circuit on the LED leads—lift out the front-plate/mirror-cage assembly, Fig. 111.

CHECKING THE SHUTTER WITH THE MIRROR CAGE REMOVED

Before replacing the mirror cage, you'll want to check the shutter operation. It would be a shame to replace the mirror cage, resolder all the wires, and then find that the shutter doesn't work.

To check the shutter replace the battery and the ground-contact screw, Fig. 108. Then, cock the shutter (at this point, the shutter should already be cocked since you removed the mirror cage in the shutter-cocked position).

Now, push down the release-button switches SW1 and SW2—the armature of the combination magnet Mg2 should spring away from the core. This action normally releases the mirror.

But with the mirror cage removed, there's nothing for the armature to release. Plus, there's nothing to push the closing-curtain armature against the core of Mg3—the mirror-tensioning lever on the side of the mirror cage normally charges the Mg3 armature. So use your tweezers to push the Mg3 armature against the electromagnet—the electromagnet should hold the armature magnetically. And release the shutter by pushing the opening-curtain latch, Fig. 112, toward the back of the camera.

The opening-curtain latch both releases the opening curtain and opens the capacitor-shorting switch. So, to get the shutter to time out at the different speeds, you'll have to hold the opening-curtain latch depressed for the full exposure. If you don't hold the opening-curtain latch depressed, the shutter will hang open. Why? Because the capacitor-shorting switch remains closed and the timing capacitor can't charge.

Continued next month.

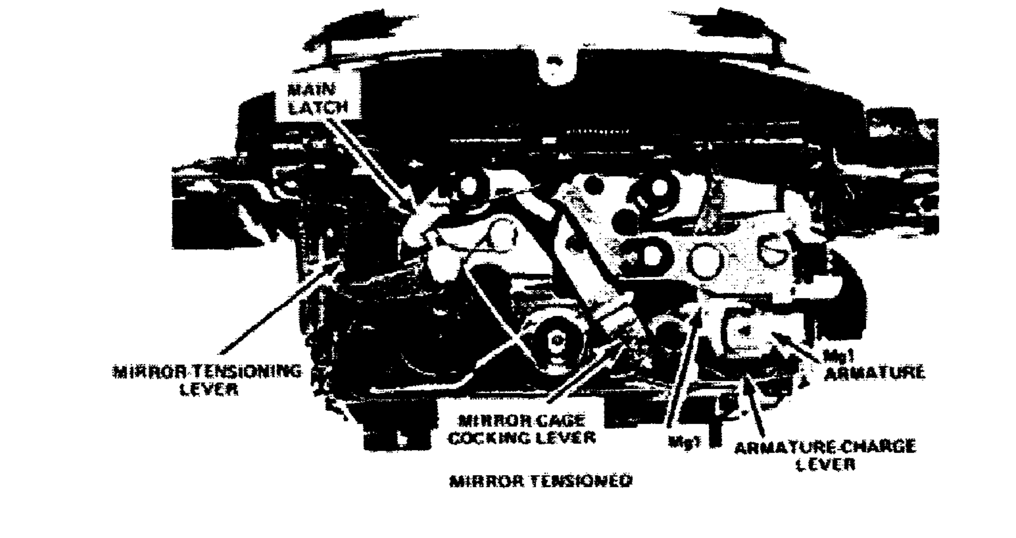


Figure 113

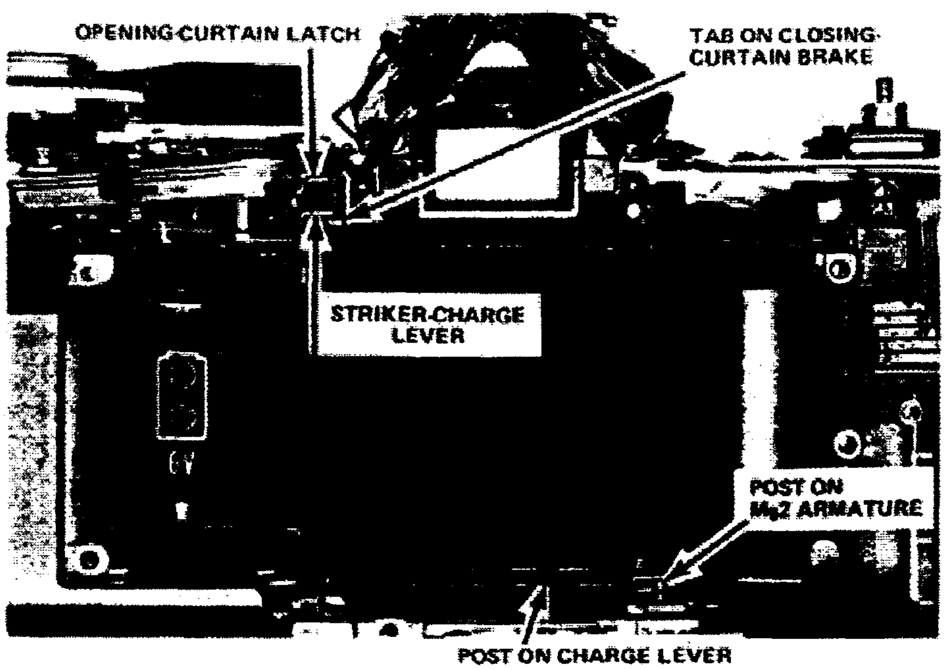


Figure 114

OPERATION OF THE MIRROR CAGE

You may have heard that the sophisticated circuitry in the AE-1 eliminates around 300 mechanical shutter parts. At first glance, it now looks like Canon put all those parts on the mirror cage.

But complex though it may appear, the mirror cage comes apart in modular chunks. The three mechanism plates are modular units — they simply attach to the sides and bottom of the mirror cage.

At the bottom of the mirror cage, Fig. 113, you can finally see the diaphragm-control electromagnet Mg1. During the cocking cycle, the post on the charge lever, Fig. 114, drives the mirror-cage cocking lever from left to right, Fig. 113. That tensions the mirror cage. And it simultaneously pushes the armature against the diaphragm-control electromagnet, Fig. 113.

Here's the place to expect a problem if the diaphragm doesn't stop down — even when you short the negative Mg1 lead to ground. There could simply be dirt between the armature and the core of the electromagnet. Or dirt may prevent the armature from pivoting freely on the armature lever.

Check also to assure that the armature contacts the electromagnet when you tension the mirror cage, Fig. 113. If the armature-charge lever fails to push the armature far enough, you'll see a space gap between the armature and the electromagnet's core. The electromagnet doesn't have enough strength to actually pull the armature against the core — it just has enough strength to hold the armature. So the armature releases immediately. And the diaphragm doesn't stop down.

In that case, you may have to loosen the two brass screws and shift the position of the electromagnet Mg1. Or you may have to reform the armature-charge lever, Fig. 113.

You can release the mirror by simulating the action of the Mg2 combination magnet. A post on the Mg2 armature ses through the body casting, Fig. [illegible]. When Mg2 releases its armature, the post strikes the main release lever, Fig. 115.

So push the main release lever toward the back of the mirror cage. The mirror should then rise to the taking position. And the Mg1 armature should jump away from the diaphragm-control electromagnet. Why? Because there's no current flowing through the Mg1 coil.

Pushing the main release lever disengages the main latch, Fig. 113. The spring-loaded mirror-cocking lever then shoots toward the back of the mirror cage, Fig. 115. A pawl attached to the mirror-cocking lever engages a tab on the diaphragm-closing lever. Consequently, the mirror-cocking lever carries the diaphragm-closing lever in a counterclockwise direction. And the diaphragm-closing lever, seen from the front of the mirror cage, moves from right to left.

The mirror-cocking lever actually has a number of jobs. Besides carrying the diaphragm-closing lever, it both tensions and releases the mirror. During the cocking cycle, the mirror-cocking lever pushes the mirror-tensioning lever toward the front of the mirror cage, Fig. 113 and Fig. 116. The tensioning-lever latch, Fig. 116, then latches the mirror-tensioning lever.

When you trip the main release lever, the mirror-cocking lever fires toward the back of the mirror cage. The end of the mirror-cocking lever then strikes the tensioning-lever latch, Fig. 115. That frees the spring-loaded mirror-tensioning lever.

Now, the mirror-lifting spring, Fig. 116, drives the mirror-tensioning lever in a clockwise direction. The mirror-lifting lever sits right above the mirror-tensioning lever, Fig. 116. The lifting-lever latch, Fig. 117, attached to the

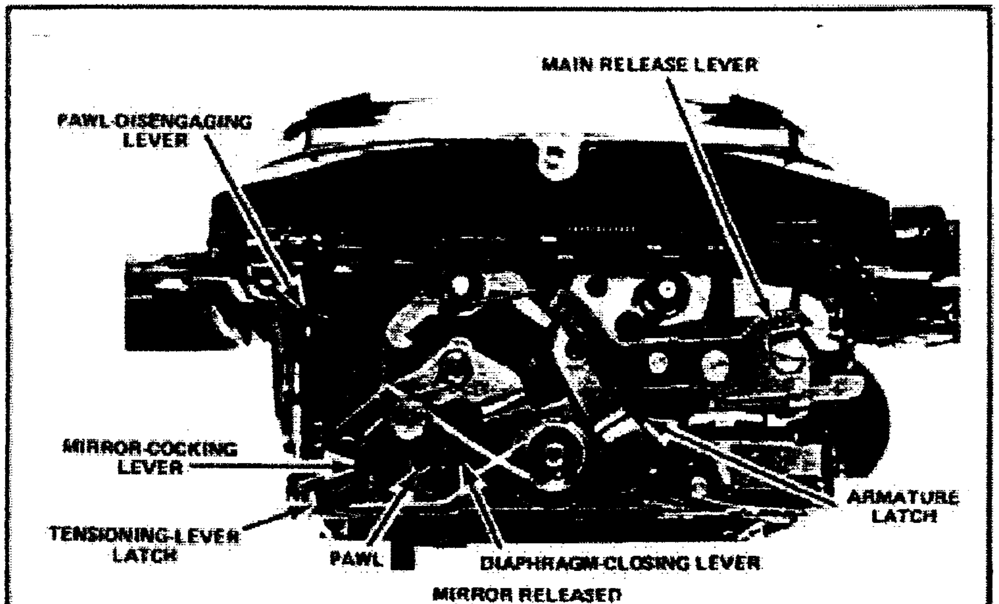


Figure 115

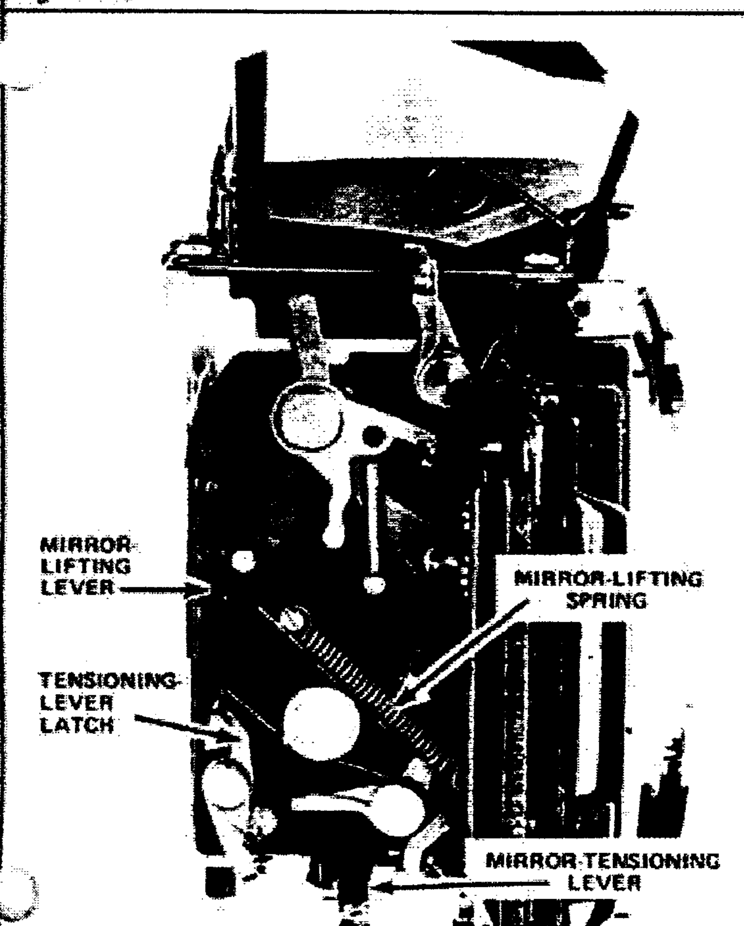


Figure 116

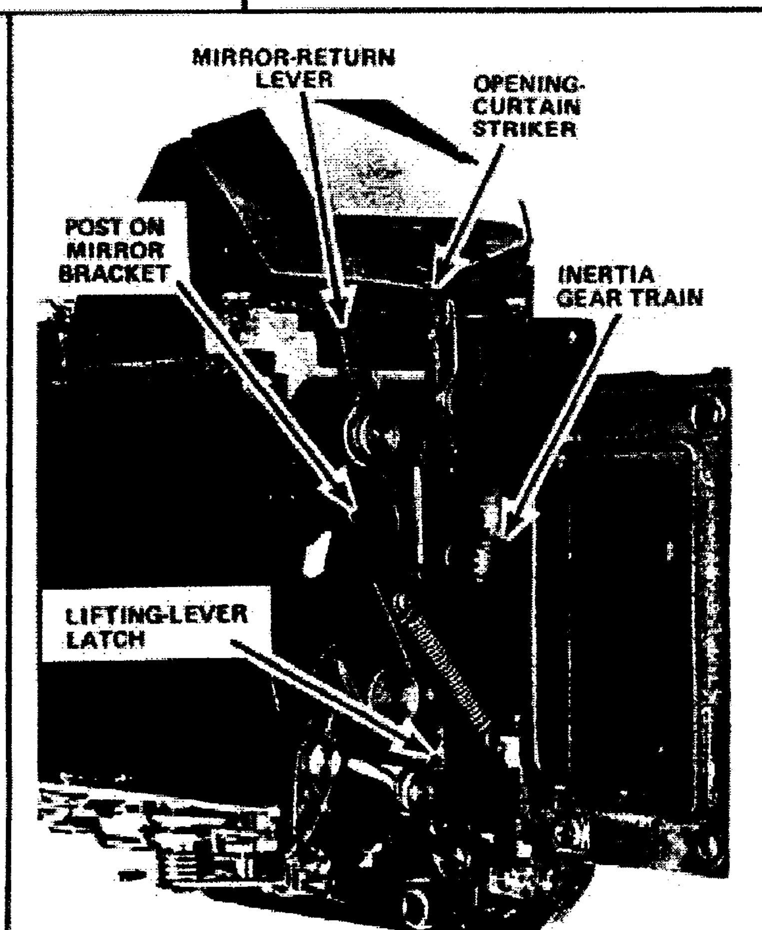


Figure 117

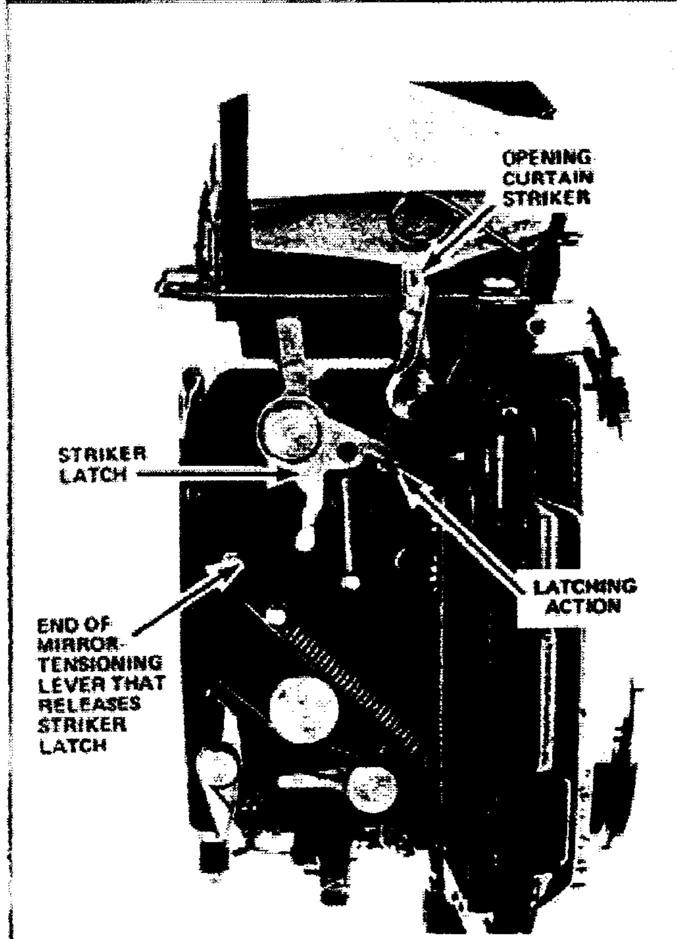


Figure 118

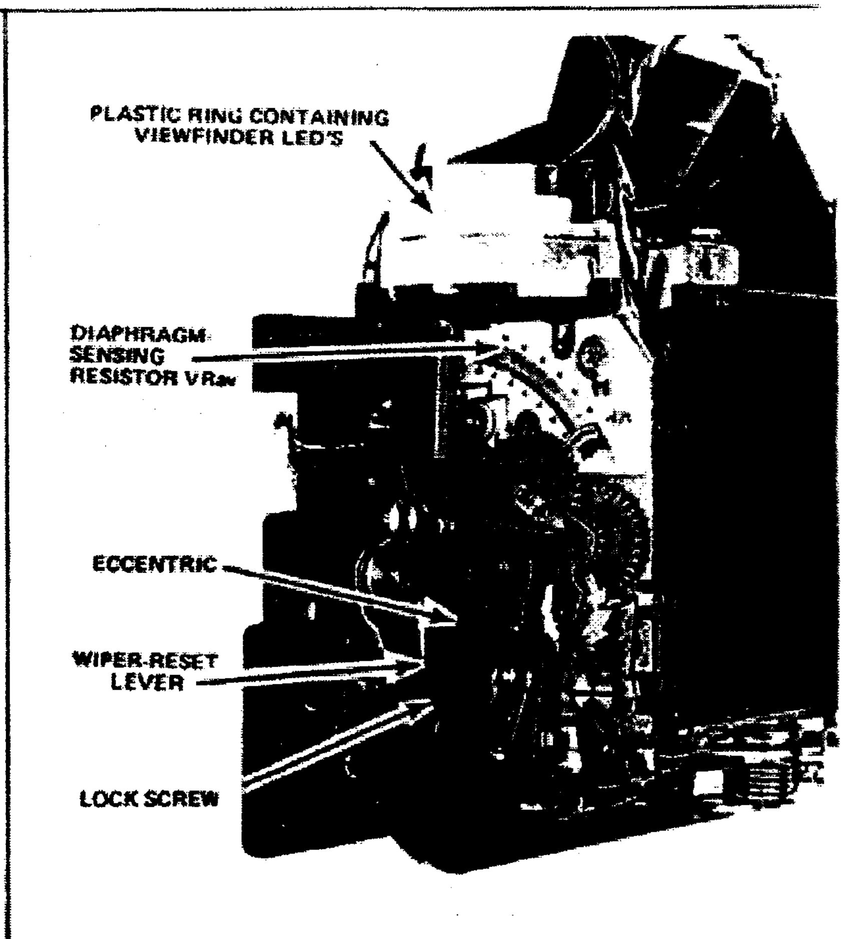


Figure 119

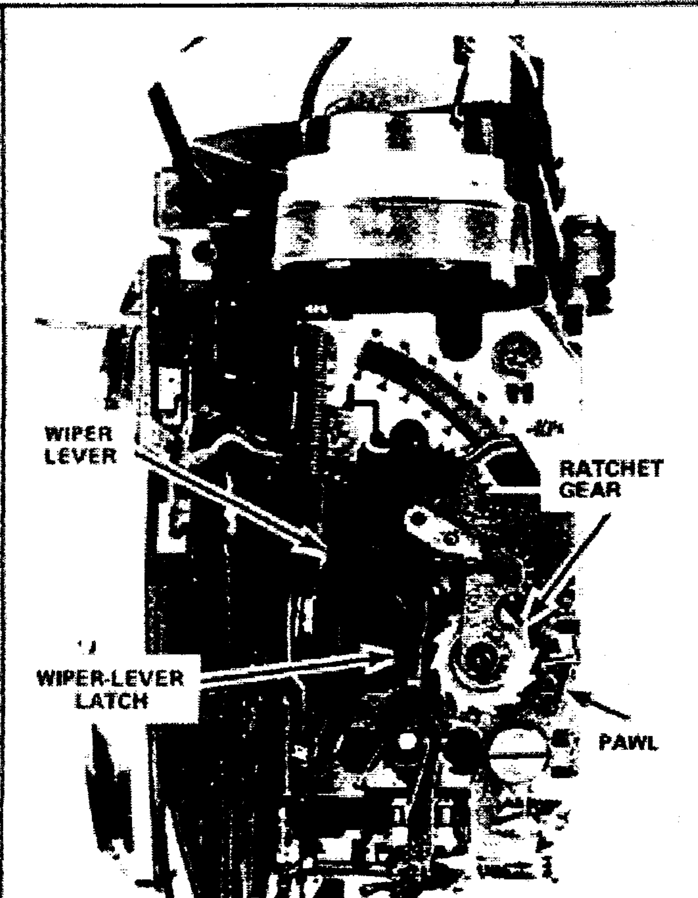


Figure 120

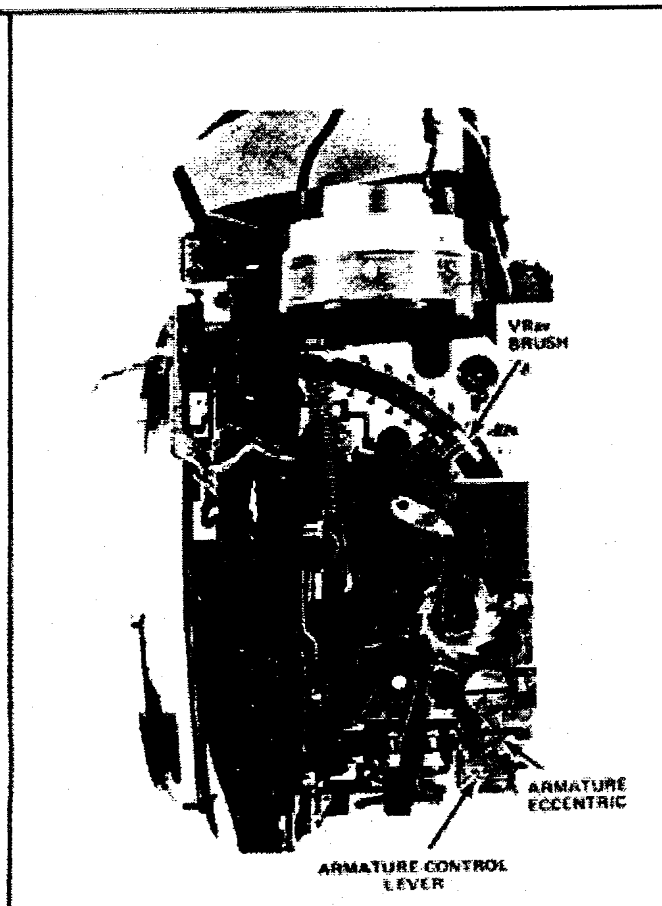


Figure 121

mirror-tensioning lever, engages the mirror-lifting lever. So the mirror-tensioning lever carries the mirror-lifting lever clockwise. And the mirror-lifting lever comes against a post on the mirror bracket, Fig. 117 — that's what moves the mirror to the taking position.

The mirror remains in the taking position as long as the lifting-lever latch engages the mirror-tensioning lever. It's up to the closing curtain to return the mirror after the exposure.

Looking in the camera body, you can see the part that returns the mirror — a tab on the closing-curtain brake, Fig. 114. When the closing curtain crosses the aperture, its wind gear strikes the closing-curtain brake mechanism. And the tab shown in Fig. 114 jumps toward the front of the camera.

The closing-curtain-brake tab then strikes the mirror-return lever, Fig. 117. That drives the mirror-return lever toward the front of the mirror cage. And the mirror-return lever actuates a link which disengages the lifting-lever latch, Fig. 117.

Now, the mirror-lifting lever can return to its rest position. So the end of the mirror-lifting lever moves away from the mirror-bracket post. The mirror-return spring (inside the mirror cage and not yet visible) then returns the mirror to the viewing position.

Notice that a gear segment on the mirror-lifting lever engages an inertia gear train, Fig. 117. Like the air piston in the Olympus, the inertia gear train in the AE-1 dampens the mirror action.

As you operate the mirror cage, you may also notice that one lever seems to be doing nothing — that's the opening-curtain striker, Fig. 117. The opening-curtain striker is the part that actually releases the opening curtain. But it's necessary to charge the opening-curtain striker during the cocking cycle.

Check the action by first cocking the mirror cage. Then, push forward the opening-curtain striker — until the opening-curtain striker is latched by the striker latch, Fig. 118.

When you now release the mirror cage, the mirror-tensioning lever strikes the striker latch. So the striker latch disengages the spring-loaded opening-curtain striker. And the opening-curtain striker fires toward the back of the mirror cage to disengage the opening-curtain latch, Fig. 114.

What part charges the opening-curtain striker? It's the striker-charge lever in the shutter mechanism. The striker-charge lever sits just beneath the opening-curtain latch, Fig. 114. Right now, the striker-charge lever seems to be floating freely in the shutter. But during the cocking cycle, one of the curtain-wind gears cams the striker-charge lever forward — against the opening-curtain latch.

THE AUTO-DIAPHRAGM UNIT

The most unique part of the mirror cage is the module on the other side — the auto-diaphragm unit, Fig. 119. Here, you can see the diaphragm-sensing resistor VRav. When you cock the mirror cage, the end of the mirror-cage cocking lever comes against the wiper-reset lever, Fig. 119. That's what resets the auto-diaphragm unit.

That VRav resistance band shown in Fig. 119 can be one of the main trouble areas in the AE-1. With the lens removed, there's an opening for dirt to reach the VRav resistor. Then, as the brush moves along the resistance band, the dirt can wear tiny breaks — breaks you can hardly see.

As mentioned earlier, a problem with the VRav resistor normally causes the diaphragm to stop down fully every time. Or, it can give you erratic diaphragm operation. We also described how you can check the VRav resistor without pulling the mirror cage (measuring to the orange wire, where you should read from around 1.3K to around 900 ohms as the diaphragm-setting lever moves down).

You can also check the diaphragm-sensing resistor with the mirror cage removed. Hook your ohmmeter between the orange wire and ground (any metal part of the mirror cage). With the mirror cage tensioned, the wiper lever should latch on the top step of the wiper-lever latch, Fig. 120. The brush that moves along the resistance band should now be nearly out of view at the top of the VRav resistor. Here, the brush should not be touching the resistance band.

So you should measure an open — no continuity between the orange wire (attached to the resistance band) and ground. Then, push in the stop-down lever. And move down the diaphragm-setting lever. The resistance should smoothly decrease, from infinity to around 1.85K as the brush reaches the bottom of its travel, Fig. 121.

If that resistance changes erratically — or if you measure an open throughout the movement of the diaphragm-setting lever — you'll probably have to replace the resistance band. You can get the ceramic circuit board with the printed resistance band as a replacement part; it's not necessary to replace the entire mirror-cage panel containing the auto-diaphragm unit.

In normal operation, the spring-loaded diaphragm pulls down the diaphragm-setting lever. Releasing the mirror causes an extension arm of the main release lever to come against the wiper-lever latch. That pushes the wiper-lever latch out of engagement with the wiper lever. The wiper lever can now move down, carrying the brush along the resistance band, as the diaphragm closes.

A gear segment attached to the wiper lever turns the three gears on the side of the auto-diaphragm unit. The last of these gears is a ratchet gear. And the pawl for the ratchet gear is part of the Mg1 armature, Fig. 120.

So the diaphragm can continue closing as long as the Mg1 electromagnet remains energized. Mg1 then holds its armature, keeping the pawl disengaged from the ratchet gear.

Once the diaphragm-sensing resistor VRav reaches the proper resistance value, Mg1 releases its armature. The pawl end of the armature then drops into engagement with the ratchet gear, Fig. 121. That arrests the gear train, stopping the wiper lever. And the wiper lever stops the diaphragm-setting lever at the proper diaphragm opening.

ADJUSTMENTS ON THE MIRROR CAGE

Earlier, we mentioned the overtravel of the diaphragm-setting lever. (Remember, you checked this overtravel before disassembling the camera.) The adjustment for the overtravel is the eccentric on the wiper-reset lever, Fig. 119.

Try holding the mirror-cage cocking lever in the fully advanced position. You should then see a slight space gap between the wiper lever and the top step of the wiper-lever latch, Fig. 122. This space gap, specified by Canon as 0.50mm, represents the overtravel that

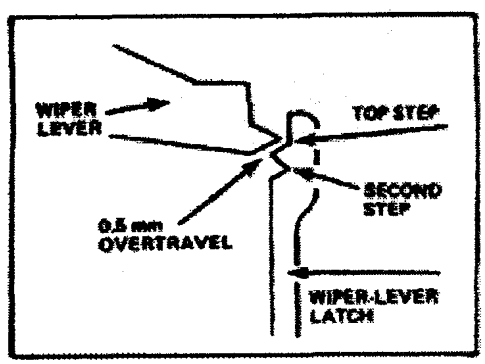


Figure 122

assures proper engagement. To adjust the overtravel, first loosen the lock screw on the wiper-reset lever, Fig. 119. Then, turn the eccentric.

There's also an eccentric on the Mg2 armature, Fig. 121. When the diaphragm-control electromagnet releases its armature, the spring-loaded armature-control lever comes against the eccentric post. The armature-control lever then drives the armature away from the electromagnet — and simultaneously brings the pawl end of the armature into engagement with the ratchet gear.

The adjustment is for the space gap between the armature-control lever and the eccentric when the armature is mechanically latched. Just push the armature against the electromagnet — until the armature latch, Fig. 115, holds the armature. Then, check the space gap between the eccentric and the side of the armature-control lever.

Canon specifies the space gap as 0.05 — 0.10 mm, Fig. 123. But it's a pretty tough clearance to measure. For that matter, it's even hard to see — the spring that hooks to the eccentric post is in the way.

There's one other test Canon recommends — count the number of rotations made by the ratchet gear during the cocking cycle. Here, you must install a lens. Then, release the mirror cage. And push the armature pawl and wiper-lever latch out of engagement — that allows the diaphragm to stop down to the smallest f/stop.

You can now make a scribe line on the ratchet gear — that makes it easier to count the rotations. Slowly cock the mirror cage. And count the number of turns made by the ratchet gear. Stop counting when the wiper lever latches on the top step of the wiper-lever latch.

If you have the f/1.4 lens installed, the ratchet gear should make 6 complete turns plus 8 teeth. With the f/1.8 lens, the ratchet gear should make 6 complete turns plus 4 teeth. An eccentric under the wiper-lever latch provides the adjustment point.

So far, we've just talked about the top step of the wiper-lever latch. What about the second step? During normal operation, the second step, Fig. 122, has no role. But it allows you to reset the auto-diaphragm unit after previewing the depth of field.

Remember, you can't check depth of field when you're set to the automatic position. You must first turn the diaphragm-setting ring to a manual f/stop. With the shutter cocked, the pawl end of the Mg1 armature remains disengaged from the ratchet gear. So, when you push in the stop-down lever, the diaphragm closes to the f/stop you've set. The stop-down slide on the back of the front plate pushes forward the main release lever. That disengages the wiper-lever latch, allowing the diaphragm to close.

Fig. 124 shows the auto-diaphragm unit disengaged. Here, we've installed a lens set to a manual f/stop. And we've pushed in the stop-down lever.

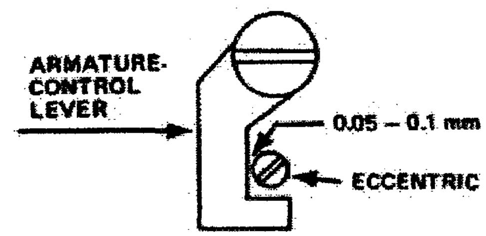


Figure 123

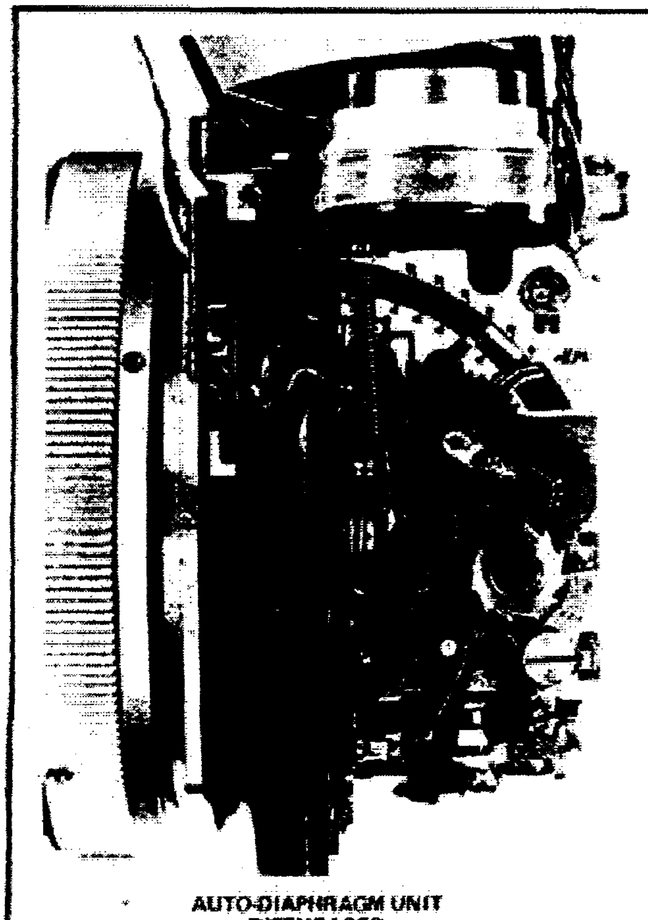


Figure 124

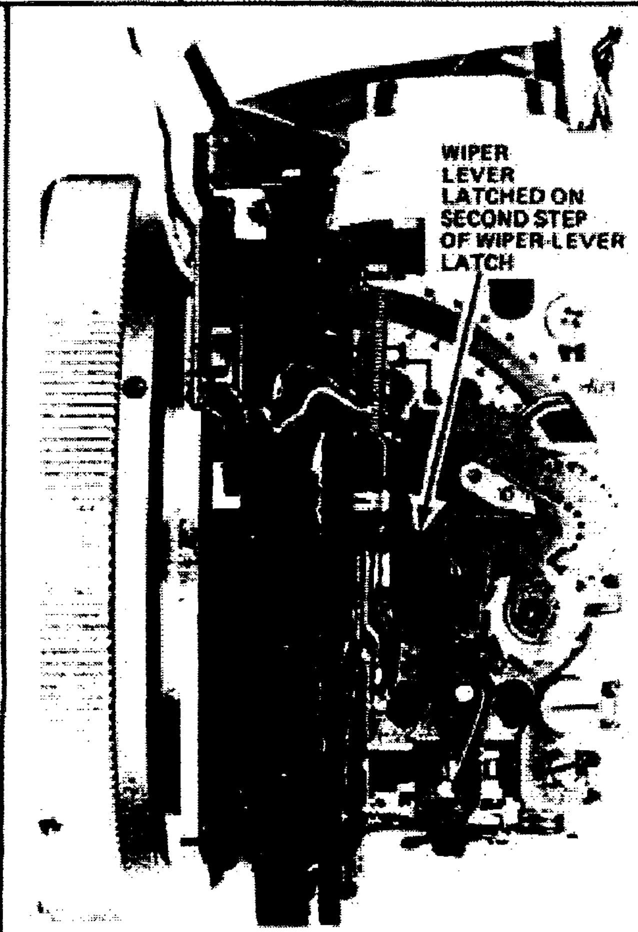


Figure 125

The next time you cock the shutter, the auto-diaphragm unti will automatically reset. You've seen how — the mirror-cage cocking lever pushes the wiper-reset lever toward the front of the era. But the shutter's already cocked. Consequently, you must relatch the wiper lever to get an automatically programmed aperture.

Just set the largest aperture. As you set larger apertures, the wiper lever moves up. And, at the largest aperture setting, the wiper lever latches on the second step of the wiper-lever latch, Fig. 125. You can now turn the diaphragm-setting ring to the automatic position and get an automatically controlled f/stop.

REMOVING THE MIRROR-CONTROL UNIT

As we indicated earlier, the mirror cage comes apart in modules. So it's not as difficult to service as it may at first appear. You can remove any of the panels without removing the other two. But the sequence we'll describe is probably the easiest if you're taking the mirror cage completely apart.

Starting with the mirror-control unit, ll first disconnect the mirror-return spring. That's probably the toughest step. You can see the mirror-return spring from the front of the mirror-cage — the long end of the spring hooks to the top of a post next to the mirror.

The short end of the mirror-return spring hooks under the top edge of the mirror cage. And it's this short end you want to disconnect. From the back of the mirror cage, peel back the right-hand end of the thin metal light trap, Fig. 126. You can now see the mirror-return spring.

A slot in the mirror cage provides clearance for the mirror-return spring. Reach under the top edge of the mirror cage and grasp the short end of the mirror-return spring with your tweezers. Then, bring the short end of the spring through the clearance slot.

In Fig. 126, also notice the bushing on the left-hand mirror pivot. This bushing takes up the lateral play in the mirror. And it'll be loose once you remove the mirror-control unit and the mirror. So, when removing the mirror-control unit, you have three loose parts to watch for the bushing, the mirror-return spring, and the mirror itself.

Now, disconnect the mirror-lifting spring from the mirror-tensioning lever, Fig. 127. And remove the mirror-lifting spring from the mirror cage (the other end of the spring hooks to a mirror-cage tab). Push the mirror-tensioning lever forward to the latched position. A clearance hole in the mirror-tensioning lever then allows you to reach one of the three screws holding the mirror-control unit.

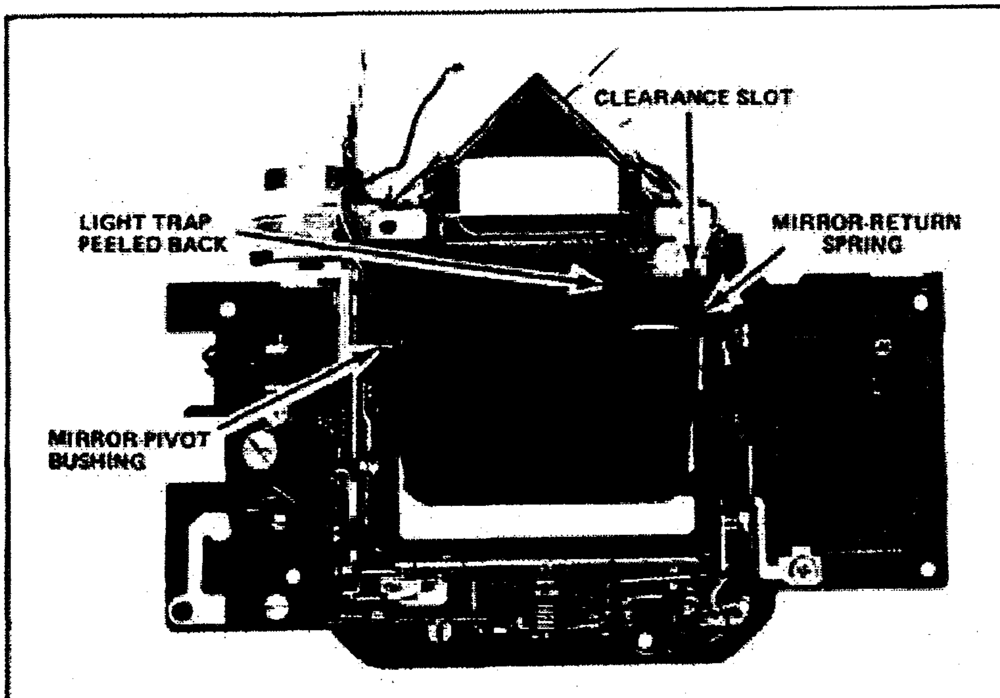


Figure 126

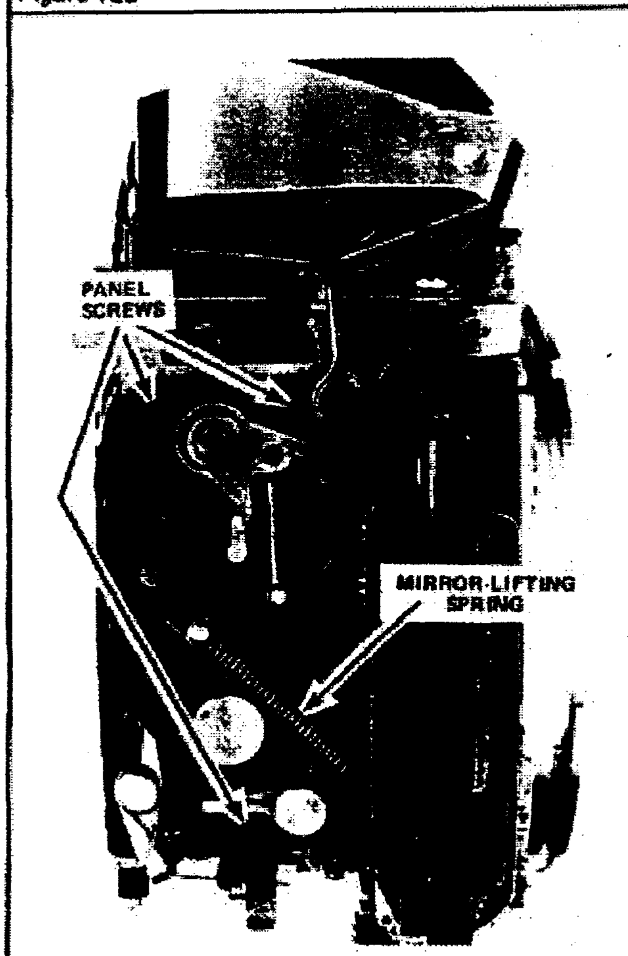


Figure 127

Remove the three screws pointed out in Fig. 127. Then, lift the mirror-control unit from the mirror cage, Fig. 128. And lift out the mirror-return spring, the mirror, and the loose bushing.

At the other side of the mirror-control unit, you can see the mirror-angle eccentric. The eccentric controls the 45° angle of the mirror. However, it doesn't take any disassembly to reach the eccentric. Just open the camera back and hold open the shutter on "bulb." You can then reach through the back of the mirror cage to adjust the eccentric.

Fig. 128 points out the two parts you must align as you replace the mirror-control unit. Make sure the lower end of the lifting-lever latch sits to the back of the mirror-cocking lever. The mirror-cocking lever must disengage the lifting-lever latch to release the mirror.

Also, make sure the long return link on the side of the mirror-control unit sits to the back of the pawl-disengaging lever, Fig. 115. When the closing-curtain brake strikes the mirror-return lever, the return link strikes the pawl-disengaging

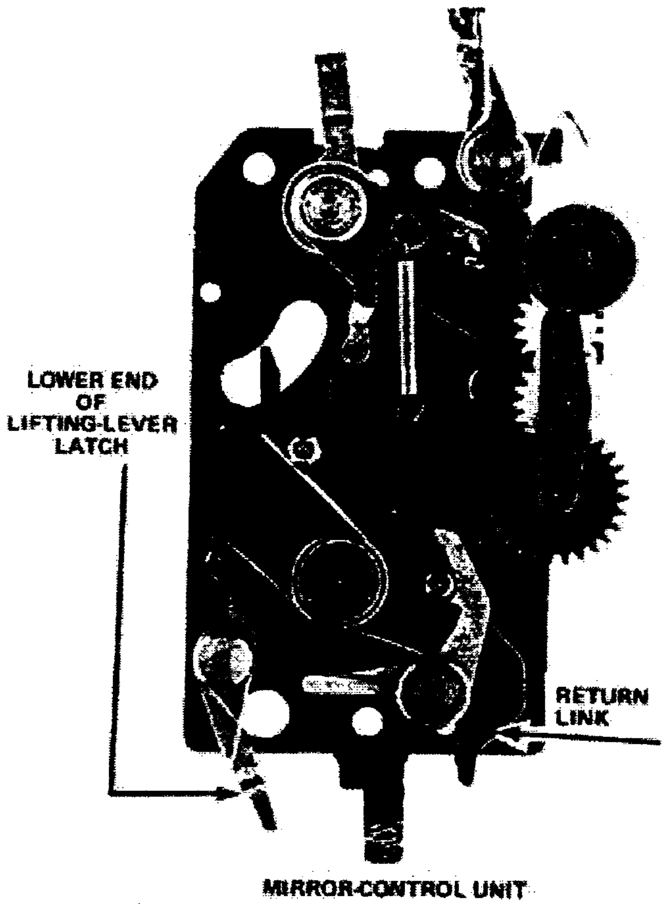


Figure 128

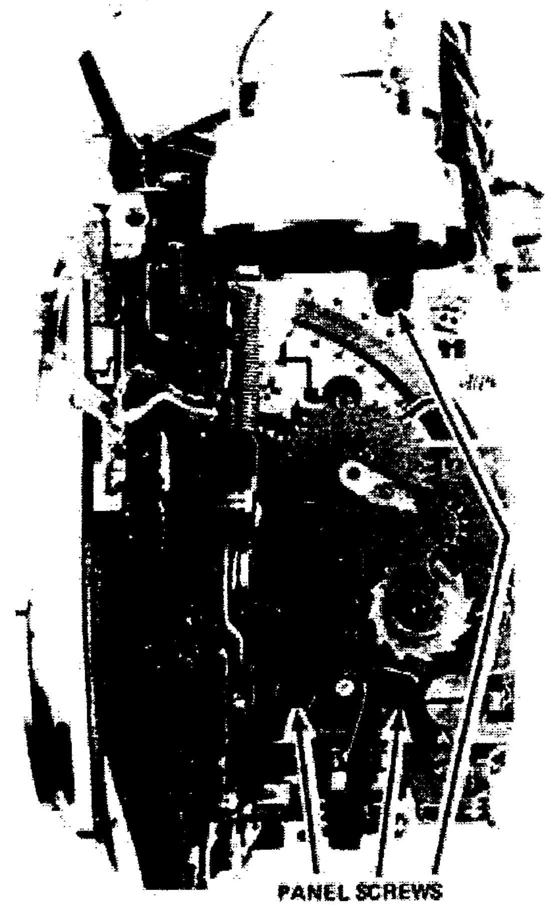


Figure 129

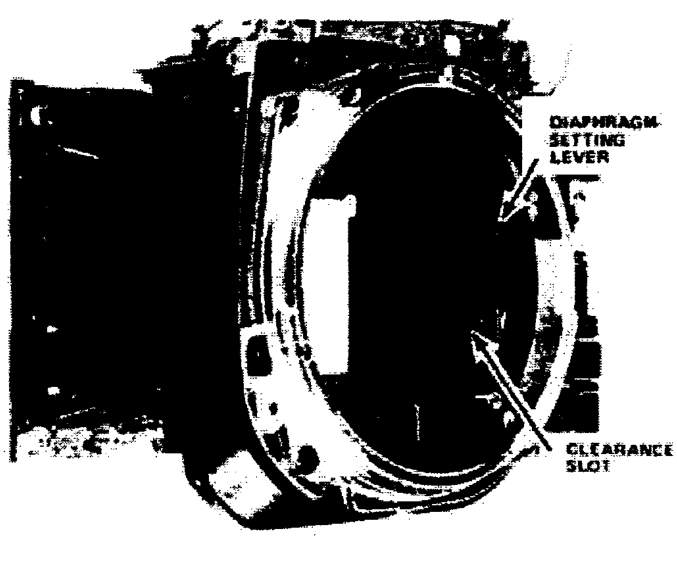


Figure 130

Figure 131

lever. The pawl-disengaging lever then pushes the diaphragm-closing pawl out of engagement with the diaphragm-closing lever. So the spring-loaded diaphragm-closing lever returns to its nor-' position. And the diaphragm reopens ne largest f/stop.

REMOVING THE AUTO-CONTROL UNIT

For most mirror-cage repairs, you may only be removing the auto-control unit. First, take out the three screws holding the auto-control unit to the mirror cage, Fig. 129.

Now, there's only one trick to removing the auto-control unit — you must move down the diaphragm-setting lever until it clears the mirror-cage slot, Fig. 130. Hold the wiper-lever latch disengaged from the wiper lever. And hold the Mg1 armature disengaged from the ratchet gear. You can then move the diaphragm-setting lever to the position shown in Fig. 131. And lift out the auto-control unit, Fig. 132.

You can now see the two wires that connect the diaphragm-sensing resistor to the circuit. The orange wire connects directly to the VRav resistance band. And the blue wire connects to VRav ·' ›ugh a resistor — resistor R1 which is printed on the circuit board.

On the back of the auto-control unit, locate the two variable resistors controlled by the maximum-aperture correction pin, Fig. 133. The maximum-aperture correction pin (still in the front plate) comes against the lower end of the lens-sensing lever. And the lens-sensing lever carries two brushes along separate resistance paths.

The larger of the two variable resistors is VRavo, the maximum-aperture-correction resistor. Information from VRavo goes only to the meter readout. But information from the smaller variable resistor, VR avc, goes to both the meter readout and to the diaphragm-closing system.

Fig. 133 and Fig. 132 actually show two separate circuit boards — the board containing the VRavo and VRavc resistance paths is separate from the board containing the VRav resistance band. And it's the board shown in Fig. 132 that you'll normally be replacing. The board containing the VRav resistance band, Fig. 132, comes separately as a ·acement part.

When you replace the auto-control unit, make sure the Mg1 armature, Fig. 133, goes to the front of the armature-charge lever (on the diaphragm-closing

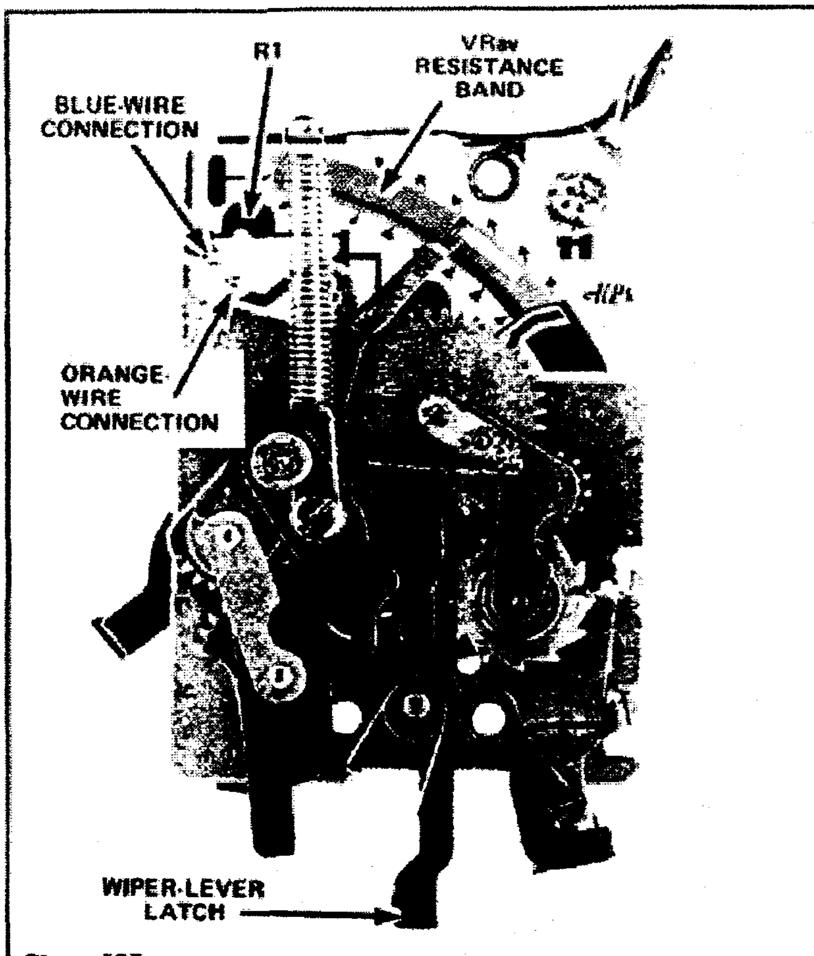


Figure 132

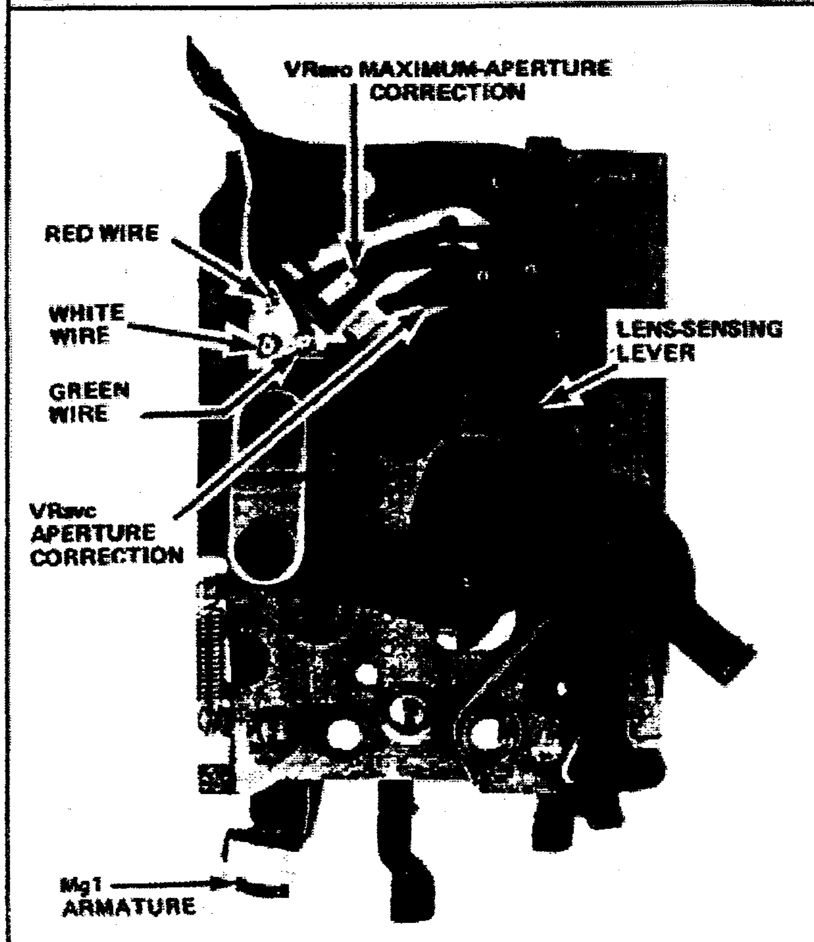


Figure 133

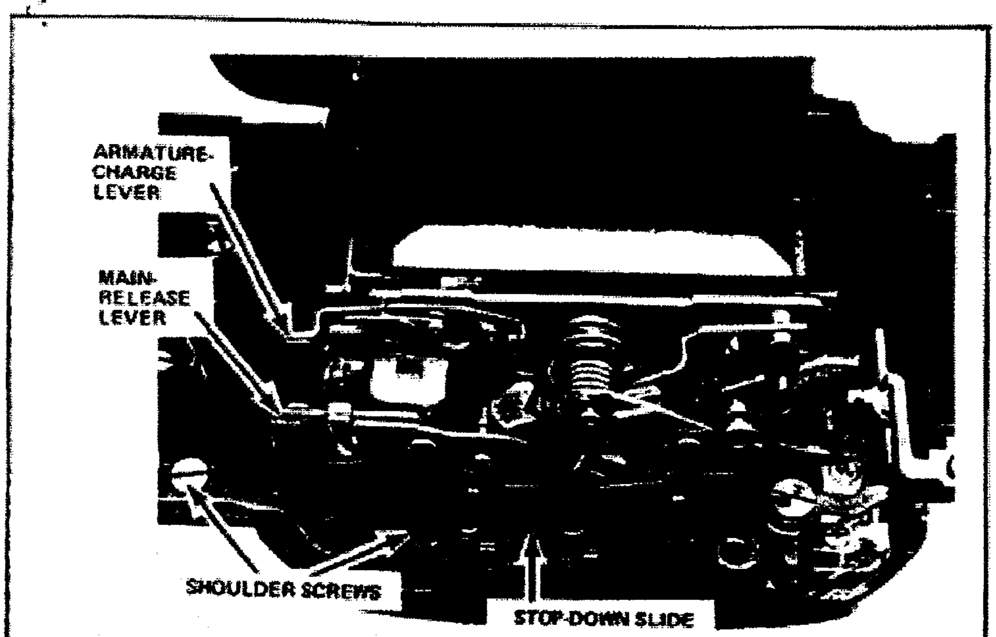


Figure 134

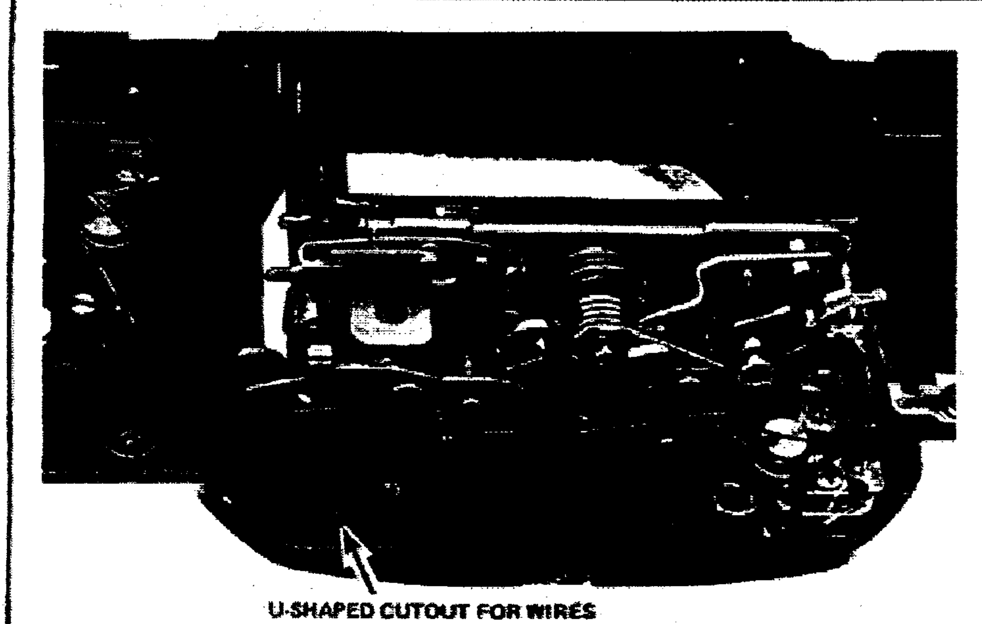


Figure 135

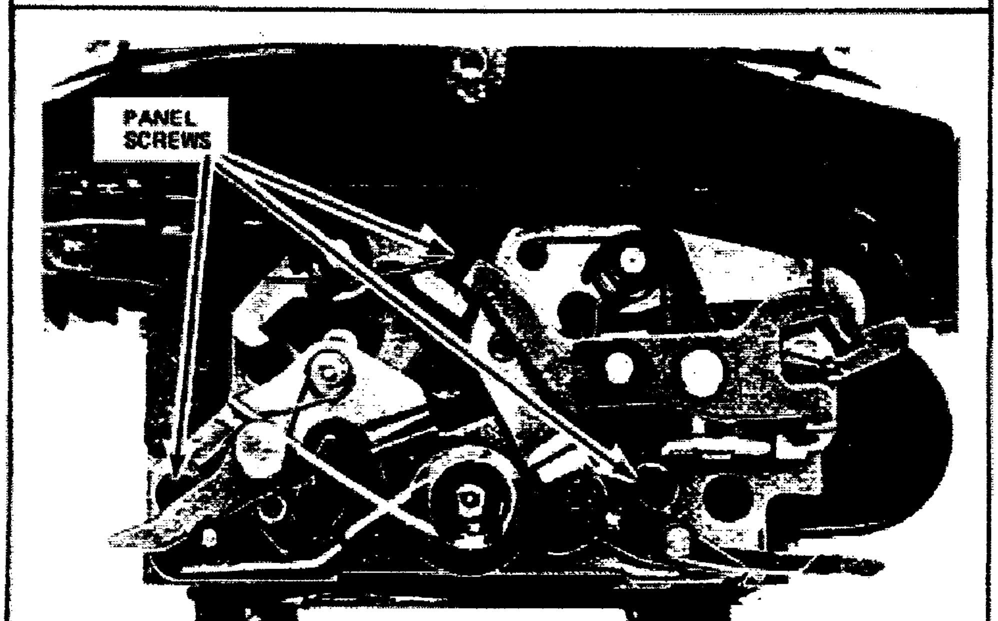


Figure 136

unit, Fig. 134). And make sure the wiper-lever latch, Fig. 132, goes to the front of the main-release lever, Fig. 134.

REMOVING THE DIAPHRAGM-CLOSING UNIT

Before removing the panel at the bottom of the mirror cage, you must free two of the three wires cemented to the back of the front plate — the red wire and the black wire that go to the diaphragm-control electromagnet Mg1. You can leave the green wire cemented in place.

Right now, the stop-down slide, Fig. 134, partially covers the wires. You'll find it easier to reroute the wires if you remove the stop-down slide. Just take out the two shoulder screws shown in Fig. 134. Then, lift out the stop-down slide.

Notice the routing of the wires in Fig. 135. Once you've freed the red wire and the black wire, remove the three screws holding the diaphragm-closing unit, Fig. 136. You'll have to manipulate the levers a little to reach all three screws. It also takes a little manipulation to lift out the diaphragm-closing unit — the upturned tab on the diaphragm-closing lever must pass through the mirror-cage slot.

One part is now loose — the maximum-aperture correction pin, Fig. 137. In Fig. 137, you also have a good view of the auto-manual switch SW11. With the lens removed, the wire blade of SW11 touches the front plate — that connects the green wire to ground. But when you push in the E-M change pin, the wire blade moves away from the front plate. You should then measure an open circuit — no continuity — between the green wire and ground.

Pushing in the E-M change pin also swings the stop-down blocking lever, Fig. 137, in a counterclockwise direction. The stop-down blocking lever then sits in the path of the stop-down slide. That's why you can't actuate the stop-down lever with the diaphragm-setting ring set to the automatic position.

As indicated earlier, you can remove the diaphragm-closing unit without removing the other two panels. However, there's then one more step involved. If you're just removing the diaphragm-closing unit, take off the cemented plate under the diaphragm-closing lever, Fig. 137. That gives you the clearance you need for the upturned tab.

DISASSEMBLY OF THE REMAINING MIRROR-CAGE PARTS

You can reach the two viewfinder LED's by lifting off the plastic ring and the galvanometer housing, Fig. . The two LED's are just press-fit into the plastic ring. To check the LED's, you can use a DC power supply.

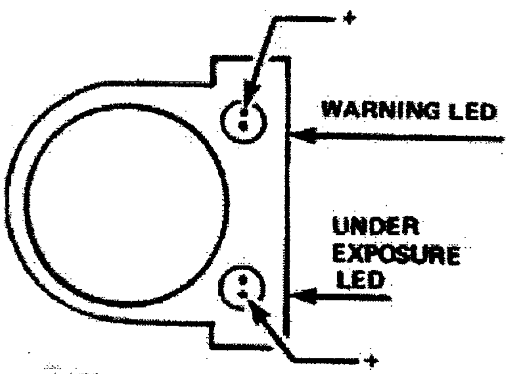
Set the power supply to 2 volts. Then, hook the positive power-supply lead to the positive LED lead, Fig. 138. And hook the negative power-supply lead to the negative LED lead. The LED should glow.

To remove the pentaprism, disconnect and remove the two pentaprism-retaining springs. Lift off the pentaprism bracket. Then, peel off the dust-seal tape around the edges of the pentaprism. As you lift out the pentaprism, watch for loose shims on the sides of the pentaprism mount.

You can now see how far in disassembly you'd have to go to reach the focusing screen. What if a customer just wants you to clean the focusing screen? You'd have to pull the front-plate/mirror-cage assembly — quite a job. Fortunately, Canon does a good job of sealing the focusing screen from dust.

Replacing the galvanometer movement just takes a couple more steps. Lift out the focusing-screen mask containing the diaphragm scale, Fig. 139. And remove the prism assembly above the galvanometer needle, Fig. 140 — two pins on the bottom of the prism assembly pass into holes in the focusing-screen frame. The two prisms, Fig. 140, route the light from the LED's to the focusing screen.

Now, disconnect and remove the galvanometer-clamping spring, Fig. 140. And lift out the galvanometer movement. ...ou remove the focusing-screen frame, ... 140, use caution — washers under the corners of the focusing-screen frame are used to adjust the focus of the viewed image.



...gure 138

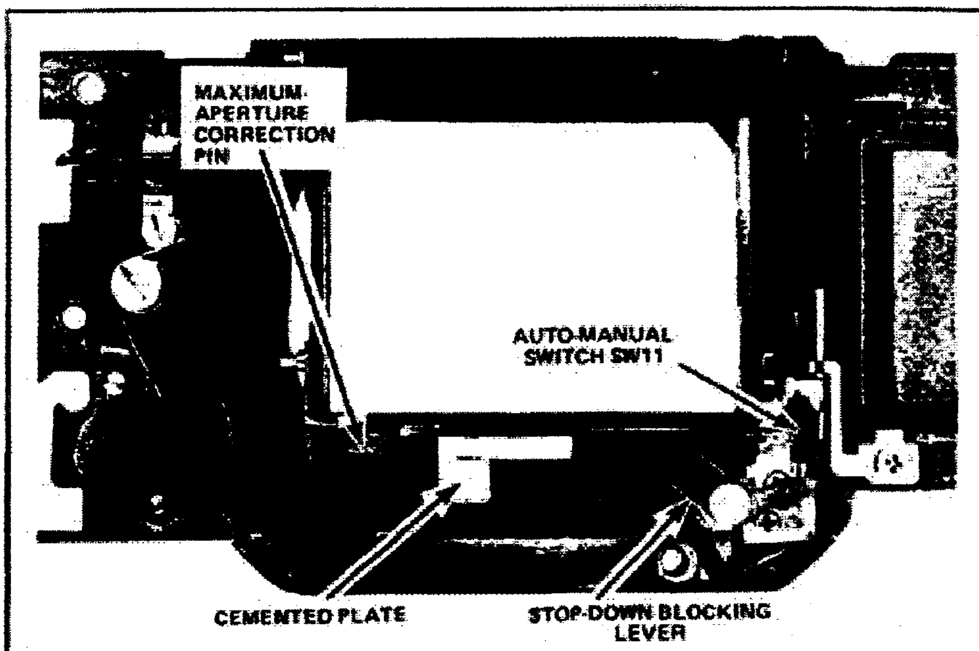


Figure 137

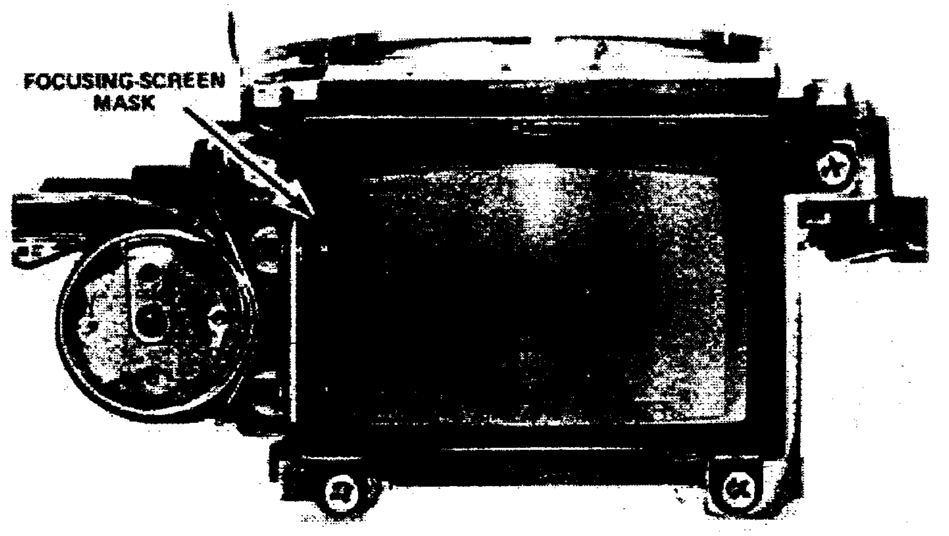


Figure 139

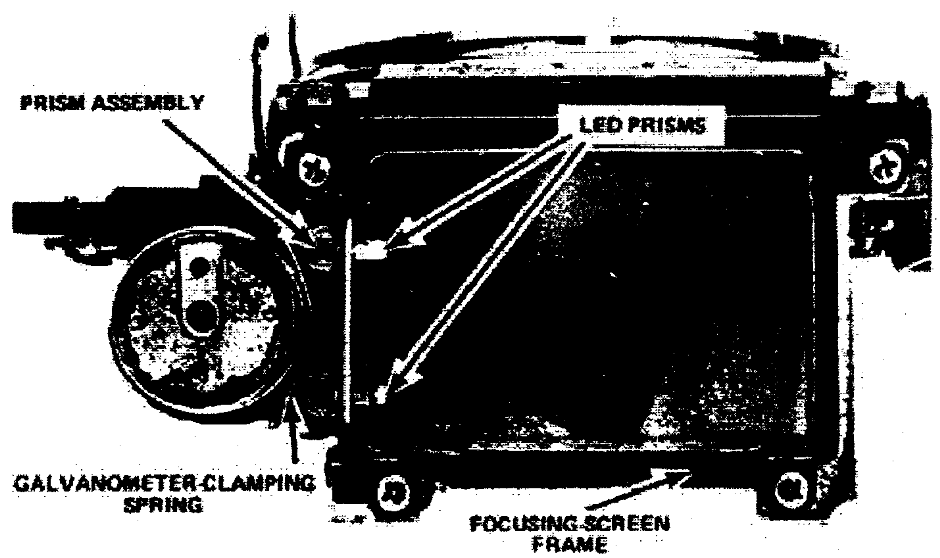


Figure 140

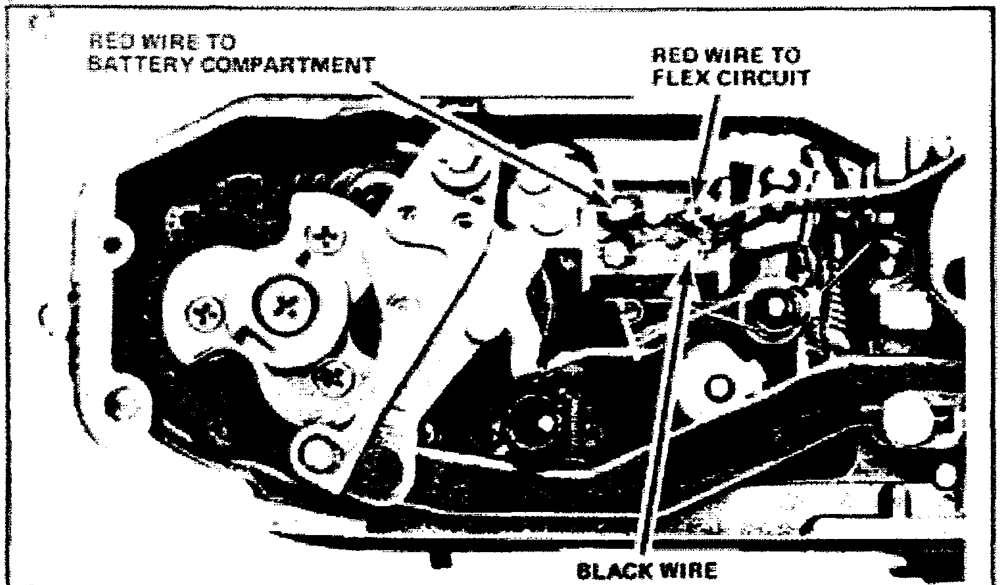


Figure 141

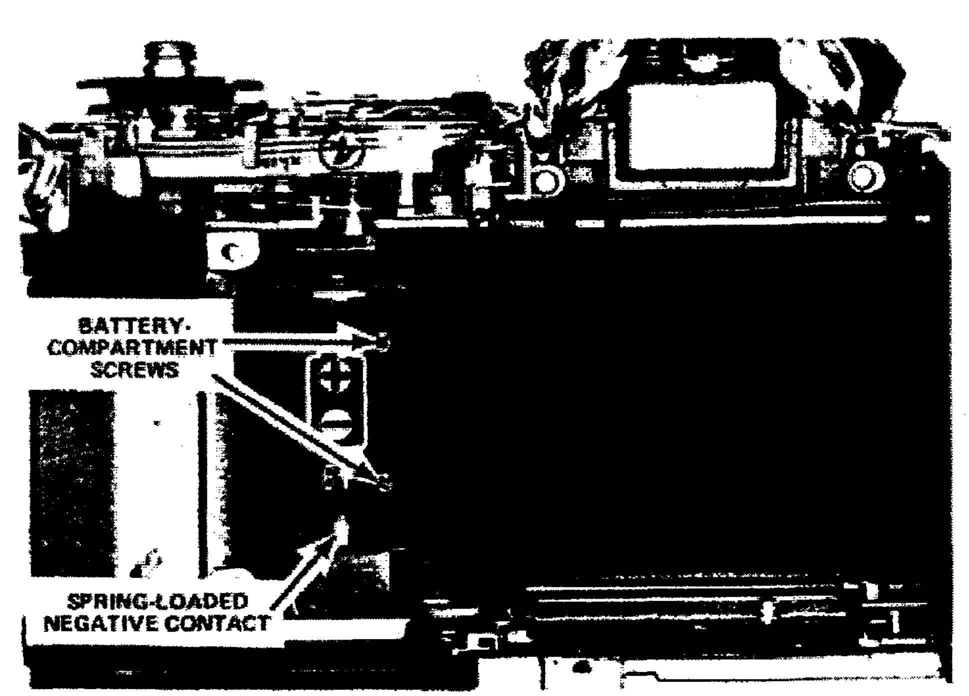


Figure 142

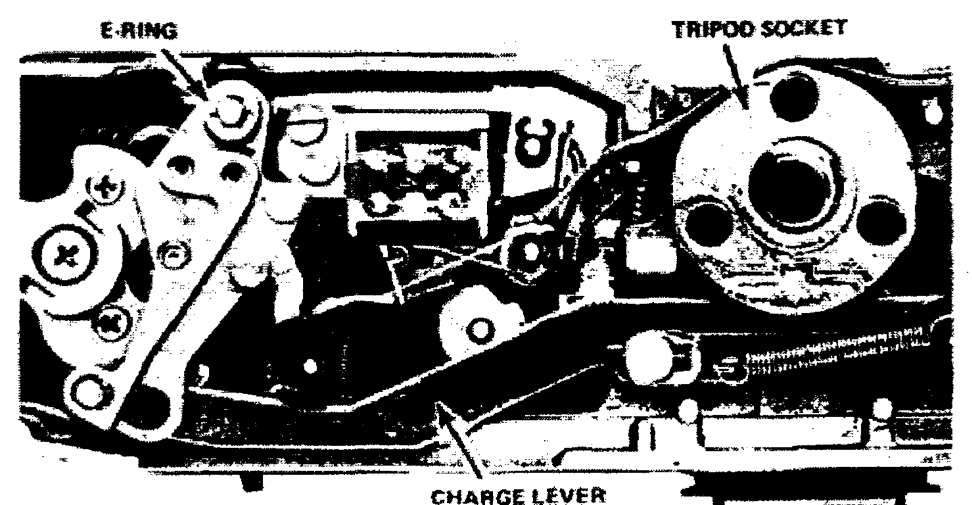


Figure 143

REPLACING THE MIRROR CAGE

We described removing the mirror cage in the shutter-cocked position. But it's easier to replace the mirror cage in the shutter-released position. So release the shutter. And make sure the Mg2 armature is away from the Mg2 combination magnet.

Also, you want the charge-lever post all the way to the left in Fig. 114. Later models of the AE-1 have a spring on the charge lever – the spring pushes the charge lever away from the combination magnet. But if your camera doesn't have a charge-lever spring, you'll find that the charge lever now can float a slight distance. If the charge lever moves too far to the right, Fig. 114, the mirror cage won't couple properly.

So it sometimes helps to tilt the camera to your left as you're seating the mirror cage. That prevents the charge lever from moving toward the combination magnet. Again, if you have a spring on the charge lever, this step isn't necessary.

The mirror cage should also be released with the mirror in the viewing position. Twist the five wires from the auto-control unit together and bring them straight up. And position the three wires at the front of the mirror cage (red, black, and green) so they're pointing straight to the front of the assembly. You're then sure that you'll be able to reach all of the wires with the mirror cage installed.

Now, clean the inside of the eyelens and the back surface of the pentaprism (it's tough to reach these optics with the mirror cage installed). If you replaced the ground plate to test the shutter, make sure you remove it again – remember, you need that play in the flex circuit.

Seat the mirror cage in the camera body. Be careful of those LED leads – make sure they pass under the flex circuit and through their holes.

Before replacing any screws, check the mirror-cage operation. Hold the mirror cage firmly in position. Then, advance the wind lever to cock the shutter. Release the shutter by pushing the Mg2 armature away from the combination magnet. If the shutter cocks and releases properly, you can replace the screws and resolder the wires.

GETTING TO THE SHUTTER

The shutter assembly comes out as a modular unit – even though it uses horizontally traveling cloth curtains. There's only one thing that's tricky in removing the shutter: getting the flex circuit out of the way.

Here, you must be extremely careful. Maybe the camera you're repairing needs curtain replacement. That can be a pretty job — providing you don't damage flex circuit in the process. So we'll describe the shortest, fastest route to removing the shutter — a route that requires a minimum of unsoldering. Just remember that if you put too much stress on the flex circuit, you've turned an easy repair into a tough repair.

Set the speed knob to the disassembly settings ("bulb" and ASA 3200. Then, once again remove the wind lever and the speed knob. You're now ready to do some disassembly at the bottom of the camera. This presents one problem — you don't want the camera to lie on the flex circuit. With the mirror cage removed, the flex circuit has no support. And it's very vulnerable to damage.

So — *don't allow the camera to rest on the flex circuit.* That can cause breaks in the circuit paths. One trick you can use is to *temporarily replace the top cover* whenever you're working on the bottom of the camera. Let the top cover protect the flex circuit.

At the bottom of the camera, unsolder the three wires from the Mg3 electromagnet (two red wires and one black Fig. 141. Be very careful to avoid disconnecting the coil leads — especially if you have the earlier style electromagnet.

The shorter of the two red wires comes from the battery compartment. So you can now remove the battery compartment by taking out its two screws, Fig. 142 — the red wire remains attached to the positive terminal. *Watch for the loose negative battery contact — and for the two compression springs under the negative battery contact.*

A small compression spring sits inside a large compression spring. Together, the two springs provide the tension for the negative battery contact. And they make good contact to ground (the camera body). Both springs will be loose once you pull the battery compartment.

Now, remove the tripod socket from the bottom of the camera, Fig. 143. You must also remove the charge lever. Again, if you have a recent model of the camera, there may be a torsion-type spring on the rewind-end pivot of the charge lever — disconnect and remove this spring.

most AE-1's, the charge lever has a snap ring at the rewind end and an E-ring at the wind-lever end, Fig. 143. (We've seen others with snap rings at both ends.) Remove the E-ring and the snap ring. But as you lift out the charge lever, *watch for a loose collar.*

The collar sits over a post on the underside of the charge lever, Fig. 144. When you cock the shutter, the charge cam comes against the collar — that drives the charge lever from left to right, pushing the Mg2 armature against the combination magnet. The collar comes in different diameters to adjust the throw of the charge lever (how far the charge lever moves during the cocking cycle). Selecting the proper diameter is a factory adjustment. The only time you may have a problem is if you lose the collar. Then, you may not know what diameter to reorder.

Next, remove the screw holding the wind coupler, Fig. 145. Canon normally uses a locking agent on the screw — a drop of acetone helps get the screw loose. But the locking agent may also be on the wind coupler. In that case, you'll find it tough to lift the wind coupler from the wind shaft.

Both the wind coupler and the wind gear, Fig. 145, fit tightly over the wind shaft. Try lifting off the wind coupler and the wind gear (you must remove these parts to pull the wind shaft and the shutter module). However, if the wind coupler and the wind gear seem too stubborn, you can leave them in place for now. They'll come off more easily after you've removed the speed-selector assembly.

For timing reference, note the position of the charge cam (mounted to the wind gear) in Fig. 145. Since the wind shaft has two flat sides, it's possible to replace the wind gear 180° out of time. Then, one of the three charge-cam lobes will be incorrectly positioned.

The charge cam turns 1/3 turn with each cocking cycle. So one of the three lobes pushes the charge lever against the Mg2 armature. At the completion of the cocking cycle, a gap between two lobes faces the charge lever. That allows the charge lever to return to its rest position.

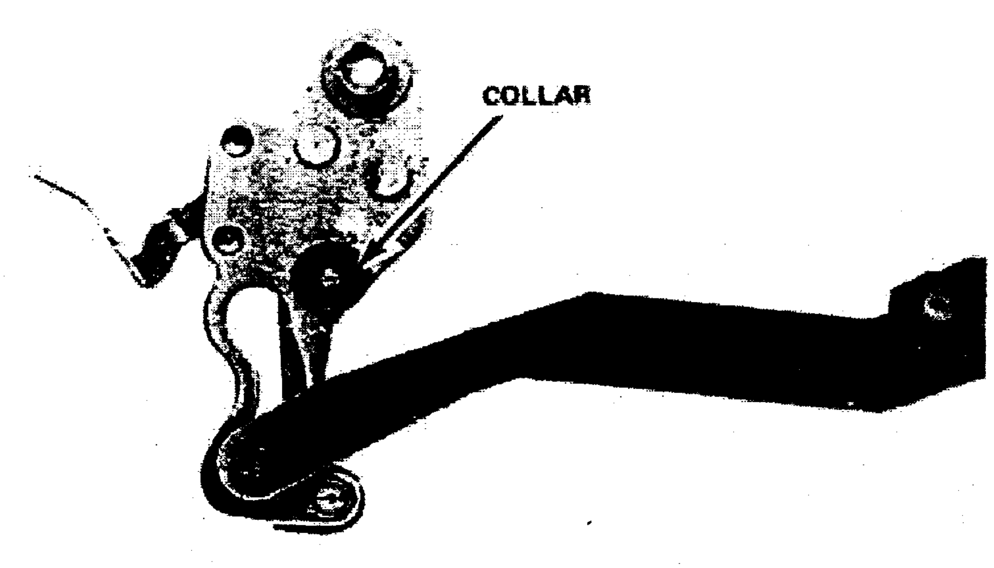


Figure 144

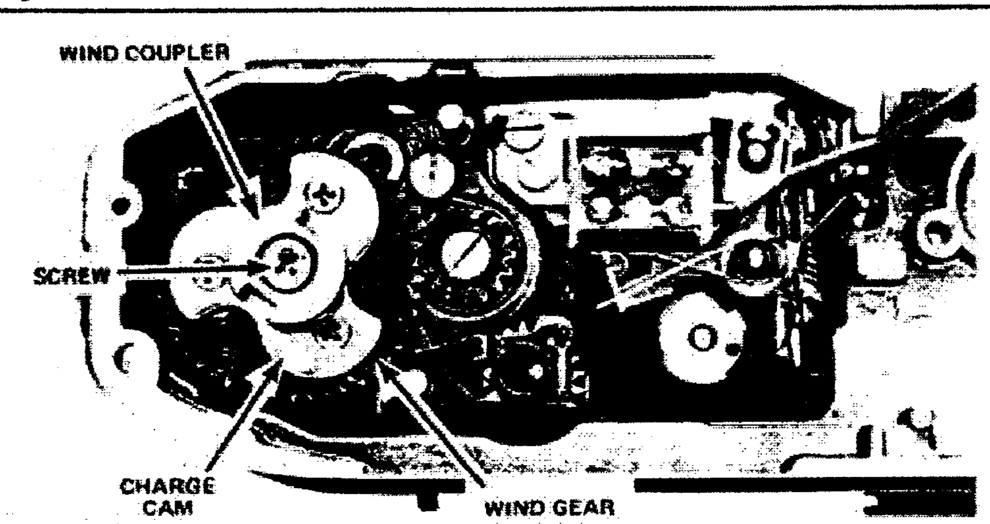


Figure 145

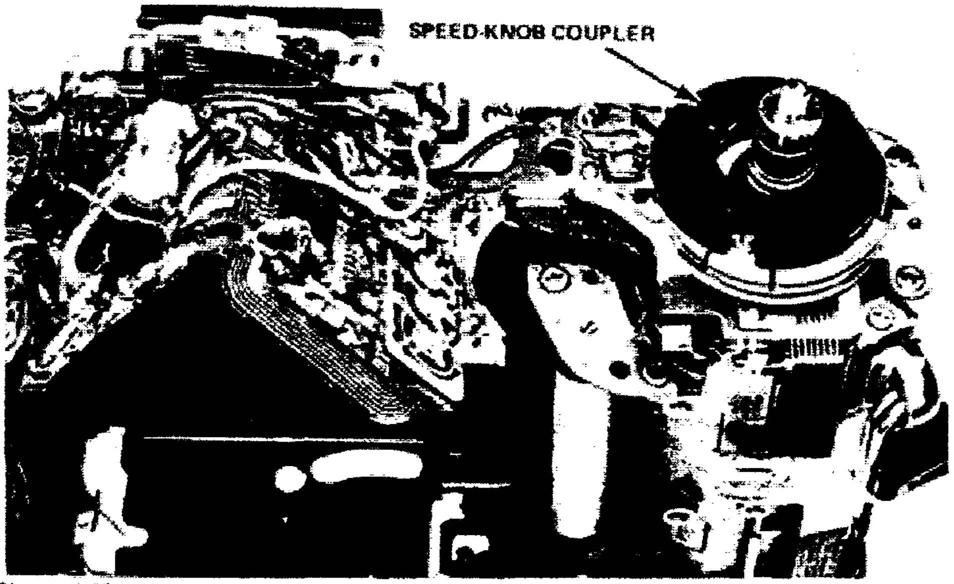


Figure 146

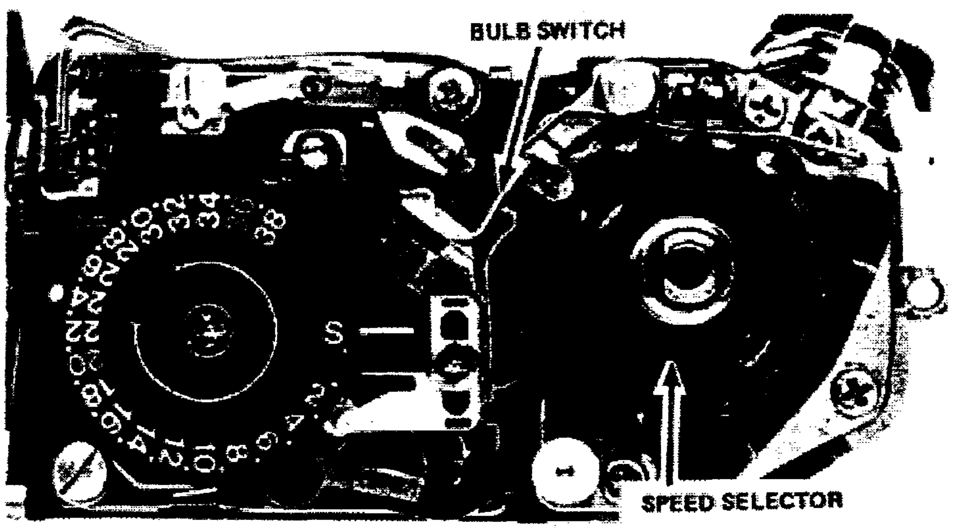


Figure 147

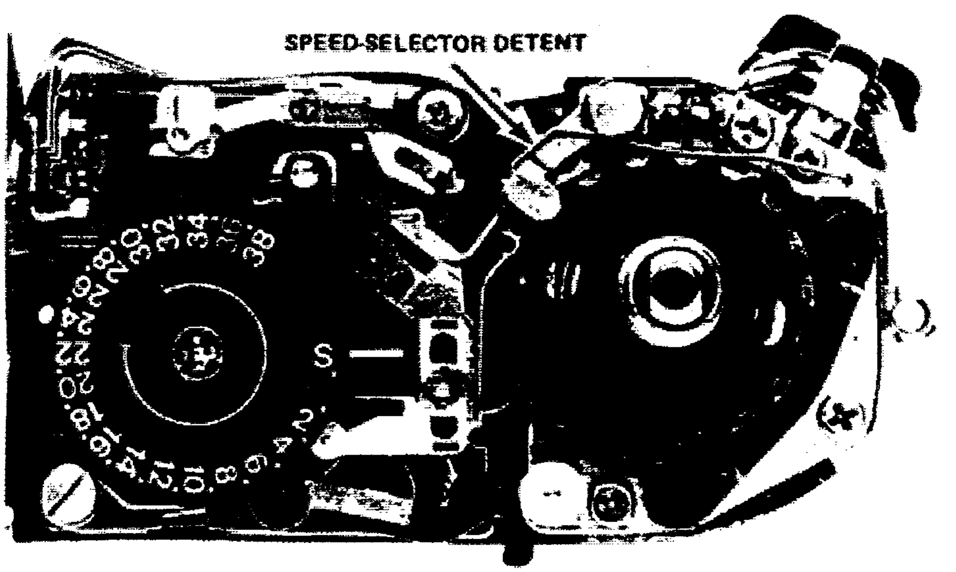


Figure 148

When you replace the wind gear, make sure the shutter's fully cocked or fully released. Then, seat the wind gear – a gap between two of the charge-cam lobes should now be pointing toward the center of the camera. And if the charge cam is 180° out of time? Then, one of the lobes points toward the center of the camera. And the charge lever can't return after the cocking cycle.

That completes the disassembly at the bottom of the camera. You can now remove the top cover (if you used it to protect the flex circuit).

REMOVING THE SPEED-SELECTOR ASSEMBLY

If you now lift off the speed-knob coupler, you'll lose the initial tension on the functional resistor. It's no major job to replace that initial tension (we described the procedure earlier). But you can save time if you don't allow the functional resistor to unwind.

Yet you still have to get the speed-knob coupler out of your way. Fortunately, there's a convenient "trick" you can use. Lift off the speed-knob coupler without disturbing the normal routing of the coupling cord around the eyepiece pulleys. Then, bring the speed-knob coupler to the opposite end of the camera. Let the tungsten wire pass over the tops of the two upper eyepiece pulleys.

Now, seat the speed-knob coupler over the rewind shaft, Fig. 146. You'll have to turn the functional resistor a little to get enough slack in the tungsten wire.

Once you've seated the speed-knob coupler, Fig. 146, replace the rewind knob – that holds the speed-knob coupler in place. The technique we've described has a couple of advantages. For one, you don't lose the initial tension of the functional resistor. Also, you don't have the speed-knob coupler dangling in your way.

You can now reach the speed selector, Fig. 147. Here, the speed selector is at the bulb setting – the setting we used for removing the speed knob. Notice how the edge of the speed selector closes the bulb switch.

At any other speed setting, the cam edge of the speed selector moves away from the bulb switch, Fig. 148. That allows the bulb switch to open. So it's easy to find the bulb position when you replace the speed selector. Just turn the speed selector until the bulb switch closes.

Now, hold aside the speed-selector detent, Fig. 148, and lift off the speed selector. That exposes the RT resistor assembly — the series of fixed resistors used to control the shutter speeds, Fig. 149. The brush on the underside of the speed selector connects the proper series resistance to ground.

For some shutter problems, all you have to do is pull the speed selector. Say the brush isn't making good contact — either to ground or to the RT resistors. You then have an open in the capacitor-charging path. And the shutter will hang open. Frequently, simply cleaning the brush and the circuit-board paths solves the problem. Or, you may have to reform the brush.

There's another possibility if the shutter hangs open — you may have an open along the string of RT resistors. Earlier, we described testing the RT resistors using an ohmmeter. If you locate an open, replace the RT resistor board that mounts to the speed-selector assembly.

In removing the shutter module, though, leave the RT resistor board in place. And remove the complete speed-selector assembly. First, you must disconnect the flex circuit from the RT-resistor pins. Locate the green capacitor-shorting-switch wire, Fig. 149 (it's usually green, although you may find variations). In the camera shown, the capacitor-shorting-switch wire solders to the RT-resistor pin that's closer to the end of the camera body.

But the capacitor-shorting-switch wire may connect to a land at the front of the flex circuit (just below the speed-selector assembly). That's a later version of the flex circuit. If the capacitor-shorting-switch wire connects to the pin as in Fig. 149, unsolder the wire.

Then, use desoldering wick to remove the solder from both RT through pins. As you're removing the solder, the pins tend to move down — they're just soldered to the RT resistor board. You may then have to heat the through pins and push them up. Be especially careful of the pin closer to the end of the camera body. If it moves down or shifts in position, it may touch the body casting. On reassembly, you'll then find the shutter hangs open — the through pin shorts the RT resistors to ground.

Completely disconnect the flex circuit from the RT resistor assembly. Notice that the end of the flex circuit passes under the spring for the speed-selector detent, Fig. 149.

Now, remove the three screws holding the speed-selector assembly, Fig. 149. Before you actually pull the speed-selector assembly, though, you should be aware of some precautions. For one, the upper section of the wind shaft stays with the speed-selector assembly. And the wind-lever return spring remains connected to the upper section of the wind shaft. The wind-lever return spring should stay in place under the speed-selector assembly. Yet one end sometimes comes loose during disassembly. In that event, you'll just have to rewind and hook the wind-lever return spring.

Also, the one-way clutch for the wind lever remains with the lower section of the wind shaft — under the speed-selector assembly. Normally, the one-way clutch remains together. However, it sometimes likes to come apart on its own as you remove the speed-selector assembly.

So be on the lookout for the parts of the roller clutch (three compression springs and three rollers). And remove the speed-selector assembly. Removing the speed-selector assembly does take a little manipulation — the bulb switch gets in the way.

On the underside of the speed-selector assembly, you can see the wind-lever return spring. One end of the wind-lever return spring hooks to the upper section of the wind shaft; the other end hooks to a post on the speed-selector plate.

Also notice that the upper section of the wind shaft has two flat sides. These sides key to the center section of the one-way clutch, Fig. 150. On reassembly, turn the center section of the one-way clutch in a clockwise direction until the slot runs parallel to the ends of the camera. The upper section of the wind shaft will then key properly with the one-way clutch.

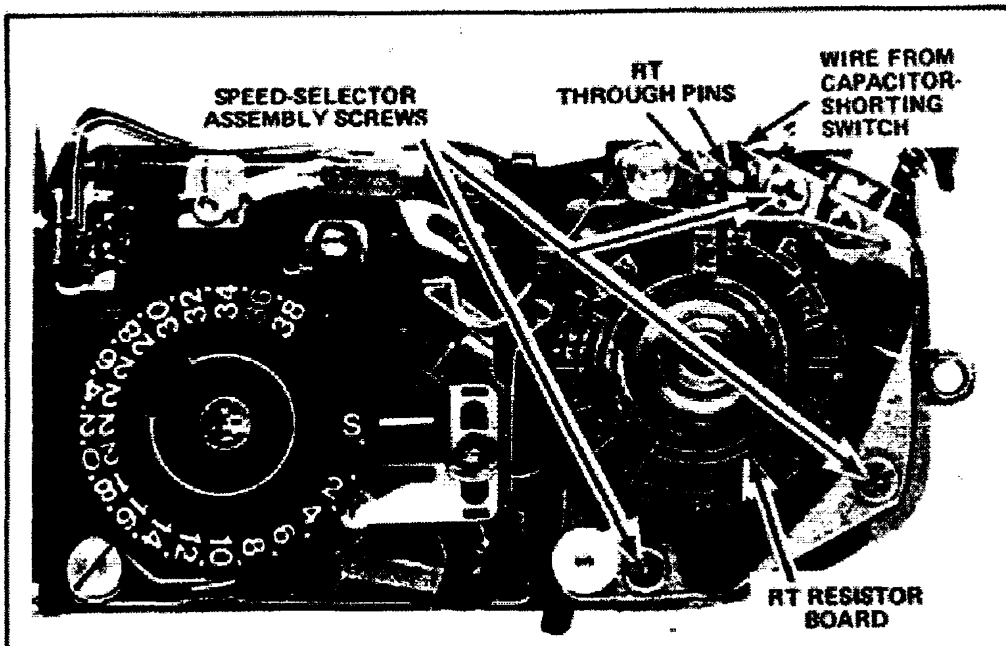


Figure 149

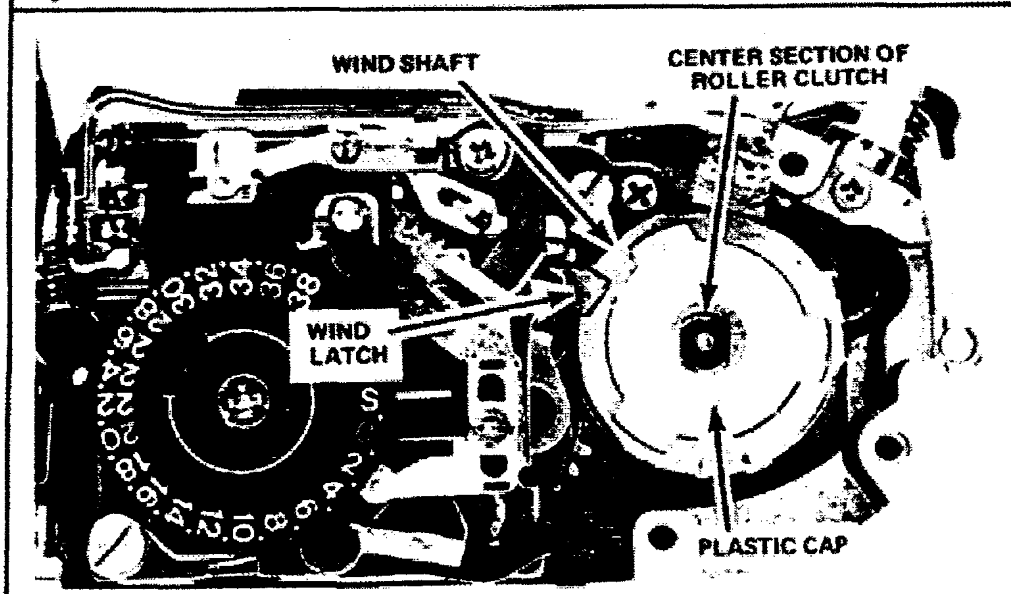


Figure 150

The plastic cover on the top of the wind shaft, Fig. 150, should hold the one-way clutch together. But if the cover comes loose, you'll have to contend with the individual parts, Fig. 151. Referring to Fig. 151, make sure that the center section of the one-way clutch is right side up. And notice the direction that the compression springs push the rollers — toward the narrower ends of the center-section slots.

To remove the wind shaft, make sure the shutter's released. Those three notches at the top of the wind shaft, Fig. 150, serve to latch the cocking mechanism at the end of the wind stroke. After you cock the shutter, the wind latch drops into one of the three notches, Fig. 151. Releasing the shutter moves the latch out of the notch and clear of the wind shaft, Fig. 152. You can then lift out the wind shaft toward the top of the camera.

What if you weren't able to remove the wind coupler and the wind gear earlier? Those parts should drop out as you remove the wind shaft. But the wind coupler and the wind gear may still be too tight — so tight that you can't lift out the wind shaft. In that case, you can use a punch to tap the bottom of the wind shaft. Drive the wind shaft toward the top of the camera, out of the wind coupler and the wind gear (it's best to disassemble the one-way clutch before tapping out the wind shaft — otherwise, you may have loose roller parts flying about the room).

The geared section of the wind shaft engages the curtain-wind pinion, Fig. 152. Looking at the geared section, you can see three large — almost square — teeth. On reassembly, start one of these square teeth into the cutout section of the curtain-wind pinion, Fig. 153. It doesn't matter which of the three teeth you use — the wind shaft turns 1/3 turn on each cocking cycle.

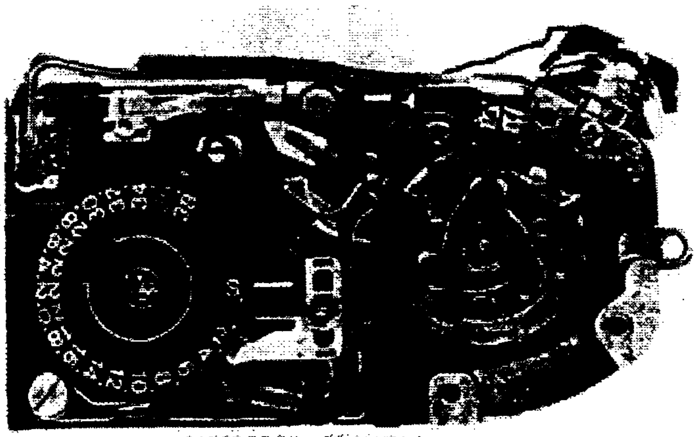
REMOVING THE COUNTER PLATE

You have four more wires to unsolder from the flex circuit to remove the shutter. Unsolder the green wire that comes from the upper hot-shoe contact, Fig. 154 — disconnect the wire from the flex circuit, not from the hot-shoe contact.

Note the flex-circuit connection of the white wire coming from the CCC contact, Fig. 155. If you have an earlier version of the camera, there may be a variation with this particular wire. So make a note as to the proper connecting land. And unsolder the white CCC-contact wire from the flex circuit.

Now, unsolder the two wires that come from the self-timer LED contacts. The red wire (sometimes a white wire) from the LED contact closer to the front of the camera connects to the TR emitter, Fig. 155. And the black wire connects to a circuit-board land, also shown in Fig. 155. Again, it's easier to unsolder these wires from the flex circuit than from the LED contacts.

Earlier, we described removing the nylon clip to reach the MOSFET IC. That's now a necessary disassembly step. Take out the nylon clip, Fig. 156, and lift out the section of flex circuit con-



PARTS OF ROLLER CLUTCH

Figure 151

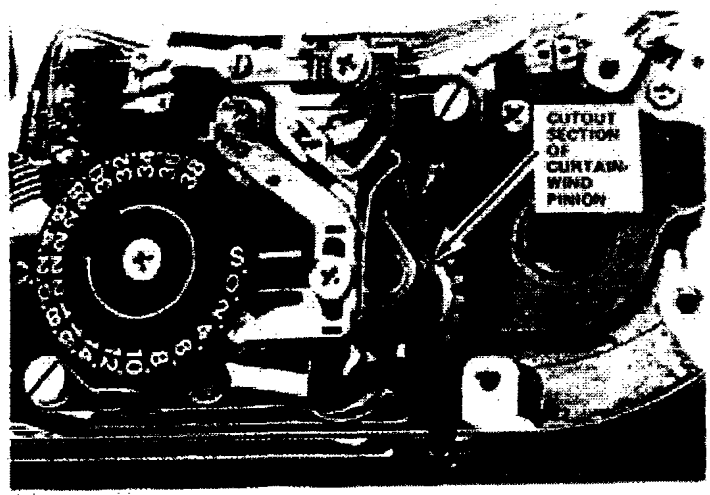
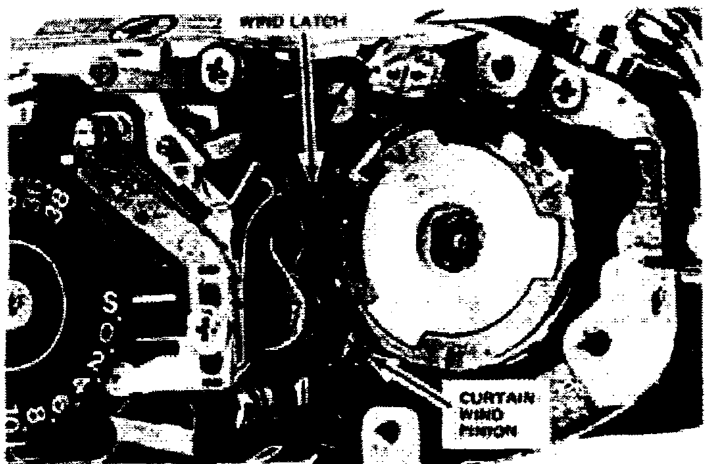


Figure 153



SHUTTER RELEASED

Figure 152

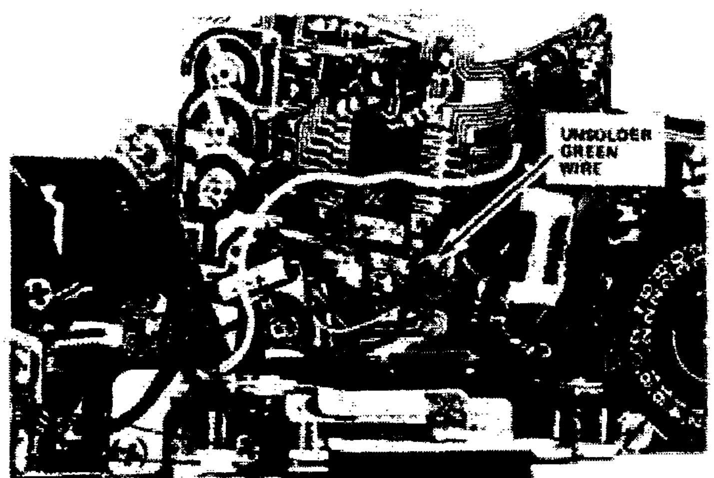


Figure 154

taining PX1, Fig. 157. Remember, the slot in the flex circuit (below PX1) must fit over the locating pin on the eyepiece assembly.

You'll next have to lift aside the counter plate, Fig. 158. But it's not necessary to unsolder any connections (unless you're replacing the flex circuit). Take out the screw holding the ground contact, Fig. 158. Lift out both the ground contact and the blade of SW5. Note again that the forked end of SW5 straddles a pin on the switch-control lever.

Also, take out the large shoulder screw shown in Fig. 158. The spring for the counter-return lever remains hooked to the counter plate. But if the spring looks as though it wants to come off, remove the spring after taking out the shoulder screw (that's better than having the spring fly off when you're not looking). The short end of the spring hooks to the side of the counter-return lever; and the long end of the spring hooks to the side of the counter plate.

You don't have to remove the counter-dial index plate. But we've removed the plate in Fig. 159, to show how the counter driver works. For reassembly reference, notice how the flat spring pushes the nylon counter driver toward the counter dial. With the camera back closed, a notch in the counter driver engages the teeth of the counter dial — it's this notch that advances the counter dial during the wind cycle.

Also notice in Fig. 159 how the counter-return lever passes through a slot in the body casting. It takes a little manipulation to get both the counter driver and the counter-return lever properly seated as you replace the counter plate.

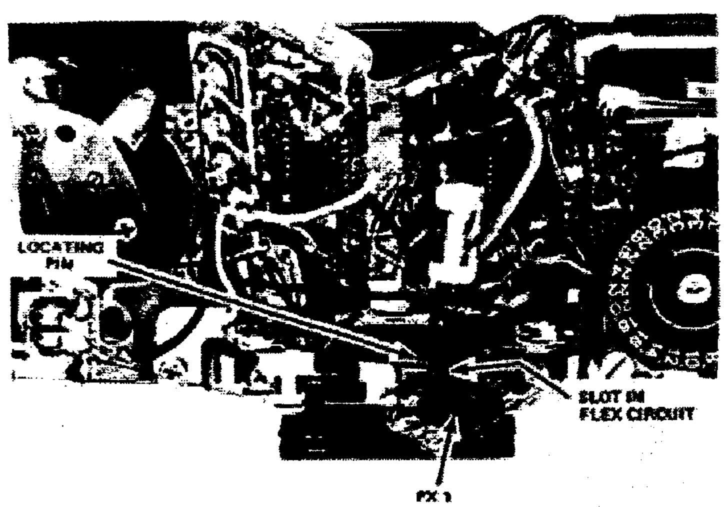


Figure 157

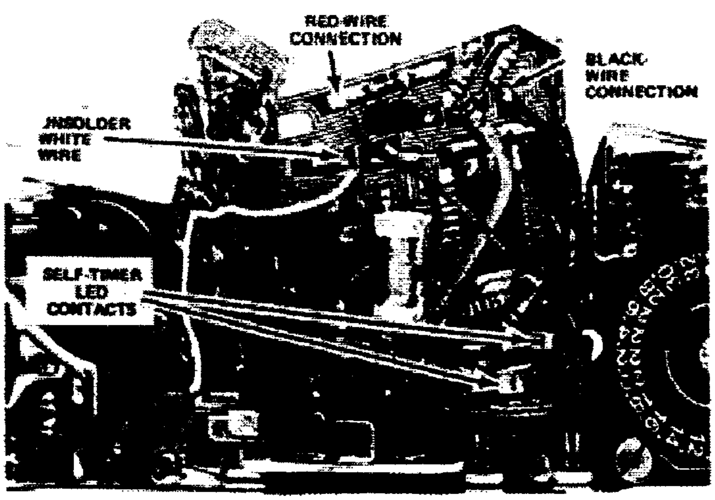


Figure 155

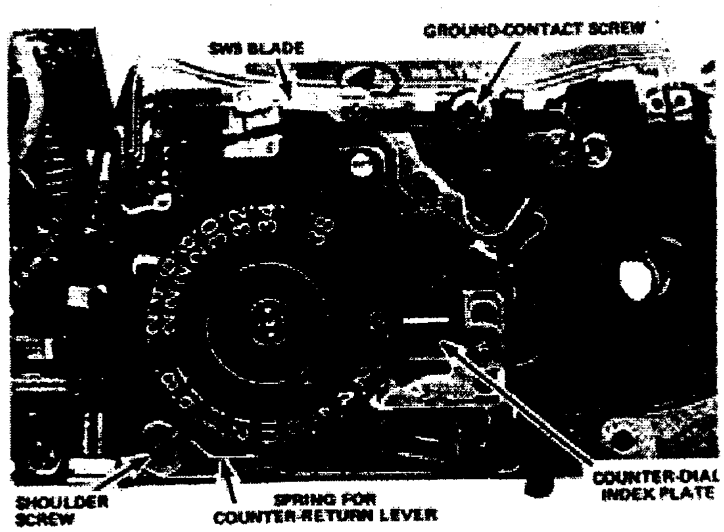


Figure 158

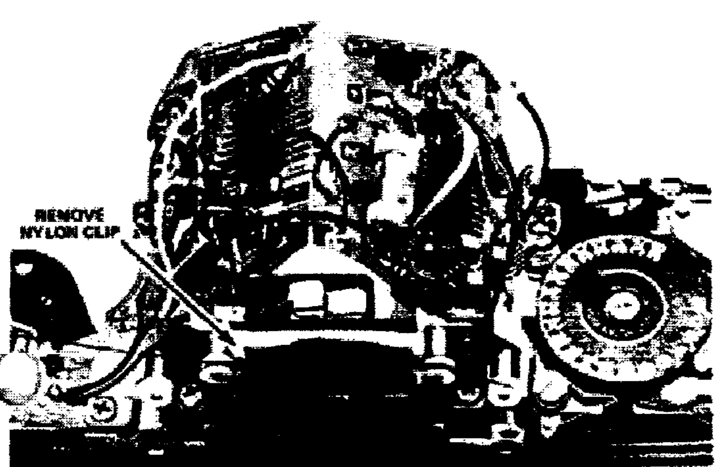


Figure 156

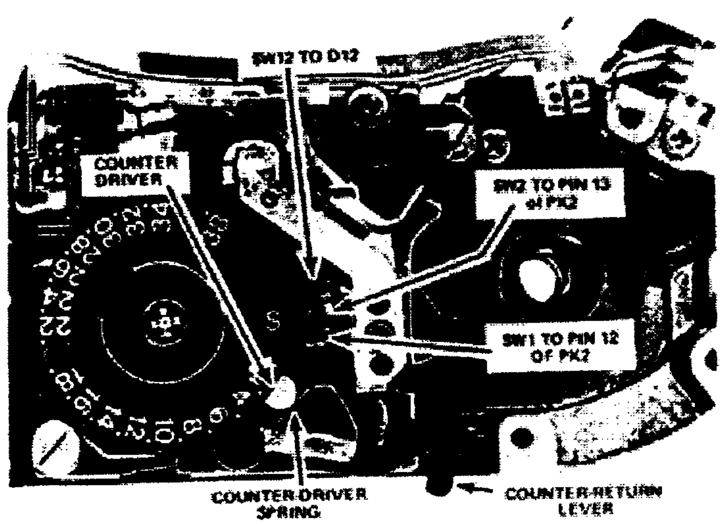


Figure 159

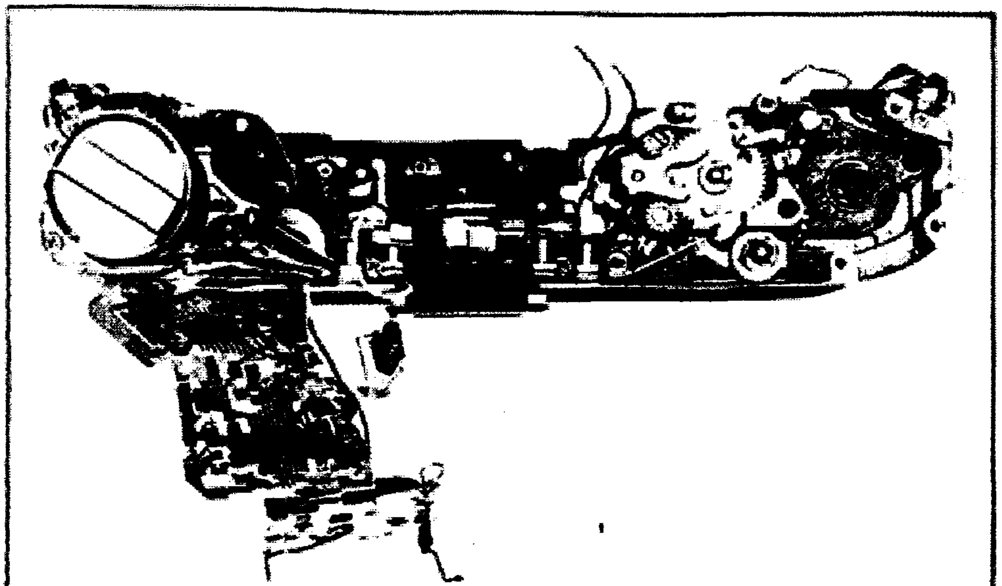


Figure 160

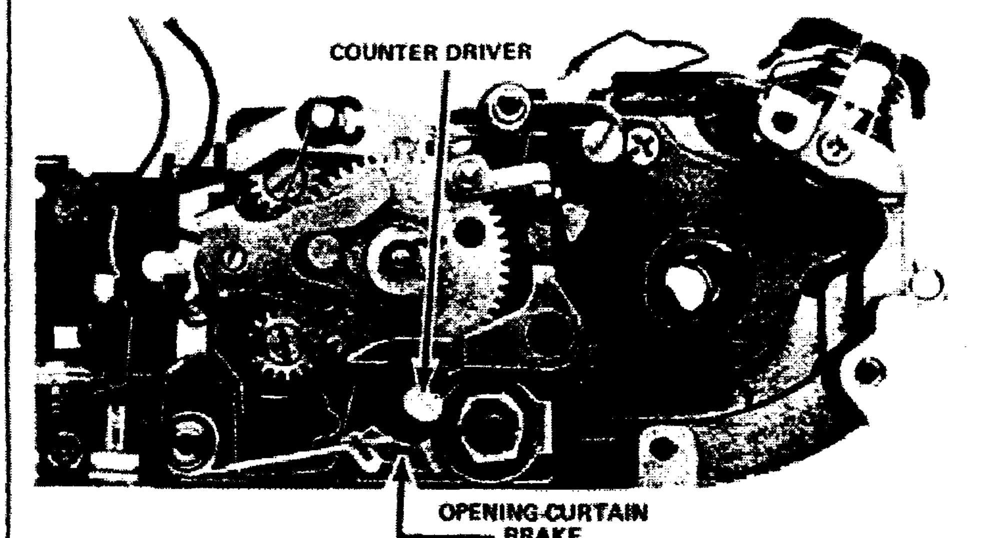


Figure 161

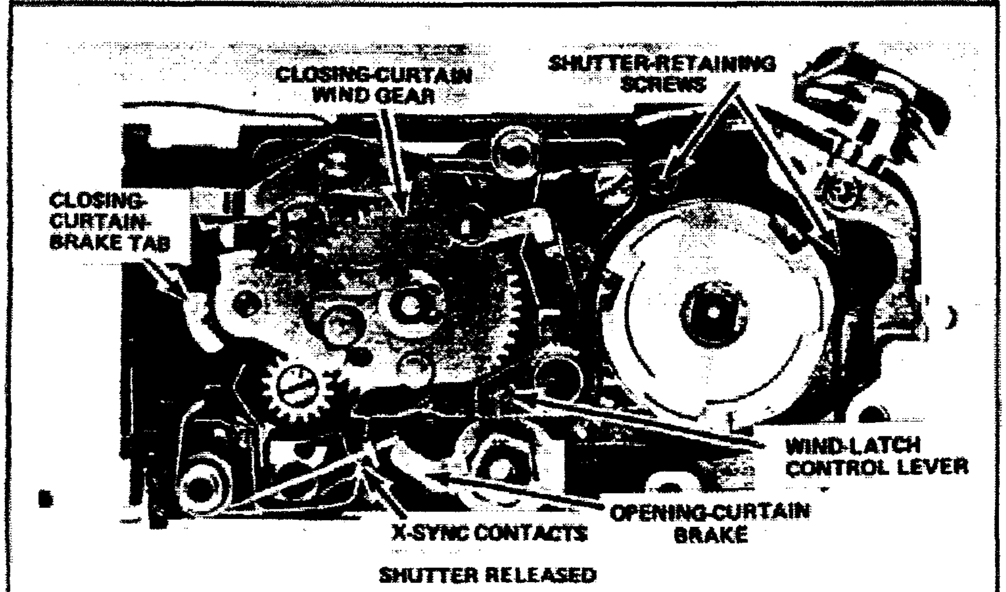


Figure 162

Removing the counter-dial index plate in Fig. 159 gives us a chance to point out the release-switch and bulb-switch contacts. You'd have to unsolder these contacts to replace a flex circuit.

Once again check to make sure you've removed the ground plate. Then, lift out the counter-plate assembly. Move the counter plate to the rewind side of the camera as shown in Fig. 160 – be very careful to avoid damage to the flex circuit.

The nylon counter driver is now loose. Push the opening-curtain brake lever, Fig. 161, toward the back of the camera. Then, lift out the counter driver. A pinion on the bottom of the counter driver engages a pinion on top of the sprocket. That's why the counter dial turns in the reverse direction as you rewind the film – it always turns with the sprocket. After you remove the counter driver, push back the opening-curtain brake lever.

SHUTTER-COCKING OPERATION

In Fig. 162, we've replaced the wind shaft to cock the shutter. But this can be a little dangerous – remember, that one-way clutch can come loose. You really should disassemble the one-way clutch before using the wind shaft as a cocking tool.

Fig. 162 shows the shutter in the released position. Cock the shutter by turning the wind shaft from the bottom of the camera. In the shutter-cocked position, the wind latch drops into a wind-shaft notch, Fig. 163. So you can't advance the wind lever a second time.

The closing-curtain wind gear, Fig. 162, controls the wind latch. In the shutter-released position, a post on top of the closing-curtain wind gear comes against the wind-latch control lever. And the wind-latch control lever holds the wind latch away from the wind shaft.

But note what happens as the closing-curtain wind gear turns to the cocked position, Fig. 163. The post on the closing-curtain wind gear then moves away from the wind-latch control lever. Consequently, the spring-loaded wind latch swings toward the wind shaft. As soon as a notch in the wind shaft reaches the wind latch, the wind latch drops into the latching position, Fig. 163.

The SW5-control lever is part of the wind latch, Fig. 163. Notice the pin pointed out in Fig. 163 – that's the pin straddled by the SW5 blade. So, by controlling the wind latch, the closing-curtain wind gear also controls SW5.

OPERATION OF THE CURTAIN BRAKES AND SYNC CONTACTS

Each curtain has its own brake. And both brakes play a role in the operation he X-sync contacts.

We've already pointed out the opening-curtain brake, Fig. 162. The opening-curtain brake lever acts against a post atop the opening-curtain wind gear (the gear under the closing-curtain wind gear). When the opening curtain crosses the aperture, the post strikes the brake lever. That drives the opening-curtain-brake lever toward the back of the camera.

But the opening-curtain-brake lever has a second function — it closes the X-sync contacts, Fig. 162. Notice that the brake holds the contacts closed in the shutter-released position. The contacts open when you cock the shutter.

So you know there must be a safety switch in the camera. Otherwise, you couldn't connect the flash with the shutter released. The closing-curtain brake doubles as the safety switch.

Even though the X-sync contacts are closed in Fig. 162, there's no contact to ground. So you don't have a complete circuit, Fig. 164. But one long tab on the contact assembly sits close to the tab on the closing-curtain brake — the same tab that returns the mirror, Fig.

When you cock the shutter, the X-sync contacts open. And the closing-curtain wind gear drives the closing-curtain brake toward the back of the camera. The tab on the closing-curtain brake then touches the tab on the contact assembly, Fig. 163. Now, as shown in the schematic, Fig. 165, you have the ground connection. Yet, since the opening-curtain brake has allowed the X-sync contacts to open, there's still not a complete circuit.

Releasing the opening curtain once again closes the X-sync contacts. But this time, the closing curtain is latched in the tensioned position. So the closing-curtain brake maintains the ground connection. As you can see the schematic, Fig. 166, there's a complete circuit to fire the flash.

As the closing curtain crosses the aperture, another stud on the closing-curtain wind gear strikes the closing-curtain brake. That cushions the closing curtain to prevent bounce. And it simultaneously disconnects the contact assembly from ground.

Both curtain brakes have the same type of adjustment. A nut pushes a compression-type brake spring against the brake lever. You can see the brake-adjusting nut for the opening-curtain brake in Fig. 163; the brake-adjusting nut for the closing-curtain brake sits just beneath the closing-curtain brake lever, Fig. 163.

Turning the brake-adjusting nut in a clockwise direction increases the braking action. You can reach the opening-curtain brake adjustment from the back of the camera — it's not necessary to remove the front-plate/mirror-cage assembly. But you do have to pull the front-plate/mirror-cage assembly to reach the closing-curtain brake adjustment.

REMOVING THE SHUTTER

It only takes a few more steps to remove the complete shutter module. So even for routine cleaning, it's probably best to pull the shutter. You can then clean and lubricate the shutter without the danger of damaging the flex circuit.

First, unsolder the red X-sync wire from the sync contact, Fig. 163. The wire runs to the X-contact connector at the other end of the camera. Note the route of the sync wire — it passes under

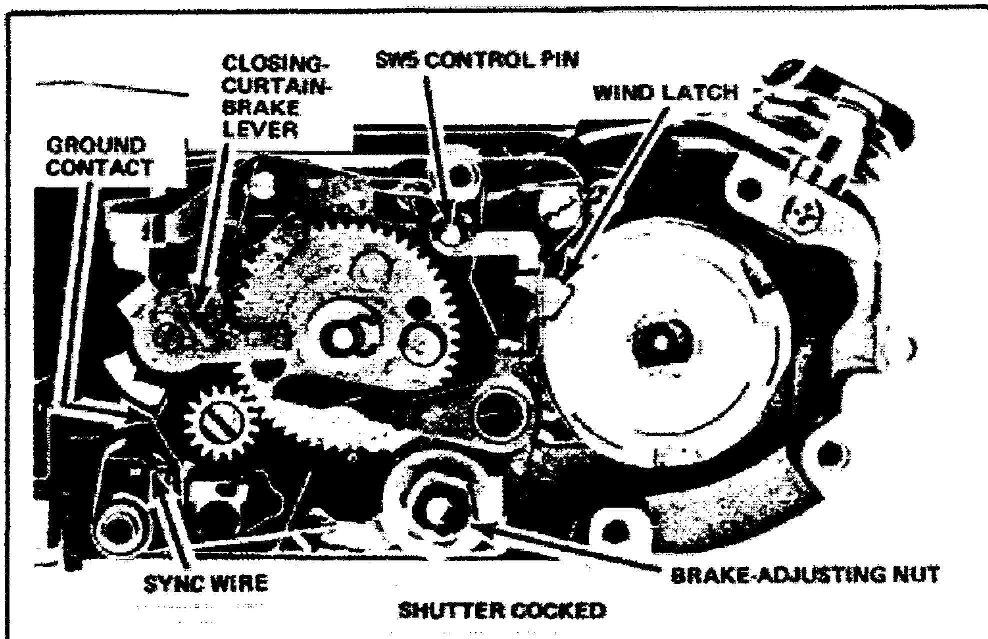


Figure 163

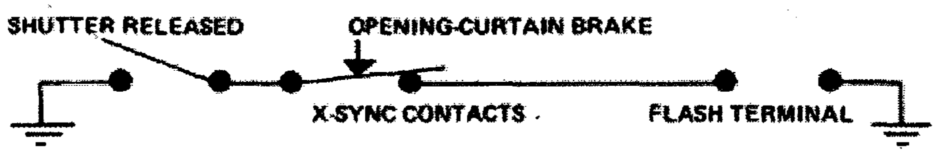


Figure 164

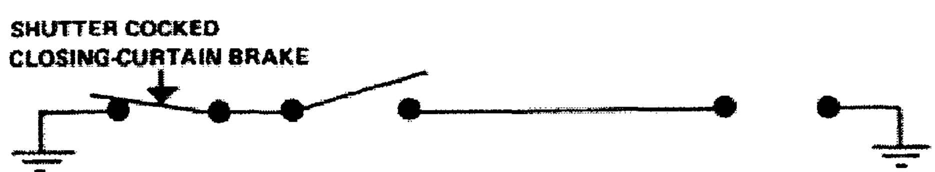


Figure 165

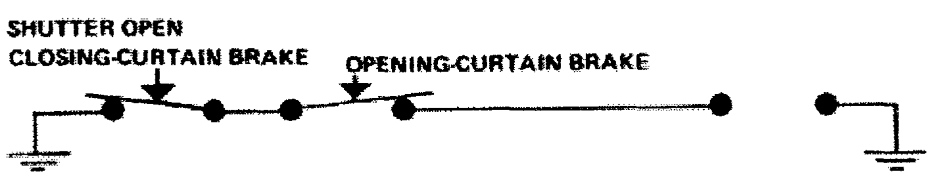


Figure 166

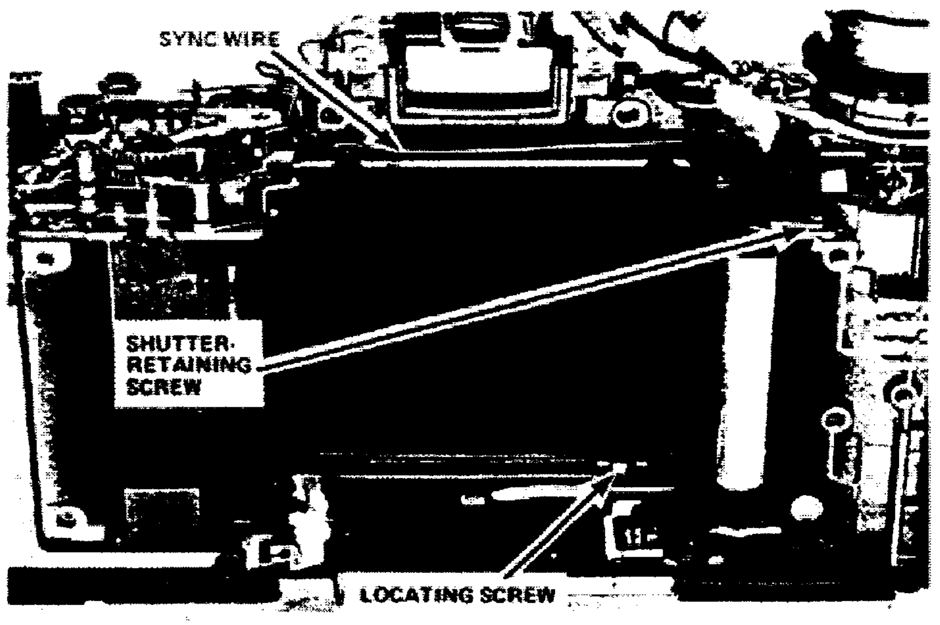


Figure 167

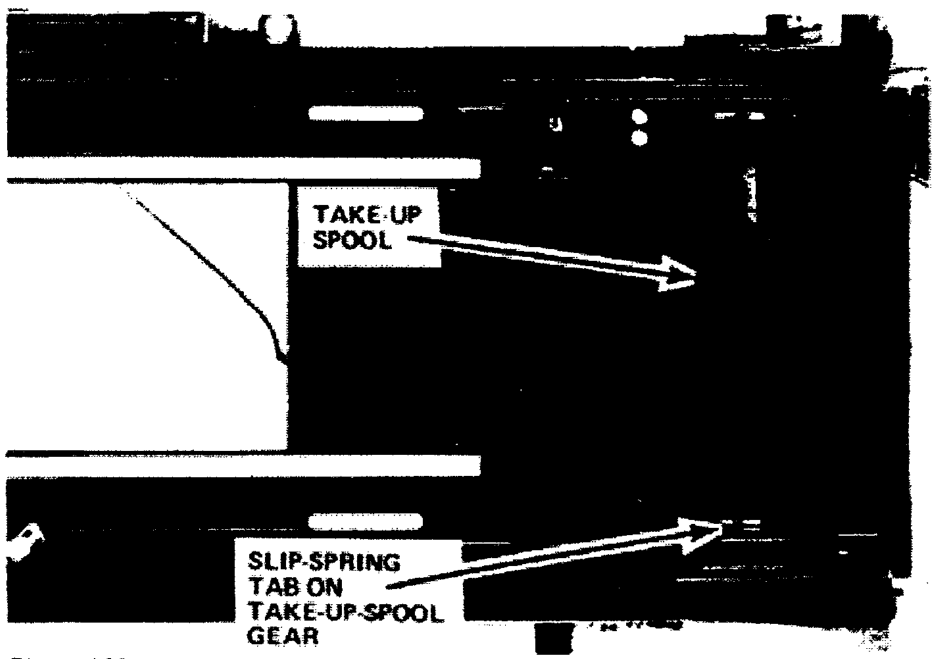


Figure 168

two L-shaped clamps on top of the shutter module, Fig. 167. Be careful to get the wire routed properly on reassembly. Otherwise, the mirror cage might clamp the wire and cause a short.

But right now it's pretty tough to disconnect the sync wire from the clamps. You'll find it easier to disconnect the sync wire as you're removing the shutter module. So take out the two screws shown in Fig. 162 (note that one is countersunk). Also, remove the shutter-module screw at the rewind end of the camera — the one partially obscured by the X-contact connector, Fig. 167.

Finally, remove the large locating screw at the bottom of the shutter, Fig. 167. And lift out the shutter module.

The wind-shaft bushing staked to the shutter module also serves as the upper pivot for the take-up spool. So the take-up spool is now loose. Lift out the take-up spool from the back of the camera, Fig. 168 — watch for the large washer under the take-up spool. You can also lift out the take-up spool gear, Fig. 168.

As yet, we haven't seen an AE-1 with a broken take-up spool. That's fortunate — you can now see how far you'd have to go in disassembly just to replace a take-up spool.

Removing the shutter module also allows you to reach the upper sprocket bearing. If you have to replace a sprocket, lift out the nylon pinion (the pinion that engages the counter driver). Then, unscrew the upper sprocket bearing.

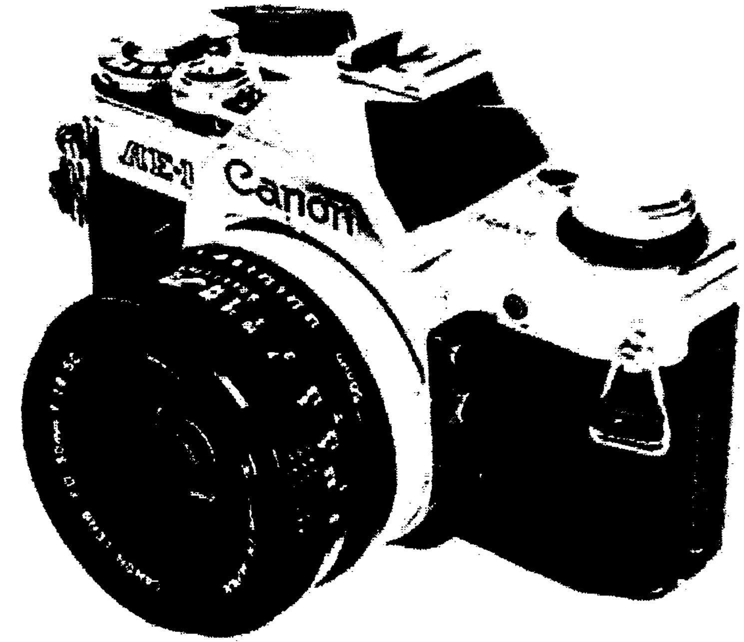
PRECAUTIONS IN REPLACING THE SHUTTER MODULE

Notice that the slip spring for the take-up spool seats around a shoulder on the take-up-spool gear. A tab on the slip spring, Fig. 168, fits into a slot on the bottom of the take-up spool.

As you seat the take-up spool, make sure its slot seats over the slip-spring tab. And test the smoothness of the take-up spool as soon as you seat the shutter module. It would be a shame to completely reassemble the camera and then find that the take-up spool is binding!

Also, as you seat the shutter module, route the sync wire through the clamps. Once you've installed the shutter, it's very tough to route the sync wire — get the wire through the clamps before you've fully seated the shutter module.

Canon AE-1



Part 5 — Conclusion

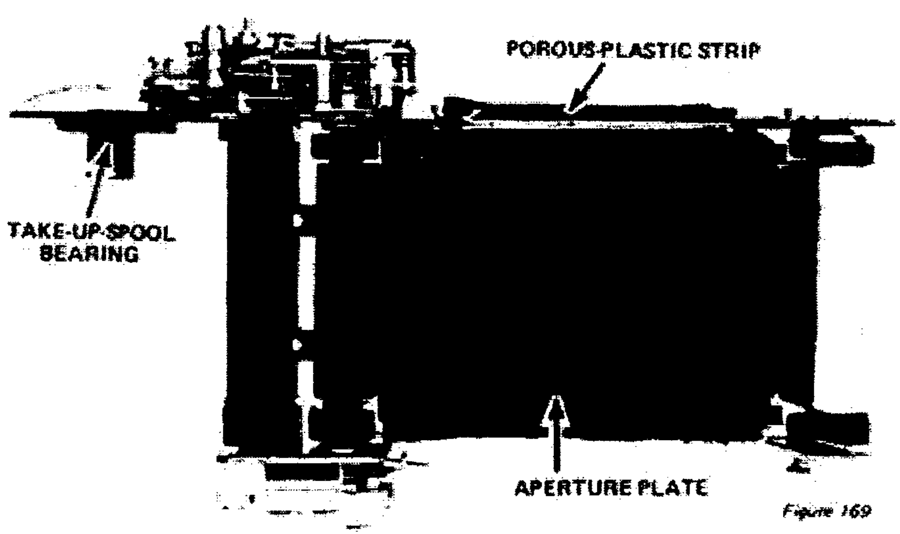


Figure 169

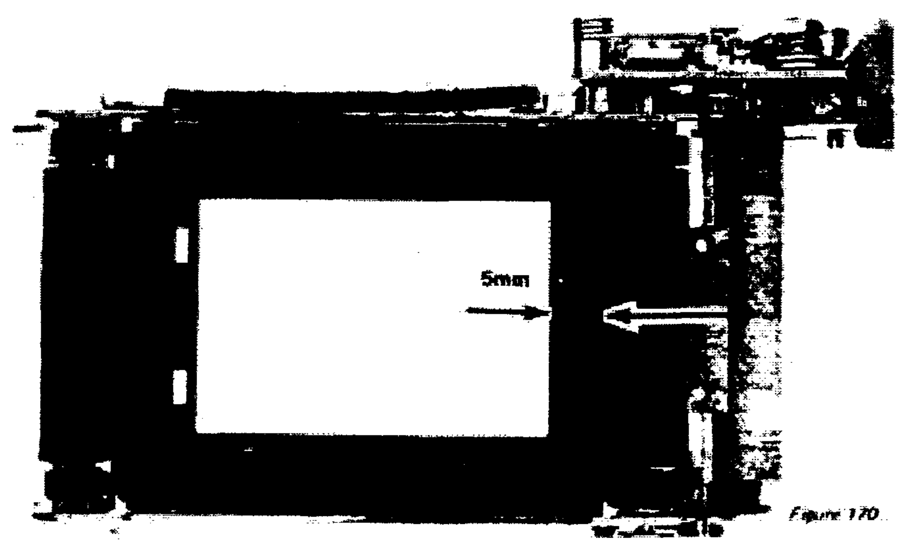


Figure 170

REPLACING AND TIMING THE SHUTTER CURTAINS

Fig. 169 shows as far as you'll probably ever have to disassemble the shutter module — even to replace curtains. It's easier to align new curtains, though, if you also remove the aperture plate. Two screws at the top of the shutter module hold the aperture plate (the screws may be covered by the strip of porous plastic cemented to the shutter module).

Before removing the aperture plate, however, you can check the curtain timing. Try turning the closing-curtain winding roller from the back of the shutter module to wind on the closing curtain. Then, hold the Mg3 armature engaged with the closing-curtain cam — that holds the closing curtain in the wound position.

Now, check the position of the closing-curtain bar. Looking at the back of the shutter module, Fig. 170, the lead edge of the closing-curtain bar should be 5mm from the opening edge of the aperture plate.

But you don't have to measure the distance. Canon has already placed convenient timing marks on the aperture plate — two dimples which show you where to align the closing-curtain bar.

To see the timing of the opening curtain, check the overlap during the cocking cycle. Turn the opening-curtain winding roller from the front of the shutter module — that winds on the curtains. And, from the back of the shutter module, check the overlap between the two curtain bars, Fig. 171.

SUMMARY ON TROUBLESHOOTING

What are the "common" repairs in the AE-1? That normally depends on how long the camera's been in service. Canon technicians doing warranty repairs have found mostly electronic problems involving component replacement. Here's where a solid knowledge of the electronic operation becomes essential – step-by-step troubleshooting guides normally won't get you to the problem.

But most of the cameras that have passed the warranty period seem to come under a different category. Their problems are frequently mechanical in nature. (One exception – the diaphragm-sensing resistor VRav.) Initially, a problem may sound like an electronic malfunction. So your first impulse may be to troubleshoot the electronic circuitry. Yet a simple mechanical malfunction often causes what *seems* to be an electronic failure.

For example, suppose the camera gets bumped on the wind-lever end. You may then find that the shutter hangs open – it won't close until you disconnect the battery.

That sounds like an electronic malfunction. But more likely, the tungsten wire has simply slipped under the speed selector. Since the tungsten wire is a conductor, it shorts the shutter-speed resistors to ground – the same effect as a short across the timing capacitor.

So just remove the top cover. And untangle the tungsten wire from the speed-selector brushes. You may also find the tungsten wire gets tangled on some other part. The customer then complains about an inoperative exposure meter. Yet there's only one problem – the functional resistor isn't moving. Chances are simply removing the top cover will allow everything to snap back into place.

During disassembly, we mentioned a couple of other "quick" repairs – switches SW5 and SW7. Whenever you have an electronic malfunction, check the switches that could cause the problem. It's far more likely to have a bad switch than it is to have a bad component.

Reforming the self-timer switch SW7 seems to be a rather common repair. If the switch remains in contact with the ground tab, you'll always get the self-timer delay. The customer may not realize what's happening – since he hasn't moved the self-timer lever, the LED remains hidden.

And if switch SW5 isn't making good contact? Then, the shutter may not release. Or, the shutter may close as soon as you let up the release button – that becomes noticeable on slow speeds. Also, the shutter won't time out after the self-timer delay.

You'll be making other "easy" repairs by simply pulling the bottom plate. Sometimes you'll encounter the camera that won't stay cocked – it releases as soon as you complete the cocking stroke.

A defective permanent magnet Mg2? That's what it sounds like. But more likely, there's a simple mechanical problem with the Mg2 armature. The keeper at the end of the armature may be dirty. Since the keeper can't pivot freely, it fails to make positive engagement with the permanent magnet. Or, the E-ring which holds the keeper to the armature may have come loose.

So, even though the AE-1 circuit may seem overwhelming, the common repairs are simple. You can make the AE-1 profitable to repair by looking for the simple things first. When you do encounter a genuine electronic malfunction, the schematic becomes your most valuable troubleshooting tool. We tried to describe most of the troubleshooting tests during disassembly. Let's now go through the more common troubleshooting steps to sum things up.

PROBLEMS IN THE EXPOSURE-METER SYSTEM

The most sophisticated part of the AE-1 circuitry involves the exposure-control system. And for any one malfunction, you could come up with a long list of possible causes. That's why troubleshooting charts aren't normally effective. You just about have to troubleshoot the camera using the schematic.

But you can limit your search by deciding the extent of the malfunction. Does the problem affect both the automatically controlled diaphragm opening and the focusing-screen readout? Or does it affect just the diaphragm opening – or just the meter reading?

If the problem affects only the diaphragm-closing system – and not the galvanometer readout – you know you're getting the proper output from amplifier AR1. Why? AR1 must be supplying the proper output before the galvanometer can read properly. The output of AR1 drives both the meter and the diaphragm-closing system.

Now, you must look for something that would only affect the diaphragm-closing system. Start by noting just what the diaphragm is doing. Does it always remain fully open? Does it always stop down fully? Or does it provide erratic openings?

Several things could cause these problems. But let's start with the most likely ones. Any of these problems could be caused by a defective diaphragm-sensing resistor VRav.

So measure the resistance between the orange wire and ground as you move down the diaphragm-setting lever. Here's where you should get the smoothly decreasing resistance as the diaphragm-setting lever moves down — from around 1.3K to less than 1K. An open would cause the diaphragm to stop down fully every time (the wiper probably isn't making good contact with the resistance band). Erratic resistance readings, normally caused by breaks along the resistance band, result in erratic diaphragm settings. And a short would cause the diaphragm to remain fully open every time.

A short across the VRav resistance band isn't too likely. If the diaphragm always remains fully open, you might first suspect the mechanical system on the mirror cage or the diaphragm-control electromagnet Mg1. Earlier, we described how you can check the mechanical system and Mg1 without pulling the front-plate/mirror-cage assembly — just short the negative lead of the electromagnet to ground.

Again, the integrated circuits should be your last suspects. Normally, if an IC's going to go bad, it'll do so during its first few hours of use. But even so, IC's can fail.

Looking at the schematic, which IC could cause a failure of the diaphragm-closing system? Actually, either PX2 or PX3 could be at fault. With PX2, there could be a failure in the memory system. And with PX3, there could be a failure in the comparator system.

You can check the memory system at pin 19 of PX2 — the output of amplifier AR4. Here's where you get the AV signal that goes to the diaphragm-sensing resistor VRav.

Measure the voltage between ground and pin 19 of PX2. With the shutter in the released position, you should measure around 0.29 volt. Cocking the shutter should cause that reading to increase to around 0.39 volt.

Then, push the release switches to release the shutter. You should now see the voltage increase — that's the AV voltage pulse memorized in the digital-to-analog converter. If the memory system works properly, you'll get a larger AV pulse as you increase the light level, set a slower shutter speed, or set a faster film speed.

Although you can check the PX2 operation with a voltmeter, an oscilloscope makes the output of AR4 even easier to see. Don't buy a scope just for the AE-1 — you'll rarely use it. But if you already have a scope, try setting it to measure DC voltage. Then, touch the vertical-input probe to pin 19 of PX2. You should see the trace move up as you cock the shutter. When you release the shutter, you should see the trace move up further. The higher the light level, the slower the shutter speed, or the faster the film speed, the higher the trace should move.

Once you know you're getting the output from amplifier AR4, you can eliminate the possibility of a defective PX2. That leaves PX3 — for some reason, comparator CP1 isn't comparing.

The output of comparator CP1 connects to pin 5 of PX3. And pin 5 connects to the negative side of the diaphragm-control electromagnet Mg1. So measure the voltage to pin 5 — you should measure the full battery voltage without closing the release-button switches. If you don't, you evidently have a break between pin 5 and Mg1. And you'll have to use a jumper wire.

If you suspect either PX2 or PX3, check the voltages at the inputs before replacing an IC. In this case, though, we've assumed that the galvanometer works properly — it indicates the right f/stop. So chances are the input voltages to both IC's are correct. The problem could be a break between pin 19 and PX2 and the diaphragm-sensing resistor (pin 19 should connect to the blue wire coming from the mirror cage), a break between pin 5 of PX3 and the diaphragm-control electromagnet, or a failure in either IC.

FAILURE OF THE READOUT ONLY

Now, let's consider that the diaphragm-closing system works fine. But the galvanometer doesn't work. The needle always remains at the top of the diaphragm scale. Or it always pegs to the bottom.

You then know you're getting the proper output from AR1 — if you weren't, the diaphragm-closing system wouldn't be working. So look for something that would affect only the meter readout. The most likely things — maximum-aperture resistor VRavo or the galvanometer itself.

If the needle doesn't move at all, check the continuity of the galvanometer coil — just measure the resistance between the red galvanometer wire and ground. The resistance of the coil should measure around 343 ohms.

You can also check VRavo, the maximum-aperture resistor on the mirror cage, using an ohmmeter. But you don't have to remove the front-plate/mirror-cage assembly. Just unsolder the red wire from VRavo that connects to VR3 on the resistor board. Measure the resistance between the red wire and ground as you push in the maximum-aperture correction pin. The resistance should smoothly increase from around 9.23K to 17.8K as the maximum-aperture correction pin moves toward the camera body.

And if you don't get this changing resistance? It could be that the brush has come off the wiper lever. You'll then have to pull the front-plate/mirror-cage assembly.

If the VRavo resistor checks properly, you can make the same test between the white wire and ground. This time, the resistance should increase from around 15.1K to 23.8K as you push in the maximum-aperture correction pin. If it does, you know you have continuity to the VRavo resistor on the mirror cage.

What else could cause the problem? Perhaps you don't have continuity between the red-wire connection and pin 4 of PX3 — or between the white-wire connection and pin 9 of PX3. An open or shorted variable resistor VR3 would be another logical (though unlikely) suspect.

Before suspecting IC PX3, check the continuity between pin 7 of PX3 and the meter resistor RM. And check the continuity between the meter resistor RM and the galvanometer. Finally, check the meter resistor itself (it should be around 1.85K) and diode D1 in the battery-test circuit. Again, we've tried to eliminate every other possibility before suspecting amplifier AR2 or amplifier AR3 inside PX3.

FAILURE OF BOTH THE METER READOUT AND THE DIAPHRAGM-CLOSING SYSTEM

The third possibility when you have an exposure-control malfunction — neither the galvanometer nor the diaphragm-setting system works. Normally, the diaphragm always stops down to the smallest f/stop and the needle always remains at the top of the diaphragm scale. Or, the diaphragm always remains fully open and the needle always pegs to the bottom of the diaphragm scale. In either case, you aren't getting the proper output from AR1.

If the needle doesn't deflect, first check transistor TR — make sure you're getting the battery voltage at the collector when you close switch SW1.

There are a couple of other standard tests you should make before you start tracing the signal — check for your Vc and KVc voltages. If you aren't getting the KVc adjustment voltage at the resistor board, the needle will peg to the bottom of the diaphragm scale. In that case, disconnect the blue wire from the resistor board (there could be a short across one of the variable resistors, draining the KVc voltage). And check for KVc at pin 8 of PX3. If you're getting the proper inputs to PX3 — yet you aren't getting the KVc output — you evidently have a bad integrated circuit PX3.

Use virtually the same technique to check the Vc voltage. You should measure the Vc voltage at the CCC contact. If you don't, disconnect the CCC contact's white wire. And check for the Vc voltage at pin 15 of PX3. Remember, you must close switch SW1 to get either of the constant voltages.

Now, you can check for the changing AV voltage — the output of AR1 at the AV contact (the same contact you use for adjusting the exposure-control system). Here, you should measure an increasing voltage as you increase the light level, set a slower shutter speed, or set a faster film speed. But, since we've assumed that neither the diaphragm nor the meter works, you'll probably measure a constant voltage at the AV contact.

Where do you go from here? You could backtrack from AR1. However, starting with the most likely things first, you can go to the beginning — to the MOSFET amplifier PX1. Trace the output signal from PX1 to see where it's getting lost.

Close switch SW1. And measure the output between pin 8 of PX1 and ground. You should measure an increasing voltage as you increase the light striking the photocell. If you don't check the voltages at the other pins of PX1. Make sure you're getting the proper inputs before you replace the IC.

Then, follow the signal through the schematic. From pin 8 of PX1, the signal goes to pin 7 of PX2 through the thermistor and resistor R RTC. Check for continuity between pin 8 of PX1 and the resistor. If you don't have continuity here, you'll have to contact the two points with a jumper wire.

If you are getting the proper output from PX1, check the output of amplifier AR5 — pin 6 of PX2. Here, the voltage should decrease — go less positive — as you increase the light level. If it doesn't, you could have a bad PX2 integrated circuit. Or, more likely, you have an open between pin 8 of PX3 and pin 7 of PX2.

So measure the resistance between these two pins. You're now measuring the resistance of the thermistor and resistor R RTC in series — around 400 ohms, depending on the temperature.

Also, check for the proper input voltages to PX2. If you're not getting the proper inputs, use the schematic to look for an open. Check for continuity between the pin that isn't getting the proper input and its connecting point in the schematic. For example, if you aren't getting the E1 voltage to pin 4, check for continuity between pin 4 and the collector of transistor TR.

In the case of the malfunction we've described (neither the diaphragm nor the meter works), there are almost endless possibilities. That's why you have to trace the schematic to locate the problem. It may require 50 pages of step-by-step troubleshooting charts to find a defective component.

For example, you could have a defective functional resistor SV — TV. Measuring the resistance between pin 6 of PX3 and ground, you should see the resistance decrease as you set slower shutter speeds. An open in the functional resistor (no contact between the brush and the resistance path) causes the needle to peg to the bottom of the diaphragm scale. A short across the functional resistor causes the needle to remain at the top of the diaphragm scale.

Another example of a unique malfunction — there's a short between the two hot-shoe contact blades. The CCC contact and the AV1 EF contact sit closely together. And, if they're touching, the diaphragm always remains fully open. Most often you'll find the short between the solder tabs for the wires.

OTHER UNIQUE MALFUNCTIONS AND CONCLUSIONS ON THE AE-1

As we indicated earlier, you'll be able to correct many electronic failures by simply retouching cold solder joints. And you can figure out most of the other malfunctions by understanding how the camera operates.

We've already covered the troubleshooting steps for the shutter. But let's consider a unique malfunction, one you can quickly diagnose by your knowledge of the camera's functions. Suppose the shutter always delivers 1/60 second — that happens, normally as a result of bumping the camera.

You know that 1/60 second is the flash speed. And the AE-1 automatically switches to the flash speed when the neon ready lamp in the Speedlite 155A turns on. The most likely malfunction? The CCC contact is shorted to ground. It's probably touching the eyepiece support. As a result, the camera always selects the flash speed.

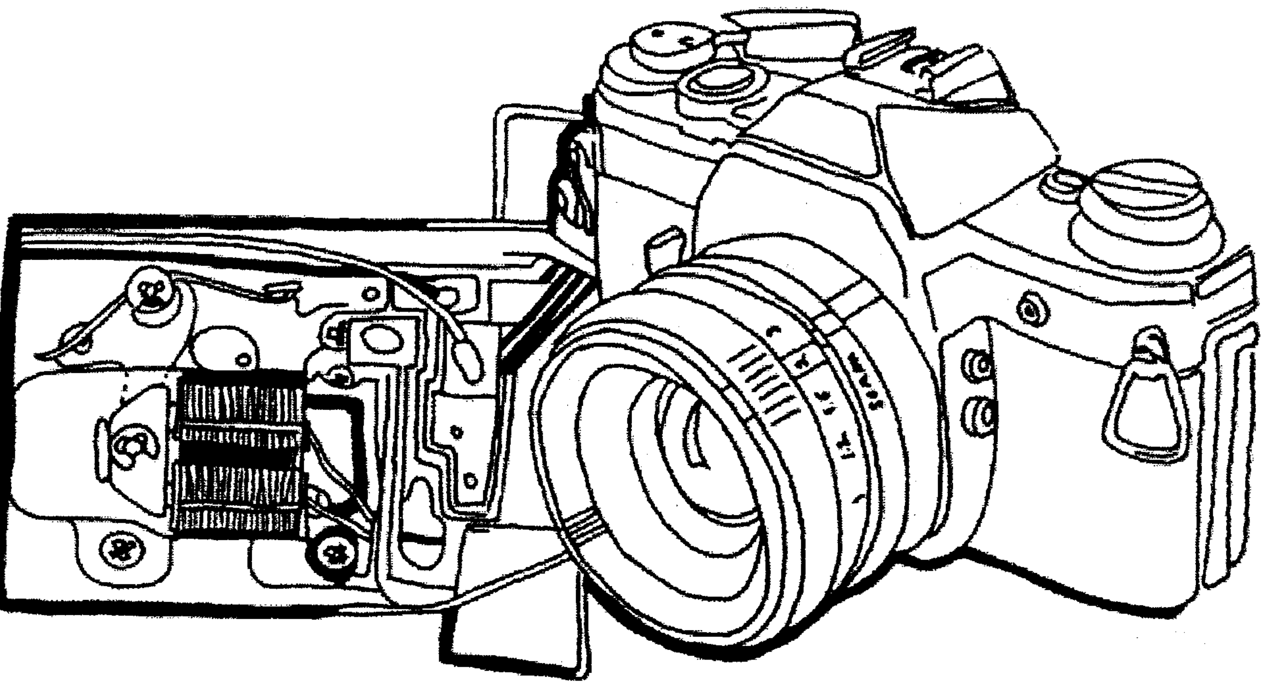
Another example — everything in the camera works, but you always get an overexposure of 1 1/2 f/stops. Both the diaphragm and the exposure-meter readout provide the same error. What would this indicate?

With the 1.5-f/stop error, don't jump immediately to the adjustments. Remember, the backlight switch allows an intentional overexposure of 1.5 f/stops. So you have an immediate clue as to where the problem might be. The backlight switch is probably shorted to ground.

What if the preview switch is shorted to ground? Then, the transistor always remains turned on. The needle deflects and the LED's flash. And the customer complains that his battery never seems to last very long.

You can correct any of these problems with just minor disassembly. That's what makes the AE-1 so economical to repair. Sure, you can run into the camera that has a defective component — one that takes a lot of time to troubleshoot. Maybe you lose money on that camera. But you make it up on those "fast-and-easy" repairs.

Revolutionary in design, controversial among technicians, the AE-1 has caused quite a change in camera concepts. We admit it took us quite a while just to figure out how the camera works. Yet someone actually sat down and designed that circuit — and made it work! There must be some mighty smart people in this photographic industry.



COMMON REPAIRS DEPARTMENT

Part 1 — Canon AE-1 and Pentax ME

Even the best of cameras have what technicians consider "common" repairs. When a particular camera comes in with a certain symptom, the experienced technician knows right where to look. Those common malfunctions may not indicate a problem with the design. In many cases, the cameras are so reliable that only a couple of symptoms seem to be repeats. But, because so many of the cameras were sold, we see those symptoms with some degree of regularity.

The Canon AE-1 and the Pentax ME provide good examples. By combining massive TV advertising with quality, both cameras have been setting sales records. So, despite the reliability, camera repair technicians see the cameras fairly frequently. Canon, for example, has sold over two million AE-1's. A particular problem may then appear to crop up quite often. However, compared to the number of cameras sold, the number of repairs seems almost insignificant.

Something else distinguishes the top-quality cameras — the "common" repairs are normally quick jobs rather than major overhauls. By contrast, the clunkers don't normally have "common" repairs. First one thing goes, then something else.

In the Canon AE-1, there seem to be two rather "common" repairs (other than mechanical problems caused by impact, such as the tungsten wire jumping its tracks). Both repairs come under the "fast-and-easy" category requiring only minor disassembly. Here they are:

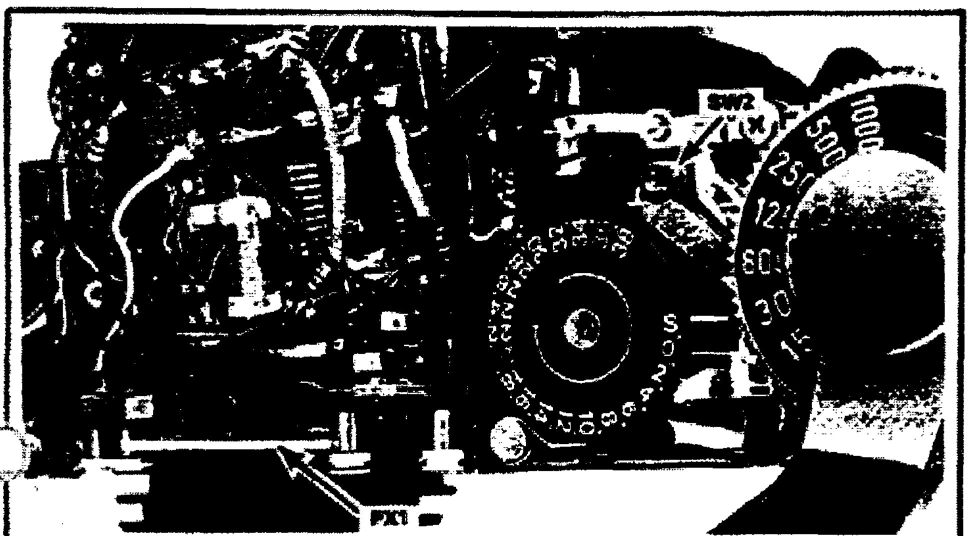


Figure 1

SYMPTOM 1

When you push the release button part way, *the underexposure LED flashes* on and off. Also, the needle always shoots to the bottom of the scale.

SOLUTION

These two symptoms normally indicate a problem with PX-1, the IC that serves as the amplifier for the photocell. Before replacing the IC, however, you might try retouching its solder connections. Also check the IC voltages to make sure the problem isn't with PX-2. You should measure 1.2V at pin 5 and around 0.6V at pin 6 of PX-3.

In many cases, simply retouching the solder connections cures the problem. If not, you'll have to replace PX-1.

SYMPTOM 2

The mirror fails to release when you push the release button. You then pull the bottom cover and push the armature

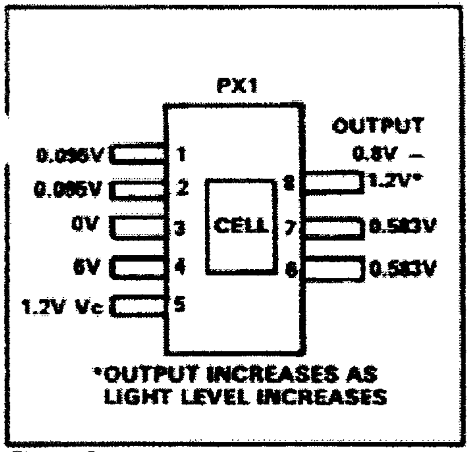


Figure 2

of the combination magnet MG2 away from the core to release the mirror. When you now operate the camera, everything works fine — the mirror releases when you depress the release button. Try as you might, you can't make the camera malfunction.

Many repair technicians might turn out the camera without going any further. Why not? It works. But have you really repaired anything?

SOLUTION

It's not likely that you've actually repaired the camera. Something must have caused the original problem. The situation is sort of reminiscent of early Pentax Spotmatics. Remember how the mirror-tensioning lever would slip to one side of the catch lever? Some technicians would simply reconnect the mirror-tensioning lever with the catch lever and consider the camera to be repaired. Yet something must have caused the mirror-tensioning lever to jump out of place.

With the Spotmatic, the original cause may have been insufficient overtravel on the mirror-tensioning lever. Or the depth of engagement between the mirror-tensioning lever and the catch lever may have been insufficient. Pentax later modified the catch lever to make the depth of engagement and the overtravel less critical.

Similarly, something must have caused the initial failure in the AE-1 — most likely, the release switch SW2. It takes a little more time to remove the top cover. But, if you improve the switch contact and clean the surfaces, you'll probably have more confidence in the repair.

The Pentax ME hasn't been around as long as the Canon AE-1. For the most part, the troubleshooting procedures follow those in other electronically controlled SLRs. Poor contact of the memory switch, for example, causes the shutter to hang open. Poor contact of the power switch ("magnet switch" by Pentax terminology) causes the shutter to deliver the fastest speed only. But, from the field feedback we've received so far, only one symptom fits the category of "common" malfunctions. Here it is:

SYMPTOM

The LEDs do not turn on when you push the release button part way. Also, the shutter delivers only its fastest speed — 1/1000 second.

SOLUTION

These symptoms normally point to the metering switch, the switch that closes when you push the release button part way (Pentax uses the term, "main switch" because the switch also connects the electromagnet to the circuit). The switch connects between the red wire at the flex circuit and the connector to the center terminal of the front-plate circuit board.

To check the switch, first measure the voltage between the red wire and ground; you should measure the full battery voltage (around 3V). Then measure the voltage to the connector at the front-plate circuit board. Here, you should measure 0V until you depress the release slide. With the release slide partially depressed, you should measure 3V. If you don't get the battery voltage at the connector, the metering switch isn't making good contact.

Here's another way to test the switch — use your tweezers to short between the red wire and the connector to the front-plate circuit board. You're then shorting across the switch. If the switch is the problem, the LED display should turn on.

Pentax specifies the adjustment on the switch by space gaps. When the release slide is latched in the partially depressed position, there should be a 0.2mm space gap between the longer switch blade and the blue insulator on the release slide. Make the adjustment by reforming the shorter switch blade. Also, when the metering switch is open, there should be a 0.2mm space gap between the two blades.

Most of our information for *Common Repairs* comes from field feedback — the symptoms repair technicians have mentioned seeing most frequently. We'd like to continue drawing from your experiences. Are there symptoms you regularly encounter in certain models? If you'll let us know, we'll try to track down causes and solutions.

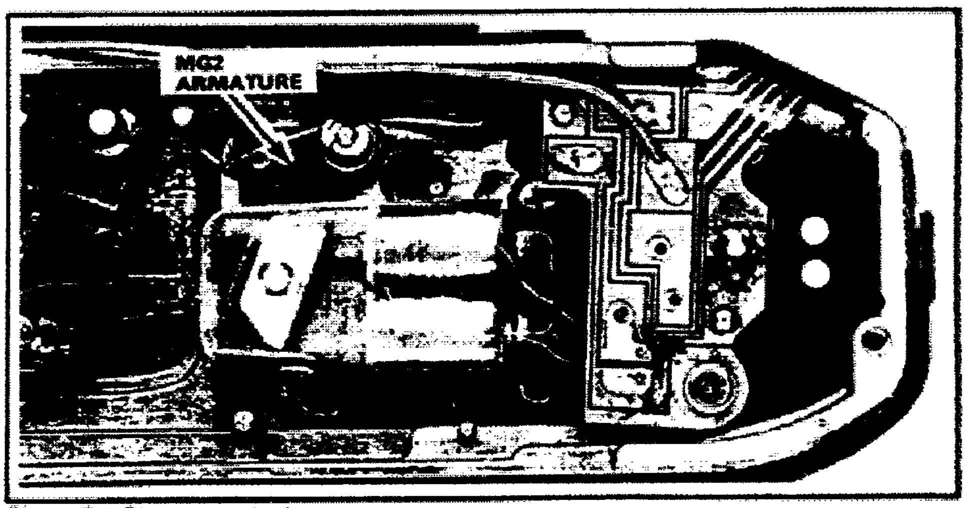


Figure 3   Shutter cocked

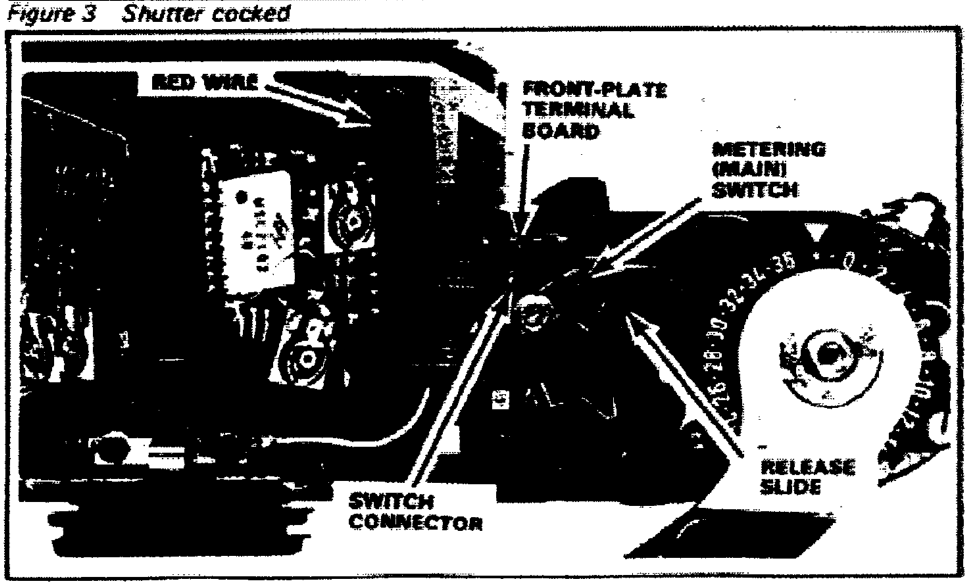


Figure 4   Pentax ME