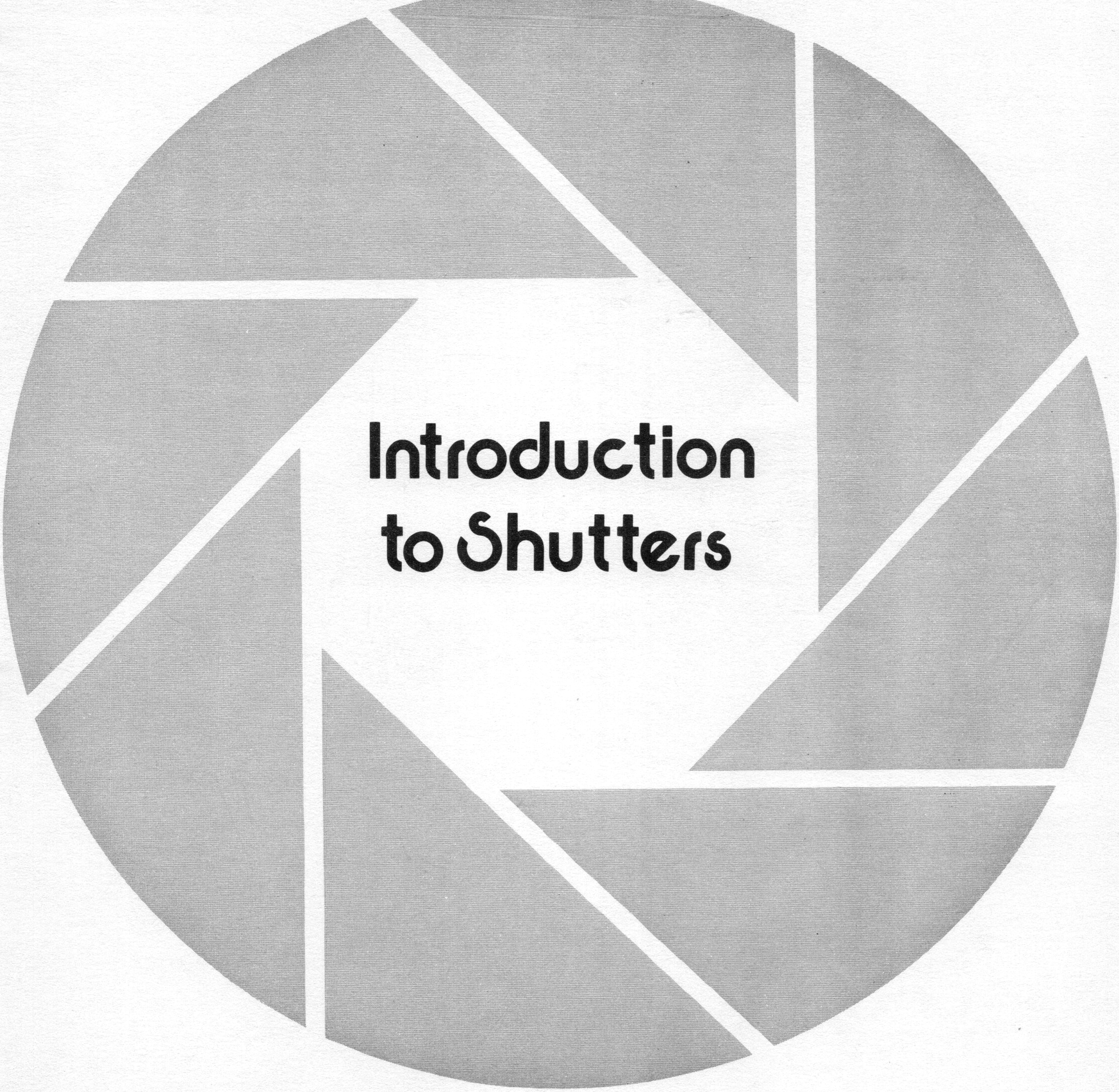
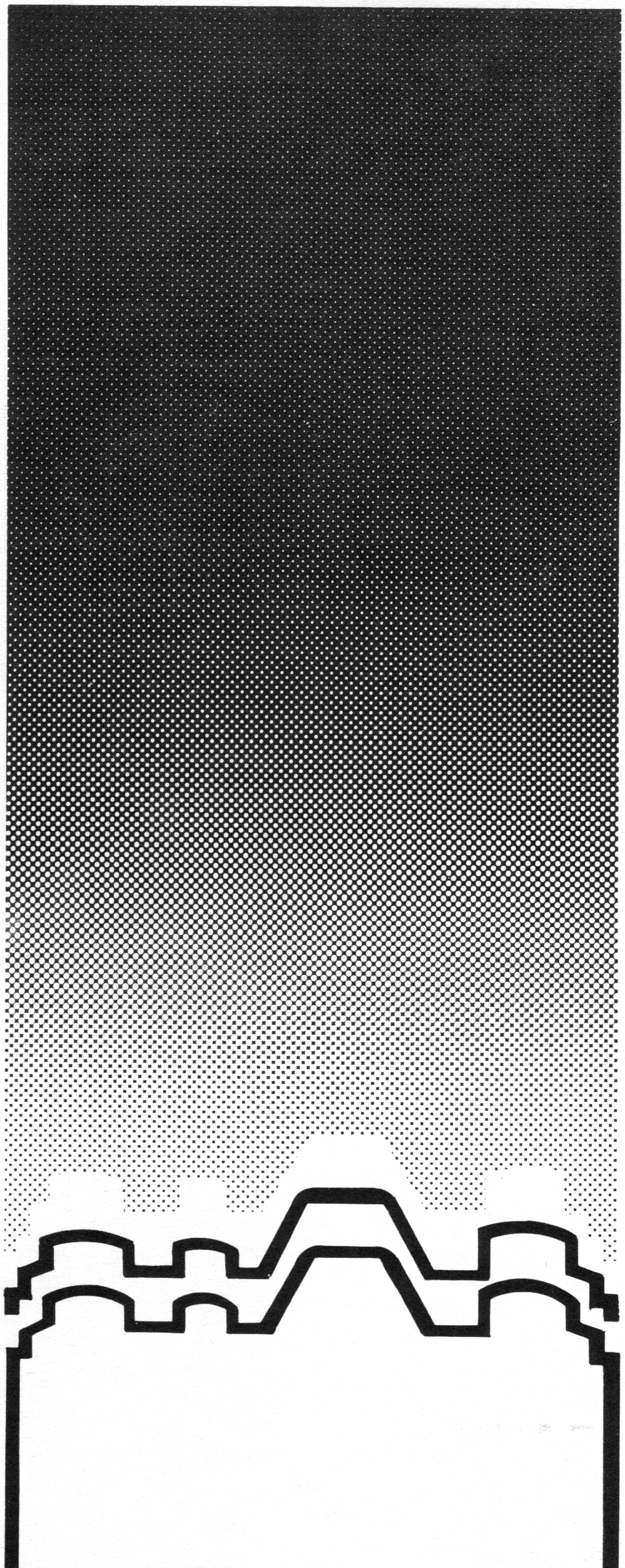
Introduction to Shutters





Author
Eugene C. Fowler

Design
Ivan Bardon

Advisory Committee
Jim Amos
Metro Camera Service

Doug Donaldson
Western Camera

Bill Glennon
Lindahl Camera

Mike Lowe
Rocky Mountain Camera Repair

Yoshio Arakawa
Pentax Corporation

Introduction to Shutters

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National Camera, Inc.
Technical Training Division

SHUTTER TYPES

You've learned that the shutter is one of the basic camera parts. And you know the purpose of the shutter — it opens and closes, controlling the length of time that light can strike the film.

There are three basic types of shutters:

1. **disc-type.**
2. **blade-(or leaf-) type.**
3. **focal-plane type.**

Each type has its own characteristics, advantages and drawbacks. The focal-plane type will be covered in detail in later assignments. So, for now we'll center our attention on the first two types.

THE DISC-TYPE SHUTTER

The disc-type shutter is the simplest of the three shutter types. It may be nothing more than a thin, metal disc as shown in Fig. 1. The disc swings away from the shutter opening to expose the film. And it then recovers the opening to end the exposure.

Fig. 2 illustrates the sequence. Pushing the camera's release button sends the disc into action. First, the disc swings to position "B." So light passes through the shutter opening to expose the film. To end the exposure, the disc swings back to position "C."

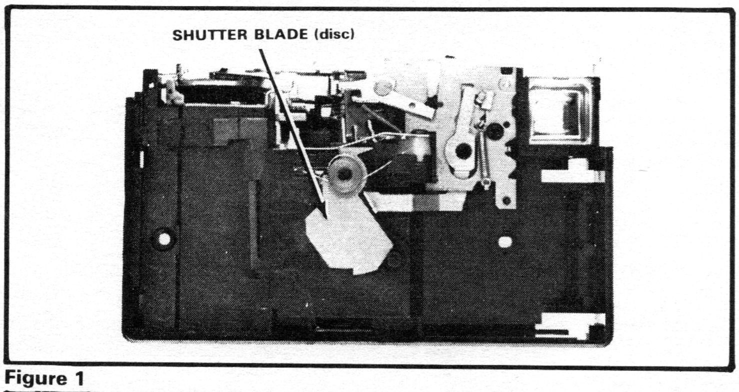


Figure 1

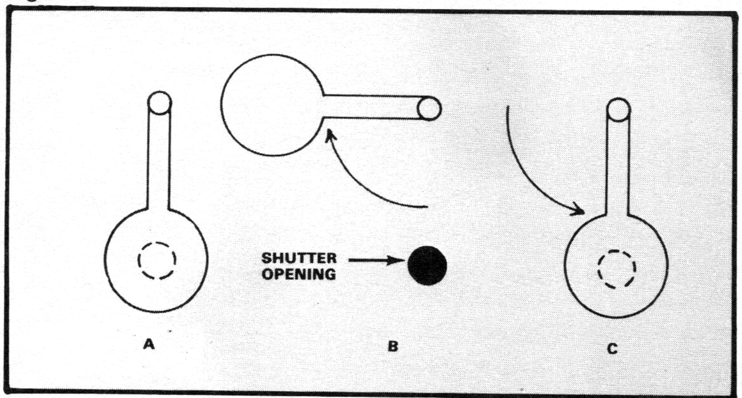


Figure 2

You'll find the disc-type shutter in many of the simpler cameras — like the box camera you studied earlier. Fig. 3 shows a typical mechanical action. Here the **disc spring** holds the disc in front of the lens opening.

When you cock the shutter, lever **A** moves to the left of the disc, Fig. 4. That tensions a large spring which drives lever **A**. Releasing the shutter allows the spring to drive lever **A** from left to right. Lever **A** then strikes the top end of the disc. That drives the disc away from the shutter opening, Fig. 5.

Now, the disc spring takes over. It snaps the disc back to the position shown in Fig. 3.

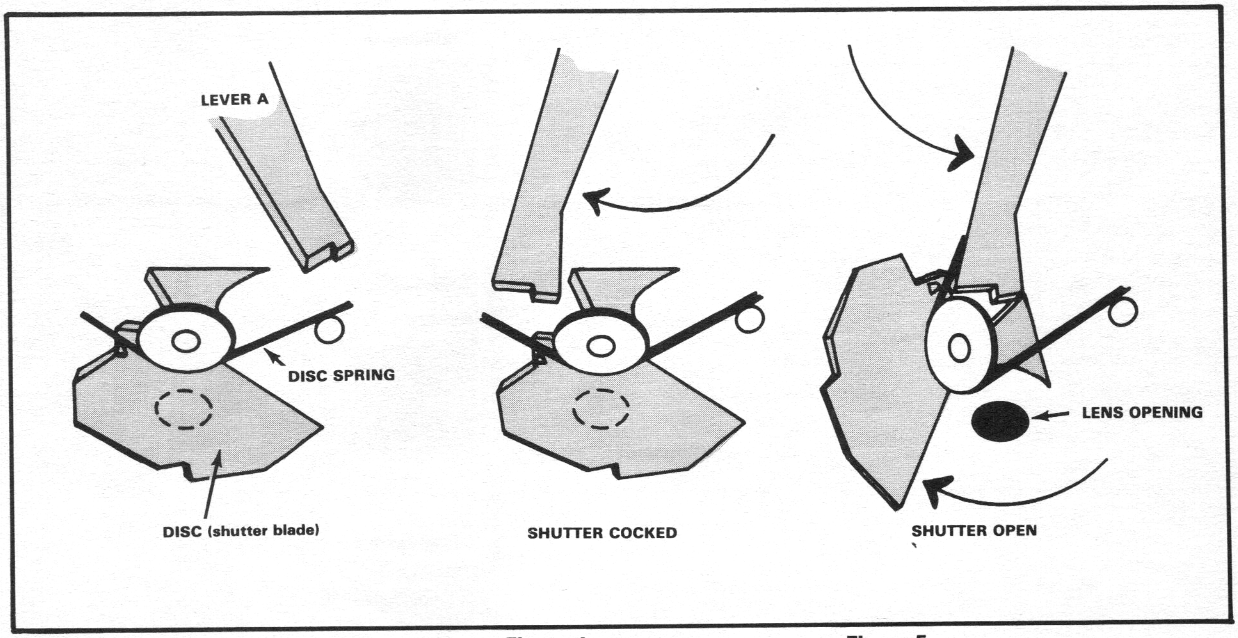


Figure 3 **Figure 4** **Figure 5**

A shutter of this type normally provides only one shutter speed. Two things determine the shutter speed:

1. **how far the disc moves**
2. **how fast the disc travels**

Suppose, for example, that you could increase the tension of the disc spring. The disc would then recover the shutter opening more quickly — a faster shutter speed.

Or, suppose you could increase the distance the disc could travel. That means it would take longer for the disc to uncover and recover the opening — a slower shutter speed.

We mentioned earlier that some of the cartridge-load cameras automatically give you a slower shutter speed for flash pictures. They provide the two shutter speeds by using the first method — changing the distance that the disc travels. Normally, a lever sits in the path of the disc, Fig. 6. The lever restricts how far the disc can move. So here's the faster speed for available-light exposures — the lever limits the disc's movement.

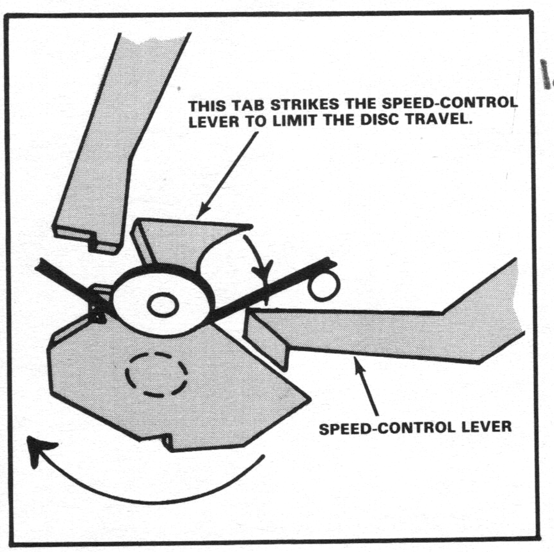


Figure 6

Installing a flashbulb then pushes the lever out of the way. Now, the disc doesn't strike the lever. So the disc travels further. That gives you the slower speed for flash pictures. Normally, the fast speed is around 1/100 second and the slow speed is around 1/30-1/40 second.

The disc-type shutter also has some variations. Fig. 7 shows another type. Here, the disc is a round piece of metal. And there's a pie-shaped opening cut in the disc. In action, the disc rotates. Light gets to the film only while the pie-shaped cutout is over the film opening.

Again, there's normally only one shutter speed. And again there are two ways to change this shutter speed. For one, you could change the speed at which the disc rotates — a faster speed for a shorter exposure. Or, you could change the size of the pie-shaped cutout. A larger cutout means a longer exposure.

The rotating-disc shutter is used most often in motion-picture cameras. Here, the disc rotates continuously at a steady, governor controlled speed. And film movement is precisely synchronized with the open/close action of the shutter. However, the film is stopped momentarily for each exposure. Film transport occurs during the "closed" interval of each shutter revolution.

Most motion-picture projectors use a similar shutter design, but with multiple cut-outs. Later in your course, you'll study motion-picture cameras and projector mechanisms in detail.

The rotating-disc shutter is usually positioned in front of the film, Fig. 8. The disc-type shutter as used in most still cameras sits right behind the lens, Fig. 9.

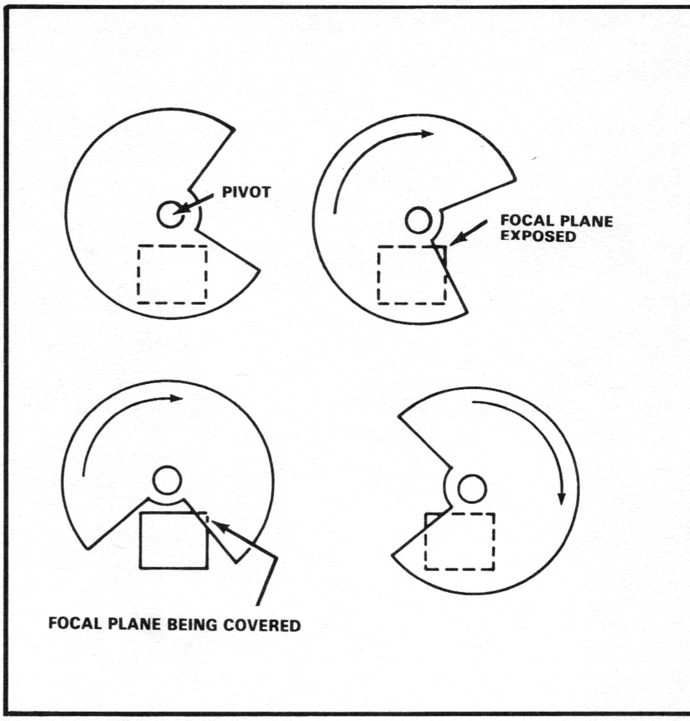


Figure 7 Rotating-disc shutter

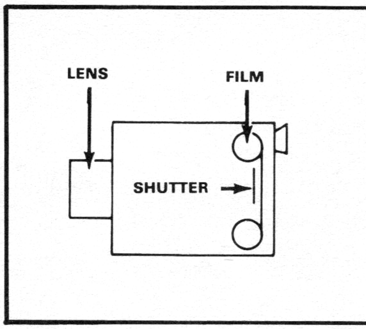


Figure 8

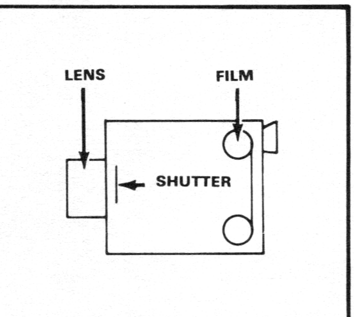
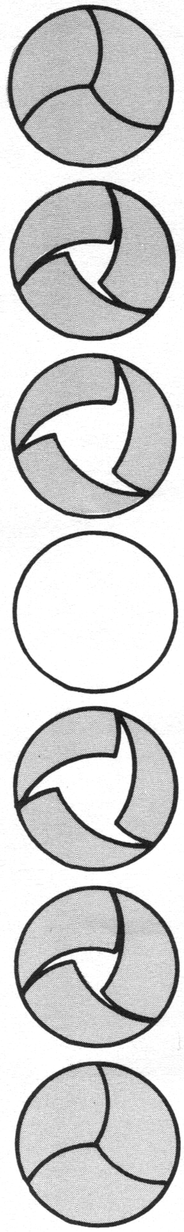


Figure 9



A
BLADES CLOSED.

B
BLADES START TO OPEN.

C
BLADES NEAR FULL-OPEN POSITION.

D
BLADES FULLY OPEN.

E
BLADES START TO CLOSE.

F
BLADES NEAR FULLY CLOSED POSITION.

G
BLADES CLOSED.

Figure 10
The blade-opening sequence in a three-blade shutter. More refined blade-type shutters use five blades.

THE BLADE-TYPE SHUTTER

The blade-type shutter looks a lot like the diaphragm you've already read about — a set of overlapping blades, or leaves, Fig. 10. (The terms "blade" and "leaf" are interchangeable. But from now on, we'll use the term "blade" when talking about shutters. And we'll use the term "leaf" when talking about diaphragms.)

With the blade-type shutter, the blades overlap one another to some degree — far enough to completely seal off the light. When the blades are closed, Fig. 10A, no light can pass through the blades. So there's no light reaching the film.

Releasing the shutter drives the blades open. Now, light can pass through the shutter opening to expose the film. The blades end the exposure by snapping closed at the proper time.

Most blade-type shutters offer a choice of shutter speeds. All that's necessary is to hold the blades open for different lengths of time. Many blade-type shutters use a clocklike timing mechanism to control the exposure — it's called a **retard mechanism.**

Spring tension drives the blades open — to the position shown in Fig. 10D. The retard then goes into action to hold the blades open. How long the retard holds the blades depends on the shutter speed you've selected.

Actually, the exposure depends on three things:

1. **how long it takes the blades to open.**
2. **how long the blades remain open.**
3. **how long it takes the blades to close.**

With most shutters, the blade-opening time and the blade-closing time are the same. And they're very fast — usually a matter of a couple of **milliseconds** or less each way. (A millisecond is a thousandth of a second — 1/1000 second = 1 millisecond.)

So the fastest shutter speed depends on how fast the blades move. Here, there's no retard. The fastest shutter speed with a blade-type shutter is normally 1/500 second. However, you'll occasionally run across some unusual blade-type shutter designs that deliver speeds up to 1/1000 second and faster.

But the slowest shutter speed depends on the retard — how long it can actually hold the blades open. The mechanical retard can only hold the blades open so long. Usually, the slowest speed with a mechanical retard is 1 second.

Other blade-type shutters have electronic speed controls. These are the **electronic shutters.** Actually, **electronically controlled shutters** would be a more accurate term. The electronically controlled shutters still use spring-driven blades that open and close. The electronic system just replaces the mechanical retard.

With the electronically controlled shutter, an **electromagnet** holds open the blades. An electromagnet is an electro-mechanical device that responds to electrical current. When current flows through the coil of wire, Fig. 12, the electromagnet holds its **armature** magnetically. And the armature in turn holds the shutter open. An electronic timing circuit decides how long the current can flow through the coil.

The fastest speed in an electronically controlled shutter still has mechanical limitations — those blades can only open and close so fast. Again, the fastest speed will be the same as in a mechanically controlled shutter. But the electronically controlled shutter can provide slower speeds. Slow speeds of several seconds are possible. Plus, the electronically controlled shutter is usually more accurate than is the mechanically controlled shutter.

Your ear will tell you whether a shutter has mechanical retard control or electronic control. Set one of the slow speeds, like 1 second. Then, release the shutter. If the shutter has a mechanical retard, you'll hear a "buzz" while the shutter's open. But the electronic system makes no noise at all.

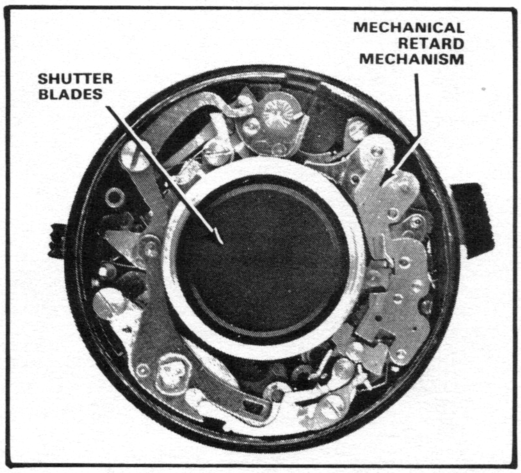


Figure 11

Inside, the modern blade-type shutter contains a complex timing device. Notice how the parts fit in a circle leaving the blades at the center. That's making maximum use of limited space.

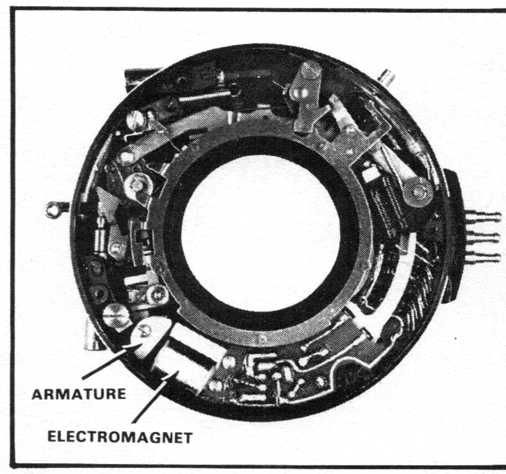


Figure 12

The electromagnet replaces the retard in an electronically controlled shutter.

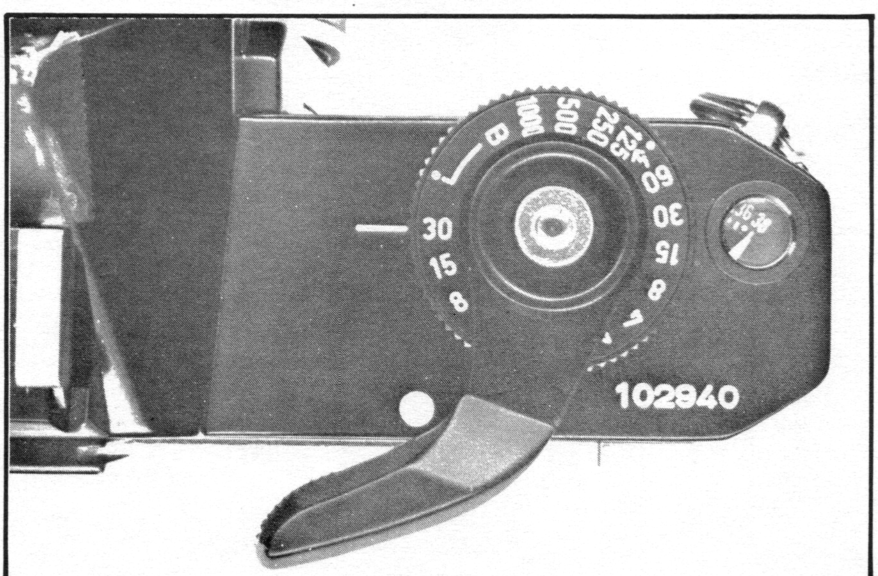


Figure 13

This electronically controlled Canon EF provides slow speeds as long as 30 full seconds using a focal-plane shutter.

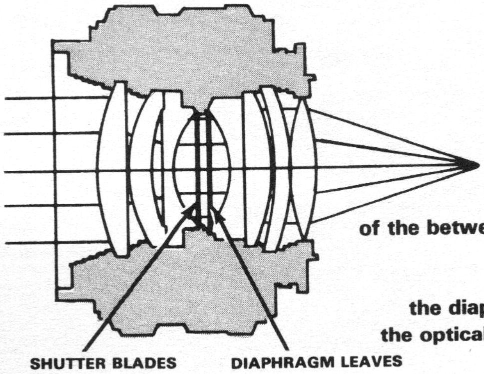


Figure 14
The blades of the between-the-lens shutter are normally right in front of the diaphragm leaves — at the optical center of the lens.

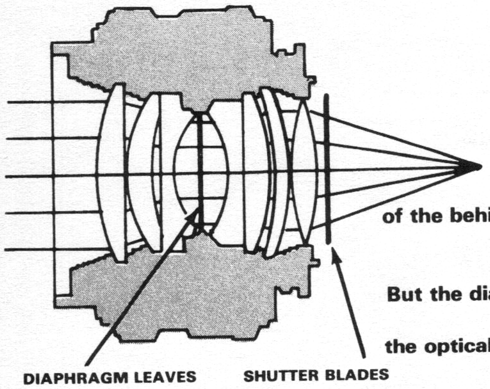


Figure 15
The blades of the behind-the-lens shutter sit behind the lens elements. But the diaphragm leaves are still at the optical center of the lens.

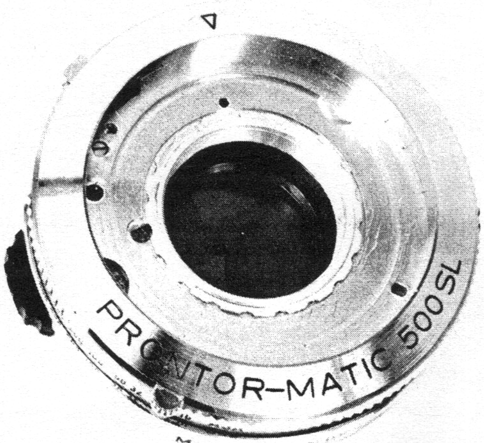


Figure 16
The shutter manufacturer supplies the blade-type shutter module to the camera manufacturer. Here's how the shutter is normally supplied— no lenses, but the shutter contains the complete operating mechanism.

LOCATION OF THE BLADE-TYPE SHUTTER

Unlike the rotating-disc shutter, the blade-type shutter can't sit directly in front of the film. It will usually be positioned in one of two positions — between the elements of the lens, Fig. 14, or behind the lens, Fig. 15.

The shutter in Fig. 14 is a **between-the-lens** shutter — the blades sit between the lens elements. The mechanical controls then form a circle around the blades, Fig. 11.

Putting the blades between the lens elements has optical advantages. But there are also drawbacks. Suppose, for example, that the camera accepts interchangeable lenses. To replace the lens, you must replace the shutter — the shutter is part of the lens assembly. So the interchangeable lenses are generally quite expensive. They have to be — you're paying for the shutter as well as for the lens.

By contrast, the shutter indicated in Fig. 15 allows easier interchange of lenses. It's a **behind-the-lens** shutter and its advantage is that you can put another lens on the camera without having to replace the shutter. The shutter remains with the camera when you remove the lens. So the interchangeable lenses can be less expensive.

There is a solution to the high-cost drawback of the between-the-lens shutter / interchangeable lens combination. It's called the **interchangeable component lens system.** Here, the shutter (and the lens elements behind the shutter and diaphragm leaves) remain with the camera. And the lens elements in front of the shutter blades interchange as a single unit. Each interchangeable component (or unit) is optically matched to the group of lens elements that remain with the shutter.

You won't see too many cameras using the interchangeable component system. It's a compromise optical design. And most manufacturers prefer the superior lens performance provided by a fully interchangeable lens system.

Both between-the-lens and behind-the-lens shutters normally come as modular assemblies. That means they're complete units, Fig. 16. You could remove the shutter from the camera (or the lens) and it would still operate.

There are exceptions to the modular design. A few blade-type shutter mechanisms are built into the body of the camera.

The camera manufacturer usually doesn't make the blade-type shutter. Other manufacturers make the shutters — and that may be all they make. Companies like **Compur, Prontor, Copal, Citizen, and Seikosha** specialize in making shutters. They then sell the shutters to different camera manufacturers. Copal and Seikosha (Seiko) also manufacture modular focal-plane shutters.

So you'll see several different cameras that use the same shutter. For example, you'll find German-made Compur shutters on German-made Rolleiflex cameras. And you'll find the same Compur shutters on Swedish made Hasselblad cameras.

Prontor is another German-made shutter. Copal, Citizen, and Seikosha are Japanese-made shutters. Any of these shutters may be designed either as between-the-lens shutters or behind-the-lens shutters. But again, the blade-type shutter must be near the lens. It can't sit right in front of the film.

You can probably visualize the problem if you put a blade-type shutter near the film. The film frame wouldn't receive uniform exposure. Rather, the center of the film would receive the most light. And the edges of the film would receive the least light.

That's because the shutter blades have to open and close. So the entire frame of film would receive light only when the shutter opened fully. As the shutter would start to open, only the center of the film would receive light. And as the shutter would start to close, it would block off the edges of the film first.

But there's no problem with the blade-type shutter located near the lens. Here, the entire frame of film gets light as soon as the shutter starts to open. Not as much as when the shutter is fully open — yet the entire frame gets the same amount of light. In effect, a partially open shutter acts like a stopped-down diaphragm. Since the blade-type shutter always goes near the lens, it's sometimes called a **front shutter** (at the front of the camera).

Figure 17
One type of blade shutter combines the diaphragm action with the shutter action. This Minolta Hi-Matic automatically controls both the diaphragm opening and the shutter speed by how far the blades open. For a small f/stop and a fast shutter speed, the blades open slightly — that gives the film a brief glimpse of the light. For a large f/stop and a slow shutter speed, the blades open fully.

TEST-YOURSELF QUIZ #1

1. What two factors determine the shutter speed delivered by a disc-type shutter?

   1. HOW FAR THE DISC MOVES
   2. HOW FAST THE DISC TRAVELS

2. Simple cartridge-load cameras have no external speed control, yet they deliver a different speed for daylight and flash exposures. How is this accomplished?

   AN ARM BLOCKS THE DISC'S TRAVEL FOR A SHORTER TRAVEL TIME - WHEN IN FLASH MODE THE ARM IS MOVED OUT OF THE WAY WHEN YOU INSERT FLASH.

3. The rotating-disc shutter in the motion-picture camera:
   A. rotates continuously.
   B. stops momentarily for each exposure.

4. The blades in an electronically controlled shutter are held open by AN ELECTROMAGNET.

5. When the blades of a shutter are positioned between the elements of a lens it's called BETWEEN THE LENS shutter.

6. Indicate the country of manufacture for the following shutters.

1. Copal JAPAN
2. Compur GERMANY
3. Seikosha JAPAN
4. Prontor GERMANY
5. Citizen JAPAN

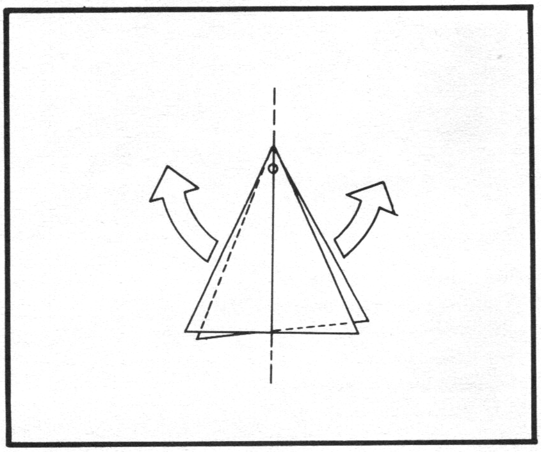


Figure 18

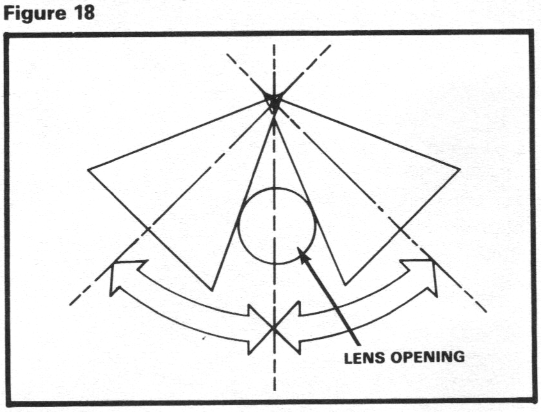


Figure 19

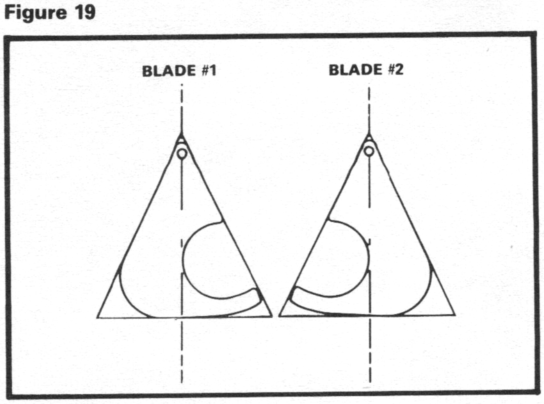


Figure 20

FUNDAMENTALS OF SHUTTER BLADE DESIGN AND CONTROL

The **two-blade shutter** is the least complex of the blade-type shutter designs you'll encounter. It is the shutter used most often in 110 pocket instamatic cameras. But its design is certainly not new or revolutionary. Two-blade shutters can be found in photographic equipment dating as far back as the late 19th century.

The current version of the shutter is perhaps the simplest and most straight forward design to date. Basically, it consists of nothing more than two, overlapping triangular blades operating from a central pivot, Fig. 18. The blades swing in opposing directions to uncover the lens opening, Fig. 19. Then swing back to complete the exposure.

In actual practice, the blade shape is modified to the form shown in Fig. 20. The cutaway areas reduce both the mass of the blades and the distance they must travel to completely uncover the lens opening, Fig. 21.

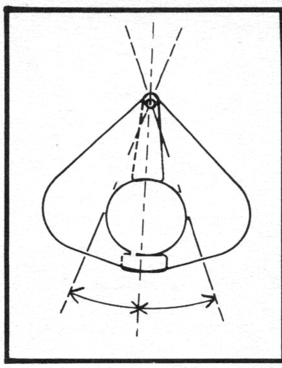
Slots are also cut into each blade as illustrated in Fig. 22. Note that the bottom of each slot is located at the center line of each blade. Observe the relationship of the two slots when the blades are in their closed, half open, and full open positions, Fig. 23. The slots act as a guide channel for the part that controls the movement of the blades.

Blade movement is controlled by the **leaf lever.** The leaf lever is a part common to all blade-type shutters, simple and complex alike. In the two-blade design a pin on the leaf lever comes into direct contact with the slot of each blade, Fig. 24.

Study the diagram in Fig. 25. Notice that the leaf lever moves in an arc at a right angle to the shutter blades. When the pin end of the leaf lever swings up or down, the pin will drive the blades open or closed, Fig. 26.

The shutter blades and leaf lever are attached to a thin metal plate called the shutter **mechanism plate,** Fig. 27. The leaf lever is installed on the back side of the plate. And the shutter blades are on the front, Fig. 28. Even though mounted on the opposite side of the plate, the leaf lever can still control the blade movement. Its pin protrudes through the curved slot shown in Fig. 27, and into the shutter blade slots, Fig. 24.

Now, lets turn the mechanism plate around, Fig. 29, and study the leaf lever in more detail. Fig. 30 shows the leaf lever



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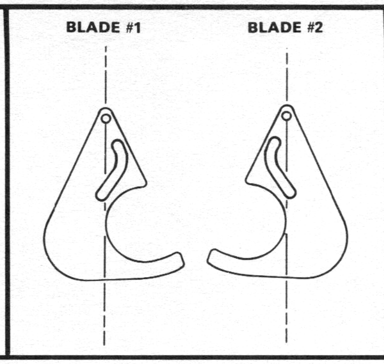

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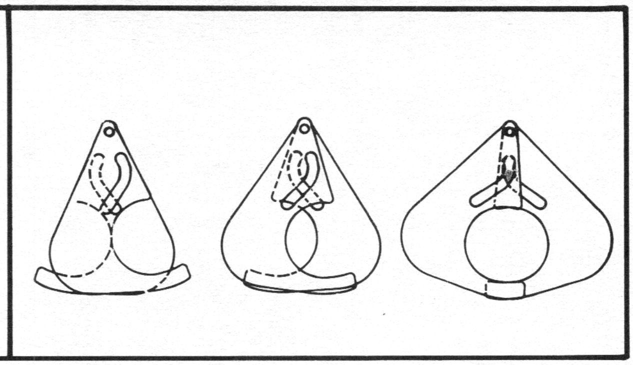

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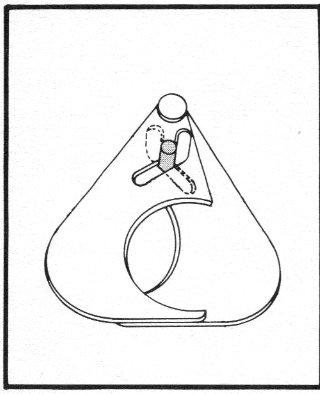

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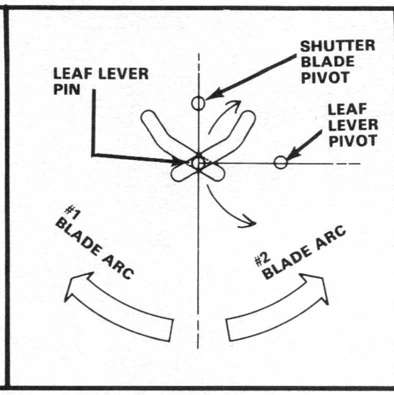

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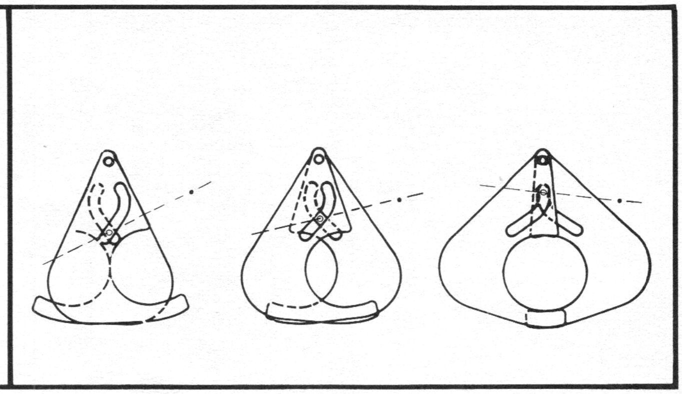


Figure 26

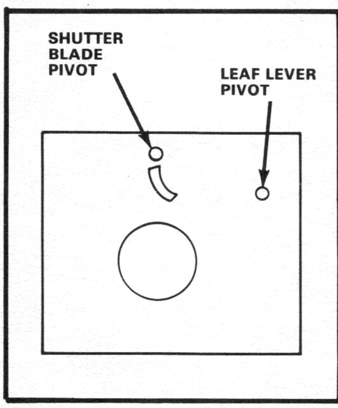
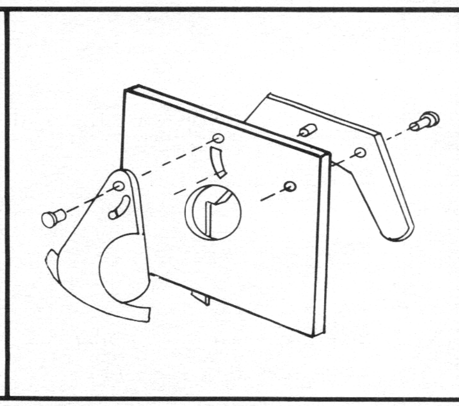


Figure 27



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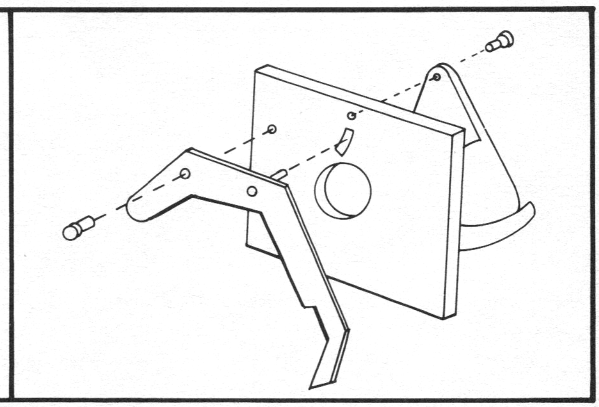

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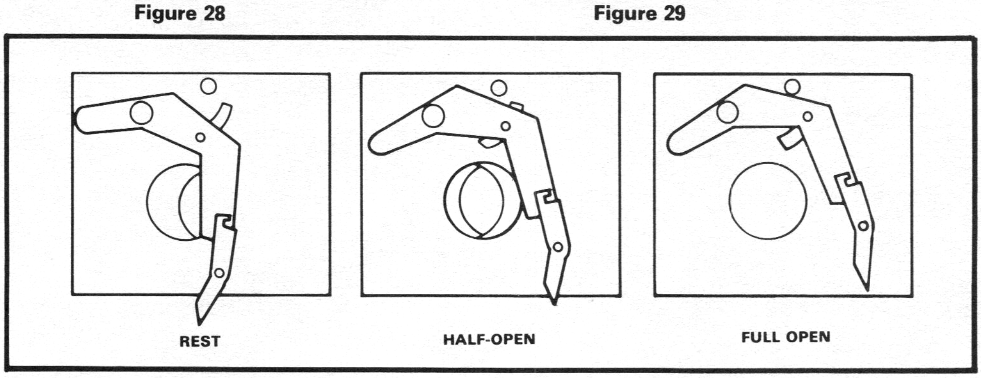

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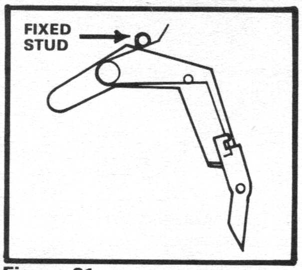

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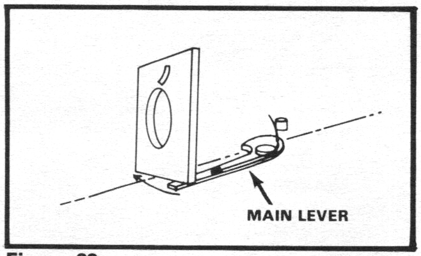

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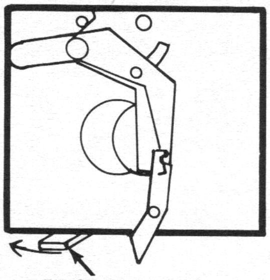

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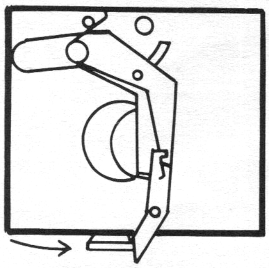
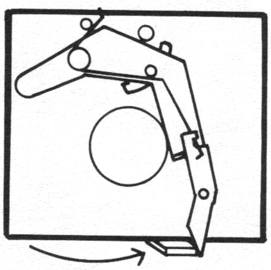


Figure 34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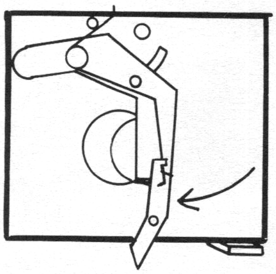
Figure 36

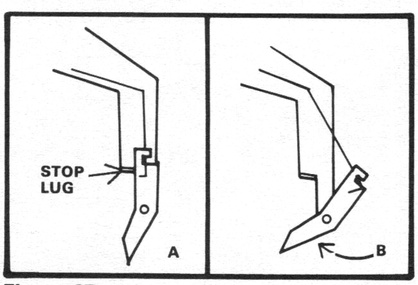

Figure 37

in its rest, half-open and full-open position. Try to visually relate this action with the movement of the shutter blades illustrated in Fig. 26.

A spring is attached to the leaf lever, Fig. 31. The **leaf lever spring** holds the leaf lever in its rest position. (The leaf lever, in turn, holds the blades closed.) When the leaf lever is moved to its open position and released, the tension on the spring will drive the lever back to its rest position. (Again, blade movement will follow the action of the leaf lever.)

The next phase of the shutters design is quite similar to the disc-type shutter discussed earlier. Remember the part we labeled "lever A" (Fig's. 3, 4 and 5)? And how lever A moved to the left side of the shutter disc during the cocking cycle. Then, when the shutter was released, lever A's spring tension would drive it back the opposite direction. And the lever would strike the top end of the disc, driving it away from the shutter opening. The disc spring would then snap the disc back to its closed position, completing the exposure.

The two-blade shutters equivalent to "lever A" is the **main lever,** Fig. 32. It also moves to the left during the cocking cycle, Fig. 33. And its drive spring is tensioned at the same time. When the main lever is released, it moves from left to right. The main lever then strikes the end of the leaf lever, Fig. 34. That drives the leaf lever (and shutter blades) to the open position, Fig. 35. The main lever continues its movement until it loses contact with the leaf lever. Then the leaf lever spring takes over, driving the leaf lever (and blades) back to the rest (closed) position, Fig. 36.

There's one leaf lever feature we haven't mentioned. Take a closer look at the end contacted by the main lever, Fig. 37. You'll notice that the tip of the leaf lever is actually a separate piece. The tension of the leaf lever spring holds the pivoting part against the stop lug, Fig. 37A.

Push the tip of the leaf lever to the right and the entire lever moves. Push it from the left and the tip swings up, but the rest of the lever will remain stationary, Fig. 37B.

Remember that the main lever must move from right to left during the cocking cycle. The pivoting tip of the leaf lever permits this direction of travel without disturbing the rest of the leaf lever. Once cocked and released, the main lever will contact the leaf lever from the proper direction to drive the blades open.

The total open/close action of the shutter takes place within a relatively short span of time — usually around 1/50 second. (The actual exposure will be about 1/100 second — we'll cover the reasons for the difference in a later lesson.) Obviously, the parts producing the exposure must move quickly. That's the job of the main and leaf lever springs. But it's not as simple a task as it might seem at first glance.

First, we're dealing with two springs, one of which must work in opposition to the other. The main lever spring has to do triple duty. It not only needs enough power to drive the main lever, but the leaf lever and shutter biades as well. And it's not just the mass of the main lever, leaf lever and shutter blades it's moving. The resistance of the leaf lever spring also enters the picture. It makes for an interesting study in spring tension balance.

Consider for a moment the end result we're after — the opening and closing of the shutter blades at a precise and uniform speed. And ideally, the speed should be the same in both directions. That's the factor that makes the spring balance touchy. Otherwise, it would just be a matter of making one spring stronger than the other. The design engineer has to make sure the ratio between spring strengths is precise.

The leaf lever spring is, of course, the lighter of the two springs. All it has to do is close the blades. *It also holds the pivoting tip of the leaf lever against the stop lug. But this is not a factor in the open/close action of the shutter.* Its lightness comes from a smaller cross-sectional diameter (gage) than that of the main lever spring — approximately .008″ to .010″ for the leaf lever spring and up to .020″ or more for the mainspring.

Spring weight variation isn't peculiar just to the two-blade shutter type. It's common to all blade-type shutters. In fact, 4. the main lever spring is generally the stoutest spring you'll find in a shutter mechanism. And the leaf lever spring is usually one of the lightest.

Spring configuration or shape is another readily identifiable spring characteristic. The configuration will, in turn, determine the springs type classification. The most common is the **torsion-type spring,** Fig. 38. It develops its power or force in a lever-like manner. The leaf lever spring we've talked about is a good example. Don't let the bends and kinks in the free ends of the spring fool you — it's still a torsion spring.

TORSION

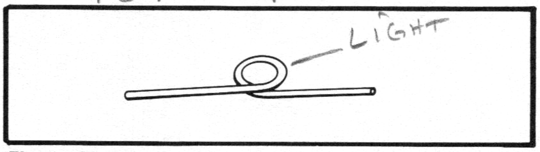

Figure 38

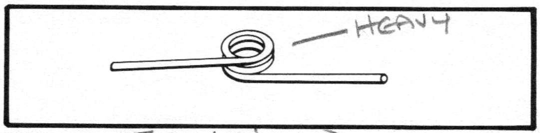

Figure 39 TENSION

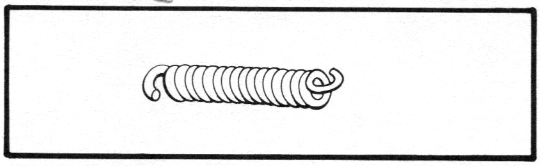

Figure 40

A torsion-type spring is used to power the main lever in many blade-type shutters. The spring wire gage will be heavier as we've already learned. And it will usually have a greater number of coils in the winding, Fig. 39. This will increase the force exerted by the spring. The same spring winding principle can be used to increase the power of lighter gage springs.

The **tension-type spring** is another, less frequently used spring type, Fig. 40. It develops its force axially — much like a stretched rubber band. You'll find it powering the main lever in some blade-type shutter designs. But, it's not used exclusively for that purpose. It's capable of providing power for a variety of different parts.

There are other spring types. But we won't discuss them at this time. They'll be covered in later assignments. For now, just keep in mind the difference between torsion and tension. Ninety-five percent of the springs you'll encounter will fall in one or the other of these two categories.

So far, we've focused our attention on the most basic parts of the two-blade shutter mechanism. Our example design is typical of the shutters you'll see in many 110 pocket instamatics. There will be little, if any, variation between models. But there are other parts in the 110 camera. And it's here where the similarities end.

The shutter's main lever is cocked and released via a series of pivoting and sliding levers. These levers link directly to the film transport mechanism. And the entire assembly operates as a single, integral unit. Every manufacturer takes a slightly different route to accomplish these operations. So the design of the individual component parts will vary from model to model.

The integral film transport and shutter cocking operation of the 110 camera is beyond the scope of this text. These mechanisms will be the subject of later assignments.

TEST-YOURSELF QUIZ #2

1. Is a leaf lever used in designs other than the two-blade shutter?

   Yes ✓ No______

2. Why is the tip of the two-blade shutter's leaf lever hinged? IT PERMITS THE MAIN LEVER TO BE COCKED WITHOUT MOVING THE REST OF THE LEAF LEVER

3. What are two factors that determine a spring's strength?

   1. GAGE (THICKNESS)
   2. NUMBER OF COILS

4. Two spring classifications were mentioned in this section. The most common is the TORSION-type spring. Less frequently used is the TENSION-type spring.

THE MULTIPLE-BLADE SHUTTER

The two-blade shutter normally provides only one shutter speed. That limits its use mainly to amateur cameras. The serious photographer needs a shutter that can deliver a full range of speeds. And that requires a more sophisticated, multiple-blade design.

You've already had a preview of the multiple-blade shutter. Its general characteristics were discussed in the section introducing the blade-type shutter. Now let's take a more detailed look at some of the shutter's basic operating parts.

The inultiple-blade design requires a more complex arrangement of parts to control and move the shutter blades. So an additional component is added to the mechanism to help accomplish this task. It's called the **blade operating ring,** Fig. 41. All the blades can be moved in unison via the partial rotation of this ring.

Most of the shutters you'll encounter will use five blades. Some less refined versions will use three. But the concept of operation will be the same in both cases. The blade shape shown in Fig. 42 is typical of most five blade shutters. And each of the five blades will be the same.

The shutter blades and blade operating ring operate on a platform called the **shutter mechanism plate,** Fig. 43. The blade operating ring rides in a milled out channel (race) in the mechanism plate. When the blade operating ring is installed in the race, its top surface will be flush with the surface of the mechanism plate, Fig. 44.

The studs on the mechanism plate and the pins on the blade operating ring fit the cutouts in the shutter blades. The elongated cutout is sized for the mechanism plate stud. And the blade operating ring pin fits through the small, round blade cutout, Fig. 45. Move the blade operating ring in a clockwise direction and the blade(s) will pivot towards the center of the opening, Fig. 46. Reverse the direction and the blade(s) will pivot to the open position, Fig. 45.

Shutter blades are **always** assembled in sequence. Each blade overlaps the blade previously installed, Fig. 47. The illustration shows a clockwise installation sequence. But some

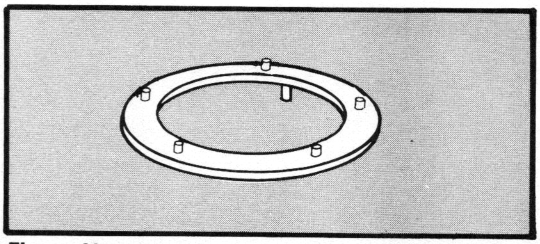

Figure 41

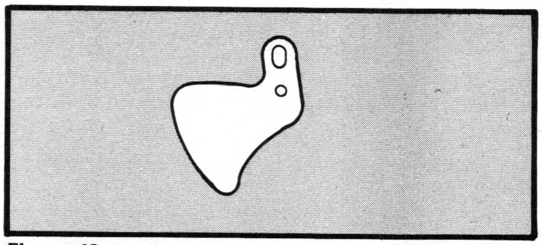

Figure 42

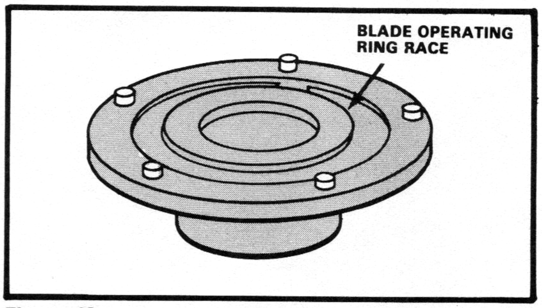

Figure 43

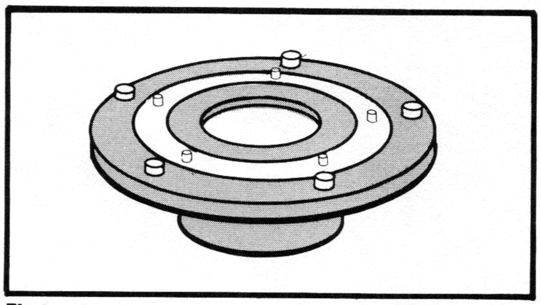

Figure 44

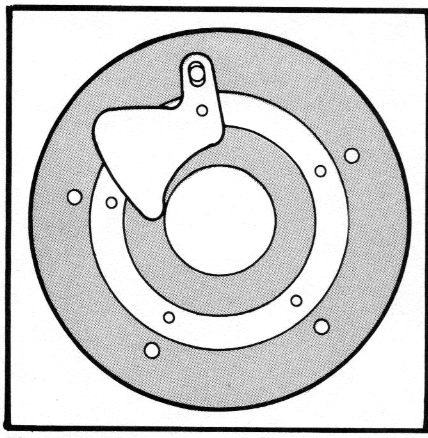

Figure 45

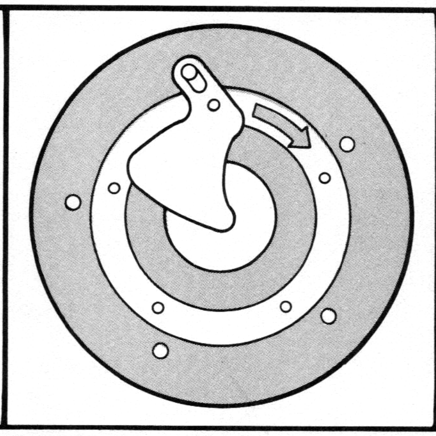

Figure 46

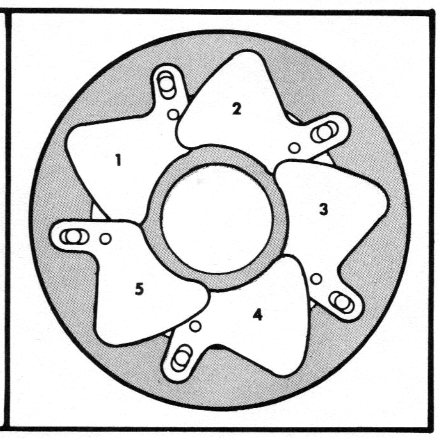

Figure 47

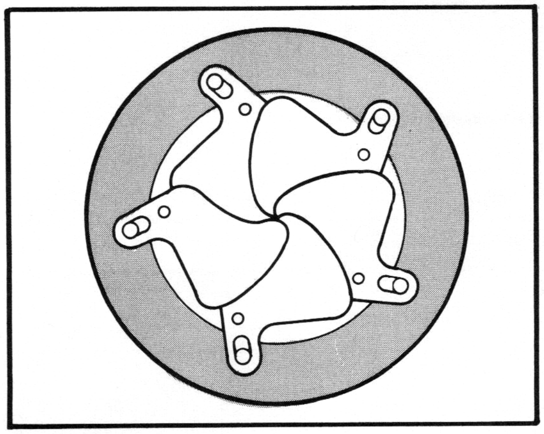
Figure 48

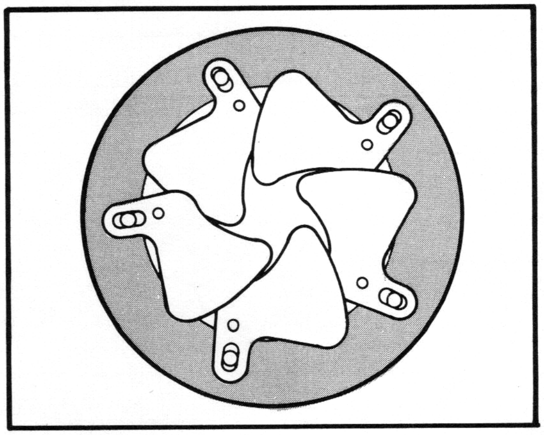
Figure 49

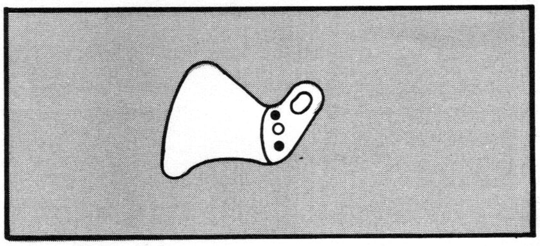
Figure 50

shutters use a counterclockwise order. In either case, the operational principle is the same. Simply make note of the directional sequence during disassembly. Then replace in the same order.

Figs. 48 and 49 show the blades in their closed and half-open positions. We've already learned that the blade opening and/or closing time is extremely fast — two milliseconds or less each way for multiple-blade shutters. Such rapid movement is possible because the blade operating ring need only rotate a short distance to move the blades from closed to full open — or vise versa. Other contributing factors are the low mass and close tolerance fit of the moving parts.

Even though the shutter blades are quite thin (less than .003″ thick), they're relatively durable. Made of nitered blue steel, they'll usually last the life of the shutter. That is, providing the shutter is properly maintained. And not subjected to abnormally hard usage. The latter usually results in the distortion of the elongated cutouts.

Always use tweezers to handle shutter blades during a repair. NEVER use your fingers. The acid from your skin can permanently etch your fingerprint into the blade.

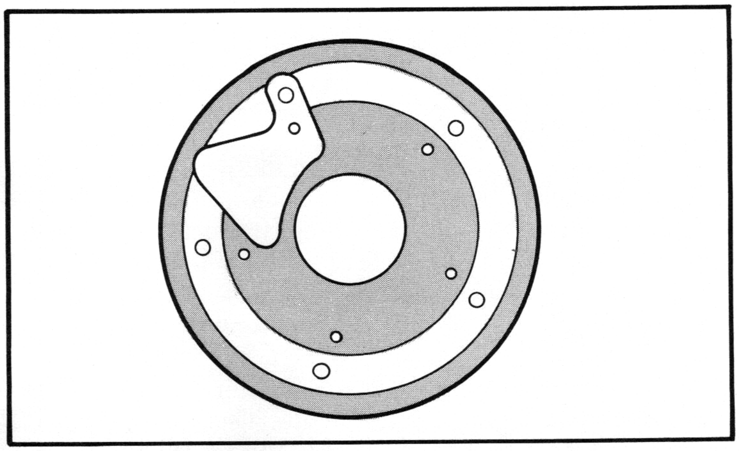
Figure 51

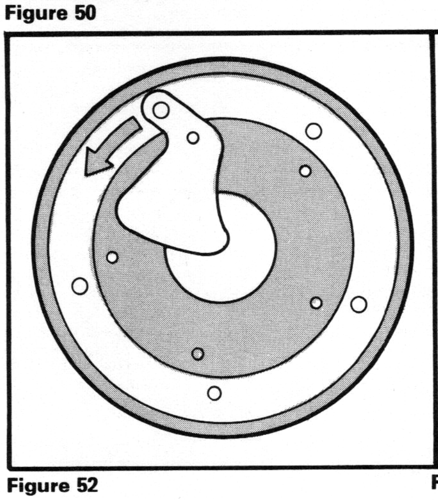
Figure 52

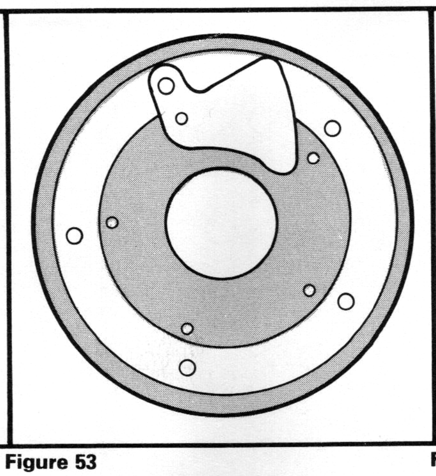
Figure 53

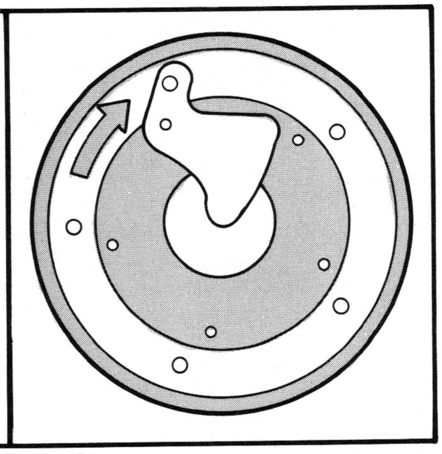
Figure 54

You'll run across some shutters with six blades. This sixth or "extra" blade is used as a spacer. And takes up any play that might be present in the blade assembly. It is located on the same stud and pin as the first blade, but is installed last on top of all the other blades.

Another variable you'll see is the "reinforced" shutter blade. An extra ply of blade material is riveted to the cutout end of the shutter blade, Fig. 50. This helps decrease the possibility of hard usage distortion in the elongated cutout.

The shutter blades aren't always driven by pins on the blade operating ring. Sometimes the moving pin/fixed stud technique will be reversed. In this design the pins are affixed to the mechanism plate. And the studs are on the blade operating ring, Fig. 51. Observe the fixed and moving part relationships between this design and the one shown in Fig. 45. Then compare the same relationships between Fig. 52 and Fig. 46.

Sometimes you'll find a reversed blade position, Figs. 53 and 54. The only operational change is in the blade operating ring rotation — clockwise to close and counterclockwise to open.

We've covered most of the shutter blade and blade operating ring variables you'll encounter. There are a few others, but you'll be learning about them later in your course. For now, just make sure you grasp the basic principles of operation we've discussed.

The rest of the shutter's mechanism (except for the diaphragm assembly) is located on the opposite side of the mechanism plate. It is linked to the shutter blades via a long stud on the back of the blade operating ring, Fig. 41. This stud protrudes through a slot in the mechanism plate, Fig. 43. And is contacted by the **leaf lever** on the other side of the plate.

The leaf lever's function is the same as in the two-blade shutter. That is, it opens and closes the blades. But not by direct contact with the blades — the blade operating ring has taken over that job. Now the leaf lever controls blade movement by activating the blade operating ring.

The leaf lever moves in an arc opposite the rotation of the blade operating ring, Fig. 55. As mentioned earlier, the blade operating ring need only move a short distance to open and close the blades. How short a distance? You can visualize the amount by studying the illustration in Fig. 56. The average arc of blade operating ring rotation will be about 10°. In a small shutter (small diameter blade operating ring), the circumferential distance of a 10° arc can be as little as one tenth of an inch or less. Obviously the larger the blade operating ring's diameter, the greater the distance it must travel to open and close the blades.

6

Since the leaf lever controls blade operating ring movement, its travel must equal that of the blade operating ring. To do so it has to swing in a wider arc. That's because of its shorter radius, Figs. 55 and 57.

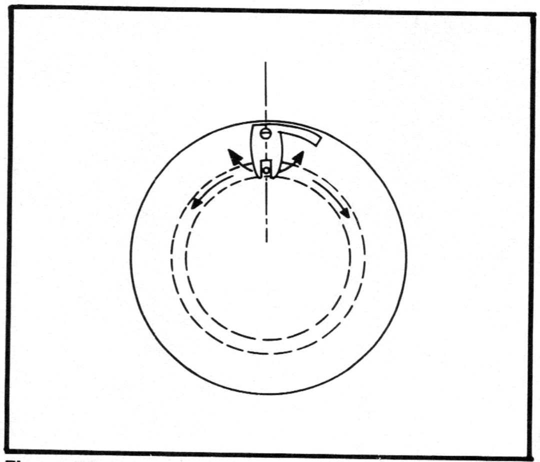

Figure 55

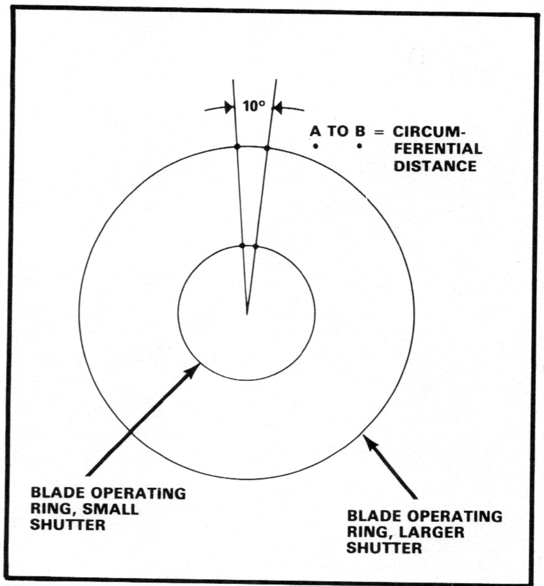

Figure 56

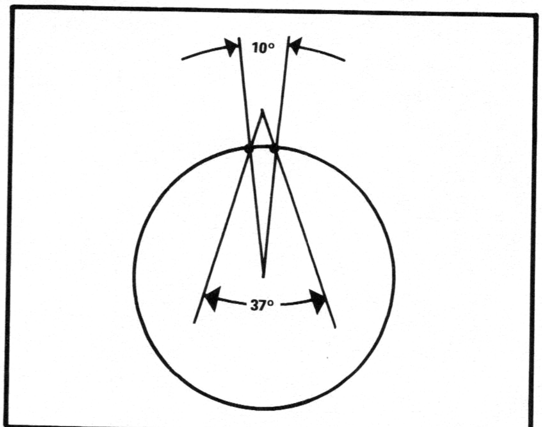

Figure 57

There's an almost infinite variety of leaf lever shapes and designs used in multiple-blade shutters. So no one design can be considered typical. Nevertheless, the leaf lever's role will always be the same — to control blade operating ring movement.

Three more parts are needed to complete the shutters basic sequence of operation — the **main lever,** the **setting lever** (sometimes called the cocking lever), and the **release lever.** These parts are as diverse in design as the leaf lever. So we'll limit our discussion just to their function within the shutter. Detailed explanations and "hands on" practice will be a part of the assignments that follow.

The main levers basic function is to control leaf lever movement. A few designs control movement in only one direction. That is, the main lever opens the blades via the leaf lever. And then the leaf lever spring takes over to close the blades — just like the two-blade shutter. However, most contemporary main levers control leaf lever movement in both directions — open AND close. In other words, the main lever has ultimate control over shutter blade action. And it maintains that control through the entire exposure cycle.

To achieve the action described, the main lever must first be moved to its "set" or "cocked" position. That's the setting or cocking lever's job. A portion of the setting lever protrudes through the housing containing the shutter mechanism. This allows the setting lever to be activated (moved) from outside the shutter housing.

Part of the release lever extends beyond the confines of the shutter housing. And is also activated externally. Both parts (setting lever and release lever) are contacted and operated by linkage in the body of the camera. Transport the film, and the linkage to the setting lever goes into action. Depress the body release, and another set of linkage transfers movement to the release lever.

When the shutter is removed from the camera, both levers can be operated manually (by hand). In some cases, such as a shutter mounted on a lens board, manual setting and releasing would be the normal mode of operation.

The release lever's primary task is to hold the main lever in its cocked position. It's also holding the main lever against the tension of its drive spring. (The main spring is tensioned during the main levers setting cycle.) Activating the release lever will free the main lever to complete the exposure cycle.

You're already familiar with two of the main springs identifying characteristics — weight (cross sectional diameter) and configuration. And again, the main spring must do multiple duty. It must have sufficient power to drive the main lever, plus all the parts controlled by the main lever's action. That includes the leaf lever, blade operating ring and shutter blades. (It also powers the retard mechanism — we'll get to that in a moment.)

Fewer demands are placed on the other springs in the shutter. Most have only one function. And that's to hold or return parts to their rest positions. This is the case with the release and setting lever springs. The leaf lever spring's function will vary, depending on main and leaf lever design.

TEST-YOURSELF QUIZ #3

1. The blades in a multiple-blade shutter are always installed in SEQUENCE.

2. Shutter blades should never be handled with the fingers. Why? ACID FROM YOUR FINGERS CAN PERMENTLY ETCH THE BLADE

3. The leaf lever's travel equals that of the blade operating ring. But it must swing in a wider arc to do so. Why? BECAUSE OF ITS SHORTER RADIUS

4. The main lever in most modern multiple-blade shutters controls leaf lever movement in both directions — open and close.

   True ✓ False____

5. What part holds the main lever in the cocked position? RELEASE LEVER

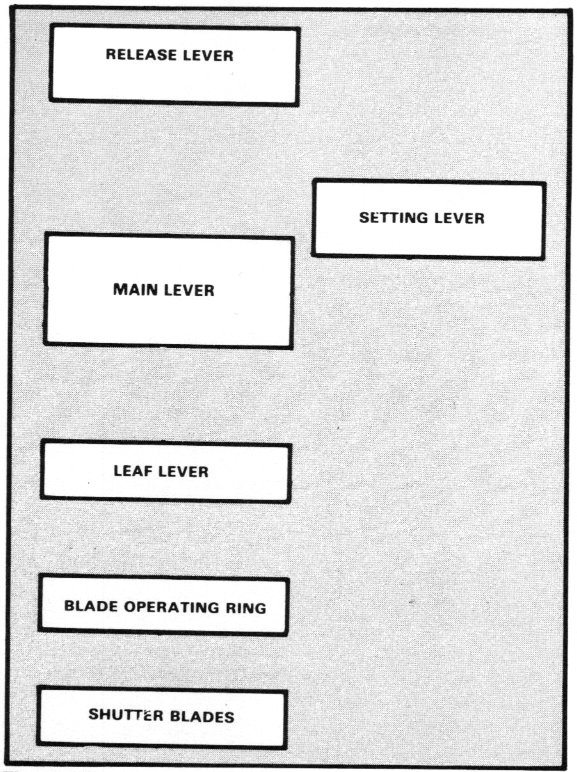

Figure 58

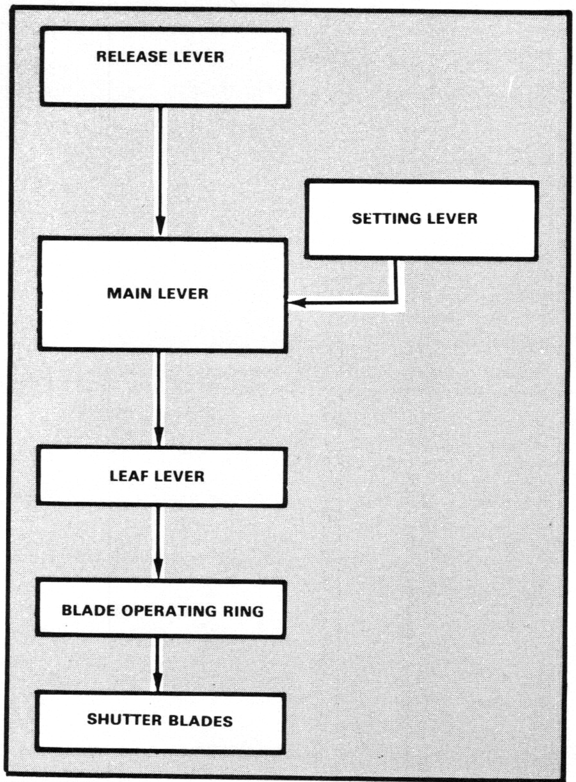

Figure 59

CHARTING THE SHUTTERS OPERATIONAL SEQUENCE

The following is a list of the moving parts we've discussed. And the order in which they were introduced.

1. Shutter Blades
2. Blade Operating Ring
3. Leaf Lever
4. Main Lever
5. Setting Lever
6. Release Lever

Reverse the sequence and with one exception, we have the actual order in which the parts are activated during an exposure cycle.

1. Release Lever
(2. Setting Lever)
3. Main Lever
4. Leaf Lever
5. Blade Operating Ring
6. Shutter Blades

(The setting lever is the exception. Its action is preparatory. And occurs prior to the exposure cycle.)

Our list gives us a pretty good picture of the sequential activation of the shutter parts. But there's another more effective technique we can use. And that's to chart or diagram the action. This is especially true when you're working with a large number of interrelated parts.

We've already taken the first step in making up an operational sequence chart. And that's to make a list of all the parts involved in the action. (Actually our list is incomplete because the springs are not shown. But we'll get to that in a moment.) Now we can start the diagram by organizing the sequenced part names into a spaced column. And drawing a box around each part, Fig. 58. Notice that we pulled the setting lever off to the side of the main shutter action.

The next step will be to indicate the direction of control. And the physical contact between parts. We'll use connecting lines and arrows to identify these actions, Fig. 59.

Only a few items remain to complete the diagram. One is the external input that starts the action. Since all action is initially activated by the finger, we'll indicate this activity by adding the word "finger" to the head of the column. And then draw in the appropriate connecting lines and arrows, Fig. 60.

We'll also need to identify the springs. But the name doesn't have to be spelled out — that would cause too much congestion in the diagram. We'll abbreviate instead. Just connect a blocked S to the part it operates, Fig. 61. Notice that we've also used an abbreviated symbol (blocked H) to represent the shutter housing, mechanism plate, stud or other nonmoving part. The double ended connecting arrows indicate spring action only.

Our chart (Fig. 61) now contains all the parts we've discussed. You'll be required to construct similar diagrams for each practice mechanism you work on. The only difference will be in the complexity of the diagram.

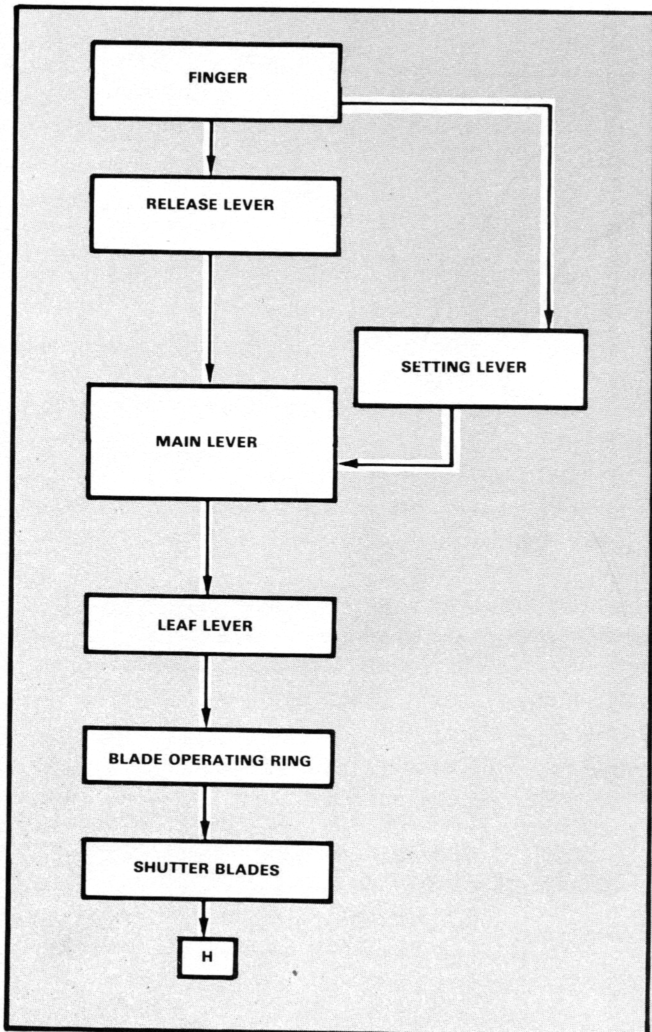

Figure 60

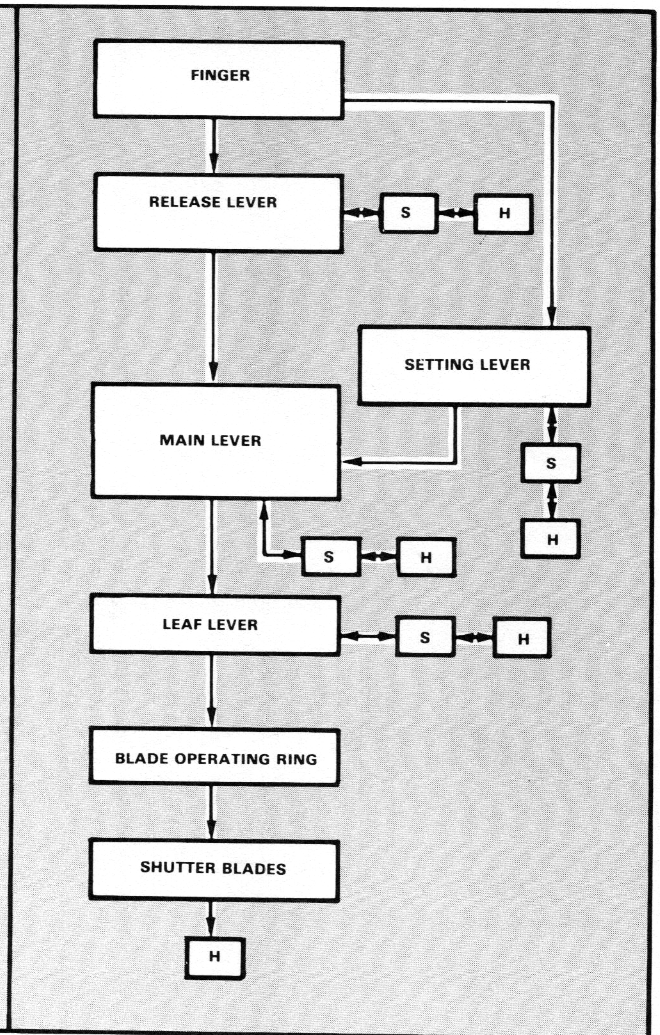

Figure 61

THE COMPLEX MULTIPLE-BLADE SHUTTER

The number of parts in a shutter dictate the complexity of the diagram. Our example chart only shows the parts in the main and preparatory shutter action — the parts needed to produce a single, instantaneous shutter speed. However, the multiple-blade shutters you'll be studying and working on are capable of producing a wide range of speeds. And that's going to increase the number of parts that need to be diagrammed.

You'll be learning about the speed controlling parts in detail in the lessons that follow. For now, we just want you to see how these parts relate to the actions already charted.

The speed controlling action is made up of the following basic parts:

1. Retard Mechanism
2. Speed Control Cam or Ring
3. Bulb Lever (and sometimes a Time Lever)

The retard mechanism regulates main lever movement. But only during the full open period of the main lever's travel. It's a "feed-back" type action. First, the main lever opens the blades. Then it contacts the retard mechanism. The power of the main spring drives the retard mechanism. Which in turn slows down the movement of the main lever. Once the retarding cycle is completed, the main lever is free to continue its travel and close the blades.

Now we'll add the retard mechanism to the chart. But with a slight change in the way we show direction of control. That's because of the feed-back type interaction between the two parts. So we'll use the most appropriate means of showing that two-way action — the opposing connecting arrow, Fig. 62. This also helps differentiate between retard and spring action.

Diagraming the retard mechanism itself can be a little more involved. It all depends on the speed range of the particular retard being charted. The most complex retards are capable of controlling speeds as long as one second. Other simpler units deliver maximum exposure times of only 1/10 or 1/25 second.

The retard device you'll see most often is the **escapement** mechanism. An escapement is a train of gears ending with a **star wheel** and **pallet,** Fig. 63. When the gears and star wheel rotate it sets up a rocking or seesaw motion to the pallet. The pallet, in turn, permits the star wheel to rotate only one tooth at a time. This is the action that slows down the movement of the gear train. In effect, the rocking of the pallet allows each tooth of the star wheel to "escape" past its prongs. Thus, the term escapement.

A diagram of the typical escapement mechanism would appear as shown in Fig. 64. The construction has been simplified by substituting the word "gearing" for the individual gears of the escapement. (The number of gears will vary between different designs.)

The pallet is mounted on a moveable platform — **the pallet control lever.** This moveable mount positions the pallet for two different modes of operation: full engagement or no engagement with the star wheel. When the pallet is engaged the mechanism operates as an escapement retard. Disengaged, the mechanism functions as a **geared inertia retard.**

The main lever contacts and drives the escapement mechanism via the retard lever. The escapement, in turn, slows down the main lever's movement during its period of contact with the retard lever. That period of contact may be as long as 1 second or as short as 1/250 second.

But what determines the duration of main lever/retard lever contact? That's where the speed control cam comes in. It controls shutter speed by varying the amount of retard lever stroke and pallet engagement. For example, it permits full 7.
retard lever stroke and full pallet engagement on the 1 second setting. It also allows full pallet engagement on the 1/2 second
10. through 1/15 second settings. But with decreasing amounts of retard lever stroke.

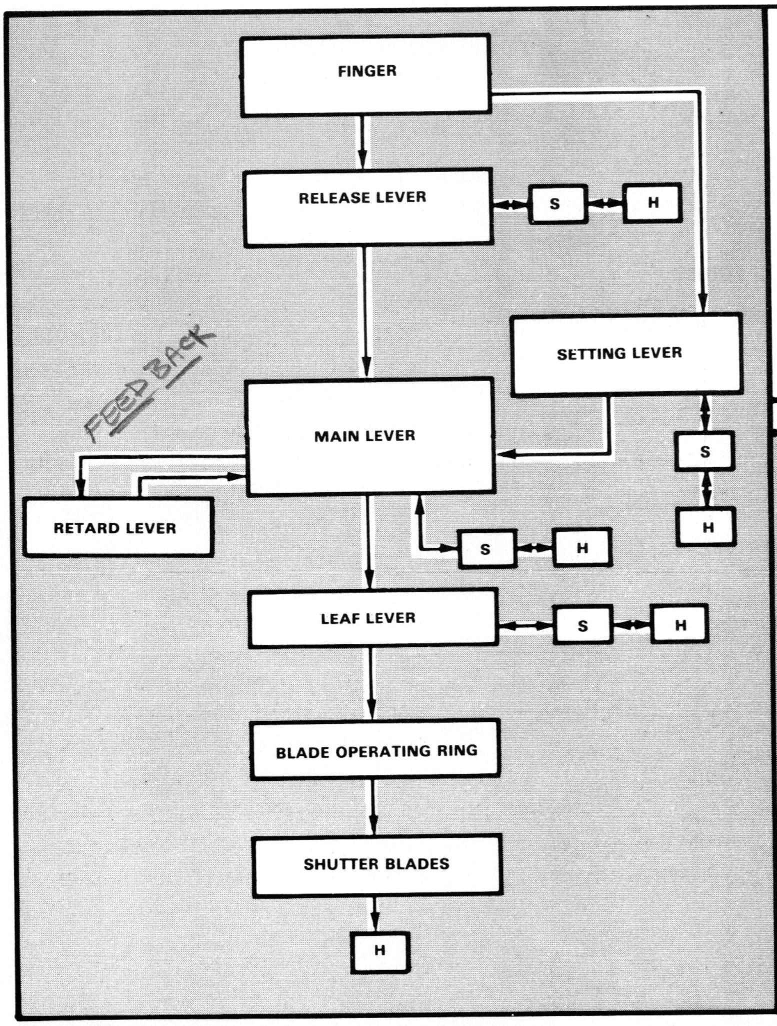

Figure 62

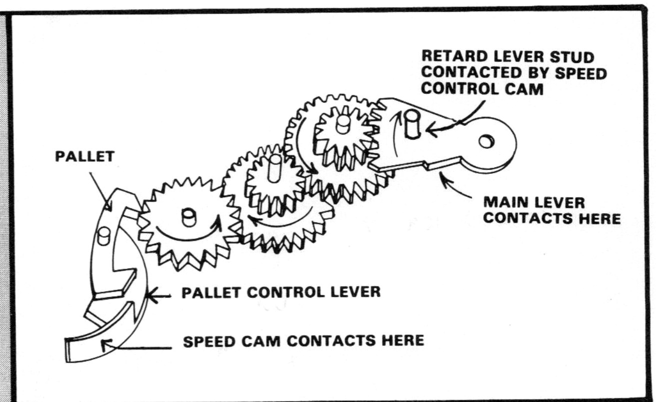

Figure 63

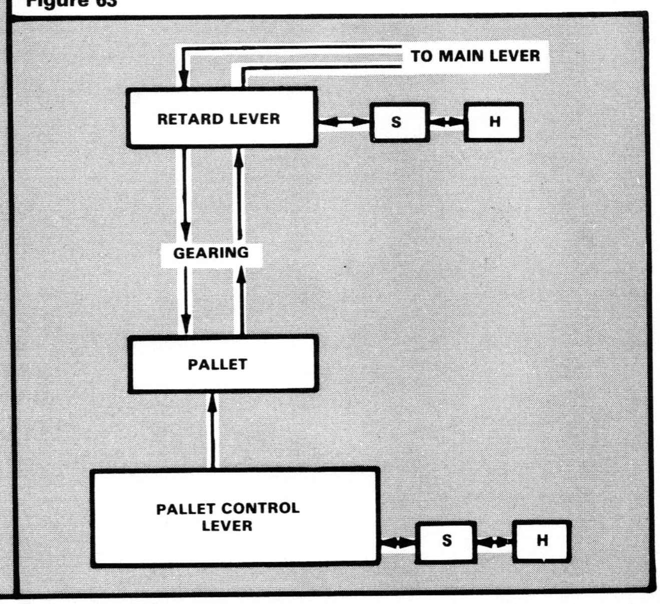

Figure 64

Full retard lever stroke is again permitted on the 1/30 second setting. But the pallet is completely disengaged. And re- 9 mains disengaged for all speeds 1/30 second and faster. Even with a full retard lever stroke, the movement of the gear train is 8 much faster. Its now acting as a geared inertia retard instead of an escapement. Each consecutive faster speed setting decreases retard lever stroke until the retard lever is no longer allowed to contact the main lever. That's the highest speed setting.

> You'll occasionally encounter shutters using a separate high speed spring for the fastest setting. Here, the retard lever deactivation occurs at the next to fastest speed setting. Then the extra power of the high speed spring is employed to achieve the top speed.

The retard lever spring (Fig. 64) serves no purpose during the exposure cycle. Its only function is to return the retard lever (and gear train) to the "ready" position. This action occurs during the setting cycle.

If the shutter is set at a non-pallet speed (1/30 sec. or faster), the relatively light retard lever spring will return the retard mechanism quickly. However, if the pallet is engaged it can take several seconds to return to the ready position. So, most shutters provide a solution to the problem — they automatically disengage the pallet after the exposure has been completed. Usually an additional lug on the blade operating ring moves the pallet control lever (and pallet) out of engagement when the blades are in the closed position. (But the pallet is freed to engage when the blades open. And the shutter is set on a pallet speed.)

A few shutters use an extension on the setting lever to disengage the pallet during the setting stroke. In even less frequent cases, an additional lug on the main lever moves the pallet out of engagement during the cocking cycle.

The pallet control lever also has its own spring (Fig. 64). And its job is relatively simple — to maintain tension against the pallet control lever. This, in turn, keeps the pallet engaged with the star wheel. The speed control cam (and other pallet disengaging parts) work against the tension of this spring when they disengage the pallet control lever (and pallet).

Now we'll add the escapement, speed control cam and connecting arrows showing direction of control to the chart, Fig. 65. Only one speed controlling part remains — the bulb lever.

The speed control cam holds the bulb lever immobile on all instantaneous speed settings. But the bulb lever is free to move on the bulb (B) setting. When the shutter is released on that setting, the "B" lever will intercept the main lever at its full open position. The main lever will remain locked in that position until pressure is removed from the release lever. Then as the release lever returns to its rest position, it disengages the

B lever from the main lever. This action is accomplished by a lug on the release lever which, depending on design, either pulls or pushes the B lever out of engagement.

Some shutters also have a time (T) setting. When this is the case, the time lever works in conjunction with the bulb lever. (Both levers are free to move on the "T" setting.) The bulb lever intercepts the main lever just like on the B setting. And when pressure is removed from the release lever, it pushes or pulls the B lever out of engagement with the main lever. But before the B lever is completely disengaged, the T lever moves into position to take over the job of blocking the main lever. At the same time, the T lever also locks the release lever before it can return all the way to its rest position. Now the shutter is locked open. And will remain in that state until the release lever is depressed again. Depressing the release lever a second time unlocks the release lever from the T lever. Then when pressure is removed, the release lever will push the T lever out of engagement.

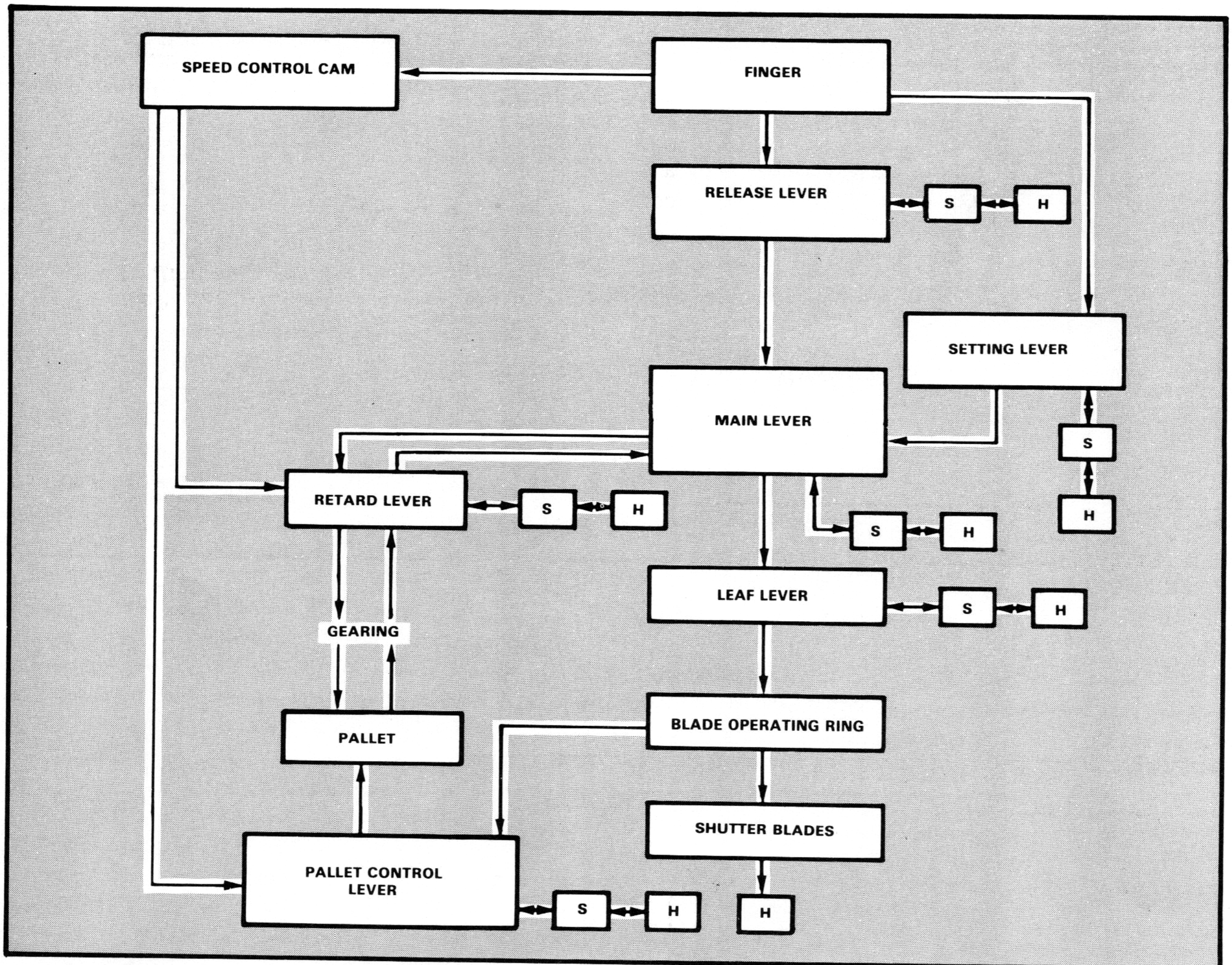

Figure 65

If the B and T action sounds confusing, don't be concerned. It'll clear up once you've had the opportunity to observe the parts in action. In the meantime, we'll add the levers, springs and direction of control to our chart, Fig. 66.

We've indicated individual springs for the B and T levers. This is the norm. But occasionally a single spring is used to operate both levers.

Our "typical" chart is almost complete. Only one component remains — the diaphragm. As mentioned in your text "The Camera and Its Variations," the diaphragm consists of a set of overlapping leaves (blades). And they operate in unison

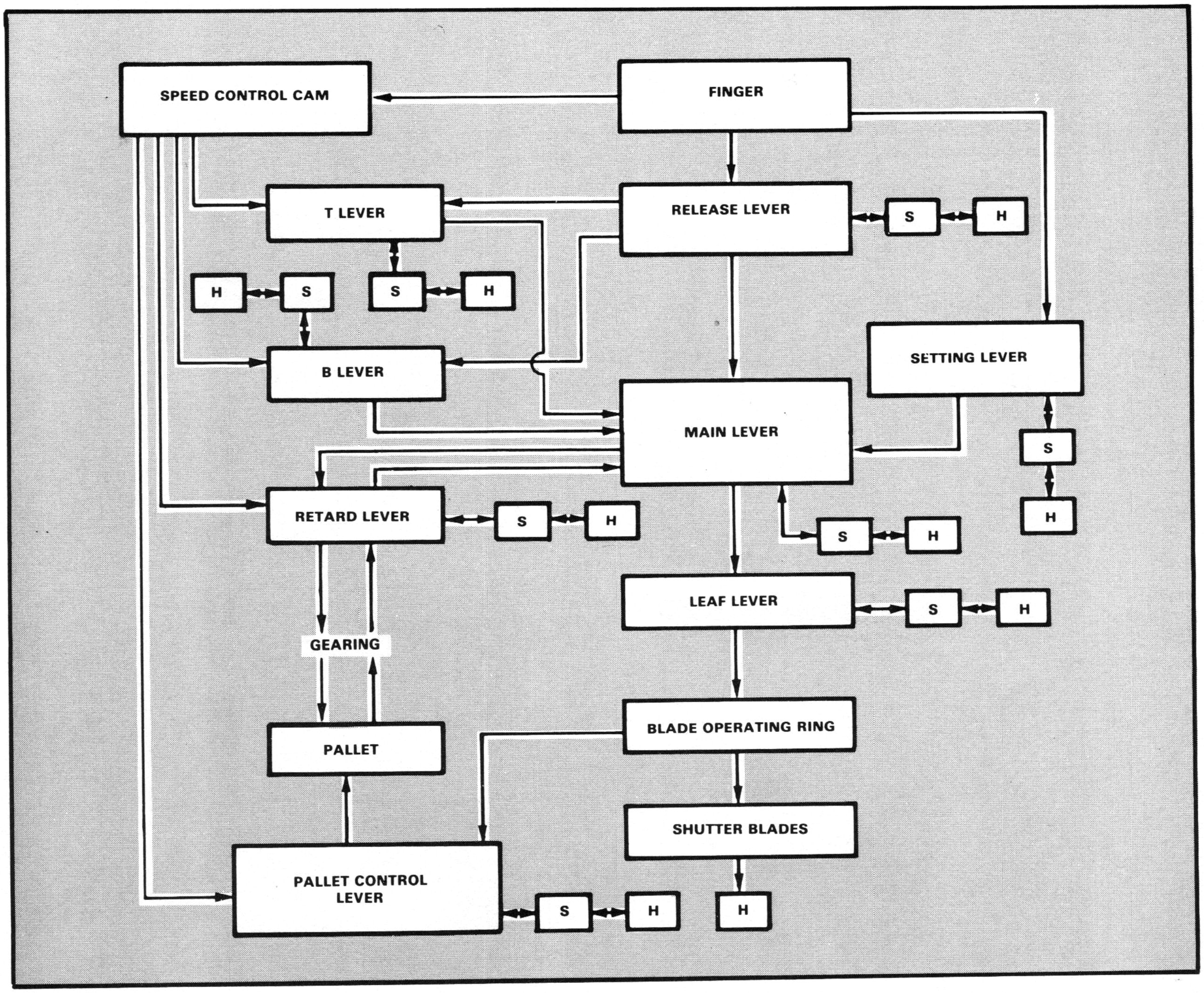

Figure 66

via a control ring. Though not precisely the same, the operation is similar to that of the shutter blades and blade operating ring.

Charting the diaphragm is easy. It functions as a complete assembly. And is activated manually, with no linkage to the rest of the shutter mechanism, Fig. 67.

In future assignments, we'll refer to the operational sequence chart as a **"cycle-of-operations."** The terminology may be different, but the concept and general layout will be the same. And that's an important point to remember. Always apply the basic rules of cycle-of-operation construction, regardless of the shutter's degree of complexity.

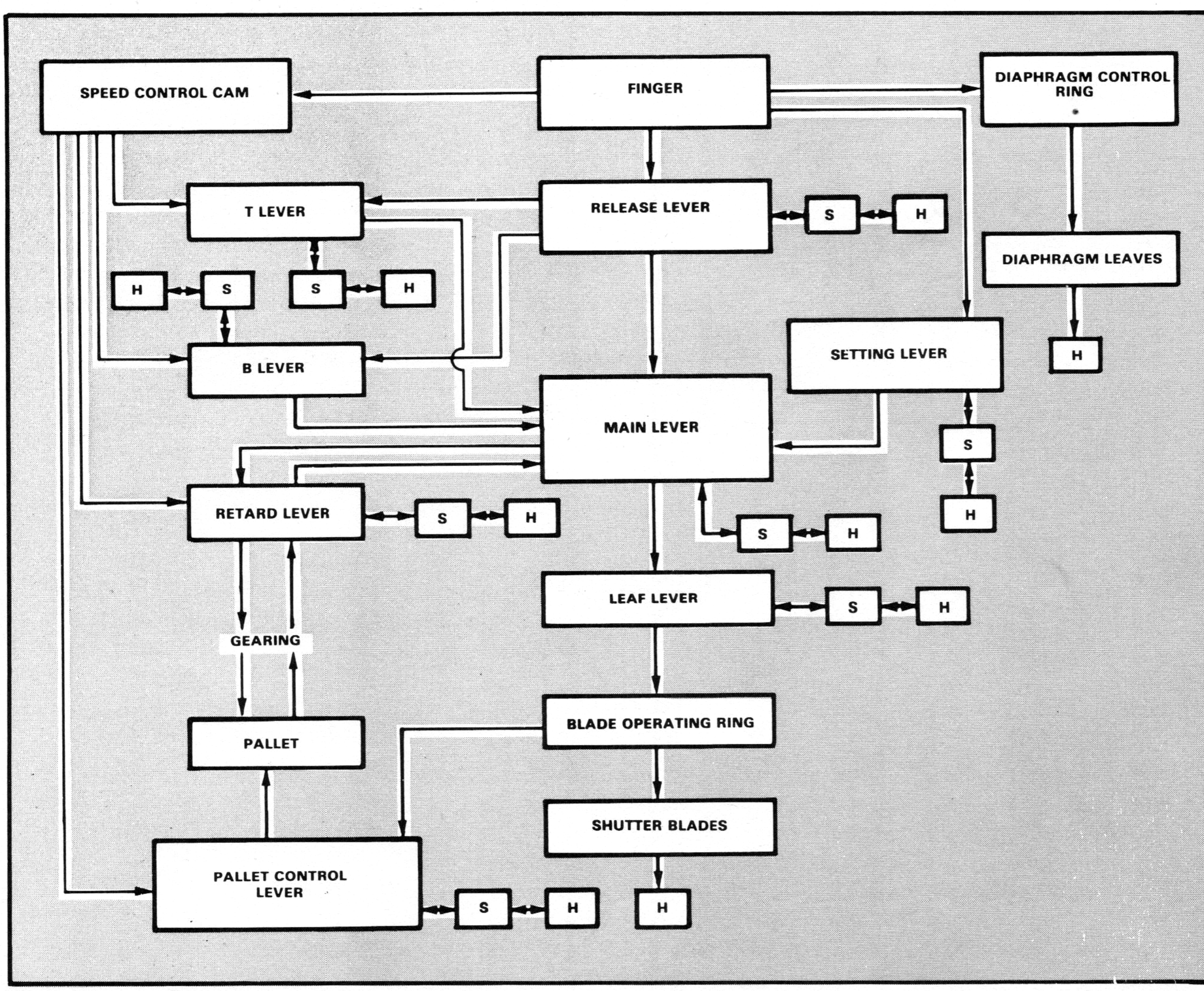

Figure 67

THE SIMPLE MULTIPLE-BLADE SHUTTER

Not every shutter you'll encounter will be more complex than the basic "**set and release**" designs discussed in this lesson. For example, some multiple-blade shutters don't require a separate setting or cocking action. They're called "**single-action**" shutters.

In the single-action design the setting lever is eliminated. And the release lever takes over the cocking duties. The shutter is both cocked and released in a single stroke of the release lever.

The main lever is carried to its set position by the downward stroke of the release lever. And then released just before the end of the stroke. The remainder of the shutter's operational sequence is the same as in the set and release design.

Though simpler in construction, there's one big drawback to the single-action design — a long and heavy release action. The set and release type simply unlatches the pre-set main lever on the release stroke. That requires a relatively short and soft release action. In contrast, the single-action release must move the mass of the main lever from its rest to set position. Plus tension the main spring.

A limited speed range is another characteristic of the single-action shutter. And that equates with simpler retard mechanism design. The geared inertia retard is the most common. Followed by less elaborate versions of the escapement retard. Less elaborate in that the gear trains are much shorter. And the pallets are non-adjustable.

In both retard types, the speed range will be about the same. With full retard stroke, maximum slow speed durations will be around 1/10 to 1/8 second. Top speeds will vary anywhere from 1/100 to 1/300 second, depending on shutter size and other design factors.

An even more limited range of speeds is provided by two other methods of speed control:

1. varying the tension on the main spring.
2. varying the length of the main lever's engagement with the leaf lever.

Both methods are rather primative in comparison to the geared retards. But they do provide an inexpensive, simple means of obtaining a two or three speed variation in speed control.

In the first method, the free end of the main spring is contacted by the speed control lever. Moving the speed control lever either increases or decreases the initial tension placed on the main spring. This in turn regulates the main lever's speed of operation.

The variable main lever/leaf lever engagement system is a little more sophisticated. Here, a portion of the speed control lever is in the form of a ramp. And the leaf lever end of the main lever rides against the ramp. On the fastest speed setting, the main lever operates against the highest point on the ramp.

This disengages the main lever from the leaf lever immediately after opening the blades. But on the slowest setting, the ramp is moved out of the way. The main lever can then stay in contact with the leaf lever longer. This allows the leaf lever to hold the blades open for a longer exposure.

A **retard weight** is used in conjunction with the two speed control systems just described. It's a pivoting weight which moves in unison with the leaf lever. And helps provide a more uniform movement of the leaf lever (and shutter blades). Similar weights are sometimes used in other shutter designs to snub or dampen the action of certain parts.

TEST-YOURSELF #4

1. The connecting lines and arrows in an operational sequence chart indicate the DIRECTION OF CONTROL and the PHYSICAL ACTION between parts.

2. Double ended connecting arrows show what kind of action? SPRING ACTION

3. Opposing connecting lines and arrows indicate:
   A. a feed-back type action. (like the action provided by a retard mechanism.)
   B. a blocking action. (like the action produced by the bulb and time levers.)

4. When the pallet in an escapement retard is disengaged, the mechanism becomes a GEARED INERTIA retard.

5. What part determines the duration of the main lever's contact with the retard lever? SPEED CONTROL CAM.

6. Most complex shutters disengage the pallet during the setting stroke. Why? IT WOULD TAKE A FEW SECONDS TO RETURN TO THE READY POSITION

7. How do you distinguish a single-action shutter from a set and release shutter? THE SETTING LEVER IS ELIMATED, THE RELEASE LEVER COCKS AND RELEASES IN A SINGLE STROKE OR ACTION

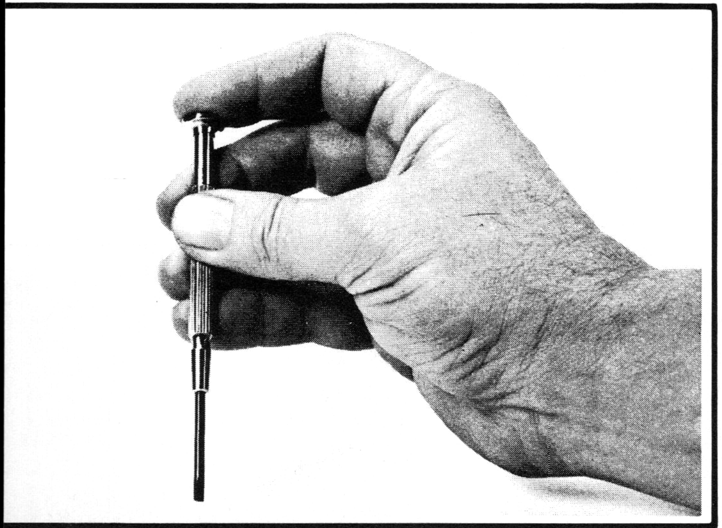

Figure 68

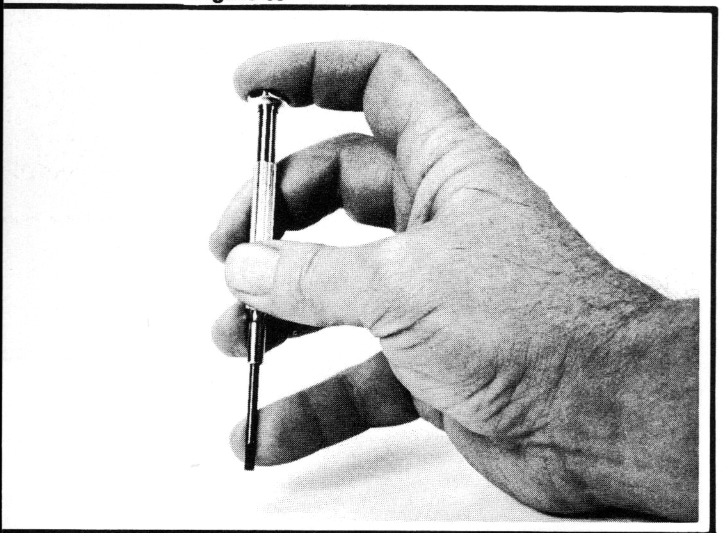

Figure 69

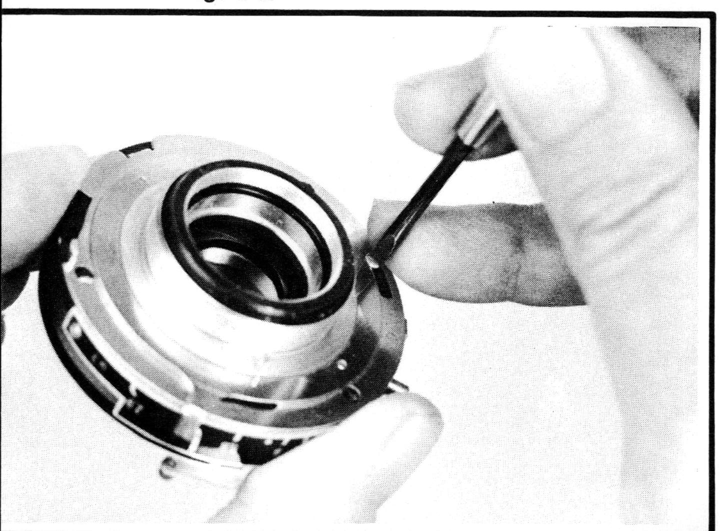

Figure 70

TOOL HANDLING TIPS

You'll soon be making your first practice mechanism disassembly. And you'll be using tools — jewelers screwdrivers and tweezers — which may not be familiar to you. Expertise in handling these tools will only come with practice. But you can exercise the proper techniques in their use right from the beginning.

THE JEWELERS SCREWDRIVER

The jewelers screwdriver is manipulated and controlled exclusively by finger action. Achieving precise control requires a light, but positive touch and the correct positioning of the fingers in relation to the tool.

Fig. 68 shows the traditional jewelers screwdriver finger/tool relationship. The first finger rests on the swivel head. And the knurled portion of the driver is rolled (turned) between the thumb and other fingers.

Another position is used when loosening or starting screws. The fingers are spread along the length of the driver, with the last finger at the tip of the blade, Fig. 69. This stabilizes the driver so the blade can be guided easily into the screw slot.

The spread finger position also permits more positive control of the driver when breaking stubborn screws loose, Fig. 70. In this situation it is imperative that you apply strong downward pressure with the swivel head finger. The finger at the tip of the blade will prevent the blade from slipping out of the slot, while the thumb and other fingers supply the twisting force needed to break the screw loose.

Once the screw starts to turn easily, the fingers are slid back to the normal position, Fig.68. And the screw is run out.

A screwdriver should never be manipulated without bracing the side of the wrist and forearm against the top of the workbench. Also, the driver should always be aligned and centered with the screw to form a continuous axial center line. Operating the driver at an angle to the screw can damage the slot, head or both.

Screwhead damage can also be caused by using the wrong size screwdriver. Select a blade width as close to the screwhead diameter as possible. If the blade width is too small it will distort the screw slot. And too large a blade can mar the area around the screw. This is especially true with countersunk screws. Also, the internal threads of a setscrew hole can be completely destroyed by too wide a blade.

One of the most common errors made by the novice technician is over and/or under-tightening screws. Applying the proper amount of torque is mainly a matter of feel and common sense. If the threads are in good condition, a screw will turn quite freely during its penetration into the threaded hole. Then a point is reached where resistance is felt. That's when the final tightening of the screw begins. From this point, a moderate amount of rotational finger pressure will snuggly tighten the screw.

There's a relatively fine line between snug and over tightened. Apply too much pressure beyond the snug point and the threads might strip. Or the screw head will snap off.

An under-tightened screw won't cause any damage during assembly. But it can create havoc once it works loose during the normal course of operation.

THE TWEEZERS

Like the jewelers screwdriver, the tweezer is controlled mainly by finger movement. Even the basic finger/tool relationship is similar, Fig. 71. But that's where the similarity ends.

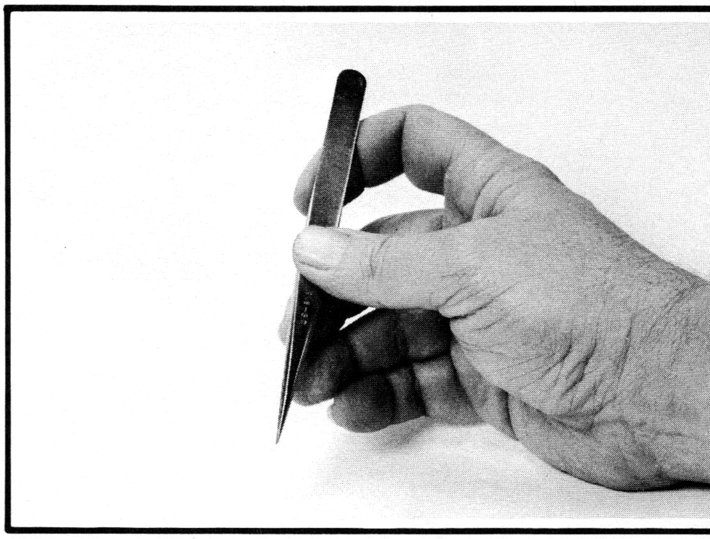

Figure 71

The tweezer's function is easy to visualize — squeeze the legs toward one another and you can grasp and manipulate any kind of small part. A simple action but not an easy one to execute properly.

Ideally, one leg of the tweezers should rest against the first two fingers while the thumb applies just enough pressure against the opposite leg to prevent the tool from slipping from your grasp. The tweezers then literally "floats" between the thumb and first two fingers. For best control, locate the thumb about mid-point between the first two fingers, Fig. 71.

To grasp and manipulate a part with finesse takes practice and the development of an acute sense of touch and feel. That may give you a clue to why we allow the tweezers to float. The thumb and fingers can then better "sense" the part being grasped.

The sensing activity starts with the thumb. Apply just enough additional thumb pressure to compress the tweezers **lightly** against the part. The contact will be physically "telegraphed" to and sensed by the fingers and thumb. Then it's a matter of interpreting the information and adjusting thumb pressure to precisely maneuver the part.

Thumb pressure is the key. Too little and the part is dropped. Too much and the part slips out of the tweezers grasp. Delicate parts can even be damaged by careless tweezer handling. The grasp must be light yet positive.

You'll also need to develop facility in regulating the tweezer's angle to suit the parts configuration and location in the mechanism. This can be controlled by rolling your wrist (and forearm) and/or drawing your second finger closer to, or away from, the palm of your hand. There's another, secondary finger/tool position we'll mention later.

Disconnecting and removing springs is one of the most common tweezer maneuvers. It's also an operation that's executed quite carelessly by many novice technicians.

Remember that a spring is under tension. And the act of disconnecting the spring is going to relieve that tension. How it's relieved is what's important. Tension should be let off slowly and under full tweezer control — never under the spring's own power.

Sometimes the coil of a torsion spring won't be retained by a screw or other retention device. It won't go anywhere as

Figure 72

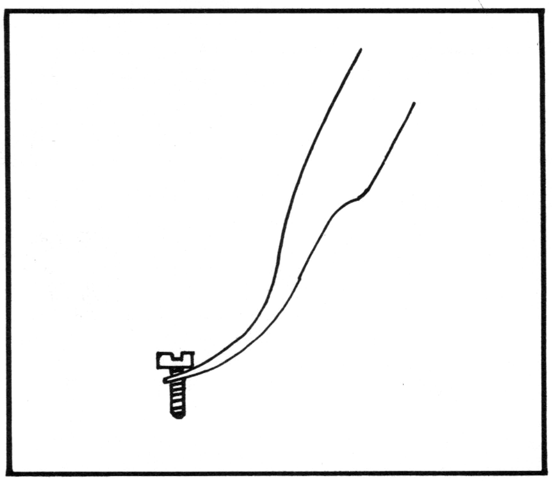

Figure 73

Figure 74

long as its connected and under tension. But disconnect it carelessly and the unwinding tension will propel the spring to places unknown.

It's relatively simple to prevent a spring from becoming airborne. Just keep the coils from moving off the post when you let tension off the spring. Fig. 72 shows one of the techniques that can be used. The screwdriver blade will retain the coils on the post. Then, when all tension has been removed, withdraw the blade. And the spring can be safely lifted from the mechanism. Reverse the procedure to reinstall the spring.

The straight tweezer illustrated is best for most fine mechanism work. However, there are a few situations where the curved leg (shank) tweezer can be advantageous. It's recommended that you become proficient with the straight style first. Then its easy to adapt the benefits of the curved shape when needed.

Screws can be maneuvered with either style tweezer. Usually it's just a matter of lifting a screw from the mechanism, or lowering it into position for starting. But on some occasions you'll need to support a screw for starting. And that's the curved type's forte.

Fig. 73 illustrates the physical advantage. The straight tweezers would have to be held horizontally — a difficult position **if** the screw is deep within the mechanism. In either case, it's a two-hand operation, Fig. 74. Once the threads are started, the tweezer is withdrawn.

As mentioned, the straight tweezer is sometimes held horizontally. This requires a different finger/tool relationship. It's similar to the way you would hold a dinner knife. The heel of the tweezer is against the palm. While the legs are held and operated between the thumb and first finger.

The tool handling techniques we've discussed are quite rudimentary. Yet, they're techniques that require concentration and practice. Hurried and thoughtless tool use can never be justified. And you'll pay the penalty with damaged and lost parts.

Be patient, and take your time.

TEST-YOURSELF QUIZ #5

1. Screw heads and screw slots can be damaged by (1) failure to stabilize the blade, (2) insufficient downward pressure on the driver, (3) using the wrong size screwdriver, (4) over-torquing the screw, and (5) OPERATING THE DRIVER AT AN ANGLE TO THE SCREW.

2. You should make sure that **every** screw is snuggly tightened. If just one internal screw is left untightened it might COME OUT DURING USE.

3. Why should you allow a tweezer to float in your grasp?

   TO PREVENT THE TOOL FROM SLIPPING

4. How can you prevent an unretained spring from flying into oblivion when it's disconnected? HOLD A DRIVER BLADE OVER THE COILS.

ANSWERS TO TEST-YOURSELF QUIZZES

QUIZ #1

1. The two factors that determine the shutter speed delivered by a disc-type shutter are (1) **how far the disc travels,** and (2) **how fast the disc travels.**

2. The speed is automatically controlled by a lever that sits in the path of the disc. Normally, the lever restricts the disc's movement. However, when a flashbulb is inserted, the lever is pushed out of the way. And the disc travels further.

3. A The motion-picture camera shutter **rotates continuously** — The film's movement is intermittent.

4. An **electromagnet** holds the blades open in an electronically controlled shutter.

5. A **between-the-lens shutter** is positioned between the elements of a lens. A **behind-the-lens shutter** is located directly behind the lens.

6. The Compur and Prontor shutters are manufactured in **Germany. Japan** is the country of manufacture for the Copal, Seikosha and Citizen shutters.

ANSWERS

QUIZ #2

1. **Yes.** It's common to a variety of blade-type shutters, simple and complex alike.

2. The hinged tip allows the main lever to move to its set position without disturbing the rest of the leaf lever.

3. (1) **The gage** (thickness or cross-sectional diameter) and (2) **the number of coils in the winding** govern a spring's strength.

4. The **torsion**-type spring is the most common. The **tension**-type is used less frequently.

QUIZ #3

1. Shutter blades are always installed **in sequence.**

2. **Always** use tweezers to handle shutter blades. The acid in your skin can permanently etch your fingerprint into the blade.

3. The leaf lever swings in a wider arc because **it has a shorter radius.**

4. T **True** -- Only a few multiple-blade shutter main lever designs control leaf lever movement in one direction.

5. The **release lever** holds the main lever in its cocked position.

QUIZ #4

1. The connecting lines and arrows indicate **direction of control** and **physical contact between parts.**

2. **Spring action** is shown by double ended arrows.

3. A A two-way or **feed-back type action** is indicated by opposing connecting lines and arrows.

4. If the pallet in an escapement retard is disconnected, the mechanism functions as a **geared inertial retard.**

5. The **speed control cam** (or ring) controls the amount of retard lever stroke. This in turn regulates the duration of main lever to retard lever contact.

6. Disengaging the pallet during the setting stroke allows the retard lever to move quickly to its ready position. If the pallet's engaged, it can take several seconds to reach position.

7. The **single-action shutter** does not require a separate setting action. The release lever both cocks and releases the shutter.

QUIZ #5

1. 5 Operating a screwdriver at an angle to the screw can damage the slot, head or both.

2. An untightened screw might work itself loose and jam the mechanism.

3. The floating tweezer grasp allows the thumb and fingers to better sense the part being held and maneuvered by the tweezer.

4. **By preventing the coils of the spring from moving off the post.**