In designing the world's first multi-mode, auto-exposure SLR, Minolta used revolutionary ideas to serve an evolutionary goal. The result is a brilliant, facile machine that extends and enhances the entire Minolta system.

Ever since the great "aperture-versus-shutter-speed-priority" debate began to surface in the early seventies, photographers and camera technicians have vociferously argued the merits and liabilities of each of these viable auto-exposure systems. Meanwhile, camera manufacturers and designers were quietly addressing themselves to two more profound and difficult questions, namely "Why can't we have both systems in the same camera?" and "How can we achieve this with a minimum of additional complication and extra cost?" It is now history that the first company to provide a concrete and affirmative answer to these speculations was Minolta, whose multi-mode XD-11 created an instant sensation when it was officially announced in late 1977. Subsequently, only one additional 35mm SLR with similar capabilities—the Canon A-1—has reached the marketplace, but the Minolta XD-11 has nevertheless established a clear trend and other similarly-featured cameras will surely follow.

Although it's understandable that one's technical interest would naturally gravitate to the XD-11's advanced metering system, it is important to realize that this landmark camera is not merely a technological freak or an object created to satisfy some marketing executive's dream. It is most emphatically a usable instrument, conceived in the Minolta tradition and grounded in Minolta's photographic philosophy. That philosophy is eminently simple—that a good camera should be capable of producing good quality pictures and accurate exposures easily, over the widest possible range of shooting conditions. It is precisely this kind of straightforward thinking that led to the development of the CLC (contrast light compensating) metering systems found in the extremely successful SR-T series of Minolta SLRs, and in numerous other successful photographic products.

While dissecting the XD-11's technical details, we will strive as far as possible, to keep Minolta's holistic design concept in mind, and as a result you will hopefully appreciate that there's a lot more to this brilliantly designed machine than a novel meter-

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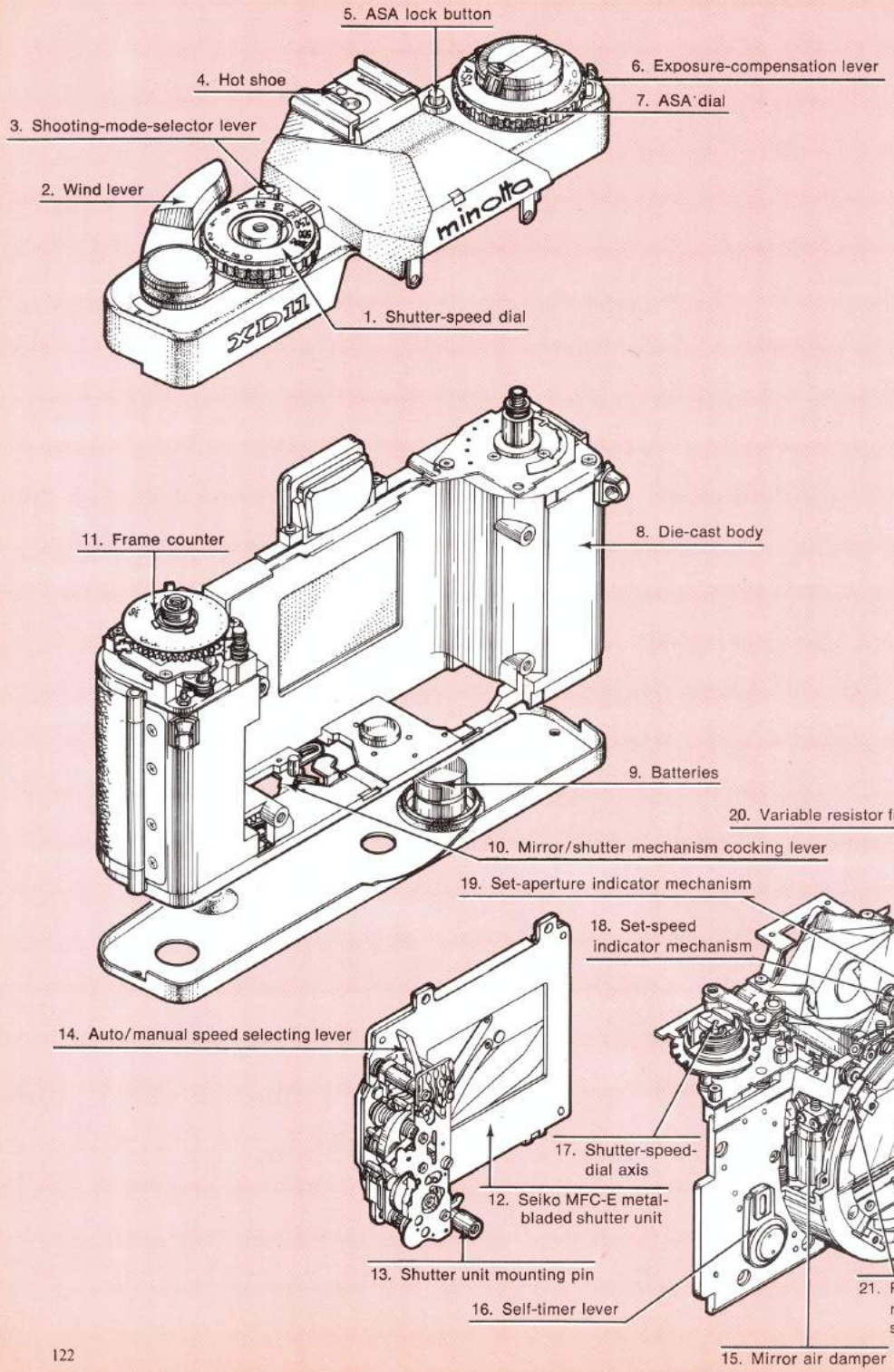
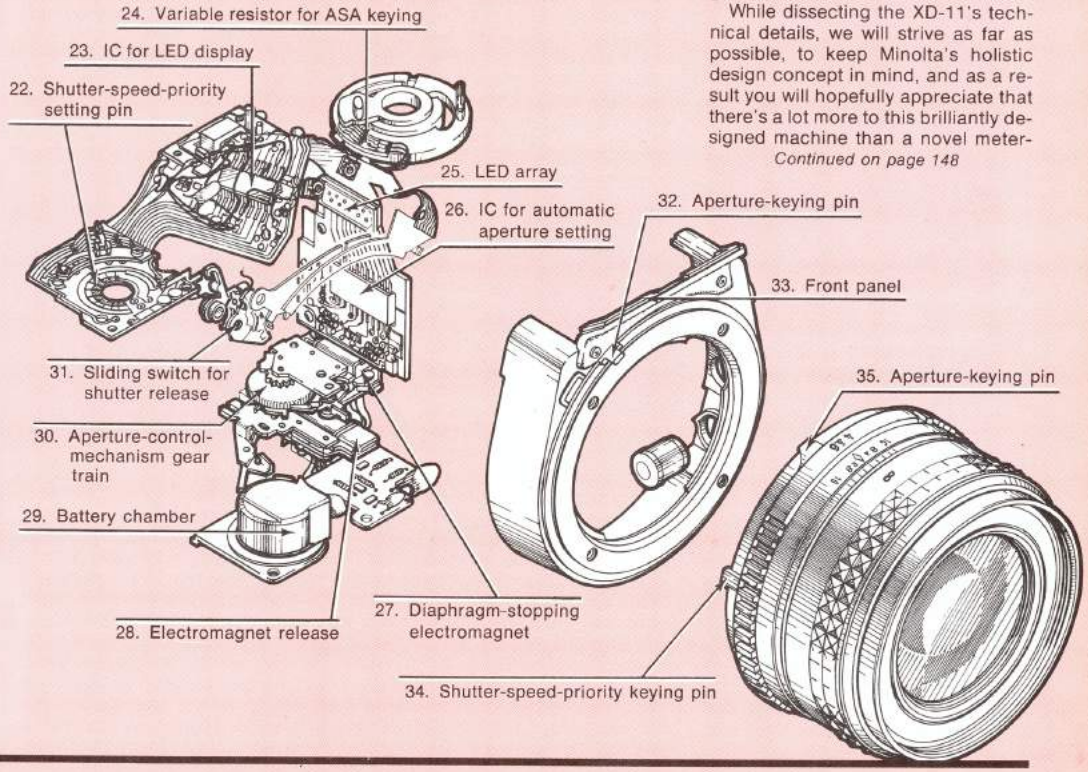




Disassembly and drawings by Tetsuo Koyama

ing system. As usual, we'll concentrate on the XD-11's most salient points and touch more lightly (if at all) on other areas.

3. The mode selector is a new kind of controlling device found only on multi-mode cameras. Until this new breed of camera was introduced, only one of the major exposure-determining factors was automated—either the lens aperture or the shutter speed. You had to set the other function manually. Furthermore, you weren't able to choose which factor you preferred to set manually and which you wanted to leave to the camera's auto-exposure mechanism.

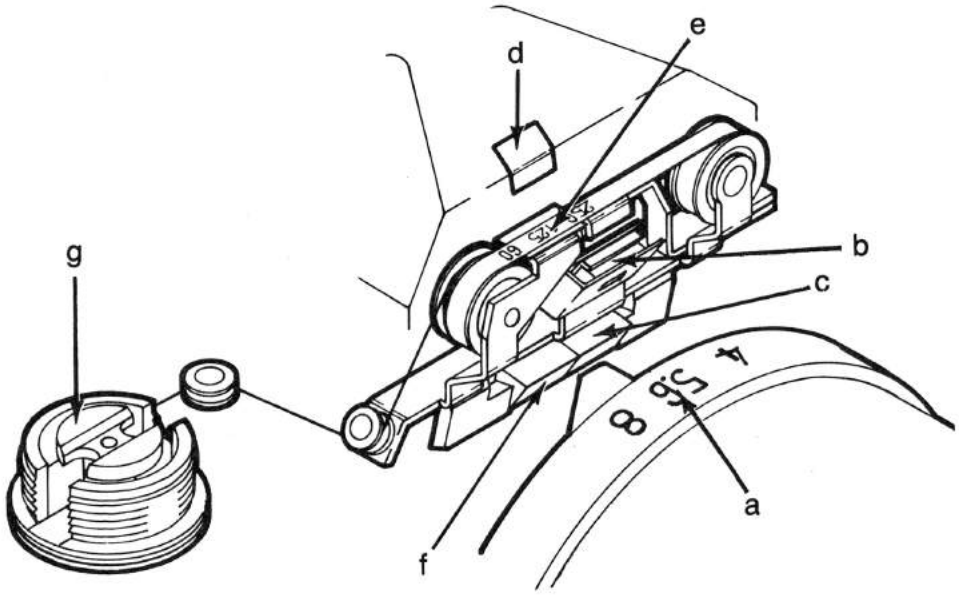
One of the principal advantages of the Minolta XD-11 is that you can select which of these two factors will be handled by the camera's auto-exposure system or, alternatively, you can select the completely manual mode, in which you set both the shutter speed and lens aperture just as you would on the classic manual 35s of the 1930s. However, with one exception that we'll get to later, the XD-11 does not allow you the option of leaving both factors to be determined by the camera. In short, programmed exposure automation is one feature that's essentially absent.

Is the XD-11 therefore less sophisticated than subsequent multi-mode cameras, notably the Canon A-1, which permits programmed automation? Not in our opinion, but you should make up your own mind as its features unfold.

4. Hot Shoe: When you slide Minolta's dedicated flash unit, the Auto-Electroflash 200X, into this shoe atop the camera, the shutter speed is automatically set to 1/100 sec., the flash sync speed for the Seiko MFC metal-bladed shutter unit. However, unlike the Canon AE-1—the first SLR with such an automatic sync-speed-setting system—the Minolta XD-11 doesn't also set its f/stop to the auto-flash aperture depending on which ASA you set on the flash unit. You have to read the aperture off the calculator dial on the flash unit and set it manually on the lens aperture ring.

9. Batteries: The XD-11's battery is not a peculiar one that's unobtainable out in the boondocks—it's the popular PX-13. What's uncommon is the voltage required to operate the camera. Most recent fully automated SLRs require 4.5 or 6-volt batteries, but the Minolta does quite nicely with a pair of PX-13s providing only 3 volts. As camera mechanisms advance, their mechanical construction becomes more sophisticated. If, at the same time the market requires smaller, lighter SLRs, the battery space problem becomes increasingly troublesome for camera designers. Indeed, the battery capacity problem is like a two-faced monster.

On the one hand it's easier to design and fabricate circuitry for a higher-voltage power supply. Why? Because even if only *part* of a circuit requires high voltage, you must have current of a suitable voltage already in the system. It's comparatively difficult to produce high voltages from a lower-voltage DC supply. In short, it's necessary to design circuitry which operates entirely at low voltages if you'd like to have a low voltage power supply in your camera. The attendant difficulties have prevented camera manufacturers from using 3-volt power supplies until quite recently.



Shutter-speed- and aperture-indicating mechanisms: Speeds are relayed via cord-and-pulley system; f/stops are reflected off aperture dial into finder. See text for details.

On the other hand, high-voltage batteries require more space, not only for the batteries themselves but also for the larger magnets required to actuate or control various mechanisms. Here is where the strong point of electronically-controlled cameras turn out to be their Achilles heel. Understanding the conflict inherent in a higher voltage power supply, Seiko wisely designed its latest metal-bladed, electronically-timed shutter with an electromagnet which operates on a 3-volt power source. And Minolta, perceiving this shutter's advantages, designed the XD-11's circuitry to operate on 3-volts. Naturally, the electromagnets are used to release the shutter and to arrest the aperture mechanism at the proper point also. It is expected that other camera manufacturers will follow Minolta's lead in cutting down their cameras' voltage requirements, enabling them to use smaller batteries.

18. Set-shutter-speed indicator: One of the most difficult problems entailed in designing a dual or multi-mode camera is how to inform the camera user what the camera is actually doing at any given moment. This is especially true if the camera automatically shifts from one picture-taking mode (the one set by the user) to another and the shutter speed and aperture are both altered.

Minolta decided to indicate both the shutter speed and the lens aperture set by the user in the viewfinder, and also to indicate which of the two factors is automatically set by the camera. In other words, you can see shutter speed and the f/number that *you* select and, in addition, the shutter speed and camera sets (in the aperture-preferred mode), or the f/stop the camera selects (when you're in the shutter-preferred mode), are both clearly visible.

Since the automatic-exposure indication is of the LED type and is mechanically rather similar to that found in other cameras (although the XD-11 has an elaborate plastic prism system to pipe the LED indication into the finder area), we'll detail the set shutter and aperture indicating mechanisms instead. Please direct your attention to the simplified drawing directly above.

As you turn the shutter dial (g) to set the shutter speed, a cord affixed to the dial base moves, pulling a large pulley (located right in front of the finder prism) via two small pulleys. A band of film, which has transparent shutter speed numbers (e) imprinted on a black base, runs over two large pulleys. As light enters through the window above (d), it illuminates one of the numbers on the film, which is reflected by the small prism below (f) and proceeds through the finder prism. The number then appears on the bottom righthand section of the finder field.

To indicate the set f/number, a mirror (b) at the front of the prism housing reflects the engraved number on the lens barrel into the plastic prism (c) right next to the set-shutter-speed relay prism and into the finder area.

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21. Shutter-speed-priority mode setting pin: To set the XD-11 to its shutter-speed-preferred mode, you have to turn the mode selector to "S" position and then turn the lens aperture ring to the smallest f/stop (highest number) position. As we'll see later, you don't really *need* to set the aperture ring to the smallest f/stop if you don't mind restricting your exposure choice to a much narrower set of aperture/shutter-speed combinations than are available when using the full AE coupling range.

As you turn the lens aperture ring to the smallest f/stop, the shutter-priority mode setting pin on the lens barrel (34) contacts its counterpart pin (21) and pushes it upward. Note that pin (21) is affixed to a bow-shaped bar, and the right end of this bar has a set of brushes. When the brushes are pushed to the extreme right-hand position, they sweep beyond the regular f/number keying position, sliding over to a set of contacts which keys the shutter-priority mode into the circuitry. Actually, once the brushes contact the f/number keying resistors, the light measurement system and exposure calculating circuitry no longer count the set f/numbers but transfer the exposure calculation on to the shutter-speed-determining system.

There are really not a great many differences between this multi-mode camera's circuitry and that found in conventional, single-mode auto-exposure cameras. Except for the LEDs' power circuit and one or two other areas, all the XD-11's circuits are of the analog type. In actuality, then, this "super" camera has been evolved directly from its immediate predecessors, the Minolta XK, the XE-7 and XE-5.

What's a combination magnet?

The only discernible difference in the XD-11's circuitry is that, in the course of its functions, it powers a couple of combination magnets. A combination magnet is basically an electromagnet which has a permanent magnet (instead of ordinary magnetite) as its core. To power a combination magnet a momentary surge of electric current must be applied to it. This is needed in order to give a strong pulse to the coil of the electromagnet, momentarily cancelling out the permanent magnet's inherent magnetism so that the armature, which converts electric power to the mechanical power, can get free of the magnet's pull.

To produce this current pulse, Minolta used a simple electric condenser instead of employing digital circuitry. This clever strategy has resulted in a power savings while in no way diminishing the accuracy or reliability of the system. In comparison, regular electromagnets re-

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quire constant current to hold the armature, and previous combination magnets required very high amperages to cancel the core's magnetism. In the future, other manufacturers are likely to follow Minolta's lead in this area.

27. Automatic-aperture stopper magnet: This is a new breed of camera part first introduced in the Canon AE-1. To construct a shutter-priority auto-exposure camera, one has to have some automatic means of stopping apertures at precisely the right position in conjunction with the light measurement system and the exposure-determining mechanisms. Furthermore, in an electronically-powered, shutter-priority camera, the stopper mechanism must be an electronic device—that is, an electromagnet. In most cases, designing such a mechanism is quite a bit easier if there's a pioneer whom you can follow. In this case, since Canon had already broken the ice, Minolta should have had relatively easy sailing—but unfortunately this wasn't the case. In fact, Minolta faced some very special difficulties. In the first place, Minolta was locked into an extensive and elaborate lens system. Worse yet, the aperture-stop-down mechanism of these lenses is not actuated by the linear movement of a lever—Minolta's aperture-stop-down lever moves along an exponentially curved cam. The smaller the set aperture, the shorter the movement of the aperture-stop-down lever, so an aperture change requiring more than 1mm of movement at wide apertures becomes less than 0.5mm at the minimum aperture. With such a non-linear movement, especially in an automatic-exposure-determining mechanism, maintaining accuracy at a constant level over the system's full operational range is extremely difficult.

This, in fact, is the major reason Minolta chose to use an instantaneous stop-down light measurement system in the XD-11 rather than metering with the lens wide open.

Exposure system countdown

Before we get into the details of this mechanism, let's get an overview of the entire exposure system sequence. As you press the shutter-release button, the light sensor reads the subject's brightness and the exposure-calculation circuit determines the exposure, factoring in the set ASA. If, at that time, you're operating in shutter-priority mode and have selected a shutter speed, the calculated exposure value is converted into a lens aperture value and then memorized in a memory condenser. The entire process up to this point can be described as a tentative exposure determination, because with the XD-11's non-linear aperture-stop-down

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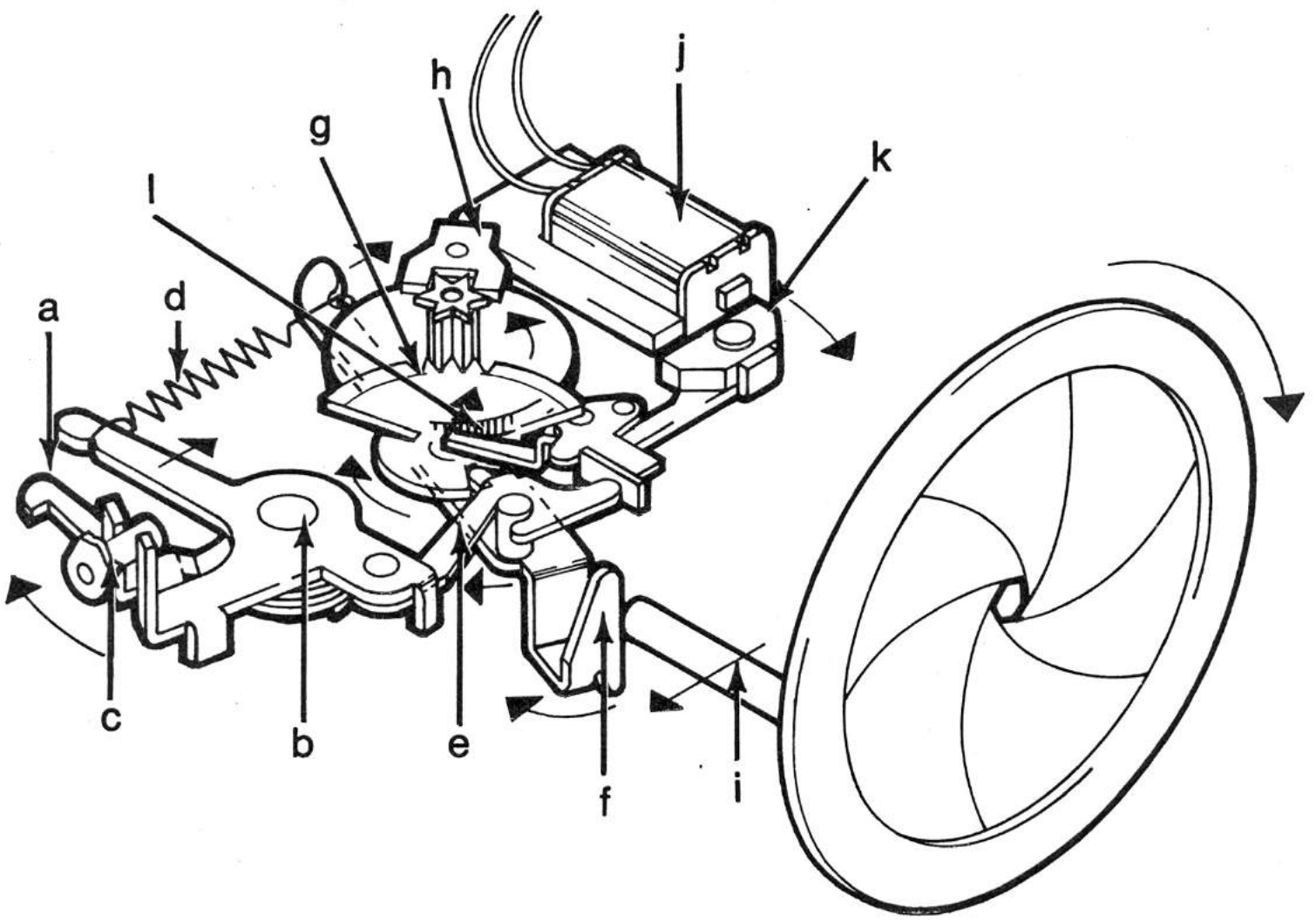
mechanism, high accuracy in aperture control cannot be guaranteed. A second process, which actually determines the exposure delivered by the camera, starts when the aperture diaphragm movement is released. As the aperture closes down, a light sensor in the finder measures the light as it's being reduced, and the sensor's circuit compares this with the pre-memorized aperture value, stored in the form of an electric voltage. When the predetermined aperture value is obtained, the above mentioned aperture comparison circuit reads the difference between the predetermined aperture value and the actual aperture size which includes some inherent error. The readout difference, also in the form of an electric voltage, is now converted into a shutter timing value, and this new exposure time is either added to or subtracted from the shutter speed you've set.

ter speed or you'll get an extremely overexposed picture, but with the XD-11 the camera does it all for you! In short, when the aperture stops down to the smallest lens opening, the difference between the precalculated lens aperture and the actual smallest aperture is now compensated by raising the shutter speed, thereby giving you have a correctly exposed picture. Another way of looking at it is this: At the extremes of the lens aperture range, the shutter-speed-priority mode is automatically changed into aperture-priority mode. There are other practical ways to take advantage of this unique feature. For example, if you set the mode-selector lever to "S," select a shutter speed, and then also set the lens aperture to any but the smallest opening you can combine the advantages of both types of exposure automation without having to manually alter any setting.

Regardless of the subject brightness, the lens closes down only to the aperture you've pre-set and from there on, the



Automatic aperture-control mechanism: Its motion is precisely regulated by a geared escapement to assure exposure accuracy at smallest apertures. See text for details.

How complicated is this system? Quite complicated indeed. In fact, it's the most complex exposure-determining system in any camera we've examined so far. But while such levels of mechanical complexity ordinarily constitute a disadvantage, Minolta's double light measurement and error-compensation system has the great advantage of more accurate exposure execution. There are also some additional side benefits. If the preliminary exposure reading includes an error exceeding one f/stop or more, the shutter speed can easily be varied to compensate for it. And in the event your set shutter speed is too slow for a very bright subject and the calculated lens aperture exceeds the smallest available lens opening, the camera can automatically compensate also. Normally meter readouts tell you that you should change the shutter speed or you'll get an extremely overexposed picture, but with the XD-11 the camera does it all for you! In short, when the aperture stops down to the smallest lens opening, the difference between the precalculated lens aperture and the actual smallest aperture is now compensated by raising the shutter speed, thereby giving you have a correctly exposed picture. Another way of looking at it is this: At the extremes of the lens aperture range, the shutter-speed-priority mode is automatically changed into aperture-priority mode. There are other practical ways to take advantage of this unique feature. For example, if you set the mode-selector lever to "S," select a shutter speed, and then also set the lens aperture to any but the smallest opening you can combine the advantages of both types of exposure automation without having to manually alter any setting.

Regardless of the subject brightness, the lens closes down only to the aperture you've pre-set and from there on, the proper exposure is obtained by adjusting the shutter speed, automatically shifting it from the speed set on the shutter dial. Fascinating—and, moreover, this is probably the direction that future fully-automated cameras will take.

Unfortunately, Minolta's brilliant system doesn't work the other way around. It cannot shift its shooting mode from aperture-preferred to shutter-speed-preferred mode for obvious reasons.

Let's now turn our attention to the XD-11's aperture-control mechanism, which the mechanically-minded will probably find more interesting.

In the simplified drawing directly above, as the shutter release disengages from lever (a), the triple armed lever (b) begins to turn clockwise, pushing against mirror release lever (c) and the hook of

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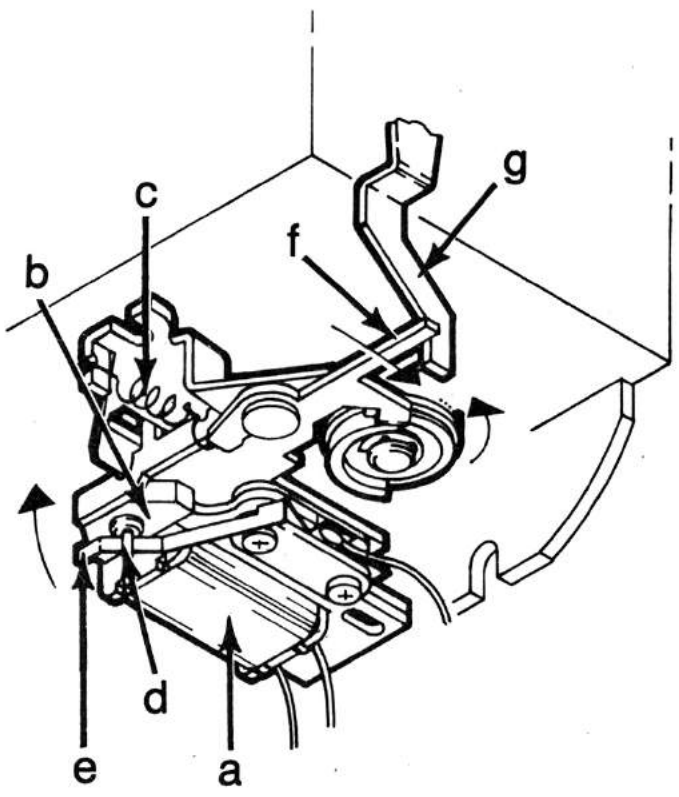
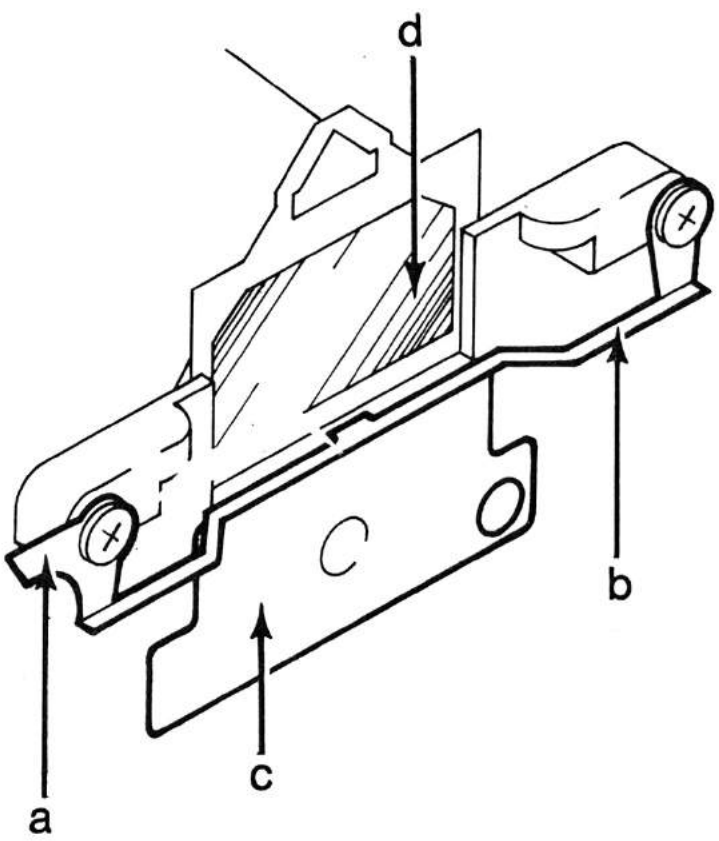
the aperture-closing lever (e). During this movement, a spring (d) which is the recocking spring of lever (f), balances the difference in turning speed between lever hook (e) and the stop-down lever (f), so there is no bounce or overrun between these two levers. While lever (f) turns clockwise, the lens aperture lever (i) (that always pushes toward the left) follows lever (f) as it turns, and the aperture begins to close. At the same time, a geared sector (g) turns clockwise at the pivot of lever (f) and revolves a milled wheel and an escapement gear in a counter-clockwise direction. The entire movement of the system is slowed and regulated by the escapement (h). The reason for such precise speed regulation of the aperture stop-down mechanism is to increase aperture-control accuracy. Without this type of regulation, system error at small apertures would be extremely high due to the aforementioned non-linear movement of the aperture stop-down lever (i).

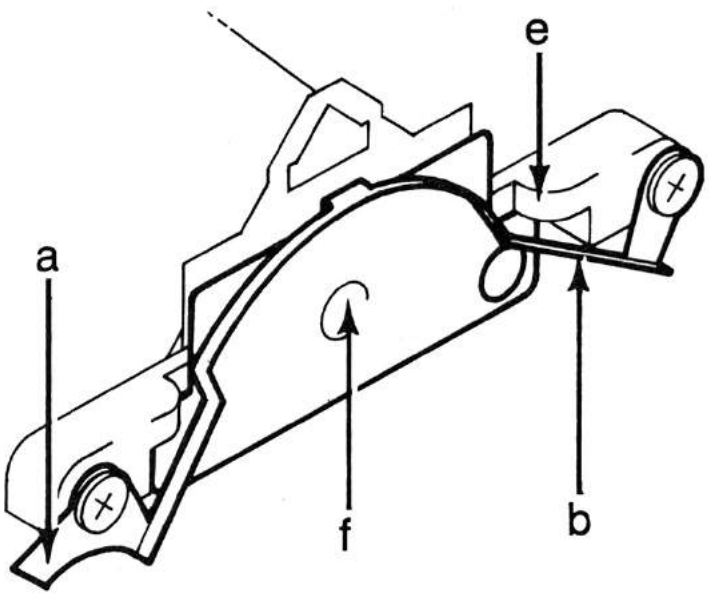
During the aperture stop-down mechanism's movement, the meter cells measure the light entering the lens and compare it with the memorized "proper" aperture size. When the proper aperture is reached, the circuit sends a current pulse to the electromagnet (j) to release the armature (k). The arm which holds the armature in place has a hooked edge (l) on its other end. Therefore, as the armature is released the hooked edge contacts the milled wheel and stops it. Thus all the interconnected gears and levers stop as well as lever (f). Of course the lens aperture lever (i) also stops when lever (f) stops, and the actual shooting aperture is thereby fixed. Like its shutter-priority auto-exposure system, the XD-11's automatic aperture-stop-down system is by far the most complicated we've yet analyzed.

28. Electromagnetic release: While Minolta is capable of producing extremely complex yet reliable mechanisms when the need arises, it also has devised some very clever ways to make very effective mechanisms that are extremely simple. The memory switch built into the XD-11's shutter-release mechanism is a good example. Please refer to the top simplified drawing on this page and we'll see how it works. When you press the shutter-release button, a release signal is given to electromagnet (a), and the armature (b) is released from the magnet by the force of spring (c). At this moment, the contact for the memory switch disconnects from pin (d) which is affixed directly to the armature. Nothing could be more direct—the exposure is measured and its electrical value is stored at the actual moment of the shutter's release. Of course, there is some small delay caused by the mechanical movement of the aperture-stop-down and mirror mechanisms (to name but two), but this is the fastest known method of memorizing the exposure. Incidentally, the armature arm (f) and connected lever (g) are used for releasing the aperture and mirror mechanisms. Minolta's cleverness does not stop here, and we'd like to give you one last example.



Electromagnetic shutter release: To appreciate its elegant simplicity, see text.





Eyepiece-blind mechanism does the job with bare minimum of components (see text below and on page 194).

Most recent high-grade SLRs are fitted with an eyepiece blind mechanism, and the XD-11 is no exception. Lever (a) in the simplified drawings directly above controls just such a blind. As you turn it counterclockwise, a blade (c) which

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hangs on a leaf spring that's actually part of the blade itself, springs upward due to its bent shape. Because it's bent, this leaf spring cannot spring back without some outside force being applied to it. So, the blind hangs in position in front of the finder eyepiece, preventing extraneous light from entering the finder. The blade cannot overshoot the mark either—it's prevented from doing so by the edge of the finder frame (e). A white dot (f) on the outside of the blind curtain indicates that the blind is closed.

In examining the internal structures of the Minolta XD-11, the basic philosophy of Minolta is designers becomes clear. Cameras must be easy for the photographer, and if solutions to technical problems entail certain complexities so be it. The automatic aperture mechanism is a good example. However, Minolta doesn't pursue complication for its own sake—only to improve the product. Indeed, in the case of the automatic-mode-shifting mechanism, Minolta's design engineers actually turned an inherent technical disadvantage of their lens system into one of the XD-11's most brilliant and worthwhile features. And far from being a drawing board *tour de force*, the XD-11 is a camera you can appreciate in a practical way every time you use it.—JASON SCHNEIDER