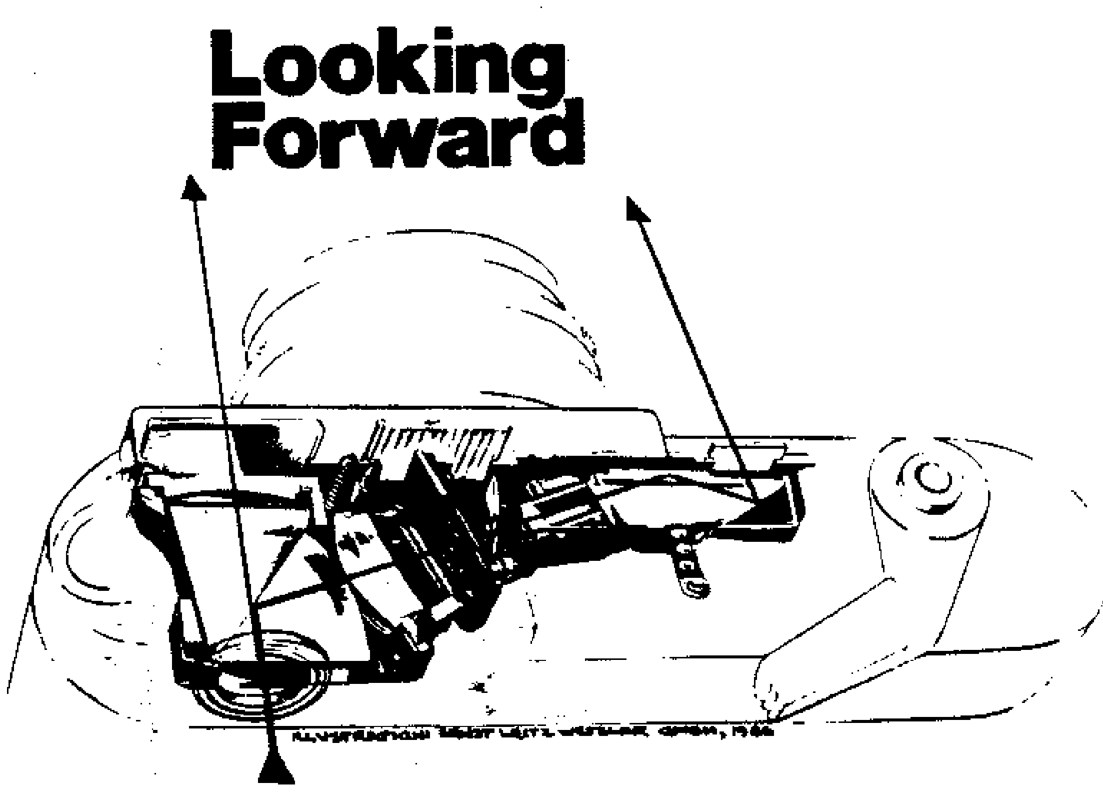


Looking Forward:

The Development of the Eye Level Viewfinder

Humble little window that it is, the direct eye level viewfinder is responsible for much of photography as we know it today, and its significance is at least as great as that of, say, built-in metering or large-aperture lenses. Without effective eye level viewing, such things as action photography, sports and even the family snapshot would be difficult indeed. As obvious as this seems, however, it has by no means always been taken for granted; as recently as the late 1940s the Rolleiflex was not provided with any effective means of direct eye level viewing, and in the 19th century it was not uncommon to find a camera with no provision whatever for viewing the scene to be photographed.

As the camera began to move from the studio into the field and technical advances began to bring handheld photography within the realm of possibility, the need for a more convenient alternative to the inverted groundglass viewing image became apparent. The first device provided for eye level direct viewing and composing was an open rectangular frame through which the scene was observed. This type of viewfinder began to appear in the mid-19th century, usually equipped with wire crosshairs and a sighting post or peephole to aid the user in properly positioning his eye. A significant advance in convenience, this type of finder suffered from uncertain accuracy as eye position was extremely critical: movement of the eye seriously affected both the angular coverage and the direction of the finder. Further, the inability of the eye to focus simultaneously both on the distant scene and the finder frame (usually a thin metal wire) sometimes made framing difficult. A final drawback was the finder's size, often being equal or near to the size of the negative in order to obtain a reasonable eye relief. Despite its disadvantages, however, various forms of this device appeared on respectable cameras from before the Civil War into the 1960s, making it the longest running viewfinder design. Notable among the more recent applications was the sports finder of the mid-1930s Rolleiflex, in which the user located the reflection of his eye in a concave mirror at the center of the crosshairs (Fig. 1). In the Speed Graphic a more conventional rear peepsight was articulated to provide parallax compensation, while the frame, attached to the lens standard, automatically compensated for rise, shifts and varying focal lengths of lens (Fig. 2). Another variation on the theme was the Minolta 16 series, in which an open frame was incorporated into the body with flat glass in front and rear to give the appearance of an optical finder.

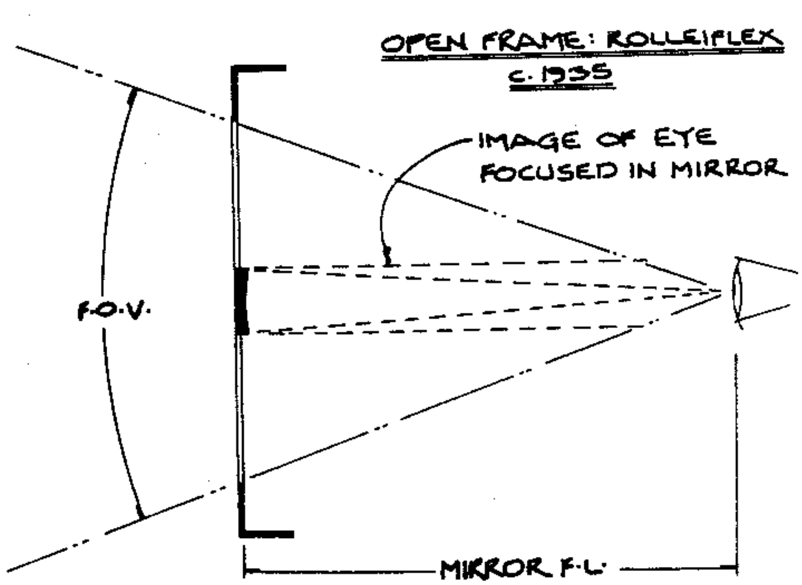


FIGURE 1

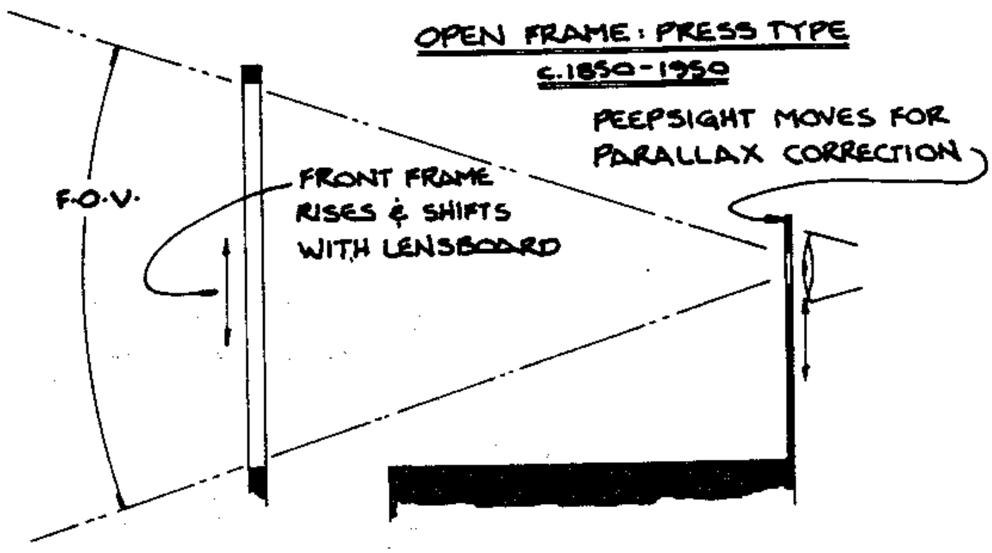


FIGURE 2

The first technical advance beyond the wire frame came before the turn of the century in the form of a single plano-concave lens, sometimes referred to as a Newtonian finder (Fig. 3). Still generally accompanied by a peepsight or sighting post and having crosshairs inscribed on the glass, the negative lens reduced the size of the image and thus that of the finder itself. In addition, it caused the eye to focus near to the lens so that the scene and the finder were simultaneously visible, and – most important – it showed the same angle of coverage virtually regardless of eye location, making lateral positioning the only critical factor. Despite its advantages, however, this type of finder generally presented a very small image to the eye and was difficult to use for those who had near-focusing difficulty (as most older people do); even with good near vision it was generally necessary to maintain an eye relief of several inches. Optically superior to the open frame but lacking its extreme simplicity, this type of finder barely lasted through the 1920s.

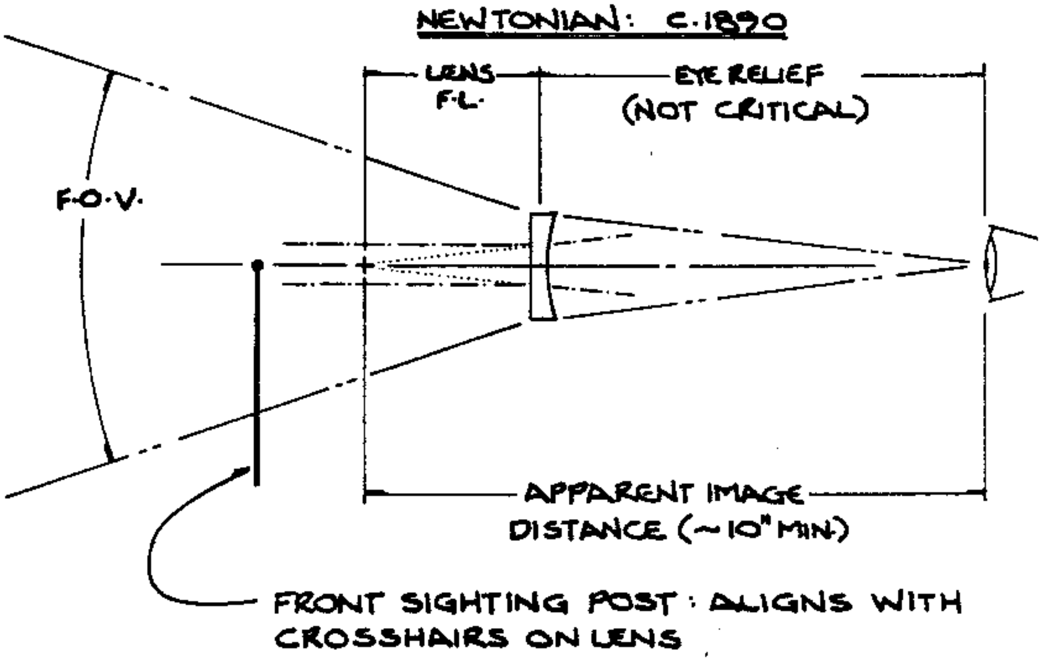


FIGURE 3

The successor to the Newtonian finder was the Galilean, or reverse Galilean, which first appeared around the turn of the century. Made by positioning a small positive lens behind the Newtonian finder in such a way in such a way that the front focal points of the two lenses coincide, the Galilean viewfinder is essentially a small Galilean telescope turned backwards so as to reduce the image rather than enlarge it. The positive eyepiece lens provided a number of advantages: first, it enlarged the image of the negative lens in front of it, albeit not to full size; second, it allowed the eye to focus at infinity while using the system, while still maintaining fairly sharp definition of the edges of the frame; and third, it provided an optically fixed eyepoint. Shifting the eye still had some effect on framing accuracy, but it was now so slight as to be negligible. Another benefit was that the degree of scale reduction, formerly a function of eye relief distance, now became fixed as the ratio of focal lengths of the front and rear lenses. Maximum eye relief was now limited by the diameter of the eyepiece lens. The Galilean viewfinder has become the basis of every "viewfinder" camera to date*, and there is no reason to expect that this optical concept will be supplanted in the foreseeable future. All current viewfinder technologies are enhancements of this optical design (Fig. 4). [* a single design, the Canon Demi of the mid-1960s, used the astronomical optical design discussed below. This system is no longer used in any viewfinder camera to my knowledge.]

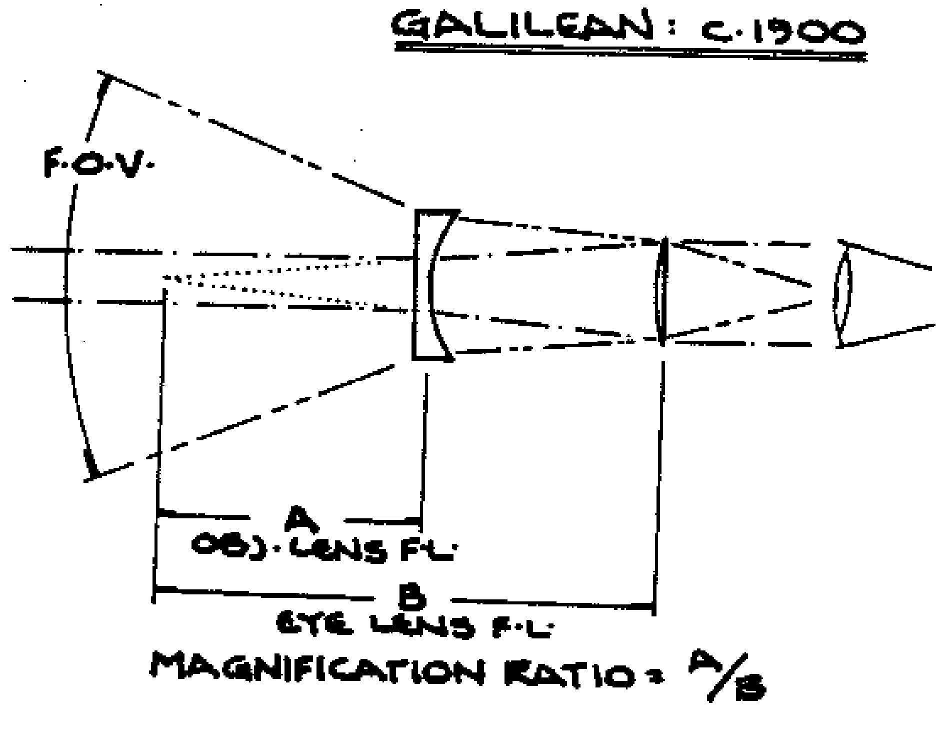


FIGURE 4

A disadvantage of the Galilean design in some applications arises from the fact that, with the front focal point of the positive lens located beyond the front lens (whose presence renders that focal point nonexistent), there is no place within the system at which an image (frame lines, for instance) can really be brought sharply to focus. The sharpest focus that can be achieved is at the periphery of the front lens. This is essentially as it should be, and quite adequate for most purposes, but for a varifocal accessory finder (and for Ernst Leitz), it wasn't precise enough.

The Leitz VIDOM accessory viewfinder, introduced in 1932, featured an optical design quite different from the conventional Galilean system. The VIDOM adopted the optical layout of an astronomical telescope, in which two positive lenses are arranged so as to come to a common focus at some point between them. The magnification ratio of the system, as well as the location of the inner focal plane, is a function of the focal lengths of the eyepiece and objective lenses. The important feature of this arrangement, for our purposes, is that if a mask is placed at this focal plane, it will appear in precise focus at the same distance as the subject when viewed through the eyepiece. For the first time since groundglass focusing, precise composition right to the edges of the frame was possible. The VIDOM finder took full advantage of this by making the mask continuously variable in size, calibrated from 35 to 135mm fields with a second reference mark to compensate for field shrinkage at close focusing distances, and by providing a manual parallax-compensation control (Fig. 5).

ASTRONOMICAL: LEITZ VIDOM
C.1932

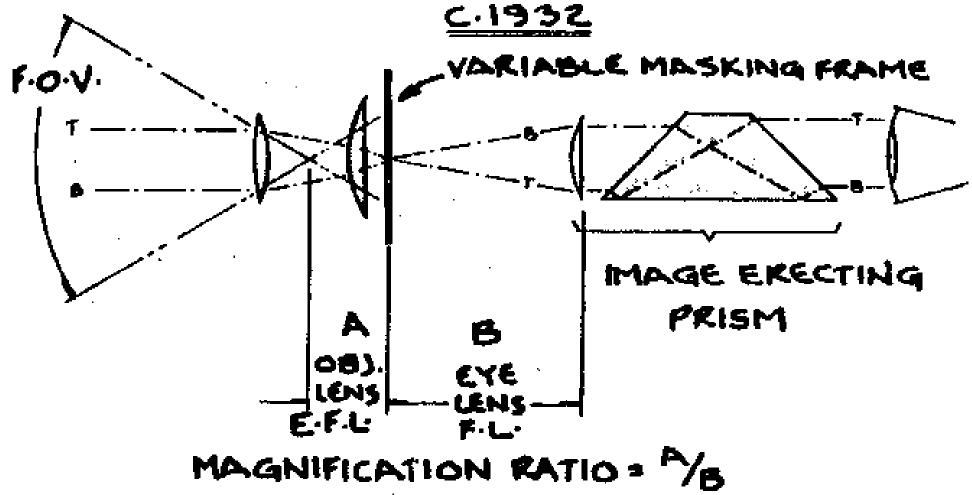


FIGURE 5

As anyone who has used one is aware, however, astronomical telescopes have a small problem when used on the ground: the image, like that on the groundglass, is inverted. The VIDOM's solution to this problem was somewhat marginal. By placing a dove prism in the eyepiece, Leitz engineers managed to erect the image vertically but left it reversed left-to-right, as in the groundglass image of a TLR. An inconvenience in normal shooting, for vertical composition this became unworkable as the image was now corrected laterally, but upside down. To alleviate this, the VIDOM eyepiece could be rotated 90° so the prism would always be right side up. There can be little wonder why, after seven years of struggling with this arrangement, users flocked to the stores upon introduction of the Imarect finder, which, by adding a roof form to the dove prism, managed to fully erect the image while retaining all of the benefits of the earlier VIDOM.

Peripheral developments have been as important to the evolution of viewfinder design as the basic optical technology. The concept of the viewfinder camera owes much of its success to such advances as coupled rangefinders, parallax compensation and projected-image displays, even though these had little to do with the optical layout of the viewfinder itself.

The separate-window eye level coupled rangefinder was, for all intents and purposes, introduced simultaneously in 1932 by Ernst Leitz and Zeiss Ikon, on the Leica II and Contax cameras respectively.

The rangefinders on these cameras were essentially similar, with a fixed beamsplitter placed before the eye, combining the transmitted image with a second image which was reflected from a pivoting mirror (a right-angle prism in the Leica) placed to one side. This mirror or prism was connected to the lens mount so as to cause the images to coincide when the subject was in focus. The narrow base of the Leica required magnification in order to attain the necessary degree of accuracy, but because of the difference in optical path length between the eyepiece and the two windows, it was not practical to incorporate magnifying optics within the rangefinder system. Therefore, the Leica (and all magnified-rangefinder cameras of this type) incorporates a very short (about 10mm long) 1.5X Galilean telescope between the eye and the rangefinder. In postwar Canons, the same device was mounted on a spindle so that it could be turned one way for 1.5X magnification, reversed to become a conventional 0.66X viewfinder, or turned sideways so that the user looked across the space between the lenses for a life-size view (Fig. 6).

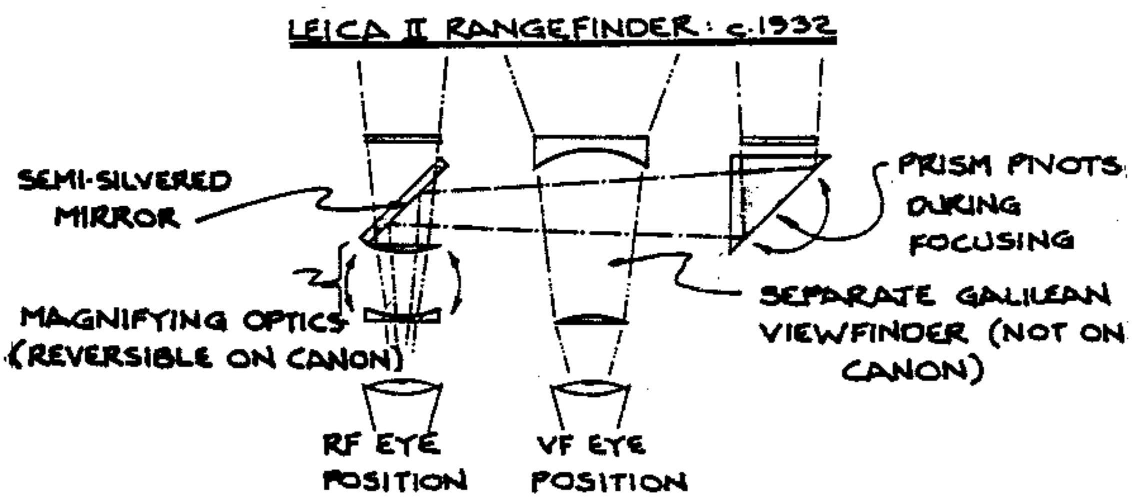
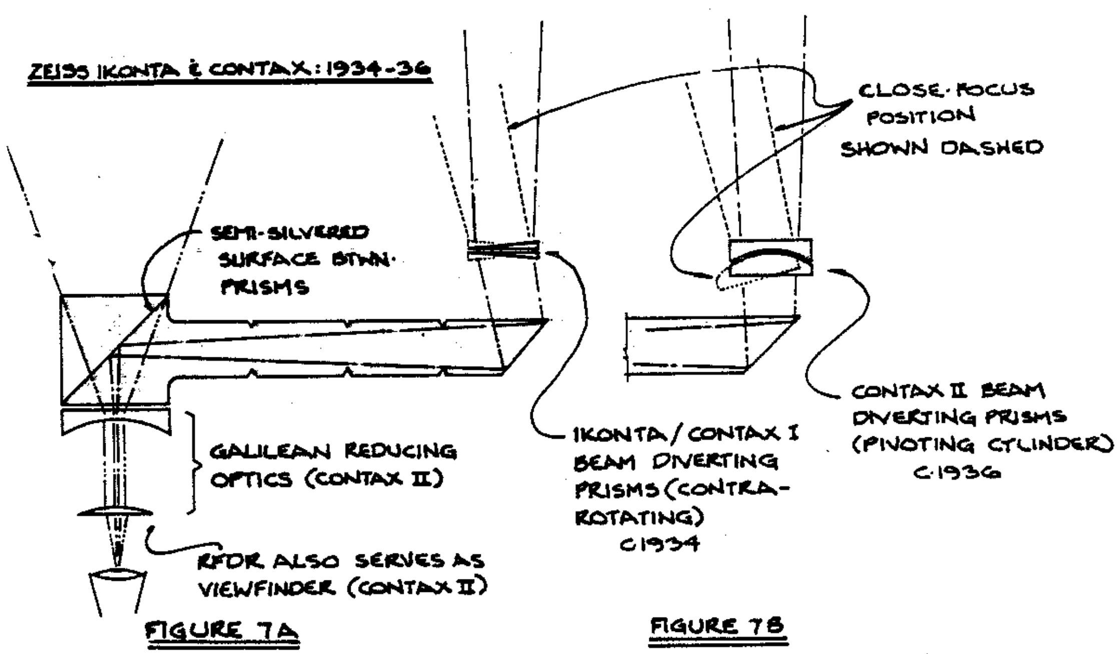


FIGURE 6

During the 1930s, the bulk of development effort in rangefinder optics was being undertaken by Zeiss Ikon. In 1934 a new rangefinder was introduced both on a redesigned Contax and on the new Super Ikonta series. In this design both the beamsplitter and the mirror at the opposite end were fixed, and were in fact surfaces of a single solid glass prism. Two glass wedges were arranged before the right hand "mirror" such that by rotating in opposite directions they constituted a variable refracting prism. This provided a remarkably durable mechanism nearly impervious to shock and temperature extremes, and lent itself nicely to Zeiss Ikon's fondness for finger-wheel focusing controls, but did not otherwise change the function or effectiveness of the rangefinder (Fig. 7a).

In 1936 a further step was taken; a relatively modest one from a mechanical and optical standpoint, but one which would have a great and irreversible impact on the design of rangefinder cameras. The two rotating wedges were replaced by a fixed glass element, flat on the front and ground to a concave cylinder on the back. Behind this cylindrical lens was a mating convex cylinder ground so that the interface between it and the front lens would be optically neutral, the pair forming a variable prism as the rear portion swung from side to side; otherwise it was much like the previous design (Fig. 7b).



The reason for this design change was to allow for a significant enlargement of the right hand rangefinder window, which in turn allowed a corresponding enlargement of the entire system; so much so, in fact, that the full field of view of a 50mm lens could now be seen through the primary beamsplitter. The secondary image appeared as a rectangle in the center of the field, corresponding very roughly to the coverage area of the 180mm Tele-Tessar, the longest lens available in a rangefinder coupled mount. This was a less useful coincidence than it may seem, because the outline of the central rectangle, with an optical distance of about five inches from the eye, could not be determined precisely while viewing the subject image which appeared at infinity.

As in the case of the Leica, a Galilean optical system was placed between the eye and the rangefinder to ensure identical magnification and focus in both branches of the rangefinder image. Here, however, it was reversed to provide a reduction of about 0.75X, rather than the Leica's 1.5X magnification. This was necessary to provide the required eye relief and full field angular coverage without further increasing the size and weight of the rangefinder prism.

This was to be Zeiss Ikon's last major contribution to viewfinder development (unless one cares to think of the 1949 Contax S as the ultimate eye level viewfinder design as well as the first "modern" SLR); the company was destined to be decimated, first by the terrible Allied air raids on Dresden during WWII, and again by the partition of Germany which left the company's facilities split between two enemy nations. The Contax IIa, introduced by the West German faction of the company in 1950, duplicated the viewfinder design of the prewar models except for a narrower base length and a change from a cylindrical to a spherical surface at the back of the movable half-prism. This was of no optical consequence except to permit (and occasionally necessitate) adjustment of the vertical position of the rangefinder image.

Although rangefinder design stabilized for a while after 1936, other developments were taking place which would materially influence the future course of rangefinder camera evolution. Significant among these: the Albada bright-frame viewfinder, the later "true projected frame" viewfinder, and automatic parallax compensation. Interestingly enough, all three of these advances first appeared on cameras which were not equipped with rangefinders.

The Albada viewfinder, which appeared in 1935 in the Zeiss Contaflex 35mm TLR as a sports finder, introduced the concept of an optically projected image defining the edges of the field. This was accomplished by designing the front element of a Galilean viewfinder so that its rear surface could act as a semi-transparent concave mirror. With a white outline painted on the front surface of the eyepiece assembly, this concave mirror was configured so as to form a virtual image of the outline at the same apparent distance as the image of the scene which was formed by the refractive properties of the same element. With the eyepiece lens then brought to focus at this common image plane, the eye was presented with a reduced-size view of the scene, around which a white frame appeared to float in space. The three advantages of this system were that, first, the scene and the outline appeared in the same plane of focus, making more precise composition possible; second, the accuracy of framing was less sensitive to eye position; and third, the visible field extended beyond the composition area so that it was easier to track moving subjects. To make the system work, however, it was necessary to provide illumination to the front of the eyepiece mount where the outline was painted. While Zeiss Ikon's approach of leaving the top and sides of the finder open for illumination was fairly successful, later attempts to duplicate the effect in enclosed, in-camera viewfinders tended to result in dim or unreliable frame projection (Fig. 8).

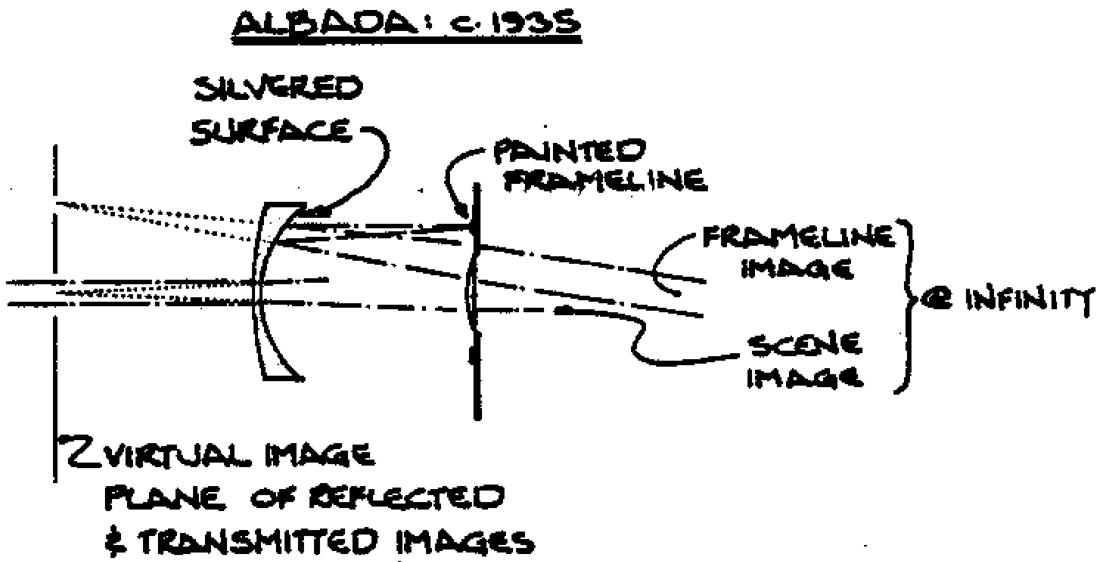


FIGURE 8

One of the less successful applications of the Albada viewfinder appeared in the 1939 Minox. Despite that minor complaint, however, this remarkable little camera boasted of an array of features beyond the scope of many larger cameras. Among these features was a new viewfinder function: a mechanical coupling between the viewfinder and the lens caused the entire optical assembly to pivot as the lens was focused, compensating automatically for parallax. Though it seems a bit odd for a camera without a rangefinder to have incorporated such a capability, considering the Minox's immense depth of field and 8 inch minimum focusing distance, parallax compensation was probably more critical than precise focus. Both the Albada finder system and the Minox parallax compensation device were heralds of features which would in time become essential elements of view/rangefinder design; but in both cases, the methods employed would be fundamentally different from these early attempts (Fig. 9).

AUTO PARALLAX COMPENSATION: MINOX, c.1939

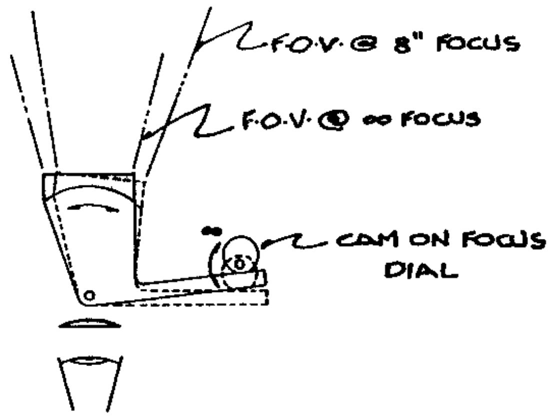


FIGURE 9

The next major step toward the present state of the art in viewfinder design came from an unexpected source. Under military contract during World War II, Argus developed a new method for presenting a sharply focused, illuminated frame into a Galilean optical system. This new design had a number of advantages over the Albada approach of a decade earlier. It was well suited to enclosed mounting, the light being admitted through a forward-facing window. Because the reticle was not physically located in the optical path, there were no restrictions on the design of the reticle. Not least in importance, the elimination of the reflecting function of the front lens made the optical design of the system somewhat more straightforward (Fig. 10).

ARGUS 21 MARKFINDER: 1947

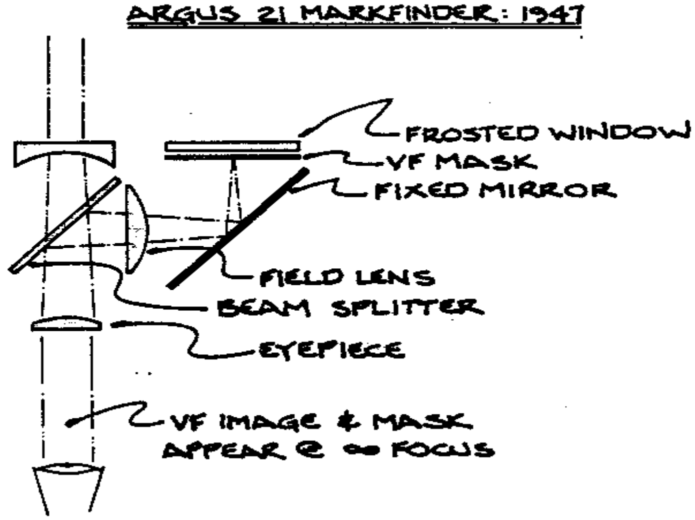


FIGURE 10

The new type of viewfinder made its civilian debut in 1947 in the Argus Model 21, a composite of prewar A-3 and C-3 parts whose only distinguishing asset was its "Markfinder". Unfortunately for Argus, the projected frame system required placement of a powerful positive lens in the middle of what might otherwise have been the optical path of a rangefinder, and Argus designers, unable to think of a way to reconcile the optical requirements of a rangefinder with those of the Markfinder system, designed the Model 21 as a scale-focusing viewfinder camera at a time when the rangefinder was a pretty standard feature in other cameras. Even four years later when, having learned that the postwar public wasn't going to shuck out over 50 bucks for a warmed over A-3, Argus decided to add a rangefinder, they found it necessary to drop the Markfinder system to make room. (See illustration at end of article)

The first viewfinder to combine automatic parallax compensation, projected framelines, and a rangefinder into a single optical system proved to be the high water mark in viewfinder development. Even now, 33 years after its introduction (*note: this article was originally written in 1987)*, no optical viewfinder has surpassed in complexity of design, in versatility, in precision, or in ease of use, the system which appeared on the Leica M3 in 1954. Leitz solved Argus' optical dilemma by building a complete astronomical telescope into the rangefinder assembly, with the inner focal point lying in the plane of the frameline mask much as it had in the VIDOM accessory finder 22 years before. This time the erecting roof prism was located at the right-hand rangefinder window so that it inverted the incoming beam before it entered the inverting optics of the rangefinder telescope. Instead of pivoting the right-hand prism to divert the beam, the telescope objective shifted as the lens was focused to accomplish the same end. By matching the focal length of the objective and the Argus-like positive field lens, the image of the rangefinder patch was given a precise 1:1 magnification to correspond to the main viewfinder (which had no optical system per se in the M3, although all later M series Leicas use Galilean optics for their less-than-lifesize finders. This obviously results in a different set of lenses and some configuration changes in the rangefinder as well. Conceptually, however, all M and CL Leicas use the same optical system). (Fig. 11)

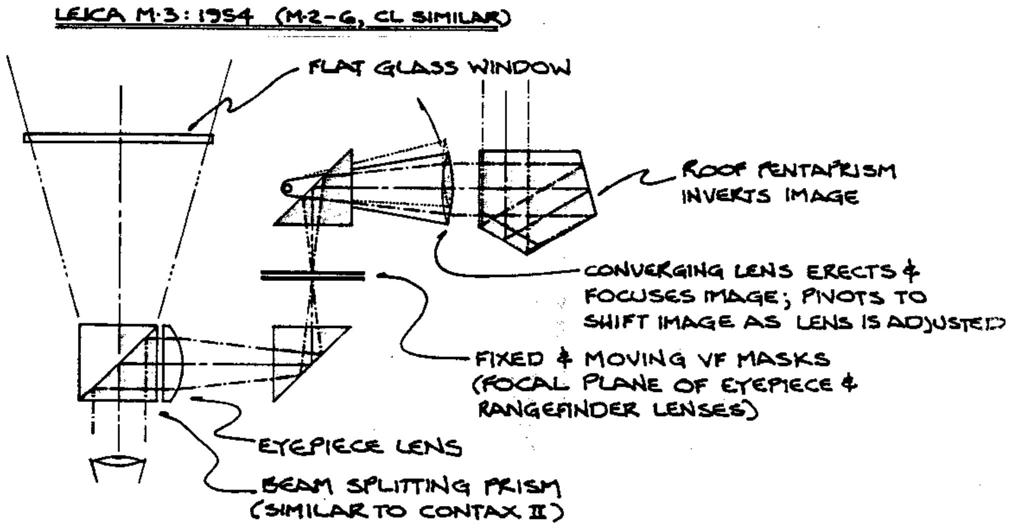
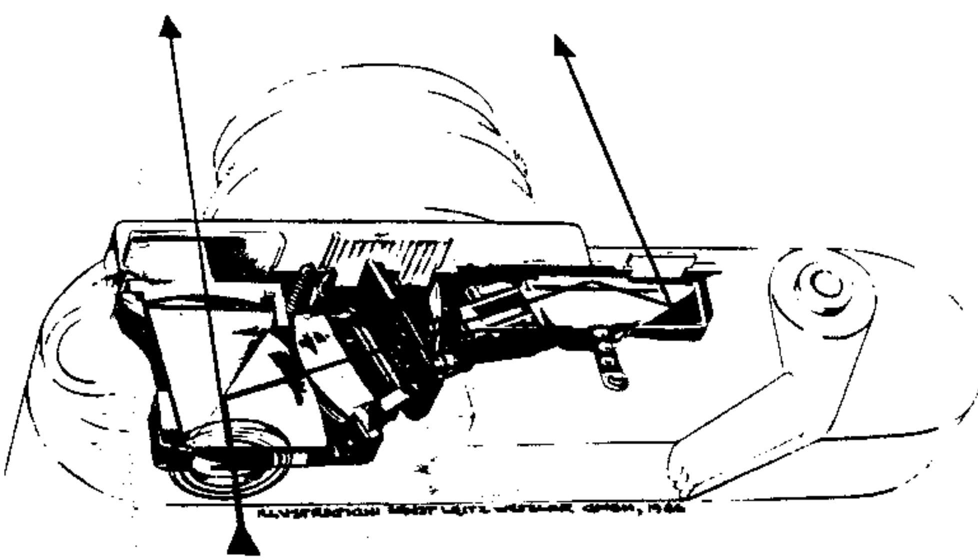


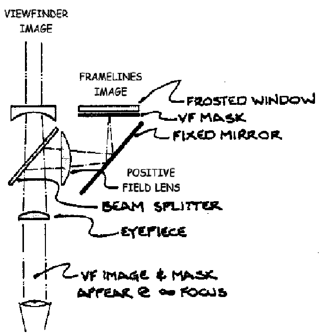
FIGURE 11



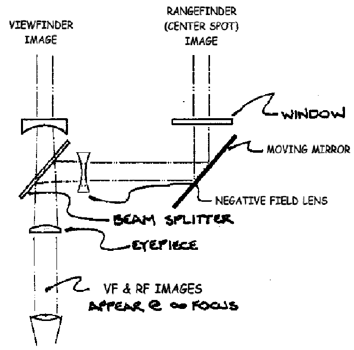
By taking this approach, at once the most obvious and the most costly solution, Leitz managed to provide a sharply defined rangefinder patch which enabled the system to be used as a split-image as well as a coincidence type rangefinder. Not content with this advantage alone, Leitz exploited the new viewfinder technology for all it was worth. Coupling the rangefinder mechanism to the viewfinder mask, they made the projected framelines move to automatically compensate not only for parallax but for field shrinkage as well. Most revolutionary of all, however, was a coupling cam in the lens mount which automatically set the size of the viewfinder field to match the coverage of the lens in use, whether it be 50, 90, or 135mm.

The Leica M may have been the ultimate development in the art of viewfinder/rangefinder design. It was not, however, the last one. The Japanese photographic industry, like Leitz, had been studying the problem of combining a coupled rangefinder into a bright-frame optical system; and also like Leitz, their solution reached the public in 1954, in the form of the Aires 35-II, an otherwise pretty ordinary fixed-lens, leaf shutter camera. The Japanese approach was much simpler and less costly than the M3's, and was very nearly as effective, its only real sacrifice being the lack of sharp definition of the outline of the rangefinder patch. This is the design which today must be considered the status quo, if not the state of the art, of viewfinder design. But how did they do it?

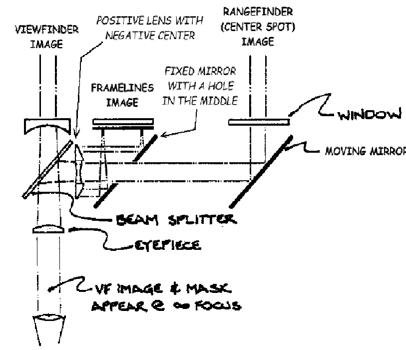
You'll recall that the basic conflict between a single-window rangefinder and a bright-frame viewfinder system was that, in order to image the frame mask, it was necessary to position a strong positive lens right in the optical path of the rangefinder; and that, in order to make the rangefinder and viewfinder images match, in most cases you'd need a powerful negative lens in essentially that same spot. Leitz had stuffed the camera full of lenses and prisms trying to get out of this box and had done an admirable job, albeit spending a small fortune on each camera in the process. What the Japanese engineers noticed, however, was that, particularly with a fixed-lens camera where you didn't have to image those tiny little 135mm frame lines, the projected framelines were out around the edges of the frame, while the rangefinder image was in the middle, and there was quite a lot of blank space in between. So, in a fit of genius that perhaps hinted a bit more at pragmatism than elegance, they placed the positive field lens exactly where the rangefinder wanted a negative lens to be; then they drilled a small hole through the center and glued in a tiny negative lens, just big enough to pass an image of the rangefinder window. The viewfinder system now consisted of a split Galilean system with two objectives of identical focal length, one eyepiece, and a beamsplitter to put the images together; with what was essentially a separate-but-concentric optical system, nothing more than a two-element magnifying glass, to project the frame lines. The rest of the rangefinder was the same pivoted mirror and window that had been around since 1932. As for the other M-series features such as parallax and frame shrinkage compensation, these could be and were provided for within the confines of this less elaborate system. Looking at the overall cost vs benefits picture, it's not hard to see why the Leitz system has found few takers in the years since 1954, and it stands as one more testament that, today as in the past, it is Leitz alone that insists on providing the ultimate product, with cost coming into consideration only when it's time to publish the price list.



ARGUS 21 MARKFINDER, 1947
(Positive field lens focuses onto frameline mask)



ARGUS C4 - C44 RANGEFINDER, 1950
(Negative field lens matches front viewfinder window to focus rangefinder image)



THE JAPANESE SOLUTION, 1954
(Just drill a hole in the positive field lens and glue a negative lens into the hole)

Argus in the USA had first developed the optical system that projected framelines into the viewfinder image from a separate mask and window. But their optical system required a positive lens for the projection, and when in 1950 they decided to add a rangefinder, which requires a negative lens in the same position, they dropped the frameline projection in favor of the rangefinder.

Recognizing the value and potential benefits of the projected framelines, Leitz in the 1954 Leica M3 combined the two by focusing the rangefinder image as well as the framelines in a common plane within the system – a very complex and costly solution, but an excellent one.

Japanese manufacturers also recognized the benefits of such a system, but the cost of Leica's approach was unacceptable for the market their cameras were designed to serve. So, also in 1954, Aires came up with a solution that achieved 90% of the Leica's benefits at 10% of the cost. Instead of providing the complex optics of the Leica system, they simply took the positive lens of the Argus Markfinder, drilled a hole in the center and cemented a negative lens like that in the Argus C4 into the hole. The negative lens in the center focused the rangefinder image in the center spot, while the outer positive lens focused the framelines around the edges. The only benefit of the Leica that this failed to achieve was sharp definition of the edges of the rangefinder spot – a detail that, frankly, few users even notice.

Argus could have done this in 1950. It's a classic example of the sort of cost effective ingenuity that Americans were famous for, and they owned the technology years before anyone else. It might not been enough to save the company, but it would have helped them stay more competitive during the critical period in the later 1950s when they fell significantly behind the Japanese competition and the writing was on the wall. They dropped the ball in 1950 and failed to pick it up as they watched the opposing team run with it.