On measuring lens resolution with Exakta cameras: errors introduced in focusing, film plane and/or viewfinder irregularities and camera vibration. M. Higgins, M. Upton, and M. Stuecheli

Abstract

In the past, variance in resolution data made difficult the comparison Exakta-mount lenses. To begin to reduce this variance for the tests reported here, we used only one lens (3.5/135 Angenieux y2) and camera (Exakta VX1000). However even with this simplification, the initial results presented more variance than thought acceptable. As described before, Exaktas often show different images in the viewfinder and at the film plane. To deal with this problem, we used a simple method of focusing. This method obviated the need for viewfinder information. With this technique, we observed an increase in resolution and a decrease in variation. Proceeding, we evaluated 13 test conditions on resolution aimed at assessing the effects of shutter speed and camera mountings. Our findings support a model in which resolution increases with increasing exposure speed and where camera mountings (tripod or encasement in rice filled bags) play a secondary role.

Introduction

Using the MTF (modulation transfer function) method, the resolution of many Exakta-mount lenses have been measured. For a full explanation of the MTF procedure see Norman Korean's site http://www.normankoren.com/Tutorials, or send an email to michaelhiggins2814@earthlink.net and ask for a copy of, 'directions'.

Much of the past work can be found in a database located in Miles Upton's site http://www.exaktaphile.com/tests/test.html. However, this list requires updating. More measurements need to be added and this revision will begin as soon as this report is finished.

Mark Stuecheli identified one problem with our original test procedures. He reported an average increase in resolution of about 20 lp/mm@10%MTF for long lenses resulting from packing lenses-cameras in sand bags and using 1/250s exposures. Mark felt that these increases were due to either or both the sandbags or rapid shutter speeds decreasing the effects of camera vibration. The original purpose of this study was to sweep up the loose ends of Mark's studies. To this goal, we tried to reduce the variance in our test methods and thus to increase the accuracy of our measurements. To start, we used only one lens and camera. However, in our preliminary studies, we found another source of error. This error was not new. Klaus Rademaker reported that in Exaktas the images seen in viewfinder and at film plane rarely coincided. Also this problem is treated in Miles Upton's book, Ultimate Exakta Repair, 2003,). Under these conditions, the viewfinder can produce a decrease in resolution by giving a fallacious impression of what is seen at the film plane. To deal with this problem, we used a simple, but tedious, method of focusing which did not depend on the viewfinder image. With this focus method in place, we began performing resolution tests aimed at quantitating the effects of exposure speed and camera dampening methods.

Materials and methods

1. Camera and lens used

These were an EXAKTA VX1000, 1195220, and an Angenieux 135-mm f 3.5 type y2 469485 at f8. For each test condition at least 10 exposures were made, developed and analyzed (see 'directions' for analysis methods, michaelhiggins2814@netzero.net or site http://www.normankoren.com/Tutorials). All exposures were initiated with a cable release.

2. Multiple Targets

In a change from the past investigations, we photographed 11 targets at once, rather than

the one used before (Fig. 1., 11. and 12.). The targets were glued to a short end of 11 Styrofoam panels (11 X 14 X 0.57 inches). Then, the blocks were glued in a stair-step fashion and placed so that Angenieux could see all 11 targets (Fig.s 11. and 12.). The hope was that errors in focus could be reconciled by choosing one of the 11 targets with the most detail. The target wedge had a thickness of about 6 inches. The depth of field was 1.79 feet for a 135-mm lens used at f8 and capable of resolving 75 lp/mm. In practice, the large depth of field rendered the wedge to be of little help. In the greatest number of cases, the central target had about the same amount of detail as the peripheral targets. In the few cases where the central target did not contain the most detail we chose the one that did. In these studies, the distance from the front element of the lens to the central target was about 22.59 feet (equals the 50x-magnification distance for 135mm lenses; see 'directions' p. 5.-6., michaelhiggins@earthlink.net or http://www.normankoren.com/Tutorials).

3. Focusing

As introduced, we have been aware of the frequent differences in Exaktas in images at the viewfinder and the film plane. The problems include errors in mirror height, in viewfinder focus insert placement and in shimming at the lens mount (Miles Upton, Ultimate Exakta Repair, 2003). In addition, the errors could extend to one's ability to accurately focus a lens in a mechanical camera. Leslie Storable in, 'View camera technique', 7th ed., Focal press, 1999, p.14, presents data which are convincing that manual focusing is much more prone to error than are automatically focussed lenses. Finally, we have been told that the accuracy of the alignment of distances on focus rings is often in error (personal communication, Miles Upton). Accordingly, to reduce some of these problems, we developed a means of focusing, which did not use the viewfinder image. We are sure that there is easier way of doing this, but we have not thought of it yet. We placed a piece of paper tape (masking tape) on the Angenieux's moveable focus ring (Fig.2.-4.). A central line was drawn on the tape corresponding to the 20-foot marking on the movable ring (Fig. 3.). Very roughly parallel lines were drawn on the masking tape with ballpoint pen to left and right of the 20-foot inscription. The average distance between lines was 0.047 inches. The precision of placement of these lines was unimportant. When looking from the front of the camera (as in Fig. 2.), the central line on the tape was designated 0 (see Fig. 3.). Lines falling to right of the central were given negative numbers (-1, -2, -3, etc.), while the lines to left of the central line were given positive numbers (1, 2, 3, etc, numbered on Fig. 3, 1-5). We soon found that no increase in resolution accompanied the turning the focus ring in the negative direction (-1, -2, and –3, the under-focused direction), but increases were observed as the focus ring was moved in the positive direction or over-focused direction.

The results of a typical test are shown in Fig. 4. Here resolution (lp/mm@10%MTF, or line pairs per mm at 10% MTF) is given as a

Fig.2.

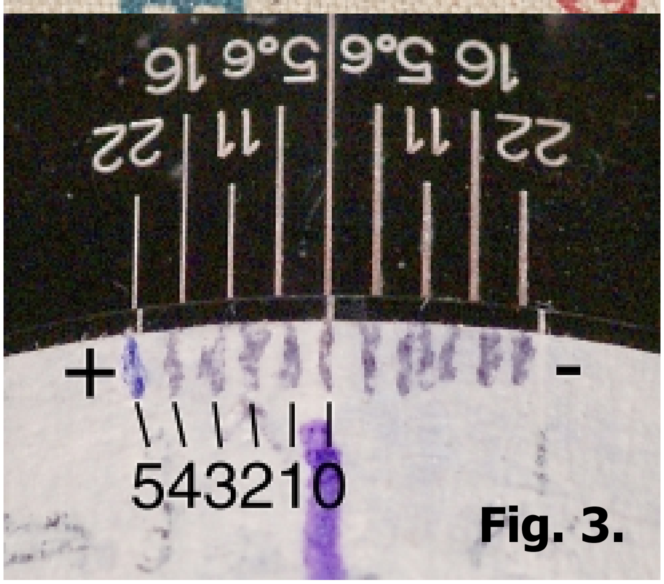

Fig. 3.

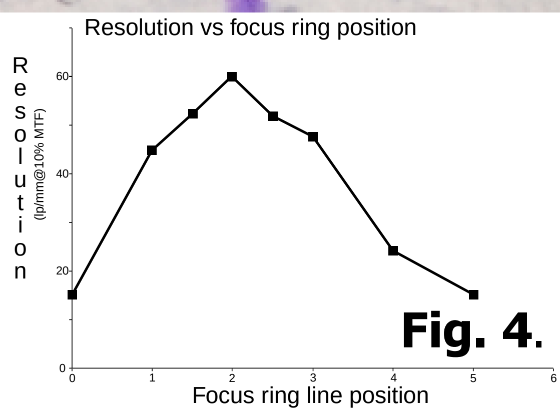

Fig. 4.

function of line positions on the tape. In this case, a peak of about 60lp/mm@10% was observed when the second positive line on the tape was selected for focus.

Unfortunately, the peak resolution vs. focus line position was not stable; it changed in shape and peak position by small amounts with different cameras and with time. For our test results, focus data (peak resolution vs. line position on the focus ring of the lens) were collected before and after each test session (about a day). Test results were not used unless the same peak resolution vs. focus ring position could be seen before and after a test period. We asked Norman Koren about our results. His response was that the most likely explanation was they were the result of an un-flat film plain. This could be aggravated or caused by film curling and geometric distortions of the film which occurs when film is left in the film plane over time. The un-flatness of film seems consistent with our studies reporting on the floating nature of the ring position giving the maximum resolution. This film plane explanation seems viable especially after the depth of focus at the film plane was calculated to be an unforgiving 0.106 mm, at f8 using a circle of confusion 0.013-mm. www.math.northwestern.edu/~len/photos/pages/dof_essay.pdf). However, after measuring resolution as a function of a stepwise rotation of the Angenieux focus ring, we became encouraged we could come close enough to critical focus over each test period that we could carry out our studies. The results of this means of focusing were promising in regard to increased mean resolution and decreased variance.

To illustrate, when we employed a viewfinder to focus a tripod mounted camera using 1/30s exposures; the average mean resolution and standard deviation were 29.52 lp/mm@10%MTF and 5.79 (standard deviation = square root of the variance). In contrast, when the focus ring was placed at a position of maximum resolution (like line position 2 in figure 5) with a tripod mounted camera using 1/30s exposures; the mean resolution and its standard deviation became 44.849 lp/mm@10%MTF and 1.95. This is equivalent to a 34.23 % in resolution and a 65.08% decrease in standard deviation.

4. Camera mountings

A. Tripod

Fig.5.

We used a Giottos (mt 8160) tripod with carbon fiber legs (Fig. 5.). The tripod was fitted with a Manfrotto 3047 head and two canvas bags filled with books (Fig. 5.).

B. Rice bag enrobement

Mark Stuecheli used sandbags. We used rice-bags. We chose rice because they could be purchased at a local supermarket and didn't care to take the chance of sandbags breaking and dumping their contents on a living room carpet.

The first step was to place a 15-lb. bag of rice on a small Table. The camera-lens combination was gently pushed into the bag to establish maximum surface contact (Fig. 6.). Next, a small 2-lb rice bag was placed on top of the

Fig. 6.

Fig. 7

Fig. 8.

Fig. 9.

Fig. 10.

lens in a manner, which did not interfere with the rotation of the high-speed knob or shutter release Fig. 7.). This bag was used to raise the working top of the lens so that the placement of additional bags would better distribute their weight between the camera and lens. Next a 5-lb bag was placed over the camera and the 2-lb bag (fig. 8.). The 5-lb bag connected the lens and camera masses for the placement of another 15-lb at the top of the pile (Fig. 9.). To investigate whether added weight would improve results, we added to the usual stack of rice bags a piece of luggage filled with books (46-lbs., Fig. 10.). Fortunately with the added weigh, our numbers showed no increase in resolution. We say fortunately because this 46-lb. weight balanced above one's head could hurt you, and in addition, it did cleave a cable release with the terminal portion of the release being jammed in the camera, and cause the separation of beautiful Isco lens with its mounting left in the camera and its barrel rolling onto the floor.

5. Illumination

The targets were photographed with incandescent or electronic flash illumination. Lighting intensities were adjusted by moving lights to and from the targets until a Minolta IV light meter indicated that the light level was suitable for f 8 exposures at a given shutter speed.

A. Incandescent

One to four Lowel Tota halogen 500 watt heads were used (Fig. 11.). Two lamps were mounted above the targets on a cross bar. The cross bar with its counterweight was attached to a light stand. The rotation of cross bar around the light stand allowed light intensity to be continuously controlled by varying the target to light distance. In addition, two other lamps were attached below the targets to a small light stand, which could move to and from the targets. Only one light was used for 1/30s exposures, whereas all four heads were utilized for 1/250s and 1/500s exposures. Under these conditions, the exposure was ideal for the 1/250s shutter time, but at 1/500s, the exposures were about ½ stop underexposed, even when the lights were moved as close as possible to the targets. However, the somewhat underexposed images made at 1/500s seemed to present enough graylevels to be usable for these tests.

B. Electronic flash

Electronic flash offers the advantage of producing much shorter exposures than the mechanical shutter of the Exakta. Moving the power switch to the lower position of the Minolta 3500x flashes further diminishes flash duration. At low power, the guide number of each unit was greatly reduced to the extent that three Minolta 3500xi flash units were needed for adequate exposures. These heads were mounted on another counterweighted cross bar (Fig. 12.). The crossbar and its three flash heads were connected to the same light stand used for the upper incandescent lights. The trigger cords from each flash unit were combined with Minolta hardware so that all three heads could be fired by one PC connection. The lights were triggered with the

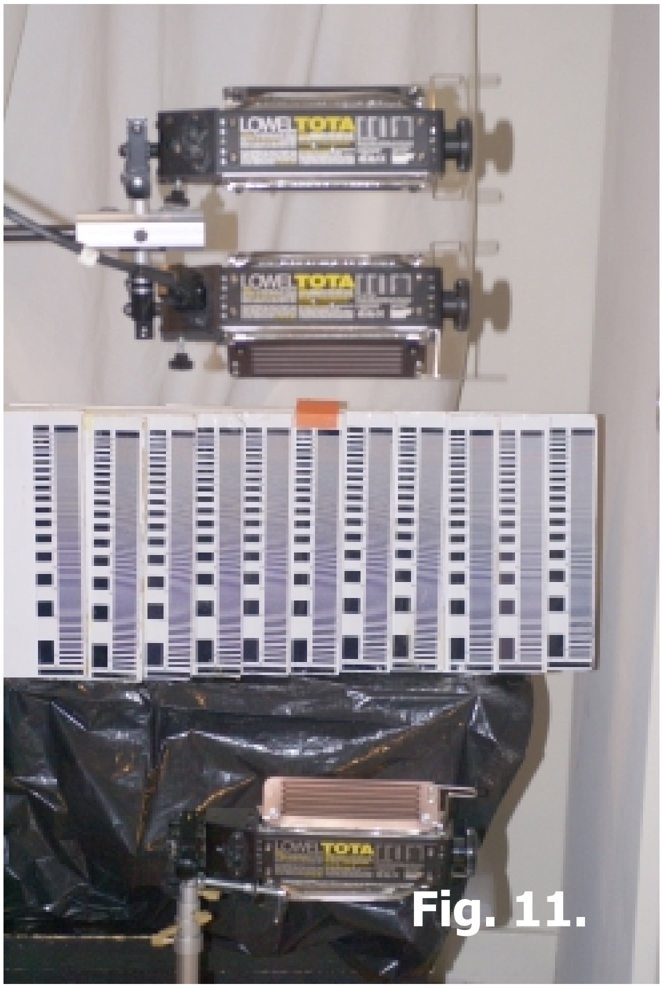

Fig. 11.

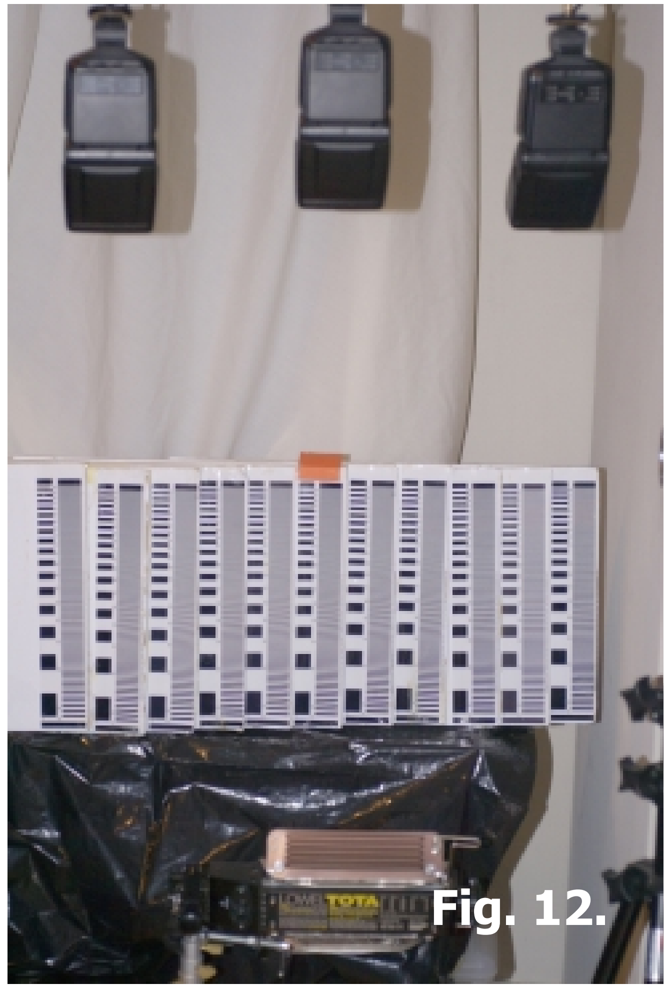

Fig. 12.

XV1000 Exakta by using a 20-meter power cord stretching from the camera to the flash heads (Fig. 13., Purchased at B&H Photo, www.bhphotovideo.com; and marketed by Hama). If distances longer than 20 meters were ever desired, two or more cords could be hooked together serially.

6. Test conditions

A. The controls

1/30s exposures were employed with a tripod and rice-bag mounted camera. By 'controls' it is meant that these results provided the set points from which other test results could be compared.

B. Rubber gaskets

Miha Steinbücher sent some remarkable


Fig. 13.

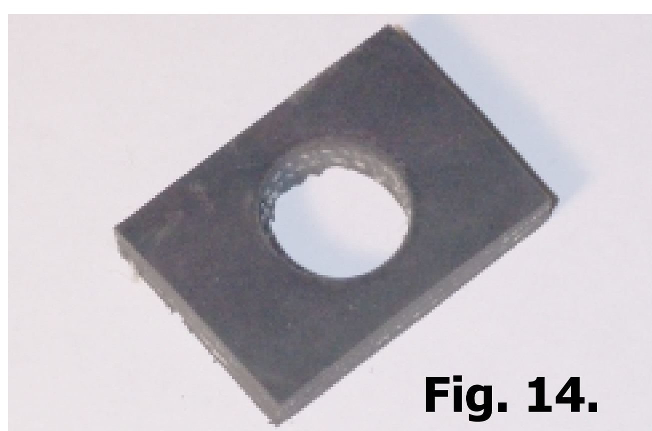
Fig. 14.

architectural photographs made with his Exakta of his native Slovenia. The photographs were so full of detail we asked how they were made. He replied that he inserted a rubber gasket (Fig. 14.) between the tripod head and an Exakta. The hard point of the camera with the tripod mount was placed though a hole in a rectangular piece of the gasket material and then the tripod was used to attach the tripod to the camera-gasket. We asked if we could use these gaskets in our tests. He gave his permission and sent two gaskets . He tells us that he now uses metal mountings, which are superior to the original rubber material. These investigations with rubber gaskets were made with 1/30s exposures

C. Long exposures

In Steve Simmons' excellent book, 'Using the view camera', he shows a picture of the interior of York Cathedral. Because of the low lighting conditions and a mostly dark interior, his exposure meter indicated two minutes at f32. However when this exposure was corrected for reciprocity (the need to extend exposures under low illumination due to film dropping in sensitivity more than predicted by the exposure meter) the exposure had to be increased to 40 minutes. The long exposure was fortunate in that a constant stream of tourists had paraded in front of his camera while the shutter was open. However, none could be seen due to the extended exposure time. We thought that long exposures might provide a simple solution to reducing camera motion problems. We used one halogen lamp whose voltage was reduced by a variable transformer. But note, we obtained the similar results with an overhead home lighting fixture and a simple wall dimmer switch. Our light meter's exposure readings were corrected for reciprocity by the use of data in Kodak's bulletin e31, 2002, 'Reciprocity and special filter data for Kodak'. A lot of different low lighting intensities yielded exposure times from a few seconds to two hours. No significant improvement was seen after about two minutes. For the data presented here, we employed 4.5 minutes to be on the safe side. The camera's shutter was opened with the 'T' shutter setting (room lighting was turned off, blinds closed and windows draped with dark cloth). A stopwatch timed the exposures.

D. 1/250 and 1/500s exposures

Mark Stuecheli used 1/250s exposures with sandbags in obtaining his higher resolution numbers. To determine the relative contribution of elevated shutter speeds and bagging, we measured the effects of the bags vs. tripod mounts with 1/250s and 1/500s exposures.

E. 1/30s exposures after a 12s delay.

Miles Upton suggested this method. The Exakta slow speed knob provided a 12s delay. Then the camera triggered a 1/30s exposure. In the initial phases, the mirror comes up in the box about 2/3 of the way and in the process, disperses a good deal of energy. After the delay, the mirror ascends to the top of the box, and then shutter opens for the 1/30s exposure and closes with relatively little noise. These experiments used both tripod and bag mountings.

F. Electronic flash

A camera and lens were mounted with either on tripod or in rice bags and the effect of the high exposure speed was provided by electronic flash. Three flash heads at the low power setting were triggered with a 20-meter power cord connecting the flash heads to the VX1000. These tests were usually done in daylight but room lighting was turned off, blinds closed and windows were draped with dark cloth.

G. Virtual mirror lockup

This test was aimed at simulating or surpass-

Table I. Effect of camera mounting and exposure speed on resolution

Row	Test conditions	lp/mm @ 10%MTF	Standard deviation
1.	Mount: tripod + rubber gasket Exposure: 1/30s	32.84	0.98
2.	Mount: tripod Exposure: 1/30s	44.85	1.95
3.	Mount: rice bags Exposure: 1/30s	50.35	4.35
4.	Mount: tripod Exposure = 4.5min.	55.50	2.42
5.	Mount: tripod Exposure = 1/250s	58.21	0.86
6.	Mount: tripod Exposure: 12s delay + 1/30s	58.57	2.08.
7.	Mount: rice bags Exposure: 1/250s	59.30	0.86
8.	Mount: rice bags Exposure:12s delay + 1/30s	59.31	3.31
9.	Mount: tripod Exposure: 1/500s	60.34	1.88
10.	Mount: tripod Exposure: mirror lockup + flash	62.43	1.22
11.	Mount: rice bags Exposure: flash	62.50	2.58
12.	Mount: rice bags Exposure: 1/500s	63.09	5.24
13.	Mount: tripod Exposure: flash	63.41	2.26

ing mirror-lockup conditions available in other cameras. Here we sought to eliminate camera movement so that its absence could be evaluated.

This work was done at night with the light dampening conditions employed above for long exposures. The tripod mounted VX1000 did not trigger the flash exposures. To avoid any interference, the flash heads were connected to a second Exakta from which flashes were initiated. No flash was used until the shutter of the VX1000 had been opened in the ‘T’ setting for 30s. After the flash, the shutter remained open for an another 15s. While the results should be free from camera noise, the camera still could be subject to mechanical vibrations common to buildings. The shutter opening times were timed with two stop-watches (one for 30s and the other for 15s).

Results and discussion

In 'Materials and Methods' we described 13 methods to test the effects on resolution of camera mountings and exposure speed. The results of these studies are shown in Table I. The first column gives the table's row numbers. The abbreviations used for each test are given in the second column. The means and standard deviations are in columns three and four. The rows have been ranked on the basis of increasing resolution. In this scheme, row 1 gives the lowest mean, 32.84 lp/mm@10% MTF, while row 13 presents the highest, 63.41 lp/mm@10%MTF. We wanted to know which of these 13 means differed enough from one another to be considered separate. To do this, we applied paired t-tests sequentially to pairs of measurements summarized in row 1 to 13. To illustrate, the first t-test was calculated from data from a camera mounted on a tripod using a rubber gasket (row 1.) and from a tripod-mounted camera with no rubber gasket (row 2.). The t-test indicated that these two means differed more than could be expected by experimental error (at the 95% confidence level; this level of significance was used through these studies). These findings suggest with respect to resolution that there is no advantage gained by placing a gasket between the camera and tripod. As for the gasket data, we must rush to say that if we were to visit Miha in Slovenia, we are certain that we would discover what he does that we didn't do. In the meantime, his beautiful, high-resolution images speak for themselves.

Added note: We sent a preprint of this paper to Miha. His comment was that the gaskets in our hands were made to be used with Manfrotto rectangular quick release plates not the hexagonal release plates which we used. From a quick study on his part, the gaskets on the hexagonal plates gave less area of support and less stability that would occur with his rectangular plates.

In the next case, the t-test was applied to measurements summarized in rows 2 (tripod mounted camera using 1/30s exposures) and 3 (bag mounted camera using 1/30s exposures). Again, the results indicated that these means differed significantly. The interpretation was that a camera mounted in rice bags using 1/30s exposures showed a significant increase in resolution when compared with camera mounted on a tripod using the same 1/30s exposures. Mark Stuecheli's bag experiments were done with 1/250s exposures, but the data in rows 2. and 3. indicate that an increase in resolution could be observed with the use of bags at 1/30s.

The study of data summarized in rows 3. (bag mounted camera using 1/30s exposures) and 4. (tripod mounted camera using 4.5 minute exposures) once again indicates that these means differed. The lower mean of the two (row 4.) is from a bag mounted camera using 1/30s exposures whereas the higher mean is from a tripod mount combined with 4.5 minute exposures. The conclusion is long exposures (4.5 minutes) can increase resolution by about 13.35 lp/mm@10%MTF.

T-tests showed the data summered in rows 5.-8. did not differ enough to be separable (they appeared to have the same mean). However, they are different from means above and below these values (different from tests listed on rows 1.-4. and 9.-13). The 1/250s results argue for higher shutter speeds increasing resolution. The data from 12s delays before the 1/30s exposures propose that the delay is probably decreasing camera vibration effects to the extent that a 1/30s exposure can obtain the same resolution as seen in 1/250s exposures. These results indicate that the delay function in Exaktas does provide many of the characteristics of the mirror lockup function. Here, neither bags nor tripod mountings presented an advantage for the exposures made at 1/250s or 1/30s after the 12s delay. As we have said, Mark Stuecheli's observed increases in resolution when both bags and 1/250s exposures were used together. Our data suggest that Mark's improved resolution scores owe more to 1/250s shutter speeds than bags.

The next highest mean occurs on row 9. (tripod mounted camera using 1/500s exposures; 60.34lp/mm). Using t-tests, the mean on row 9 was shown to differ from all other means in Table I. These observations indicate that resolution can be increased by further increasing shutter speed to 1/500s
An another application of t-tests, projected the existence of another group of four inseparable measurements (rows 10.-13.). Again, these improved resolution figures correlate with increasing exposures speeds (1/500s or electronic flash). One member of this group, the 1/500s exposures made with a bag mounting (row 12.; 63.09lp/mm@10%MTF) produced a mean greater than from that resulting from 1/500s exposures made on a tripod mounted camera (row 9.;60.34lp/mm@10%MTF). Thus, in this case bags provided an advantage; however, most of the increase in resolution was due to 1/500s exposures rather than bags. This seems consistent with the 1/500s tripod mount exposures (row 9.) producing a 15.49 lp/mm@10%MTF increase over 1/30s exposures made from a tripod (row 2.) wherefore the 1/500s exposures from bag mounts offered only 2.75 lp/mm@10% MTF increase over the tripod mounted camera using 1/500s exposures.

The data from the electronic flash using bag and tripod mounts (rows 11. -13.), again presented the argument that increasing exposure speed increasing resolution. This increase was indifferent to mounting (bag or tripod).

The virtual mirror lockup method was designed to show how resolution would be affected if all sources of camera movement were reduced to zero. With this technique, nothing was moving in the camera 30s before and 15s after the electronic flash exposure. We indicated that the only possible source of vibration could be movement inherent to the building in which the tests were run. With this caveat, we believe that most of our test goals were fulfilled, and that our virtual mirror lockup condition produces results provisionally independent of camera motion. Since the virtual mirror lockup measurement cannot be divided from the other three methods in rows 11.-13, we assume that all of these conditions form results which are unaffected by camera noise. In all these cases, resolution must reflect other limitations such as optics, attaining the smallest circle of confusion possible for a given lens at the film surface, film plane flatness problems, etc.

Limits of resolution

Are these resolution scores the highest numbers of which our Angenieux is capable? In three cases, the Angenieux produced images which measured in excess of 70lp/mm@10%MTF. On examination of the 3 negatives, we found them to be consistent with the resolution numbers measured (they were superb images). We can think of no testable reason why such images should not have been produced routinely (other than for variable curling of film).

Plans for the future

We don’t see the need for further tests as done in the past. We think we have successively demonstrated what an Exakta owner past and present could have expected from their cameras and lenses (1936-). The present study shows that many Exaktas probably produced resolution results below what their lenses were capable. If you can think of anything to increase resolution measurements including methods of using digital photography, we could be persuaded to come out of retirement. In this regard, does anyone know of any digital cameras (8MP or greater) that can be modified to take Exakta mount lenses? This would be a good next step.