EVERYTHING YOU NEED TO KNOW ABOUT YOUR LIGHT METER

DARKROOM & CREATIVE CAMERA TECHNIQUES

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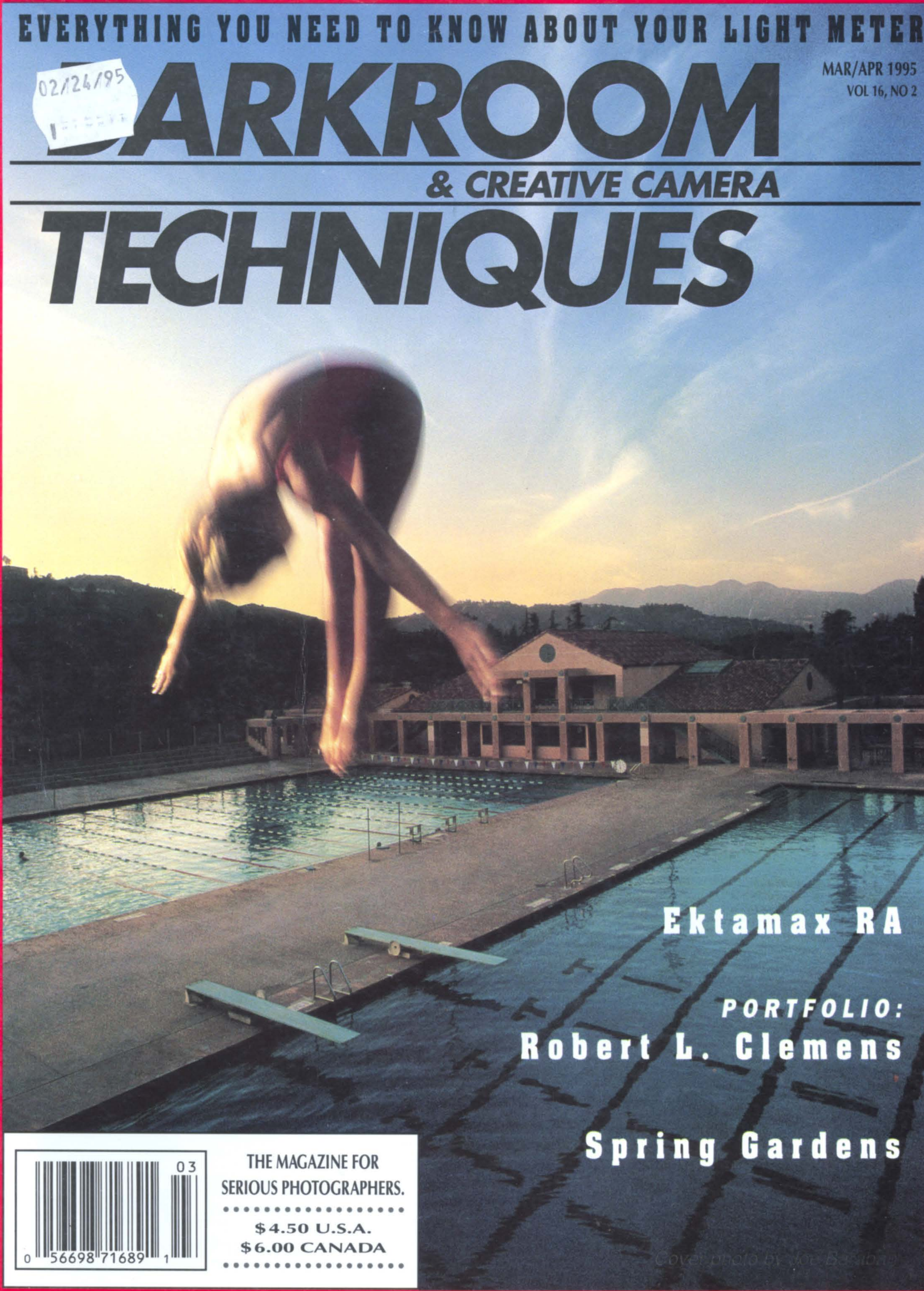

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A Light Meter Practicum

PART I: TESTING FOR LINEARITY

By William Schneider

- *Have you ever metered a scene, placed the shadows on Zone III for lots of detail, and then found that the shadow exposures were nearly transparent in the resulting negative?*
- *Are your photographs shot in dim light situations consistently overexposed, and those shot in brilliant light underexposed?*
- *Are all your early morning and late evening negatives thin?*

If you have problems like these, you may think they're caused by your camera or your technique, but perhaps they're not. Perhaps your light meter is to blame.

Even with today's advanced technology, inaccurate or poorly designed light meters are more prevalent than they should be. In a series of three articles, of which this is the first, I will detail several experiments which will allow you to evaluate the performance of your own individual light meter. This first article describes a way to check the linearity of your meter's response to various light levels, without resorting to expensive test equipment. The second article deals specifically with testing flare levels in spot meters and how flare causes underexposed shadows. The third article will deal with the sensitivity of light meters to infrared light and correction filters for that problem.

Uncovering the Problem

Since 1981, I have owned no less than nine modern, multi-hundred-dollar light meters from both Japanese and German manufacturers. Not because I like to collect light meters; rather, it was because I found many problems with the reliability and accuracy of my meters. At first, I blamed my own carelessness for the exposure problems I experienced. But further experimentation and testing provoked questions about the accuracy of the equipment. Using some readily obtainable materials and a little thought, I devised some methods for testing light meters at home. What I found concerning light meter accuracy was unsettling.

Light Meter Nuts'n'Bolts

Before continuing, a brief overview of light meter technology might be in order:

A light meter is a dumb instrument not unlike a thermometer. A thermometer reacts to heat and indicates temperature on a scale. Likewise, a light meter senses the amount of light falling on its receptor and indicates a measured intensity. While the operation of a thermometer is easy to understand, a light meter utilizes complex electronic circuits to perform its task. If you consider the major components of a light meter separately, it becomes easier to understand its operation. The major components of a light meter are:

1. The optical system in front of the meter's sensing cell;
2. The light sensitive component, usually an electric photocell;
3. An electronic circuit that amplifies and interprets the output of the photocell; and
4. A readout that transforms the output voltage from the circuit into useful exposure information.

The optical system can consist of a simple transparent protective cover over a photocell, a translucent dome on an incident meter, a color-correcting filter, or the complex lens and prism system found in spot meters. The complexity of the spot meter's optical system invites flare problems that can artificially inflate the apparent light level. This can lead to gross underexposure of shadows in some situations.

In the past, the light sensitive components of meters were made of cadmium sulfide or selenium, but today's meters use silicon photodiode cells because they're more sensitive. Because most modern silicon photocells react to the red part of the spectrum more strongly than films do, they indicate a brighter light than is really present if the light is rich in infrared or is reddish. Sunrises, sunsets, and tungsten lights are rich in the red portion of the spectrum, and this can lead to metering problems. Manufacturers sometimes correct the photocell with filters that block some of the red light, to better match the spectral response of film. If this is not done adequately, photographs made in reddish late-day light or under tungsten light are often underexposed. The meter reacts strongly to the reddish light and indicates plenty of available light when—as far as the film's sensitivity is concerned—that isn't the case.

The electronic circuit and readout are prone to accuracy problems. Ideally, a doubling of the amount of light should be indicated by an exact doubling of the light meter reading. If the electronics are not adjusted for a linear response, they don't accurately register proportional increases or decreases in light. This results in a correct exposure reading at only one light level, and incorrect exposures at other light levels. This article deals with a practical way to judge whether your meter response is linear.

Linearity

Accurate meter linearity is key to achieving consistent exposures under widely varying light levels. A meter must "know" that a five stop change in light is a five stop change—not $4^1/_3$ stops, 6 stops, or some other miscalculation.

It is important to note that meter linearity is different from a meter offset. An offset is a fixed difference between the meter reading and the amount of light actually present. For example, curve B in figure 1 depicts the response curve of a meter that reads 2 stops low under all light levels. It still has a proportional response to light, but always exhibits a 2 stop error (or offset) from the correct reading. If the meter itself can't be recalibrated, this 2 stop offset can be corrected either by adjusting the ISO setting or by performing the calculation mentally when shooting. The usual ways of testing film E.I. using the meter automatically compensate for any meter offset.

Non-linear and non-proportional responses are harder to detect, and simple ISO adjustment will not work as a fix. Curve A shows a non-proportional light meter response. Note that it is accurate at one light level, but grows increasingly inaccurate under lower and higher light levels.

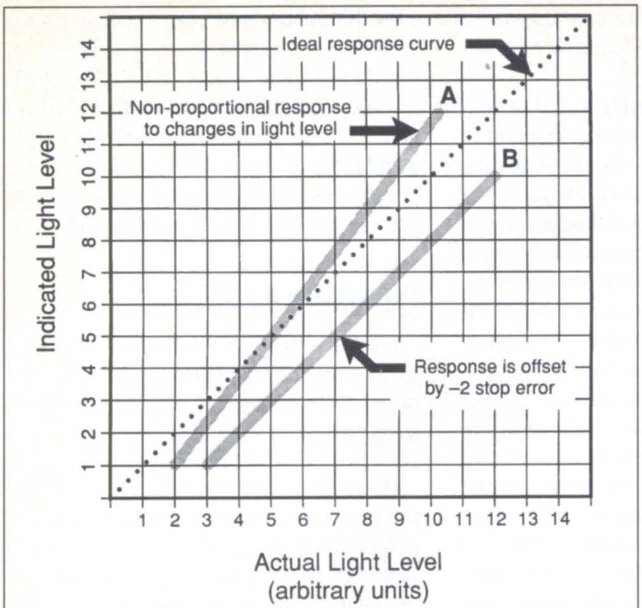

Figure 1. The graph shows two common types of meter miscalibrations. A constant offset error is easily compensated for, but a non-proportional miscalibration spells trouble.

For simplicity throughout the rest of this article, I will use the term non-linear to mean both non-proportional and non-linear meter behavior.

One of my first spot meters was an analog 1° Soligor that gave good exposures in daylight, but became increasingly inaccurate in dimmer light. Because I had bought the meter second-hand, I assumed that a new replacement would cure my problems. I then bought a modified digital version of the Soligor. While this meter was an improvement over the original, it still exhibited some exposure irregularities. I suspected meter non-linearity, and I sought ways to test my meters without allowing other errors such as a color shift to affect the measurement.

To test a light meter, you need a source of light. To test linearity, you need to be able to control the light intensity in a series of steps from dim to bright. Using a gray card and daylight might work, but it is hard to control just the light level without introducing other variables. For example, you could meter and shoot a gray card in direct sunlight, and then move it into shade, but the color temperature would certainly shift, possibly affecting the meter's reading. Using neutral density filters permits light level changes without appreciably changing color temperature, but stocking up on the various filters costs a small fortune and sunlight's changeable nature as clouds come and go remains a potential source of error.

Because of the problems with natural light, I sought a good source of artificial light for the tests. One apparent way to control light levels is to use a lamp controlled by a dimmer switch, but that method is flawed because it shifts the color temperature of the light dramatically toward the red as the light is dimmed. Most tungsten lights are very red to begin with, and further shifting toward red would make matters worse. You would not know if a linearity problem, a color sensitivity problem, or a combination of the two had affected your measurements. Because most of my exposures are made outdoors, light of about the color temperature of daylight was most desirable for my tests.

My solution required nothing more than a slide projector, a piece of translucent Plexiglas, and a color correcting gel. Figure 2 shows a sketch of the setup. The slide projector provides a bright light source that has reduced infrared content. A piece of translucent milk Plexiglas that has a color-temperature correcting gel taped to it becomes the meter target. If you haven't already guessed, light intensity is changed by simply moving the projector further from, or closer to, the Plexiglas target. This modulates the strength of the light without changing the color temperature of the light source. I then made a series of metered exposures on slide film at various light levels and compared the densities of the processed transparencies to see if they matched.

The Light Source

A slide projector makes a good bright light source without as much infrared in the light as a tungsten bulb alone produces. Most slide projectors use infrared-passing reflectors (a cold mirror) and infrared-absorbing filters to eliminate as much of the heat as possible before the light passes through the slide. If you look through the reflector of a slide projector bulb, you can see a red color through it. In operation, this allows a large portion of infrared and near infrared light to pass harmlessly out the back of the reflector, while only the visible light gets reflected forward to the slide. In addition to the special reflector, most slide projectors also have a heat absorbing glass filter placed between the lamp and the slide. Together, these two devices prevent "cooking" a slide, and reduce the large infrared "hump" in tungsten light's spectrum.

Because the remaining rays are still reddish, place a blue color-correction gel somewhere in the light path before the Plexiglas target. The blue-filtered slide projector light closely approximates the color of daylight without having excessive infrared. I taped a small sheet of Rosco Tough Blue 50 to the back of the Plexiglas, although a blue Wratten 80A filter could be substituted. Rosco and Lee filters are substantially cheaper than Wratten filters and they are durable enough for use over studio lights. You can find them at theater supply shops or from well-stocked photography dealers. All of these filters convert reddish 3200 degree Kelvin light to 5500 Kelvin to match the characteristics of daylight.

Interestingly, the ANSI standard for testing light meters specifies a color temperature slightly redder than standard 5500° Kelvin daylight. ANSI publication PH3.49-1971 recommends using a 2854 K tungsten light source filtered to 4700 K for use with exposure meter tests.

If you already have an 80A screw-on camera filter, you can simply tape it over the projector lens to color the outgoing light for the test. If the meter to be tested is the one in your camera body instead of a hand-held unit, then you can simply screw the filter onto the front of your lens instead of taping it to the Plexiglas. The critical thing to make sure of is that the meter and the film in the camera see the same color-corrected light.

The meter target is a piece of translucent white Plexiglas illuminated from behind by the slide projector. I used a sheet from the

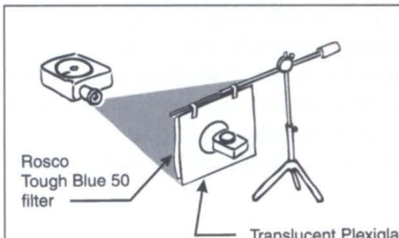

Figure 2a. This diagram shows the major components of a setup to test light meter linearity. Step one is to meter the light with the meter to be tested.

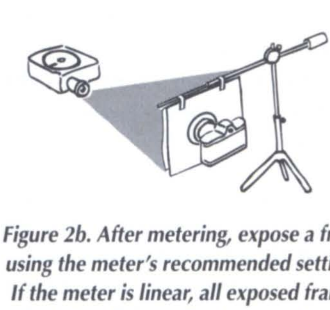

Figure 2b. After metering, expose a frame using the meter's recommended settings. If the meter is linear, all exposed frames should exhibit nearly the same density.

top of a light table. The light passing through to the front of the sheet is metered and photographed for the test. While I used a light stand with a boom to support the Plexiglas, you can enlist the steady arm of a friend if you wish. Whatever you use, make sure that you can easily change the distance between the slide projector and the Plexiglas sheet to change the light level. On the Plexiglas, use a grease pencil to mark a circle about the size of the camera lens diameter. This ensures that you meter and photograph the same spot. You will find that the illumination from a slide projector can vary quite a bit from beam center to edge, and the marked circle reduces the possibility of error.

Check your Camera!

You will use your camera to make slides or negatives of the illuminated Plexiglas target. If a light meter is linear, it will suggest exposures that result in matching densities regardless of the light level. Using your camera to produce slides or negatives from the metered Plexiglas target requires a camera to have accurate shutter speeds and apertures. You should check your shutter speeds regularly anyway, so this is your excuse to do it! Make sure that you ask for a list of actual speeds produced at the various shutter speed settings. Don t be too alarmed if the highest shutter speeds aren't very accurate—a shutter's fast speeds are typically error-prone, and can be avoided for testing purposes. If you can't find a local test facility to check your shutter, be sure to investigate the inexpensive hand-held shutter speed tester available from Calumet. Generally speaking, apertures are not as likely to cause exposure errors as shutters are, but you should avoid the largest and smallest apertures just in case.

An inaccurate camera introduces significant experimental error, and will produce misleading results.

Performing the Experiments

The light coming through a Plexiglas sheet positioned about a foot in front of my slide projector's lens is as bright as the lightest object that I encounter in daylight—white paint in sunshine. That is about EV 16 at EI 100 for me and thus, that's where I start. Make sure that the light coming through the Plexiglas sheet is uniform in the area to be tested. Take a meter reading of the light while holding the meter against the target circle. Set the suggested exposure on the camera (avoiding the fastest shutter speed and the smallest aperture), focus at infinity, and expose a frame while pressing the lens into position on the target circle. Write down the meter reading and the frame number of the exposure. You can also write down shutter speeds and apertures to aid troubleshooting later on.

I use the light meter being tested to help establish the distances for the remaining light levels. I aim to make test exposures at 1 stop (1 EV) intervals to produce plenty of data to graph later on, so I just move the Plexiglas target until the meter indicates a one stop change. I make another exposure, and move the target sheet again. I found that the light level drops to about EV 7 (which is a nine stop change) when the sheet is positioned about 20 feet from the slide projector. At this point it becomes difficult to further reduce light levels by increasing distance. The inverse square law states that you have to multiply distance by 1.4 to get another 1 stop change in light, and this requires more space than I have in my house.

To achieve lower light levels, I cut a cardboard disk and punched a $1/4$" hole in the center to make a crude aperture. This fits against the rear element of the projector lens and blocks most of the light through the lens (See Figure 3). With the aperture in place, I can reduce light levels down to EV 2 at the 20 foot mark. The lens with aperture projects an uneven light pattern, but just position the target circle in a relatively even part of the beam for the test.

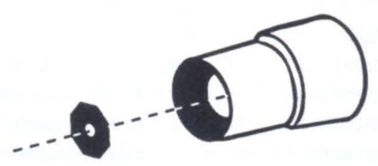

Figure 3. Cut a small cardboard disk and punch a $1/4$" hole in it to create a light-reducing aperture for the projector lens.

Besides avoiding the fastest shutter speeds and aperture extremes because these are often inaccurate, avoid shutter speeds shorter than $1/2$ second to prevent film reciprocity effects from affecting the results.

Evaluating the Results

After all the test exposures have been made, develop the film and look at the densities of the various frames. I request that the developing lab not cut or mount the film, to make identifying the various frames easier. A perfectly linear meter should produce closely matching densities in all the frames. A non-linear meter will produce densities that don't match, and indicates that the meter is a candidate for repair or replacement.

I found that slide film is a good test medium because its high contrast amplifies exposure errors. In addition, the color of the slides tells something about how close the light source is to standard daylight. My testing shows that the filtered slide projector light is slightly greenish, but still close to a medium shade of gray. Some deviation from an ideal gray is unavoidable, so don t worry too much if it doesn't exactly match a gray card. In terms of color for this test, close is good enough.

Quantifying the Results

If the test exposures closely match in density, don't worry about quantifying how much error a particular meter has. A linear meter is a good meter, and slight offset inaccuracies are corrected by proper film testing.

However, if I find significant fluctuations in test exposure density, I usually plot the data to spot trends. Because I have access to a densitometer, I have a way to quantify (in stops) the relative accuracies of my meters. I can read the density of the test frame and compare it to the film's characteristic curve. With a little care, this works surprisingly well. I determine my own characteristic curve rather than rely on manufacturers printed "spec sheets" to avoid potential pitfalls. Manufacturers sometimes improve their films, and don't bother to update the film information. Besides, most manufacturers' data are plotted in exposure units other than stops, which makes transposition troublesome.

To make your own characteristic curve, shoot a roll of slide film with different exposures ranging from 4 stops underexposed to 4 stops overexposed in $1/2$ stop increments. Use the same filtered slide projector light and Plexiglas target that you use for testing the meter and be sure to identify the exposure settings of each frame. After processing, plot the densities of the different exposures against the exposure in stops to create the characteristic curve. I use a horizontal scale of -4 through +4 stops for plotting, with 0 representing the indicated exposure setting. With most slide films, an indicated exposure will produce a medium-gray density of about 0.75, and that pretty well agrees with exposures made with my good meters.

With the characteristic curve plotted, you can take density readings from the meter test and compare them to the characteristic curve. For example, I found that a one-half stop exposure change means a 0.13 change in slide density for my test film near medium gray exposures. With this data in mind, if the density of a meter test exposure is a thin 0.62 (0.75 - 0.13 = 0.62), the meter underread the amount of light by $1/2$ stop. This method can be extended to the other meter test exposures, and a table can be made of exposure errors vs. various light levels tested. Being able to quantify the response of your meter allows you to plot the infor-

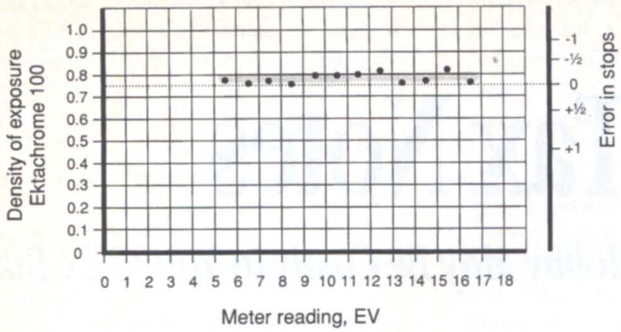

Figure 4. A plot of the densities of frames exposed using my Minolta Flashmeter III. It shows linear behavior under a wide range of illuminations.

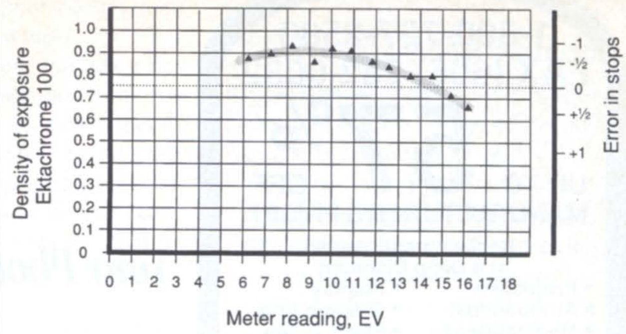

Figure 5. A plot made using the author's older Soligor spotmeter. It is a candidate for retirement or repair. Its error approaches 1 stop (toward underexposure) at EVs 8-10 (ISO 100).

mation for a quick look at how your meter performs. A graph makes error trends immediately apparent. See Figure 4 for a performance plot of my Minolta Flashmeter III. It is very linear, but shows that it produces transparencies just a little more dense than my aim point of 0.75 density. Compare the performance of the Minolta against my Soligor, as shown in Figure 5. Non-linear response to light is apparent in this graph, and my personal experience has proved this particluar meter undependable. It is a candidate for the repair shop.

If your meter successfully passes the linearity test, you can relax—until the next issue, when I will deal with flare and how it affects spotmeter readings. In that article I will describe a very simple test for detecting flare levels in the meter system, and suggest several fixes for better, more accurate metering.

References

American National Standard for General-Purpose Photographic Exposure Meters (Photoelectric Type), publication PH3.49-1971, New York, NY: American National Standards Institute, Inc., 1971.

Rosco Videokits—Light Control Color Correcting Materials for Video and Film Production, instruction pamphlet packaged with Rosco videokit, Port Chester, NY: circa 1986. ■

Athens, Ohio resident William Schneider teaches photography and desktop publishing classes in Ohio University's School of Visual Communication. Before obtaining his MFA degree in photography, Schneider worked 7 years as an engineer in the research labs of Battelle Memorial Institute in Columbus, Ohio. He is an active participant in the emerging computer graphics field, but still enjoys quality time in his traditional darkroom.