The "Norwood Director" family of photographic exposure meters

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ABSTRACT AND INTRODUCTION

An important family of photographic exposure meters consists of meters which in the earlier days of the family all had the name "Norwood Director". The family has a fascinating history with respect to the meters themselves and with respect to the various people and firms involved. In this article I try to paint the overall picture of this family and its story, and describe most of the meters in it.

Appendixes discuss certain technical complexities in this area.

1 GENERAL

1.1 Incremental descriptions

When a certain feature is introduced at a particular model of the line, it will be discussed there. If there is no mention of this feature in the description of a following model, we may in general assume that it is still in play there.

1.2 Our personal collection

We have specimens of several of the meter models discussed here in our personal collection. These are indicated by a "smiley face" next to the main photograph of the model. Unless indicated otherwise, the photographs of these are by the author.

1.3 Other photo credits

Several photos in this article are copyright James Ollinger or John D. de Vries, and are used by permission. Thanks, guys.

1.4 The unit of illuminance

Most of the meters discussed here have a basic meter movement scale calibrated in the non-SI (US customary) unit of *illuminance* which is variously written as “footcandle”, “foot-candle”, or “foot candle”, or abbreviated as “ft-cd” or *fc*. There is no applicable standard that makes one of those forms of the term “correct”.

The forms “foot-candle” and “foot candle” and the abbreviation “ft-cd” are deprecated as they suggest that the unit is the product of the unit “foot” and the unit “candle”, which it is not. Thus I uniformly use the form “footcandle” for the unit itself.

On the other hand, when the unit name is presented on the face of a specific meter as “foot candles”, “foot-candles”, “ft-cd” or “*fc*”, I will use that form when discussing the markings.

1.5 The light measurement system

Except for those later models described in section 10, all the meters described in this article use a photovoltaic photocell, which generates an electrical voltage when exposed to light. Its output is directly read by a passive microammeter. No battery is involved.

2 THE NAISSANCE OF THE "NORWOOD CONCEPT"

In the mid 1930's, incident light exposure metering in the common studio situation of the lighting of a human subject with two light sources (under the key-fill technique) required at the least taking two measurements with an incident light exposure meter, combining them mathematically, and then feeding the composite result into the meter's exposure calculator to develop the exposure recommendation.

Donald W. Norwood had the vision that a reflected light exposure meter in which the photo sensor was a hemisphere, rather than a flat plate as in most meters of that type, would be able, in a single measurement, to develop an optimal exposure recommendation over a range of subject and lighting situations.

Subjective tests under controlled conditions, as well as a period of practical use of prototype meters of this configuration, seem to have confirmed Norwood's intuition.

Norwood was granted a patent in 1940 on this scheme.

Although the original concept was of an actual hemispherical photo sensor, Norwood later realized that a translucent hemispherical "light-receiving member" (I call it the “receptor”), mounted over a flat photo sensor, would produce essentially the same behavior and be much less costly to manufacture. The meters discussed here use that implementation.

All meters discussed in this article use this concept in their principal “incident light” photographic exposure metering modes.

More detail on Norwood’s invention, including some “questionable” aspects of his seminal paper on the topic, are found in the companion article by the same author, “Norwood’s dome: a revolution in incident light photographic exposure metering”, probably available where you got this.

3 THE METERS AND THEIR MAKERS

In the following sections, I discuss essentially all meter models in the “Norwood Director” dynasty, organized by the firm that made them, and in sequence of introduction within each firm.

In some cases, I will jump back and forth between makers to keep the discussions of the meters in the right chronological order of their appearance.

4 PHOTO RESEARCH CORPORATION

4.1 Founding

Norwood's colleague cinematographer Karl Freund, likely at Norwood's urging, founded Photo Research Corporation in 1941, and began the design of an exposure meter to exploit Norwood's concept, presumably under license under the Norwood patent.

Figure 1. Karl Freund (center) in 1941

Image: International Encyclopedia of Cinematographers

Figure 1 shows Freund in 1941 (with Risë Stevens and Nelson Eddy, on the set of "The Chocolate Soldier") using what we believe to have been an early prototype of this new meter (*cf*. figure 2). It looks very much like the “Model A” meter I will discuss next.

Figure 2. Norwood Director exposure meter ("Model A")

4.2 The Norwood Director exposure meter, "Model A"

The new meter came into general production in 1946 under the name "Norwood Director" (This name was likely adopted at the 11th hour; the Bakelite housing of the meter had molded in just "Norwood Exposure Meter"). This model is today referred to by exposure meter historians as the “Norwood Director, Model A”, although that notation was never used by the manufacturer. We see this model in Figure 2.

This model was made for many years, but under the name "Norwood Director" for only about a year, owing to other industry developments.

On the back of the "turret" is an exposure calculator, essentially a specialized circular slide rule. The user sets the film sensitivity (speed) and the reading of the meter movement proper (in footcandles) into the calculator. The user can then note any one of a number of equivalent exposure time (shutter speed) and aperture (f-number) combinations (any of which constitutes the exposure recommendation given by the meter).

All other meters discussed herein (other than the M3) use an exposure calculator following this overall principle, although the design is rather different (and differs in details among those models).

5 THE “BROCKWAY FIRM” ERA

5.1 American Bolex

In 1947, American Bolex (owned by the Brockway family), at the time the US distributor of the Paillard-Bolex motion picture cameras, apparently acquired the exclusive rights to the trademark "Norwood

Director", and apparently as well non-exclusive rights under Norwood's patent covering the meter's unique operating principle.

We can only conjecture how this came to happen. Perhaps Don Norwood felt that Photo Research was not sufficiently aggressive in marketing Norwood's patented design concept and sought a second channel of exploitation. And perhaps Ezra Brockway, the head of American Bolex, foresaw that he would soon lose his Paillard-Bolex franchise and that the firm would need a new product line.

5.2 Norwood Director Model B

5.2.1 *Introduction*

American Bolex, through the work of industrial designer Alpheus Maple, gave the meter a wholly new (and much more stylish) physical design, and, beginning in 1948, that firm marketed the new design under the "Norwood Director" name. This model was called the Model B (apparently acknowledging the original model, made by Photo Research, to be "Model A"). We see it in Figure 3.

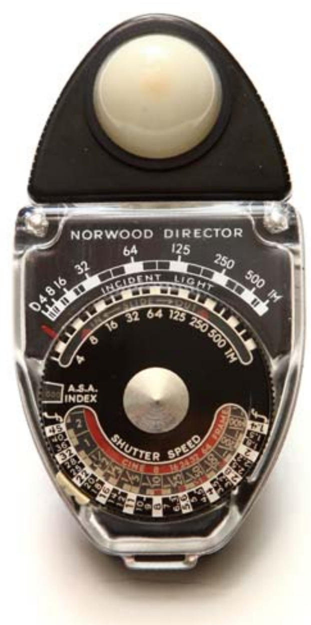

Figure 3. Norwood Director exposure meter Model B

This model carried the marque "Norwood Director" on the front, and the nameplate on the rear said "Norwood Director" and "American Bolex Company, Incorporated".

All future direct descendants of this meter have essentially the same photometric scheme, measuring "mechanism", and physical and aesthetic design, through the present time, where they can be found in the current production (as of 2022) Sekonic Model L-398A (*cf*. Figure 18).

5.2.2 *The turret*

The photoelectric sensor with the hemispherical receptor over it are mounted on a turret so that the receptor can be aimed as appropriate (normally toward the camera) while the body of the meter is pointed in the direction that will best allow the photographer to read the meter.

5.2.3 *Working the calculator*

To set the exposure index, the user moves a tab (on one of the calculator rings) until it is aligned with the "A.S.A index" window, at which time the current index setting appears in that window. Then, while holding the tab in that position, the user turns the main dial, which causes different exposure index values to march through the window. When the desired value is in place, the sensitivity setting process is complete.

To enter into the calculator the luminance indication of the meter movement, the user turns the main dial until a pointer points to the indication on a "proxy" for the meter movement scale on the calculator itself. There are actually two arrows. One, white and marked "L", is used with the meter in its "low range) (*i.e.*, with the “high slide”–*cf*. section 5.2.4–not in place). The other, red and marked "H", is used with the meter in its "high range) (*i.e.*, with the “high slide” in place).

5.2.4 *The range-multiplying slide*

The meter is supplied with a range-multiplying "slide", a perforated metal plate that can be placed in a slot to lie between the receptor and the actual photosensitive sensor. It attenuates the light by a factor of 32 [1], and thus multiplies the measurement range of the meter movement by that factor. Since the basic meter movement scale runs to 1000 footcandles, this allows the determination of the exposure recommendation for illuminance up to 32,000 footcandles.[2]

When the slide is in place, the indication of the meter movement proper is entered into the calculator against a second “arrow”, offset by an amount corresponding to the attenuation ratio of the slide (thus making the algebra continue to work properly).

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[1] But for simplification this is often stated as 30.

[2] The "typical sunlight" contemplated by the familiar photographer's exposure rule of thumb called "sunny 16" has a luminance of about 6500 footcandles.

5.2.5 *What is actually measured?*

Although the reading of the meter might seem to be that of the physical property of *illuminance*, that is not quite so.[3] For it to strictly measure illuminance, the response of the meter to light arriving from different directions would have to vary as the cosine of the angle of arrival of the light component (measured with respect to the axis of the collector).

That is intentionally not true for the "Norwood principle" receptor. Its theoretical "directivity", which platted in polar coordinates closely follows a curve known technically as a *cardioid,* suits it to follow Norwood's empirically-validated principle of optimal single measurement exposure determination in the case of multiple-source illumination of a subject.

But for certain purposes, it is necessary to make an actual determination of illuminance. In such cases, the hemispherical dome receptor (called a "Photosphere") is removed by the user and replaced with a flat disk receptor (called a "Photodisk"). This gives the meter very nearly the "cosine" directivity pattern needed to properly measure luminance. The illuminance reading is taken directly from the indication of the meter movement proper.

There are, however a number of complications in this matter, which are discussed in detail in one of the appendixes of the companion article cited in section **Error! Reference source not found.**.

5.2.6 *Reflected light measurement*

In some cases, it is not practical to use incident light exposure metering (perhaps the subject is a wild animal, which we would not want to approach to make an incident light measurement at its location). In this case, the photographer may have to resort to *reflected light exposure measurement*.

This is in fact the type of exposure metering used for most amateur photography, and is the technique practiced (in elaborated form) by basic camera automatic exposure control systems. In this technique, the meter measures the average luminance ("brightness") of the scene (averaged over an angular span which ideally would match the field of view of the camera).

This meter can be configured for this mode of measurement. The Photosphere is removed and replaced by a component called a "Photogrid". It serves to collect the light arriving from the subject in a

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[3] And in fact the manual aptly refers to what the meter determines as the "effective illumination", a term drawn from Norwood's seminal paper on this principle.

way that is indicative of the average luminance of the subject over a field of view that would be broadly typical for the camera.

With the Photogrid in place, the indication of the meter movement is entered into the calculator using as second “arrow” (in fact, the one used when the range-multiplying slide is in use for incident light measurements—the design of the Photogrid is such as to make that convenience workable).

This same basic arrangement will be found on all the other meters described here (other than the Model M3).

6 MEANWHILE, BACK AT PHOTO RESEARCH

6.1 The “Spectra” meters

Meanwhile, Photo Research, which evidently still had rights under the Norwood patent, but seemingly no longer rights to the "Norwood Director" tradename, continued to manufacture the meter in essentially its original design (essentially identical to the “Model A”), now under the tradename "Spectra."

6.2 Spectra Professional Model P-250

6.2.1 *General*

Figure 4 shows the Photo Research Spectra Professional Model P-250 (*ca*. 1961) front and back.

Figure 4. Spectra Professional, Model P-250

It is little changed from the Norwood Director, "Model A", except that the zero set "screw" has been moved to the rear.

Also the basic range of the meter movement indication is to 250 footcandles, rather than 1000 as in the Norwood Director "Model A".

6.2.2 *The exposure calculator*

On the back of the "turret" is a circular exposure calculator similar in concept to that used on, for example, the Norwood Director Model B. Its operation is essentially as described in section 5.2.3. We see it in close-up in figure 5.

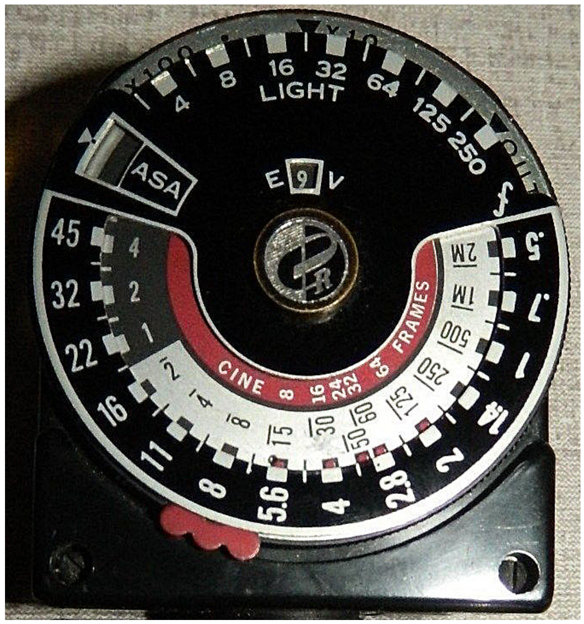

Figure 5. Spectra Professional, Model P-250, calculator

The exposure index is set in terms of ASA speed.

In addition to giving the exposure recommendation in terms of numerous pairs of shutter speed and f-number, it is given as a single number, the APEX logarithmic quantity Ev (exposure value)

6.2.3 *The range-multiplying slides*

The meter is supplied with two range-multiplying "slides", perforated metal plates that can be placed in a slot to lie between the receptor and the actual photoelectric sensor. They attenuate the light by factors of 10 and 100, and thus multiply the illuminance measurement range of the meter by those factors. Since the basic meter scale runs to 250 footcandles, this allows the measurement of illuminance up to 25,000 footcandles. (Full sunlight is about 11,000 footcandles.)

6.2.4 *The direct-reading feature*

This model included provision for what is often described as the "direct reading" mode of the meter.

To support this, the meter face, in addition to the footcandle scale, has a scale reading directly in f-numbers. This is not used in the basic mode of the meter (when the circular calculator is used). But in this mode, the calculator is not used.

A set of slides, similar to the range-multiplying slides, were supplied for use in this mode. (In fact the two range-multiplying slides are also used in this role.) Each slide was labeled with an ASA film speed, and were implicitly associated with the shutter speed 1/50 sec (the normal shutter speed in 24 frames/s professional cinematography).

The photographer, knowing the ASA speed of the film being used (and assuming that the 1/50 second shutter speed is in fact applicable) chooses the slide marked with that film speed and inserts it. Now, after the meter measures the light, the recommended f-stop is read directly from the meter face. There is no need to use the exposure calculator.

If in fact the shot will involve a shutter speed other than 1/50 second, the slide to use for the shutter speed and film speed in use can be reckoned using a table in the manual.

6.2.5 *Measurement of illuminance*

In the same vein discussed above for the Norwood Director, Model B, for the measurement of luminance, the hemispherical receptor can be replaced by the use with a disk receptor.

7 BACK TO THE BROCKWAY FIRM

7.1 General

In 1948, Paillard-Bolex established its own US distributorship, putting American Bolex out of that business. By now the manufacture and sale of the Norwood Director exposure meters had become prominent for American Bolex. Ezra Brockway, now presumably prohibited from using the "Bolex" name through loss of distributorship status, changed the firm's name to Director Products Corporation.

7.2 Norwood Director Model C

As a result, the Norwood Director meter became the Model C, but with no substantive changes. It said "Norwood Director" on the front and "Norwood Director" and "Director Products Corporation" on the back.

7.3 Norwood Director Model C Color-Matic

7.3.1 *General*

Later in the production of the Model C, the manufacturer added a form of the "direct reading" mode of the meter (which we heard about earlier, in section 6.2.4, in connection with the Spectra Professional, Model P-250). The meter was then known as the "Color-Matic" version of the Model C, but that was not reflected on the nameplate. We see this model in figure 6.

Figure 6. Norwood Director exposure meter Model C (Color-Matic version)

This is the last model of this design to carry the name “Norwood Director” on the front.

7.3.2 *The direct-reading feature*

The direct-reading mode introduced with this variant of Model C was promoted under the name "Color-Matic", and was intended to help photographers use the newly-introduced Kodachrome reversal color film.

To support this mode, the meter face, in addition to the footcandle scale, has a scale reading directly in f-numbers. This is not used in the basic mode of the meter (when the exposure calculator is used).

Also, the meter is provided with a special "direct-reading" attenuating slide, red in color, set up for "direct reading" with a film speed of ASA 10 (that of the Kodachrome film of the time) and a shutter speed of 1/50 sec (a common shutter speed for use with that film).

With this slide in place, after measuring the light, the recommended f-stop (predicated on the film speed and shutter speed) is read directly from the meter face. There is no need to use the calculator dial.

At a later time, sets of slides were made available (for use with this model and later models) to extend the "direct reading" functionality to other combinations of film speed and shutter speed (essentially as described in section 6.2.4 for the Spectra Professional Model P-250). The photographer, knowing the speed of the film and the preordained shutter speed, chooses a slide marked with that combination of factors and inserts it. As before, after the meter measures the light, the recommended f-stop is read directly from the meter movement scale.

7.4 Norwood Director Color-Matic Model D—"Director Products Corporation"

The company later decided to adopt its new corporate name as the "marque" for this type of meter, which resulted in the Norwood Director, Model D (again with no substantive changes).

Figure 7 shows a Norwood Director, Model D of this variety.

Figure 7. Norwood Director Model D—"Director Products Corp."

This model says "Director Products Corporation" on the front; on the back, it says "Director Products Corporation" and that the meter is a "Norwood Director Color-Matic exposure meter, Model D".

Except for the badging and nameplate changes, this model is indistinguishable from the Model C, Color-Matic version.

7.4.1 *The direct-reading feature*

As with the "Color-Matic" version of the Model C, this model includes provision for what later came to be known as the "direct reading" mode of the meter (but again here only a specific instance of it). (See section 7.3.2 for a full description.)

7.5 Norwood Director Colo-Matic Model D—"Brockway"

For later production of the Model D, the company decided to use the marque "Brockway". Figure 8 shows a Model D of that variety.

This version says "Brockway" on the front; on the back, it says "Director Products Corporation" and that the meter is a "Norwood Director Color-Matic, Model D".

Figure 8. Norwood Director Model D—"Brockway"

7.6 Model M2

The firm then changed its name to "Brockway Director Corporation", and this basic meter design became (without substantive change) the Model M2. It said "Brockway" on the front; the back said "Brockway Director Corporation" and that it was a "Norwood Director exposure meter, Model M2". We see it in figure 9.

Except for the badging and nameplate changes, this model is indistinguishable from the Model D.

This is the last model of this design to carry the “Norwood Director” name.

Figure 9. Norwood Director exposure meter Model M2

7.7 Overview of the era

As you can see, nothing really happened to the design of the meter during this era other than a lot of badge and nameplate changes to track changes in the corporate name and branding strategy of what I call, overall, "The Brockway Firm".

8 NORWOOD DIRECTOR MODEL M3

The Norwood Director Model M3 (sometimes written "M-3") was made by Brockway Director Corporation beginning in 1952. We see it in figure 10.

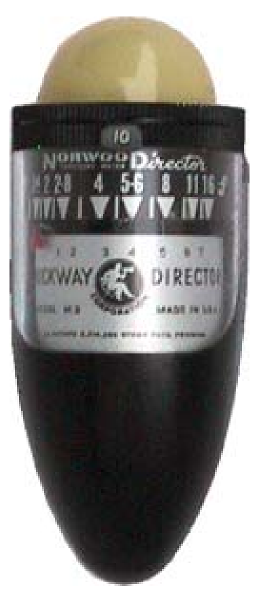

Figure 10. Norwood Director Model M3

This is a unique meter, quite small, and despite its name is not really a proper member of the “Norwood Director” family. It essentially only operates in a direct reading mode. A slide marked with the appropriate combination of exposure index and shutter speed is inserted. The meter reads the incident light, and the indication is directly in terms of the recommended f-number.

I will not discuss this model in detail.

9 ENTER SEKONIC

9.1 Introduction

The rights to the product were transferred in several stages from Brockway Camera Corporation (the final name of that firm) to Sekonic Electric Co., Ltd., of Japan, which over the years made several models of this general design.

9.2 Brockway Studio S, Model S

The first model in this family made by Sekonic, introduced in 1957, was in fact presented as a product of Brockway Camera Corporation, and was known as the Brockway Studio S exposure meter (Model S). The motivation seemingly was that Sekonic was not, at the time, a name well recognized in the United States, while Brockway was well known because of this famous exposure meter line, for which there was an important and loyal user community.

Figure 11 shows a Brockway Studio S meter (Model S).

Figure 11. Brockway Studio S (Model S)

This model differs little (other than in its livery and the design of the exposure calculator) from Model M2. It carries the name “Brockway” on the front. The rear nameplate says “Sekonic Studio S”, Brockway Camera Corporation, and “made by Sekonic Electric Company”.

This model came with a set of three direct-reading slides (one of which doubles as the "high range" slide).

It does include provisions for working with a single-value logarithmic exposure designation system used for a while on some Polaroid cameras. It also delivers the exposure recommendation in a form known as the LVS (Light Value System), a precursor to, and numerically identical to, the APEX exposure value, Ev.

9.3 The Sekonic Studio S, Model S

Next, however, essentially this same meter[4] (with a change in the color of the meter dial and the outer ring of the calculator) became fully identified with Sekonic, and was then called the Sekonic Studio S (Model S)[5] (introduced in 1957). We see it in Figure 12.

Figure 12. Sekonic Studio S, Model S

[4] However, the layout of the meter scale differed between the two models, suggesting that the Sekonic Studio S might use a different photocell and/or meter movement than the Brockway Studio S. And, perhaps as a result, the weight of the Sekonic Studio S is about 0.15 ounce less than that of the Brockway Studio S.

[5] In Japan known as the Sekonic model L-28/L28A).

It carried the name “Sekonic” on the front. The rear nameplate said “Sekonic Studio S” and “Sekonic Electric Company”.

We see the calculator meter scale and dial close-up in Figure 13.

Figure 13. Sekonic Studio S calculator dial

To set the exposure index, the main dial is held stationary and the silver center dial is turned with the use of a small post (seen in the figure at about 2 o'clock on the outside of the center dial) until the appropriate ASA speed appears in the ASA window.

Note that, because the meter has the "direct read" feature, each "cardinal value" on the meter scale is marked with both a luminance value and a "direct read" f-number (*e.g.*, 125 and 5.6).

This model alone (among the true “Norwood Director” meters) uses a unique way of entering the meter movement reading into the exposure calculator, using the “direct reading” f-number on the meter movement scale rather than footcandle value.

To enter the meter reading into the calculator, the user moves the main calculator dial until an index line (there are actually two, marked "IN" and "OUT", for use with the high slide in or out) falls, on a secondary set of f-numbers on an adjacent dial, on the f-number found on the meter movement scale at the needle position (interpolating between the markings as needed).

In the figure, meter needle is at 250/8; thus the IN index has been set on the red number "8".

In effect, the "direct read" f-numbers on the meter scale are used as an arbitrary number for transferring the meter movement reading onto the calculator (not, as in all other meters of this family, the "footcandle" indication of the meter movement).

Using such a secondary set of f-numbers on the calculator, rather than a scale reading in footcandles, has an advantage: they also give the f-number recommended by the meter when the exposure time is indicated on a nearby scale marked in terms of cinematic frame rates (each of which implies an exposure time)–note "64", "32", "24" etc. in red at about 2 o'clock on the center dial.

Totally separate from this part of the calculator (at the opposite side of the main dial) are the familiar sets of adjacent exposure times (as shutter speeds) and f-numbers.

This whole thing is perhaps a bit "too clever", and is not found on later models, all of which use the meter movement indication in footcandles for transfer of the meter movement indication into the calculator.

The Sekonic Studio S was (in two variants) known in Japan as Model L-28/L-28A. We will see shortly the effect of this on the numbering of some future models for the U.S. market.

9.4 Sekonic Studio Deluxe, Model L-28C2

9.4.1 *General*

The Sekonic Studio S, known in Japan as Model L-28/L-28A, became the progenitor of the "L-28" series, which continued in the U.S. with the Studio Deluxe Model L-28c, introduced in 1964. An advanced version of the L-28A, called the L-28A2, was introduced in 1970.

Figure 14. Sekonic Studio Deluxe, Model L-28c (L-28c2 essentially identical)

Also introduced in 1970 was an advanced version of the L-28c, called the Studio Deluxe Model L-28c2. It was produced until 1976. We see the L-28c in Figure 14 (the L-28c2. was almost identical).

The differences in the "-c" models were primarily an enlargement of the range of f-number covered by the calculator (plus, for the L-28c2, some similar changes in the range of some other scales).

9.4.2 *The needle lock feature*

A new feature found in the Models L-28c and L-28c2 was a "needle lock", operated by a button in the center of the exposure calculator dial. With the button not depressed, the meter pointer is locked in its present position.

After the meter is properly oriented for the reading, the button is depressed until the needle settles and then released. Thus, the meter movement reading has been "captured", and the photographer is free to move the meter to where it could be most easily read and the exposure settings reckoned on the calculator dial.

9.4.3 *The receptors*

Another new design feature in those two models is that the three receptors for the photoelectric sensor—the incident light hemisphere, the incident light diffuser disk, and the reflected light grid—which previously were mounted with a slip fitting—are now more securely mounted with a bayonet connection. These three elements, until now known as the Photosphere, Photodisk, and Photogrid, are now known as the Lumisphere, Lumidisk, and Lumigrid.

9.4.4 *The exposure calculator*

There are a number of design changes in the exposure calculator dial. One is that there is now provision for setting the exposure index both in terms of ASA speed and also in DIN degrees (the German logarithmic film speed rating system of the time, widely used in Europe). The ASA speeds are labeled at 1/3-stop intervals (making for a very cluttered scale). The exposure recommendation is also reported as the consolidated logarithmic APEX value, Ev.

A prominent design improvement is the thick, "knob-like" main dial on the exposure calculator.

On the calculator, the dial that is tuned to set the exposure index has a small post to grasp to turn it. One need not hold the main dial to do this.

Here, to set the calculator to the meter reading, thus user turns the main dial to bring the footcandle value indicated by the meter movement, on a ring on the main dial, into alignment with an arrow on an adjacent ring. This same basic arrangement is found on the calculators on all subsequent models.

There are actually two arrows. One, white and marked "L", is used with the meter in its "low range" (i.e., with the high slide not in place). The other, red and marked "H", is used with the meter in its "high range) (i.e., with the high slide in place).

Figure 15. Direct reading slides for Model L-28c and L-28c2

Adapted from photo by John D. de Vries
Used by permission

9.4.5 *Direct reading slides*

A set of direct reading slides, in a nice leather case, came with this model. We see it in figure 15.

Some of the slides were functional duplicates. For example, there is a slide designated ASA 25, 1/30 sec and another one designated ASA 50, 1/60 second. They are identical in their behavior. The provision of the "duplicate" slides was probably to avoid having multiple markings on the slide.

9.5 Sekonic Studio Deluxe, Model L-398

An important further model is the Sekonic Studio Deluxe, Model L-398, introduced in 1976 and made through 1989. We see it in figure 16.

Figure 16. Sekonic Model L-398

The calculator is much the same as on the L-28c, but the main dial is a bit larger in diameter, and the arrangement for showing the location of “1/3 stop” increments in aperture is made a bit easier to follow. No intermediate aperture values are labeled.

There is a small knurled pad to turn the dial that is turned to set the film sensitivity (which can be done in terms of either the ASA speed or the DIN index). The ASA speeds are only marked at full-stop intervals. The exposure recommendation is also reported as the APEX exposure value, Ev.

This model also incorporates the needle lock feature introduced on the Model L28C, but here it is called the "needle stopper" feature. As before, it is operated by a button in the center of the exposure calculator dial. Ordinarily, with the button not depressed, the meter pointer is locked in its present position.

After the meter is properly oriented for the reading, the button is depressed until the meter needle settles and then released. Thus, the meter reading has been "captured", and the photographer is free to move to meter to where it can be most easily read and the exposure settings reckoned on the calculator dial.

In this model, if it is not wanted for the meter needle to be locked when the "stopper" button is not pressed, the button can be pressed and turned a quarter turn clockwise, whereupon the button itself is locked down, in the "needle released" state.

On the calculator, the dial that is tuned to set the exposure index has a small pad of "corrugations" to use to turn it. This makes it less likely that this dial will be turned inadvertently, as it might be in the previous model where there was a small post on the dial.

The scale of the meter proper is labeled at different footcandle values than in previous models. This is a byproduct of the change in the incident light calibration constant, C, in this model from the previous model’s value, 270, to 340.

This changes the association of footcandle values and the f-numbers on the direct reading scale. The basic design of the scale is that each footcandle value that receives a label is associated with an f-number. Sekonic wanted to maintain the "standard" list of f-numbers, and thus the footcandle values chosen to receive labels had to change.

The "screw" on the rear to adjust the zero position of the meter is enlarged from the previous model and provided with a wider slot to allow it to be adjusted with a coin.

9.6 Sekonic Studio Deluxe II, Model L-398M

The next model in the series is the Sekonic Studio Deluxe II, Model L-398M. It was introduced in 1989 and made through 2005. We see it in figure 17.

The major new feature of this model is the memo pointer, a small red pointer that can be set to "remember" a meter reading. It is especially useful when measuring two light sources to determine their illuminance ratio. It is moved with a thin ring located just below the main dial. The model number suffix “M” is in fact from “memo”.

The exposure index is entered in terms of ISO speed (essentially numerically equivalent to the ASA speed).

The calculator has been rearranged in terms of “what moves with what.” The meter scale markings and calculator dial markings have been made larger for improved legibility. Calibration-wise, for the same meter indication in footcandles and exposure index, the exposure recommendation is about 1/6 stop less than for the L-398.

Figure 17. Sekonic L-398M

There is a small difference in the exact spacing of the values on the meter scale itself, a hint that this model uses a different meter movement than the L-398.[6]

The three collectors for this model, the Lumisphere, Lumidisk, and Lumigrid, are physically-distinguishable from those provided with model L-398, even though they use the same bayonet-type attachment.[7] The Lumisphere and Lumidisk of this set in fact have slightly different photometric properties from the earlier ones.

The L-398M to have a different value of its calibration constants than the L-398.

The Lumigrid is improved over the Photogrid by having a transparent window on the inside, preventing dust from getting to the photocell though the grid holes.

9.7 Sekonic Studio Deluxe III, Model L-398A

The last meter so far of the principal family under discussion here is the Sekonic L-398A Studio Deluxe III. It was introduced in 2006. At

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[6] Another clue is that the magnetic polarity of the meter magnet is seemingly reversed from that of the L-398, as noted from the external magnetic field.

[7] Those for the L-28c, L-28c2, and L-398 have 36 "teeth" and two white dots to show how the item should be oriented to engage the bayonet fitting. Those for the L-398M and L-398A have 30 “teeth” and one dot.

this writing (September 2022) this model is still made by Sekonic ($229.00 at B&H Photo-Video). We see it in figure 18.

Figure 18. Sekonic L-398A

Unlike all earlier models, which used selenium photocells, the L-398A uses an amorphous silicon photocell. The model number suffix, “A”, is in fact from “amorphous”. Other than that, the L-398A is essentially identical to Model L-398M. The exposure calculator is essentially identical to that of the L-398M.

As in Model L-398M, the exposure index is set in terms of ISO speed.

9.8 Sekonic Studio Deluxe III, Model L-398A, 70th anniversary edition

A special version of the L-398A was introduced in 2021 to celebrate the 70th anniversary of Sekonic’s becoming the manufacturer of the Norwood Director line of meters. It is in a burgundy livery with rose-gold accents. We see it in figure 19.

Figure 19. Sekonic L-398A, 70th anniversary edition

10 SOMETHING A LITTLE DIFFERENT

10.1 Introduction

The three following models fit into the family of meters just described in that they use the Norwood principle for their major incident light metering mode, and have the receptor on a revolving turret. But they differ (in varying degrees) in their operating principles and the size, shape and style of the body from the “classic” meters recently described here.

These models are all notably larger than the later “classical” models.

10.2 Sekonic System Meter, Model L-228

10.2.1 *General*

This model was introduced in 1974 and was made through 1985. It differs from the earlier models of the genre in using a silicon photodiode as the light detector, with a transistor amplifier (powered by a battery of four small “button cells”[8]) to drive the meter movement. This was the first model of the family to use a battery supply, all the “classic” ones using passive measurement systems.

We see it in figure 20.

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[8] Originally G13 mercury cells, no longer available. It is believed that LR44 or 357 cells can be used instead.

Figure 20. Sekonic System Meter, Model L-428

Its main housing is quite different in shape and appearance than the classic models in the genre. The calculator dial has a very clean look.

This model is significantly larger than, for example, an L-398, being over 1-1/8″ taller. In figure 21, we see a size comparison.

Figure 21. Sekonic L-398, L-428

It also weighs about 50% greater than the L-395. The weight and shape do not make it easy to hold.

10.2.2 *Operation*

To make a measurement, a small button on the right side of the meter is depressed to energize the circuitry. If desired, the button can be locked down (ON) by rotating a lever coaxial to the button. It can also be locked OFF (to prevent it from being depressed inadvertently) in the same way. When the button is not depressed, the meter movement pointer is locked in position, which can be used to capture the reading.

10.2.3 *Battery check*

The battery state can be checked by pressing a small button on the rear of the meter (it releases the needle lock). The meter movement indicates the battery state, and the pointer should fall in an area highlighted in red if the battery is OK for operation.

10.2.4 *Measurement range*

The principal advantage over the classic models is that this model has a substantially greater range of incident light illuminance that can be measured. Compared to the L-398A, the low end of the range is 7 stops lower, while the high end is one stop higher.

10.2.5 *Exposure scales*

The aperture scale runs from f/1 to f/90. The exposure time scale runs from 1/4000 sec to 60 min. The scale of exposure shown as the APEX exposure value, Ev, runs from Ev-7 through Ev+24

10.2.6 *Meter movement scale and ranges*

The scale of the meter movement is not calibrated in illuminance units but rather is an arbitrary logarithmic scale with “one stop” steps (with 1/3 stop intervals indicated). The movement indication is transferred to the calculator using these number on this scale.

The meter movement system can be switched to one of two different ranges with a slide on the left side of the meter. A different set of numbers appears on the scale for each range. The range change does not involve anything in the optical path; it works by changing the gain of the meter movement amplifier.

In the low range, the range of the indication is 1 through 12. In the high range the range is 12 through 22. The high range is suggested for initial measurements. If the indication of the meter movement is off the scale at the low end, then one should change to the low range.

10.2.7 *Standard receptors*

The standard interchangeable receptors comprise three known by the familiar names Lumisphere, Lumidisc, and Lumigrid[9] used for the familiar purposes. They are similar to those used on the L-398A, but are however a bit larger in diameter.

They mount with the familiar bayonet mount (here with three lugs and three notches). There is a white dot in the recess in which the receptor mounts, but no alignment dots (there could be three) on the receptor (at least in the one receptor we have, the Lumisphere type). The rim of the receptor is knurled in only two healthily narrow opposite regions.

For reflected light metering, the receptor used is called the “reflected light filter” rather than the “Lumigrid”. It is in fact not gridlike (but not really filter-like either).

10.2.8 *Optional calculator units*

The standard calculator unit may be replaced by the user with optional calculator units (“dials”) for various special purposes. Many of these are used in connection with optional special purpose receptors.

The calculator dials are change by unscrewing the retaining screw in the center of the dial, which has a knurled knob on it. The screw is captive, and remains with the dial. The alternate dials each have their own retaining screw. A peg on the body engages a slot on the hub of the dial to properly orient it.

10.2.9 *The movie dial*

One optional calculator dial (not related to a special purpose receptor) is used for motion picture work. On its shutter speed scale, the indications are not in terms of seconds but rather in terms of frame rates (frames/sec), presumably predicated on the shutter angle being 180°. The marked speeds are 8, 16, 32, etc. frames/sec, with secondary marks at the intervening “1/3 stop” positions. There is a special mark indicating the shutter speed associated with the motion picture frame rate of 24 frames/second (used for “commercial” motion pictures).

10.2.10 *Optional receptors*

A number of optional receptors for special tasks are available. For each of these, a special alternate calculator dial (provided with the receptor) is used. These receptors are:

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[9] Although in the manual this is called the “reflected light filter”, perhaps apt since it is not grid-like (but it is not really filter-like either).

- Narrow angle reflected light receptor with viewfinder. This provides a conical measurement field of view approximately 10° in diameter. The viewfinder provides for being certain just what is being measured.

- Enlarger attachment. Used to measure exposure on the print in enlarger operation.

- Pinpoint attachment. This is used to measure the illuminance at specific point on the ground glass of a view camera. It has a long fiber optic “pigtail” whose tip can be readily moved to the point(s) of interest.

- Microscope attachment. Used to determine exposure for photomicrography.

10.2.11 *Operation*

The exposure index (nominally, the sensitivity of the film being used (as the ASA speed, equivalent to today’s ISO speed, or the European DIN index) is set into the appropriate window by turning the topmost disk of the calculator dial, which has two sets of three small ribs to grip it for this purpose. (The entire calculator dial will turn when this is done.)

The meter is then placed near the subject, with the dome aimed at the camera. The measurement button is pressed for a short while and then released, which will lock the meter moment pointer at the measured indication, which is noted.

The outermost knurled rim of the calculator dial is then turned until the red arrow with the solid white dot label points to the meter movement indication value in the window just above the pointer.

The photographic exposure recommendation is given on the two adjacent scales at the bottom, one for the exposure time and one for the aperture as an f-number. Any adjacent pair of those values constitutes the recommended photographic exposure. Alternatively, the recommended photographic exposure as the APEX *exposure value* Ev can be read in the window at the top of the calculator.

10.2.12 *Reflected light exposure measurement*

The Lumisphere receptor is replaced with the reflected light filter. Again the film sensitivity is set as previously described.

With the meter at the camera location, the receptor is aimed towed the subject and a measurement taken. The rest of the process is as described above, except that the red arrow marked with a white dot in a white circle is used to set the calculator to the meter movement indication.

10.2.13 *Measurement of illuminance*

To measure actual luminance (as for example the illuminance upon an industrial work surface), the Lumisphere receptor is replaced by the Lumidisk receptor, the meter is oriented with the receptor surface parallel to the target surface of interest, and the measurement taken.

The meter movement indication is read and used with a table in the manual to get the illuminance in lux.

10.3 Sekonic Autometer L-418

10.3.1 *General*

This model was introduced in 1977 and was made through 1980. In it, a silicon photo diode is used as the photosensitive element. There is no mechanical meter movement. Instead, to make a measurement, when the measurement button is pressed, a servomechanism (involving a small DC motor and a feedback potentiometer) turns the calculator “input dial” until it corresponds to the observed illuminance or luminance. Operation then proceeds in the familiar manner.

We see it in figure 22.

Figure 22. Sekonic Autometer L-418

The main housing generally follows the shape of the “classic” meters of this genre, but the appearance is quite different. It is however significantly larger than, for example, an L-398, being almost 0.9” taller.

The circuitry and servomechanism are powered by a 1.5V manganese battery (AA size).

Like the L-428, compared to the classic models this model offers a greater sensitivity to low illumination levels. Compared to the L-398A, in incident light mode with the dome receptor, the lower end of its range is 8 stops lower. The upper end of its range is the same.

When the measurement button is pressed, a battery check indicator lights briefly to indicate that the battery is OK for use. The calculator “input dial” (in this case, the dial that carries the shutter speed scale) rotates automatically to a position indicative of the measured illuminance or luminance.

After taking a measurement, when the measurement button is released, the calculator input dial remains in the position to which it was set during the measurement. The calculator is then read in the familiar way.

If desired, the measurement button can be locked ON by rotating a lever coaxial to the button. It can also be locked OFF (to prevent it from being depressed inadvertently) in the same way.

10.4 Standard receptors

The standard interchangeable receptors are known by the familiar names Lumisphere, Lumidisc, and Lumigrid, used for the familiar purposes. They mount with a bayonet mount.

The receptors used with this model are slightly larger in diameter than the receptors used in the “classic” models. It appears that they are different in their details from those used in the L-228. For one thing, their bayonet mount has two lugs (and notches) rather than three. There is a white alignment dot on the turret to which the receptors mount, and the receptors have two white alignment dots.

10.4.1 *Narrow reflected light receptor*

An optional receptor provides, for the reflected light mode, a narrow conical field of view with a soan of 10°. It includes a viewfinder to allow accurate aiming.

10.4.2 *Exposure recommendation in Ev*

The exposure recommendation, in addition to being provided as a continuum of exposure time–f-number combinations, is shown in terms of the APEX photographic exposure value, Ev.

10.4.3 *Motion picture usage*

To felicitate usage in a motion picture context, the exposure time scale, in addition to the familiar markings in seconds, contains a secondary set of markings in terms of shutter speed (frames/second), presumably predicated on the shutter angle being 180°.

There are two special marks, indicating the shutter speeds associated with motion picture frame rates of 24 frames/second (used for “commercial” motion pictures) and 18 frames/second (used for 8 mm and super 8 motion pictures)

10.4.4 *Reflected light measurement*

To make a reflected light measurement, the Lumisphere receptor is replaced by the Lumigrid receptor (here, not grid-like, but the traditional name is carried forward).

The entire calculator dial assembly is then rotated clockwise until the pointer on it points not to the “INCIDENT” dot on the case but rather now to the “REF.-VIEW”[10] dot. This is a change of +4 stops in the calculator result for a given position of the input dial, needed to recognize the different photometric properties of the Lumisphere and Lumigrid receptors and the meter’s values of C and K.

10.4.5 *Measurement of illuminance*

To measure actual luminance (as for example the illuminance upon an industrial work surface), the Lumisphere receptor is replaced by the Lumidisk receptor and the film sensitivity is set to ASA 100.[11] The meter is oriented with the receptor surface parallel to the target surface of interest, and the measurement taken.

The luminance (in footcandles) is read from a scale on one calculator dial, pointed to by an arrow on another dial (the “input dial”).

10.4.6 *Succession*

This model was succeeded in 1981 by the Sekonic Studio Auto II meter, model L-448 (see section 10.5)

10.5 Sekonic Studio Auto II meter, model L-448

10.5.1 *General*

This model was introduced in 1981, superseding model L-418, and was made through 1985. In it, again a silicon photo diode is used as the photosensitive element. It operates in essentially the same fashion.

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[10] The term “VIEW” refers to the fact that this setting is also used when using the 10° angle of view reflected light receptor with viewfinder.

[11] This is not because the film sensitivity enters into the process, but rather just because, for convenience of the calculator construction, the luminance scale is on a disk that is also rotated to set the film sensitivity, and by setting the latter to 100 this scale is put in its proper “working position”.

The overall shape, size, and appearance are almost identical to the L-418. We see it in figure 23.

Figure 23. Sekonic Studio Auto II meter, model L-448

10.5.2 *Operation and calculator*

The overall mode of operation of this model, and the operation of its calculator, are essentially identical (except as may be mentioned here) to those matters for the model L-418 (see section 10.3).

10.5.3 *Calculator*

The calculator has been "cleaned up" by the removal of the dedicated cine frame rate scale, as is discussed in section10.5.5.

The direction in which the calculator scales run has been reversed from that on the L-418.

10.5.4 *The receptors*

The three standard receptors are called Lumisphere, Lumidisc, and Lumigrid. They look to be quite similar to those used on model L-418. However, the alignment dot on the turret is red, and on the Lumisphere and Lumidisc and the alignment dots on the receptors are red, which probably signals that they are not interchangeable with those used on the L-418 (perhaps they are different photometrically).

10.5.5 *Motion picture usage*

Unlike on the model L-418, on this model there is no secondary scale of shutter speeds marked in terms of motion picture frame rates.

However, on the basic shutter speed dial there are two marks, indicating the shutter speeds associated with motion picture frame rates of 24 frames/second (used for “commercial” motion pictures) and 18 frames/second (used for 8 mm and super 8 motion pictures)[12].

10.5.6 *Reflected light measurement*

To make a reflected light measurement, the Lumisphere receptor is replaced by the Lumigrid receptor (here again not grid-like, but the traditional name is carried forward).

The entire calculator dial assembly is then rotated counterclockwise until the “REF” dot on it (rather than the “INC” dot) is against a pointer on the case. This is a change of +4 stops in the calculator result for a given position of the input dial, needed to recognize the different photometric properties of the Lumisphere and Lumigrid receptors and the meter’s values of C and K.

10.5.7 *Measurement of illuminance*

The measurement of illuminance generally proceeds as for the L-418 (see section 10.4.5), except that in this model there is no footcandle scale on the calculator. Rather, after an illuminance measurement has been taken (again with the film sensitivity set to ASA 100[13]), the exposure recommendation in terms of Ev is read. That is used with a table in the manual to get the illuminance value in lux.

11 THE NORWOOD SUPER-DIRECTOR—ANOTHER BRANCH OF THE FAMILY TREE

We now visit a "third branch" of the Norwood Director dynasty, made by a fourth entity, in which the "Norwood Director" name is (in a way) revived for a product.

In the late 1950s, Don Norwood founded a company called Helio-Tech, in Pasadena, California. There he developed a unique meter, known as the Norwood Super-Director, introduced in 1958. We see it in its later (and most common) version in figure 24. Its overall construction was very much a miniaturized version of the classic Norwood Director series of meters.

It was actually manufactured and sold by the Japanese company Walz.

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[12] Again, it is presumed that this are predicated on a shutter angle of 180°.

[13] In this case, because it is the calculated value Ev that is read, the film sensitivity does actually enter into the process. The illuminance table is predicated on the film sensitivity being set to 100.

For incident-light exposure metering, the meter is equipped with the familiar Norwood-style hemispherical diffuser, known here as the Heliosphere. It mounts with a press fit.

Figure 24. Norwood Super-Director

This meter was highly oriented toward direct reading operation. Rather than utilizing a set of fixed attenuating slides to prepare it for use with different combinations of exposure index and shutter speed, there was instead an ingenious adjustable light attenuating element, known as the Heliovalve, which was normally in place. We see it in Figure 25, both loose and in place in a Super Director meter.

With the lever on this set to a certain position (corresponding to a specific combination of exposure index and shutter speed), identified by a letter, the meter indication is directly in terms of f-number. For the basic Heliovalve, the range of letters is AA and then A through K. The higher letters correspond to less attenuation, and thus, in effect, to a lower meter range.

Figure 25. Heliovalve

Adapted from photos by John D. de Vries
Used by permission

There is, nevertheless, a circular exposure calculator of generally-familiar nature, which can be brought into the process when a more conventional *modus operandi* is desired (such as when the shutter speed cannot be preordained). In this case, the Heliovalve, if in place, serves to shift the range of the meter. The letter indicating the Heliovalve setting is set into a window on the calculator for proper coordination; with the Heliovalve out, the setting is "S".

There was available an alternate Heliovalve with a different range (letters L-P), intended for use with high-sensitivity film and/or low light levels. An earlier version of the meter was supplied with a black Heliovalve with a range of only C-K.

The meter can be equipped with a grid, known as the Heliogrid, to equip the meter for reflected-light metering.

In the reflected light mode (using the Heliogrid), the Heliovalve is removed, and there is no provision for extension of the meter range. The "valve" setting on the calculator is set to "F" to match the calculator to the photometric properties of the Heliogrid.

In the reflected light mode it turns out that for an exposure index of ASA 32 and a shutter speed of 1/50 sec, the meter is "direct reading"—the f-number recommendation can be read directly from the meter scale. That is really sort of an accident, but so we shouldn't miss taking advantage of it, those specific predicates are marked on the Heliogrid.

The zero adjust "screw" is on the rear of the meter, under the nameplate, which must be removed to reach it.

11.1 The Sekonic Handi Lumi Model 246 illuminometer

11.2 Introduction

Not a photographic exposure meter, the Sekonic *Handi Lumi Model 246* illuminometer is intended only for the measurement of illuminance, but is so similar to the exposure meters discussed above that I include it here. We see it in figure 26.

Figure 26. Sekonic "Handi Lumi" model 246 illuminometer

As you can see, this is designed around the "chassis" of a typical Norwood Director exposure meter.

11.2.1 *The scale units*

For the American market, this model could be ordered with the scales denominated in *footcandles* or *lux*. For the Japanese market, only the lux version was available (in part owing to the strict Japanese "metrication" laws). The model number is the same for both options. The figure shows the footcandle scale version.

11.2.2 *The "medallion"*

In a Norwood Director exposure meter, the space below the meter dial is filled with the circular exposure calculator. There is of course no such thing in a Model 246. But if Sekonic had used essentially the same wholly-transparent front housing as in the Norwood Director meters, we would have for the lower part of the instrument a nice view of the innards of the meter movement, fascinating to me but not really stylish. And if they had actually used the very same housing part, it would have had in its center one or more holes by which the exposure calculator would have been mounted, certainly *nikulturniy*.

Rather than designing a wholly-new front cover part, Sekonic decided to replace the exposure calculator with a stylish circular “medallion”, reminiscent of a tiny fancy drink coaster with a pebbled leather insert.

I think the resulting overall design of the meter is charming, in a “art deco” sort of way.

11.2.3 *Receptor configuration*

The basic configuration of the meter is with a disk-type light receptor in place (referred to in the manual as a “Lumidisc”). It is similar to the Lumidisc provided with the Model L-398 exposure meter (and like it has a bayonet mount). However, it is different as to the profile of the white receptor proper, which rises slightly above the mounting ring rather than being slightly underflush with it as in an L-398 Lumidisc, and is slightly concave. My guess is that this is to give the meter a directivity pattern than more closely follows the ideal cosine pattern that that of the exposure meters in their Lumidisc mode.

The basic collector also includes a color compensation filter (which appears greenish in color). (See section 11.2.5.)

11.2.4 *Meter ranges*

In this configuration described above, the meter scale (the black one is applicable) runs from 0 to 500 footcandles.[14]

The meter movement scale (meter scale, actually) is approximately linear with illuminance over most of the range. This is in distinction to the Norwood Director exposure meters, in which the meter movement scale is roughly logarithmic with illuminance over most of the range (which fits better photographic use, where we think of changes in “stops”). This difference no doubt comes about through changes in the shape of the magnet pole tips in the meter movement.

For higher illuminance levels, the user inserts into a slot just behind the Lumidisk a “10X” slide, a perforated metal plate that attenuates the light by a factor of 10 on its way to the photocell. (This is conceptually identical to the “high slide” provided with Norwood Director exposure meters. But that has an attenuating factor of 32.)

The result is that the range of the meter is now 0-5000 footcandles[15]. The black scale is read and the reading multiplied by 10.

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[14] In the lux-denominated version, 0-5000 lux.

[15] In the lux-denominated version, 0-50,000 lux.

For lower illuminance levels, the regular Lumidisk collector is removed and replaced by a special “low range” one. Its photometric transfer coefficient is 5 times that of the normal Lumidisk. We can recognize it in that it has two red, rather than white, dots to indicate its proper alignment with the bayonet mount when mounting the collector. It also does not have the greenish-looking incorporated filter (presumably how it comes to have a higher transfer coefficient—see section 11.2.5).

Because of its higher photometric transfer coefficient, with it in place the meter sensitivity is 5 times normal. Thus the meter range is 0-100 footcandles.[16] The luminance reading is taken directly from the red scale on the meter face.

The 10X slide is not used in connection with the “low range” Lumidisc collector.

11.2.5 *Color compensation*

The basic Lumidisc collector provided with this model includes a filter (looks greenish) such that, with this collector in place, the overall spectral response of the instrument (the “weighting” it gives to light components of different wavelengths) is essentially that prescribed by CIE norms for the determination of illuminance.

The low-range Lumidisk does not include such a filter (which has a significant “attenuation” at all wavelengths), so as to have the higher photometric transfer coefficient needed to give the meter its lower range.

Accordingly, when measuring light from different common source types, a correction factor from a table in the manual is applied (based on the typical spectral distribution of sources of that type). The amount of correction needed is quite modest. The factor used to apply the correction runs from 0.8 to 1.1, 1.0 being “no correction”. For incandescent or normal fluorescent lighting, the factor is in fact 1.0.

12 BACK TO THE PHOTO RESEARCH BRANCH OF THE FAMILY TREE

Meanwhile, over the years, Spectra Cinema, Inc., successor to Photo Research, continued until at least 1998 to make, under the Spectra name, exposure meters little different in design from the Norwood Director "Model A", as well as variants with improved features.

They now manufacture sophisticated digital exposure meters, still generally utilizing the Norwood hemispherical collector principle for their incident light modes.

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[16] In the lux-denominated version, 0-1000 lux.

13 THE DOME LIVES ON

Sekonic also uses the Norwood hemispherical collector principle in many of their current digital exposure meters offering incident light metering, their overall designs however being dramatically different from the meters described above. Certain other manufacturers also continue to use the Norwood-concept hemispherical collector in their incident-light exposure meters.

14 STATED CALIBRATION CONSTANTS

14.1 Introduction

The calibration constant C, for incident light metering [and K, for reflected light metering] determine the standard relationship between the observed illuminance (or luminance) and (for a given film sensitivity setting) the exposure recommendation.

The international standard for this does not prescribe a specific value of C (or K), since there is no “correct value”. Rather, an allowable range is defined. The manufacturer of an exposure meter is free, within the specified range, to choose a value he feels will give exposure results that the users will feel are desirable.

There is a rationale for there being different values of C when a cardioid pattern (“dome”) receptor is in use and when a cosine (“disk”) receptor is in use. This is discussed in detail in Appendix A.

14.2 Values for later Sekonic meters.

14.2.1 *Stated by the manufacturer*

	Value of C		
Model	**Dome receptor**	**Disk receptor**	**Value of K**
L-28c	270*	Not stated	12.4
L-398	340	Not stated	12.5
L-398M	340	Not stated	12.5
L-398A	340	250	12.5

*For illuminance in the SI unit, *lux*. Actually stated in the manual and on the unit nameplate as 25, which relates to the unit of illuminance being *footcandle*.

This table gives the values of C and K that Sekonic states in the documentation for several of the later meters in the Norwood Director line. In only the latest of these is the value of C for the disk receptor configuration stated. And it isn’t really of any significance, since it only pertains to photographic exposure determination, and it is recommended to always do that with the dome receptor in place.

The values of C and K are those for use when the underlying illuminance and luminance are given in SI units (lux and cd/m^2).

On these models (and the others by Sekonic), the value of C (for the dome receptor mode) is given on the meter nameplate.

14.2.2 *But maybe not*

However, various tests done here, combined with analyses of the exposure calculators of these meter models, suggest that we cannot rely on any of these meters, in the incident light mode, to accurately behave as suggested by these stated values of C. (We have not done similar analyses with regard to the reflected light mode and the values of K.)

This situation is discussed in detail in Appendix A..

15 APPENDIXES

Extensive technical discussions of some related topics pertaining to the behavior of all the meters discussed above are given in these appendixes:

- Appendix A, The conundrum of the two values of C
- Appendix B, Measuring illuminance and the “footcandle” scale
- Appendix C, Photometric evaluation of specimen Sekonic L-398A meter

16 ACKNOWLEDGEMENTS

Thanks to John D. De Vries for his extensive support in many ways of my learning about these exposure meters, and for the use of his excellent photographs. His site has extensive information on the Norwood Director line of exposure meters. Here is a good place to start:

http://www.johndesq.nl/director/index.html

Thanks again to James Ollinger for the wealth of information on his site about exposure meters. Much of my research was guided by that information.

The Norwood Director section of his exposure meter site can be found here:

http://www.jollinger.com/photo/meters/other/norwood-article1.html

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Appendix A
The conundrum of the two values of C

A.1 INTRODUCTION

A.1.1 Two kinds of meters

International standard ISO 2720-1794, which in effect prescribes the behavior of exposure meters,[17] recognizes two classes of meter, the “cardioid directivity” type and the “cosine directivity” type. Both directivity patterns are defined by the standard, to a precision of about 1/6 stop.

(In the body of this article, we see that the makers of the “Norwood” family of photographic exposure meters contemplate that the “cardiod” directivity mode (with a hemispherical receptor) would be used for all photographic exposure metering *per se*, and that the “cosine” directivity mode (with a “flat” receptor) would be used only in connection with photographic lighting setup, or for non-photographic illuminance measurement tasks.

But in fact (especially by those who are more cynical about the “Norwood” approach to exposure measurement, or for situations where the “Norwood” approach just does not seem appropriate, the “cosine directivity” mode (that is, measurement of the true incident illuminance upon some plane of interest) is utilized.

So, to support both measurement approaches, ISO 2720 provides separate ranges of C for both types of meter. The values of the range for the cardioid-directivity meter are essentially 4/3 the values of the range for the cosine-directivity meter.

A.1.2 The conundrum

What does this mean? We might think that the exposure equation is expected to be based on the illuminance, *E*, as created by a single beam of light arriving along the axis of the dome or perpendicular to the plane of the disk. Certainly for that situation, we would think that both types of meter should deliver the same exposure recommendation.[18]

So there is a conundrum here.

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[17] The title of the specification weasel-words that, saying that the document is a “Guide to product specification”

[18] In fact, the procedures intimated by the standard for testing the calibration of a meter are predicated on such a “head on” test light beam.

A.2 THE STANDARD EXPOSURE EQUATION

A.2.1 Introduction

International standard ISO 2720-1074 defines how the behavior of exposure meters, of both reflected light and incident light varieties, is quantified. It presents, albeit in a different form, what I call the *standard exposure metering equation for incident light metering*:

$$\frac{t}{N^2} = \frac{C}{E\,S} \qquad (1)$$

where t is the exposure time to be used (in seconds), N is the f-number of the aperture to be used, E is the measured illuminance upon the scene (in lux[19]), S is the sensitivity of the film or digital imager (as an ISO speed number), and C is the incident light metering constant (a parameter of the specific meter).

The quantity t/N^2 can be thought of as quantifying the recommended photographic exposure, a combination of exposure time ("shutter speed") and aperture ("f-number"). We note that greater values represent greater exposure settings (from a greater exposure time and/or a lesser f-number, and thus a larger aperture).

We can unclutter the equation a bit by using the symbol P for the recommended photographic exposure, thus:

$$P = \frac{C}{E\,S} \qquad (2)$$

We note that if (while C and S remain unchanged) we increase E, the measured scene luminance, the exposure recommendation must decrease (a fact of course well recognized in photography).

Finally we note that (with S unchanged) to maintain a given value of P when we lower the value of C, we must have a lower value of E as well. We can look at this situation, in which the meter gives the same response (a value of P) for a lower value of E, as an increase in the "sensitivity" (to light) of the meter. Thus we can say that an decrease in the value of C represents an increase in the *sensitivity* of the meter.

A.2.2 About C

The standard does not prescribe a specific value of C, but rather states a range of allowable values. This recognizes the fact that there is no unique value of exposure for a certain scene that is "ideal". In

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[19] Or. alternatively, in footcandles, but if so then C will have a different value from when E is denominated in lux.

reality, a manufacturer may choose for his exposure meter a value of C that he feels will in the most cases for the most users give an exposure result that the user will consider “right”.[20]

But the standard prescribes two different allowable ranges of C, one applicable to meters with a cardioid directivity pattern and one for meters with a cosine directivity pattern. The range for cardioid pattern meters is essentially 4/3 as great as the range for cosine pattern meters.

What’s with that? This is the conundrum I address here.

A.2.3 Which E is that?

We know from the definition in the standard about testing for the value of C that the this value is defined in terms of the meter’s exposure recommendation output for a given incident illuminance **when that illuminance is from a quasi-point source**; that is, for illumination arriving from a single direction (presumably aligned with the “axis” of the meter), “head-on” illumination.

So an inference as to the calibration of a meter in terms of its rated value of C pertains to the “head-on” sensitivity.

But I suspect it is also assumed that in actual use, the illumination is uniformly omnidirectional (as is, for example, approximated in a typical midday outdoor setting). And the prescribed values of C (a range) are presumably chosen so as to produce a “desirable” exposure result in this realistic lighting situation (not in the situation, used for calibration testing, where the only light source is exactly “head-on”).

A.3 AN EXAMPLE

A.3.1 Introduction

Now, suppose just by way of example, a manufacturer of a “dual mode” meter chose to use a C of 400 for the cardioid mode and a C of 300 for the cosine mode (following the ratio between the ranges of the two values given by the standard).

That means that the “head on” sensitivity of the meter in the cosine mode would have to be 4/3 times the sensitivity of the meter in the cardioid mode (the implied sensitivity varying as the inverse of C, as we saw earlier).

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[20] The standard nobly describes the selection of a value of C or K by statistical analysis of the observations of a large number of observers as to the “acceptability” to them of sample images taken with various exposures over a range of subjects illumination conditions. And that may in fact be what the manufacturers do.

But, regardless of the mode of the meter (maybe there **is** no meter), for a given illuminance field we would wish to use the same exposure settings for the actual “shot”. Thus we would want either mode of the meter, for a subject in a given uniformly omnidirectional illuminance field, with the corresponding value of C for that mode in effect, to recommend the same exposure settings. Will that actually work out?

A.3.2 Assumed directivity patterns

Before I proceed, we will need to assume a specific directivity function for both modes of the meter. For the cosine mode, I will assume that in fact the directivity pattern is the theoretical one.

Recall that this pattern is zero beyond 90°, since for light arriving from such an angle, it would strike the back of the receptor/sensor.

As to the cardioid pattern, we know that the theoretical pattern would not likely be achieved, owing to progressive shading of the receptor by the meter body as we pass 90°.

As a quick and dirty recognition of this decline from the theoretical cardioid directivity function beyond 90°, I will just assume that the pattern is the theoretical one up through an angle of 105°, and then drops off to zero[21] [22].

A.3.3 The overall response of the meter

For the real meter, what the meter considers to be *E* is the sum of the influence of the light striking the meter’s receptor from all directions, the impact of a ray from any certain direction being weighted by the meter’s directivity in that direction.

In our numerical model, we do that by integrating, over the appropriate range of angles, the product of (a) a constant (representing the uniform illumination field), (b) the value of the meter’s directivity for that angle, and (c) the inverse of the assumed value of C (the assumed relative overall sensitivity of the meter). I actually do that by discrete summation in steps of 1°.

I do that for the theoretical cardioid pattern (over a range of 0-105°) and the theoretical cosine pattern (over a range of 0-90°).

The two results are essentially equal.

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[21] Why that particular limit? Because it makes the answer come out just right. (Hey—that sort of thing worked for Norwood!)

[22] In effect, I assume that this would have the same results as the pattern assumed for “actual use” by the wonks who wrote the standard, who of course don’t tell us anything about this.

Thus, in both modes, for our assumed uniform omnidirectional illumination field, the meter would give essentially the same exposure recommendation, a requirement I postulated earlier.

This only works out when we have different values of C for the cardioid and cosine directivity modes, and in fact only if those two values of C have the ratio essentially implied by the standard.

A.4 IN PRACTICE

A.4.1 "Norwood Director" style meters

I note that in all of the manuals I have for "Norwood Director" style meters, made by a succession of manufacturers, there is no discussion of using the meter with the "disk" receptor for the determination of photographic exposure. In all those manuals, only in the one for the Sekonic L-398A are separate values of the C of the meter for the hemisphere and disk receptor modes given. But again, in that manual, there is no discussion of using the meter with the "disk" receptor for the determination of photographic exposure. So the second value of C is not of any consequence.

A.4.2 The Sekonic L-408 meter

This is a digital exposure meter, with both incident light and reflected light metering modes.

The receptor for the incident light mode is a hemisphere, but by depressing it, it becomes part of a receptor system that essentially has a cosine response (and thus is suitable for the measurement of illuminance). It is then equivalent to a disk receptor.

In the manual for this meter, the use of the meter in this "disk-like" configuration is only discussed in connection with the determination of balance between separate photographic light sources, and for the measurement of illuminance in other than a photographic exposure determination scenario, never in the context of photographic exposure determination.

In neither of those situations is the matter of the incident light metering calibration constant, C, pertinent. Nonetheless, the manual states separate values of C for the hemisphere receptor and disk receptor configurations.

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Appendix B
Measuring illuminance and the "footcandle" scale

B.1 BASIC METER OPERATION

In most of the exposure meters of the "Norwood Director" design, the meter movement itself gives its indication on a scale marked in terms of illuminance, always in the unit *footcandle*. The user then enters that indication into the exposure calculator (a form of circular slide rule) by turning the input dial of the calculator until a pointer is at the meter movement indication.

The scale of that calculator dial, also denominated in footcandles, is logarithmic, just like the basic scales on the classical linear slide rule. That is, successive equally-spaced scale marks might be 40, 80, 160, 320, etc.

The user has also set the film speed on another input dial.

Now, two adjacent concentric scales, one marked in exposure time (shutter speed) and the other in aperture (as an F-number), present the output of the calculator, the *exposure recommendation*, as a continuum of equivalent combinations of those two attributes.

B.2 THE CALCULATOR AND THE STANDARD EXPOSURE METERING EQUATION

It might seem that the calculator should work the standard exposure metering equation, which is:

$$\frac{t}{N^2} = \frac{C}{E\,S} \qquad (3)$$

where t is the exposure time to be used (in seconds), N is the f-number of the aperture to be used, E is the illuminance on the scene, S is the sensitivity of the film or digital imager (as an ISO speed), and C is the incident light metering constant (a fixed parameter of the meter).

Note that t/N^2 is what I call the *photographic exposure*, and larger values represent greater photographic exposure.

B.3 TWO VALUES OF C

B.3.1 Introduction

But we learned in Appendix A why it is appropriate for a meter to have different values of C for exposure metering with a disk (cosine pattern) receptor and with a dome (cardioid pattern) receptor. How do we accommodate that? There are three well-known ways.

B.3.2 Two arrows for the input dial

A direct solution is that, for the “input” dial of the calculator, there are two arrows against which the meter movement indication is set, one to be used with the disk receptor is in use and one when the dome receptor is in use. If the meter movement indication in both cases is the actual observed illuminance, then these are separated by the distance corresponding to the ratio between the two values of C.

In any case, this implementation is not used in any of the Norwood Director family of meters.

B.3.3 Different photometric transfer coefficients

A second solution involves what I call the *photometric transfer coefficient* of the two receptors themselves. This quantity is the ratio of the average illuminance upon the sensor proper to the illuminance upon the receptor (in the case of the dome receptor, this would be for a test illuminance arriving along the axis of the dome).

If the ratio of this property for the two receptors is the ratio of the two values of C adopted for the meter, then this story can work out properly.

Note, however, that this means that if, with one of the receptors in place, the indication of the meter movement is in fact the actual illuminance upon the receptor, with the other receptor in place, the indication cannot be the actual illuminance upon the receptor. In the latter case, that indication is just an arbitrary way of transferring the meter movement indication into the calculator. (Or perhaps in both cases.)

This is not any problem when actually doing exposure metering. In that context, in fact, the meter movement indication (albeit in illuminance units) is just an arbitrary way of transferring the meter movement indication into the calculator.

Where there might be a problem is when using the meter not for exposure determination but rather in just measuring actual illuminance for some other purpose.

But in fact the measurement of actual illumination calls for a meter with a cosine response. Thus, for that work, we must put the disk receptor in place.

And so we might reasonably assume that the design of all this is such that with the disk receptor in place, the meter movement indication, in footcandles, is in fact the observed illuminance.

Then, when doing actual photographic metering with the dome receptor in place (recommended for must such tasks), the meter movement indication becomes just an arbitrary way of transferring the indication into the calculator. And why not? In that work, we do not treat the indication of the meter movement as a “result”.

This is the approach seemingly used on the meters of interest here.

What a lovely story. But as we will see shortly, it just doesn’t always happen that way.

B.3.4 A hybrid approach

It could well be that in designing a meter, for a tidy design of the two receptors we would end up with their having different photometric transfer coefficients, but not separated by a ratio that was the same as the ratio of the stated values of C for the two receptors.

In that case, we can again use “two arrows” for the input dial, now separated by the proper value to take account of both the ratio of the stated values of C and the ratio of the photometric transfer coefficients of the two receptors.

I will not discuss the various ramifications of this approach.

This is not done on any of the meters of interest.

B.4 RECOMMENDATION TO THE READER

Much of the work in this appendix depends on concepts, terms and symbols introduced in Appendix A. If the reader has not yet read that appendix I suggest it be read now.

B.5 TYPICAL STATED VALUES OF C

The documentation for the Sekonic L-398A, the most recent (and presumably last) of the Norwood Director family of exposure meters, says that for the meter in the hemisphere mode the value of C is 340; for the disk mode, the value of C is 250.

B.6 THE “CALCULATOR C”

Without doing any photometric testing, we can learn a bit about the realities of an actual meter by “reverse engineering” its calculator.

We set arbitrary values of S and E, and note a resulting pair of t and N values. We then plug all those values into this form of the standard exposure metering equation:

$$C = \frac{t\,E\,S}{N^2} \qquad (4)$$

This value of *C* is what I call the *calculator C*. If in fact the value of *E* (the meter movement indication) is the actual illuminance, then the behavior of the meter follows the standard exposure metering equation in accordance with that value of C.

Suppose the *calculator C* is in fact the stated C for the disk mode. Then if in fact the meter movement indication, *M*, is the actual illuminance, the meter with the disk in place will indeed behave as per the stated value of C.

In that case, with the dome in place (for which the stated C in this example is a different value), for the meter to behave as dictated by that value of C will require the meter movement to indicate an illuminance **not** the actual illuminance upon the receptor.

But we have already ascertained that this is OK. The only task for which we take the meter movement indication as the “meter reading” is the measurement of luminance (not an exposure measurement). That is properly done with the disk in place, and in the above story in that mode the meter movement indication must be the actual illuminance.

B.7 BUT IN REALITY

So is that story actually fulfilled by the exposure meters of interest here? No. We see a specific example of this for the Sekonic L-398A, the last of the “Norwood director” style analog exposure meters, in Appendix C

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Appendix C
Photometric evaluation of specimen Sekonic L-398A meter

C.1 DEFINITION OF TERMS AND QUANTITIES

C.1.1 Meter movement indication

I use the term meter movement indication, *M*, for the value shown by the meter needle, which in the meter of interest is denominated in footcandles.

C.1.2 Calculator input

The input dial of the calculator is, in usual exposure metering operation, set to the value of the meter movement indication, *M*. Accordingly, I use the symbol *M′* for the input dial setting.

C.1.3 Calculator C

C.1.3.1 *Definition*

I use the term *calculator C* (C_C) for the value of C that a meter would exhibit if the calculator input, *M′*, were in fact precisely the actual observed illuminance, *E*.

It is in any case defined by:

$$C_c = \frac{t\,M's}{N^2} \qquad (5)$$

C.1.3.2 *Determination*

We determine C_C by inspection of the calculator, setting *M′* and *S* to handy values and noting a matching pair of *t* and *N* values, and then using equation 5 to get C_C.

C.1.3.3 *Shortcut to C*

Having determined the value of C_C for a meter's calculator, then in photometric testing we can determine the actual value of C for the different receptor modes merely by noting the meter movement indication, M_T, and the test illuminance causing it, E_T, and then using this equation:

$$C = C_C \frac{E_T}{M_T} \qquad (6)$$

This saves the tedium of, for each test, determining a value of *M*, setting the calculator, and then reading T and N precisely, and then calculating the attained value of C.

C.1.4 Exposure recommendation

In normal use, the output of the meter we use is a photographic exposure recommendation (PER), a recommended set of equivalent combinations of the exposure time (shutter speed), *t*, and the aperture as an f-number, *N*, for which I use the symbol *P*. It is of course defined thus:

$$P = \frac{t}{N^2} \qquad (7)$$

My term “recommended” is to remind us that (a) the photographer may or may not set the camera that way and (b) there is no “correct” exposure, nor exposure result.

C.2 SCALES

The scales on the exposure calculator are all logarithmic (just like the basic scales on a conventional linear slide rule). The markings on the meter movement scale are logarithmic.

C.3 CAVEAT

The light source used for the photometric testing was not ideal, and did not match the specification in the standard.

The illuminometer used to determine illuminance of the test illumination does not have its calibration traceable to any standard.

The scales on the meter for *t* and *N* are only marked in one-stop increments. They can be credibly read to a precision of 1/4 stop, and, with a little imagination, to 1/10 stop. The scales for *M* and *M′* are marked at 1/2 stop points, but the practical resolution is (again with a little imagination) to 1/10 stop.

As a result of all this, we should not consider the numerical results reported here to be precise. Neither should we be surprised that two sets of photometric tests, made with different light levels, led to significantly differing results as to the meter properties. We should not conclude from this that the properties being investigated vary with light level, just that two tests each had considerable uncertainty.

C.4 STATED VALUES OF C

The manufacturer of the meter, in the “specifications” section of the official manual, gives the value of C for the cardioid (dome) mode as 340, for the cosine (disk) mode, 250. The ratio between these is 1.36, quite near the 1.33 intimated (but not prescribed) by the standard.

C.5 OBSERVATION AND MEASUREMENT RESULTS

C.5.1 Calculator C

The calculator C was determined, based on careful observations of the calculator, to be approximately 318.

If we consider equation 6, we see that, if the meter movement indication, M, is to actually show the observed luminance, E (as we feel is vital in the disk mode if we are to use the meter to measure actual luminance), then the actual value of C (in the disk mode) must be the same as the calculator C.

But we have just observed that, in this meter model, the calculator C is about 315, whereas the manufacturer states the C for the disk mode as 250. So, even before we have made any photometric measurements, we are off on a bad foot.

C.5.2 Photometric measurements

C.5.2.1 *Conditions*

Two sets of measurements were made on the specimen L-398A meter. In each the meter was exposed "head on", to a light beam whose luminous flux density was measured at the meter site with an illuminometer.

In each case, measurements were taken of the meter movement indication with both types of receptor in place. The receptors were the ones furnished with the meter as we received it.

C.5.2.2 *Results*

The raw results of the photometric tests are given in this table, which also continues to give the values of *C* implied by the data:

Test illum.	Dome receptor			Disk receptor		
	Met. mvt. ind.			Met. mvt. ind.		
lux	ft-cd	lux	C	ft-cd	lux	C
900	98.5	1060	270	80	861	332
1155	121	1302	282	113	1216	302

Perhaps the most startling result is that, for both tests, the C in the dome receptor mode is less than that in the disk mode. Based on the rationale described in Appendix A and its extensions, we would have expected the C in the dome mode to be **greater** than that for the disk mode.

In any case, for neither mode is the exhibited value of C very close to the stated value. That is summarized by this table:

Test illum.	Dome receptor				Disk receptor			
	Value of C		Error		Value of C		Error	
lux	Stated	Actual	%	stops	Stated	Actual	%	stops
900	340	270	-19.1	-0.33	250	332	+32.8	+0.41
1155	340	282	-15.3	-0.21	250	302	+20.8	+0.27

Note that an actual value of C that is lower than that intended results in a photographic exposure recommendation (PER), *P*, that is lower than that intended.[23]

Most often, it is the dome receptor mode that would be used for actual exposure metering. There we see that the meter could be expected to recommend an exposure about 1/4 stop lower than intended. That is, however, not “substantial” in photographic terms.

In special cases where the disk mode is used for actual exposure metering, we can expect a PER of about 1/3 stop higher than intended. That is, however, still not really “substantial” in photographic terms.

A separate issue is that of when we use a meter of this type to actually measure actual illuminance (as to measure the illuminance on a work table). In that case, the meter movement indication is the result we take from the meter. No photographic concepts are involved, and the exposure calculator is not involved.

Only the disk receptor mode is really of concern here, as that mode is needed to measure actual illuminance.

Based on our testing, the implications on this usage are shown in this table:

Test illum.	Disk receptor		
	Meter mvt. ind.		Error
lux	ft-cd	lux	%
900	80	861	-4.3
1155	113	1216	+5.3

The substantial difference between our two tests makes it hard to conclude what error in this type of work might be expected. Still. for this type of task, an error of the magnitude seen here is not usually problematic.

[23] We must be mindful that such a PER is not “incorrect”, given that there is no “correct” exposure nor exposure result.

C.6 CONCLUSION

There are certainly a few oddities noted during the photometric testing and related analysis of the Sekonic L-398A exposure meter. But, at the end of the day (if our specimen is typical of the model), It looks as if the meter performance for exposure determination should lead to exposure recommendations close to those we would expect to get from a meter with the values of C stated in this meter’s specifications. (I have to say it that way since there is no such thing as a “correct” exposure recommendation.)

As to the use of the meter (with the disk receptor in place) to measure actual illumination, there again the error observed in our testing is not so great that it would probably be problematic in typical uses of this type.

Again I caution the reader that the photometric testing done here was not “highly reliable”, and so the results above might not be as accurate as we might wish.

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