Depth of field slide rule

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This document discussed slide rule for calculating depth of field in photography.

Background

Depth of field (DOF) in photography is the distance between closest and farthest objects that will reproduce acceptable sharpness in the image. DOF depends in simple term on focus distance s, focal length f, aperture N and circle of confusion c that is a function of image format (sensor size). The four parameters define the near limit DOF (D_n) and far limit DOF (D_f). It is not always clear to a photographer how these parameters are related in practice. For this purpose a special slide rule was developed that can be used to estimate the distances and in that way to gain intuition of the underlaying laws. This document uses mathematics found from Ref.[1] where more detailed models are also discussed.

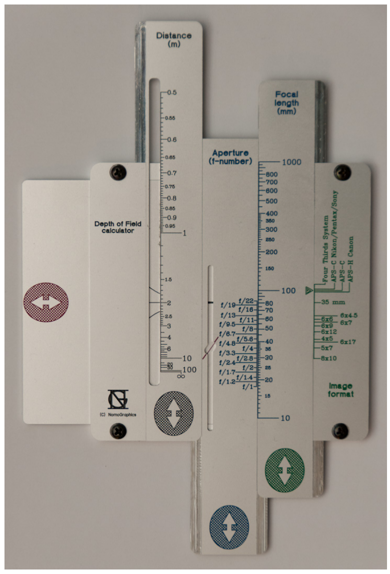

Figure 1: Depth of field slide rule implementation made of anodiced aluminium. The texts and scales are engraved and infilled with colour.

[1] Wikipedia. Depth of field — Wikipedia, the free encyclopedia, 2011. [Online; accessed 27-October-2011]

Theory

We use the following simple model for the slide rule construction. Hyperfocal distance H is the minimum distance to subject where D_f extends to infinity. It is given as

$$H \approx f^2/Nc, \tag{1}$$

where f, N and c are focal length, f-number (aperture) and circle of confusion, respectively. Circle of confusion (CoC) is the largest blur allowed for a sharp image. There is no single criteria for CoC. In the slide rule we use a common value $d/1500$ that takes c as the frame diameter divided by 1500[2].

[2] Wikipedia. Circle of confusion — Wikipedia, the free encyclopedia, 2011. [Online; accessed 27-October-2011]

For D_n and D_h we use the expressions:

$$D_n \approx Hs/(H+s) \tag{2}$$

and

$$D_h \approx Hs/(H-s). \tag{3}$$

Slide rule realization

In Fig.2 is illustrated parts that make one implementation of the equations above as a slide rule with four moving parts. In Fig.3 is illustrated the use of the slide rule with example numbers. It is to

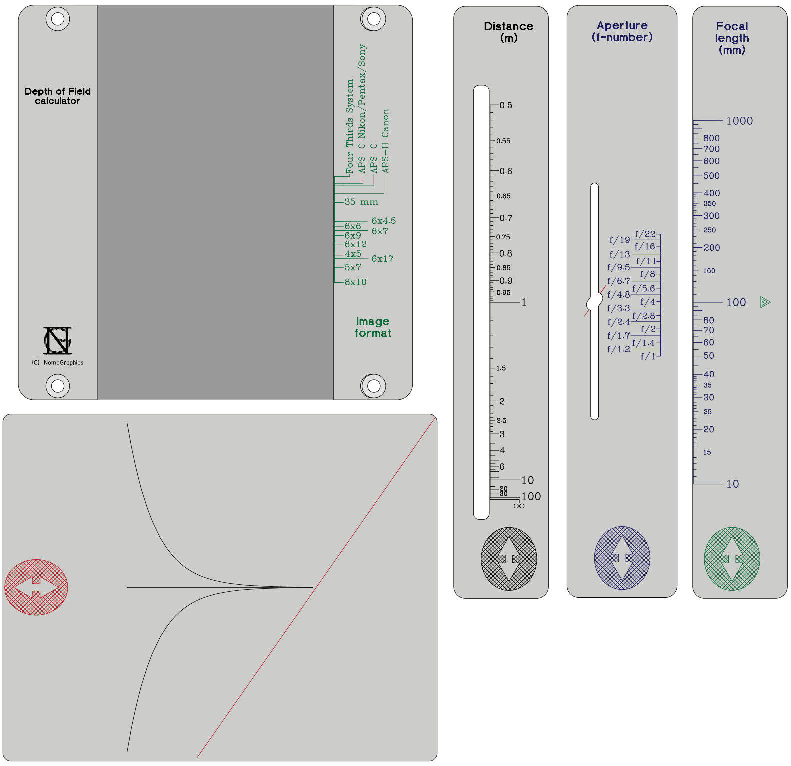

Figure 2: Pieces of the slide rule. Top left: bottom plate, the "fixed" part. Bottom left: slide with horizontal black line marking focus distance s and lines for D_n and D_f. Red line is for aligning horizontal potion by using red line in Aperture slide. From right: Focal length slide, Aperture slide and Distance slide.

be noted that hatched colored ovals with arrows indicate direction of the moving part and the respective scale. For example by moving Focal length slide with green oval is used to select image format that has scaling marked with green color. Big slide with red oval is used to transfer result of vertical slides that actually calculates hyperfocal distance (not marked), and has lines for finding relations between s, D_f and D_n with distance slide.

Nomographic solution

It is always interesting to test alternative ways to present equations. In Fig.4 is represented a nomographic solution of the equations as a reference. It is to be noted that this specific problem seems to be more adequate for a slide rule. But this subject of course depends on personal taste.

Discussion

We have presented an implementation of the depth of field slide rule. It is combination of traditional slide rule parts and a horizontal moving part that in practice has similar lines that are found in many zooms lenses. Due to limitations of the slide rules only a simple approximation is implemented. When accurate results are needed one should consult literature or specific programs with more accurate equations.

The intuition over the variables affecting depth of field is not always clear. In order to gain intuition a graphical approach is more beneficial than just plain equations. For this purpose the slide rule was constructed. Other reason was the fact that this example presented a complex slide rule geometry to be constructed.

For most people this kind of device is of no use because one can see thorugh the camera finder or in the LCD what part of figure is blurred and what is sharp. However, problem specific or special slide rules are in some circuimtances very effective. This slide rule is an example using the forgotten technology that still today has value in many problems from medicine to engineering.

References

[1] Wikipedia. Circle of confusion — Wikipedia, the free encyclopedia, 2011. [Online; accessed 27-October-2011].

[2] Wikipedia. Depth of field — Wikipedia, the free encyclopedia, 2011. [Online; accessed 27-October-2011].

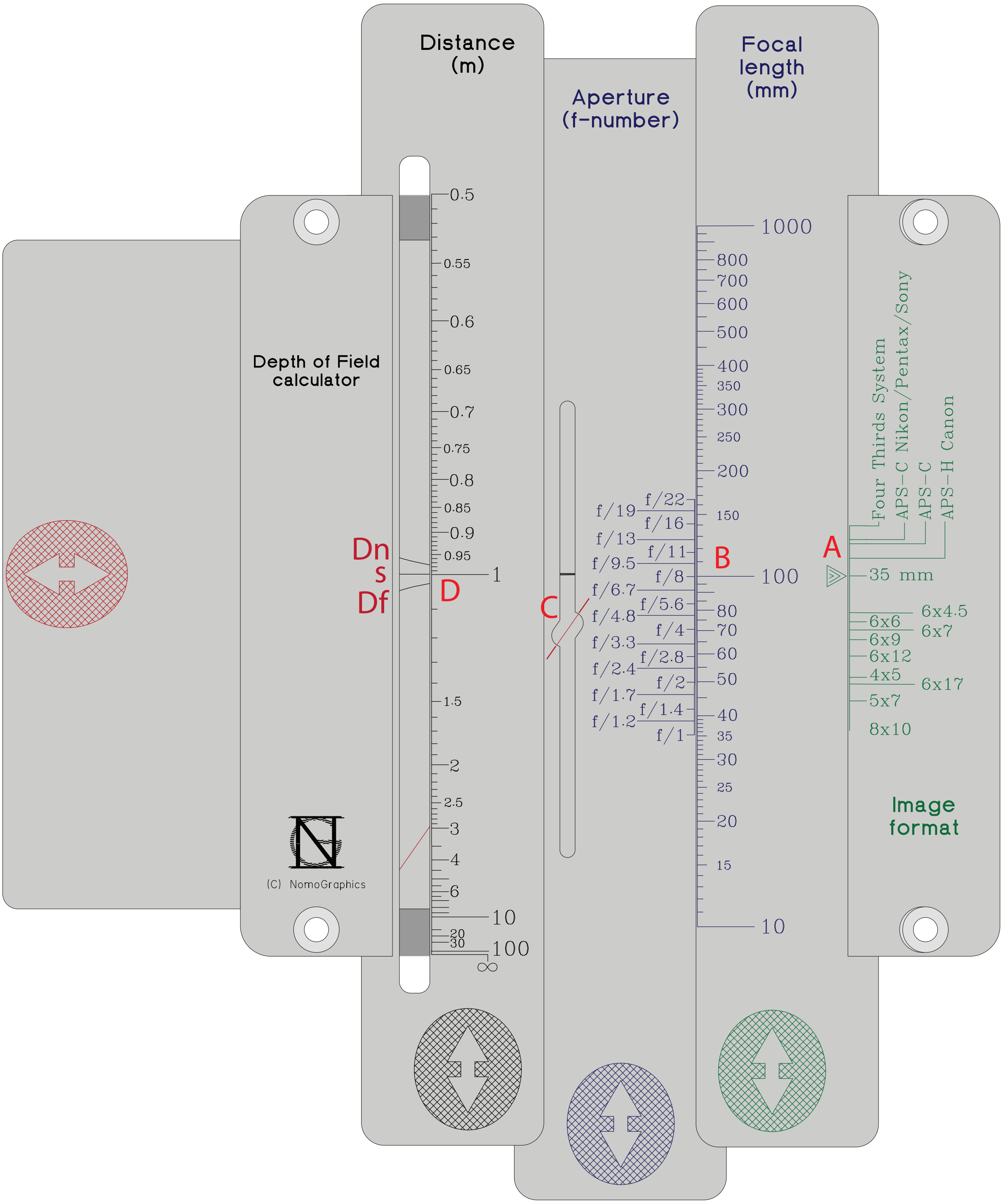

Figure 3: Use of the slide rule. (A) Select image format [35mm]. (B) Select aperture and and focal length [e.g. 100 mm, f/8]. (C) Align red marker by sliding bottom plate horizontally. (D) select focus distance s [1m] and read D_n and D_f.

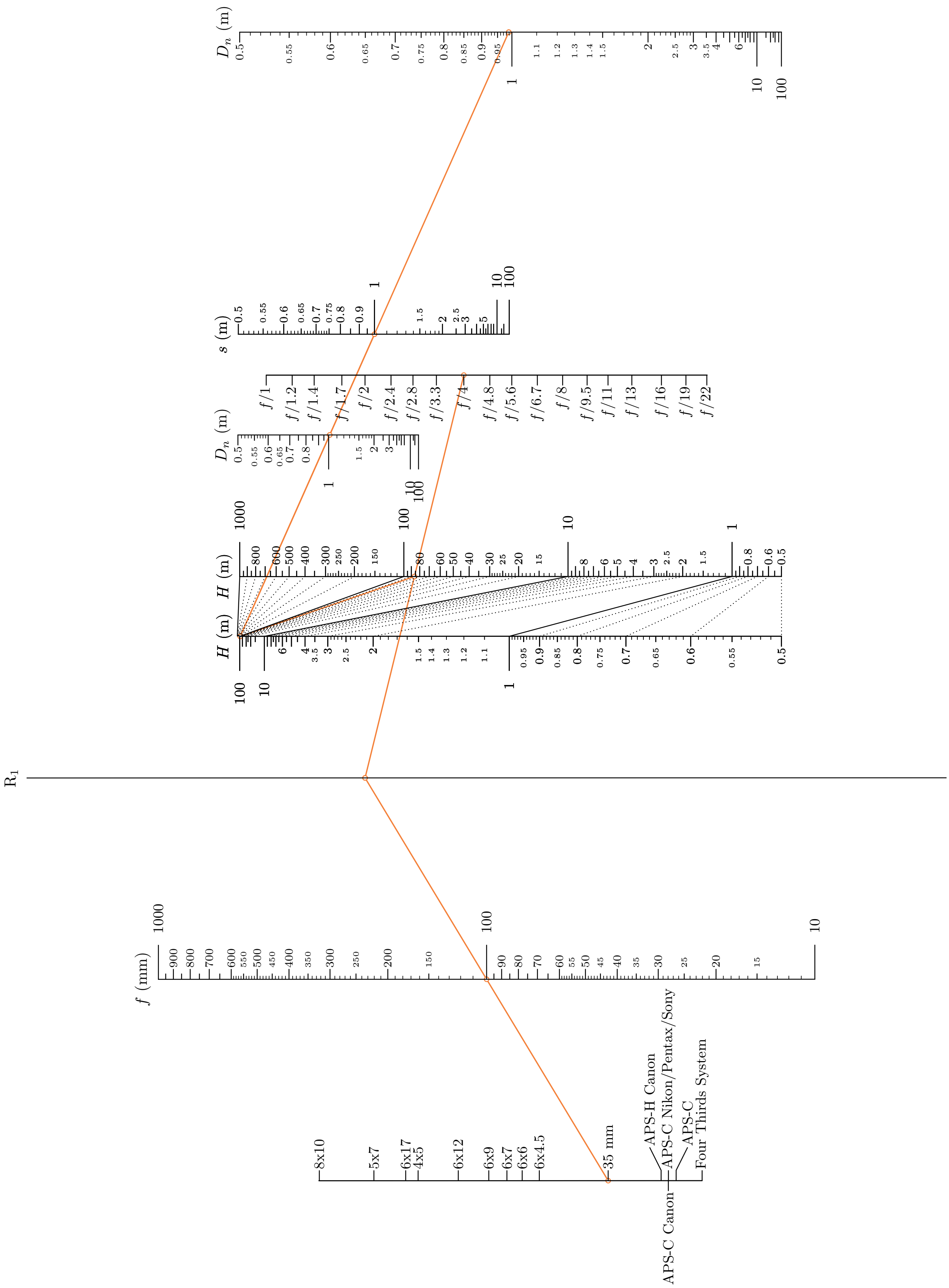

Figure 4: Nomographic solution for depth of field as an alternative. ©NomoGraphics Oy.