PRINT EXPOSURE COMPUTER

Filed Oct. 19, 1946

FIG. 1.

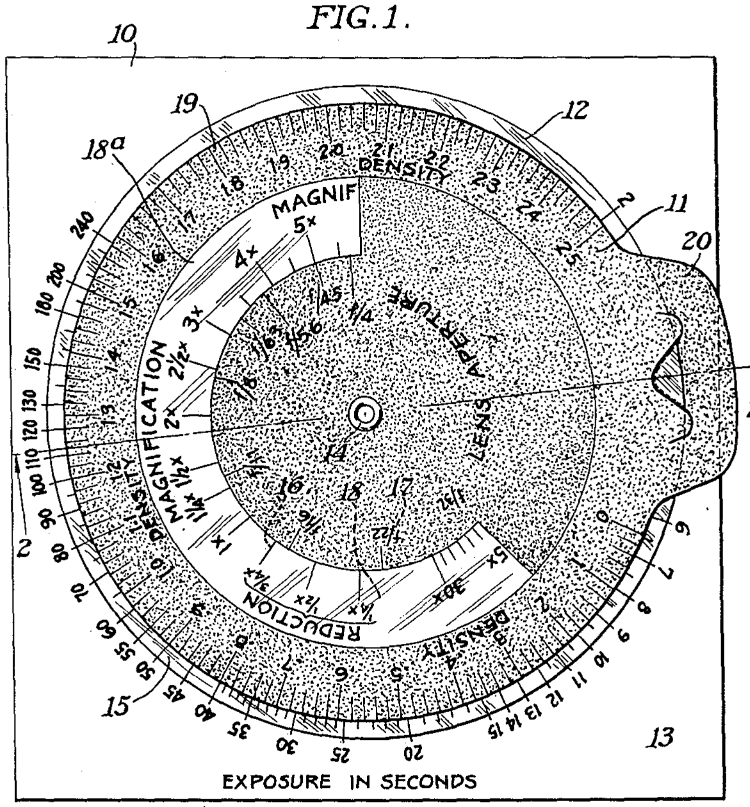


FIG. 2.

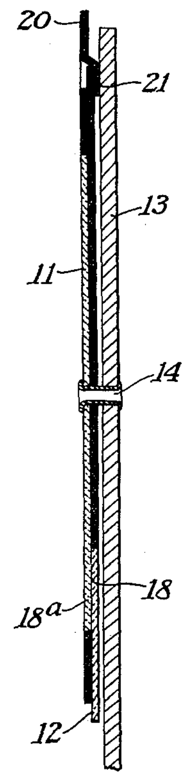


FIG. 3.

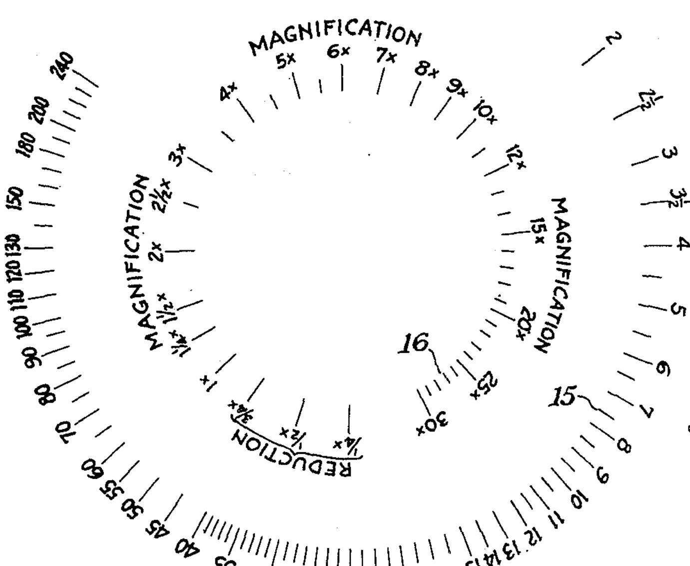
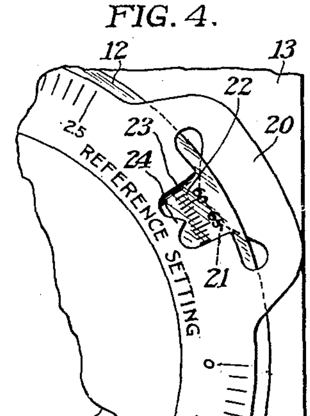


FIG. 4.



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PRINT EXPOSURE COMPUTER

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9 Claims. (Cl. 235—64.7)

1

The present invention relates to a calculator for photographic use and more particularly to an exposure computer for use in photographic printing processes for determining exposures according to density readings.

The use of an enlarger in printing on any given photographic material ordinarily involves the solution of a problem involving four variables. These are magnification, lens aperture, negative density and printing exposure time. A variation in any one of the four requires corresponding changes in one or more of the remaining variables. If it is desired to change the magnification, a corresponding change in the exposure time or lens aperture, or in both, will be required, if prints of a uniform density are to be obtained. Differences in negative density, of course, can be compensated for by varying the printing exposure but could also be taken care of by a variation in the lens aperture. In printing in color by the dye transfer process, the matrix printing times for a single picture will ordinarily vary, as is well known in the art. These printing times are generally determined by the densities measured in diffuse white highlights of the separation negatives. Thus, it is apparent that printing with an enlarger requires that four interdependent variables be taken into consideration and that a change in any one of the four factors necessitates a new solution of the problem.

Various formulae have been suggested as a means toward solving the above problem. These are generally inadequate in that all four factors or variables are not taken simultaneously into account. Charts of relative exposures have also been provided but these are subject to the same shortcomings as the formulae. The solution of formulae, moreover, requires a considerable amount of time and, of course, are always subject to the possibility of error.

It is, therefore, an object of this invention to provide a print exposure computer in which, after the relative values of magnification, lens aperture, negative density and printing exposure have once been determined for a particular sensitive material, these values may be set into the computer to facilitate the solution of additional problems when one or more of said factors are varied.

It is a further object of this invention to provide a print exposure computer of the circular type having thereon scales indicating magnification, lens aperture, negative density and exposure time.

2

It is a still further object of this invention to provide a print exposure computer which is simple in construction, inexpensive to produce and relatively foolproof in operation.

Other objects and advantages of the invention will become apparent from the following description taken in connection with the accompanying drawing, and it will be apparent that many changes may be made in the details of construction and arrangement of parts shown and described without departing from the spirit of the invention as expressed in the accompanying claims. We, therefore, do not wish to be limited to the exact details shown and described as the preferred form only has been shown by way of illustration.

In the drawing, Figure 1 is a plan view of the print exposure computer; Figure 2 is a sectional view of the computer taken on the line 2—2 of Figure 1; Figure 3 is a plan view of the scales on the base plate of the computer; and Figure 4 is a partial plan view of a modification.

The print exposure computer 10 consists of two discs 11 and 12 mounted for independent rotation upon the base plate 13 as noted in Figures 1 and 2. The discs are preferably formed of cellulose acetate and the base plate of Bristol board. It is apparent though that other materials may be employed. For instance, all three elements may be formed of Bristol board or cardboard. The pin 14 serves both as a pivot and as means to secure the three elements 11, 12 and 13 together as a unit. The base plate 13 has thereon two circular scales (see Figure 3), an outer logarithmic scale 15 indicating the printing exposure in seconds, and an inner scale 16 representing the magnification (or reduction) in diameters. The disc 12 which immediately overlies the base 13 has an inner circular scale 17, the graduations of which represent lens apertures or f-numbers. The scale 17 of disc 12 and the scale 16 of base plate 13 are in abutting relationship and the graduations of one may be set off against those of the other. This is made possible by the annular, clear window 18 in disc 12 which overlies the magnification scale 16. Obviously, in place of the clear window the disc 12 may have an opening therein of size and shape similar to the window 18.

The top disc 11 includes a peripheral scale 19, representing negative density values. The central area of the disc 11 also includes a clear area 18a through which the lens aperture scale 17 on disc 12 and the magnification scale 16 on the base plate 13 may be viewed. The discs 11 and

12 are of almost the same diameter with the lower disc 12 being slightly larger, whereby disc 11 may be rotated relative to disc 12 while the latter is held immovable by the pressure of a finger against the edge thereof. The protruding edge of disc 12 is preferably transparent and clear of any figures or graduations whereby the graduations of the density scale 19 may be made to abut against those of the exposure scale 15 by viewing the latter partly through the transparent edge. The upper disc 11 is further provided with a projecting lip 20 by which the disc may be grasped for rotation thereof. Integral with the lip is an inwardly extending tab 21 which rides under and grips frictionally the peripheral edge of the underlying disc 12. The inherent resiliency of this tab serves to retain the two discs 11 and 12 in frictional engagement whereby the two may be rotated in unison relative to the bottom dial or base plate 13 merely by grasping the lip 20. This frictional engagement is of a sufficiently low value, however, to permit disc 11 to be readily rotated relative to disc 12 merely by grasping the lip 20 of disc 11 between the fingers of one hand and allowing a finger of the other hand to bear against the protruding edge of the disc 12, as above noted.

While unnecessary for the operation of the computer, a fifth scale 22 may be included close to the peripheral edge of the disc 12 as seen in Figure 4. This scale, preferably in degrees, is exposed in the notch 23 and together with the reference marker 24 provides a means by which the two discs may be reset relative to each other, if necessary, after such relative setting has been disturbed. It also serves as a method for checking this relative setting after the two discs are supposedly rotated in unison, as when it is decided to vary the magnification or lens aperture, as will be discussed below. As noted in Figure 4, the notch 23 and tab 21 are so located on the disc 11 that the whole is readily stamped or cut out of a single piece of material.

The various scales on the computer have been calculated as follows:

A range of negative density graduations from 0 to 2.5 is uniformly spaced about the periphery of the upper disc 11 and covers exactly 300°. It has been found that in printing with an enlarger the relationship between negative density and printing exposure follows generally the formula

$$D=\log E \tag{1}$$

where D is the negative density and E the printing exposure in seconds. Since 2.5 units of density cover 300° on the computer, the angular position in degrees α for any density reading follows the simple formula

$$\frac{\alpha}{300}=\frac{D}{2.5}$$

Eliminating D by substituting from Equation 1 and solving for α

$$\alpha=\frac{\log E\times 300}{2.5} \tag{2}$$

where α now indicates the angular position in degrees for any exposure time.

It has also been found that the relationship between magnification and printing exposure can be expressed by the formula

$$E=(M+1)^2 \tag{3}$$

where M is the magnification.

If E_1 is the printing exposure corresponding to a magnification of M_1 and E_2 similarly corresponds to M_2, then the angular change β on the scale 16, which represents a change in magnification from M_1 to M_2, is determined by substituting in Equation 2 the values of E in terms of magnification, as expressed in Equation 3. Thus

$$\beta=\frac{\log (M_2+1)^2\times 300}{2.5}-\frac{\log (M_1+1)^2\times 300}{2.5}$$

and

$$\beta=120\ [\log (M_2+1)^2-\log (M_1+1)^2] \tag{4}$$

Since the speeds of the photographic objective are inversely proportional to the squares of its f-numbers

$$E_2=\frac{f_1^2}{f_2^2}\times E_1 \tag{5}$$

where E_2 is the printing exposure corresponding to the lens aperture or f-number f_2 and E_1 similarly corresponds to f_1. The angular change γ on the scale 17, which represents a change in f-number from f_1 to f_2, is determined by substituting in Equation 2 the value of E as expressed in Equation 5. Thus

$$\gamma=\log\left(\frac{f_1^2}{f_2^2}\times E_1\right)\times\frac{300}{2.5}-\log E_1\times\frac{300}{2.5}$$

$$\gamma=120\left(\log\frac{f_1^2}{f_2^2}+\log E_1-\log E_1\right)$$

and

$$\gamma=120\log\left(\frac{f_1}{f_2}\right)^2=240\log\frac{f_1}{f_2} \tag{6}$$

With the exception of the magnification and exposure scales which are positioned on a single element, each of the other scales is placed on a separate disc. Since the magnification scale is never set off directly against the exposure scale but is employed, as will be understood from the discussion of the use of the computer, primarily through the intermediary of other scales to indicate change in exposure time accompanying change in magnification, it is unnecessary that the various scales be plotted in any particular position relative to each other so long as they are all plotted to the same angular scale.

In using the print exposure computer the enlarger is first set at the magnification and aperture most frequently used. A test tablet, which is merely a graduated series of densities, is now placed in the negative plane and a test print made, using an average exposure time for the material being tested. The test print is then completely processed. This print is now examined and the step selected in the test print which shows the depth of tone which it is desired to reproduce from measured densities in the negatives. The density of the step in the test tablet which produced the step selected in the test print is determined. The lens aperture scale 17 is set relative to the magnification scale 16 to indicate the magnification and f-number used in making the above test print. Holding the base element 13 and disc 12 fixed relative to each other, the density scale 19 is set to show the density of the step, above determined, opposite the exposure time used for the test.

In printing from the negatives, selected densities are now measured in the negatives and the printing or exposure times are read on the computer opposite the selected densities. Moreover, if the magnification or lens aperture is to be changed, discs 11 and 12 are rotated without changing their relative position and the new values of magnification and/or aperture set off against each other. The computer will then continue to indicate correct exposures for the material tested. Obviously, if a different sensitive material is to be employed, the computer must be reset and the whole of the above procedure should be repeated. Similarly, even if the same material is to be used, but after a lapse of a considerable time, it may be desirable to make a new test print inasmuch as the characteristics of certain sensitized materials change considerably with age.

In using the computer for making prints by the dye transfer process, after the test print or matrix has been exposed, it is completely processed, dye cyan and then transferred to paper. The cyan print is now examined, preferably through a Wratten No. 29 filter, and the first step is selected which shows a definitely perceptible transfer of color. This is the depth of tone which it has been found most desirable to print from densities measured in white highlights—not specular reflections—of separation negatives. After the computer has been set, just as in the case for black and whites, the matrix exposure times are read on the computer opposite the densities which have been measured in the diffuse white highlights of the separation negatives.

It is also obvious that the present device can be employed in ordinary contact printing. When it is so used, only the exposure and density scales are used.

Obviously, the scales may be rearranged in various ways and the computer still function as intended. For instance, the magnification scale 16 may be located on the disc 12 and the lens aperture scale 17 placed on the base plate 13. Similarly, the exposure scale 15 and the density scale 19 may be interchanged in regard to their locations.

It is also understood that the word "magnification," as used herein, is used in a broad sense and includes "magnifications" of less than unity or, in other words, reductions.

From the foregoing description, it will be apparent that we have provided means for obtaining all of the objects and advantages of this invention.

What we claim and desire to secure by Letters Patent of the United States is:

1. A photographic computer comprising a base plate, a pivot secured to said plate, two superposed discs rotatably mounted on the pivot, a circular density scale and a circular exposure scale concentric about said pivot, one of said scales being positioned about the peripheral edge of one of said discs, the other on said base plate in abutting relation with the scale on the disc, two additional circular scales concentric about said pivot, indicating magnification and lens aperture, one of said latter two additional scales being positioned on the other of said discs and the other scale on said base plate, the latter two scales being in abutting relation with each other and being positioned inwardly of the first two scales, and transparent sections in the two discs whereby the scales on the lower disc and base plate will be visible despite the overlying discs.

2. A photographic print exposure computer comprising a base plate, a pivot secured to said plate, two superposed discs rotatably mounted on the pivot, a circular density scale concentric about the pivot and positioned about the peripheral edge of the top disc, a circular exposure scale concentric about the pivot and positioned on said base plate, said two scales being in juxtaposition whereby the graduations of one may be set off against the graduations of the other, a circular magnitfication scale on the base plate concentric with and lying inwardly of the exposure scale, a circular lens aperture scale concentric about the pivot and positioned upon the lower of the superposed discs, the magnification and lens aperture scales being in juxtaposition whereby the graduations of the one may be set off against the graduations of the other, transparent sections in said two discs whereby the magnification and lens aperture scales may be viewed therethrough, resilient means integral with one of said two discs providing a releasable, frictional engagement between the two discs, whereby the discs may be readily rotated in unison or independently of each other, a fifth circular reference scale, concentric with the other scales and positioned about the peripheral edge of the lower of the superposed discs, a window in the top disc through which said fifth scale is visible, and a reference marker on said top disc adjacent said window by which relative positions of said two discs may be determined.

3. A photographic print exposure computer comprising a base plate, a pivot secured to said plate, two superposed discs rotatably mounted on the pivot, a circular density scale concentric about the pivot and positioned about the peripheral edge of the top disc, a circular exposure scale concentric about the pivot and positioned on said base plate, said two scales being in juxtaposition whereby the graduations of one may be set off against the graduations of the other, a circular magnification scale on the base plate concentric with and lying inwardly of the exposure scale, a circular lens aperture scale concentric about the pivot and positioned upon the lower of the superposed discs, the magnification and lens aperture scales being in juxtaposition whereby the graduations of the one may be set off against the graduations of the other, transparent sections in said two discs whereby the magnification and lens aperture scales may be viewed therethrough, resilient means integral with one of said two discs providing a releasable, frictional engagement between the two discs, whereby the discs may be readily rotated in unison or independently of each other, and said lower disc having a transparent edge projecting slightly beyond the edge of said top disc, whereby the lower disc may be readily held immovable while the upper disc is rotated relative thereto.

4. A photographic computer comprising a base plate, a pivot secured to said plate, two superposed discs rotatably mounted on the pivot, a circular density scale and a circular exposure scale concentric about said pivot, one of which is positioned on one of said discs, the other on said base plate, both scales being in abutting relationship, two additional circular scales concentric about said pivot, one indicating magnification, the other lens aperture, one being positioned on the other of said discs and the other scale on said base plate, the latter two scales also being in abutting relationship, the relationship between the density and exposure scales being determined by the equation

$$D = \log E$$

where D is the negative density and E the printing exposure, the relationship between the magnification and exposure scales being determined by the equation

$$E=(M+1)^2$$

where M is the magnification and E the printing exposure, and the relationship between the lens aperture and exposure scales being determined by the equation

$$E_2=\frac{f_1^2}{f_2^2}E_1$$

where E_2 is the printing exposure corresponding to a lens aperture having an f-number of f_2 and E_1 corresponds to f_1.

5. A photographic computer according to claim 1 in which the relationship between the density and exposure scales is determined by the equation

$$D=\log E$$

where D is the negative density and E the printing exposure, in which the relationship between the magnification and exposure scales is determined by the equation

$$E=(M+1)^2$$

where M is the magnification and E the printing exposure, and in which the relationship between the lens aperture and exposure scales is determined by the equation

$$E_2=\frac{f_1^2}{f_2^2}E_1$$

where E_2 is the printing exposure corresponding to a lens aperture having an f-number of f_2 and E_1 corresponds to f_1.

6. A photographic computer comprising a base plate, a pivot secured to said plate, two superposed discs rotatably mounted on the pivot, a circular density scale and a circular exposure scale concentric about said pivot, one of said scales being positioned about the peripheral edge of one of said discs, the other on said base plate in abutting relation with the scale on the disc, a circular magnification scale and a circular lens aperture scale concentric about said pivot, one of the latter two scales being positioned on the other of said discs and the other scale on said base plate, the latter two scales being in abutting relation with each other and positioned inwardly of the first two scales, the relationship between the density and exposure scales being determined by the equation

$$D=\log E$$

where D is the negative density and E the printing exposure, the relationship between the magnification and exposure scales being determined by the equation

$$E=(M+1)^2$$

where M is the magnification and E the printing exposure, and the relationship between the lens aperture and exposure scales being determined by the equation

$$E_2=\frac{f_1^2}{f_2^2}E_1$$

where E_2 is the printing exposure corresponding to a lens aperture having an f-number of f_2 and E_1 corresponds to f_1, transparent sections in the two discs whereby the scales on the lower disc and base plate will be visible despite the overlying discs, and resilient means providing a releasable, frictional engagement between the two discs,

whereby the two discs are readily rotatable as a unit or independently of each other.

7. A photographic print exposure computer comprising a base plate, a pivot secured to said plate, two superposed discs rotatably mounted on the pivot, a circular density scale and a circular exposure scale concentric about said pivot, one of said scales being positioned about the peripheral edge of the top disc, the other on said base plate and in juxtaposition with the scale on the top disc, whereby the graduations of one may be set off against the graduations of the other, a circular magnification scale and a circular lens aperture scale concentric about said pivot, one of the latter two scales being positioned on the lower disc and the other on said base plate, the latter two scales being in juxtaposition whereby the graduations of one may be set off against the graduations of the other, said latter two scales being positioned inwardly of the first two scales, clear sections in said two discs whereby the magnification and lens aperture scales may be viewed therethrough, resilient means integral with one of said two discs providing a releasable, frictional engagement between the two discs, whereby the discs may be readily rotated in unison or independently of each other, said lower disc having a transparent edge projecting slightly beyond the edge of the top disc, whereby the lower disc may be readily gripped to hold such immovable while the top disc is rotated relative thereto.

8. A photographic print exposure computer comprising a base plate, a pivot secured to said plate, two superposed discs rotatably mounted on the pivot, the lower disc having a transparent edge projecting slightly beyond the edge of the top disc to provide finger gripping means for holding the lower disc immovable while the top disc is rotated, a circular density scale concentric about said pivot and positioned about the peripheral edge of the top disc, a circular exposure scale concentric about the pivot and positioned on said base plate, said two scales being in juxtaposition whereby the graduations of one may be set off against the graduations of the other, a circular magnification scale on the base plate concentric with and lying inwardly of the exposure scale, a circular lens aperture scale concentric about said pivot and positioned upon the lower of the superposed discs, the magnification and lens aperture scales being in juxtaposition whereby the graduations of the one may be set off against the graduations of the other, clear sections in said two discs whereby the magnification and lens aperture scales may be viewed therethrough, resilient means integral with one of said two discs providing a releasable, frictional engagement between the two discs, whereby the discs may be readily rotated in unison or independently of each other, the relationship between the density and exposure scales being determined by the equation

$$D=\log E$$

where D is the negative density and E the printing exposure, the relationship between the magnification and exposure scales being determined by the equation

$$E=(M+1)^2$$

where M is the magnification and E the printing exposure, and the relationship between the lens aperture and exposure scales being determined by the equation

$$E_2=\frac{f_1^2}{f_2^2}E_1$$

where E_2 is the printing exposure corresponding to a lens aperture having an f-number of f_2 and E_1 corresponds to f_1.

9. A device according to claim 8 and further including a fifth circular reference scale concentric with the other scales and positioned about the peripheral edge of the lower of the superposed discs, a window in the top disc through which said fifth scale is visible and a reference marker on said top disc adjacent said window by which relative positions of said two discs may be readily determined.

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