November 23, 1963

Reasonably well set up with enlarger, trays, tank, chemicals.
Enlarger bought second hand at Moorestown Camera corner $60. Marked Sun Ray and Mastercraft model 45. Sun Ray Photo Co N.Y. N.Y.
Original lens Carl Zeiss Jena Tessar f:4.5 135mm 923471
Shutter F. Deckel, München 1045621
Enlarger designed for 4x5 negatives.

Ceiling limits the vertical travel of the enlarger to 31" from bed to negative carrier.
Bellows will contract to 3" from lens carrier to negative carrier.

Bought an Argus A2B (101675) 35mm camera for $2 to use the lens. f:4.5 about 50mm

Also tried 25mm lens from Keystone Movie Camera f:1.5. Very poor

Built recessed mounts for each.

Built 2¼ x 2¼ negative carrier.

Bought 6'x2' sheet 0.064" aluminum, Dead soft. $10.80 in Camden.

Bought ½ yard of black velveteen $1.40

First problem: I move the camera (2¼ × 2¼ Argus 40 twin lens reflex) on almost every shot. The shutter is hard to push. Some better luck using the cable release but still not very good. Fastest shutter speed is 1/150 sec.

Lens	Magnification min	Magnification max
135 mm	1×	3.4×
50 mm	4.4×	13×
25 mm	26×	10.4×

Theoretical limiting resolution of lens focussed at infinity:

F = focal length   f: number = $f = \frac{F}{W}$
where W is lens diameter.

$\alpha = 1.22\ \lambda/W$ using $\lambda = 0.4\mu$ ← violet

$\alpha \doteq 0.5\ \frac{1}{W}$

For green (0.55μ)
$\alpha = 0.67\ \frac{1}{W}$

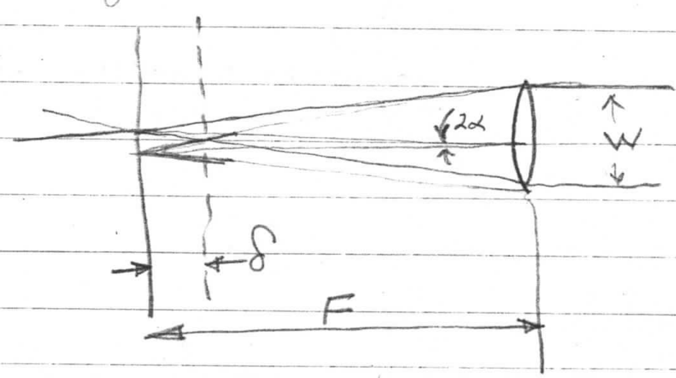
the spatial wavelength at negative, $\lambda_n = \alpha F$

$\lambda_n = 1.22\ \frac{\lambda F}{W} = 1.22 \lambda f \doteq 0.5 f\ (\mu)$

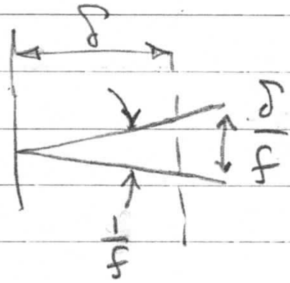
For red (0.65μ)
$\alpha = 0.79\ 1/W$

f	λ_n theoretical limiting resolution of lens at negative (microns)	$\pm\delta$ theoretical depth of field at negative (microns)
1	0.5	± 0.5
1.4	0.7	± 1.0
2	1.0	± 2.0
2.8	1.4	± 4.0
4	2.0	± 8.0
5.6	2.8	± 16.0
8	4.0	± 32.0
11.	5.5	± 64.0
16.	8.0	± 128.0
22	11.0	± 256.0
32	16.0	± 512.0

<u>Depth of field</u>:



subtended angle of lens seen by negative resolution element $= 2\tan^{-1}\frac{W}{2F} \doteq \frac{W}{F} \equiv \frac{1}{f}$.



$$\frac{\delta}{f} = \lambda_n = 0.5 f \text{ (microns)}$$

$$\delta = 0.5 f^2 \text{ (microns)}$$

For the usual limit that the field diagonal is equal to the focal length –
N is the number of resolvable cycles across the diagonal

$$N \lambda_n = F$$

$$\lambda_n = 0.5 f \text{ (microns)}$$

$$N = \frac{F}{\lambda_n} = \frac{F}{0.5 f \text{ (microns)}}$$

For perfect lens:

f \ F	12 mm	25 mm	50 mm	75 mm	100 mm	135 mm
1	24,000	50,000	100,000	150,000	200,000	270,000
1.4						
2	12,000	25,000	50,000	75,000	100,000	135,000
2.8						
4	6,000		25,000		50,000	
5.6						
8	3,000	6,000	12,500		25,000	
11.						
16.	1,500	3,000	6,000		12,000	
22.				6,000		
32.	750	1,500			6,000	8,500

neglecting coma, aberrations, ...

Acceptable prints.

Criterion of limit of visual acuity at a viewing distance of 20", 500 mm.

Taking the performance of the eye as 1 mm resolution at a distance of 3 meters (high contrast ruler marks merge)

$$\alpha = \frac{1\,mm}{3000\,mm} = 0.3\,mr.$$

at 500 mm viewing distance $\lambda_{print} = \frac{1\,mm}{6} = 0.17\,mm.$ 166μ

6 cycles/mm is very high except at very high contrast.

In a 5"x7" print $125_{mm} \times 175_{mm}$ diagonal 210 mm

210 mm x 6 cycles/mm = 1260 cycles.

For test pictures:

Using 12" scale with 1 mm markings.

at 50 cycles/mm on negative magnification is 50X

$$\frac{39.37\ \text{inches/m}}{12\ \text{inches/ft}} = 3.29\ \text{ft/m}$$

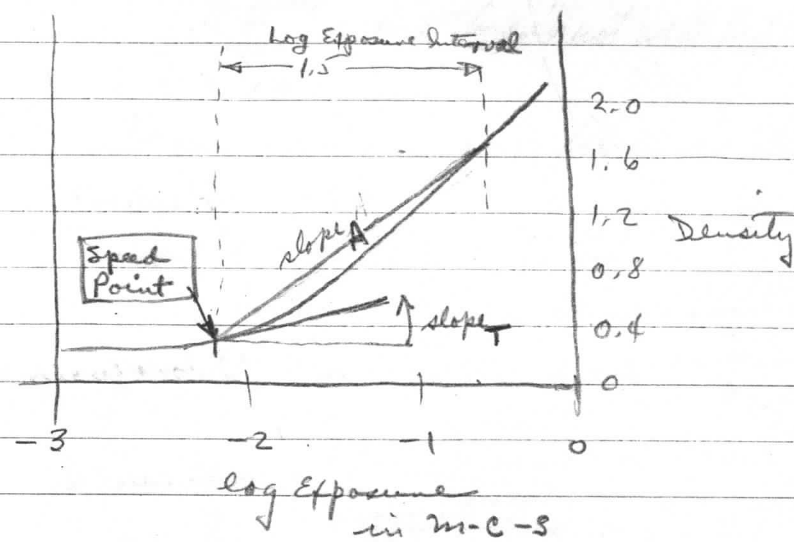
Distance to target = 75 mm x 50 = 3750 mm = 3.75 m
= 12.18 ft

Light levels.

at 24" from 100 w bulb in bullet reflector Incident light meter reads 50 ft candles.

For example – a picture of a light bulb. Assume uniform output over 2" diam.

ASA speed from old Kodak Handbook

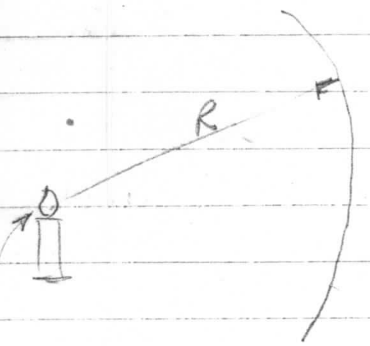


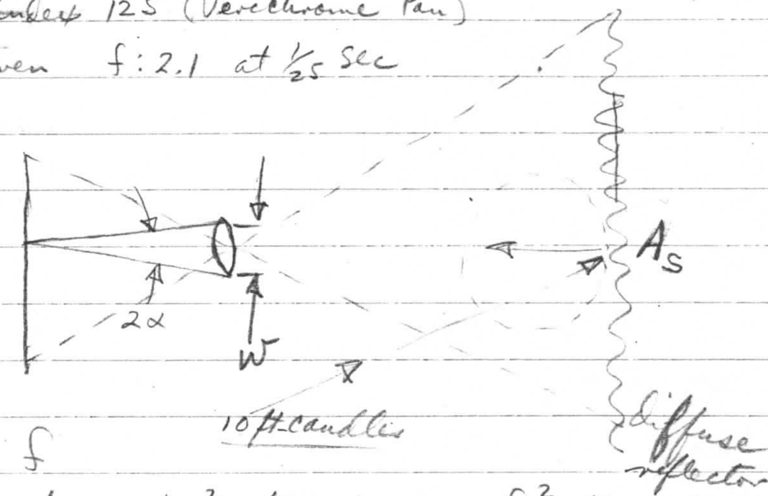
$$\frac{\text{Slope}_A}{\text{Slope}_T} = 3 \quad \text{at speed point}$$

$$\text{ASA Speed} = \frac{1}{E\ (\text{in mcs})}$$ Rounded off to nearest multiple of $\sqrt[3]{2} \times 100$

This determines the minimum exposure –

Using scales on GE exposure meter.
Assume 10 ft candles incident light,
Exposure index 125 (Verichrome Pan)
Result given f:2.1 at 1/25 sec





$2\alpha = f$

Solid angle $= 4\alpha^2$ sterradians $= f^2$ sterradians
18% reflectivity is considered typical.

luminous intensity in $\frac{\text{lumens}}{\text{steradian}}$ = candlepower $\equiv P$
at a distance R
the $\frac{\text{lumens}}{m^2} = I$

On the area of the scene, the light flux density is 10 lumens/ft²

1 meter candle $= 1 \frac{\text{lumen}}{m^2}$ = the unit of illumination (I)

I × Reflectivity = brightness (in lamberts)

For a sheet diffuse reflector as large as the camera field of view, the light intercepted by the lens is the same as that emitted by an area of the same size on the reflector.

Thus the 10 ft candles become $10 \frac{\text{lumens}}{ft^2}$

or $10 \frac{\text{lumens}}{ft^2} \times \frac{(3.29 ft)^2}{m^2} = 108 \frac{\text{lumens}}{m^2}$

at 18% reflectivity, the brightness is $B = 0.18 \times 108 \frac{\text{lumens}}{m^2} = 19.4 \frac{\text{lumens}}{m^2}$

The area within the field of the lens is about

$\frac{\pi F^2}{4}$ but this is not well defined -

The illumination at the film is then

$$I = B \frac{\frac{\pi W^2}{4}}{\frac{\pi F^2}{4}} = B \frac{W^2}{F^2} = \frac{B}{f^2}.$$

at f:2.1.

$$I = \frac{19.4 \frac{\text{lumens}}{m^2}}{(2.1)^2} = 4.4 \frac{\text{lumens}}{m^2}$$

or 4.4 meter-candles.

with $t = \frac{1}{25}$ sec

$E = 4.4 \text{ m.c} \times \frac{1}{25} \text{ sec} = 0.176 \text{ mcs}$

$\frac{1}{0.176} = 5.7$ $\quad \Sigma = -0.755$

Comparing this point with $\frac{1}{125}$ mcs

$$\frac{0.176}{\frac{1}{125}} = 22$$

~~The old rating of 50 on Verichrome $\frac{1}{50}$ mcs~~

~~$$\frac{0.176}{\frac{1}{50}} = 8.8$$~~ not significant since meter was based on a speed of 125

at a distance of 1 ft light meter reads 3 with cover open from 18% reflective card.

at a distance of 2 ft meter reads 50 $\frac{\text{lumens}}{ft^2}$

at a distance of 1 ft would be 200 $\frac{\text{lumens}}{ft^2}$

at 18% reflectivity $0.18 \times 200 \frac{\text{lumens}}{ft^2} = 36$
Does not check —

Try for a density of 1 on 100% reflectivity

The recommended development for $\gamma = 0.70$
$\log E = -0.85$ $E = 0.14$ mcs

$I = \frac{B}{f^2}$ where I is illumination on film
B is brightness of source

at $f:4.5$ $\frac{1}{100}$ sec

$$I = \frac{0.14\ mcs}{\frac{1}{100}s} = 14 \text{ meter candles} = 14 \frac{\text{lumens}}{m^2}$$

$$= 14 \frac{\text{lumens}}{m^2} \times \frac{m^2}{10.7 ft^2} = 1.3 \frac{\text{lumens}}{ft^2}$$

Required Brightness

$$B = f^2 I = (4.5)^2\, 1.3 \frac{\text{lumens}}{ft^2} = 26.5 \frac{\text{lumens}}{ft^2}$$

Distance from 100w bulb in bullet.

$$\sqrt{\left(\frac{50}{26.5}\right)(2ft)^2} = \sqrt{7.5}\,ft = 2.75 ft.$$

$$= 2'9''$$

First test $f\ 4:5$ $\frac{1}{100}$

Second test $f\ 5.6$ $\frac{1}{50}$

from 12'9"

Wedge marked at $\lambda_1 = 1cm$

$\lambda_2 = 2cm$ $\lambda_3 = 3cm$

Film was heavily fogged - apparently from leaving out light baffle in tank for about 5 sec under the light.

Second roll

#1 f 4.5 $\frac{1}{100}$ sec 12'9" to tgt 2'9" to light
single 100w in bullet

#2 f 5.6 $\frac{1}{50}$ sec same

#3 f 8.0 $\frac{1}{25}$ sec same

#4 f 4.5 $\frac{1}{100}$ sec 6'4½" 2'9" to light

#5 5.6 $\frac{1}{50}$ } double exposure
~~#6~~ 8 $\frac{1}{25}$

#6 5.6 1/50 6'4½"

#7 8 1/25 6'4½"

#8 f 4.5 $\frac{1}{100}$ pattern in corner

#9 f 4.5 $\frac{1}{100}$ " " opposite diag corner

10 " corner

11 " corner

12 " deliberately focused to "5,31"

11/25/63

Not particularly good - 1mm marks at 25X are barely visible - Various exposures should be used to see the effect - The more heavily exposed frames look better (sharper).

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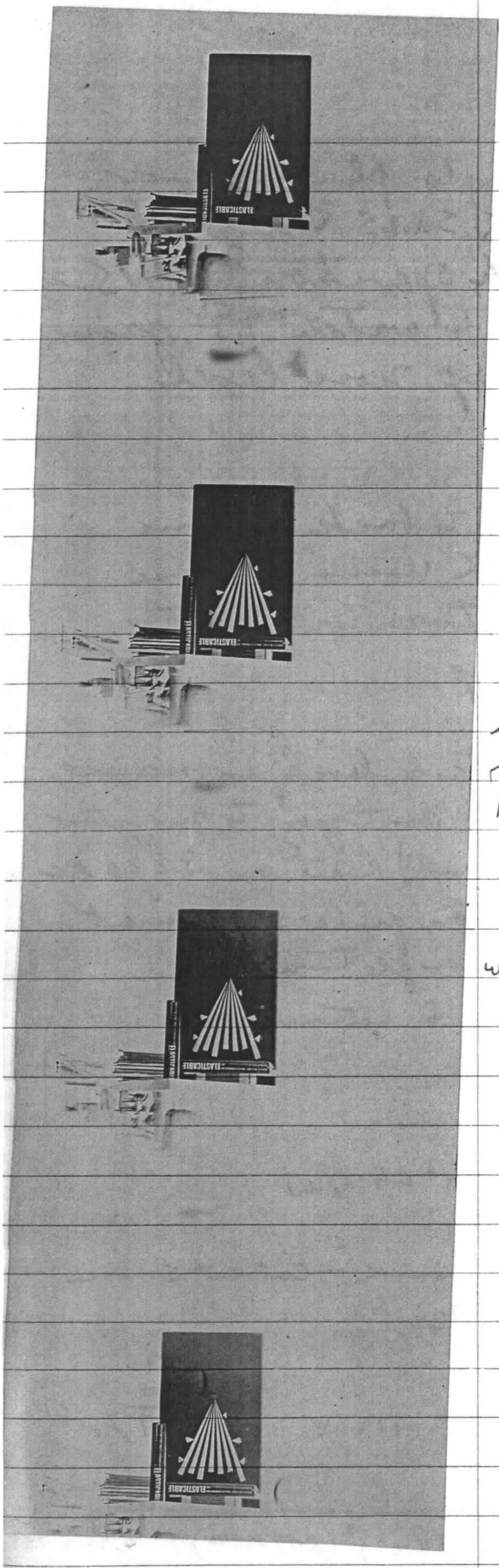

#1 f 4.5 1/150 sec 6'4½" Single 100w bullet at 2'9"

2 f 4.5 1/100

3 f 4.5 1/50

4 f 4.5 1/25

5 f 4.5 1/150 3'2¼"

6 4.5 1/100

7 4.5 1/50

8 4.5 1/25

(5–8: forgot to refocus)

9-10-11-12 Helen With Photoflood

used speed of 160 on imported panchromatic film.

The 25mm lens resolves the 1mm scale while the 50mm lens does not – on the #4 frame – maximum magnification for both – Both wide open f:1.5 and f:4.5 –