Ikea led lamp aka Lum-i-Pas for microscopist

There seems to be still available in Ikea Jansjö led usb lamps. I have modified an older Jansjö with 3W, 4V and 0.75A power supply. My first microscope with a proper condenser is Zeiss LgOB1 with a mirror. I wonder if man can build Köhler illumination from an Ikea lamp. I believe that answer is: yes you can.

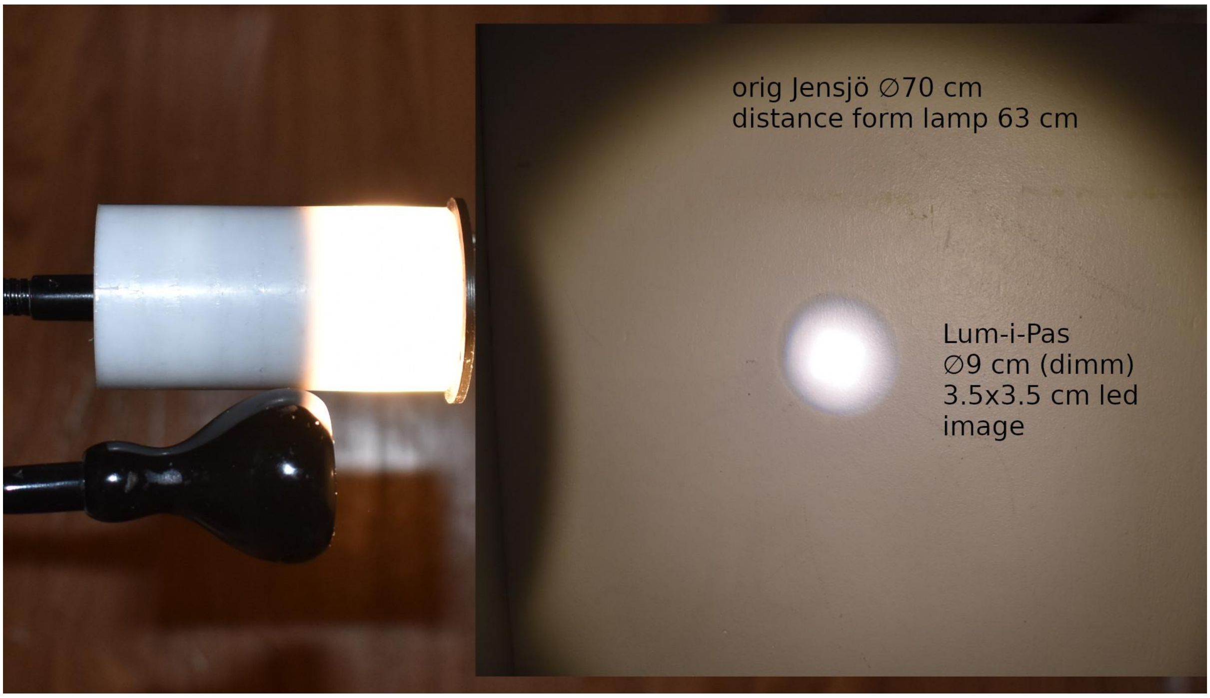
General

In the picture are LgOB1 & 8x0.2 obj without tube, piece of baking paper as sample and Lum-i-Pas : in PiP is the view in the roof (170 cm from sample is image ⌀13cm (even 40x was clear, but I had not camera tripod available at a moment, 1/20 shutter speed was too long), both condenser lens in place and as high as possible).

The innovation is to move Jansjö plastic front lens 30 mm forward: because of a whimsical geometric coincidence the result is a fairly well concentrated parallel beam.
For unknown reasons, I must next speculate with angles, numerical aperture, cones, etc.

Conventional lamps radiate light to practically the whole sphere. A Lambertian power led radiates 120° cone (“n.a” = sin(120°/2) = 0.9, minus because a cone is diverging instead of convenging). Power led radiating area (about 2x2 mm) generates more like planar wavefront. In the next table also the value of the distance to power 2 per enlightened area is calculated (after condenser the n.a is only relevant, but r2/a is helper idea to understand how much there are light (relation isn't linear: distance to power of 2 / area (in "reverse" order to emphase: bigger value is better))).

config	deg of cone [°]	numerical aperture [ ]	r2/a [ ]
Led only	120	-0.9	0.1
Jansjö	60	-0.5	0.6
Lum-i-Pas	1.5	-0.03	320



Jansjö and Lum-i-Pas light projected 62 cm to the wall.

Köhler illumination is explained in many places (conjugate planes are important too…)
https://www.microscopyu.com/microscopy-basics/conjugate-planes-in-optical-microscopy
https://zeiss-campus.magnet.fsu.edu/print/basics/kohler-print.html
http://www.microscopy-uk.org.uk/mag/artdec17/go-kohler.html

pg rule: in the image forming / field / objects planes you must place only useful things: sample under the objective or a measurement scale in the / under eyepiece; no dirt & dust or image of the lamp (filament). Aperture planes are important for lightning.

Lum-i-pas diode image should set:

- set & focus to generate suitable size of spot
- move Lum-i-pas so that the focused spot hits the mirror at the correct angle (set a piece of paper in the mirror and move the lamp or scope to have a focused image of led in it, angle can be verified from tube (without ocular and paper)).

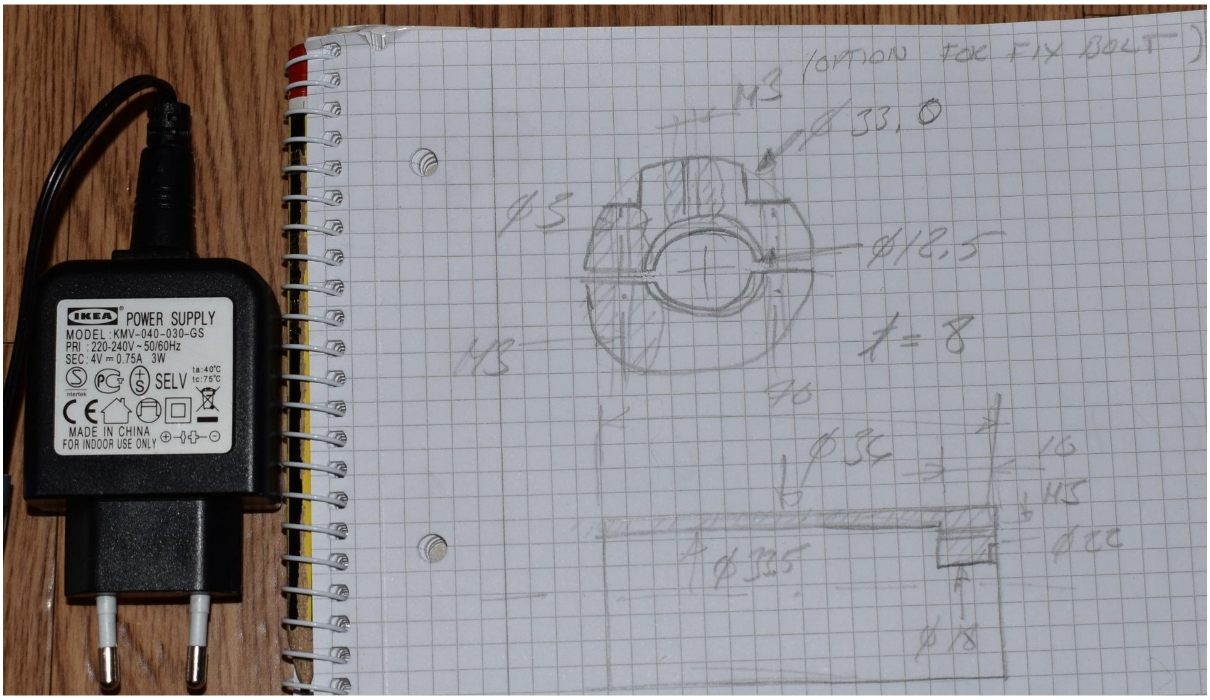
Optimum place for focused lamp image is in the front / lower focal point of the condenser. The condenser height must adjust too. A mirror may have curvature / magnification on the other side: test both.

Mechanical & electrical points

My first prototype was a clamped collar with lens and recycled aperture iris. Lum-i-Pas beam is so parallel that conventional field diaphragm is useless (at least when you can adjust spot's size with distance of lamp). Current version is based:

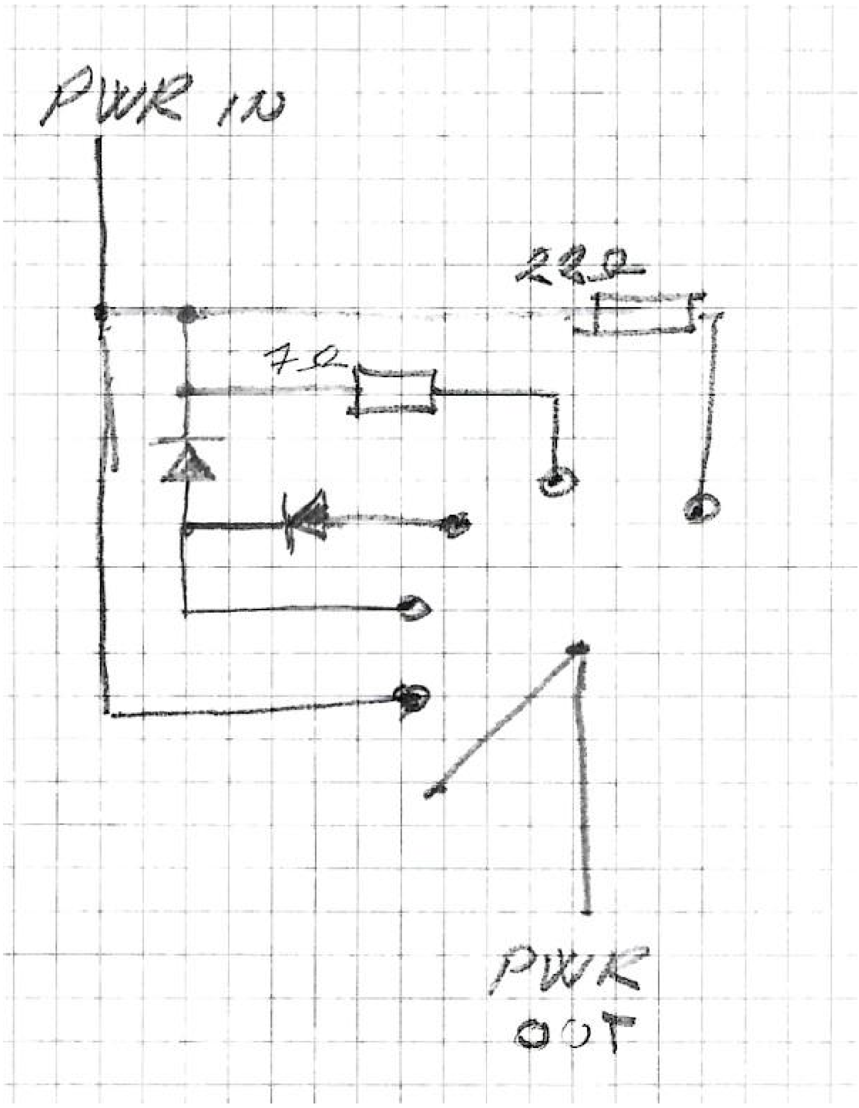
- saddle in Jansjö's waist
- tube with lens seat
- front lens holding disk (lens has turned "inside" out)

The draft shows dimensions of the turned pieces of mine (from pom). You may replace the lathe by 3-d printer and suitable plastic tube, tape & cupboard etc.



Maximum intensity of Lum-i-Pas is suitable for camera sensor cell, but the human eye needs dimming. Unlike traditional voltage driven lamps, led is a current driven component. The state of art method for led dimming is pulse width modulation PWM. https://zeiss-campus.magnet.fsu.edu/articles/lightsources/leds.html has the PWM circuit for dimming, but does not have a modulator itself (Arduino has been used as a modulation signal source). It is easy to find a ready PWM box with adjustment for a bigger voltage (series of leds, I don't know if they are suitable to drive single led).

I am a mechanical (*definitely not electrical*) engineer but have some electrical components on my shelf. For voltage adjustment I made some measurements. Despite Jansjö power values, the current of undimmed led is 0.5A and voltage 4V (real power is 2W instead of 3W). I worried about the power dissipation of the component and picked them from the heavy side. More or less random choices were two diodes (give constant voltage drop), 7 and 22 ohm resistors and a rotary switch. Circuit:



Leds reduce current to 200 - 300 mA. The smaller resistor gives about the same values. After tests I have mostly used 22 ohm (gives only 50 mA to led) for my eyes and an extra filter to dim more.

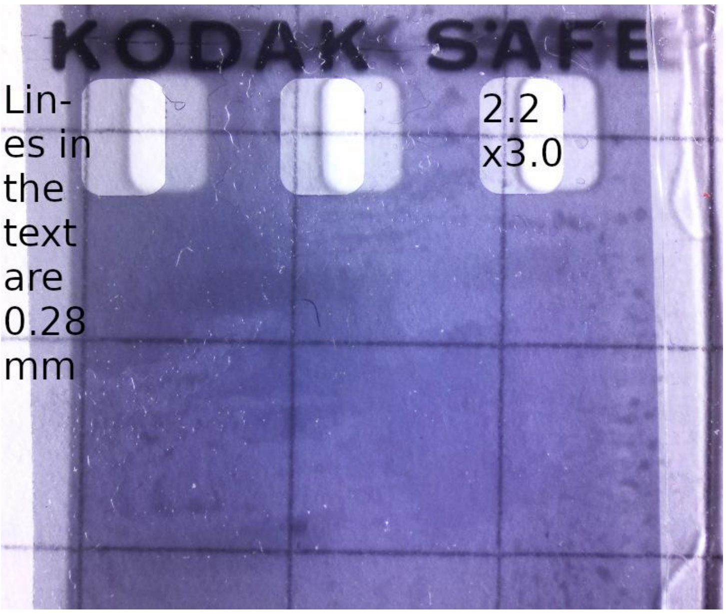
Note 1: Reducing voltage may turn light yellowish.

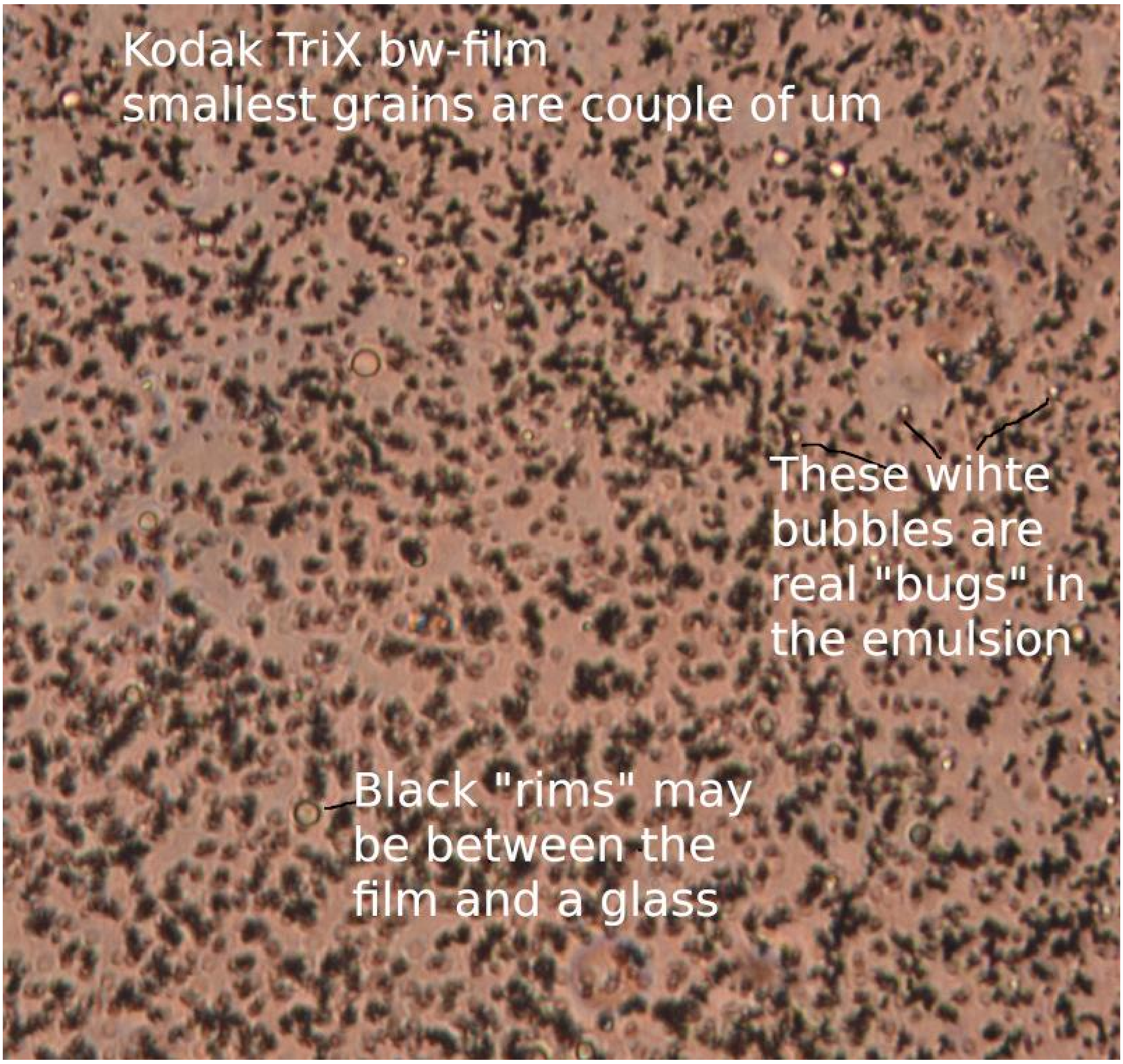
Note 2: These values may be suitable for the same production lot only.

Note 3: In PWM dimming with some frequencies may interfere with other parts.

Test images

Zeiss gives a hint from the film as a test sample. Unexposed black&withe film grain sizes are around 1 micrometer, color film grains are bigger. Because of curvature you must glue the front glass (and have bubbles etc). You always have total black areas in manufactured text, so only high exposed areas (it’s negative: low light generates black) are my favorites.


KODAK SAFE
Lin-
es in
the
text
are
0.28
mm
2.2
x3.0

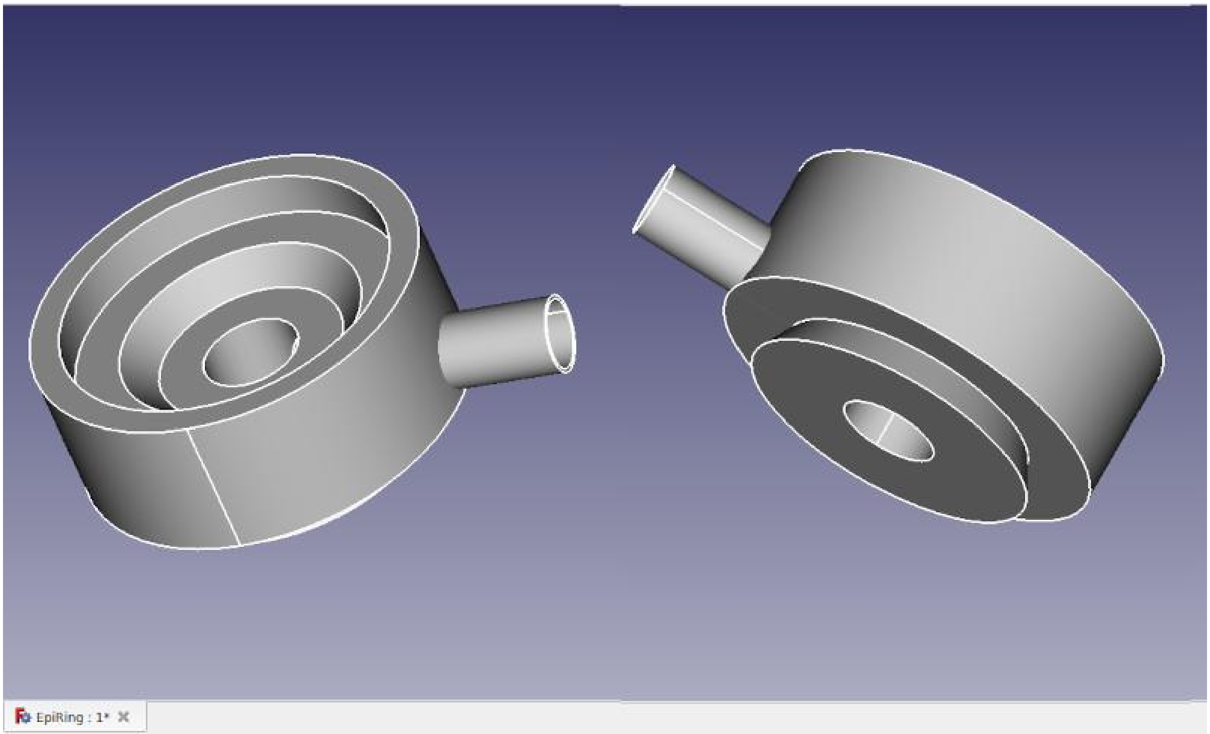

Kodak TriX bw-film
smallest grains are couple of um
These wihte
bubbles are
real "bugs" in
the emulsion
Black "rims" may
be between the
film and a glass

Real camera films aren't common any more. For non-hobbyist (possible sellers of old microscopes) I will recommend baking paper as a test sample: it's common and ready for test without preparation.

Future plan

Other scopist has found Jansjö too:
https://www.quekett.org/about/reports/2023-epi-illumination-public has used unmodified lamp in epi accessory.

In my scope the easiest place to set the epi system may be into a 'tube fitting collar', but I haven't any beam splitter. If you have an extra pellicle mirror, a small beam splitter prism etc and you are ready to donate it; I promise to test and report results. I haven't the slightest clue, what is the correct ratio between transmitted & reflected beam, need for extra filter (polarization), special coatings in a lens etc.



It seems like 14 - 15 mm is the optimum side length for a mirror / prism. Input aperture of the eyepiece tube is 13 mm.
Lum-i-Pas (with given dimension) can focus 65 mm from the lens, then the led image is 4 x 4 mm (it fits in a tube in the picture).
And if and when we don't forget the rule (don't put extra into image forming / object plane) 90 mm from lens to sample seems possible geometry with 5 x 5 mm enlightened area in an objective.

Comments to the author Pasi Grönqvist, Finland are welcomed,
email – vihervitsa AT gmail DOT com.

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