

# Adding a Darkfield Stop to the Nikon Labophot Abbe Condenser



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Revision History		
Revision	Description of Changes	Date
1	Initial Release	April 11, 2016
2	Add SDR-21 pipe recommendation	May 3, 2016

## Introduction

The circular dovetail used to mount the condensers on many Nikon and Olympus microscopes, while technically superior to the collar mounts used in earlier equipment, makes the insertion of a simple darkfield stop into the condenser light-path a difficult task. In order for a darkfield stop to be effective, it needs to be located very near (ideally in the same optical plane as) the aperture diaphragm in the condenser, and the presence of the mounting dovetail makes this difficult to accomplish.

In a typical collar-mount condenser, the filter slot or tray located on the bottom of the condenser is close enough to the aperture diaphragm such that a simple darkfield stop works well when placed in the slot or tray. However, the presence of the dovetail ring on the bottom of many condensers prevents a darkfield stop attached to the underside of the condenser from being close enough to the aperture diaphragm to achieve effective darkfield. In order to achieve darkfield in these condensers, the stop needs to be inserted up into the under-bore of the condenser, so as to place it near the aperture diaphragm.

This document describes the construction of a simple insert that will position a darkfield stop in the proper position within the Nikon Labophot Abbe condenser shown in Figure 1. This Nikon condenser is compatible with the Nikon Labophot and Optiphot microscopes, as well as the Olympus BH-2 (BHT, BHTU, and BHS) microscopes.



Figure 1: Abbe condenser from Nikon Labophot

## Parts Needed

In order to construct a darkfield insert for the Nikon condenser shown in Figure 1, you will need the following parts and materials:

- Nikon MXA20495 33 mm filter holder
- Short section of 1" diameter PVC pipe (SDR-21 is preferable, but schedule 40 may also be used)
- Darkfield stop with an outer diameter 33 mm and a center stop diameter as described later in this document
- Adhesive to bond the darkfield stop onto the PVC pipe (LOCTITE® 598 or PRO SEAL® 80046 black RTV silicone)
- Flat-black optical paint or a wide-tipped black Sharpie® permanent marker

## Determining Dimensions of Darkfield Stops

With a darkfield stop of the proper size installed in a standard Abbe condenser (and assuming it is properly centered within the optical path), it should be possible to set up the microscope to achieve darkfield for the 4x, 10x, and 20x objectives, with little difficulty. Although each objective should ideally be used with a dedicated stop sized to the numeric aperture of the specific objective, in practice, a single stop sized for the 20x objective will provide acceptable darkfield for the 4x, 10x, and 20x objectives.

The following procedure is a good method for determining the diameter of the stop needed for a specific objective, when using the Labophot condenser. First, set up the microscope for Köhler illumination and center the condenser using the desired objective (20x is recommended) and then move the slide to a clear area. Next, remove one of the eyepieces and sight down the ocular tube to observe the back focal plane of the objective (if possible, use a phase telescope or Bertrand lens to do this). Close the condenser aperture until the edges of the diaphragm leaves become visible, and then open it until the illuminated disk just fills the exit pupil. The aperture is now set to the minimum theoretical diameter of the stop needed to achieve darkfield for this objective. Since the scale of the Labophot condenser is marked for aperture diameters, you can read the required stop diameter directly off of this scale. Add 10% or so to this diameter to allow for imperfections in condenser centering and setup, and you are ready to fabricate the darkfield stop.

## Fabricating Darkfield Stops

There are several methods that can be used to fabricate darkfield stops. Regardless of which method you choose, be sure to blacken the finished stop using flat-black paint or a black Sharpie® marker in order to reduce optical reflections. Stops can be cut from various materials, with card stock being perhaps the easiest to work with (which can be cut by hand with an X-Acto® knife). If you have access to a laser cutter or CNC milling equipment, many other options are available to you. An alternative method is to place an opaque black circle of the required diameter onto the center of a clear glass disk or colored glass filter with a 33 mm diameter. If you routinely use a blue filter in the optical path to provide balancing for the otherwise warm halogen lighting in your microscope, you can use a 33 mm blue filter to make the darkfield stop, thereby making the filter integral to the darkfield insert such that a stand-alone filter is not required for darkfield. You can also print darkfield stops onto transparency film using an Inkjet or LaserJet printer.

## Constructing the Darkfield Insert

The first thing needed is a Nikon MXA20495 filter holder (see Figure 2 and Figure 3). This part was made to allow a 33 mm diameter filter to be installed into the under-bore of the Abbe condenser for the Nikon E200 microscope, but it fits nicely into the Labophot condenser shown in Figure 1 as well. The MXA20495 was available from Nikon for \$17 at the time this document was written.



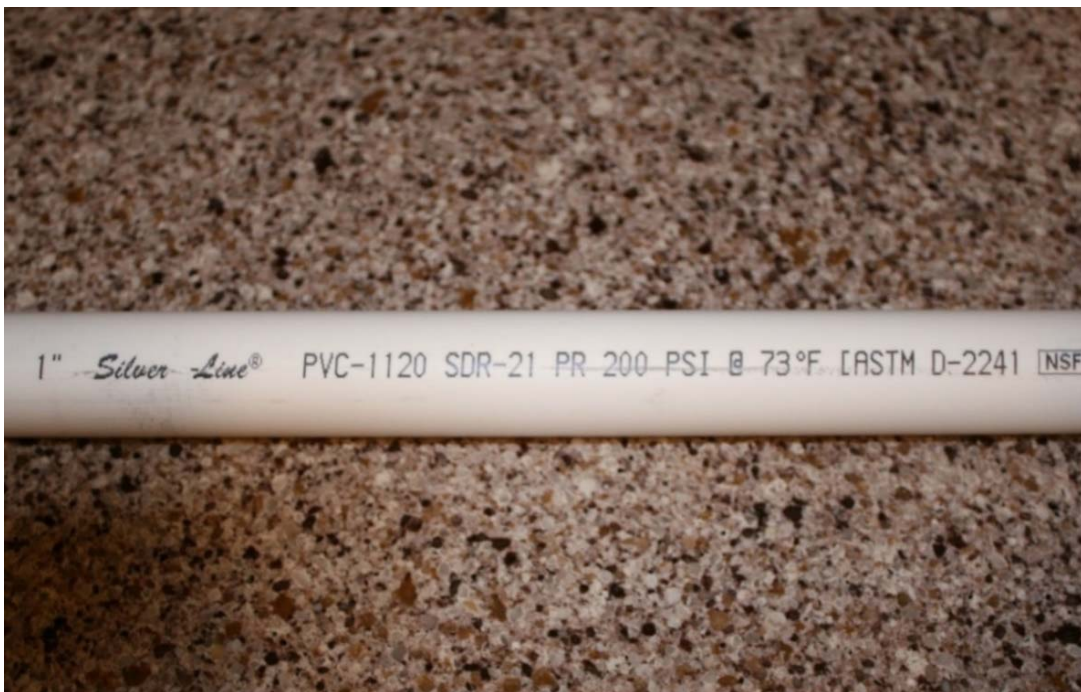
Figure 2: Nikon MXA20495 filter holder





**Figure 3:** A better view of the Nikon MXA20495 filter holder

Next, obtain a section of 1" diameter SDR-21 PVC (see **Figure 4**), which is sometimes referred to as class 200 or PR-200 PVC. If SDR-21 cannot be found, you may use schedule 40 PVC pipe instead, but SDR-21 is preferable since it has a much thinner wall thickness (see Figure 5).<sup>1</sup> Either way, the outside diameter of this pipe is 33.4 mm, which snaps into the MXA20495 filter holder nicely. Cut a section of this pipe to a length of 1½" with nice, true end cuts.<sup>2</sup> Remove any burrs or sharp edges from the cut pipe section.



**Figure 4:** A view of the markings of the preferred SDR-21 PVC pipe

<sup>1</sup> SDR-21 PVC has .063" wall thickness, whereas Schedule 40 has .113" wall thickness. The thinner wall of SDR-21 allows for a greater numeric aperture of the resulting light cone.

<sup>2</sup> Be careful with the length of the pipe section. Depending on the thickness of the darkfield stop that you plan to use, the length may need to be decreased in order to prevent the darkfield stop from contacting the aperture diaphragm and damaging the iris leaves of the condenser. The end cuts must be true or the centering of the darkfield stop within the light path will be poor.



**Figure 5:** A view of the difference in wall thicknesses in SDR-21 PVC (left) and Schedule 40 PVC (right)

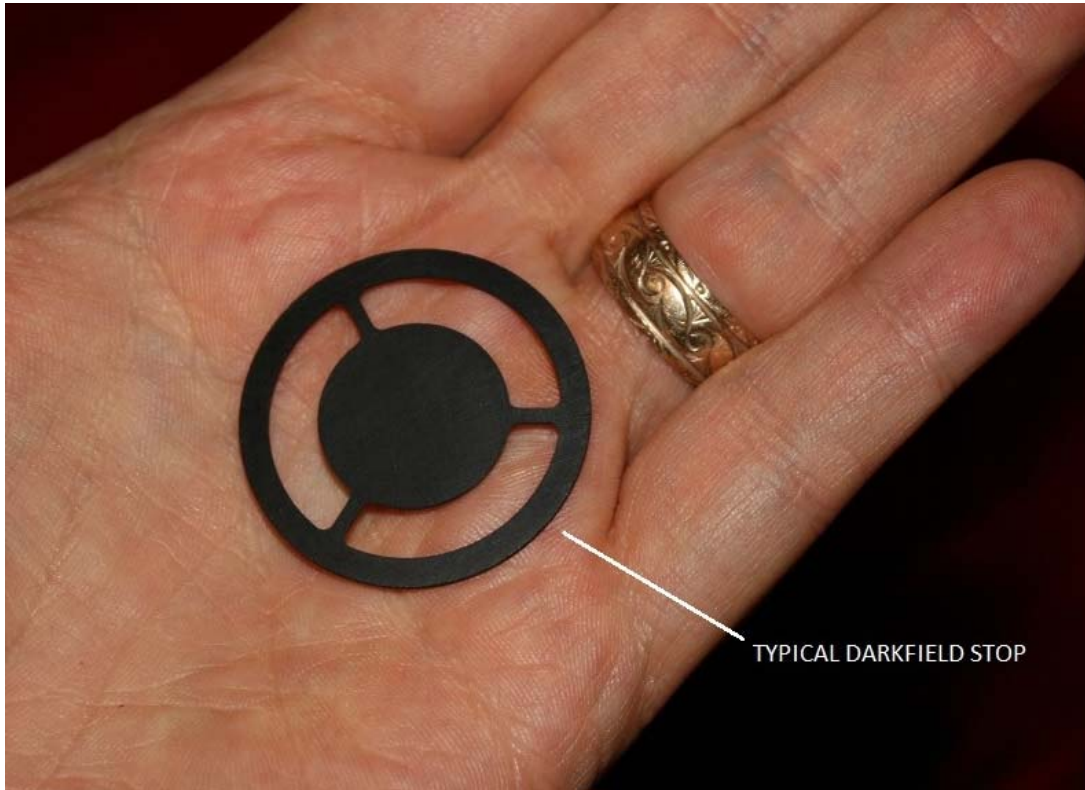
Verify that the PVC pipe section snaps into the MXA20495 filter holder (see Figure 6). It should fit as is, but if the fit seems too tight, lightly sand the outside diameter until the fit is acceptable.



**Figure 6:** PVC pipe section snapped into Nikon MXA20495 filter holder



Obtain or fabricate a darkfield stop with an outside diameter of 33 mm (or slightly less) and with a stop diameter as determined earlier (see Figure 7).



**Figure 7:** A typical “spider” or “wheel” style darkfield stop

Verify that the darkfield stop fits onto the end of the PVC pipe without overhanging the pipe wall (see Figure 8).



**Figure 8:** A view of how everything fits together

Remove the PVC pipe section from the Nikon MXA20495 filter holder and use flat-black optical paint or a wide-tipped black Sharpie® marker to blacken the pipe (be sure to blacken the inside, outside, and both ends of the pipe). Re-insert the PVC pipe section into the MXA20495 filter holder and secure with adhesive if the fit is loose. Secure the darkfield stop onto the other end of the PVC pipe section using adhesive (see Figure 9). Allow the adhesive to fully cure.



**Figure 9:** The finished darkfield insert, after “blacking” the pipe and assembling the pieces

Slide the finished darkfield insert into the under-bore of the Nikon condenser (see Figure 10) and press it into place (see Figure 11), being extremely careful the first time you do this so as to not damage the iris diaphragm if for some reason the insert is too long.



**Figure 10:** Installing the finished darkfield insert into the Nikon condenser





**Figure 11:** The Nikon condenser equipped for darkfield

The Nikon condenser is now equipped for darkfield. Hold the condenser up against a light-colored background and look into the under-bore so you can see the darkfield stop. Adjust the aperture diaphragm until the aperture is just slightly larger than the visible stop. You should be able to tell how well the darkfield stop is centered in the condenser by judging the uniformity of the ring of light around the stop (the centering may be off if the end cuts of the PVC pipe are not true). Poor centering should be corrected.



**Figure 12:** Looking into the under-bore of the darkfield-equipped Nikon condenser

The darkfield-equipped Labophot condenser is now ready to be installed onto your Nikon or Olympus microscope for darkfield applications.



## Setting Up for Darkfield Illumination

Install the modified condenser onto the microscope stand. Position a slide with a suitable high-contrast specimen on the stage. Set the condenser height so that the upper lens surface is approximately 2.0 mm below the specimen (or 0.8 mm below the bottom surface of a standard 1.2 mm glass slide). Fully open both the condenser aperture diaphragm and the field diaphragm and select the 40x objective. Adjust the focusing and positioning of the specimen, which should now appear in brightfield.<sup>3</sup> Remove one of the eyepieces and sight down the ocular tube to observe the back focal plane of the objective (if possible, use a phase telescope or Bertrand lens to do this). Close the aperture diaphragm until the illuminated ring is slightly smaller than the exit pupil. Adjust the condenser centering screws to obtain a properly centered bright ring. Re-install the eyepiece and fully open the condenser aperture once again. At this point, the lower power objectives (4x, 10x, and 20x) should provide darkfield illumination.

## Going Beyond Darkfield

The basic insert described in this document can be used for other applications beyond simple darkfield illumination. Rheinberg filters or asymmetrical oblique stops may be used, for example, instead of the darkfield stop to provide these additional capabilities to your microscope.

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<sup>3</sup> The specimen should appear in brightfield, assuming that the diameter of the darkfield stop was chosen for the 20x objective as described in this document.