BrainXell: Phase Contrast Microscope Condenser for Observation of Multiwell Cell Culture Plates

Product Design Specification

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Function:

BrainXell, represented by Mr. Michael Henrickson faces a common problem experienced by many lab technicians globally. When using phase microscopes on different sized well plates, the area of high resolution seen on each well is smaller than the entire area seen by the microscope. Our team seeks to expand the area of high resolution phase contrast to the entire well by creating a customized condenser. The condenser will keep the same level of resolution as the current condenser used by the client, and function with a variety of different well plates.

Client requirements:

- Expand the area of contrast
- Be used for black and white well plates
- Condenser should fit already existing equipment
- A new condenser is easier to distribute than new well-plates or a new microscope
    - This leaves open the option of trying different lighting techniques

Design requirements:

1. Physical and Operational Characteristics
    a. *Performance requirements:*
        i. The condenser must allow the user to increase the area of effective phase contrast viewing in standard 96-well plates with opaque walls from <25% to >75%.
        ii. The condenser must maintain a resolution of 1.22µm with 10X magnification objective lenses and 0.959µm with 20X magnification objective lenses with a tolerance of ±25%.
        iii. The condenser must be compatible with a Nikon ECLIPSE Ts2 microscope.
        iv. The condenser must be removable and interchangeable with other standard condensers.
        v. The condenser must be compatible with standard 96-well plates with opaque walls.

b. *Safety:*
    i. The condenser does not interact with the electrical components of the microscope, so no additional marking is required.
    ii. The condenser cannot produce any residue that may damage the specimen or harm the user.
    iii. The condenser must not perforate any safety equipment or damage the body of the user during interaction.
    iv. The condenser surface cannot exceed 44℃ for risk of thermal burning. [1]
c. *Accuracy and Reliability:*
    i. The goal for this project is to maintain the accuracy and reliability of current phase contrast microscopy -- BrainXell uses the Nikon ECLIPSE Ts2.
        1. The Nikon ECLIPSE Ts2 uses the ELWD (extremely long working distance) condenser has a numerical aperture of 0.3, working distance of 75 mm and magnification of 10x, 15x, and 20x. [2]
        2. These specifications should be maintained or improved to allow for consistent accuracy and reliability.
    ii. The condenser should also be reliable enough to give consistent results each time images are taken.
d. *Life in Service:* Establish service requirements, including how short, how long, and against what criteria? (i.e. hours, days of operation, distance traveled, no.of revolutions, no. of cycles, etc.)
    i. The condenser must withstand up to 24 hours of continuous laboratory use.
    ii. The condenser must withstand 10+ years of daily laboratory use
    iii. The condenser must remain usable after 10,000 cycles of removal.
e. *Shelf Life:*
    i. The condenser for a phase microscope has no expiration date if stored properly and used in the correct operating environment.
f. *Operating Environment:*
    i. The ideal operating environment for a phase microscope is between 32º-104ºF and the maximum humidity should be no more than 85%.
    ii. Storing conditions for the condenser must be dry, with low humidity, and not in direct sunlight.
    iii. A dust cover must be used when the microscope is not in use for an extended period of time. [3]
g. *Ergonomics:*
    i. There are many ergonomic issues with the condenser. The useability of the condenser is important to reach Köhler Illumination. The placement of the condenser must fit the size of the light source and the focus to achieve accurate results. Without proper fitting of the condenser, quantitative results are less accurate and harder to calculate. The condenser is adjusted with the aperture and will give the highest quality image. The aperture must be in an easily located position on the microscope and will have the correct height in relation to the objective. [4]

h. *Size:*
    i. The condenser must fit in the space of current standard condensers:
    ii. The current condenser used in the Nikon ECLIPSE Ts2 is the ELWD Condenser which must not exceed 75 mm in length.[2]
i. *Weight:*
    i. The condenser must weigh between 90-200 grams.[5]
j. *Materials:*
    i. Condenser materials should be taken into consideration with the watts of lamp used. Common materials for condensers include plastic or metal.
    ii. The field lens should be constructed out of glass.[6]
k. *Aesthetics, Appearance, and Finish:*
    i. The form and texture of the finish of the condenser must be standardized with the Nikon ECLIPSE Ts2 microscope.
    ii. The color and shape should be consistent with current condensers (black and cylindrical) [2]

2. Production Characteristics
    a. *Quantity:*
        i. Only one unit is needed for testing in this course. If the results are satisfactory with the users, more can be made for use by other users experiencing phase resolution issues with their current condensers.
    b. *Target Product Cost:*
        i. The specified budget for the prototype is $1500.
        ii. The product cost should be at or below the cost of the Nikon Phase Contrast ELWD 0.3NA Condenser at $1,150. [7]

3. Miscellaneous
    a. *Standards and Specifications:*
        i. FDA approval is not required for the fabrication of a Class I microscope condenser, as well as, all GMP regulations. This is true as long as the condenser is not labeled or otherwise represented as sterile. [8]
    b. *Customer:*
        i. The customer needs the condenser to be able to be adaptable to different kinds of plates, with focus on the Grainer-96 plates
        ii. The client prefers resolution of the edges of the visible lens to not be opaque and to be equally as transparent as the center of the visible lens.
        iii. The customer would also like the resolution and contrast to be our highest priorities, with limiting tradeoff between lower resolution for more area.

    c. *Patient-related concerns:*
        i. Microscopes should generally be sanitized and cleaned after 200 hours of service, or more frequently depending on daily usage.

ii. Microscope condensers are extremely fragile pieces and must be cleaned thoroughly and carefully. [9]
iii. There is no specified shelf life for this device

d. *Competition:*
   i. *Patent US 9041788B2* - This apparatus includes a light illumination, an illumination optical system, a calculation device used to calculate the plurality of the first electronic image. [10]
      1. This device has a similar illumination optical system and calculation.
   ii. *Patent US 8576483B2* - This invention contains an illumination optic system, first and second image creation optic system, an illumination- focused diaphragm section . [11]
      1. This device has a more complex illumination optic system, however, may be similarities in sections.
   iii. *Patent US 6924892B2* - This device includes a source of polarized light, an intensity of light detector, a condenser for providing light to the specimen, and support mounting. [12]
      1. Has a variation retarder with multiple sections, each addressable by a control signal. Similar to our light diffraction mechanism.

References

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