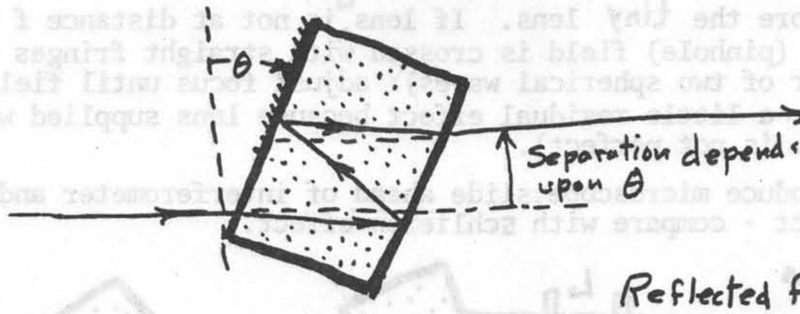
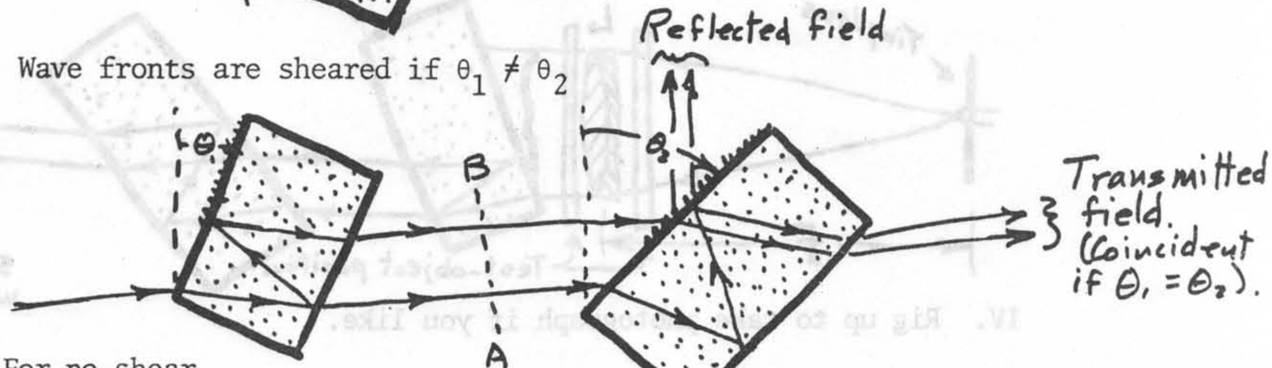
Mach – Zehnder or
Jamin Interferometer Experiment Notes

I. Look at our instruction book.

II.



Wave fronts are sheared if $\theta_1 \neq \theta_2$



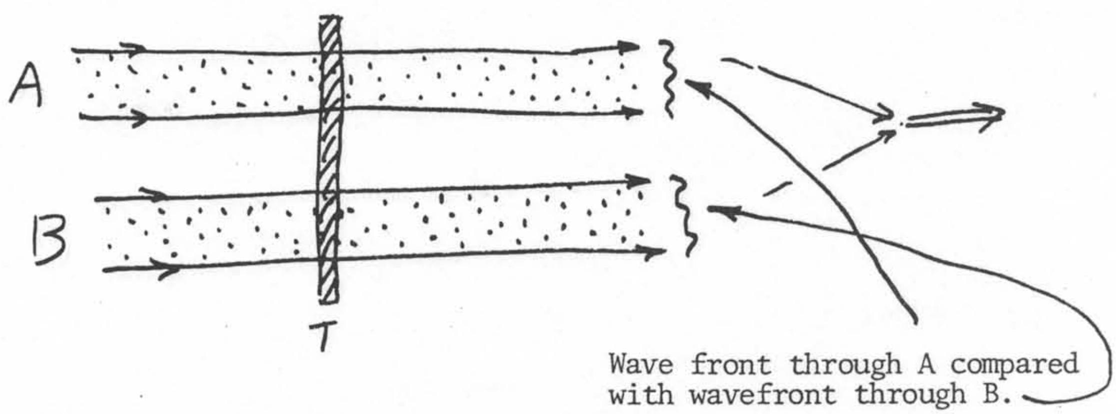
For no shear.

1) Rotate θ_2 until spots overlap
2) Shine a white light in and look for white light fringes - helpful to use replica grating and look at bands in spectrum.

With shear eliminated, field is a uniform tint: Note transmitted & reflected field are complementary - with this adjustment useful for interferometric testing of glass sheet or thermal (density) gradients.

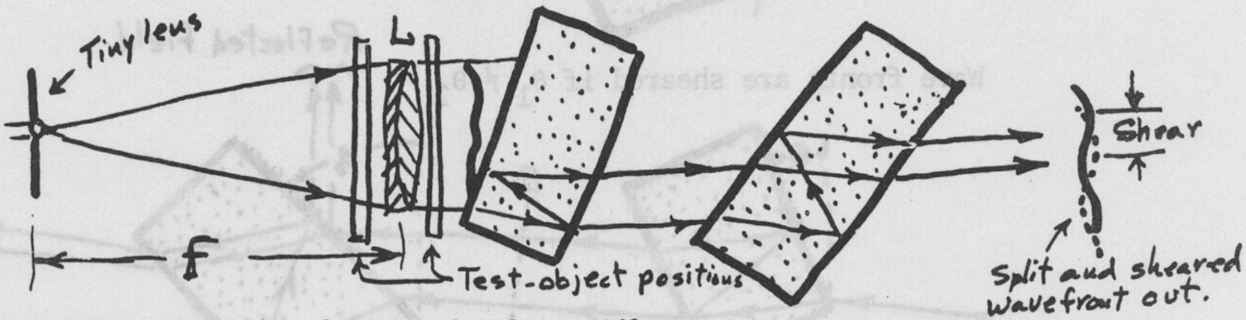
a) Put in a glass sheet at A.
b) Put in a hot soldering gun at A.

Note differential effect if test slab, T, extends through both A & B beams.



III. Introduce shear (Shearing Interferometer) - lateral shear.

- Rotate one piece so $\theta_1 \neq \theta_2$
- with no lens, laser spots transmitted (or reflected) show lateral shear - note that these two pencils of light are parallel.
- Restore the tiny lens. If lens L is not at distance f from diverging lens (pinhole) field is crossed with straight fringes (lateral shear of two spherical waves): adjust focus until field is uniform (note a little residual effect because lens supplied with bench type intf. is not perfect).
- introduce microscope slide ahead of interferometer and note shearing effect - compare with schlieren effect.



IV. Rig up to take photograph if you like.

V. Compare with Mach-Zehnder interferometer

Set up with discrete mirrors and beamsplitters on an optical table

Opt. Eng. Serial No. 011

Inspected By M.G Miller

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INSTRUCTION MANUAL

Physics 625 Lab Experiment

FOR

Mach-Zehnder (Jamin version)

MODEL 18

BENCHTOP INTERFEROMETER

OPTICAL ENGINEERING, INC.
11550 Western Avenue
Stanton, California 90680

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II OPTICAL DESIGN

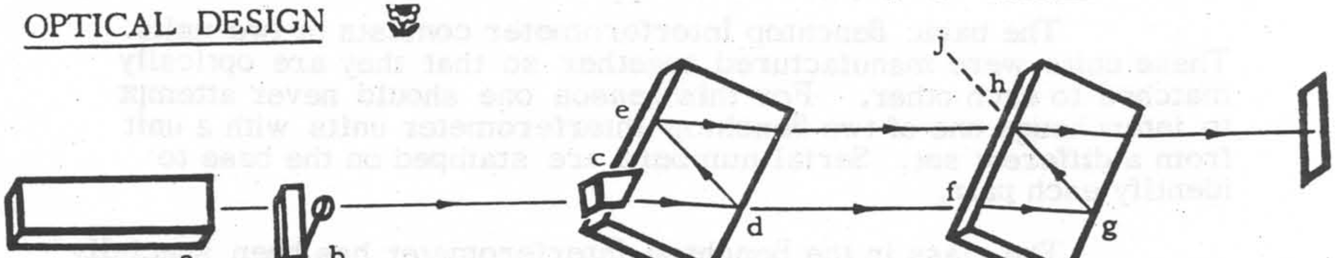


Figure 1

The Benchtop Interferometer is technically a Jaman type interferometer, although in usage it is very similar to the Mach-Zehnder design. The accompanying figure shows the essential features and optical path of the Model 18-A. A HeNe laser (a) emits light which passes through a diverging lens (b) then through collimating lens (c). Lens (c) snaps in place over the input aperture of the interferometer to simplify the collimation alignment. (A comparable high quality commercial beam expanding telescope capable of filling the interferometer's 1" x 1" input aperture could be used instead of this system.) The expanded laser light then enters the first element (a solid piece of glass) and strikes a 50% partially reflecting surface (d). The reflected component then strikes a totally reflecting surface (e) which is parallel to surface (d). This internal double reflection assures that the two beams emerging from the first piece of glass will always be parallel even if the glass is rotated. The transparent test object is inserted into one of these parallel beams. The beams can then travel any desired distance before entering the second element of the interferometer. In the second block of glass the beams are superimposed with surface (g) being totally reflecting and surface (h) being partly reflecting. Two beams (i) and (j) emerge containing the interference patterns. One beam has the negative fringe pattern of the other. It is usually most convenient to view the transmitted beam (i) when it strikes a white surface or Optical Engineering's viewing/photographic accessory. With no test placed in one of the parallel beams, the output beam (i) is uniformly illuminated across the entire aperture (an infinite fringe) indicating both the optical quality of the interferometer and the perfect alignment of the superimposed beams. Significant rotation of one of the glass blocks produces a flickering in the output beam. (This is caused by constructive and destructive interference.) However, once the rotation is stopped, the interferometer is still in perfect alignment with an infinite fringe once more appearing in the output beam. The only alignment concern is positioning the two blocks to obtain use of the full aperture.

For some experiments it is more desirable to have parallel interference fringes across the field rather than an infinite fringe. To obtain parallel fringes with the interferometer it is necessary to insert an optical wedge into one of the beams, preferably at point (f). A wedge which attaches to the interferometer housing at this point is also available.

III COMPONENTS

This section describes the components which are present in the Model 18-A Benchtop Interferometer and the Model 18-K Interferometer Kit.

(A) Benchtop Interferometer

The basic Benchtop Interferometer consists of two units. These units were manufactured together so that they are optically matched to each other. For this reason one should never attempt to interchange one of two Benchtop Interferometer units with a unit from a different set. Serial numbers are stamped on the base to identify each pair.

The glass in the Benchtop Interferometer has been specially mounted to minimize the effects of temperature variations. Under normal operating conditions one need not be concerned with temperature effects except perhaps to avoid handling the components in a way which would produce large temperature gradients in the glass.

The holders for the Benchtop Interferometer are adjustable in height. Two set screws are used to lock the height of the unit. An Allen head wrench is also provided for adjustment of the set screws. It is possible to tighten these Allen head set screws with just enough pressure so that a height adjustment can be made while still maintaining sufficient friction to hold a desired elevation during rapid set ups. Another Allen head adjustment screw is provided in the base of the unit and also serves as one of the three feet of the unit. This adjustment is used primarily as an angular adjustment to correct for vertical angular misalignment. Normally one would not need to make an adjustment with this screw.

Care should be taken in handling the Benchtop Interferometer to avoid touching the surfaces. When cleaning is necessary, the surfaces should be cleaned following the instructions on cleaning in Section V of this Manual.

(B) Beam Expanding Telescope (Model 18-K)

The Beam Expanding Telescope contained in the kit consists of two lenses. The larger of the two lenses referred to as the collimating lens, is mounted in a special holder so that it can slip over the input aperture of the Benchtop Interferometer. A black line is provided on this metal fixture to help align this lens. When the lens is properly positioned the black line on the lens holder should be positioned so that it appears to be a continuation of the single black line painted on the top of the Benchtop Interferometer housing. The second lens referred to as the expanding lens, is a small short focal length lens mounted in a brass housing. This expanding lens should be adjusted to the proper heighth and then positioned near the helium neon laser so that light passing through it will diverge until it is collimated by the large lens attached to the Interferometer case.

(C) Optical Reference Wedge (Model 18-K)

This wedge is used when it is desired to have parallel interference fringes across the field of view. The actual angle in this wedge is quite shallow but it is sufficient to deviate one of the beams relative to the other so that about 10 uniform, straight fringes are produced across the 1" aperture. The wedge is mounted in a metal housing which slips on to the Interferometer housing. This wedge should be positioned in front of one of the input apertures of the rear component. When the wedge is properly placed into the beam in the Benchtop Interferometer the thinest part of the wedge is up (i.e. closest to the side of the housing with the black line on it).

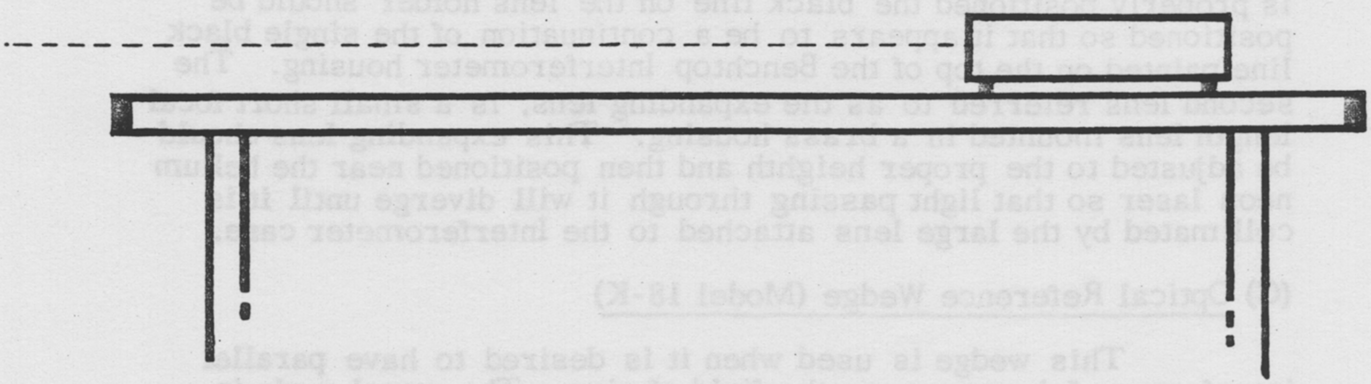
(D) Viewing/Photographic Accessory, (Model 18-K)

This accessory is provided to assure brilliant photographs or vivid experiment displays even when competing against bright background illumination. The black metal structure provides a narrow field of view for the special frosted glass screen. When positioning this unit the long metal structure should point towards the laser and the viewing screen should be closest to the viewer. This screen provides narrow angle forward scatter so that the image appears very bright when one views the image looking down the direction of the laser beam. However, the intensity of this image falls off very rapidly when one moves off to the side of the screen or attempts to view the image from the opposite side of the frosted screen.

IV SETTING UP THE BENCHTOP INTERFEROMETER

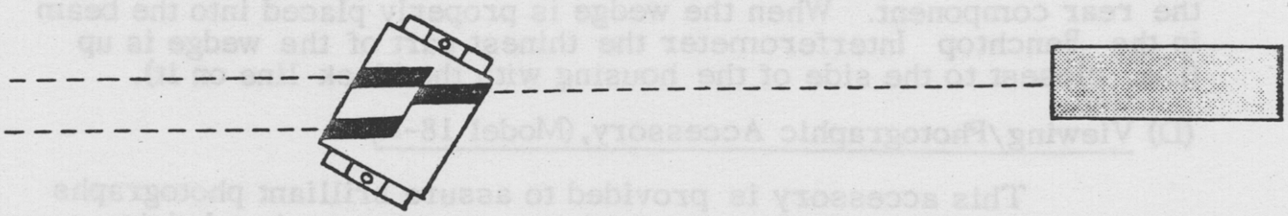
(A) Setup Requirements

Before giving detailed instructions on the set-up of the Benchtop Interferometer it is best to give a brief statement of the overall requirements. First of all, for normal applications the Benchtop Interferometer requires a parallel beam of light. An imperfectly collimated light can produce distortions which appear to be imperfections in the optical quality of the Interferometer or in the parts being tested. The collimated light must pass through the two components of the Interferometer to obtain the optical path shown in Figure 1. Black lines have been drawn on the metal cases to help with the positioning of these parts. The angles and seperations of these lines indicate the projected optical paths and therefore should be used as guides in the set-up. It is also desirable to position the two components of the Benchtop Interferometer so that they are parallel to each other. The interference pattern is observed by allowing the recombined beam to strike a white card or the Viewing/Photographic Accessory. Parts to be tested are inserted into one of the two parallel beams shown in Figure #1.



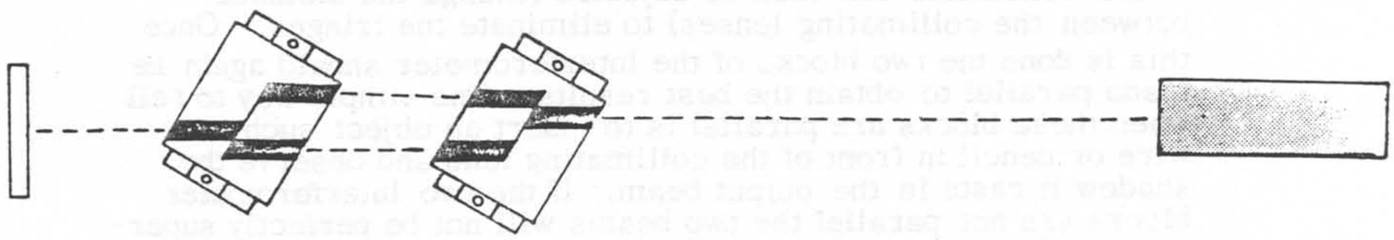
(B) Setup Procedure

(1) Set-up the helium neon laser as shown so that the beam is parallel to the table top.

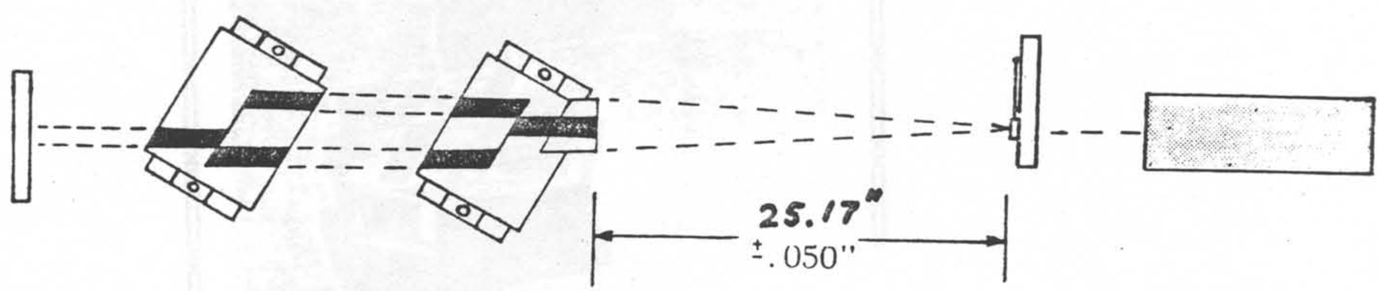


(2) One of the Benchtop Interferometer units should be placed on the table at a distance no closer than 27" from the laser and preferably about 35" from the laser. The height of the glass block should be adjusted so that the center of this block is at the same elevation as the unexpanded helium neon laser beam. The unit should then be positioned so that the single black line points towards the helium neon laser and the double black lines point away from the helium neon laser.

With proper positioning the unexpanded helium neon laser will enter the center of the clear aperture on the glass block and emerge as two beams from the backside of the block.



(3) Position the second unit of the Benchtop Interferometer as shown. If this unit is not parallel to the first, two beams will emerge from the exit aperture of this unit. Rotate the second unit to superimpose the two emerging beams. If there is a vertical seperation between these two beams it may be necessary to adjust the set screw in the base of the unit to bring the two beams together. Then adjust the sideways position of this unit so that the beam emerging from the back of the unit is centered in the exit aperture.



(4) If the user is supplying his own collimating optics, insert the beam expanding telescope into the system. If one is using the optics supplied with Model 18-K then slide the collimating lens into place over the front of the input aperture as shown. The lens should be oriented so that it is within 3^{o} of being perpendicular to the laser beam. This can be quickly checked by observing the light reflected off the surface of the lens and directing this light back towards the laser. Next slide the beam expanding lens into place. Adjust the height and position of this lens so that the laser beam passes through the small hole in the brass mount. The seperation between the collimating lens and the expanding lens should be **25.17"** when measured as shown in the above drawing. Make fine adjustments in the position of the lens so that the diverging beam strikes the collimating lens. Following these instructions a uniform fringe should be produced in the output beam.

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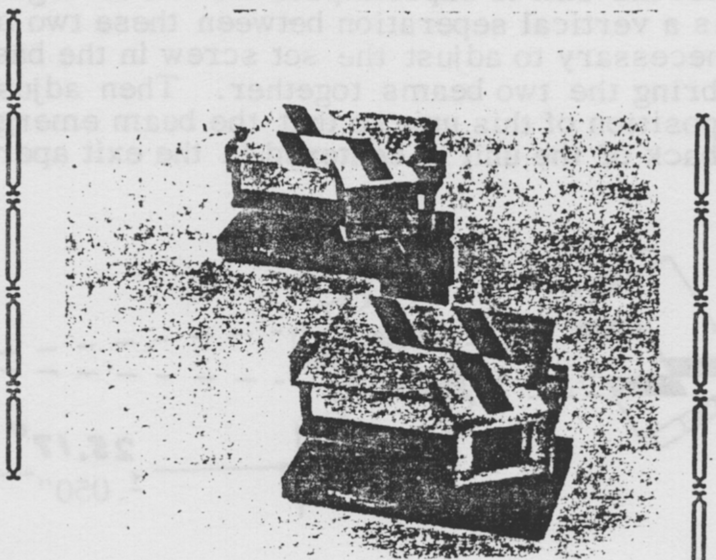
(C) Checking Beam Collimation

It is possible to use the Benchtop Interferometer to check the collimation of the input beam. To do this, the second unit of the Benchtop Interferometer should be positioned so that it is not parallel with the first unit but is about 3° off parallel. This can be done by sliding one end off the base plate about 1/4" from the parallel position. If the light source is not perfectly collimated this will produce vertical fringes in the output beam. The focus of the collimator can then be adjusted (change the distance between the collimating lenses) to eliminate the fringes. Once this is done the two blocks of the Interferometer should again be made parallel to obtain the best results. One simple way to tell when these blocks are parallel is to insert an object such as a wire or pencil in front of the collimating lens and observe the shadow it casts in the output beam. If the two Interferometer blocks are not parallel the two beams will not be perfectly superimposed and this will cause the shadow to have a double image. As the Interferometer blocks are rotated parallel the two shadows will be superimposed. Check to be sure that the sideways and verticle positioning of the glass elements allows full use of the aperture.



(D) Reference Fringes

If it is desired to have parallel fringes across the aperture instead of an infinite fringe there are two ways of producing these fringes. First of all, it is possible to insert the optical wedge into one of the two beams. It is best to place this wedge on the second Interferometer block as shown in the above photograph. Another way of producing these fringes is to purposely use non-parallel light and rotate one of the Interferometer blocks to produce any fringe spacing desired. When this approach is used seperation between the two lenses of the collimating attachment should be approximately 23". This mehtod of producing parallel fringes can only be used when testing objects less than 1/8" thick or such things as heated air. Objects such as thick pieces of glass introduce a large enough optical pathlength difference between the two beams that it is necessary to use parallel light to avoid obtaining misleading results.

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(E) Differential Interferometry

At times it is desirable to compare the optical quality of one optical component to another and display only the variations between these two components. To obtain this result, the two components to be compared are each inserted into one of the parallel beams. This technique is very useful in examining objects such as large windows which may contain a uniform wedge which introduces deviation but no distortion. When the window is placed between the Interferometer blocks so that the two parallel beams pass through different areas of the window, the wedge angle in the window is subtracted out and only the distortion between the two areas is displayed. Objects such as lenses can also be compared but these require a more elaborate set-up. With lenses it is necessary to position each lens so that the optical centers of the lenses are superimposed in the recombined beam. Small translational changes from this perfect superposition can introduce so many fringes that it is impossible to see anything. Therefore an XYZ translating table would be required for such differential experiments. Besides this critical transverse positioning of the lenses it is also necessary to position the lenses so that they will come to a focus at the same distance from the partial reflecting surface in the second interferometer block. As seen in Figure 1, the beam which passes through (f) has a longer pathlength before it reaches the partial reflector at (h). Adjusting for the index of refraction of the glass, the lens inserted into the beam which passes through (f) has to be 3.6" closer to point (f) than the seperation between the other lens and point (h). Of course if there is any difference in the focal lengths between the two lenses, the appropriate adjustments for this variation must also be made.

V TESTING MIRRORS

When testing mirrors with the Benchtop Interferometer the alignment insensitivity of the instrument has been lost. For mirrors one needs to use only one of the Benchtop Interferometer units. The two beams which emerge from the single unit must each strike a mirror. One of the mirrors being the reference mirror and the other the mirror which is being tested. The reflected light from each of the mirrors is directed back into the Interferometer unit where it is superimposed on surface (d) in the Figure 1. Each mirror must be mounted in a precision mirror mount to obtain the fine angular adjustments required. One can superimpose the two reflected beams by observing the light which is directed back towards the laser after passing through lens C in Figure 1. At point (b) in Figure 1 these two beams will be brought to a focus. Adjusting the angles of the mirrors to superimpose these two focal points will produce a visible interference fringe pattern on the beam which emerges from point (d).

VI CLEANING

Care should be taken to avoid fingerprints on any of the optical surfaces of the Benchtop Interferometer. However, if the surfaces do need to be cleaned it is best to use a paper tissue moistened with acetone. Care should be taken to avoid getting acetone on any of the painted surfaces. Also, acetone should never be used in cleaning the optical wedge. Instead this wedge can be cleaned sufficiently merely by rubbing the surfaces with a dry paper tissue.

VII WARRANTY

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