BECK INTERFEROMETER MANUAL
(FOR MICHELSON INTERFEROMETER EXPERIMENT)

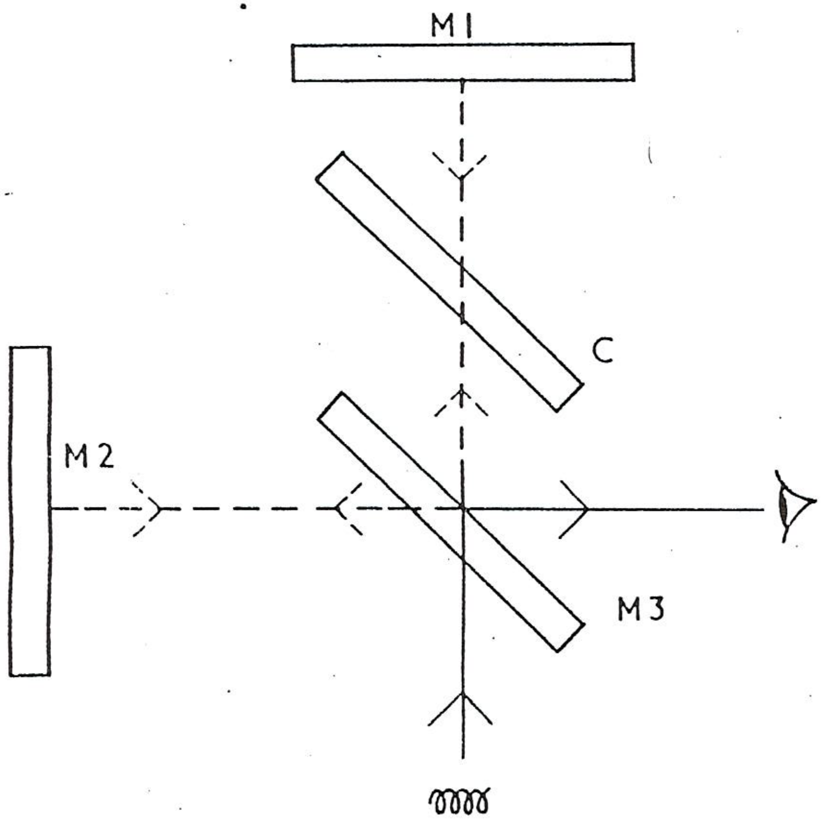

Fig. 1

INTRODUCTION

The applications of interference methods in pure and applied physics are numerous. - The Beck Interferometer is designed to facilitate two of the better-known methods, Michelson and Fabry-Perot, by the student or technician simply fitting standard units to the same base. This handbook describes how the interferometer units are fitted and how adjustments are made to obtain the various interference fringes.

Many applications will occur to the reader once the possibilities of the interferometer are realized, and for this reason stress has been laid on the purely functional aspects of the instrument.

The function of the Michelson interferometer is to divide a beam of light into two parts at a semi-reflecting plate and recombine them at the same surface. Figure 1 opposite explains this in diagram.

The mirror M1 has tilt adjustments for rendering its image, which is reflected in the semi-reflecting plate M 3, parallel to mirror M2. The path length from M2 to M3 is controlled by sensitive micrometer adjustment. The compensating plate C, is situated between M1 and M3 in order that the divided beams of light have equivalent glass paths.

The Michelson interferometer obtains interference effects by means of two coherent reflected beams, but the Fabry-Perot interferometer employs multiple reflection between two parallel mirror surfaces which are themselves partly transparent. The multiple reflections produce a distinctive interference pattern composed of bright circular fringes on a dark field. As with the Michelson interferometer, one mirror can be traversed by micrometer adjustment and the other mirror tilted.

The construction of the Interferometer base permits conversion to be made to the alternative interferometry method. For example, you may have a Michelson assembly and wish to perform Fabry-Perot interferometry. The 6292 Fabry-Perot conversion unit allows you to do so. Conversely, a Fabry-Perot assembly can be made into a Michelson with the 6291 conversion units.

The illumination requirements of both interference methods are fulfilled by the 6281 Twin lamp unit which incorporates tungsten and mercury-vapour sources. The output of these lamps is adequate for most applications.

A gas cell (6290) and accessories are available for facilitating the measurement of the refractive indices of gases by Michelson methods.

We believe that if the instructions in this handbook are followed you will obtain excellent results and share our contention that the Beck Interferometer is indeed a first-class instrument.

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

ASSEMBLY INSTRUCTIONS

Interferometer, Conversion Units and Accessories:

6280	Beck Interferometer. Base with Michelson units.
6292	Fabry-Perot conversion unit.
6285	Beck Interferometer. Base with Fabry-Perot units.
6291	Michelson conversion units.
6293	Telescope, with mounting bracket and collecting lens.
6281	Twin lamp and control unit 240 v.
6281A	Twin lamp and control unit 110 v.
6290	Gas cell for Michelson assembly.
6288	Vacuum pump (for use with 6290).
6289	Manometer (for use with 6290).
6294	Needle Valve (for use with 6290).

The Interferometer Base:

The interferometer can be mounted in three positions, each being suitable for Michelson or Fabry-Perot interferometry.

1. Flat on a table-top, for providing a horizontal viewing position.

2. Inclined on a table-top. The instrument is supplied with two legs of equal length and one short leg which screw into sockets underneath the base. The legs must be screwed tightly into the sockets, the long legs nearest the viewing position and the short leg at the opposite end. The legs splay outwards to provide extra stability for the instrument. Inclined viewing is generally more comfortable when the interferometer is being used at normal table-heights.

3. On an optical bench. The interferometer is easily adapted to the Beck Triangular and Precision Lathe Bed optical benches, this being the position usually preferred for Fabry-Perot interferometry.

Underneath the base and in the meridian of the viewing axis are two sockets which accept legs. The legs serve as pins which locate into optical bench accessory carriers and ensure the viewing axis of the interferometer coincides with the axis of the optical bench. If a long leg and a short leg are used, the remaining long leg can be used for mounting the twin lamp unit onto another accessory carrier for bringing the lamp window to the same height as the interferometer entrance aperture.

The interferometer can be used in Michelson form on an optical bench. The instrument is mounted as previously described, but certain interferometer units must be specially arranged (page 7).

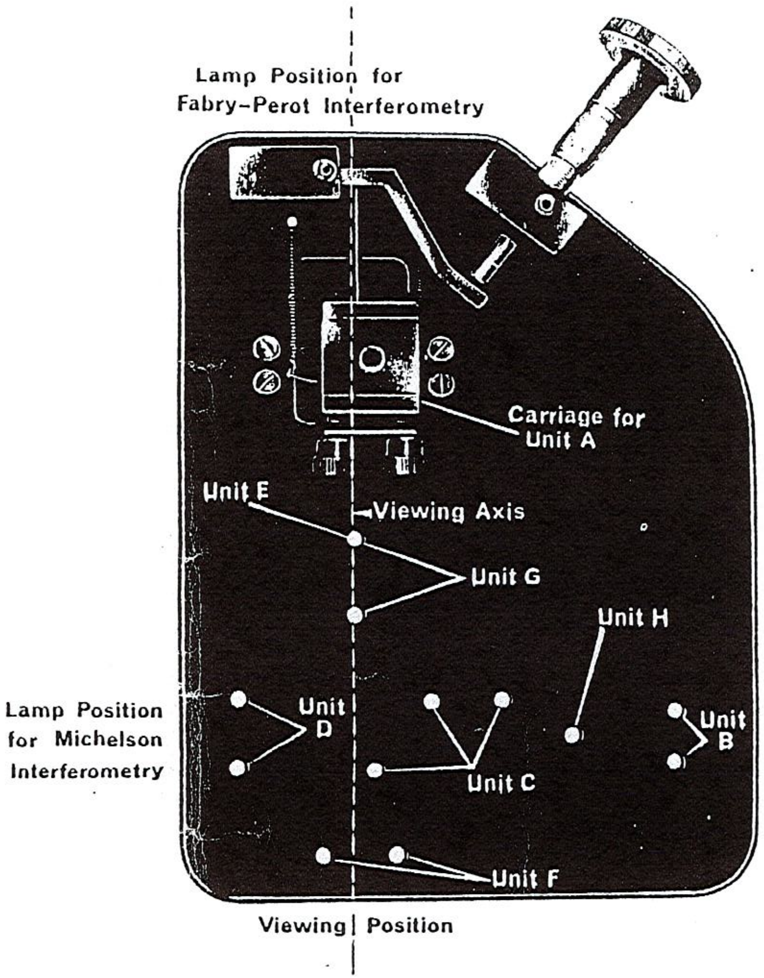

Fig. 2

An incorporated feature of the base is the mirror carrier which can be traversed along the viewing axis by means of a micrometer control actuating a pivoted beam coupled to the carrier. The beam provides a 5 : 1 reduction. The micrometer has 25 millimetres movement and vernier graduations for reading .01 millimetre. It can be removed from its mounting to make provision for alternative devices, thereby facilitating further applications of the instrument.

When assembled and adjusted for use, the interferometer can be accurately calibrated by counting the number of fringes of a specific wavelength that occur in the field of view over a distance determined by two micrometer settings. A mercury green filter which isolates a wavelength 546.0742 millimicrons in the mercury spectrum is recommended for this purpose.

The base accommodates the various interferometer units in the positions indicated in Figure 2 opposite.

Interferometer Units:

Caution - When removing the units from their polythene wrappings, care must be taken not to place the fingers on the aluminised mirror surfaces.

Unit A - This unit is used in Michelson and Fabry-Perot assemblies and is attached to the carrier by two large milled-head screws. The aluminium coated face of the mirror must be towards the viewing position. For Fabry-Perot operations the mirror is arranged to project above the carrier. For Michelson requirements the mirror is arranged in the lower position (i.e. below the milled-head screws).

Unit B - is a Michelson component and is fitted to the base by passing two bolts through the appropriate holes in the base and screwing them tightly into the unit.

The mirror can be tilted by the two controls at the back of the unit.

Unit C - This is the Michelson beam-dividing head. It also incorporates the compensating plate. Pass the three bolts attached to the unit through the relative holes in the base and secure by the nuts and washers underneath.

Unit D - comprises two clips for retaining a diffusing screen or filter and is intended for use with the light source when it is applied to Michelson interferometry. Pass the two bolts through the unit into the base and fix firmly by nuts and washers underneath.

Unit E - The Fabry-Perot etalon. This unit consists of a mirror on a bracket incorporating controls for tilting the mirror.

Before installation, adjust the mirror by means of the tilt controls until it is approximately vertical to the base of the unit. The carrier that accommodates unit A must then be traversed backwards to its fullest extent by means of the path-length control. Pass the bolt on the unit through the correct hole, ensuring that the aluminium coated face of the mirror is towards unit A. Rotate the unit slightly until the mirror is approximately parallel to the mirror on unit A.

Unit E is then clamped tightly by means of a nut underneath the base.

Unit F - The telescope is primarily intended for Fabry-Perot applications, but is also a useful accessory for the Michelson interferometer. The telescope stand has two apertures. The top aperture is for Fabry-Perot use and the bottom for Michelson. It is fixed to the base by passing the two bolts attached to the unit through the holes in the base, and screwing-on the nuts underneath.

The collector lens, which is specifically intended for Fabry-Perot use, is fitted into the aperture at the back of unit A.

Units G and H - Unit G, the Michelson gas cell, has connection points for a pump, a manometer and a gas cylinder. Two bolts permit the unit to be attached to the base. The glass windows on the cell require compensation, therefore Unit H, which is supplied with the cell, must be included in the optical train in the position indicated in Figure 2.

ARRANGING MICHELSON INTERFEROMETER UNITS FOR OPTICAL BENCH MOUNTING.

When using the interferometer in its Michelson form on an optical bench, the viewing position is changed to the position normally occupied by unit D and the light source.

Under these conditions, unit D is fitted to the holes specified for the telescope stand, (unit F).

Unit F can be installed in the position normally allotted to unit D.

When the instrument is mounted, the viewing position is disposed 90° to the optical bench axis, and the twin-lamp unit aligned to the optical bench axis and unit D.

Illumination.

The 6281 twin lamp and control unit will meet the requirements of Michelson or Fabry-Perot interference methods irrespective of the position chosen for mounting the instrument.

The unit comprises a 4 watt low-pressure mercury-vapour lamp and a 6.3 volt 0.3 amp tungsten lamp. Control apparatus and switches for the lamps are incorporated with the unit.

It is necessary at all times to ensure the lamp is in good alignment with the entrance apertures of the interferometer assemblies. In the case of the Fabry-Perot units, this will be in the meridian of the viewing axis and in the Michelson assembly at 90° to the viewing axis, aligned to the beam-dividing unit.

The lamp unit will require raising from the table if the instrument is used in the inclined position for Michelson interferometry or if the instrument is placed flat on the table for Fabry-Perot. Generally, a block of wood of suitable thickness will be satisfactory for doing this, but there is scope for considerable improvisation.

If the instrument is mounted in the inclined position for Fabry-Perot interferometry, the lamp should be placed about ten inches from the instrument. If then, the lamp is tilted slightly to render the front of the lamp approximately parallel to the mirror units, the illumination will be further improved.

For other combinations of instrument position and interference method, the lamp should be placed about four inches from the entrance aperture of the interferometer.

The lamp unit may be mounted on the Beck Triangular and Lathe-bed optical benches, by utilising one of the long legs supplied with the instrument as a saddle-pin. The pin is screwed into the boss underneath the unit and located into one of the various carriers used on the optical benches.

The spring-clips on the front of the unit can be used to retain filters.

HOW TO OBTAIN INTERFERENCE FRINGES

The Michelson Interferometer

Initial Adjustment

The interferometer is assembled in accordance with the preceding instructions and the twin-lamp unit suitably placed.

Switch-on the mercury lamp and clip the metal pointer onto the diffusing screen so that it coincides with the 12 o'clock position.

Align the eye with the viewing axis about ten inches from the instrument. Three reflected images of the pointer will then be visible in the beam-dividing head (fig.3).

Slight adjustment of the tilt controls on unit B will indicate which of these images can be moved. The initial adjustment technique consists of superimposing this image on the right-hand image of the stationary pair of images (fig.4).

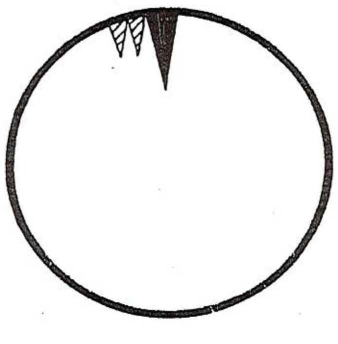

Fig. 3

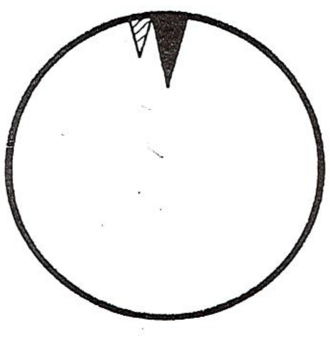

Fig. 4

The tilt-controls must be adjusted carefully to produce exact vertical and horizontal coincidence of the two images, and when this has been accomplished interference fringes will be visible.

The shape and location of the interference fringes are determined by the disposition of the mirrors to each other as seen in the beam-dividing head. It follows that specific fringe patterns occur at focal positions ranging from infinity to the surfaces of the mirrors.

Unequal Path Lengths, non-parallel mirrors.

This condition produces hyperbolic fringes. The fringes are composed of sections of circles surrounding a centre which is displaced from the field of view.

Unequal Path Lengths, parallel mirrors.

By making careful adjustments to the tilt controls, the mirrors can be made exactly parallel to each other. This will produce a pattern of completely circular fringes with a centre visible in the field of view. If there is very little difference in the path lengths, few fringes will be present.

Circular fringes are sited at infinity, and some practice in adapting the eye to view the fringes as if looking at a distant object may be necessary.

Figure 5 is an interferogram depicting circular fringes.

Equal Path Lengths, parallel mirrors.

If the path lengths from the mirror to the beam-dividing mirror are equal within ± 5 fringes it is possible to detect interference fringes by means of the tungsten light source, (white light fringes).

The circular fringes that result from unequal path lengths have an order of interference that decreases from the centre outwards (fig.5).

To obtain zero path difference, keep the mercury vapour lamp on and turn the path length control in whichever direction causes the circular fringes to move inwards to the centre of the fringe pattern.

As the path length difference is decreased, the circular pattern will contract so much that only a single fringe will be visible.

The tilt controls are then adjusted to produce about ten vertical hyperbolic fringes across the field. Turn the path length control until the fringes are straight (fig.6).

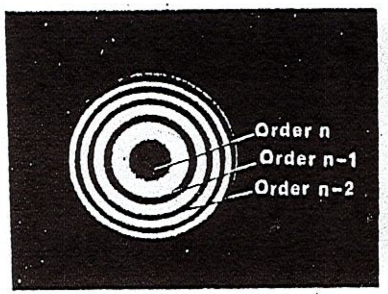

Fig. 5

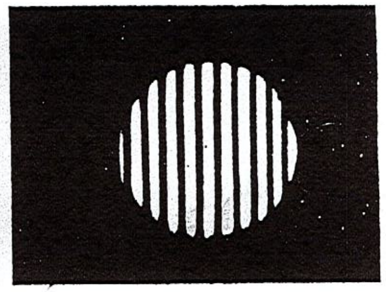

Fig. 6

Switch the tungsten lamp on and continue turning the path length control very slowly until a group of bright fringes with a distinctive dark band in the middle appears in the field.

Bring the dark band to the centre of the field and switch the mercury lamp off. The fringes will remain visible.

Extremely small adjustments to the tilt controls will cause a single fringe to completely fill the interferometer field. As this condition is approached the selected fringe may tend to pass out of the field, and so the path-length control must be adjusted to effect its re-entry.

The optimum interference condition is a totally black field, but atmospheric inhomogeneties and the extremely small deviations from flatness that prevail in the mirrors usually prevent this. However, efforts to perfect the technique are well-rewarded and good results will soon be obtained easily and reliably.

The Fabry-Perot Interferometer

Assemble the interferometer in accordance with the instructions and place the twin-lamp unit in the appropriate position.

If available, fit the collector lens to unit A, but do not place the telescope in position.

Align the eye with the viewing axis about ten inches from the instrument and place the pointer between the lamp and the entrance aperture of the interferometer so that it appears in the field of view as shown in figure 7. The pointer must be held about four inches from the collecting lens. If the lamp is sufficiently close to the interferometer or if a collecting lens is not used, the pointer may be attached to the lamp-unit by means of the filter clips.

Adjustment entails making the mirror surfaces parallel to each other. This is achieved by adjusting the tilt controls on unit E until the reflections that are seen are exactly coincident with the pointer.

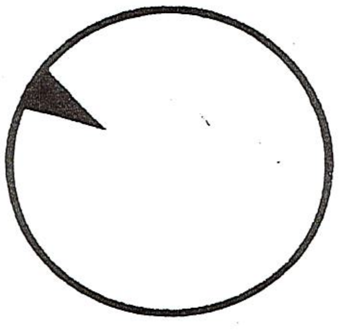

Fig. 7

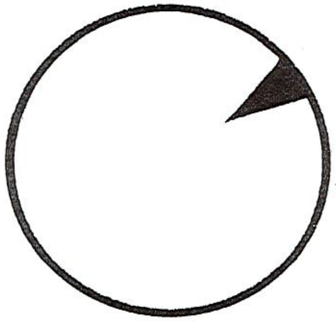

Fig. 8

The pointer is then placed in the position shown in figure 8 and the procedure repeated.

Fabry-Perot interference fringes are located at infinity and are visible if the plates are sufficiently parallel, and the focus of the eye is allowed to drift as if viewing a distant object.

The telescope, which must be focused to infinity, can now be introduced and the fringes examined more closely.

The detection of Fabry-Perot interference fringes depends on adapting the eye to view the mirrors as if they were set at infinity. Some conscious effort may be required at first in accomplishing this, but persistence will soon bring success.

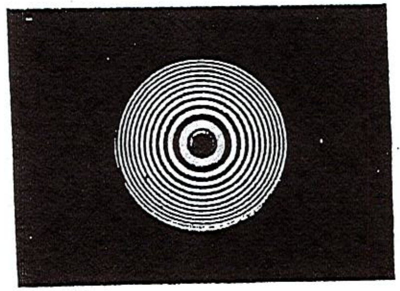

Fig. 9

Figure 9 is an interferogram showing Fabry-Perot fringes as seen with a mercury-green filter.

Care of the Interferometer

The mechanical construction of the interferometer is such that it does not require any specific maintenance.

However, the aluminized mirrors on units A, B and C are prone to damage, so care must be exercised when cleaning the surfaces of the mirrors. The mirrors should not be touched with the fingers or needlessly exposed to damp atmospheric conditions.

A dry No.6 Squirrel-hair brush is useful for removing dust from the mirrors but, whenever possible, their serviceability can be prolonged by