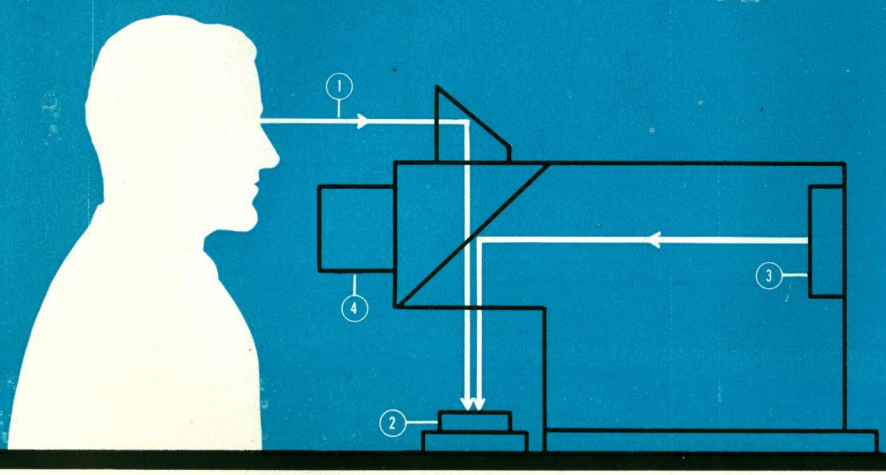
the OPTRON interference viewer

PATENT APPLIED FOR
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The OPTRON interference viewer



1. The user sits comfortably while observing a clear, undistorted image of the patterns.

2. The test pieces are illuminated and viewed on a line perpendicular to the surface. Errors from angular distortion are eliminated.

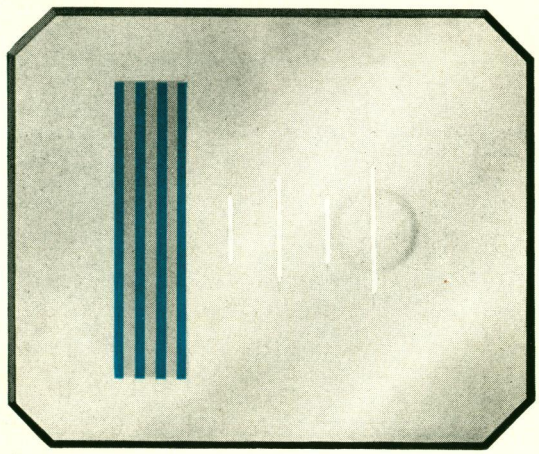
3. The monochromatic (one-color) light source is concealed, hidden from the observer, reducing eye-strain and eliminating confusion.

4. Any convenient scale can be superimposed on the pattern, permitting direct measurements or comparisons of straightness with definite standards.

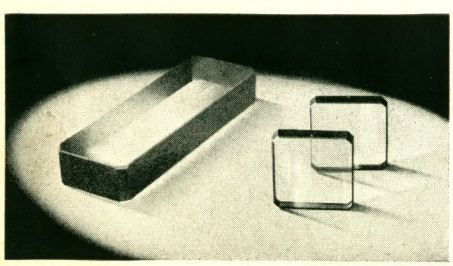
The Optron Viewer is an instrument of unique design which brings greater convenience and uniformity to optical interference measurements. The surface being examined—either for flatness or for size—is both illuminated and viewed on a line perpendicular to the surface.

Hence no errors can be introduced by viewing the surfaces from an angle different from the angle of illumination. A pattern appears the same to different observers, making instruction—or checking by more than one observer—simple and straightforward.

In addition to this basic advantage, the Optron Viewer incorporates two other improvements over conventional devices: First, the observer need not stand to use the Viewer, but can sit comfortably while observing the clear, undistorted image of the interference pattern. Second, he can superimpose a straight line or dimensional scale on the image of the pattern, and make direct comparisons of straightness or direct measurements between bands, without using a ruler or straightedge, without guesswork.



The drawing above shows an example of a scale used to simplify checking a ball diameter against a standard gage block. The scale makes it easy to locate the center of the ball any specified distance from the master block.

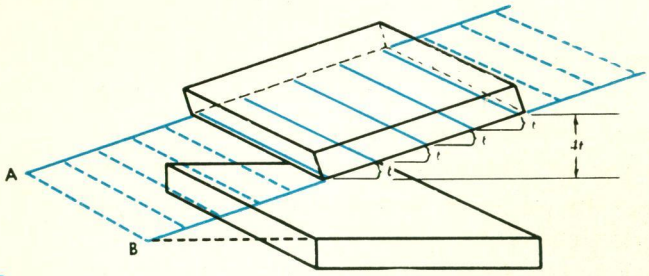


other Optron products

Optical flats, quartz or pyrex, flat within 1/10 wave. Furnished square-shaped, for easy handling, up to 6″ x 6″* or in bars up to 10″ long by 2⅜″ wide. **Plane Parallels,** parallel within ½ second. **Prisms and Mirrors** of all types.

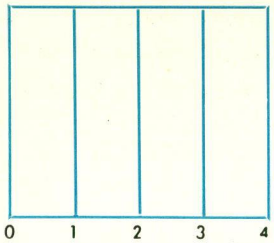
**Tested against a 6″ flat certified by Bureau of Standards to be flat within 1/20 wave.*

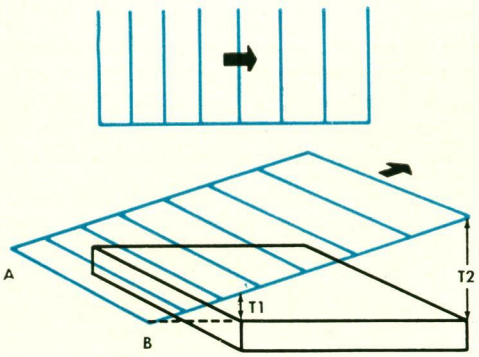
BASIC PRINCIPLES of optical measurements



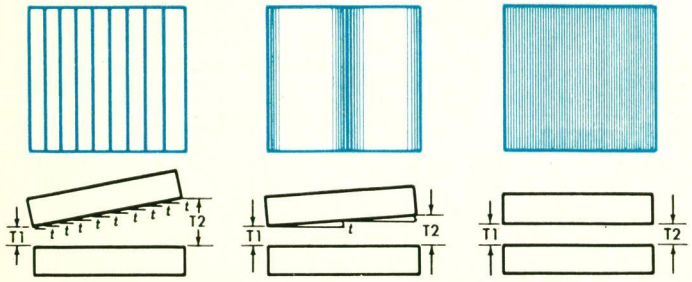
1 Flats form air wedge whose planes intersect at AB.

2 When planes bounding air wedge are flat, interference bands are straight, parallel, and evenly spaced.





3 Bands move to thick end of wedge when top flat is pushed down in the middle.



4 **(a)** Angle large: many bands. **(b)** Angle small: few bands. **(c)** Angle zero: uniform color.

To use optical flats effectively for measuring surface contours and for comparing the size of precision articles with standardized or master gage blocks—it is necessary to understand two basic principles which underlie the formation of so-called interference patterns. These principles are best illustrated by the patterns formed by two optical flats. A careful study of the following picture-story of interference patterns—plus some actual practice with the Optron Interference Viewer—will provide all that is needed for the effective use of the Viewer.

The first principle is best shown as follows: If you place the plane surfaces of two optical flats together horizontally, they will generally come to rest with a very thin film of air between them. Because of very small dust particles present, generally one edge of the film will be thicker than the other, giving a wedged shape to the film.

For convenience, let us assume that these two planes (shown in figure 1) intersect at line AB, and that this line is parallel to the left-hand edge of the optical flats. When you observe these flats with the Optron Viewer, you will see a number of equally spaced bands crossing the flats. (See figure 2.) *These bands are thickness contours of the air wedge formed between the two flats.* The contour interval or the *change in thickness* of the air wedge which occurs between any two adjacent bands (t) is equal to one-half the wavelength of the light which illuminates the flats. (The light used in the Optron Viewer has a wavelength of 21.6 millionths of an inch. Hence (t) the *change in film thickness* is 10.8 millionths.) The bands are parallel to the line of intersection AB, and are equally spaced. (See figure 2.)

Now, since each band represents a thickness change of 10.8 millionths, you can readily figure the *thickness change* from one edge of the flat to the other by counting the number of bands, starting with the left-most band as "zero." It is somewhat like walking up a flight of stairs: you start on band "zero," and each step you take represents a *change* of 10.8 millionths. In figure 2, for instance, from left to right, you would count *four* bands, and would then know that the air film changed in thickness by four times 10.8 millionths, or about 43 millionths of an inch.

We have assumed that the two planes in figure 1 intersected on the left-hand side of the flat. However, it is quite obvious that the same pattern could have been formed if these planes had intersected at the right. How do we determine which is the thickest part of the air film? To do this, let us see what happens to the pattern if we reduce the thickness of the air film uniformly by pressing on the center of the topmost flat.

As we press on the flat in this fashion, we cause the line of intersection to move toward the flats, and in so doing we cause the entire pattern of bands to move in the same direction: namely, toward the thickest portion of the air wedge. Let's try it: If the bands move toward the right, as in figure 3, then the thickest part of the film is at the right. Remember this: *When the film thickness is reduced uniformly the bands always move toward the thickest part of the air film.*

Note also that if we lift up gently on the top flat so as to steepen the angle of the air wedge, as in figure 4, more bands become visible. This is because the difference in film thickness between one side and the other has been increased. If we press in such a way that the angle of the wedge is made smaller, the number of bands decrease, and finally, when the angle is zero, one band will widen out until it spreads uniformly over the entire surface of the flats.

summary

If the plane surface of an optical flat is placed on the plane surface of another, and viewed from above with monochromatic (one-colored) light, straight, parallel and equally spaced bands are visible. These bands are parallel to the intersection of the two planes which bound the air wedge. Between any two adjacent bands, the air film changes in thickness by 10.8 millionths of an inch. The greater the angle between the planes, the more bands are visible. The thickest side of the wedge can be found by pressing down on the middle of the top flat, causing the entire pattern to move toward the thickest side.

how to identify deviations from flatness

In examining a surface which deviates from flatness by placing an optical flat above it, the bands you observe will be curved, out of parallel, or unevenly spaced. You will also observe that by manipulating the top flat to change the wedge angle or thickness, many different patterns can be obtained.

No matter how the patterns for any one surface may change—and no matter how irregular the patterns appear—you can always rely on the two principles we have stressed:

1. ***Between any two adjacent bands, the air film changes in thickness by one-half the wavelength of the light, or 10.8 millionths of an inch.***

2. ***When the film thickness is reduced uniformly, the bands always move toward the thickest part of the film.***

With these facts in mind, let us examine some typical band patterns, and determine the shape of the surfaces. To do this, place an optical flat on the unknown surface and observe the patterns.

5 If the pattern looks like this with bands forming parts of concentric circles . . .

(See note below)



6 And by manipulating the top flat, the pattern can be made to appear like this—the surface is spherical, and is either convex or concave.



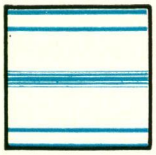
7 If, when you press on the middle of the top flat, the bands move outward—the film is thickest at the outer edges, and hence the surface is convex.



8 If on the other hand, the bands move inward toward the center when you press in the middle, the film is thickest at the center, and the surface is concave.



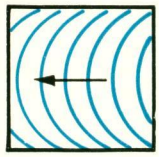
9 If the pattern looks like this, with the bands straight but not spaced evenly . . .



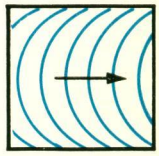
10 And by manipulating the top flat the pattern can be changed to look like this—then the surface is cylindrical and is either convex or concave.



11 If pressure on the middle makes the entire pattern move to the left (in the direction the "bows" would shoot an arrow) the surface is convex.



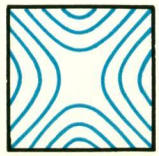
12 If pressure in the middle makes the pattern move to the right, the surface is concave.



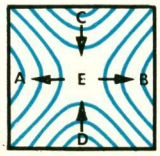
13 If the pattern looks irregular, like this, with curved bands and uneven spacing . . .



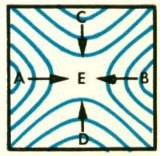
14 And when adjusted for the minimum number of lines, it appears like this — the surface is saddle shaped. Either high at A and B and low at C and D (or vice versa).



15 In this case, when film thickness is reduced uniformly, bands, like water, run "downhill." If pressure in middle makes bands move as shown, C and D are high, E is lower, A and B lowest.



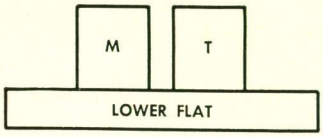
16 If the bands move this way then E is lower than A, B, C, and D, and the surface can be pictured as having depressions running along both diagonals.



Note: *Dotted line connecting ends of one band shows where a straight band would be if the test surface were plane. However, this band* ***departs from straightness*** *by a distance equal to 2 bands. Hence the test surface in figure 5* ***deviates from flatness*** *(along the dotted line) by 2 bands, or 21.6 millionths of an inch.*

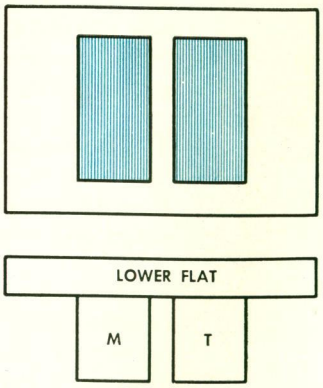
17

Wring master block (M) and test block (T) on flat so that wedge angle is zero.



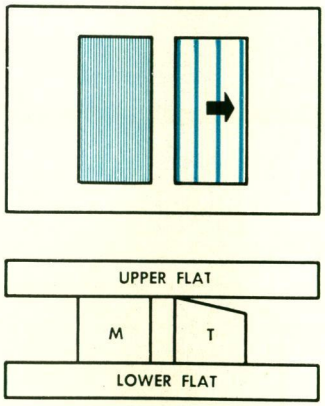
18

When wedge angle is zero, uniform color will show from underside.



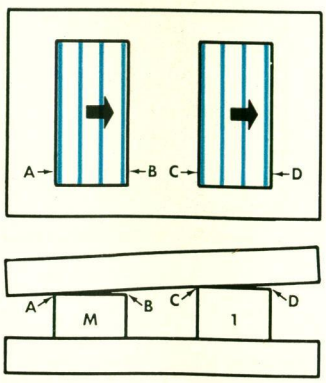
19

Adjust top flat to obtain uniform color on one block. Then number of bands on other block shows deviation in parallelism.



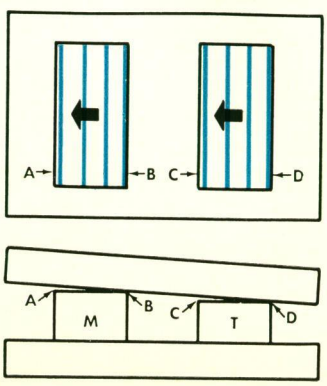
20

Arrows show how bands move. Bands move away from lines of contact. Thus contact is at edges A and C, and (T) is higher than (M).



21

Contact is at edges B and D. So (T) is lower than (M).



how to determine the parallelism of an unknown gage block

Once the flatness or deviation from flatness, of a gage block has been determined (by the methods described on the preceding pages) it is possible to check the "test" block for parallelism by comparison with a master gage block. To do this, wring the master block and the test block on an optical flat. (See figure 17.) Both surfaces must be extremely clean. To make sure the film thickness is uniform for both blocks, examine them through the lower flat to see that patterns of uniform color are obtained. (See figure 18.)

Next, place a second flat above the two blocks, and manipulate it so as to obtain a uniform color on either block. If the wedge angle is made zero on the master block (so that one band spreads uniformly over its surface) then any error in parallelism in the test block is indicated by the number of bands which appear on the test block. The patterns shown in figure 19, for instance, indicate that the test block is out of parallel by three bands (32½ millionths). The bands move away from the high portion of the test block when the top flat is pressed down, reducing film thickness uniformly.

The same results are obtainable by adjusting the top flat to produce uniform color on the test block and observing the bands on the master.

how to determine the size of an unknown gage block

Wring both the master and the test block to a flat, so that their bases will be in the same plane. (It is best to separate the blocks by a distance equal to or twice the width of the master.) Then place a flat above them and wring it down as far as possible on the top surfaces. If a wringing contact is obtained on both blocks, they are equal in height to within one band. If they differ in height by more than one band, a wringing contact will result along one edge of each block or along an edge on the master and a point on the test block. You can determine the location of the lines or point of contact by the fact that the bands move away from them.

In figure 20, for example, bands move as shown by arrows. Hence contact is made along edges A and C and the test block is *higher* than the master.

In figure 21, contact is made along edges B and D. Hence the test block is *lower* than the master.

To measure the difference in height between the master and the high portion of the test block, first count the number of bands on the master. Then determine the distance between the lines of contact *in terms of the width of the master block*. If the lines of contact are separated by *one* block-width, multiply the number of bands by *one*. If they are separated by two block-widths, multiply by *two*, and so forth.

For example, let us assume we have obtained the patterns shown in figure 22, and that the bands have moved as indicated by the arrows. This tells us that there is contact along line B-B′ and at point D′. Hence point D′ is *lower* than line B-B′.

There are 1½ bands on the master, and 2 block-widths between B-B′ and D′. So D′ is 3 bands (32½ millionths) lower than the master.

We can figure the relative heights of the other corners of the test block by counting bands:

Point C′ is 2 bands lower than D′.
Point D is 3½ bands lower than D′.
Point C is 5½ bands lower than D′.

measurements within one-tenth of a band

The method of measuring heights as shown in figures 20, 21 and 22 gives us dimensions to within one band, but is not accurate enough to give us fractions of bands. We have measured in units of *bands*, or 10-millionths; now we want to measure in terms of *tenths of bands*, or one-millionths.

Let's go back to figure 21, which tells us that the test block is shorter than the master, and that the deviation is greater than six bands but less than seven bands. Now let us determine this deviation more precisely.

To do this, wring the master and the test block on the lower flat. The blocks should be side by side for this test. Then place a flat above the blocks (do not wring it down) and manipulate it to obtain an air wedge, with the bands running at right angles to the line of separation between the blocks.

If the bands on the test block do not line up with bands on the master, the amount of shift is a measure of the *fraction of one band* by which the height of the test block differs from the height of the master. (The shift is somewhat like the shadows of a ladder falling on a flight of stairs, as shown in figure 23.)

For example, if we knew from previous tests that the test piece was from six to seven bands *shorter* than the master—the pattern in figure 24a would tell us that the difference is 6.4 bands, or 69 millionths of an inch shorter. The pattern on the master has shifted 4/10 of a band *ahead* of the pattern on the test piece.

Note that we measure from a band on the lower block . . .

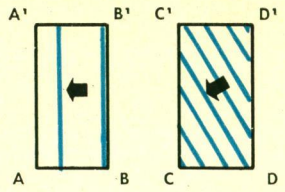
in the direction the bands move when the top flat is pressed in the middle . . .

to the next band on the higher block.

If we knew that the test piece was from two to three bands higher than the master—the pattern shown in figure 24b would tell us that the difference is 2.3 bands, or 25 millionths of an inch higher.

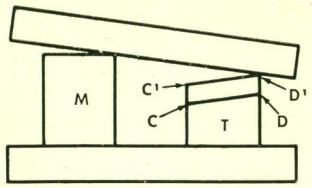
measuring parallelism with Haidinger bands

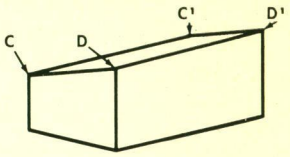
With the Optron Viewer, you can measure the parallelism of two opposite surfaces of a gage block, seal, parallel block, etc., by wringing two optical flats to the piece as shown in figure 25. Look into the Viewer, focussing your eyes as though looking into the distance and you will observe a bull's-eye pattern directly beneath your eye. If there is a deviation in parallelism, lateral movement of the eye toward the thicker side of the air wedge will cause more ring-shaped bands to appear at the center and move outward like waves from a pebble dropped in water. Whenever a band appears or disappears, the thickness of the space has changed by one band, or 10.8 millionths. This method is effective for measuring objects up to ½ inch thick, and will show deviations in parallelism from ½ second to 15 seconds.

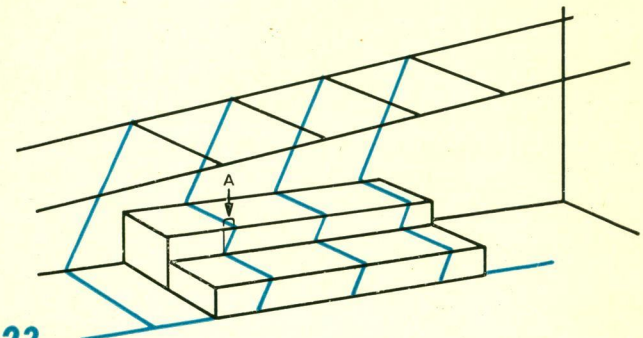


22

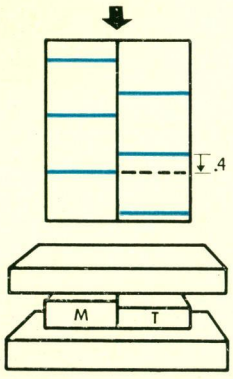
Arrows show how bands move. Contact is at line BB′ and point D′. So (T) is lower than (M), and D′ is high point on (T).

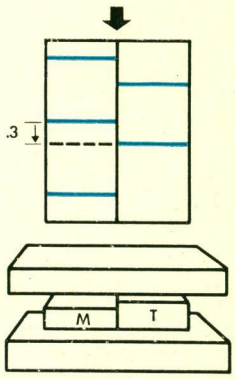






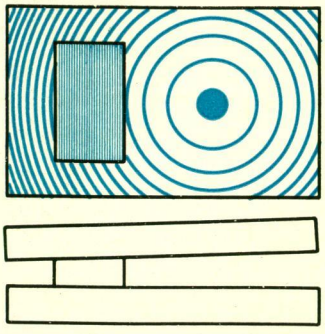
23 Band patterns shift like shadows on stairs. Amount of shift is indicated at A.





24 (a) Bands on (M) have shifted *ahead* of bands on (T). Shift is 4/10 band.

(b) Bands on (T) have shifted *ahead* of bands on (M). Shift is 3/10 band.



25

Optron Viewer permits convenient use of Haidinger bands in measuring deviations in parallelism from ½ to 15 seconds.

OPTRON

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