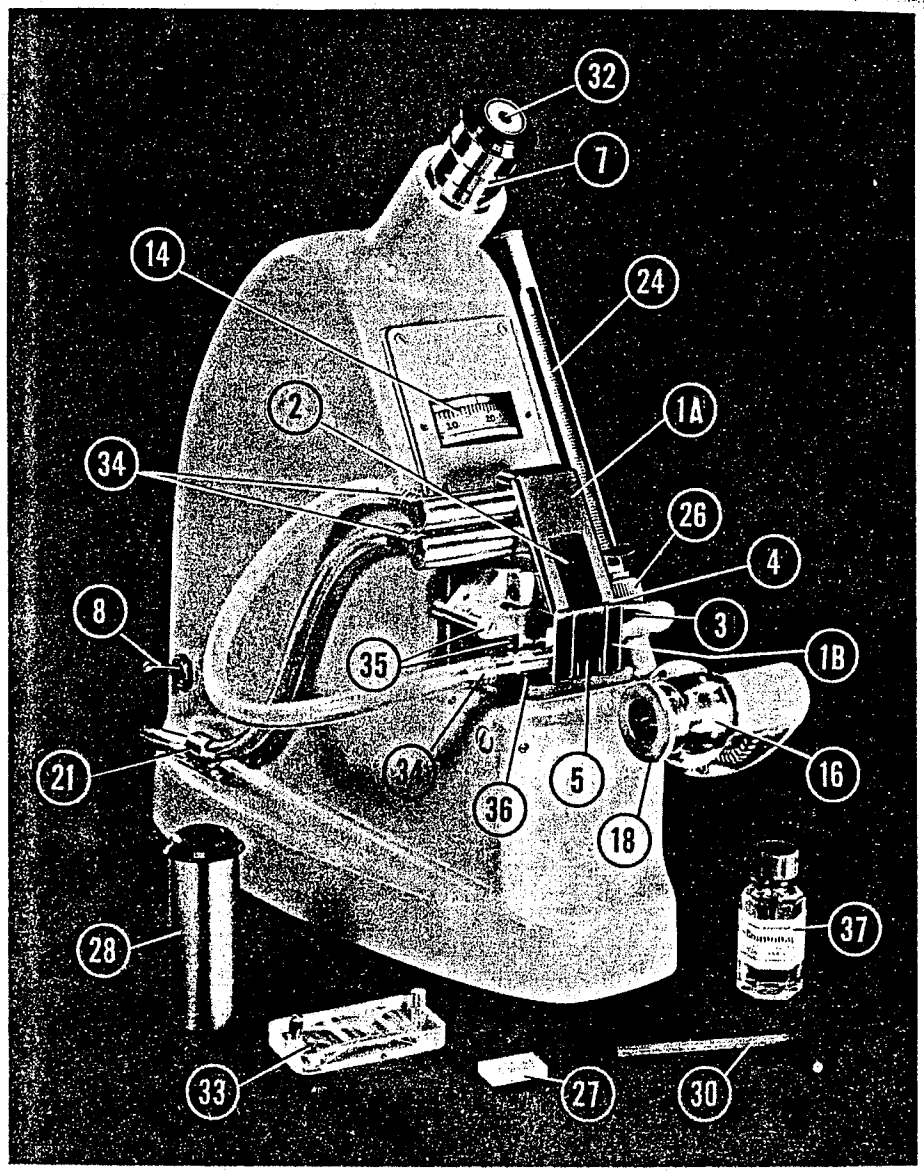


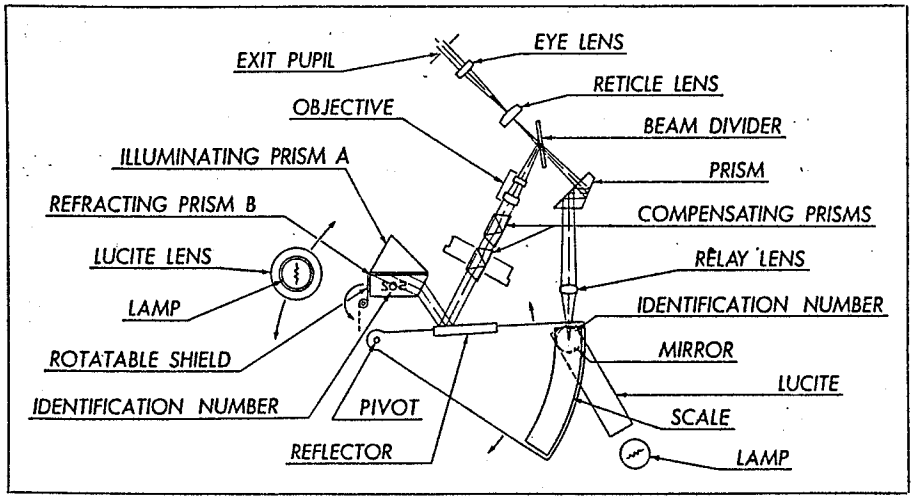
Figure 1

CAUTION

Do not attempt to use this instrument, clean the prisms, or make any adjustments until you have first read this manual completely.

REFRACTOMETER COMPONENTS

1A. Upper prism case
1B. Lower prism case
2. Illuminating prism
2A. Refracting prism
3. Prism housing lever 334558-114
4. Liquid channels
5. Prism shield 334558-164
6. Glass scale plate
7. Eyepiece - Catalog No. 33-45-68
8. Momentary contact switch 533103-598ND
9. Mirror
10. Sector
11. Coarse hand wheel
12. Fine adjustment hand wheel
13. Friction disc drive
14. Compensator Scale dial
15. Field lamp - Catalog No. 33-33-10
16. Toric lens 334558-138
17. Arm 334558-137
18. Shield control 334558-140
19. Transformer 334558-211ND
20. Scale Lamp - Catalog No. 33-33-10
21. Tube Ring 334558-108
22. Trap door
23. Slotted lever
24. Thermometer - Catalog No. 33-45-22
25. Knurled collar 334558-256
26. Thermometer knurled collar 334558-256
27. Test piece - Catalog No. 33-45-85
28. Extra auxiliary eyepiece - Catalog No. 33-45-69
29. Adjustment cover
30. Hex key 211186-295ND
31. Adjusting screw
32. Exit pupil
33. Compensator cover 334558-314
34. Nipples for hose attachment
35. Lower hinge screws
36. Screws
37. 1 Bromonaphthalene - Catalog No. 33-45-81



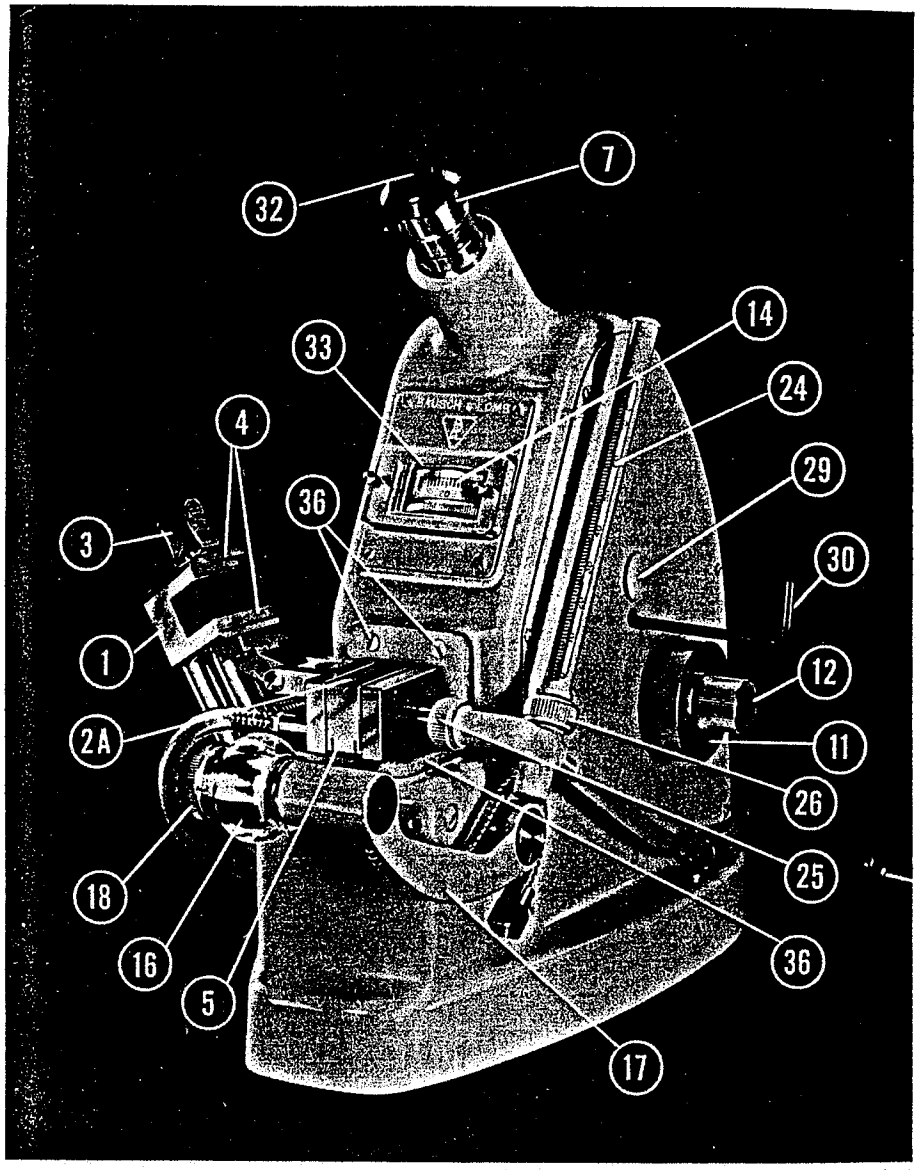


Figure 2

BAUSCH & LOMB
ABBE-3L REFRACTOMETER

Unpacking the Instrument

Prisms and eyepieces are covered with paper, and the whole instrument is protected by a dust cover. Included are the following accessory items.

1. Thermometer with a Metal Guard Tube (2-24)
2. One Hex Socket Screw Key (2-30)
3. Dispensing Bottle with 1-Bromonaphthalene (1-37)
4. Standard Glass Test Piece (2-27)
5. Plastic Cover for Compensator (2-33)
6. Dispersion Tables
7. Reference Manual
8. Plastic Dust Cover

All products of Bausch & Lomb are thoroughly tested and inspected, and carry our unqualified guarantee against defects in material and workmanship.

In the event that this equipment is received in a damaged condition, and the package, box, or crate in which it was shipped shows evidence of rough handling, call in at once a representative of the common carrier responsible and make a claim for damages.

If for any other reason this equipment is found to be damaged, out of adjustment or defective, please advise us promptly. Any legitimate claims arising from defective material or faulty workmanship will receive prompt attention.

Do not make any unnecessary changes in adjustment or take apart optical systems or mechanical assemblies unless you are thoroughly familiar with the construction, and are willing to be responsible for damage or maladjustment which may result.

You can make easy and quick refractometric measurements with your Bausch & Lomb Abbe-3L Refractometer. Here is a rugged and extremely versatile instrument that gives you accurate control and exact determinations. Careful selection of raw materials, highly skilled workmanship, and over 100 year of experience in the optical industry assures you of unending satisfaction with this Bausch & Lomb quality instrument.

For preliminary study of the unit, a sample of distilled water may be used but the operator

SHOULD NOT CLEAN THE PRISMS OR MAKE ANY ADJUSTMENTS UNTIL HE HAS READ THE REFERENCE MANUAL COMPLETELY.

This instrument is designed for use on the 110 or 120 volt AC line, 50 to 60 cycles.

Description of the Instrument

Any instrument of the Abbe type consists essentially of (a) a refracting prism system (b) an appropriate scale, (c) a compensation system consisting of Amici prisms which permit the use of white light, and (d) a telescope with crosshairs which permits the borderline of total reflection to be observed and set precisely. This instrument differs from conventional types in that the refracting prism is fixed and horizontal and that the observing eyepiece is directly above the measuring prism. A pivoted mirror is used to move the total reflection dividing line. The index scale is attached to this moving mirror. A single eyepiece is used to observe both the total reflection field and the scale.

Liquids are measured by introducing a thin film between the upper and lower refracting prisms. Solids are measured by affixing them to the surface of the lower prism by means of a suitable contact liquid which must be higher in index than the sample to be measured.

The Prism System

The upper prism case (1-1A) carrying the illuminating prism (1-2) is opened by exerting upward pressure on the prism housing lever (2-3). When the prisms are closed a liquid sample may be introduced by pipette or dropper through the channel between the prism boxes (2-4). The measuring prism is mounted in the lower housing with its polished surface facing upward. The manner in which this surface is treated will determine in great measure the

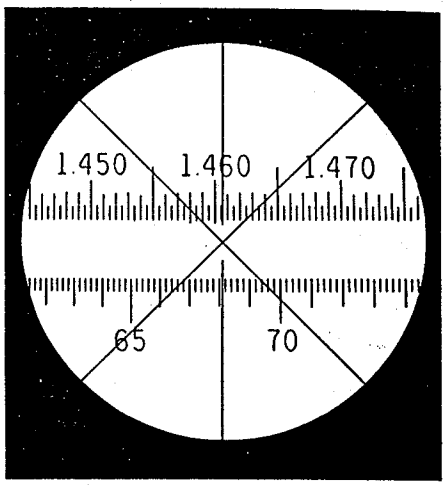


Figure 3

useful life of the instrument. If it becomes scratched and striped through improper cleaning, the sharpness of the dividing line will decrease and the scale settings will become less accurate. In the following text, careful directions are given for cleaning the prisms.

The prism housings are hollow and provide for the flow of liquid to hold the prism at a constant temperature. The liquid from the controller enters the lower prism housing (1-1B) past the thermometer bulb and upper prism housing, (1-1A) through a short "jumper" tubing and out.

A small hinged shield on the end of the lower prism housing (2-5) blocks off the front face of the refractometer prism to prevent the entrance of stray light. When making readings by reflection where the light must enter the front face of the refraction prism, the shutter is rotated out and down toward the base of the instrument. Its polished surface may be used as a reflector to provide optimum illumination.

The Scales

The index and "total solids" scales are photographed on a transparent glass plate (5-6) which is rigidly attached to the sector arm inside the housing. The scales are read through the eyepiece (2-7) by depressing the momentary contact switch (1-8) on the side of the instrument. Depressing the switch, lights the internal scale lamp while the main outside lamp is turned off simultaneously. The eyepiece should be focused to give the best image of the reticle-scale combination. The index scale is designed to read directly to five units in the fourth place with estimation to one in the fourth. The "total solids" scale is based directly on the 20°C International Sucrose Tables and reads directly to 0.2% with easy estimation to 0.1%. You will note that the 41.5% and 68% lines have been extended on the scale. This has been done to aid the citrus and preservative industries in making end point readings easier. This scale has been cemented in place and cannot be moved without damaging it.

Identification Numbers

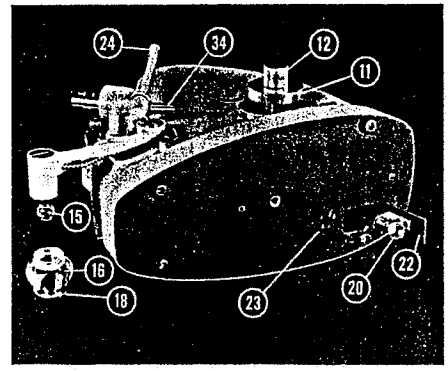
When the scale is rotated to the low end of the range, by means of the hand wheel, a small engraved number will appear in the field. This number identifies the prism glass and should be the same as that appearing on the vertical inside face of the refracting (lower) prism (2A). The number on the prism may be seen by holding a small flashlight near the outer end of the prism. The serial number of the instrument appears on the name plate.

WHEN CORRESPONDING REGARDING THE INSTRUMENT OR A SPARE PRISM OR WHEN ORDERING PARTS, BOTH NUMBERS SHOULD BE GIVEN.

Index Setting Control

As indicated previously, a mirror (5-9) is used to direct the total reflection line from the refracting prism into the viewing system. It is mounted on a pivoted ball bearing sector (5-10). Its position, calibrated in index or "percent solids" is indicated on the scales (5-6) attached to the sector. This sector is moved by turning the concentric hand wheels on the side of the instrument. The larger of the two (4-11) is a fast friction disc drive (5-13) traversing the entire index range in two and a quarter turns. The smaller (4-12) is a slow planetary ball bearing drive requiring eleven turns to traverse the range. Any slight backlash which may exist in the system is of no consequence in the accuracy of setting since the scales and the mirror constitute a rigid member and, hence, remain always in the same alignment. For adjustment purposes the relative position of the scale and mirror is adjustable

Figure 4



but this is a factory adjustment only.

Because of the ball bearing nature of the drive mechanism, lubrication problems have been virtually eliminated.

Compensation System

The compensator unit differs from that in older Abbe instruments in that both prisms of the unit move together in the same direction. The scale dial (1, 2 or 5-14) serves to rotate them. With this system compensation is different than in the older counter rotating forms. When correct compensation has been secured, the borderline will be achromatic at the center of the field with a faint red dispersion showing at one extremity and a faint blue dispersion showing at the other. The system should be set so that the short achromatic section of the borderline is centered on the crosshairs. The standard dispersion charts supplied with the instrument are used for evaluating the (C-F) dispersion. Directions for their use are found on the charts.

A "snap-on" plastic cover (2-33) is provided to cover the compensator scale dial. This is of particular value in production line applications where it is undesirable to change the compensator reading. The cover also prevents samples from running inside the instrument.

Eyepieces

The standard instrument comes equipped with a 2X eyepiece (Cat. No. 33-45-68) which is best suited for the majority of applications. For those fluids producing a line that is blurred, a lower power eyepiece (Cat. No. 33-45-69, 1.3X) will assist in setting the line accurately. This eyepiece should be ordered separately.

Illumination

The field lamp (4-15) is carried in a plastic toric shaped housing (4-16) at the extremity of the rotating arm (5-17). A knurled ring (5-18) at the end of the housing controls an internal shield. The lamp is of the miniature type and is operated from an internally mounted transformer (5-19) which also serves the scale lamp (4-20). A line switch is used to control the power to the transformer while a momentary contact switch (1-8) on the side of the instrument determines which of the two lamps is activated. Normally the field lamp is on while the internal scale lamp is off. Depressing the momentary contact switch lever reverses this condition. This assures an unbiased reading. It eliminates any tendency to set the instrument to a known reading.

If it is necessary to change the field lamp unscrew the toric shaped housing (5-16) from the swinging arm (17). To replace the scale lamp swing open the trap door (4-22) on the bottom of the instrument. This door is released by rotating the slotted lever (4-23). A coin may be inserted in the slot if the lever turns with difficulty.

When ordering replacement lamps use No. 605 General Electric flashlight lamps (6.15 volt—.50 amp.), our Cat. No. 33-33-10.

Thermometer

The thermometer is attached in

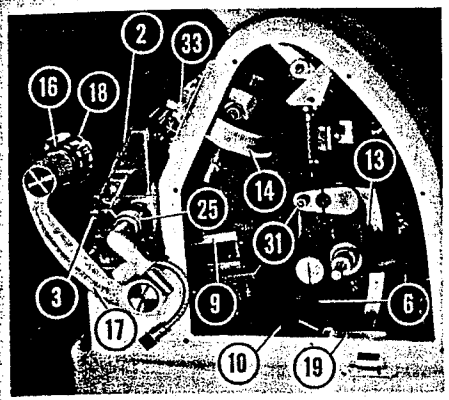


Figure 5

upright position by means of the knurled collar (2-25). By loosening the collar slightly the thermometer may be adjusted to any desired reading position. To loosen the elbow, the collar (2-25) should be turned counterclockwise and then tightened again when the thermometer is in the desired position. At the base of the thermometer guard tube is a second collar (2-26) the loosening of which permits that unit to be rotated to bring the scale toward the operator. The Cat. No. of the complete assembly is 33-45-21.

Care of the Instrument

The Abbe-3L has been designed to provide maximum convenience and precision of reading. All operating parts are protected as far as possible from the sample materials and solvents. In spite of all that a designer can do, however, trouble will ultimately result unless an operator follows certain basic practices in the daily use of the instrument. These are discussed at some length in the following paragraphs and it is strongly urged that an operator train himself along the lines suggested.

1. The refractometer must be kept scrupulously clean at all times. Dust, oil, and solid materials, if allowed to accumulate, on any part of the instrument, will find their way into bearings and hinges causing wear and eventual misalignment. The operator should make it a practice at the close of each day's work to clean all exposed surfaces thoroughly.

2. The prism (2, and 2A) should be thoroughly cleaned after each test and should be kept closed when not in use. In this type of instrument, the glass of which the prisms are made is of high refractive index and is inherently soft. It is therefore easily damaged by surface scratching and corrosion. If a dust film is allowed to accumulate on the polished surface its removal can cause more damage than many hours of actual service. The gradual deterioration of surface quality results in hazy borderlines and, hence, every care should be exercised to protect and preserve the prism surfaces. This is especially to be watched when solid materials are being measured. Special directions are given for the use of the standard test piece and these apply equally well to all solid materials.

3. Prisms should always be cleaned immediately after use. Where possible, wipe first with clean dry lens tissue followed by a tissue or cotton swab dampened

with water, alcohol, or other suitable solvent. A dilute solution (0.1% - 0.5%) of a non-ionic detergent such as Triton X-100 or Tergitol NPX may be used if necessary. Some other soaps and detergents have been known to fog the prisms. Never use a sharp object such as a knife, needle, etc., on either the prism or the seal around the prism. Even a slight crack in the sealer may cause serious damage to the prism mounting which will necessitate considerable repair. Do not dry the surfaces by rubbing with cotton. Lens tissue, if kept in a closed container, may be employed if used lightly. Thoroughly washed linen may also be safely used. Avoid the use of any cleaning means, either linen or tissue which has been lying about on the work table where it can pick up dust and grit.

The sealer around the prisms is a chemically resistant epoxy resin. While it has been found to give generally good protection toward numerous materials, there are a few solvents which are known to attack it. Among these are:

1. N, N — Dimethylformamide
2. Phenols, cresols, and other tar acids
3. Acetic Acid Solutions
4. N, N — Dimethylacetamide

Other materials to which the sealer has been known to have unsatisfactory resistance over long periods of time or at elevated temperatures are:

1. Tetrahydrofuran
2. Mixtures of esters, especially methyl acetate and vinyl acetate
3. Some Lacquer Thinners

In the above instances other sealers have been found to give satisfactory performance for the specific solvents in question. These may be obtained on special order.

Strong mineral acids and bases will quickly fog the prisms and should not be used.

The internal mirror (5-9) is first surface aluminum and should not be touched except with a camel's hair brush. This brush may also be used on the scale (5-6). However, since the instrument is almost completely enclosed except for one or two functional openings it is not anticipated that these elements will need attention except under very unusual circumstances.

If circulating water is used at elevated temperatures, the prism box must be heated and cooled slowly to prevent large thermal differences which might crack the prism.

Bibliography

For a detailed discussion of Refractometry, see Arnold Weissberger, editor, Physical Methods of Organic Analysis, Vol. 1, Part II, Chap. XVIII.

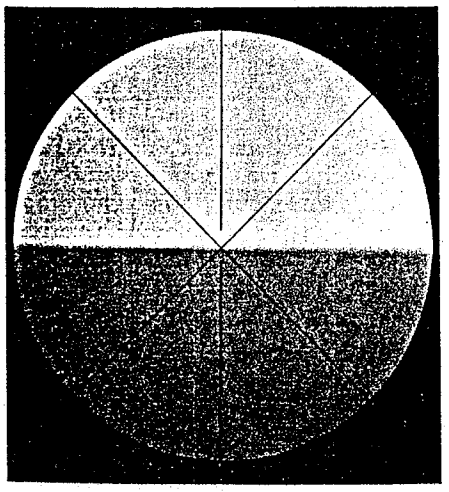
METHODS FOR READING THE INSTRUMENT

I. General Instructions

The following general directions apply in making any reading with the instrument. Specific directions for various types of material appear below.

1. After the sample is in position on the instrument, set the scale at the approximate value expected. (To see the scale depress the momentary contact switch (1-8) on the side of the instrument.)
2. Release the switch and bring the borderline, which will probably be strongly colored, near the crosshair and compensate the color by adjusting the position of the dial (5-14). The borderline should be faintly blue on one side and faintly red on the other.

Figure 6



3. Observe the crosshairs sharply focusing the eyepiece if necessary and bring the dividing line upon their intersection by means of the coarse or fine hand controls.
4. Read the index by depressing the momentary contact switch (1-8), estimating the fourth place.
5. If working with liquids, record both index and the prism temperature at the time of reading.

II. Transparent and Viscous Liquids

For the measurement of liquids and especially those of an organic nature, hydrocarbons, vegetable oils and the like, excellent temperature control is necessary and thorough cleaning of the prism between samples is equally necessary. The cement used to retain the prisms is a thermo-setting plastic, which is almost completely unaffected by organic solvent, fruit acids, etc.

If the liquid is free flowing or only slightly viscous, it may be introduced by means of a pipette or dropper through one of the channels (1-4) alongside the prism. If it is quite viscous it is best placed upon the prism (1B) spreading it over the face with a wooden applicator. The prisms are then closed slowly allowing the excess to squeeze out into the space between the metal mounts. NEVER USE GLASS OR METAL APPLICATORS AGAINST THE PRISM FACE.

In order to secure the best line with any liquid or semi-liquid material, it is essential that the space between the prism be uniformly filled. To determine whether or not this condition exists, examine the exit pupil (2-32) with a low power magnifier. Nonuniformity of filling will be evidenced by dark areas in the bright disc. It is also possible by this method to detect contamination of the sample which may have arisen from improper cleaning. Contaminating materials entering the measuring space from the metal or cement areas will be indicated by dark tongues or striations, extending into the bright area from top or bottom. Where either bubbles or contaminating materials are detected, it is preferable to clean the prism surfaces again, though bubbles may sometimes be eliminated by opening and closing the prisms slightly two or three times. Bubbles are often caused by the adherence of foreign materials, especially those of an oily nature, to the glass surfaces. These prevent complete wetting of the surfaces as the samples flows in from the channel. This emphasizes again the need for thorough cleaning between samples.

Illumination in this case should be directed through the ground face of the upper prism. After sample is placed on the prisms and the illumination is set, follow the general instructions outlined above.

III-A. Use of the Standard Test Piece

The measured glass test piece (1-27) provided with the instrument is for the purpose of securing precise adjustment of the scale in its relation to the position of the total reflecting dividing line. Proper use of this accessory is of prime importance. The first essential operation is the proper cleaning of the two surfaces (one on the polished face of the lower prism and the second on the test piece) which are to be placed in contact. Before applying the contact liquid (1-bromonaphthalene) these two surfaces should be carefully cleaned as described above with a suitable solvent and ether. Just before applying the contact liquid two surfaces should be brushed with a clean camel's hair brush to remove any grit or loose particles which may have remained after the liquid cleaning. If the surfaces are viewed at almost grazing incidence these residual particles are easily seen. This brush, like the tissues or linen mentioned above should be kept in a closed stoppered container like a test tube. When the operator is sure that both surfaces are properly cleaned, a small drop of 1-bromonaphthalene should be put upon the surface of the test piece and the two surfaces brought together. The size of the liquid drop should be of the order of one cubic millimeter, the aim being to provide just enough to fill the test piece area completely without having a liquid bead around its edge. Too much liquid will cause the test piece to slide and too little will give an incomplete contact and a poor borderline. When the small drop has been placed on the test piece the two surfaces should be brought together gently, the polished end of the test piece being toward the illuminator and engraved side up. If, on contact, there is the least trace of roughness or grittiness, remove the test piece immediately and clean both surfaces again.

When certain that there is no grit or dirt in the liquid space, move the test piece around gently to thin out the liquid film, and spread it evenly over the contact area, keeping the sliding motion at a minimum. If these operations are properly carried out, the test piece will adhere firmly to the prism surface.

Prepare a thin piece of white paper in the form of a small, one layer cylinder which may be inserted in the open end of the lamphouse so that it is between the lamp (4-15) and the plastic lens (4-16). This will give the necessary diffusion of light to properly read a solid sample. (Liquid samples do not require this diffuser.)

With the test piece in position and the illuminating prism (2) swung sideways out of the way depress the momentary contact switch (1-8). Set the scale of the instrument at the index value engraved on the surface of the test piece and swing the illuminant (4-15) to a position directly in line with the prism surface. Release the momentary contact switch (1-8). Adjust the lamp shield (4-18) so that the best contrast is secured between the two halves of the field. Make sure that the line as set does not shift with motion of the lamp. Turn the compensator dial (5-14) until the dividing line is correctly compensated (red at one end and blue at the other).

In passing, it is well to note that any solid specimen to be measured should possess at least one surface that is optically flat, in order that good contact may be achieved. A further requirement for correct reading on a solid specimen is that the edge toward the source be sharp. If this edge is rounded a poor borderline will result. The type of sharpness needed is like that obtained when a piece of glass is broken.

III-B. Checking and Adjusting with Test Piece

When the operator has succeeded in putting the test piece into proper position he can proceed with a check of the scale and compensator positions. To check the scale the borderline should again be carefully compensated so that the achromatic portion lies symmetrically upon the crosshairs and is set so that it crosses the intersection exactly. If, with this setting, the index read on the scale differs from that engraved on the test piece (1-27) some adjustment error is indicated. To correct this rotate the small cover (2-29) near the concentric band wheels (2-11) (2-12) disclosing a small hole. Inserting the hex socket screw key (2-30) into this hole, engage the adjusting screw (5-31) and turn it to move the scale image sideways until the proper reading as marked on the test piece is obtained. This completes the adjustment. Remove the key and close the hole.

While the test piece is in position, the compensator (2-14) may also be checked for two possible errors. As in the older form of instrument the compensation prisms have two positions of rotation, one on each side at either of which an achromatic borderline may be secured. The dividing line should first be set as precisely as possible on the crosshairs in either position of compensation. The compensating dial should then be

rotated to the second position (on the opposite side of the zero point) without disturbing the setting of the dividing line. If the compensators are in good working order the position of the dividing line should not have changed with the reversal. If the reading of index differs by a discernible amount it is an indication that the compensators have developed deviation, and that the instrument should be returned to the factory for repair. These troubles sometimes occur due to deterioration of the cement layers, causing shifting of prism elements, and cannot be corrected by the user. However, should such a defect be found in the course of a series of experiments or during a seasonal run in any industry, the instrument can still be used until it is convenient to return it for repair, provided one condition is observed. All readings of index should be made with the compensators set on the same side of the zero point. As long as the instrument is set for one compensator position by means of the test piece and that position used for all index readings, the results will be correct. This, however, is only a stop gap procedure and if deviation exists the instrument should be returned for repair.

While checking the compensators for deviation the direct and reversed readings of the scale should be noted. If they are not the same, the readings should be averaged. If index only is of interest a difference between the two compensator readings causes no error. If the compensator readings are too different the instrument should be returned to the factory for repair.

When these adjustments have been carefully checked remove the test piece and clean it and the prism surface with a suitable organic solvent.

Other test pieces are available for checking other parts of the scale; see listing at the end of this manual.

III-C. Other Transparent Solids

All readings on transparent solids should be made in accordance with the test piece directions as given under the heading: "Use of the Standard Test Piece." In the case of such materials the character of the dividing line is materially affected by (A) the planeness of the contacting surface; (B) the sharpness of the edge toward the source of light; (C) the inherent homogeniety of the material itself.

As mentioned above, the contracting surface should be flat to a few wavelengths or better and the forward edge should be sharp. Striated materials will usually give poor lines and there is little that can be done to help such a situation.

The liquid used for contacting the material to the prism face must always have a higher index than the material itself. Up to an index value of 1.64, the contacting liquid supplied with the instrument (1-bromonaphthalene) is satisfactory. Above that index, methylene iodine ($n_D = 1.74$) must be used. The latter should be kept in the dark and corked, as exposure to air and light result in darkening due to liberation of free iodine. This darkening can be prevented by adding a strip of copper or a few copper shot to the bottle in which it is kept. Other materials such as anise oil ($n_D = 1.55$)

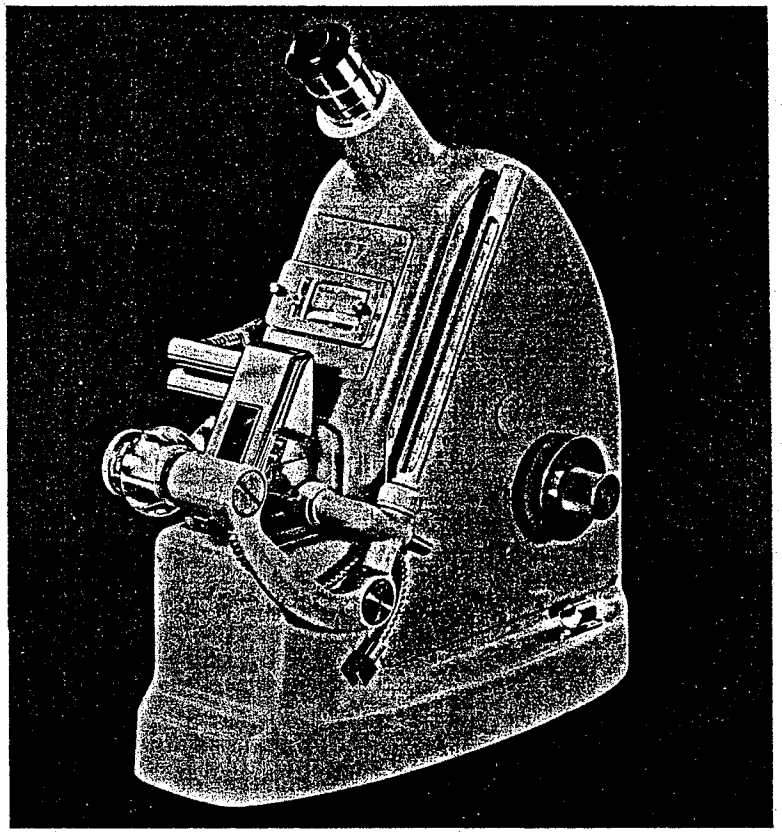


Figure 7

can be used where the indices of materials are lower. Their only advantage, however, is that they may make the interference fringes used for the positioning somewhat more easily seen.

In general, the temperature coefficient of index change is so small in the case of solids that no temperature control is required. However, with some of the newer plastic materials this may not always be true. Where there is doubt, the temperature coefficient should be checked.

IV. Opaque Materials

This type of material is seldom encountered but when it is necessary to secure such readings, they must be obtained by reflection methods which at best are not too satisfactory. The method of attaching a solid sample is the same as in the case of transparent solids by a suitable liquid. When measuring by reflection the prism shield (2-5) on the lower prism is swung down and the light is directed downward toward this shield from which it is reflected into the front face of the measuring prism. A borderline is formed just as when