

MANUAL  
FOR  
BALLOON THEODOLITE  
MODEL 8304/BT901

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BALLOON THEODOLITE  
MODEL 8304

1.0 INTRODUCTION

- 1.1 The Model 8304 Balloon Theodolite is a precision optical instrument used to track a balloon during its' ascent into the upper atmosphere. By providing azimuth and elevation angles of the balloon, the theodolite can be utilized to determine wind direction and speed in the upper atmosphere if the angles are recorded against a time base.
- 1.2 The theodolite includes two telescopes, the finding scope and the tracking scope, that share a common eyepiece. The wide-angle finding scope is used while initially searching for the balloon. Once the balloon is aligned, the tracking scope is used to follow its ascent. Switching between the two scopes is readily accomplished by turning a knob on the theodolite body. Both scopes have a right angle optical path to the eyepiece which allows the eyepiece to remain in the same horizontal plane over the entire range of elevation angles.
- 1.3 The tracking mechanism utilizes perfectly engaged worm gears. During the initial search for the balloon, the theodolite can be rotated rapidly by hand. Once tracking begins, two fine adjustment knobs are used to keep the balloon in sight. The azimuth and elevation scales are visible inside the eyepiece; thus, the observer can easily track the balloon and read the scales simultaneously. Both scales can be read to a resolution of  $.05^\circ$ .
- 1.4 A cross hair reticle is visible in the eyepiece to aid the observer in centering the theodolite on the balloon. During daytime observations, a small mirror directs ambient light into the instrument to illuminate the scales. For nighttime observation, two small LED lamps are powered with the provided power supply to illuminate the scales and reticle.
- 1.5 Initial set-up requires orienting the theodolite to north for azimuthal reference and leveling for elevation reference. A compass which mounts on the theodolite body is provided for azimuthal reference, and a bubble level with leveling adjustments is provided for elevation reference.
- 1.6 Additional standard accessories include lens shades, optical filters (yellow and green), spare lamps, maintenance tools, and a carrying case. An optional mounting tripod, Model 83040, is available.

2.0 SPECIFICATIONS

- 2.1 Finding scope
  - Power..... 3.5X
  - Objective diameter..... 10 mm
  - Field of view..... 17°
  - Resolving power..... 16 seconds
- Tracking scope
  - Power..... 25X
  - Objective diameter..... 50 mm
  - Field of view..... 2.5°
  - Resolving power..... 3 seconds
- Measuring range
  - Azimuth..... 0 to 360°
  - Elevation..... -5 to 185°
- Angle resolution..... 0.05°
- Leveling..... bubble level, 3 leveling screws
- Orientation..... compass
- Filters..... yellow and green
- Illumination..... reticle, azimuth and elevation scales
- Power supply..... 4 AA size batteries
- Tripod (optional)..... Adjustable wooden legs from 39" to 61" (990 to 1550 mm)
- Theodolite size..... 10.5"H X 8.5"W X 7.0"D  
(267 X 216 X 178 mm)
- Carrying case size..... 14.0"H X 13.0"W X 9.5"D  
(356 X 330 X 241 mm)
- Weight
  - Theodolite..... 8.8 lbs. (4.0 kg)
  - Theodolite in carrying case..... 16.5 lbs. (7.5 kg)
  - Tripod..... 10.4 lbs. (4.7 kg)

3.0 INSTALLATION

- 3.1 This instrument is thoroughly tested and fully calibrated at the factory and is ready for installation. Please refer to the return authorization card included in the packing box if damage has occurred. Also, notify Qualimetrics, Inc.
- 3.2 Mounting: Place the tripod, Model 83040, on firm ground. Asphalt or dirt is a good base since the tripod legs can penetrate into it. Use the foot pedals on each leg to force them into the ground as far as possible. Avoid placing the tripod on structures, such as a wooden deck, that can deform with different weight distributions.
- 3.3 Secure the theodolite to the tripod using the large knob screw on the tripod.
- 3.4 Leveling: Use the following procedure to level the theodolite:

- a) Tighten the azimuthal angle lock (20).
- b) Adjust the elevation angle to exactly  $0.00^\circ$  (see Paragraph 4.4 for an example of angle adjustment and reading).
- c) The three leveling adjustments form a triangle at the theodolite base. Align the theodolite's line of sight to any one of these triangular sides. In other words, the bubble level (2) should run parallel to one of the triangular sides.
- d) Adjust the two leveling screws (10) that join the triangular side of interest until the bubble moves to the exact center of the bubble level, as marked by the solid gold lines.
- e) Note the exact azimuth angle at this point and add or subtract  $90^\circ$  from it. Rotate the theodolite to this new angle.
- f) Adjust the remaining level screw (10) so that the bubble becomes centered again.
- g) The theodolite should now be leveled. Rotate it to any azimuthal position and see that the bubble remains in dead center. If it does not, repeat the above procedure. If leveling does not occur go to Step 5.2 for a procedure in calibrating the bubble level.

3.5 Orientation: Use the following procedure to correctly orient the theodolite for azimuth angle:

- a) Release the azimuthal angle lock (20).
- b) Attach the compass to the mount (16).
- c) Unlock the compass needle by rotating the screw knob on the bottom of the compass in a counter clockwise direction.
- d) Rotate the theodolite until the red compass needle aligns to magnetic north.
- e) Tighten the azimuthal angle lock (20).
- f) Turn lock (19), push in the azimuthal angle setting (18), and turn until the azimuth scale reads  $0.00^\circ$ .
- g) Refer to Figure 1 to find the declination for your area. Rotate the azimuthal angle adjustment (21) to offset the theodolite by this amount. For in-

stance, if the declination for your area is  $18^{\circ}\text{E}$ , rotate the azimuth  $18^{\circ}$  counter-clockwise, or until  $342.00^{\circ}$  is read on the azimuth scale.

- h) Reset the azimuthal angle setting (18) to  $0.00^{\circ}$ . The theodolite will now indicate angles referenced to true north. Turn lock (19) to prevent any additional alteration to the setting of the azimuth setting.

3.6 Daytime Observation: If the theodolite is to be used in daylight hours, flip the illumination mirror (17) open and peek through the eyepiece. If the scales are not illuminated well, rotate the intensity adjustment (12) to the right. The angle of the mirror may need to be adjusted to achieve well lit scales. Use the sun shields and lens filters for best observation in high glare conditions.

3.7 Nighttime Observation: If the theodolite is to be used for tracking a balloon ascent at night, remove the compass and insert the power supply in its place. Plug a cable into the scales illumination lamp (11) and into the reticle illumination lamp (15), and connect these two cables to the power supply. Adjust intensity adjustment (12) for proper illumination of the scales.

#### 4.0 OPERATION

4.1 Once the theodolite is set-up as described in Section 3.0, a balloon flight may be recorded. The theodolite's azimuth and elevation angles may be rotated by hand for coarse adjust and by adjustments (21) and (13) for fine adjust.

4.2 Balloon Observation: Generally, two people will be needed to track a balloon: one to track the balloon and read the angles, the other to call out time intervals. Before releasing the balloon, switch knob (4) so that vision is through the finding scope. Rotate the vertical axis of the theodolite to find the grounded balloon, and then focus on the balloon by rotating the eyepiece.

4.3 Release the balloon at a precise time. During the initial stages of flight, track the balloon with the coarse sighting (14), while quickly turning the theodolite by hand. Once the angular speed of the balloon has decreased, peek through the eyepiece and center the balloon in the reticle using the fine adjustments. Once the balloon is aligned, switch over to the tracking scope by turning (4) to the alternate position. Always keep the balloon in focus by adjusting the eyepiece. If the balloon should move out of sight, switch back to the finding scope until the balloon becomes more stable in the sighting.

4.4 The azimuth and elevation angles should be read at one minute intervals with the balloon exactly in the center of the reticle. The angles are seen through the eyepiece with the top scale representing elevation and the bottom scale representing azimuth. Vernier scale divisions represent angles to the nearest  $0.05^\circ$ , as illustrated in the example of Figure 2.

4.5 Wind speed and direction in the upper atmosphere can be obtained, by measuring angles at selected time intervals and assuming a constant rate of ascension of the balloon. Figure 3 shows balloon specifications for various balloons sold by Qualimetrics, Inc. These specifications are taken for hydrogen-inflated balloons. Helium inflated balloons may produce slightly different results.

4.6 Survey Applications: The Model 8304 can be a useful tool for surveying. The plumb bob included in the accessories is used to mark the vertical axis through which the theodolite passes.

#### 5.0 CALIBRATION

5.1 Caution: The Model 8304 is a precision optical instrument. Any adjustments should only be performed by personnel trained in the calibration of such instruments.

5.2 The theodolite can be set-up using the procedures described in Section 3.0. However, if the theodolite does not level as described in Step 3.4, use the following procedure for adjusting the bubble level:

- a) Before making any adjustments, make sure the tripod is on a solid foundation.
- b) Perform a), b), c), and d) of Step 3.4.
- c) Rotate the azimuth exactly  $180^\circ$
- d) If the bubble is not centered in the bubble level, adjust the two footscrews again so that the bubble moves half the distance back to the center.
- e) Remove both access screws (3) with the screwdriver.
- f) Using the bubble level adjust tool, adjust the position of the bubble level until the bubble moves to the exact center of the level.
- g) Rotate the azimuth by  $90^\circ$  and center the bubble with the other footscrew (previously not adjusted).

h) Repeat the procedure until the bubble is centered for all azimuth angles.

5.3 If too much backlash develops in the azimuthal drive, tighten adjustment screw (8) slightly to correct the problem. DO NOT OVERTIGHTEN THIS SCREW.

## 6.0 MAINTENANCE

6.1 The following cautions should be observed while using this precision optical instrument:

a) Always rotate all moveable parts in a gentle and even manner. Never use force on any part.

b) Never drop or mishandle the theodolite.

c) If moving the instrument more than half a mile in the field, place it back in its carrying case.

d) If the theodolite is transferred from a very cold outside environment to a mild indoor room, keep the instrument in its carrying case for about 2 hours to allow for temperature equalization.

6.2 The outer glass faces of the optical elements can be cleaned of dust with a dry, soft brush and wiped clean with a flannelette. Never touch the optics with fingers!

6.3 If the scales and reticle should become stained with dirt or dust, they can be cleaned by first removing access screws (6) and (9) and then cleaning with a fat-extracted cotton, soaked in a mixture of ether and alcohol.

6.4 Replace the illumination lamps when needed by unscrewing from the theodolite and carefully removing the two small side screws. The LED and mount can be replaced with a new one. Re-assemble and replace.

6.5 Never allow the batteries to remain in the power supply for long periods of time. To remove or replace the batteries, pull up on the aluminum cover until the batteries are exposed. Replace them with equivalent AA size noting polarity, then put back the cover.

## 7.0 ILLUSTRATIVE DRAWINGS AND PARTS LIST

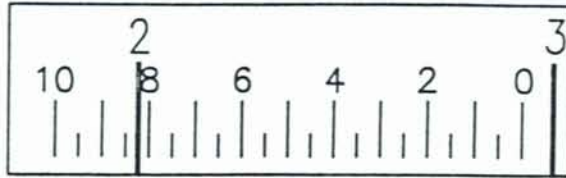
7.1 Illustrative drawings identifying each part described in this manual are included in the following pages. Refer to them while reading the text.

7.2 No parts list is included with this instrument. For information regarding replacement parts, contact the factory and refer to this manual, 8304-001, ECN 2598.

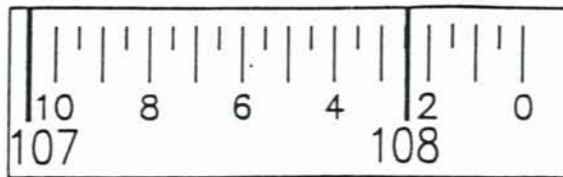
8.0 WARRANTY

8.1 All instruments are warranted for one year, unless otherwise specified, against defects in material or workmanship. Should any instrument prove to be defective within the warranty period, upon written notice and return of the instrument freight prepaid, Qualimetrics will, at its option, repair or replace the defective unit and return it freight collect. Instruments abused, improperly used or installed, and modified or altered by others, may cancel warranty.





ELEVATION = 2.82°



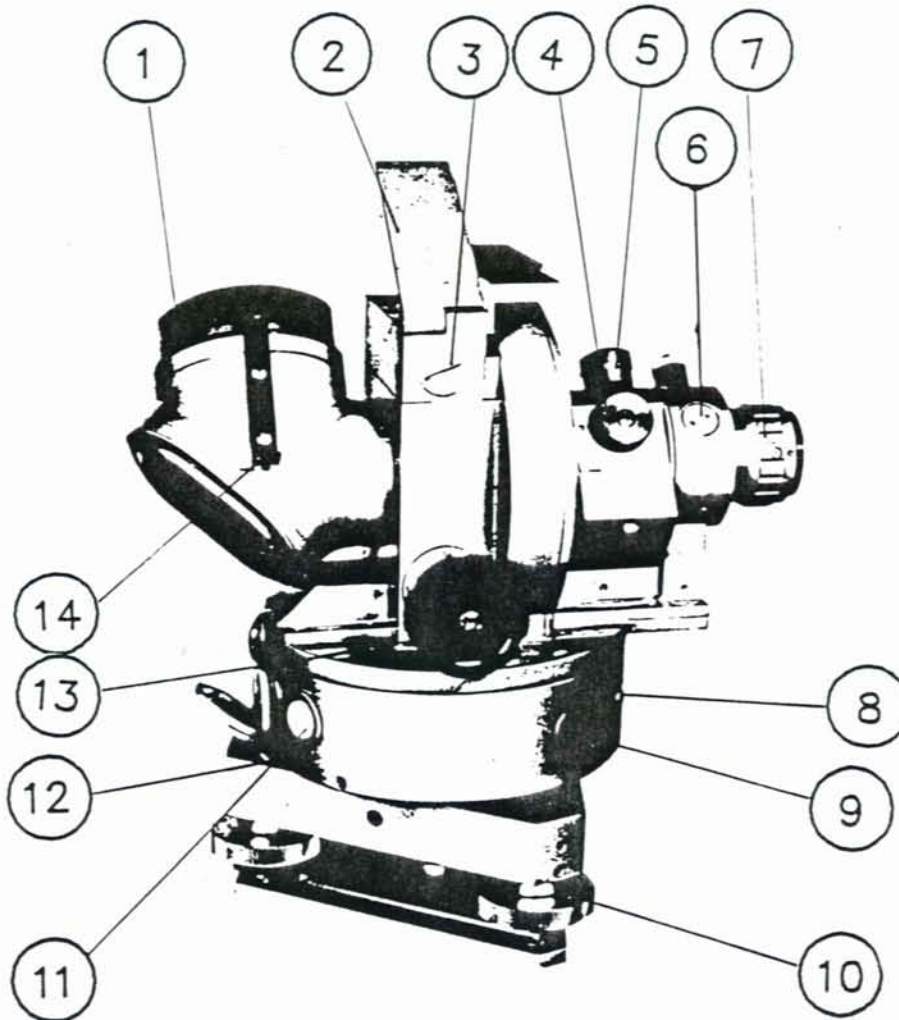
AZIMUTH = 108.25°

FIGURE 2  
EXAMPLE ILLUSTRATING SCALE READING

Cat. No.	Nominal weight gm	Color	Average alt. before burst km	Average burst diameter m	Insp. inflation diameter m	Specifications for altitude test		
						Payload gm	Free lift gm	Ascent rate m/min.
8210	10 ± 3	red	7	0.6	0.5	—	50	150
8220	20 ± 4	red	10	0.93	0.75	—	130	200
8221	20 ± 4	black	10	0.93	0.75	—	130	200
8222	20 ± 4	natural	10	0.93	0.75	—	130	200
8230	30 ± 4	red	12.5	1.02	0.85	—	140	200
8231	30 ± 4	black	12.5	1.02	0.85	—	140	200
8232	30 ± 4	natural	12.5	1.02	0.85	—	140	200
8233	100 ± 10	red	15	1.33	1.25	—	160	200
8234	100 ± 10	black	15	1.33	1.25	—	160	200
8235	100 ± 10	natural	15	1.33	1.25	—	160	200
8236	200 ± 10	natural	19	2.7	1.65	—	850	350

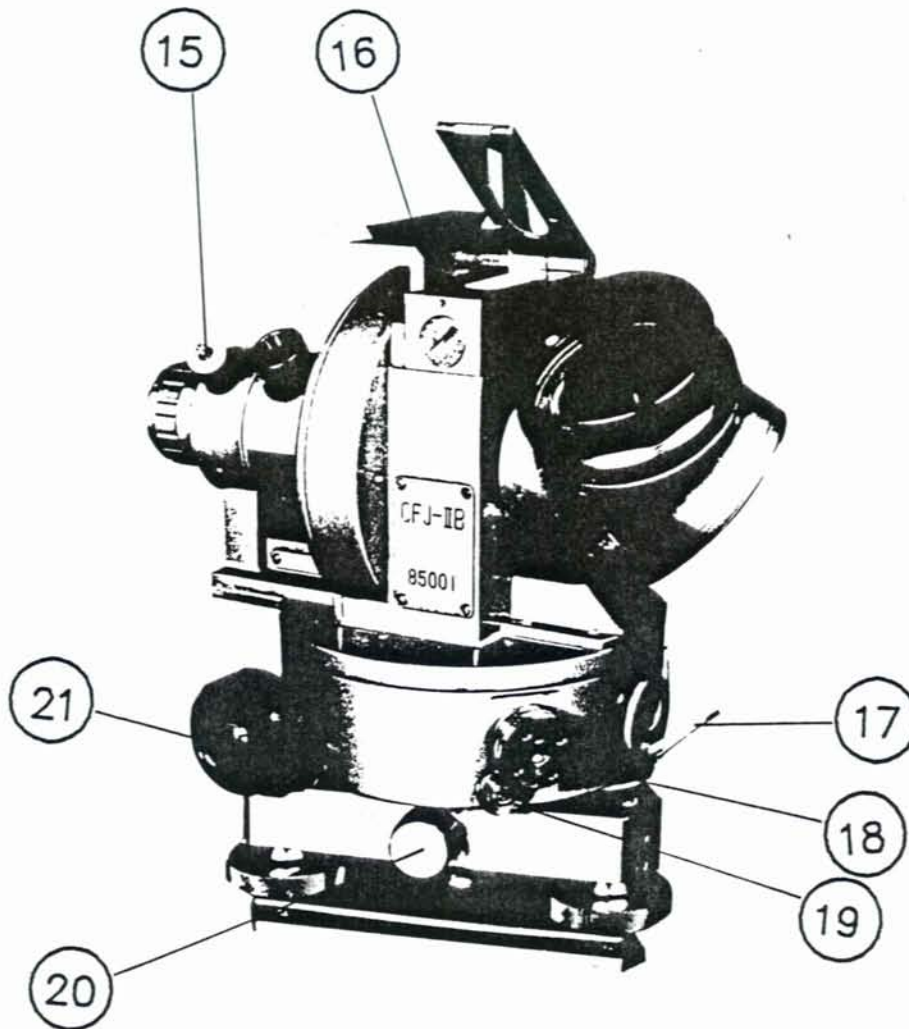
FIGURE 3  
BALLOON SPECIFICATIONS

FIGURE 4  
ILLUSTRATIVE VIEW OF THE MODEL 8304



- |  |  |
|--|--|
| 1. TRACKING SCOPE                              | 8. ADJUSTMENT SCREW, AZIMUTHAL DRIVE         |
| 2. BUBBLE LEVEL (WITH MIRROR)                  | 9. ACCESS SCREW, OPTICAL MAINTANENCE         |
| 3. ACCESS SCREWS, BUBBLE LEVEL ADJUSTMENT (2X) | 10. LEVELING ADJUSTMENTS (3X)                |
| 4. SWITCH-OVER KNOB, TRACKING/FINDING SCOPE    | 11. ILLUMINATION LAMP (FOR SCALES)           |
| 5. FINDING SCOPE                               | 12. INTENSITY ADJUSTMENT, SCALE ILLUMINATION |
| 6. ACCESS SCREW, EYEPIECE MAINTANENCE          | 13. ANGLE ADJUSTMENT, ELEVATION              |
| 7. EYEPIECE                                    | 14. COARSE SIGHTING                          |

FIGURE 5  
ADDITIONAL ILLUSTRATIVE VIEW OF  
THE MODEL 8304



- 15. ILLUMINATION LAMP, RETICLE
- 16. COMPASS AND POWER SUPPLY MOUNT
- 17. ILLUMINATION MIRROR
- 18. AZIMUTHAL ANGLE SETTING
- 19. LOCK, AZIMUTHAL ANGLE SETTING
- 20. LOCK, AZIMUTHAL ANGLE
- 21. AZIMUTHAL ANGLE ADJUSTMENT

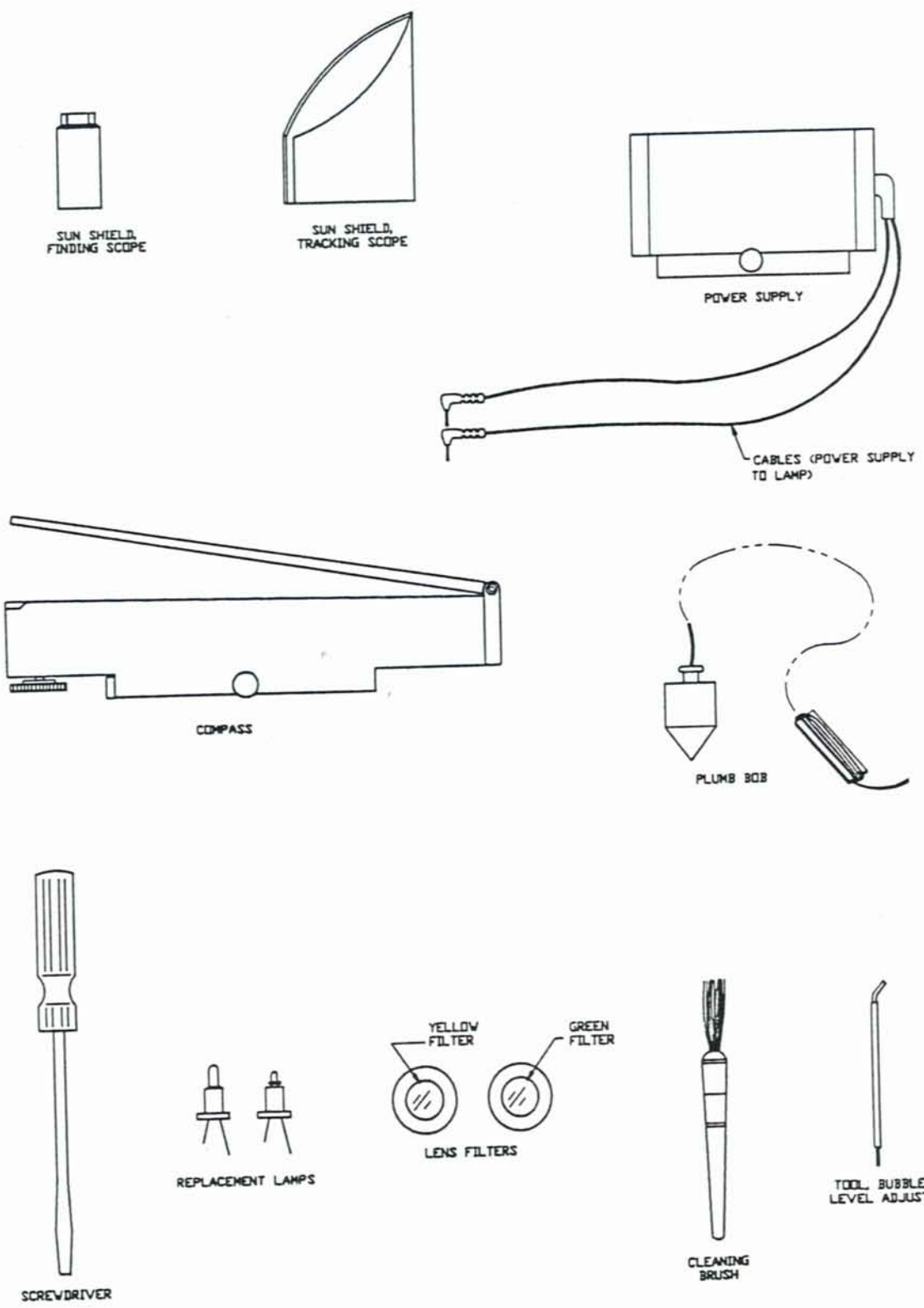


FIGURE 6  
 ILLUSTRATIVE DIAGRAM OF  
 ACCESSORIES FOR THE MODEL 8304