

Chapter 4

Targets and Signals

A target is generally considered to be a nonilluminating signal. Target requirements can be met by three general types: tripods, bipeds, and poles, all of which may incorporate variations. The targets are constructed of wood or metal frameworks with cloth covers.

Section I TARGETS

SIZE, SHAPE, AND COLOR OF TARGETS

For ready bisection, the target should be as narrow as possible without sacrificing distinctness. The easiest of targets to bisect are triangular in shape, with square- and rectangular-shaped targets being next. Targets that are round are the poorest of targets due to problems in pointing during repeated observations. These targets should be avoided whenever possible. A target which subtends an angle of four to six seconds of arc will be easy to bisect. Since one second of arc equals 0.5 centimeters at a 1-kilometer distance, an angle of six seconds requires a target 3 centimeters wide at that distance or 30 centimeters at 10 kilometers. Under adverse lighting conditions, the target width will have to be increased. To make a target readily visible against both light and dark backgrounds, it should be constructed of alternating bands of red and white or orange and yellow. Flags of an appropriate size may be added to aid in finding the target or by filling the background with blaze orange cloth to contrast the target. All cloth used on the targets should be slashed after construction to minimize wind resistance and to avoid pilfering in areas where cloth may be valuable.

LOCATION OF TARGETS

The location of targets by observers is sometimes a difficult and tedious task, depending upon the type of terrain and foliage in the area. In jungle-type areas where the targets are not profiled or silhouetted, they are very difficult to locate without direct sunlight shining on them. To expedite the location of targets, it sometimes becomes necessary to use some method of illuminating the target area. Five of the generally accepted methods are –

- The lighting of highway-type flares
- The use of a handheld flashing mirror
- The use of a strobe light unit, if available
- The use of colored smoke grenades during daylight hours
- Vehicle headlights

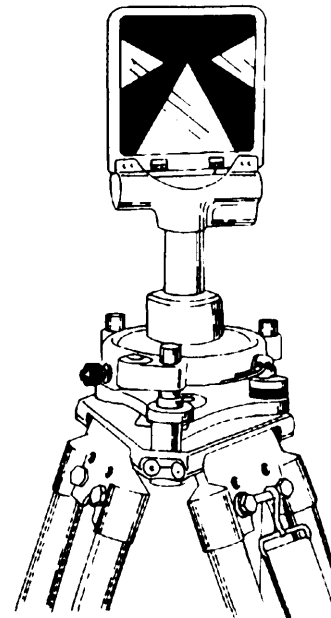
Once the area of the target is located, it becomes a simple task to find the exact location of the target. The use of iridescent cloth on the target in place of regular signal cloth is recommended if the cloth can be interchanged, especially in jungle areas.

TYPES OF TARGETS

Target Set

The target set is a precise survey target device generally used for short traverse lines (approximately 4 kilometers). The target set assembly (Figure 4-1) consists of a lower and upper group (TM5-6675-244-15). The lower group is a tribrach with a three-screw leveling head, circular bubble, and optical plumbing device. The upper group contains a plate with three triangles, a long level vial, and a lighting attachment. The upper group is removable and interchangeable with the theodolite.

Figure 4-1. Target set assembly



Use. In traverse operations where continual backlights and foresights are needed and where distances are not excessive, the target sets can be used in a leapfrog technique. The actual distance the target can be seen depends on background, lighting, and weather conditions.

Pointing. Care must be taken in pointing the target at the observer in order to eliminate the appearance of distortion of the target when viewed through the telescope. A disadvantage of the target set is that only one at a time may be set at a station.

Tripod Target

The tripod-type target is the most satisfactory from the standpoint of stability, simplicity of construction, durability, and accuracy. It ranges from a simple hood of cloth, cut and sewn into a pyramid shape and slipped over the instrument tripod, to the permanent tripod with the legs embedded in concrete, sides braced, vertical pole placed at the top, and the upper part boarded up and painted. Temporary tripod targets may be constructed of 2-inch by 2-inch lumber, pipe, poles, or bamboo joined at one end by wire, or

bolts threaded through drilled holes. The tripod must be guyed and plumbed (Figure 4-2) and the legs should be set in depressions to prevent lateral movement. On uneven ground, one leg may have to be shortened or dug in to maintain a symmetrical appearance from all directions. Signal cloth wrapped around the tripod should be used only on lower-order (fourth-order) work, as it is almost impossible to make it symmetrical around the station.

Biped Target

Biped targets are more simply constructed than tripods, but are less stable and must be strongly guyed. Figure 4-3 shows an issued surveying beacon. It is a biped target and is carried disassembled in a canvas case about 53 inches long. It can be assembled, erected, and plumbed by two people in 15 minutes or less and can be dismantled and packed in 5 minutes. If this target must be left standing in the weather for any extended period, the rope guys should be replaced with wire and two more guys added at each end of the crossbar. In soft ground, the pointed legs will sink unevenly because of wind and rain, and should be set in holes bored in the end of wooden stakes driven flush

Figure 4-2. Tripod targets

Improved tripod signals

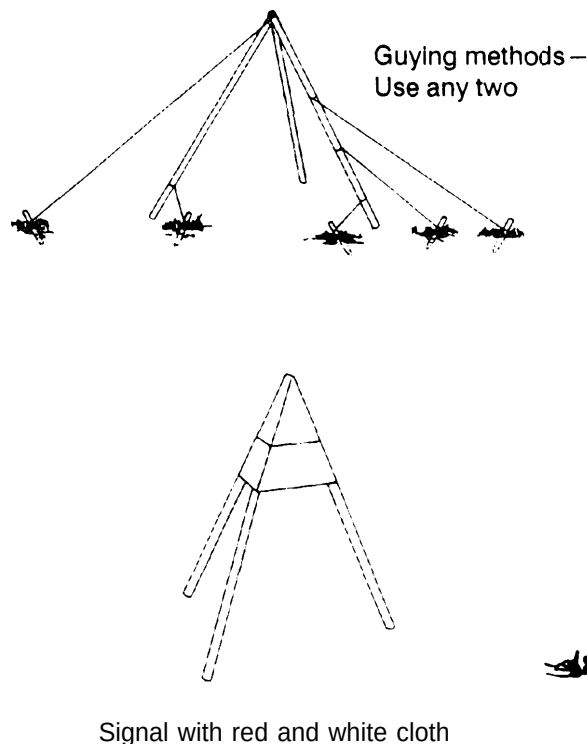
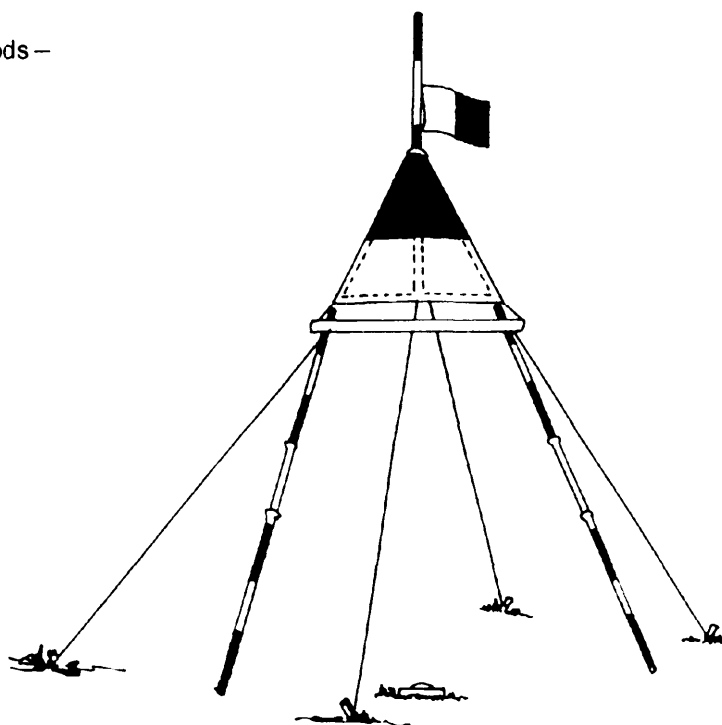


Figure 4-3. Biped target



with the ground or in a short piece of 2-inch by 4-inch lumber laid flat in a shallow hole.

Pole Targets

Pole targets (Figure 4-4) are seldom used because the station cannot be occupied while the target is in place. In certain cases, as when a picture point is to be intersected or an unoccupied station must be used and the cutting of lines of sight is extremely difficult or impossible, a pole target which can be seen above the medium-sized trees may be erected. The staff may be constructed of 2-inch by 2-inch lumber or cut poles, varying from about 2 inches (5 centimeters) to 6 inches (15 centimeters) in diameter. The method of joining sections of 2-inch by 2-inch lumber and the construction of a panel target are shown in Figure 4-4. The target must be plumbed by manipulating the guy wires or ropes. Special care must be taken when warped or crooked boards are used to construct pole targets, and they must be checked for eccentricity.

CENTERING AND PLUMBING TARGETS

When setting a target, it must be plumbed exactly over a station. A target is said to be eccentric when the

vertical center is not on the vertical line passing through the station mark. The proper correction can always be made for eccentricity by remembering the approximation **a second is a foot at 40 miles** (actually 39.065 miles) or that an inch represents about $3 \frac{1}{4}$ seconds at a distance of 1 mile. Always check a target or signal that has been observed for eccentricity. Any eccentricity found must be recorded so that the computer can be certain of the facts when correcting the observations.

PHASE

When observations are made on targets in the daylight, errors in the horizontal angle measurements due to unequal lighting of a target are referred to as phase (Figure 4-5). When one side is brightly lighted and the other is in the shadows, the observer tends to favor the sunlit side. Sometimes, with a skylined white target, the reverse is true and the dark side is favored. Phase is an eccentricity which could be corrected for, if its exact amount were known. The observer is rarely able to measure its amount accurately, since influencing factors such as the angle of the sun with the line of sight, the opacity of the signal, the shape of the

Figure 4-4. Pole targets

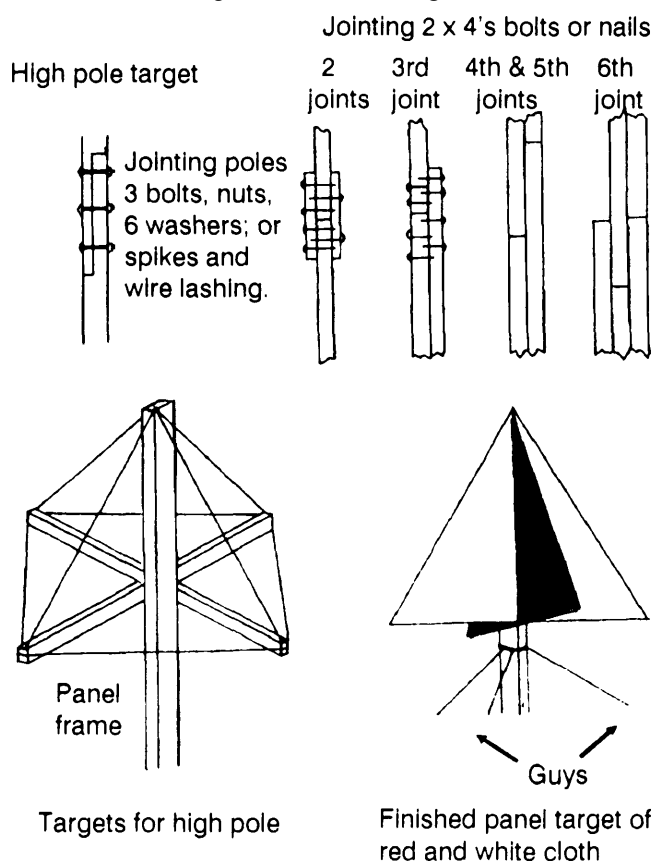
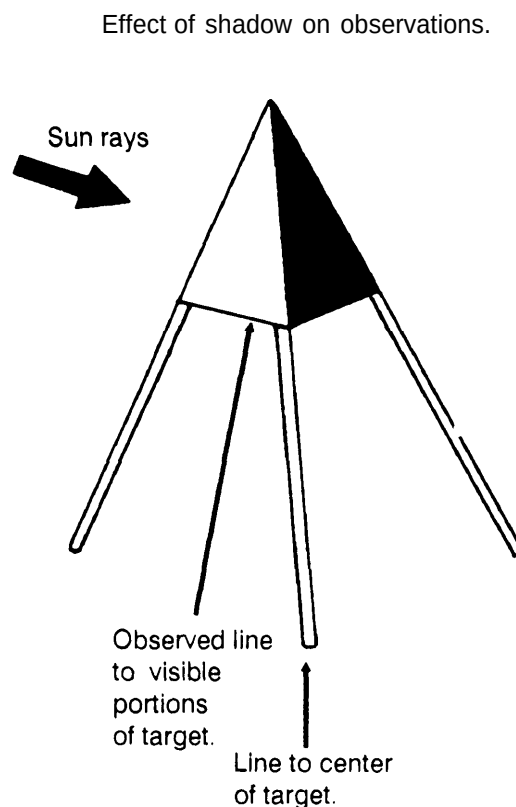


Figure 4-5. Phase



object sighted upon, and the intensity of the sunlight change rapidly. Trigonometric formulas for the correction of phase based upon the direction of the sun

have appeared in some textbooks, but are rarely practical. It is usually best to delay observations until poor conditions improve or no longer exist.

Section II SIGNALS

Signals are those survey targets that are either illuminated by natural sunlight (heliotope) or are electrically lighted by use of wet or dry cell batteries. The observations for all second-order, Class I triangulation and traverse are usually done at night by using signal lights because of more stable atmospheric conditions which allow for better pointings. Observations may be made during daylight hours using lights, but for high accuracy surveys this is done only under extreme conditions.

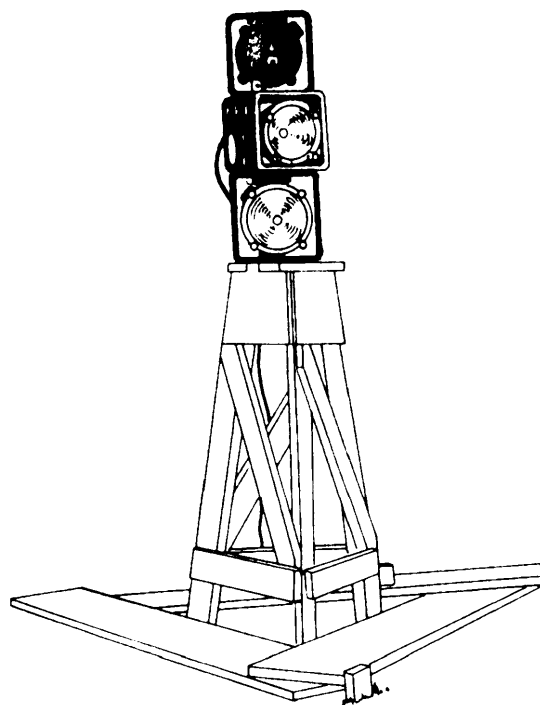
SIGNAL LIGHTS

The most commonly used signal light has a 5-inch reflector. These signal lights (Figure 4-6) are used as illustrated for lines of sight in excess of 8 kilometers, but by masking the face of the light they can be used for shorter lines of sight. A 5-inch light should **not** be used on lines of sight shorter than 5 miles (8 kilometers). This rule of thumb (no more than 1-inch diameter per mile observed) should be applied to other sizes of lights.

Pointing

The exact horizontal and vertical pointing of the light is very important. If the light is not pointed exactly toward the instrument, only a portion of the reflector will be observed and in some cases this portion will not be plumbed over the station mark. The instrument operator must check the pointing prior to starting the observations by viewing the light through the telescope. During hazy weather and especially on long lines of sight, the view through the telescope may appear as a bright spot surrounded by a flare. The instrument operator should request the lightkeeper to swing the light slightly in a horizontal and vertical arc while it is being viewed through the telescope until the best pointing can be determined. The best pointing will be when the light is the brightest. The light is then stopped and locked into position. The bottom light, if lights are stacked, must be pointed first as shown in Figure 4-6. It can be adjusted for brightness by adding or removing batteries. The light should never be improperly pointed to reduce its brilliance as this will create an eccentric light.

Figure 4-6. Stacking of 5-inch lights



Masking

The light can be masked to reduce the size and brilliance by covering equal portions of the lens both above and below and to the right and left of the center of the glass face. When masking a light, opposite sides of the glass must be masked equally to eliminate eccentricity. One method of masking is shown in Figure 4-7. This type of masking is very good for distances between 6 to 10 kilometers on normal nights. A sheet of orange scribe paper is required but any other color would work almost as well. When using the orange paper as a masking material, the light will present an orange glow with a brilliant white cross for pointing on by the observer. At maximum ranges, the orange glow is practically invisible through the telescope and at minimum ranges the glow will help in identification of the light.

Focusing

The light is focused by means of a screw at the rear of the bulb socket. By turning this screw, the position of the bulb is changed in relationship to the reflector. If the light is not properly focused, it will appear as a fuzzy ball in the telescope. The light may be focused at night by shining it on a flat surface about 50 meters away and adjusting until the beam is slightly larger than the light. When no distant object is available, afield expedient is to hold one's hand about 6 inches in front of the light and adjust until a dark spot the size of a quarter appears in the center of the beam.

Brilliance

The brilliance of the light is determined by the type of light bulb and the amount of voltage being used. The light is issued with two different bulbs: the standard 3.7-volt bulb and a 6.0-volt bulb. The amount of voltage needed will vary with the lighting requirements. The various battery arrangements are shown in Figure 4-8. If dry cell batteries are not available or are too weak, a field expedient is to connect two lights with 6-volt bulbs in series and then connect them to a 12-volt wet cell battery. Never apply more voltage to the bulbs than their rated value.

Stacking

When lights to several observers from the same station are needed, the lights are stacked, generally on a range pole tripod as shown in Figure 4-6. If lights are stacked over a station, they must be leveled and plumbed over that station mark. The first (lowest) light must be leveled and plumbed, then the other lights are attached and individually checked for level. Care must be taken when attaching additional lights to the pole not to knock the other lights out of plumb.

Figure 4-7. Masking of 5-inch light

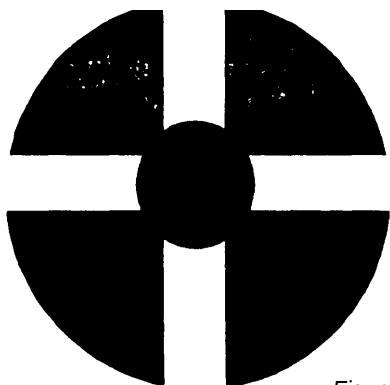
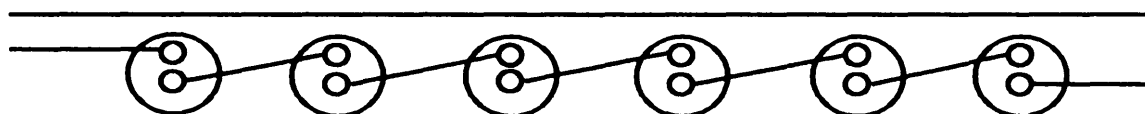
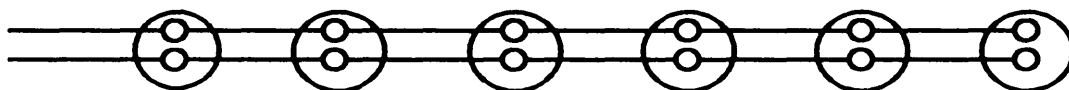


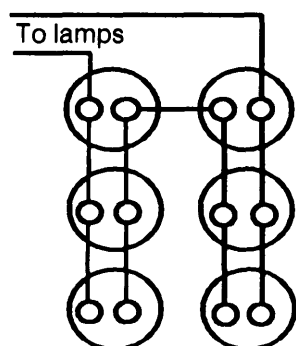
Figure 4-8. Battery wiring diagram



① Cells connected in series. Output 9 volts, 24 amperes.

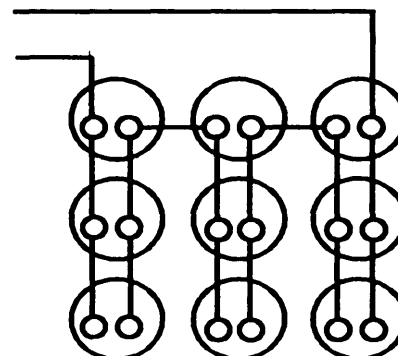


② Cells connected in parallel. Output 1 1/2 volts, 144 amperes.



③ Series-parallel connection. Output 3 volts, 72 amperes.

Outputs are based on the assumption of dry cells with an average of 1 1/2 volts and 24 amperes each.



④ Series-parallel connection. Output 4 1/2 volts, 72 amperes.

Ranging

When observations are made from a small (low) instrument stand, it is sometimes impossible to plumb the lights directly over the station mark. If this occurs, it is acceptable to use lights on range. The lights must be lined in on range to all stations with a theodolite. The standard theodolite tripod or range pole tripod is used as a stand and should be from 4 to 30 meters from the station. Care must be taken to avoid introduction of eccentricities when using lights on range.

TARGET SET

As previously mentioned, the target set is a precise survey lighting device. It is also a precise survey lighting device (Figure 4-9) used for short traverse lines (approximately 4 kilometers). When the target set is used for night observations, it requires the attachment of an accessory lighting unit on the back of the target. The lighting unit consists of a metal hood with a light bulb mounted in the center. For the older target sets, the hood hangs on two small metal studs mounted at the top rear of the target. For the newer target sets, the hood slides down over the sides of the target from the rear.

Use

The target set is used as a signal in the same way as when it is used as a target, as discussed in Section I.

Pointing

Extreme care must be taken in the pointing of this device. The lighting attachment must be pointed directly at the observer in order to eliminate the appearance of uneven lighting of the target's triangles.

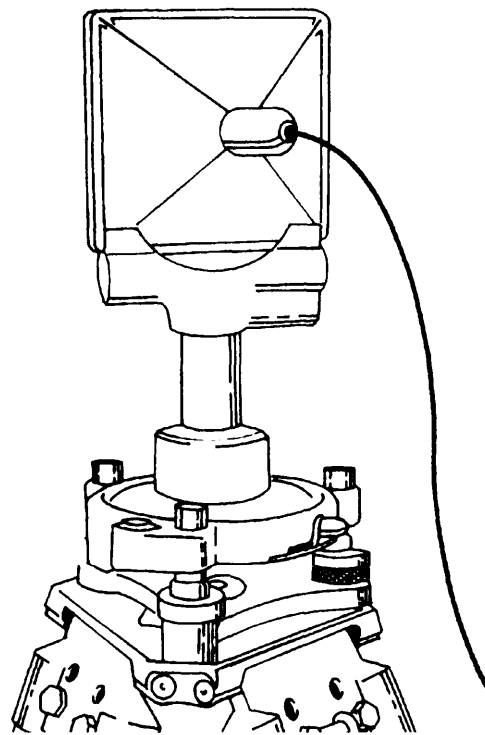
HELIOTROPES

The heliotrope is a device which reflects the sun's light through a pair of mirrors set over a station mark and pointed toward the observer on another station mark.

Characteristics and Procedures

The issued heliotrope consists of a flat base to which are attached two plane mirrors and a pair of sights (Figure 4-10). The base may be mounted on any standard tripod and plumbed directly over a station mark. It can be fitted in the wild-type tribrach and mounted on the tripod. One mirror is fixed to the base; it may be rotated and tilted, and it directs the reflected sunlight through the sights to the observer. If the sun is in the direction of the observer, the fixed mirror is all that is needed. The second mirror is on a movable arm for use when the sun is shining toward the observer. It

Figure 4-9. Lighting assembly for target



serves to direct the light into the fixed mirror and from there to the observer. No provision is made for adjusting the pointing in a vertical plane; however, flat wood chips or folded cardboard shims between the bottom of the heliotrope and the tripod head will solve this problem. The main point to remember is that all fittings must be tight, since any play or looseness will cause trouble when the observer sights on the heliotrope. Whichever mirror is receiving the direct sunlight must be attended at all times. Due to the apparent motion of the sun, the sunlight will stop hitting the receiving mirror about every three minutes. Thus, the receiving mirror must be moved with the sun in order to maintain the light source for the observer. The receiving mirror should be just tight enough so that light taps with the fingertip or a pencil will maintain the correct angle. The two sights are seldom aligned perfectly with the light apertures, and tests should be made prior to use so that the proper allowances can be made.

Use

Many surveyors tend to shy away from using the heliotrope because they have not been able to get good results due to faulty pointing techniques. There are times when use of this instrument is the only way to solve a line of sight problem. The intense rays of the

reflected sunlight are visible through hazy and smoky atmosphere when no other signals can be detected and the range is essentially unlimited. The heliotrope's use is limited by: first, the necessity for sunlight; second, the difficulty in using it as a target while making simultaneous observations from the same ground station; and third, the difficulty of aligning without radio communications. The second difficulty can be solved by placing the heliotrope to one side of the station and making careful measurements of its eccentricity. It can also be used in this position for simultaneous vertical angle measurements by measuring the difference of elevation from the true station. The third difficulty is not often present, since most survey parties are equipped with radio. The observer, while sighting through the telescope and with the radio in hand, gives a running stream of one-way directions to the heliotrope attendant until the observer has a steady

light in the telescope. At this time, the heliotrope attendant needs only to note the position of the sun's image on the sight and periodically adjust the sun mirror. When occupying a station with a heliotrope, the signal tender must continually adjust the mirror to maintain a steady light.

EXPEDIENT LIGHTS

There are many types of expedient lights or signals that can be used when standard equipment is not available or is inoperative. No attempt will be made here to list or illustrate all the different types of expedient lights or signals that can be used. These include the headlight of a vehicle, a masked lantern, a boxed light bulb, or chemical illumination lights. The survey party chief must use experience gained in the field and ingenuity to determine the proper expedient for a particular condition or problem.

Figure 4-10. Heliotrope

