Aimable Air/Sea Rescue Signal Mirrors

by Malcolm G. Murray Jr., *North Carolina Gamma '52*

THE AIR/SEA RESCUE signal mirror is a small, inexpensive, seemingly simple device used to signal for help over long distances by aimed sunlight reflection. Military personnel and civilians, in distress in wilderness and sea environments, have used it for many years. Unlike other emergency signaling devices such as radios and flares, a mirror is not subject to battery or chemical exhaustion. This article will review the history of this device, provide technical details of variations over the years, and describe what is currently available with advice for selection and use.

I first became interested in signal mirrors more than 40 years ago as a pilot in search of ocean fishermen in distress. I made hundreds of primitive buoyant plastic signal mirrors for the fishermen on the island of Aruba, where I worked for 18 years. I have developed some improved designs and been issued two U.S. patents on signal mirrors, and manufacture several hard-coated polycarbonate plastic and laminated glass models (by hand, and in small batches).[1,2] Feedback from users indicates that lives may have been saved and rescue times reduced in several emergencies.

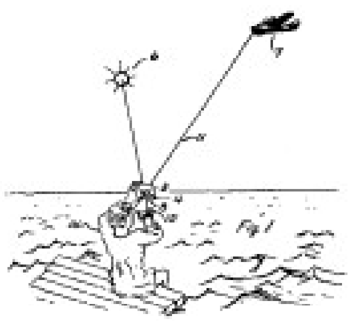
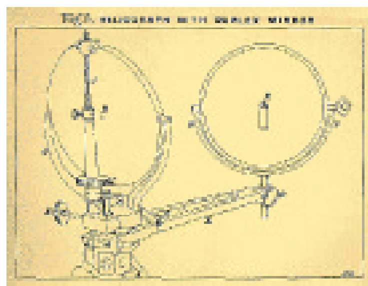


Figure 1 The best-known of WWII mirrors was the 3x5-inch cross-in-glass GE version.

This pre-WWI postcard (left) shows a posed group of heliograph signalers, circa 1906. The diagram below is from an 1886 Army signalling manual.



HISTORY: 13TH CENTURY TO 1973

Reflected sunlight signaling is mentioned in an account of the 13th-century Venetian traveler Marco Polo's visit to the Far East. The emperor was alerted to Polo's arrival by sunlight signals reflected between mountaintops along his route.

More verifiable is the use of the heliograph—a tripod-mounted sunlight-reflecting device aimed at a distant target. Its reflection could be interrupted to send dot-and-dash messages, in response to movement of a telegraph key. Relay systems using strategically placed signalling stations on mountaintops were used to send short messages quickly, over long distances in sunny weather. The British used such systems in military campaigns in northern India and Afghanistan in the 19th century. Later in that century, the U.S. Army used heliographs similarly during the Indian Wars in what are now the southwestern states. Although telegraph systems had been established in the area, Native Americans would cut the wires, then cleverly tie them together so that the severed location was not obvious. The heliograph network avoided this problem.[3]

Extensive use was made of air/sea rescue signal mirrors by military personnel during World War II. The distance record was set by a sea survivor in the Pacific, whose signal was seen by a pilot 105 miles away![4] Such distances were only possible, of course, with surface-to-air signaling. With surface-to-surface signaling, the earth's curvature limits range to six to ten miles, depending on heights above surface of the signaler and target. More typically, a 3x5-inch signal mirror will be effective at 20 miles surface-to-air. With the sun high, the reflection can be aimed in any direction. A circular horizon sweep requiring about one minute can thus cover about 1,200 square miles.

The best known of WWII mirrors was the 3x5-inch "cross-in-glass" type, produced in large quantities by General Electric, based on a design by Larry L. Young[5] (*Fig. 1*). This mirror required two hands to aim and somewhat of a "juggling act" to coordinate the back light spot with the mirror-cross aperture and the view of the target. For a survivor bouncing in a life raft or someone on land needing to climb a tree for a clear line of sight, two-hand aiming is impractical—one hand is needed to hang on!

Later WWII and subsequent military mirrors overcame this problem, with one-handed aimers that worked well (*Fig. 2*).[6,7,8]

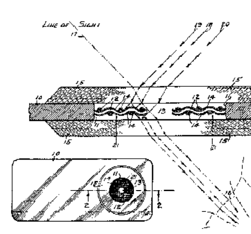
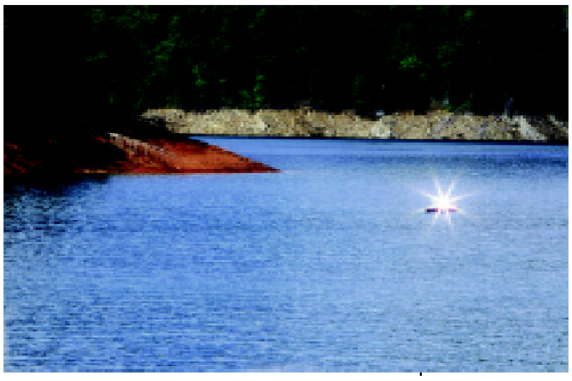


Figure 2 Retrodirective screen-glass signal mirror, one-handed version.

Most WWII mirrors used tempered glass. Occasionally the tempering caused distortion that reduced reflective strength. In a stress test, I intentionally dropped such a mirror from waist height

Figure 3 Mid-1940s mirror protected from corrosion by a foil-lined sealed kraft paper wrap, which must be destroyed to use.

onto a concrete sidewalk—it bounced and did not break. When dropped a second time, it shattered into many small, non-hazardous pieces. These mirrors were not laminated, and their reflective metal deposit was protected only by back paint. Many came in sealed paper or cloth packaging, with aluminum foil lining. After the package was opened, the mirror was vulnerable to corrosion. *Figure 3* shows an example of corrosion-resistant packaging. The sealed packaging also made it likely that the survivor would not have practiced using the mirror before the actual emergency in order to develop proficiency under relaxed conditions. Later military signal mirrors made of laminated glass during the Vietnam era were more resistant to corrosion, but not entirely immune. Considering that some raft survivors floated 133 and 139 days before rescue[9, 10], a mirror that corrodes quickly may be of limited value.



SUE WILTSE

3x 5-inch plastic signal mirror in use in one-person kayak from a point approximately one mile away.

Glass, of course, breaks easily upon impact with a hard surface. Even tempered glass may do so with a second impact, as described earlier. A further problem with glass mirrors used at sea is that they will sink quickly if dropped overboard. Lanyards, which are attached to most signal mirrors, help to prevent this. (At the end of this article, I will mention additional approaches for providing shock resistancy and buoyant packaging, as well as integrally buoyant and impact-resistant mirrors.)

In addition to glass signal mirrors, metal ones were sometimes used. Their reflective strength was relatively poor, around 30 percent of that of the same size glass. Corrosion was occasionally a problem, but the better ones avoided this with proper selection of materials. *Figure 4* shows a corrosion-resistant metal mirror, but it required two hands to aim, a disadvantage. This mirror is a better design compared with similar Vietnam-era equipment, and uses a larger mirror with a narrower aiming spoon. In the 1960s, plastic signal mirrors began to appear. Plastic's light weight (making buoyancy easy to achieve) and breakage resistance made it attractive for such use. We believe that Frederick Ehrsam produced the first plastic signal mirror[11] (*Fig. 5*).

SIGNAL MIRRORS CURRENTLY AVAILABLE

Many signal mirrors have appeared in more recent years, and most are still the standard 3x5-inch size. *Figure 6* shows a recent model, one that I produce. A major exception is shown in *Figure 7*, which is not a mirror as such, but a compact disk! This is an example of a flat reflecting surface that can be used as an improvised signal mirror by shining the sun's reflection through a vee in one's outstretched hand, while sighting the target through the center hole. If no hole is present, sight over the top edge center of the "mirror." Even a shiny credit card has been used successfully in this way to summon help.[12]

QUALITATIVE PERFORMANCE TESTING

To do this, reflect the sun (completely unblocked by clouds) against a shaded vertical surface at least 50 feet away. The reflected spot should be approximately round (the sun is spherical) and of uniformly bright intensity. An irregular light spot of varying intensity indicates mirror distortion and a weaker signal. I usually bend my plastic mirrors to correct distortion and improve the spot pattern. An odd situation happened once during such a check when a crescent-shaped reflected spot kept appearing—during an eclipse of the sun!

QUANTITATIVE PERFORMANCE TESTING

Any mirror will give its strongest signal when reflected toward the sun and its weakest signal when reflected

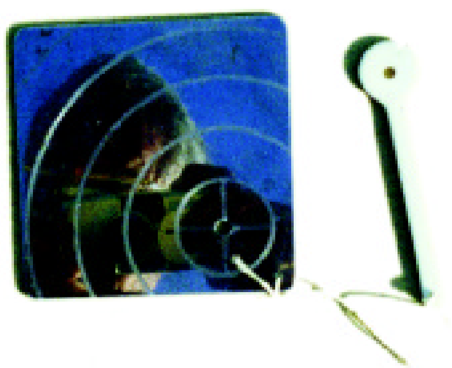


Figure 4 Plated non-ferrous metal signal mirror with plastic aiming spoon (British, 1940s).

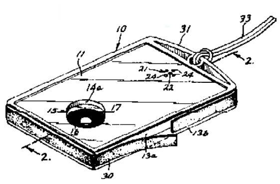


Figure 5 Retrodirective screen buoyant plastic signal mirror: the first plastic version.[11]

Figure 6 Buoyant 3x5-inch plastic retrodirective screen signal mirror with night-reflective back and a retractable aimer.

opposite the sun. Plastic mirrors vary more in this manner than glass ones. To get a reasonable average for consistent test results, perform your test when the sun is approximately 90 degrees from the target direction. In the mornings between 8:30 and 10:00 a.m., I place a tripod on the sidewalk in front of my 80-ft.-long windowless shop with the lights off. Aiming at the white inside wall at the back, I first set a similar size glass mirror in the tripod fixture and measure its reflected spot intensity with a digital lightmeter, getting, for example, 1,000 foot-candles. Then I repeat with the plastic mirror I wish to test. If I measure 750 foot-candles, this mirror tests at 75 percent. I reject those testing below 70 percent. Most test from 75-to-85 percent. Retractable aimer mirrors usually measure in the low 90s. Plastic signal mirrors from other sources have varied from 11-to-69 percent in my tests.

For newer designs, I do not rely entirely on this short-range testing. In Aruba, I would climb Mt. Yamanota, the highest point on the island, and signal to a friend at California Point, 12 miles away. In Texas, I signal between the 480-foot-high San Jacinto Monument on the Houston Ship Channel and a point three-to-five miles away, with the help of another person and cell phones. Once I tested in a low-wing Shinn airplane with canopy open in flight. I signaled to a radio-equipped friend on the ground 10 miles away, who saw the light flash clearly, despite not seeing the plane through the industrial haze common to the area.

PROTECTIVE PACKAGING

Foil-lined packaging is useful in storage, but must be destroyed to remove the mirror. It makes more sense to construct the mirror so it will not corrode. To accomplish this, I use a black synthetic rubber edge sealant and attach a lanyard without penetrating the lamination for the signal mirrors that I produce.

Reusable packaging is worthwhile. It provides a convenient place to carry paper (preferably high wet strength) instructions and anti-static cleaner that will keep the mirror clean and protect from scratching. It also provides a way to carry the mirror on an equipment line or belt. For glass mirrors, careful packaging can provide impact protection and buoyancy.

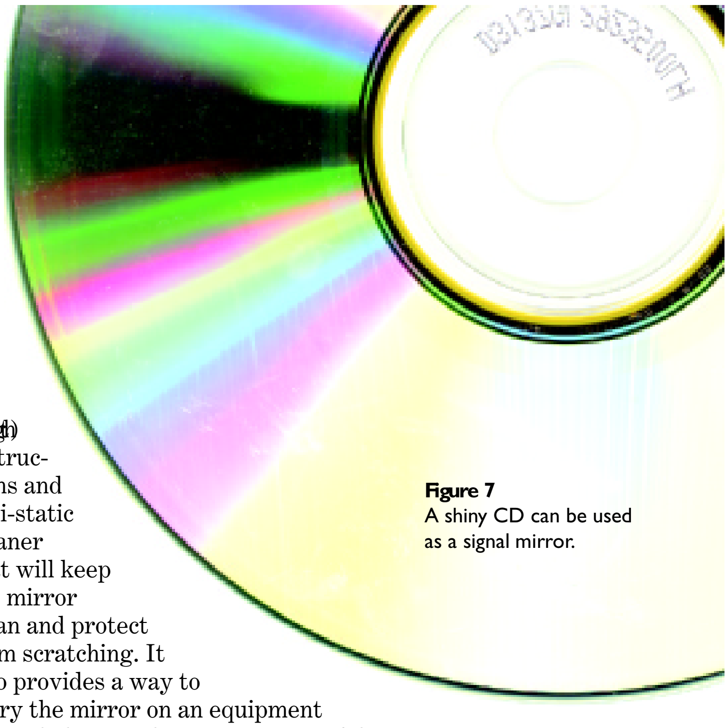


Figure 7
A shiny CD can be used as a signal mirror.

ADVICE FOR CHOOSING A SIGNAL MIRROR

Signal mirrors come in a variety of sizes, materials, and designs—with varying performance levels and features. Here is my advice for choosing one:

Size: The 3x5-inch size is most popular and practical for the majority of users. Scuba divers usually prefer small 2x3-inch mirrors to signal dive boats.

Materials: Avoid metal mirrors. They have few advantages and many disadvantages. My plastic mirrors outsell my glass ones ten-to-one for good reason. Be sure that the plastic mirror you buy is a good one—test its spot pattern as described earlier. Many pilots get both a glass and a plastic signal mirror. If the glass one survives a forced landing or ditching, they use it for its stronger signal, keeping the plastic one as a backup.

Buoyancy: If you need it, get it.

Aimer: Buy a mirror with a one-handed aimer because you may need your other hand for something else.

Lamination: Avoid any mirror with unsealed lamination. Check by looking along the edges, especially at the corners, for gaps. Put a mirror corner into your mouth, blow, and check for air exiting at the other corners.

Price: Price varies from $13 to $34 for good signal mirrors, including shipping. Even the most expensive signal mirror is affordable. Get one that works, and do not worry about the price!

Sources: *www.malcolmmurray.com*; *www.survivalinc.com*; and *www.avmarspecprod.com*.

ADVICE FOR USE

Here are suggestions on how to use a mirror effectively. I suggest that on the first sunny day after receiving your signal mirror you take it out and try using it with the provided instruction sheet. Usually, about 10-to-15 minutes' practice will let you develop proficiency in aiming at a distant target or in sweeping the horizon. Like riding a bicycle, the skill will be retained for life.

1. Move your cap with visor out of the way.
2. Learn to use it under relaxed conditions—*before* an emergency!
3. Grip the mirror *edges* with finger *tips*. *Do not let your fingers protrude over the front, partially blocking the reflective surface*!
4. Put the sun's reflection onto your outstretched "other" hand and keep it there, *before* bringing the back of the mirror to your eye and looking through the aimer. Then lower the hand and aim the mirror at your target, using the aimer light spot.
5. Do not use a mirror to aim the sun's reflection toward a person, vehicle, or airplane at close range—this could cause momentary blindness and result in an accident. Keep it away from children, small mammals, and irresponsible adults.

Additional articles on signal mirrors can be found in References 13 through 17.

Malcolm G. Murray Jr., *North Carolina Gamma '52,* P.E., received his B.S. from Duke in 1952 and M.S. from Stanford in 1961, both in mechanical engineering. He is a registered engineer in Texas and the District of Columbia and a pilot (now inactive) licensed in the U.S. and the Netherlands, with instructor and instrument ratings. He served in the U.S. Army from 1955-57, mostly at Ft. Belvoir, VA, doing field service tests on prototype portable electric-generator sets. During1952-55 and1957-72, he worked at a large oil refinery on the Dutch Caribbean island of Aruba, for the firm now known as ExxonMobil. From 1974-82, he worked at Exxon's chemical plant in Baytown, TX.

Since retiring from Exxon, he has been active in industrial machinery shaft/coupling alignment work (Murray & Garig Tool Works)—making patented tools, consulting, and training throughout the U.S. and in five other countries. Since 1994, he has had a second one-man company, Rescue Reflectors, Inc., making aimable air/sea rescue signal mirrors. He has seven U.S. patents, on alignment tools and signal mirrors and has written numerous magazine articles and one book on industrial machinery shaft/coupling alignment. He is a member of ASME and the Vibration Institute and is a first lieutenant in the Civil Air Patrol.

Author is shown aiming a 3x5-inch plastic signal mirror at a cloud. PHOTO BY ROBERT H. BRADFORD JR.

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