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No. 2

AIR SEA RESCUE BULLETIN

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ILLUSTRATIONS

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SIGNALING WITH MIRROR

R. S. HUNTER FINDS DEVICE IS "EXTREMELY VALUABLE" RESCUE AID

An article discussing the effectiveness of four methods of mirror signaling has been prepared by Richard S. Hunter of the National Bureau of Standards, and is quoted as follows:

Those who have not seen the proof find it hard to believe, but flashes of sunlight from a tiny mirror no more than 3 x 4 inches in size can be seen at distances three to five times those at which a much larger life raft or lifeboat can be recognized at sea. A mirror for signaling with the aid of sunlight is thus an extremely valuable device for the downed aviator or ship-wrecked sailor to use in attracting the attention of possible rescuers. Since mirrors for signaling are inexpensive and quite compact, they are now included in practically all survival kits and life-boat lockers of United Nations planes and ships.

Although signaling mirrors may be surprisingly small, they must be shiny and reasonably flat to be effective. They owe their effectiveness to the fact that they direct practically all the sunlight which falls on them in a narrow cone of directions. When a mirror is not flat, the flashes of sunlight reflected from it are spread out and weakened, the amount of the spreading depending upon the departure of the mirror from planarity. This spreading of the directions of reflection is illustrated in figure 1.

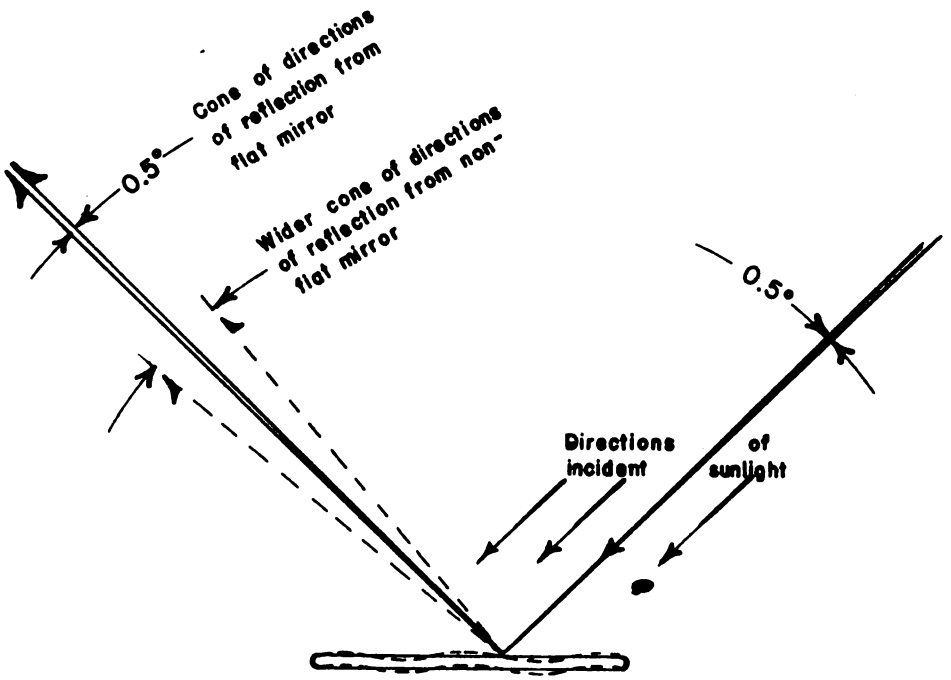

Figure 1. Diagram showing the directions of reflection of sunlight from flat and non-flat mirrors

Silver and aluminum deposited on glass and chromium-plated sheet steel have been used in the manufacture of mirrors specifically designed for signaling. However, almost anything which is reasonably flat and shiny enough to reflect images can be used to improvise a signaling device. A metal toilet mirror can be used without change. A shiny tin can can be cut open and flattened by hand. Pieces of flat glass and flat plastic windshields and windows make good signaling mirrors. Flat metal mirrors need to be only 3 x 4 inches in size to produce signals which will be visible at any distance from which rescue craft can be seen. Mirrors which are not of metal or not flat need to be larger.

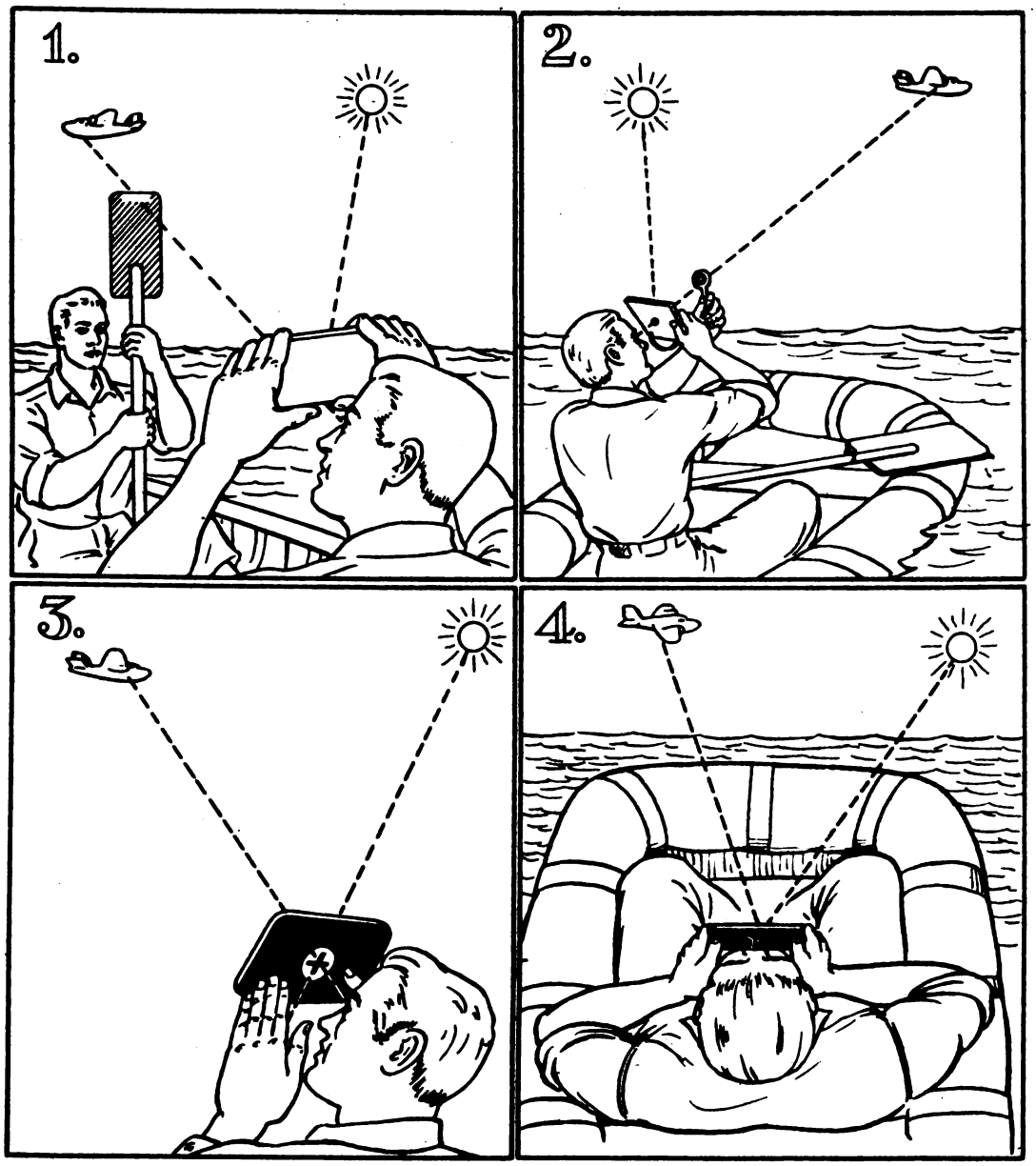

Figure 2. Diagram illustrating four methods of aiming mirror flashes of sunlight: (1) Sighting surface, (2) Foresight (British mirror), (3) Rearsight (G. E. mirror), and (4) Reflex button.

AIMING METHODS The difficult part of signaling with a mirror is always in aiming the reflected sunlight toward the signaling target. It is impossible to determine by guess the proper angle at which to hold a mirror so that it faces exactly half way between the sun and target. Many schemes to aid in finding this angle have been suggested. Only the four which are suggested in instructions or found in survival equipment furnished by the British and American services are described here. Diagrams showing the essential elements of each of these four schemes are given in figure 2.

(1.) Sighting-Surface Method of Aiming. The simplest of the four aiming schemes requires a nearby surface adjacent to the signaler's line of sight to the signaling target. To aim the beam of mirror-reflected sunlight by this method, the signal is first directed onto this sighting surface where the resultant bright spot can be seen. The mirror is then twisted to bring this bright spot as close as possible on the surface of the line of sight to the target. The mirror is then slowly oscillated so that the beam of reflected sunlight alternately leaves the sighting surface toward the target and returns again. For effective signaling, the mirror should be held close to the eyes of the signaler and on the opposite side of his line of vision from the sighting surface as shown in square 1 of figure 2. When the mirror is so held, the sighting surface does not intercept flashes of light aimed at the target, and the path of the reflected sunlight is properly parallel to the line of sight during part of each oscillation.

In a survival manual supplied to our armed forces about two years ago it was suggested that a survivor on land use a nearby tree or tall bush as a sighting surface. If the target was an airplane in the sky, the survivor was instructed to keep the tree or bush between him and the plane so that he could repeatedly test the direction of his signals by throwing flashes onto the tree. This suggested method would thus be classed as a sighting-surface method of signaling.

A retired surveyor in Texas, Mr. W. D. Twichell, has described the use of a mirror-twisting method of signaling which he found practical for communication between members of his surveying parties. This is essentially a sighting-surface method of signaling because mirror flashes of sunlight reflected off the nearby ground are used as guides for aiming to targets near the horizon.

Unfortunately there is no ground or vegetation on the open sea. If a lifeboat or life raft does not carry mast or sail, a signaler must have someone else in his boat raise an oar in the manner shown in square 1 of figure 2 to provide a sighting surface. If no raised surface can be had, as when there is only one survivor in a raft, this survivor can go into the water and then use part of the raft as the sighting surface. In experiments on water this method has proved difficult to use because of the confusing motions of the boat or raft caused by waves.

(2.) Foresight Method of Aiming. For aiming signals by the foresight method, a small key or foresight is substituted for the large sighting surface of the previous method. This small foresight is held in front of the mirror as illustrated in square 2 of figure 2, which shows the standard British signaling mirror in use. This mirror is 4 x 4 inches in size and made of polished stainless steel. The white key, which is attached to the mirror by 8 inches of string, has a round head about the size of a penny with a hole in the center and a stem about 2 inches long.

The signaler holds the mirror with one hand close to his head and the foresight with the other hand 8 inches beyond. The sighting hole in the bottom corner of this mirror causes a dark round shadow to be reflected in the otherwise bright beam from the face of the mirror. The small dark shadow is readily seen when reflected onto the white key close by. The mirror and key are held so that the signaler's line of sight through the two holes extends to the target and then the angle of the mirror is adjusted until the dark spot of light corresponding to the viewing hole of the mirror is centered on the hole in the key. Since the reflected image of sighting hole is thus in the line of sight to the target, the sunlight reflected by the mirror is directed toward the target.

This method suffers from the fact that the foresight and mirror must be held in line with the target while the device is in use, and from the fact that the line of sight to the target must pass through two small holes. The target is therefore much harder to see than when it can be watched with unobstructed vision. On water the problem of signaling with a mirror to a rapidly moving airplane is chiefly to keep the airplane in view while the signals are being aimed.

(3.) Rearsight Signaling Method. Reflection of a spot of light off the rear surface of the signaling mirror is used in this method to aim light reflected from the front of the mirror toward the target. A rearsight signaling mirror must be shiny on both sides. It must have a sighting hole. The small pencil of sunlight which passes through this hole is intercepted as shown in square 3 of figure 2 by either the signaler's hand or some part of his face. The small bright spot formed on the signaler's person is seen by him in the rear of the mirror at the same time he sights the target through the viewing hole.

To aim signals the signaler adjusts the angle of this mirror until this spot of light in the rear of the mirror disappears into the sighting hole. Since light travels in straight lines and the front and back surfaces of this mirror are parallel, the signaler knows when he makes this adjustment that flashes of light from the front of the mirror are aimed in his line of sight.

SIGNAL MIRRORS TESTED. . .Types of signal mirrors used as rescue equipment were demonstrated recently in Albemarle Sound, North Carolina. The photograph above was taken during the Learned type mirror test.

--Official U. S. Coast Guard photo--

The mirror shown in square 3 is the G.E. rearsight signaling mirror. The mirror is 4 x 5 inches in size and is made of aluminum evaporated onto specially strengthened glass. The viewing hole is made in the shape of a cross to provide a somewhat wider field of view for the signaler than is given by round hole. This G.E. mirror and a steel rearsight mirror which is chromium-plated on both sides and has a round hole in the center for aiming are the two signaling mirrors now most widely found with U. S. survival equipment.

(4.) Reflex-Button (Learned) Aiming Method. The idea for this ingenious method was submitted to the National Inventors Council for use in the war effort by a Californian named C. H. Learned. A reflex-button signaling mirror is equipped with a retro-directive reflector of the type widely employed for marking vehicles and road hazards. This type of reflector reverses the direction of any incident light so that in night traffic any button will appear bright from every vehicle which illuminates it by headlights.

To make a signaling mirror, this device is used in conjunction with a glass mirror. Near the center of the mirrorized coating on the glass, a clear window about 3/4 of an inch square is made in the mirror. As shown in square 4 of figure 2 there is inclined behind this window and attached at one edge of a retro-directive reflector button about the same size as the window. For signaling, the mirror is held so that sunlight coming through the window will strike the reflector button almost perpendicularly. A reversed beam of sunlight, therefore leaves the button toward the sun, but is partially reflected by the glass surfaces of the window. The signaler, as he looks through the window toward the target, sees the partially reflected part of this reversed beam of sunlight as an image of the sun. The image appears to him in the direction in which the mirror reflects sunlight because the reflections forward and rearward from the same surface are in opposite directions. This image is usually red in color because the reflector button is customarily red. High grade retro-directive reflector buttons are required to give images of the sun which are small and not badly distorted.

The reflex-button signaling mirror has four important advantages over the other aiming methods which have been described: (1) The signaler has a large area of clear window rather than a small peep hole through which to observe his target. (2) The signaler does not need to look for reflected light on a nearby surface at the same time he is observing the distant target. (3) The direction of reflection is shown at all times by the spot of red light. (4) There is no difficult problem of focusing the eye as (in other methods) the signaler looks first at a nearby spot and then at the distant target, because (in the reflex-button method) the spot is focussed at infinity.

In the hands of one who has practiced the different methods of signaling, a reflex-button signaling mirror will aim signals to a target with greater frequency, and will reach the target throughout a greater area of the sky than will any of the other types of mirrors. For this reason, the branches of the services which require survival equipment are now investigating the possibility of substituting this new type of signaling mirror for those they now possess.

The model of the reflex-button signaling mirror prepared by one manufacturer has a number of additional reflex buttons exposed from the rear face so that the device has value as a guide for rescue work at night. With eight yellow reflex buttons of the same construction as the red button used for aiming the sunlight signals, the rear side of the mirror will return yellow flashes toward a two-cell flashlight which will be visible 1/2 mile from a flashlight on a clear dark night.

CONCLUSIONS

Tests have been conducted jointly by the National Bureau of Standards and the U. S. Coast Guard to compare the effectiveness of the four methods of mirror signaling described above. In these tests, subjects trained briefly and then made repeated attempts to direct flashes of sunlight from a life raft on water to a circling patrol plane two to five miles away. Only one subject worked at a time and he alternately used one and then another of the aiming methods. The average frequencies with which flashes were received by the plane from the different mirrors are as follows:

	Average number of flashes observed per minute
Mirror aimed by sighting surface method	0.2
British foresight mirror (4"x4")	8.0
General Electric (4"x5") rearsight mirror	14.0
Reflex-button (3"x4") mirror	35.0

It seems safe to conclude from these results that the new reflex-button method of aiming mirror signals is superior to those which have been proposed and used in the past.

Of the four methods of signaling, the third or rearsight method seems the most worth memorizing. According to the above results, it is the second most effective method, and it is a method which can be readily improvised for signaling with different mirror materials. The usual toilet mirror which is supplied to service men is shiny on both sides and has a hole near one end by which it is hung. Such a mirror can be used without modification as a rearsight signaling mirror. A flattened piece of tin can can be used after a hole is punched in it. A flat piece of glass or clear plastic can be aimed by the rearsight method if a piece of opaque sheet material with a hole near the center is held in front of a small part of the whole transparent mirror. That part of the glass behind the opaque sheet material becomes that part of the mirror which is used for rearsight aiming.

The use of colored mirrors to give colored signals has been proposed. The distances from which colored signals will be visible are, in general, somewhat less than the distances from which signals produced by uncolored but otherwise identical mirrors can be seen. It has been suggested, however, that colored signals are much more likely to be heeded by the passing observer than uncolored signals. Waves, fish, floating objects and wet rocks can all produce flashes of sunlight such as are frequently seen at sea. It is therefore supposed that uncolored flashes from a signaling mirror will be less likely than colored flashes to attract the attention of the passing observer and be recognized as something caused by man. A bright orange-red color is suggested for use on colored signaling mirrors.

* * *

SEA MARKER ORDER ISSUED FOLLOWING COMPARATIVE TESTS

Navy BuAer has conducted comparative tests of the standard life jacket and life raft dye sea markers.

Fluorescein dye powder is packaged in a 10-ounce can for rafts; for jackets, in a waterproof fabric packet with rip-tab, containing 3 ounces of dye.

It was found that the life jacket marker:

(1) Affords a superior slick.
(2) Packs more easily.
(3) Provides a more easily controlled intermittent signal. (Once opened the canned dye may become doughy.)

Accordingly, Technical Order No. 53-44, April 17, 1944, directs that all cans of sea marker (Specifications M-582 and AN-S-10) in life rafts and pararafts be replaced by packets (Specification M-566) in the ratio of three dye packs for each can.

This order adds: "The use of a dye sea marker has been found to be most effective when searching aircraft are at altitudes in excess of 900 feet. At altitudes less than 900 feet the expending of dye as a signalling medium is questionable and life raft crews should be governed by local conditions of the sea, i.e., the effectiveness of the dye decreases with roughness of the sea."

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NAVY AIRBORNE LIFEBOAT MARK X, PNEUMATIC RESCUE BOAT

A compact, non-rigid boat has been adopted by the Equipment and Material Branch of the Bureau of Aeronautics to be dropped from the bomb bays of the TBF "Avenger" for rescue operations. The boat will hold ten men, is about 15 feet long and 8 feet wide, has two cross-seats inflated by a hand pump, two vertical bulkheads, and a top rail or "splash tube" which is inflated by carbon dioxide. The side pockets of the boat carry repair equipment, sailing instructions, navigation charts, hand pump, sails, oars, and sea anchor.

The Mark X and its supplementary emergency equipment are packaged in five containers and dropped in train from the bomb bays of the carrier based plane. The gear includes two revised shipwreck kits, one outboard motor, a fuel container with sufficient fuel for a fifty-mile voyage, and a container with the pneumatic boat. It is tied together with 70 yards of buoyant rope between each container, and dropped from an altitude of approximately 200 feet at an air speed of about 90 to 100 knots. The complete gear weighs approximately 600 pounds. These airborne rescue boats are on order and deliveries will begin 1 September 1944. It is planned that there will be about ten boats per carrier. (NOTE: An article on Airborne Lifeboats used by all Services will appear in a forthcoming issue of the BULLETIN.)