feet until he would be able to put in protection. After climbing up ten or twelve feet, and before placing protection, Schuler fell off, landing on his feet and breaking his left leg in two places. (Sources: Donna L. Symns, Watson.)

Analysis: Mike did not successfully spot Bruce for two reasons: (1) He was not directly below Bruce, in fact he was at least six feet from the ideal spotting position. This may have been just as well, since (2) Bruce came down feet first. It would have been difficult and perhaps disastrous had Mike tried to slow him. Bruce also contributed to the accident by not having any protection in. Ideally he should have stood on our shoulders to put something in, or gone up, placed protection, rested, and then climbed the full pitch. Since you lose hard-man points for safety procedures like this, nobody does these things. I didn't last summer. However, the week following the accident, when I climbed Moby Dick, I did (Source: Watson.)

California, Yosemite Valley. On June 7th Mike Blake (age 19) and Jerry Vogler (33) were completing an ascent of the Nose of El Capitan. Vogler had reached the summit slabs at the top of the bolt ladder and tied off the rope to his second. Blake was ascending the tied-off rope, using Jumars and removing the protection. Almost at the end of the bolt ladder, about fifteen feet from the top, he made an unknown error. Speculation has centered around his use of the Jumars and the possible failure of a tie-off loop. Blake fell about 150 feet to the end of the rope. The rope broke about twelve feet from the top, and he fell 3,000 feet to his death at the base of El Capitan. (Sources: Raffi Bedayn, Mark Forbes, Mead Hargis, Peter Thompson.)

Analysis: Examples of rope failure are rare, and this one aroused intense interest when it was learned that the rope was about one year old and had been used for only about twenty days of climbing. Speculation grew that the rope might have been defective, specifically that it could be much older than the owner thought and that aging processes had reduced its strength. A captain in the Austrian Mountain Corps was visiting the Valley and lent his authority to two observations: that the rope was far more faded than a fresh orange Mammut rope should be after twenty days of use, and that the core fibers were distinctly yellowed. The captain said that for one year after manufacture little yellowing could be observed in rope cores, but beyond that it became increasingly noticeable. The Valley climbing community became concerned that other ropes might have similar unknown defects. The Blake rope was forwarded to the American Alpine Club's equipment safety committee for analysis and testing.

Helmut Microys, a member of the committee, transported the rope to Switzerland for testing by Arova Lenzburg AG, the makers of Mammut rope. An identification thread in the core established that it had been manufactured between October 1970 and June 1971. It had been shipped to Eiger Mountain Sports, California, the distributors for Mammut, in one of four shipments in the first half of 1971. The rope had been purchased by Jerry Vogler in June 1972, either in Encino or West Los Angeles, California.

The rope was tested at the Mammut plant on July 24th and 25th, 1973, in the presence of Helmut Microys. (1) Visual examination. The rope showed general deterioration of the mantle, with many small tears most likely from Jumar use. Several of these tears located near the break appeared to be fused (nylon melts at about 480 degrees F.). Many fibers at the break were fused. After this visual examination the Mammut experts estimated that the rope would prove to be still safe, but that it had neared its proper retirement time. (2) Microscopic examination.

First, various demonstration fiber samples were studied — they had been subjected to a wide variety of forces, including cutting with a knife, with a rock, tensile break, stress over an edge. The many areas of mantle damage on the Blake rope were evidently from Jumar use. The fusion of core fibers near the break was confirmed under magnification. A comparison of those fibers with the demonstration samples suggested that the rope broke because of a sudden shock load over a relatively sharp edge. (3) Edge strength. Four individual tests were performed to determine the energy absorption capacity of the rope when stressed over a carabiner. The average breaking force was 1062.5 kp and the energy absorption capacity was 185.0 mkp/m. (A new rope has a capacity of about 300 mkp/m, and 180 mkp/m is considered the minimum to hold a severe fall.) On the basis of this figure the Mammut staff predicted that the rope would be able to hold one UIAA standard drop test. (4) Drop test. The rope sustained one drop test conducted according to UIAA requirements. It broke on the second drop. The location of the break was not influenced by several nearby areas of mantle damage.

Conclusions. A rope is considered safe if it can hold one UIAA standard drop test, and by this criterion the Blake rope was safe since it held one drop *after* Blake's own fall. However, a rope should be retired before dropping below the minimum of holding just one severe fall. On this basis the Blake rope had only a few more hours of useful life left — a total lifespan of perhaps twenty-five days of that kind of climbing. Another factor worthy of consideration is the force generated by Blake's fall, which is related to the so-called "fall factor." (The fall factor is obtained by dividing the length of the fall by the length of rope available to absorb the force. For example, if a leader climbs ten feet above his belayer and then falls, stopping ten feet below his belayer, that would be a fall of 20 feet divided by 10 feet of available rope, giving a fall factor of 2.) The fall factor in the UIAA drop test is 1.78. Blake fell somewhat less than the full length of his rope, giving a fall factor slightly below 1. Despite the spectacular length of the fall, it could have generated only a moderate force, one which both the rope and a human body should withstand. One can thus deduce that some unfavorable circumstance existed, such as a small sharp edge — perhaps a nubbin only half an inch high, or a bolt or bolt hanger.

Barring any local weakness in the rope, one must conclude that the Blake rope did not break because it was too old, too used, or too weak. The possibility of a local weakness cannot be discarded, whether from a mechanical or chemical cause. Inquiry revealed that it would be impossible to reconstruct a local weakness with any degree of certainty. However, the equipment safety committee was able to conclude that the failure of the Blake rope was not caused by a general defect of the entire rope.

Comments on speculation. According to the Mammut manufacturers, the rope was not faded. It was made with a "dark orange" mantle which was subsequently succeeded by a brighter "signal orange." Fresh samples of both mantles were displayed. The surface of the Blake rope was dirty, but the interior fibers were unaffected. The effect of ultraviolet radiation (sunlight) on nylon ropes is slight in comparison to deterioration from use. In recent tests by Mammut, ropes continuously exposed for one year (over 2,000 hours of sunshine) retained 70% of their original strength. Chemical air pollution in urban areas is a more serious enemy of nylon than intense sunlight at high elevations. Under good storage conditions (dark, dry, room temperature), five years on the shelf would not significantly affect a rope's strength. Core fibers are not necessarily white. Mammut

ropes were made with yellow core material until early 1972, since then with white. The Austrian army captain was totaly misinformed on this point — an example of how authority and apparent knowledge can combine to confound an already unaware climbing public. (Sources: Mead Hargis, Helmut Microys, Edward Nester, Peter Renz, Peter Thompson.)

The investigation of this accident drew on an unusual number of people and organizations, including Arova Lenzburg AG (Mammut ropes), the National Park Service, Recreational Equipment, Inc., M. Teufelberger (Edelweiss ropes), the Commission du Matériel de Sécurité of the Union Internationale des Associations d'Alpinisme, and the safety committee and equipment safety committee of the A.A.C. The climbing public's knowledge of ropes proved to be meager in comparison with the importance of ropes in climbing. The accident itself, however, might have been prevented by entirely unsophisticated procedures. Jumars are well known to lend themselves to errors, especially on traverse, and they cannot be relied upon to stop a fall. The climber must attend to safety on the last few feet of the climb and at the end of the day as well as at the crux move. On long aid climbs one precaution would be for seconds as they move up the rope to tie in again occasionally, so that they could never fall the full length of the rope.

California, Yosemite Valley. On June 17th Charles Stanbrough (age 19) set out to solo the Steck route on Higher Cathedral Spire. The next day his body was found at the base of the route. He did not sign out and none of his friends had missed him. (Source: Peter Thompson.)

Analysis: Stanbrough was using a 9 mm perlon rope and a 3/8″ Goldline prussik loop for self-belay. Apparently an aid placement failed about 180 feet off the ground. The faulty aid placement and the use of an old rope reflect Stanbrough's judgment, but probably he did not realize that his self-belay arrangement almost certainly would not work. The principle of the prussik knot requires that the prussik loop rope be of distinctly smaller diameter than the climbing rope. Perlon of 9 mm and 3/8″ Goldline are virtually the same diameter. The problem is compounded when the prussik loop is of a relatively stiff rope that tends not to grip of its own accord. Common sense dictates that the prussik loop should have a reasonable diameter for safety's sake, which in turn means that in most prussiking situations 11 mm perlon or 7/16″ Goldline will be the climbing rope preferred.

California, Yosemite Valley. On July 16th Jerrold Goodwin (age 31) and Benjamin Wells (32) were on the first pitch of the MW Route of Sunnyside Bench. A falling body hurtled past and landed on the scree sixty feet below. Goodwin and Wells immediately downclimbed and found Brian Quinn (18) lying on his side with obvious multiple injuries. He had a strong heartbeat but was not breathing. The climbers dispatched two bystanders for help and attempted to clear the victim's nose and throat. A physician ascended the scree slope and directed mouth-to-mouth resuscitation and external heart massage. The physician decided that immediate evacuation was necessary, but the first ranger to arrive said no evacuation should be tried until additional help arrived, for which he radioed. The ranger had a resuscitator which proved useless as it lacked an airway. The victim's tongue had swollen to block his mouth, his nose was clogged, and his pulse was lost. An improvised stretcher was brought up, but Quinn was dead on arrival at Yosemite hospital. The victim had been "leading" three other young people up sloping ledges toward the Class 5 portion of the Waterfall Route. None of the four